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11.0 CUTTER SEALER AND SPLICER MECHANISMS

The PPS/DP EAC contains four cutter/sealers (C/Ss), the aft backup cutter, two tunnel seal and record traps (TSRTs), and two splicer mechanisms (splicer/cutters). These are all spring-loaded, pyro-actuated devices used in the termination and recovery of film (see Part 3, Section 12).

11.1 Function

Cutter/sealers 1 and 2 are mounted on the capsule covers of SRV 1 and SRV 2 respectively. When actuated, they cut any film not rolled into the SRV, and seal the capsule against the external environment.

Cutter/sealers 3 and 4 and the TSRT assemblies are mounted in the 9 and 5 TSRT enclosures. The cutter/sealers act as film-path light and pressure seals after the separation of SRV 1, and as redundant cutters to C/S 1. Their location aft of the tunnel separation points ensures that any film trapped in the tunnel will not affect separation of the ejectable adapter (EA). The TSRTs, cutter/sealers with the blade removed, trap and hold any film left between the TSRT enclosures and splicers. They also serve as redundant light and pressure seals for the 9 and 5 film paths. To ensure that the free end of any film trapped by the 9 TSRT does not enter the film path to SRV 2, a shield is mounted aft of the Station 34.5 bulkhead between the TSRT and the film path to SRV 2.

The aft backup cutter (ABUC) is a cutter/sealer with the sealing gasket removed. Mounted in the film supply enclosure, it acts as a redundant cutter to C/S 2. The 9 and 5 splicer mechanisms are located in the film supply enclosure, attached to their respective supplies. The film is guided to take-up (T/U) 1 by the splicer mechanisms until commanded to transfer the path to T/U 2. Upon actuation, the film strand is spliced onto the leader from T/U 2 and then severed ahead of the splice. The film tail is free to be rolled into SRV 1, while the splicer guides the remaining film into SRV 2 for the second half of the mission.

The functions of the cutter/sealer and splicer mechanisms are summarized in Table 3.11-1. Figure 3.11-1 shows the location of the devices with respect to other components in the vehicle.

The following sections describe a typical cutter/sealer and a splicer. Due to the similarities of the cutter/sealers, TSRTs, and the aft backup cutter, one example will apply to all, with differences being noted where appropriate.

11.2 The Cutter/Sealer Mechanism

As shown in Figures 3.11-2 through 3.11-5, the cutter/sealer consists of four subassemblies: the baseplate, the pivot door assembly, the latching mechanism, and the electrical connector and circuit board. Each cutter/sealer is approximately 15 inches long overall, and weighs about 3 pounds. The baseplate opening measures 1.5 by 10.75 inches, with the actual free-film path slightly less due to encroachment by the cutter/sealer blade guard (see Figure 3.11-4). No smaller cutter/sealer has been designed for the 5 film subsystem.

11.2.1 Latching Mechanism

The latching mechanism holds the pivot door open until the cut/seal function is commanded. The latch release is actuated by redundant pyrotechnic devices (dimple motors), either one of which is capable of operating the

TABLE 3.11-1

FUNCTIONS PERFORMED BY CUTTER/SEALER AND SPLICER MECHANISMS

Function		Primary Mechanism	Backup Mechanism
Splice film strand to leader from Take-up 2 (9 or 5)		9 Splicer Mechanism 5 Splicer Mechanism	(None)
Cut film entering SRV 1	All film rolled into SRV 1	9 Splicer Mechanism 5 Splicer Mechanism	Cutter/Sealer 1 (9&5)
	Film not rolled into SRV 1	Cutter/Sealer 1 (9&5)	Cutter/Sealer 3 Cutter/Sealer 4
Seal SRV 1		Cutter/Sealer 1 (9&5)	(None)
Seal 9 and 5 film paths to film supply enclosure during second half of mission		Cutter/Sealer 3 and Cutter/Sealer 4	TSRT 9 and TSRT 5
Trap film strand exiting from splicer mechanism (9 or 5) if not rolled into SRV 1		TSRT 9 TSRT 5	(None)
Cut film strands entering SRV 2		Cutter/Sealer 2 (9&5)	Aft Backup Cutter (9&5)
Seal SRV 2		Cutter/Sealer 2 (9&5)	(None)

Note: 9 refers to 9.5-inch wide film
5 refers to 5-inch wide film

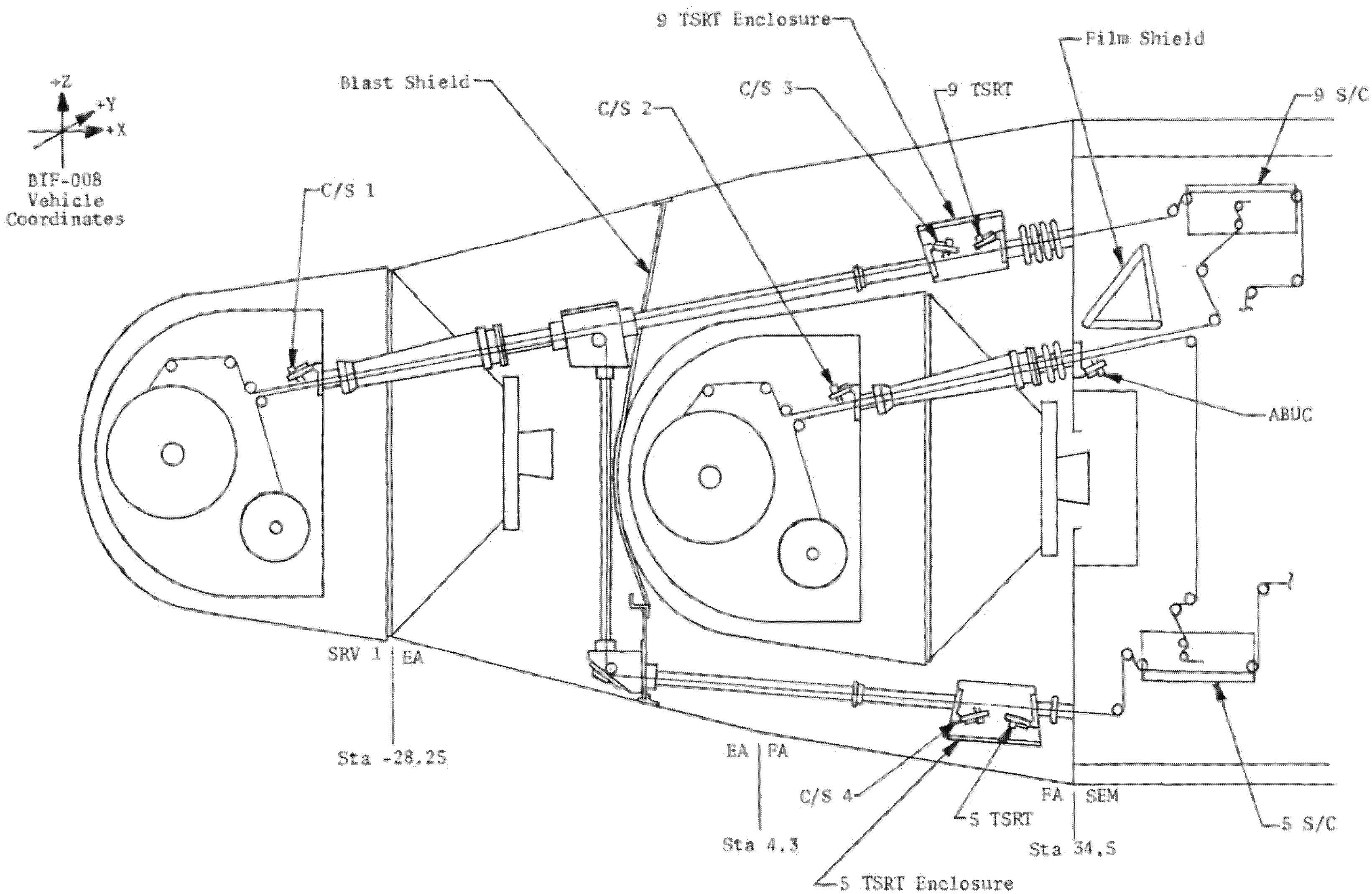


Figure 3.11-1. Cutter/Sealer and Splicer Mechanism Locations

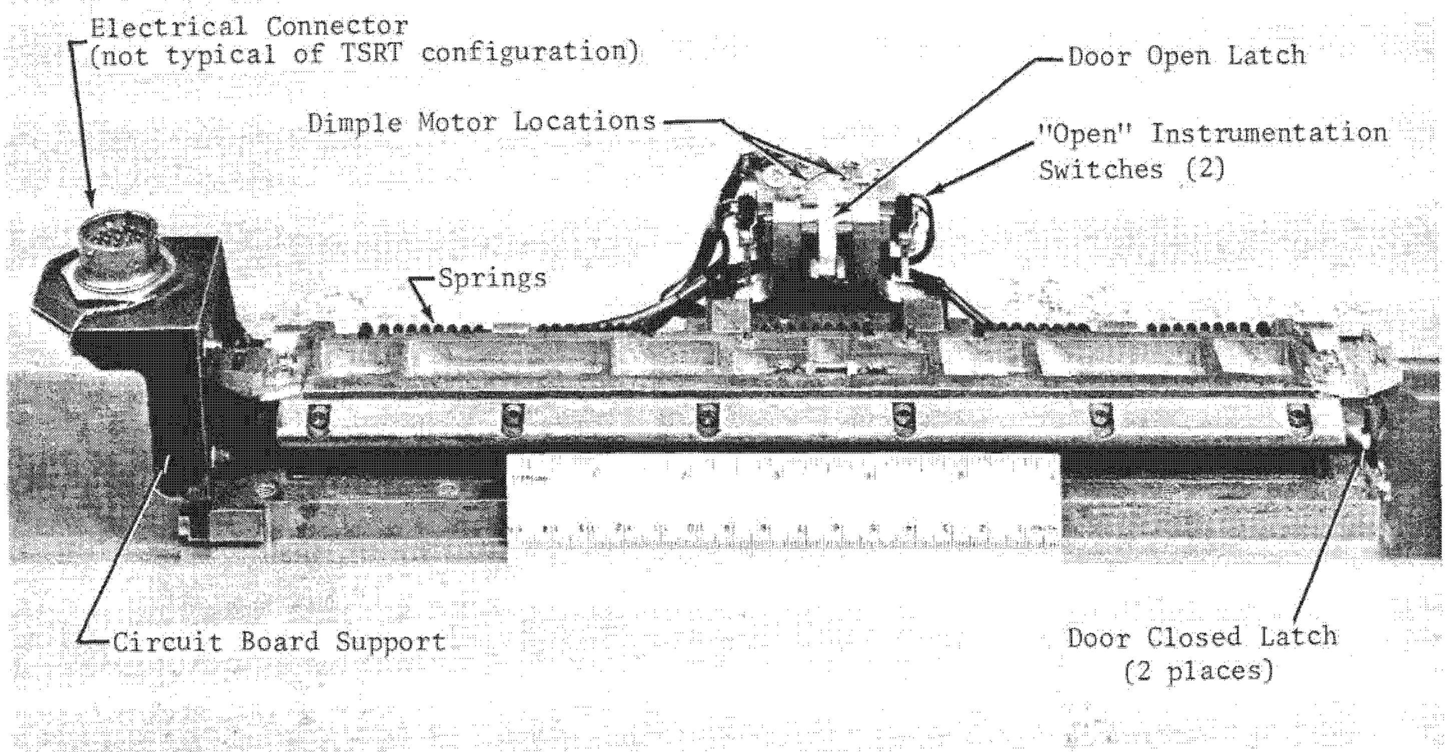


Figure 3.11-2. Cutter/Sealer Assembly (Partially Closed)

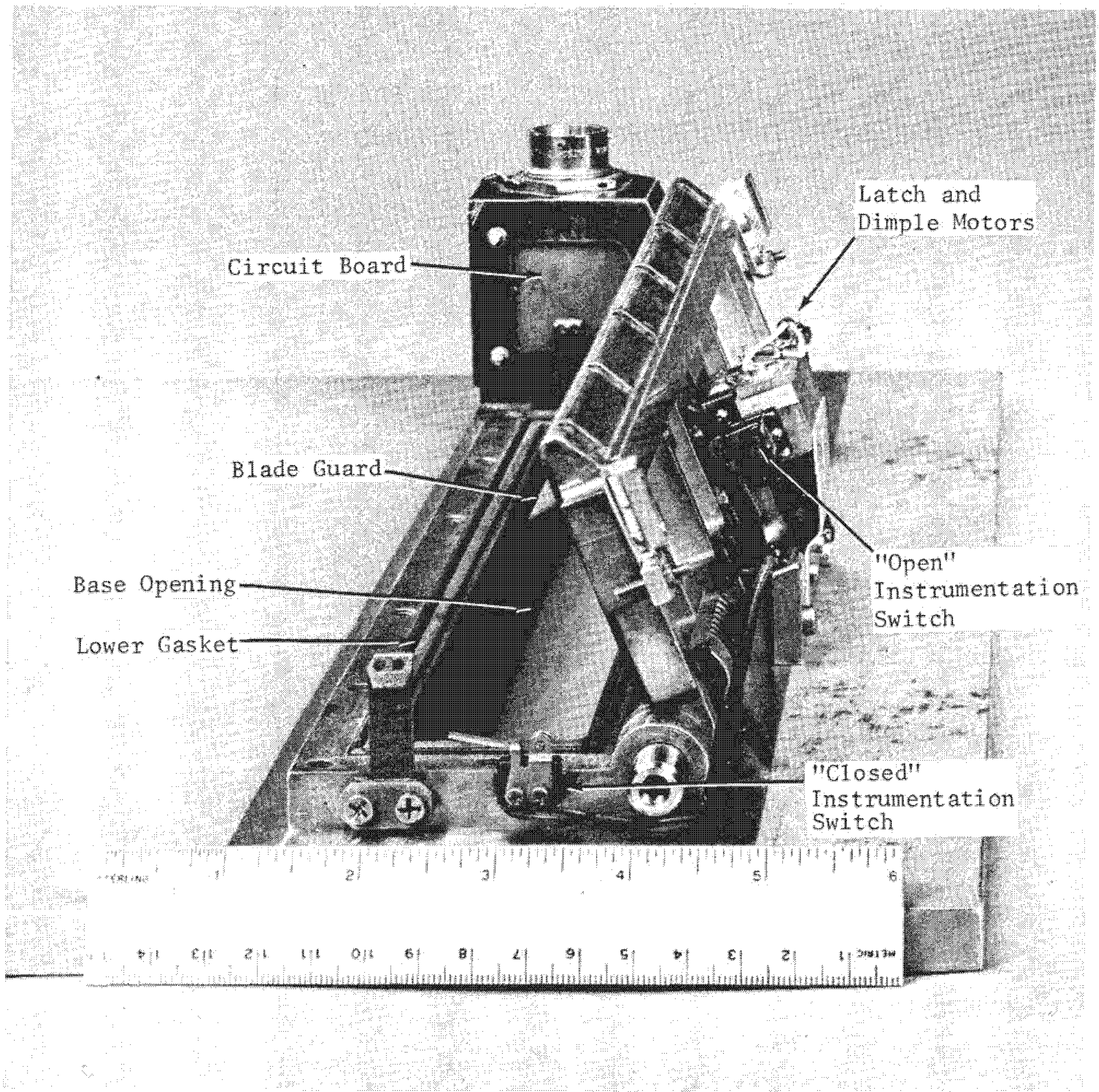
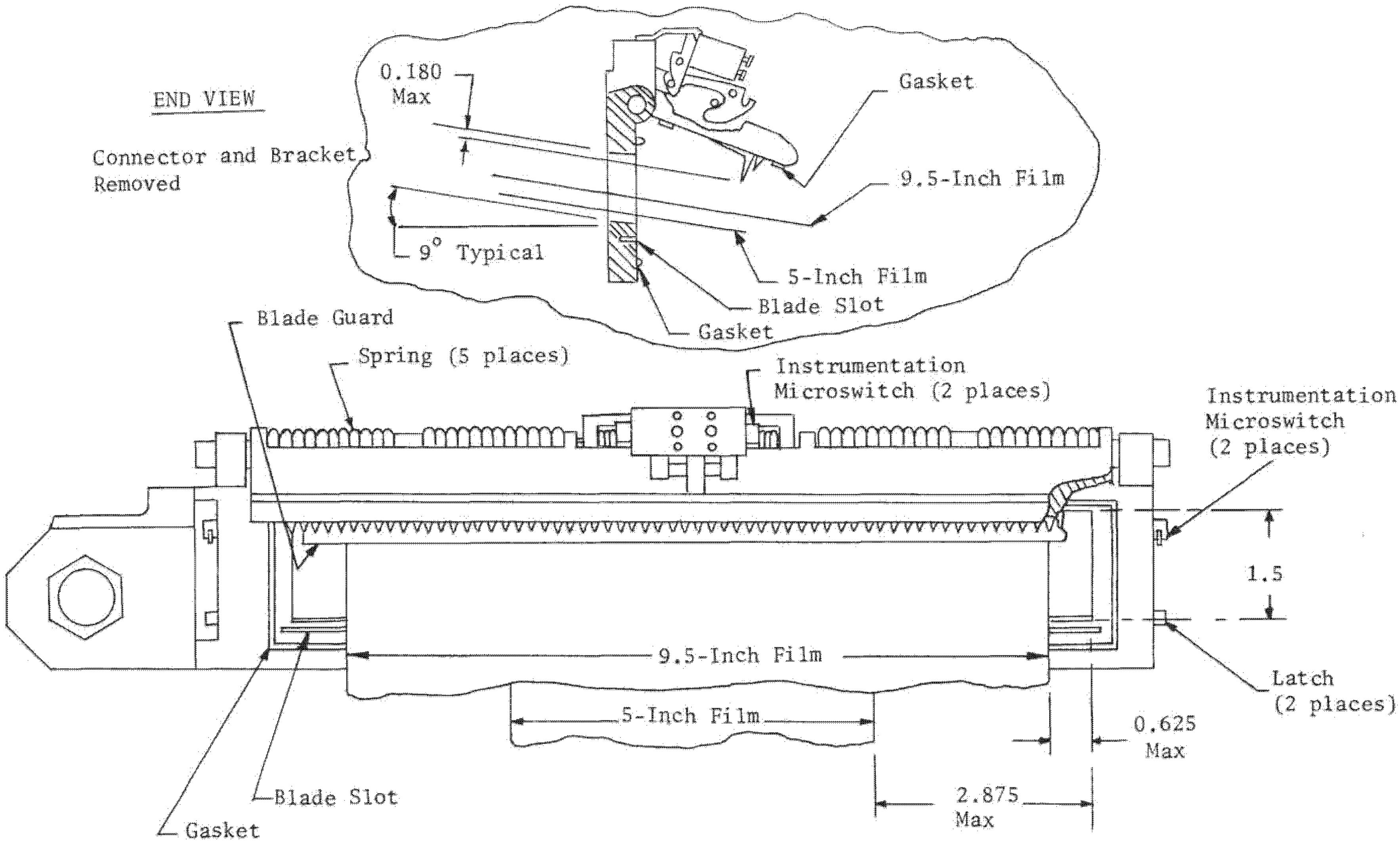


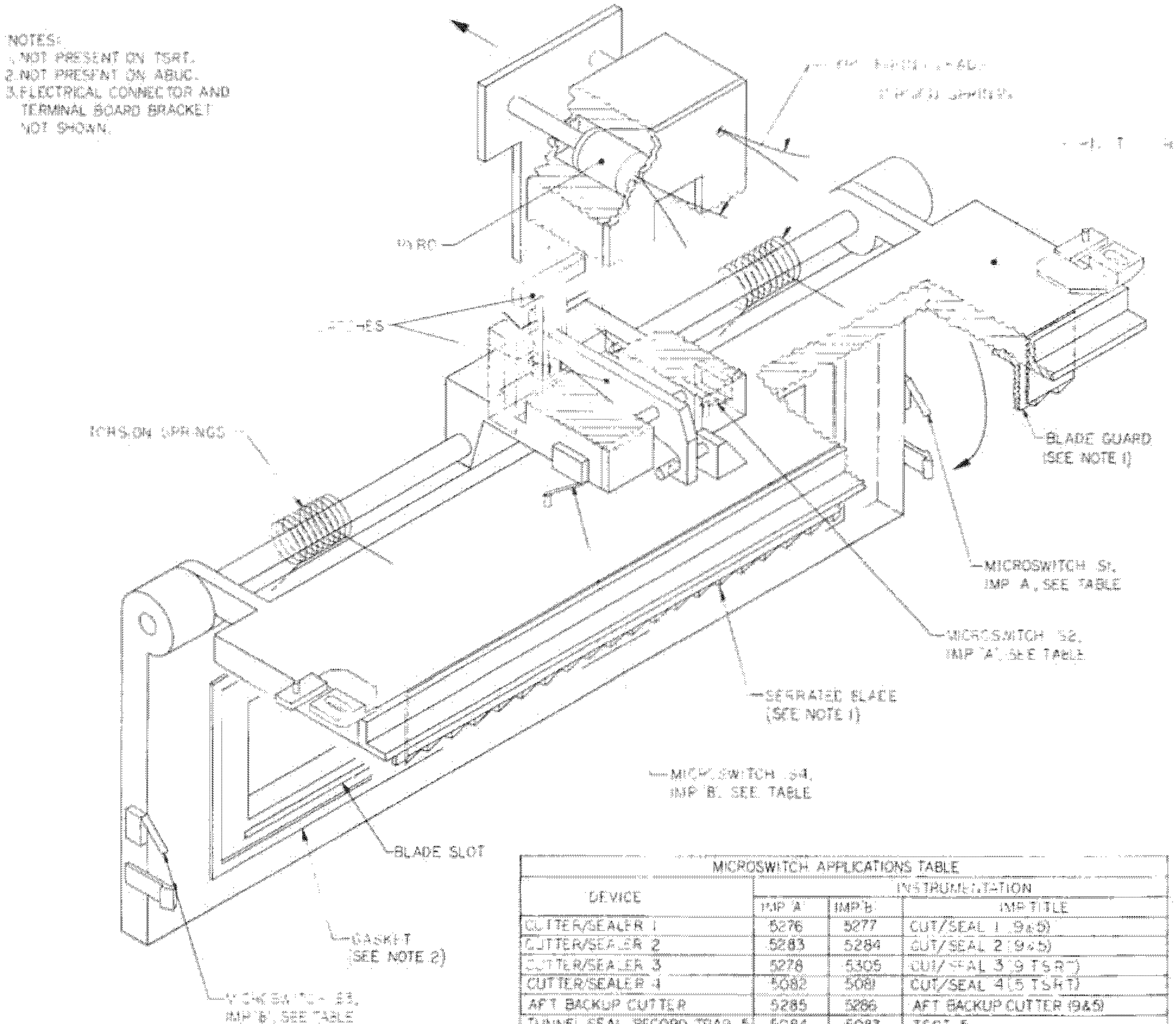
Figure 3.11-3. Cutter/Sealer Assembly (Open)



3.11-7

NOTES: 1. Base opening measures 1.5 x 10.75 inches.
2. Drawing is not to scale.
3. Dimensions are in inches.

Figure 3.11-4. Cutter/Sealer Film Path Space Location



MICROSWITCH APPLICATIONS TABLE

DEVICE	INSTRUMENTATION		
	IMP A	IMP B	IMP TITLE
CUTTER/SEALER 1	5276	5277	CUT/SEAL 1 (9&5)
CUTTER/SEALER 2	5283	5284	CUT/SEAL 2 (9&5)
CUTTER/SEALER 3	5278	5305	CUT/SEAL 3 (9 TSRT)
CUTTER/SEALER 4	5082	5081	CUT/SEAL 4 (5 TSRT)
AFT BACKUP CUTTER	5285	5286	AFT BACKUP CUTTER (9&5)
TUNNEL SEAL/RECORD TRAP-5	5084	5083	TSRT 5
TUNNEL SEAL/RECORD TRAP-9	5279	5280	TSRT 9

Figure 3.11-5. Typical Cutter/Sealer Device

Handle via BYEMAN
Control System Only

mechanism. Separate, electrically isolated firing signals are provided to each pyro on twisted, shielded wires from the initiator electronics unit.

11.2.2 Pivot Door Assembly

The pivot door supports the serrated cutting blade and the blade guard. In the event that film tension is lost, the guard will prevent damage to the film by the knife blade. Torsion springs along the door hinge provide the driving force for operation. A gasket on the door seats on an identical gasket in the baseplate forming a light- and pressure-tight seal when the door is closed. Note that, as stated previously, the cutting blade and blade guard are removed from the TSRT mechanisms, and the gaskets are removed from the aft backup cutter.

11.2.3 Electrical Interconnection and Instrumentation

All electrical signals, including the pyro firing pulses, are routed through a single 19-pin connector at one end of the cutter/sealer. The bracket supporting this connector also supports a mounting board for the instrumentation circuitry. The bracket on TSRT devices is slightly different in that the connector is extended from the TSRT by a short length of cable. The microswitches illustrated in Figure 3.11-5 are used to monitor the door position, providing redundant outputs. Switches S1 and S2 and their associated processing circuitry are powered from the +5-vdc instrumentation supply, while switches S3 and S4 and their processing circuitry are powered from the +15-vdc supply. The output levels for these monitors are identical:

0.50 volt	Actuation has not occurred.
2.50 volts	The pivot door is in transit.
4.50 volts	The operation is complete.

11.2.4 Cutter/Sealer Operation

The following discussion refers to Figure 3.11-5.

Upon command, the dimple motors in the latching mechanism are actuated, forcing the upper latch to pivot rearward. The lower latch is then released and the torsion springs pull the door free. The door is forced shut by the springs and the film strand(s) severed by the knife blade. Under normal force loads the door is held shut by the residual force of the springs. Two latches, which supply a positive locking force, are included to guard against the effect of shock loads or other abnormal forces.

11.3 Splicer Mechanism

Mechanical details of the splicer mechanism are illustrated in Figures 3.11-6 through 3.11-8. Each splicer measures approximately 5 x 7.5 x 14 inches, and weighs about 10 pounds. For purposes of discussion, the mechanism has been broken down into four subassemblies: the pyrotechnic dimple motors and drive linkage, the shuttle assembly, the platen assembly, and the electrical connectors and instrumentation.

11.3.1 Dimple Motors and Drive Linkage

The drive linkage, illustrated in Figure 3.11-8, consists of the encoder shaft, the drive shaft, and the crank bars and pantograph arms.

The encoder shaft is geared 1:1 to the drive shaft. The instrumentation encoder is mounted at one end of the encoder shaft, while at the opposite end the latch wheel and latch provide the holding force and actuation control for the splicer. The latch is released by firing redundant dimple motors, either

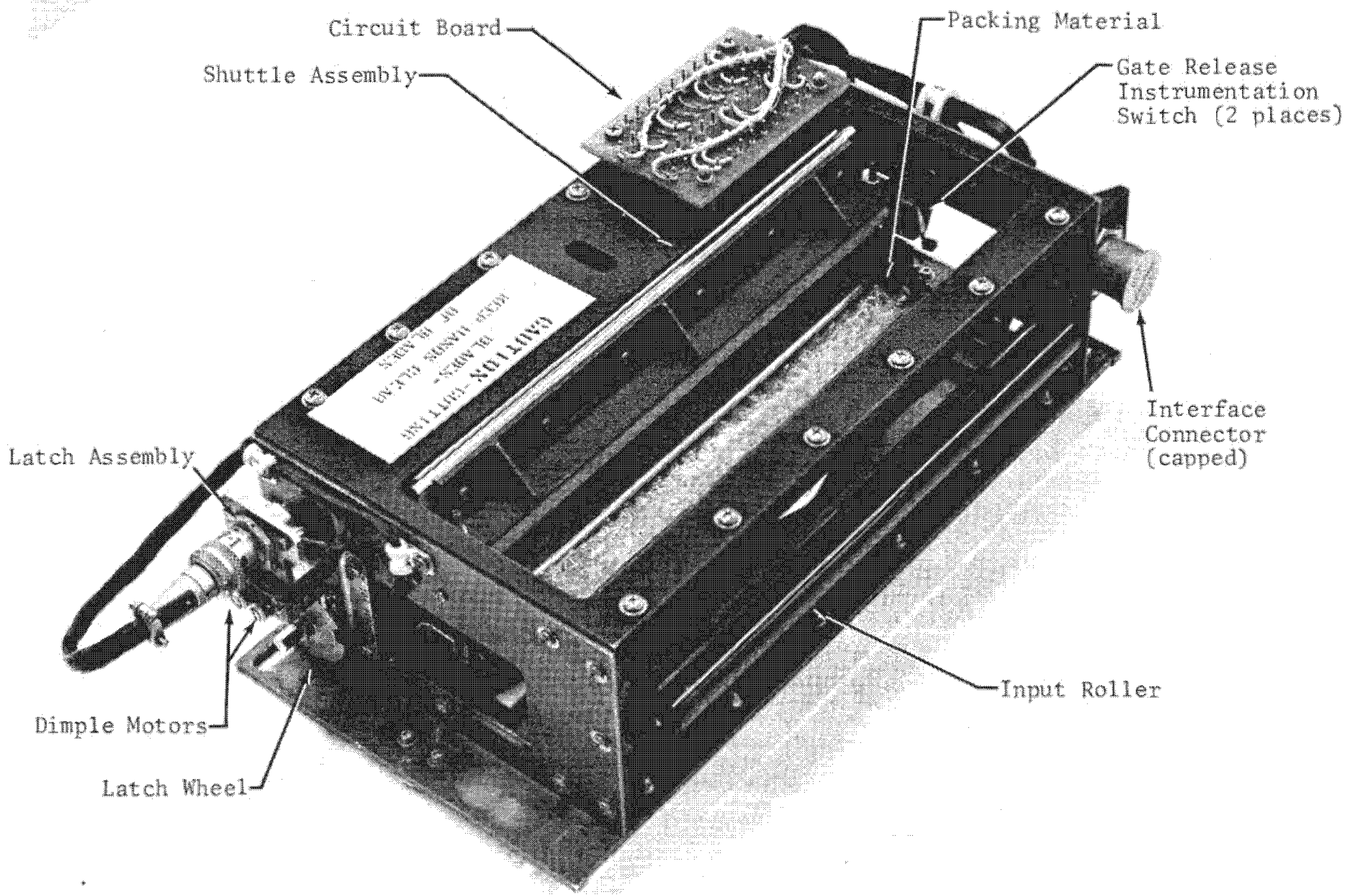
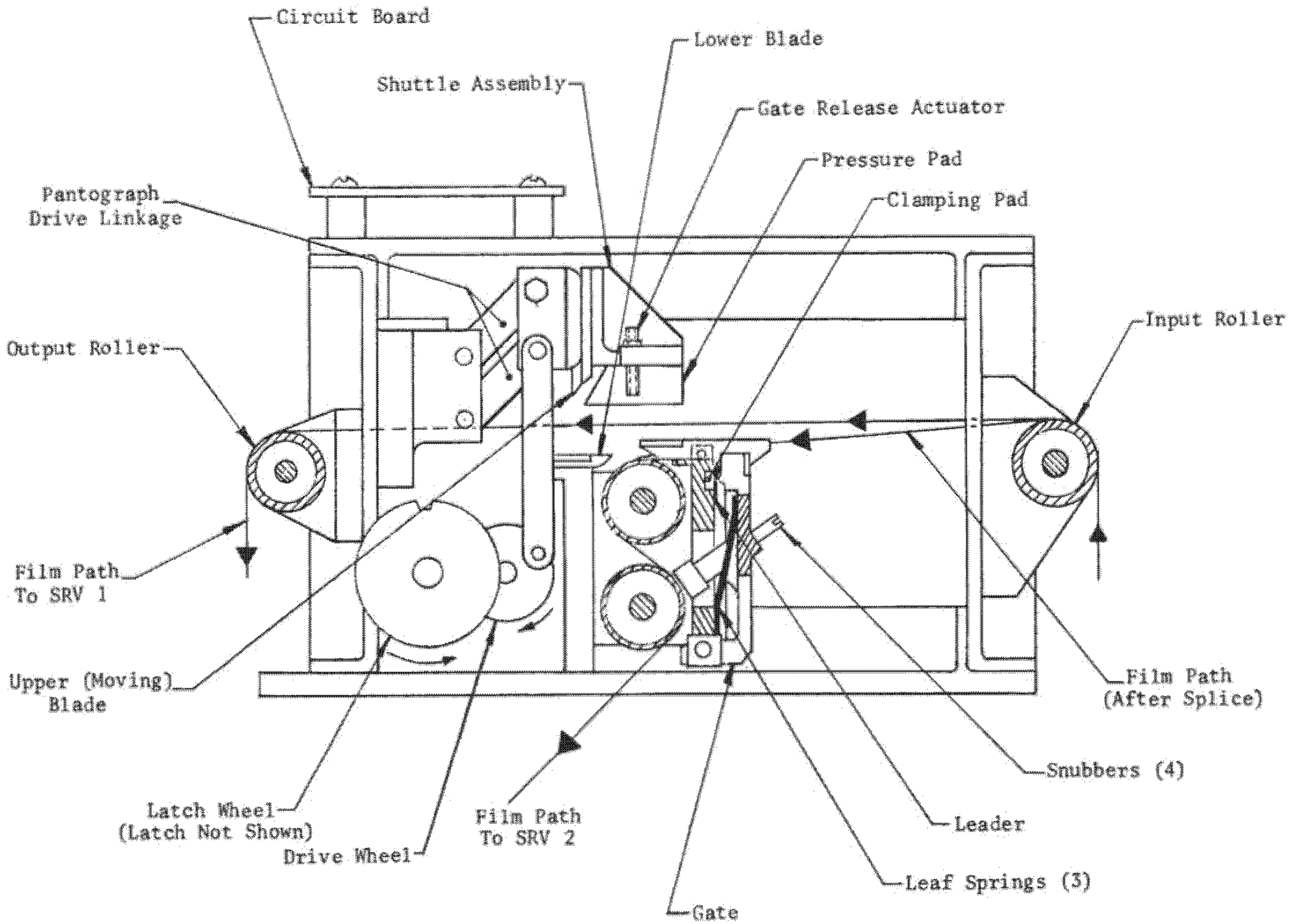
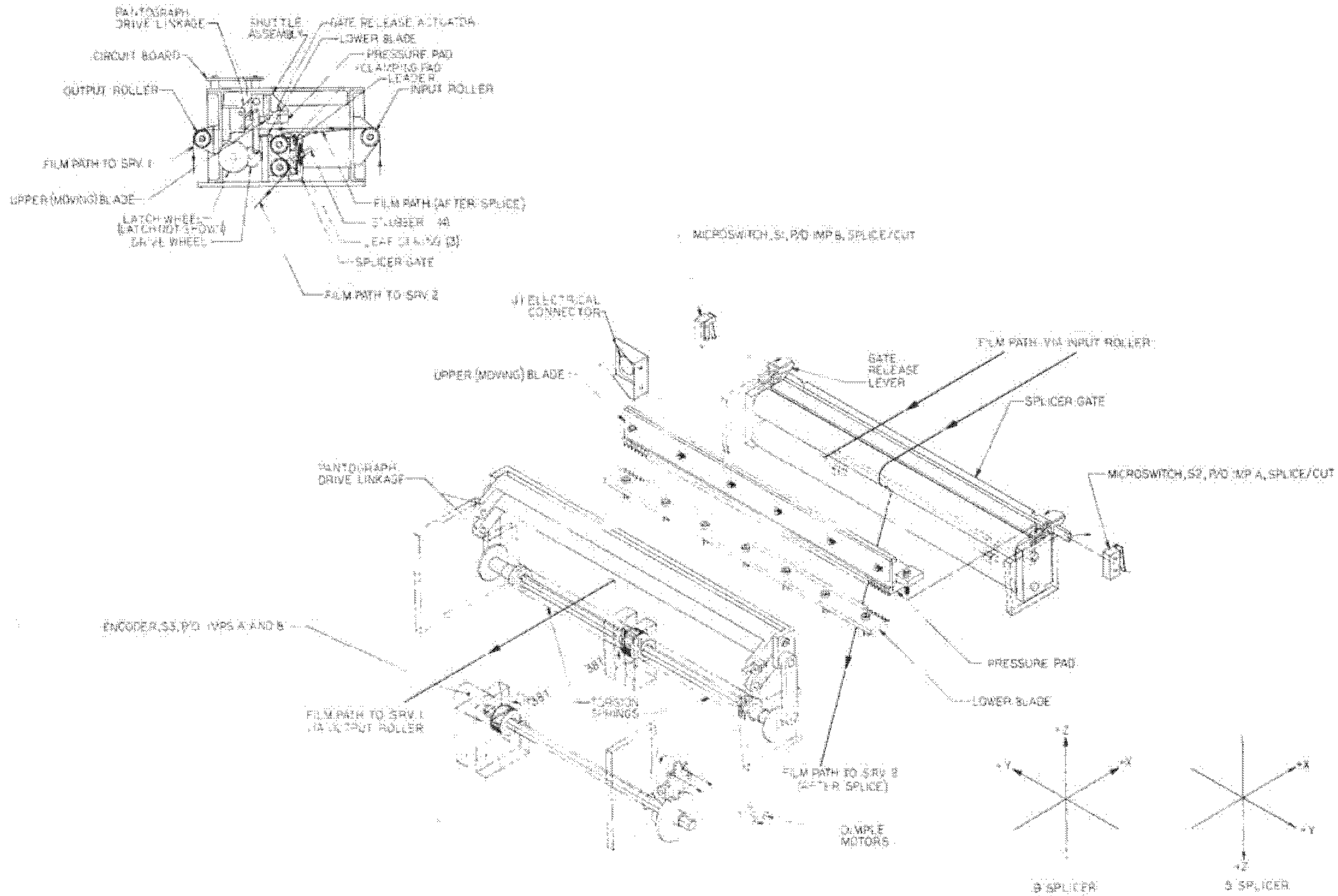


Figure 3.11-6. Splicer Mechanism



Note: Side panel cut away
to show assembly.

Figure 3.11-7. Splicer Mechanism Components



DEVICE	INSTRUMENTATION		
	IMP A	IMP B	IMP TITLE
SPLICER MECHANISM - 5	5086	5085	5 SPLICE/CUT
SPLICER MECHANISM - 9	5281	5282	9 SPLICE/CUT

NOTES:
1. AXES SHOWN ARE BIF-008 VEHICLE COORDINATES
2. THE FOLLOWING COMPONENTS ARE NOT SHOWN: INSTRUMENTATION CIRCUIT BOARD, SNUBBERS AND LEAF SPRINGS ON GATE, J2 CONNECTOR ON LATCH MECHANISM
3. IN SOME INSTANCES THE SHAPE OF A COMPONENT HAS BEEN MODIFIED TO CLARIFY ITS FUNCTION

Figure 3.11-8. Splicer/Cutter Device

one of which is capable of providing sufficient force for the task. Separate firing pulses are provided to each on twisted, shielded wires from the initiator electronics unit.

Torsion springs mounted on the drive shaft provide the energy for the splicing operation. The driving force is transmitted to the encoder shaft through the mating gears, and to the pantograph linkage by two crank bars, one at each end of the shaft. Use of the pantograph arm design to generate the shuttle motion ensures that the shuttle assembly will press squarely on the splicing platen.

11.3.2 Shuttle Assembly

The shuttle assembly is a metal structure supporting the upper blade and pressure pad. The blade has a serrated edge which meshes with a similar stationary blade on the lower structure to sever the film strand just after the pressure pad has formed the splice. At each end of the shuttle structure is a setscrew which activates a gate release lever after the splice/cut has been accomplished.

11.3.3 Platen Assembly

The platen assembly is composed of the platen housing, film-guide rollers, and gate structure. The platen assembly holds the film leader from SRV 2 and provides a surface upon which the shuttle assembly can press together the film strand and leader/splicing tape. The platen housing supports two film-guide rollers and the gate structure. A special inset on the housing forms a pad against which a serrated edge on the gate clamps the leader. A positive stop leader is incorporated to prevent the leader strand from being pulled out of the splicer inadvertently (see Figure 3.11-9). Four adjustable

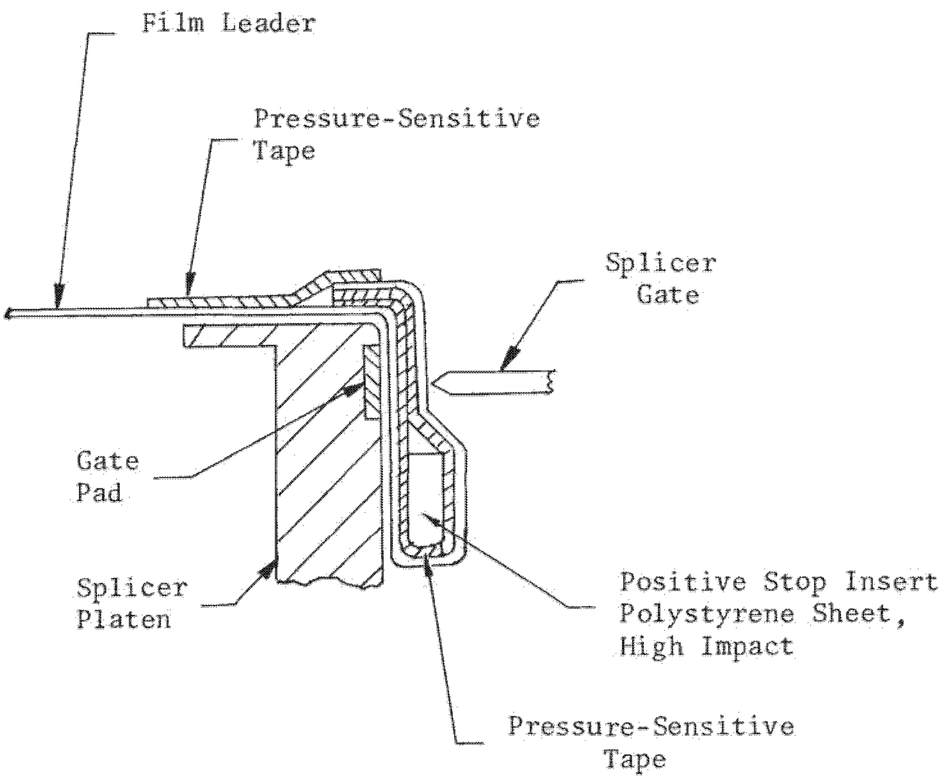


Figure 3.11-9. Positive Stop Leader

clamping posts (snubbers) are mounted on the gate and extend through slots in the platen housing to hold the leader tight against the lower roller. The snubbers are used as an assembly aid and are not considered the primary holding mechanism for on-orbit operation. The gate, when released by the shuttle assembly, is forced away from the platen housing by three leaf springs, freeing the leader and spliced film to be rolled into SRV 2. At the same time, a tab at each end of the gate releases an instrumentation microswitch monitoring gate position.

11.3.4 Electrical Connectors and Instrumentation

All electrical signals, including the pyro firing pulses, are routed through a single 19-pin connector. A second connector, supported by the latch mechanism, directs the pyro firing pulses from the input connector to the dimple motors.

Circuitry for the instrumentation monitoring points consists of the gate microswitches, a dual-track mechanical encoder, and the necessary signal processing electronics. With the exception of the microswitches and encoder, all instrumentation circuitry is contained on a single terminal board attached to the splicer housing. Redundant instrumentation outputs are generated, one powered by the +15-vdc regulated supply, the other by the +5-vdc regulated supply. Each is isolated electrically from the other, and consists of a single-gate microswitch, one track of the encoder, and the associated electronics (see Figure 3.11-8).

Output of the monitors occurs in four discrete steps and is the same for either point:

1.0 volt The assembly is cocked. (After release of the assembly, the 1.0-volt output will remain until the drive shaft has rotated 10 degrees.)

1.5 volts The assembly is not cocked. (This level begins at 12 degrees rotation, the encoder switching point, and continues until gate release.)

Note: The actual splice/cut operation occurs between the not-cocked and gate-release positions.

3.5 volts The gate is released at 120 degrees rotation. (Microswitch is released.)

4.5 volts Encoder switching point occurs at 155 degrees rotation. (This level continues through the remainder of rotation.)

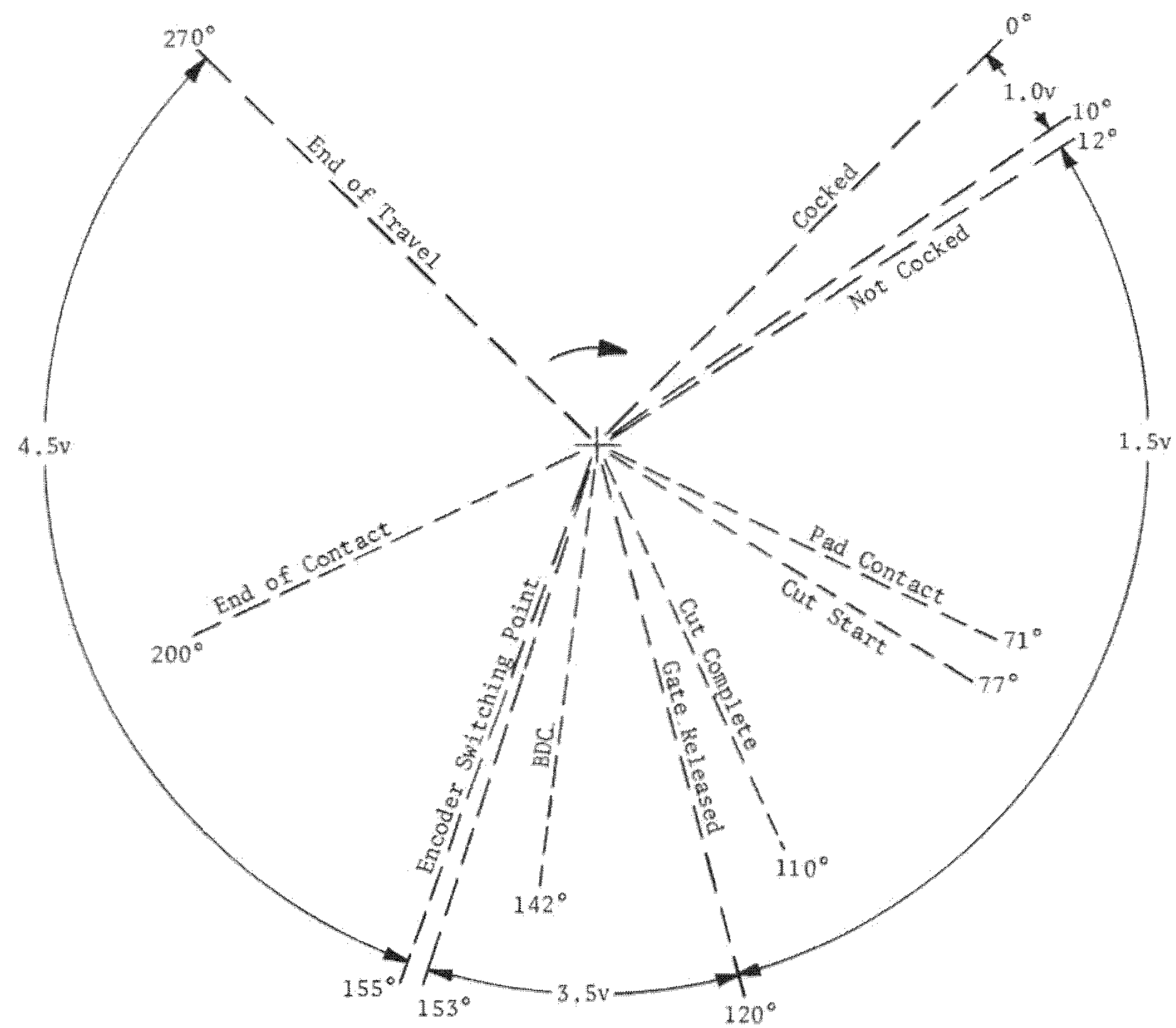
11.3.5 Splicer Mechanism Operation

The splicer mechanism guides the film strand going to SRV 1 until it is commanded to splice this strand onto the leader from SRV 2. Actuation of the pyrotechnic dimple motors releases the latch wheel on the encoder shaft, allowing the torsion springs to drive the splicer. The drive shaft rotates and imparts a cranking motion to the pantograph arm connecting links (crank bars), driving the shuttle assembly downward. The film strand is pressed onto the leader/splicing tape from T/U 2 by the pressure pad, and the upper and lower knife blades mesh, severing the film strand at a point just ahead of the splice. As the shuttle moves lower, a post at each end of the assembly activates a gate release lever, and leaf springs force the gate backwards to free the leader. The drive shaft continues to rotate, lifting the shuttle assembly clear of the film. Shuttle motion is stopped at approximately 270 degrees of rotation by contact of the upper shuttle section with the splicer housing. Total time for the splicing operation is typically 125 milliseconds from the beginning of motion to the end of the cycle. Figure 3.11-10 illustrates the sequential events of splicing as a function of drive shaft rotation.

At this point, the film has been attached to the leader from SRV 2, the film strand to SRV 1 has been cut, and the gate has been released. The leader and film are then free to be pulled into SRV 2. As a part of the splicing operation, the SPLICE/CUT command (9 or 5) has also closed a set of relays in the initiator electronics unit, steering the take-up control signals to both take-up 1 and take-up 2, and allowing the loose film strand to be rolled into SRV 1 as take-up 2 operates. The control signal will be removed from take-up 1 upon execution of the ROLL-IN TERMINATE command.

11.4 Instrumentation Summary

A summary of the instrumentation associated with the cutter/sealers, the aft backup cutter, the tunnel seal and record traps, and the splicer mechanisms is presented in Table 3.11-2.



Notes: (1) Position versus event numbers typical; unit-to-unit variation may exceed ±5 degrees.
(2) Bottom dead center (BDC) corresponds to maximum pad pressure.
(3) Voltage levels represent instrumentation output states.

Figure 3.11-10. Sequential Events vs Shuttle Drive Position

TABLE 3.11-2

INSTRUMENTATION SUMMARY

IMP	Title	Description	Power
5276	Cut/Seal 1 (9 and 5)	Two microswitches with associated divider circuitry, located on the cut/seal mechanism, monitor the status of the mechanism. One switch monitors the cocked position of the door before actuation, and the other monitors the completed transition of the door to the cut (closed/latched) position. The output is in three states: (1) quiescent (0.50 volt) (2) in-transit (2.50 volts) (3) completed (4.50 volts) This description applies to all cutter/sealer-style mechanisms; cutter/sealers 1 through 4, TSRT 9, TSRT 5, and the aft backup cutter (see IMPs 5277, 5283, 5284, 5278, 5305, 5081, 5082, 5279, 5280, 5083, 5084, 5285, 5286).	+5 vdc
5277	Cut/Seal 1 (9and 5)	Redundant case of IMP 5276*	+15 vdc
5283	Cut/Seal 2 (9 and 5)	Similar to IMP 5276	+5 vdc
5284	Cut/Seal 2 (9 and 5)	Redundant case of IMP 5283*	+15 vdc
5278	Cut/Seal 3 (9 TSRT)	Similar to IMP 5276	+5 vdc
5305	Cut/Seal 3 (9 TSRT)	Redundant case of IMP 5278*	+15 vdc

* Electrically and mechanically redundant.

IMP	Title	Description	Power
5082	Cut/Seal 4 (5 TSRT)	Similar to IMP 5276	+5 vdc
5081	Cut/Seal 4 (5 TSRT)	Redundant case of IMP 5082*	+15 vdc
5279	Tunnel Seal and Record Trap (9)	Similar to IMP 5276	+5 vdc
5280	Tunnel Seal and Record Trap (9)	Redundant case of IMP 5279*	+15 vdc
5084	TSRT (5)	Similar to IMP 5276	+5 vdc
5083	TSRT (5)	Redundant case of IMP 5084*	+15 vdc
5285	Aft Backup Cutter (9 and 5)	Similar to IMP 5276	+5 vdc
5286	Aft Backup Cutter (9 and 5)	Redundant case of IMP 5285*	+15 vdc
5086	Splice/Cut (5)	An encoder and a microswitch with associated divider network, located in the splicer mechanism, monitors the three separate functions representative of the splice/cut operation. The encoder has two separate switching outputs representative of the initial status (cocked/not-cocked) and the position of the shuttle assembly motion (before BDC/after BDC). BDC (bottom-dead center) is the position corresponding to maximum pad pressure on the platen. BDC occurs after the splice/cut has been performed. The microswitch indicates the gate position (latched/not-latched). The normal initial and completed conditions are: latched,	+5 vdc

* Electrically and mechanically redundant.

IMP	Title	Description	Power
		before BDC, and cocked (1.0 volt); not-latched, after BDC, and not-cocked (4.5 volts). The transition levels are: latched, before BDC, not-cocked (1.5 volts); not-latched, before BDC, not-cocked (3.5 volts).	
5085	Splice/Cut (5)	Redundant case of IMP 5086*, using similar inputs from separate encoder tracks and a separate microswitch	+15 vdc
5281	Splice/Cut (9)	Similar to IMP 5086	+5 vdc
5282	Splice/Cut (9)	Redundant case of IMP 5281*	+15 vdc
5536	Cut/Seal 1 1	A latching relay in the initiator electronics unit monitors generation of a pyro firing pulse for pyro 1 in cutter/sealer 1. The output is connected either to instrumentation return, or when closed by a firing pulse, to +5 vdc in series with an isolation resistor. The output is digitized by the digital telemetry unit (DTU), resulting in a binary signal: "0" Quiescent "1" Fired Individual monitors and firing circuits are provided for the redundant pyros in the device.	+5 vdc
5537	Cut/Seal 1 2	Similar to IMP 5536, monitors the firing pulse output to the redundant pyro in cutter/sealer 1	+5 vdc
5546	Cut/Seal 2 1	Similar to IMP 5536	+5 vdc

* Electrically and mechanically redundant.

IMP	Title	Description	Power
5547	Cut/Seal 2 2	Similar to IMP 5536, monitors the firing pulse output to the redundant pyro in cutter/sealer 2	+5 vdc
5538	Cut/Seal 3 1	Similar to IMP 5536	+5 vdc
5539	Cut/Seal 3 2	Similar to IMP 5536, monitors the firing pulse output to the redundant pyro in cutter/sealer 3	+5 vdc
5544	Cut/Seal 4 1	Similar to IMP 5536	+5 vdc
5545	Cut/Seal 4 2	Similar to IMP 5536, monitors the firing pulse output to the redundant pyro in cutter/sealer 4	+5 vdc
5540	TSRT 5 1	Similar to IMP 5536	+5 vdc
5541	TSRT 5 2	Similar to IMP 5536, monitors the firing pulse output to the redundant pyro in TSRT 5	+5 vdc
5542	TSRT 9 1	Similar to IMP 5536	+5 vdc
5543	TSRT 9 2	Similar to IMP 5536, monitors the firing pulse output to the redundant pyro in TSRT 9	+5 vdc
5530	Aft Backup Cutter 1	Similar to IMP 5536	+5 vdc
5531	Aft Backup Cutter 2	Similar to IMP 5536, monitors the firing pulse output to the redundant pyro in the aft backup cutter	+5 vdc
5534	5 Splice/Cut 1	Similar to IMP 5536	+5 vdc
5535	5 Splice/Cut 2	Similar to IMP 5536, monitors the firing pulse output to the redundant pyro in the 5 splicer mechanism	+5 vdc
5532	9 Splice/Cut 1	Similar to IMP 5536	+5 vdc

IMP	Title	Description	Power
5533	9 Splice/Cut 2	Similar to IMP 5536, monitors the firing pulse output to the redundant pyro in the 9 splicer mechanism	+5 vdc
5119	CBM for IEU (#5)*	Latching relays, operating in parallel with the command relays of the IEU, monitor the receipt of commands from the satellite control section. Four relays and a resistance network form a D/A converter whose output occurs in 16 discrete steps ranging from 0.25 volt to 4.75 volts in 0.3-volt increments: Bit 1 (LSB) = Cut/Seal 2A** Bit 2 = Cut/Seal 1A Bit 3 = 5 Splice/Cut A Bit 4 (MSB) = 9 Splice/Cut A	+15 vdc
5121	CBM for IEU (#6)*	Similar to IMP 5119, monitors the "side B" input circuitry: Bit 1 (LSB) = Cut/Seal 2B Bit 2 = Cut/Seal 1B Bit 3 = 5 Splice/Cut B Bit 4 (MSB) = 9 Splice/Cut B	+5 vdc

* CBM - Command Bit Monitor
** A refers to "side A" input circuitry in the IEU.

11.5 Command Summary

11.5.1 Splice and Cut Commands

9 SPLICE AND CUT (P02766, P01766, P03766)

5 SPLICE AND CUT (P02573, P01573, P03573)

Function: a. Actuate the splicer mechanism (9 or 5)

b. Connect the 9 and/or 5 take-up control signals to SRV 2

Interlocks: Enable the 9 ROLL-IN TERMINATE and/or 5 ROLL-IN TERMINATE commands

Comments: a. Film must be stationary for execution of these commands.

b. Tension should be removed from the splice soon after formation (typically within 10 minutes).

c. After execution of the first splice/cut, the loose tail of the film must be rolled into SRV 1 before any film is moved in the other camera subsystem.

11.5.2 Cut and Seal 1 Command

CUT AND SEAL 1 (P02572, P01572, P03572, MP00045)

Function: Actuates - cutter/sealer 1
cutter/sealer 3
cutter/sealer 4
TSRT 5
TSRT 9

Comments: This command is not normally given prior to rolling in the 9 film and 5 film left between SRV 1 and the splicer mechanisms after the SPLICE AND CUT commands are executed.

11.5.3 Cut and Seal 2 Command

CUT AND SEAL 2 (P02577, P01577, P03577, MP00062)

Function: Actuates - cutter/sealer 2
aft backup cutter

12.0 TERMINATION AND RECOVERY

The recovery of film is accomplished by ejection, deorbit, and retrieval of the two satellite reentry vehicles (SRV's). Prior to ejection, the SRV's are supported by the dual recovery module (DRM) portion of the PPS/DP EAC which contains the auxiliary equipment (film tunnels, TSRT's, etc.) necessary for on-orbit operation and ejection upon command.

Subsequent to separation, the SRV is an independent system which must effect satisfactory deorbit and atmospheric reentry, and must expedite recovery (air catch or water retrieval). Each SRV provides for monitoring and transmission of pertinent deorbit/recovery events through two independent radio frequency (RF) beacons.

12.1 Dual Recovery Module (DRM)

The dual recovery module consists of SRV 1, the ejectable adapter (EA), and the fixed adapter (FA), with SRV 2 mounted within the FA. The DRM also contains auxiliary equipment for film transfer and SRV ejection, including: the film tunnels, the cutter/sealer and TSRT mechanism, the blast shield and blast shield valve, pin-pullers and ejection pistons, and associated interconnection cabling. Figure 3.12-1 illustrates the internal configuration of the module. For a more detailed discussion of the components, refer to Part 3, Section 1.

12.2 Photographic Satellite Vehicle (PSV) Recovery Maneuvers

Prior to execution of the ARM/TRANSFER/SEPARATE command sequence (12.3.1.3), the SRV remains passive except for the film take-ups, internal heaters, and

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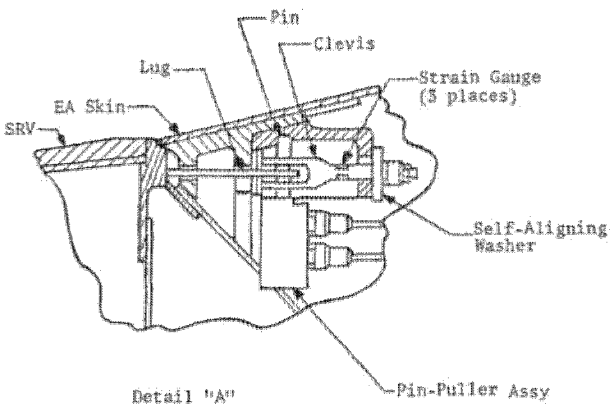
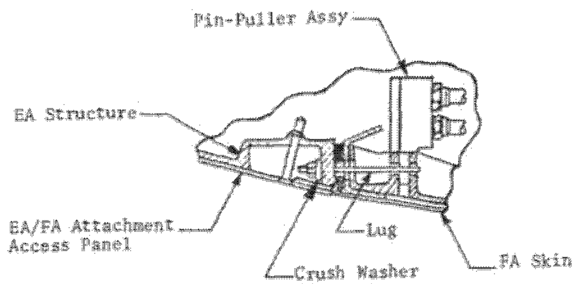




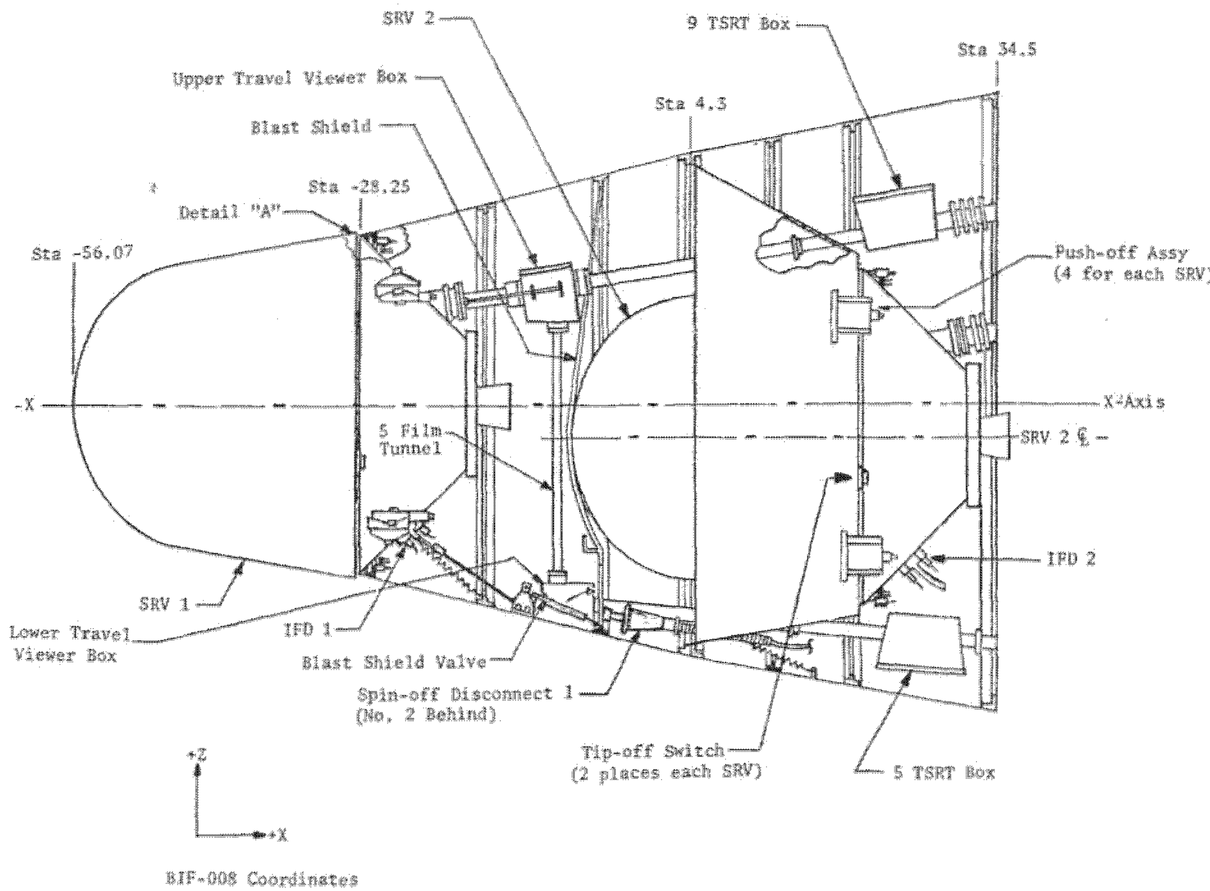


Figure 3.12-1. DRM Internal Components

instrumentation. Before ejection of either SRV or the EA, the PSV must be placed in the proper orbital attitude with respect to the orbital velocity vector. It is the responsibility of the satellite control section to position the vehicle in this attitude through either a powered maneuver or inertial flight.

12.2.1 Powered Maneuver

The attitude for SRV ejection is nose aft, pitched down (see Figure 3.12-2). When a powered sequence is used, a yaw maneuver of 180 degrees is followed by a pitch down to the desired attitude.

12.2.2 Inertial Maneuver

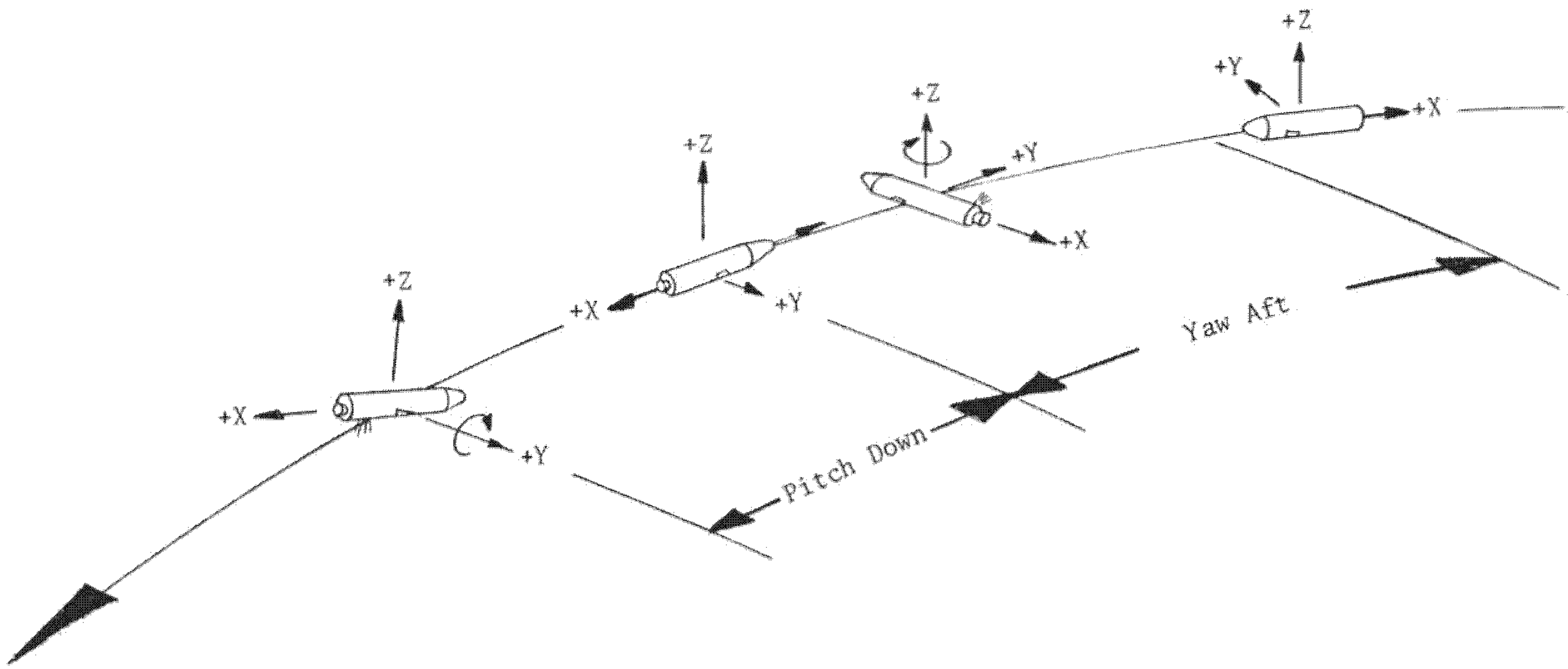
A considerable savings in control gas is realized if the recovery attitude is achieved using the inertial flight mode (see Figure 3.12-3).

12.2.3 Thermal Constraints

During recovery, the vehicle may be rolled to position the EA and FA pin-pullers away from the direction of flight, limiting pin-puller temperature rises, and reducing COM curvature (hotdogging). The use of a roll maneuver on past missions (typically 36.5 degrees) has proven effective in maintaining acceptable levels for both. In addition, powered maneuvers into and out of the recovery attitude are required under certain orbital conditions. For a further description of thermal constraints refer to Part 2, Section 14.5.

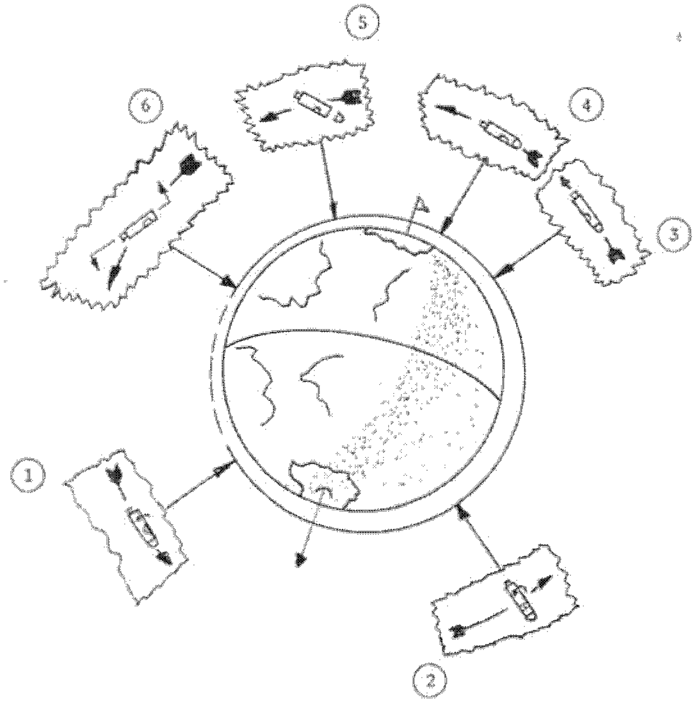
12.2.4 Timing

In normal missions, SRV 1 will be recovered near the midpoint of the mission and SRV 2 prior to the time of PSV deboost. In most instances, it is also possible to recover both SRV 1 and 2 on the same revolution if necessary, or



NOTE: Coordinates shown are BIF-008
vehicle coordinates.

Figure 3.12-2. Powered Yaw and Pitch Maneuver



Mini-Gas Yaw Around

1) Establish inertial (0-rate) pitch and yaw. Start 4°/minute roll (i.e., 180°/45 minutes).

2) Maneuver 50% complete (usually at apogee).

3) "Belly-down" rearward flight; start nose pitching up at geocentric (4°/minute) rate.

Inertial Pitch Down

4) Establish inertial flight at time defined by:

$$\left| \text{Separation Time} - \frac{\text{desired pitch down angle}^\circ}{4^\circ/\text{minute}} \right|$$

5) Separation

6) Reestablish "belly-down" rearward flight by starting geocentric rate (reverse) and reconnecting horizon sensor error signal which will return vehicle to level.
Repeat steps 1, 2, and 3 for return to normal flight; "belly-down", nose pitching down at geocentric rate.

Figure 3.12-3. Inertial Recovery Sequence Maneuvers separately on any day of the mission.* For the sake of clarity, the PSV recovery events will be discussed individually for each SRV.

12.3 Ejection

All recovery-related ejectable components are mated to the PPS/DP EAC using pyrotechnic pin-puller assemblies. Actuation of the pyros releases the component, which is then pushed off by spring-loaded ejection pistons.

12.3.1 SRV 1 Ejection Sequence**

Although it is not required, SRV 1 is not normally ejected until both the 9 and 5 take-up spools have been completely filled.

12.3.1.1 SPLICE/CUT Command. Prior to initiation of the ejection sequence for SRV 1, both the 9 and 5 film strands leading to take-up (T/U) 1 will have been severed, and the strands from the camera spliced onto the leaders from T/U 2 by the 9 and 5 splicer mechanisms. Actuation of the 9 and 5 film splicers is commanded independently, allowing the switchover for each film strand to be performed any time prior to the beginning of the ejection sequence. Execution of the SPLICE/CUT (S/C) command also applies the T/U control signals to both T/U 1 and T/U 2 for the respective film subsystems (9 and 5). Normally, tension is removed from the splice by commanding a 10-foot camera operation shortly after the splice/cut sequence. The wrap-up of 10 feet of film onto T/U 2 will also cause T/U 1 to roll the loose strand of film into SRV 1. The length of loose film to be rolled-in is approximately 8.5 feet for the 9 subsystem, and 11 feet for the 5 subsystem.

*Restrictions on this freedom are a function of the particular orbit parameters involved and must be evaluated for each occurrence.
**For interlocks on the command sequence, see Section 12.10: Command Summary.

The control signal is removed from T/U 1 by execution of the ROLL-IN TERMINATE (RIT) command.

12.3.1.2 CUT/SEAL 1 Command. The CUT/SEAL 1 command, normally given after the 9 RIT and 5 RIT commands, activates the cutter/sealer on SRV 1 (C/S 1), the backup cutter/sealers in the 9 and 5 TSRT enclosures (C/S 3 and C/S 4) and the TSRT mechanisms (TSRT 9 and TSRT 5). These devices seal the SRV for recovery and seal the film tunnels against light, and against debris from the SRV 1 retro-rocket. Additionally, the cutter/sealers will cut any film not rolled onto the T/U spools, and the TSRT mechanisms will clamp and hold any film left in the film tunnel between the TSRT's and splicers to ensure that it cannot jeopardize the second half of the mission.

12.3.1.3 EPSM 1 ON Command. The SRV 1 recovery battery heaters (EPSM 1) are normally commanded ON four revolutions (three revolutions minimum) prior to SRV ejection to establish the proper operating temperature for battery activation. If the batteries are activated at low temperatures, a sufficient voltage level might not be reached within the required time for SRV recovery subsystem operation.

12.3.1.4 ARM/TRANSFER/SEPARATE (ATS) Commands.* On the recovery revolution, the PSV positions the SRV in the proper recovery attitude (reference Section 12.2) and the SRV is ejected by execution of the ATS command sequence:

1) ARM — The ARM command activates the recovery batteries, powering the SRV programmers and event beacons and starts the recovery programmer back-up timer.

2) TRANSFER — 1.8 seconds** prior to separation, the TRANSFER command activates the SRV thermal batteries and inflight disconnect 1 (delayed action). A lanyard pulls the loose IFD cable clear of the SRV, simultaneously releasing the blast shield valve. Separation of IFD breaks an electrical ground through the connector, enabling the SRV dual ejection programmer.

*For interlocks on the command sequence, see Section 12.10: Command Summary
**Actual values are controlled by GE RESD.

3) SEPARATE The SEPARATE command actuates spinoff disconnect 1 and the two pin-pullers holding SRV 1, which is then ejected by push-off springs.

At this point, the SRV is completely independent of the photographic satellite vehicle and the internal dual ejection programmer has taken control.

12.3.2 Ejectable Adapter and SRV 2 Ejection.*

Following ejection of SRV 1, the second SRV is still contained within the DRM, protected by the EA and blast shield. The opening in the blast shield has been covered by the blast shield valve, and the film tunnels sealed by the cutter/sealers and TSRT's in the TSRT enclosures. The PSV normally remains in this configuration during the second half of the mission.

12.3.2.1 Ejectable adapter (EA) Ejection. EA ejection normally occurs one revolution prior to the ejection of SRV 2 (three revolutions maximum) with the satellite oriented in a nose aft, level flight attitude. SPINOFF DISCONNECT 2 is commanded, isolating the EA from the remainder of the PSV. A spring retractor in the FA pulls the disconnected portion of the cable rearward, clear of the separation path for SRV 2. At this point, the EA is held only by the three pin-puller assemblies. Actuation of the pin-pullers releases the EA, and it is pushed off by three equally spaced ejection pistons.

Since clearance around the nose of SRV 2 is extremely limited, unequal ejection forces might cause the EA or the film tunnels to contact the SRV and damage its ablative shield. Therefore, the piston springs are assembled in matched sets to minimize any imbalances. (Reference Part 2, Section 15: Ejection Analysis.)

*For interlocks on the command sequence, see Section 12.10: Command Summary.

12.3.2.2 SRV 2 Ejection. SRV 2 is sealed upon execution of the CUT/SEAL 2 command, activating the cutter/sealer mechanism mounted on the SRV (C/S 2) along with the aft backup cutter. Normally, CUT/SEAL 2 will not be commanded until all the remaining film (both 9 and 5) has been rolled into SRV 2.

SRV 2 ejection follows the same procedure as described for SRV 1. The recovery battery heaters (EPSM 2) are turned on a sufficient time prior to separation to stabilize the battery temperatures, and the normal ARM/TRANSFER/SEPARATE command sequence is executed. Figure 3.12-4 and Tables 3.12-1A and 3.12-1B summarize the ejection and recovery sequence for each SRV.

NOTICE

The following section is included for informational purposes only. General Electric Reentry and Environmental Systems Division (GE RESD) manufactures the satellite reentry vehicle, and is solely responsible for successful execution of the recovery sequence after proper separation from the PPS/DP EAC.

Event timing, operational constraints, and design information in this section have been provided by General Electric RESD and are not intended to be contractually binding in any aspect; nor is the information herein guaranteed by General Electric RESD or BIF-008 to be current.

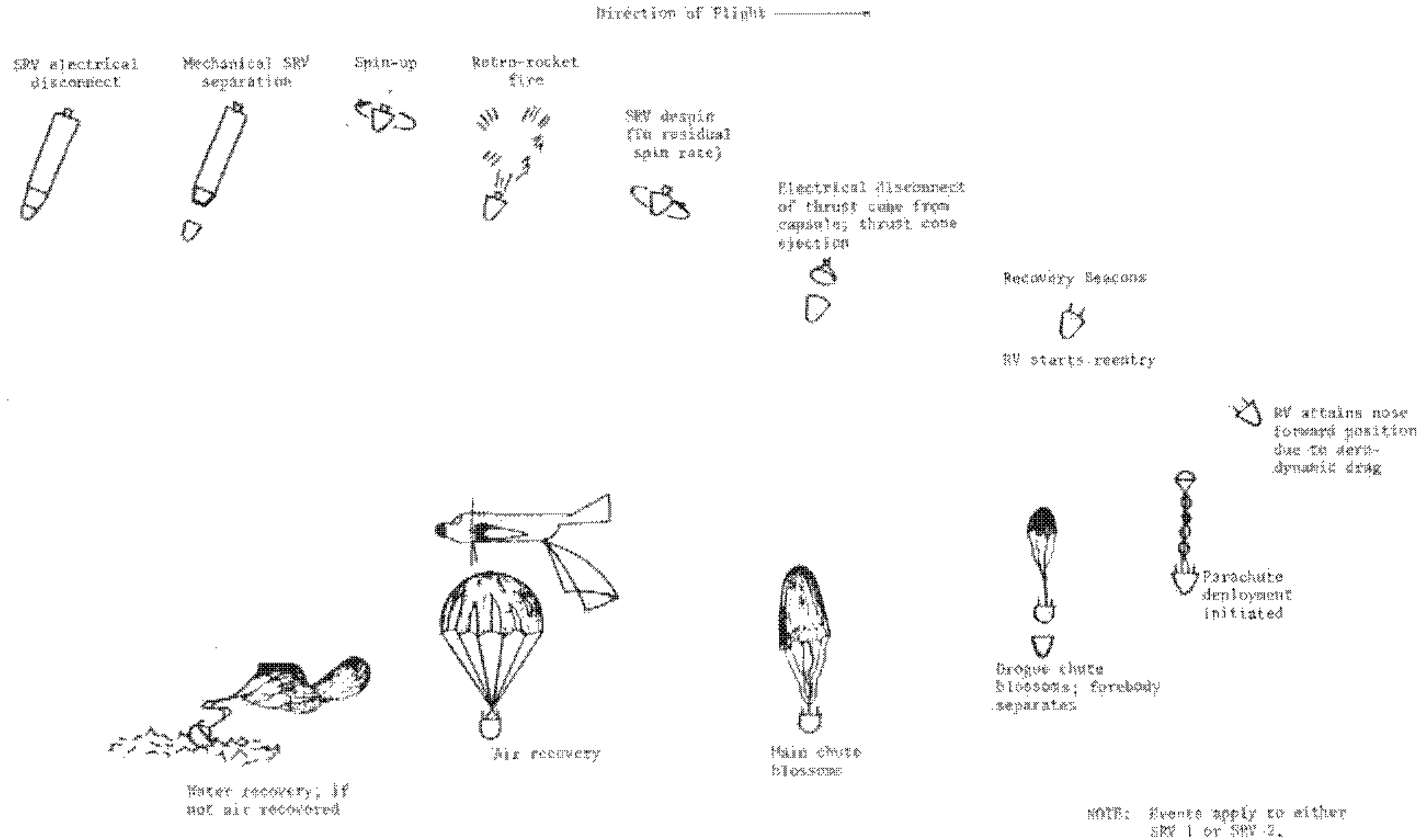


Figure 3.12-4. SRV Sequence of Events

TABLE 3.12-1A
PRIMARY MODE RECOVERY SEQUENCE

Event or Command	Time of Occurrence (Sec)*	Description
1. ARM Command	$T_0 - 120$ to $T_0 - 1992$ } TA	Activates both recovery batteries. Beacon 1 starts operating from battery 1. Recovery programmer channel 1 powered. Recovery programmer backup timer starts. Beacon 2 starts operating from battery 2. Recovery programmer channel 2 powered.
2. TRANSFER Command	$T_0 - 0$	Thermal batteries fired. SV/SRV in-flight disconnect (IFD) fired (delay type).
	$T_0 + 0.4 = T_D$	SV/SRV IFD operates, dual ejection programmer starts.
3. SEPARATE Command	$T_0 + 1.8$	SV/SRV mechanical separation.
4. Spin Signal	$T_D + 3.4 = T_S$	Spin squibs fired.
5. Retro-Rocket Signal	$T_S + 7.56 = T_R$	Retro-rocket fired.
6. Despin Signal	$T_R + 11.75 = T_{DS}$	Despin squibs fired.

*All times are nominal values unless otherwise indicated, and are controlled by GE RESD.

TABLE 3.12-1A (CONT'D)

Event or Command	Time of Occurrence (Sec)*	Description
7. T/C Separation Signal	$T_{DS} + 2.0 = T_{SEP}$	Cable cutters fired. T/C - RV IFD fired.
8. G Switch Closure	Nominal 3.7g increasing deceleration (T_{GC})	G switch closes. Recovery programmer backup sequence inhibited.
9. G Switch Opening	Nominal 3g decreasing deceleration (T_{GO})	G switch opens. Recovery programmer primary timers start timing.
10. Cover Ejection	$T_{GO} + 26 = T_P$	Cover ejection cartridges fired. Cover ejected. Decelerator chute deployed. Main chute bagline cutters initiated. Forebody normally separates at this time.
11. Main Chute Deployed (reefed)	$T_P + 10.0 = T_{MC}$	Main chute bagline cutters operate. Main chute deployed (reefed). Reefing line cutter initiated. Forebody separates if it did not during event 10.
12. Main Chute Blossoms	$T_{MC} + 4.0$	Reefing line cutters operate. Main chute fully blossomed.

*All times are nominal values unless otherwise indicated, and are controlled by GE RESD.

TABLE 3.12-1A (CONT'D)

Event or Command	Time of Occurrence (Sec)*	Description
13. Air Recovery	Variable (15,000 to 5,000 feet altitude)	Aircraft snatches capsule.
14. Water Impact	Variable	Capsule impacts (occurs only if event 13 is not successful).
15. Search and Retrieval	Variable	Search and retrieval (if event 14 occurs).
16. Sink	Event 14 + 40 hours	Capsule sinks (occurs only if event 15 is not successful).

*All times are nominal values unless otherwise indicated, and are controlled by GE RESD.

TABLE 3.12-1B
BACKUP MODE RECOVERY SEQUENCE

Event or Command	Time of Occurrence (Sec)*	Description
B-1. thru B-6.	Same as events 1 thru 6 of Table 3.12-1A.	
B-7. B/U Timer T/C Separation Signal	T_A + 2048	One pyro within each set of cable cutters fired (if not already fired by event 7 of Table 3.12-1A). One T/C - RV IFD squib fired (if not already fired by event 7 of Table 3.12-1A).
B-8. B/U Timer Cover Ejection**	T_A + 2808	Cover ejection cartridges fired, cover ejected, chutes deployed, etc. This B/U sequence is designed to take place prior to or during high atmospheric heating; therefore destroying the capsule.

*All times are nominal values unless otherwise indicated, and are controlled by GE RESD.

**Occurs only if backup recovery sequence is not inhibited by Event 8 of Table 3.12-1A (G switch closure).

12.4 Satellite Reentry Vehicle

As shown in Figure 3.12-5, the SRV is composed of two major sections; the thrust cone (T/C), and the reentry vehicle (RV).

The thrust cone contains the deorbit subsystem, which functions to place the vehicle in a reentry trajectory, and includes the retro-rocket motor and spin/despin cold gas jets. After operation of the despin jets, the deorbit subsystem initiates separation of the thrust cone from the RV to reduce the reentry mass and allow the parachutes to deploy. The recovery programmer provides a backup thrust cone separate signal (at ARM plus 2048 seconds) to separate the thrust cone if deorbit subsystem's signal had failed.

The reentry vehicle consists of a recoverable capsule (containing a 9x5 take-up assembly, beacons, batteries, and a programmer), a forebody (with an ablative heat shield and liner), a parachute, and a thermal cover. These are held together by 4 ejector pistons which, when fired simultaneously, eject the thermal cover and mechanically disconnect the capsule from the forebody. The thermal cover ejection causes the drogue parachute deployment which results in the forebody/capsule separation and initiates the release of the main canopy.

12.5 SRV Deorbit and Recovery Events

Once ejected, the SRV acts solely in response to the internal deorbit and recovery programmers. Upon separation of IFD 1 (the DRM/SRV 1 IFD), the dual ejection programmer is enabled and begins timing. The spin jets are fired approximately 3.4 seconds later (2.0 seconds after PPS/SRV separation), and impart a high-rate spin to the SRV about its longitudinal axis for stabilization. This spinning helps maintain the PSV imposed deorbit angle during retro-fire, limiting reentry vehicle impact dispersion. The retro-rocket is ignited after spin-up and places the vehicle in a ballistic re-entry trajectory. After burnout, a second set of cold gas jets fire, slow-

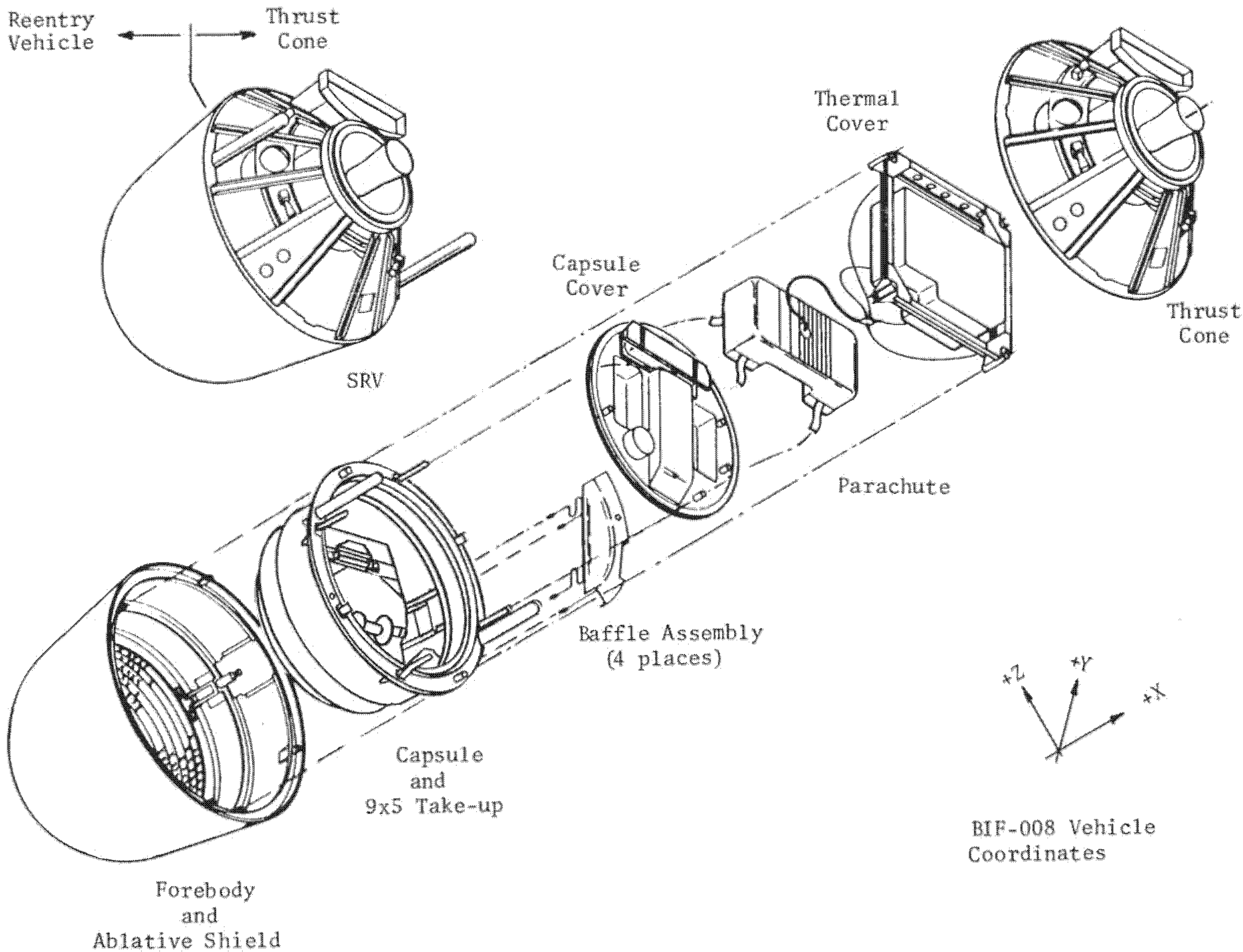


Figure 3.12-5. SRV Assembly - Exploded View

ing the spin rate so that the aerodynamic forces encountered during reentry can reorient the vehicle attitude. Having completed its task, the thrust cone (T/C) portion of the SRV is then ejected and the recovery programmer assumes control.

Upon reentering the Earth's atmosphere, the vehicle attains a nose-first attitude, with the heat shield protecting the recoverable capsule. As the deceleration force increases, the G switches close, inhibiting the backup recovery sequence. When the force decreases, the G switches reopen and the primary timers of the recovery programmer are enabled.

Approximately 26 seconds after the programmer starts, the thermal cover on the aft end of the reentry vehicle is ejected, deploying the drogue parachute, and the forebody is released. The main chute is then deployed in a reefed condition, dereefed, and the capsule descends on a fully blossomed parachute until caught by the recovery aircraft.

In the event that the G switches do not inhibit the recovery programmer backup sequence, the backup sequence will fire the devices releasing the thrust cone from the RV 2068 seconds after ARM. Similarly, the backup sequence will fire the pyrotechnic devices separating the thermal cover from the forebody approximately 2808 seconds after ARM. With parachute deployment taking place prior to or during the high atmospheric heating phase, the parachute and capsule will be destroyed by aerodynamic heat.

Should the capsule land in water (aerial recovery unsuccessful), it is weighted to float nose down. The recovery beacons will continue to transmit until the batteries are exhausted. If the capsule has not been retrieved within 40 hours (nominal time), a dissolvable plug in the nose will allow flooding and sinking to prevent unauthorized recovery of the film.

12.6 SRV Structure

The structure of the SRV includes (1) the forebody, (2) the recoverable capsule and parachute covers, and (3) the thrust cone.

The forebody is a sphere/cone structure 27.6 inches long and 33.6 inches in diameter at the aft end, and consists of a phenolic glass liner (reinforced by internal structural rings) and an ablative heat shield. The recoverable capsule, which is contained within the forebody and supported by the forebody structure, is a sphere/cylinder 25.56 inches in diameter (excluding mounting ring) and approximately 19.53 inches long (excluding thermal cover). The 9x5 film take-up assembly, manufactured by BIF-008, and the cutter/sealer, manufactured by Lockheed Missiles and Space Company for BIF-008, are installed in the recoverable capsule by GE RESD (reference Part 3, Section 2). Thermal baffles are mounted on the aft side of the recovery capsule to protect the capsule cover mounted components from the high reentry heat flux.

The heat shield is an ablative material covering the forebody of the SRV, which is painted as required for passive thermal compensation while on-orbit. Additional control is provided by internal insulation and the inclusion of electrical heaters powered from the PPS/DP EAC. The shield protects the SRV payload against aerodynamic heating, ablating as the RV enters the atmosphere.

The parachute assembly thermal cover protects the parachutes during initial reentry. After thermal cover ejection, the forebody is free to fall away from the capsule.

The thrust cone is a truncated, conical-shaped structure containing the deorbit subsystem, and is approximately 10.58 inches long, excluding the retro-rocket nozzle, with major and minor diameters of 33.31 and 13.89 inches respectively. It is attached to the forebody by a looped cable on each side of the SRV. Four guillotine-style pyrotechnic cable cutters (two per loop) sever the cables to release the T/C from the reentry vehicle.

The electrical interface between the SRV and the PPS/DP EAC is through a 55-pin connector mounted on the thrust cone portion of the SRV. This connector, a pyro-actuated in-flight disconnect, carries all the electrical signals for the SRV including power and commands, and a ground wire between SRV and PPS/DP EAC structures. Additional connectors on the SRV are used for testing and have arm plugs installed for flight.

Two lug assemblies on the forebody mate with the pin-pullers on the PPS/DP EAC to fasten the SRV to the satellite vehicle. Four ejection-plunger pads are built into the thrust cone surface as interface points for the PPS/DP EAC spring-loaded ejection plungers. Two additional pads are coincident with the tip-off switch plungers which monitor the separation status for instrumentation purposes.

To eject the SRV from the PPS/DP EAC, the electrical IFD is separated, the pin-pullers are released approximately 0.9 second later, and the SRV is moved away by the ejection plunger forces.

The film chute extends from the recoverable capsule through the thrust cone to mate with the film chute from the PPS/DP EAC using a special flanged adapter. A similar connection is employed between the RV and thrust cone portions of the SRV to allow separation of the T/C during reentry.

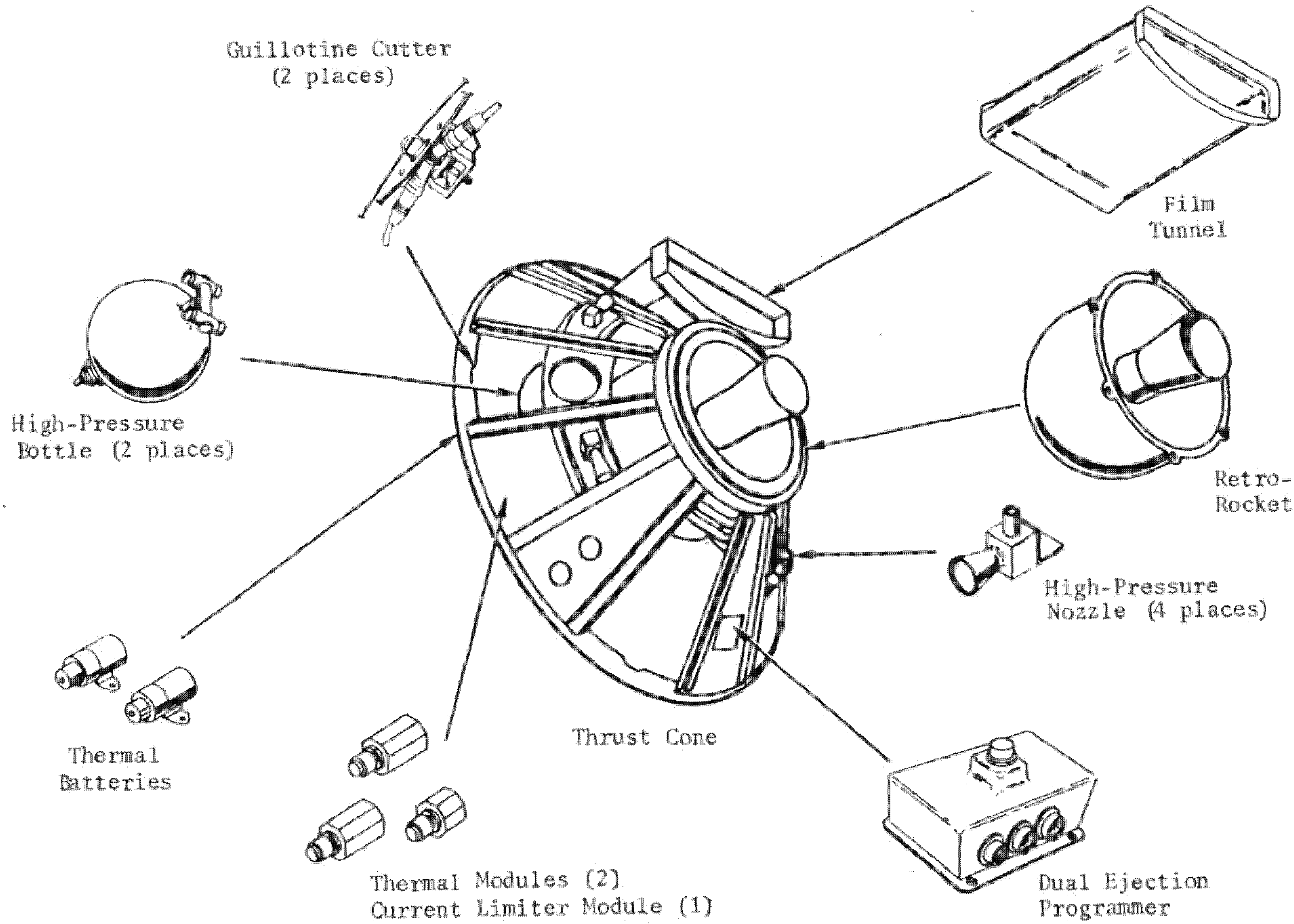
12.7 Deorbit Subsystem

The deorbit subsystem controls events 4 through 7 of Table 3.12-1A. It is contained entirely within the thrust cone (Figure 3.12-6), and consists of the following major components:

(1) dual ejection programmer

(2) thermal relay modules

(3) thermal batteries



3.12-24

Figure 3.12-6. Thrust Cone

(4) retro-rocket assembly

(5) spin-despin subsystem

(6) cable cutters

(7) T/C-RV in-flight disconnect

(8) film tunnel

12.7.1 Dual Ejection Programmer and Thermal Relay Modules

The ejection programmer is a dual (redundant) channel electronic unit providing the event timing and firing control for the deorbit functions; spin, retro-fire, despin, and T/C ejection. Thermal relay modules are incorporated to protect the system from possible electrical short circuits in the thrust cone pyrotechnic devices after actuation.

12.7.2 Thermal Batteries

Power for the deorbit subsystem is provided by two thermal batteries, each powering a single channel of the programmer. The TRANSFER command from the PPS/DP EAC fires the battery activation matches, and also initiates the time-delay PPS/SRV in-flight disconnect.

12.7.3 Retro-Rocket Motor

The retro-rocket motor assembly, consisting of the retro-rocket and ignitors, provides the necessary velocity increment to the SRV to effect the deorbit maneuver. The motor itself is a solid fuel device designed for controlled burning to limit acceleration forces experienced by the SRV components.

A breakwire installed across the exit of the retro-rocket nozzle alters the event beacon modulation providing an indication of successful firing (see Section 12.8.5).

12.7.4 Spin and Despin Subsystems

The spin and despin subsystems each consist of a gas pressure tank and explosive valve, and two diametrically opposed gas nozzles. The subsystems are essentially identical, with the lower despin force being obtained by charging the despin tank to a pressure lower than the spin tank. When released, the gas is directed through high pressure tubing to the nozzles to form a force couple about the SRV roll axis.

12.7.5 Thrust Cone Ejection

Following completion of the despin event, the thrust cone is jettisoned from the reentry vehicle to reduce weight and permit operation of the recovery subsystem. Separation from the reentry vehicle is accomplished by four (2 pairs of redundant) pyro-actuated cable cutters. Simultaneously, a second in-flight disconnect (the T/C-RV IFD) is fired, breaking the electrical interface between the T/C and reentry portions of the SRV. As a fail-safe feature, the recovery programmer will provide backup of the initiation cable cutters and SRV T/C-RV IFD. An electrical monitor senses separation of the thrust cone and alters the event beacon modulation to indicate successful completion.

12.8 Recovery Subsystem

Like the deorbit subsystem, the recovery subsystem remains dormant during orbital flight until the electrical arm signal from the PPS/DP EAC activates the recovery batteries, powering the recovery beacons and programmer. The recovery subsystem takes control of the RV reentry and retardation events following the deorbit sequence. Components of the subsystem include the batteries, the recovery programmer, the RF beacons, the recoverable capsule valving hardware, and the battery and orbital heaters (see Figures 3.12-7 through 3.12-9). The orbital heaters, although not a part of the recovery subsystem, are included here due to their presence in the recoverable capsule.

12.8.1 Recovery Batteries and Battery Heaters

Recovery subsystem power is provided by two remotely activated electrolytic batteries having an operating range of 14.8 to 17.0 volts. Within each battery, dual initiators are fired by the electrical arm signal to activate the electrolyte charging system. To assure performance, each battery contains a heater capable of raising the electrolyte temperature to an adequate operational range prior to actuation. Thermostats maintain the temperature at the proper level. Power for the battery heaters, EPSM 1 in SRV 1, and EPSM 2 in SRV 2, is provided by the satellite vehicle power supply via commandable switches in the PPS/DP EAC.

12.8.2 Orbital Heaters

The orbital electrical heater tapes, like the battery heaters, are powered through commandable switches in the PPS/DP EAC. They are thermostatically controlled and serve as a supplemental heat source, maintaining the capsule internal temperature in a safe range. The heater tapes and controls are mounted circumferentially inside the recoverable capsules (Figure 3.12-7), and are set to maintain the temperature above 35F (nominal), with a backup thermostat to limit temperature to 67F (nominal).

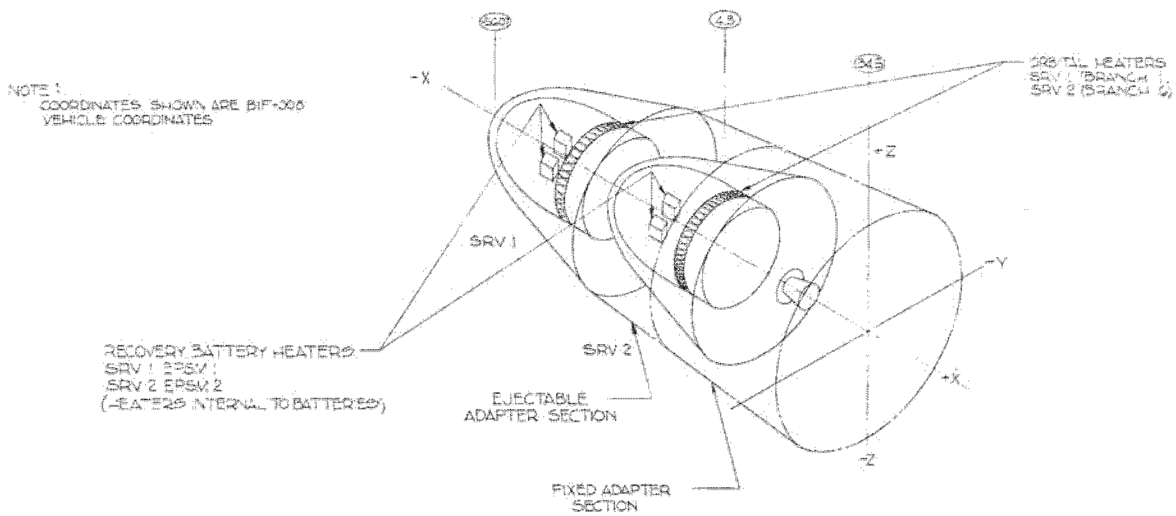


Figure 3.12-7. SRV Heater Branches

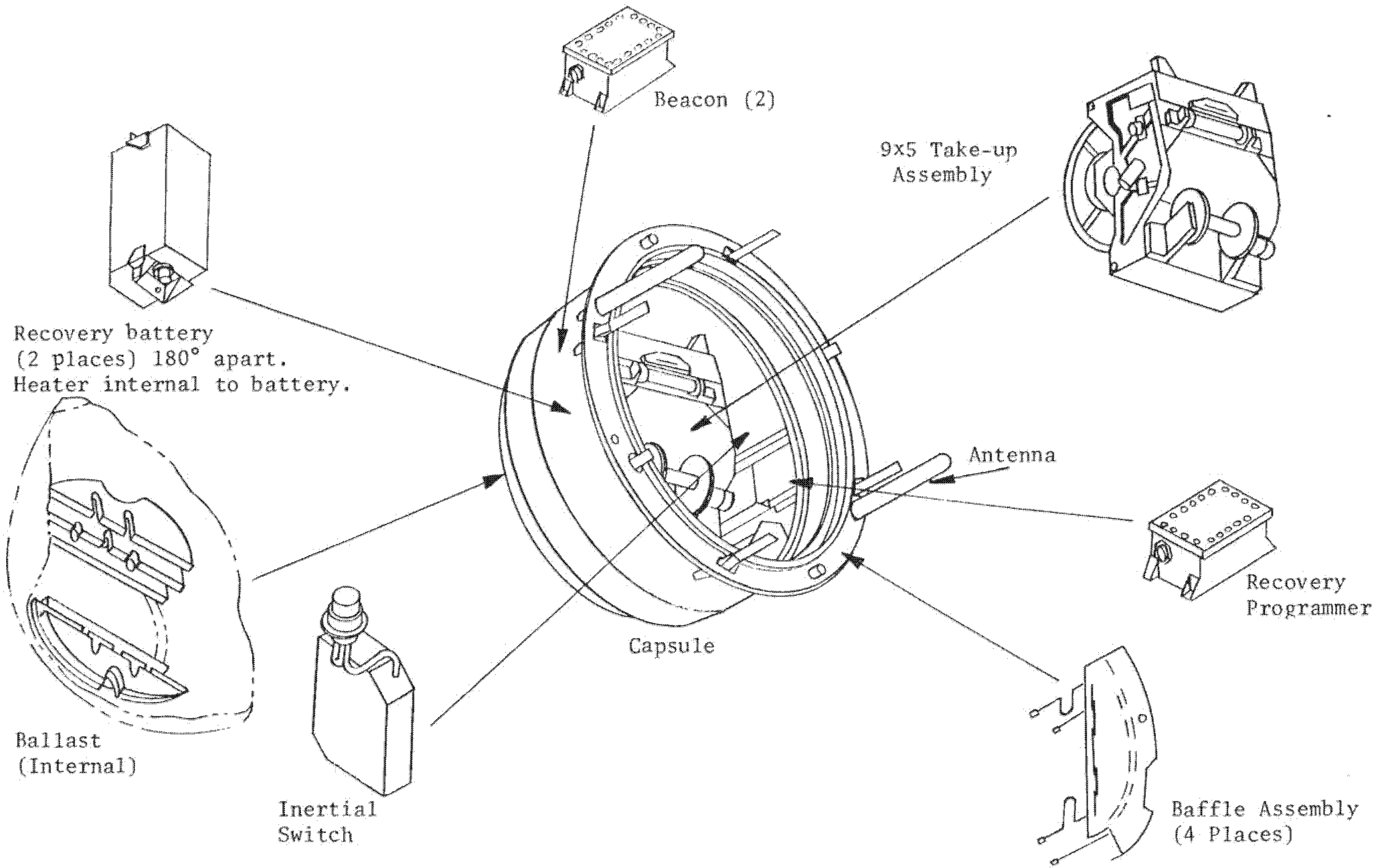


Figure 3.12-8. Recoverable Capsule

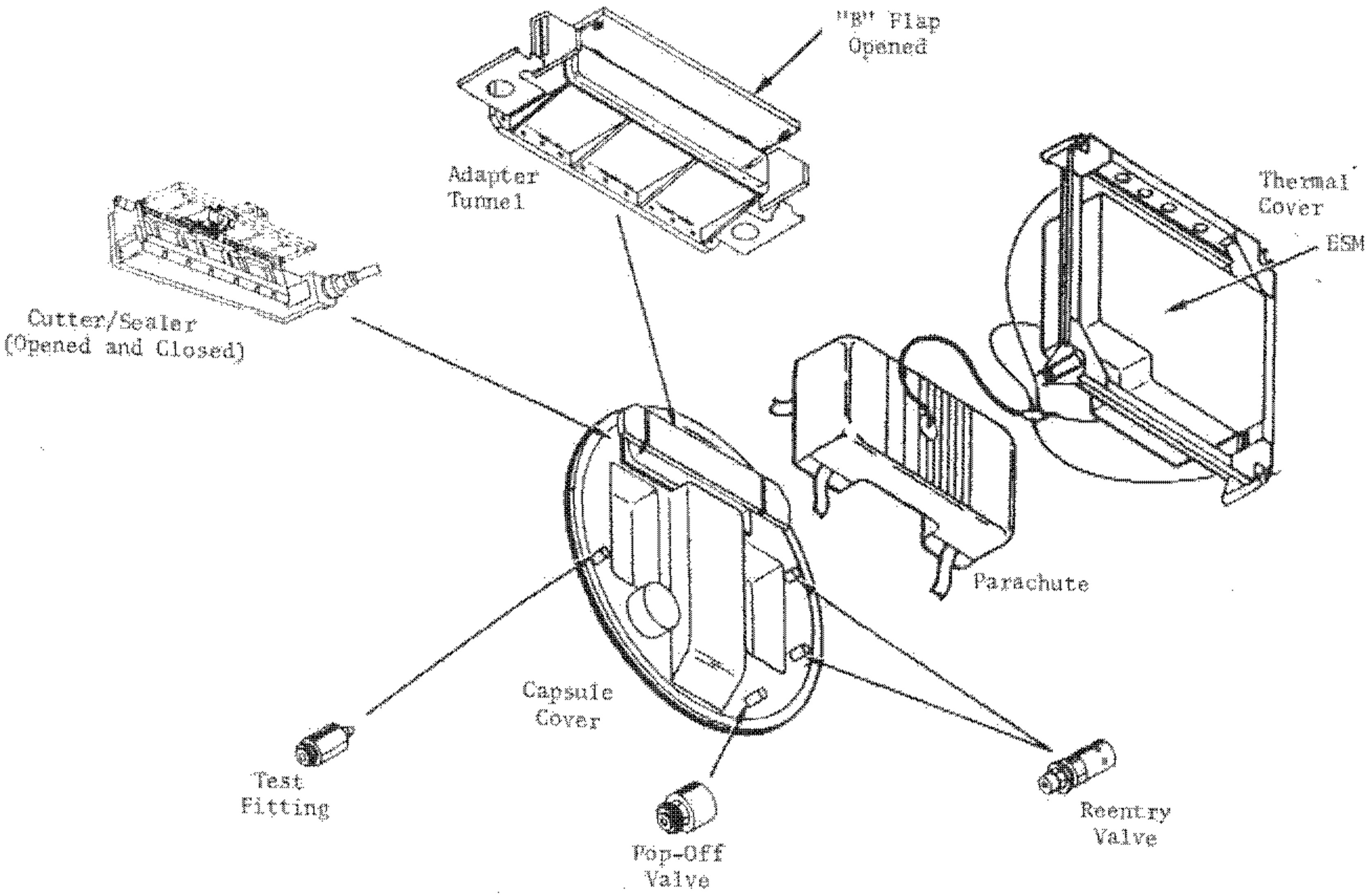


Figure 3.12-9. Capsule Cover

12.8.3 Recovery Programmer

The recovery programmer consists of the primary sequence dual-channel circuits (each channel operating from a single, separately dedicated battery), the backup sequence circuit (which is powered by recovery battery 1), and the pyro firing circuitry. The two independent pyro-firing circuits each control one-half of the pyrotechnic devices in the subsystem so that a failure in one side will not disable the redundant pyros.

The recovery programmer sequence of operations is outlined in Tables 3.12-1A and 3.12-1B. Changeover from backup to primary control is accomplished by action of the G switches which are acceleration sensitive switches that close and reopen in response to the changing deceleration forces experienced during reentry.

12.8.4 Parachute Assembly and Deployment

The parachute assembly is mounted on the capsule cover and protected during reentry by the thermal cover and baffle assemblies. Final retardation of the capsule is accomplished by two parachutes deployed in three stages of deceleration:

(1) First stage deceleration is supplied by the decelerator, or drogue chute. Actuation of the ejection pistons simultaneously releases the thermal cover, capsule, and forebody. The parachute is deployed, the main parachute release is initiated, and the forebody falls away as the capsule is slowed down.

(2) Second and third stage deceleration is provided by a single main parachute which is reefed during the second stage of deceleration and fully open during the third stage. The

purpose of the staging sequence is to reduce the peak loads on the main canopy. During the second stage, if not previously accomplished by the first stage deceleration (drogue chute), the main chute aerodynamic drag provides the force required to separate the recoverable capsule from the R/V forebody, permitting the forebody to free fall without drag augmentation. After a four-second reefing interval, the main chute canopy fully inflates and provides sufficient drag to achieve a descent rate compatible with air retrieval requirements.

12.8.5 Recovery Beacons

The primary function of the beacons is to serve as a location aid for the search and recovery operations. As a secondary function, each beacon telemeters performance data from the SRV. The event beacon transmits critical event sequencing information such as retro-fire and thermal cover ejection, while the deceleration beacon transmits deceleration data from the reentry vehicle.

12.8.6 Capsule Valving Hardware

The capsule valving hardware functions so as to limit differential pressure between the capsule and its external ambient pressure. The valving also serves to maintain capsule flotation integrity following water impact, and allows the capsule to sink if recovery is unsuccessful.

Several pressure-sensitive valves are used to permit entry of air into the capsule during reentry, and to exhaust air as it sinks. During ascent, the major portion of venting is done via the film tunnel. The capsule pop-off relief valve may or may not assist in this function depending on the pressure levels reached.

The sink valve is a dissolvable plug which allows flooding of the capsule after a predetermined length of time when immersed in sea water. As the internal pressure increases due to the entering of water, the capsule pop-off relief valve opens to exhaust the air. This water-in/air-out process continues until the capsule sinks.

12.9 Instrumentation

12.9.1 Satellite Reentry Vehicle Instrumentation

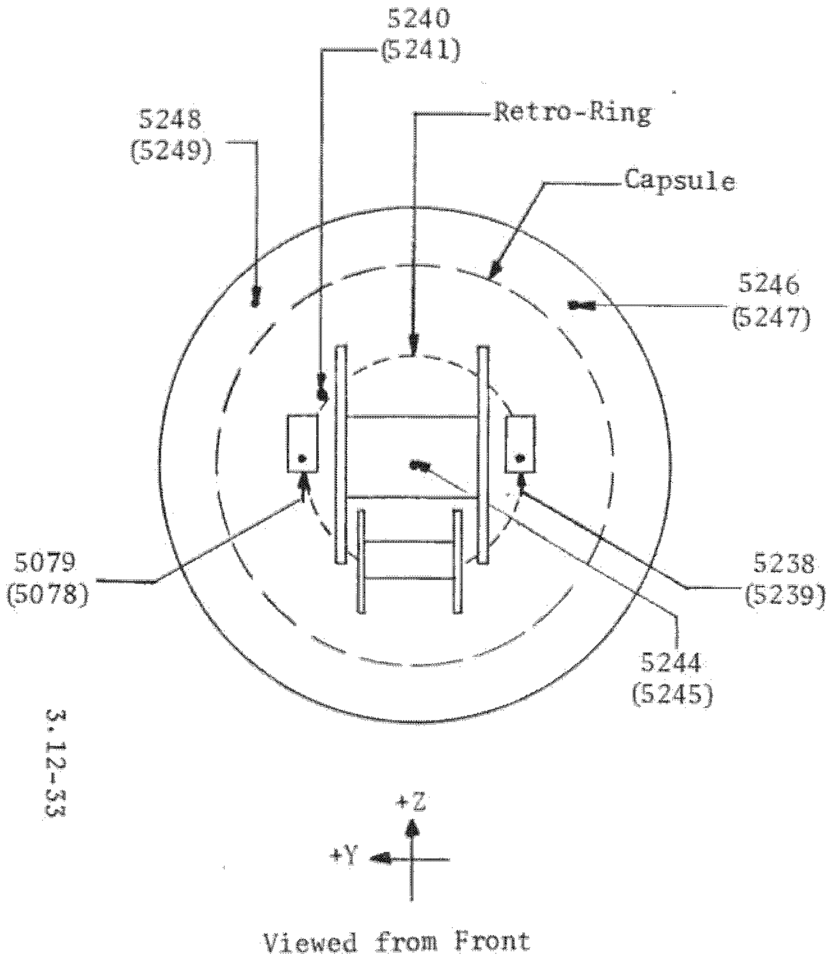
Six temperature points and three battery-voltage monitors make up the instrumentation for the SRV. Each temperature sensor is a resistor/thermistor voltage divider circuit. The recovery battery voltage is measured by a resistance network generating individual and combined readings.

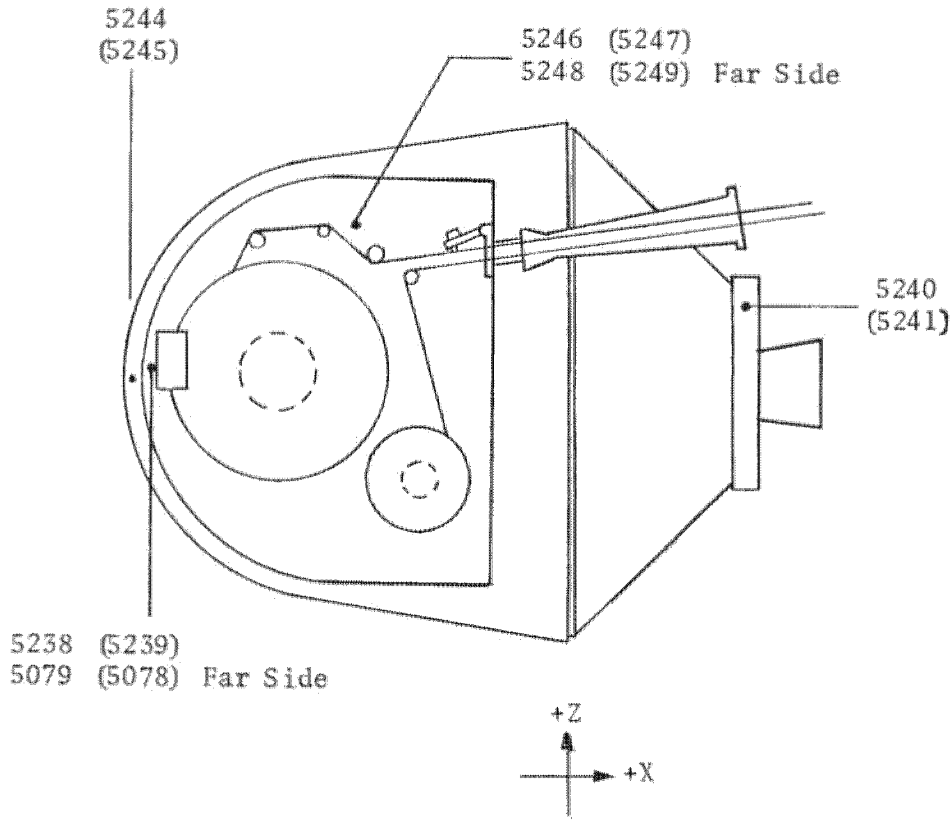
All instrumentation points in the SRV are powered by the PPS/DP EAC instrumentation supplies, +5 and +15 vdc. Output characteristics are fully compatible with DTU input requirements and receive no additional processing within the PPS/DP EAC. The temperature monitor locations for each SRV are illustrated in Figure 3.12-10.

A summary of the temperature sensors and other SRV monitors is presented in Table 3.12-2. Only those points monitored through the satellite vehicle telemetry subsystem are included. Functions monitored via the SRV recovery beacons, and those monitored during preflight testing by support equipment are not listed.

12.9.2 Termination and Recovery Related PPS/DP EAC Instrumentation

A great number of PPS/DP EAC monitors are associated with the recovery of film. Table 3.12-3 lists the most important of these. Sensors associated with the cutter/sealer, TSRT, and splicer mechanisms are not listed here, but are described in Part 3, Section 11.





NOTES:
1. Coordinates are BIF-008 vehicle coordinates.
2. Code numbers shown refer to SRV 1 (SRV 2).

Figure 3.12-10. SRV Temperature Sensor Locations

TABLE 3.12-2

SRV INSTRUMENTATION

IMP	TITLE	DESCRIPTION	POWER
5238	Temperature SRV 1 Recovery Battery, +Y Side	Resistor/thermistor voltage divider circuit. Nonlinear output, 30F (3.8 volts) to 130F (1.35 volts)	+5 vdc
5079	Battery 2 Temperature, SRV 1	Identical to IMP 5238	+5 vdc
5240	Temperature SRV 1 T/C Retro Attach Point	Resistor/thermistor voltage divider circuit. Nonlinear output, 10F (4.15 volts) to 140F (1.15 volts)	+15 vdc
5244	Temperature SRV 1 F/B Liner Skirt, X-Axis	Resistor/thermistor voltage divider circuit. Linear output, -150F (1.53 volts) to 300F (4.99 volts)	+15 vdc
5246	Temperature SRV 1 F/B Liner Skirt, +45 Degrees	Resistor/thermistor voltage divider circuit. Nonlinear output, -150F (1.88 volts) to 200F (5.0 volts)	+15 vdc
5248	Temperature SRV 1 F/B Liner Skirt, -45 Degrees	Identical to IMP 5244	+15 vdc
5291	Recovery Battery 1, SRV 1	Part of combined voltage divider network. Linear output, 0 volt (0.5 volt) to 17.0 volts (5.05 volts)	+15 vdc
5292	Recovery Battery 2, SRV 1	Identical to IMP 5291	+15 vdc

TABLE 3.12-2 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5295	Recovery Batteries, SRV 1	Resistance network combining voltage of battery 1 (E_{B1}) and battery 2 (E_{B2}) according to the transfer function: $E_{out} = 0.5 + 0.095\ E_{B1} + 0.181\ E_{B2}$	+15 vdc
5239	Temperature SRV 2 Recovery Battery, +Y Side	Identical to IMP 5238	+5 vdc
5078	Battery 2 Temperature, SRV 2	Identical to IMP 5238	+5 vdc
5241	Temperature SRV 2 T/C Retro Attach Point	Identical to IMP 5240	+15 vdc
5245	Temperature SRV 2 F/B Liner Skirt, X-Axis	Identical to IMP 5244	+15 vdc
5247	Temperature SRV 2 F/B Liner Skirt, +45 Degrees	Identical to IMP 5246	+15 vdc
5249	Temperature SRV 2 F/B Liner Skirt, -45 Degrees	Identical to IMP 5246	+15 vdc
5293	Recovery Battery 1, SRV 2	Identical to IMP 5291	+15 vdc
5294	Recovery Battery 2, SRV 2	Identical to IMP 5291	+15 vdc
5296	Recovery Batteries, SRV 2	Identical to IMP 5295	+15 vdc

TABLE 3.12-3

SRV RELATED PPS/DP EAC INSTRUMENTATION

IMP	TITLE	DESCRIPTION	POWER
5109	CBM* for IEU (#1)	Latching relays, operating in parallel with the command input relays of the IEU, monitor the receipt of commands from the satellite control section. Four relays and a resistance network form a D/A converter whose output occurs in sixteen (16) discrete steps ranging from 0.25 volt to 4.75 volts in 0.3-volt increments: Bit 1 (LSB)** = TRANSFER 2A**** Bit 2 = ARM 2A Bit 3 = TRANSFER 1A Bit 4 (MSB)*** = ARM 1A	+15 vdc
5116	CBM for IEU (#2)	Similar to IMP 5109: Bit 1 (LSB) = SEPARATE 2A Bit 2 = EA SEPARATE A Bit 3 = EA DISCONNECT A Bit 4 (MSB) = SEPARATE 1A	+15 vdc
5117	CBM for IEU (#3)	Similar to IMP 5109: Bit 1 (LSB) = TRANSFER 2B Bit 2 = ARM 2B Bit 3 = TRANSFER 1B Bit 4 (MSB) = ARM 1B	+5 vdc

*Command Bit Monitor
**Least Significant Bit
***Most Significant Bit
****"A" refers to side A input circuitry in the IEU

TABLE 3.12-3 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5118	CBM for IEU (#4)	Similar to IMP 5109: Bit 1 (LSB) = SEPARATE 2B Bit 2 = EA SEPARATE B Bit 3 = EA DISCONNECT B Bit 4 (MSB) = SEPARATE 1B	+5 vdc
5119	CBM for IEU (#5)	Similar to IMP 5109: Bit 1 (LSB) = C/S 2A Bit 2 = C/S 1A Bit 3 = 5 S/C A Bit 4 (MSB) = 9 S/C A	+15 vdc
5121	CBM for IEU (#6)	Similar to IMP 5109: Bit 1 (LSB) = C/S 2B Bit 2 = C/S 1B Bit 3 = 5 S/C B Bit 4 (MSB) = 9 S/C B	+5 vdc
5122	CBM for IEU (#7)	Similar to IMP 5109: Bit 1 (LSB) = MINIMAL ARM 1 ENABLE Bit 2 = VIEWPORT DOOR BLOW A Bit 3 = VIEWPORT DOOR BU A Bit 4 (MSB) = HATCH COVER EJECT A	+15 vdc
5123	CBM for IEU (#8)	Similar to IMP 5109: Bit 1 (LSB) = MINIMAL ARM 1 AND 2 ENABLE Bit 2 = VIEWPORT DOOR BLOW B Bit 3 = VIEWPORT DOOR BU B Bit 4 (MSB) = HATCH COVER EJECT B Note: If MINIMAL ARM 1 AND 2 ENABLE is commanded before MINIMAL ARM 1 ENABLE, instrumentation will not indicate execution of the command.	+5 vdc

TABLE 3.12-3 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5159	CBM for IEU (#9)	Similar to IMP 5109: Bit 1 (LSB) = 5 ROLL-IN TERMINATE B Bit 2 = 9 ROLL-IN TERMINATE B Bit 3 = 5 ROLL-IN TERMINATE A Bit 4 (MSB) = 9 ROLL-IN TERMINATE A	+15 vdc
5500	SRV 1, Arm 1	A latching relay, located in the IEU, is operated by the pyro-firing pulse, providing an indication of firing signal output to the pyrotechnic device. The monitor is either shorted to instrumentation ground, or connected to the +5 vdc instrumentation power through an isolation resistor. The output is digitized in the DTU, resulting in a binary signal (quiescent/fired). "0" = Quiescent "1" = Fired	+5 vdc
5501	SRV 1, Arm 2	Similar to IMP 5500, monitors the firing pulse output to arm pyro 2 in SRV 1.	+5 vdc
5524	SRV 2, Arm 1	Similar to IMP 5500, monitors the firing pulse output to arm pyro 1 in SRV 2.	+5 vdc
5525	SRV 2, Arm 2	Similar to IMP 5500, monitors the firing pulse output to arm pyro 2 in SRV 2.	+5 vdc
5502	SRV 1, Transfer, Thermal Battery 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 in the thermal battery.	+5 vdc

TABLE 3.12-3 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5503	SRV 1, Transfer, Thermal Battery 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 in the thermal battery.	+5 vdc
5526	SRV 2, Transfer, Thermal Battery 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 in the thermal battery.	+5 vdc
5527	SRV 2, Transfer, Thermal Battery 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 in the thermal battery.	+5 vdc
5504	SRV 1, Transfer, IFD 1 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for IFD 1.	+5 vdc
5505	SRV 1, Transfer, IFD 1 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for IFD 1.	+5 vdc
5360	Blast Shield Valve	A 5KΩ potentiometer attached to the blast shield valve monitors the valve position, providing a linear output ranging from 4.5 volts (closed) to 0.5 volt (open).	+5 vdc
5528	SRV 2, Transfer, IFD 2 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for IFD 2.	+5 vdc
5529	SRV 2, Transfer, IFD 2 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for IFD 2.	+5 vdc
5564	SRV 1 Separation +Y	A microswitch, actuated by a spring-loaded plunger mounted on the forward EA ring near +Y, senses the separation of the SRV. The output is connected either to ground (unseparated), or to a two-resistor voltage	+ 15 vdc

TABLE 3.12-3 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5564 (Cont'd)		divider circuit putting out 4.0 volts (separated). The output is digitized by the DTU, resulting in a binary signal: "0" = Not Separated "1" = Separated	
5565	SRV 1, Separation -Y	Similar to IMP 5564, the plunger is mounted on the forward EA ring near -Y.	+5 vdc
5508	SRV 1, Separation +Z 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for the +Z pin-puller.	+5 vdc
5509	SRV 1, Separation +Z 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for the +Z pin-puller.	+5 vdc
5510	SRV 1, Separation -Z 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for the -Z pin-puller.	+5 vdc
5511	SRV 1, Separation -Z 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for the -Z pin-puller.	+5 vdc
5566	SRV 2 Separation +Y	Similar to IMP 5564, the plunger is attached to the SRV 2 mounting ring in the FA near +Y.	+15 vdc
5567	SRV 2 Separation -Y	Similar to IMP 5564, the plunger is attached to the SRV 2 mounting ring in the FA near -Y.	+5 vdc
5512	SRV 2, Separation +Z 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for the +Z pin-puller.	+5 vdc

TABLE 3.12-3 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5513	SRV 2, Separation +Z 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for the +Z pin-puller.	+5 vdc
5514	SRV 2, Separation -Z 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for the -Z pin-puller.	+5 vdc
5515	SRV 2 Separation -Z 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for the -Z pin-puller.	+5 vdc
5574	Spinoff Disconnect 1	Two parallel continuity loops through spin-off disconnect 1 connect the IMP output to ground. When the circuit is broken by separation of the connector, the IMP output is connected through a 45KΩ resistor to the +5 vdc instrumentation power supply. The output is digitized by the DTU, resulting in a binary signal: "0" = Connected "1" = Disconnected	+5 vdc
5506	SRV 1, Separation Spinoff Disconnect 1 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for spinoff disconnect 1.	+5 vdc
5507	SRV 1, Separation Spinoff Disconnect 1 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for spinoff disconnect 2.	+5 vdc
5575	Spinoff Disconnect 2	Similar to IMP 5574, but has only one continuity loop, which goes through spinoff disconnect 2.	+5 vdc

TABLE 3.12-3 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5516	Spinoff Disconnect 2 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for spinoff disconnect 2.	+5 vdc
5517	Spinoff Disconnect 2 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for spinoff disconnect 2.	+5 vdc
5568	EA Separation 276 degrees, +5 vdc	Similar to IMP 5564. The spring-loaded plunger is attached to the forward edge of the FA at approximately 276 degrees, and is on the -Z side of the pin-puller.	+5 vdc
5569	EA Separation 36 degrees, +5 vdc	Similar to IMP 5564. The plunger is attached to the forward edge of the FA at approximately 36 degrees, and is on the +Z side of the pin-puller.	+5 vdc
5570	EA Separation 156 degrees, +5 vdc	Similar to IMP 5564. The plunger is attached to the forward edge of the FA at approximately 156 degrees, and is on the -Y side of the pin-puller.	+5 vdc
5571	EA Separation 276 degrees, +15 vdc	Similar to IMP 5564. The plunger is attached to the forward edge of the FA at approximately 276 degrees, and is on the +Z side of the pin-puller.	+15 vdc
5572	EA Separation 36 degrees, +15 vdc	Similar to IMP 5564. The plunger is attached to the forward edge of the FA at approximately 36 degrees, and is on the -Z side of the pin-puller.	+15 vdc

TABLE 3.12-3 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5573	EA Separation 156 degrees, +15 vdc	Similar to IMP 5564. The plunger is attached to the forward edge of the FA at approximately 156 degrees, and is on the +Y side of the pin-puller.	+15 vdc
5518	EA Separation 36 degrees 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for the EA pin-puller located at 36 degrees.	+5 vdc
5519	EA Separation 36 degrees 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for the EA pin-puller located at 36 degrees.	+5 vdc
5520	EA Separation 156 degrees 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for the EA pin-puller located at 156 degrees.	+5 vdc
5521	EA Separation 156 degrees 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for the EA pin-puller located at 156 degrees.	+5 vdc
5522	EA Separation 276 degrees 1	Similar to IMP 5500, monitors the firing pulse output to pyro 1 for the EA pin-puller located at 276 degrees.	+5 vdc
5523	EA Separation 276 degrees 2	Similar to IMP 5500, monitors the firing pulse output to pyro 2 for the EA pin-puller located at 276 degrees.	+5 vdc
5003	Environmental Branch 1,2,4, and 5 Parking Brake On/Off	Latching relays tracking the command input relays of the command processor monitor the receipt of commands from the satellite control section and feed either 0.0 volt or 5.0 volts to an integrated circuit D/A	+5/±15 vdc

TABLE 3.12-3 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5003 (Cont'd)		converter. Four relays and one 4-bit D/A converter form the IMP. Output occurs in sixteen(16) discrete steps ranging from 0.25 volt to 4.75 volts in 0.3-volt increments: Bit 1 (LSB) = Env. Branch 1 On/OFF Bit 2 = Env. Branch 2 On/Off Bit 3 = 5 Parking Brake On/Off Bit 4 (MSB) = Env. Branch 4 On/Off	
5004	Environmental Branch 5,6, EPSM 1, EPSM 2 On/Off	Similar to IMP 5003: Bit 1 (LSB) = Env. Branch 5 On/Off Bit 2 = Env. Branch 6 On/Off Bit 3 = EPSM 1 On/Off Bit 4 (MSB) = EPSM 2 On/Off	+5/±15 vdc
5577	Environmental Branch 1 Voltage Monitor	A two-resistor voltage divider circuit connected across branch 1 power feed line in the PM and C monitors the voltage level. Output is digitized in the DTU to yield a binary signal (On/Off). "0" = Off "1" = On	Self
5582	Environmental Branch 6 Voltage Monitor	Similar to IMP 5577, monitors the branch 6 power feed in the PM and C.	Self
5583	EPSM 1 Voltage Monitor	Similar to IMP 5577, monitors the EPSM 1 power feed in the PM and C.	Self

TABLE 3.12-3 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5584	EPSM 2 Voltage Monitor	Similar to IMP 5577, monitors the EPSM 2 power feed in the PM and C.	Self
5133	Environmental Current Branch 1, Branch 6, EPSM 1, and EPSM 2	A 0.01Ω current-sensing resistor in the power return line in the PM and C generates a voltage proportional to the combined currents for branches 1 and 6, and EPSM 1 and 2. The signal is amplified within the PM and C to produce a linear output ranging from 0.2 volt (0.0 amps) to 5.0 volts (4.48 amps).	±15 vdc

12.10 Command Summary

12.10.1 Splice and Cut Commands

9 SPLICE AND CUT (P02766, P01766, P03766)
5 SPLICE AND CUT (P02573, P01573, P03573)

Function: (a) Actuates the splicer mechanism (9 or 5)

(b) Connects the 9 and/or 5 take-up control signals to SRV 2.

Interlocks: 9 SPLICE AND CUT enables 9 ROLL-IN TERMINATE
5 SPLICE AND CUT enables 5 ROLL-IN TERMINATE

Comments: (a) Film must be stationary for execution of these commands.

(b) Tension should be removed from the splice shortly after formation (typically within 10 minutes).

(c) After execution of the first splice/cut, the loose tail of the film must be rolled into SRV 1 before any film is moved in the other camera subsystem.

12.10.2 Roll-In Terminate Commands

9 ROLL-IN TERMINATE (N02652, N01652, N03652)
5 ROLL-IN TERMINATE (N02752, N01752, N03752)

Function: Removes the indicated take-up control signal from take-up 1.

Interlocks: 9 ROLL-IN TERMINATE enabled by 9 SPLICE AND CUT
5 ROLL-IN TERMINATE enabled by 5 SPLICE AND CUT

Comments: These commands should not be given until the cut end of film has been rolled into SRV 1 after 9 SPLICE AND CUT, or 5 SPLICE AND CUT. The lengths of film to be rolled in are approximately 8.5 feet for the 9 subsystem and 11 feet for the 5 subsystem.

12.10.3 Cut and Seal 1 Command

CUT AND SEAL 1 (P02572, P01572, P03572, MP00045)

Function:
(a) Actuates - Cutter/Sealer 1
(b) Actuates - Cutter/Sealer 3
(c) Actuates - Cutter/Sealer 4
(d) Actuates - TSRT 5
(e) Actuates - TSRT 9

Comments: This command is not normally given prior to rolling in the 9 film and 5 film left between SRV 1 and the splicer mechanisms after the SPLICE AND CUT commands are executed.

12.10.4 SRV 1 Arm Command

SRV 1 ARM (P02571, P01571, P03571, MP00051)

Function: Fires the pyros which activate the recovery batteries in SRV 1 and starts the recovery programmer back-up timer.

Interlocks:
(a) SRV 1 ARM from the MCS (MP00051) must be enabled by MCS TERMINATION ENABLE 1 (SWRTC 1), or MCS TERMINATION ENABLE 2 (SWRTC 2).

(b) SRV 1 ARM enables SRV 1 TRANSFER.

Comments: Normally given between 120 and 1992 seconds* prior to SRV 1 TRANSFER.

Activation of the recovery batteries powers the recovery beacons and the recovery programmer.

*Timing requirements are controlled by GE RESD.

12.10.5 SRV 1 Transfer Command

SRV 1 TRANSFER (N02754, N01754, N03754, MN00111)

Function: (a) Fires the pyros which activate the thermal batteries in SRV 1.

(b) Actuates IFD 1 (delay type pyros).

Interlocks: (a) SRV 1 TRANSFER is enabled by SRV 1 ARM.

(b) SRV 1 TRANSFER enables SRV 1 SEPARATE.

Comments: Command follows SRV 1 ARM by 120 to 1992 seconds*.

Separation of IFD 1 enables the dual ejections programmer in SRV 1.

12.10.6 SRV 1 Separate Command

SRV 1 SEPARATE (N02657, N01657, N03657, MN00112)

Function: (a) Activates the pin-pullers releasing SRV 1 from the PPS/DP EAC.

(b) Actuates spinoff disconnect 1.

Interlocks: SRV 1 SEPARATE is enabled by SRV 1 TRANSFER.

Comments: Command is given 1.8 ± 0.2 seconds after SRV 1 TRANSFER.*

12.10.7 Spinoff Disconnect 2 (EA Disconnect) Command

SPINOFF DISCONNECT 2 (P02763, P01763, P03763, MP00052)

Function: Actuates spinoff disconnect 2 (EA Disconnect)

Interlocks: SPINOFF DISCONNECT 2 enables EA SEPARATE.

*Timing requirements are controlled by GE RESD.

12.10.8 EA Separation Command

EA SEPARATE (N02646, N01646, N03646, MN00121)

Function: Actuates the pin-pullers releasing the EA from the PPS/DP EAC.

Interlocks: EA SEPARATE is enabled by SPINOFF DISCONNECT 2.

Comments: The EA should not be separated until burnout of the retro-rocket on SRV 1. It is normally separated on the revolution prior to SRV 2 separation.

12.10.9 Cut and Seal 2 Command

CUT AND SEAL 2 (P02577, P01577, P03577, MP00062)

Function: Actuates cutter/sealer 2 and the aft back-up cutter.

12.10.10 SRV 2 Arm Command

SRV 2 ARM (P02764, P01764, P03764, MP00061)

Function: Fires the pyros which activate the recovery batteries in SRV 2 and starts the recovery programmer back-up timer.

Interlocks: (a) SRV 2 ARM from the MCS (MP00061) must be enabled by MCS TERMINATION ENABLE 2 (SWRTC 2).

(b) SRV 2 ARM enables SRV 2 TRANSFER

Comments: Normally given between 120 and 1992 seconds prior to SRV 1 TRANSFER, depending on recovery battery temperature.*

Activation of the recovery batteries powers the recovery beacons and the recovery programmer.

*Timing requirements are controlled GE RESD.

12.10.11 SRV 2 Transfer Command

SRV 2 TRANSFER (N02757, N01757, N03757, MN00114)

Function: (a) Fires the pyros which activate the thermal batteries in SRV 2.

(b) Actuates IFD 2 (delay type pyros).

Interlocks: (a) SRV 2 TRANSFER is enabled by SRV 2 ARM.

(b) SRV 2 TRANSFER enables SRV 2 SEPARATE.

Comments: Command follows SRV 1 ARM by 120 to 1992 seconds.*

Separation of IFD enables the dual ejection programmer in SRV 2.

12.10.12 SRV 2 Separate Command

SRV 2 SEPARATE (N12000, N11000, N13000, MN00117)

Function: Actuates the pin-pullers releasing SRV 2 from the PPS/DP EAC.

Interlocks: SRV 2 SEPARATE is enabled by SRV 2 TRANSFER.

Comments: Command is given 1.8 ± 0.2 seconds after SRV 2 TRANSFER.*

12.10.13 MCS Termination Enable 1 Command

MCS TERMINATION ENABLE 1 (SWRTC 1)

Function: This command enables the SRV 1 ARM command from the minimal command subsystem.

*Timing requirements are controlled by GE RESD.

Interlocks: This command is necessary before MCS SRV 1 ARM will be executed by the IEU.

12.10.14 MCS Termination Enable 2 Command

MCS TERMINATION ENABLE 2 (SWRTC 2)

Function: This command enables the SRV 1 ARM and SRV 2 ARM commands from the minimal command subsystem.

Interlocks: This command is necessary before MCS SRV 2 ARM will be executed by the IEU.

Comments: Provides a redundant means of enabling MCS SRV 1 ARM.

12.10.15 Heater Power On Command

HEATER POWER ON (N02661, N01661, N03661)

Function: Provides power to all heater branches, including EPSM 1 and EPSM 2, and provides power to the 5 parking brake circuitry.

Interlocks: 5 OP ON (operational power) disables the 5 parking brake. The circuitry will not be enabled until both 5 OP and 5 parking brake power are OFF.

12.10.16 Heater Branch Off Commands (Branches 1 and 6 Only)

HEATER BRANCH 1 OFF (N02755, N01755, N03755)
HEATER BRANCH 6 OFF (N02742, N01742, N03742)

Function: Removes power from the indicated heater branch.

12.10.17 EPSM On Commands

EPSM 1 ON (N02747, N01747, N03747)
EPSM 2 ON (N02655, N01655, N03655)

Function: Provides power to the indicated heater branch.

Comments: Normally given four revolutions prior to recovery of the associated SRV, depending on the SRV temperature.

12.10.18 EPSM Off Commands

EPSM 1 OFF (N02644, N01644, N03644)
EPSM 2 OFF (N02745, N01745, N03745)

Function: Removes power from the indicated heater branch.

12.10.19 M6V WORD Command

(M6V002YZ)

Function: Controls the environmental heater branches and 5 parking brake. This command also controls the DTU states. The pressure transducer and the +5-and ±15-volt instrumentation power supplies are switched by the DTU commands.

Bit	Function
Implicit	Spare
33-1	DTU 1 ON
33-0	DTU 1 OFF
34-1	DTU 2 ON
34-0	DTU 2 OFF
35-1	Heater branches 1,2,4,5 and 6, and 5 parking brake ON
35-0	Heater branches 1,2,4,5 and 6, and 5 parking brake OFF
36-1	EPSM 1 ON
36-0	EPSM 1 OFF
37-1	EPSM 2 ON
37-0	EPSM 2 OFF
38-1	Spare
38-0	Spare

Interlocks: DTU 1 and 2 are logically interlocked in the PM and C to preclude simultaneous operation. Commanding DTU 1 ON while DTU 2 is already operating will remove power from both sides of the DTU. One side must be in the OFF state to permit the other to receive power.

5 OP ON disables the 5 parking brake. The circuitry will not be enabled until both 5 OP and 5 parking brake power are OFF.

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13.0 S1-PRG SENSOR EXPERIMENT

The S1-PRG (platen reference gage) sensor system is an assembly of prime-like* mechanical and electrical components intended to furnish auxiliary information on parameters directly related to PPS/DP EAC focus stability. The parameters monitored are:

(1) The mechanical analog of a segment of the S_1 distance (primary mirror to aft end of RCFLA) (S1 sensor)

(2) The mechanical equivalent of the back vertex focal distance (S_6) at the +Y and -Y ends of the 9 platen (PRG sensors (2)).

In operation the S1-PRG system serves as both an experimental sensor and as in-factory support equipment. During PPS/DP EAC assembly and testing at the factory, the S1-PRG system can be used for the following:

(1) Camera mounting verification (PRG sensors only)

(2) Broomstick test measurement (S1 sensor only)

(3) Monitoring of in-factory stability (S1 and PRG sensors).

On-orbit, the system is employed to examine changes or rates of changes in the measured distances with time and also during special events. The most significant results this experiment should provide are, in order of importance:

(1) Through-launch shift of monitored distances

*Being experimental, the sensor system hardware is not obligated to meet all the requirements of prime hardware. However, prime-like components are used to the greatest extent possible.

(2) Early drift of monitored distances

(3) Long-term drift of monitored distances.

13.1 Measured Parameters

The S1-PRG system makes three direct, noncontact measurements of distances within the PPS/DP EAC. The S1 sensor measures the distance between the -Z side, aft end, of the Ross corrector and field lens assembly (RCFLA) housing and the +Y, -Y mean (average) position of the A-frame attachment points on the inside surface of the camera optics assembly (COA).

The two PRG sensors measure the distance from the +Y and -Y walls of the forward (-X) end of the RCFLA to the 9 platen pivot frame which can be related to the optical S_6* distance (-X end of the RCFLA to the image plane). Measurements are made to points approximately ±6.25 inches from the PPS/DP EAC optical centerline. Since two measurements are made, both tilt and displacement can be sensed.

13.2 Sensor System Function

The system operates under control of the command processor. Nominal 24.5-volt and ±15-volt power supplied by the power monitor and control unit (PM and C) are conditioned internally. The electrical function of the system can be in any one of three modes selectable by command:

(1) Off

(2) Read

(3) Calibrate ("health check")

*For optical distance figures, reference Part 3, Section 3.

Signals collected by the sensors are conditioned for the telemetry system in the sensor encoder and processing electronics module (SEPE) located within the COA. The health check function provides, via a motor driven mechanism, a target which lies a fixed distance from each sensor to establish a reference baseline.

13.2.1 Method of Sensing

Measurements are made using noncontacting inductive proximity detectors. The sensor itself is the coil in the "tank" circuit of a transistor Colpitts oscillator which operates at approximately 2 MHz. The object sensed must be a conductor; in this case, Invar metal. Proximity of the conductive target to the sensor coil loads the tank circuit and hence changes the oscillator's tank voltage. A linearizing stage converts the tank voltage change to an output which is linear within 1 percent over the operating range of the detector.

The proximity detectors and their associated modulator/demodulator electronics units containing the oscillator circuits are physically separate items. The modulator/demodulator units are mounted on the -X side of the COA bulkhead just above the RCFLA (reference Part 3, Section 1, Figure 3.1-29). The detectors are mounted at the sensor locations and connect to the modulator/demodulator units through coaxial cabling.

13.2.2 Targets

The targets function as entirely passive entities. The mechanical design characteristics for all three sensor targets are similar and are discussed in Section 13.5. Target response to thermal disturbance is minimized by design and by material selection.

13.3 S1 Sensor Mechanical Configuration

The S1 sensor consists of two major mechanical assemblies, the S1 gage assembly which holds the sensor and health check mechanism, and the rod and truss assembly which furnishes the target (see Figure 3.13-1).

13.3.1 Rod and Truss Assembly

The S1 rod and truss assembly (Figure 3.13-2) supplies the dimensional coupling between the interior walls of the COA and the aft end of the RCFLA. A stiffened diamond truss fabricated from cold drawn Invar tubing is used. The truss spans the internal structure parallel to the Y-axis at the A-frames and provides, at its center, one point of support for an Invar rod which reaches from the truss to the S1 gage assembly mounted on the RCFLA. The rod is approximately 24 inches long and lies parallel to the X-axis. The rod's forward end contains the S1 gage target.

13.3.2 S1 Gage Assembly

The S1 gage assembly is a mechanical frame which provides support for the active portion of the inductive proximity detector and for the health check components. A more detailed description of the gage assembly design, which is common to the PRG gage assemblies, is given in Section 13.4.1 following. The S1 gage assembly has attached to it a nylon bushing for support of the forward end of the S1 rod in the Y and Z directions. Mounting to the RCFLA is made using an adapter to provide proper spacing and orientation.

13.3.3 Rod, Truss, and Gage Interface

The S1 rod and truss assembly design effectively decouples the truss from mounting point inputs (torsion, compression, tension, and bending forces),

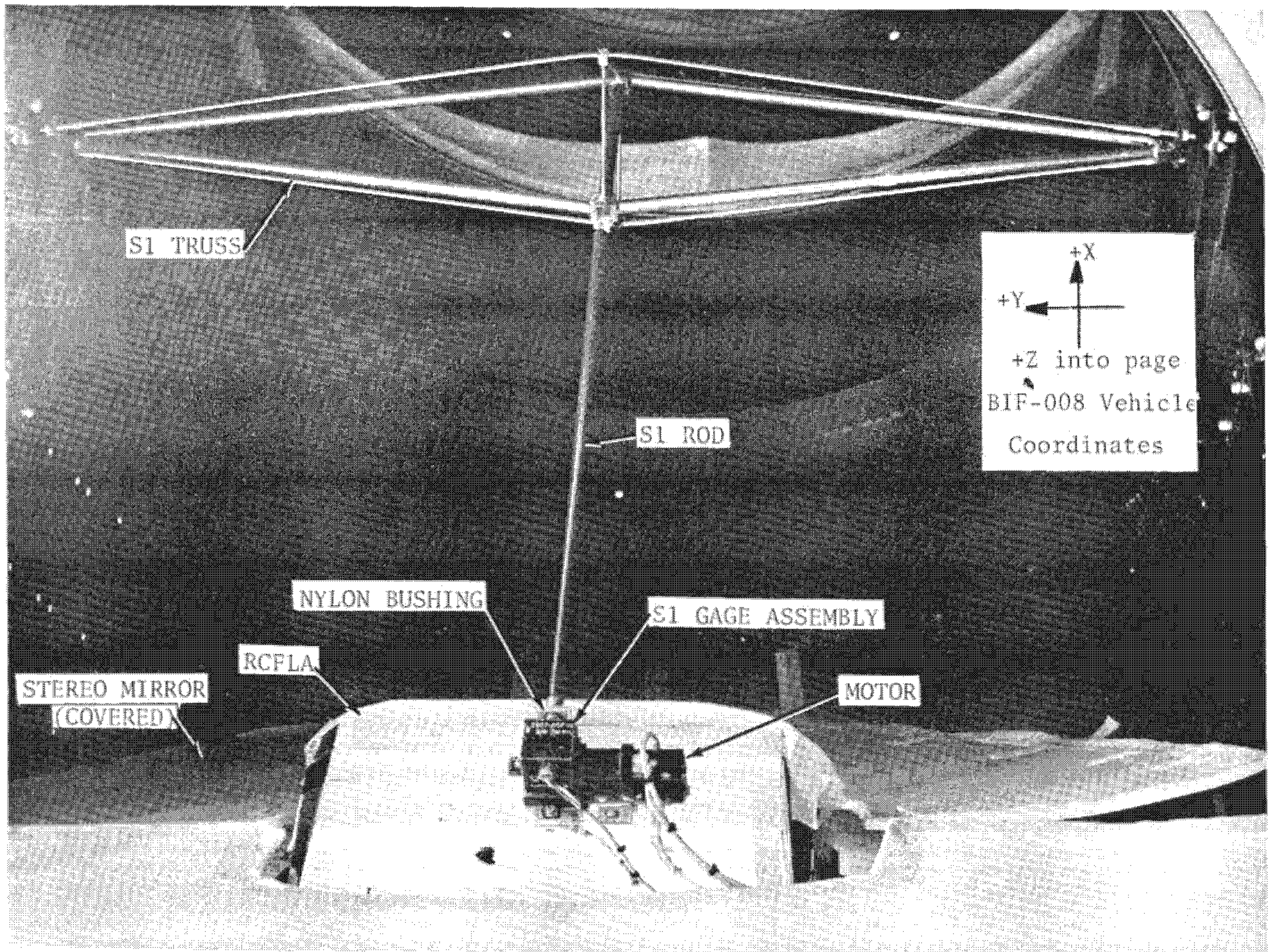


Figure 3.13-1. S1 Sensor Assembly

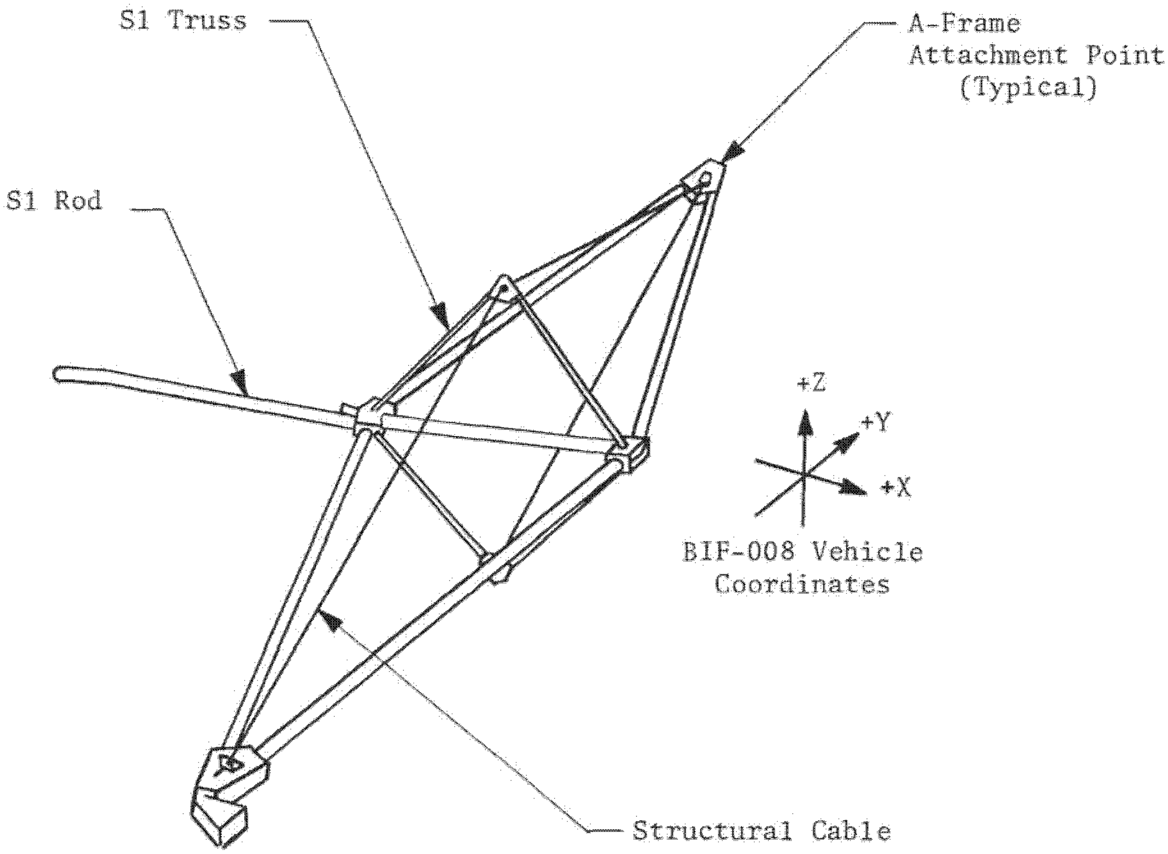


Figure 3.13-2. S1 Rod and Truss Assembly

and also decouples the rod from both the truss and the S1 gage. Decoupling is accomplished by spherical bearing-flexure mounting of the truss and flexure-bushing retention of the rod. There is no X axis coupling of the rod (target) and gage assembly.

13.3.4 S1 Sensor Nominal Separations

Nominal physical sensor face to S1 target face separation in a 1G environment is 0.090 inch for a load-compensated vehicle in an X axis horizontal attitude. For a vertical attitude, as at the launch pad, nominal separation is 0.082 inch. The decrease is due to loading induced deflection of the RCFLA and assumes camera weight present. Nominal separation on-orbit is 0.090 inch independent of vehicle attitude.

13.4 PRG Sensor Mechanical Configurations

The two PRG sensor assemblies are mounted within the forward (-X) end cavity of the RCFLA at the +Y and -Y extremes of the RCFLA housing. The sensors are entirely within the space envelope of the RCFLA. Electrical signal and power lines are carried into the RCFLA through hermetically sealed connectors located at points immediately adjacent to each sensor in the +Z direction. The two sensing locations are as follows:

PRG-1	Y = 6.47 in.	
	Z = 0.0 in.	Coordinates are referenced to the
PRG-2	Y = -6.25 in.	optical axis
	Z = -0.5 in.	

13.4.1 Sensor Geometry

Identical sensor assemblies are used for both PRG sensors and the S1 sensor.

The sensor structure is a monolithic, nearly cubic Invar support frame within which (or upon which) are mounted:

(1) The inductive sensor

(2) A dc gearhead motor

(3) A health check slide and retaining components

(4) The health check slide drive lever and cams

(5) Microswitches to control motor status

The sensor attaches to the RCFLA at three points using short pedestal standoffs which are integral to the support frame.

Visual appearance and scale of the assembly are shown in Figure 3.13-3. Both internal components and the exterior configuration are illustrated.

13.4.2 PRG Sensor Mounting

Figure 3.13-4 illustrates the PRG sensor mounting locations (and the S1 sensor location) as well as the modulator/demodulator units and the sensor encoder and processing unit. The internal mounting of the PRG sensors with respect to the RCFLA wall is shown in greater detail by Figure 3.13-5. Sensors are held by screws, with an epoxy material applied to the screws to effect both locking and hermetic sealing. A total of five support points are involved, three as shown in Figure 3.13-4 and two applied as additional support for the dc motor which would otherwise be cantilevered.

13.5 Sensor Targets

PRG targets are carried by the 9 pivot frame assembly of the dual platen camera. The targets are Invar rods which terminate in 0.6-inch diameter Invar discs (see Figure 3.13-6). Disc faces are set perpendicular to the

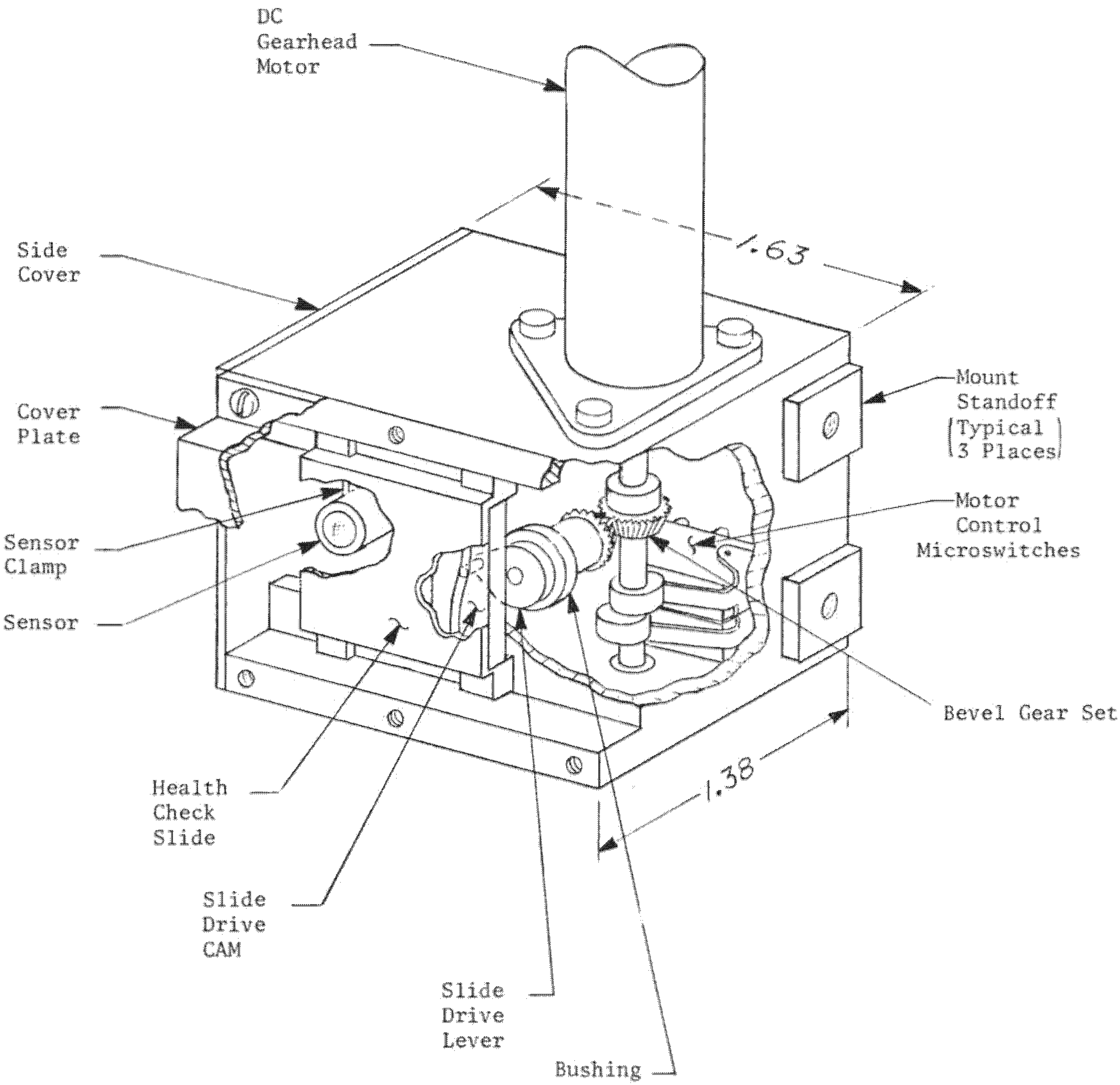


Figure 3.13-3. Typical Sensor Assembly

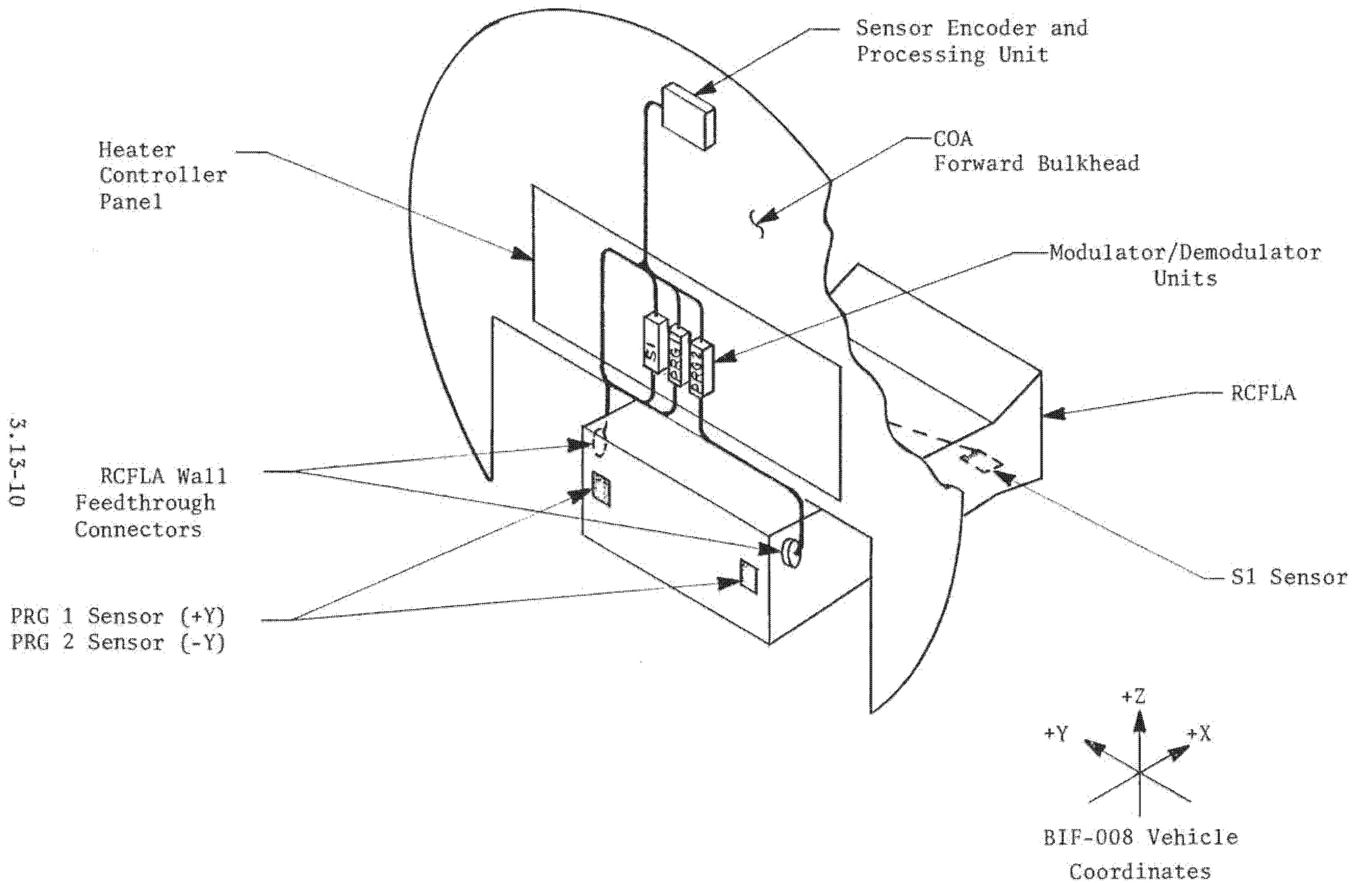


Figure 3.13-4. S1-PRG Component Locations

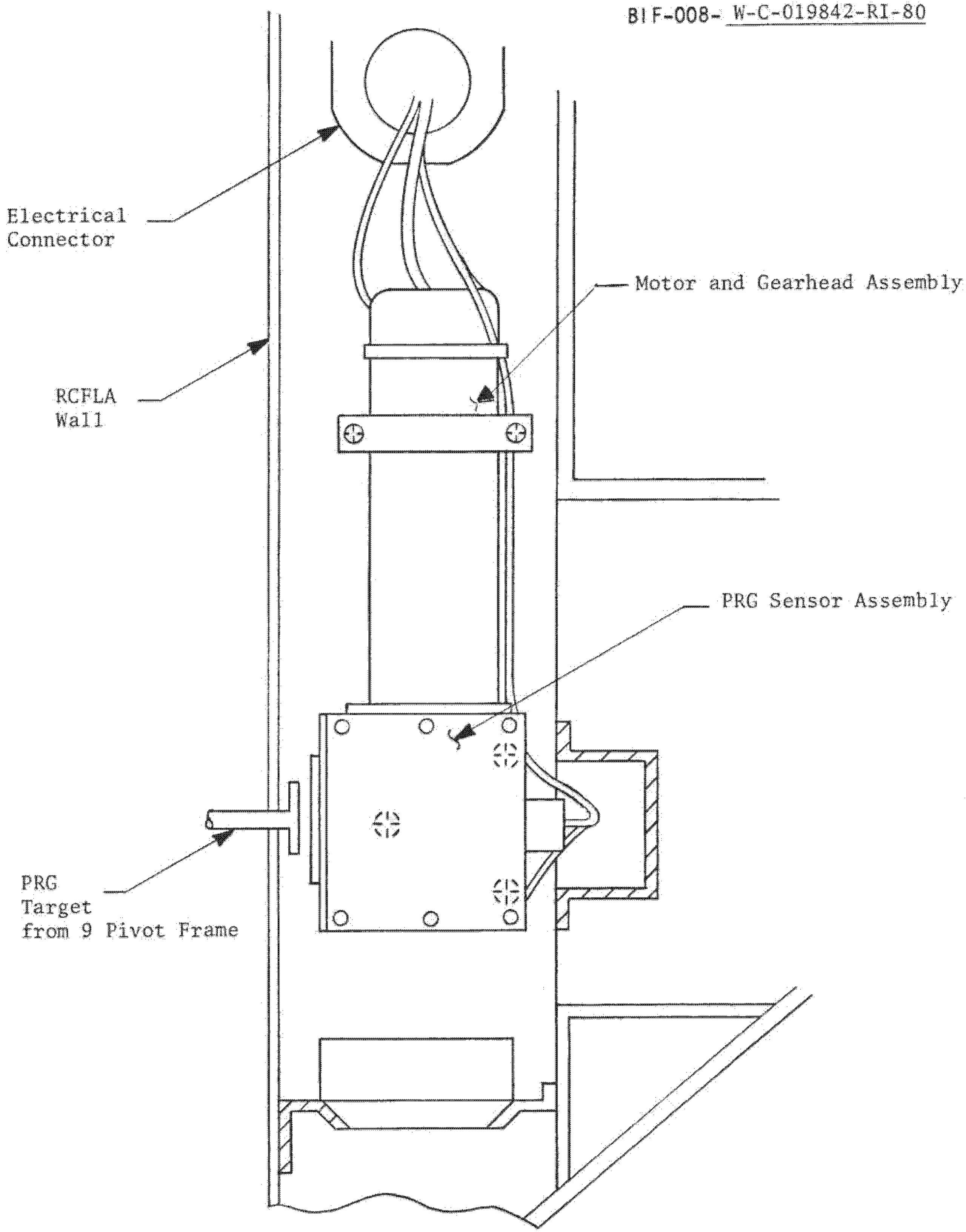


Figure 3.13-5. Typical PRG Sensor Mounting

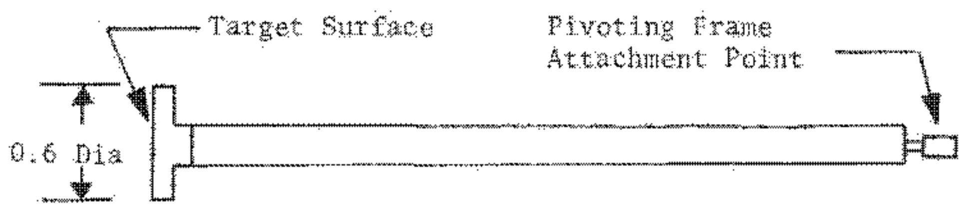


Figure 3.13-6. PRG Target

sensor axes at the nominal position. Motion of the targets follows an arc as the pivot frame is adjusted about its pivot point, with the result that the disc faces do not remain perpendicular to the sensor axes. Since the two targets are mounted at unequal distances from the pivot point, the amount of tilt varies from one to the other and yields a different response (output versus separation) for each sensor.

The S1 target which is welded to the S1 rod is a polished Invar disc, similar to the PRG discs. Unlike the PRG targets, the S1 target surface remains perpendicular to the sensor axis as the separation changes.

13.6 Health Check (Calibration) Slide

Each gage assembly is equipped with a movable Invar target which can be placed a fixed and repeatable distance from the sensor to establish a reference measurement. The slide is driven by a gear-reduced permanent-magnet dc motor using a special cam and gear arrangement as shown previously in Figure 3.13-3. Leaf springs hold the slide in contact with the surface on which it moves.

The slide drive train functions in the following manner.

The lever-pin arm attaches to the motor through a bevel gear set. As the arm rotates, the pin on the arm rides in a cam-slot on the slide moving the slide in or out of the sensor field. Motion is stopped at the commanded position (calibrate or operate) by cams on the motor output shaft which actuate microswitches to interrupt power. Movement from one position to the opposite requires 180 degrees of lever-pin arm and motor shaft rotation (the drive ratio through the bevel gears is 1:1).

To prevent hysteresis, the cam slot on the slide is arranged to give two dwell zones, one for the operate and one for the calibrate positions. The motor input, slide output motion relationship is indicated in Figure 3.13-7.

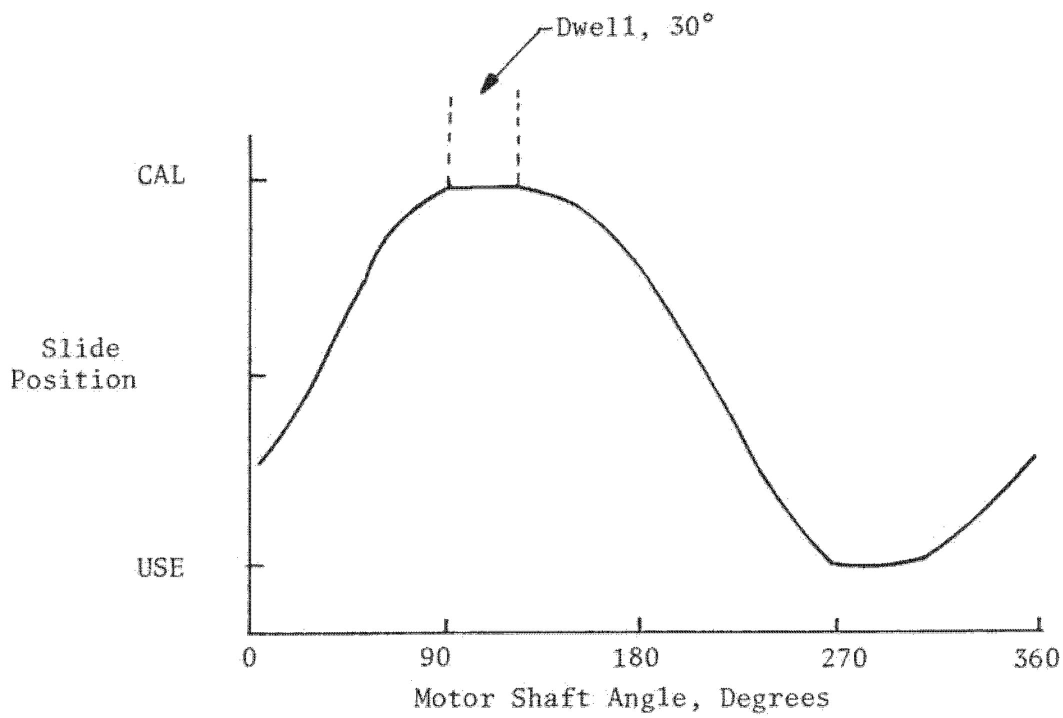


Figure 3.13-7. Slide Input-Output Position Relation

13.7 S1-PRG Sensor System Electronics

Signal generation for the three sensor assemblies occurs at the three probe modulator/demodulator electronics units. The output signals correspond to target position with a calibration constant of 94 volts/inch over the 0.1 inch sensing range. Output voltage range is 0-10 volts nominal.

To accommodate the 0-5 volt operating range of the telemetry system and to obtain adequate system resolution with prevailing telemetry granularity, the sensor signals are "dc offset" and amplified. These functions, as well as power conditioning, occur within the SEPE unit.

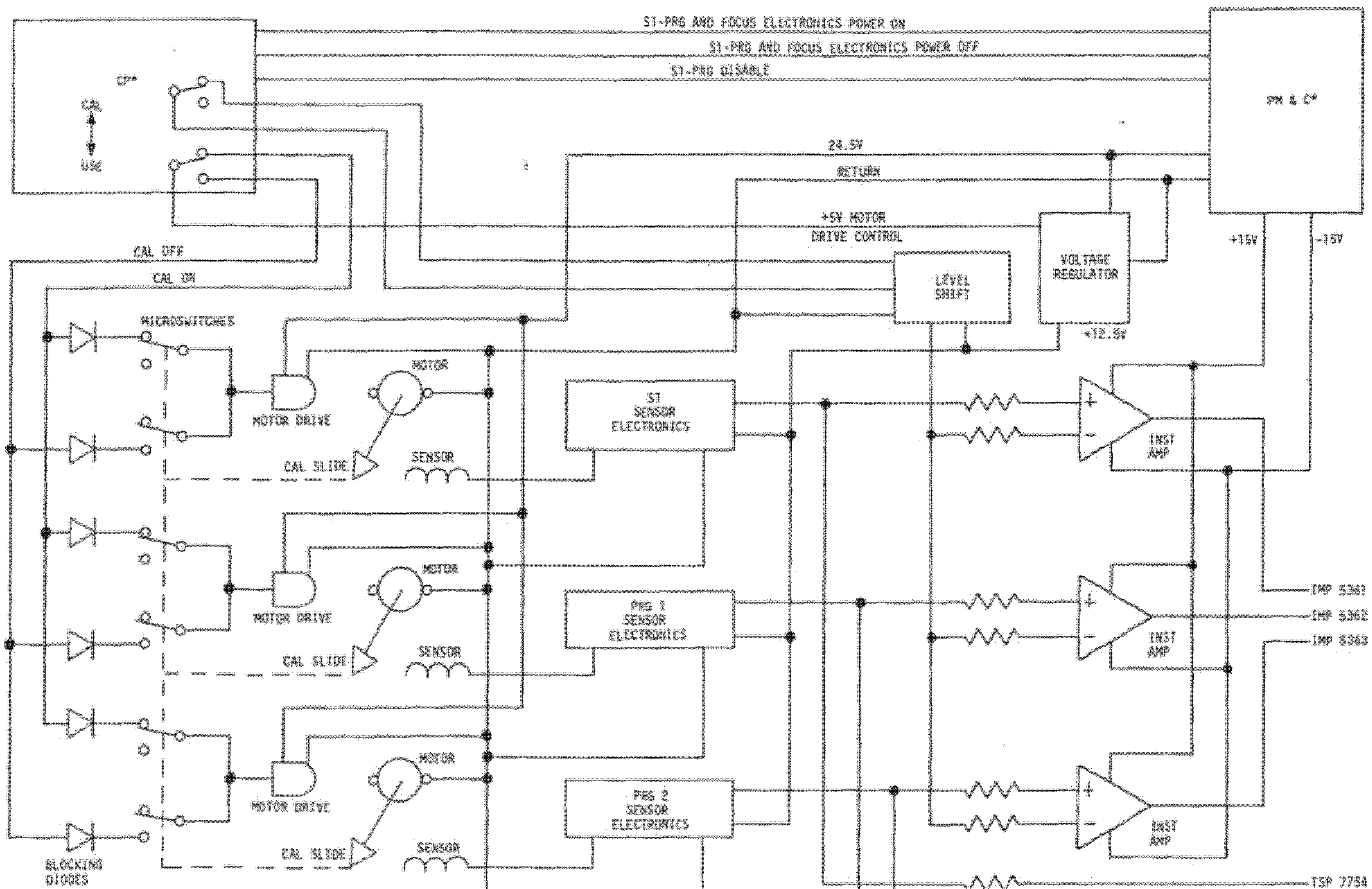
13.7.1 Sensor Encoder and Processing Electronics (SEPE) Unit

The SEPE unit furnishes input power conditioning, output signal conditioning, motor control switching functions and command activated dc level offset. The isolation diodes used to prevent switch cross talk in the motor control lines are mounted to a circuit board attached to the COA bulkhead.

Figure 3.13-8 is an electrical block diagram of the entire S1-PRG system showing the interconnection of the various functions. Also shown are the appropriate PM and C and CP functions.

13.7.1.1 Power Conditioning. Nominal 24.5 volt input power is supplied through a soft-switch in the PM and C. A precision integrated circuit voltage regulator reduces this to provide a stable 12.5 vdc (nominal) for the sensor electronics. A +5 vdc output is also provided for the slide motor control circuitry and is switched by commandable relays in the command processor (CP).

13.7.1.2 Output Signal Conditioning. Precision instrumentation amplifiers operating at an overall gain of approximately 3.1 amplify the sensor output signal to improve signal resolution through the DTU. At the same time, these



* FOR CIRCUIT LOGIC REFERENCE:
CP PART 3, SECTION 9
PM&C PART 3, SECTION 7

Figure 3.13-8. S1-PRG Sensor System Block Diagram amplifiers operate in conjunction with the level shifting circuit to provide a dc offset for the sensor signal as described in the following section.

13.7.1.3 Level Shifting (dc offset). A voltage divider network is employed in the normal operate mode to reduce the sensor output dc level. To accomplish this, the network feeds a portion of the 12.5 vdc regulated output to the inverting inputs of the instrumentation amplifiers where it is subtracted from the sensor output. At the nominal target-sensor separation distance (corresponding to zero platen position for the PRG sensors), the output of the sensors is 6.55 volts. After level shifting and amplification, the instrumentation amplifier output is 2.50 volts. At an amplifier gain of 3.1, the full system range is approximately 14.7×10^{-3} inches or $\pm 7.35 \times 10^{-3}$ inches around the nominal point.

Level shifting is inhibited for health check (calibrate) mode operation.

Establishment of the nominal output voltages is performed during buildup of the camera optics assembly. For the calibrate mode, when the health check slide is in front of the proximity detector, voltage levels are set by moving the detector closer to or further from the slide. In the operate mode, PRG sensor voltage levels are adjusted by shifting the sensor assemblies with respect to the platen targets. The S1 sensor output voltage is changed by moving the S1 target.

13.7.1.4 Direct (Hardline) Test Outputs. Direct outputs of the sensor signals are provided for test purposes. The outputs are isolated by 10 KΩ resistors and are routed to the junction box test connector (J217).

13.7.1.5 Motor Control. Motor control sensing is provided by two microswitches in the gage assembly. The switches are normally closed, and are tripped open individually by cams on the motor shaft, one corresponding to the retracted position and the other the advanced position of the health check slide.

A commandable relay connects +5-volt motor control power from the SEPE unit to one of the two switches depending on the commanded state. When the motor reaches that state, a cam opens the powered switch, removing control power, and the motor is stopped. Upon commanding the opposite state, power is transferred to the second microswitch, which is closed, and the motor is again set in motion. As the motor turns, the open switch closes. However, protective diodes in the line prevent current from being coupled back through this switch. When the new commanded state is reached, the switch receiving control power is opened so the motion is halted. Total time to drive the slide from one position to the other is approximately 32 seconds.

Once motion has begun, commanding the opposite state before both microswitches are closed will halt the drive. Motion can be resumed by repeating the original command. If an opposite command is given after both switches are closed, the system will satisfy the original command and continue driving to satisfy the second command.

Actual drive power for the motors is derived from the 24.5-volt unregulated supply. Motor control power from the microswitches activates optical isolator couplers which control a transistor switch. This switch provides 24.5-volt power to the motor through a filter network which controls voltage rise time.

13.8 System Operation

Operation of the S1-PRG system involves in-factory, launch pad, and on-orbit use. As a part of in-factory use, baselines for orbital operation are established.

13.8.1 Factory Use

For in-factory testing, system output is available in two forms: the encoded output which is conditioned to DTU input requirements (0-5 vdc range) and direct sensor hardline output (0-10 vdc range).

13.8.1.1 Sensor Calibration. Sensor system calibration occurs in two parts. The basic sensors are calibrated as matched sensor head and modulator-demodulator electronics pairs at the part level. The instrumentation amplifier channels are calibrated at the SEPE assembly level. If G(V) is measured SEPE channel gain characteristic, V(X) is the sensor calibration, X is relative distance and V_o is the offset voltage, then the encoded signal transfer characteristic calibration $V_E(X)$ is given by:

$$V_E(X) = G\left[V(X) - V_o\right]$$

13.8.1.2 Baseline Data. The sensor output baseline is established simultaneously with the optical measurement of position of best focus. Readings from the three sensors, obtained during COA load-compensated optical testing, are recorded and corrected to optical best focus. These three data points form the '0' G baseline (on-orbit use).

13.8.2 Pre-Launch Use

Pre-launch operation of the system is accomplished with the PPS/DP EAC in the vertical attitude (-X up) and readings can be compared to factory vertical baselines. The following encoded signal outputs apply:

S1-	-	out-of-band but still directly related to factory reading*
PRG	-	in-band but displaced from horizontal baseline values

*S1 out-of-band condition results from RCFLA deflection due to self and camera load. This should be consistent from factory-to-pad with the exception of any long-term sensor drift.

13.8.3 On-Orbit Use

During launch and orbit injection, S1-PRG power is turned on four seconds after EGS clock start, which occurs at SECO. S1-PRG power remains on for 384.8 seconds, providing 204.8 seconds of usable data.

On-orbit, the S1-PRG power is turned on and off in conjunction with the FOCUS ELECTRONICS POWER (FEP) ON/OFF command. Power can be removed from the S1-PRG system while leaving focus power on by execution of S1-PRG DISABLE. The disable applies only once and is overridden by the next FOCUS ELECTRONICS POWER ON command.

The S1-PRG calibrate mode requires S1-PRG power to be on. Execution of S1-PRG CALIBRATE then places the health check slide in the calibrate position. Calibration ends in conjunction with the focus sensor calibrate off signal and the slide is withdrawn from the sensor path.

Planned usage on-orbit is variable from flight-to-flight and even within a given flight as conditions change. For this reason, no detailed description is provided here. However, it is expected that the sensor system will be operated as soon as practical after launch to monitor any through-launch shift, and then operated whenever the focus sensor system is on. Calibrations will most likely be performed several times early in the mission to identify any short-term drift in the separation parameters. The system can then be calibrated as desired during the remainder of the mission to track long-term drift characteristics.

A prime consideration during any usage is the necessity for a significant warm-up period to stabilize output readings. Operational experience has shown that a 180-second warm-up time is required for every normal read use.

Fifteen minutes (900 seconds) warm-up minimum will be used prior to each S1-PRG calibration cycle.

13.9 S1-PRG Instrumentation Summary

A summary of the S1-PRG sensor system instrumentation outputs is presented in Table 3.13-1.

TABLE 3.13-1

S1-PRG EXPERIMENTAL SYSTEM INSTRUMENTATION SUMMARY

IMP	TITLE	DESCRIPTION	POWER
5361	S1 Output	An inductive proximity detector mounted on the lower (-Z) portion of the RCFLA housing monitors separation between the detector and an Invar target on the S1 rod. The rod extends from near the detector to a truss assembly connected to the A-frame support points of the COA. The distance measured by the S1 sensor is a segment of the optical S1 distance, that is, the distance from the +X surface of the first RCFLA lens element to the front surface of the primary mirror. Output of the sensor is processed by the sensor encoder and processing module to conform to the 0-5 volt telemetry range and is linear from -7.42×10^{-3} inches (0.0 volts) to $+7.42 \times 10^{-3}$ inches (5.0 volts). Distances quoted are measured with respect to the nominal position. Positive changes indicate target motion in the +X direction (separation increases). The telemetry output at nominal is 2.50 volts. For the calibration or "health check" mode in which a slide target is positioned a fixed distance from the sensor, the output is nominally 1.80 volts. Changes from this are linear and follow the same separation versus volts output slope as produced in the normal operational mode.	±15 vdc

TABLE 3.13-1 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5362	PRG-1 Output	Similar to IMP 5361, the detector is attached internal to the RCFLA housing near the dual platen camera at coordinates Y = 6.47; Z = 0.00.* The target for the sensor is attached to the 9 pivot frame and the sensor is used to determine changes in the optical S_6 distance (from the -X surface of the last Ross lens element to the image plane for an infinity target). Output of the sensor is processed in the sensor encoder and processing unit and is linear from -6.77×10^{-3} inches (0.0 volts) to $+6.77 \times 10^{-3}$ inches (5.0 volts). Nominal output level is 2.50 volts. A positive change indicates target motion in the -X direction (separation increases). The calibrate mode nominal output is 1.80 volts with a response curve slope which matches that of the normal mode.	±15 vdc
5363	PRG-2 Output	Similar to 5362, the sensor is located at Y = -6.25; X = -0.5** The nominal output level (zero separation change) is 2.50 volts in the normal mode and 1.80 volts in the calibrate mode. The response curve is linear and for the normal mode ranges from -7.42×10^{-3} inches (0.0 volts) to $+7.42 \times 10^{-3}$ inches (5.0 volts). The slope of the calibrate response curve is identical to the normal curve.	±15 vdc

*Coordinates referenced to optical axis.

TABLE 3.13-1 (CONT'D)

IMP	TITLE	DESCRIPTION	POWER
5007	5 Focus Drive Enable/Inhibit, 5 Minus/Stop, 5 Plus/Stop, S1-PRG Cal On/Off	Latching relays tracking the command input relays of the command processor monitor the receipt of commands from the satellite control section and feed either 0.0v or 5.0v to an integrated circuit D/A converter. Four relays and one 4-bit D/A converter form the IMP. Output occurs in sixteen discrete steps ranging from 0.25v to 4.75v in 0.3v increments. Bit 1 (LSB)* = 5 Focus Drive Enable/Inhibit Bit 2 = 5 Minus/Stop Bit 3 = 5 Plus/Stop Bit 4 (MSB)**= S1-PRG Cal On/Off	+5/±15 vdc
5024	9 Focus Drive Enable/Inhibit, 9 Minus/Stop, 9 Plus/Stop, S1-PRG Disable/Enable	Similar to IMP 5007: Bit 1 (LSB) = 9 Focus Drive Enable/Inhibit Bit 2 = 9 Minus/Stop Bit 3 = 9 Plus/Stop Bit 4 (MSB) = S1-PRG Disable/Enable	+5/±15 vdc
5615	S1-PRG Power Monitor	A two-resistor voltage divider network across the S1-PRG power feed in the PM and C monitors the voltage output level. The output is converted in the digital telemetry unit to yield a binary signal (on/off): "0" = Off "1" = On	Self

*LSB - Least Significant Bit
**MSB - Most Significant Bit

13.10 S1-PRG Sensor System Command Summary

13.10.1 S1-PRG Command

(4V0252bZ, 4V0152bZ, 4V0352bZ, bits 35, 37, and 38)

Function: This command controls the S1-PRG operate and calibrate modes and the focus sensor. It is also the normal means of operating the viewport doors. The bit functions are:

Bit No.	Function
Implicit	Spare
35-1	FEP ON, S1-PRG Enable, S1-PRG Power ON
35-0	FEP OFF, S1-PRG Power OFF
36-1	DOOR OPEN
36-0	DOOR CLOSE
37-1, 37-0, 38-1, 38-0	Focus Calibrate Modes

Sequence	Mode	Bit 37	Bit 38
A	Focus Cal OFF, S1-PRG Cal OFF	0	0
B	Focus Cal ON, High Frequency, Low Amplitude	1	0
C	Focus Cal ON, High Frequency, High Amplitude	1	1
D	Focus Cal ON, Low Frequency, High Amplitude	0	1

Interlocks:

S1-PRG sensor system power is turned off independently by the S1-PRG DISABLE command. S1-PRG disable is utilized if S1-PRG power off is desired while FEP is on.

13.10.2 S1-PRG CAL Command

(N02645, N01645, N03645)

Function: This command activates the S1-PRG calibrate function. The calibrate function involves physical movement of the calibrate slides.

Interlocks:

(1) The S1-PRG calibrate function should only be commanded when FEP is on.

(2) Execution of Focus Cal OFF turns off S1-PRG Cal (S1-PRG CAL OFF).

Comments:

(1) This command is the only means of providing the S1-PRG calibrate signals.

(2) The S1-PRG Cal on and off functions require a minimum of 32 seconds to complete movement of the calibration targets. The S1-PRG sensor system must remain on for at least 32 seconds following S1-PRG CAL OFF.

13.10.3 S1-PRG DISABLE Command

(N02744, N01744, N03744)

Functions: This command removes power from the S1-PRG sensor system. It is furnished as a means of removing S1-PRG power while leaving FEP on.

Interlocks: This command is reset by commanding FEP ON.

Comments: The S1-PRG Cal on and off functions require a minimum of 32 seconds to complete movement of the calibration targets. The S1-PRG sensor system must remain on for at least 32 seconds following S1-PRG CAL OFF.

PART 4 - DESIGN, MANUFACTURE, TEST AND FIELD SUPPORT

1.0 DESIGN

The design of the Photographic Payload Section/Dual Platen Extended Altitude Capability (PPS/DP EAC) represents the latest step in an evolutionary process which began with the design of Flight Model (FM) 1. This vehicle, the first of the Gambit series, was launched on a seven-day reconnaissance mission in 1967. Hardware improvements since then have resulted in improved ground resolution, extended orbit lifetime, and greater film load.

The changes effective on FM's 48 through 54 were directed toward an increase in the capability to respond to a wide range of target characteristics and requirements. This improved flexibility is the result of the inclusion of the dual platen camera which, with appropriate film loads, provides a choice of film types for each target. The added requirements arising from the need for extended altitude capability necessitated further changes which are effective on FM's 52 through 54. These changes responded to the EAC requirements of lower film drive speed resulting from longer slant ranges.

Other improvements in the areas of power, hardware redundancy, pyrotechnic event commanding and pointing accuracies have increased the probable information return for the required 45-day mission. These improvements have also contributed to the decision by the Air Force to plan missions of up to 60-day duration.

1.1 Design Baseline (Non-EAC)

A basic ground rule established for FM's 48 through 54 was that design changes were to be limited to those required to implement the dual platen camera and such other changes as directed by the Air Force. These directed changes are summarized in the following paragraphs.

1.1.1 Frequency Phase Lock Loop (FPLL) Drive

This drive system improves film utilization by providing rapid start-up and shut-down, thereby reducing film usage at the beginning and end of a frame. (see Part 3, Section 2.)

1.1.2 Variable Width Slit

The sixteen discrete positions (a minimum of 12 is required by contract) provide the capability to properly expose a broader range of film types under all expected conditions of target illumination. The design chosen (see Part 3, Section 2) eliminates the slit-closed failure mode.

1.1.3 Improved Focus Detection System

This improvement is designed to increase signal-to-noise ratio, reducing data variability. Furthermore, the improved signal-to-noise ratio, an increased sample rate, and data processing with the dynamic filter software (see Part 3, Section 9) are expected to increase the number of usable focus estimates.

1.1.4 Replacement of Separation Controller and Switchover Electronics with Initiator Electronics Unit (IEU)

The functions of the separation controller and switchover electronics are performed by a new unit, the initiator electronics unit (IEU). Improvements are realized through separate commanding of SRV's, direct commanding of pyrotechnic devices, additional instrumentation for indicating command receipt and function execution, and redundancy of critical events.

1.1.5 Redesigned Command Processor

The added reliability of redundant command sources in the SCS is extended further by continuing the redundancy through the PPS/DP EAC command processor.

1.2 Extended Altitude Capability (EAC) Baseline

Certain design changes were necessitated by the Extended Altitude Capability requirements. These design changes are summarized in the following paragraphs and are treated extensively in the appropriate subsections elsewhere in these volumes.

1.2.1 Frequency Phase Lock Loop (FPLL) Drive

The available film drive speed range has been expanded to accommodate the lower speeds required for operation at altitudes up to 470 nmi. The "surveillance" or low-mode range is from 3.37 in./sec to 23.6 in./sec, while the "search" or high-mode range is from 0.8425 in./sec to 23.6 in./sec. The approach chosen (See Part 3, Section 2.5.3) utilizes a commandable high/low "switch". Redundant means are provided for switching into and out of the high altitude range.

1.2.2 Focus Detection System

The wide range of slant ranges which must be accomodated by the EAC PPS necessitates changes in the reticle and electrical filter characteristics. (See Part 3, Section 6.0)

1.2.3 Dual Platen Camera

Required changes in the dual platen camera include changes to the FPLL encoder, the addition of a second smear slit in the Primary Recording System (PRS) and the addition of a smear slit to the Secondary Recording System (SRS).

The encoder change involves incorporation of a higher number of segments. (See Part 3, Section 2.)

The second smear slit in the Primary Recording System (PRS) is designed to ensure an adequate number of smear samples at higher altitudes for a dual-mode (Surveillance and Search) mission. (See Part 1, Section 4.5.)

1.2.4 Command Processor

Changes have been made to incorporate the added commands required to shift from the conventional to the extended range. Included are command outputs to the: Camera (DISABLE the SRC circuit), Focus Detection Subsystem (change amplifier and filter characteristics), and FPLLE (change encoder segment responses).

Additionally, a further change, not necessitated by EAC, but requested by the Air Force is the CAMERA AUTOMATIC OFF (CAO) feature. The CAO is designed to provide redundancy to CAMERA OFF functions when one half of the ECS has been disabled. Intentionally disabling half of the ECS is under consideration as a power-saving technique.

1.3 Non-Baseline Items

As the design progressed, it became apparent that additional, relatively minor changes would have to be made. These changes included those necessitated by parts obsolescence and those incorporated to increase reliability through added redundancy. Changes and improvements have also been incorporated in test equipment.

2.0 RELIABILITY

High reliability has been a major objective throughout the existence of the Gambit program. (The overall BIF-008 Gambit Reliability Program is configured to meet the intent of the guidelines established by MIL-STD-785A, Reliability Program for Systems and Equipment Development and Production). The program evolution from 7-day missions to a 90-day mission (Flight 50) has required intensive reliability efforts to assure hardware compatible with the associated increases in mission requirements. Maximized on-orbit reliability has been achieved through a meticulous design effort, an extensive qualification program, and thorough testing at multiple assembly levels.

Designing reliability into the 9 x 5 hardware has been a major goal since the earliest conceptual phases. Techniques and philosophies for maximizing reliability were established by determination of: The types of redundancy; the degree of redundancy; the assembly level at which redundancy should be implemented; and, in many cases, how to best use existing hardware where redesign was not practical or not permitted.

2.1 Reliability by Attention to Design Details

One of the basic factors in the development of high reliability hardware is a design compatible with this goal. This is best accomplished by implementing formal design reviews which examine and critique the design in detail for all facets of reliability during the development phase of the hardware design. The review items include but are not limited to:

(a) Design simplicity

(b) Standardized parts/components/materials of certified high reliability

(c) Design compatible with performance requirements

(d) Interface compatibility (piece part, component and subsystem)

(e) Design compatible with environmental extremes

(f) Adequate safety margins demonstrated by test and worst case analyses

(g) Recognition of test requirements

(h) Testability of the hardware - particularly in redundant areas

(i) Adequacy of redundancies - at all assembly levels

(j) Recognition and identification of all major failure modes and mechanisms

(k) Minimization of single point failure modes.

These items are generally examined at the component (box) level. However, each component may employ piece-part redundancy and high reliability circuitry and/or techniques. Redundancy is also extended to the subsystem level where practical.

2.2 Reliability Through Redundancy

In order to illustrate the reliability merits of the entire PPS/DP EAC, it is necessary to consider the system as being composed of various subsystems and treat each one separately. Ten subsystems have been selected for discussion and block model illustration. No attempt has been made to determine an individual numerical figure of merit.

It is apparent from the models that different types and various degrees of redundancy are employed for each subsystem. This is due primarily to the piecemeal evolution and continually increasing performance required of the hardware. The intended usage of the PPS/DP EAC hardware demands improved reliability as well as performance well beyond earlier configurations. A second major factor is piece-part obsolescence resulting in redesigns that are closer to a state-of-the-art. The most significant improvements in reliability (PPS/DP EAC compared to previous configurations) are associated with the command, initiator (pyrotechnic) and camera subsystems.

The subsystem discussions and models presented normally deal with the most critical functional requirements; i.e., power 'ON' rather than power 'OFF'; 'SET' rather than 'RESET'; etc. In most cases, the above examples are symmetrical in terms of reliability modeling and, therefore, will not be further discussed. Many functions employ additional reliability techniques (redundancy) at the piece part and circuit level which are not apparent at the subsystem level. Such redundancies are treated in those sections of this handbook where individual components are described.

2.2.1 Initiator Subsystem

Figure 4.2-1 depicts the typical redundancy characteristics of the upgraded initiator (pyrotechnic) subsystem.

Redundant initiator commands are received by the initiator electronics unit (IEU) from both decoders A and B of the extended command system (ECS). A third command from the minimal command system (MCS) may also be utilized. MCS commands are not available for: main hatch ejection; 5 splice and cut; 9 splice and cut; viewport door backup; and viewport door blow. The received commands are redundantly processed to the initiator firing circuits. There are two independent initiator firing circuits for each electro-explosive device (EED) used in the PPS/DP EAC. Either initiator (pyro or squib)

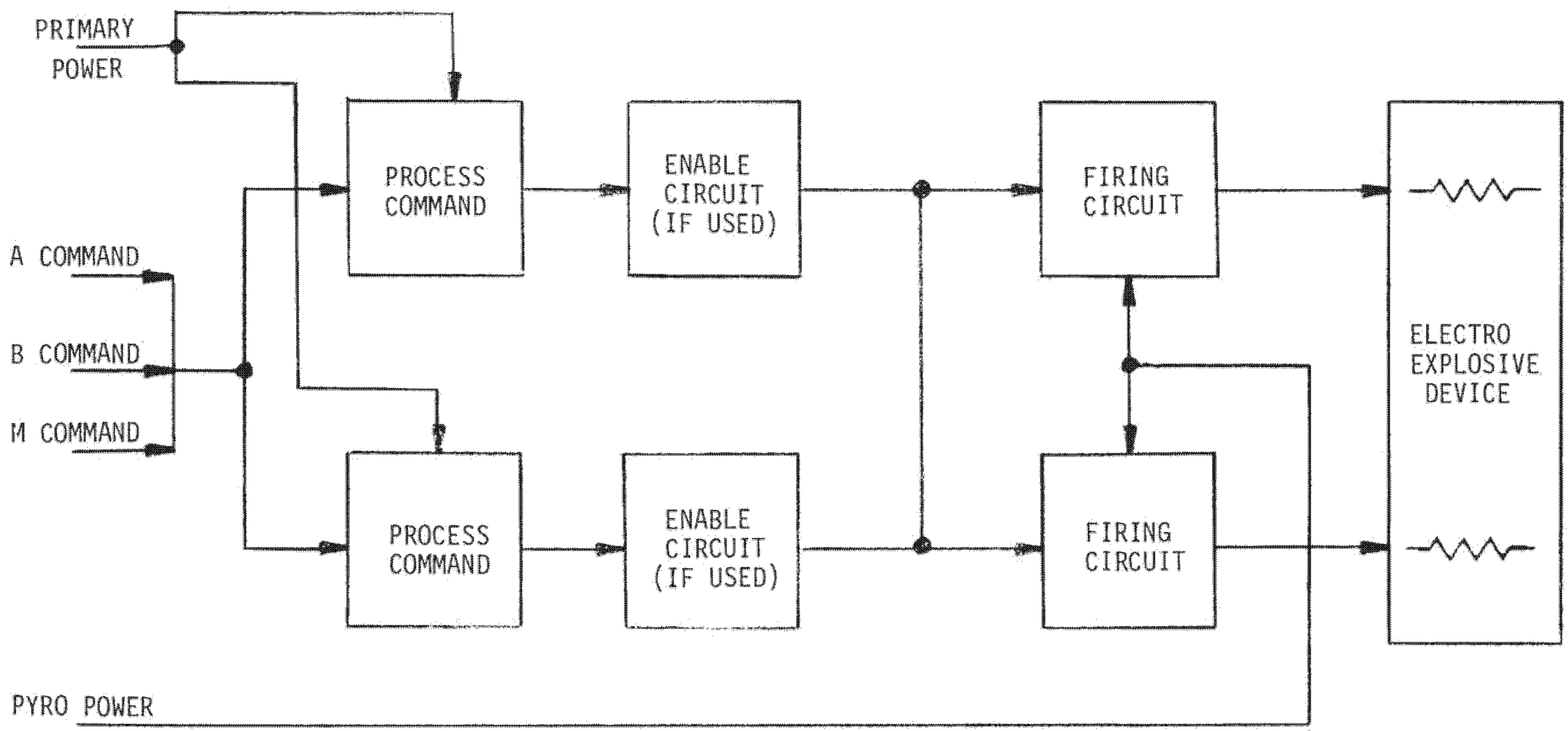


Figure 4.2-1. Initiator Subsystem (Typical)

will actuate the EED. With the exception of the backup functions, the EEDs employed on the PPS/DP EAC are extremely critical and their operation is essential since the EEDs are not redundant. Examples of EEDs used are pin-pullers, spin-off and in-flight disconnects, cutter sealers and splicer/cutters.

Primary power is routed from the power monitor and control unit to the IEU via two individual lines. This provides redundant primary power and also permits the redundant features of the IEU to be easily tested since the lines remain isolated within the IEU.

Initiator or pyro power is received at the IEU from the SCS ON 9 twisted shielded pairs of conductors and is subsequently distributed to the 64 firing circuits. While this approach does offer reliable delivery of power, the main purpose is to minimize voltage drop due to line losses.

2.2.2 Mirror Positioning Subsystem

Figures 4.2.2 and 4.2-3 depict the typical redundancy characteristics of the stereo and crab servos which comprise the mirror positioning subsystem.

Redundant position and power commands from the ECS are received and redundantly processed by the command processor (CP). The CP features a selectable (A or B but not both) mode of the redundant position and power functions which are steered by a redundant ECS command. Application of power to the servos is accomplished by either of two power (soft*) switches which react to the selected processed function. The same power switches are employed for both stereo and crab servos. Position information for the stereo servo has an additional "execute" circuit (implicit with ECS variable word) whereas the crab servo does not - selected bits A or B are directly ORed without an "execute". Also, the crab position is commanded by a total of five bits

*A "soft" switch is one where voltage rise and fall times are controlled.

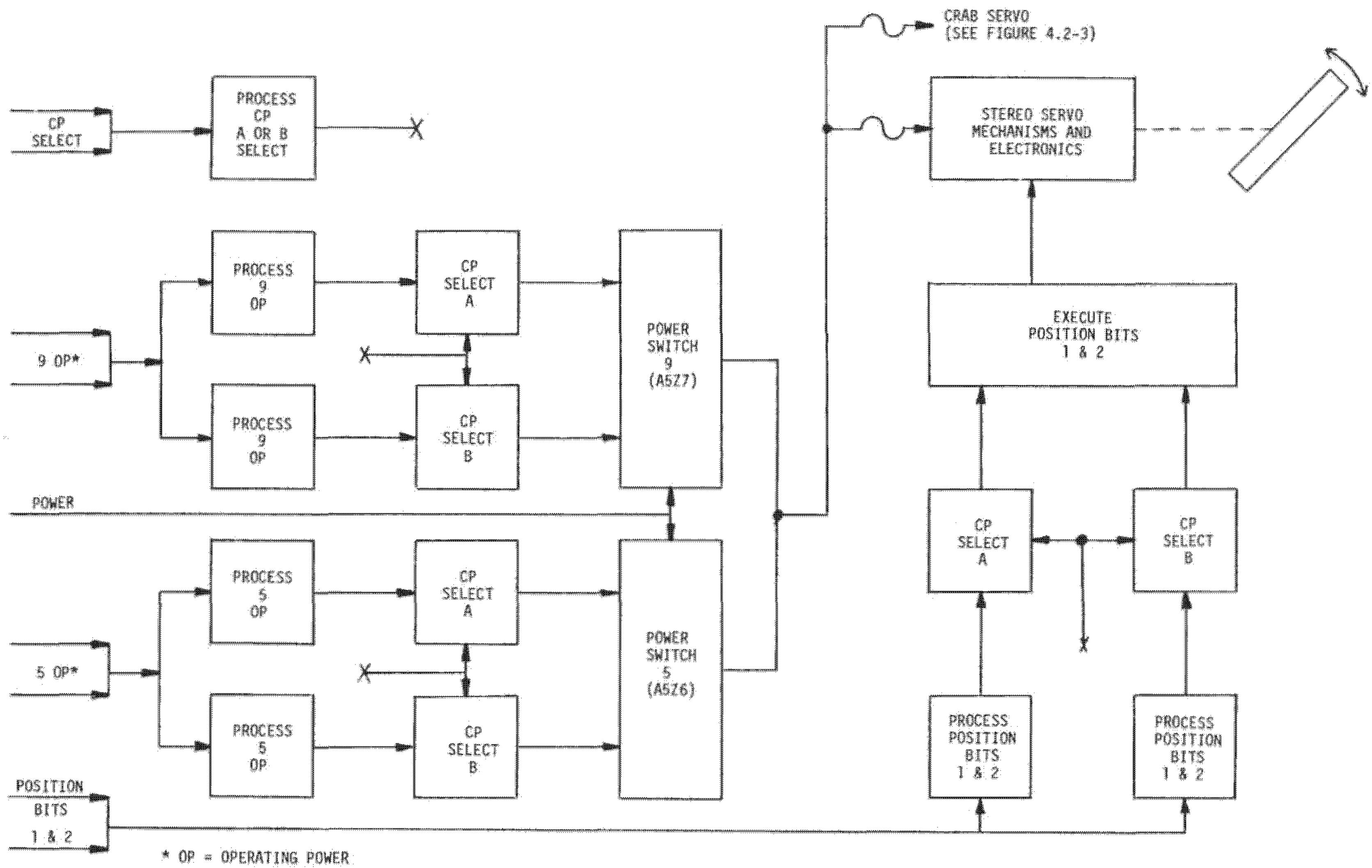


Figure 4.2-2. Stereo Servo Redundancy

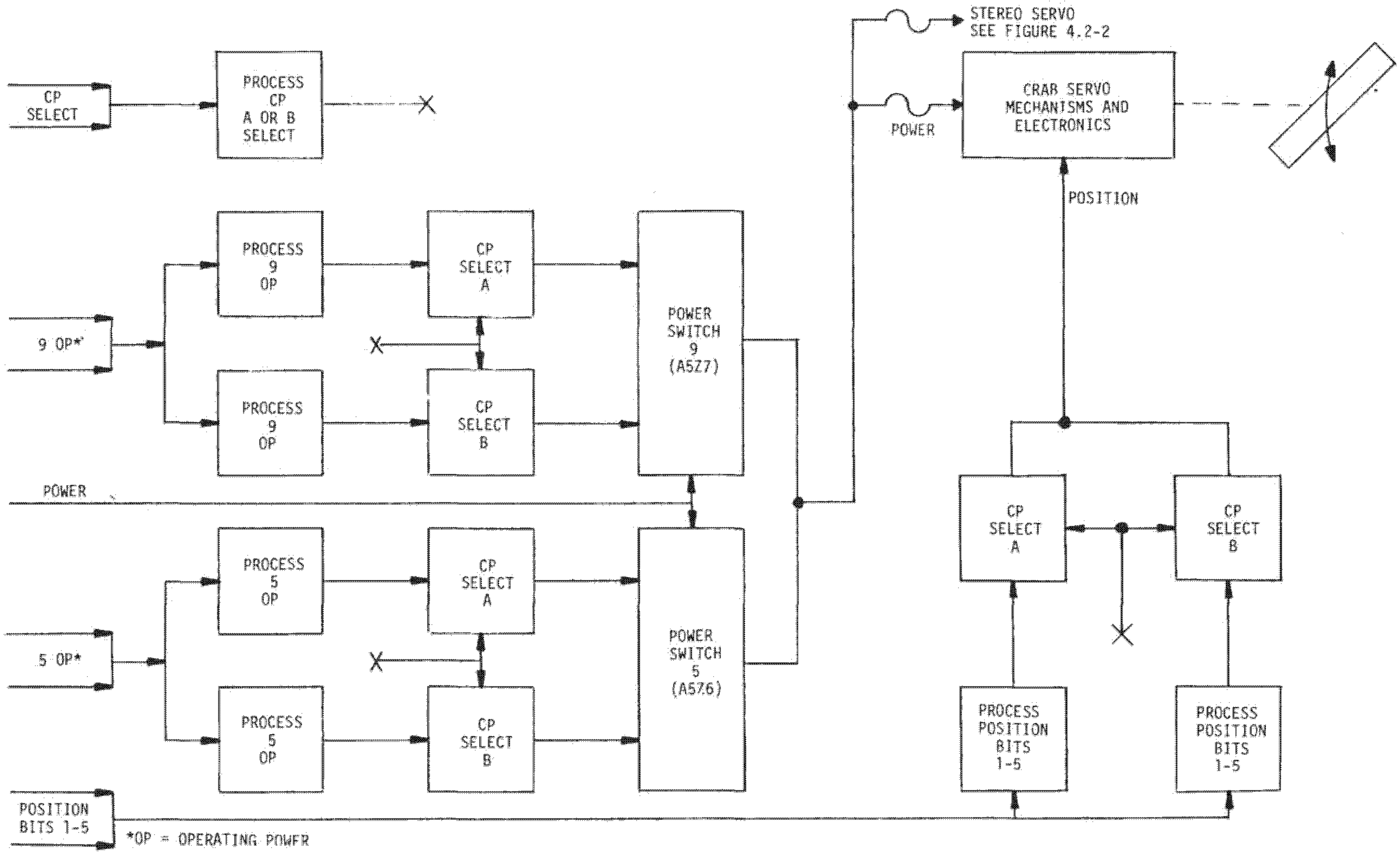


Figure 4.2-3. Crab Servo Redundancy

rather than the two bits utilized for the stereo position. The 1's and 0's for each bit are symmetrical for reliability modeling purposes so both states are not shown.

2.2.3 Instrumentation Subsystem

Figures 4.2-4, 4.2-5 and 4.2-6 illustrate the major portions of the instrumentation subsystem. The focus sensor, SI-PRG sensors and the film path pressure transducer are all considered a part of this subsystem.

As shown in Figure 4.2-4, the instrumentation subsystem is designed with a pulse code modulated telemetry (PCM) slave unit which employs two totally redundant and independent "sides" (PCM #1 is "side #1" and PCM #2 is "side #2"). Both of these sides communicate with the master digital telemetry unit (MDTU) by independent address and reply lines. Either side (not both) can be commanded ON by any one of four commands: the usual ECS decoder A or decoder B (10V**) commands, a variable word command from the MCS or a real time command also from the MCS. In addition to powering the PCM unit, either set of PCM commands also energizes the 5-volt regulator and the ±15-volt converter (both located in the PM and C), which are utilized by most of the instrumentation points (sensors, transducers, switches, etc.) throughout the PPS/DP EAC.

Redundant monitoring of individual instrumentation points which are of primary interest is accomplished by employing both power sources (+5 volts and ±15 volts) applied to two similar sensing units (sensors, transducers, switches, etc.). These units are generally located as functionally close to

**See Part 3, Section 9 for a description of command types.

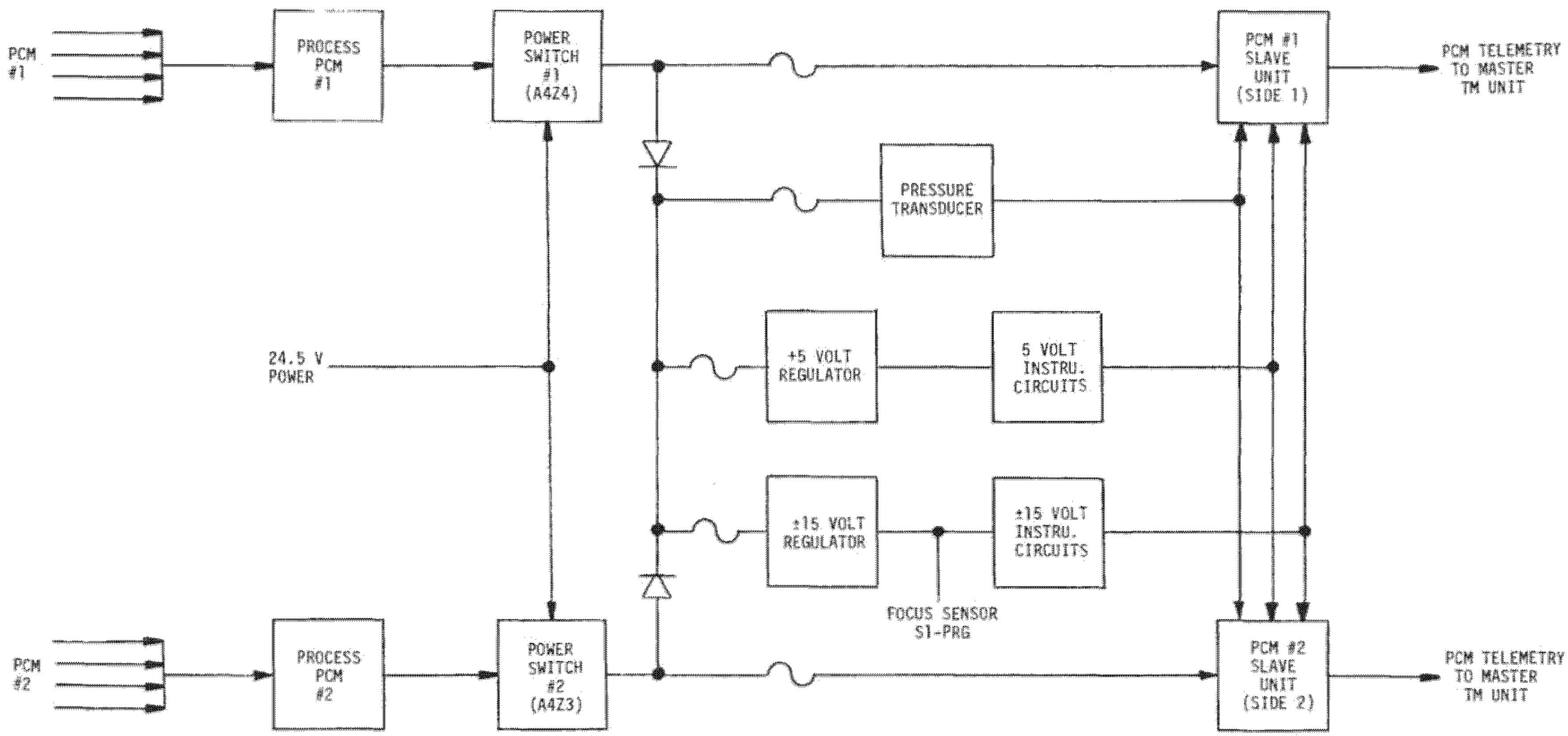
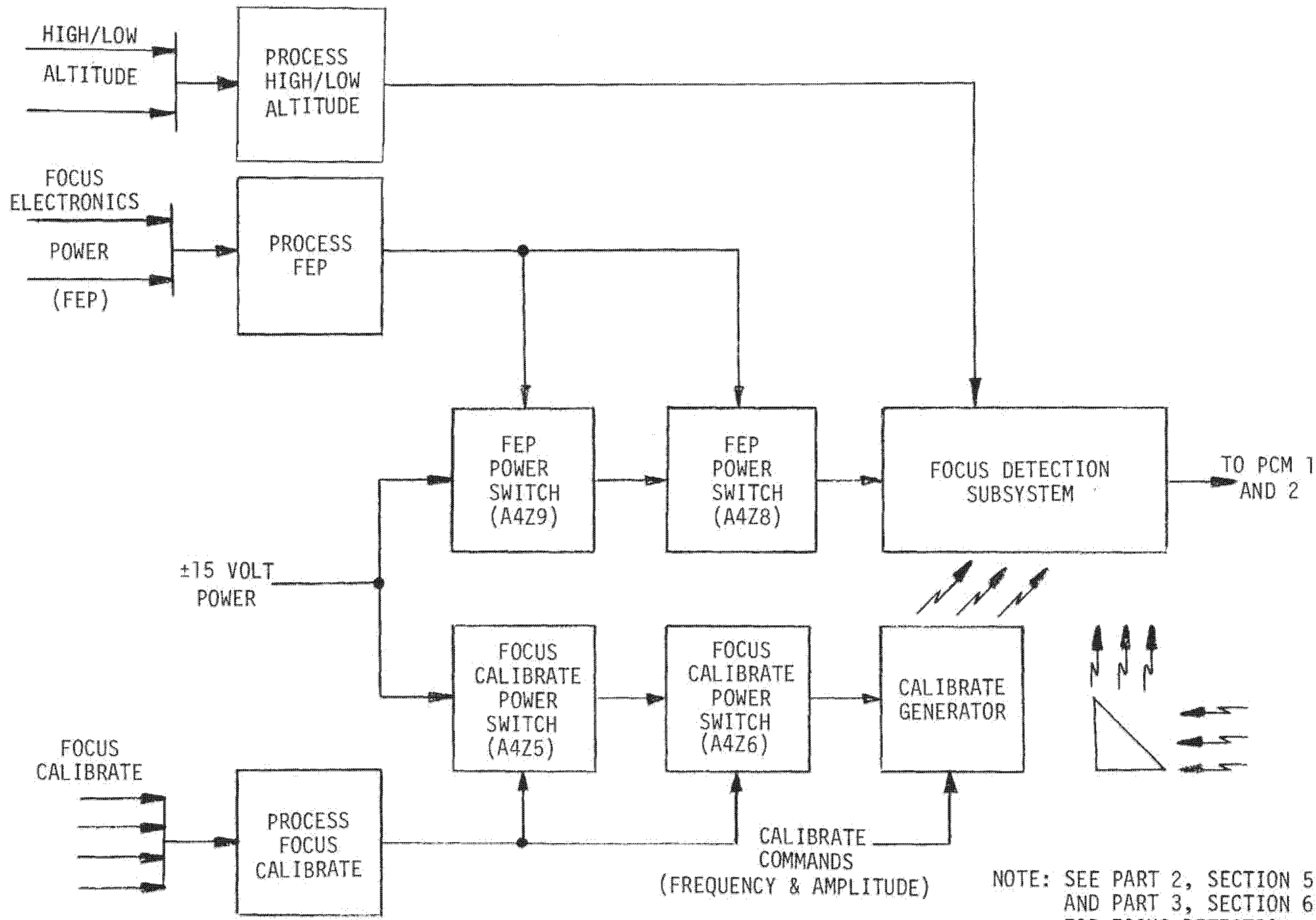


Figure 4.2-4. Instrumentation Subsystem



NOTE: SEE PART 2, SECTION 5 AND PART 3, SECTION 6 FOR FOCUS DETECTION SUBSYSTEM DETAILS.

Figure 4.2-5. Focus Detection Subsystem

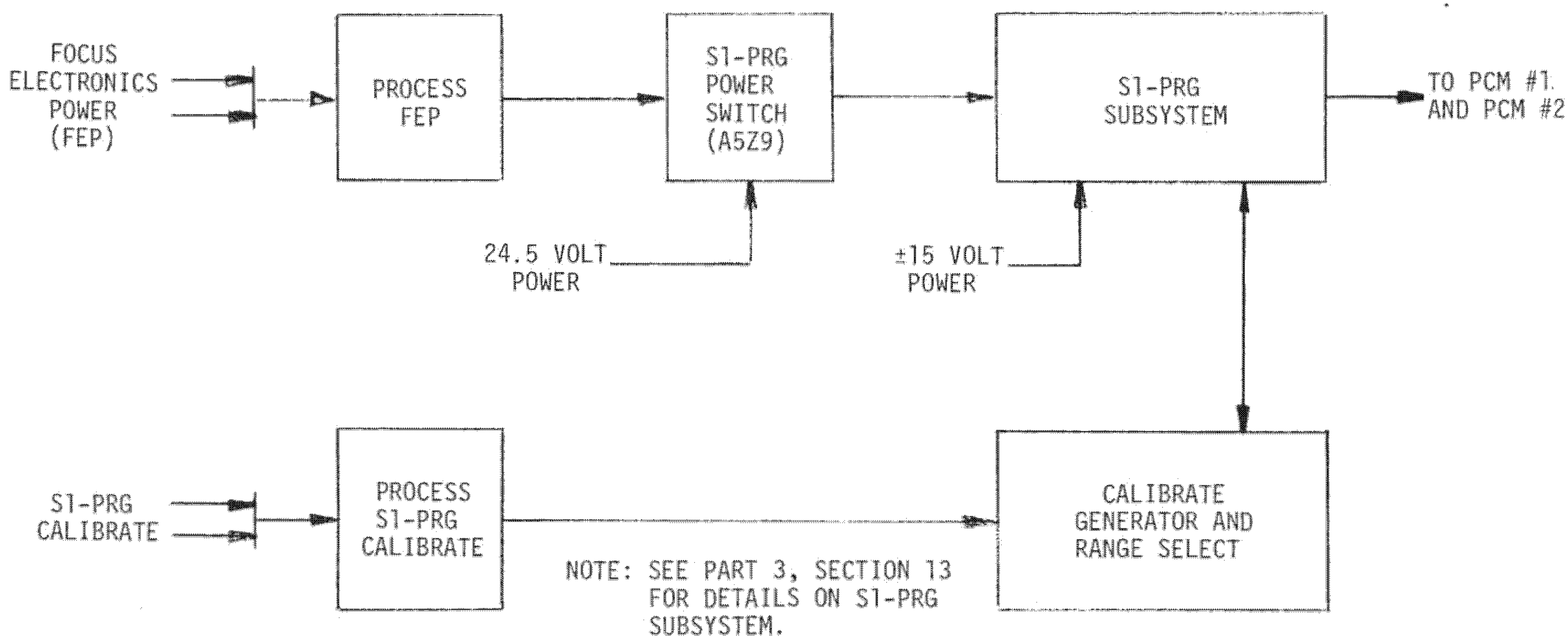


Figure 4.2-6. S1-PRG Subsystem

each other as possible. The points and functions to be monitored have been selected and instrumented in such a manner that either power source would provide adequate information and diagnostics to monitor the health of the PPS/DP EAC during operation.

Figure 4.2-4 also illustrates the non-redundant (and noncritical) use of the film path pressure transducer. This is a self-contained instrument and is monitored by both sides of the PCM unit.

Figure 4.2-5 shows the reliability model of the focus sensor subsystem. Two commands are available to activate the sensor while four commands (not shown) are provided for turn-off. The focus sensor calibrate circuitry is both activated and turned off by four possible commands. This particular subsystem is designed with higher emphasis on disabling rather than enabling as can be seen by the series power switches (rather than parallel) and the two additional commands available for turn-off. For the EAC configuration, the High/Low Altitude function has been added to the focus detection electronics and the calibration generator has been given extended capabilities. The High/Low Altitude commanding incorporates a unique reliability scheme in that redundancy is accomplished by employing either decoder A or decoder B commands (but not both simultaneously) which results in additional failure work-arounds. Focus sensor output information is routed to both sides of the PCM unit for telemetering.

Figure 4.2-6 is a simplified model of the S1-PRG subsystem. The S1-PRG hardware uses the same processed commands for turn-on as used for the focus sensor. There are six possible commands for turn-off (four described previously for focus sensor OFF and two assigned as S1-PRG OFF). The calibrate function has redundant 'ON' commands but, as in the focus sensor calibrate, can utilize four possible 'OFF' commands. The S1-PRG subsystem being noncritical is, therefore, designed with more emphasis on turn-off than on turn-on. Output information is redundantly processed in the PCM unit.

2.2.4 9 and 5 Camera Platen Drive Subsystems

The hardware involved and the operation of both the 9 and 5 camera subsystems are identical for modeling purposes. Figure 4.2-7 illustrates the redundancy and reliability characteristics of both platen drive subsystems.

All commands employed by the camera drive subsystem are received redundantly from the ECS. Either of two cross-strapped power switches receive "CP SELECT" steered and redundantly processed commands and, in turn, route operating power to both redundant halves of the frequency phase lock loop electronics (FPLLE). Actual turn-on of the FPLLE drive is accomplished by the redundantly combined and processed film drive ON and FPLLE select side commands (both sides operating simultaneously is not possible). Each FPLLE side is dedicated to independent windings of the platen drive motor.

Commanded platen speed information is processed redundantly with each of the two sides of the FPLLE receiving one set of bits. A redundant encoder and encoder processor is employed for speed feedback information, each output being fed back independently to the corresponding half of the FPLLE.

For the EAC configuration, two additional redundant commands were incorporated to accommodate the lower camera speeds required for high-altitude photography. The commands initiate the necessary loop dynamic changes in the FPLLE and also select the proper encoder feedback frequency.

2.2.5 Nominal Platen Adjust (NPA) Subsystem

Both the 9 and 5 subsystems are identical for modeling purposes and are totally independent from one another. The NPA subsystem employs a variety of different forms of redundancy with the drive mechanism itself being the only item subject to a single point failure. The slant range compensation (SRC) subsystem is not

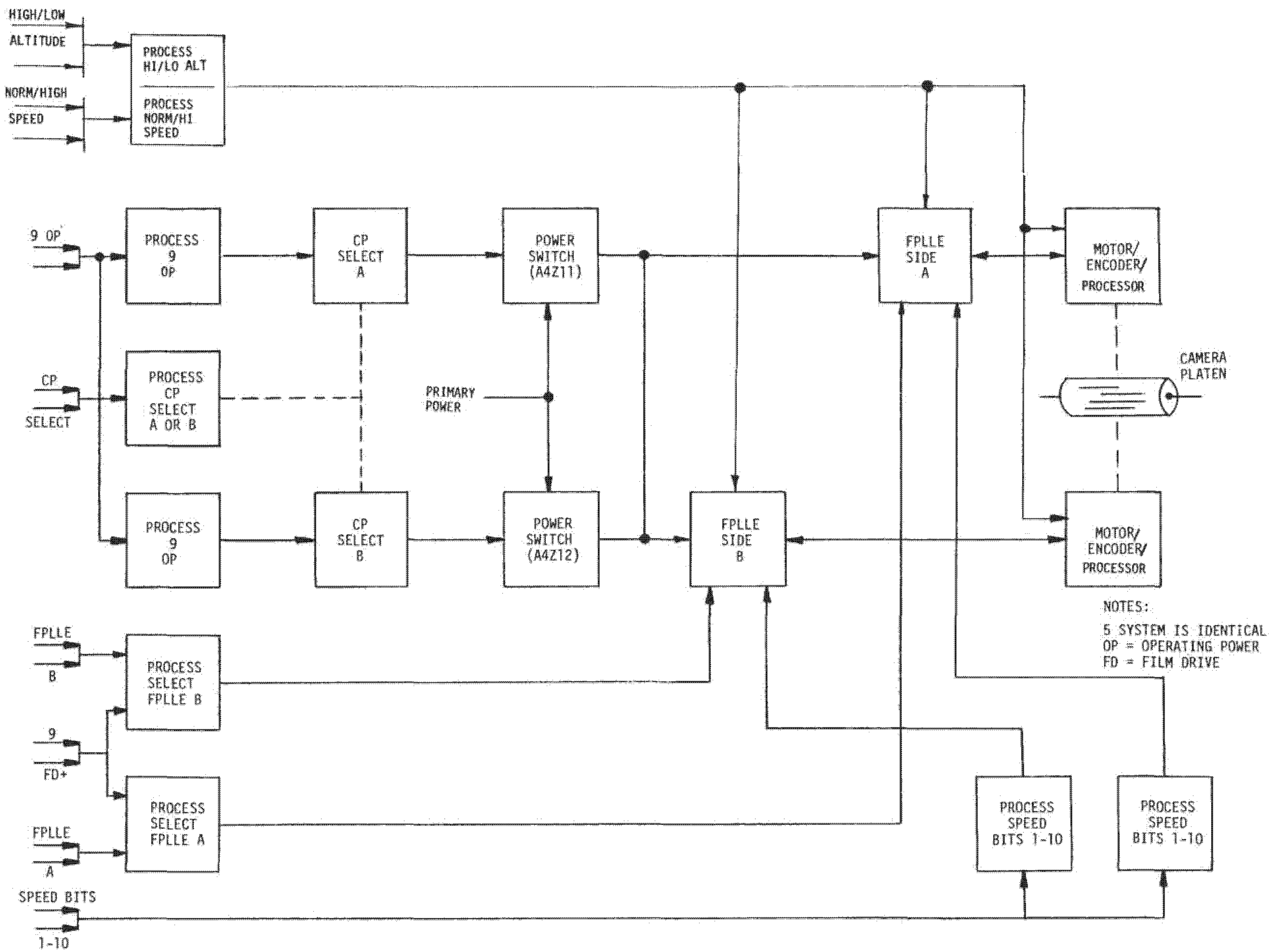


Figure 4.2-7. 9 Camera Platen Drive Subsystem

considered as a backup subsystem to the NPA (although the converse is true) due to the limited platen adjustment capabilities and the restricted commanding possibilities inherent in the SRC.

Figure 4.2-8 illustrates the many redundancy features of the NPA. Redundant ECS normal commands are employed for:

(1) Enabling or inhibiting the selected primary or backup side of the subsystem. These commands apply/remove unswitched power to the motor drive circuitry and are redundantly processed.

(2) Selecting either the primary or backup mode. Both modes are ORed at the NPA motor and each mode operates half of a redundant brake. The difference between the modes is the technique by which the motor power is "clocked". The primary mode utilizes the 20 Hz timing signal C while the backup mode is clocked from the slower 5 Hz ECS command repetition rate.

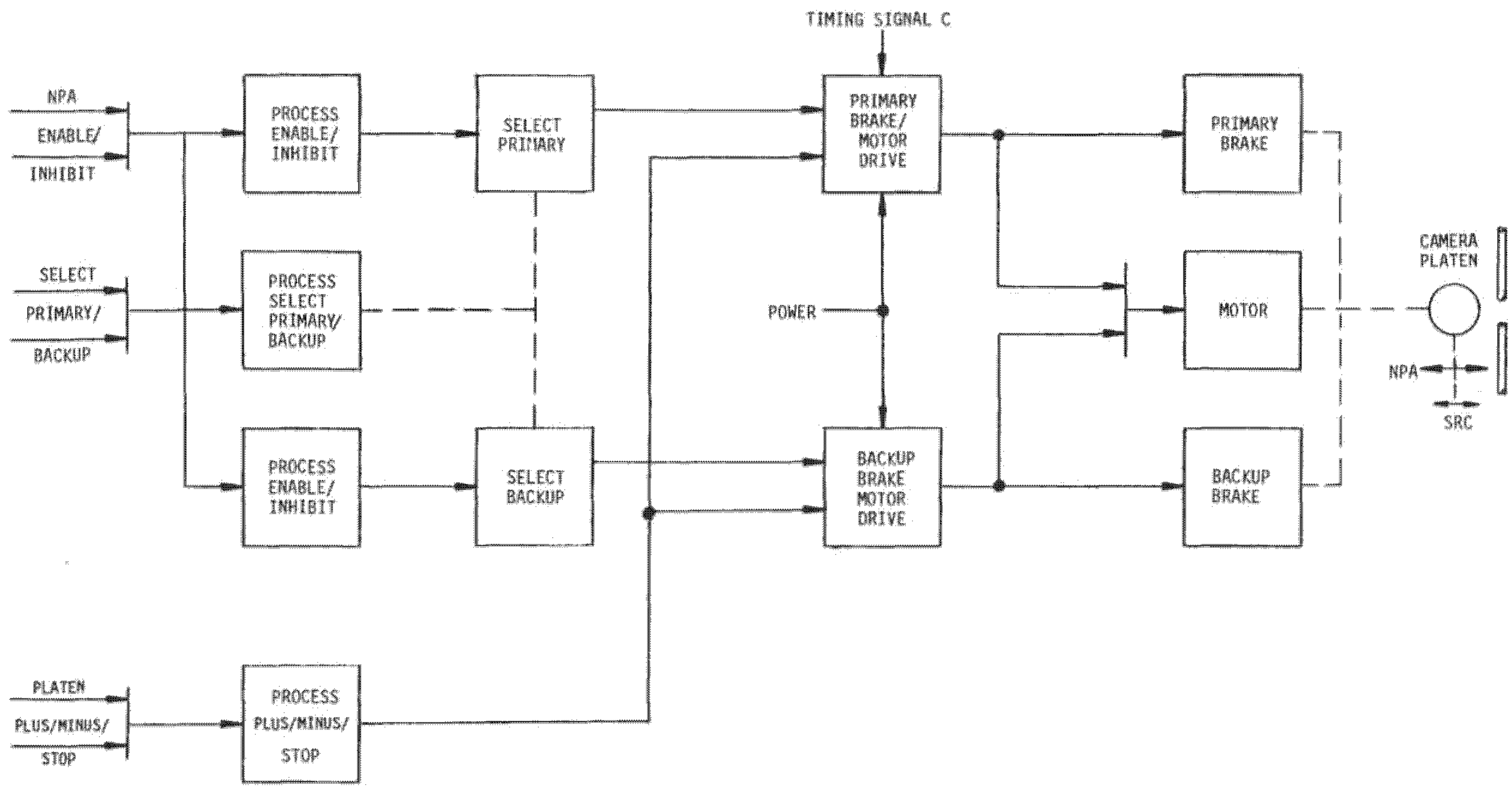
(3) Platen start plus platen start minus, and platen stop.

The NPA subsystem is one of the most reliable designs in the PPS/DP EAC and offers a great deal of flexibility.

2.2.6 Slant Range Compensation (SRC) Subsystem

Both the 9 and 5 SRC subsystems are identical for modeling purposes. This subsystem employs very little redundancy primarily due to the relatively less consequences of failure. However, the function performed by the SRC subsystem can also be accomplished by the NPA subsystem, Paragraph 2.2.5 (the NPA and SRC subsystems are mechanically linked together). The NPA, while providing finer granularity requires a longer time to move a given distance resulting in the need for additional ground planning. The SRC adjustment is controlled by the first four bits of the film drive speed command (see Appendix H).

Figure 4.2-9 illustrates the minimal redundancy of the SRC subsystem. The ON or ENABLED mode requires both operating power (OP) and film drive ON (FD+) along with



4.2-16

Figure 4.2-8. NPA Subsystem (9 & 5 Identical)

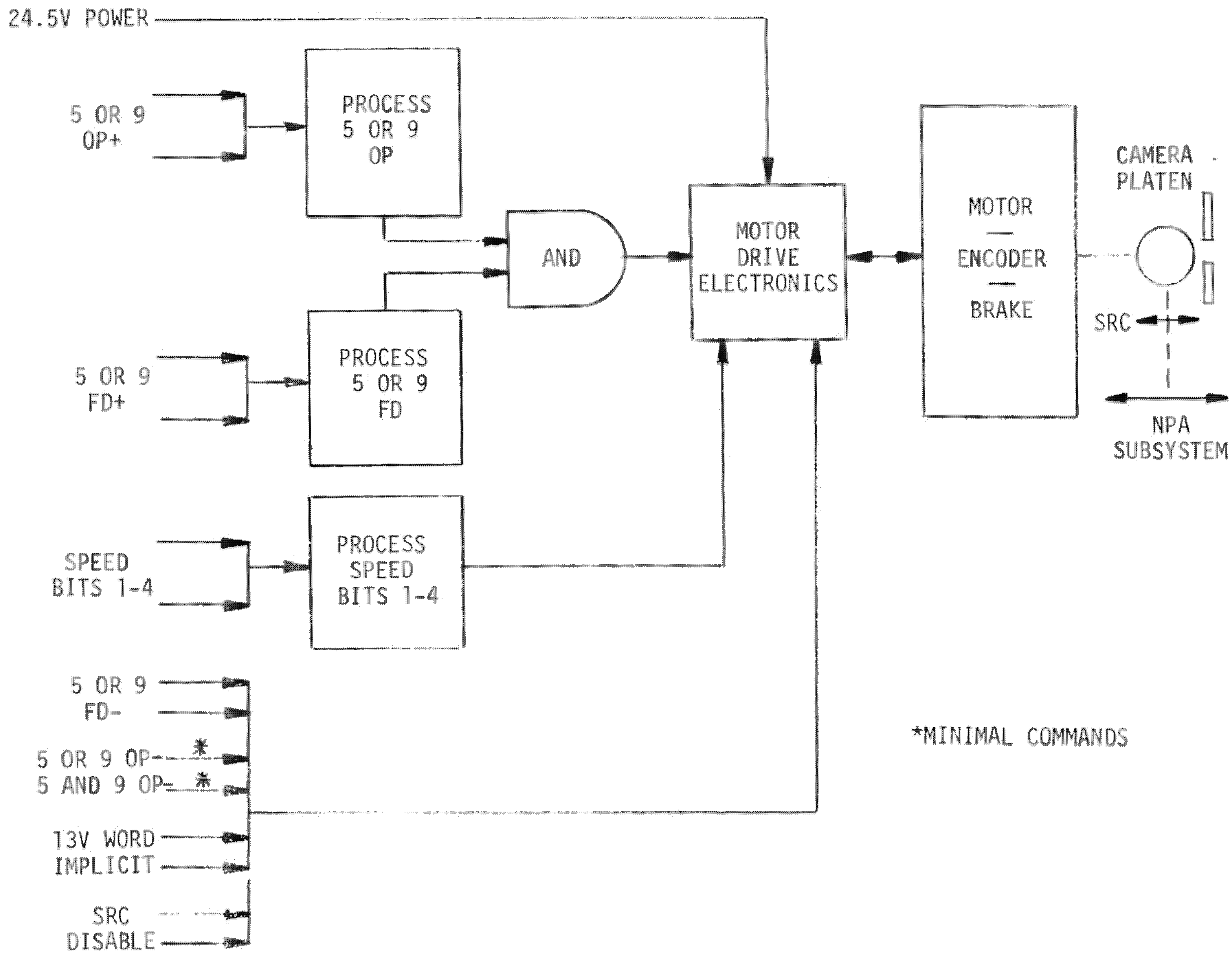


Figure 4.2-9. SRC Subsystem (9 and 5)

the first four speed bits. All of these commands are received redundantly from the ECS. The FD+ and OP commands enable the SRC drive circuitry and permit the SRC motor to adjust the platen until the encoder output satisfies the desired position as dictated by the speed bits.

Due to the consequences of the possible failure modes, emphasis is placed on disabling the SRC subsystem. The drive circuitry is disabled (24.5v power removed) by any of the following commands: redundant film drive OFF (FD-); redundant SRC DISABLE; redundant 13V command word implicits; minimal 5 or 9 OP OFF received singly; minimal 5 and 9 OP OFF received singly.

2.2.7 Variable Exposure Mechanism (VEM) Subsystems

Both the 9 and 5 subsystems are identical for modeling purposes and, as in the NPA and SRC subsystems, are totally independent from one another. The VEM model closely resembles the previously discussed NPA model and is considered one of the most straightforward and classical usages of redundancy in the PPS/DP EAC system.

Figure 4.2-10 illustrates the features of symmetrical and classical redundancy applied to the VEM subsystems. Redundant enable/inhibit commands are received and processed redundantly. These commands apply/remove unswitched power to the logic and motor drive circuitry and are steered by the redundant select VEM Side A/Side B command. The four redundant position commands (bits) are processed redundantly.

The VEM logic and motor drive circuitry for both side A and side B are identical. Both sides provide motor drive power which is ORed at the motor. A dual encoder supplies independent position feedback for each side.

2.2.8 9 Film Handling System

A redundancy block diagram for the 9 film handling system is shown in Figure 4.2-11. There are two basic commands required to operate the 9 film handling

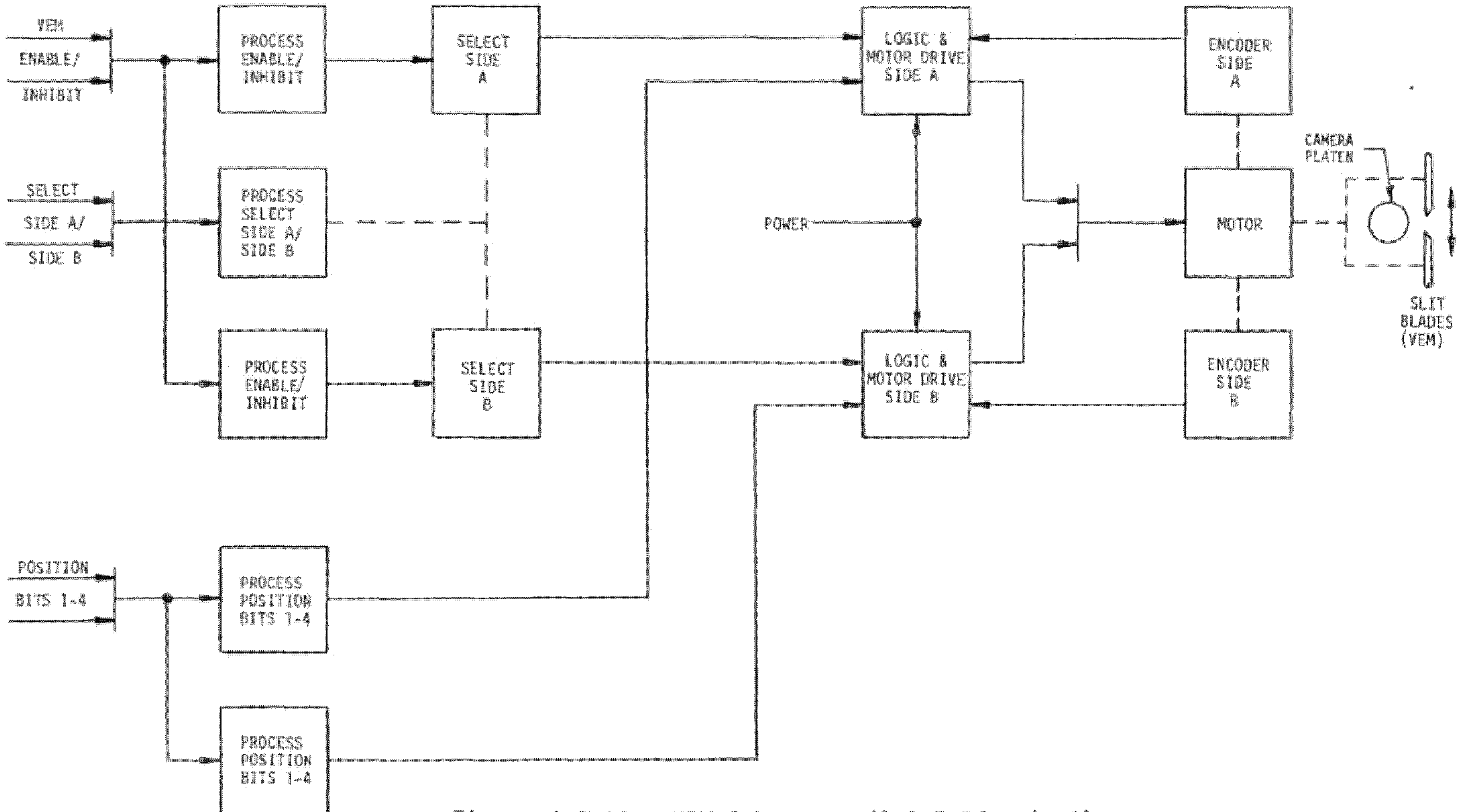


Figure 4.2-10. VEM Subsystem (9 & 5 Identical)

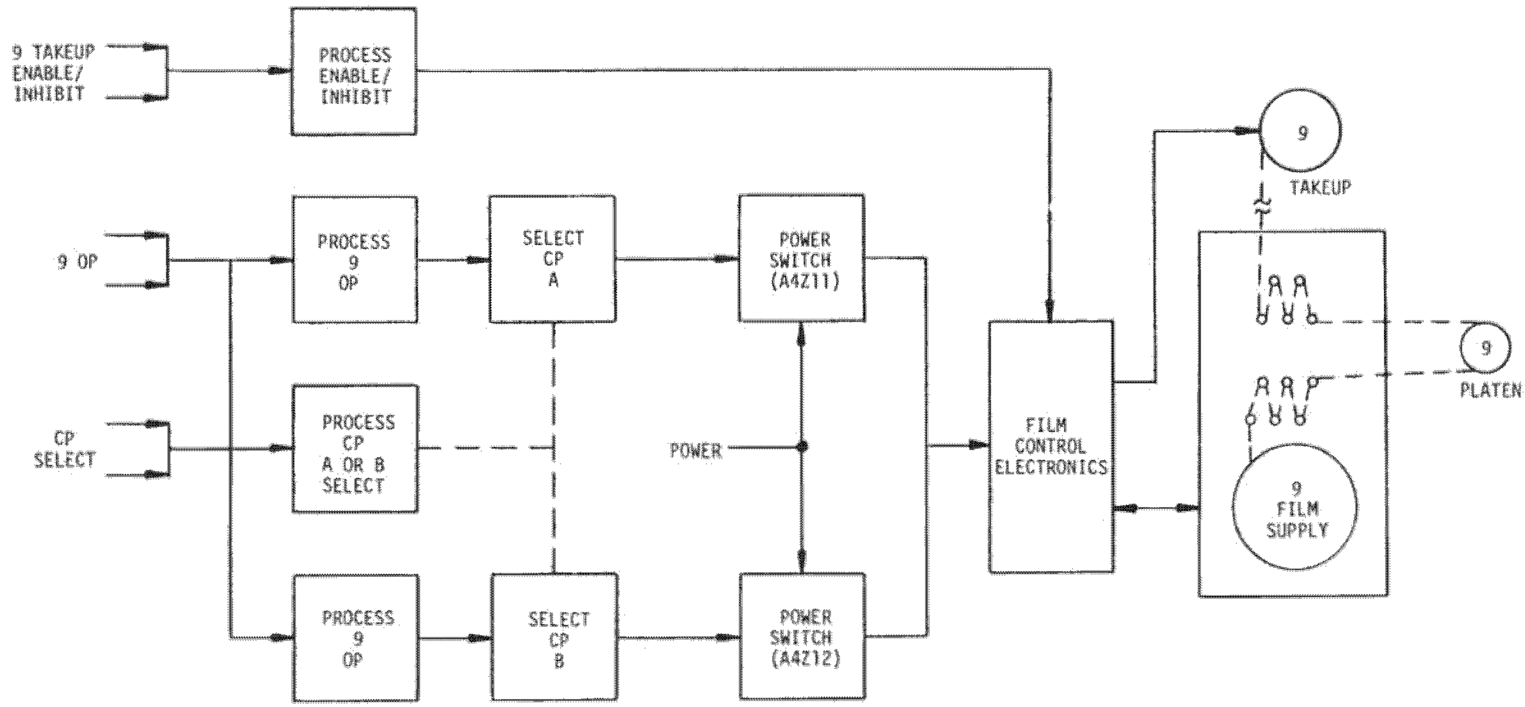


Figure 4.2-11. 9 Film Handling Subsystem

system. They are the 9 OP ON/OFF and the 9/5 TAKE-UP ENABLE/INHIBIT commands. These commands are received by the PPS/DP EAC redundantly from each redundant ECS decoder. The 9 OP ON/OFF commands are processed redundantly in the command processor unit. The desired high reliability of this subsystem is enhanced via two parallel cross-strapped power switches located in the power monitor and control unit. This is the identical hardware and scheme employed for the camera drive subsystem (see Paragraph 2.2.4 and Figure 4.2-7). A receipt of the redundant 9/5 TAKE-UP ENABLE/INHIBIT command results in a relay switch contact closure in the command processor unit. An internal logic switch located in the film control electronics unit (FCE) executes the "ENABLE" function. This command has no redundancy feature. However, the 9 supply looper "full" and "empty" logic switches, located in the 9 supply unit, will perform the film take-up cycle ENABLE/INHIBIT function in the absence of this command. The 9 system, while employing several redundant circuit design features, also is subject to many single point failure modes. This system does not contain a backup or redundant mode operational provision. However, the reliability of the 9 film handling system is enhanced by the liberal redundancy maintained exclusive of the system's internal design.

2.2.9 5 Film Handling System

A redundancy block diagram for the 5 film handling system is shown in Figure 4.2-12. There are three basic commands associated with the operation of the 5 film handling system. They are the 5 OP ON/OFF, the 5 take-up ENABLE/INHIBIT, and the 5 parking brake ON/OFF. All commands are received redundantly from the ECS decoder.

The 5 OP is processed redundantly in the command processor. To enhance reliability, two parallel (cross-strapped) power switches, located in the power monitor and control unit, execute the 5 OP ON/OFF function. This is the identical hardware and scheme employed for the 5 camera platen drive subsystem.

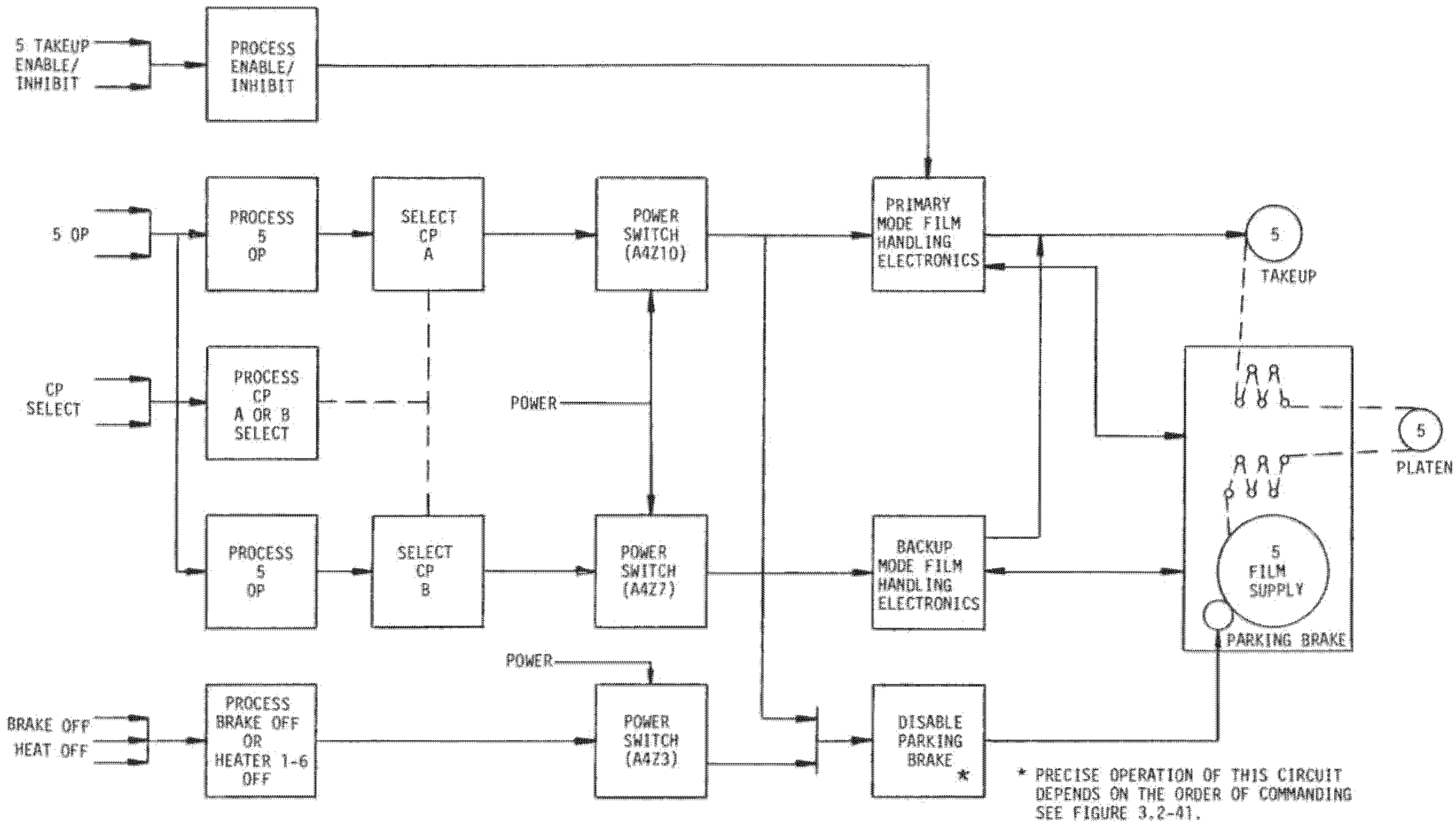


Figure 4.2-12. 5 Film Handling Subsystem

Receipt of the redundant 9/5 take-up ENABLE/INHIBIT command results in a relay switch contact closure in the command processor unit. An internal logic switch located in the film handling electronics (FHE) executes the ENABLE function. This command has no redundancy features. However, the 5 supply looper FULL and EMPTY logic switches, located in the supply unit, will perform the film take-up cycle ENABLE/INHIBIT function in the absence of this command.

The 5 parking brake ON/OFF command is processed through a series path in the command processor and power monitor and control units. To increase the reliability of the system, a fail-safe design feature in the supply parking brake circuitry has been provided. In the event that the parking brake power cannot be removed by command, an interlock relay in the 5 supply unit will disable this function with the application of 5 OP power.

The film handling electronics unit contains backup mode operation circuitry which provides a large degree of functional redundancy. This backup mode design minimizes the number of single point failure modes while supplying an alternate mode film take-up cycling capability.

2.2.10 Thermal Environment Control Subsystem

The thermal environment of the PPS/DP EAC is controlled primarily by three items: a heating system, the external paint pattern, and viewport door operation.

2.2.10.1 Heater System and Paint Patterns. The heater system and paint patterns are discussed in detail in Part 3, Section 8 of this document. There are, however, reliability considerations which have been factored into the thermal control subsystem design. The heating system is a series of "branch" switches which feed a larger number of heater controllers that in turn thermostatically control power to individual heating zones (tapes). There are 7 branch switches (branches 1, 2, 4, 5, 6, EPSM 1*, EPSM 2*) which will respond to any one of three commands for both ON or OFF (EPSM has five for ON and three for OFF). Generally, they are all commanded ON by a common command and OFF by individual command (many combinations are available). The PPS/DP EAC can tolerate two heaters (controllers) failed ON in a worst case hot orbit and half of the heaters OFF in a worst case cold orbit.

2.2.10.2 Viewport Doors. The viewport doors are an essential part of the thermal control scheme. They restrict heat loss from the COA when closed and may be used as a secondary means of cooling when open. However, the primary reliability concern is that the doors are not only operable for thermal considerations, but also for photography. The viewport door mechanisms are designed with an ordnance initiated backup drive system and also an ordnance initiated, but less desirable, door blow scheme (doors remain permanently open). Details of the design and operation of the viewport door subsystem are found in Part 3, Section 5 of this handbook. Figure 4.2-13 and 4.2-14 show the primary and backup modes for viewport door operation from a redundancy standpoint.

The primary mode (Figure 4.2-13) is initialized by the launch preset ground command prior to launch. Shortly after launch, the primary drive mechanism is enabled by the operation of redundant (lock-out) switches which result from the ordnance initiated main hatch eject event. Redundant OPEN/CLOSE commands provide non-redundant power steering to the motor drive/mechanical linkage for door operation.

*EPSM: Environmental Power, SRV Minimum (SRV Battery Heater).

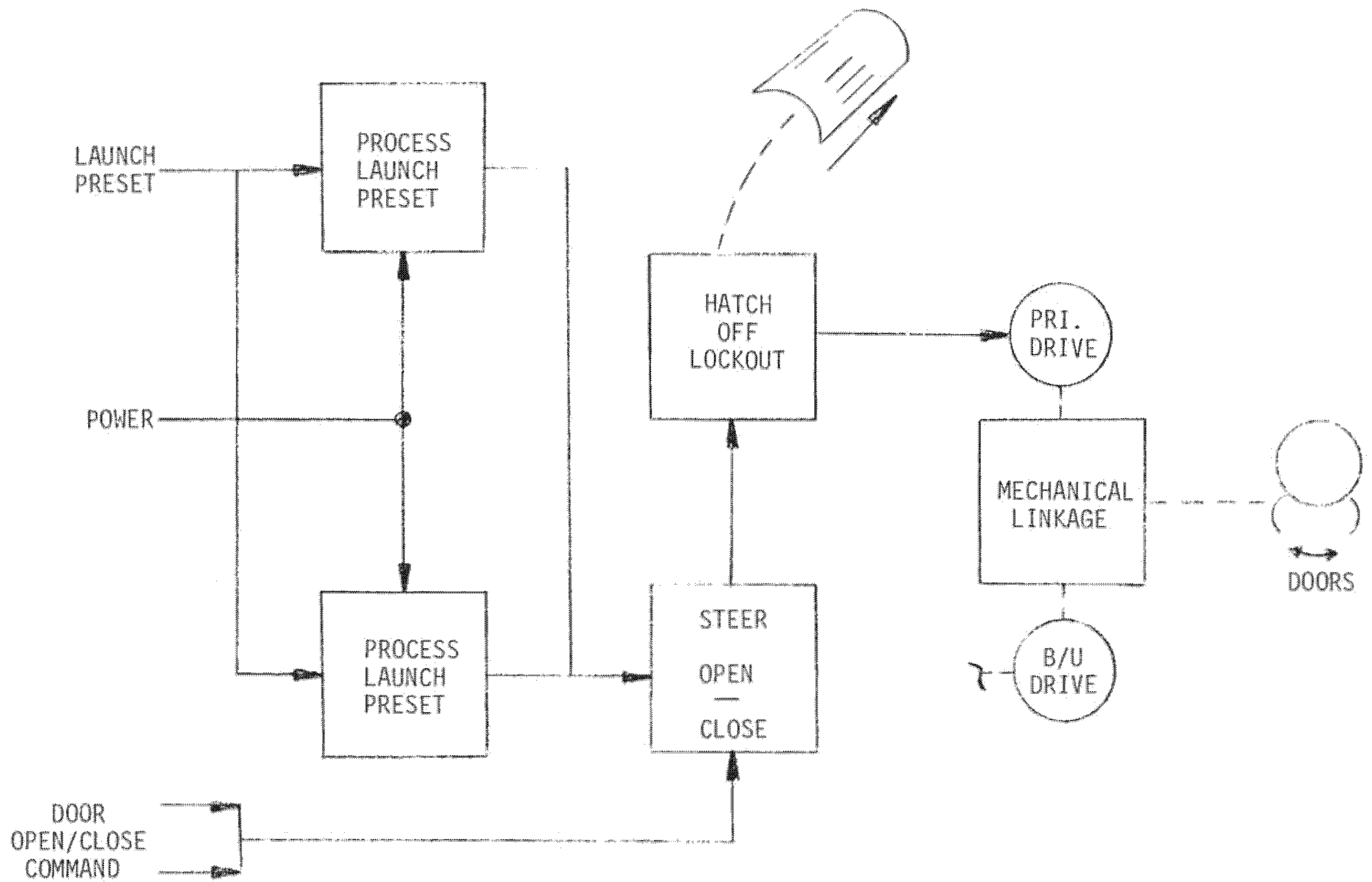


Figure 4.2-13. Primary Mode Viewport Door Operation

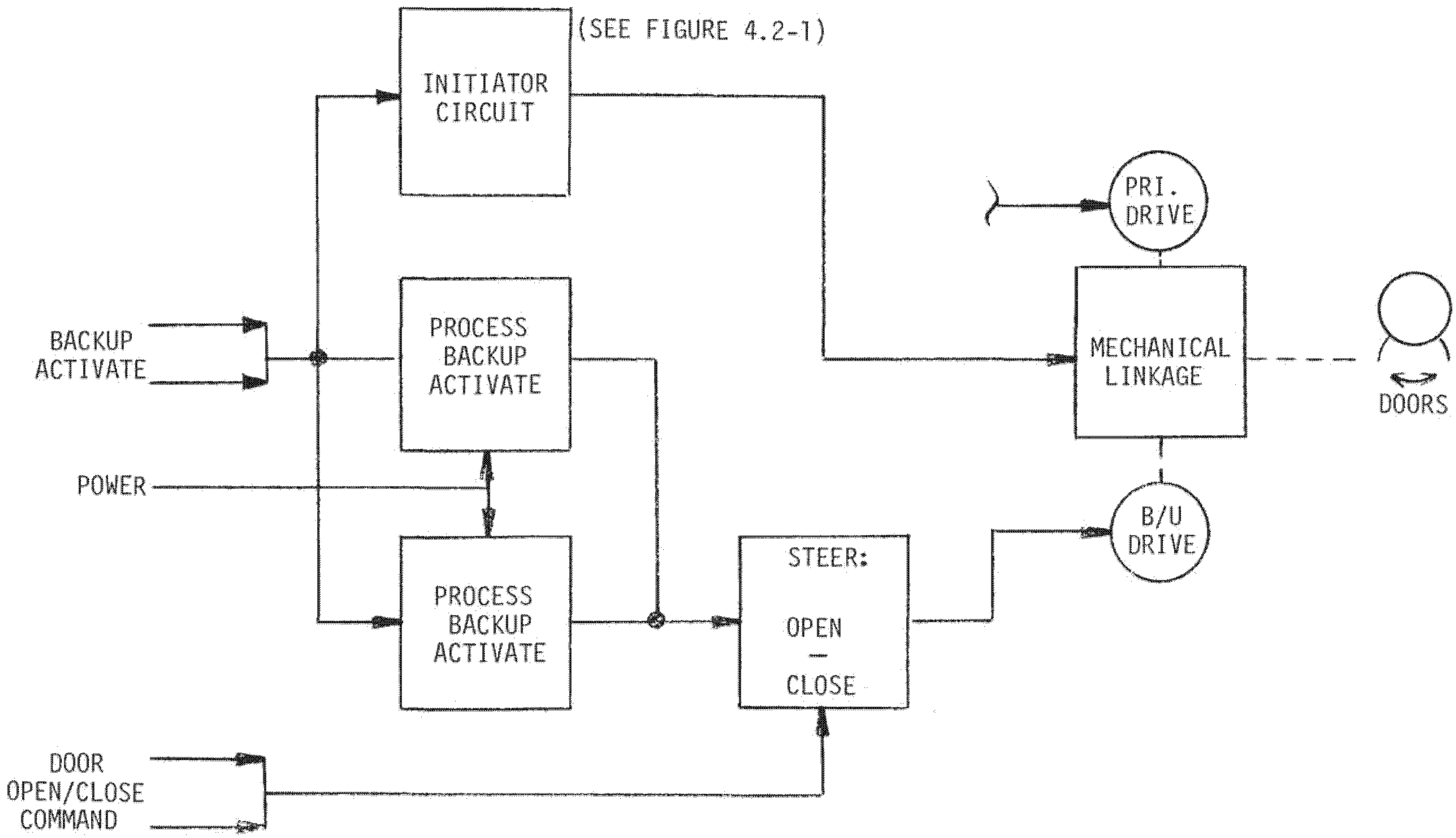


Figure 4.2-14. Backup Mode Viewport Door Operation

The backup or redundant mode (Figure 4.2-14) is accomplished by issuance of the redundant backup command. This command performs two functions:

(1) Electrically disables the primary mode while enabling the backup mode, and

(2) Redundantly initiates an ordnance device which mechanically disables the primary mechanism and enables the backup mechanism.

The redundant OPEN/CLOSE command now provides non-redundant power steering (reversing function) to the backup motor drive/mechanical linkage for door operation.

2.3 Qualification Program

The following paragraphs briefly summarize the PPS/DP EAC Qualification Program. Detailed information can be found in BIF-008 specifications:

(a) 1402-320 and 1402-320 Addendum A, Environmental Design Criteria

(b) 1402-558, Qualification/Confidence Test Plan for FO-7, and

(c) 1402-558-2, Qualification/Confidence Test Plan for EAC Configuration.

2.3.1 Philosophy

The qualification Program is intended to verify design adequacy and to demonstrate a minimum level of equipment capability. The test conditions and parameters are more severe than those expected during the lifetime of the equipment in order to provide high confidence that the margins inherent in the PPS/DP EAC hardware design are adequate.

2.3.2 Purpose

The purposes of the qualification program are:

(a) To verify the capability of the unchanged, new or significantly modified portions of the PPS/DP EAC design to meet functional and environmental requirements, when subjected to extremes of environmental conditions.

(b) To discover and identify failure modes not previously detected by analysis.

(c) To identify unexpected interactions between portions of the PPS/DP EAC, especially in those areas changed for the 9 x 5 design which must work in harmony with unchanged areas.

(d) To verify the adequacy of the manufacturing, inspection and acceptance test procedures, and support equipment.

(e) To contribute confidence in the overall reliability by fulfillment of the above.

2.3.3 Qualification Testing

Qualification testing is designed to demonstrate that hardware, representative of production, can meet its specified functional performance requirements during and/or after exposure to designated extremes of environments. The effort consists of a series of tests on the major elements and components of the PPS/DP EAC (9 x 5) system. The tests simulate the types of environments encountered by the hardware and include verification of specified performance at multiple assembly levels.

2.3.3.1 Qualification Test Criteria. The test criteria, test levels and parameters involved are based on the requirements originating from the General System Specification (GSS), further defined in BIF-008 specification 1402-320 (Environmental Design Criteria) and delineated in detail in BIF-008 specification 1402-558 (Qualification/Confidence Test Plan). The environmental test levels to which the hardware are subjected are generally more severe than maximum anticipated operational levels for the following reasons:

(a) To compensate for inaccuracies in the knowledge of actual operational environmental levels.

(b) To offset the fact that certain environments are encountered simultaneously in actual use, but are applied separately during testing.

(c) To compensate for normal variations in individual components of the same design.

(d) To provide additional confidence in the ability of the 9 x 5 hardware to survive the actual levels.

(e) To partially offset the statistical limitations of the small sample size.

(f) To verify that a margin of safety is inherent in the design.

(g) To account for the fact that a given piece of hardware may experience a test history excessively greater than normal.

2.3.3.2 Test Hardware. Qualification test hardware is hardware which has experienced all the normal fabrication, buildup, assembly, handling, environments, test procedures and processes to which typical flight hardware would be subjected. This hardware is dedicated to qualification testing use only and is not subsequently delivered for flight.

2.3.4 Demonstrated Qualification Summary

Table 4.2-1 delineates the demonstrated environmental capabilities of each major component and module. (Due to the evolution of both the Gambit Program and subsequently the hardware, all items do not reflect similar levels of qualification.) The reader must be aware that values appearing in Table 4.2-1 are Test values and not necessarily Qualification limits. The reasons for differences are contractual, test method (equipment limitations) or intentional overtest as described by Paragraph 2.3.3.1. (In general, an overtest of 25% is employed by BIF-008.)

TABLE 4.2-1

RELIABILITY

QUALIFICATION TESTS

References:	1402-320	Environmental Design Criteria, Qual. & Accept. Test Levels for B^2
	1402-320-A	Environmental Design Criteria for New Designs and Acceptance and Qualification Test Requirements for FM-48 through 54
	1402-558	Qualification/Confidence Test Plan for FO-7
	1402-558-2	Qualification/Confidence Test Plan for EAC Configuration

Notes:

1. Tests listed are tests performed during the K, B^2 or FO-7 programs or planned/performed for the EAC Configuration.
2. Additional specification or requirements are detailed in 1402-320.
3. This table reflects the qualification status and expected results of certain tests currently in progress.

Key:	*	=	B^2 Qualification Test Results
	**	=	K-Qualification Test Results
	No Asterisk	=	FO-7 Qualification Test Results
	#	=	EAC Configuration Test Specification
	(A)	=	FO-7 Qualification Vibration Test to Acoustic Test Results (ATR) Spectrum

Abbrev.:	PRS	=	Primary Record System (9)
	SRS	=	Secondary Record System (5)
	CRP Test	=	Combined Record Path Test - Includes all film handling hardware
	T/A	=	Thermal Altitude
	DTV	=	Developmental Test Vehicle
	ECCT	=	Extended Cycle Confidence Test

NAME	PRL	VIBRATION	ACCELERATION	SHOCK	TEMP	HUMIDITY	TEST LIFE	PRESS. CHNG.	EMI	T/A & OTHER TESTS
PPS/DP EAC	30250	*Sine: X axis *Random: X axis							DTV	*Static Test: Max. Accel - Y,Z axis *Max. Joint Tension - Y,Z axis
SEM/DRM	30251	*Sine: X axis		Pyro: Actuate & monitor selected pyro devices					1402-524	Proof Press: 0.50 psig max. *Acoustic
FWD. BARREL (Also refer to PRI. & B/U. ACTUATOR)	30653						**1200 cycles each viewport door system			**Proof Press: 4.29 psig Limit 5.92 psig Ultimate
TAKE-UP	30951	Random: X,Y,Z axis	15.8g-X axis 7.0g -Y,Z axis	Recovery: 35g peak X,Y,Z axis	See T/A test		Primary - Test: 600 min. or 14,000 cycles Mission: 75 min. or 9,000 cycles Secondary - Test: 160 min. or 2,500 cycles Mission: 20 min. or 1000 cycles.	dp/dt: 800 torr/ min. to 10^{-5} torr & return	1402-524	CRP test: 84 days, cycle 20F to 100F at 10^{-5} torr.
SUPPLY 9	31050	# Random: (A) X,Y,Z axis	*9.5g-X axis aft, 2.0g-X axis fwd. 1.2g-Z axis		See T/A test		Test: 1200 min. or 28,800 cycles Mission: 150 min. or 7,200 cycles		*Mil. Spec. 1-26600	CRP test: 84 days, cycle 20F to 100F at 10^{-5} torr.
SUPPLY 5	31055	# Random(A):X,Y,Z axis Brake Powered	15.8g-X axis 7.0g-Y,Z axis		See T/A test		Test: 320 min. or 8000 cycles Mission: 40 min. or 5000 cycles	dp/dt: 800 torr/ min. to 10^{-5} torr & return	1402-524	CRP test: 84 days, cycle 20F to 100F at 10^{-5} torr.
CRAB SERVO	31102	Sine: X,Y,Z axis	*15g,-X axis 3g,+X axis 5g,Y,Z axis	Handling: 30g peak X,Y,Z axis	*Non-oper. 10F-160F Oper. 30F to 110F	*95% @ 110F	25 hrs. actual ON time @ 11% max. duty cycle. 14,250 cycles.		Partial 1402-524 & *MIL-I-26600	*ECCT 20,000 cycles, 75F at 10^{-5} torr.
STEREO SERVO	31103	Sine: X,Y,Z axis	*15g-X axis 3g,+X axis 5g,Y,Z axis	Handling: 30g peak X,Y,Z axis	*Non-oper. 5F-160F Oper. 30F to 110F	*95% @ 110F	25 hrs. actual ON time @ 11% max. duty cycle. 18,250 cycles.		Partial 1402-524 & *MIL-I-26600	*ECCT 26,000 cycles 75F at 10^{-5} torr.

NAME	PRL	VIBRATION	ACCELERATION	SHOCK	TEMP	HUMIDITY	TEST LIFE	PRESS. CHNG.	EMI	T/A & OTHER TESTS
CAMERA (9x5)	31250	# Sine: X,Y,Z axis	# 8.4g, -X axis # 6.2g, -Y,Z axis		See T/A test		Cycles per subtable. Test + CRP Test	# dp/dt: 800 torr/ min. to 10^{-5} torr & return	1402-524	CRP test: 84 days cycle 65F to 75F at 10^{-5} torr. On select days cycle 55F to 85F. # T/A test: 75 days 20 cycles 65F to 75F at 10^{-5} torr.
9 Film Drive & Cntrl.							36,000 22,500			5x9 I.F. Marker Assemblies Test: Sine vib to CAMERA spec. (tungsten filament lamp marker assemblies).
5 Film Drive & Cntrl.							10,000 6,250			
9 Focus Adjust							18,600 11,630			
5 Focus Adjust							5,200 3,250			
9 SRC							18,600 11,630			
5 SRC							5,200 3,250			
9 Variable Slit							9,600 6,000			
5 Variable Slit							2,800 3,000			
DTU	31462	Random: X,Y,Z axis Powered	21.2g - X,Y,Z axis	Handling: 40g peak- X,Y,Z axis	Non-op. 160F	80% @ 110F 98% @ 160F	Test: 900 hrs.	dp/dt: 15 torr/ sec. avg. to 10^{-5} torr & return.	1402-524	Mission life simul: 56 days cycle -30F to 160F at 10^{-5} torr. Qualified for 20F to 110F.
AMP. HR. METER (also refer to PM&C)	31604	*Sine: X,Y,Z axis *Random:X,Y,Z axis			*20F to 150F @ 10^{-3} torr.	*95% @ 105F 95% @ 35F			*Mil Spec. I-26600	*Acoustic test: 150 db max.
COMMAND PROCESSOR	31652	# Random: X,Y,Z axis Powered	**15g,-X axis 3g,+X axis 5g,Y,Z axis	# Handling: 30g peak- X,Y,Z axis	# Non-op. 0F to 160F	95% @ 160F	Test: 500 hrs.	dp/dt: 800 torr/ min to 10^{-5} & return.	# 1402-524 Partial	# Mission life simul: 20 days cycle 20F to 110F at 10^{-5} torr.
PM&C	31655	Random (A): X,Y,Z axis Powered	**15g,-X axis 3g,+X axis 5g,Y,Z axis	Handling: 30g peak X,Y,Z axis	Non-op. 0F to 160F	95% @ 160F	Test: 350 hrs.	dp/dt: 800 torr/ min to 10^{-5} torr & return.	1402-524	Mission life simul: 60 days cycle 20F to 110F at 10^{-5} torr.

NAME	PRL	VIBRATION	ACCELERATION	SHOCK	TEMP	HUMIDITY	TEST LIFE	PRESS. CHNG.	EMI	T/A & OTHER TESTS
INST. PROCESSOR	31754	Random (A): X,Y,Z axis Powered	*15g,-X axis 3g,+X axis 5g,Y,Z axis	Handling: 30g peak- X,Y,Z axis	Non-op. 0F to 160F	95% @ 160F	Test: 250 hrs.	dp/dt: 800 torr/ min. to 10^{-5} torr & return.	1402-524	Mission life simul: 60 days, cycle 20F to 110F at 10^{-5} torr.
HEATER CONTROLLER	31800	QUALIFIED BY SIMILARITY TO PRL 31851 STANDBY (GROUND) HEATER CONTROLLER								
STANDBY (GROUND) HEATER CONTROLLER	31851	*Random: X,Y,Z axis	*15g X,Y,Z axis					*dp/dt: 800 torr/ min. to 10^{-6} torr & return.	*Mil Spec. I-26600	
FOCUS SENSOR (TESTED IN CAMERA)	31940	# Sine: X,Y,Z axis	# 8.4g, X axis 6.2g, Y,Z axis		See T/A test		Test: 100 hrs.	# dp/dt: 800 torr/ min. to 10^{-5} torr & return.	1402-524	# T/A Test: 75 days, 20 Cycles 65F to 75F at 10^{-5} torr.
FPLLE	32050	# Random: (A) X,Y,Z axis		Handling: 30g peak X,Y,Z axis	Non-op. 0F to 160F	95% @ 160F	See Camera for cycles. (PRL 31250)	dp/dt: 800 torr/ min. to 10^{-5} torr & return.	# 1402-524	Mission life simul: 60 days, cycle 20F to 110F at 10^{-5} torr.
CABLES, INT. STRUC. (COA)	32150	Random: X,Y,Z axis Powered	21.2g X,Y,Z axis		Non-op. 0F to 160F	95% @ 160F		dp/dt: 800 torr/ min to 10^{-5} torr & return.		Flexure test: Flex. main trunk 1X Flex. connec. region 100X Bend = 4X bundle dia.
STEREO MIRROR & MT. (Also refer to COA)	32301	*Random X,Y,Z axis	*15g max. X axis, 5g max. Z axis		*Non-op. 60F to 90F	*86% @ 60F 86% @ 90F				**Static Load test: 125% of Design limit load. X,Y,Z axis combinations.
END BELL ASSEMB. (Also refer to COA)	32801	*Sine: X,Y,Z axis								**Static Load test: 125% of Design limit load.

NAME	PRI	VIBRATION	ACCELERATION	SHOCK	TEMP	HUMIDITY	TEST LIFE	PRESS. CHNG.	EMI	T/A & OTHER TESTS
PLATEN REF. GAGE (SENSORS)	32805	Sine: X,Y,Z axis			See T/A test			dp/dt: 800 torr/ min. to 10^{-5} torr & return.	1402-524	Mission life simul: 10 days, cycle 55F to 85F at 10^{-5} torr.
S-1 GAGE (BEAM)	32806	Sine: X,Y,Z axis	Static 15g X axis 5g Y,Z axis							
S-1 PRG & SENSOR PWR SENSOR ENCODER AND PROCESSING ELECTRONICS (SEPE)	32807	Sine: X,Y,Z axis			See T/A test			dp/dt: 800 torr/ min. to 10^{-5} torr & return.	1402-524	Mission life simul: 10 days, cycle 55F to 85F at 10^{-5} torr.
CAMERA OPTICS ASSY.	33150	Sine: X axis								
SEM	33250	Random (A): X,Y,Z axis	*9.38g,-X axis 1.25g,-Y axis 3.13g,+Z, -Z axis (all values approx.)							*CRUSH test: 0.8psig limit press. 1.0 psig ultimate press. *BURST test: 4.0 psig limit press. 5.0 psig ultimate press.
FCE	33350	Random (A): X,Y,Z axis	*15g,-X axis 3g,+X axis 5g,Y,Z axis	Handling: 30g X,Y,Z axis	*Non-op. 0F to 160F	*100% @ 160F *Oper: 80% @ 30F 80% @ 110F	Test: 100 hrs. (33% duty cycle)	dp/dt: 800 torr/ min. to 10^{-5} torr & return.	1402-524	Mission life simul: 60 days, cycle 20F to 110F at 10^{-5} torr.
FHE	33355	Random (A): X,Y,Z axis		Handling: 30g X,Y,Z axis	Non-op. 0F to 160F	95% @ 160F	Test: 320 hrs.	dp/dt 800 torr/ min. to 10^{-5} torr & return.	1402-524	Mission life simul: 60 days, cycle 20F to 110F at 10^{-5} torr.
DREA	33450	Random: X,Y,Z axis		Handling: 30g X,Y,Z axis	Non-op. 0F to 160F	95% @ 160F	See Camera for cycles. (PRL 31250)	dp/dt: 800 torr/ min. to 10^{-5} torr & return.	1402-524	Mission life simul: 60 days, cycle 20F to 110F at 10^{-5} torr.

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NAME	PRL	VIBRATION	ACCELERATION	SHOCK	TEMP.	HUMIDITY	TEST LIFE	PRESS. CHNG.	EMI	T/A & OTHER TESTS
C/S ASSEM. ABUC (Also refer to TSRT PRL 35056)	33500 33551		** 15g,-X axis 3g,+X axis 5g,Y,Z axis		** Non-op. -30F to 125F		50 actuations total, includes 15 after ATP		**Mil. Spec. I-26600	CRP test: 84 days, cycle 20F to 100F at 10^{-5} torr. *REL. SUBSTANTIATION TEST: 25 cycles @ nom. tension. 25 cycles at zero tension.
CABLES, SEM/DRM	30652	Random: X,Y,Z axis Powered			*Oper: 0F to 160F	*Oper: 80% @ 110F	56 days cycle from 20F to 110F @ 10^{-5} torr.	dp/dt 800 torr/ min. to 10^{-5} torr & return.		FLEXURE TEST: Flex main trunk 1X. Flex connec. region 100X. Bend = 4X bundle dia
IEU	33850	Random (A): X,Y,Z axis Powered	15g X,Y,Z axis	Handling: 30g X,Y,Z axis	Non-op. 0F to 160F	Non-op. 95% @ 160F	TEST: 320 hrs. Each pyro circuit 50 actuations.	dp/dt 800 torr/ min. to 10^{-5} torr & return.	1402-524	Mission life simul: 28 days, cycle 20F to 110F at 10^{-5} torr. (Double cycle rate)
INTERNAL STRUCTURE	33901		Static load 7.5g X axis, aft 4.3g X axis, forward							
SPLICER MECH. 589	34450	Random: X,Y,Z axis	* 15g,-X axis 3g,+X axis 5g,Y,Z axis	*30g, X,Y,Z axis	*Oper: 110F		50 actuations total		*Mil. Spec. I-26600	CRP test: 84 days, cycle 20F to 100F at 10^{-5} torr. Operate on test day 38.
VIEWPORT DOOR ELECTRONICS	34800	Random (A): X,Y,Z axis Powered	* 15g,-X axis 3g,+X axis 5g,Y,Z axis		See T/A test	*Non-op. 80% @ 110F	TEST: 288 hrs			Mission life simul: 56 days, cycle 30F to 110F at 10^{-5} torr.

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NAME	PRL	VIBRATION	ACCELERATION	SHOCK	TEMP	HUMIDITY	TEST LIFE	PRESS.CHNG.	EMI	T/A & OTHER TESTS
DRM	35050	Sine Survey: X,Y,Z axis Sine: X,Y,Z axis Random: X,Y,Z axis			See T/A test			-	*Mil. Spec. I-26600	CRP test: 84 days, cycle 20F to 110F at 10^{-5} torr. EA Ejection Test: Verify by analysis. *DRM/SES/Tunnels Burst Test: 0.5 psig limit press. 0.625 psig ultimate press.
EA	35051									*Ejection Test: SRV & EA ejection
FA	35052									*Proof Pressure Test: 3.13 psig.
TSRT	35056	*Random: X,Y,Z axis		*35g. X,Y,Z axis (18 times total)	See T/A test		*Rel. Substantiation Test: 50 actuations.			CRP test: 84 days, cycle 20F to 110F at 10^{-5} torr.
TILT FRAME COUPLERS PRIMARY	35151-9	Random:X.Y,Z axis								T/A Test 0.1 to 1 Torr. 55-85 F
TILT FRAME COUPLERS SECONDARY	35151-5	Random: X,Y,Z axis								T/A Test 0.1 to 1 Torr. 55-85 F
PRIMARY VIEWPORT DOOR ACTUATOR	-									56 days @ 10^{-5} torr 30F-110F,3575 cycles
B.U. VIEWPORT DOOR ACTUATORS	-	Random (A): X,Y,Z axis			See T/A test					75 days, 20F to 110F @ 10^{-5} torr. 5,000 full cycles. Current signature.
DIMPLE MOTOR	-	Sine: X,Y,Z axis	15g max X,Z axis	30g max X,Y.Z axis	-65F to 160F	95% at 160F for 28 days		Alt. test: 10^{-5} torr.		WATER IMMERSION TEST per Mil Spec. E5272.
ASI-9 SQUIB	-	Sine: X,Y,Z axis Random: X,Y,Z axis		40g max X,Y,Z axis	-65F to 160F					75 days, -65F to 160F @ 10^{-8} torr.

3.0 MANUFACTURING

Each hardware contractor for the Gambit Reconnaissance System produces a complete unit, which, when mated and operated with other units, is capable of meeting the appropriate requirements of the Gambit General System Specification.

3.1 Aerospace Vehicle Buildup

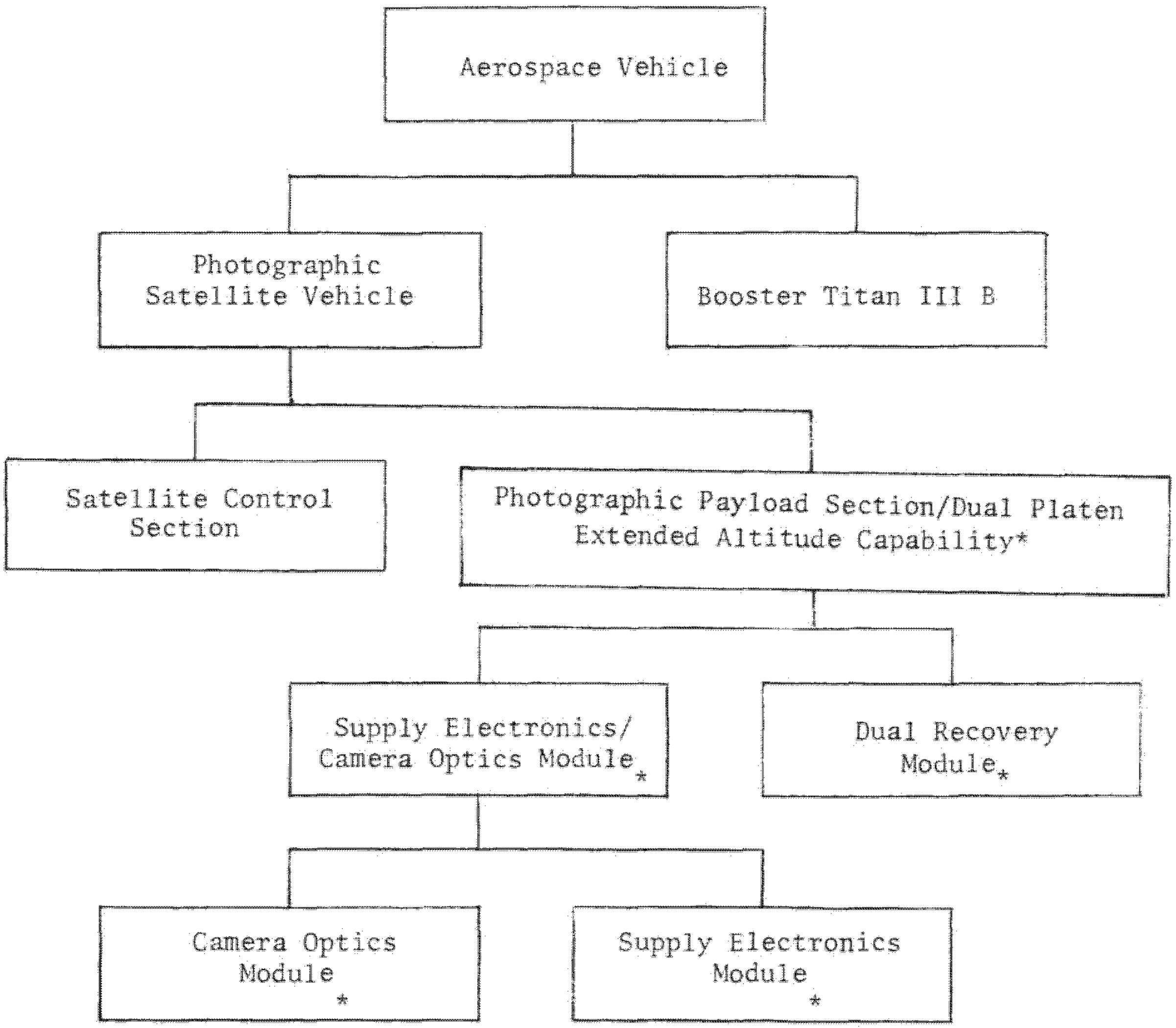
A block diagram of the buildup of the aerospace vehicle at the pad is shown in Figure 4.3-1. Those components which are the responsibility of BIF-008 are identified by asterisks. The following sections deal with the manufacturing of those BIF-008 components identified on the figure.

3.1.1 Factory-to-Pad Concept

The factory-to-pad concept describes the PPS/DP EAC assembly and test procedure wherein the PPS/DP EAC section of the satellite vehicle is assembled and acceptance tested at the factory. The completed PPS/DP EAC is shipped directly to the launch pad and mated with other sections of the aerospace vehicle, ready for final testing.

3.1.2 Manufacture/Test Interdependency

Manufacturing operations and test operations are mutually supportive; neither operation can proceed alone. In this section, testing which must be completed at each step of assembly is indicated. A more detailed presentation of testing is then provided in Part 4, Section 4.



*Responsibility of BIF-008.

Note: In order of assembly, the satellite control section is mated to the booster prior to mating with the PPS/DP EAC.

Figure 4.3-1. Aerospace Vehicle Buildup

3.2 PPS/DP EAC Modules

Of necessity, work on components of the three modules which comprise the PPS/DP EAC proceeds simultaneously. When complete, these three (the camera optics module (COM), the supply electronics module (SEM), and the dual recovery module (DRM)) are mated to form the finished PPS/DP EAC and final acceptance testing is performed at the PPS/DP EAC level. The following sections describe the assembly of each module, and their interconnection to complete the PPS/DP EAC.

3.2.1 Camera Optics Assembly (COA)

The COA assembly flow shown in Figure 4.3-2 begins with construction of the basic COA structure. Upon completion of the structure, it is shipped to Goddard Spaceflight Center for demagnetization and then returned to BIF-008 facilities for further assembly. Here the heater tapes are placed on the structure and cabling and other wiring attached. After testing, the structure is ready for installation of the optical components.

3.2.1.1 Optical Components Manufacturing. Manufacturing of the optical components proceeds simultaneously with construction of the COA structure. The stereo and primary mirrors are ground and polished (see Figure 4.3-3), and a high reflectance deposition coating is applied. The mirrors are then acceptance tested for optical quality, potted to their mounts, and again tested for quality. The stereo mirror is now ready for installation in the COA structure.

The primary mirror must first be installed in the end bell assembly and tested in conjunction with the Ross corrector and field lens assembly (RCFLA). The end bell assembly, which has already been completed by this time, including heater tape installation, supports the primary mirror at three points. This allows the primary mirror to be mounted in any one of three discrete

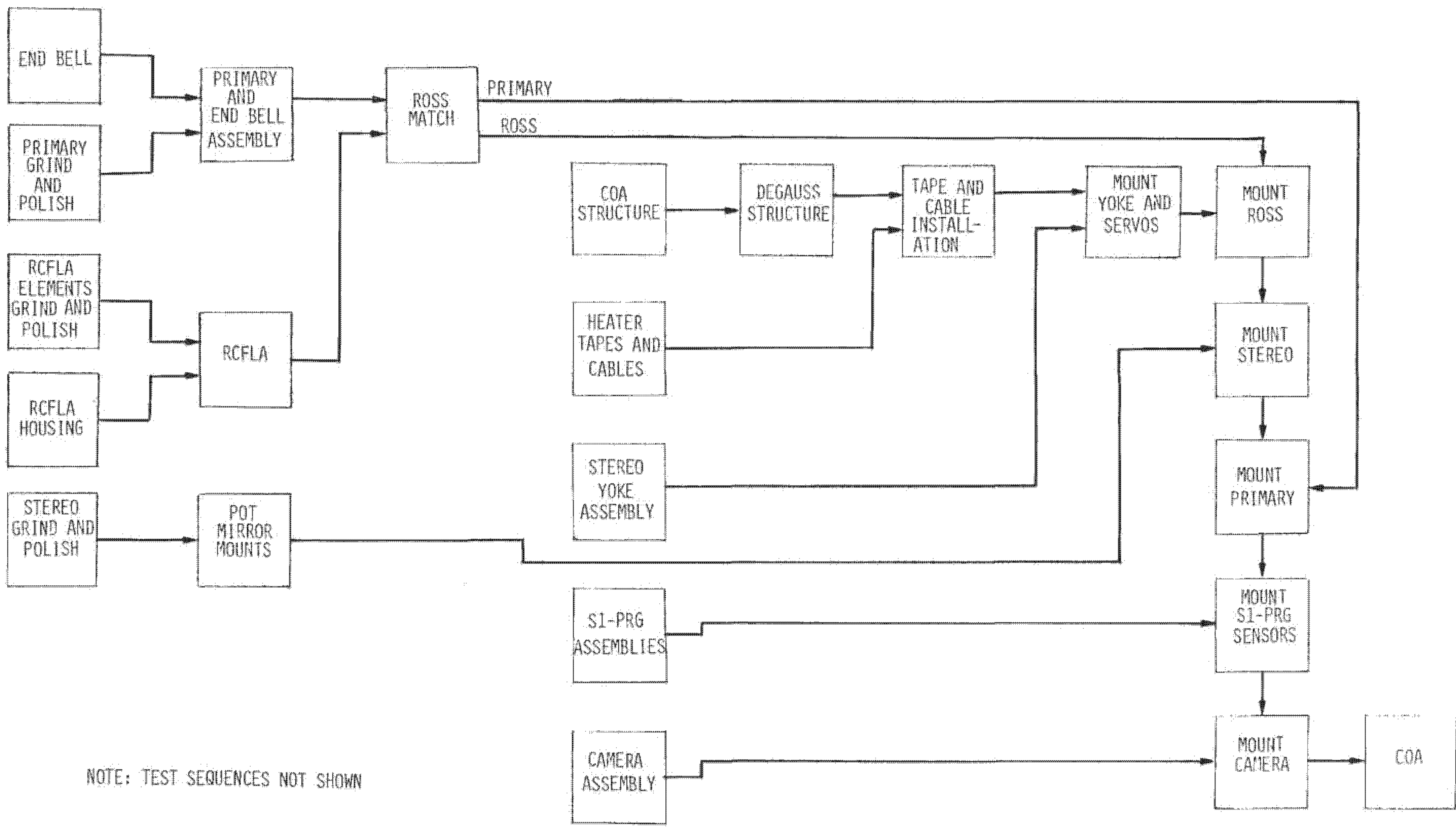
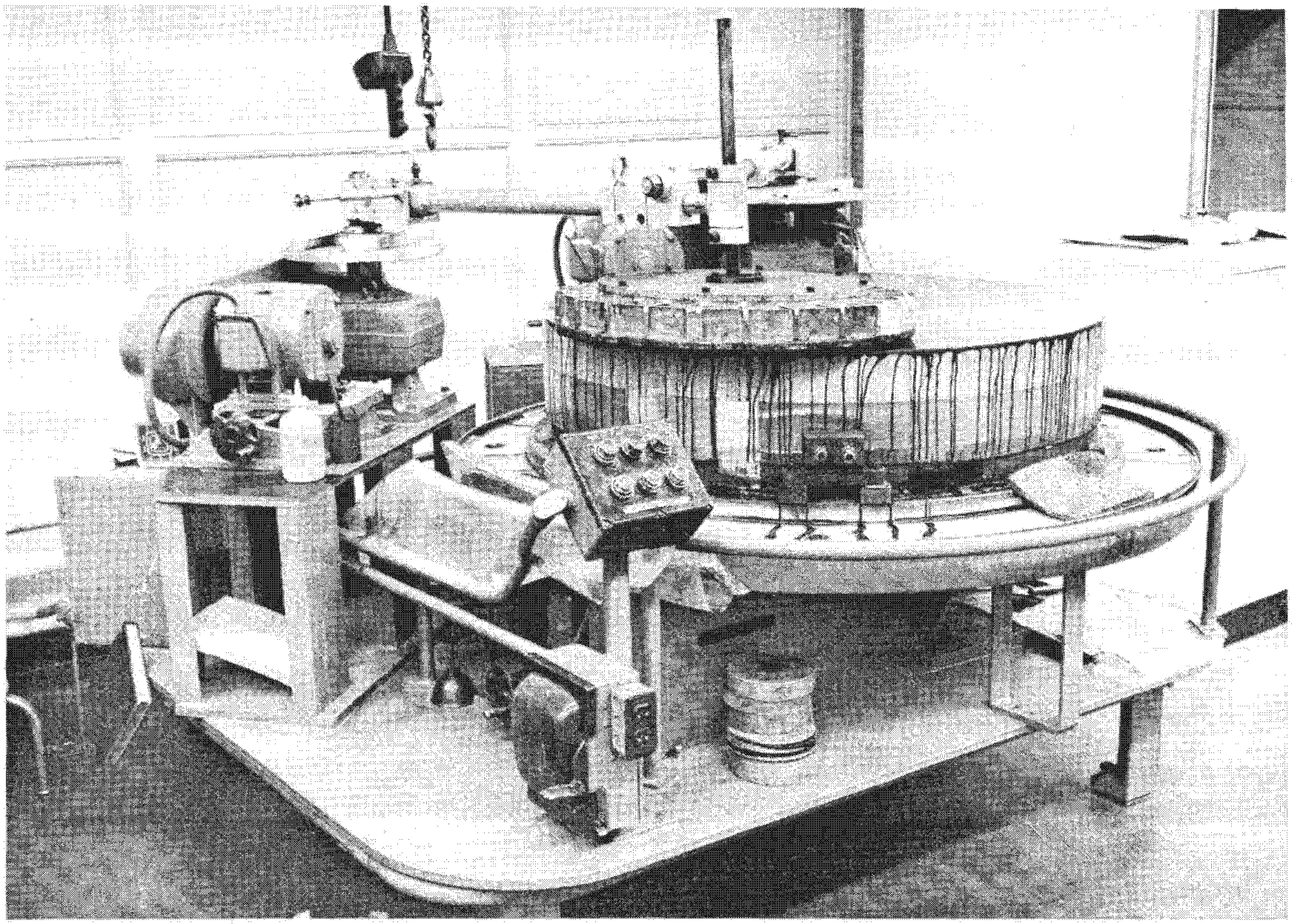


Figure 4.3-2. COA Assembly Flow



NOTE: Grinding lasts approximately 90 days,
polishing approximately 70 days.

Figure 4.3-3. Polishing Primary Mirror

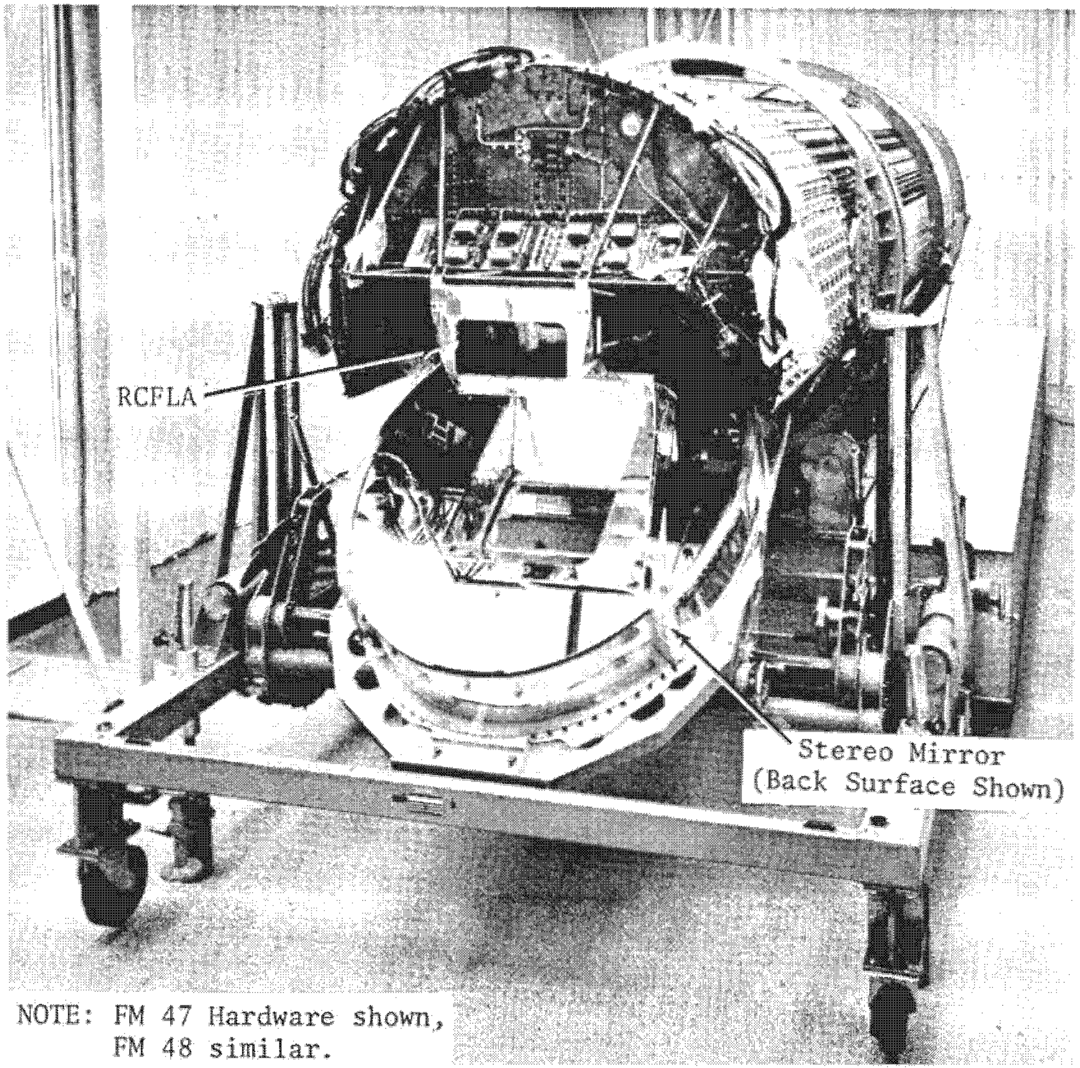
positions 120 degrees apart. The preferential orientation for mounting is determined from primary and stereo mirror surface quality testing to optimize system performance.

Simultaneous with manufacturing of the mirrors, the five Ross corrector lens elements are ground, polished, and acceptance tested. Following this, the anti-reflection and minus-blue filter coatings are applied, and the elements are cut to the required rectangular dimensions for assembly.

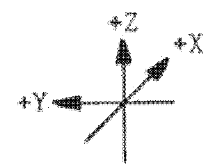
RCFLA buildup occurs in a vertical orientation with the optical axis parallel to the gravity vector. Lens element three (third element from the +X end of the RCFLA) is aligned to the camera mounting surfaces and the alignment holes of the RCFLA housing and potted in place. The remaining lens elements are installed and aligned to lens three. The assembled RCFLA is then acceptance tested. After performance of the Ross-primary mirror matching test, the RCFLA is ready for mounting in the COA structure.

3.2.1.2 Optical Component Mounting and Alignment. Optical component mounting to the COA structure begins with installation of the RCFLA, after which the stereo mirror is mounted (see Figure 4.3-4) and some testing performed. Next, the primary mirror and end bell assembly is installed following the procedure shown in Figure 4.3-5. First, an autocollimating axicon leveled to gravity is aligned to the optical axis of the third Ross element to establish the COA optical axis. The mirror and end bell assembly is then mounted on the COA and aligned to the axis established by the axicon.

The stereo mirror is the last optical component aligned. As shown in Figure 4.3-6, two theodolites, each leveled to gravity, are used to align the stereo mirror. First, the COA structure is rolled until the roll reference mirror on the RCFLA housing autocollimates the source from theodolite number one. The second theodolite is aligned perpendicular to the optical axis using an



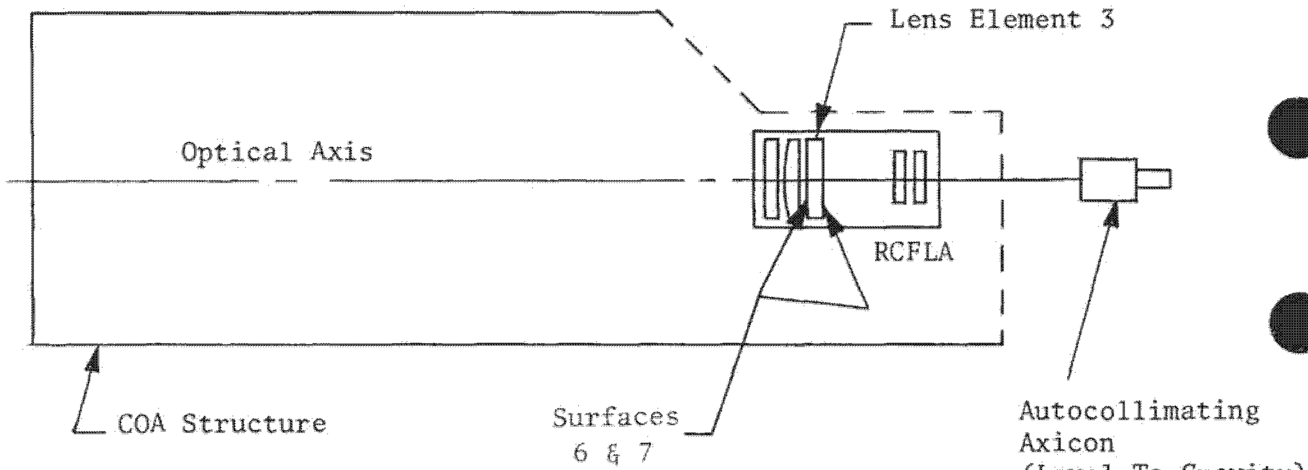
NOTE: FM 47 Hardware shown,
FM 48 similar.



BIF-008 Vehicle
Coordinates

Figure 4.3-4. Assembling Stereo Mirror to COA

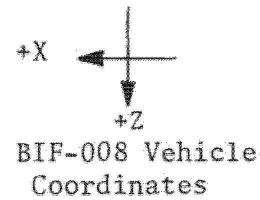
Alignment Of Axicon To Optical Axis Of Third Ross Element



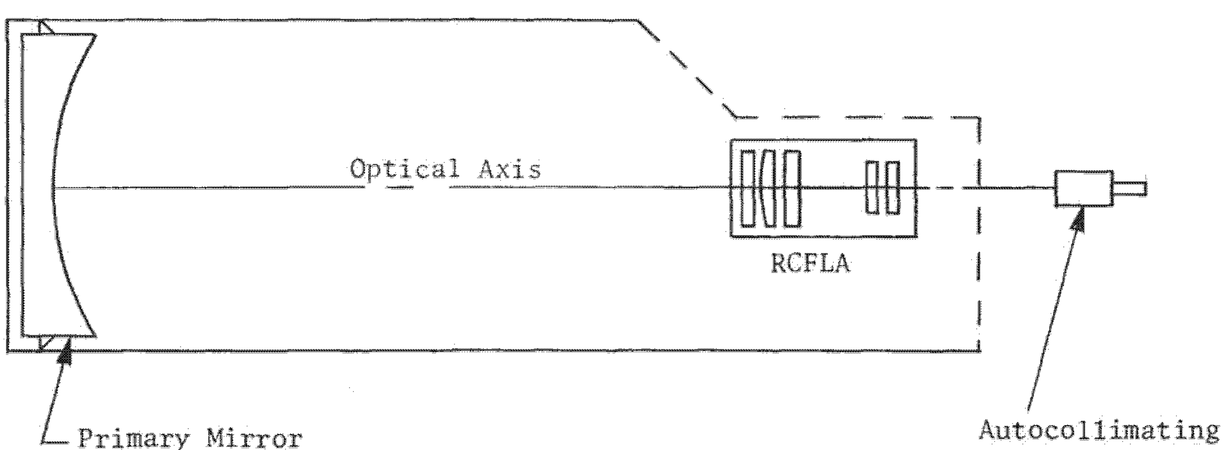
Notes:
1. Not shown is the alignment of RCFLA elements 1,2,4,5 to element three optical axis.

2. Stereo mirror removed for clarity.

3. Alignment performed in -Y up attitude.



Alignment Of Primary Mirror To Optical Axis



Views From Top (Note 3)

Figure 4.3-5. Primary Mirror Alignment

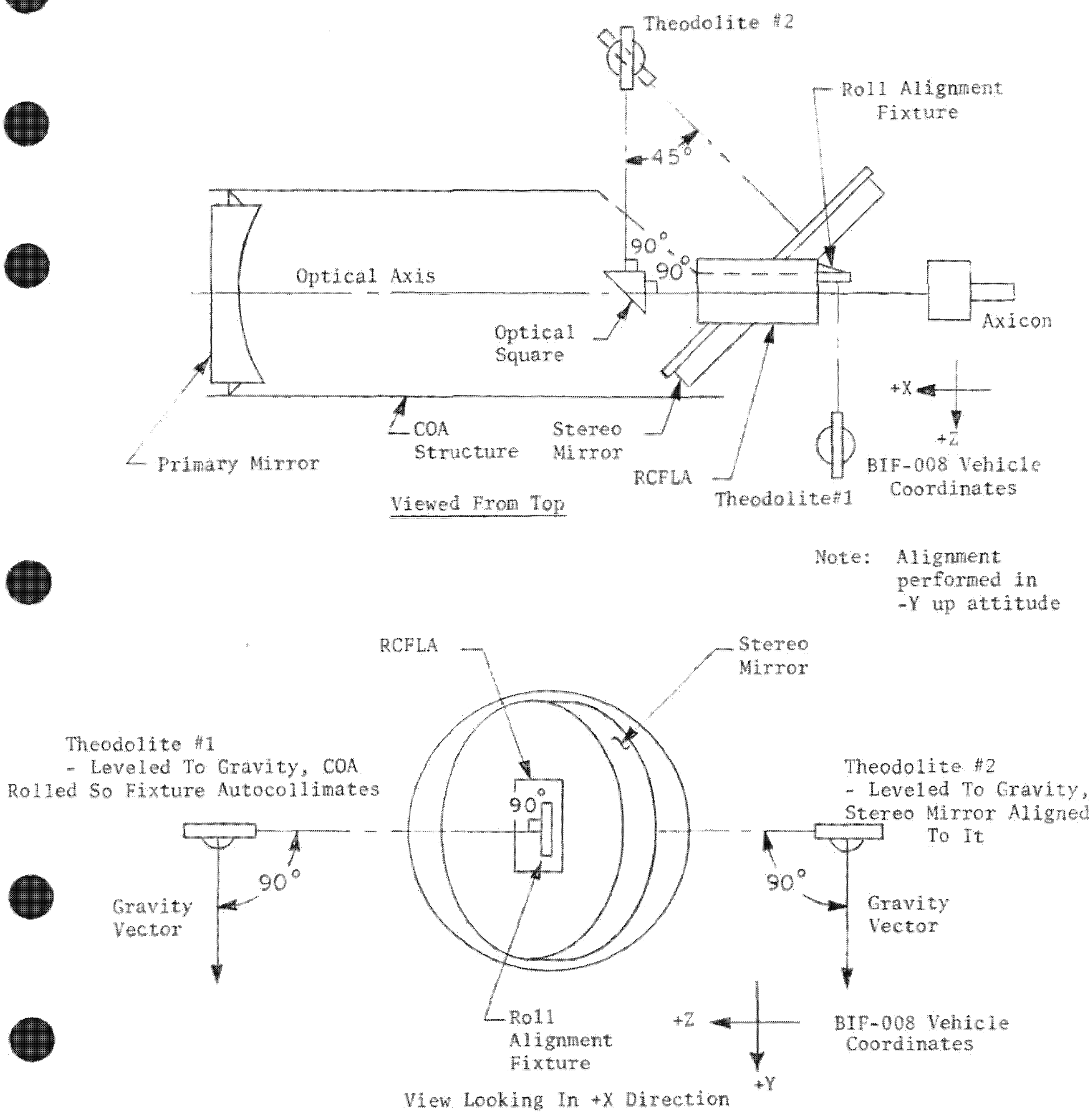


Figure 4.3-6. Alignment Of Stereo Mirror To Optical Axis

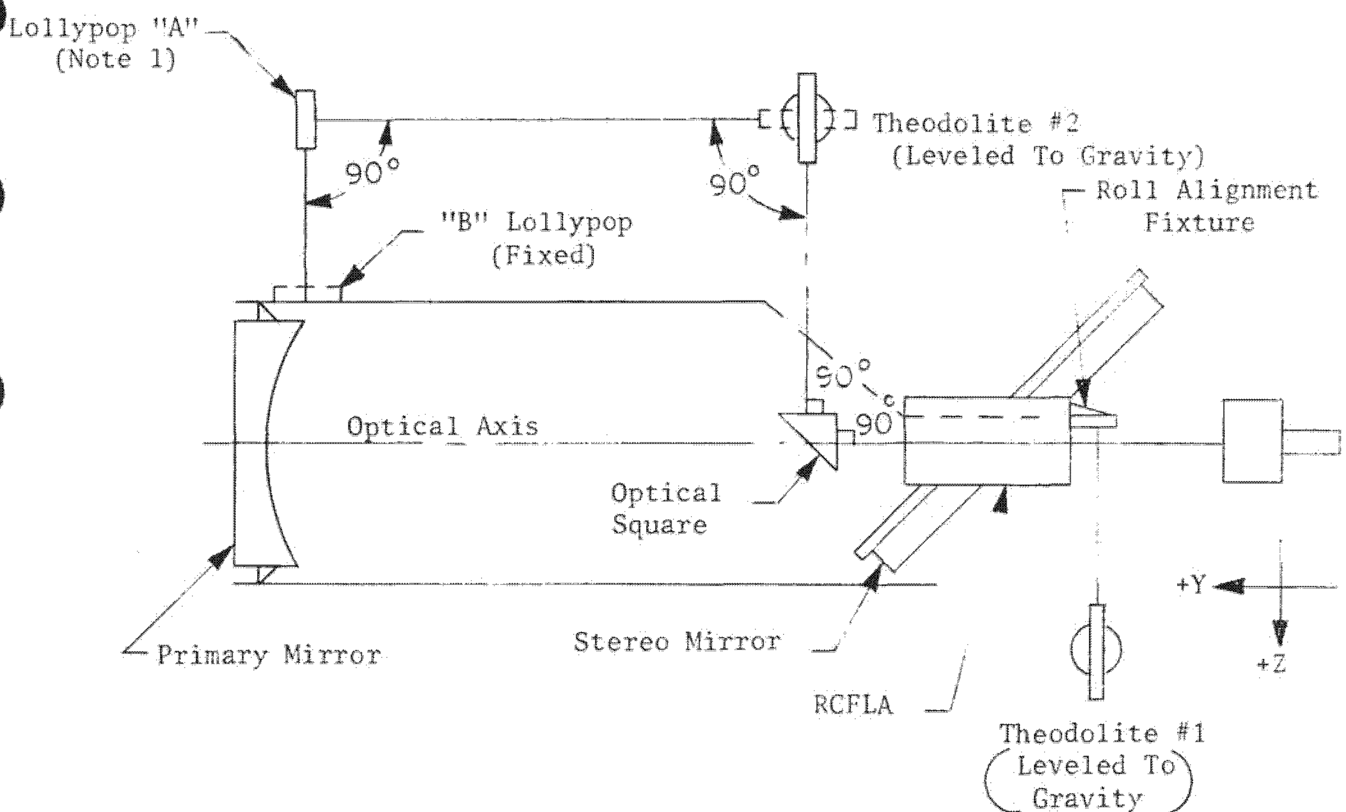
optical square and swung 45 degrees toward the stereo mirror. Aligning the mirror to this source positions it at the required 45 degrees to the optical axis.

3.2.1.3 A and B Reference Mirror ("Lollypop") Alignments. After mounting the optical components, the A and B reference mirrors or "lollypops" used in assembly of the camera optics module are aligned to the optical axis. The COA is placed in a -Y up attitude as shown in Figure 4.3-7 using theodolite number one and the roll alignment reference mirror on the RCFLA housing. Lollypop A is attached to the COA structure and the mirror adjusted to autocollimate theodolite number two, establishing a line parallel to the optical axis. Lollypop A is removed and lollypop B is attached to the structure. Since the B reference mirror is fixed, a third theodolite is used to measure the difference between the leveled theodolite and the angle needed to autocollimate off the mirror (reference Figure 4.3-7). This is performed in both the +Y up and -Y up attitudes and the average angle used at the COM level to position the COA in roll.

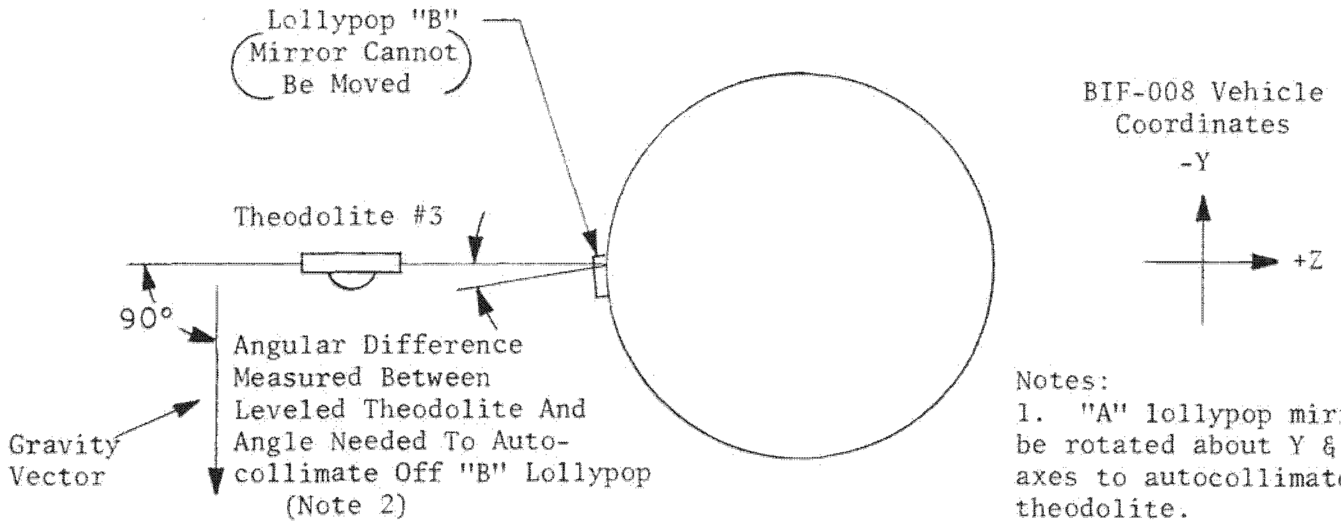
3.2.1.4 S1-Platen Reference Gauge (S1-PRG) and 9x5 Dual Platen Camera Mounting. The S1-PRG sensors are installed after alignment of the reference mirrors.* Nominal output voltage for the S1 sensor is set by adjusting the target position in the X direction with respect to the sensor. The two PRG sensors are installed but left unpinned pending determination of best focus position from COA previbration testing.

After S1-PRG installation, the dual platen camera is mounted to pads on the RCFLA housing. Previbration testing is then performed to determine best focus position and establish previbration baselines for the camera. Following this,

*For a description of the S1-PRG experimental hardware, reference Part 3, Section 13.



View From Top



+X View

Notes:
1. "A" lollypop mirror can be rotated about Y & Z axes to autocollimate theodolite.

2. Angular difference measured in both +Y and -Y up attitudes and average used at COM level.

Figure 4.3-7. Alignment Of A&B Reference Mirrors To Optical Axis the two PRG sensors are adjusted to their nominal output levels by positioning the entire sensor assembly for each with respect to its target and the sensors pinned in place. S1 and PRG previbration baselines are established for these conditions.

After completion of S1-PRG mounting, and previbration testing, the COA is vibrated with a camera mass simulator installed, and again tested. This is the last optical testing performed on the COA, and S1-PRG operational baselines and best photographic focus position baselines are established at this time. The camera is selectively shimmed at the mounting pads to optimize axial performance and equalize field performance for the 9 system.

3.2.2 External Structure

The external structure, which is the structural shell for the PPS/DP EAC consists of five major assemblies:

(1) The Aft barrel

(2) The Forward barrel

(3) The supply electronics structure (SES)

(4) The fixed adapter (FA)

(5) The ejectable adapter (EA)

Manufacturing of the structure is performed by Lockheed Missiles and Space Company (LMSC) under subcontract to BIF-008. In addition, LMSC produces many of the internal and nonstructural components as well.

For the forward barrel, nonstructural subcontract components include the hatch ejection mechanisms, the viewport doors, and the door drive components. For the SES, the junction box, the film supply enclosure, cabling, electrical heaters, thermal instrumentation, and other components are installed by LMSC.

In the EA and FA, LMSC provides the film tunnels (excluding rollers), the blast shield and blast shield valve, electrical cabling and pyrotechnic devices, mounting and ejection components for the satellite reentry vehicles and the EA, and thermal and ejection instrumentation.

All external and internal surfaces, excluding mating surfaces, are finished by LMSC to minimize electrical conductivity, galvanic corrosion, surface contamination, and corrosion during storage. Magnesium component-mounting surfaces are finished with Iridite 15 and aluminum component-mounting surfaces with Iridite 14. Metallic mating surfaces are made conductive through the use of conductive finishes. PPS/DP EAC external thermal finish patterns on the EA and FA are applied by BIF-008 at BIF-008 facilities. All other thermal finish patterns (aft barrel, forward barrel, and SES) are applied by LMSC.

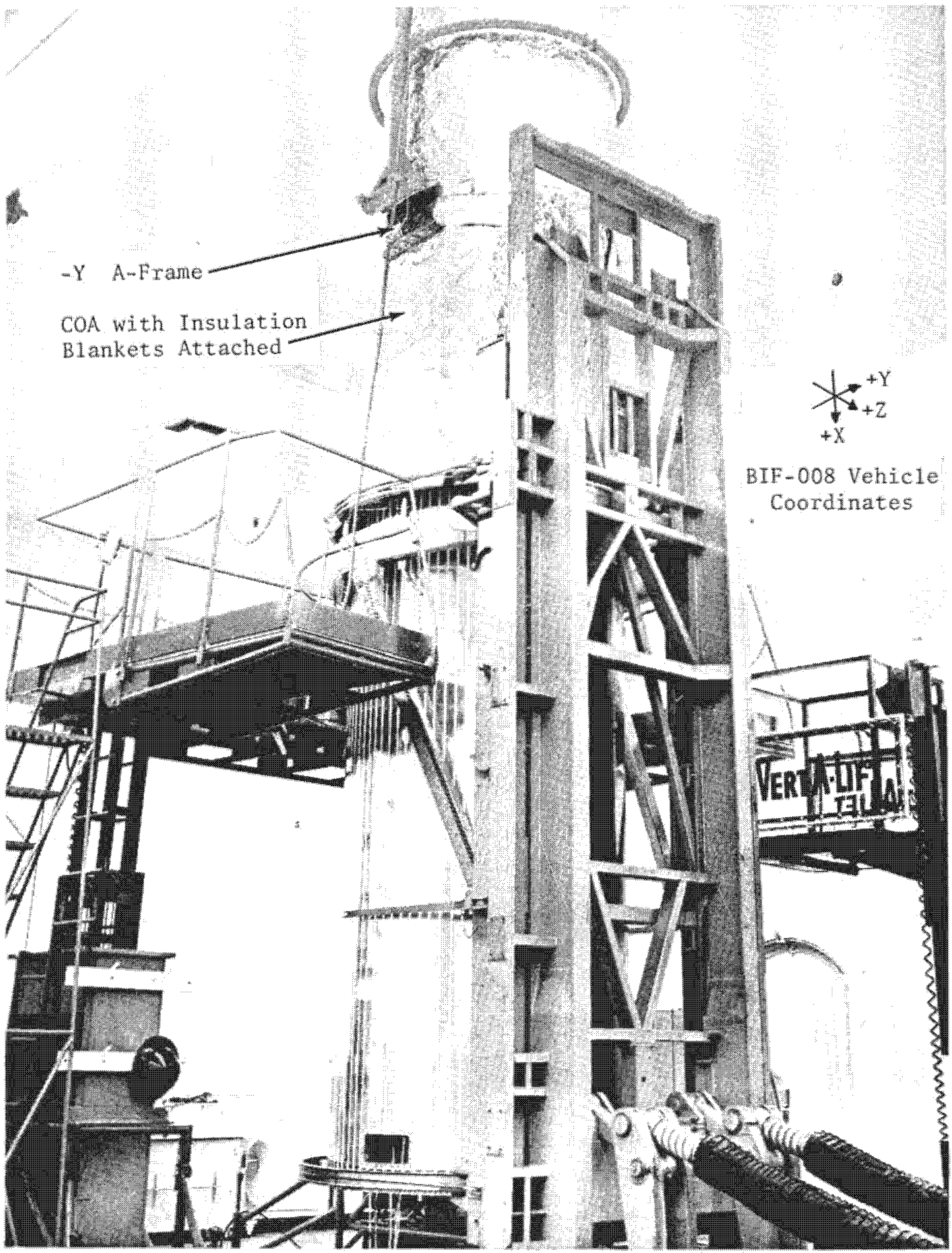
3.2.3 COM Assembly

Assembly of the COM begins with preparation of the aft barrel for mating with the COA. The fiberglass eccentric and spherical support bearing for the COA broomstick is attached to the COM aft bulkhead and the structure erected for mating in a vertical position. The forward tape support screen is attached to the forward end of the COA, and insulation blankets are installed completely enveloping the COA.

The blanketed COA is erected and lowered vertically into the aft barrel as shown in Figure 4.3-8 until the A-frame supports are in position to be bolted to the Station 150 ring of the aft barrel.

At this point, the COA is adjusted in roll with respect to the aft barrel axes. To accomplish this, an interface alignment gauge (Figure 4.3-9) identical to that used for aligning the satellite control section* is attached to the aft barrel as shown in Figure 4.3-10, and the B lollypop is attached to the COA.

*Reference Part 3, Section 1



NOTE: FM 47 Hardware shown,
FM 48 similar.

Figure 4.3-8. Mating COA to Aft Barrel

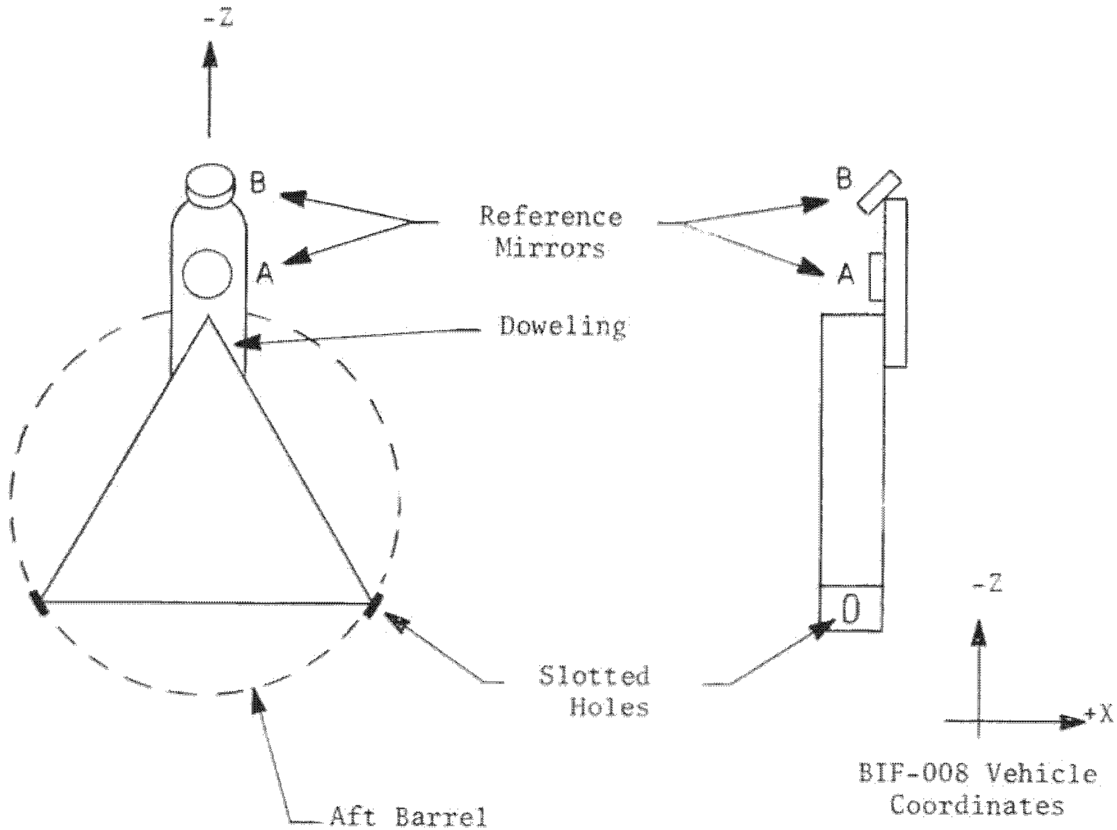


Figure 4.3-9. Interface Alignment Gauge

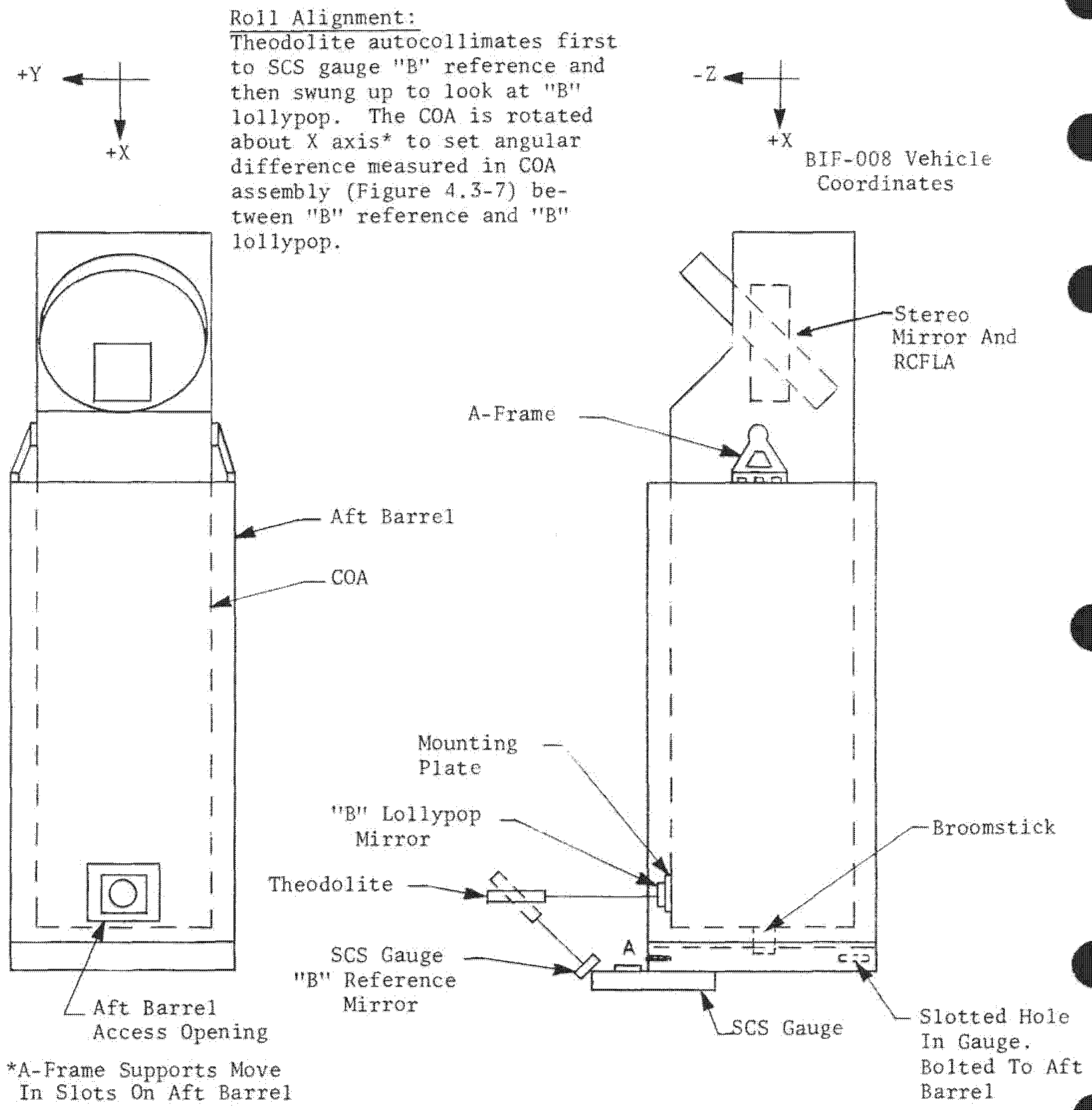


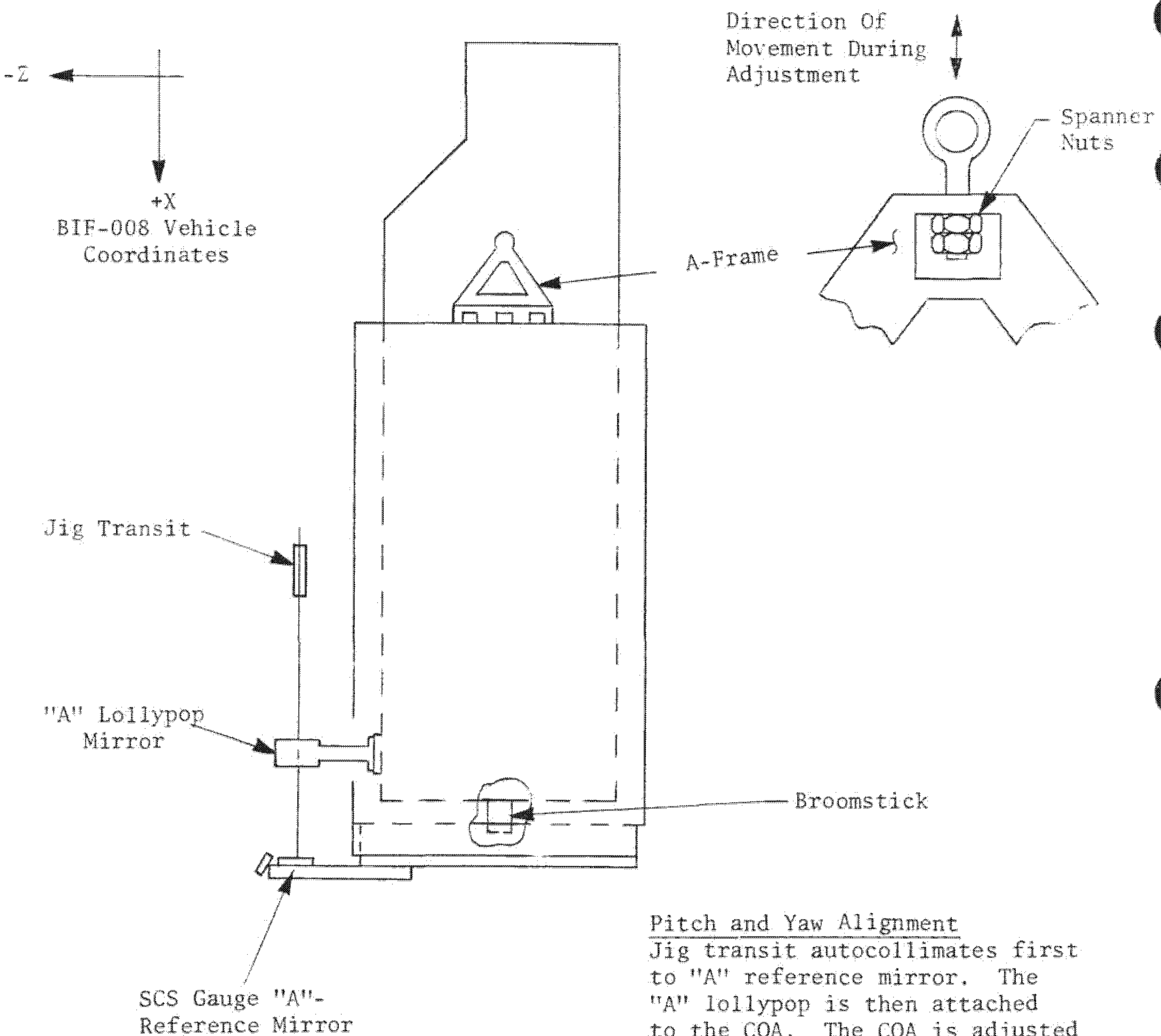
Figure 4.3-10. Optical Axis To Vehicle Axis Roll Alignment

A theodolite is aligned to mirror B on the gauge, and then swung up to look at the B lollypop. The COA is rotated about the X axis to establish the angular offset measured during COA assembly (Section 3.2.1.3), aligning the optical and external structural axes in roll. When alignment is achieved, the A-frames are bolted and pinned to the aft barrel support ring.

Next, the forward barrel (minus the ejectable hatch and viewport doors) is assembled to the aft barrel by lowering it down over the COA and attaching it to the aft barrel at station 150. The COM remains vertical after this for alignment of the optical and external structure axes in pitch and yaw. Figure 4.3-11 illustrates the procedure. A jig transit is aligned to the A reference mirror of the interface gauge. The A lollypop is then installed on the COA, and the COA aligned so that the A lollypop mirror autocollimates with the jig transit by positioning of the broomstick eccentric mount and adjustment of the -Y A-frame arm.

At the completion of the pitch and yaw alignment, the optical axis of the COA must be aligned coincident with the X axis of the external structure in the XY plane. This alignment is accomplished by installing the forward barrel interface gauge on the station (Sta) 77 forward barrel interface. There are reference surfaces on the camera and on the interface gauge. Measurements are made using depth micrometers to determine the Y and Z axis translation position of the COA relative to the forward barrel. Adjustments in Y translation are made by using the adjustable A-frame and broomstick eccentric. Generous tolerances in Z axis translation preclude the need for adjustments. Pitch and yaw alignment are maintained during the translation adjustment by maintaining autocollimation between the A lollypop and SCS A mirror.

Following the alignment sequence, the COM is lowered to horizontal and the forward end moved into a laminar flow tent. The camera is cleaned and the bellows installed. A "hot-dog" simulation test (reference Part 4, Section 4) is per-



<u>Pitch and Yaw Alignment</u>
Jig transit autocollimates first to "A" reference mirror. The "A" lollypop is then attached to the COA. The COA is adjusted by the broomstick eccentric and the adjustable (-Y) A-frame so that the "A" lollypop autocollimates with the jig transit.

Figure 4.3-11. Optical Axis To Vehicle Axis Pitch And Yaw Alignment formed to check for any mechanical coupling between the COA and external structure, and the COM is complete and ready for final testing and inspection.

3.2.4 SEM Assembly

The basic SEM structure is formed by the SES manufactured by LMSC. Figure 4.3-12 illustrates the SEM assembly flow following completion of the SES by LMSC.

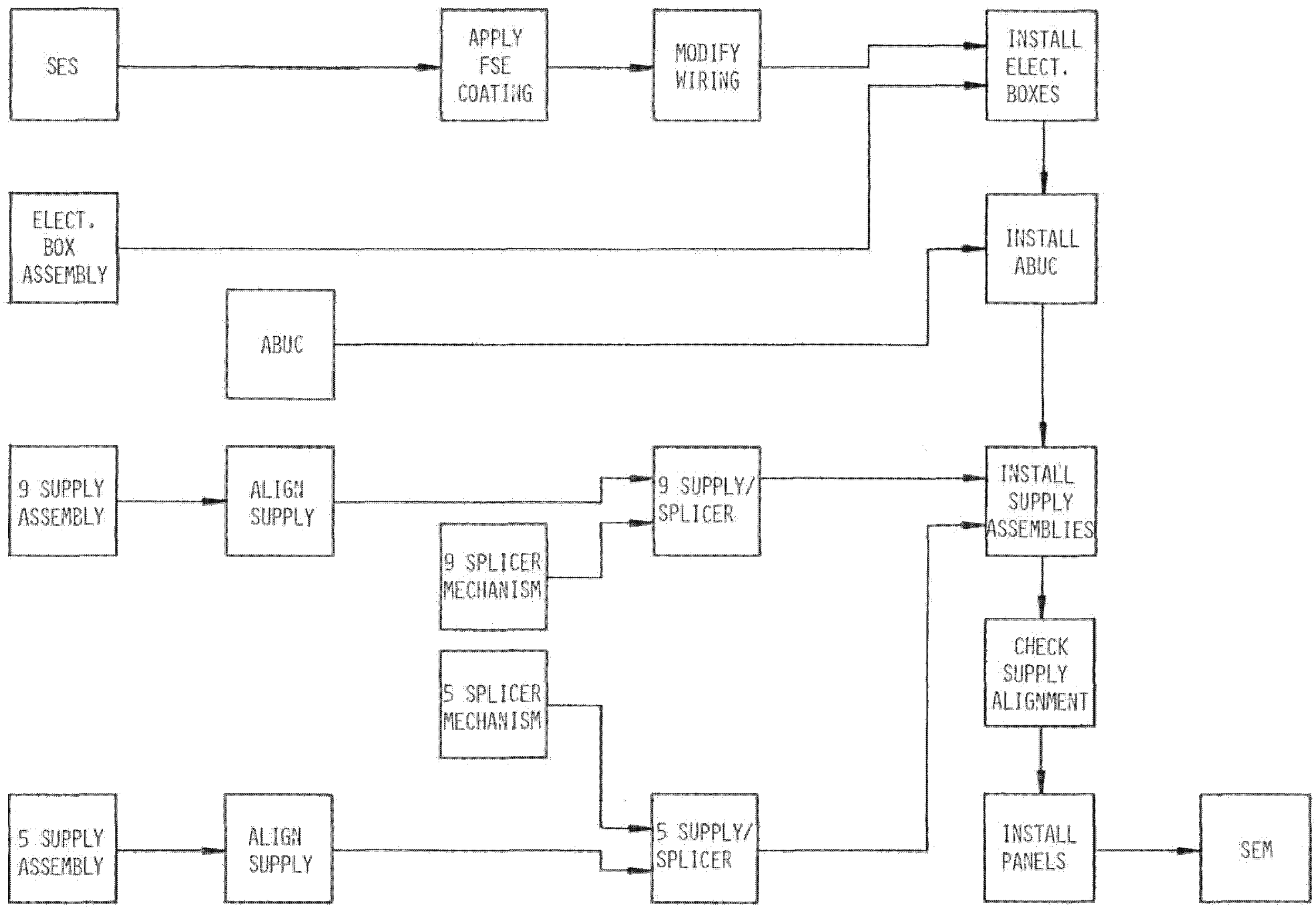
Upon receipt at BIF-008 facilities, the SES is disassembled and inspected. A sticky "fly paper" coating is applied to the inside surface of the film supply enclosure to trap any contaminants that come in contact, and any necessary wiring modifications are accomplished in the junction box and electrical harnesses. After electrical testing, the SES is ready for installation of the remaining components, including the film supplies and electronic boxes.

3.2.4.1 Film Supply Assemblies. The 9 and 5 supply assemblies, excluding splicer mechanisms, are built at BIF-008 facilities.

Assembly of the 9 supply begins with construction of the spool core and drive assembly, and the frame and looper assembly (reference Part 3, Section 2). The two are then combined to form the basic 9 supply. Next, the supply rollers and components are aligned for proper film tracking and the completed assembly tested. The splicer mechanism is installed and the entire assembly tested once more prior to installation in the SEM.

The 5 supply is assembled and aligned much like the 9 supply. However, the spool drive is not internal to the core and thus two separate initial assemblies are not required.

3.2.4.2 Electronic Box Assembly. The majority of electronic units are designed and built by BIF-008. Those not manufactured by BIF-008 include the following:



NOTE: TEST SEQUENCES NOT SHOWN

Figure 4.3-12. SEM Assembly Flow

(1) Viewport door electronics

(2) Initiator electronics unit

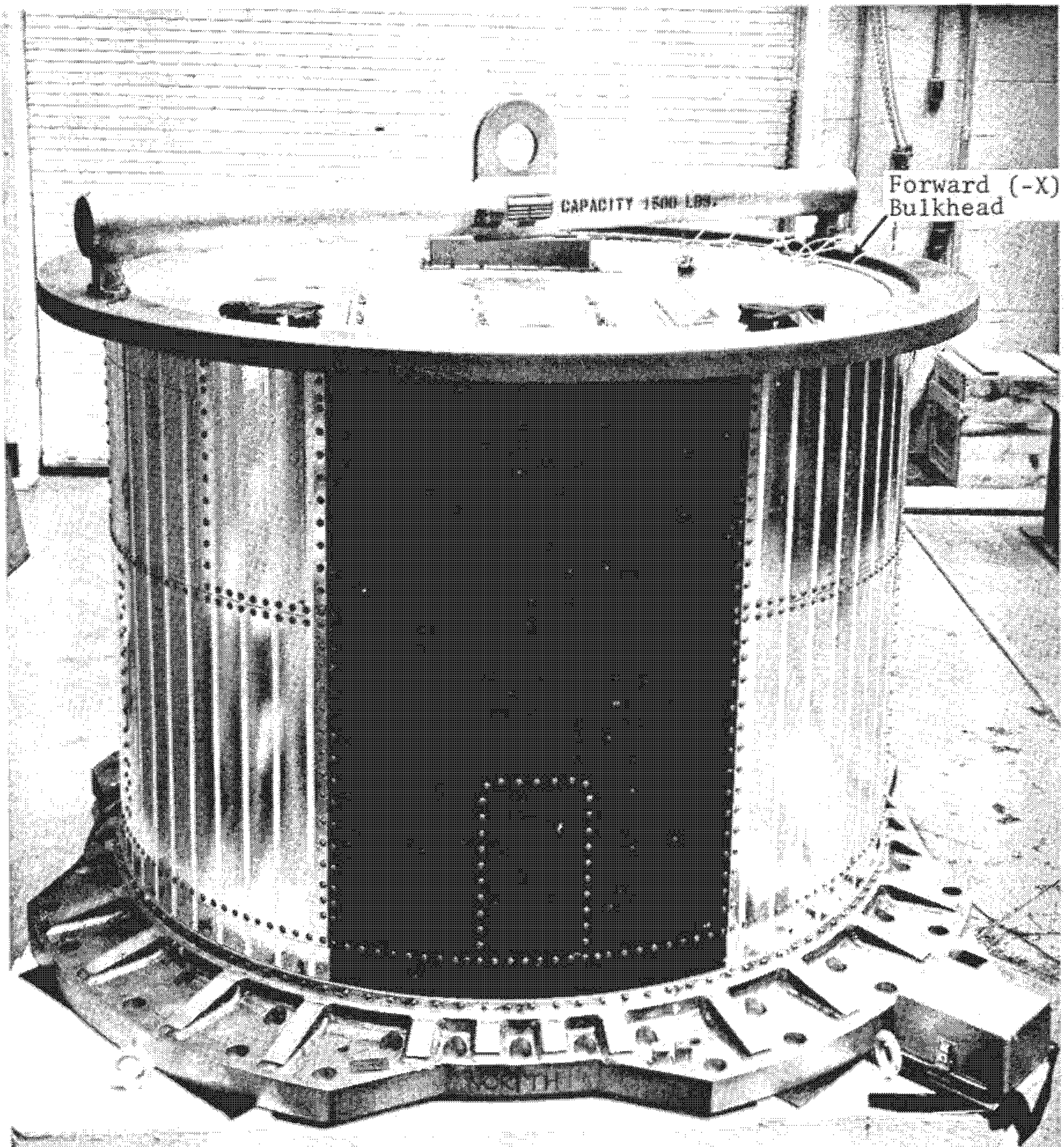
(3) Digital telemetry unit

Each box is tested at various stages of assembly and acceptance tested prior to installation in the SES. Purchased units are tested by the subcontractor and then acceptance tested upon receipt at BIF-008 facilities. In addition, BIF-008 retains the right to review and inspect subcontractor designs and assembly procedures to ensure reliability of the units.

3.2.4.3 Splicer Mechanisms and Aft Backup Cutter. Other major components of the SEM include the 9 and 5 splicer mechanisms which become part of the respective supply assemblies, and the aft backup cutter which mounts on the +X side of the forward SEM bulkhead. All three are subcontract items manufactured by LMSC.

3.2.4.4 Final SEM Assembly. Final assembly of the SEM starts with installation of the film supply enclosure venting valves and other small components. Next, the various electrical boxes are mounted to their support rails and connectors mated. Installation of the aft backup cutter and the 9 and 5 film supplies completes assembly of the SEM, and it is ready for acceptance testing.

Following acceptance testing, a previbration alignment verification check is performed to measure the alignment of the 9 and 5 supplies to each other and to the Sta 34.5 interface. The supplies are not adjustable so their alignment to the interface depends on the mechanical tolerances built into the SES. The SEM is then sent through vibration testing and the supply alignments checked again to determine if any shifting has occurred. After a final inspection, the SEM is ready for mating to the COM (see Figure 4.3-13).



NOTES: 1. FM 47 Hardware shown, FM 48 similar.

2. SEM Mounted on Vibration Fixture.

[redacted]

Figure 4.3-13. Supply Electronics Module (-Z View)

3.2.5 DRM Assembly

BIF-008 construction of the DRM begins with receipt of the EA and FA from LMSC. After inspection, the thermal pattern finish is applied. Simultaneous with this, the cutter/sealer (C/S) and tunnel sealer record trap (TSRT) mechanisms manufactured by LMSC are installed in the 9 and 5 TSRT assemblies and the assemblies mounted in the FA. After TSRT mounting, the film tunnel insulation blankets and blast shield blanket are attached. The EA and FA are then mated for testing and separated again following testing for mating with the satellite reentry vehicles. Figure 4.3-14 summarizes these and following assembly steps.

3.2.5.1 Satellite Reentry Vehicles (SRV's). Design and assembly of the two SRV's is the responsibility of General Electric Reentry and Environmental Systems Division (GE RESD), an associate contractor on the Gambit Program. BIF-008 manufactures and supplies the 9 x 5 take-up mechanisms to GE RESD for installation in the recoverable capsule portion of the SRV. The film path C/S device installed by GE RESD is also supplied by BIF-008, and, like all other C/S devices in the PPS/DP EAC, is manufactured by LMSC. After assembly, GE RESD tests the SRV's, aligns the film take-ups, and then ships the SRV's to BIF-008 for integration with the EA and FA.

3.2.5.2 DRM Final Assembly. Upon receipt at BIF-008 facilities, the SRV's are fully inspected and tested. SRV 1 is mounted on the EA and SRV 2 on the FA. Film take-up alignment is checked and further testing performed. Following this, the EA and FA, with their respective SRV's attached, are mated, and the assembled module acceptance tested to verify operation and establish a pre-vibration baseline. After vibration, take-up alignment is again checked and the DRM completely retested. An overall inspection is performed, and the DRM is ready for mating with the SEM and COM (see Figure 4.3-15).

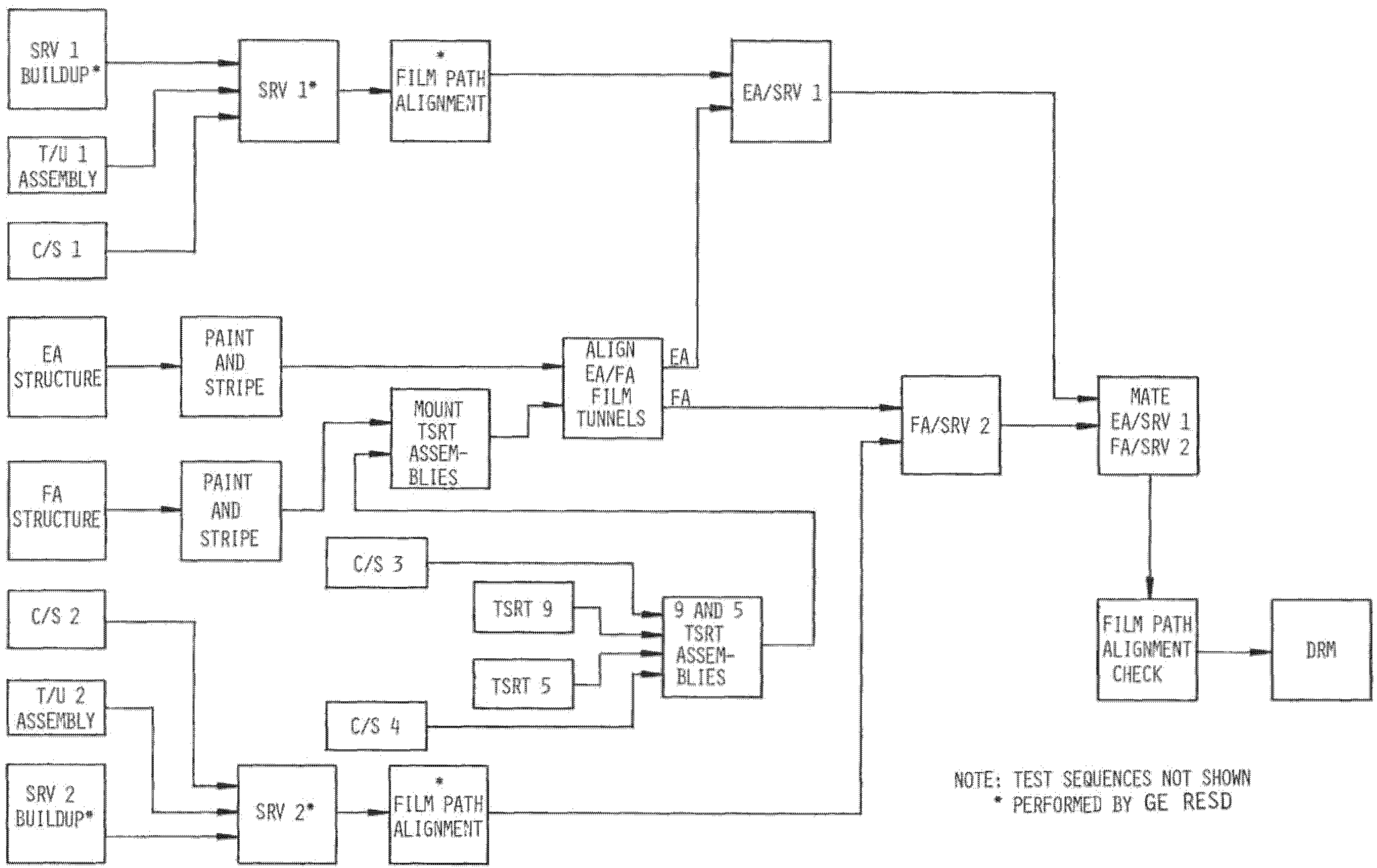


Figure 4.3-14. DRM Assembly Flow

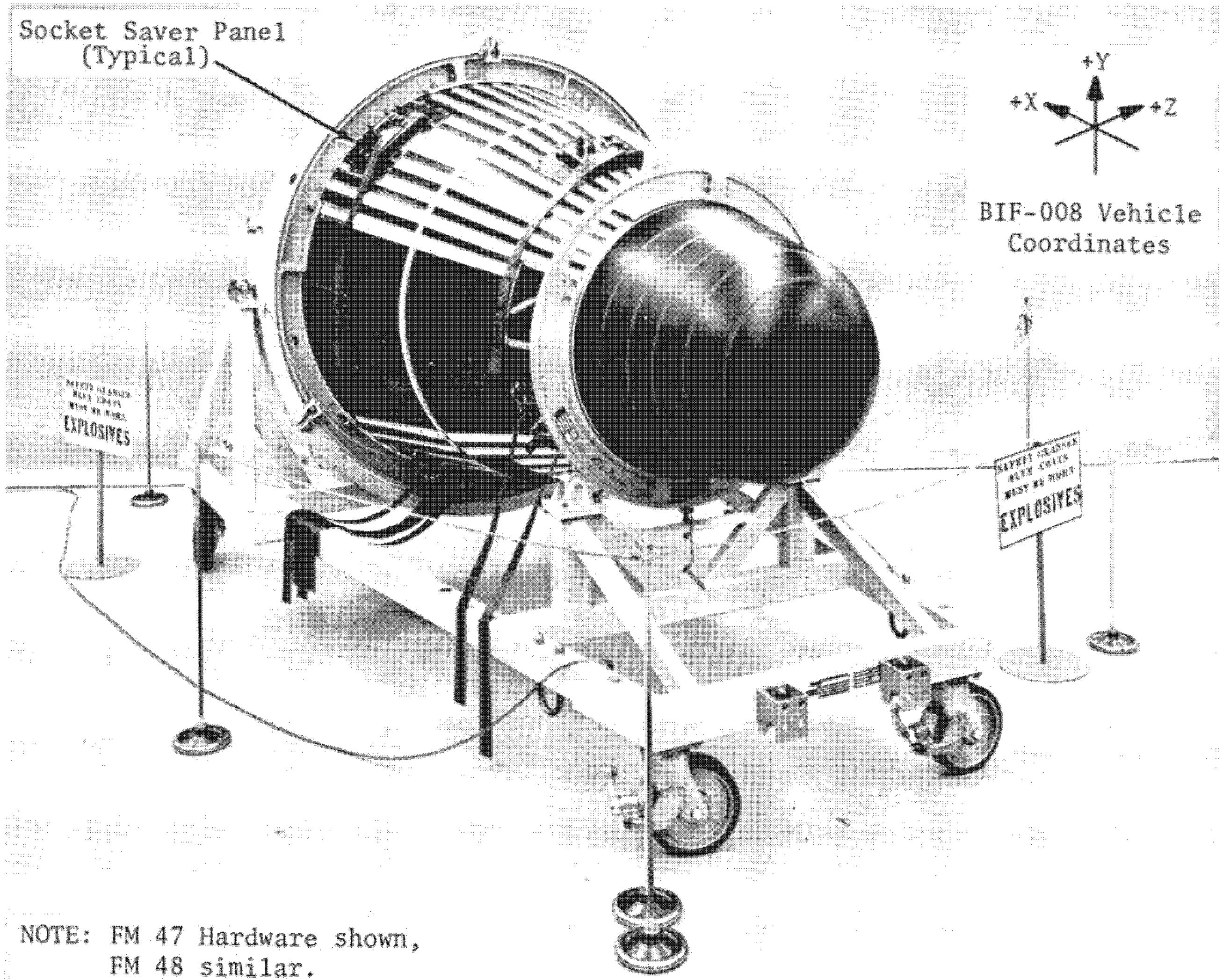


Figure 4.3-15. Dual Recovery Module

3.2.6 PPS/DP EAC Assembly

PPS/DP EAC assembly consists of mating and testing the three separate modules: the SEM, COM, and DRM. In the assembly sequence, the SEM and COM are mated first to form the SEM/COM unit (Figure 4.3-16) and broomstick testing is performed to check for any mechanical coupling between the COA and external structure.* An additional test measures the mass moment of inertia about the vehicle X axis. The DRM is then mated to the SEM/COM to complete the PPS/DP EAC. (DRM X-axis mass moment of inertia is measured during DRM testing and is combined analytically with the SEM/COM mass moment.) At this point, a full acceptance test is run to ensure proper vehicle operation.

After testing, the viewport doors are installed on the forward barrel, the vehicle pyrotechnic devices are loaded and final testing is performed. The vehicle is then cleaned and prepared for storage or shipment. Figure 4.3-17 illustrates the completed PPS/DP EAC.

*Reference Part 4, Section 4

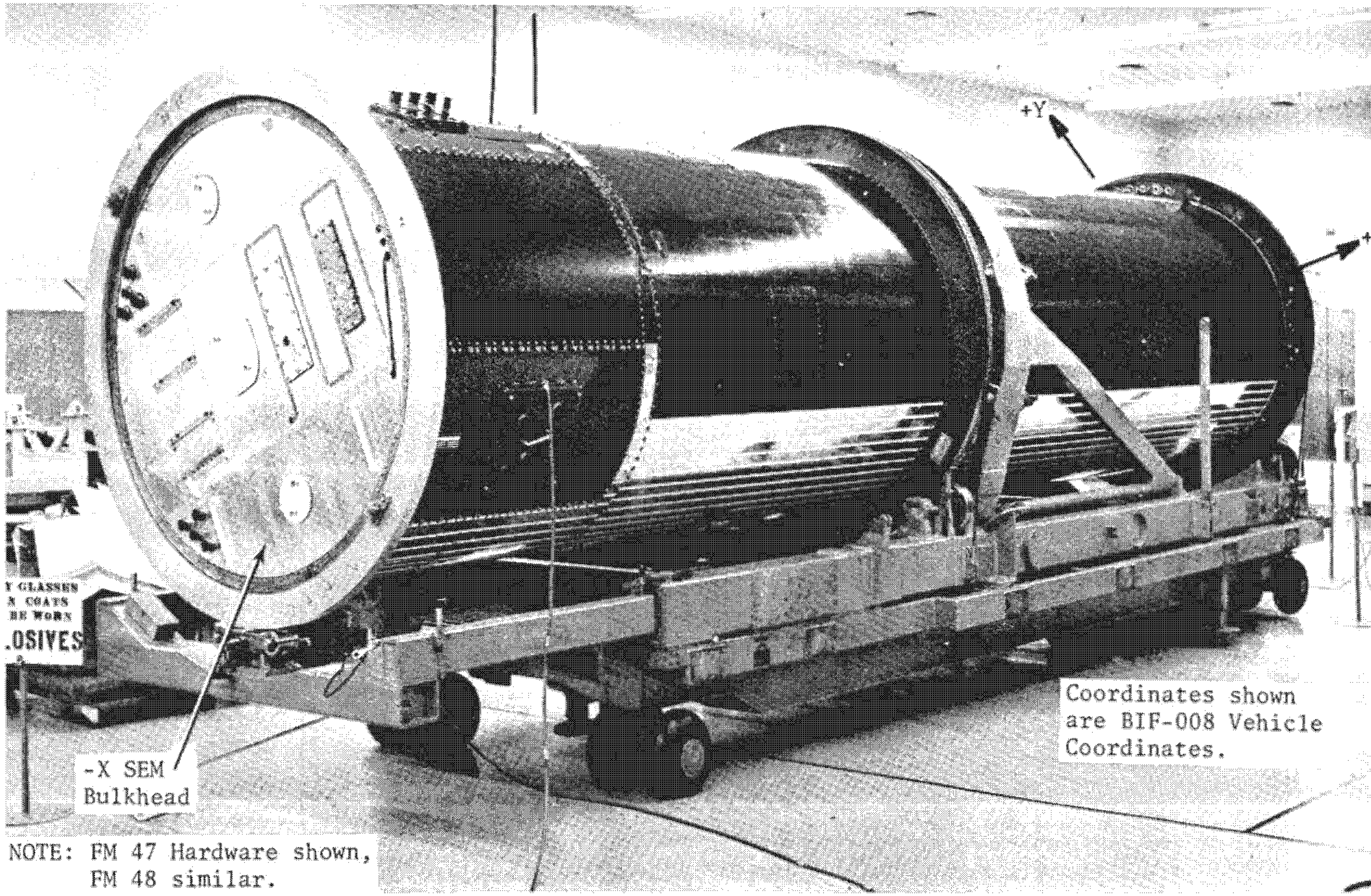
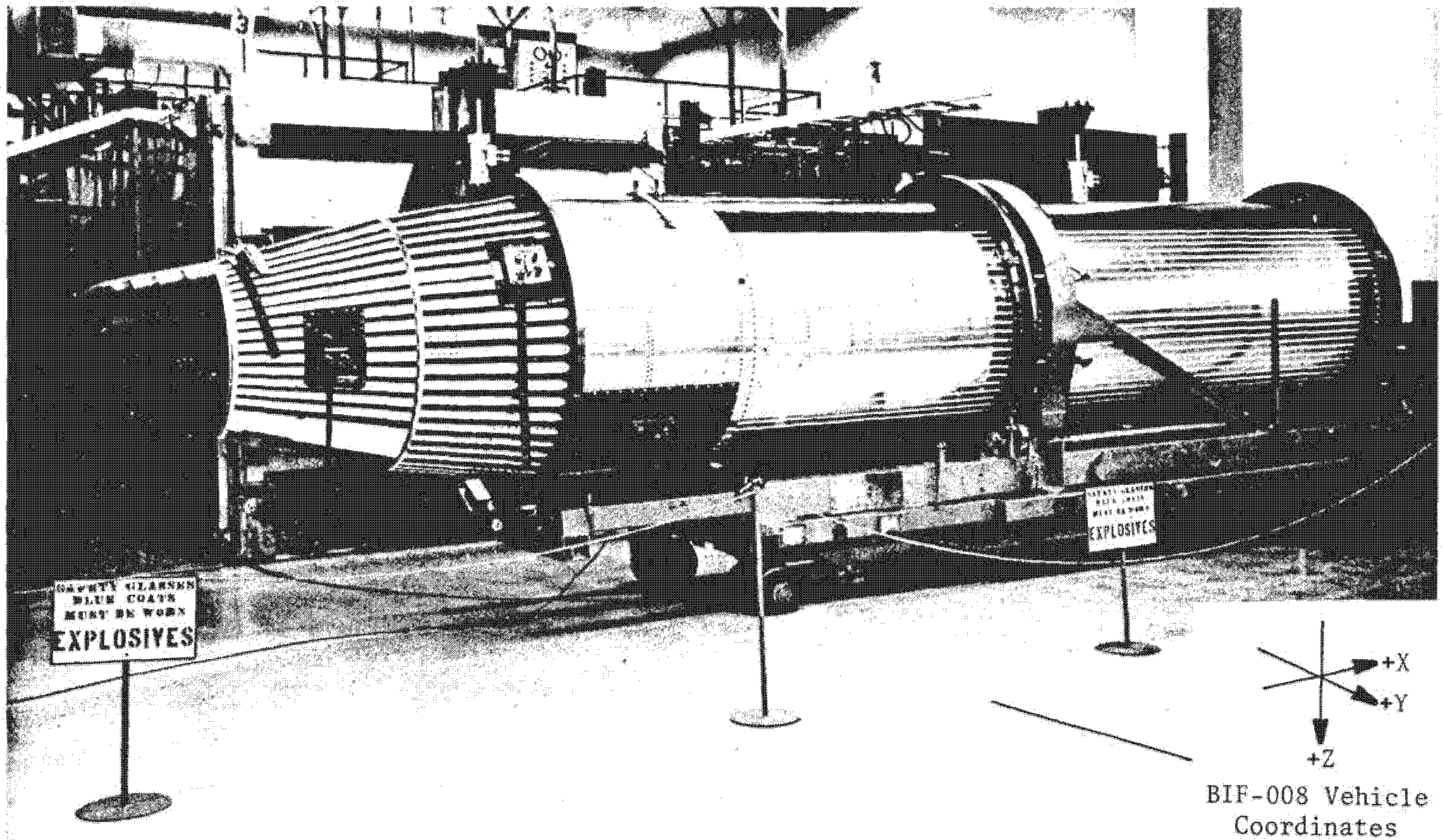


Figure 4.3-16. SEM/COM Assembly



Note: Hardware shown is representative of FM-47. FM-48 differs in that the aft diameter of SRV 1 is slightly greater than the forward diameter of the ejectable adapter.

Figure 4.3-17. PPS/DP EAC

4.0 TESTING

Comprehensive testing of components, major assemblies, modules and the photographic payload section/dual platen extended altitude capability (PPS/DP EAC) is performed to assure that the BIF-008 deliverable hardware meets specified requirements for performance, reliability and in-use environmental conditions.

Environmental design and test criteria have been established for the PPS/DP EAC modules, major assemblies and components through a series of specifications, the compliance with which will result in a high-performance PPS/DP EAC.

4.1 Optical Components and Camera Optics Assembly Testing

Testing of the camera optics assembly (COA) for optical quality and performance proceeds from testing of the individual optical components to acceptance testing of the completed COA.

4.1.1 Lens and Mirror Component Testing

Optical components are tested for surface quality, proper dimensions, and other factors pertinent to each individual element. These tests are performed after manufacturing of the components and at various stages of assembly.

4.1.1.1 Primary Asphere and Stereo Mirror. Acceptance testing of the primary and stereo mirrors includes interferometric evaluation of surface quality, as well as measurements of reflectance and of the vertex radius of the primary mirror. Simplified diagrams of the optical test setups employed to evaluate the quality of the stereo and primary mirrors are shown in Figure 4.4-1. The effect of gravity-induced distortion on the surface quality of the large light-

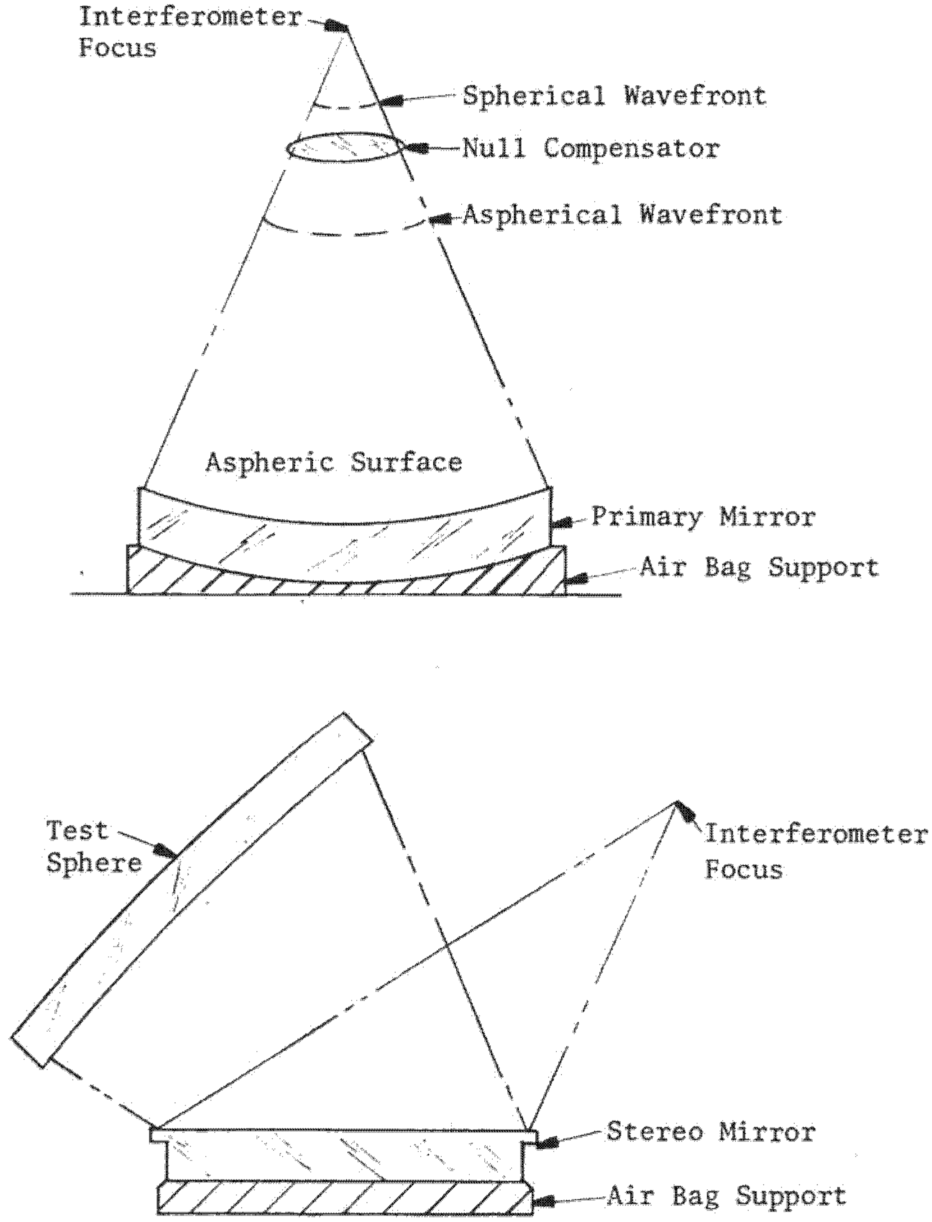


Figure 4.4-1. On-Back Primary and Stereo Mirror Tests

weight mirrors is minimized by supporting the mirror on its back on a properly inflated air bag. In each case, an interferometer is located at the equivalent center of curvature for the aspheric primary mirror or the test sphere for the stereo mirror. The two-element refractive null compensator which is used in the evaluation of the primary mirror converts the aspheric wavefront produced by the primary mirror to a spherical wavefront for interferometric evaluation. The error contribution of the test sphere and null compensator are accurately known and are taken into account when evaluating the quality of the primary and stereo mirrors. Surface quality measurements are first made after the deposition of the high reflectance coating and again after the mirrors have been potted into their mounts. During the testing of mounted mirrors, the mounts are counter-balanced so that their weight does not degrade the surface quality of the optic.

4.1.1.2 Ross Corrector and Field Lens Assembly (RCFLA) Testing. Measurements made on finished RCFLA elements or, where appropriate, on representative glass samples, include: surface irregularity, radii, element thickness, index of refraction, partial dispersion, homogeneity and birefringence.

Acceptance testing of the assembled RCFLA includes measurements of the alignment of the elements, air spacing and leak rate.

4.1.2 Lens Assembly and COA Testing

The Ross match and COA level testing are performed with the optical axis horizontal and the primary, stereo and autocollimating test mirrors supported on edge. The testing is conducted in the +Y up and -Y up vehicle orientations. An autocollimation technique employing a 48-inch diameter test flat is used to define the best focus position for an object at infinity. Figure 4.4-2 is a simplified diagram of the test setups for the Ross match and COA level optical

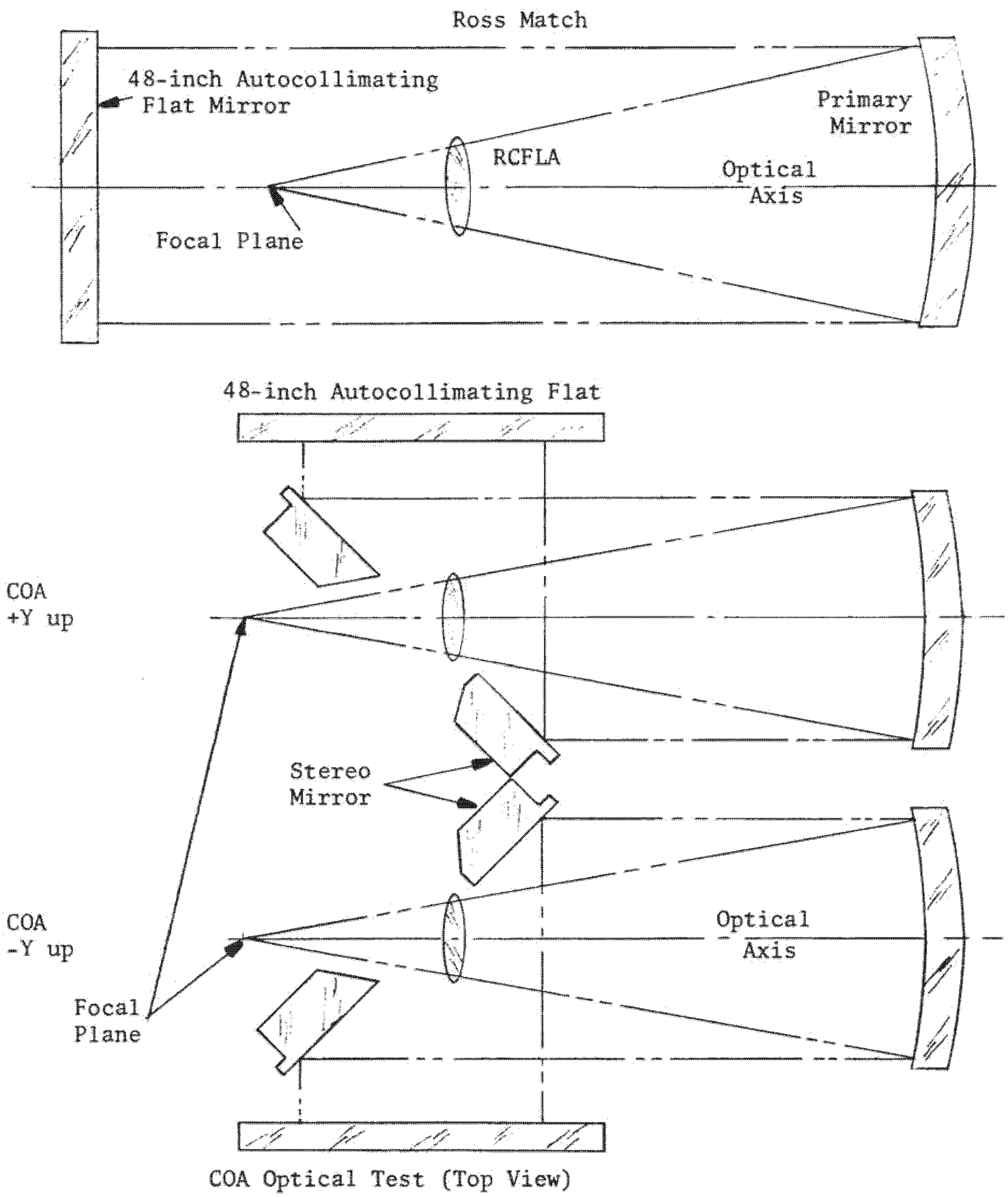


Figure 4.4-2. Ross Match and COA Level Optical Test Set-Ups

testing. The object (tri-bar target, interferometer, etc.) is located at the approximate point of focus of the lens. Accordingly, the beam of light reflected from the surface of the primary is collimated and is reflected by the stereo mirror to the autocollimating test flat which folds the beam back into the lens. The test flat is adjusted to properly position the return image.

During the double-pass autocollimation process, lens aberrations and surface errors encountered are twice as large as those experienced in the single-pass flight condition. While the effect of this process on wavefront errors is linear, the modulation produced by the lens is affected in a nonlinear fashion. Accordingly, double-pass resolution measurements cannot be rigorously interpolated to single-pass quality estimates. As an alternative, samples of double-pass interferometric wavefront quality are processed by various computer programs to provide rigorous predictions of optical and photographic performance. A description of this technique can be found in Part 2, Section 12, "Optical Analysis".

4.1.2.1 Ross Match Testing. After acceptance testing, the mounted primary mirror is installed in the end bell assembly. The RCFLA and primary mirror (which constitute the lens of the COA) undergo an in-process Ross match test which has the following objectives:

(a) Evaluation of the wavefront quality of the lens devoid of stereo mirror surface and on-edge gravity distortion errors.

(b) Optimization of RCFLA and primary mirror alignment.

(c) Evaluation of lens back-focus distance, image plane tilt and field-curvature characteristics.

Objectives (a) and (b) are achieved via axial interferometry obtained in both test attitudes and averaged to minimize any effect caused by distortion of the optical components due to gravity. The contribution of the calibrated wavefront error of the autocollimating test flat is removed from the Ross match wavefront during interferometric processing. An estimate of system wavefront quality and OQF are made by addition of the wavefront errors of the Ross match and stereo mirror to the wavefront. Back-focus and image-plane characteristics are assessed through static, double-pass, "white-light" photographic, tri-bar resolution testing which is performed on axis and at the ±1.05 degree semifield positions. Back-focus and field curvature are controlled by adjusting the air space (S_1) between the primary and the RCFLA.

4.1.2.2 COA Buildup. After Ross match testing, the RCFLA, the stereo mirror and the primary mirror (assembled in its end bell) are installed in the internal structure. The primary mirror/RCFLA alignment, which was determined at the Ross match level, is transferred to the COA. The assembly-aid reference mirror "A" and the stereo mirror are aligned to the optical axis of the RCFLA.

The "B" (Roll) reference mirror is installed and measured.* The effect of gravity-induced structural distortion on system alignment is accounted for by setting the alignment equal to the average of the gravity-induced displacements encountered as the vehicle is rolled 180 degrees relative to gravity. This technique involves a simple application of Hooke's law to a structure which exhibits little hysteresis effect.

4.1.2.3 COA Testing. Testing at the COA level is complicated by the gravity-induced distortion of the surface of the stereo mirror which is supported on edge (trunnion axis vertical), and the distortion of the COA structure. The on-edge gravity distortion of the stereo mirror is minimized by supporting the mirror on test jacks inserted into the side mounts of the mirror 1 3/8 inches forward of its center of gravity. A nominal upward force of 250 pounds push and pull is applied at the gravity-bottom and gravity-top

*Reference Part 4, Section 3 for a description of optics and reference mirror alignment.

side mounts, respectively. This action minimizes the gravity distortion of the stereo mirror and removes its weight from the internal structure.

During testing, the COA is mounted in a cradle and supported in a manner similar to its mounting in the external structure. The COA is supported by the "A" frames and by the rod or "broomstick" of the primary mirror end bell assembly which is in turn supported in a spherical bearing. The influence of gravity on the internal structure tilts and decenters the RCFLA relative to the primary mirror. Load compensation forces are applied at critical points of the structure and of the RCFLA to reduce structural deflections and RCFLA/primary mirror misalignment. Figure 4.4-3 illustrates the condition of the COA for uncompensated and load-compensated cases.

Although the gravity distortion of the stereo mirror has been minimized through load compensation, measurements of wavefront quality made in any single test attitude are in error (deviate from the "ZERO-G" wavefront) by the amount of residual gravity-induced distortion present in the stereo mirror after load compensation. This residual component of gravity-induced distortion is cancelled by averaging the wavefront optical path difference (OPD) arrays obtained in the +Y up and -Y up orientations of the COA.

A similar averaging technique is employed to eliminate the effects of residual structural distortion on the determination of best photographic focus and image-plane characteristics. A simplifying assumption is made that these parameters are equally and oppositely affected by vehicle orientation to gravity. Best photographic focus (BPF) and image-plane characteristics are then derived from the average of results obtained in the +Y up and -Y up test attitudes.

Photo-optical testing occurs at the nominal anticipated operational temperature (65.5F) and in a soft (optical) vacuum environment to minimize the effects of

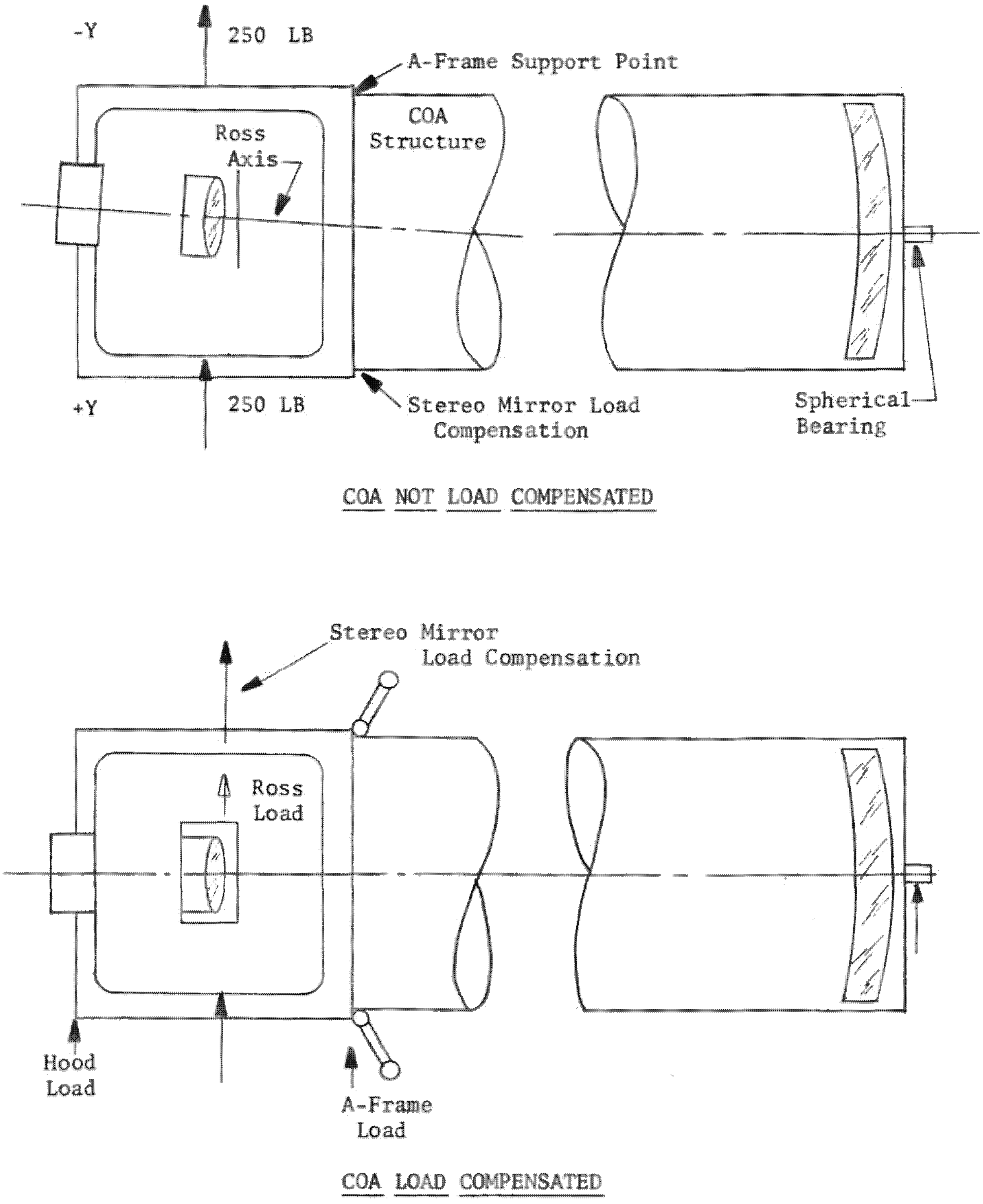


Figure 4.4-3. Condition of COA for Testing

thermally-induced air stratification or turbulence in the long air-test optical path.

Final assessment of optical performance is made at the full COA assembly level after COA vibration at acceptance levels. Estimates of the single-pass, static, heterochromatic optical quality factor (OQF) and limiting tri-bar resolution at 2:1 contrast are derived from wavefront samples obtained axially, at the center of the 5 platen position, and at the ±1.05 degree semi-field angle positions. The measured indices of the manufactured refractive elements are employed in the software program used to compute modulation transfer functions (MTF's) and resolution values. This permits incorporation of the specific axial- and field-color aberrations to the OQF of the manufactured lens. Smear MTF's calculated from the 9 and 5 film drive component optical encoder and drive smoothness tests are used to predict dynamic quality factors and limiting resolution values of the COA.

Post-vibration testing includes a calibration of those photo-optical parameters required for flight operations. These include:

(1) effective focal length (EFL)

(2) settling time of the stereo mirror

(3) stereo-mirror instrumentation and line of sight (LOS)

(4) "A" and "B" reference mirror LOS

(5) integrated transmittance for the 9 and 5 systems

(6) S1-PRG operational baselines

BPF and image-plane characteristics are assessed via double-pass, static, through-focus, tri-bar resolution testing performed axially and in the ±1.05 degree semi-field positions. These results are adjusted for testing/operational environmental differences.

The camera is selectively shimmed to the mounting pads of the RCFLA to optimize axial performance and equalize field performance for the 9 film drive subsystem. Confirmation of proper platen setting is derived from "through-platen interferometry" occurring under thermally-stabilized and load-compensated conditions, in the ±Y orientations. Through-focus interferometry acquired through 8 mm objectives located in the 9 and 5 platens is evaluated to confirm that both platens are set at their best focus positions. S1 sensor and PRG operational baselines are established for these conditions.

4.1.2.3.1 Objective of COA Testing. Objectives of COA testing are:

(1) To verify that the basic optical parameters are set in compliance with appropriate drawings and specifications.

(2) Detection of errors in the assembly of the optical components.

(3) To determine the single-pass level of performance of the system.

(4) To determine the focal plane of the system.

(5) To demonstrate the stability of the photo-optical parameters during acceptance-level vibration.

(6) To calibrate the photo-optical parameters required for flight operation.

The standard COA acceptance test flow is summarized in the paragraphs which follow.

4.1.2.3.2 Pre-Vibration Testing.

(1) Measure S1 and RCFLA/primary mirror alignment.

(2) Load compensate in the +Y up attitude.

(3) Perform axial interferometry and static tri-bar resolution testing.

(4) Roll the COA to the -Y up attitude and load compensate.

(5) Perform axial interferometry and static tri-bar resolution testing.

(6) Establish S1 and PRG sensor vibration baselines.

4.1.2.3.3 COA Vibration. COA vibration comprises X-axis sine vibration over the 10 to 50-Hertz frequency range. Figure 4.4-4 shows the COA on the vibration fixture.

4.1.2.3.4 Post-Vibration Testing

(1) Measure S1 and RCFLA/primary mirror alignment.

(2) Assess stability of S1 and PRG sensors through vibration.

(3) Load compensate in the +Y up attitude.

(4) Perform interferometric and static tri-bar resolution tests on axis and in the fields.

(5) Roll the COA to the -Y up attitude and load compensate.

(6) Perform interferometric and static tri-bar resolution tests on axis and in the fields.

(7) Evaluate stability of quality and focus over 10F range.

(8) Measure: a. Effective focal length

b. Stereo mirror crab and stereo angles

c. Instrumentation

d. "A" and "B" reference mirror angles

e. Stereo mirror settling time

(9) Perform through-platen interferometry to confirm platen position. Establish S1 and PRG sensor flight baselines.

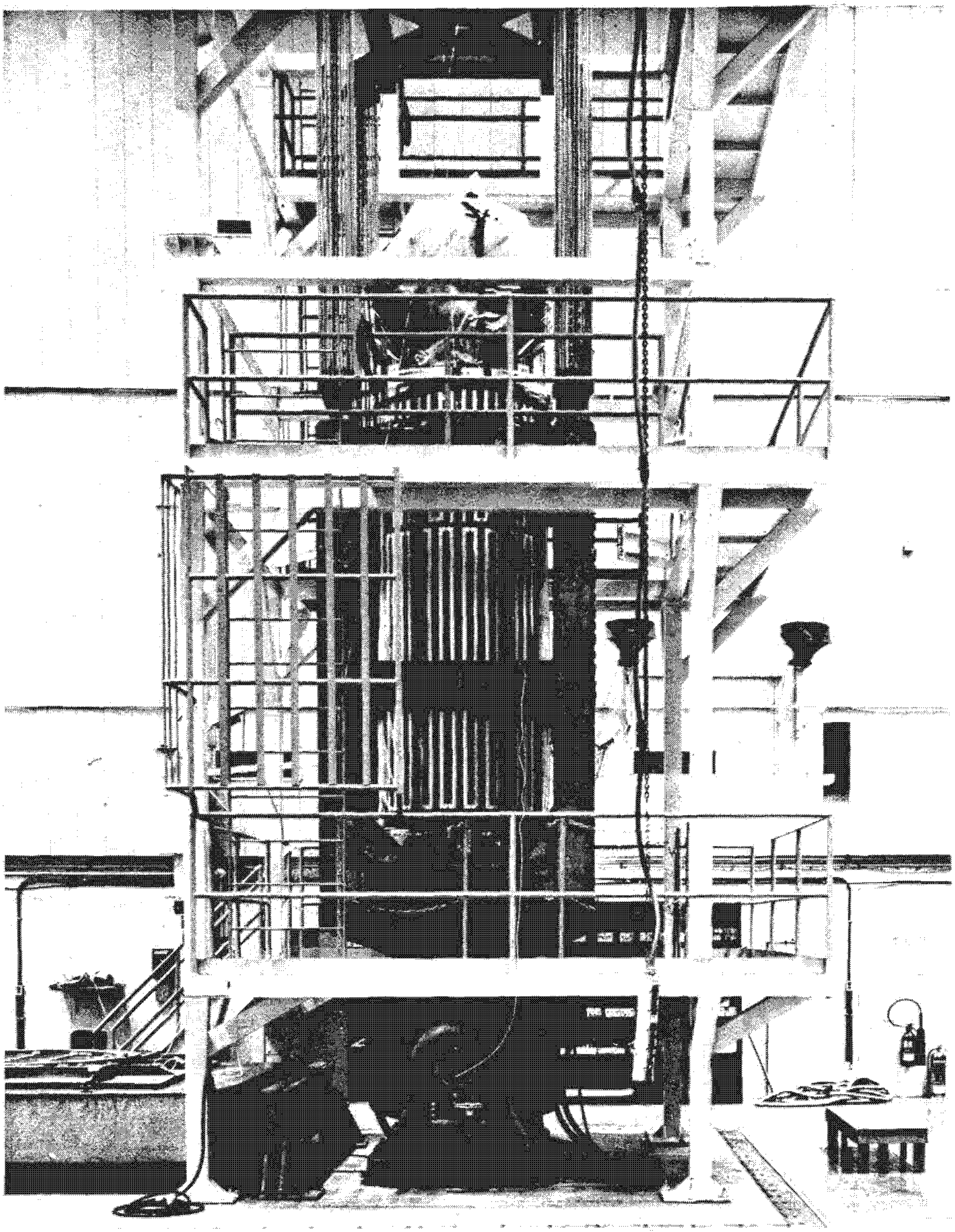


Figure 4.4-4. COA on Vibration Fixture

After acceptance testing, the COA is committed to COM and higher-level assembly buildup. The kinematic nature of COA support in the external structure, coupled with clearance checks at critical points, and proven handling techniques, elminate the necessity of photo-optical testing at higher levels of assembly. The standard COA assembly and test flow described in these paragraphs is shown in Figure 4.4-5.

4.2 Electrical/Mechanical Component Testing

"Component" is a term used to denote a black box rather than a part. Component testing begins with in-process tests designed to demonstrate integrity of wire runs and functional operation at selected points in the assembly/buildup stages. In-process testing is performed on electrical boards, modules, motors, encoders, potentiometers and box subassemblies. The objective of in-process testing is to perform checks to verify operation or detect part defects and assembly errors at the earliest practical point in the assembly cycle with a minimum test complexity.

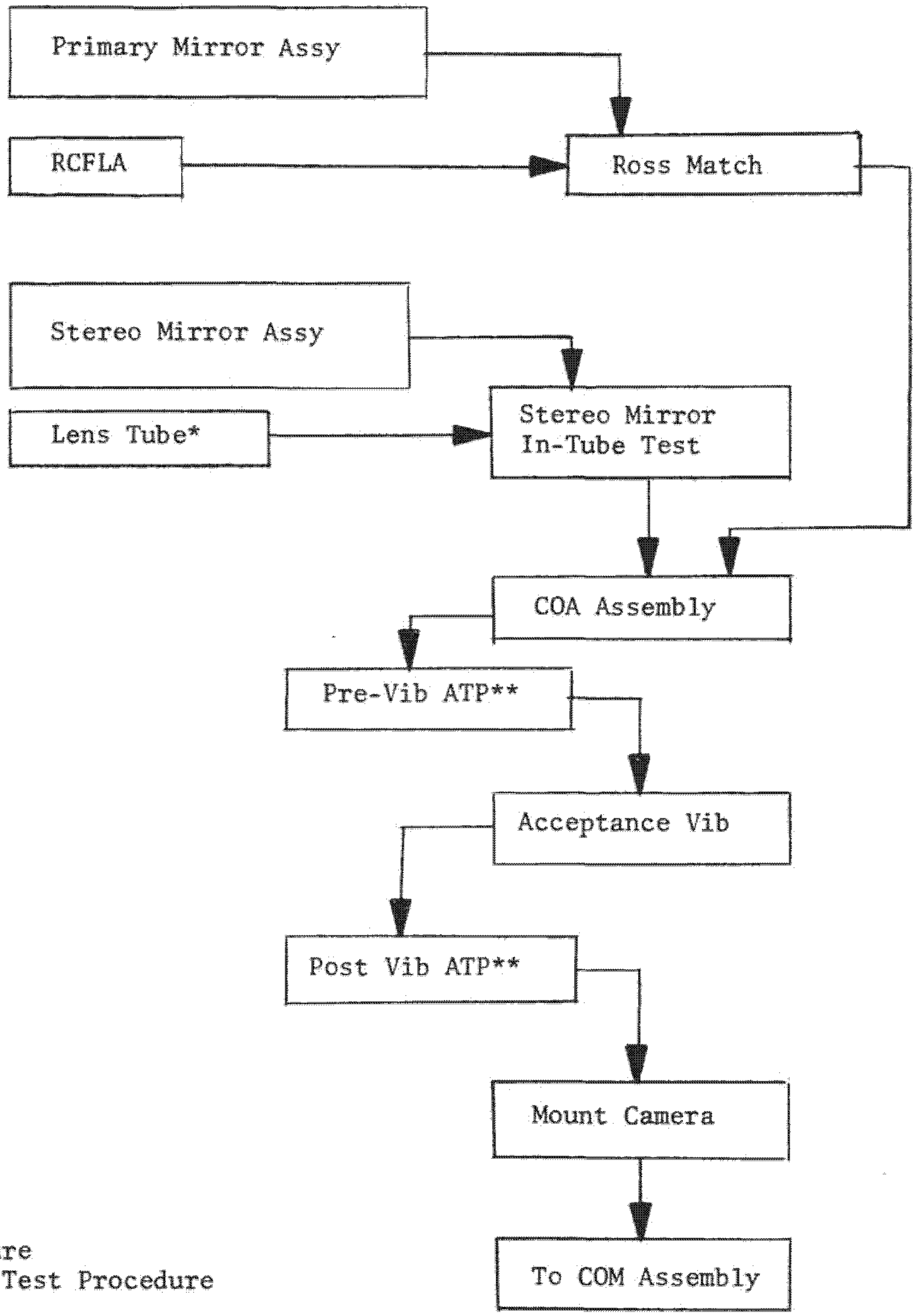
4.2.1 Acceptance Testing

Acceptance testing is conducted on all assembled components utilizing either specialized test equipment or the common use test set (CUETS) shown in Figure 4.4-6. These tests verify that the electro-mechanical-optical parameters comply with the appropriate drawings and specifications. In addition, calibration data is obtained for those parameters not available in higher-level testing. A typical acceptance test flow is as follows:

(1) In-process testing

(2) Insulation resistance and continuity tests

(3) Electro-mechanical-optical functional operation



* COA Structure
**Acceptance Test Procedure

Figure 4.4-5. COA Assembly and Test Flow

4.4-15

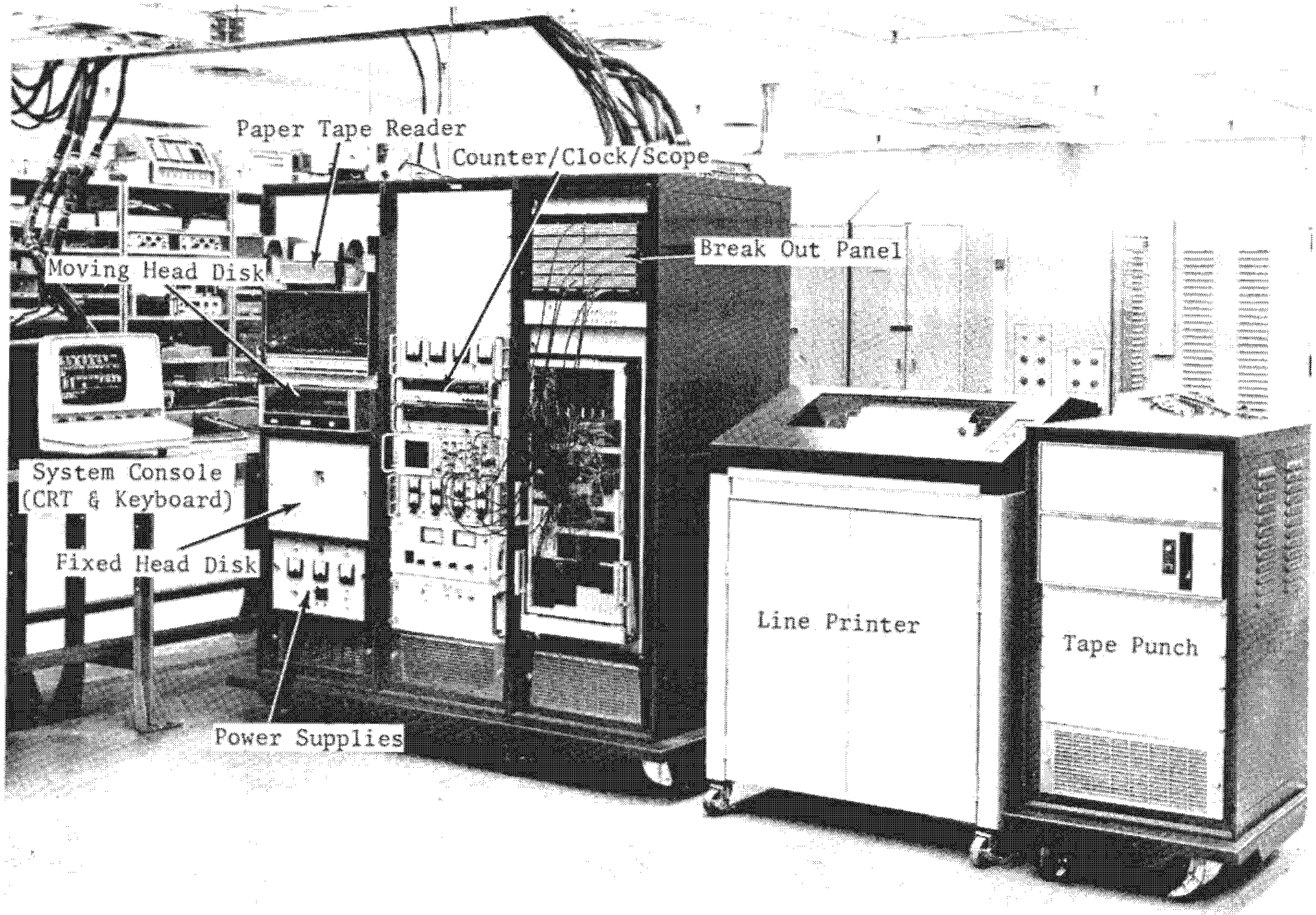


Figure 4.4-6. CUETS System

(4) Environmental testing as required:

a. Functional hot test

b. Functional cold test

c. Functional vacuum test

d. EMI test

(5) Vibration (three-axis random) (power on as required)

(6) Post vibration testing consisting of items 2 through 4 above, as appropriate

(7) Mass properties measurements

In addition, system-like testing of the film-handling components (film supplies, the dual platen camera and the take-up mechanisms) is performed to determine film-handling performance prior to the buildup of the major assembly. The test set for the film-handling system is shown in Figure 4.4-7.

4.3 Major Assembly Electro/Mechanical Testing

Major assembly testing includes acceptance tests of the camera optics module (COM), the supply electronics module (SEM), the satellite reentry vehicles (SRVs), the dual recovery module (DRM), and the photographic payload section/dual platen extended altitude capability (PPS/DP EAC). These tests are designed to evaluate performance to specification requirements and to detect, as early as possible, defects and failure areas. Testing of major modules and of the complete assembly is accomplished in a systems-level concept using functional tests which check interaction of components as well as integration and performance of such subsystems as film handling, command and instrumentation subsystems, environmental control subsystems, etc. In addition, the pre-launch validation test sequences are performed (with the vehicle horizontal) at ambient pressure, factory temperature, and representative launch pad voltage conditions for baseline comparison to later field execution.

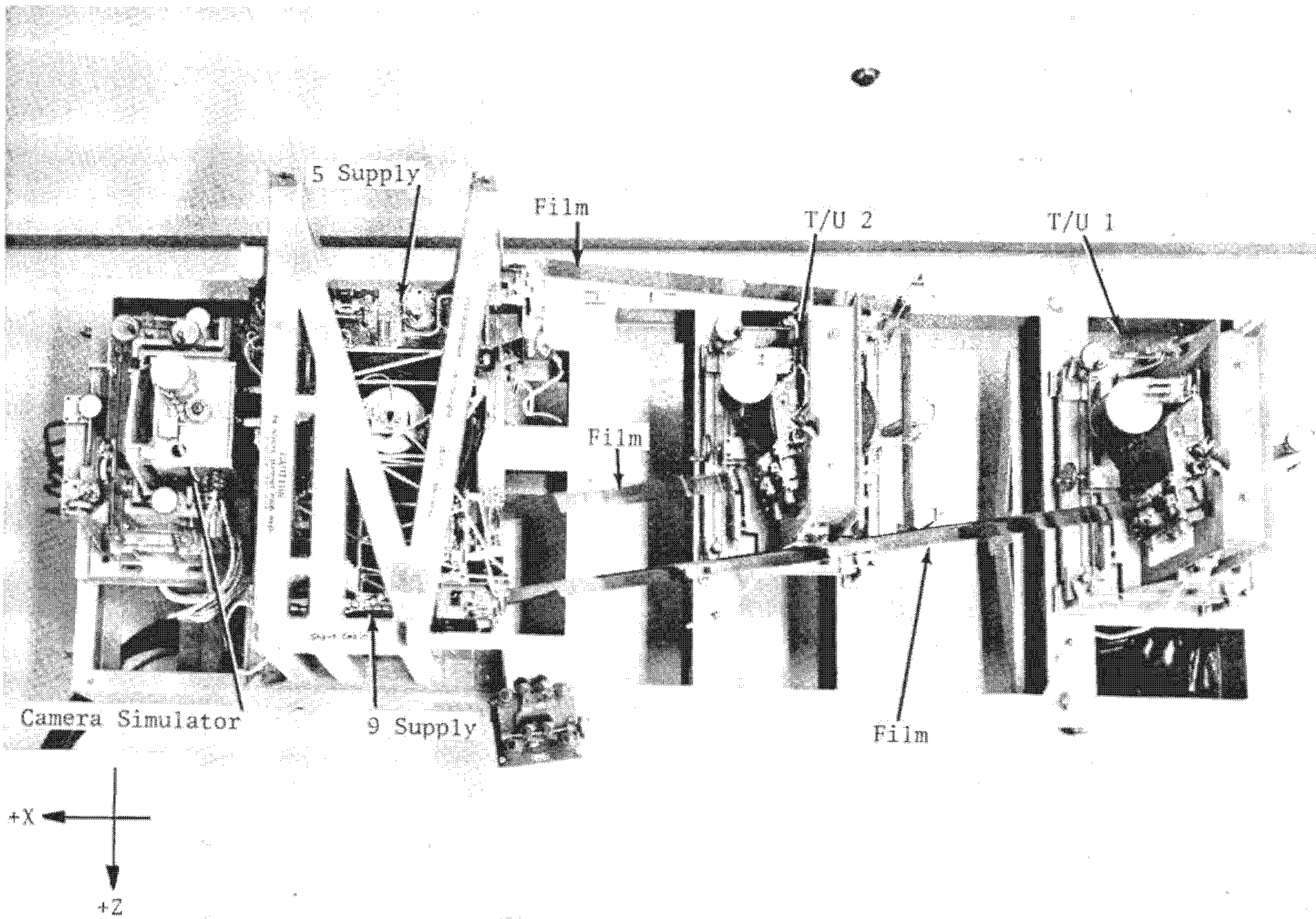


Figure 4.4-7. Supply Assembly Test Set

Following acceptance testing of the PPS/DP EAC and Air Force buy off, the unit is placed in protective storage until 12 days prior to shipment. At this time, a pre-shipment, functional revalidation test is performed. A data review is held with the Air Force and the unit is shipped to Field Activity South (FAS) for field flight-readiness validation, arming and launching.*

4.3.1 Camera Optics Module (COM) Acceptance Testing

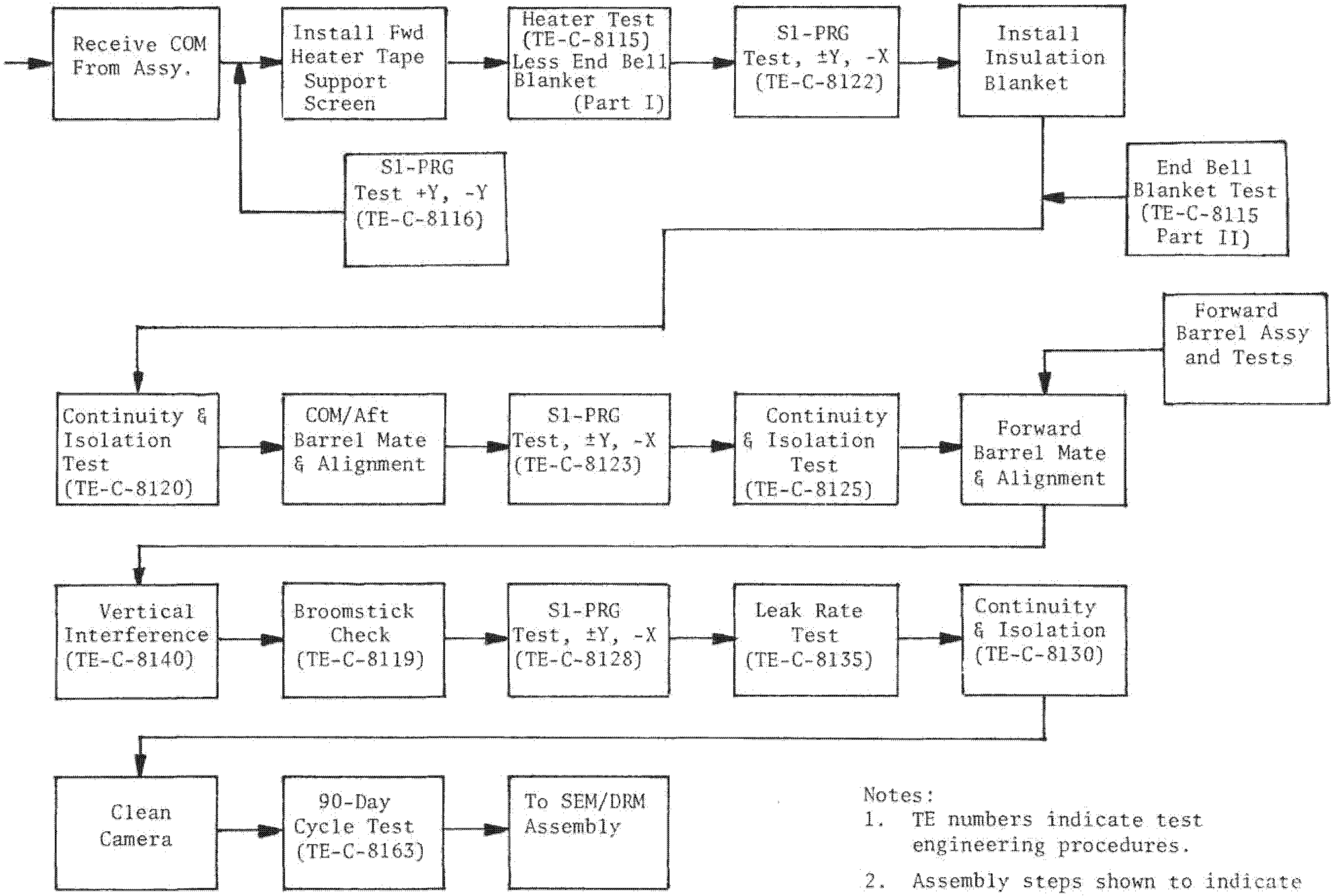
The COM is acceptance tested in accordance with the test flow shown in Figure 4.4-8. The camera optics assembly was fully tested during buildup, and no further lens system optical quality testing is performed. (Note: Section 4.1 covers the pre- and post-vibration testing of the optical system.) However, additional electrical and mechanical testing is performed at the COM level, including the "hot-dog"** simulation test (broomstick check) to determine whether there is any mechanical coupling between the COA and the external structure. During this test, the broomstick is translated in the ±Y and ±Z directions, 0.093-inch and 0.500-inch respectively. As the broomstick is moved, the S-1 instrumentation is monitored for any changes which would indicate mechanical coupling.

As a separate effort, the forward barrel is given an operational test of the viewport door prior to mating with the COM. Further tests are performed at the PPS/DP EAC level. Following COM testing, the COM and SEM are mated, the weight determined and the I_{xx} measurement made (I_{xx} = mass moment of inertia about the vehicle X axis).

4.3.2 Supply and Electronics Module (SEM) Acceptance Testing

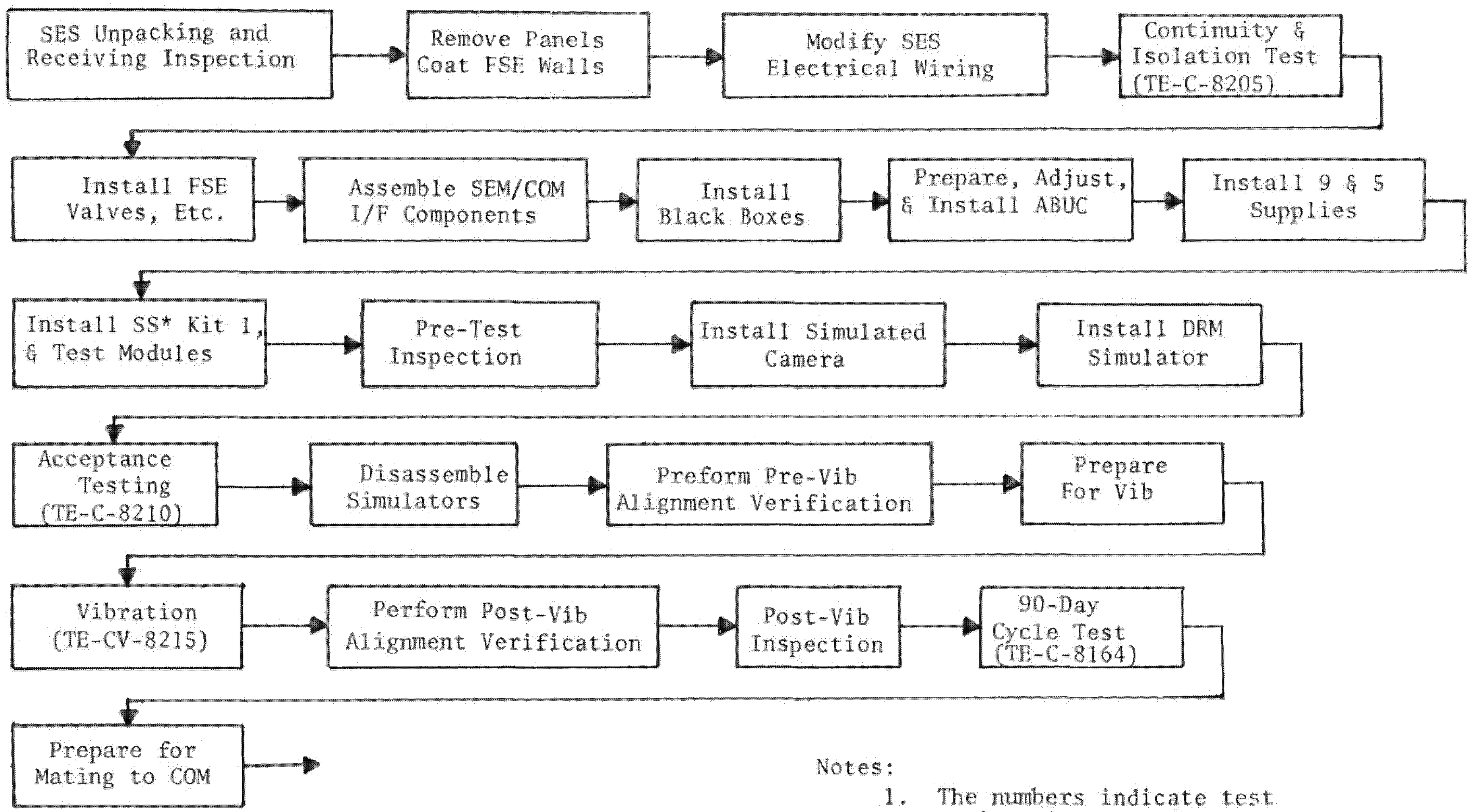
The SEM is acceptance tested in accordance with the test flow shown in Figure 4.4-9. When received in-house, the supply and electronics structure (SES)

*Reference Part 4, Section 5, Storage and Shipment.
**"Hot-dogging" refers to bending of the external structure due to thermal influences.



Notes:
1. TE numbers indicate test engineering procedures.
2. Assembly steps shown to indicate levels at which testing is performed.

Figure 4.4-8. COM Assembly and Test Flow



*Socket Saver

Notes:

1. The numbers indicate test engineering procedures.
2. Assembly steps shown to indicate levels at which testing is performed.

Figure 4.4-9. SEM Assembly and Test Flow is modified as necessary* and tested. SEM level testing then starts, beginning with electrical continuity and leakage, followed by a "POWER ON" sequence where each system is "carefully" turned on (since this is the first time that all the components (black boxes) have worked together in a system) and monitored for proper operation. The instrumentation verification portion of SEM testing sets each instrumentation point (including some on the DRM and COM simulators) to all allowable levels to verify that the readings are within specification. The film-handling systems are operated for the first time in the tracking test. The camera operations and system level tests are functional tests which serve as the pre-vibration baseline for the PPS/DP EAC tests. There is no post-vibration SEM test. All post-vibration SEM testing is accomplished at the PPS/DP EAC level where failure analysis, repair and replacement capabilities are essentially identical to those at the SEM level.

4.3.3 Dual Recovery Module (DRM) Acceptance Testing

The DRM consists of two satellite reentry vehicles (SRV's), an ejectable adapter (EA) and a fixed adapter (FA). After receipt from the manufacturer,** each unit is inspected for physical defects and acceptance testing performed.

4.3.3.1 EA and FA Acceptance Testing. The EA/FA and tunnel seal and record trap (TSRT) assembly and test flow is shown in Figure 4.4-10. As a part of the receiving inspection procedure, and also following painting and striping and installation of the TSRT assemblies, the EA and FA are tested for:

(1) Electrical continuity

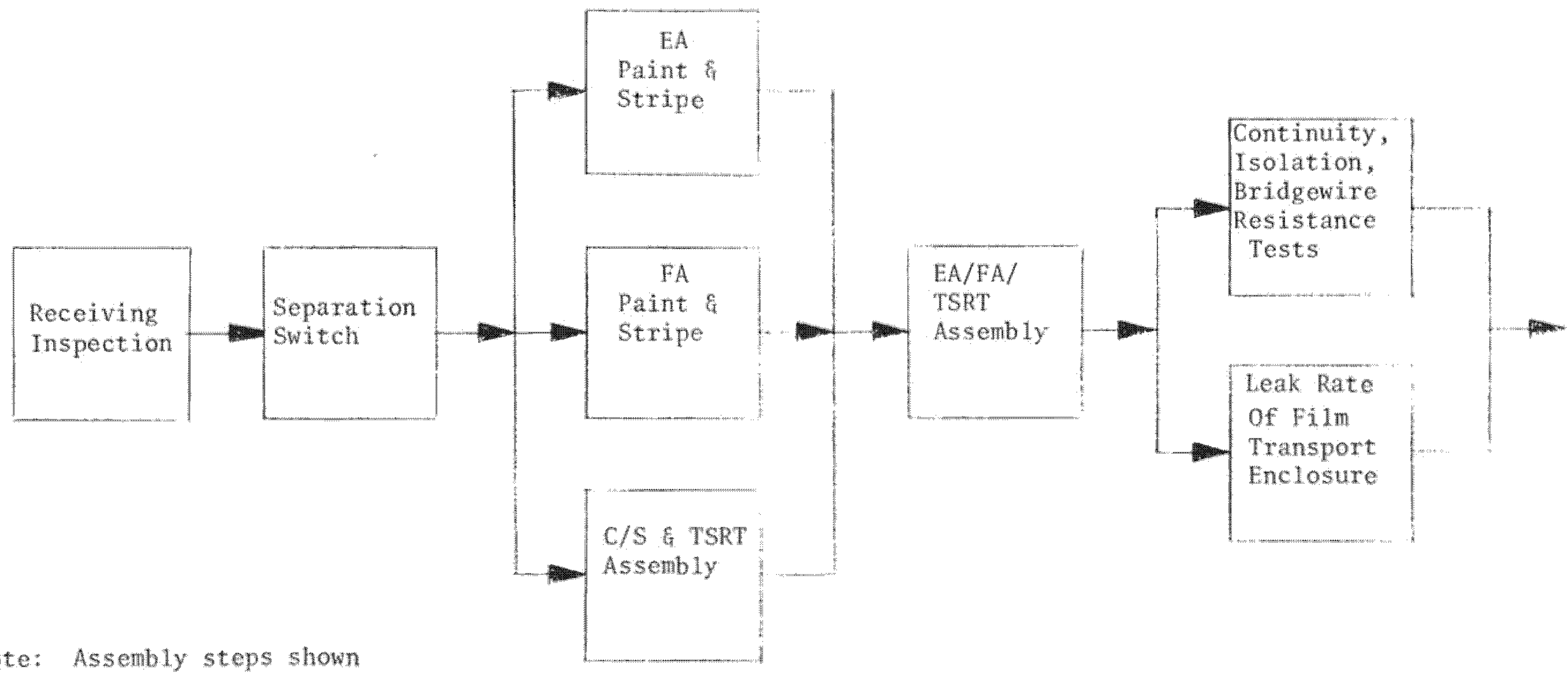
(2) Isolation resistance

(3) Bridgewire resistance of the pyrotechnic circuits

(4) Leak rate of the film path enclosure

*Reference Part 4, Section 3.

**General Electric Reentry and Environmental Systems Division manufactures the SRV's. Lockheed Missiles and Space Company manufactures the EA and FA.



Note: Assembly steps shown to indicate levels at which testing is performed.

Figure 4.4-10. Assembly Flow and EA/FA/TSRT Test

4.3.3.2 SRV Acceptance Testing. The SRV's are tested in accordance with the test flow of Figure 4.4-11. The major points checked before integration of the SRV's into the DRM are:

(1) Bridgewire resistance of pyrotechnic circuits

(2) Electrical continuity

(3) Isolation resistance

(4) Leak rate of the film take-up enclosure

(5) Film take-up operation

(6) High pressure leak check of the spin and despin bottles

(7) Reentry programmer functions

4.3.3.3 DRM Buildup and Testing. DRM buildup and testing starts with mounting of the SRV's in the EA and FA* and checking the alignment of the film take-ups. To assure proper operation, electrical continuity checks, isolation resistance checks, leak rate of the film enclosure and reentry programmer function checks are performed (see Figure 4.4-12). The DRM is vibrated to acceptance levels, and the weight, center of gravity and I_{xx} values are determined (I_{xx} = mass moment of inertia about the X axis).

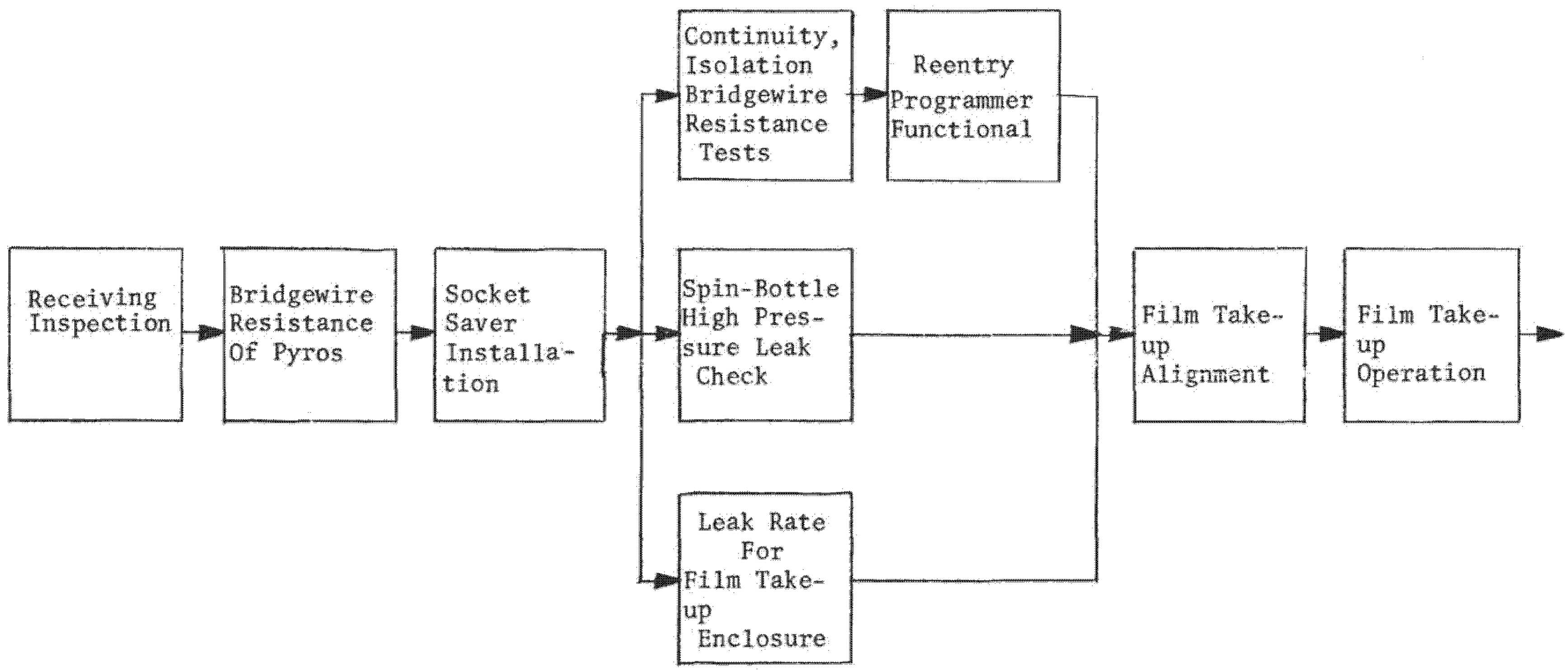
After the vibration of the DRM, take-up alignment is checked and the DRM is completely retested according to test procedures which encompass the following:

(1) Electrical continuity

(2) Isolation resistance

(3) Bridgewire resistance

*Reference Part 4, Section 3 for order of assembly.



Note: Assembly steps shown to indicate levels at which testing is performed.

Figure 4.4-11. Assembly Flow and SRV Test

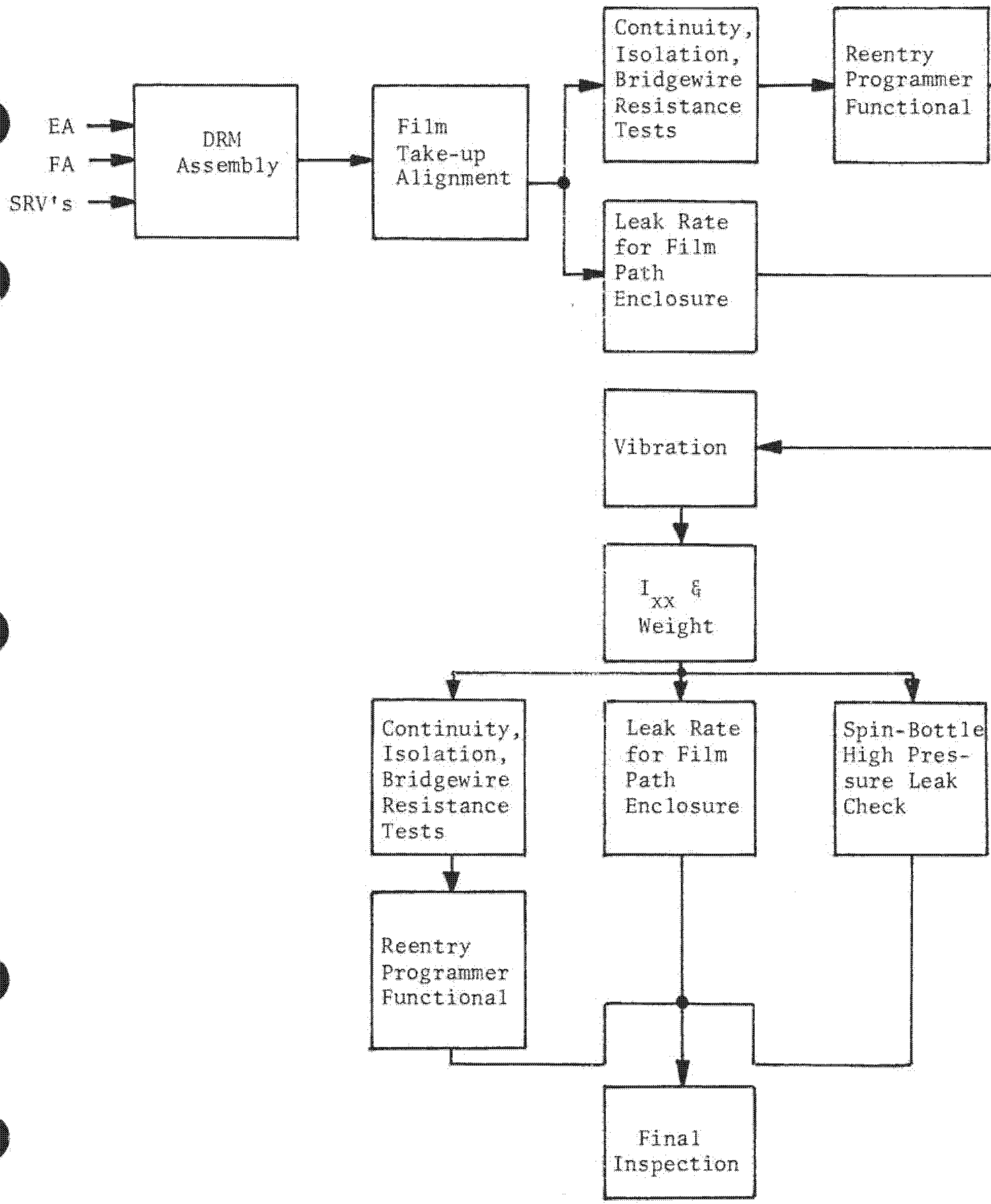


Figure 4.4-12. Assembly Flow and DRM Test

(4) Leak rate of the film enclosure

(5) High-pressure leak check of the spin and despin bottles

(6) Reentry programmer function

Following an overall inspection, the DRM is ready to be integrated with the SEM and COM.

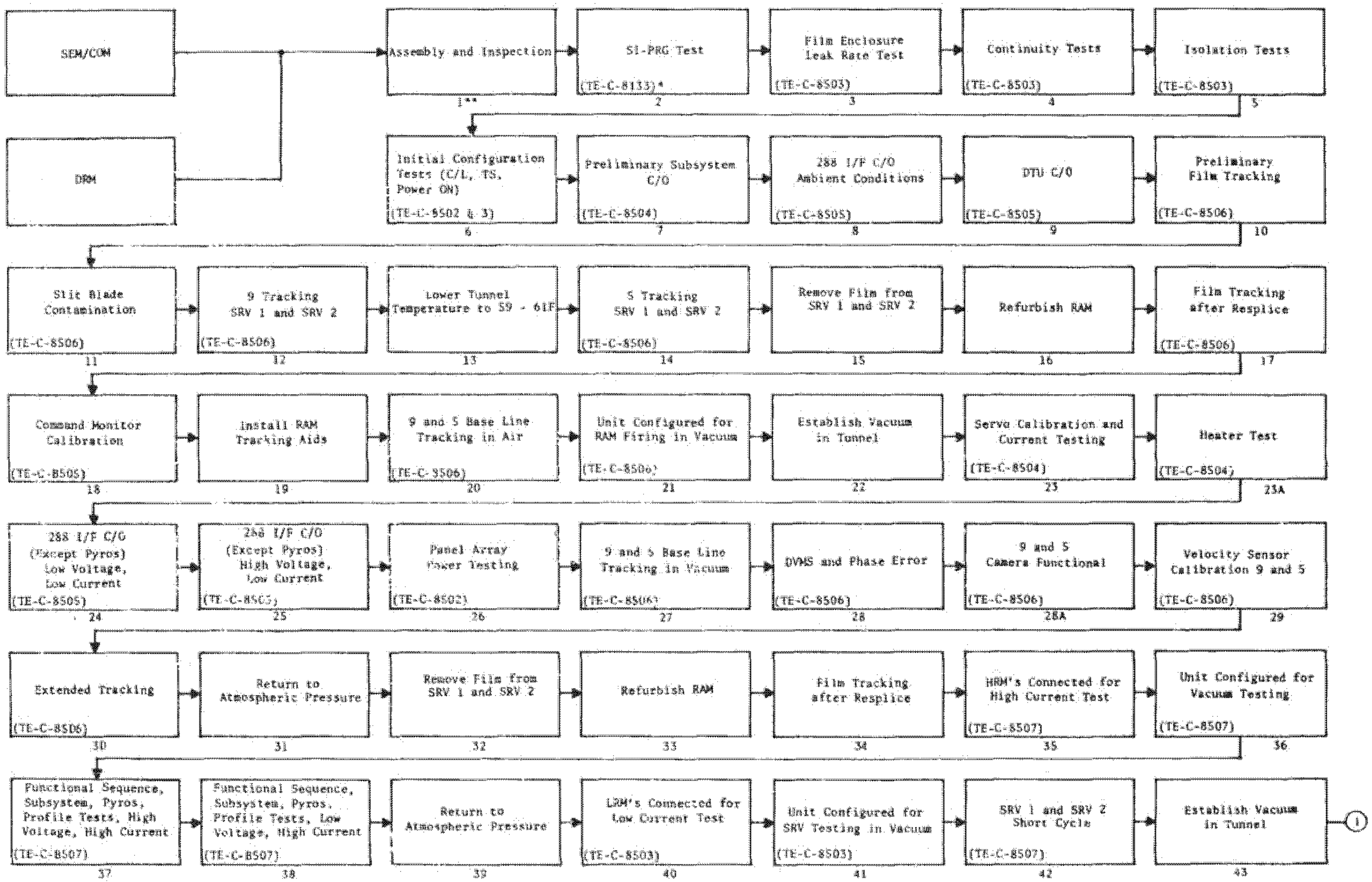
4.3.4 Photographic Payload Section/Dual Platen Extended Altitude Capability (PPS/DP EAC)

The PPS/DP EAC is assembled and tested in accordance with the flow plan shown in Figure 4.4-13. A brief description of each step in the flow plan is presented by Table 4.4-1.

Final assembly begins with mating of the SEM and COM to form the SEM/COM unit. The broomstick test which simulates hot-dogging is repeated to verify there is no coupling between the COA and external structure (reference paragraph 4.3.1). An I_{xx} value is determined for the SEM/COM using the test setup shown in Figure 4.4-14, and combined with the I_{xx} value of the DRM (reference paragraph 4.3.3.3.) to obtain an overall I_{xx} value for the PPS/DP EAC. After SEM/COM testing, the DRM is mated to the SEM/COM and the PPS/DP EAC prepared for testing. Figure 4.4-15 presents a view of the general assembly area where PPS/DP EAC testing takes place.

Prior to PPS/DP EAC functional testing, tests are performed to validate the SEM post-vibration condition and DRM post-vibration film tracking. (Tracking tests are deferred to the PPS/DP EAC configuration so that they may be performed on a unified film-handling subsystem.)

Functional testing of the PPS/DP EAC encompasses exercising all PPS/DP EAC systems excluding the SRV sequences which are checked separately (RECAL testing).



* Test Engineering (TE) Procedures
** Numbers refer to Descriptions on Table 4.4-1

Figure 4.4-13. PPS/DP EAC Assembly and Test Flow from Buildup to Shipment

Approved for Release: 2017/02/14 C05097360

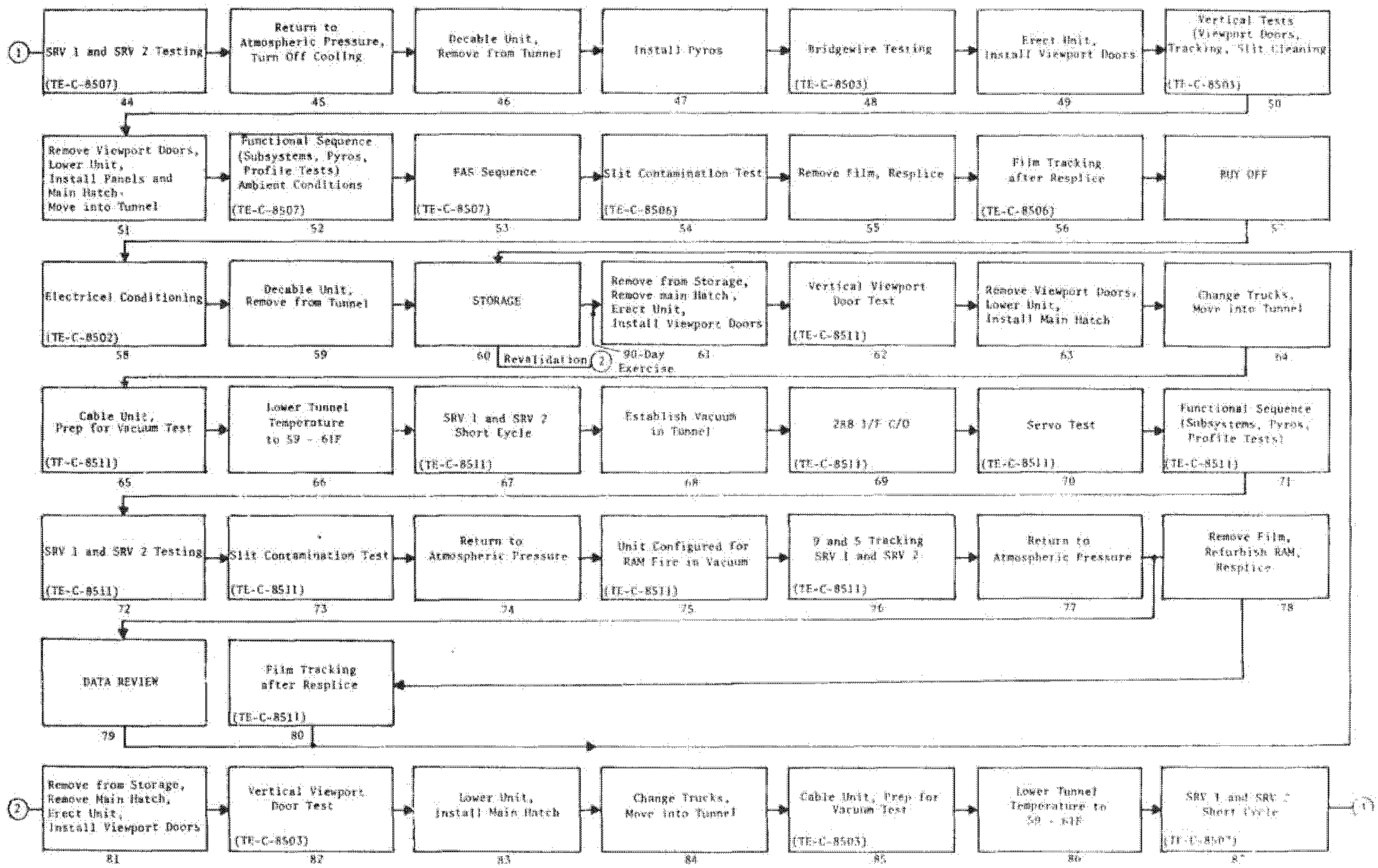


Figure 4.4-13. Cont'd

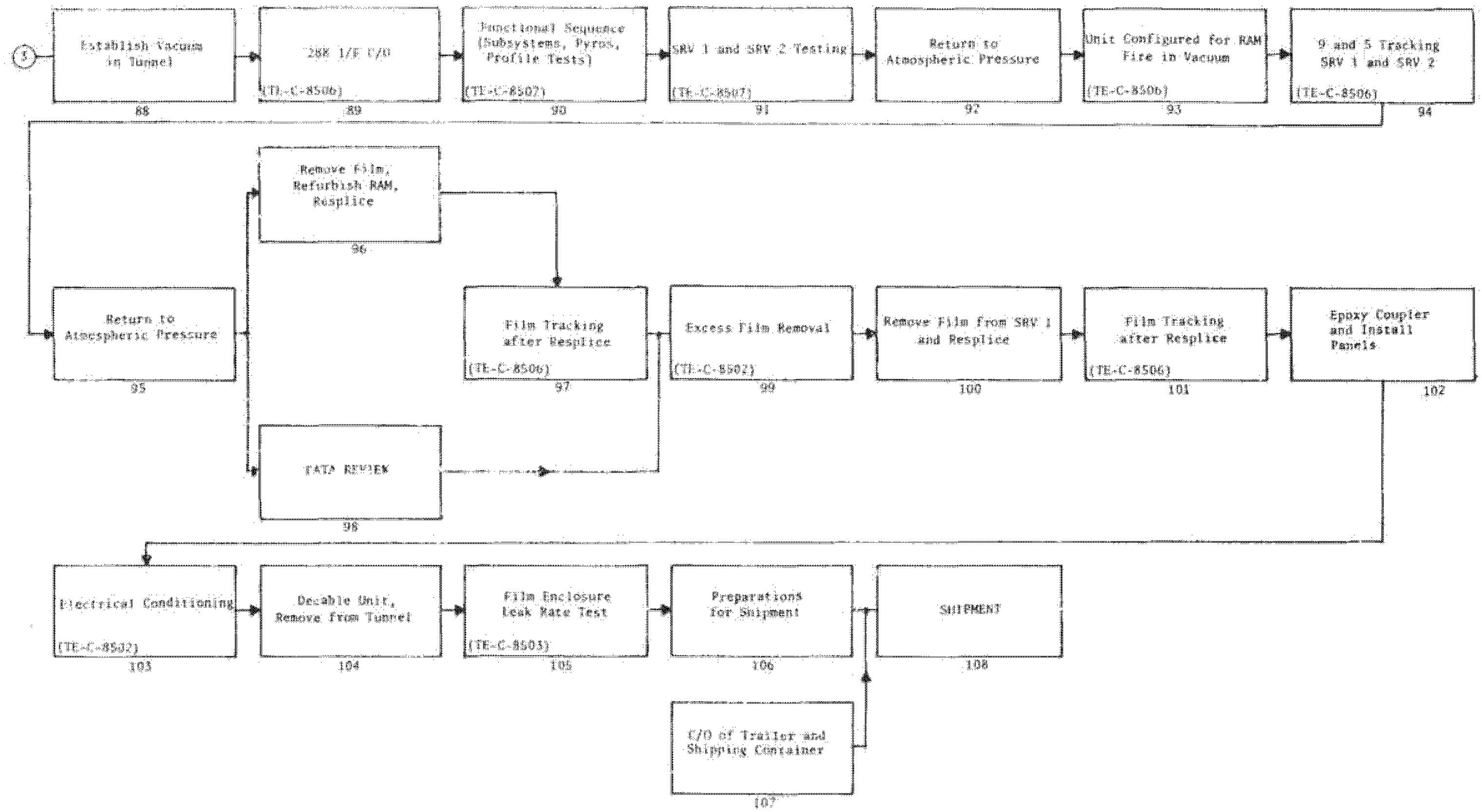


Figure 4.4-13. Cont'd

TABLE 4.4-1

PPS/DP EAC TEST AND ASSEMBLY FLOW DESCRIPTION

Block*	Test or Procedure**
1	ASSEMBLY INSPECTION After the SEM/COM and DRM are mated, a final inspection is made and the unit prepared for acceptance testing.
2	S1-PRG TEST After DRM mate, S1-PRG measurements in the ±Y orientation are made in the calibration and operation mode.
3	FILM ENCLOSURE LEAK RATE TEST The film enclosure is tested for tightness by pumping in air to 2 inches of water pressure and measuring pressure drop after 13 seconds. This is done for +Y film supply enclosure (FSE) vent capped and uncapped. The PPS is moved into the "test tunnel" when leak rate testing is completed.
4	CONTINUITY TESTS Continuity measurements are made for command lines from the PPS/SCS interface (I/F); bridgewire measurements are made at safe/arm receptacles; command line resistance and resistance of input power and signal lines are measured.
5	ISOLATION TESTS Electrical isolation between structure, returns, and feeds at the PPS/SCS I/F are measured.
6	INITIAL CONFIGURATION TESTS Checkout of continuity loop (C/L) and timing signals (TS) are made. The initial power up sequence is performed to verify initial configuration.

* Block numbers refer to flow chart (Figure 4.4-13).
** Test and Procedure steps from flow chart (Figure 4.4-13).

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
7	PRELIMINARY PPS SUBSYSTEM CHECKOUT (C/O) All subsystems are operated except film handling, SRV's, and pyrotechnic. Currents are measured and instrumentation outputs recorded and verified to be correct.
8	PPS/SCS I/F C/O (AMBIENT CONDITIONS) All I/F commands from both decoders are sent to the PPS/DP EAC across the I/F.
9	DTU C/O Operation of the DTU system is verified for both sides. This includes using all formats allowed and checking cross strapping capabilities to the MDTU.
10	PRELIMINARY FILM TRACKING A short tracking test is run to verify 9 and 5 platen drive and film handling operations.
11	SLIT BLADE CONTAMINATION TEST Film in the 9 and 5 film-drive system is exposed to light from a bulb on the primary mirror for a specified period. This film is later evaluated for indications of slit blade contamination.
12	9 TRACKING SRV 1 & 2 An extensive tracking test is run at several different speeds to verify camera and film handling operation in the strip mode. Adjustments are made, if necessary, at tilt frame couplers and RAM. The RAM is then fired and tracking into SRV 2 is performed, in the same manner as done for SRV 1 tracking.
13	ENVIRONMENTAL LAB LOWERS TUNNEL TEMPERATURE The temperature of the test tunnel is set to 59 - 61F. This is done to allow checkout of the environmental system and to perform other test sequences at this low temperature.

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
14	5 TRACKING SRV 1 & 2 An extensive tracking test is run at several different speeds to verify camera and film handling operation in the strip mode. Adjustments are made, if necessary, at tilt frame couplers and RAM. The RAM is then fired and tracking into SRV 2 is performed, in the same manner as done for SRV 1 tracking.
15	ASSEMBLY REMOVES FILM The 9 and 5 film is removed from both take-ups. The film from SRV 1 is processed and the contamination test film evaluated. The system is respliced to SRV 1.
16	ASSEMBLY REFURBISHES S/C
17	FILM TRACKING AFTER RESPLICE Short tracking test for 9 and 5 film-handling systems is run to verify proper operation after film resplice and S/C refurbishment.
18	COMMAND MONITOR CALIBRATION All levels of command bit monitors (CBM's) possible are commanded and verified.
19	INSTALL RAM TRACKING AIDS Assembly installs a special data track assembly at the RAM, to allow data tracks to be placed on the 9 and 5 film at the RAM location during 9 Baseline Tracking test.
20	9 & 5 BASELINE TRACKING IN AIR Film is run in the strip mode with the camera and RAM data tracks ON. This test is run in the +Y and +Z orientation. Evaluation of 9 and 5 film is made after film removal to verify tracking requirements are satisfied.
21	UNIT CONFIGURED FOR RAM FIRE IN VACUUM RAM test block is installed with live dimple motors. RAM safety

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
	device removed and all FSE covers are torqued down with FSE vent cap removed.
22	ENVIRONMENTAL LAB ESTABLISHES VACUUM IN TUNNEL
	The pressure in the tunnel is lowered to less than 1 mm hg.
23	SERVO CALIBRATION AND CURRENT TESTING
	Calibration of crab and stereo servos, 9 and 5 slit mechanisms, 9 and 5 NPA, and 9 and 5 SRC is performed. Current test for crab and stereo servo motors is also performed.
23A	HEATER TEST
	Flight and ground heaters are operated and currents measured for each branch and zone.
24 & 25	PPS/SCS INTERFACE C/O
	This test is performed at high voltage and low current for all I/F commands from both decoders except the pyrotechnic functions. The test is then repeated at low voltage and current.
26	SOLAR ARRAY POWER TESTING
	Main power to the PPS/DP EAC is varied by a delta of plus or minus 3 volts every 0.1 - 0.2 second around normal voltage while all PPS/DP EAC systems are exercised.
27	9 & 5 BASELINE TRACKING IN VACUUM
	This test is similar to air baseline test. Test is performed with unit in +Z orientation.
28	DVMS & PHASE ERROR
	Film is run at several speeds in the high altitude normal and high speed, low altitude normal and high speed ranges while acquiring DVMS and phase error data. This test is done for both sides of the FPLLE.
	Each speed in the high altitude normal and low altitude normal range is run three times at varying frame lengths.

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
28A	9 & 5 FILM DRIVE FUNCTIONAL A functional test is performed on the 9 and 5 platen drive systems. Film is run at various speeds, all SRC steps checked, FPLLE C/O, slit C/O, crab and stereo servo C/O, simultaneous 9 and 5 operations, simultaneous commanding, and focus system C/O and camera automatic off system C/O.
29	VELOCITY SENSOR CALIBRATION Several speeds in the low altitude normal FPLLE range are run. A full looper and one long strip shot is run for each speed. Calibration of the velocity sensor is done post-test by a special computer program using the velocity data recorded on the tape during the test.
30	EXTENDED TRACKING Extensive film tracking into SRV 1 is performed throughout the full speed range of the film-drive system. The S/C is then fired, transferring film into SRV 2. The same tracking test is then repeated into SRV 2. Both 9 and 5 systems are tested in this manner.
31	ENVIRONMENTAL LAB RETURNS TUNNEL TO ATMOSPHERIC PRESSURE Unit is returned to ambient pressure to reconfigure for further testing.
32	ASSEMBLY REMOVES FILM FROM SRV 1 AND SRV 2 Film is removed from SRV 1 and SRV 2 and sent to processing. This film is then evaluated for correct format and other attributes. The system is respliced to SRV 1.

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
33	ASSEMBLY REFURBISHES S/C
34	FILM TRACKING AFTER RESPLICE Short tracking test for 9 and 5 film-handling system is run to verify proper operation after film resplice and S/C refurbishment.
35	HRM's CONNECTED In preparation for high current testing, high current resistor modules (HRM's) are connected to pyrotechnic safe/arm receptacles and the high current instrumentation module (HIM) to the IEU receptacle.
36	ENVIRONMENTAL LAB ESTABLISHES VACUUM IN TUNNEL The pressure in the tunnel is lowered to less than 1 mm hg.
37 & 38	FUNCTIONAL SEQUENCES All systems are exercised except the SRV's. The servo systems are run from extreme to extreme and redundant sides of each system are operated. This test is performed twice; once at high voltage and current and once at low voltage and high current.
39	ENVIRONMENTAL LAB RETURNS TUNNEL TO ATMOSPHERIC PRESSURE Unit returned to ambient pressure to reconfigure for further testing.
40	LRM's CONNECTED HRM and HIM plugs removed and low current resistor modules (LRM's) and the low current instrumentation module (LIM) connected to safe/arm and IEU receptacles for low current testing.
41	UNIT CONFIGURED FOR SRV TESTING IN VACUUM The FSTE cables are connected to SRV 1 and SRV 2 receptacles.

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
42	SRV 1 AND 2 SHORT CYCLE Functional testing of the normal (primary mode) recovery sequence for SRV 1 and SRV 2 is performed.
43	ENVIRONMENTAL LAB ESTABLISHES VACUUM IN TUNNEL The pressure in the tunnel is lowered to less than 1 mm hg.
44	SRV 1 & SRV 2 TESTING All functional testing of SRV's is performed. This includes redundant (channel 1 and 2), fault (channel 1 and 2), primary mode, and B/U mode functions.
45	ENVIRONMENTAL LAB RETURNS TUNNEL TO ATMOSPHERIC PRESSURE, TURNS OFF COOLING Tunnel pressure is returned to ambient conditions and cooling in tunnel is turned off in preparation for further testing.
46	UNIT DECABLED AND REMOVED FROM TUNNEL
47	ASSEMBLY INSTALLS PYROS Installation of remaining live pyrotechnic devices is accomplished.
48	BRIDGEWIRE TESTING Bridgewire measurements of all pyros are made. This testing includes a resistance measurement of each drive line and isolation line from structure.
49	ASSEMBLY ERECTS UNIT AND INSTALLS VIEWPORT DOORS The PPS/DP EAC is placed on erector truck and erected to install viewport doors and perform vertical testing.
50	VERTICAL TESTING Viewport door testing is performed at high, low, and nominal

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
	voltages. 9 and 5 film tracking is run for strip and short burst times. The 9 and 5 slit blades are cleaned. The stereo mirror boot assembly is installed and the crab servo run to verify fit.
51	ASSEMBLY LOWERS UNIT
	Remaining panels are installed and the ejectable hatch is installed. The unit is moved into the tunnel for final testing.
52	FUNCTIONAL SEQUENCES
	All systems are exercised except the SRV's. The servo systems are run from extreme to extreme and redundant sides of each system operated. This test is performed at ambient temperature and pressure.
53	FAS SEQUENCES
	Test sequences which are peculiar to Field operations are run at this time. This includes the Functional Test (similar to Factory Functional), Interreaction tests and Health Check. The Interreaction tests run several subsystems simultaneously to verify that the PPS/DP EAC and Control Section function normally when various systems are operating together. The Functional Test differs from the Factory Test because of unit orientation in the Field which can result in carriage drift and film slippage.
54	SLIT BLADE CONTAMINATION TEST
	Film in the 9 and 5 film-drive systems is exposed to light from a bulb on the primary mirror for a specified period. This film is later evaluated for indications of slit blade contamination.
55	ASSEMBLY REMOVES FILM
	Film is removed from SRV 1 and sent for processing. The film is respliced to SRV 1. The processed film is checked to evaluate the results of the contamination test.
56	FILM TRACKING AFTER RESPLICE
	Short tracking test for 9 and 5 film-handling system is run to verify proper operation after film resplice and S/C refurbishment.

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
57	BUYOFF Unit is bought off by the Air Force.
58	ELECTRICAL CONDITIONING The unit is configured electrically, and then bridgewire, drive line resistance, no voltage, and isolation measurements made with the DTU off and power applied.
59	DECABLE UNIT AND REMOVE FROM TUNNEL Unit is returned to assembly for storage.
60	STORAGE Unit is stored in the clean room or storage tent on an erector truck. Every 7 days the unit is rotated 90 degrees. The unit is stored on an erector truck for quick reaction to perform vertical testing, if the unit is called up for usage.
61	REMOVE FROM STORAGE, REMOVE COVER AND ERECT UNIT Assembly removes unit from storage for the 90-day exercise. The main hatch is removed and the unit erected.
62	VERTICAL VIEWPORT DOOR TEST Viewport door testing is performed to satisfy ATP and 90-day storage requirements. This encompasses testing at high, low, nominal voltage, and at least 90 seconds of Primary and Backup motor ON time. Assembly performs strain gage measurements and finalizes COM Area.
63 & 64	ASSEMBLY LOWERS UNIT Remaining panels are installed and the ejectable hatch is installed. The unit is moved into the tunnel for final testing.
65	CABLE UNIT PREP FOR VACUUM Unit is cabled for testing, with FSTE cables connected to SRV 1 and

TABLE 4.4-1 CONT'D)

Block	Test or Procedure
	SRV 2 receptacles. All FSE covers torqued down with +Y FSE vent cap removed.
66	FILM TRACKING AFTER RESPLICE
	Short tracking test for 9 and 5 film-handling systems run to verify proper operation after film resplice.
67	SRV 1 AND SRV 2 SHORT CYCLE
	Functional testing of the normal (primary mode) recovery sequence for SRV 1 and SRV 2 is performed.
68	ENVIRONMENTAL LAB ESTABLISHES VACUUM IN TUNNEL
	The pressure in the tunnel is lowered to less than 1 mm hg.
69	288 I/F C/O
	This test is performed at nominal voltage and low current for all I/F commands from both decoders except the pyro functions.
70	SERVO TEST
	The crab, stereo, SRC, NPA, slit, and S1 CAL MOTOR are operated for a total of at least 90 seconds ON time.
71	FUNCTIONAL SEQUENCES
	All systems are exercised except the SRV's. The servo systems are run from extreme to extreme, and redundant sides of each system operated.
72	SRV 1 & SRV 2 TESTING
	All functional testing of SRV's is performed. This includes redundant (channels 1 & 2), fault (channels 1 & 2), primary mode, and B/U mode functions.

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
73	SLIT BLADE CONTAMINATION TEST Film in the 9 and 5 film-drive systems is exposed to light from a bulb on the primary mirror for a specified period. This film is later evaluated for indications of slit blade contamination.
74	ENVIRONMENTAL LAB RETURNS TUNNEL TO ATMOSPHERIC PRESSURE Unit returned to ambient pressure to reconfigure for further testing.
75	ENVIRONMENTAL LAB ESTABLISHES VACUUM IN TUNNEL The pressure in the tunnel is lowered to less than 1 mm hg.
76	SRV 1 & SRV 2 TRACKING The 9 film-handling system is run in the strip mode into SRV 1 to verify proper operation. The S/C is then fired and the tracking test repeated into SRV 2. This sequence is repeated for the 5 film-handling system.
77	ENVIRONMENTAL LAB RETURNS TUNNEL TO ATMOSPHERIC PRESSURE, TURNS OFF COOLING Tunnel pressure is returned to ambient conditions and cooling in tunnel is turned off in preparation for further testing.
78	REMOVE FILM, REFURBISH RAM, RESPLICE Film is removed from SRV 1 and SRV 2. The film from SRV 2 is sent for processing. The film is respliced to SRV 1. Assembly refurbishes the RAM. The processed film is checked to evaluate the results of the contamination test.
79	DATA REVIEW The data from the 90-day cycle is reviewed.
80	FILM TRACKING AFTER RESPLICE Short tracking test for 9 and 5 film-handling systems run to verify proper operation after film resplice and S/C refurbishment.

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
81	REMOVE FROM STORAGE, REMOVE HATCH AND ERECT UNIT Assembly removes unit from storage for final vent test. The main hatch is removed and the unit erected.
82	VERTICAL VIEWPORT DOOR TEST Viewport door testing is performed at high, low, and nominal voltages. Assembly performs strain gage measurements and finalizes COM Area.
83 & 84	ASSEMBLY LOWERS UNIT Remaining panels are installed and the ejectable hatch is installed. The unit is moved into the tunnel for final testing.
85	CABLE UNIT PREP FOR VACUUM Unit is cabled for testing, with FUTE cables connected to SRV 1 and SRV 2 receptacles. All FSE covers torqued down with +Y FSE vent cap removed.
86	ENVIRONMENTAL LAB LOWERS TUNNEL TEMPERATURE The temperature of the test tunnel is set to 59 - 61F. This is done to allow checkout of the environmental system and to perform other test sequences at this low temperature.
87	SRV 1 & 2 SHORT CYCLE Functional testing of the normal (primary mode) recovery sequence for SRV 1 and SRV 2 is performed.
88	ENVIRONMENTAL LAB ESTABLISHES VACUUM IN TUNNEL The pressure in the tunnel is lowered to less than 1 mm hg.
89	288 I/F C/O This test is performed at nominal voltages and low current for all I/F commands from both decoders except the pyro functions.

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
90	FUNCTIONAL SEQUENCES All systems are exercised except the SRV's. The servo systems are run from extreme to extreme, and redundant sides of each system operated.
91	SRV 1 & SRV 2 TESTING All functional testing of SRV's is performed. This includes redundant (channels 1 & 2), fault (channels 1 & 2), primary mode, and B/U mode functions.
92	ENVIRONMENTAL LAB RETURNS TUNNEL TO ATMOSPHERIC PRESSURE Unit returned to ambient pressure to reconfigure for further testing.
93	ENVIRONMENTAL LAB ESTABLISHES VACUUM IN TUNNEL The pressure in the tunnel is lowered to less than 1 mm hg.
94	SRV 1 & SRV 2 TRACKING The 9 film-handling system is run in the strip mode into SRV 1 to verify proper operation. The S/C is then fired and the tracking test repeated into SRV 2. This sequence is repeated for the 5 film-handling system.
95	ENVIRONMENTAL LAB RETURNS TUNNEL TO ATMOSPHERIC PRESSURE, TURNS OFF COOLING Tunnel pressure is returned to ambient conditions and cooling in tunnel is turned off in preparation for further testing.
96	REMOVE FILM, REFURBISH RAM, RESPLICE Film is removed from SRV 1 and SRV 2. The film from SRV 2 is sent for processing. The film is respliced to SRV 1. Assembly refurbishes the RAM. The processed film is checked to evaluate the results of the contamination test.

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
97	FILM TRACKING AFTER RESPLICE Short tracking test for 9 and 5 film-handling systems run to verify proper operation after film resplice and S/C refurbishment.
98	DATA REVIEWED The revalidation data is reviewed with the Air Force.
99	EXCESS FILM REMOVAL The excess 9 and 5 film, above the operational use figure, is run into SRV 1. Burst and strip modes of operation are used to run 1, 5, 10, 20, 50, or 100 foot lengths as required.
100	ASSEMBLY REMOVES FILM FROM SRV 1 9 and 5 film is removed from SRV 1 and system respliced back to SRV 1.
101	FILM TRACKING AFTER RESPLICE Short tracking test for 9 and 5 film-handling systems run to verify proper operation after film resplice.
102	EPOXY COUPLERS & RAM SCREWS, PANEL INSTALLATION Assembly performs required work.
103	ELECTRICAL CONDITIONING The unit is configured electrically, and then bridgewire, drive line resistance, no voltage and isolation measurements made with the DTU off and power applied.
104	DECABLE UNIT AND REMOVE FROM TUNNEL Unit is removed from tunnel and the FSE prepared for final leak rate test.
105	FILM ENCLOSURE LEAK RATE TEST The film enclosure is tested for tightness by pumping in air to

TABLE 4.4-1 (CONT'D)

Block	Test or Procedure
	2 inches of water pressure and measuring pressure drop after 13 seconds. This is done for +Y FSE vent capped and uncapped.
106 & 107	ASSEMBLY SHIPPING PREPS
	Final assembly preparations of unit prior to shipment. Checkout of trailer and shipping container performed. The PPS/DP EAC is placed into the shipping container and the container loaded onto trailer.
108	SHIPMENT

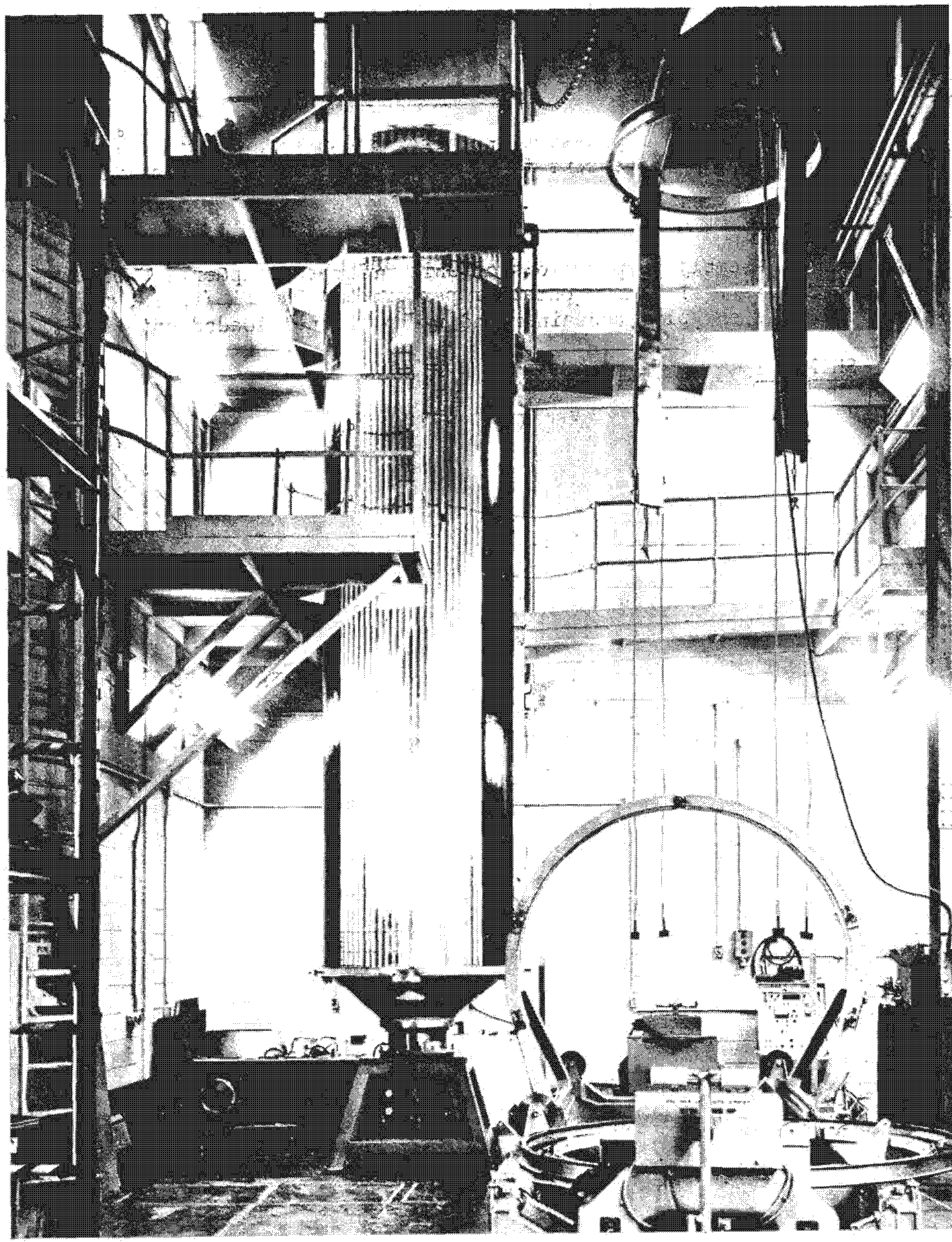


Figure 4.4-14. SEM/COM I_{xx} Measurement Equipment

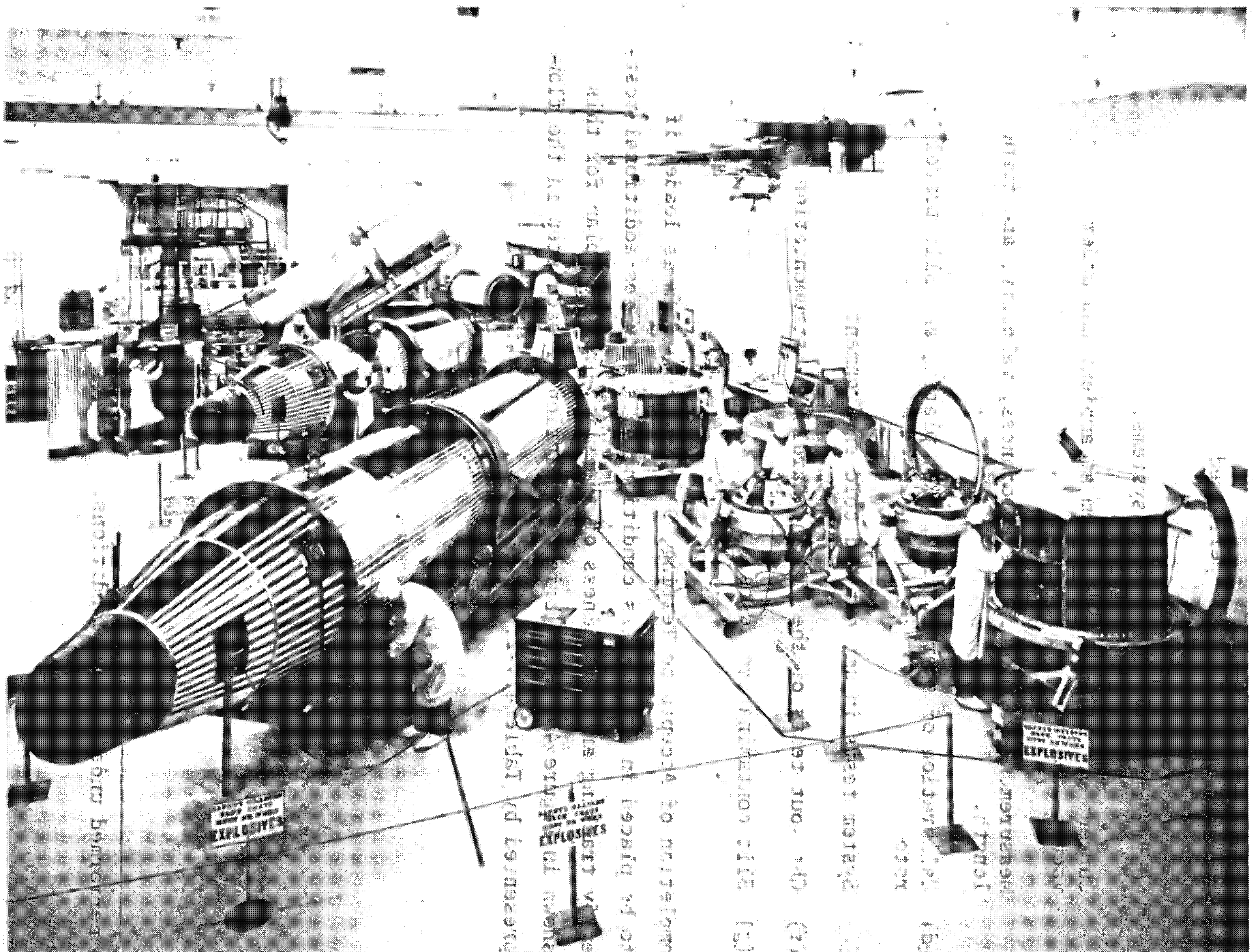


Figure 4.4-15. General View of Assembly Area

In addition, the following tests are performed:

(a) Continuity of the electrical systems.

(b) Current profiles of the system at ambient and under vacuum conditions.

*(c) Measurements of film drive smoothness, velocity, and frame length.

*(d) Calibration of stereo, crab, SRC, platen, and slit travel rates.

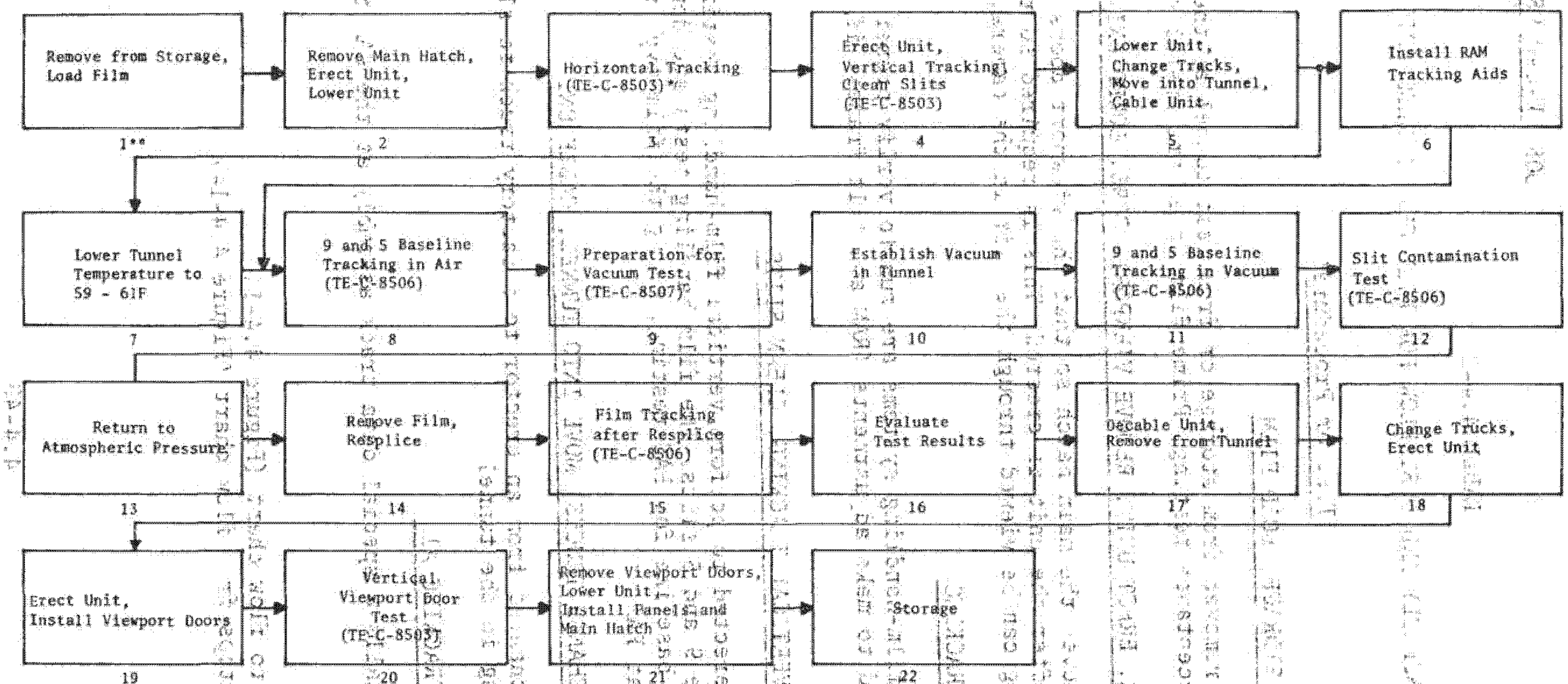
*(e) System tests in ambient and cold environments.

(f) Checkout tests of the DTU and hardline instrumentation.

(g) Slit contamination tests.

At the completion of Acceptance Testing, 9 and 5 prime film is loaded if unit is to be placed in a readiness condition. This requires additional testing to verify tracking and cleanliness of the slit. The flow plan for this work is shown in Figure 4.4-16. A brief description of each step in the flow plan is presented by Table 4.4-2.

*Testing performed under vacuum conditions.



* Test Engineering (TE) Procedures

** Numbers refer to Block Descriptions on Table 4.4-2

Figure 4.4-16. PPS/DP EAC Assembly and Test Flow for Film Change

TABLE 4.4-2

PPS/DP EAC ASSEMBLY AND TEST FLOW FOR FILM CHANGE DESCRIPTION

Block*	Test or Procedure**
1	REMOVE FROM STORAGE, LOAD FILM The unit is removed from storage or from test tunnel at the end of normal acceptance testing. Prime film loads are installed.
2	REMOVE COVER, ERECT UNIT, REMOVE VIEWPORT DOORS, LOWER UNIT Assembly removes the main hatch so that the viewport doors can be removed after the unit is erected. This is required so that film tracking can be viewed through the slit in the camera.
3	HORIZONTAL TRACKING The 9 and 5 film-handling systems are run to verify proper operation and to make adjustments (RAM and tilt frames) if required.
4	ERECT UNIT, VERTICAL TRACKING, CLEAN SLITS The unit is erected to perform vertical film-handling testing and clean the 9 and 5 slits. The film-handling tests are done to acquire a baseline for FAS testing, using the film type that will be run at FAS.
5	LOWER UNIT, CHANGE TRUCKS, MOVE INTO TUNNEL, CABLE UNIT The unit is changed from an erector to a factory truck to allow vacuum testing in the tunnel.
6	INSTALL RAM TRACKING AID Assembly installs a special data track assembly at the RAM to

* Block numbers refer to flow chart (Figure 4.4-14)

** Test and Procedure steps from flow chart (Figure 4.4-14)

TABLE 4.4-2 (CONT'D)

Block	Test or Procedure
	allow data tracks to be placed on the 9 and 5 film at the RAM location during a baseline tracking test.
7	LOWER TUNNEL TEMPERATURE 59 - 61F
8	9 AND 5 BASELINE TRACKING IN AIR
	Film is run in the strip mode with the camera and RAM data tracks ON. This test is run in the +Y and +Z orientation. Evaluation of 9 and 5 film is made after film removal.
9	PREP FOR VACUUM TEST
	All FSE covers are torqued down with +Y FSE vent cap removed.
10	ESTABLISH VACUUM IN TUNNEL
	The pressure in the tunnel is lowered to less than 1 mm hg.
11	9 & 5 BASELINE TRACKING IN VACUUM
	This test is similar to the air baseline test. Test is performed with unit in +Z orientation.
12	SLIT CONTAMINATION TEST
	Film in the 9 and 5 film-drive systems is exposed to light from a bulb on the primary mirror for a specified period. This film is later evaluated for slit contamination.
13	RETURN TO ATMOSPHERIC PRESSURE
	Unit is returned to ambient pressure for further assembly and testing.
14	REMOVE FILM, RESPLICE
	Film is removed from SRV 1 and sent for processing. The film is respliced to SRV 1.

TABLE 4.4-2 (CONT'D)

Block	Test or Procedure
15	FILM TRACKING AFTER RESPLICE Short tracking test for 9 and 5 film-handling systems run to verify proper operation after film resplice.
16	EVALUATE TEST RESULTS All test results from test cycle are evaluated at this time. This includes processed 9 and 5 films for slit contamination and camera/RAM data tracks for proper tracking.
17	DECABLE UNIT, REMOVE FROM TUNNEL Unit is removed from the tunnel for final floor test.
18	CHANGE TRUCKS, ERECT UNIT Unit is moved from a factory to an erector truck to allow for required vertical assembly/test operations.
19	ERECT UNIT, INSTALL VIEWPORT DOORS Unit is erected and viewport doors are installed by Assembly.
20	VERTICAL VIEWPORT DOOR TEST Viewport door testing is performed at high, low, and nominal voltages.
21	LOWER UNIT, INSTALL PANEL AND MAIN HATCH Remaining panels are installed and the main hatch is installed.
22	STORAGE Unit is placed in storage in a readiness condition. See PPS/DP EAC Assembly and Test Flow (Figure 4.4-13) for further details for storage and retest.

4.3.5 Pyrotechnic Subsystem Testing

Electrical checkout of the PPS/DP EAC includes verification of pyrotechnic subsystem performance using the end-to-end electronics (EEE) test equipment.

For EEE testing, and also for storage of the vehicle, special low-current resistor modules are inserted between the vehicle arm plugs and their sockets. These act as safety plugs to prevent accidental firing of a pyrotechnic device and allow a trickle current to be fed through the device bridgewire for testing. Additional types of EEE hardware modules simulate pyros or monitor current in the system under test, and four special modules are used which allow testing of the viewport door and take-up motors.

4.3.5.1 Resistor Module Types. Low current resistor modules (LRM's) are used for low current testing measuring bridgewire resistance. Each LRM puts a resistive load in series with the bridgewire and acts as a "safe" connector. High current resistor modules (HRM's) allow high current testing through vehicle cabling and connections to verify cable integrity and measure system impedance. Each HRM simulates the actual bridgewires.

The low and high current instrumentation modules (LIM and HIM) are used on the initiator electronics unit (IEU) between IEU connector J8 and arm plug W99, and indicate current drain during testing. The HIM plug is used with HRM's (high current testing), and the LIM plug with LRM's (low current testing). For high current testing, dummy pyros are installed wherever possible, and the remaining live pyros (in the cutter/sealer and tunnel seal and record trap mechanisms) bypassed by test cables.

There is one special RAM* module which allows firing of the splicer mechanism to test the splice, and also the take-up power switching functions. The

*RAM (record attach mechanism) is an unclassified term for splicer mechanism.

RAM module allows actuation only of the splicer mechanisms while protecting all other pyrotechnic devices associated with that arm plug.

For testing the primary and backup viewport door motors and the 9 and 5 take-up motors, there are four motor subsystem modules (MSM's) which can be placed between junction box connector J216 and arm plug W98. These four different types either simulate or allow actual feedthrough to the motors. For example, one plug simulates the two viewport door motors and allows the take-up motors to be driven. Motors that are simulated are fed a trickle current to check integrity.

The remaining resistor module types are special HRM's and LRM's used at the PPS/DP EAC level for SRV testing. These allow monitoring up to the arm plug connectors on the SRV but not through the bridgewires. RECAL equipment handles all SRV bridgewire testing.

In the final configuration, the PPS/DP EAC is shipped with LRM's installed as safe connectors, and safe plugs* installed where no LRM's are used.

4.3.6 PPS/DP EAC Revalidation Testing

For a vehicle which has completed acceptance testing and is in storage in excess of 21 days, a revalidation test is performed prior to shipment. The factory revalidation accomplishes the following:

a. Demonstration of proper operation of all PPS/DP EAC subsystems including splicer mechanism activation for tracking/logic checks of the film-handling system, and both SRV's.

*Reference Part 3, Section 7.

b. Exercise of all motors, encoders and potentiometers that can be activated consistent with the limitations of safety and configuration. The viewport door primary and backup systems are included because of their mission-critical function and inaccessibility at the pad checkout.

c. Testing in a fully assembled configuration. (for safety and pad-testing considerations, panels with electrical connections (socket-saver cables and panels) are installed in the factory cycle and are not removed until the arming tasks at the pad.)

d. Performance of the full system level test sequence in vacuum.

Every 90 days a unit in storage is tested to operate all motors, encoders, potentiometers, rollers, and other mechanical parts that are normally tested during PPS/DP EAC Acceptance Testing. Proper operation of electrical systems is also verified.

The configuration for this test is dependent on whether the unit being tested is considered a primary unit or backup unit. A primary unit is the next unit to be shipped. Testing on this unit is done at 60F. A backup unit is tested at clean room temperature and pressure.

The 90-day exercise and Revalidation Test are very similar, with minor differences as indicated on the PPS/DP EAC Test Flow, Figure 4.4-13. This enables a quick turnaround in case a unit is called up for usage during a 90-day exercise or within 21 days after this test.

Due to usage of 9 and 5 prime film during the 90-day exercise, reloading of 9 and 5 film loads may be required before call up of unit. In this case, a special test flow has been planned and is detailed in Figure 4.4-14. This is the same plan that was used to initially load 9 and 5 prime loads.

4.3.7 Computerized Systems Level Testing

Continuing for Flight Models 48 through 54, computer capability provides control of commands to the vehicle as well as monitoring of hardline and telemetry responses. The closed-loop system issues a time-correlated series of commands to the vehicle and associated support equipment, monitors response to the commands, determines the correctness of the response consistent with the status of the vehicle's configuration and performs several data-analysis subroutines. This computer system is known as "Programmable Logic Test Equipment" (PLTE) and has been in use since FM-42.

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