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This document contains 126 classified sheets including the front and back cover.

PHOTOGRAPHIC SYSTEM REFERENCE HANDBOOK
FOR
GAMBIT RECONNAISSANCE SYSTEM
WITH
EXTENDED ALTITUDE CAPABILITY
(EAC)

VOLUME 3

Prepared by
BIF-008

Under Contract

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25X1

Approved by:

J. Paulson

1 July 1980

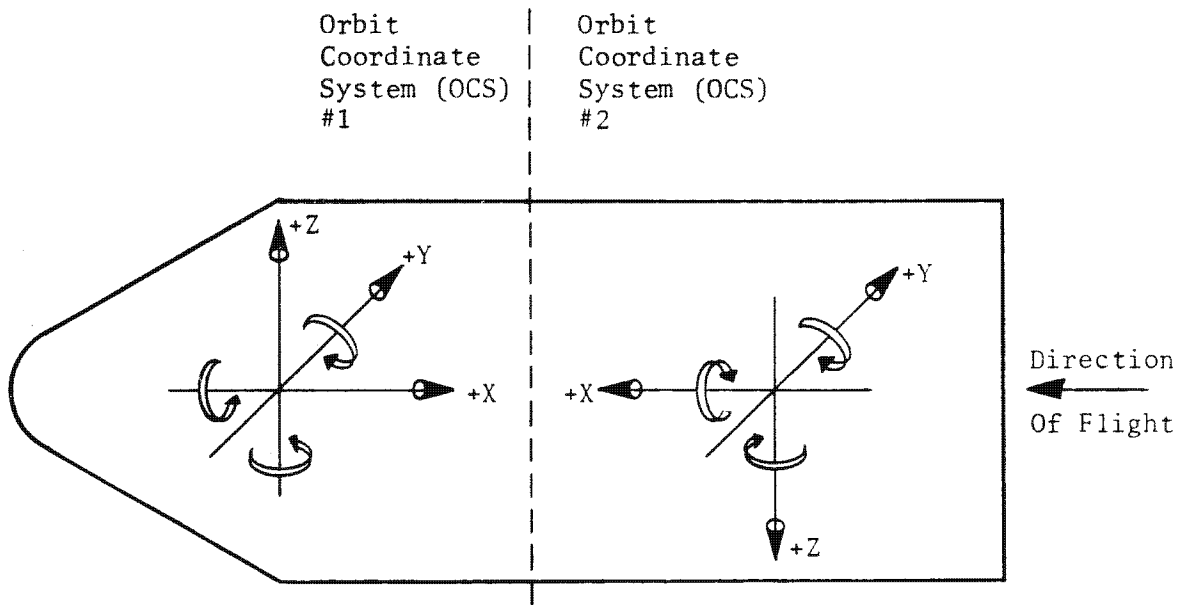
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2.0 9 x 5 DUAL PLATEN CAMERA AND FILM HANDLING SUBSYSTEM

The 9 x 5 dual platen camera and film handling subsystem provides the means to transfer and expose film in the PPS/DP EAC. The subsystem moves film from the supplies to the camera, records an image on the film, and then moves the exposed film to the take-up spools for later recovery. To simplify this section, the camera components and film-handling components will be discussed separately.

Figure 3.2-1 presents an overall block diagram of the 9 x 5 camera and film handling subsystem. The locations of the camera and film handling components, excluding electrical boxes (see Part 3 Section 1) are shown in Figure 3.2-2.

2.1 Film Handling Subsystem Description

The following components comprise the 9 x 5 film handling subsystem:

- (1) two supply assemblies (9 and 5)
- (2) two 9 x 5 take-up mechanisms and their associated spools
- (3) two electronic control units
- (4) film guidance and alignment devices

The supply assemblies store unexposed film and supply film to the camera as needed. The assemblies also act to control film tension throughout the subsystem.

The take-up assemblies (one in each SRV) store the exposed 9 and 5 films for

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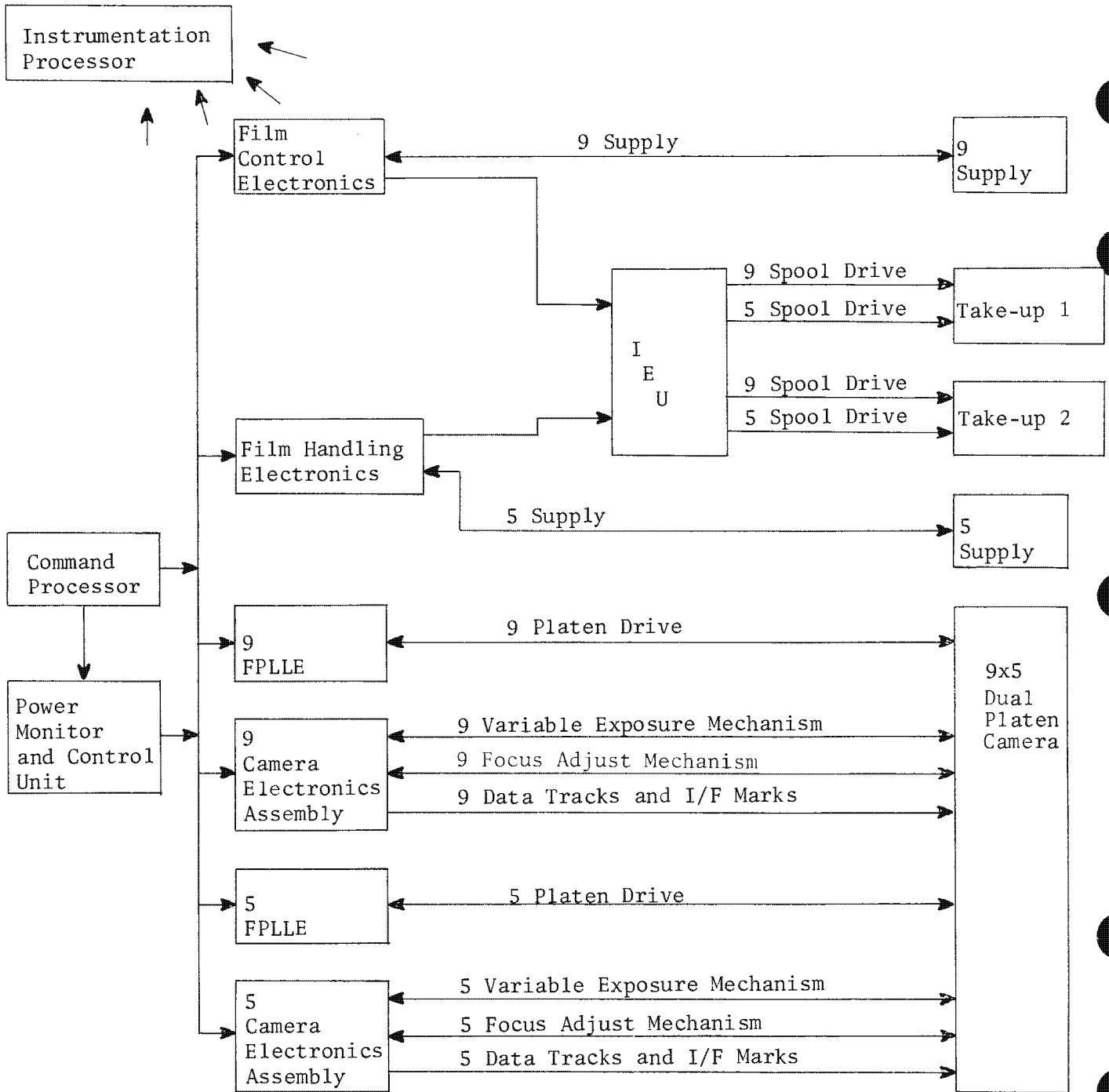


Figure 3.2-1. 9x5 Dual Platen Camera And Film Handling Subsystem Block Diagram

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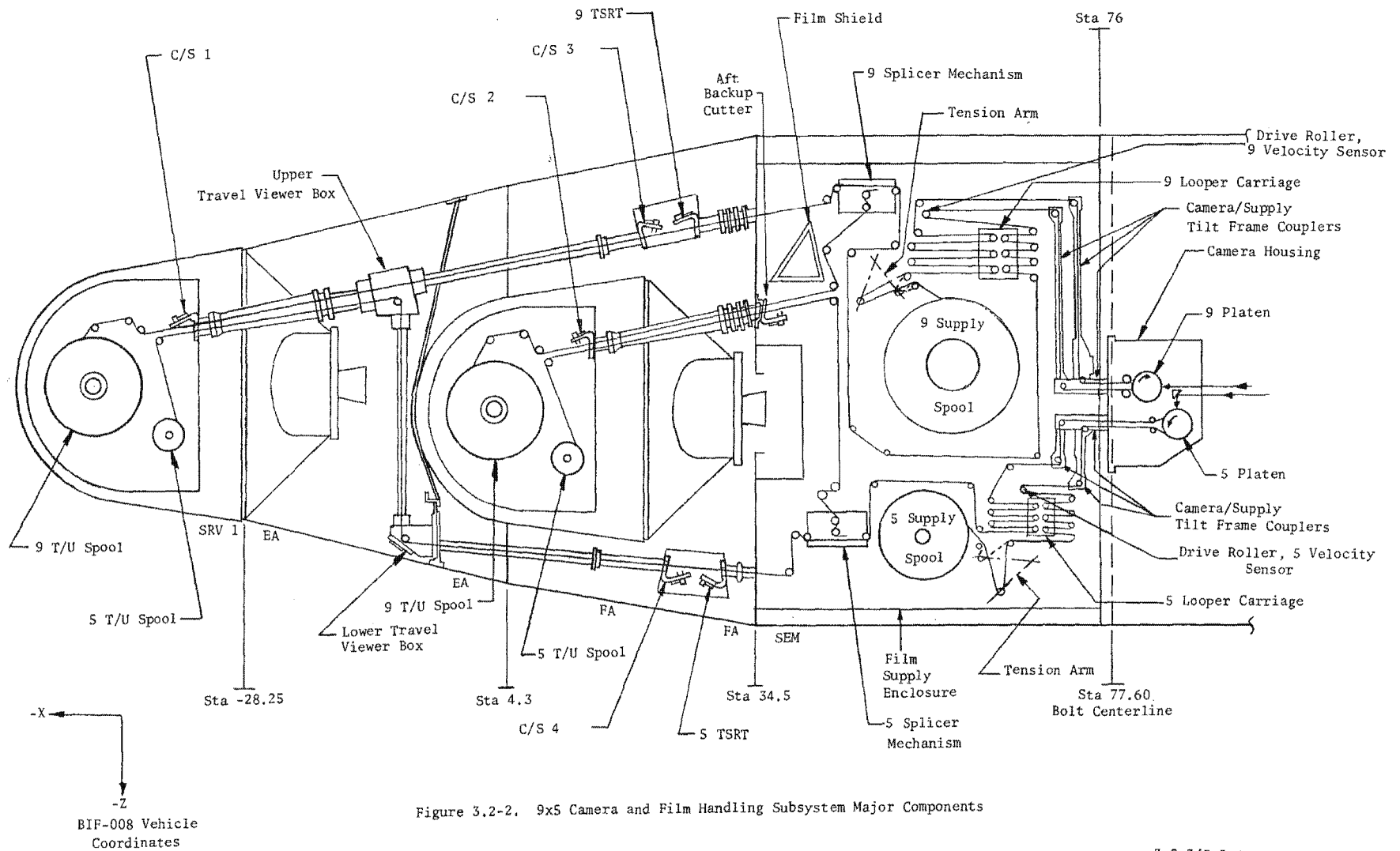


Figure 3.2-2. 9x5 Camera and Film Handling Subsystem Major Components

3.2-3/3.2-4

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subsequent recovery and assist the supply assemblies in controlling film tension.

The two electronic units (film control electronics (9) and film handling electronics (5)) control the transport of the film by the supply and take-up assemblies.

The film guidance and alignment devices ensure smooth, damage-free movement of the film through the subsystem.

2.1.1 9 and 5 Supply Assemblies

Each supply assembly is held in a single framework, and consists of a supply spool assembly containing the film spool and spool drive, a looper assembly having a supply and take-up side with a free-running carriage between, a tension arm assembly, film transport and guiding devices, and associated instrumentation (see Figures 3.2-3 and 3.2-4). A splicer/cutter mechanism attaches to each supply frame, and guides the film to either take-up 1 or take-up 2.

2.1.1.1 Supply Spool Assemblies. The supply spool assemblies are self-contained units to which the film spools are mounted to facilitate changing. Each assembly can be removed from the main supply frame either before or after assembly into the supply and electronics module (SEM).

2.1.1.1.1 9 Supply Spool Assembly. The 9 spool assembly, Figure 3.2-5, consists of a fixed spool-support spindle and a rotating spindle which form a frameless dc torque motor driving the supply spool. Two redundant coil electromechanical brakes connect to the rotating spindle through a single gear train. The spool mounts on the rotating spindle and has a 6-inch diameter core with 20.25-inch outside diameter flanges. The maximum capacity of the 9 supply spool is 12,241 feet of 0.002-inch thick film or equivalent

3.2-5

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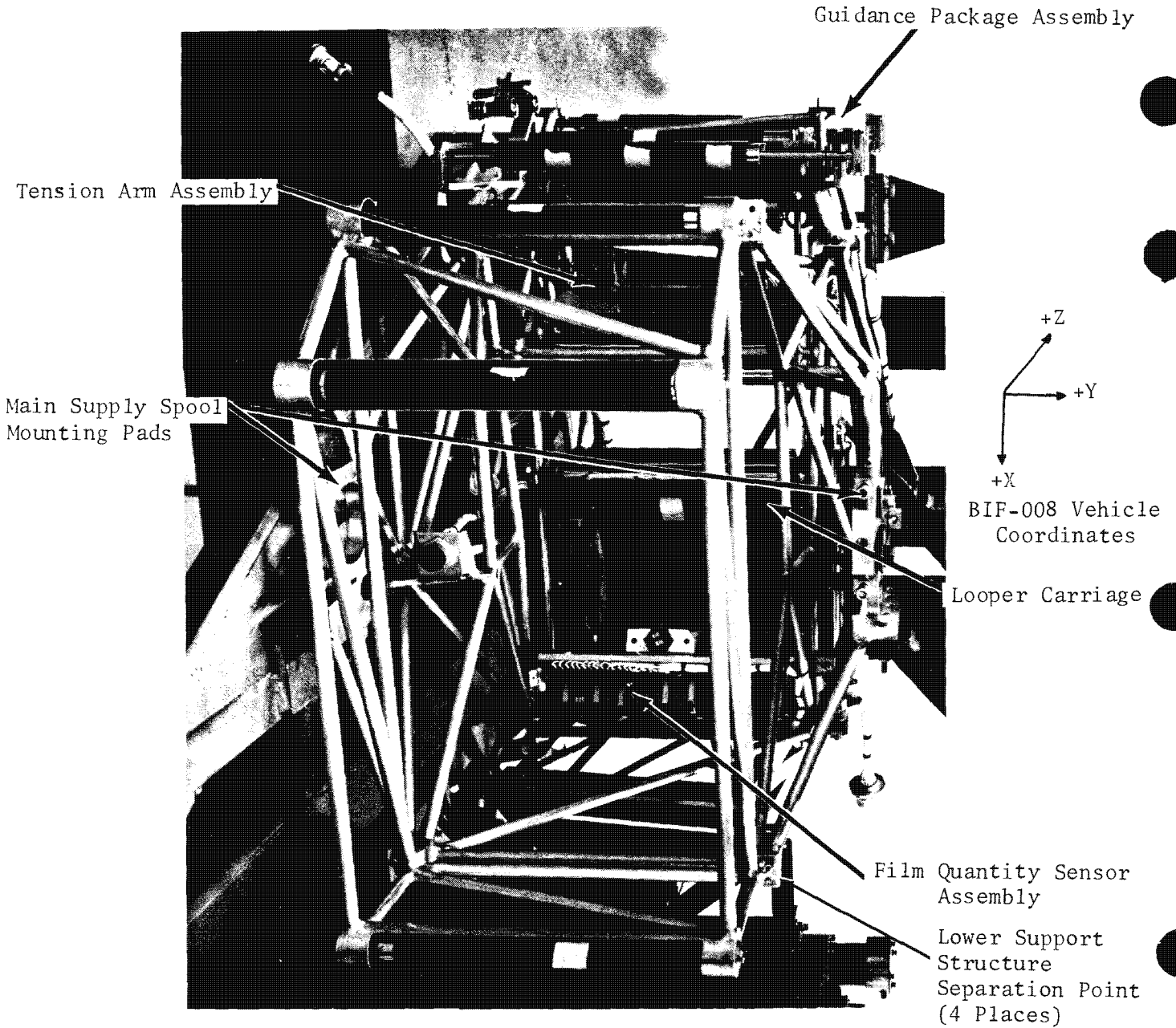


Figure 3.2-3. 9 Supply and Looper Assembly Without Supply Spool

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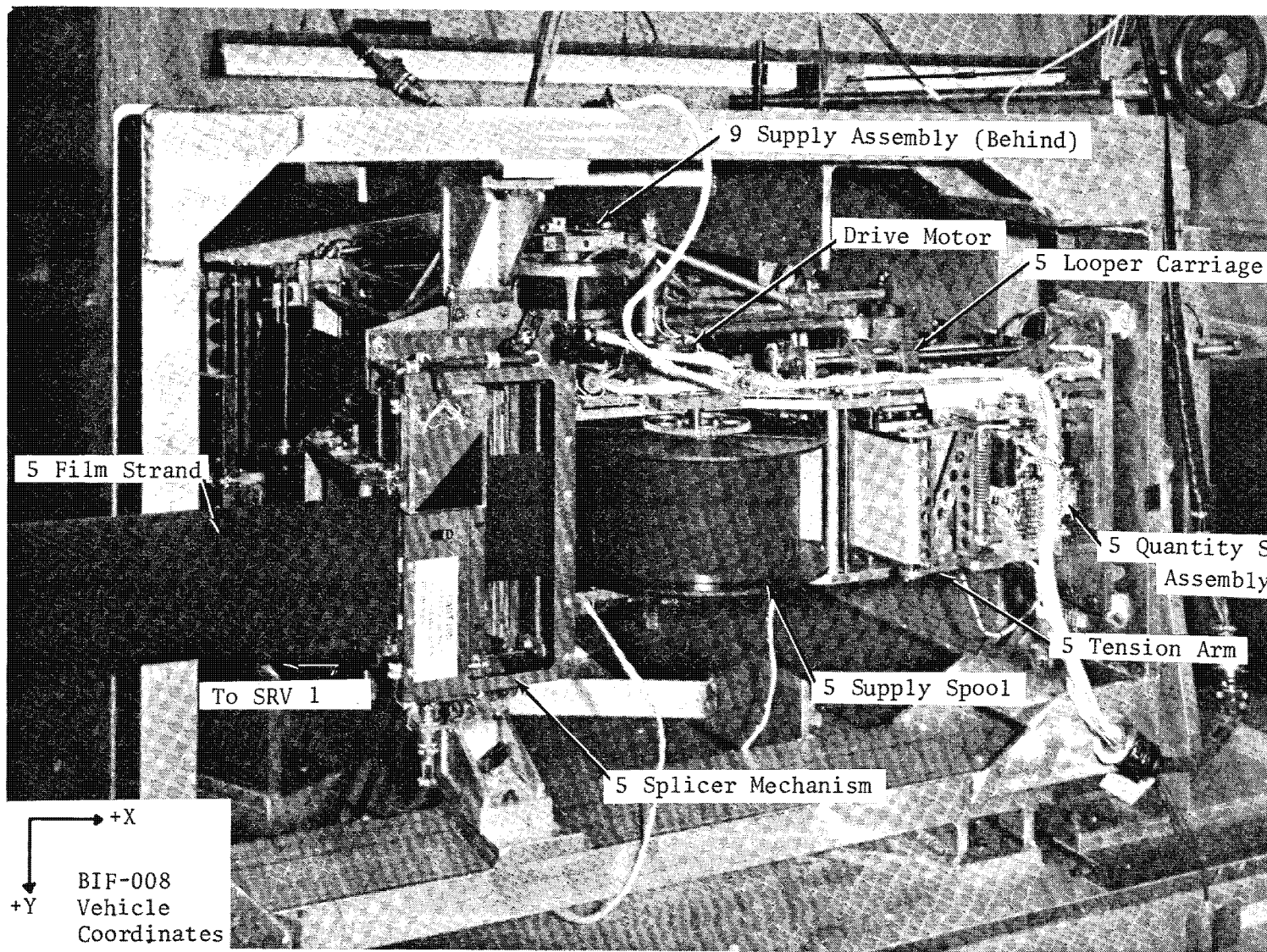


Figure 3.2-4. 5 Supply Assembly (Breadboard)

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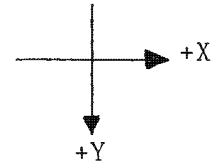
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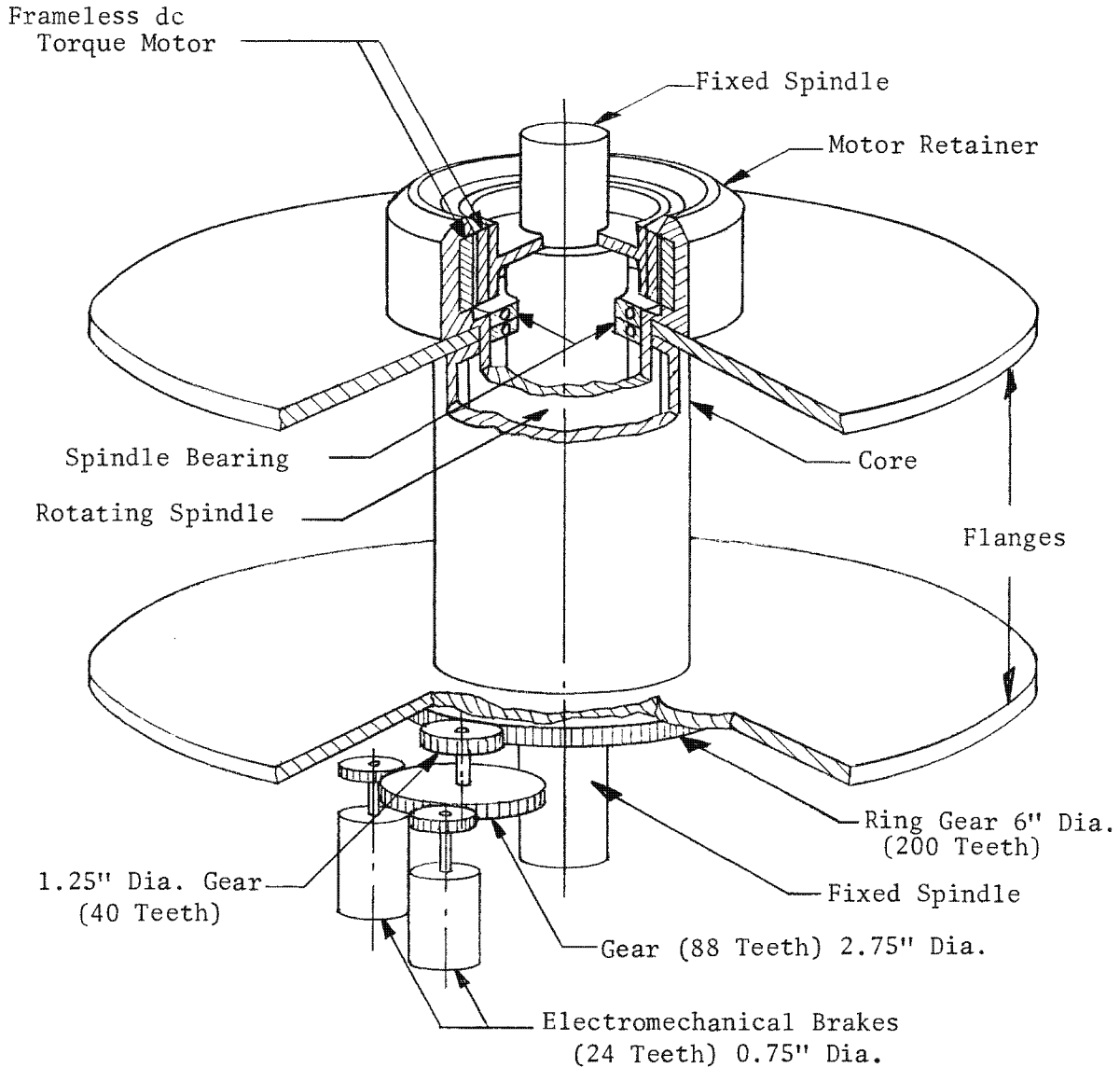
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Note:

Core = 6 inches in diameter
Spool = 20.25 inches OD



BIF-008 Vehicle Coordinates



All Gears: 10 Teeth/in. of Circumference

Gear Ratio: 18:1

Figure 3.2-5. 9 Supply Spool Assembly

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(10,800 feet of operational film, the remaining capacity available for storing test film).

The supply spool drive, consisting of the fixed and rotating spindles and the mechanical brakes, is powered through the film control electronics. The fixed spindle contains the stator portion of the motor and supports the dual brake assembly and its gear train. The rotating spindle is supported on the fixed spindle by ball bearings. The armature of the torque motor is fastened to the rotating spindle together with a ring gear which meshes with the brake gearing.

The supply motor accelerates or decelerates the supply spool to maintain constant film tension, excluding minor tension transients, over the entire range of film spool inertias. The supply spool is stopped by a combination of supply motor power reversal and, if necessary, application of the brakes. (Brakes are needed only for deceleration with a large supply spool inertia.)

The two brakes, which are normally engaged, connect to the spindle through an 18:1 gear reduction, yielding a minimum braking torque of approximately 19 foot-pounds. The brakes act as holding brakes during all inactive periods of the mission, including launch and orbit adjusts. The brakes are mechanically connected in parallel and are disengaged simultaneously during normal take-up operations. Each brake assembly incorporates two actuating coils, either of which is capable of disengaging that brake. The coils are connected into the control circuitry in such a manner that a failure of any one coil or its actuating circuit will not result in a failure to disengage both brakes.

2.1.1.1.2 5 Supply Spool Assembly. The 5 spool assembly, shown in Figure 3.2-6, consists of a spindle supporting a 3.00-inch diameter spool core with 11.0-inch outside diameter flanges, driven by a dc torque motor through a spur gear attached to the spindle. The dual coil electromechanical brake

3.2-9

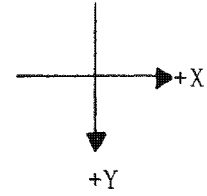
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Note:

Core = 3.00 inches diameter
Spool = 11.0 inches OD



BIF-008 Vehicle
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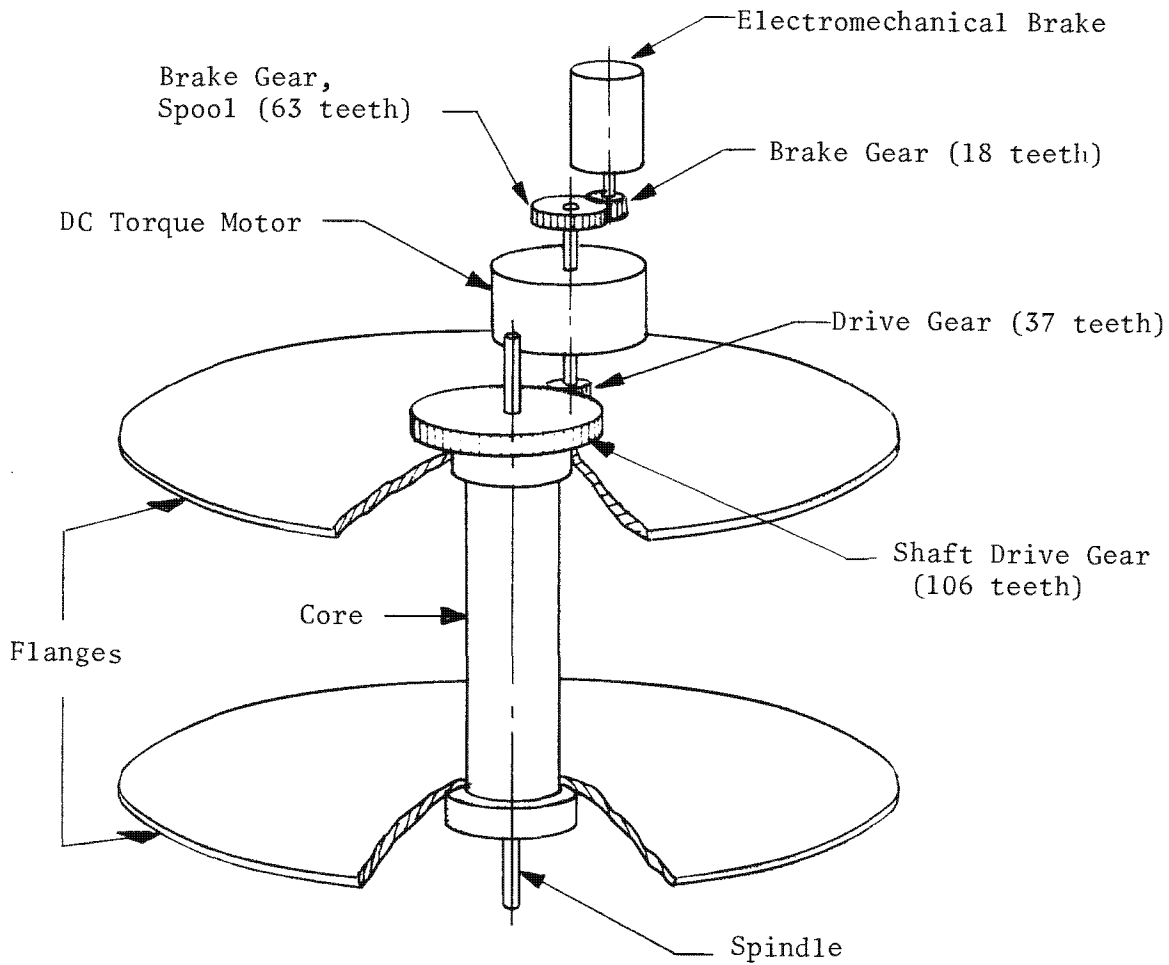


Figure 3.2-6. 5 Supply Spool Assembly

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connects to the supply drive through a spur gear attached to the motor shaft. The maximum capacity of the spool is 3,665 feet of 0.002-inch thick film or equivalent, with 3,000 feet of operational film and the balance of the spool capacity available for storing test film.

The 5 supply drive is similar to the 9 drive except that the motor is mounted to the side of the supply frame and is a self-contained unit. As in the 9 system, the torque motor is used to drive the supply spool in the forward direction, and to provide reverse torque for stopping or slowing forward rotation of the spool.

The drive uses the electromechanical brake to prevent spool movement during periods of nonoperation. The brake is normally engaged and requires power to either of its two coils to release. When fully engaged, the brake provides approximately 3 foot-pounds of braking torque at the supply spool. During normal operation the brake aids the supply motor dynamic braking in deceleration of the supply spool.

During launch the brake is assisted by application of a small reverse current to the drive motor through a separately dedicated circuit. Referred to as the 5 parking brake function, the additional holding force provided is necessary to prevent spool rotation due to launch vibration.

2.1.1.2 Frame and Looper Assemblies. The 9 and 5 frame and looper assemblies are functionally identical. Therefore, the following discussion may be applied to either.

The frame and looper assembly is a rigid-frame structure supporting all other supply subassemblies, including a full film load and a splicer mechanism. The frame includes the looper carriage and other fixed rollers as an integral part of the assembly.

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The looper system is composed of two film storage locations (supply side and take-up side) connected by a free-moving carriage. The action of the looper carriage within its frame enables the camera to withdraw film from one side of the looper and return it to the other, up to the design capacity of the looper, without supply spool or take-up spool operation. Figure 3.2-7 shows the looper system, with the rollers which orient and direct the film from the supplies through the camera and onto the take-ups.

The carriage assembly (Figure 3.2-8) consists of six rollers mounted to a truck which is free to slide back and forth on two longitudinal rods. Because there is no force exerted on the truck except by film tension, the position of the carriage is determined solely by the quantity of film in both sides of the storage looper. A decrease in the quantity of film in the take-up side of the looper is accompanied by an equal increase in quantity on the supply side of the looper. The resultant carriage translation drives a spiral roller cam by means of a post on the carriage. The cam rotates the shafts of two position-indicating potentiometers used for instrumentation, and also drives encoders, S1 and S2, generating the "empty" and "full" electrical limit feedback signals used to control film handling. The 9 and 5 supply encoders also generate the CAMERA AUTOMATIC OFF signals used by the CP to automatically turn off the camera in case an "OFF" command from the interface is not present. Figure 3.2-9 is a photograph of the 5 supply showing the carriage and spiral cam.

The film capacity of the 9 and 5 loopers between mechanical stops is 60.0 and 45.0 inches respectively, and 36.8 inches between electrical stops for both.

The electrical range is not centered within the mechanical range. When the 9 carriage moves so as to empty the take-up side, the electrical trip point (supply looper full) occurs with 17.45 inches of film remaining before contact with the mechanical stop. When the carriage moves so as to fill the take-up side, the electrical trip point (supply looper empty) occurs with 54.25 inches of film in the looper ($54.25 - 17.45 = 36.8$ inches). The corresponding points for the 5 looper carriage are 6.5 and 43.3 inches respectively.

3.2-12

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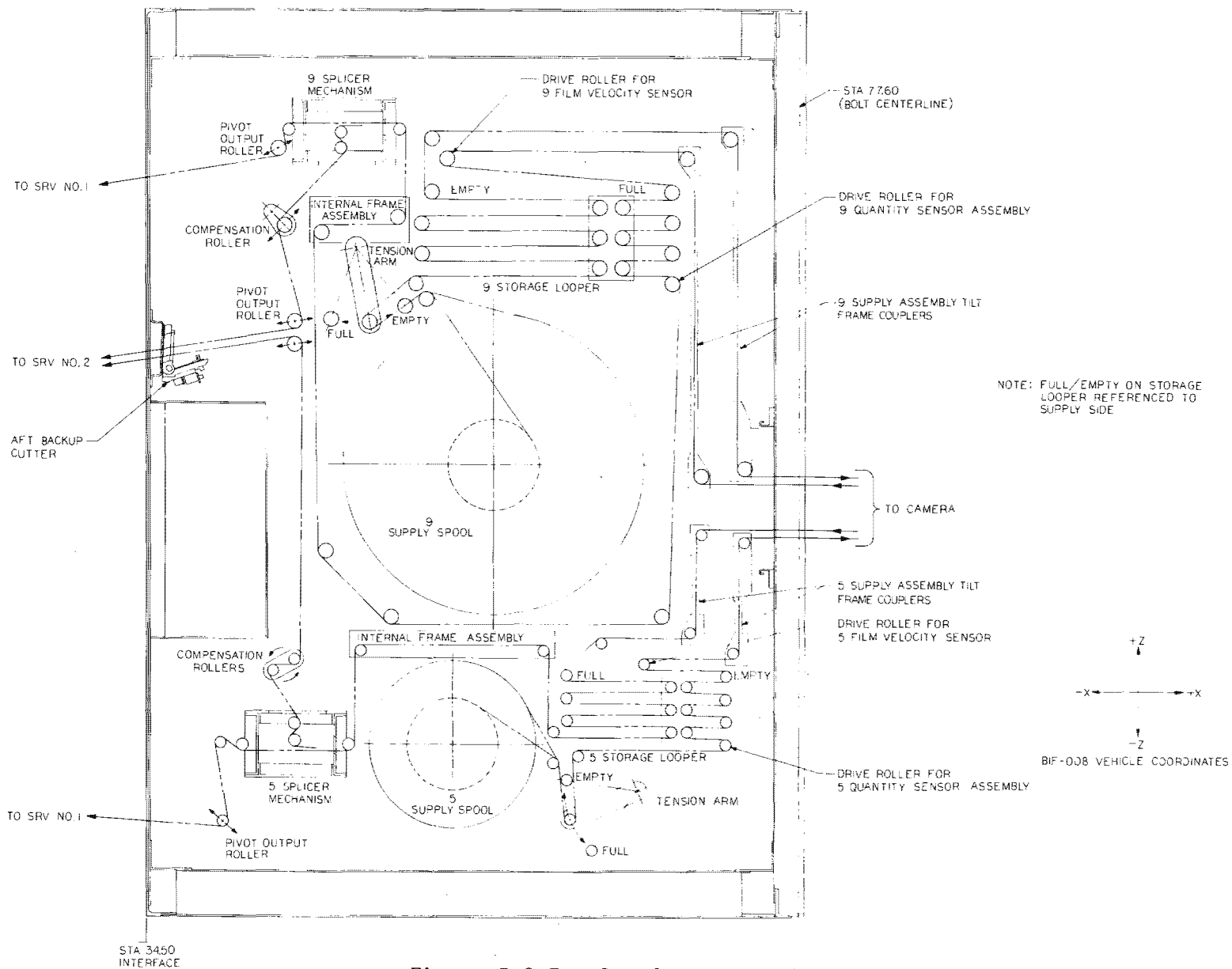


Figure 3.2-7. 9 and 5 Supply Assemblies

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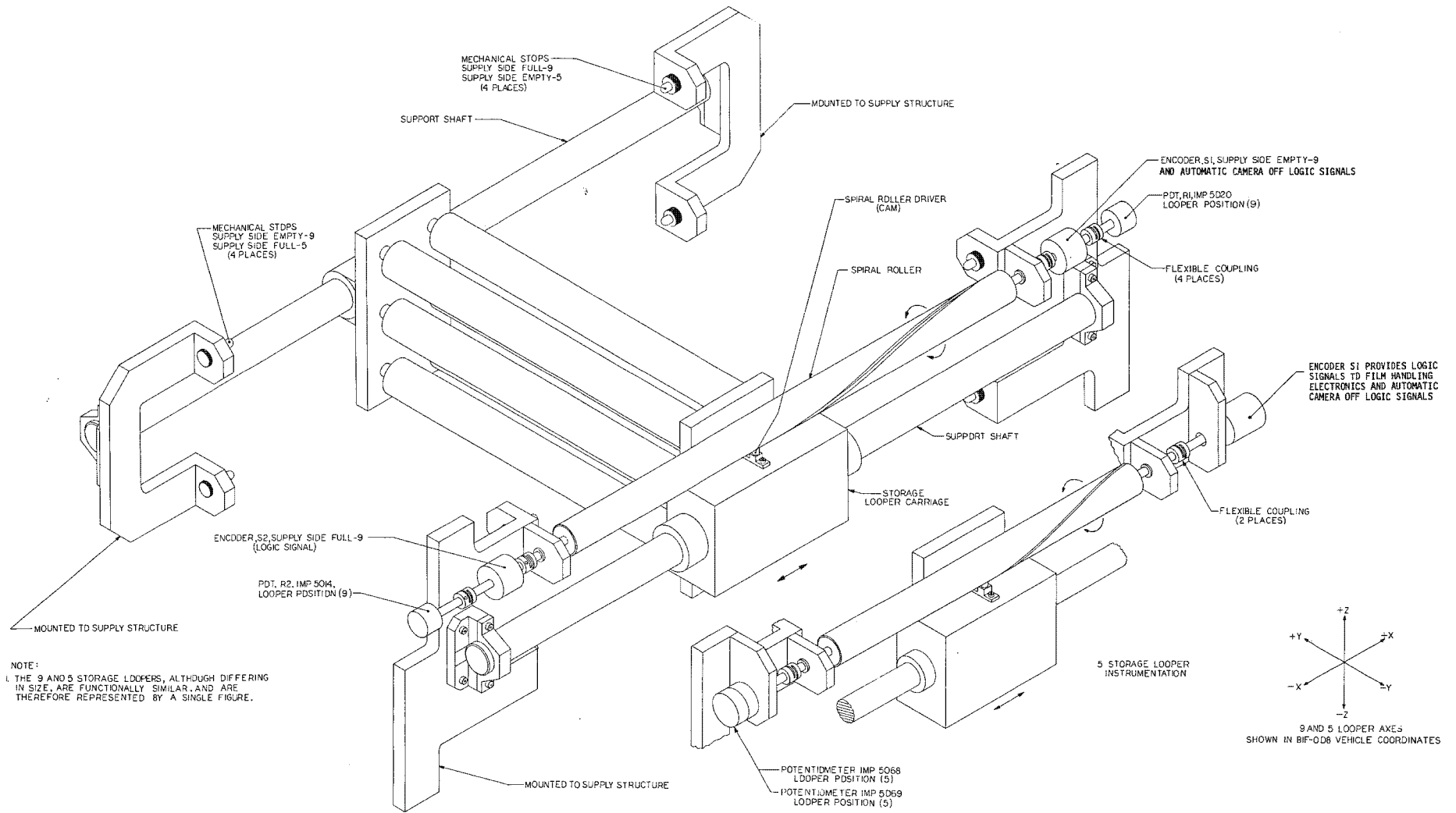


Figure 3.2-8. 9 and 5 Looper Carriage Assemblies and Instrumentation

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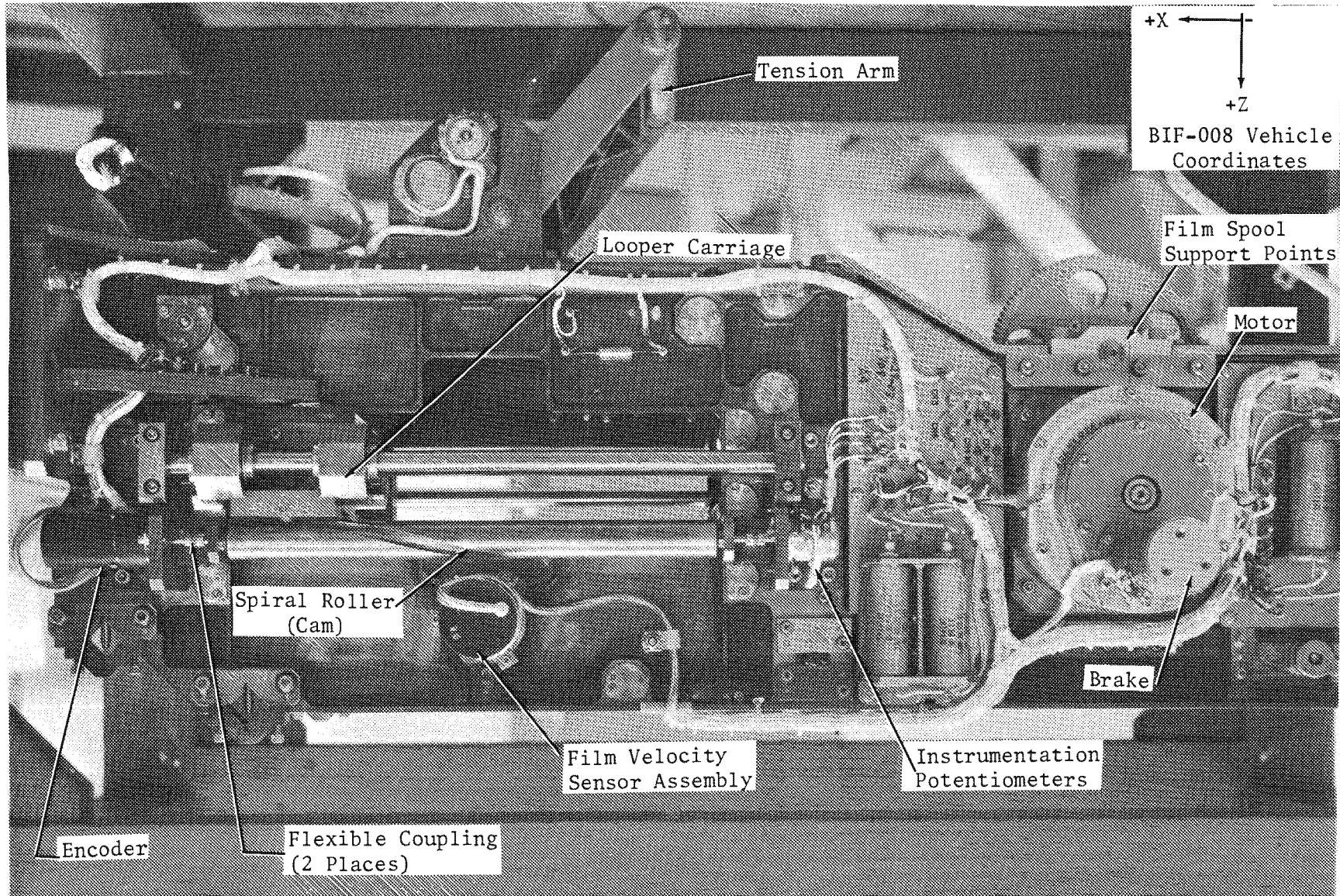


Figure 3.2-9. 5 Supply Assembly (-Y View)

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2.1.1.3 9 and 5 Tension Arm Assemblies. The 9 and 5 tension arm assemblies (Figure 3.2-10) are functionally similar and will be treated here together, with minor differences identified.

The tension arm assembly consists of a roller attached to a pivoting arm on the looper assembly, plus an encoder and two concentric potentiometers driven by the arm shaft.

(Text continued on page 3.2-20)

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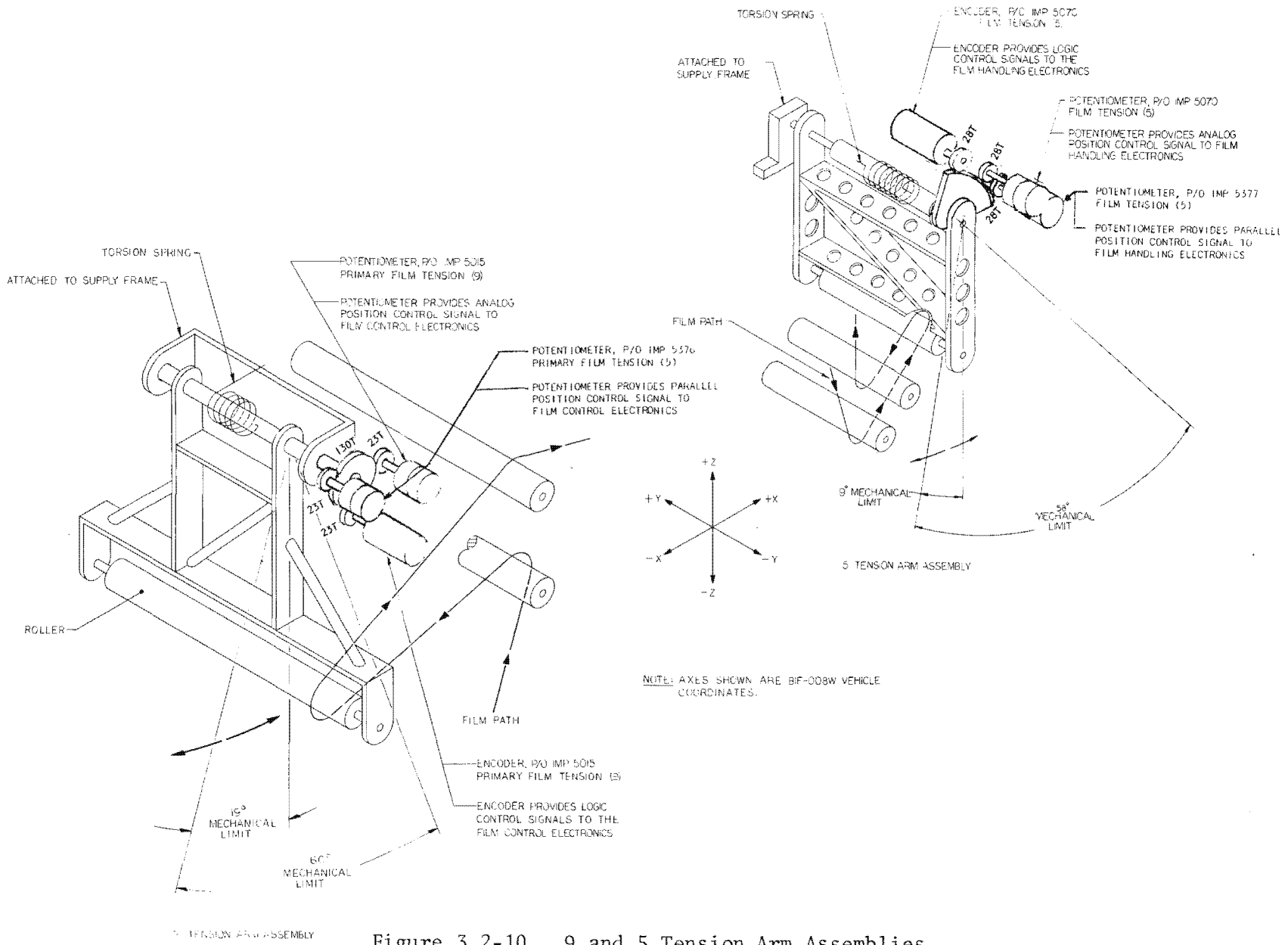


Figure 3.2-10. 9 and 5 Tension Arm Assemblies

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The tension arm acts as a limited film supply to absorb temporary mismatches in supply/receiver rates. A torsion spring attached to the pivoting arm maintains a tension of 3.0 ± 0.25 pounds for the 9 subsystem and 1.5 ± 0.25 pounds for the 5 subsystem throughout the physical capacity of the tension looper.

The 9 tension arm has a radius of 5.0 inches with a 60-degree travel between mechanical stops giving a maximum film capacity of 9.6 inches. The 5 tension arm is 5.0 inches in radius with a 58-degree travel between stops, resulting in a maximum film capacity of 9.4 inches.

The tension arm encoder and four potentiometers are connected to the arm shaft as shown in Figure 3.2-10. The 9 encoder has four tracks which provide the Full, Near Full, Approaching Full, and Empty logic signals to the film control electronics (9). Additional tracks yield high and low tension signals used in conjunction with an instrumentation potentiometer. The quantity of film in the 9 tension looper at the encoder electrical Full position is 8.7 inches, at the Near Full position is 8.2* inches, at the Approaching Full position is 4.55 inches, and at the electrical Empty position is 0.3 inch.

The 5 encoder has three tracks which provide the Full, Approaching Full, and Empty logic signals to the film handling electronics (5). Additional tracks yield high and low tension signals used in conjunction with an instrumentation potentiometer. The quantity of film in the 5 tension looper at the encoder electrical Full position is 8.8 inches, at the electrical Empty position is 1.3 inches, and at the electrical Approaching Full position is approximately 6.7 inches.

The four potentiometers actually consist of two ganged dual cup potentiometers; one having the element of both cups made of infinite resolution conductive plastic and the other having the element of both cups wirewound. The two

* 8.2 inches is true for OM-50 only.
For FM-51 and on, this number is 6.3 inches.

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potentiometers are directly connected with the same gear ratio to the tension arm. The shafts of the two potentiometers are synchronized. The wiper of one cup of the conductive plastic potentiometer is connected to the wiper of one cup of the wirewound potentiometer. This common wiper supplies the appropriate control electronics with a voltage (error signal) proportional to the amount of film stored in the tension looper. This paralleling of wipers provides redundancy for the error signal so that an open wiper or element in either potentiometer will not result in the loss of the error signal.

The other cup of the conductive plastic potentiometer in conjunction with the encoder provides a linear voltage output proportional to the tension arm position with discontinuous voltage jumps at the electrical Full and Empty positions. The other cup of the wirewound potentiometer provides a redundant linear voltage output without the discontinuous voltage jumps at the tension arm extremes. Both of these instrumentation signals are used for vehicle telemetry (refer to Section 2.1.1.6).

2.1.1.4 Supply Guidance and Compensating Devices. The following discussion refers to Figure 3.2-7.

2.1.1.4.1 Tilt-Frame Couplers. Tilt-frame couplers are included in both systems (9 and 5) to ensure correct tracking of the film from the looper assembly to the camera and from the camera back to the looper. The tilt-frame couplers are supported by the supply frames and the camera housing cover, and are self-adjusting for all lateral and rotational displacement which might occur between the supplies and the camera. The couplers overcome component displacements by allowing the film strands between the supply and camera to undergo neutral axis twists. A manual adjustment capability between the supply and camera portions of the tilt-frame couplers allows for accurate lateral positioning of the film relative to the camera platen. The coupler assemblies also contain an internal damping frame on the input roller leading

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to the camera, which helps to isolate film handling disturbances that might otherwise affect performance of the camera. The design of the 9 and 5 couplers are similar except for lengths and roller dimensions.

2.1.1.4.2 Splicer Mechanism/Supply Alignment. Each supply frame incorporates a four-pad mounting surface for a splicer mechanism. The mounting can be adjusted to control Y-axis alignment between the splicer and supply. An adjustable frame assembly within the supply structure, at the input side of the splicer mounting, can be used to provide small values of Y-axis translation in film tracking between the supply and splicer.

2.1.1.4.3 Supply Assembly Output Alignment. The four output rollers guiding film from the supply assemblies toward the 9 x 5 take-up mechanisms are pivot rollers (pivoting about the longitudinal axis), which allow the film to undergo neutral axis twists to ensure correct tracking into the take-up mechanisms. The supplies also include a set of compensating rollers in the film path to take-up 2. These are spring-loaded so that at various tension levels the rollers will move to shorten or lengthen the film path to take-up 2. This movement compensates for the worst case increase in path lengths which could be caused by thermal expansion of the vehicle, and prevents excessive tension in the film leaders from take-up 2 to the splicer mechanisms.

2.1.1.5 9 Supply Assembly Lower Support Structure. The lower support structure and main support structure of the 9 supply are tubular aluminum weldments. The lower structure includes three rollers which guide the 9.5-inch wide film strand around the supply spool from the carriage assembly to the splicer mechanism location (reference Figure 3.2-7). This lower structure can be separated from the main support structure for removal of the supply spool assembly. When installed in the film supply enclosure, the 9 lower support structure and spool cannot be removed without first removing the entire 5 supply assembly. Figure 3.2-3 shows the 9 supply and looper assembly mounted on a test fixture, and indicates the four separation points for the lower support structure.

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2.1.1.6 Instrumentation

2.1.1.6.1 9 and 5 Tension Arm Instrumentation. The instrumentation cup of the conductive plastic potentiometer and the mechanical encoder on each tension arm, in conjunction with a resistance network (located in the supply assembly in the 9 subsystem and in the film handling electronics in the 5 subsystem), generate a tension arm position telemetry signal. Figure 3.2-11 is a schematic of the circuit, applicable to either the 9 or 5 subsystem.

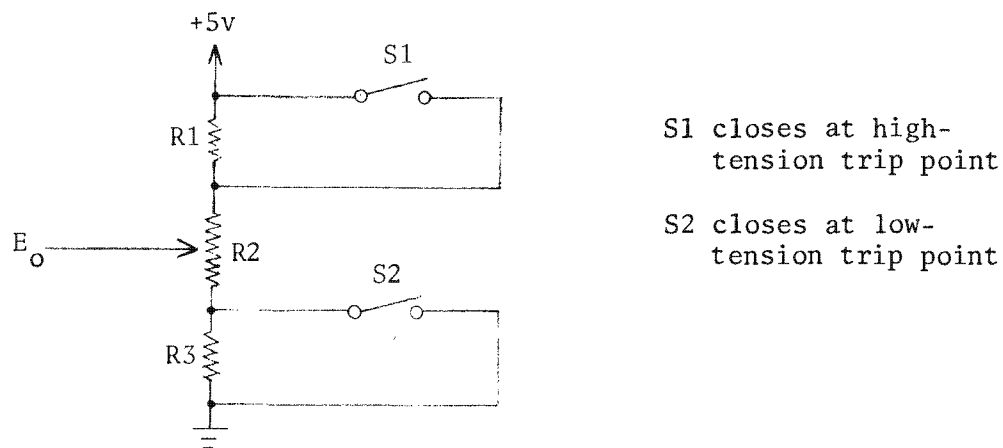


Figure 3.2-11. General Tension Arm Instrumentation Circuit

Switches S1 and S2 represent tracks on the mechanical encoder. The potentiometer yields a linear voltage output as a function of arm position. The encoder, by removing either R1 or R3 from the circuit, depending on arm position, causes the output discontinuities shown in Figure 3.2-12.

The instrumentation cup of each wirewound potentiometer produces a redundant linear voltage output with the same slope, but uses the +15-volt instrumentation supply and does not have the encoder trip points. The schematic of the redundant instrumentation is similar to that in Figure 3.2-11, except that +15 volts is used and there are no encoder switches.

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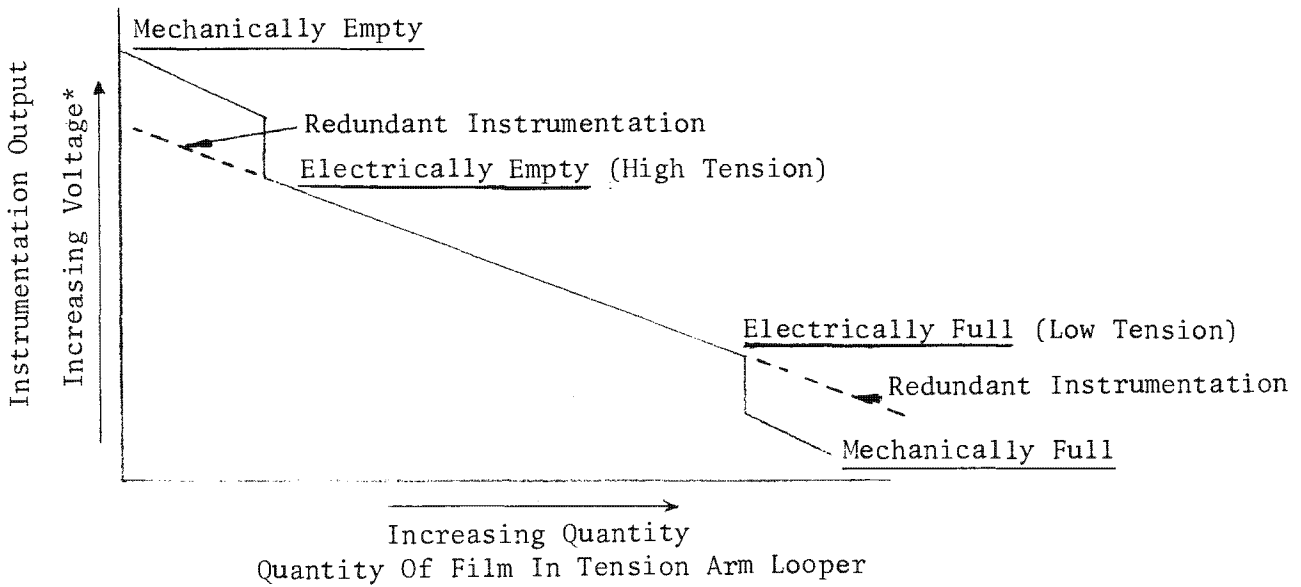


Figure 3.2-12. General Tension Arm Instrumentation Output

*Absolute voltage levels are provided in the Calibration Book supplied with each flight model.

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Table 3.2-1 summarizes the quantities of film and approximate film tension at the electrical and mechanical limits for both the 9 and 5 tension arms.

TABLE 3.2-1
TENSION ARM INSTRUMENTATION DATA

| | IMP 5376 and IMP 5015 <u>9 Tension Arm</u> | IMP 5377 and IMP 5070 <u>5 Tension Arm</u> |
|---------------------------------------|---|---|
| Mechanically Full: Inches of Film | 9.6 | 9.4 |
| Electrically Full: Inches of Film | 8.7 | 8.8 |
| Approximate Film Tension | 2.73 pounds | 1.47 pounds |
| Electrically Empty: Inches of Film | 0.3 | 1.3 |
| Approximate Film Tension | 3.15 pounds | 1.54 pounds |
| Mechanically Empty: Inches of Film | 0.0 | 0.0 |

2.1.1.6.2 9 and 5 Velocity Sensor Assemblies. The velocity of film being transferred by the camera from the supply to the take-up side of the looper is monitored by means of a 100-line optical incremental encoder directly coupled to a film path idler roller (see Figure 3.2-7 for roller locations).

Each line generates a pulse which is amplified, shaped, and used to increment an 8-digit binary counter in the supply assembly. The counter runs from 0 to 255, resetting on the next pulse and continuing. Calculation of the number of pulses per unit time indicates the average film velocity during the measured period for velocities greater than 0.84 inch per second (ips) and less than 23.6 ips.

Each velocity sensor roller is 0.750 inch in diameter, yielding one pulse for every 0.024 inch of film passing. Figure 3.2-13 is a conceptual representation of the velocity sensor assembly.

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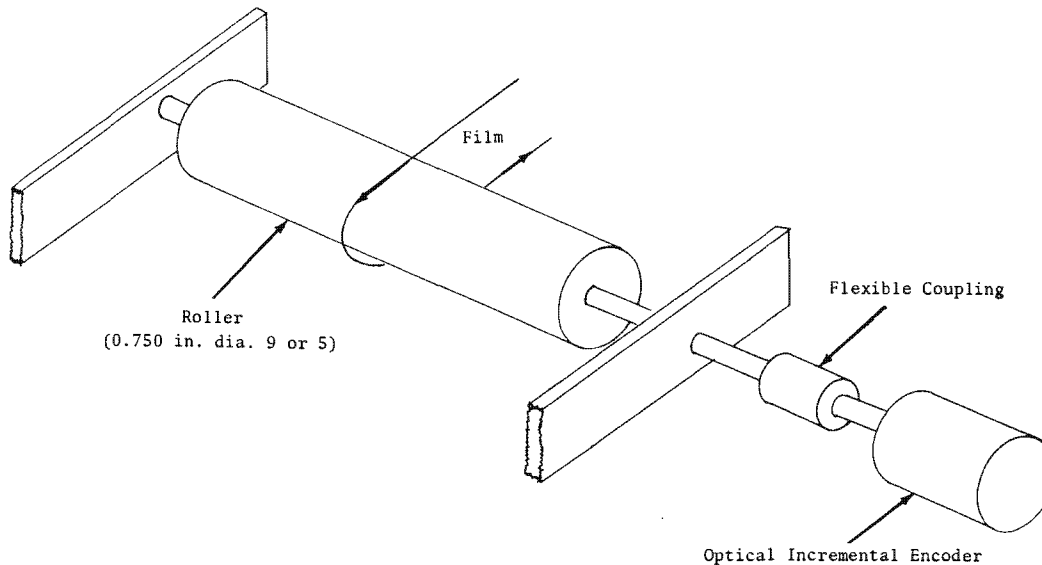
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Figure 3.2-13. Film Velocity Sensor Conceptual Representation

2.1.1.6.3 9 and 5 Quantity Sensor Assemblies. Both the 9 and 5 supplies have quantity sensor assemblies mounted to their respective frames which measure the amount of film transferred between supply and take-up (refer to Figure 3.2-7 for the sensor drive-roller locations).

The 9 subsystem film quantity is measured by three sets of dual concentric potentiometers and associated resistance networks in the supply assembly. The coarse and fine potentiometers are connected to one end of an idler roller through a spring-loaded gear, gear train, and gear reducer. A separate spring-loaded gear drives the medium potentiometers through another gear reducer from the opposite end of the same roller, as shown in Figure 3.2-14. Both spring-loaded gears are set to slip at 2 inch-ounces of torque. Therefore, if any binding were to occur in the quantity measuring system, the

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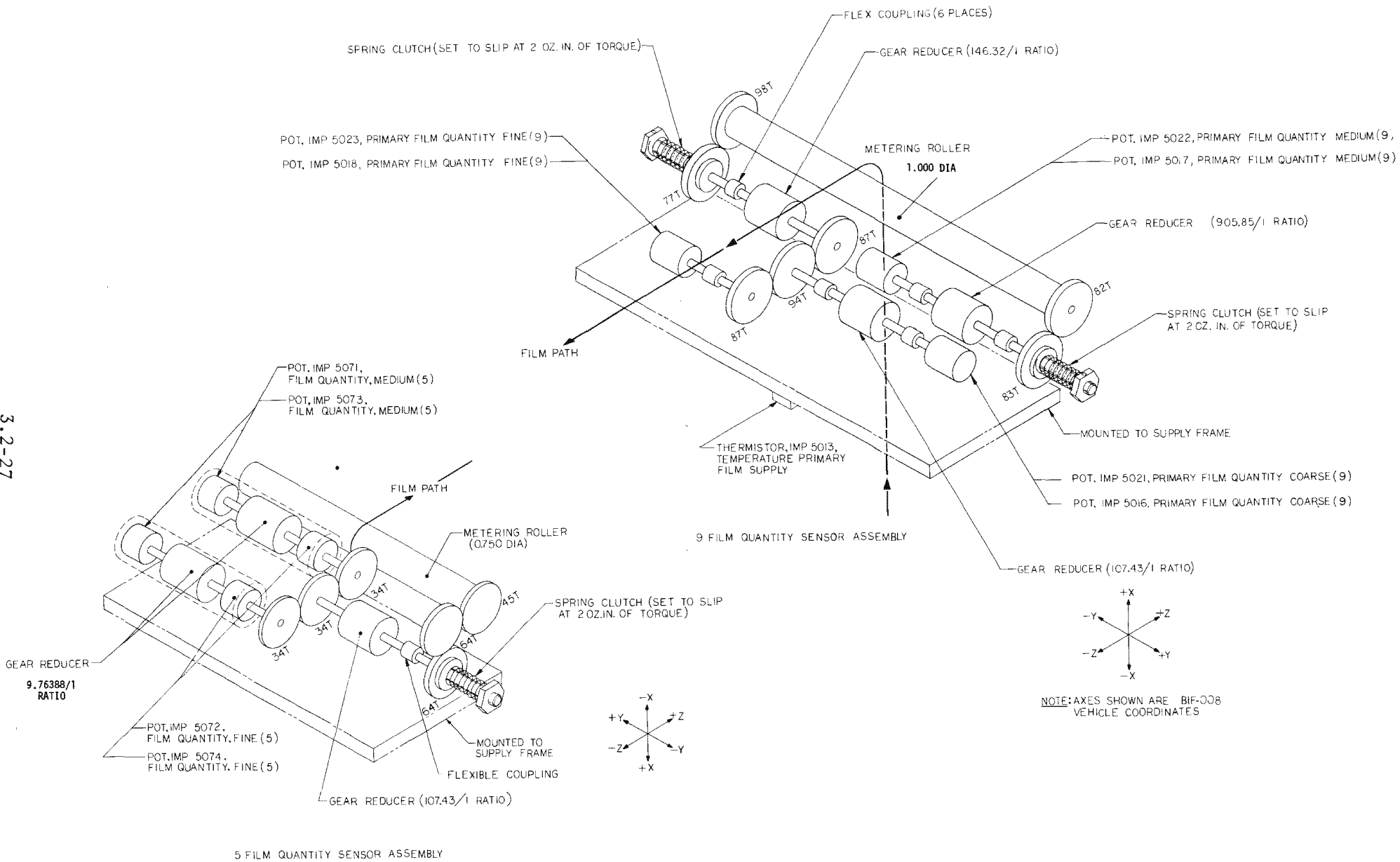


Figure 3.2-14. 9 and 5 Film Quantity Sensor Assemblies

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film transport system would continue to function. One cycle of the fine potentiometers represents 30.1 feet of film, one cycle of the medium potentiometers 240 feet, and one cycle of the coarse potentiometers 3490 feet.

The 5 film quantity sensor assembly is similar to the 9, but has only two sets of potentiometers. The redundant, dual-section potentiometers, with an internal gear ratio of 9.76388:1 between sections, are driven by an idler roller through a gear train and gear reducer (Figure 3.2-14). The potentiometers and gear train are isolated from the film handling system by means of a slip clutch which limits the drag of the quantity sensor assembly to less than 2 in.-oz. One cycle of the fine potentiometers represents 29.9 feet of film, and one cycle of the medium potentiometers represents 292 feet.

2.1.1.6.4 Film Supply Temperature Sensors. Two temperature sensors are mounted on each supply assembly for monitoring the splicer mechanism and internal film supply enclosure temperatures. IMP 5243 on the 5 supply assembly and IMP 5302 on the 9 supply assembly are each located near the base of their respective splicer mechanisms. The 9 film supply temperature sensor, IMP 5013, is glued to the lower back of the 9 quantity sensor assembly baseplate (Figure 3.2-14). The 5 film supply temperature sensor, IMP 5076, is glued to the +Y side of the main supply structure, approximately 1 inch above (+Z) the spindle support point.

2.1.1.7 Supply Assembly and Alignment. Similar assembly procedures are employed for the 9 and 5 supplies. The spool axis is the basic reference for the unit. The spool mounting brackets are adjusted and pinned during assembly so as to align the spool axis to the mounting interface. Each roller or subassembly with rollers is adjusted and pinned by means of an accurate assembly fixture so that all rollers are parallel in two planes to

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the spool axis. The frame assembly maintains this alignment throughout assembly, test, and operation on orbit.

2.1.1.7.1 9 Supply Alignment Verification. Two mirrors that have been aligned to the supply spool axis during assembly of the supply are used to check the 9 supply alignment in the FSE by providing a fixed reference to measure against. The upper mirror (+Z) can be placed parallel to the film path to establish a line-of-sight for checking the position of the 5 supply, as explained below. The 9 supply reference mirror assembly is strictly support equipment; it does not remain with the vehicle.

2.1.1.7.2 5 Supply Alignment Verification. An alignment mirror, permanently mounted to a cross member of the 5 supply frame, is used to check the alignment between the 5 supply unit and the 9 supply unit. The mirror is set parallel to the spool axis and positioned so that the line-of-sight established by the 9 supply reference can be used to verify the alignment of the 5 supply.

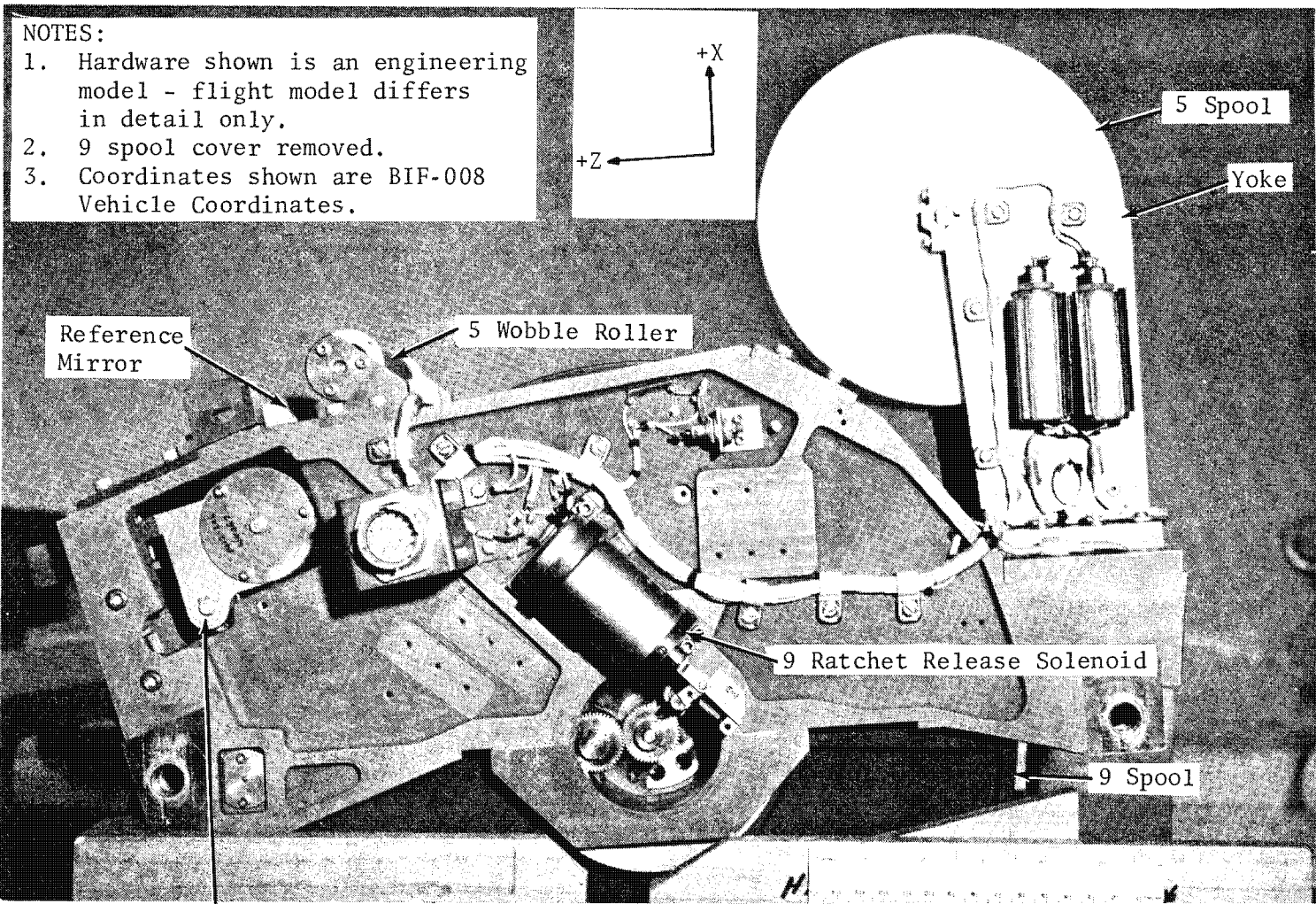
2.1.2 9 x 5 Take-up Assemblies

The 9 x 5 take-up assemblies are devices which respool the 9.5-inch wide and 5-inch wide films used in the PPS/DP EAC storing them for later recovery. The 9 x 5 take-ups also act in conjunction with the supply assemblies to control film tension in the 9 and 5 film handling subsystems. Identical take-up (T/U) units are mounted in each of the two satellite reentry vehicles (T/U 1 in SRV 1, and T/U 2 in SRV 2). Figures 3.2-15 and 3.2-16 show a representative 9 x 5 take-up assembly.

2.1.2.1 Take-up Spools. Each take-up mechanism has a separate take-up spool for the 9 and 5 film strands, with an Approaching Full warning switch consisting of a pivoting arm, mechanical encoder, and wheel on each spool. The wheel contacts the edge of the film as the spool fills, forcing the pivoting

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Displacement Compensator Assembly

Figure 3.2-15. 9 x 5 Take-up Assembly (-Y View)

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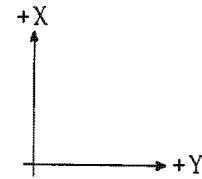
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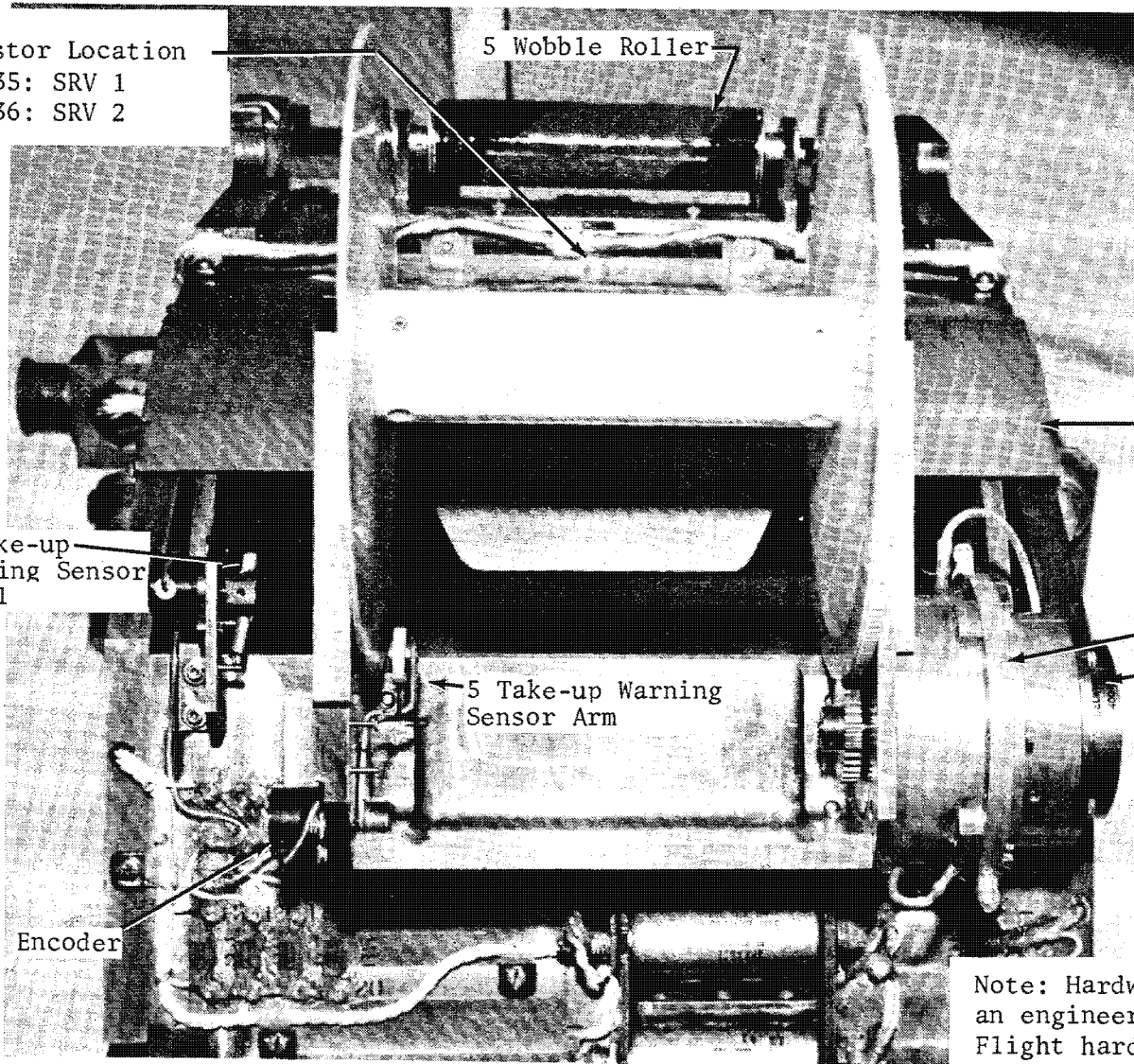
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Thermistor Location
IMP 5235: SRV 1
IMP 5236: SRV 2

5 Wobble Roller



BIF-008 Vehicle
Coordinates



9 Spool Cover

9 Take-up
Warning Sensor
Wheel

5 Drive Motor
Ratchet Assy

5 Take-up Warning
Sensor Arm

Encoder

Note: Hardware shown is
an engineering model.
Flight hardware differs
in detail only.

Figure 3.2-16. 9 x 5 Take-up Assembly (-Z View)

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arm outward. The arm drives the encoder directly, causing a change in voltage on the instrumentation point at the trip level, i.e., when the remaining spool capacity is 500 feet for the 9 spool and 300 feet for the 5 spool, assuming nominal 0.002-inch thick film. The associated resistance network is mounted on the take-up frame and generates four discrete output levels covering all combinations of 9 and 5 spools not full and approaching full, as follows:

- (1) 2.0 volts - 9 spool not full
5 spool not full
- (2) 2.5 volts - 9 spool not full
5 spool approaching full
- (3) 3.0 volts - 9 spool approaching full
5 spool not full
- (4) 4.5 volts - 9 spool approaching full
5 spool approaching full

Table 3.2-2 summarizes the spool dimensions, film capacities, and instrumentation sensor trip points (IMP 5298, T/U 1, and IMP 5080, T/U 2).

TABLE 3.2-2.

9 AND 5 TAKE-UP SPOOLS DATA SUMMARY

| | <u>9 Spool</u> | <u>5 Spool</u> |
|-----------------------------|----------------|----------------|
| Core Diameter (inches) | 3.93 | 1.43 |
| Flange Diameter (inches) | 13.5 | 7.0 |
| Spool Capacity (feet)* | 5400 | 1500 |
| Warning Sensor Trip Point: | | |
| Inches from center of spool | 6.437 | 3.120 |
| Film on spool (feet)* | 4900 | 1200 |

*Based on 0.002-inch thick film and allowance for film leader.

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2.1.2.2 9 Take-up Spool Drive. Each 9 T/U spool is core-driven by a 24-volt dc motor which has an internal speed reducing gearbox (22.78:1) for increased torque (see Figure 3.2-17). The output shaft is coupled to the spool through spur gears (3:1 reduction) to further lower the speed and increase the torque. The motor is capable of respooling 36.8 inches of film from the supply unit (the capacity of the take-up looper between electrical limits) and returning to rest within 3.0 seconds, or, within 3.5 seconds when the drive voltage is less than 24.5 vdc and less than 500 feet or more than 4000 feet of film is on the take-up spool. The motor has a straight line speed-torque characteristic with a slope that compensates as nearly as possible for the change in torque required as the quantity of film on the spool increases (see Figures 3.2-18 and 3.2-19). Electromagnetic interference (EMI) filters are inserted into the motor power feed and return lines to ensure that the drive meets system EMI requirements.

The combined 9 T/U spool motor current (for both T/U 1 and T/U 2) is monitored in the film control electronics (FCE) unit by means of a dropping resistor in the return line. The output is amplified in the FCE to produce a 0.5-volt to 4.85-volt signal for a current of 0.0 ampere to 3.0 amperes (IMP 5267).

2.1.2.3 5 Take-up Spool Drive. Each 5 take-up spool is mounted on a shaft supported by the yoke frame (reference Figure 3.2-15). The spool core and flange are plastic, with teeth molded into one flange for the spool rim drive. The drive module, consisting of a dc torque motor, ratchet, and tooth clutch, mounts to the yoke so that the drive gear meshes with the spool rim gear as shown in Figure 3.2-20. The gear ratio increases the effective motor torque by a factor of six.

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- NOTES
1. AXES SHOWN ARE BIF D08W VEHICLE COORDINATES.
 2. WARNING SENSOR SET AT 6.437 IN. FROM CENTER OF CORE.
 3. CORE - 3.93 IN. DIA, O.D. - 13.5 IN.

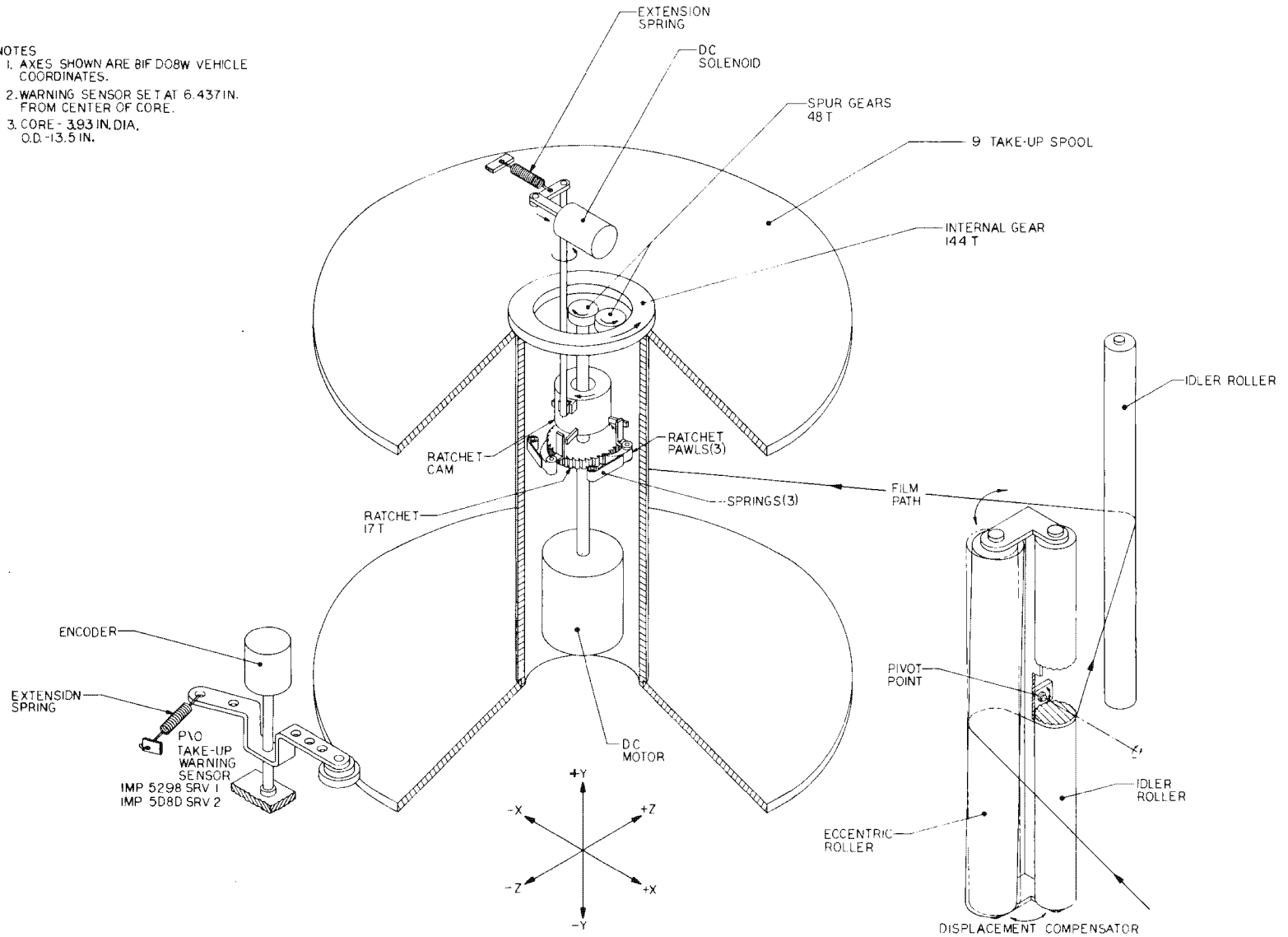


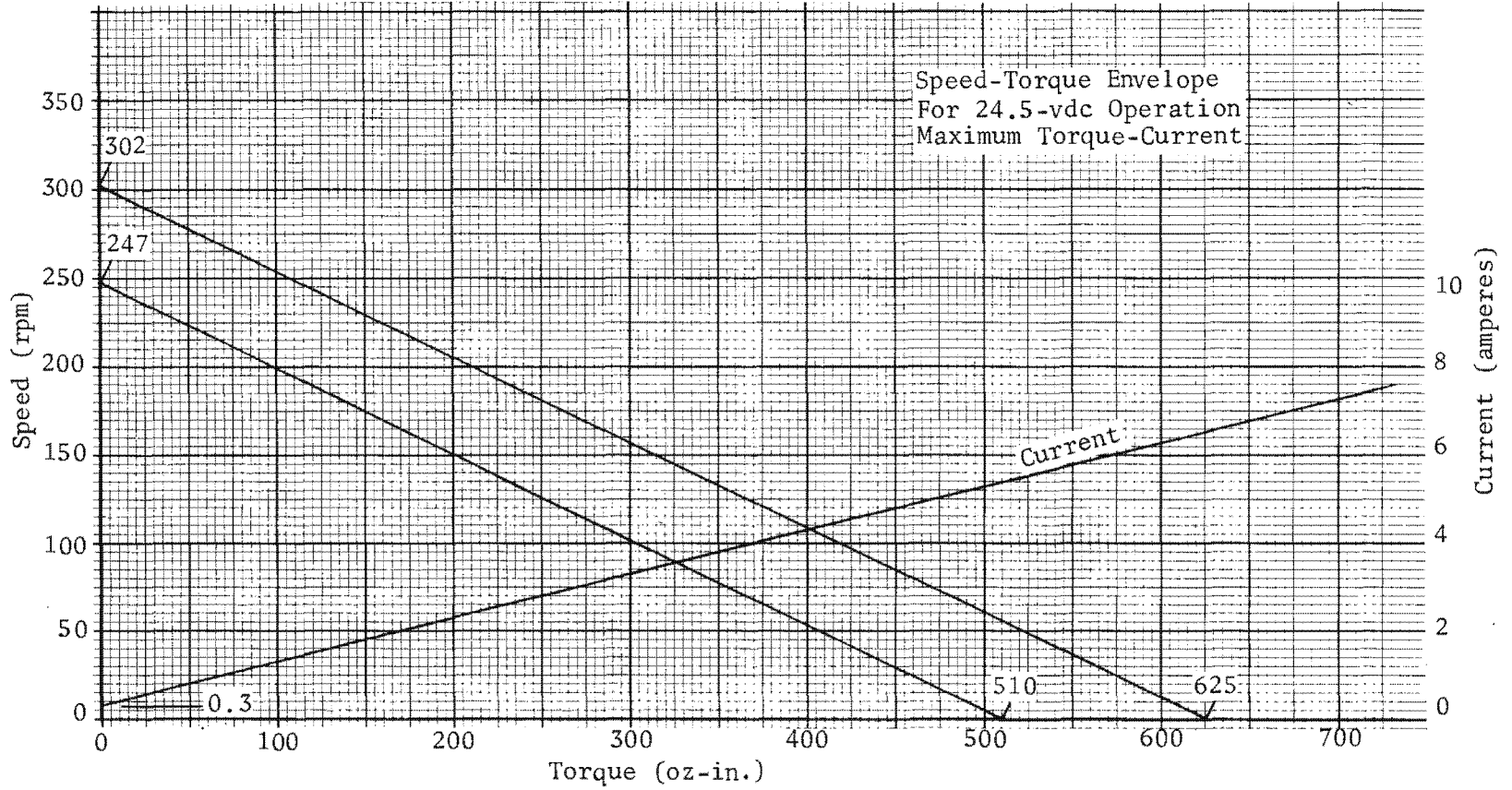
Figure 3.2-17. 9 Take-up Spool Assembly

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Figure 3.2-18. 9 T/U Motor Performance Curves

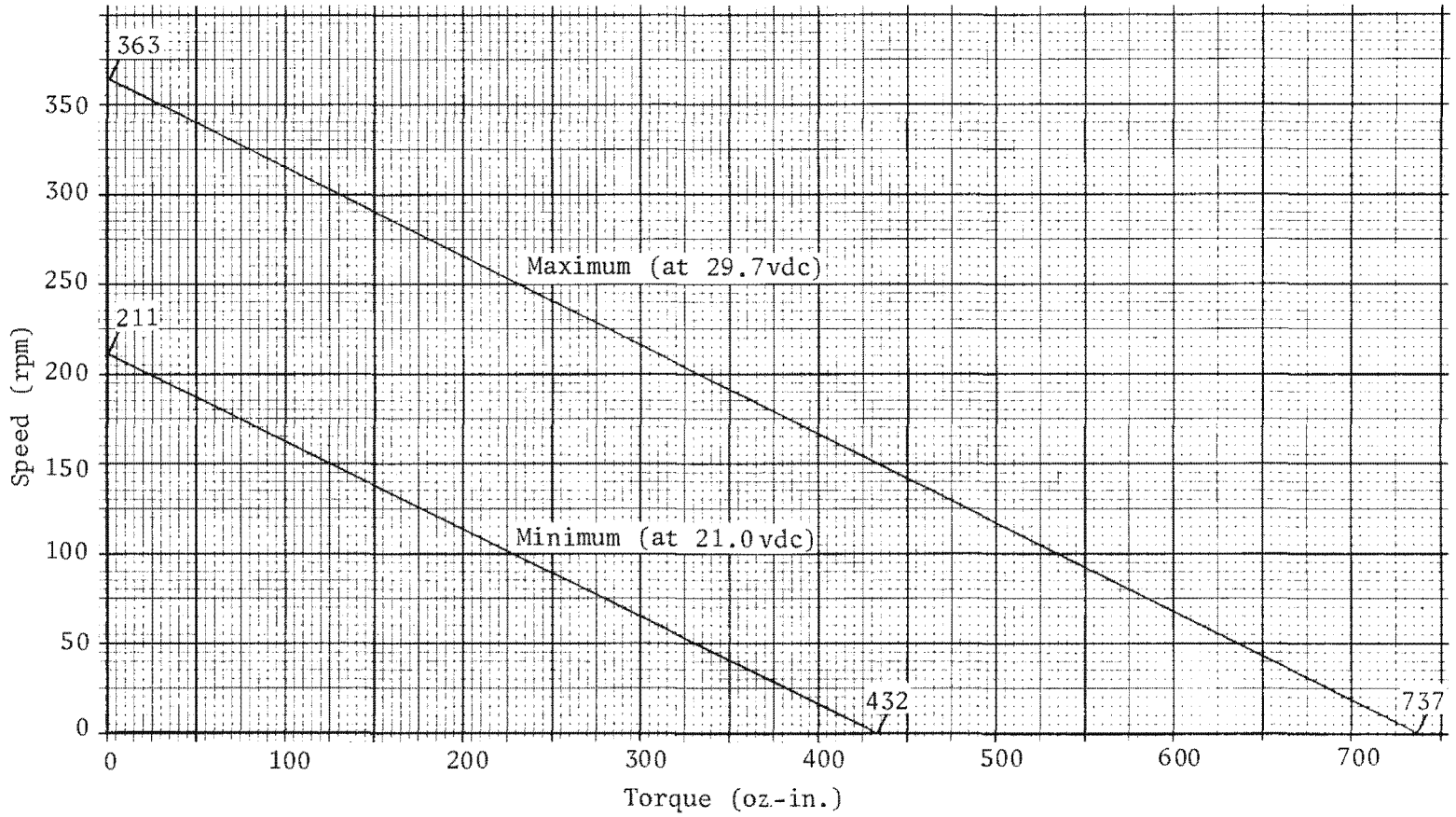


Figure 3.2-19. 9 T/U Motor Speed-Torque Envelope

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NOTES

1. AXES SHOWN ARE BIF-008 VEHICLE COORDINATES.

2. WARNING SENSOR SET AT 3.120 IN. FROM CENTER OF CORE.

3. CORE 1.43 IN. DIA. O.D. 7.0 IN.

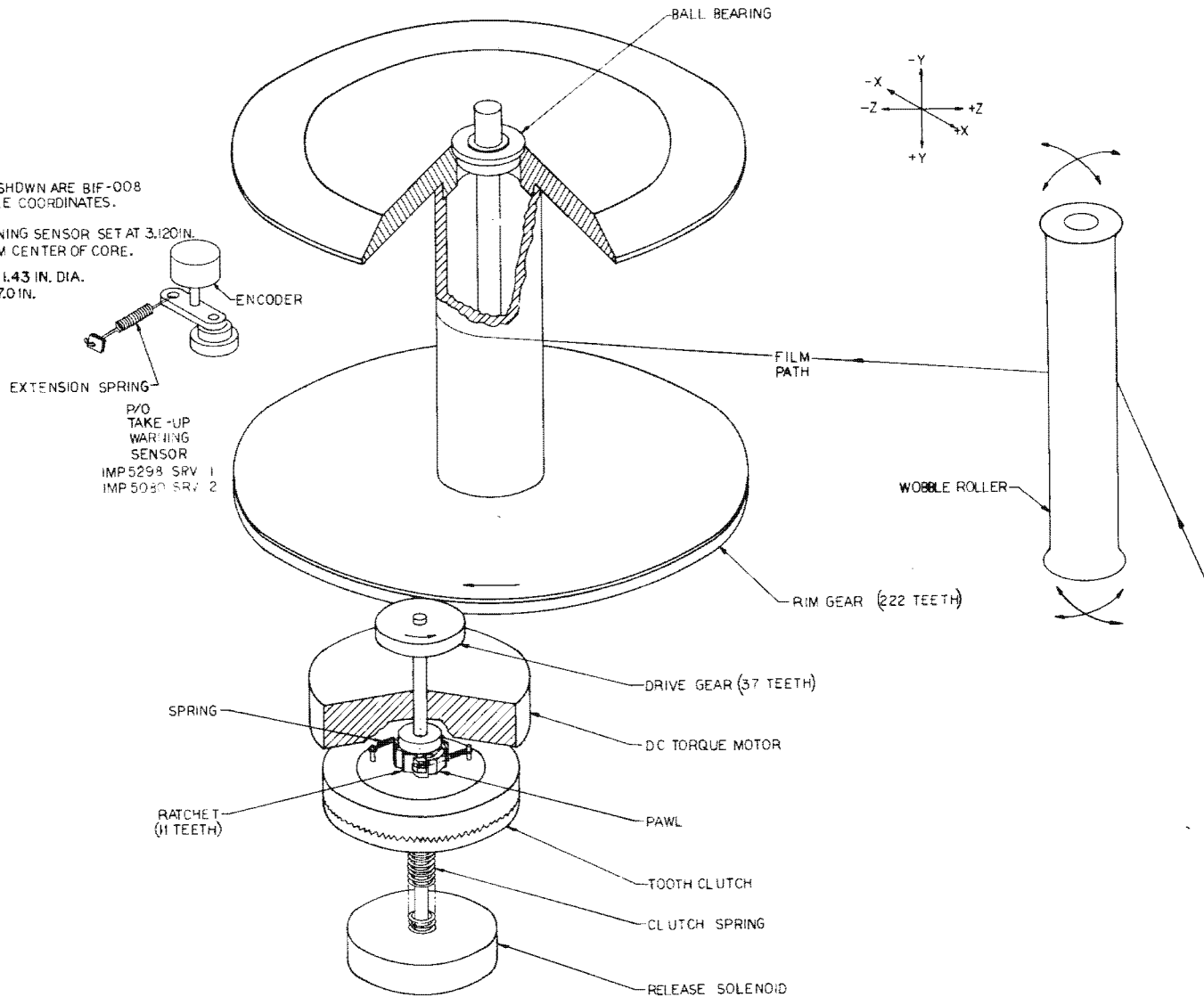


Figure 3.2-20. 5 Take-up Spool Assembly

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The 5 T/U is able to empty an electrically full take-up looper (36.8 inches of film) and come to rest within 3.0 seconds. The speed-torque characteristics are shown in Figure 3.2-21. To minimize variations in the characteristics of the take-up drive, the operating voltage is regulated at 18.7* vdc in the film handling electronics (FHE) module. EMI filters, similar to those used in the 9 T/U drives, are inserted into the power lines to prevent excessive electrical noise in the system.

The combined 5 spool drive current for both T/U 1 and T/U 2 is monitored by a dropping resistor in the power return line at the FHE. The instrumentation output (IMP 5075) is amplified to produce a linear signal ranging from 0.25 volt to 4.75 volts (0.0 ampere to 2.0 amperes).

2.1.2.4 Take-up Spool Clutches. To prevent the film spools from backing-up and unwinding film during use, each spool is fitted with a ratchet-and-pawl mechanism. The three pawls in the 9 system can be disengaged by energizing the solenoid linked to the pawl release cam. As the cam is rotated, pins force the pawls outward, releasing the ratchet (see Figure 3.2-17).

For the 5 take-up (Figure 3.2-20), the ratchet-and-pawl mechanism is released by a tooth clutch. The ratchet is connected to the motor shaft and rotates with it. The two pawls and tension springs are attached to the upper clutch plate. The lower clutch plate, which is free to move only in an axial direction, is held to the upper plate by the clutch spring and prevents the upper plate from turning. An electromagnet is energized to release the tooth clutch and allow the upper plate and pawls to turn with the ratchet about the motor axis.

After the ratchet mechanism has been released on a spool, the motor can be reversed and film removed from the spool for ground testing, or for processing after recovery. There is no circuitry in the PPS/DP EAC which can release the

* Speed-torque curve plotted for 18.9 vdc operation (Specification Limit)

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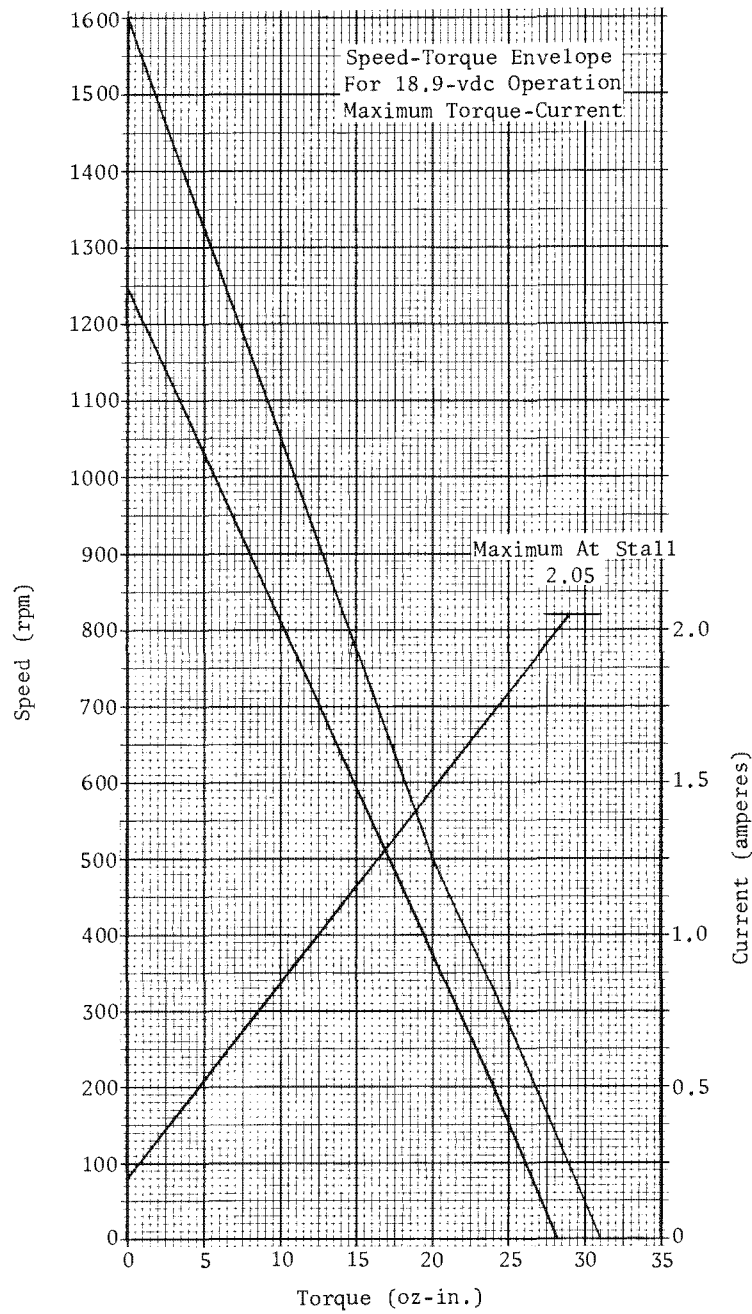


Figure 3.2-21. 5 T/U Motor Performance Curves

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ratchet and allow film to despool while on-orbit; the release mechanism can be powered only through a test connector. To prevent reversal of a motor while the spool ratchet is still engaged, a switch is provided in the motor-reversing circuit which is closed only when the release mechanism (tooth clutch or solenoid) reaches the extreme of its travel.

2.1.2.5 9 x 5 Take-up Mounting Frame. All components of the T/U assembly are mounted on a single structure consisting of two side plates separated by cross members. The 5 spool support yoke is mounted on one of these cross members as shown in Figure 3.2-15. A plate attached to the frame behind the 5 take-up spool covers the 9 spool, preventing any interference between the two film strands, which might otherwise occur when one or both strands are free (as after splicing). The entire assembly is fastened to the recovery capsule by four adjustable mounts which are part of the SRV, providing translational adjustment in the X and Y directions plus a small amount of rotational adjustment about the X-axis for the entire mechanism.

2.1.2.6 9 x 5 Take-up Film Strand Guidance. Film guiding devices are required to direct the film strands and to correct for misalignments between components along the film path. The devices used for this application operate by converting lateral and angular misalignments of the film path within the plane of the film into helical (neutral axis) twists along the length of the redirected path.

Three basic requirements for film guiding are:

- (1) a means for providing compliance to allow the film to be redirected
- (2) a means for indicating the correct film path direction
- (3) a force to redirect the film in that direction

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In the displacement compensator, consisting of a pivot frame supporting an eccentric roller and an idler roller for the 9.5-inch wide film, compliance comes from tilting the compensator frame and from the friction-reducing action of the eccentric roller; direction comes from orienting the pivot axis of the compensator frame and the next following idler roller; and force comes from the tension distribution in the film. Weights on the compensator frame are pinned in position after mounting the rollers to balance the assembly. The frame is then attached to the main take-up structure at its pivot point. A simplified version of the displacement compensator is used for guiding the 5-inch wide film. It consists of a pivoted wobble roller (two degrees of freedom) attached to the support structure.

The four pivot rollers in the 9 and 5 supply assemblies (reference Section 2.1.1.4) each have one degree of freedom and a 90-degree film wrap, and ensure correct tracking between the supply and take-up assemblies. In addition, the 5 film path to SRV 1 requires two intermediate idler rollers, one in the 5 travel viewer box and one in the 9 travel viewer box, to guide the film around SRV 2 and into SRV 1.

2.1.2.7 Alignment. The 9 film spool axis is the basic reference for all components of the T/U assembly, including the guidance rollers and the 5 film spool. A mirror with cross hairs is aligned to the 9 spool axis and mounted on the T/U frame so that it is visible from various locations in the film chutes. The reference mirror can then be used in conjunction with optical support equipment to align the 9 x 5 take-up assembly in the SRV. At higher levels of assembly, the mirror serves as a reference point for checking the alignment of the 9 and 5 supply assemblies in the film supply enclosure (Section 2.1.1.4.3).

2.1.2.8 9 x 5 Take-up Instrumentation. In addition to those points previously described (the take-up warning sensors and take-up motor current monitors), the only other instrumentation points directly associated with the

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9 x 5 take-up assemblies are temperature sensors (IMP 5235 on T/U 1 and IMP 5236 on T/U 2). Each thermistor is glued to a frame cross member and is centered on the Z-axis just below (-Z) the 5 wobble roller. Processing electronics for the thermistor output are located in the instrumentation processor.

2.2 9 x 5 Dual Platen Camera Description

The 9 x 5 dual platen camera is a strip camera with the image focused through a slit aperture onto moving film. The camera system utilizes both 9.5-inch wide and 5-inch wide films wrapped around their respective cylindrical platens, thereby maintaining the proper position in the image plane of the PPS/DP EAC optical system. Control of camera functions is accomplished by the 9 and 5 frequency phase lock loop electronics and the 9 and 5 camera electronics assemblies located in the SEM.

The camera assembly consists of the camera housing, the camera tilt frame couplers, and the 9 and 5 pivot frames within the housing. Each pivot frame supports a film platen and platen drive, and a variable exposure mechanism (VEM). Each pivot frame is attached to the camera housing at two points and is supported at a third point by the associated focus adjust mechanism (FAM).

The size and shape of the optical beam at the focal plane allows only the 9 platen to be centered directly on the optical axis. A folding mirror, centered 0.725 inch below (-Z) the optical axis, is used to divert the image-forming rays toward the 5 platen (-Z direction). A second mirror, above (+Z) the axis, diverts the image to the focus detector assembly on the 9 pivot frame (reference Part 3, Section 6). Figure 3.2-22 is a simplified diagram of the camera housing internal components, showing the relationship of the 9 and 5

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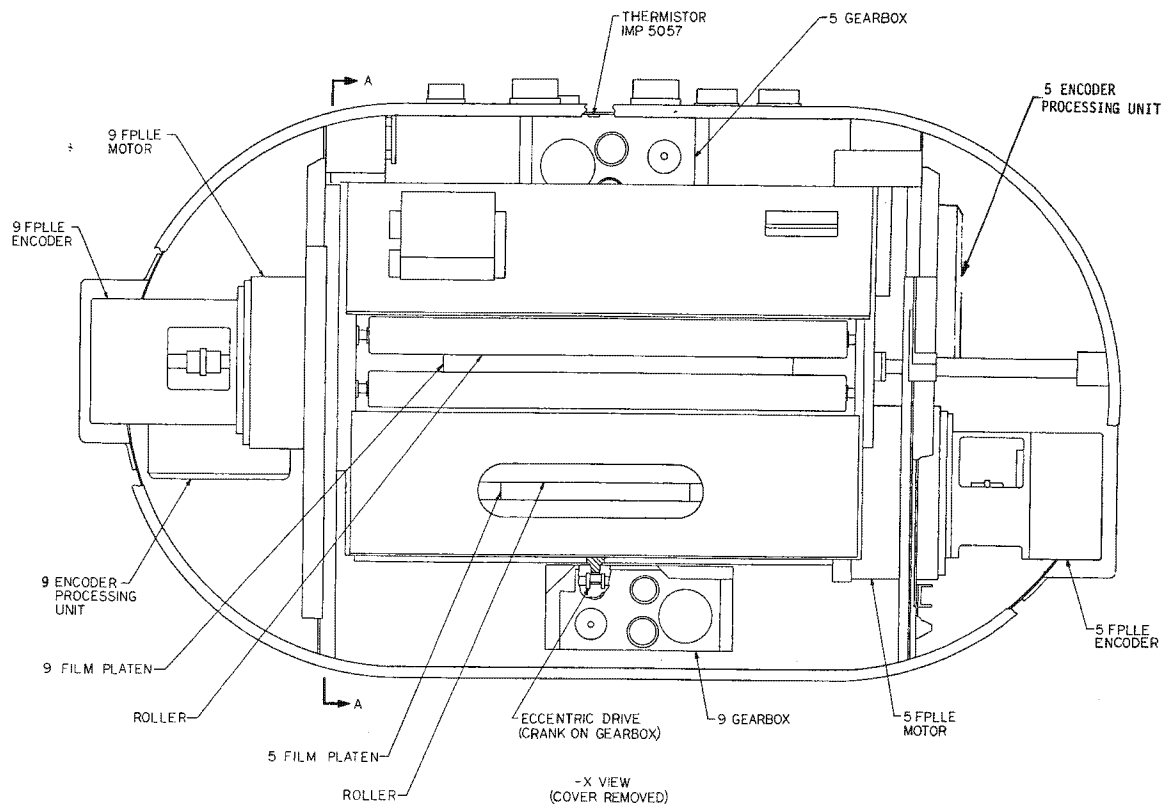
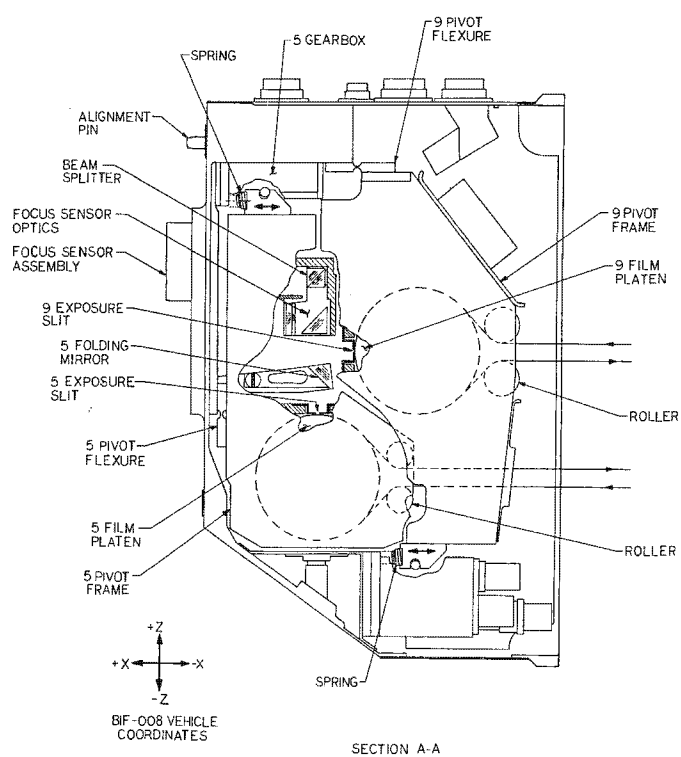


Figure 3.2-22. 9 x 5 Dual Platen Camera Internal Configuration

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pivot frames, folding mirrors, and the focus detector assembly. Also shown is the encoder processing unit, which is used to transmit the platen drive optical encoder feedback signals to the frequency phase lock loop electronics (FPLLE) units.

2.2.1 Camera Housing

The camera housing shown in Figure 3.2-23 is a shell that encloses the major components of the dual platen camera, with the exception of the electronic units (i.e., FPLLEs and camera electronics assemblies) which are mounted in the SEM. The housing is supported by the Ross corrector and field lens assembly, with the last element of the RCFLA fully potted on the perimeter and with a gasket at the camera/RCFLA interface to seal the film path. At the -X end of the camera, the camera tilt frame couplers attach to the supply assembly tilt frame couplers and a bellows seals the film path between the FSE and camera housing.

The housing itself is a riveted structure consisting of a baseplate, skin, top ring, and cover. A high reflectance outer surface limits thermal input and a low reflectance inner surface, coupled with internal baffles, limits film flare effects.

Internally, a set of braces near each end are riveted to the baseplate and skin to provide rigidity. Additional rigidity is provided by a triangular shaped torque tube which connects the braces and is also riveted to the baseplate and skin. The cover, which attaches to the top ring and the braces, provides a mounting surface for the tilt frame couplers. The camera baseplate, which mounts to the RCFLA interface, contains two pins to which all camera internal components are aligned.

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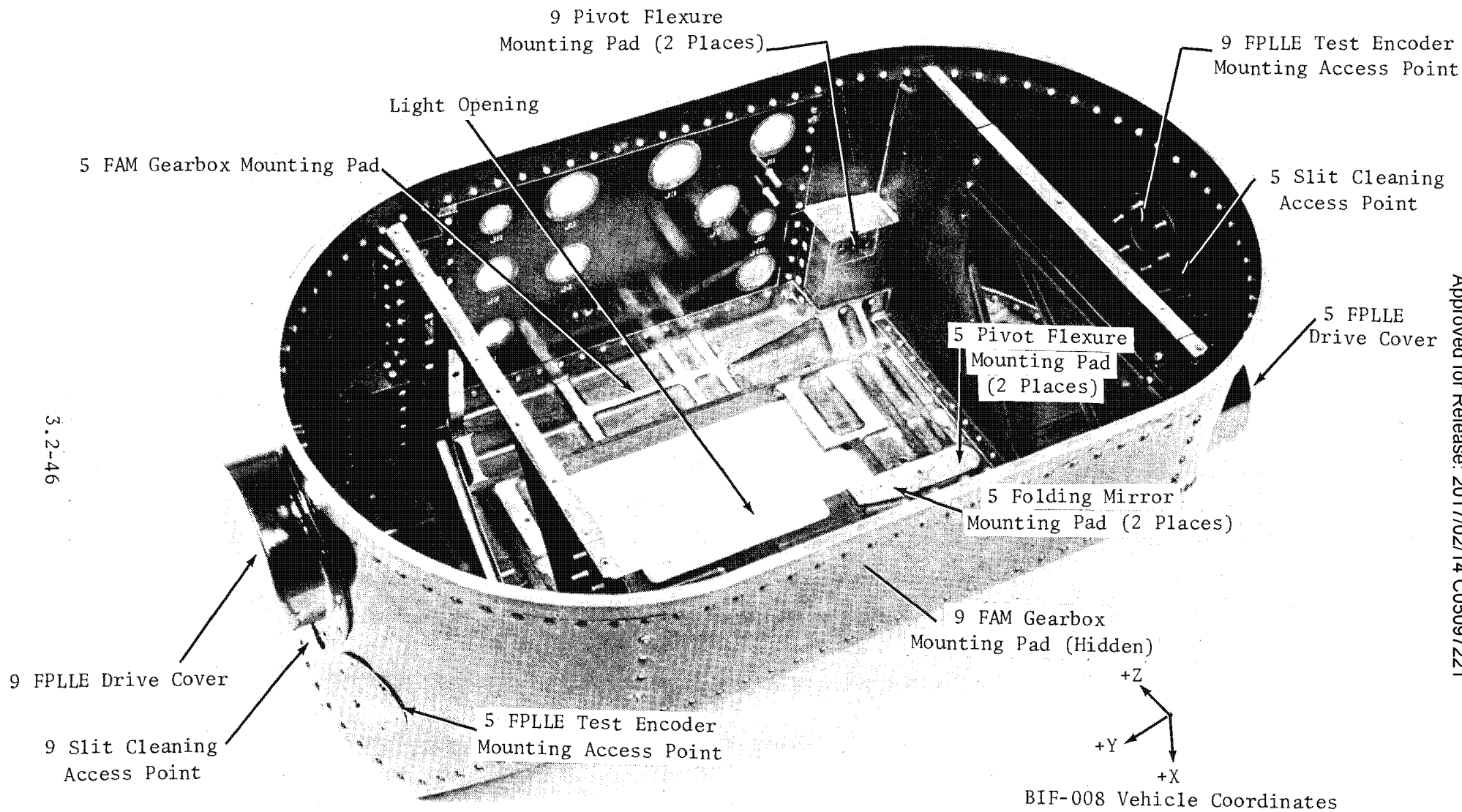


Figure 3.2-23. Camera Housing (Cover Removed)

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The 9 platen is located on the optical axis in the $\pm Z$ direction, parallel to the two mounting pins about the X-axis, and parallel to the camera mounting surface about the Z-axis. The 5 platen is parallel to the mounting surface and optically parallel to the 9 platen.

For instrumentation purposes, a thermistor is mounted on each pivot frame near the platen drive motor and encoder to monitor the frame temperature.

2.2.2. 9 and 5 Pivot Frame Assemblies

The 9 and 5 pivot frame assemblies shown in Figures 3.2-24 and 3.2-25 mount to the camera housing structure through two flexures at one end, and through the FAM gearbox by means of an eccentric drive shaft at the other end. The 9 pivot frame provides mounting for the platen, FPLLE film-drive components, the 9 variable exposure (slit) mechanism, the input and output film guidance rollers, and the focus detector assembly (not shown in Figure 3.2-24).

The 5 pivot frame supports a similar set of components, excluding a focus detector, modified to accommodate the narrower width film.

2.2.2.1 Platen Drive Assembly. The 9 and 5 platens are each driven by a frequency phase lock loop servo system consisting of the platen and its drive motor, an optical encoder, and a frequency phase lock loop electronics (FPLLE) unit. The phase lock loop design used in the PPS/DP EAC incorporates the desired characteristics of fast start-up and stopping for film conservation and drive smoothness compatible with performance requirements.

The drive assemblies for the 9 and 5 subsystems are essentially the same. The Invar platen is attached to aluminum shafts which rotate in preloaded duplex bearings mounted in the side walls of the pivot frame. On one end the drive motor is mounted directly to the shaft and the optical encoder is connected to this shaft by a flexible coupling. The coupling is covered by a damping material to reduce the transmissibility of motor disturbances to

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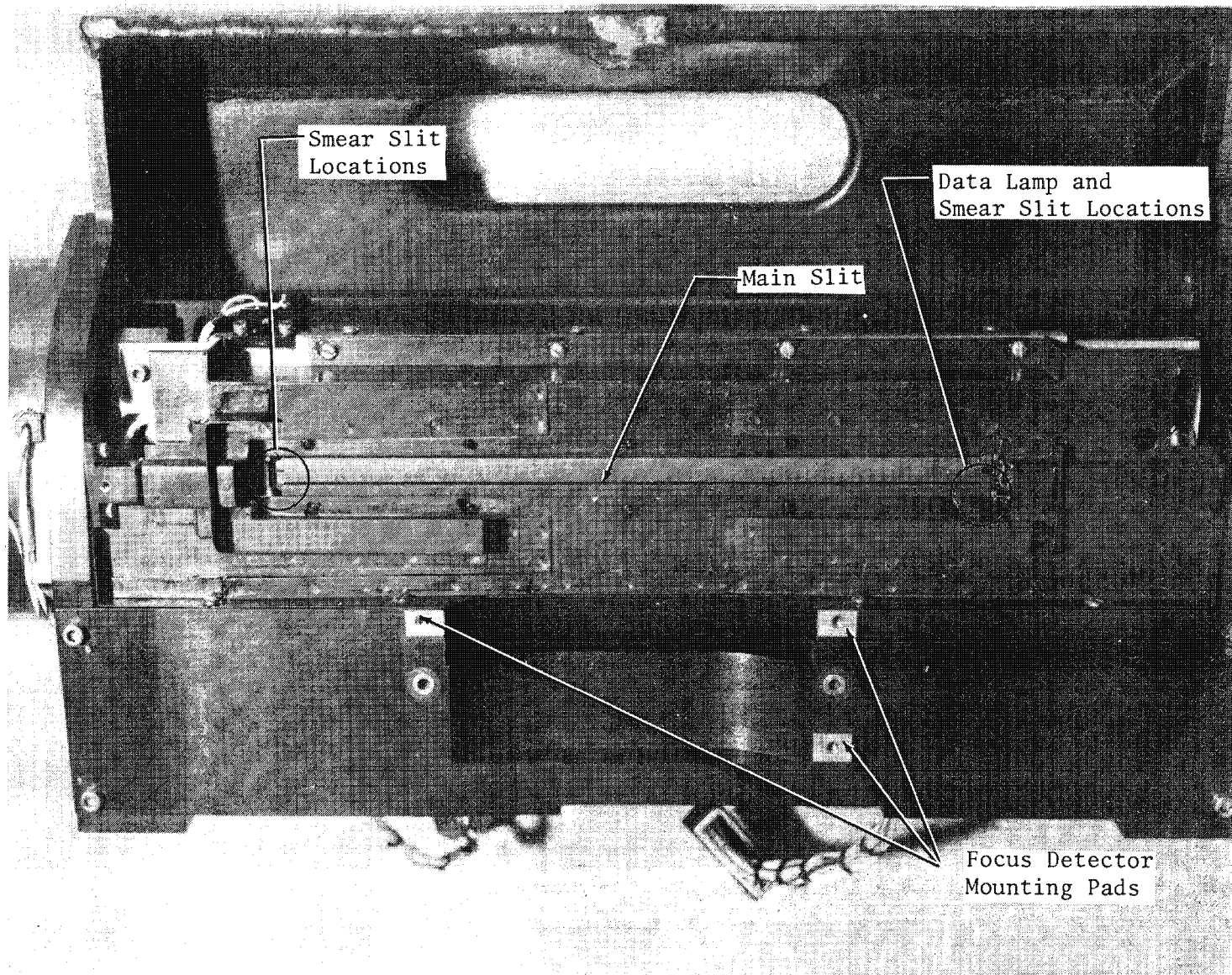


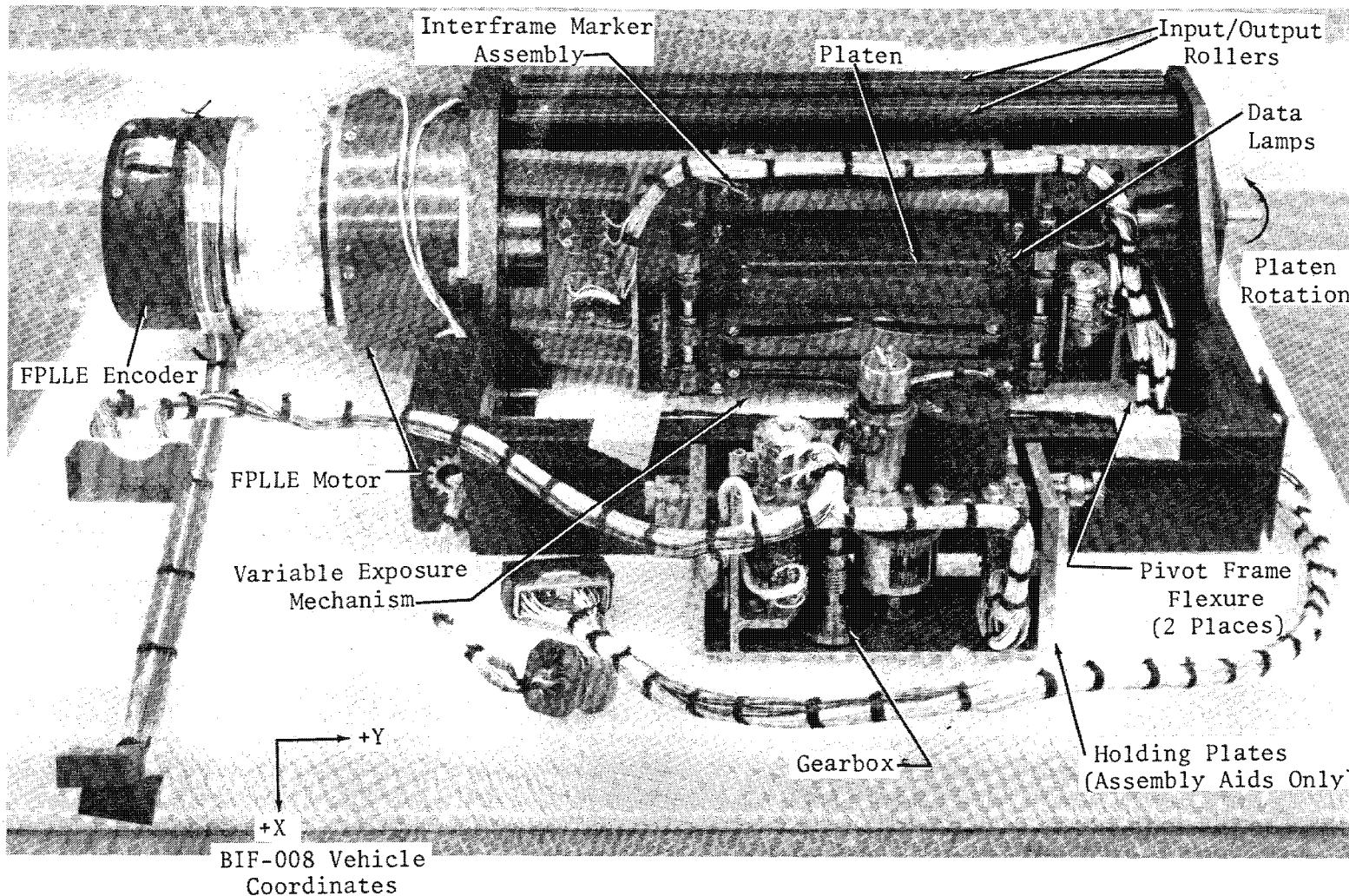
Figure 3.2-24. 9 Pivot Frame Assembly

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Figure 3.2-25. 5 Pivot Frame Assembly

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the encoder. At the other end, the bearing is free to float in the pivot frame to allow for thermal expansion, and the shaft accommodates the attachment of an external test encoder.

2.2.2.1.1 Film Platen. The platen is a 3.5-inch diameter, machined, Invar tube coated with Electrofilm (a bonded dry lubricant) to provide the necessary coefficient of friction between the platen and film, and to minimize reflection of imaging light back into the film emulsion. The 9 platen contains three objective lenses, and the 5 platen contains one objective lens for the purpose of measuring the position of the platen surface with respect to the optical image plane after installation of the camera on the COA. The single 5 platen objective is centered on the optical axis. One objective of the 9 platen is placed on the optical axis, and the remaining two objectives are located at the 1.05-degree, half-field angle positions.

The objectives are high quality, 8-mm focal length lenses designed to fit into threaded tubes in the platens. The tubes run perpendicular to the platen axis, facing small openings in the platen at each end. A plug permits access to the objective during assembly and alignment, and then closes the opening to the size of the hexagonal hole in the plug to prevent dimpling of the film during operation. The plug on the 5 platen is visible behind the exposure opening in Figure 3.2-25.

2.2.2.1.2 Platen Drive Motor. Each platen has a redundant drive system. This is accomplished by two permanent-magnet, frameless, dc torque motors in a single housing, which can be powered by redundant sides in the FPLLE (refer to Section 2.5.3). Further reliability is gained by having redundant brushes in each motor. The rotors are mounted on an adapter sleeve which mates with the platen shaft on the same diameter as that used for the bearings. The permanent magnet fields and brushes are assembled to the motor housing, and this in turn is attached to the pivot frame.

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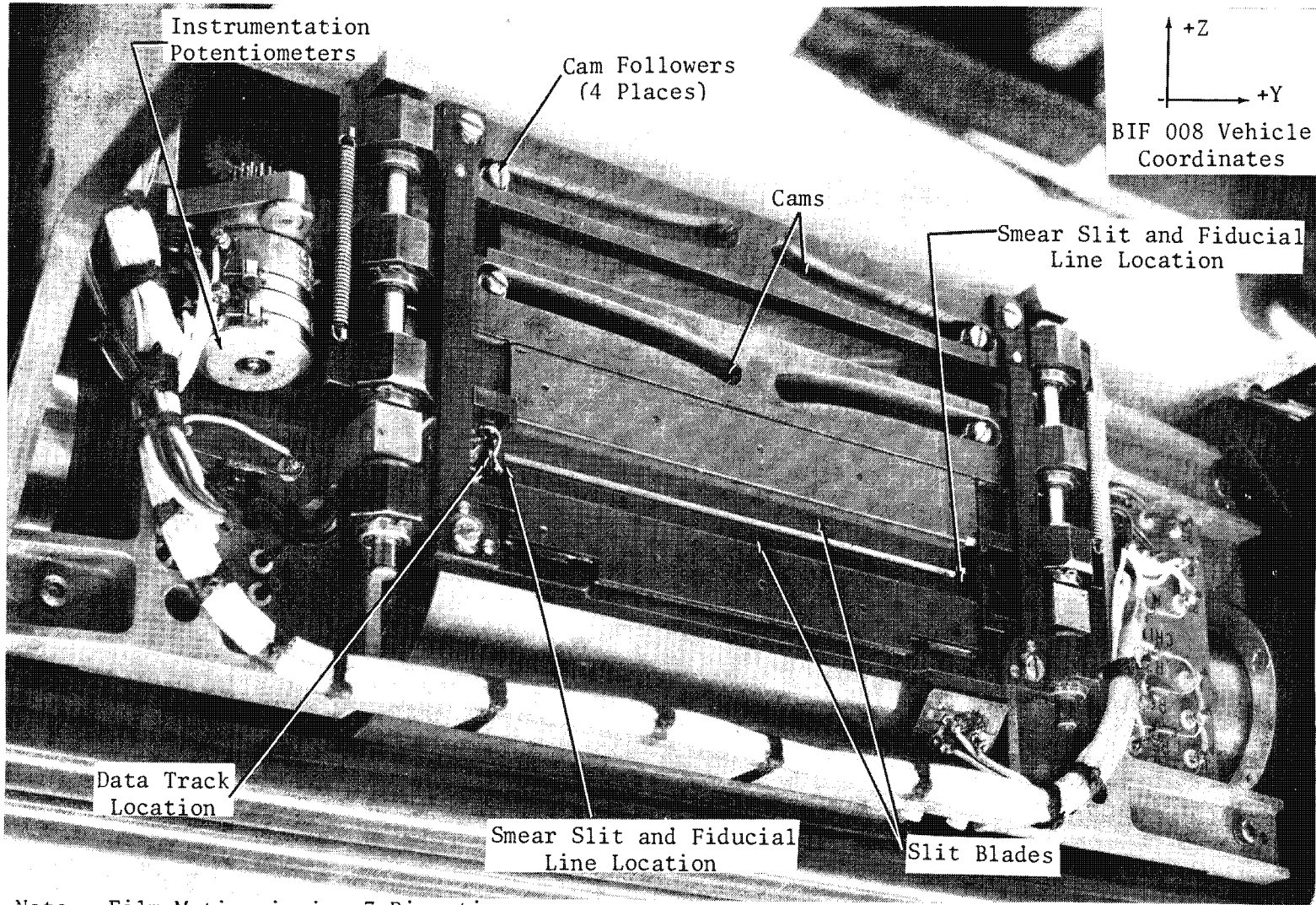
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2.2.2.1.3 Platen Drive Encoder and Encoder Processor. The optical encoder consists of a 3-inch diameter code disk and 8 readout stations, with 4 stations (90° apart) being paralleled to produce redundant channels. The disk and slits have chrome-on-glass patterns generating 9,000 code cycles per revolution. The readout stations each consist of a light-emitting diode (LED) and four photo-detectors. One detector pair generates a sine signal and the other detector pair generates a cosine signal. The assembly is contained in a single housing coupled to the platen shaft. Two encoder processors are mounted on the camera housing. One processor is used to process the 9 encoder signals and the other processes the 5 encoder signals. Each processor has isolated redundant channels for shaping the encoder output waveform, and utilizes line drivers to relay the information to the FPLLE.

2.2.2.2 Variable Exposure Mechanism. The variable exposure mechanisms, also known as the slit mechanisms, control exposure of both the 9-inch and 5-inch wide films by positioning moveable blades in front of the respective platens. The blades, driven by cams as shown in Figure 3.2-26, provide 16 nominal slit openings for each subsystem. The variable exposure mechanisms are also used to place additional information on the films, to aid in post-flight analyses. LEDs, controlled by the camera electronics assembly modules, produce data tracks (vehicle clock information) in both subsystems. Interframe marks are produced along the edge of the film by apertures illuminated by incandescent lamps that are also controlled by the camera electronics assembly. The slit blades, in addition to controlling exposure levels, generate fiducial lines to delineate the main scene, and provide the smear slits which create a double exposure to be used in measuring smear.

2.2.2.2.1 Variable Exposure Mechanism Blade Control. Positioning of the slit blades is controlled by the lead screw driven cam/cam follower assemblies

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Note: Film Motion is in -Z Direction

Figure 3.2-26. 9 Variable Exposure Mechanism

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which are pictured in Figures 3.2-27 and 3.2-28. To understand the motion of the blades, it is important to note that the outer cam is connected to the outer blade, and the inner cam is connected to the inner blade. Thus, as the cam followers move inward and force the cams closer together, the blades are driven further apart. A guide rod is added parallel to the lead screw for greater system stability. The cam/cam follower concept prevents complete closure of the blades as a result of any single failure.

A one-piece mounting frame provides support for all VEM components including the blade guide rods, lead screw, lead screw guide rod, motor, encoder, potentiometers, data lamps, interframe marker, and required components for the fiducial lines and smear slits. The frame, in turn, attaches to the mounting pads of the respective pivot frame.

The narrowest slit openings, which require the smallest tolerances, are positioned near the mounting frame to minimize inaccuracies caused by flexing of the lead screw and guide rod. A minimal amount of backlash is required in the drive to prevent binding of the mechanism, and springs are used to maintain contact between the cam follower and control side of the cam groove to eliminate the effects of this backlash. Flats added to the cam surface for the eight smallest positions compensate for any drive system positional inaccuracies in the low range. A continuous curve generates the remaining eight positions, and in conjunction with the encoder deadband, results in two discrete slit widths for each step from 9 to 15, depending on the direction from which the step is approached. The resultant difference in exposure level is of such small magnitude that this slit variability is generally ignored.

Table 3.2-3 lists the nominal slit width for each position. The ratio between successive operational slit widths is approximately 1.334, i.e., $0.125 \log E$ (exposure).

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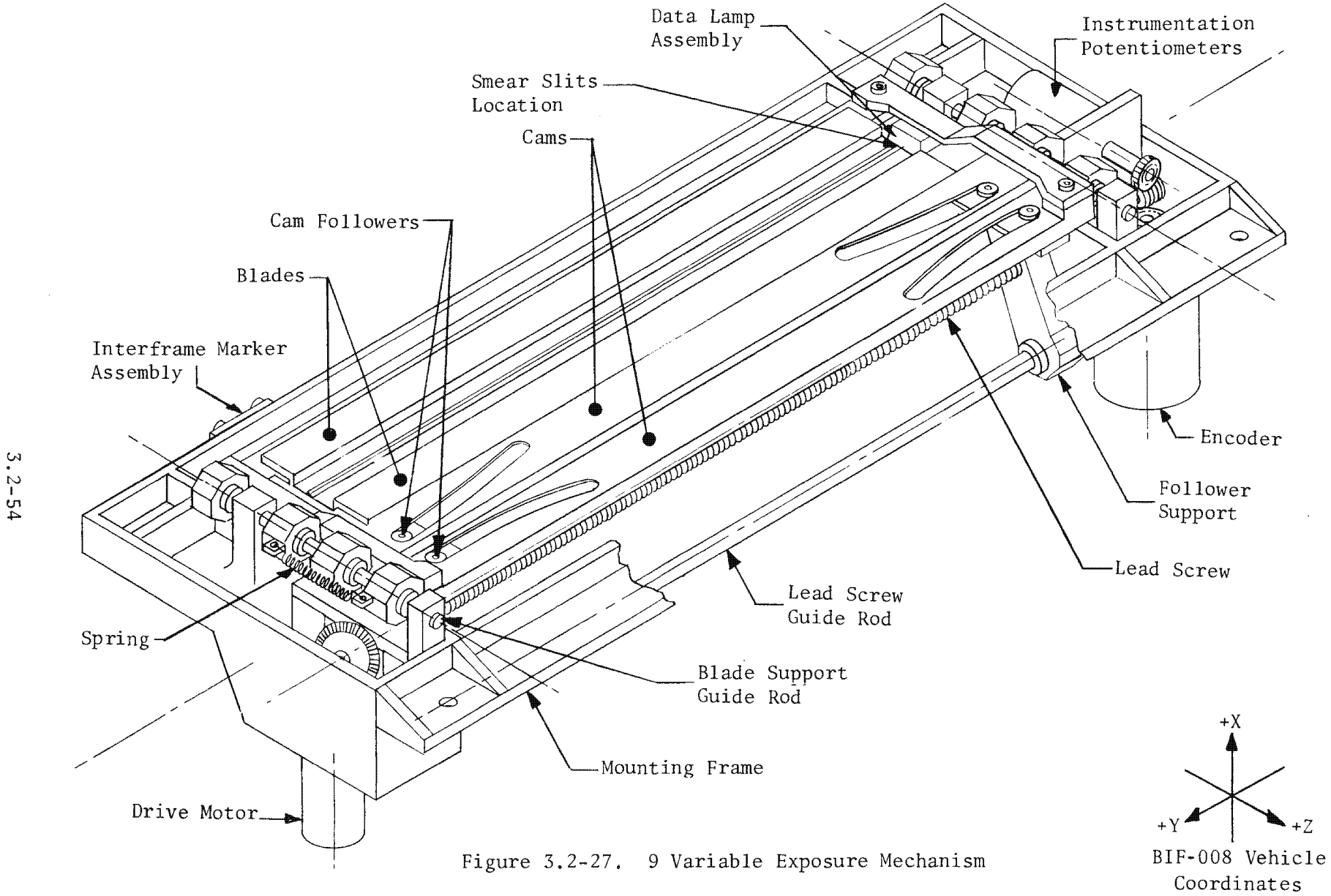


Figure 3.2-27. 9 Variable Exposure Mechanism

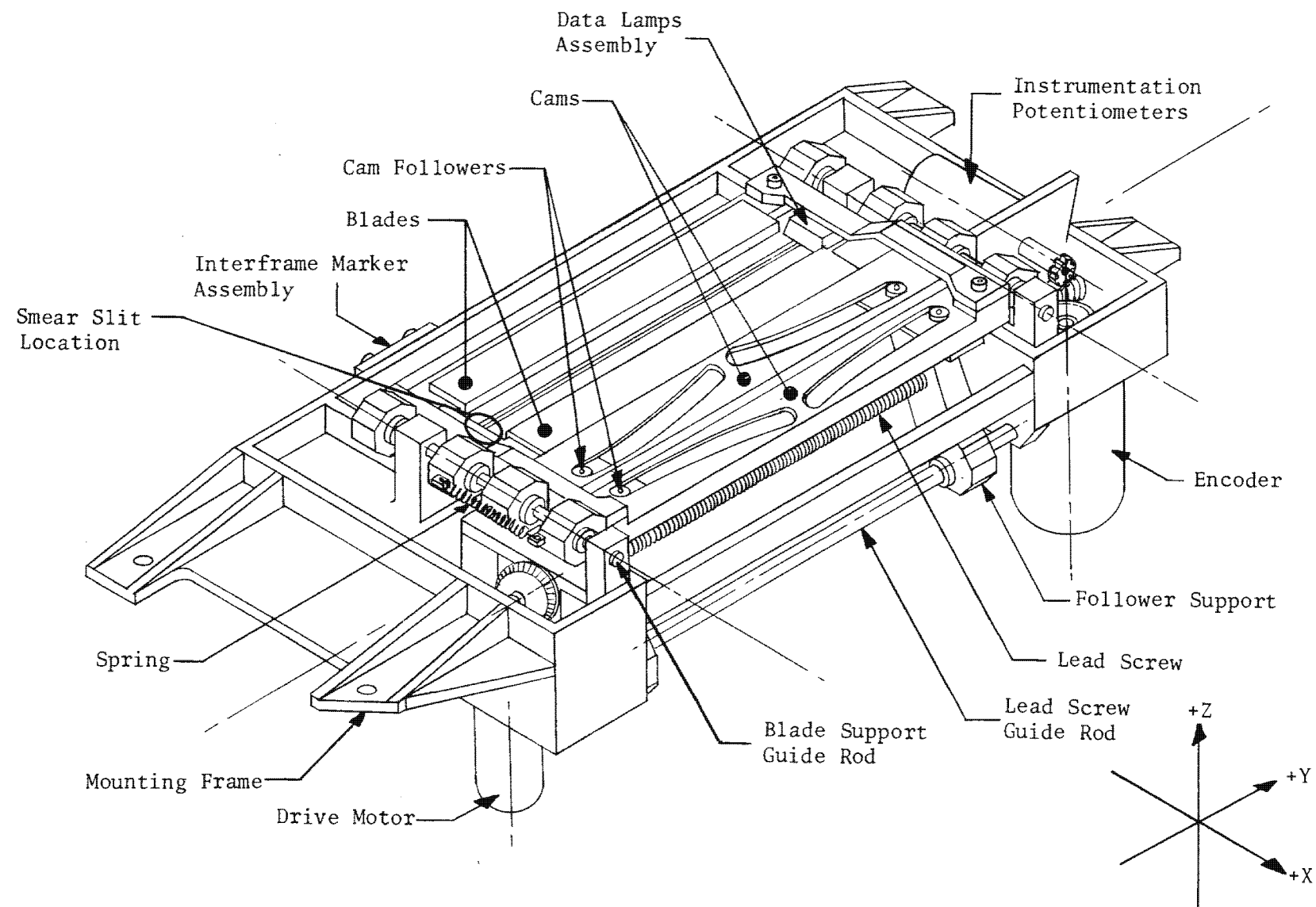
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Figure 3.2-28. 5 Variable Exposure Mechanism

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TABLE 3.2-3
OPERATIONAL SLIT WIDTHS

| <u>Slit Position</u> | <u>Nominal Slit Width (inch)</u> |
|----------------------|--|
| 1 | 0.0040 |
| 2 | 0.0054 |
| 3 | 0.0072 |
| 4 | 0.0094 |
| 5 | 0.0126 |
| 6 | 0.0168 |
| 7 | 0.0224 |
| 8 | 0.0300 |
| 9 | 0.0400 |
| 10 | 0.0534 |
| 11 | 0.0712 |
| 12 | 0.0948 |
| 13 | 0.1266 |
| 14 | 0.1686 |
| 15 | 0.2250 |
| 16 | 0.3000 |

2.2.2.2.2 Variable Exposure Mechanism Drive. Each VEM is controlled by a closed loop servo system consisting of an ac motor, an optical encoder, and control circuitry in the associated camera electronics assembly. The time needed to move from one operational slit to the next larger or smaller is 1.0 second maximum.

The motor is a 2-phase hysteresis synchronous type which runs at approximately 6500 rpm. Internal gearing reduces the speed by 27:1 so that the output shaft rotates at approximately 240 rpm. This drive force is transmitted through the

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slit mechanism gear train shown in Figure 3.2-29 to the lead screw, the optical encoder, and the instrumentation potentiometers.

Positional feedback data for each electronics unit is provided by the dual track optical encoder which rotates 21 degrees for each of the 15 transitions (16 steps). Step 1 is at the 5-degree encoder centerband position and step 16 at 320 degrees. The cam mechanical stops occur at -2.5 and 324.5 degrees. Total encoder station bandwidth is ± 3 degrees around the nominal centers.

The two instrumentation potentiometers and their associated processing networks in the camera produce redundant signals indicating slit position. Driven by a helical gear on the lead screw shaft, they must rotate approximately 470 degrees to cover the full range of slit positions. Thus the monitor outputs, IMPs 5049 and 5050 on the 9 VEM, and 5055 and 5056 on the 5 VEM, appear as two overlapping voltage cycles.

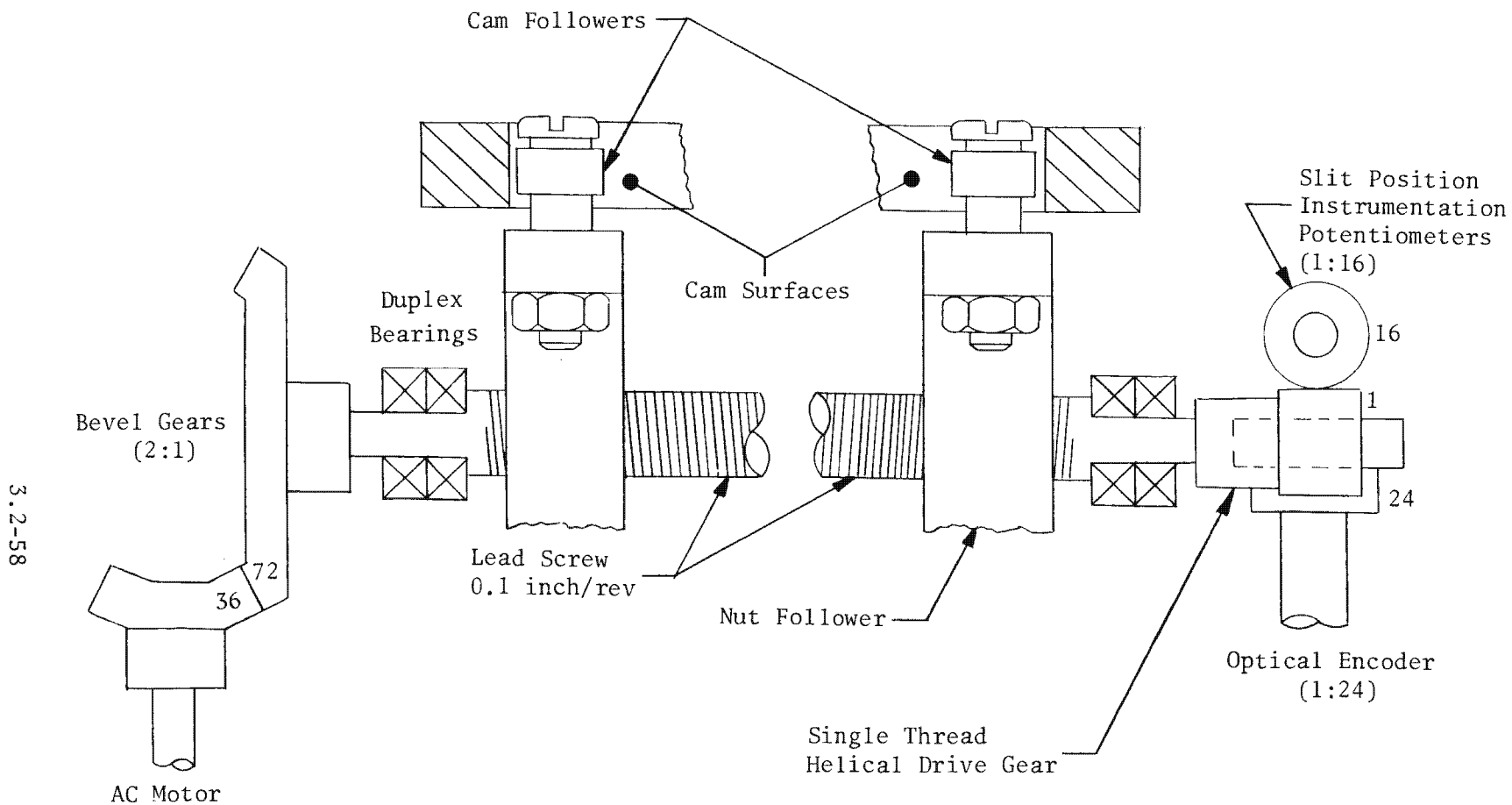
2.2.2.2.3 Film Marking Assemblies. Each variable exposure mechanism produces the fiducial lines, data tracks, interframe marks and smear slit images present on returned film. The film formats and pertinent dimensional information are shown in Figures 3.2-30 and 3.2-31.

2.2.2.2.3.1 Data Tracks. There are two pairs of data tracks on each exposure mechanism. One pair is designed for low mode and one pair for high mode. For either mode, the two data tracks, A and B, provide timing information in the form of light pulse exposures representing the vehicle timing signals. (Timing signal A inverted and logically summed with timing signal B.) (See Section 2.5.4.2.4.) This combined signal is generated in the associated camera electronics and used to control two LEDs mounted on either side of each slit centerline.

The LED circuit board supports a 0.020-inch thick glass mask with apertures etched in chrome to control the apparent size of the LED chip and to limit data

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Figure 3.2-29. Variable Exposure Mechanism Drive System Schematic

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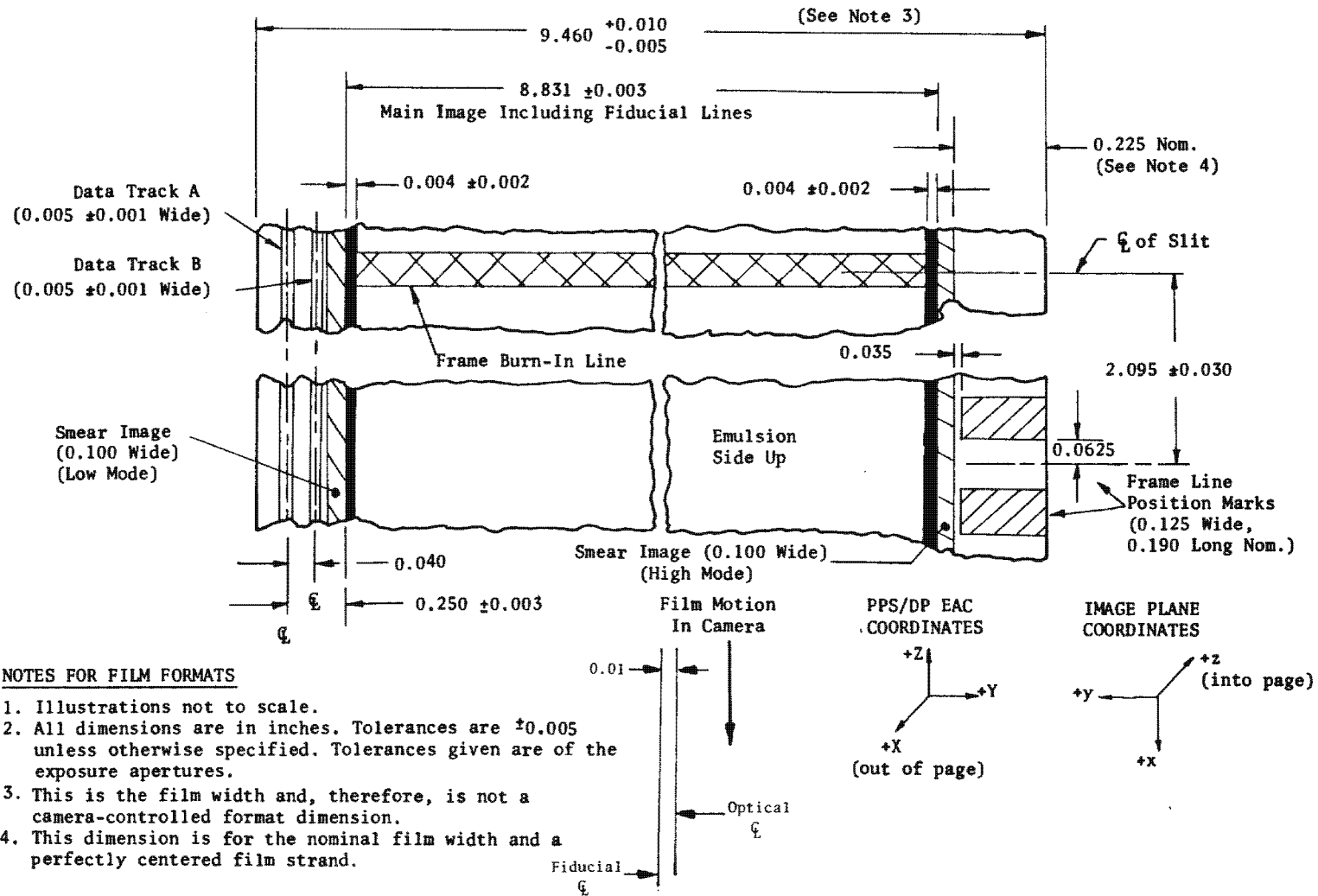


Figure 3.2-30. 9 Film Format

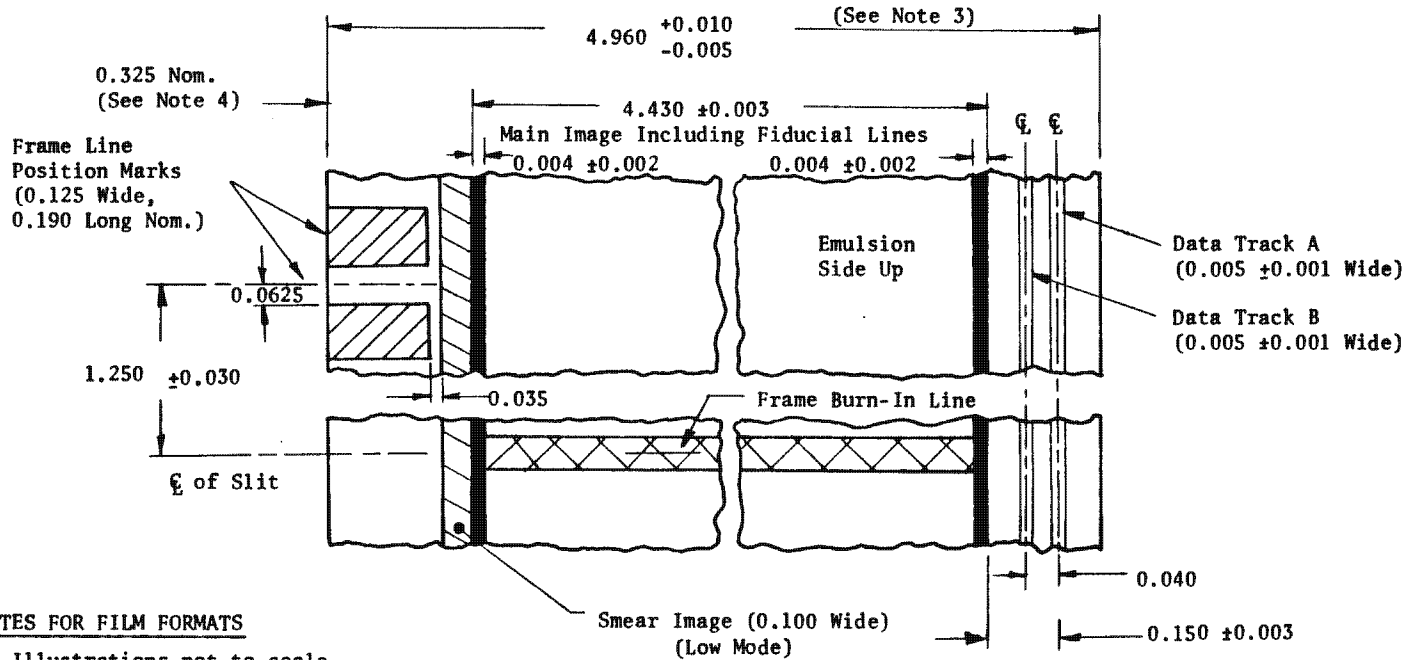
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NOTES FOR FILM FORMATS

1. Illustrations not to scale.
2. All dimensions are in inches. Tolerances are ± 0.005 unless otherwise specified. Tolerances given are of the exposure apertures.
3. This is the film width and, therefore, is not a camera-controlled format dimension.
4. This dimension is for the nominal film width and a perfectly centered film strand.

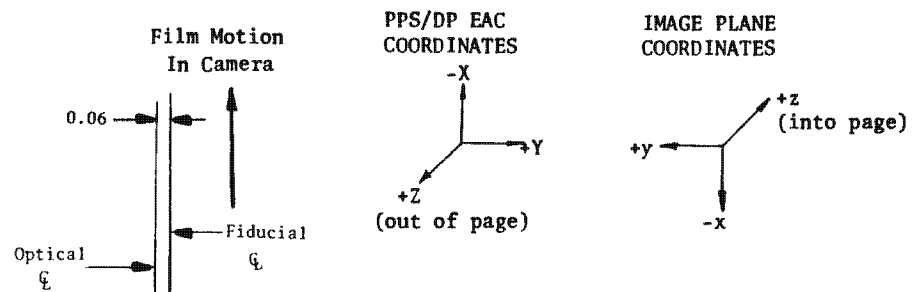


Figure 3.2-31. 5 Film Format

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track edge spreading.

The following matrices show the position of the data lamps and also show the size of the mask apertures.

| Data Lamp | Position with Respect to Slit ζ | Distance from Slit ζ (Referenced to Direction of Film Motion) | <u>LOW MODE</u> | |
|-----------|---------------------------------------|---|------------------|----------------|
| | | | Aperture Size | |
| | | | LED | Platen |
| A | Outside | 0.05 After | 0.008 Dia. | 0.001 x 0.005 |
| B | Inside | 0.05 Ahead | 0.008 Dia. | 0.001 x 0.005 |
| | | | <u>HIGH MODE</u> | |
| A | Outside | 0.15 Ahead | 0.002 x 0.008 | 0.0005 x 0.005 |
| B | Inside | 0.15 After | 0.004 x 0.008 | 0.0005 x 0.005 |

The relative data lamp positions are the same for both the 9 and 5 slit mechanisms. Each LED emits light at a wavelength of approximately 6600 \AA to which all candidate films are sensitive. The light level of each LED is adjusted during assembly by fixed select-in-test resistors.

2.2.2.2.3.2 Interframe Marks. The interframe marks are two rectangular exposures placed on the film just before the start of a photographic operation indicating the end of one frame and the beginning of the next. Placement of the interframe marks with respect to the slit centerline is shown in the film format figures.

The interframe marker output is the radiant flux emitted by the recorders which sensitizes the film in such a manner as to permit the markers to appear on the Versamat-processed Type 124 negative at a minimum density of 2.0 above gross fog.

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Light output is provided by two tungsten filament incandescent lamps mounted to an epoxy-glass board. A metal block on the VEM supports the lamp assembly and contains the two rectangular apertures. The amount of light is adjusted during assembly by fixed select-in-test resistors.

2.2.2.2.3.3 Smear Slits and Fiducial Lines. The smear slits and fiducial lines on both 9 and 5 films are created by the shape of the slit blades and masks shown in Figure 3.2-32. The fiducial apertures are considerably wider in the direction of film travel than the main exposure slit, providing a narrow band of high exposure at each edge of the main scene.

The smear slit images on the 9 film (data track side) and 5 film (interframe position mark side) are produced by identical size blade apertures. These images are to be used for low-mode analysis. Each image is a double exposure (at differing levels) of the same scene produced by a leading and a lagging aperture with the following widths:

$$\text{Leading } w_{S_n} = w_8 - \left(\frac{w_8 - w_n}{2} \right) = \frac{w_8 + w_n}{2} \quad \text{Lagging } w_{S_n} = \frac{w_8}{2} - \left(\frac{w_8 - w_n}{2} \right) = \frac{w_n}{2}$$

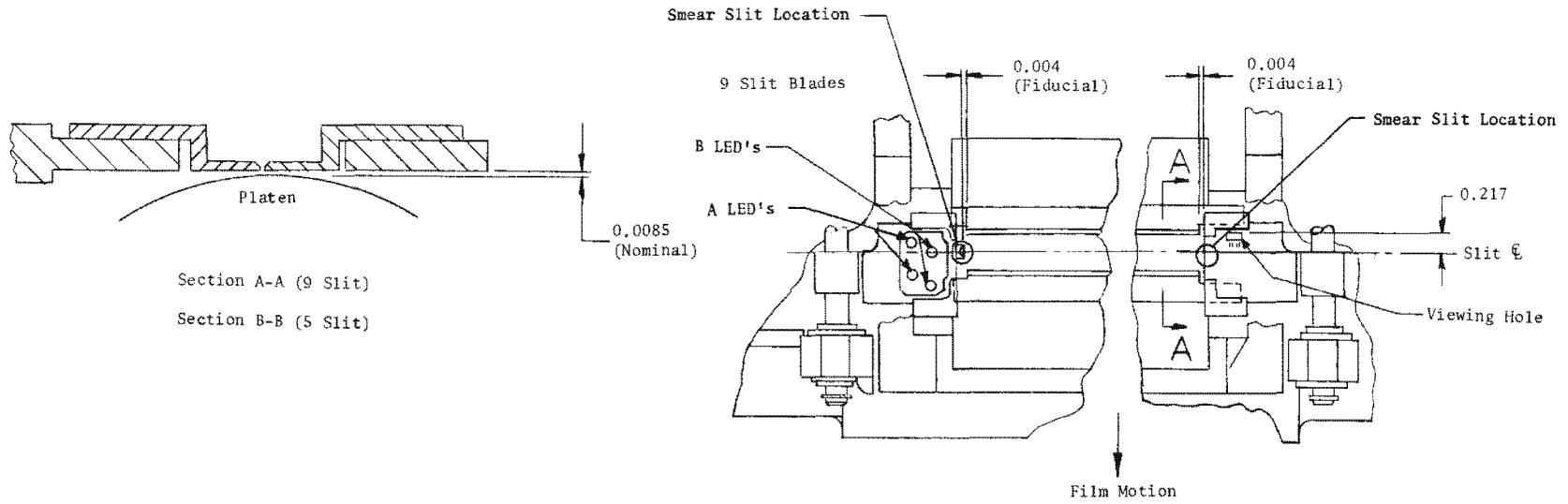
where: w_{S_n} is smear slit width for n^{th} exposure slit position

w_8 is the exposure slit width for the 8^{th} exposure slit position

w_n is the exposure slit width for the n^{th} exposure slit position

The center-to-center spacing of the smear-slit pair (leading and lagging) associated with a specific operational exposure slit position is determined by the following relationship:

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NOTES:

1. The viewing hole for film tracking (0.125 x 0.064) is at least partially open for slit steps 15 and 16.
2. Interframe markers not shown. Spacing between interframe marker assembly and platen is 0.008 inches (minimum).
3. All dimensions in inches.

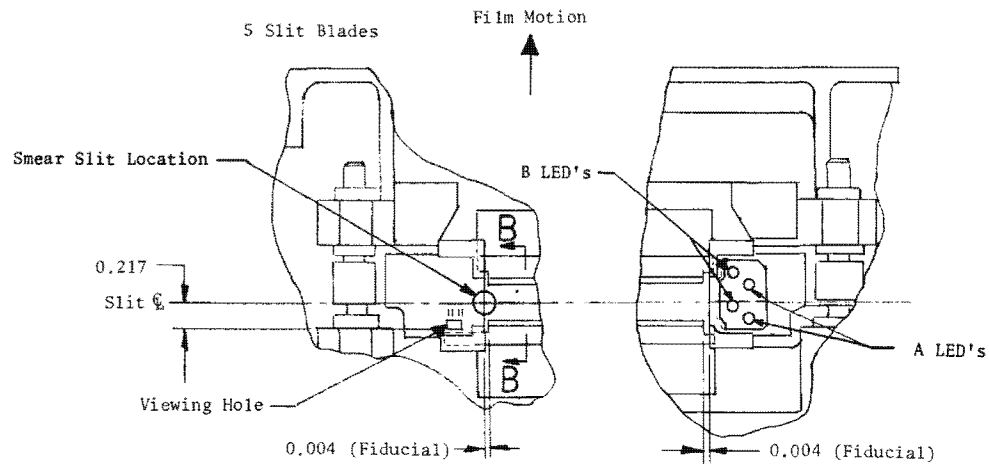


Figure 3.2-32. 9 and 5 Slit Blade Details

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$$C \rightarrow C = 0.0855 + \frac{w_{S_n} \text{ Leading} + w_{S_n} \text{ Lagging}}{2}$$

Use of the smear image in analyzing system performance is discussed in Part 2, Section 4.

The smear slit image on the 9 film (interframe position mark side) is specifically designed for high-mode analysis.

The image is a double exposure as above produced by leading and lagging apertures with the following widths:

$$\text{Leading } w_{S_n}^{(1)} = \frac{w_n + W_2}{2} \quad (3/2)$$

$$\text{Lagging } w_{S_n}^{(2)} = \frac{w_{S_n}^{(1)}}{3}$$

where: $w_{S_n}^{(1)}$ is the leading smear slit width for n^{th} exposure slit position

w_n is the n^{th} slider width opening

W_2 is the 2nd slider width opening

$w_{S_n}^{(2)}$ is the lagging smear slit width

The center-to-center distance is determined by the following relationship:

$$C \rightarrow C = 0.0214 + \frac{w_{S_n}^{(1)} + w_{S_n}^{(2)}}{2}$$

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Use of the smear image in analyzing system performance is discussed in Part 2, Section 4.

2.2.2.2.4 VEM Alignment. Each VEM is aligned to its respective platen as follows:

- (1) The centerline of the slit aperture is centered on, and remains parallel to the platen longitudinal axis throughout its operating range.
- (2) The surface of the slit blade is nominally 0.0085 inch from the platen.

A difference exists between the optical centerline and the fiducial centerline in each film subsystem. The difference is slight, 0.0405 inch for the 9 VEM and 0.009 inch for the 5 VEM, but should be included when analyzing returned photography.

2.2.2.3 Focus Adjust Mechanism. The focus adjust mechanisms (9 and 5) control the focusing function in the PPS/DP EAC by positioning the platens at the required focus setting. The FAM moves the entire pivot frame assembly about its two pivot flexures through the use of an eccentric drive (the FAM gearbox) as the third frame support point (see Figure 3.2-33).

Focus adjustment is of two types:

- (1) Slant Range Compensation (SRC) - which is a closed loop system with platen position determined by the four most significant bits of the commanded film-drive-speed.
- (2) Nominal Platen Adjustment (NPA) - which is an open loop system used to compensate for image plane shifts from factory setting as determined through focus detector subsystem data or analysis of film from SRV 1. The NPA also is used to compensate for varying thicknesses of film and in performing special system experiments.

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NOTE: Pivot frames shown in proper relationship for the Z direction, separated in the X direction for clarity.

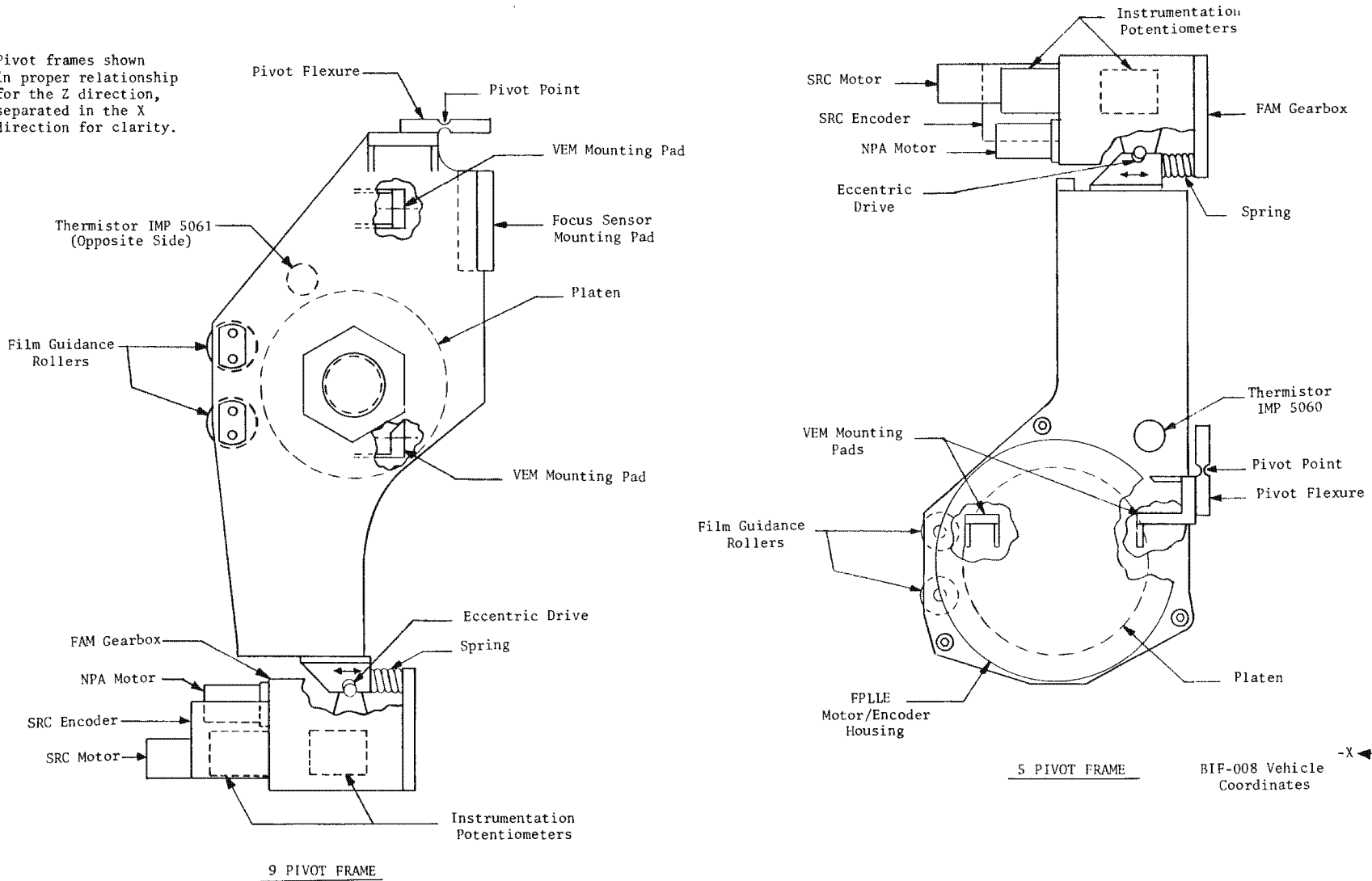


Figure 3.2-33. 9 and 5 Pivot Frame Assemblies

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The SRC system provides 16 discrete steps, moving the platen 0.0045 inch in 15 increments of 0.0003 inch each. Step 10 is at the factory best-focus position (or at best focus as adjusted by the NPA subsystem) and step 1 is +0.0027 inch from there (positive reference: toward the Ross corrector). Adjustment occurs at the rate of 4 steps within a maximum time of 0.20 second.

The NPA subsystem covers a range of 0.024 inch centered at factory best focus, with a step granularity of 0.0001 inch. The two available NPA drive modes produce different rates of travel; 5 steps per second in the primary mode and 1 step in 0.8 second in the backup mode.

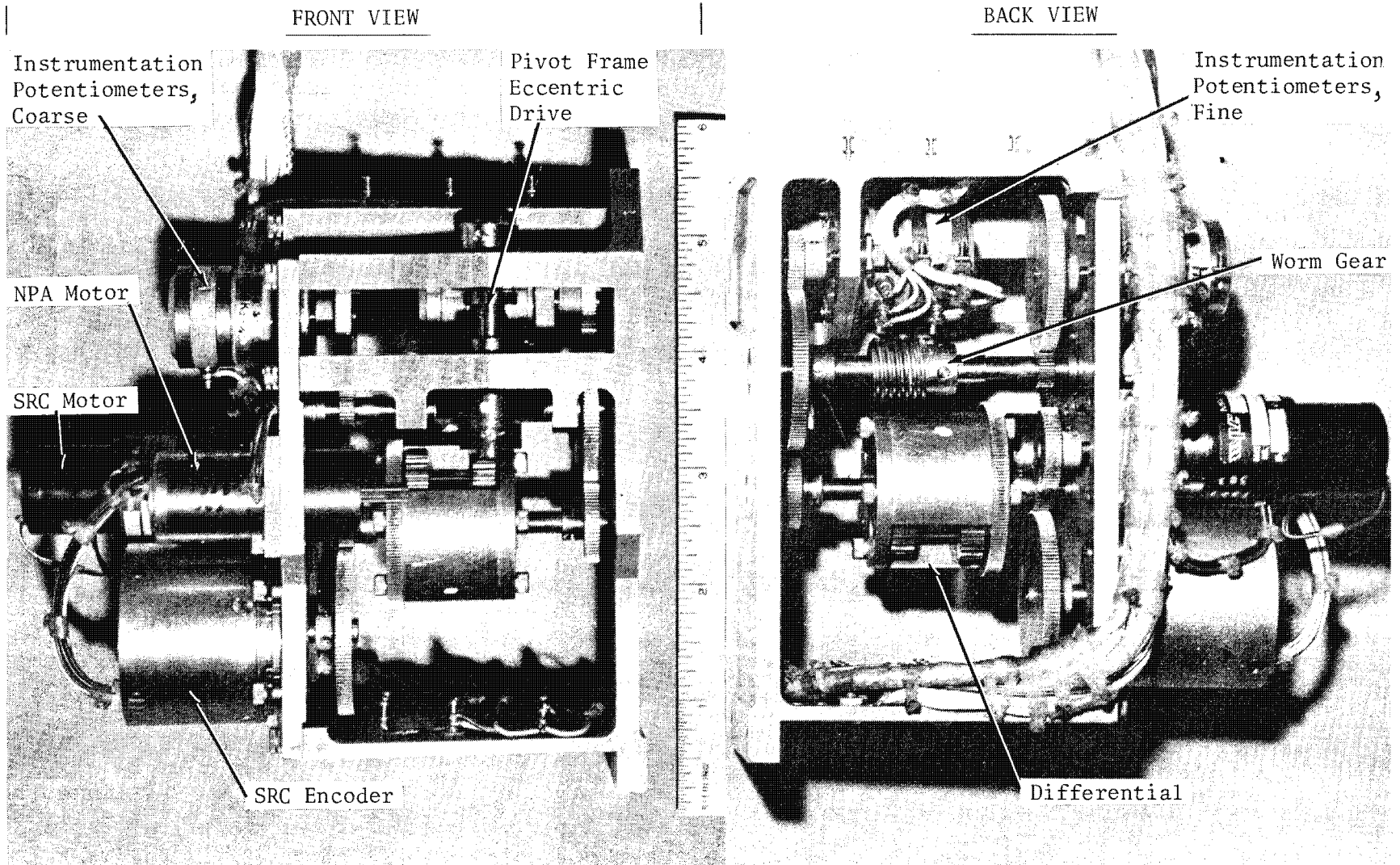
System redundancy is achieved through the use of two drive motors, allowing the NPA system to be used as a backup for the SRC system, if necessary. Complete electrical redundancy is provided in the drive circuit for the NPA system. Dual springs are used at the attachment of the gearbox and pivoting frame to remove any system backlash.

Electronic control circuits for the two FAM drives are located in their respective camera electronics assemblies. For a description of these units and the operational characteristics of the FAM mechanisms, refer to Subsection 2.5.4.

2.2.2.3.1 FAM Gearbox. The FAM gearbox assembly, illustrated in Figures 3.2-34 and 3.2-35, consists of a mechanical gear differential driven by the NPA stepper motor and the SRC ac motor. The output of the differential drives the instrumentation potentiometers and a worm gear that meshes with a sector gear attached to the pivot frame eccentric drive. Both the NPA and SRC motors incorporate mechanical holding brakes to prevent motion when the other is driving. The gearbox has mechanical stops at each side of the sector gear limiting the total focus adjustment to 0.024 inch. The two gearboxes mount to the camera housing as shown previously in Figure 3.2-22.

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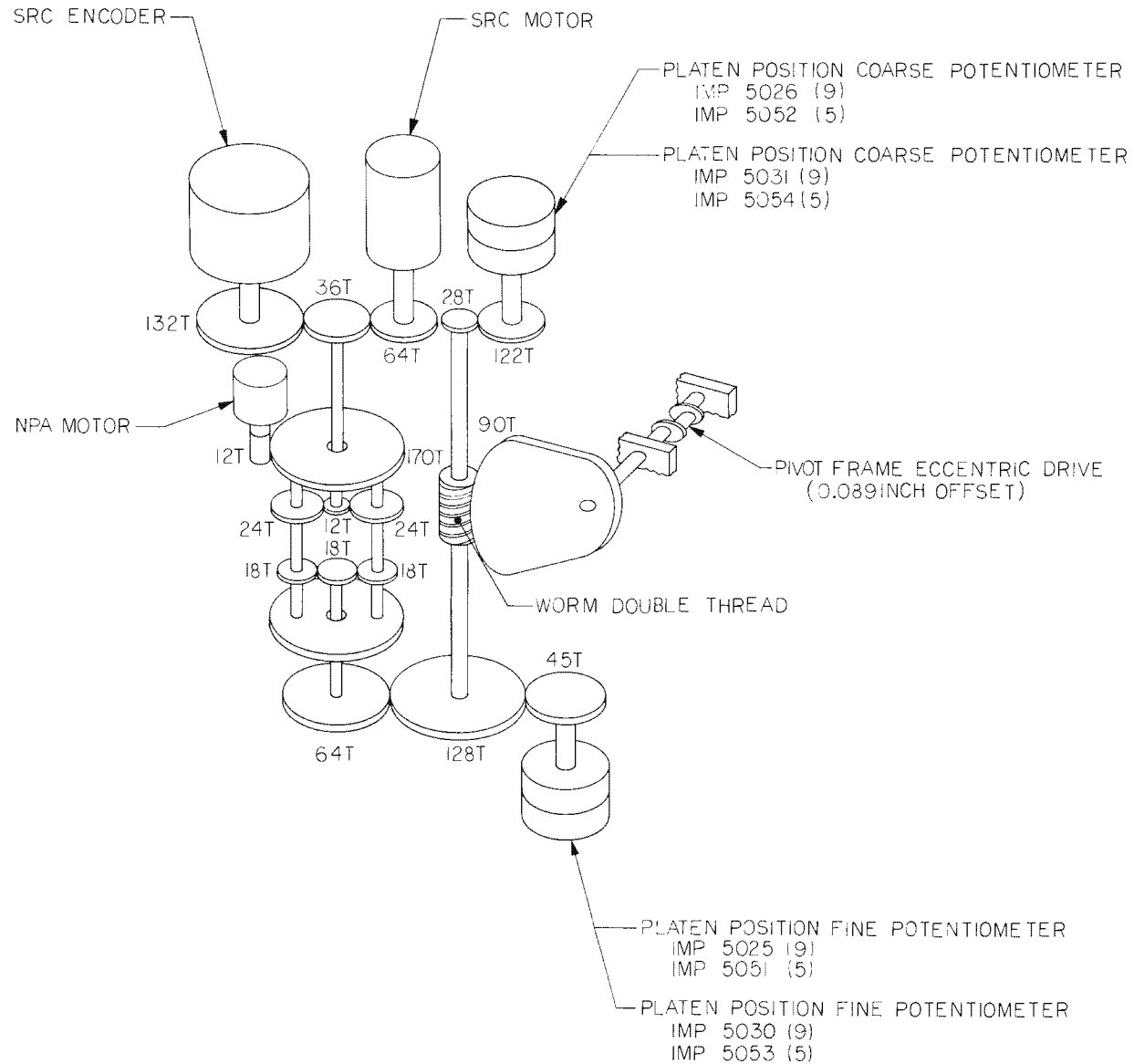
3.2-68

Figure 3.2-34. Focus Adjust Mechanism Gearbox

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Figure 3.2-35. Focus Adjust Mechanism Gear Train

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The 5 and 9 subsystem dimensions from the pivot point of the flexures to the platen, and from the pivot point to the gearbox-drive shaft are in the proper proportion to allow use of the same gearbox design for both, and are as follows:

| | <u>9 Subsystem</u> (inches) | <u>5 Subsystem</u> (inches) |
|--------------------------------------|--------------------------------|--------------------------------|
| (1) Pivot point to platen centerline | 5.080 | 2.830 |
| (2) Pivot point to drive shaft | 11.178 | 6.228 |

2.2.2.3.2 Pivot Frame Flexures. The transverse circular pivoting flexures supporting the pivot frames require no lubrication and have no contacting (rolling, sliding, etc.) surfaces. The gradual necking-down keeps stress concentrations to a minimum, and alignment difficulties are virtually eliminated by accurate machining of the circular cutouts. The flexures are attached to machined pads in the camera housing.

At the nominal factory focus position (set to best focus for an 87.5 nmi slant range), the 9 and 5 platens are in line with the optical centerline. The pivoting motion of focus adjustment and behavior of the flexures introduce an error in the alignment which reaches a maximum of 2.9×10^{-4} inches in the 9 subsystem and 5×10^{-4} inches in the 5 subsystem at the extremes of travel. The total focus error introduced is not considered since it is accounted for by calibration.

2.2.2.3.3 FAM Instrumentation. The platen position instrumentation in each subsystem consists of two dual, concentric rotary potentiometers geared to the worm drive shaft (reference Figure 3.2-35). The four potentiometers produce redundant, fine and coarse platen position signals. The coarse potentiometers cover a range of 0.024 inch in approximately 350 degrees of rotation. The fine potentiometers rotate approximately 12.4 times for one

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revolution of the coarse, producing several voltage cycles over the complete range of platen travel. Processing instrumentation for all eight monitors is located in the camera housing. The points are assigned as follows:

| <u>9 Subsystem</u> | <u>IMPs</u> |
|-------------------------|---------------|
| Platen Position, Fine | 5025 and 5030 |
| Platen Position, Coarse | 5026 and 5031 |
| <u>5 Subsystem</u> | |
| Platen Position, Fine | 5051 and 5033 |
| Platen Position, Coarse | 5052 and 5054 |

2.3 Film Path Distances

Figure 3.2-36 illustrates the overall film path of the PPS/DP EAC listing path lengths for each segment and diameters for each roller. Table 3.2-4 summarizes the most pertinent distances for quick reference.

2.4 Operational Description

Operation of the 9 x 5 dual platen camera and film handling subsystem can be separated into two cycles; a photographic cycle where unexposed film is transferred from the supply side of the looper, exposed in the camera, and returned to the take-up side of the looper, and a take-up cycle where the exposed film is transferred from the take-up side of the looper to the take-up spool while the supply spool simultaneously refills the supply side of the looper with fresh film. Operation in the strip mode, (or any photographic activity which causes the supply side of the looper to empty) results in performing a take-up cycle while a photographic cycle is in progress. A simplified operational schematic is shown in Figure 3.2-37.

The following is a brief discussion of a photographic cycle and the 9 take-up and 5 take-up cycles. For more detailed information, refer to the control electronics description: the film control electronics (9 take-up

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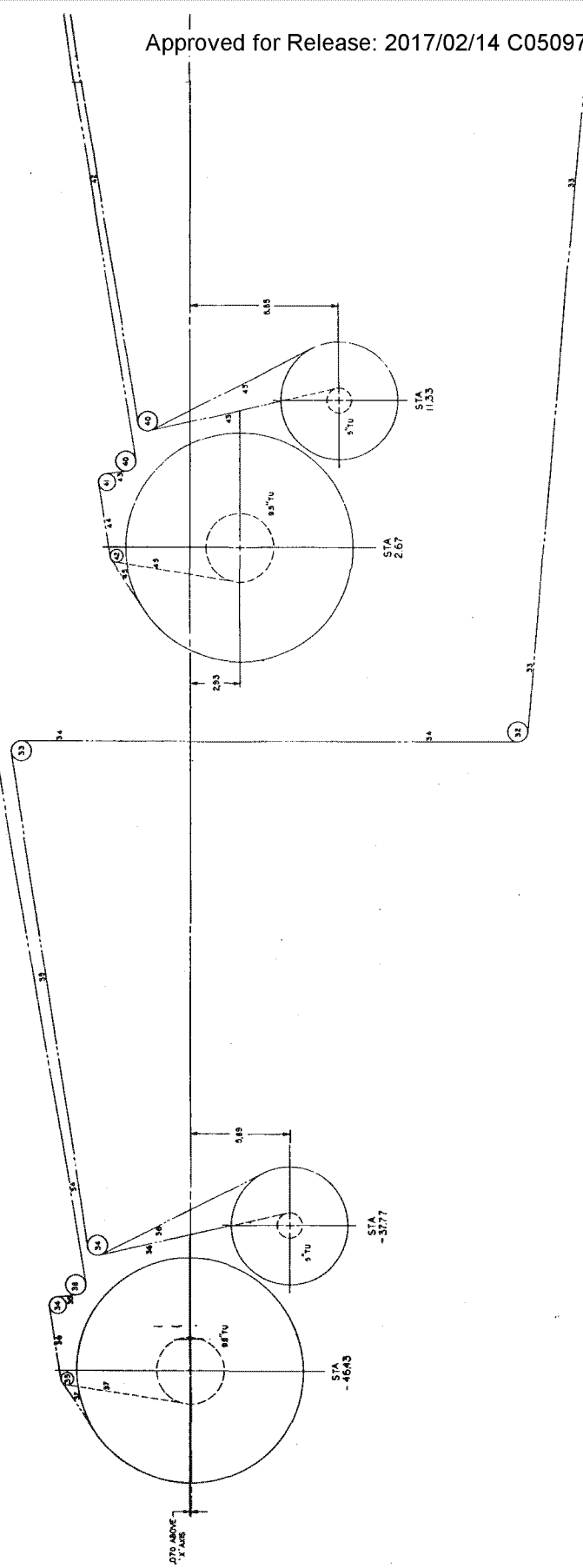
3.2-72

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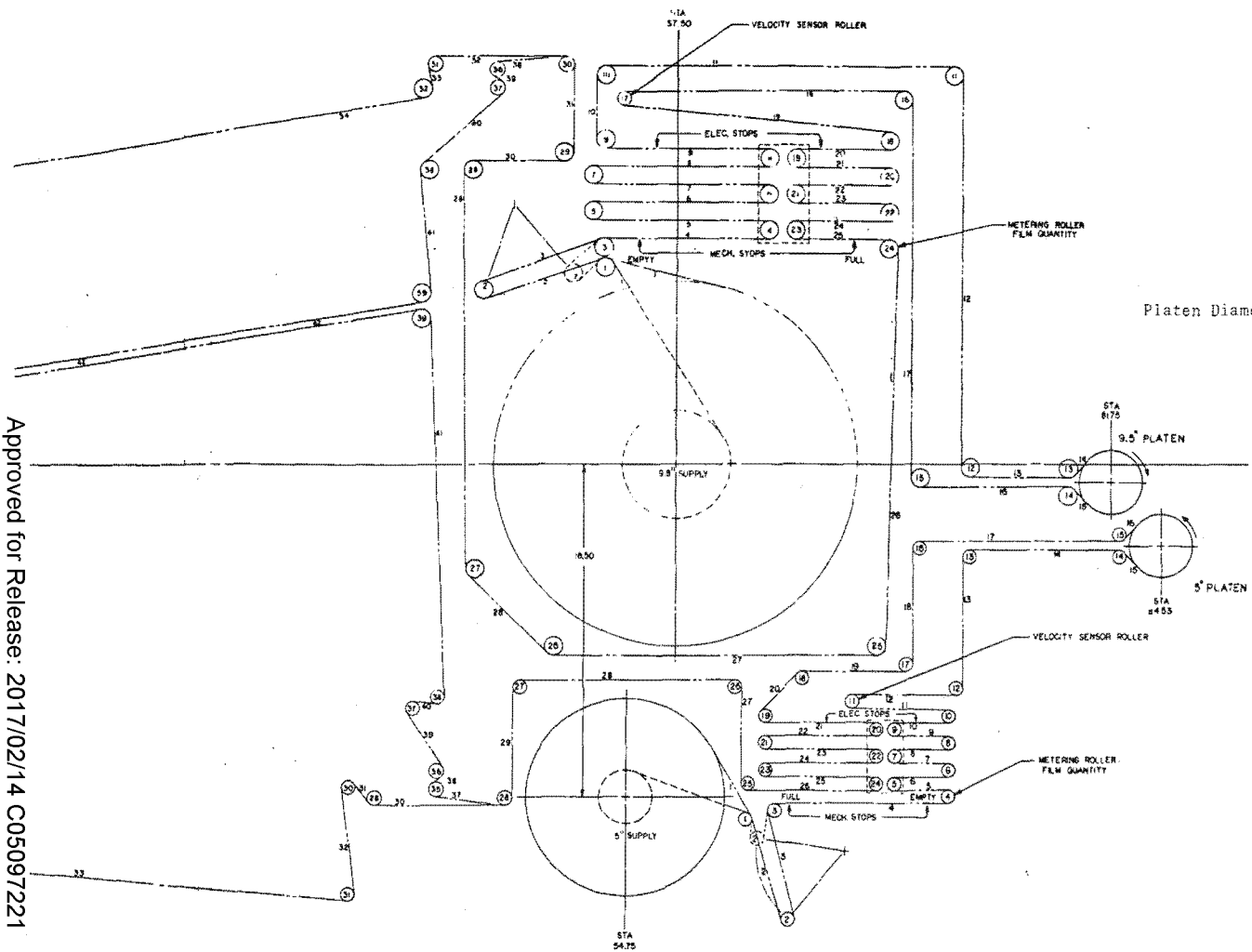
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NOTES:

- (1) Numbers shown on film path are as follows:
 (a) Indicates roller number.
 (b) Indicates distance number. All numbers on the film path are placed on the emission side of the film.
- (2) Distances are either measured from the center of wrap on one roller to the center of wrap on the next or to the tangent point on the film spool.
- (3) Where two distances are listed, values represent the possible minimum and maximum lengths.
- (4) Storage longer conditions of being BOPF and full are referenced to the supply side of the loop.



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Platen Diameter = 3.500 inches
(both cases)

5-inch Supply
Dist. No. Rollers Length

| | | |
|------|-------|--------|
| 1. | SUP-1 | 4.424 |
| | SUP-1 | 6.914 |
| 2. | 1-2 | 1.699 |
| | 1-2 | 6.721 |
| 3. | 2-3 | 2.482 |
| | 2-3 | 7.010 |
| 4. | 3-4 | 10.610 |
| | 3-4 | 10.681 |
| *5. | 4-5 | 1.928 |
| | 4-5 | 9.428 |
| *6. | 5-6 | 1.928 |
| | 5-6 | 9.428 |
| *7. | 6-7 | 1.928 |
| | 6-7 | 9.428 |
| *8. | 7-8 | 1.928 |
| | 7-8 | 9.428 |
| *9. | 8-9 | 1.928 |
| | 8-9 | 9.428 |
| *10. | 9-10 | 1.928 |
| | 9-10 | 9.428 |
| 11. | 10-11 | 6.584 |
| 12. | 11-12 | 6.690 |
| 13. | 12-13 | 7.902 |
| 14. | 13-14 | 8.766 |
| 15. | 14-PL | 5.440 |

* Mechanical stops. For electrical s, subtract 1.087 from the maximum.
+ Mechanical stops. For electrical s, subtract 0.280 from the maximum

Figure 3.2-36. PPS/DP EAC Film Path Distances

5 FILM SUBSYSTEM

9 FILM SUBSYSTEM

| 5-inch T/U 1 | | | |
|--------------|---------|--------|--|
| Dist. No. | Rollers | Length | |
| 16. | DR-15 | 5.440 | |
| 17. | 15-16 | 11.576 | |
| 18. | 16-17 | 7.090 | |
| 19. | 17-18 | 6.240 | |
| 20. | 18-19 | 3.688 | |
| +21. | 19-20 | 1.774 | |
| | 19-20 | 9.274 | |
| +22. | 20-21 | 1.928 | |
| | 20-21 | 9.428 | |
| +23. | 21-22 | 1.928 | |
| | 21-22 | 9.428 | |
| +24. | 22-23 | 1.928 | |
| | 22-23 | 9.428 | |
| +25. | 23-24 | 1.928 | |
| | 23-24 | 9.428 | |
| +26. | 24-25 | 2.634 | |
| | 24-25 | 10.134 | |
| 27. | 25-26 | 5.964 | |
| 28. | 26-27 | 12.464 | |
| 29. | 27-28 | 6.789 | |
| 30. | 28-29 | 7.693 | |
| 31. | 29-30 | 2.036 | |
| 32. | 30-31 | 6.652 | |
| 33. | 31-32 | 48.617 | |
| 34. | 32-33 | 30.436 | |
| 35. | 33-34 | 28.898 | |
| 36. | 34-T/U | 11.163 | |
| | 34-T/U | 11.839 | |

| 5-inch T/U 2 | | | |
|--------------|---------|--------|--|
| Dist. No. | Rollers | Length | |
| 37 | 28-35 | 4.564 | |
| 38. | 35-36 | 1.270 | |
| 39. | 36-37 | 4.359 | |
| 40. | 37-38 | 2.071 | |
| 41. | 38-39 | 21.699 | |
| 42. | 39-40 | 35.552 | |
| 43. | 40-T/U | 11.163 | |
| | 40-T/U | 11.839 | |

Roller Diameters
5 Subsystem

| Roller No. | Dia(in.) |
|-------------|----------|
| 1 | 0.750 |
| 27 | 0.750 |
| 28 | 0.800 |
| 29 | 0.800 |
| 30 | 0.750 |
| 31 | 0.750 |
| 32 | 1.166 |
| 33 | 1.166 |
| 34 | 1.166 |
| 35 | 0.800 |
| 36 | 0.800 |
| 37 | 0.750 |
| 38 | 0.750 |
| 39 | 0.750 |
| 40 | 1.166 |
| Supply Core | 3.00 |
| T/U Core | 1.43 |

| 9.5-inch Supply | | | |
|-----------------|---------|--------|--|
| Dist. No. | Rollers | Length | |
| 1. | SUP-1 | 6.709 | |
| | SUP-1 | 11.755 | |
| 2. | 1-2 | 2.735 | |
| | 1-2 | 7.624 | |
| 3. | 2-3 | 3.188 | |
| | 2-3 | 7.901 | |
| *4. | 3-4 | 2.746 | |
| | 3-4 | 12.831 | |
| *5. | 4-5 | 4.071 | |
| | 4-5 | 14.071 | |
| *6. | 5-6 | 4.071 | |
| | 5-6 | 14.071 | |
| *7. | 6-7 | 4.071 | |
| | 6-7 | 14.071 | |
| *8. | 7-8 | 4.071 | |
| | 7-8 | 14.071 | |
| *9. | 8-9 | 2.990 | |
| | 8-9 | 12.990 | |
| 10. | 9-10 | 4.347 | |
| 11. | 0-11 | 20.222 | |
| 12. | 11-12 | 22.339 | |
| 13. | 12-13 | 5.887 | |
| 14. | 13-PL | 5.460 | |

| 9.5-inch T/U 1 | | | |
|----------------|---------|--------|--|
| Dist. No. | Rollers | Length | |
| 15. | PL-14 | 5.460 | |
| 16. | 14-15 | 8.699 | |
| 17. | 15-16 | 21.584 | |
| 18. | 16-17 | 16.580 | |
| 19. | 17-18 | 16.104 | |
| +20. | 18-19 | 3.981 | |
| | 18-19 | 13.981 | |
| +21. | 19-20 | 4.071 | |
| | 19-20 | 14.071 | |
| +22. | 20-21 | 4.071 | |
| | 20-21 | 14.071 | |
| +23. | 21-22 | 4.071 | |
| | 21-22 | 14.071 | |
| +24. | 22-23 | 4.071 | |
| | 22-23 | 14.071 | |
| +25. | 23-24 | 3.678 | |
| | 23-24 | 13.678 | |
| 26. | 24-25 | 22.911 | |
| 27. | 25-26 | 18.456 | |
| 28. | 26-27 | 6.580 | |
| 29. | 27-28 | 22.652 | |
| 30. | 28-29 | 5.455 | |
| 31. | 29-30 | 5.610 | |
| 32. | 30-31 | 8.107 | |
| 33. | 31-32 | 1.935 | |
| 34. | 32-33 | 86.766 | |
| 35. | 33-34 | 2.115 | |
| 36. | 34-35 | 5.072 | |
| 37. | 35-T/U | 3.664 | |
| | 35-T/U | 7.365 | |

* Mechanical stops. For electrical stops, add 1.083 to the minimum; subtract 2.783 from the maximum.
 + Mechanical stops. For electrical stops, add 2.783 to the minimum; subtract 1.083 from the maximum.

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For electrical stops, add 0.280 to the minimum; subtract the maximum.

For electrical stops, add 1.087 to the minimum; subtract the maximum

9 FILM SUBSYSTEM

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Length

9.5-inch Supply
Dist. No. Rollers Length

| | | |
|-----|-------|--------|
| 1. | SUP-1 | 6.709 |
| | SUP-1 | 11.755 |
| 2. | 1-2 | 2.735 |
| | 1-2 | 7.624 |
| 3. | 2-3 | 3.188 |
| | 2-3 | 7.901 |
| *4. | 3-4 | 2.746 |
| | 3-4 | 12.831 |
| *5. | 4-5 | 4.071 |
| | 4-5 | 14.071 |
| *6. | 5-6 | 4.071 |
| | 5-6 | 14.071 |
| *7. | 6-7 | 4.071 |
| | 6-7 | 14.071 |
| *8. | 7-8 | 4.071 |
| | 7-8 | 14.071 |
| *9. | 8-9 | 2.990 |
| | 8-9 | 12.990 |
| 10. | 9-10 | 4.347 |
| 11. | 0-11 | 20.222 |
| 12. | 11-12 | 22.339 |
| 13. | 12-13 | 5.887 |
| 14. | 13-PL | 5.460 |

9.5-inch T/U 1
Dist. No. Rollers Length

| | | |
|------|--------|--------|
| 15. | PL-14 | 5.460 |
| 16. | 14-15 | 8.699 |
| 17. | 15-16 | 21.584 |
| 18. | 16-17 | 16.580 |
| 19. | 17-18 | 16.104 |
| +20. | 18-19 | 3.981 |
| | 18-19 | 13.981 |
| +21. | 19-20 | 4.071 |
| | 19-20 | 14.071 |
| +22. | 20-21 | 4.071 |
| | 20-21 | 14.071 |
| +23. | 21-22 | 4.071 |
| | 21-22 | 14.071 |
| +24. | 22-23 | 4.071 |
| | 22-23 | 14.071 |
| +25. | 23-24 | 3.678 |
| | 23-24 | 13.678 |
| 26. | 24-25 | 22.911 |
| 27. | 25-26 | 18.456 |
| 28. | 26-27 | 6.580 |
| 29. | 27-28 | 22.652 |
| 30. | 28-29 | 5.455 |
| 31. | 29-30 | 5.610 |
| 32. | 30-31 | 8.107 |
| 33. | 31-32 | 1.935 |
| 34. | 32-33 | 86.766 |
| 35. | 33-34 | 2.115 |
| 36. | 34-35 | 5.072 |
| 37. | 35-T/U | 3.664 |
| | 35-T/U | 7.365 |

9.5-inch T/U 2
Dist. No. Rollers Length

| | | |
|-----|--------|--------|
| 38. | 30-36 | 4.639 |
| 39. | 36-37 | 1.306 |
| 40. | 37-38 | 6.301 |
| 41. | 38-39 | 7.863 |
| 42. | 39-40 | 37.948 |
| 43. | 40-41 | 2.115 |
| 44. | 41-42 | 5.072 |
| 45. | 42-T/U | 3.664 |
| | 42-T/U | 7.365 |

Roller Diameters
9 Subsystem

| Roller No. | Dia(in.) |
|------------|----------|
| 1 | 1.000 |
| ↓ | ↓ |
| 16 | 1.000 |
| ↓ | ↓ |
| 17 | 0.750 |
| ↓ | ↓ |
| 18 | 1.000 |
| ↓ | ↓ |
| 29 | 1.000 |
| ↓ | ↓ |
| 30 | 0.800 |
| ↓ | ↓ |
| 31 | 1.800 |
| ↓ | ↓ |
| 32 | 1.000 |
| ↓ | ↓ |
| 33 | 1.166 |
| ↓ | ↓ |
| 34 | 1.000 |
| ↓ | ↓ |
| 35 | 0.750 |
| ↓ | ↓ |
| 36 | 0.800 |
| ↓ | ↓ |
| 37 | 0.800 |
| ↓ | ↓ |
| 38 | 1.000 |
| ↓ | ↓ |
| 39 | 1.000 |
| ↓ | ↓ |
| 40 | 1.166 |
| ↓ | ↓ |
| 41 | 1.000 |
| ↓ | ↓ |
| 42 | 0.750 |
| Supply | 6.00 |
| Core | |
| T/U Core | 3.93 |

* Mechanical stops. For electrical stops, add 1.083 to the minimum; subtract 2.733 from the maximum.

+ Mechanical stops. For electrical stops, add 2.733 to the minimum; subtract 1.083 from the maximum.

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in.)

10

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TABLE 3.2-4
FILM PATH LENGTHS

| <u>Distance (1)</u> | <u>9 (inches)</u> | <u>5 (inches)</u> |
|--|-------------------|-------------------|
| Splicer to SRV 1 T/U Spool (2) | 103 | 131 |
| Splicer to SRV 2 T/U Spool (3) | 66 | 78 |
| Slit to SRV 1 T/U Spool | 298 | 214 |
| Slit to SRV 2 T/U Spool | 260 | 159 |
| Slit to Film Quantity Metering Roller | 109 | 85 |

- (1) Assumes full T/U spool; looper carriage at supply side electrically full position
- (2) Assumes 3.5 inches from cutting point to output roller of splicer mechanism
- (3) From approximate splicing point

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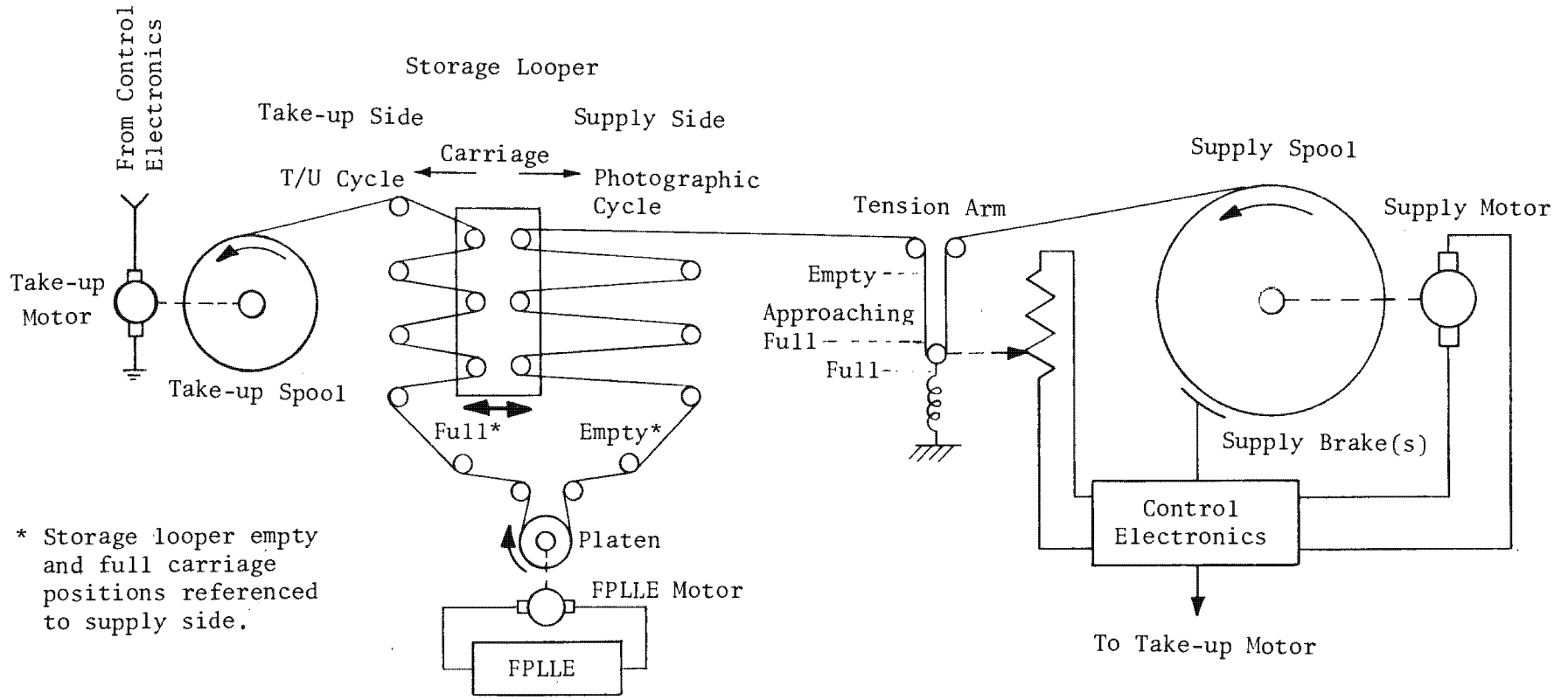


Figure 3.2-37. Film Handling Operational Schematic

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cycle), the film handling electronics (5 take-up cycle), and the frequency phase lock loop electronics (photographic cycle), which follow this subsection.

2.4.1 Simplified Photographic Cycle

Performance of a photographic cycle requires operational power (OP) to be ON for the commanded subsystem(s). Prior to beginning film motion, the proper exposure slit opening is selected and the roll, crab, and stereo positions set. Sufficient transition time must be allowed for setup, or image quality could be degraded.

Film drive (9 and/or 5) is started by execution of the 14V WORD* command, containing the 10 film-drive speed bits. The film-drive speed, selected for correct image motion compensation, controls the FPLLE and dictates the correct focus position (slant range compensation step) for the platen.**



. If the SRC subsystem is unable to reach the proper platen position in this 300 millisecond period, degradation will result until the platen is positioned correctly and settled. To avoid this, the 14V WORD can be commanded with operational power OFF prior to the photographic period. No film motion will occur, but the SRC subsystem will begin moving the platen to the desired focus position allowing additional drive time over and above the normal 300-millisecond film start-up period. Commanding OP ON will initiate the normal photographic sequence. Normally, however, the transition will be completed prior to the required film drive ON time. The 14V WORD or 13V WORD OFF command is then executed, leaving the subsystem ready for a photographic sequence.

25X1

*14V WORD signifies a 14 variable bit command word. Refer to Part 3, Section 9 for further explanation.

**The SRC step picked is correct only in the normal film-drive speed range.

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Interlocks exist in the film control subsystems to prevent image degradation as much as practical. Any vibrational disturbance in the vehicle may affect platen drive smoothness. To avoid this, execution of the 14V WORD command implicitly removes power from both the 9 and 5 slit mechanisms and inhibits both the 9 and 5 take-up cycles. The take-up inhibit will be overridden by either of two occurrences to prevent damage to the system:

- (1) A low-tension condition in the film handling subsystem (monitored by the tension arm) or,
- (2) The supply side of the storage looper reaching its electrically empty trip point.

The slit mechanism inhibit is not automatically overridden. However, slit motion can be resumed by recommanding the desired slit position.

While simultaneous operation of both 9 and 5 film subsystems is possible, only one film-drive speed is available with the 14V WORD. Consequently, only one of the film subsystems may be optimized in terms of image motion compensation, as discussed in Section 3, Part 2.

Motion of film during the photographic cycle can best be understood by reviewing the film handling operational diagram (Figure 3.2-37). Rotating the platen pulls film from the supply side of the storage looper, past the exposure slit, and returns it to the take-up side. The looper carriage moves continuously to the right as film is transferred from one side to the other. Since an equal amount of film is replaced on the take-up side as is removed from the supply side, no film motion will occur elsewhere in the system as long as the take-up cycle remains inhibited. Since film tension remains essentially constant, no film is transferred to, or from, the tension looper.

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2.4.2 Simplified Take-up Cycle

A take-up cycle (for either the 9 or 5 system) is initiated whenever the supply side of the storage looper reaches its electrically empty limit, or a 9/5 TAKE-UP ENABLE command is given and the looper carriage is not at the electrically full position.** Once begun, the take-up cycle will be stopped either by the supply side of the storage looper tripping the opposite limit switch (electrically full), or the film drive being commanded ON in either film subsystem, provided the looper supply side is not electrically empty. If the take-up cycle was initiated while the film drive was on, it will continue until the supply side of the looper has been completely refilled, unless a repeat film drive ON command is given while the looper carriage is between its two electrical limits.*

Should the tension arm reach its electrically full limit (low tension) with the film system quiescent (a take-up cycle not in progress), the take-up spool will begin driving, and continue until the tension has returned to satisfactory levels. This condition will not initiate a full take-up cycle. A high tension signal from the tension arm will release the supply brake but will not cause the motor to begin driving while the take-up cycle is inhibited.

For the 9 subsystem, the take-up cycle is performed the same whether it is explicitly commanded, or caused by an empty supply side on the storage looper. In the 5 subsystem, the method of performing a take-up cycle depends on its cause. Commanding 9/5 TAKE-UP ENABLE initiates a cycle similar to the 9 subsystem.** However, the 5 subsystem incorporates a backup mode of operation which is initiated when the supply side of the 5 storage looper reaches its electrically empty limit. This mode uses only the supply brake, rather than the brake and drive motor to control film tension, requiring the take-up motor to pull film from the supply spool as it rolls in exposed film.

*A T/U cycle (emptying an electrically full looper and coming to rest) requires 3.0 seconds maximum (3.5 seconds in the 9 subsystem when the voltage is less than 24.5 vdc and there is less than 500 or more than 4000 feet of film on the T/U spool).

**When more than one 9/5 TAKE-UP ENABLE command is given without an intermediate TAKE-UP INHIBIT (14V WORD) command, only the first 9/5 TAKE-UP ENABLE will be effective. This is due to an interaction between the command processor and the film handling electronics.

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The take-up spool drive and the supply brake in either subsystem employ digital closed-loop systems for operation, while the supply drive motor is controlled by an analog closed-loop system. The take-up drive is turned ON by those signals which initiate a take-up cycle (looper supply side empty; 9/5 TAKE-UP ENABLE command), or by the tension arm encoder low-tension signal. The drive is turned OFF by the end of the take-up cycle (looper supply side full; film drive ON command being given), or by the tension arm returning to an acceptable range, if a high-tension condition was the initiating factor.

Supply drive in the 9 subsystem, or in the 5 subsystem for primary mode of operation, is controlled in response to an analog voltage signal from the associated tension arm position potentiometer. A comparator circuit in the control electronics (FCE or FHE) provides forward or reverse drive, as needed, to maintain the tension arm at its nominal rest position.

The supply brake is released by energizing the brake coil circuitry, which is controlled by the tension looper reaching the electrically empty state (high tension), by the storage looper reaching its electrically full position, or by the 9/5 TAKE-UP ENABLE command being given while the looper carriage is between the empty and full positions. In the backup mode of operation, the 5 supply brake is normally released and is then engaged whenever the tension arm encoder reaches the tension looper APPROACHING FULL position.

Film motion during a take-up cycle is somewhat complex and coverage of all possible situations will not be included here. What follows are three simplified descriptions; the first is typical of the 9 subsystem take-up cycle, the second is typical of the 5 subsystem primary mode cycle, and the third describing the 5 backup mode.

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At the beginning of the take-up cycle, the 9 take-up drive is turned ON and the supply brake disengaged. As the take-up runs, it pulls film from the take-up side of the storage looper, causing the supply side to begin filling at the same rate (the looper carriage in Figure 3.2-37 moves to the left). No film motion occurs in the camera unless a photograph is being taken simultaneously. Initially, fresh film is acquired from the tension looper as the supply has not started moving. This results from a built-in delay in the control circuitry incorporated to lessen system perturbations.

If the supply drive was immediately enabled, the initial position of the tension looper might be such that the supply would begin to drive backwards. Then, as the combination of a reverse supply drive and the take-up drive emptied the tension looper, the supply would have to reverse itself and begin to run forward.

Instead, by the end of the delay period (0.2 second), the tension arm should be moving towards high tension and the supply will immediately start in the forward direction, attempting to match the take-up and supply velocities by responding to tension arm displacement. The take-up and supply continue to run until the digital closed-loop system is satisfied by a full supply side on the storage looper, or until a film drive ON command is given in either the 9 or 5 subsystem. Any time the bidrive circuit is not supplying power to the motor (either during or between take-up cycles), shunt switches in the circuit are closed to provide dynamic braking of the spool. When the take-up motor is turned OFF, a full supply spool will tend to overshoot the nominal tension state. Because a slightly, below normal tension condition is not harmful, this is an acceptable condition.

If the film drive is turned ON during a take-up cycle, the take-up drive will be disabled and the take-up spool dynamically braked. The supply drive will remain enabled and the brake disengaged for a maximum of 0.5 second

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after the command to allow the system to reach nominal tension. In a similar fashion, when the take-up is stopped due to the supply side of the storage looper being filled, the supply drive remains enabled and the brake coil is energized for up to 1.5 seconds to reach nominal tension. During either period, an approaching full tension looper condition will engage the supply brake to assist the motor in stopping the spool. When the forward velocity of the spool becomes negative (sensed by tension arm rate of movement), the supply torque motor is turned OFF to prevent it from driving against the engaged brake.

As the spool empties, its inertia is reduced and it can be stopped by action of the motor alone. Under this condition, the approaching full encoder position is not reached, and the brake will not enter into the process of decelerating the spool. The supply will reverse until the tension looper returns to the rest position. Power is removed when the FCE delay time is reached.

In terms of film motion, the 5 subsystem primary take-up cycle is similar to the 9 subsystem. However, the 5 subsystem incorporates only one delay timer circuit in the FHE. The small mass of the supply spool (relative to the 9 supply) does not affect the performance of the subsystem to any great extent in the primary take-up mode.

At the beginning of the 5 cycle, the supply brake is released, and the supply and take-up drives enabled. The take-up begins transferring film from the take-up side of the storage looper while the supply side fills at the same rate. The supply is driven in response to the absolute position and rate of change of the tension arm, attempting to maintain nominal tension by matching the supply and take-up rates. Whenever the supply motor is not being driven (either during or between take-up cycles), and power is being provided to the FHE (5 OP), both shunt switches in the motor bidrive are closed, providing dynamic braking of the spool.

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When the take-up cycle is stopped, either by the supply side of the storage looper becoming full or by commanding film drive ON in either subsystem (assuming the carriage is between its empty and full limits), power is removed from the take-up motor and the supply brake is applied. The supply drive remains enabled for an additional 0.1 second to assist in stopping the supply and adjusting film tension. Even though it is not energized, the brake is not engaged during the initial part of this period due to the time constant of the holding coil and the mechanical behavior of the assembly. The brake will be fully engaged approximately 70 milliseconds after power has been turned OFF.

The backup mode of operation for the 5 take-up cycle depends solely on the take-up drive to move film throughout the subsystem. The backup mode is actuated whenever the storage looper supply side becomes electrically empty. The take-up drive turns ON and begins transferring film from the take-up side of the looper to the take-up spool, as in the primary mode. However, since the supply drive is not enabled, the take-up drive must pull film from the supply to refill the looper while the supply brake is used to control film tension as much as possible. The brake coil is energized (brake released) whenever the tension arm encoder has not exceeded the tension arm APPROACHING FULL switching point. The brake is engaged as necessary during the cycle to slow the supply and to prevent an excess of film from being released into the 5 subsystem. The take-up drive is stopped and the supply brake is engaged when the storage looper has been refilled. Throughout the cycle, the shunt circuit in the supply bidrive is enabled, providing dynamic braking of the supply to aid in limiting supply spool acceleration rates.

Even though the subsystem is operating in the backup mode, a high-tension condition during the cycle (tension looper electrically empty) will cause the primary mode brake-release coil to be energized with a consequent

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increase in the total supply-brake current as monitored by the 5 supply-brake current instrumentation sensor.

The ON/OFF characteristic of the supply brake in the backup mode creates large tension excursions during the take-up cycle, introducing perturbations into the film handling subsystem and degrading any photographic activity that may be taking place. For this reason, it is generally desirable to command a TAKE-UP ENABLE before the looper reaches its empty state, allowing all take-up operations to be performed in the primary mode.

2.5 9 x 5 Dual Platen Camera and Film Handling Subsystem Electronic Control Units

Six electronic units are directly linked to the 9 x 5 camera and film handling subsystem; the two frequency phase lock loop electronics boxes (9 and 5), the two camera electronics assemblies (9 and 5), the film control electronics (9), and the film handling electronics (5). Each interfaces with components of the subsystem and with other control units of the PPS/DP EAC including the command processor, the power monitor and control unit, and the instrumentation processor. Although it is not discussed here, the initiator electronics unit is also involved with the film handling subsystem as it controls all pyrotechnic functions in the PPS/DP EAC and contains the circuitry which switches the take-up control power from T/U 1 to T/U 2.

2.5.1 Film Control Electronics

The film control electronics, also known as the record control electronics (RCE), directs all functions related to handling of the 9.5-inch film between supply and take-up, exclusive of the platen drive. As such, it consists of power switches for the supply motor, the take-up motor, and the

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supply brake, a logic circuit to provide film handling control, and circuitry for instrumentation outputs. The FCE is part of a closed-loop control system in which the supply and take-up motors and supply brake are operated in response to feedback signals from the tension arm position transducers and the looper carriage position encoders.

The unit is powered through the 9 operational power switch in the power monitor and control unit and receives commands from the command processor. Instrumentation outputs are directed to the instrumentation processor.

2.5.1.1 Film Control Electronics Unit. The FCE unit is mounted on the +Y side of the film supply enclosure in the supply electronics module (reference Part 3, Section 1). The unit is approximately 12" x 4.5" x 7", excluding mounting feet, and weighs approximately 9 pounds. Electrical interfaces with other PPS/DP EAC components occur through one 32-pin connector and one 61-pin connector.

2.5.1.2 FCE Logic Operation. Figure 3.2-38 is a logic diagram for the film control electronics. In addition to operational power and instrumentation power, the FCE receives input signals and generates output control signals as described below.

2.5.1.2.1 FCE Logic Inputs. The FCE accepts the following feedback signals from the film handling subsystem, and commands from the CP:

- (1) Storage looper Supply Side Full and Supply Side Empty signals which are generated by separate mechanical encoders in the looper assembly, each of which provide redundant output signals.

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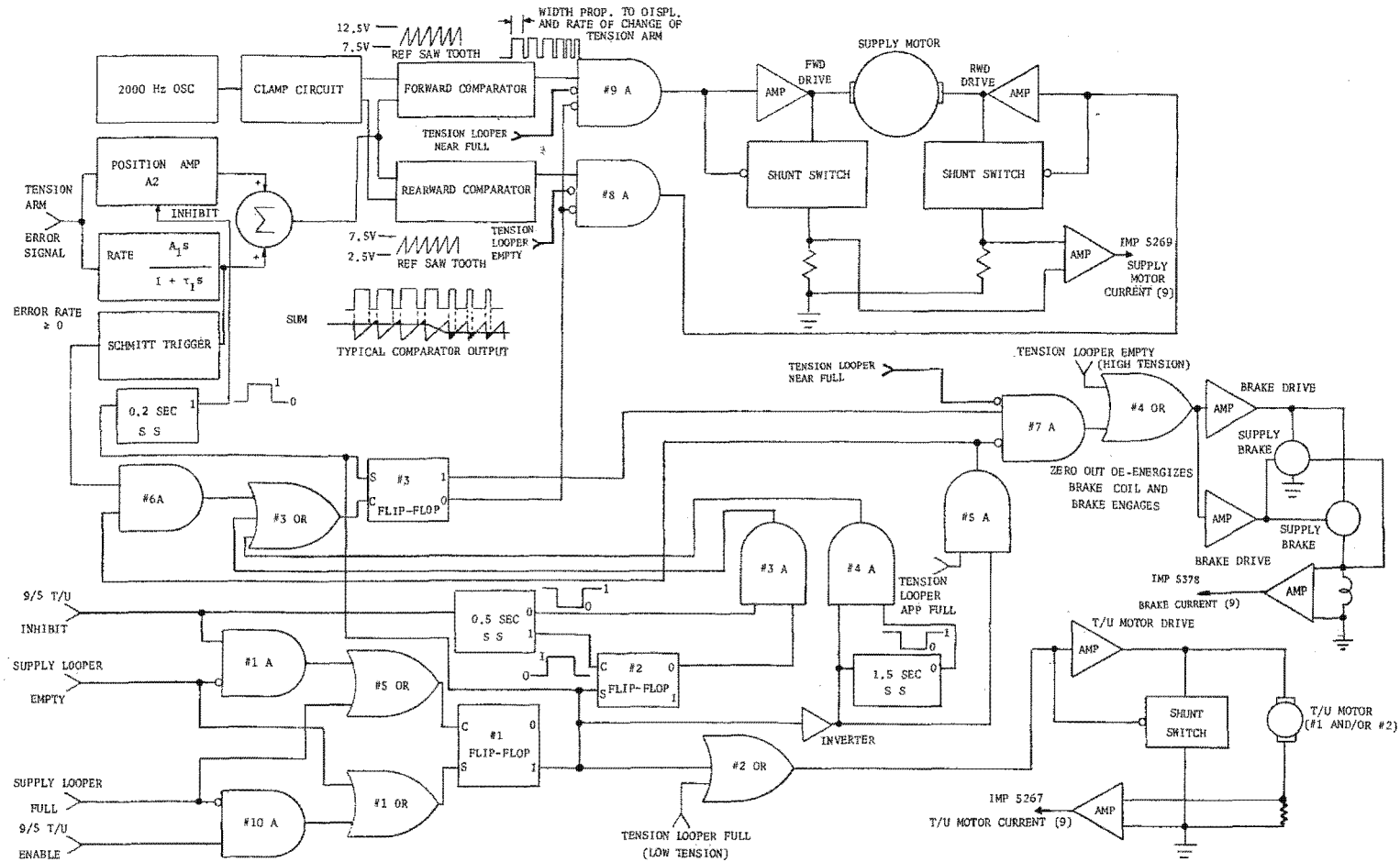


Figure 3.2-38. Film Control Electronics Logic Diagram

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- (2) Tension Looper Empty, Tension Looper Near Full, Tension Looper Approaching Full, and Tension Looper Full signals that are generated by a multi-track mechanical encoder geared to the tension arm, producing redundant outputs for each signal;
- (3) An analog Tension Arm Error (displacement) signal generated by a potentiometer geared to the tension arm;
- (4) 9/5 TAKE-UP ENABLE and 9/5 TAKE-UP INHIBIT (implicit with 14V WORD execution) commands that are sent directly from the command processor.

2.5.1.2.2 FCE Logic Outputs. The logic output descriptions which follow are referenced to the logic diagram of Figure 3.2-38.

- (1) 9 Take-up ON* - 9 take-up motor power is supplied whenever:
 - a. A storage looper Supply Side Empty signal is received;
 - b. A 9/5 TAKE-UP ENABLE command is received and the looper supply side is not full (assuming a 9/5 TAKE-UP INHIBIT command was executed sometime following the previous 9/5 TAKE-UP ENABLE);
 - c. 9 operational power is commanded ON from an OFF state and the supply side of the looper is not full;
 - d. A Tension Looper Full (low tension) signal is received;
- (2) 9 Take-up OFF - 9 take-up motor power is removed whenever:
 - a. A storage looper Supply Side Full signal is received;
 - b. A 9/5 TAKE-UP INHIBIT command is received and the Supply Side Empty signal is not present;
 - c. The tension looper has returned to an acceptable range (only if the take-up was turned ON by a Tension Looper Full signal).

*The 9 take-up will turn on briefly, jogging the film, whenever 9 OP is turned ON either by a 9 OP ON command or a redundant 9 OP OFF command (reference Part 3, Section 7). If the take-up side of the looper is not electrically empty, commanding 9 OP ON will initiate a take-up cycle just as if a TAKE-UP ENABLE command was given.

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- (3) 9 Supply Power ON - Power is provided to the supply motor bi-drive circuit at either of the following times:
- a. 0.2 second after a storage looper Supply Side Empty signal is received;
 - b. 0.2 second after a 9/5 TAKE-UP ENABLE command is received, providing the looper supply side is not already full.
- (4) 9 Supply Power OFF - Power is removed from the supply drive under any of the following conditions:
- a. 0.5 second after a 9/5 Take-up Inhibit signal, provided the Supply Side Empty signal is not present, or,
 - b. 1.5 seconds after 9 take-up power is turned OFF by a Supply Side Full signal, or,
 - c. whenever the 9 take-up drive is OFF, a Tension Looper Approaching Full signal is received, and the velocity of the tension arm is less than or equal to zero (i.e., the supply is beginning to turn rearward).
 - d. whenever a Tension Looper Near Full signal is received, the forward supply motor drive is disabled.
 - e. whenever a Tension Looper Empty signal is received, the rearward supply motor drive is disabled.
- (5) 9 Supply Brake Released - The 9 supply brake is normally engaged. The brake release coil is energized only when:
- a. a Tension Looper Empty signal is received, or,
 - b. the 9 supply motor is enabled (except for case 4c. where the supply drive remains enabled for a short time after the take-up is OFF and a Tension Looper Approaching Full signal is received during that period, applying the brake).

2.5.1.3 Supply Motor Bidrive Control. Operation of the supply motor drive is a relatively complicated process which requires a rigorous explanation for clarity, beginning with the tension arm error signal processing circuitry.

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The Tension Arm Error signal, an analog voltage proportional to tension arm position, is used by the FCE to produce a relative Tension Arm Displacement signal and an Arm Velocity (rate) signal. These two are then applied to an analog-to-pulse-width converter consisting of a summer amplifier, sawtooth generator, clamping circuit, and two differential comparators generating the forward and reverse supply drive (refer to Figure 3.2-38).

The sawtooth-generator wave train is applied to the clamping circuit, producing two sawtooth outputs; one clamped above 7.5 volts, and one clamped below 7.5 volts. Each is then applied to a separate differential comparator.

The summer amplifier combines the Tension Arm Displacement and Arm Velocity signals, producing a combined error signal relative to a 7.5-volt (zero error) level. The summer amplifier output is applied to the complementary inputs of both differential comparators.

A pulse output of the forward comparator is developed for the duration of time that the summer amplifier output exceeds the upper-clamped sawtooth. Similarly, the rearward comparator produces a pulse for the duration of time the summer output is less than the low-clamped sawtooth (see Figure 3.2-39). The pulse width produced is proportional to the error signal level; i.e., proportional to the displacement and rate of change of the tension arm. The output of each comparator is applied to its respective forward or rearward drive circuit and thus the supply motor responds to forward or rearward pulses whose average value determines the power applied to the motor.

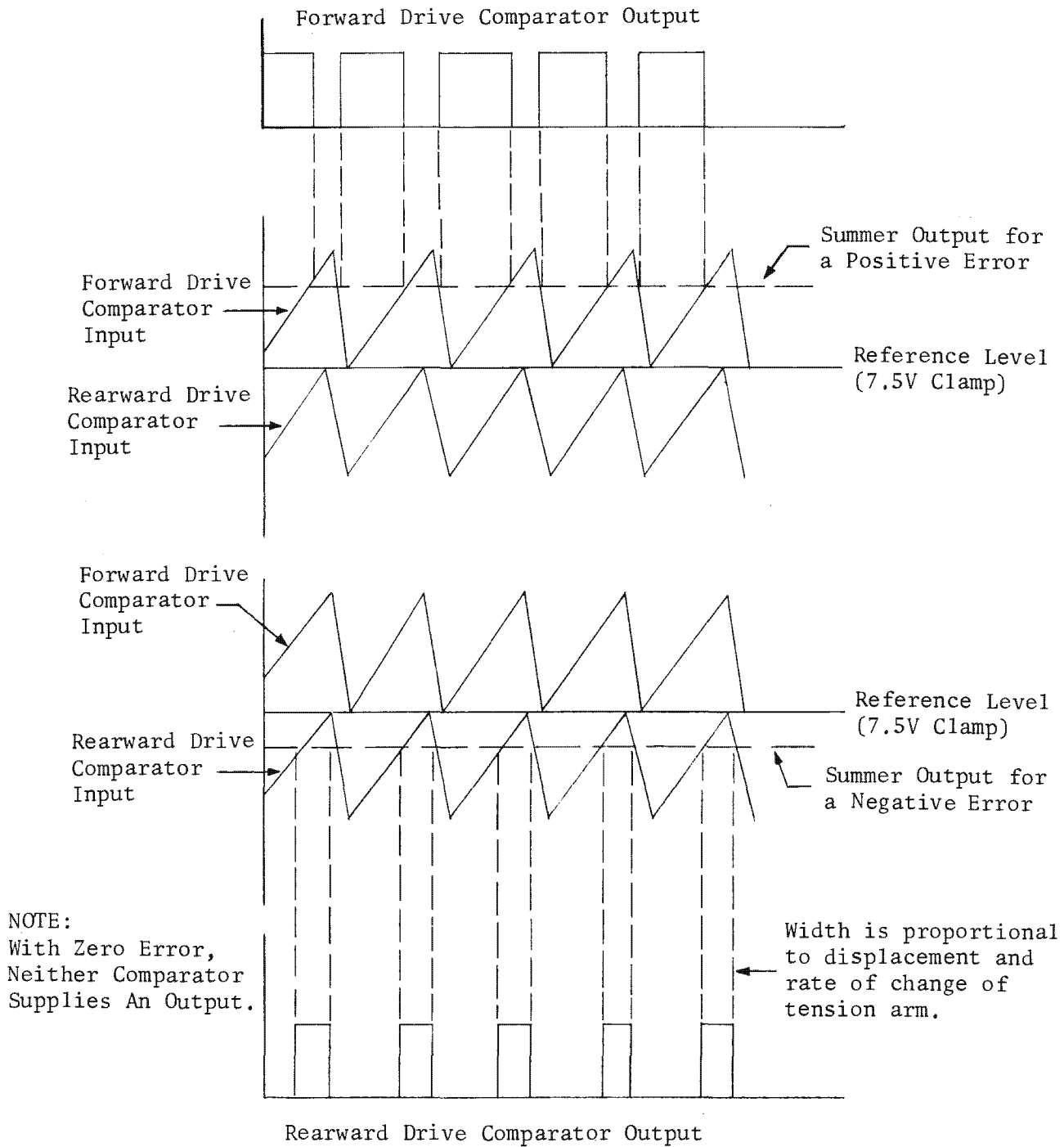
To aid in stopping the high inertia of the 9 supply spool, the bidrive circuit shunt transistor switches are both ON (switches closed) when neither forward nor rearward drive power is applied. The motor is dynamically braked during this period, acting as a generator supplying power to the switch load. Rearward power will be applied during the stopping phase whenever the combined error signal so dictates.

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NOTE:
With Zero Error,
Neither Comparator
Supplies An Output.

Width is proportional
to displacement and
rate of change of
tension arm.

Figure 3.2-39. Clamp Circuit and Comparator Operation

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Early in a mission, while the supply spool is still relatively full, the supply brake may be needed to assist in stopping the spool after a take-up cycle. The brake will be applied if the tension looper near full position is encountered. A Schmitt trigger monitors the Tension Arm Error Rate signal and fires when it detects a positive rate (arm velocity is less than or equal to zero (looper emptying)). This signal is used by the control electronics to remove power from the supply motor if the take-up is OFF and a Tension Looper Approaching Full signal has been received.

When beginning a take-up cycle, the displacement portion of the error signal is inhibited for 0.2 second. This is done in case the residual tension arm position from the previous cycle indicates a low-tension condition; in which instance the supply motor would try to remove film from the looper to restore tension while the take-up is removing film from the storage looper take-up side, resulting in a sudden high-tension condition. By blocking the supply drive circuit for 0.2 second, film tension can be increased smoothly by the T/U alone. Figure 3.2-40 illustrates this under the worst-case condition of a large supply load.

2.5.1.4 FCE Instrumentation. The FCE monitors take-up motor and supply motor currents (IMPs 5267 and 5269 respectively) as well as brake current (IMP 5378) using dropping resistors in the power return lines. The signals are amplified to levels compatible with Digital Telemetry Unit (DTU) input requirements and transmitted to the DTU through the instrumentation processor.

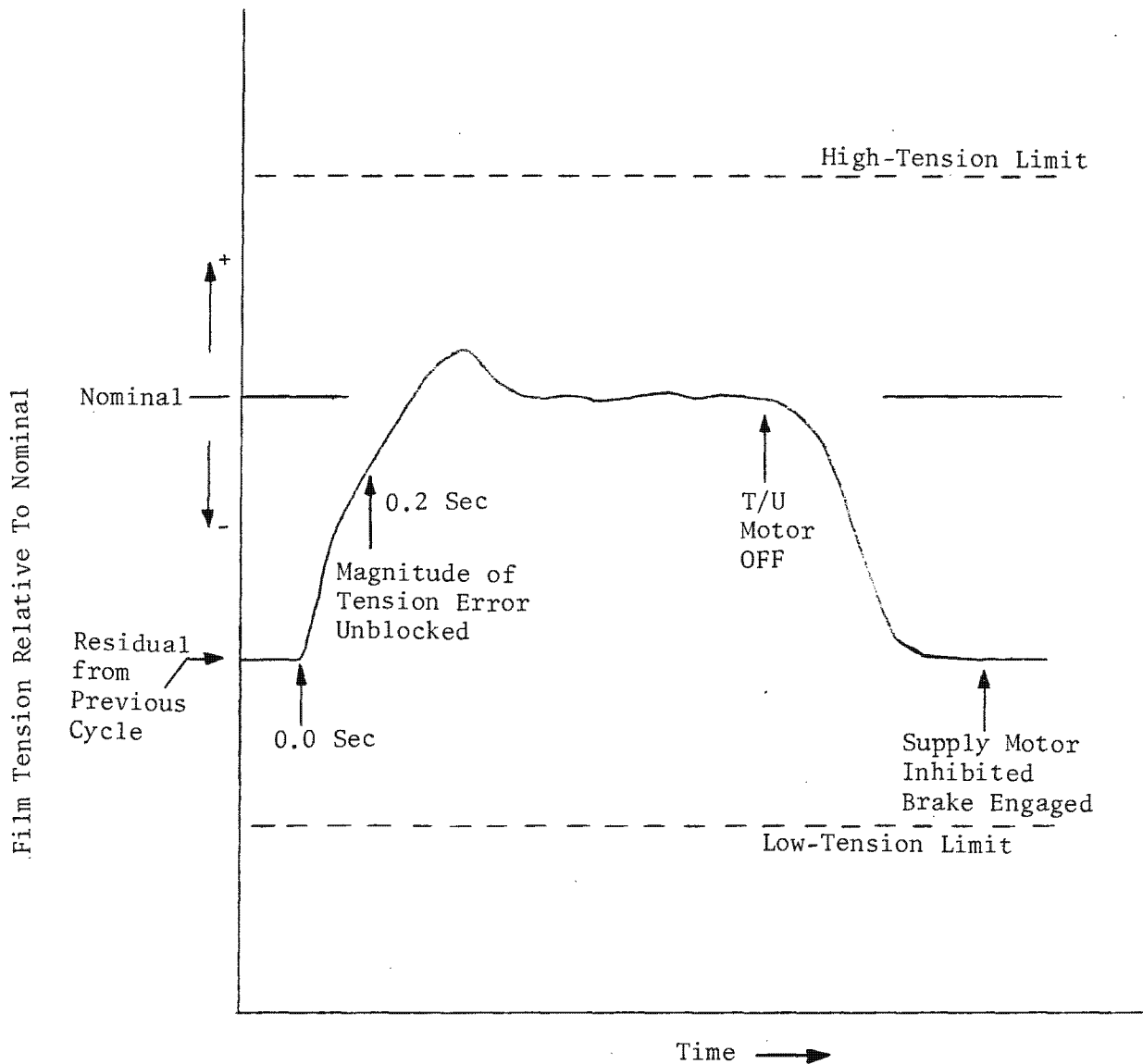
2.5.2 Film Handling Electronics

The film handling electronics, also known as the record handling electronics (RHE), is the counterpart in the 5 film handling subsystem to the film control electronics of the 9 film handling subsystem. The FHE is an integral

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(Typical Tension Under Large Supply Loads)

Figure 3.2-40. Film Tension vs Elapsed Time

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part of the 5 subsystem, operating the 5 take-up and supply motors and the 5 brake, in response to feedback signals from the 5 looper carriage position encoder and 5 tension arm encoder and potentiometer, and in response to vehicle commands.

In addition to film handling components, the FHE interfaces electrically with the power monitor and control unit, the command processor, the instrumentation processor, and the initiator electronics unit. Application of 5 operational power, switched in the PM and C, energizes all circuits within the FHE, exclusive of instrumentation circuitry, and prepares the unit to operate in conjunction with the balance of the 5 subsystem components. Instrumentation power is supplied whenever either digital telemetry unit is commanded ON.

2.5.2.1 Film Handling Electronics Unit. The FHE is located in the supply electronics module on the +Y side of the film supply enclosure (reference Part 3, Section 1). The unit measures approximately 12" x 4.3" x 7", excluding mounting feet, and weighs slightly less than 10.5 pounds. A 32-pin connector and a 61-pin connector constitute the electrical interface with other PPS/DP EAC components.

2.5.2.2 FHE Logic Operation. Figure 3.2-41 is a simplified logic diagram for the film handling electronics. The FHE contains logic circuitry for two modes of operation. In the primary mode, the supply drive functions as the major means for proper maintenance of film tension. In the backup mode, the supply drive is not powered, and film tension is controlled through the supply brake, tension arm, and take-up motor interaction. The logic input signals, and the control signals generated, are described below.

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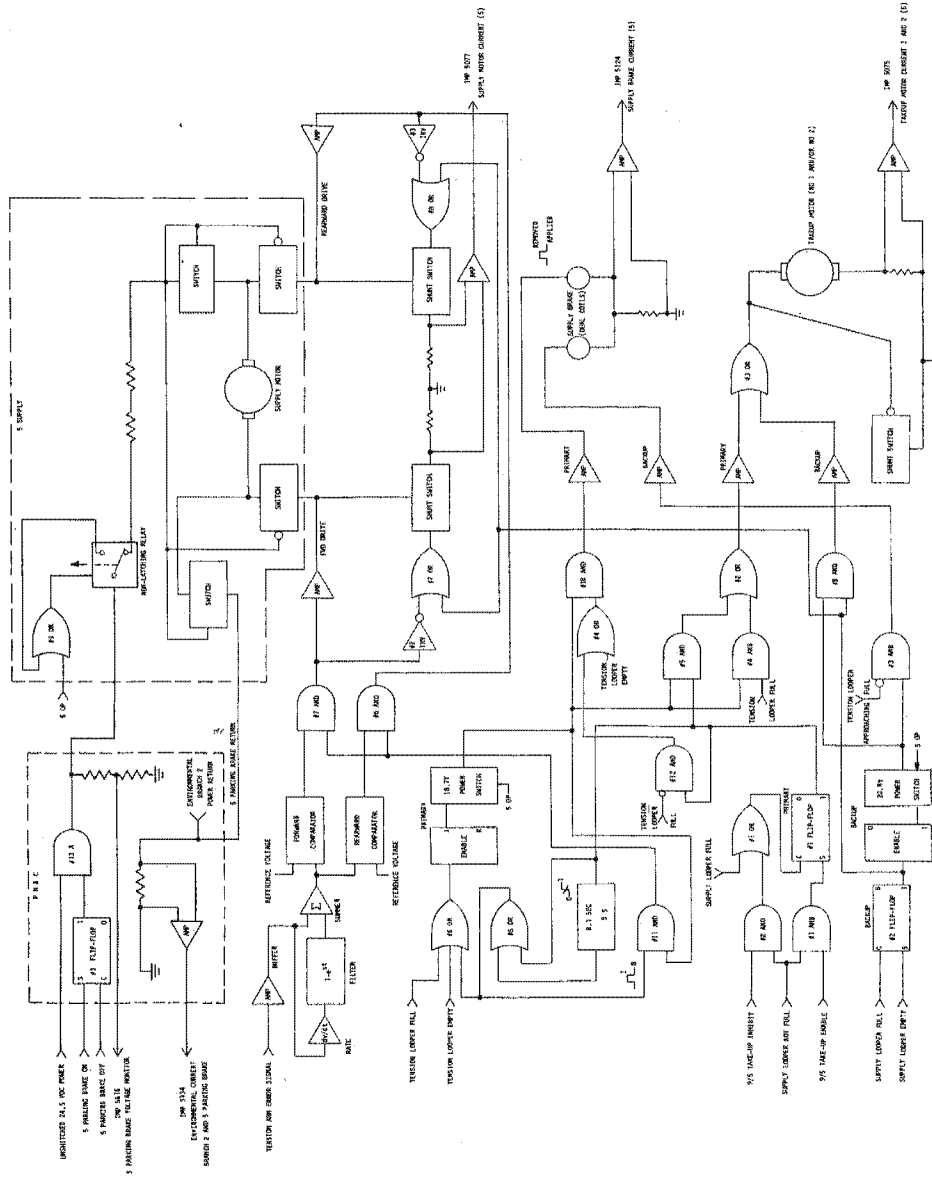


Figure 3.2-41. 5 Film Handling Subsystem Logic Diagram

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2.5.2.2.1 FHE Logic Input Signals. The FHE receives the following feedback signals from the film handling subsystem and commands from the CP:

- (1) Storage looper Supply Side Full and Supply Side Empty signals which are generated by a multi-track mechanical encoder on the 5 looper assembly (redundant outputs are provided for Supply Side Full and Supply Side Empty signals in the primary mode and a separate pair of redundant outputs for a Supply Side Full signal in the backup mode);
- (2) Tension Looper Empty, Tension Looper Approaching Full, and Tension Looper Full signals provided by a dual (redundant) channel mechanical encoder geared to the 5 tension arm;
- (3) An analog Tension Arm Error (displacement) signal from a potentiometer geared to the tension arm;
- (4) 9/5 TAKE-UP ENABLE and 9/5 TAKE-UP INHIBIT (implicit with 14V WORD execution) commands from the command processor.

2.5.2.2.2 FHE Logic Outputs. The explanations which follow are referenced to the logic diagram of Figure 3.2-41.

- (1) Take-up ON - 5 take-up motor power is supplied whenever:
 - a. A 9/5 TAKE-UP ENABLE command is received and a Supply Side Full signal is not present* (the looper carriage is between the empty and full states);
 - b. 5 operational power is commanded ON from an OFF state and the supply side of the looper is not full;
 - c. A storage looper Supply Side Empty signal is received, causing a switchover to the backup mode of operation;
 - d. A Tension Looper Full (low tension) signal is received.

*9/5 TAKE-UP ENABLE will not be executed unless a 9/5 TAKE-UP INHIBIT command has been executed following the last 9/5 TAKE-UP ENABLE.

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- (2) 5 Take-up OFF - 5 take-up motor power is removed whenever:
- a storage looper Supply Side Full signal is present;
 - a 9/5 TAKE-UP INHIBIT command is received (14V WORD), and a Supply Side Empty signal is not present;
 - the Tension Looper Full signal is removed (only if the take-up drive was initiated by a Tension Looper Full signal).
- (3) 5 Supply Power ON* - Power is supplied to the 5 supply motor bidrive circuit (which controls the actual supply drive in response to tension arm feedback signals) under the following condition:
- 9/5 TAKE-UP ENABLE is commanded and neither the storage looper Supply Side Full nor Supply Side Empty signals are present.
- (4) 5 Supply power OFF - The 5 supply bidrive circuit power is removed as follows:
- 0.1 second after a 9/5 TAKE-UP INHIBIT command (14V WORD) is received, or,
 - 0.1 second after the 5 take-up drive is turned OFF by a Supply Side Full signal.
- (5) 5 Supply Brake Released - The supply brake is normally engaged. The brake release coil is energized whenever:
- a Tension Looper Empty signal is present;
 - the supply motor bidrive is enabled, except during the 0.1 second delay prior to turning the supply bidrive power OFF (see 4a and 4b above);

*The 5 supply will turn briefly, jogging the film, whenever 5 operational power turns on, whether due to a 5 OP ON command, or a redundant 5 OP OFF command (reference Part 3, Section 7).

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Note: Even though the brake coil is not energized during the delayed turn-off period, the brake is not fully engaged due to the time constant of the coil until approximately 70 milliseconds into the delay period.

- c. a take-up cycle is being performed in the backup mode and the Tension Looper Approaching Full signal is not present.

2.5.2.3 FHE Tension Arm Error Feedback Signal Processing and Dynamic Braking Control. In the primary mode of operation, the FHE continually processes the analog Tension Arm Error feedback signal and drives the supply based on the result obtained. Whenever neither forward nor rearward drive power is being applied, both transistor shunt switches are closed, dynamically braking the motor. Similarly, the take-up spool will also be dynamically braked whenever it is not being driven.

Predictable characteristics for the take-up drive have been obtained by using regulated power for the drive circuit. Two voltage regulators in the FHE provide power to the take-up motor and also to the supply brake. The primary mode regulator is turned ON whenever a 9/5 TAKE-UP ENABLE command is received, or the Tension Arm Full or Tension Arm Empty signal is present, providing 18.7 volts to the brake and take-up circuits. The backup mode regulator is turned ON by a Looper Supply Side Empty signal and turned OFF by a Looper Supply Side Full signal. When ON, the regulator produces a 20.4-volt output which, due to drops in the FHE circuitry, is reduced to near 18.7 volts at the take-up spool motor.

2.5.2.3.1 FHE Film Tension Arm Error Signal Processing. The 5 Tension Arm Error signal processing is similar to that used by the FCE for 9 Tension Arm Error signal, and will not be discussed in detail here. The initial portion of the circuitry is virtually identical to the FCE; the Tension Arm Error signal is used to generate a relative Tension Arm Displacement signal and an Arm Velocity (rate) signal which are summed to produce a single error value

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for the forward and rearward drive comparators. Here the similarity ends. Rather than employing a sawtooth-wave train as the comparator reference, the error signal is compared to different dc voltages at the forward and rearward comparators. If the voltage output from the summer amplifier lies between the reference voltages, no drive is applied to the supply motor. If the summer amplifier voltage falls outside the rearward or forward limit, the supply is driven in that direction to bring the error back within the reference limits.

2.5.2.4 FHE Instrumentation Output. The instrumentation signals representing take-up motor current, supply motor current, and supply brake current (IMPs 5075, 5077, and 5124 respectively) are produced in the FHE using resistors to monitor current in the power return lines. The signals generated are amplified to levels compatible with DTU input requirements, and transmitted to the DTU through the instrumentation processor.

Also located in the FHE are the processing circuits for the film tension, film quantity, and looper position instrumentation points. The output signals, as generated, require no further processing and are sent directly to the instrumentation processor for output to the DTU.

2.5.2.5 5 Parking Brake. The 5 parking brake circuitry, although not contained in the FHE, is shown in the logic diagram (Figure 3.2-41) due to its presence in the 5 film handling subsystem. Essentially, the parking brake supplies a small reverse current to the supply motor to assist the mechanical brake in preventing spool rotation during launch. The parking brake is inhibited by commanding 5 OP ON, and, if the parking-brake power is ON when 5 operational power is removed, the brake circuitry will not be re-enabled until 5 PARKING BRAKE OFF is commanded. Otherwise, the function is enabled whenever 5 OP is OFF, and the parking brake power can be turned ON at anytime.

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2.5.3 9 and 5 Frequency Phase Lock Loop Electronics

Operation of the 9 and 5 platen drives is controlled by the 9 and 5 FPLLE units, respectively. As the block diagram of Figure 3.2-42 shows, each FPLLE consists of two redundant sides (A and B) with each side receiving a separate feedback signal and controlling a separate motor coil. Internally the 9 and 5 units are identical except for a gain control resistor which reduces the gain in the 5 subsystem to compensate for the lower platen inertia.

Redundancy is preserved throughout the entire subsystem. The power monitor and control unit supplies operational power to each FPLLE on four pairs of wires via the same switches that provide FCE and FHE power. The lines are fused individually on each side in the FPLLE module. Separate power switches are provided for the two channels, A and B, of the command processor output, with the output of the two 9 OP and 5 OP switches paralleled inside the PM and C (refer to the PM and C logic diagram in Part 3, Section 7).

The command processor supplies separate ON/OFF commands directly to each side of the FPLLE for both the 9 and 5 units. Since the CP also controls the PM and C power switches, a redundant method of shutdown is obtained which prevents a catastrophic failure in one FPLLE from affecting operation of the other. The CP also supplies a separate (electrically isolated) ten-bit drive speed command (14V WORD) to each side of each FPLLE. However, processing of the film-drive speed command in the CP is performed in such a manner that the two subsystems cannot operate simultaneously at differing speeds, although either side of one FPLLE can be operated simultaneously with either side of the other FPLLE.

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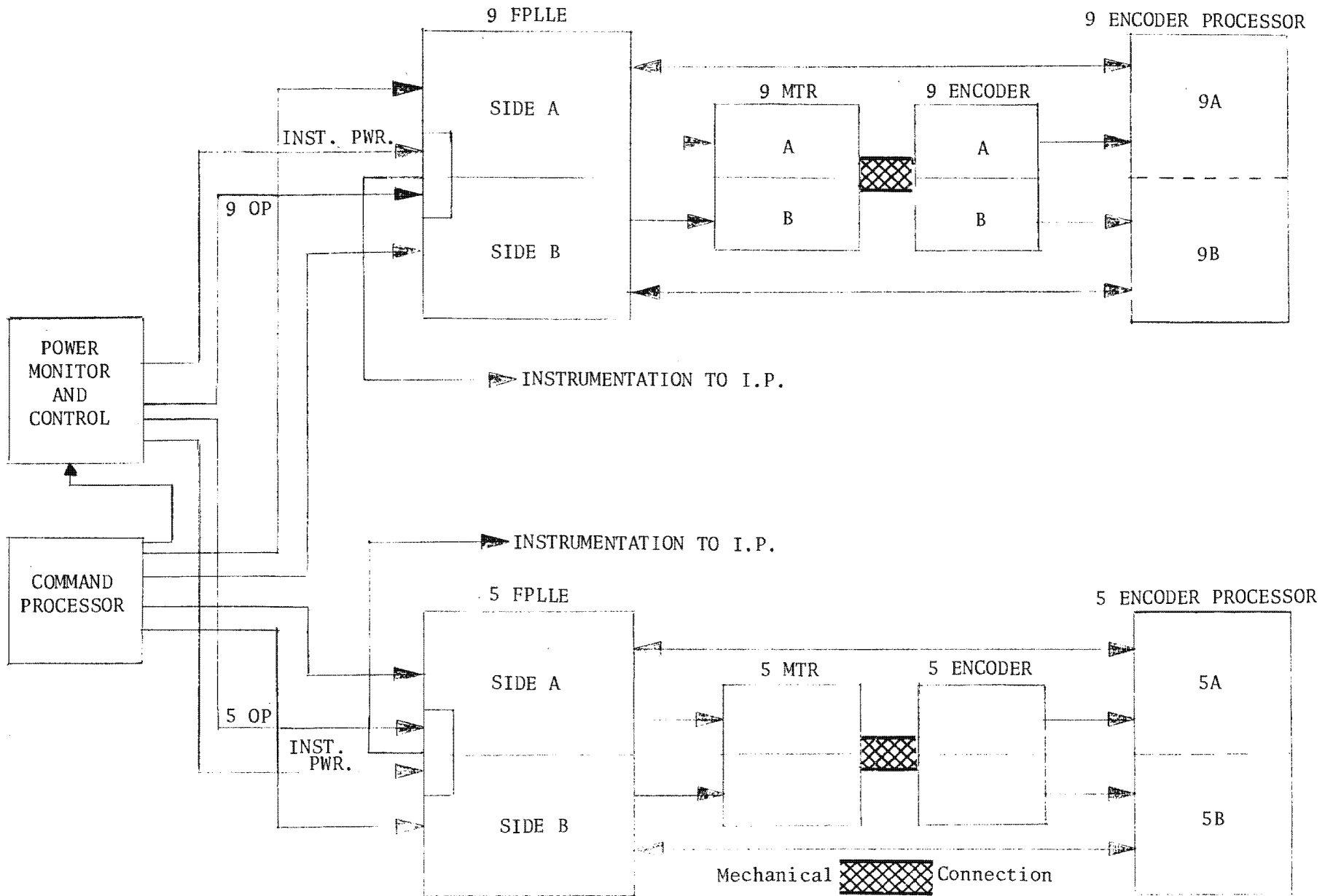


Figure 3.2-42. FPLLE Subsystem Block Diagram

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The 9/5 RUNOUT command combines the functions of the 9/5 OP ON commands and the 9/5 film drive ON command, selecting the normal speed range for the FPLLE (see 2.5.3.2 below) and setting the two most significant bits of the film-drive speed to "1". The remaining eight bits are unchanged from the last executed state.

2.5.3.1 FPLLE Mechanical Description. The Frequency Phase Lock Loop Electronics (either 9 or 5) consists of an aluminum base plate with two identical stacks of six boards. The base plate assembly contains the high power transistors used for the motor drive, logic power regulators, and power switches. The four boards mounted on the base plate are aluminum, and contain the medium power circuitry. The remaining boards are printed circuits which contain the low-level digital and analog components. The two stacks represent sides A and B of the FPLLE, and are interconnected only at the power sources, and at the current and loop error instrumentation summing circuitry described in Subsection 2.5.3.4. A plastic dust cover protects both stacks.

The two FPLLE units (both of which are mounted on the -Y side of the film supply enclosure) are each approximately 10" x 12" x 6" and weigh about 16 pounds. Electrical connectors J1 through J4 carry the power and control signals between the FPLLE and the PPS/DP EAC. A fifth connector (J5) carries only test signals and is not used on-orbit.

2.5.3.2 FPLLE Operation. The film-drive system operates in four speed ranges:

| | |
|------------------|------------------------------------|
| Normal: | 3.37 - 11.8 inches/second |
| Normal | <input type="text"/> inches/second |
| Normal ÷ 4 (EAC) | 0.84 - 2.95 inches/second |
| (Normal ÷ 4) x 2 | 1.68 - 5.9 inches/second |

25X1

The EAC range provides the speeds for high-orbit photography. Each range is divided into 1023 linear steps (1024 discrete speeds) represented by the ten-bit film-drive speed command. The following equations represent the

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film-drive speed in inches per second as a function of commanded film-drive speed step $N(0 \leq N \leq 1023)$:

$$(1) \text{ FDS}_{\text{normal}} = 3.37 + \frac{N(11.8 - 3.37)}{1023}$$

(2)

$$(3) \text{ FDS}_{\text{EAC}} = 0.84 + \frac{N(2.95 - 0.84)}{1023}$$

$$(4) \text{ FDS}_{\text{EAC} \times 2} = 1.68 + \frac{N(5.9 - 1.68)}{1023}$$

At the time of film drive "ON" command execution, power is applied to the control electronics (assuming operation power is "ON" in the commanded subsystem) and a nominal 150-millisecond delay follows for internal logic synchronization. Power is then applied to the platen drive motor and the starting circuit accelerates the motor until a frequency match is obtained between the FPLLE reference and the optical encoder feedback signal (system is in lock). This occurs within 150 milliseconds as the design goal for speeds greater than 11.8 inches per second. Once in lock, the phase loop detector is enabled, and the high-resolution portion of a photographic cycle begins.

The detector attempts to maintain a constant phase difference between the reference signal and the encoder output; i.e., a constant platen velocity, by varying FPLLE motor current as a function of the phase difference.

At the film drive "OFF" command, the FPLLE provides two stages of braking current to the motor, switching to the low braking torque when the platen rate falls below 2 ips (0.5 ips for EAC and EAC x 2), and then coasting when the speed falls below 0.5 ips (0.1 ips for EAC and EAC x 2) until power is off. Power is removed 150 milliseconds after command receipt. Part 2, Section 10 provides a detailed

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description of the film start-up and stop transients during a photographic cycle. These transients must be taken into account when determining individual frame lengths from the total camera ON time and the commanded film-drive speed.

2.5.3.3 FPLLE Electrical Design. The following describes a single frequency phase lock loop electronics module. Since the 9 and 5 modules are essentially alike, the information will apply equally to either.

The FPLLE consists of two identical halves isolated from each other except for the common power and command input connectors and the instrumentation circuitry. Upon command, each side delivers power to its associated motor, encoder, and channel of the encoder processor. The two channels (one for each encoder side) contained in each encoder signal processor are electrically isolated. The output of each encoder side is amplified and squared in the processor and fed back to the FPLLE to complete the servo loop as shown in Figure 3.2-42. In the EAC speed range, the output of the encoder is frequency multiplied by four by the processor electronics.

The block diagram of Figure 3.2-43 represents one channel of a FPLLE unit. The associated motor, encoder, and encoder processor are included to close the feedback loop. Each block is described more fully in the following sections to illustrate the operation of the phase lock loop circuitry.

2.5.3.3.1 ON/OFF Control Circuit. The ON/OFF control circuit monitors ON/OFF command status, and, through use of separate logic and series switches, controls the 24.5-volt main power input (operational power) and the logic and operational amplifier supplies (+5 volts and +6/+12 volts respectively). The switches are separate so that a single-failure mode cannot prevent selection of the alternate FPLLE system. In addition, logic level signals are provided to the start and brake circuits to control their operations.

2.5.3.3.2 Power Supplies. This block represents the integrated circuit regulators that provide power to the logic and the operational amplifiers, and switched 24.5-volt power to the power amplifier.

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2.5.3.3.3 Crystal Oscillator and Divider. The crystal oscillator provides the basic clock frequency for the system. The frequency divider allows oscillator operation at a reasonable frequency (≈ 110 KHz) while providing a low frequency (≈ 430 Hz) signal to the reference generator phase detector.

2.5.3.3.4 Reference Generator Phase Detector. The phase detector, summing amplifier, filter, voltage controlled multivibrator (VCM) and programmable counter form a frequency phase lock loop frequency synthesizer. The phase detector compares frequency and phase of the programmable counter output (reference 2.5.3.3.8) with the divided crystal output. The resulting outputs are pulses of fixed amplitude at the divided crystal oscillator frequency. Pulse widths appearing on either the up or down detector output lines represent deviation from perfect frequency/phase match.

2.5.3.3.5 Reference Summing Amplifier. The reference summing amplifier accepts the separate up/down phase detector outputs and combines them into a single dc signal with positive and negative pulses representing reference generator loop error.

2.5.3.3.6 Filter. The filter consists of two sections; the first for loop compensation and the second to eliminate high frequency noise. The output is an error signal between 9 and 12 volts which controls the multivibrator frequency.

2.5.3.3.7 Voltage Controlled Multivibrator. The multivibrator delivers a square wave output at a frequency demanded by the filtered error signal. The range is 3.5:1 with a maximum output frequency of ≈ 618 KHz.

2.5.3.3.8 Programmable Counter. The programmable counter output delivered to the reference generator phase detector is the VCM output frequency divided by a variable (409 to 1432) representing the commanded drive speed. Frequency/

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phase comparison with the divided crystal oscillator frequency results in an error signal that, when summed and filtered, forces the VCM to run at a multiple of the divided oscillator frequency. This system results in a linear variation in reference signal frequency with command while maintaining the stable characteristics of a crystal oscillator.

2.5.3.3.9 Divider. The divider is a ripple counter which reduces the VCM output frequency by 64 to obtain the proper range for comparison with the encoder signal.

2.5.3.3.10 Phase Detector. The motor-drive loop phase detector is similar to that in the reference generator loop. It compares the frequency/phase of the encoder feedback signal, with the reference generator signal, which represents commanded speed. Pulses representing deviation from perfect phase match are obtained at the up and down outputs.

2.5.3.3.11 Gate. Logic gates are included in both the up and down detector output lines to inhibit the detector output during system startup. This prevents the filter from assuming an incorrect charge and delaying system lock.

2.5.3.3.12 Summing Amplifier Number 1. The motor-drive loop Number 1 summing amplifier is similar to that used in the reference generator. The output is the combined gated-phase detector outputs which consist of positive and negative pulses representing motor-loop directional errors. The summing amplifier output pulse width represents the magnitude of deviation from perfect lock.

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2.5.3.3.13 Filter. The motor-drive loop filter consists of two sections as follows:

- (1) A two-pole low-pass filter that detects the average voltage from summing amplifier Number 1.
- (2) A phase lag network that introduces 12 db of high-frequency attenuation for loop stability when in the EAC speed range. In the normal speed range this section defaults to a unity gain buffer amplifier as a result of a relay contact opening.

The output of the motor-drive loop filter is an error signal between 2 and 10 volts with 6 volts representing zero loop error.

2.5.3.3.14 Delay and Start Circuit. The delay and start circuit contains logic to prevent motor operation for 150 msec while the power supplies and reference generator stabilize after an ON command. Following the initial delay, the start circuit delivers a signal representing a fixed motor acceleration rate to motor-drive loop summing amplifier Number 2. When a frequency match signal is obtained from the phase detector, the forced start signal is removed and the detector gates are enabled.

2.5.3.3.15 Brake Circuit. The brake circuit contains logic which, when triggered by the control circuit, monitors system speed. The brake circuit logic delivers a signal to the Number 2 summing amplifier that forces deceleration in each of two fixed rates dependent on actual system speed by switching to the low braking torque at approximately 2 ips (0.5 ips for EAC) and coasting below 0.5 ips (0.1 ips for EAC). Power is removed after 150 msec.

2.5.3.3.16 Summing Amplifier Number 2. Summing amplifier Number 2 receives the start, stop, and loop error signals, and delivers a composite error signal to the power amplifier to operate the motor. The output is 6 volts at perfect system lock with excursions to 2 and 10 volts representing a demand for full torque in the slower and faster directions respectively.

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2.5.3.3.17 Power Amplifier. The power amplifier is a bridge-type amplifier operated in the current mode. The output characteristic is 0.36 ampere per input volt. The amplifier contains current-limiting circuitry to allow selection of the alternate system in the event of an excessive current overload.

2.5.3.3.18 Motor, Encoder, and Encoder Processor. The three remaining blocks, the motor, encoder, and encoder processor, are not components of the FPLLE module. Each has been described earlier as a part of the 9 x 5 dual platen camera. A brief summary is included here to complete the FPLLE explanation:

- (1) Motor - The motor is a brush-type torque motor having 12.8 ohms resistance and peak torque of 1.2 ft-lbs at 21.2 volts. The motor is installed directly on the drum shaft.
- (2) Encoder - The encoder is an optical type that delivers 9,000 pulses per revolution on two separate output lines that are shifted in phase by 90°.
- (3) Encoder Signal Processor - In the normal speed range the signal processor amplifies and squares one of the encoder quadrature outputs and delivers it through a line driver to the phase detector for comparison to the reference generator output. In the EAC range, the encoder processor frequency multiplies the encoder output frequency by four by firing one shot at each edge of the sine and cosine encoder outputs and performing an "OR" operation on the pulses. The signal is sent to the phase detector through the same line driver. The processor multiplies the encoder frequency by four when a relay contact located inside the FPLLE electronics module is closed.

2.5.3.4 Instrumentation. Two instrumentation points are available from the FPLLE to aid in determining the health of the unit. These two, the current and loop instrumentation points, combine the measurements from each side of the FPLLE, sending a single output to the instrumentation processor for each function.

2.5.3.4.1 FPLLE Current Instrumentation Monitor. The current drawn by sides A and B is continually sensed by a dropping resistor in the return line for each side. The signals are amplified, summed, and delivered to the instrumentation

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processor as a voltage representing total FPLLE current (IMP 5092 for the 9 FPLLE and IMP 5098 for the 5 FPLLE). Since both sides cannot be operated simultaneously (lockout circuitry is in the CP), the instrumentation signal represents the ON-side current drain. Output is on a 600 ma/volt scale with a bandwidth of 100 hertz.

2.5.3.4.2 FPLLE Loop Error Instrumentation Monitor. The loop-error monitor represents phase error, or the relationship between the reference signal and encoder signal supplied to the motor-drive loop phase detector (Figure 3.2-43). The inputs are obtained from the loop filters (side A and side B), summed, and delivered to the instrumentation processor as a voltage representing encoder lag (IMP 5097 for the 9 FPLLE and IMP 5156 for the 5 FPLLE). The instrumentation function has a slope of 16 mv/degree, and a bandwidth of 100 hertz.

2.5.4 9 and 5 Camera Electronics Assemblies

The camera electronics assemblies (CEA), more commonly known as the 9 and 5 drum recorder electronics assemblies (DREA), comprise the electronic control for all the previously described camera hardware, excluding the actual film drive. The 9 and 5 CEA units are functionally identical in every aspect. Therefore, the following sections describing the CEA functions will apply equally to either subsystem.

2.5.4.1 Camera Electronics Assembly Mechanical Description. Each CEA unit (both of which are mounted on the +Y side of the film supply enclosure in the SEM) measures approximately 10" x 12" x 16" and weighs about 20 pounds. Each unit consists of an aluminum base plate with two stacks of circuit boards (11 boards total) protected by a plastic dust cover. The base plate assembly contains the high-power transistors used for the slant range compensation and variable exposure mechanism motor drives and for the SRC power switch. Five of the boards are aluminum and contain medium power circuitry. The four aluminum boards with the most power to dissipate are mounted directly to the base plate. The other six boards are printed circuits which contain low-power digital and analog components. Each board, except A-11 which is half-size, is secured in eight places with the main structural element being the base plate.

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The CEA electrical interface consists of six connectors mounted together on an aluminum plate. Connectors J1 through J5 carry the power and control signals between the CEA and other components of the PPS/DP EAC. Connector J6 is not used during flight since it contains test points only useful during ground testing.

2.5.4.2 Camera Electronics Assembly Operation. As the block diagram in Figure 3.2-44 shows, the CEA controls the focus adjust subsystem (slant range compensation and nominal platen adjustment), the variable exposure mechanism, and the data tracks and interframe marks.

2.5.4.2.1 Slant Range Compensation. Slant range compensation (SRC) is controlled by a closed-loop servo system that provides automatic platen position adjustment as a function of the four most significant film-drive speed command bits. The SRC has 16 equally spaced discrete positions over a 4.5-mil range enabling the system to compensate for film-drive speeds in the normal range of 3.37 ips to 11.8 ips. Step 10 is at factory best focus (or at best focus as adjusted by the NPA subsystem) and Step 1 nominally +0.0027 inch from there (positive reference: toward the Ross Corrector).

Use of the FPLLE extended drive-speed range cannot be correctly compensated for by the SRC system. If the SRC is not disabled by command, it will continue to operate based on the four most significant FDS bits. This operation will not result in proper positioning of the platen. In the mode, the platen must be positioned through the use of the nominal platen adjust system.

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The SRC subsystem will change the platen position at a rate of 4 steps (0.3 mil/step) in 0.20 second. The SRC circuitry is turned ON and OFF in conjunction with the associated film drive ON/OFF command (14V WORD),

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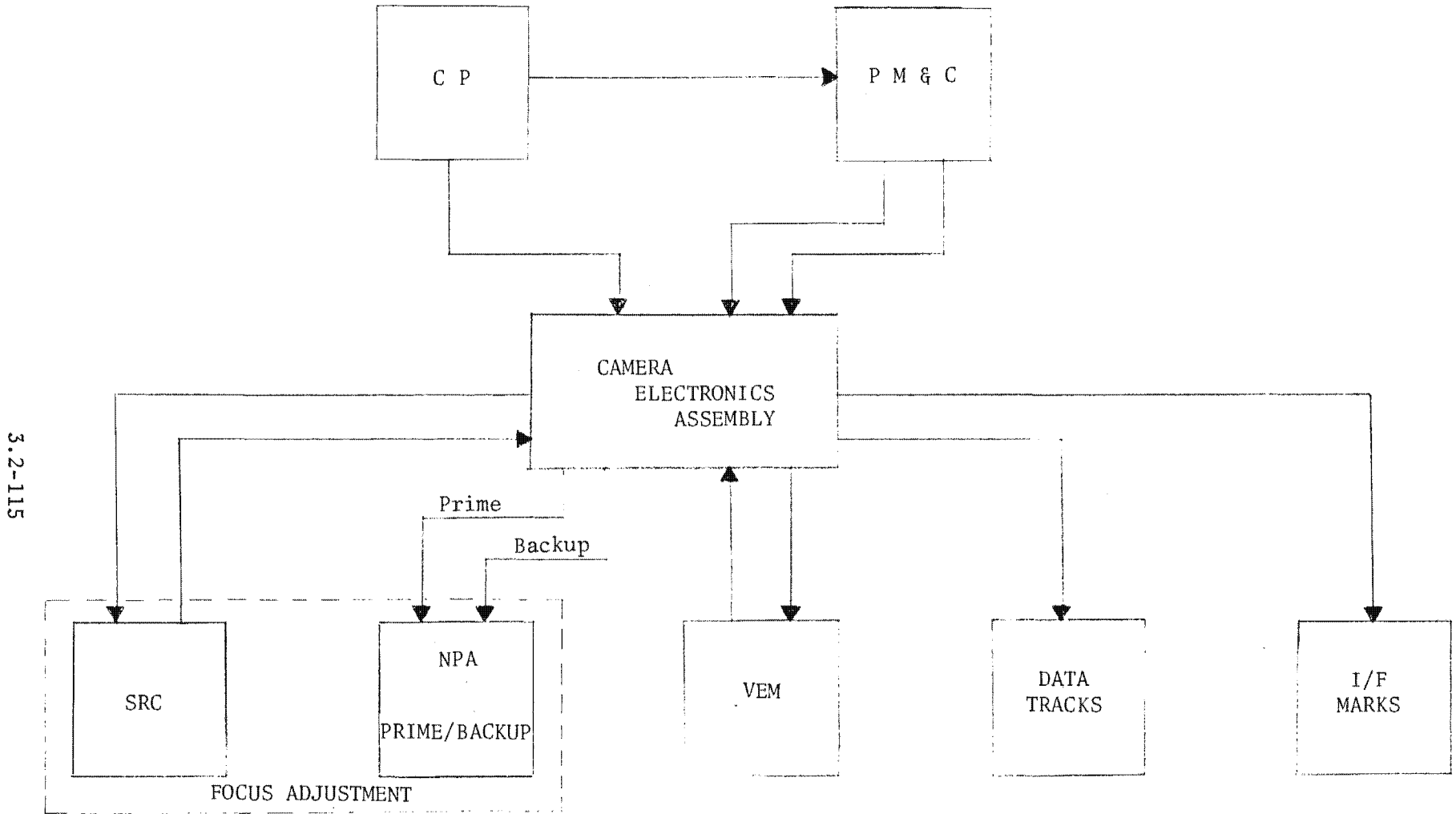


Figure 3.2-44. CEA Subsystem Block Diagram

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and will function whether or not operational power is ON in that subsystem. The SRC can be disabled by command (9 SRC DISABLE and 5 SRC DISABLE), and will not function with the film drive until the disable has been removed by commanding OP ON in the affected subsystem.

The SRC subsystem, shown in Figure 3.2-45, is a closed-loop servo using an ac motor as the drive and an optical encoder as the sensing device. The system has no redundancy within itself but its function can be assumed by the NPA drive, should it become necessary. Since much of the circuitry is similar to the other functions in the CEA, a block-by-block description is provided here.

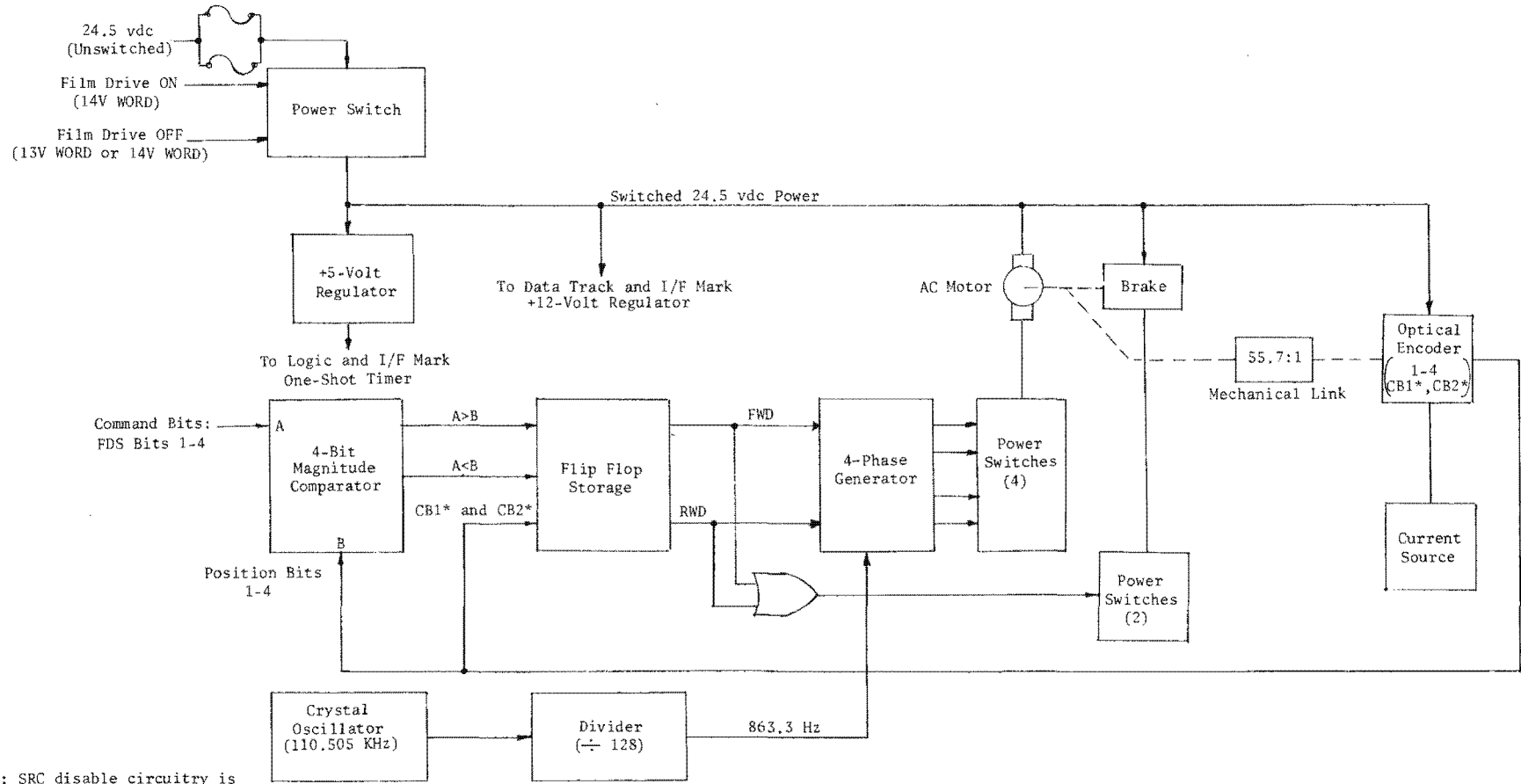
- (1) 24.5-Volt Power Switch - The SRC system has its own power switch which greatly reduces the power consumption of the system. With receipt of a film drive ON command, 24.5-volt power is applied to the SRC +5-volt regulator, the SRC ac motor common, the SRC brake common, the SRC encoder current source, and the data signal +12-volt power regulator. A film drive OFF command removes power.

The unswitched primary power from the PM and C is fused by two 5-ampere fuses in parallel to guard against short circuits. The power switch is provided with rise and fall time control for EMI control.

- (2) +5-Volt Regulator - The +5-volt regulator consists of a pre-regulator (zener diode with an emitter follower), an integrated circuit regulator, and an external pass transistor. The regulator is current-limited for protection against short circuits.

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NOTE: SRC disable circuitry is located in the command processor, Reference Part 3, Section 9.

* Centering bits 1 and 2

Figure 3.2-45. SRC Block Diagram

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- (3) Four-Bit Magnitude Comparator - The comparator accepts the four-bit command and four-bit encoder position data signals and provides separate outputs to the storage register that controls the drive direction.
- (4) Storage Register - The flip-flop storage register accepts the comparison information from the four-bit comparator and holds it between each SRC station. The comparison information is only allowed to be read into the flip-flop when the encoder is within the centering bit (CB1 or CB2) area of each SRC station. The output of the flip-flop is logically combined to remove the SRC brake whenever movement is required. The flip-flop consists of two cross-coupled NAND gates with appropriate gating for the centering bit enable/inhibit functions.
- (5) Oscillator - The oscillator unit consists of a crystal oscillator and internal divider producing a frequency of 110.505 KHz. The oscillator is the same as that employed in the FPLLE unit.
- (6) Divider - Two binary counters divide the oscillator output down to 863.3 Hz which is provided to the four-phase generator as the clock signal.
- (7) Four-Phase Generator - The four-phase generator accepts the clock pulses and direction information and generates the correct switching sequence to drive the motor phases. Each of the outputs controls one of the four motor-power switches, turning on one phase at a time in the correct order of rotation.

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- (8) Motor Power Switches - Each phase of the ac motor is driven by a separate PNP-NPN transistor pair with controlled rise and fall times. Each PNP stage is driven by a gate on the four-phase generator.
- (9) Brake and Power Switches - The brake has redundant coils and is engaged (mechanically) when no power is applied. The brake develops 2 oz -in. minimum torque and is used for stopping the SRC system at the end of a cycle and to hold the SRC whenever the NPA system is being powered. Separate power switches are provided for each coil, which are energized (brake released) whenever the SRC drive is operating.
- (10) Encoder - The encoder is a non-contact optical device incorporating LEDs and phototransistors. The glass code disk contains six tracks of information; the four-bit position word (bits 1-4) and two centering bits (CB1 and CB2). There is one LED and phototransistor for each track of information. The LEDs are electrically in series and driven by a current source. Zener diodes are placed in parallel with each LED to preclude complete system failure in the event of a single LED failure.

When the four-bit position feedback word is equal to the four-bit position command word and the centering bits indicate the center of the station, the stop sequence is initiated. The four-phase generator stops cycling and current to the brake release coils is turned OFF, engaging the brake. At the same time, a one-shot timer causes phase four (4) of the motor to be powered for approximately 60 msec. This combination of mechanical and dynamic braking assures that the platen will stop in the center of the station.

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- (11) Encoder Current Source - The encoder LED current source consists of a simple zener diode and NPN transistor stage which delivers approximately 25 ma.
- (12) AC Motor - The ac motor is a two-phase, four-pole permanent magnet hysteresis, synchronous type which turns at 6500 rpm. The motor is fitted with a 27:1 gearhead on the front and a brake on the rear. The geared-down motion is applied through the focus adjust mechanism gearbox to both the pivot frame eccentric drive and the optical encoder shaft.

2.5.4.2.2 Nominal Platen Adjustment. The nominal platen adjustment (NPA) subsystem can be used to move the platen over a range of 24 mils (± 12 mils from factory best focus) in 0.1-mil increments to compensate for the following:

- (1) Physical changes in the PPS/DP EAC resulting in a shift of the focus position from the factory setting.
- (2) Differing thicknesses of the various film types used in the PPS/DP EAC.
- (3) Inability of the SRC subsystem to correctly compensate for the image distance
.
- (4) Failure of the SRC subsystem (the NPA can be used as a backup on a frame-by-frame basis).

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In operation, the NPA mechanism shifts the entire SRC range, changing the relationship of SRC step number versus platen position by driving the platen to a new position without moving the SRC encoder. Should the nominal focus point change from the factory setting (or if a different film thickness is encountered), a one-time adjustment by the NPA mechanism will bias each of the 16 SRC steps to accommodate the new requirements.

The nominal platen adjust electronics consists of a primary and backup circuit, both connected to the phases of a single motor, and each operating a separate coil of a single brake which is an integral part of the motor. Both primary and backup systems are open-loop servos which require analysis of instrumentation to verify platen position. Selection of the primary or backup mode is controlled by command in the command processor, steering the FOCUS DRIVE ENABLE and FOCUS DRIVE INHIBIT commands to either the primary or backup power switch in the CEA.

Primary mode platen motion is started by receipt of either a normal stored program command (NSPC) or real time command (RTC) indicating the direction of travel, PLATEN PLUS (toward the RCFLA) or PLATEN MINUS (away from the RCFLA) (refer to Part 3, Section 9 for an explanation of command types). Motion initiated by a normal command will continue at the rate of 0.5 mil/second until a PLATEN STOP command is received. Use of a real time command to move the platen turns on the platen drive and also triggers a timer in the CP which latches the direction relay for 100 milliseconds beyond the end of the last RTC received, resulting in a movement of 0.1 mil for each RTC. Motion will be stopped either by receipt of a PLATEN STOP command, or by the timer reaching its trip point and resetting the direction relay.

Backup mode operation can only be controlled by real time PLATEN PLUS or PLATEN MINUS commands. Once started, motion will continue at the rate of 0.1 mil in 0.8 second only so long as commands continue to be received by

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the CP. The drive will be stopped 100 milliseconds after the end of the last command, or upon receipt of a PLATEN STOP command, whichever occurs first.

2.5.4.2.2.1 NPA Operation. The following descriptions refer to Figures 3.2-46 and 3.2-47.

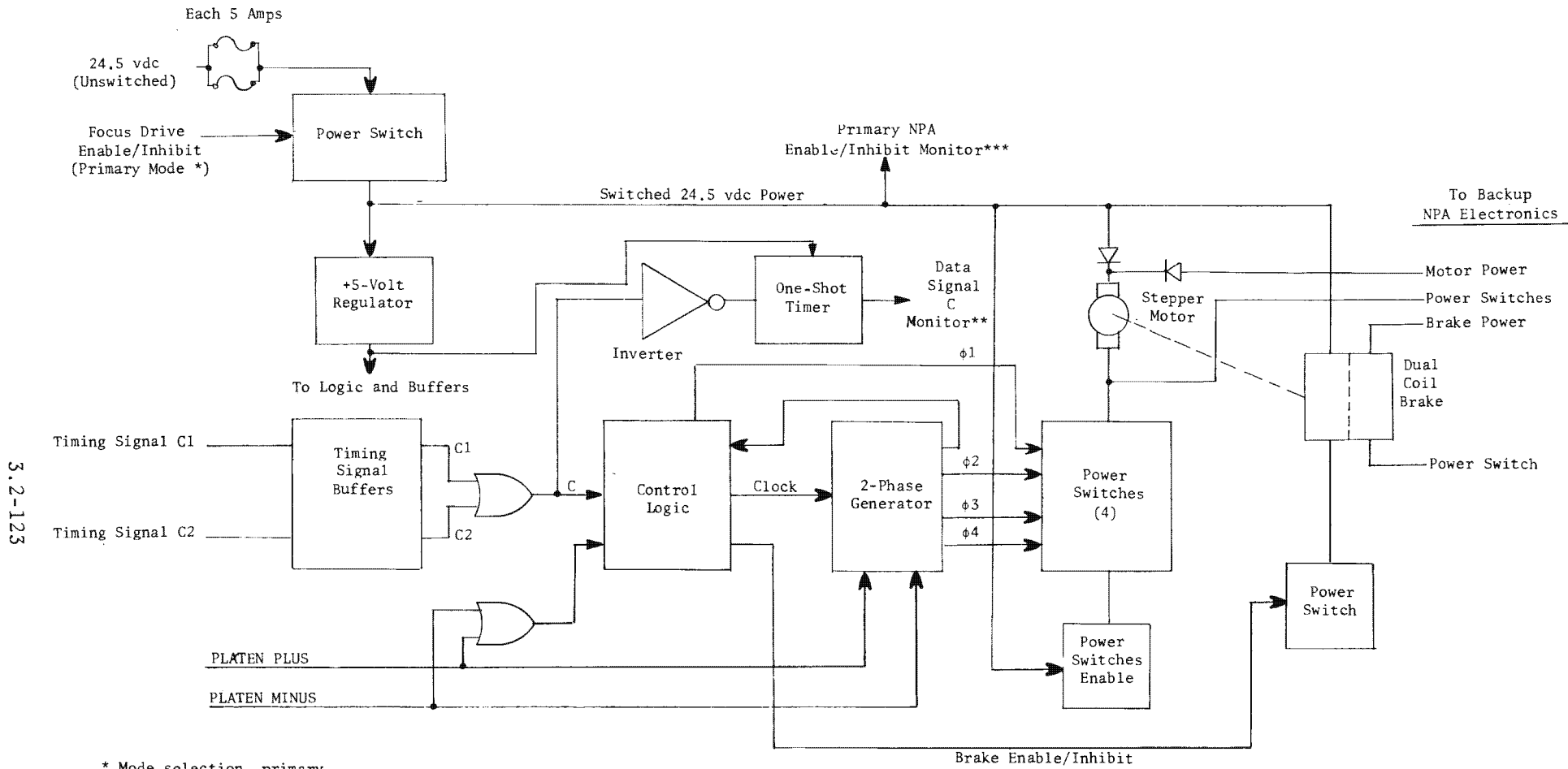
- (1) Primary NPA Operation - In the primary mode, when an enable command is received, a one-shot timer fires which releases the brake, resets the logic and powers phases three (3) and four (4) of the motor for approximately 28 msec. This causes the NPA logic and motor to reset to its proper starting position (i.e., the nearest 0.1-mil increment of platen motion). The brake is then engaged and power removed from phases three (3) and four (4) until a direction command is received.

The direction command controls the sequence in which the four phases are generated. The four-phase generator consists of a four-state ring counter with two of the states representing one phase and the other two states representing a second phase. The remaining two phases are the inverse of the first two. The ring counter is cycled by a clock signal derived from timing signals C1 and C2 (two 20-Hz square waves logically summed (C1 + C2)). The clock signal is enabled only when a direction command is present.

For a PLATEN PLUS command, the phases are generated in the sequence 3 and 4, 3 and 2, 2 and 1, 1 and 4, causing a counter-clockwise rotation of the NPA motor as viewed from the shaft end. A PLATEN MINUS command causes phases to be powered in the

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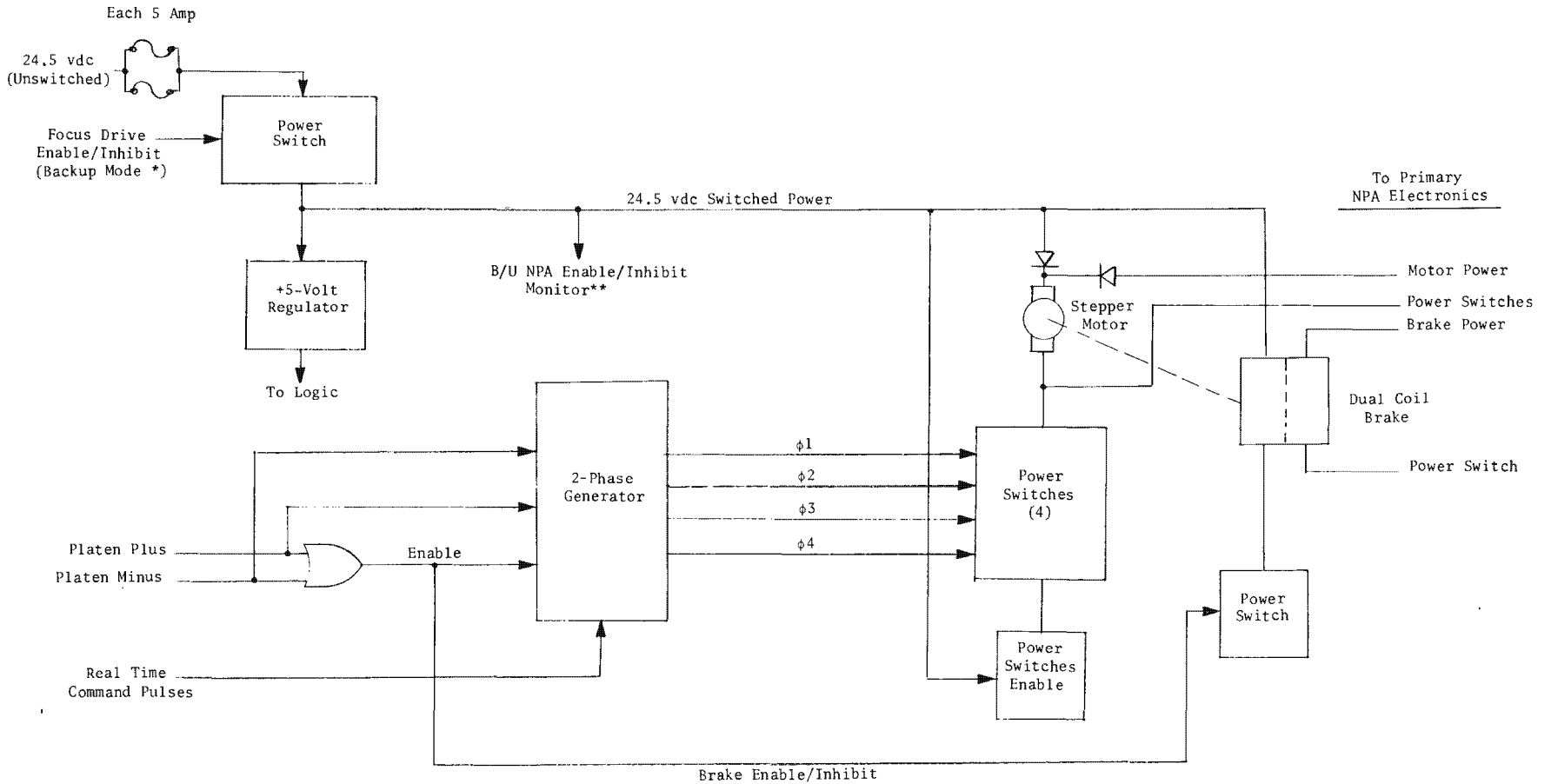
* Mode selection, primary or backup, is performed in the command processor. Reference Part 3, Section 9
 ** Bit 2 of IMP 5063 (9 CEA), or, IMP 5066 (5 CEA)
 *** Bit 4 of IMP 5063 (9 CEA), or, IMP 5066 (5 CEA)

Figure 3.2-46. Primary NPA Block Diagram

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* Mode selection, primary or backup, is performed in the command processor. Reference Part 3, Section 9
 ** To Bit 3 of IMP 5063 (9 CEA), or IMP 5066 (5 CEA)

Figure 3.2-47. Backup NPA Block Diagram

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sequence 3 and 4, 4 and 1, 1 and 2, 2 and 3 driving the motor clockwise. The motor is a two-pole permanent magnet stepper motor, and rotates once in 200 milliseconds, moving the platen 0.1 mil.

The tolerances on the length of the direction command and the coincidence between timing signal C and the direction command make it possible that the electronics will not receive an integral multiple of four timing signal C pulses during the command period. Since the number could be off by one pulse (plus or minus), the motor would be off by $\frac{1}{4}$ revolution, causing a 0.025-mil error in platen position. For this reason, when the direction command is removed, a one-shot timer is triggered which keeps the mechanical brake released, resets the logic and powers motor phases 3 and 4 for approximately 28 msec., resetting the motor to the same angular position at the end of every direction command.

- (2) Backup NPA Operation - The backup mode of operation is like the primary mode with two exceptions. First, the backup NPA uses a buffered 100-msec duration real time command (RTC) pulse from the command processor as the clock signal for the four-phase generator. In the command processor the same real time command pulse triggers a timer which latches the appropriate direction relay for 100 msec beyond the end of the last RTC pulse. This causes the NPA motor to rotate $\frac{1}{4}$ revolution for each RTC command received. Thus, four RTC commands are required to move the NPA one step (0.1 mil).

Second, the backup NPA does not reset to the same angular position each time the circuit is enabled. Nor does it reset at the end of

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a direction command. However, when a direction command is received, the starting position of the four-phase generator will always be the same, causing the motor to return, if necessary, to the same starting position as in the primary mode. To avoid the possibility of driving the platen to an unwanted position, backup commands are normally given in groups of four.

2.5.4.2.3 Variable Exposure Mechanism Control. The variable exposure mechanism (VEM), either 9 or 5 described in Section 2.2.2.2, is controlled by a closed-loop servo system with an optical encoder providing the positional feedback signal. The VEM, or slit mechanism, provides 16 discrete exposure levels to compensate for various film characteristics, drive speeds, and scene input. The slit widths vary from 0.0040 inch to 0.3000 inch with a ratio between consecutive steps of 1.334; i.e., $0.125 \log E$ (exposure). A maximum time of one second is required to attain the next wider or narrower slit. As explained in Subsection 2.2.2.2.1, the variable exposure mechanism will exhibit a hysteresis effect for steps 9-15 due to action of the cam and encoder. The positive stops in the cam prevent total closure of the slit and also stop the mechanism before it can exceed the recoverable drive limits.

Electronically, the variable exposure subsystem consists of redundant control circuits selectable by command (SLIT A SELECT and SLIT B SELECT). Mechanically, the system has a single drive motor, and a dual track encoder. Executing the film drive ON command in either subsystem will inhibit the slit electronics drive in both, even with the operational power OFF. The drive will not restart with the film drive OFF command regardless of the actual slit position versus the commanded position. Motion can be restarted while the film is running, by again commanding the desired slit position.

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2.5.4.2.3.1 VEM Operation. The VEM runs on unswitched power (24.5 volts nominal) which is directly supplied to the common of the motor (see Figure 3.2-48). Execution of the slit position command (a 4V WORD) controls a transistor switch providing power to the 5-volt regulator for the VEM logic. Power is also provided to a current source which powers the light emitting diodes in the optical encoder, and the motor control power transistors are enabled.

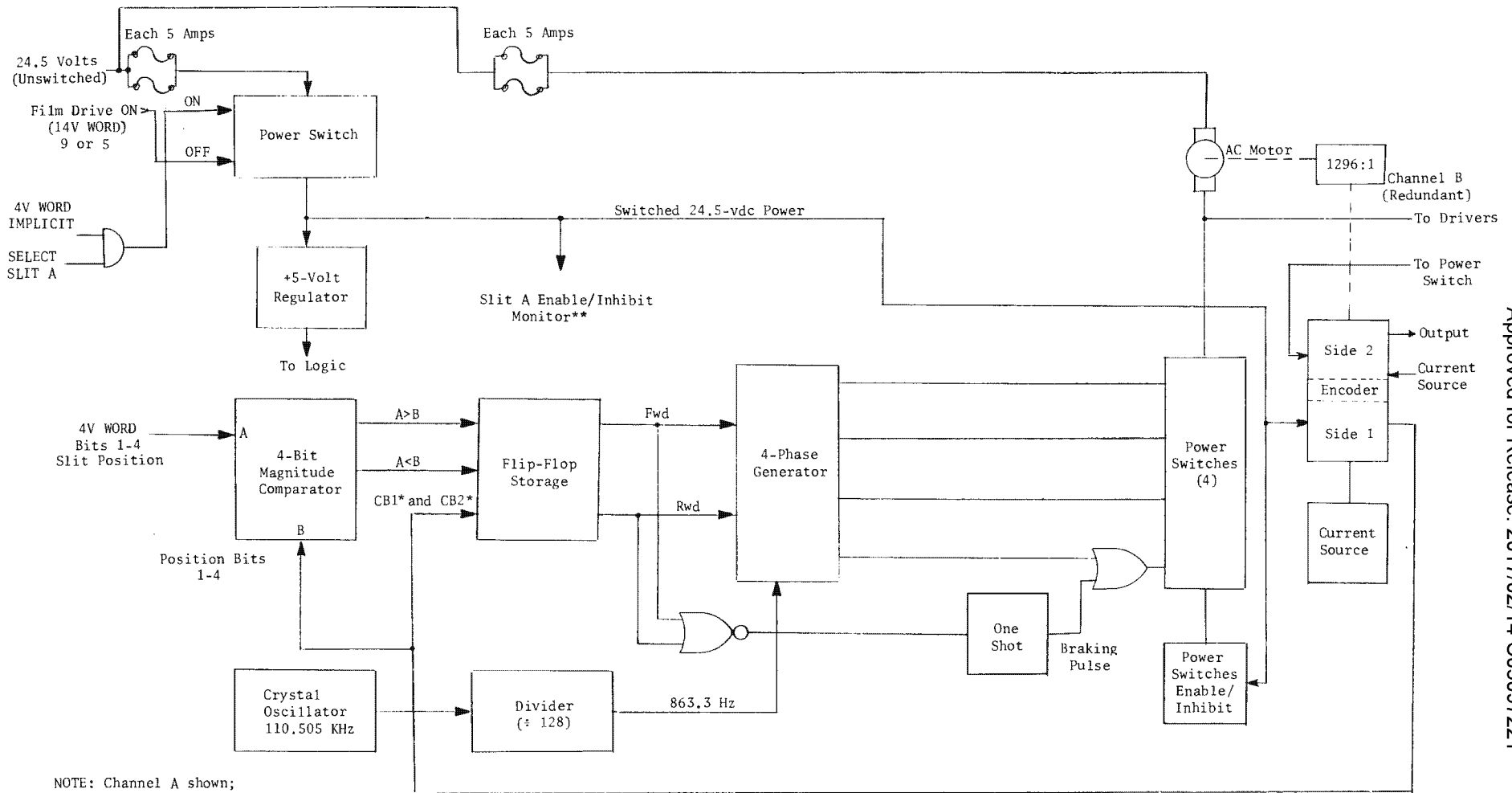
The VEM control circuitry is similar to that used for slant range compensation. The 4V WORD slit command defines one of 16 unique exposure slit widths. In the digital magnitude comparator, the four-bit position feedback word is compared to the position command and a signal is generated telling the logic whether to move the slit and, if so, in which direction. This information is fed into a three-state flip-flop circuit along with the centering-bit information. Each centering bit indicates an area slightly offset from the center of each position so that the area where the two centering bits overlap defines the center of the station. The flip-flop output changes to reflect the direction information from the comparator only when the center of a position is sensed. When the commanded position is reached, the output of the centering bits controls the direction of motion to drive the slit to the station center.

The motor is a two-phase four-pole permanent magnet hysteresis, synchronous motor which runs at approximately 6500 rpm. This is geared down within the motor by 27:1 so that the output shaft of the motor shaft turns at approximately 240 rpm. This motion is applied through the gears in the exposure mechanism to both the slit drive and optical encoder shafts.

The motor is controlled by a four-phase generator which turns on the motor power switches in the correct sequence for forward or rearward drive as determined by the output of the flip-flop storage register. The generator,

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NOTE: Channel A shown;
Channel B is identical.
*Centering Bits 1 and 2
**To Bit 4 of IMP 5064 (9 CEA), or,
IMP 5065 (5 CEA).
Slit B Enable/Inhibit monitor is
connected to Bit 3 of the respective
IMPS.

Figure 3.2-48. VEM Block Diagram (Channel A)

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essentially a four-state ring counter, is cycled by an 863.3 Hz clock signal derived from the 110.5 KHz crystal oscillator. The motor power switches have controlled rise and fall times to minimize EMI generation inherent with fast switching rates.

When the four-bit position feedback word is equal to the four-bit position command word and the centering bits indicate the center of the position, the stop sequence is initiated. The ring counter stops cycling and the phases are turned off. At the same time a one-shot timer is triggered which causes phase four of the motor to be powered for approximately 60 msec. Powering phase four by itself provides sufficient braking action to assure the mechanism will stop within the centerband of the position.

2.5.4.2.4 Data Tracks and Interframe Marker. The data tracks and interframe marker electronics in the CEA utilize the same power switch and the same 5-volt regulator as the SRC circuitry. In addition, there is a 12-volt regulator to supply power to the data track LEDs and the interframe marker incandescent lamps (see Figure 3.2-49).

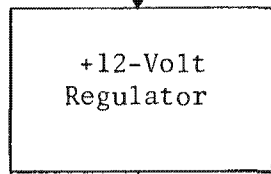
When the SRC is enabled, power is provided to the interframe marker circuit triggering a one-shot timer which powers the interframe marker lamps for 25 milliseconds. This causes a pair of marks on the film indicating the start of a frame.

The data track electronics receives two timing signals, A and B, from the SCS portion of the vehicle, which are generated by the extended command subsystem clock. Timing signal B is a 500 Hz square wave. Timing signal A consists of a sync pulse followed by a 24-bit time code (least significant bit first) which is presented every 200 msec. The time code has a period of 2 ± 0.002 msec and is synchronized to timing signal B. The inverse of timing signal A is logically combined with timing signal B ($\bar{A}B$) and the output used to power

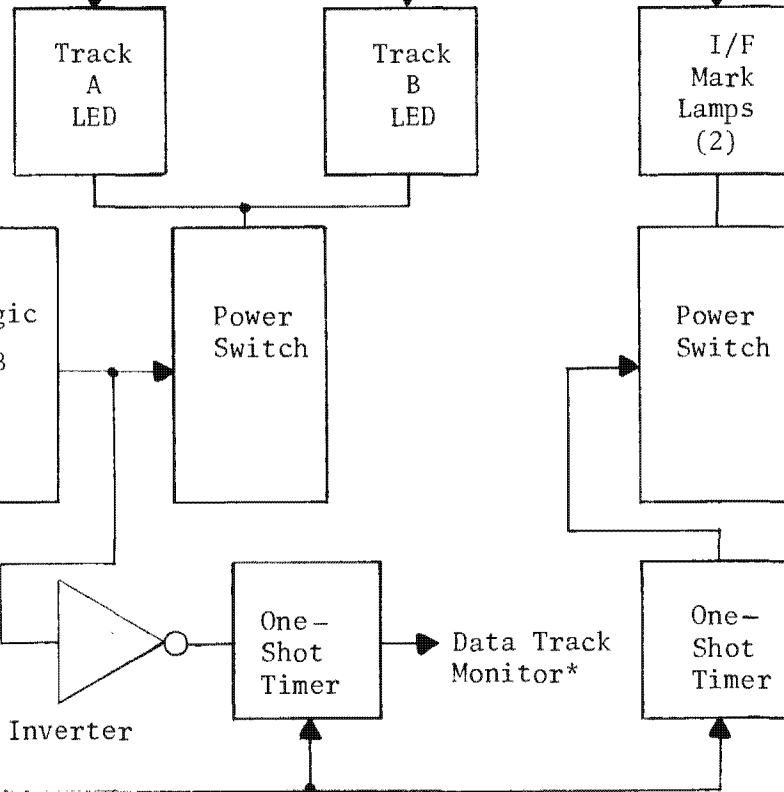
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24.5 vdc
Switched Power
(From SRC Switch)



+12 Volts



*Bit 2 of IMP 5064 (9 CEA),
or IMP 5065 (5 CEA).

From SRC +5-volt Regulator

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Figure 3.2-49. Data Track and Interframe Marker Block Diagram

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two separate LEDs in the camera. The LED for data track A is mounted 0.05 inch past the exposure slit centerline (in terms of film motion) near the outer edge of the film. The LED for Track B is placed 0.05 inch before the slit and approximately 0.04 inch inside of Track A. (For reference, see the 9 and 5 film formats, Figures 3.2-30 and 3.2-31 respectively).

2.5.4.2.5 Camera Electronics Assembly Instrumentation. Each CEA unit has three internal instrumentation circuits, a current monitor and two eight-level circuit status monitors. One eight-level point indicates the state of the A and B VEM control circuits (enabled/inhibited), and the presence or absence of the data track timing signal (\overline{AB}). The other eight-level point indicates the condition of the primary and backup NPA drives (enabled/inhibited), and the presence or absence of the combined timing signal C ($C1 + C2$). The current sensor (IMP 5062 in the 9 subsystem and IMP 5157 in the 5 subsystem) measures the total current the CEA draws from the 24.5 vdc power supply, including all logic power in the unit, and all power for the SRC, NPA and VEM motors. A voltage is developed across a resistor in the power return line and amplified to give a transfer function of 1.67 volts/amp. Since the circuit is not a true differential amplifier, any common mode voltage between the 24.5 vdc power return and the instrumentation return will be seen at this output. The bandwidth of the current instrumentation monitor is approximately 800 hertz.

The variable exposure mechanism A and B control circuit enable/inhibit and data track instrumentation point (IMP 5064 in the 9 subsystem and IMP 5065 in the 5 subsystem) produces six valid levels. Since both A and B control circuits for the VEM cannot be enabled simultaneously unless a failure has occurred, the remaining two possible levels are eliminated. Each VEM power switch provides 24.5 volts to an optical coupler connected to one input of a four-bit digital/analog (D/A) converter; circuit B to Bit 3, and circuit A to Bit 4 (the most significant bit). The data track signal, \overline{AB} , is used

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to trip a retriggerable one-shot timer. If the data track signal is absent for more than 75 milliseconds, Bit 2 of the D/A converter output will indicate the signal is missing. This point does not indicate that the data tracks are being placed on the film as power for the LEDs is available only when the SRC power switch is closed. The least significant bit of the D/A converter is not used, resulting in an output that varies from 0.25 to 3.25 volts in 0.6-volt increments for all valid levels.

The NPA primary and backup enable/inhibit and data signal C instrumentation point (IMP 5063 in the 9 subsystem, and IMP 5066 in the 5 subsystem) has only four valid levels. Both the primary and backup NPA circuits cannot be enabled simultaneously unless there has been a failure, eliminating two possible states, and, since the timing signal C logic uses primary NPA power, it is not valid for the instrumentation point to indicate the absence of timing signal C when the primary NPA is inhibited, eliminating two more possible states.

Each NPA enable switch controls power to one side of an optical coupler, with the output of each coupler connected to an input of a four-bit D/A converter; the primary NPA enable to Bit 4 (the most significant bit), and the backup NPA enable to Bit 3. Timing signals C1 and C2 are logically combined, and trip a retriggerable one-shot timer, the output of which is fed to Bit 2 of the D/A converter. If both timing signals C1 and C2 are absent for more than 75 milliseconds, the instrumentation point will indicate the loss. The least significant bit of the converter is not used so that the valid outputs of this point range from 0.25 to 3.25 volts in 0.6-volt increments, excluding the 0.85- and 2.05-volt levels.

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2.6 9 x 5 Dual Platen Camera and Film Handling Subsystem Instrumentation

Table 3.2-5 summarizes those instrumentation points associated with the 9 and 5 film handling subsystems. Table 3.2-6 is a summary of those points that are related to the 9 x 5 dual platen camera.

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TABLE 3.2-5

FILM HANDLING SUBSYSTEM INSTRUMENTATION: 9 AND 5

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|--------------------------|--|--------------|
| 5015 | Primary Film Tension (9) | <p>A potentiometer and an encoder (which also furnishes logic signals to the film control electronics) geared to the shaft of the 9 tension arm, monitor the tension arm position. The associated circuitry, located in the 9 supply assembly, combines the outputs of the two sensors, producing a signal as follows:</p> <p>A linear voltage, with two discontinuous points, representing tension arm position in terms of film quantity.</p> <ul style="list-style-type: none"> a. 9.6 inches - mechanically full: 0.05 volt b. 8.7 inches - electrically full- switch point, voltage discontinuity from 0.40 to 0.94 volt c. 4.55 inches - approaching full: 2.5 volts d. 3.5 inches - nominal rest point: 2.9 volts e. 0.3 inch - electrically empty - switch point, voltage discontinuity from 4.05 to 4.60 volts | +5 vdc |

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TABLE 3.2-5 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|--|---|--------------|
| | | f. 0.0 inch - mechanically empty: 4.72 volts | |
| | | Values shown are nominal and will vary with each vehicle. For specific figures refer to the appropriate flight model calibration book. | |
| 5376 | Primary Film Tension 9 | A potentiometer geared to the shaft of the 9 tension arm, monitors the tension arm. The associated circuitry, located in the 9 supply assembly, produces a signal as follows: A linear voltage representing tension arm position in terms of film quantity. | |
| | | a. 9.6 inches - mechanically full: 0.05 volt | |
| | | b. 8.7 inches - electrically full: 0.94 volt | |
| | | c. 4.55 inches - approaching full: 2.5 volts | |
| | | d. 3.5 inches - nominal rest point: 2.9 volts | |
| | | e. 0.3 inch - electrically empty: 4.05 volts | |
| 5379 | 9 Camera Auto OFF, 5 Camera OFF, Camera Auto OFF, Altitude Select | A combination command bit monitor (CBM) and function monitor consists of latching relays which verify receipt of commands in the command processor and indicate whether the Camera Automatic OFF (CAO) circuits in each camera system have acted to issue Automatic Camera OFF commands. Four relays and a resistance network form a D/A converter whose output occurs in 16 discrete steps ranging from a 0.25 to 4.75 volts in 0.3 volt increments. | +5/±15 vdc |

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TABLE 3.2-5 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|------------------|--|--------------|
| | | Bit 1 (LSB) = 9 CAMERA AUTO OFF/NORMAL | |
| | | Bit 2 = 5 CAMERA AUTO OFF/NORMAL | |
| | | Bit 3 = CAMERA AUTO OFF ENABLE/DISABLE | |
| | | Bit 4 = ALTITUDE SELECT HIGH/LOW | |
| 5070 | Film Tension (5) | <p>A potentiometer and an encoder (which also furnishes logic control signals to the film handling electronics) geared to the 5 tension arm shaft, monitor the tension arm position. The associated circuitry, located in the film handling electronics, combines the outputs of the two sensors producing a signal as follows:</p> <p>A linear voltage, with two discontinuous points, representing tension arm position in terms of film quantity.</p> <ol style="list-style-type: none"> 9.4 inches - mechanically full: 0.03 volt 8.8 inches - electrically full - switch point, voltage discontinuity from 0.5 to 1.0 volt 6.7 inches - approaching full: 1.85 volts 5.05 inches - nominal rest point: 2.5 volts 1.3 inches - electrically empty - switch point, voltage discontinuity from 4.0 to 4.5 volts 0.0 inch - mechanically empty: 5.0 volts <p>Values shown are nominal and will vary with each vehicle. For specific figures refer to the appropriate flight model calibration book.</p> | +5 vdc |

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TABLE 3.2-5 (CONT'd)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|-----------------------------------|---|--------------|
| 5377 | Film Tension 5 | <p>A potentiometer geared to the 5 tension arm shaft, monitors the tension arm position. The associated circuitry, located in the film handling electronics produces a signal as follows:</p> <p>A linear voltage, representing tension arm position in terms of film quantity.</p> <ul style="list-style-type: none"> a. 9.4 inches - mechanically full: 0.03 volt b. 8.8 inches - electrically full: 1.0 volt c. 6.7 inches - approaching full: 1.85 volts d. 5.05 inches - nominal rest point: 2.5 volts e. 1.3 inches - electrically empty: 4.0 volts | |
| 5016 | Primary Film Quantity, Coarse (9) | 9 film quantity is measured by three potentiometers and associated divider networks located in the 9 supply. The coarse and fine potentiometers are geared to one end of an idler roller (on the take-up side of the looper) through a spring-loaded gear (clutch), gear train, and gear reducer. A separate spring-loaded gear drives the medium potentiometer through another gear reducer from the opposite end of the same roller. Both spring-loaded gears (spring clutches) are set to slip at 2 oz.-in. One potentiometer cycle (0.5 to 4.5 vdc plus the deadband) represents 30.1 feet for the fine, 240 feet for the medium, and 3490 feet for coarse. | +5 vdc |
| 5017 | Primary Film Quantity, Medium (9) | | +5 vdc |
| 5018 | Primary Film Quantity, Fine (9) | | +5 vdc |

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TABLE 3.2-5 (CONT'd)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|-----------------------------------|--|--------------|
| 5021 | Primary Film Quantity, Coarse (9) | Potentiometers, identical to and ganged with potentiometers for IMPs 5016, 5017, 5018, produce redundant instrumentation signals. | +15 vdc |
| 5022 | Primary Film Quantity, Medium (9) | | +15 vdc |
| 5023 | Primary Film Quantity, Fine (9) | | +15 vdc |
| 5071 | Film Quantity, Medium (5) | A two-section potentiometer assembly, with an internal gear ratio of 9.76:1 between sections, and associated processing circuitry in the FHE measure 5 film quantity. The potentiometer assembly is geared to one end of an idler roller (between the supply spool and storage looper) through a spring-loaded clutch and gear train. The clutch is set to slip at 2 oz.-in. One cycle of the fine potentiometer (0.25 to 4.75 volts plus the deadband) represents 29.9 feet of film; one cycle of the medium potentiometer, covering the same voltage range as the fine, represents 292 feet. | +5 vdc |
| 5072 | Film Quantity, Fine (5) | | +5 vdc |
| 5073 | Film Quantity, Medium (5) | A two-section potentiometer identical to that used for IMPs 5071 and 5072, and geared to the same idler roller, produces redundant film quantity instrumentation outputs. | +15 vdc |
| 5074 | Film Quantity, Fine (5) | | +15 vdc |
| 5014 | Looper Position (9) | A potentiometer, turned by a spiral roller (cam) that is rotated by motion of the looper carriage, monitors the position of the looper carriage. The associated voltage divider network is located in the 9 supply assembly. The output voltage | +5 vdc |

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| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---------------------|---|--------------|
| | | is directly proportional to the amount of film in the take-up side of the storage looper (or, inversely proportional to the amount on the supply side). The output range is 0.0 inch (0.72 volt) to 60 inches (4.44 volts). Electrically empty and full points (referenced to the take-up side) for the film control electronics logic occur at 17.45 inches (1.80 volts) and 54.25 inches (4.08 volts) respectively. | |
| 5020 | Looper Position (9) | A potentiometer, driven by the opposite end of the spiral roller as the potentiometer for IMP 5014, produces a redundant looper carriage position output signal. | +15 vdc |
| 5068 | Looper Position (5) | A potentiometer, turned by a spiral roller (cam) that is rotated by motion of the 5 looper carriage, monitors the position of the looper carriage. The associated processing circuitry is located in the FHE. The output voltage is directly proportional to the amount of film in the take-up side of the storage looper (or, inversely proportional to the amount on the supply side). The output range is 0.0 inch (0.54 volt) to 45 inches (4.45 volts). Electrically empty and full points (referenced to the take-up side) for the film handling electronics occur at 6.5 inches (1.1 volts) and 43.3 inches (4.31 volts) respectively. | +5 vdc |
| 5069 | Looper Position (5) | Redundant case of IMP 5068. The potentiometer is driven by the same end of the spiral roller cam as the potentiometer for IMP 5068. | +15 vdc |

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TABLE 3.2-5 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|-------------------------------------|--|-------------------------------|
| 5298 | Take-Up Warning (9 and 5), SRV 1 | An approaching full warning switch for each spool, consisting of a pivoting arm and wheel which rides on the film wrap when the spool is near full and drives a mechanical encoder, closes when the remaining spool capacity is 500 feet for the 9 and 300 feet for the 5, based on 0.002-inch thick film. The two outputs are combined by a resistance network in the 9 x 5 take-up assembly to produce a four-state signal as follows: <ol style="list-style-type: none"> 1. 2.0 volts - 9 spool not full 5 spool not full 2. 2.5 volts - 9 spool not full 5 spool approaching full 3. 3.0 volts - 9 spool approaching full 5 spool not full 4. 4.5 volts - 9 spool approaching full 5 spool approaching full | +15 vdc |
| 5080 | Take-Up Warning (9 and 5), SRV 2 | Identical to IMP 5298, monitors the 9 and 5 spool approaching full states for the 9 x 5 take-up assembly in SRV 2. | +15 vdc |
| 5019 | Film Path Pressure | A diaphragm responds to slight differential pressures of the inside of the film supply enclosure with respect to the outside. A coil is located on each side of the diaphragm to sense the motion. The corresponding inductance changes determine the frequency of an oscillator which is demodulated into a proportional analog output voltage. The range of the IMP is 0 mm of Hg (0.37 volts) to 4.63mm of Hg (5.0 volts). | 24.5 vdc (DTU switched power) |

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TABLE 3.2-5 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|-------------------------------------|--|--------------|
| 5591 | 9 OP Voltage Monitor | A two-resistor voltage divider network connected across the 9 OP power feed in the PM&C monitors the voltage level. Output is digitized in the DTU to yield a binary signal (On/Off). "0" = <u>Off</u> "1" = <u>On</u> | Self |
| 5269 | Supply Motor Current (9) | Resistors in the supply power return lines (forward and reverse) generate voltages proportional to the supply motor current plus bias current for the drive circuitry. The outputs are amplified and combined in the film control electronics module producing a linear signal from -7 amperes (0.5 volt) reverse-drive current to +7 amperes (5.0 volts) forward-drive current. | ±15 vdc |
| 5267 | Primary Take-up Current 1 and 2 (9) | A resistor in the power return line from the 9 spool drive motors on take-up 1 and take-up 2 generates a voltage proportional to the combined current drawn by the two motors (they are driven simultaneously only during the switchover from T/U 1 to T/U 2, i.e., during the period between execution of 9 SPLICE/CUT and 9 ROLL-IN TERMINATE). The output is amplified in the film control electronics producing a linear signal from 0.0 ampere (0.5 volt) to 3.1 amperes (5 volts). | ±15 vdc |
| 5593 | 5 OP Voltage Monitor | Similar to IMP 5591, monitors the on/off status of 5 operational power. | Self |
| 5077 | Supply Motor Current (5) | Similar to IMP 5269, but located in the film handling electronics module, IMP 5077 monitors | ±15 vdc |

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TABLE 3.2-5 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---|---|--------------|
| | | the 5 supply motor current. The output is piecewise linear ranging from -5.4 amperes (0 vdc) to 0.0 ampere (2.3 vdc) for reverse drive, and from 0.0 ampere (2.7 vdc) to +6 amperes (4.9 vdc) for forward drive. The monitor output is 2.5 vdc with the bidrive disabled. The discontinuity between 2.3 vdc and 2.7 vdc is caused by the current sense resistors also measuring the bidrive circuitry bias currents. | |
| 5378 | Supply Brake Current | The brake current shall be monitored, so that for a 0 to 1.05 ampere brake current a 0 ±0.2 through 5 ±0.2 volts dc analog instrumentation output shall be available. The output transfer function shall be linear. | |
| 5075 | Secondary Take-Up Motor Current 1 and 2 (5) | Similar to IMP 5267 in the 9 subsystem, monitors the combined motor current for the 5 take-up spool motors on T/U 1 and T/U 2. Both motors receive power only during the period between execution of 5 SPLICE/CUT and 5 ROLL IN TERMINATE. The output is linear from 0.0 ampere (0.25 volt) to 2.0 amperes (4.75 volts). | ±15 vdc |
| 5124 | Supply Brake Current (5) | The currents for the primary and backup release coils in the 5 supply brake are monitored by resistors in the return lines within the film handling electronics module. The two signals are combined and amplified within the FHE to produce a linear signal from 0.08 ampere (0.5 volt) to 0.4 ampere (4.6 volts). The signal is nonlinear below 0.08 ampere with the IMP output reaching its lower voltage limit (0.25 volt) at 0.04 ampere. Accuracy of the IMP is such that it is able to indicate only | ±15 vdc |

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TABLE 3.2-5 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---|--|-------------------------|
| | | the presence or absence of a brake coil load as indicated below: | |
| | | $E_o^* < 1.0 \text{ v}$ Brake Engaged | |
| | | $1.15 \text{ v} < E_o < 3.0 \text{ v}$ One coil energized, brake disengaged | |
| | | $E_o > 3.05 \text{ v}$ Both coils energized, brake disengaged | |
| 5616 | 5 Parking Brake Voltage Monitor | A two-resistor voltage divider network across the 5 parking brake power feed in the PM&C monitors the voltage level. Output is digitized in the DTU to yield a binary signal (<u>On/Off</u>): $\text{"0"} = \underline{\text{Off}}$ $\text{"1"} = \underline{\text{On}}$ | Self |
| 5134 | Environmental Current Branch 2, and 5 Parking Brake Current | A resistor in the branch 2 and 5 parking brake power return line in the PM&C generates a voltage proportional to the current flowing. The output is amplified in the PM&C producing a linear signal from 0.0 ampere (0.18 volt) to 5.0 amperes (4.9 volts). | $\pm 15 \text{ vdc}$ |
| 5033 | 9 NPA Prime/BU, 5 NPA Prime/BU, T/U Enable/Inhibit | 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 converter. Three relays and one 4-bit D/A converter form the IMP. Output ranges from 0.25 volt to 1.15 volts and 2.65 volts to 3.55 volts in 0.3 volt increments within each range. | $+5/\pm 15 \text{ vdc}$ |

* E_o represents the instrumentation point output voltage.

TABLE 3.2-5 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---|---|--------------|
| | | Bit 1 (LSB) = 5 NPA Prime/BU | |
| | | Bit 2 = 9 NPA Prime/BU | |
| | | Bit 3 = N/C | |
| | | Bit 4 (MSB) = T/U Enable/Inhibit | |
| 5119 | CBM for IEU (Number 5) | A command bit monitor (CBM), consisting of latching relays in parallel with the command relays of the IEU, monitors 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: | +15 vdc |
| | | Bit 1 (LSB) = C/S 2A | |
| | | Bit 2 = C/S 1A | |
| | | Bit 3 = 5 S/C A | |
| | | Bit 4 (MSB) = 9 S/C A | |
| 5121 | CBM for IEU (Number 6) | Similar to IMP 5119 | +5 vdc |
| | | Bit 1 (LSB) = C/S 2B | |
| | | Bit 2 = C/S 1B | |
| | | Bit 3 = 5 S/C B | |
| | | Bit 4 (MSB) = 9 S/C B | |
| 5003 | Environmental Branches 1, 2, and 4, and 5 Parking Brake On/Off | Similar to IMP 5033, with an output from 0.25 volt to 4.75 volts in 0.3-volt increments: | +5/±15 vdc |
| | | 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 | |

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TABLE 3.2-5 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|--------------------------------------|--|--------------|
| 5013 | Temperature, Primary Film Supply | A thermistor, mounted on the back of the 9 film quantity sensor assembly, monitors the temperature near the 9 supply spool. The output is scaled in the instrumentation processor producing a nonlinear signal from 10F (4.75 volts) to 130F (0.54 volt). | +15 vdc |
| 5076 | Temperature, Secondary Film Supply | A thermistor, mounted on the +Y side of the 5 supply frame near the supply spool support, monitors the supply temperature. The output is scaled in the instrumentation processor, generating a nonlinear signal from 10F (4.75 volts) to 130F (0.54 volt). | +15 vdc |
| 5235 | Temperature, SRV 1 Film T/U Assembly | The instrumentation thermistor is glued to a take-up frame cross member, and is centered on the Z-axis just below (-Z) the 5 wobble roller. The output is processed in the instrumentation processor, resulting in a nonlinear signal from 10F (4.75 volts) to 130F (0.54 volt). | +15 vdc |
| 5236 | Temperature, SRV 2 Film T/U Assembly | Similar to IMP 5235, monitors the temperature of T/U 2. | +15 vdc |

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TABLE 3.2-6

9X5 DUAL PLATEN CAMERA INSTRUMENTATION

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---------------------------|---|--------------|
| 5092 | FPLL Current Monitor (9) | The current drawn by 9 FPLLE sides A and B is sensed by a dropping resistor in the return line for each side. The signals are amplified, summed, and delivered to the instrumentation processor. Since both sides cannot be operated simultaneously, the signal represents the ON side current drain. The output is linear from 0.0 ampere (0 volt) to 3.0 amperes (5.0 volts), with a bandwidth of 100 Hz. | ±15 vdc |
| 5097 | FPLL Loop Diagnostic (9) | The outputs from the 9 FPLLE loop filters (side A and side B) are summed, and delivered to the instrumentation processor as a voltage representing encoder phase lag (with respect to the drive reference signal). Output is linear from 0 degree (0.7 volt) to 268 degrees (5.0 volts). | ±15 vdc |
| 5098 | FPLL Current Monitor (5) | Similar to IMP 5092; monitors the 5 FPLLE current drain. | ±15 vdc |
| 5156 | FPLL Loop Diagnostic (5) | Similar to IMP 5097; monitors the 5 FPLLE phase error. | ±15 vdc |
| 5606 | 9 Film Velocity, Count 1 | The velocity of the film being transferred by the camera from the supply side to the take-up side of the storage looper is monitored by a 100-line optical encoder attached to a film path idler roller. The optical encoder produces pulses which are | +5 vdc ↓ |
| 5607 | 9 Film Velocity, Count 2 | | |
| 5608 | 9 Film Velocity, Count 4 | | |
| 5609 | 9 Film Velocity, Count 8 | | |
| 5610 | 9 Film Velocity, Count 16 | | |
| 5611 | 9 Film Velocity, Count 32 | | |

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TABLE 3.2-6 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|----------------------------|---|-----------------------|
| 5612 | 9 Film Velocity, Count 64 | amplified and used to increment an eight-digit binary counter. The counter runs from 0 to 255, resetting on the next pulse and continuing. Each bit is fed to a discrete input in the above DTU yielding eight instrumentation points, each indicating the "0" or "1" state of a single bit position. | ↓ +5 vdc |
| 5613 | 9 Film Velocity, Count 128 | | |
| 5598 | 5 Film Velocity, Count 1 | Similar to IMPs 5606-5613; monitors the 5 film velocity. | +5 vdc ↓ +5 vdc |
| 5599 | 5 Film Velocity, Count 2 | | |
| 5600 | 5 Film Velocity, Count 4 | | |
| 5601 | 5 Film Velocity, Count 8 | | |
| 5602 | 5 Film Velocity, Count 16 | | |
| 5603 | 5 Film Velocity, Count 32 | | |
| 5604 | 5 Film Velocity, Count 64 | | |
| 5605 | 5 Film Velocity, Count 128 | | |
| 5591 | 9 OP Voltage Monitor | A two-resistor voltage divider network connected across the 9 operational power feed in the PM and C monitors the 9 OP voltage level. Output is digitized in the DTU to yield a binary signal (ON/OFF). "0" = OFF "1" = ON | Self |
| 5593 | 5 OP Voltage Monitor | Similar to IMP 5591; monitors the ON/OFF status of 5 operational power. | Self |

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| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|-----------------------------|---|--------------|
| 5025 | Platen Position, Fine (9) | Fine and coarse potentiometers with associated voltage divider networks are located in the 9 focus adjust mechanism gearbox. The outputs are linear over the full range of platen travel (± 12 mils). The coarse potentiometer cycles once (0.0 to 5.0 volts) over the full 24-mil range, while the fine potentiometer cycles once for each 2 mils of motion. The output levels are centered around 0.0 mil (2.5 volts). | +5 vdc |
| 5026 | Platen Position, Coarse (9) | | +5 vdc |
| 5030 | Platen Position, Fine (9) | Redundant case of IMPs 5025 and 5026. The potentiometers are ganged with those used to generate IMPs 5025 and 5026. | +15 vdc |
| 5031 | Platen Position, Coarse (9) | | +15 vdc |
| 5051 | Platen Position, Fine (5) | Identical to IMPs 5025 and 5026. The potentiometers are located in the 5 focus adjust mechanism gearbox and monitor the position of the 5 platen. | +5 vdc |
| 5052 | Platen Position, Coarse (5) | | +5 vdc |
| 5053 | Platen Position, Fine (5) | Redundant case of IMPs 5051 and 5052. The potentiometers are ganged with those for IMPs 5051 and 5052. | +15 vdc |
| 5054 | Platen Position, Coarse (5) | | +15 vdc |
| 5049 | Slit Position (9) | A potentiometer geared to the 9 variable exposure mechanism (slit mechanism) drive shaft monitors the slit position. The associated voltage divider network is located on the VEM assembly. The potentiometer is rotated approximately 500 degrees from steps 1 to 16, genera- | +5 vdc |

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TABLE 3.2-6 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---|--|--------------|
| | | ting slightly more than one voltage cycle (0.0 to 5.0 volts) for the full range of travel. | |
| 5050 | Slit Position (9) | Redundant case of IMP 5049. The potentiometer is ganged with the potentiometer used for IMP 5049. | +15 vdc |
| 5055 | Slit Position (5) | Identical to IMP 5049; monitors the position of the 5 slit mechanism. | +5 vdc |
| 5056 | Slit Position (5) | Redundant case of IMP 5055; identical to IMP 5050 on the 9 slit mechanism. | +15 vdc |
| 5063 | Primary NPA Enable/Inhibit, B/U NPA Enable/Inhibit, Data Signal C (9) | A four-bit D/A converter in the 9 camera electronics assembly monitors the enable status of the primary and backup NPA, plus the presence of timing signal C1 or C2. Timing signals C1 and C2 are logically combined to trigger a retriggerable one-shot timer so that if the signal is absent for more than 0.075 sec, the D/A converter will indicate the signal is missing. Since timing signal C logic uses primary NPA power, the presence or absence of signal C cannot be determined when the primary NPA is inhibited. Valid output levels range from 0.25 volt to 3.25 volts in 0.60 increments excluding the 0.85-volt and 2.05-volt levels. | ±15 vdc |

- Bit 1 (LSB)* = No connection
- Bit 2 = Data signal C
- Bit 3 = B/U NPA enable/inhibit
- Bit 4 (MSB)** = Primary NPA enable/inhibit

* Least Significant Bit
 ** Most Significant Bit

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| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---|--|--------------|
| 5066 | Primary NPA Enable/Inhibit, B/U NPA Enable/Inhibit, Data Signal C (5) | Identical to IMP 5063; monitors the NPA and data signal C functions in the 5 camera electronics assembly. | ±15 vdc |
| 5064 | Slit A Enable/Inhibit, Slit B Enable/Inhibit, Data Tracks (9) | A four-bit D/A converter in the 9 camera electronics assembly indicates the enable status of the A and B VEM circuits, and whether or not the data track signal is present. The data track signal (\overline{AB}) is used to trigger a retriggerable one-shot timer so that if the signal is absent for more than 0.075 sec the D/A converter will indicate the signal is missing. The output varies from 0.25 volt to 3.25 volts in 0.6-volt increments for all valid states. Bit 1 (LSB) = No Connection Bit 2 = Data Tracks Bit 3 = Slit B Enable/Inhibit Bit 4 (MSB) = Slit A Enable/Inhibit | ±15 vdc |
| 5065 | Slit A Enable/Inhibit, Slit B Enable/Inhibit, Data Tracks (5) | Identical to IMP 5064, monitors the VEM and data track functions in the 5 camera electronics assembly. | ±15 vdc |
| 5062 | DREA Current (9) | A dropping resistor in the power-return line senses the total current the 9 camera electronics assembly draws from the 24.5 vdc power supply, including all logic power, plus motor power in the SRC, NPA, and VEM. The current signal is amplified to give an output range of 0.0 to 5.0 volts for 0.0 to 3.0 amps, with a bandwidth of 800 Hz. | ±15 vdc |

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TABLE 3.2-6 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---|---|--------------|
| 5157 | DREA Current (5) | Identical to IMP 5062; monitors current drawn by the 5 camera electronics assembly. | ±15 vdc |
| 5029 | 9 Camera ON/OFF, 5 Camera ON/OFF, 9 OP ON/OFF, 5 OP 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 converter. Four relays and one 4-bit D/A converter form the IMP. Output occurs in 16 discrete steps ranging from 0.25 volt to 4.75 volts in 0.3-volt increments: Bit 1 (LSB) = 9 Camera ON/OFF Bit 2 = 5 Camera ON/OFF Bit 3 = 9 OP ON/OFF Bit 4 (MSB) = 5 OP ON/OFF | +5/±15 vdc |
| 5036 | 9 OPS Counter Bits 1,2,3, Spare | Similar to IMP 5029; a counter circuit feeding the D/A converter increments at each 9 film drive OFF command that has been preceded by a 9 film drive ON command (14V WORD): Bit 1 (LSB) = No connection Bit 2 = 9 OPS counter Bit 1 Bit 3 = 9 OPS counter Bit 2 Bit 4 (MSB) = 9 OPS counter Bit 3 | +5/±15 vdc |

The circuit is a binary counter running from 0 to 7, resetting to 0 at the next pulse, and continuing.

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TABLE 3.2-6 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---|---|--------------|
| 5037 | 5 OPS Counter Bits 1,2,3 Spare | Similar to IMP 5036; counts the number of 5 film drive ON/OFF command pairs: Bit 1 (LSB) = No connection Bit 2 = 5 OPS counter Bit 1 Bit 3 = 5 OPS counter Bit 2 Bit 4 (MSB) = 5 OPS counter Bit 3 | +5/±15 vdc |
| 5005 | 9 FPLL Select Side A, 9 FPLL Select Side B, 5 FPLL Select Side A, 5 FPLL Select Side B | Similar to IMP 5029: Bit 1 (LSB) = 9 FPLL select Side A Bit 2 = 9 FPLL select Side B Bit 3 = 5 FPLL select Side A Bit 4 (MSB) = 5 FPLL select Side B | +5/±15 vdc |
| 5046 | Stereo Bit 1 Stored, Stereo Bit 2 Stored, CP Select A/B, FPLL Speed Range High/Normal | Similar to IMP 5029: Bit 1 (LSB) = Stereo Bit 1 stored Bit 2 = Stereo Bit 2 stored Bit 3 = CP select A/B Bit 4 (MSB) = FPLL speed range high/ normal | +5/±15 vdc |
| 5027 | FDS Bits 1,2,3,4 | Similar to IMP 5029: Bit 1 (LSB) = FDS Bit 1 (MSB) Bit 2 = FDS Bit 2 Bit 3 = FDS Bit 3 Bit 4 (MSB) = FDS Bit 4 | +5/±15 vdc |
| 5028 | FDS Bits 5,6,7,8 | Similar to IMP 5029: Bit 1 (LSB) = FDS Bit 5 Bit 2 = FDS Bit 6 Bit 3 = FDS Bit 7 Bit 4 (MSB) = FDS Bit 8 | +5/±15 vdc |

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TABLE 3.2-6 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|--|--|--------------|
| 5032 | PCM 1 ON/OFF, * PCM 2 ON/OFF, FDS Bits 9,10 | Similar to IMP 5029: Bit 1 (LSB) = PCM 1 ON/OFF Bit 2 = PCM 2 ON/OFF Bit 3 = FDS Bit 9 Bit 4 (MSB) = FDS Bit 10 (LSB) | +5/±15 vdc |
| 5024 | 9 Focus Drive Enable/ Inhibit, 9 Minus/Stop, 9 Plus/Stop, S1-PRG Disable/Enable | Similar to IMP 5029: 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 |
| 5007 | 5 Focus Drive Enable/ Inhibit, 5 Minus/Stop, 5 Plus/Stop, S1-PRG Cal ON/OFF | Similar to IMP 5029: 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 |
| 5033 | 9 NPA Prime/BU, 5 NPA Prime/BU, T/U Enable/Inhibit | Similar to IMP 5029: Bit 1 (LSB) = 5 NPA Prime/BU Bit 2 = 9 NPA Prime/BU Bit 3 = No connection Bit 4 (MSB) = T/U Enable/Inhibit | +5/±15 vdc |
| 5000 | 9 Slit Bits 1,2,3,4 | Similar to IMP 5029: Bit 1 (LSB) = 9 Slit Bit 1 (LSB) Bit 2 = 9 Slit Bit 2 Bit 3 = 9 Slit Bit 3 Bit 4 (MSB) = 9 Slit Bit 4 (MSB) | +5/±15 vdc |

*PCM is an alternate notation for DTU.

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| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|--|---|--------------|
| 5001 | 5 Slit Bits 1,2,3,4 | Similar to IMP 5029: Bit 1 (LSB) = 5 Slit Bit 1 (LSB) Bit 2 = 5 Slit Bit 2 Bit 3 = 5 Slit Bit 3 Bit 4 (MSB) = 5 Slit Bit 4 (MSB) | +5/±15 vdc |
| 5006 | 9 Slit Enable/Inhibit 9 Slit Select A/B, 5 Slit Enable/Inhibit 5 Slit Select A/B | Similar to IMP 5029: Bit 1 (LSB) = 9 Slit Enable/Inhibit Bit 2 = 9 Slit Select A/B Bit 3 = 5 Slit Enable/Inhibit Bit 4 (MSB) = 5 Slit Select A/B | +5/±15 vdc |
| 5047 | Data Tracks and SRC, 9 Enable/Inhibit 9 Enable/Disable, 5 Enable/Inhibit, 5 Enable/Disable | Similar to IMP 5029: Bit 1 (LSB) = 9 Enable/Inhibit Bit 2 = 9 Enable/Disable Bit 3 = 5 Enable/Inhibit Bit 4 (MSB) = 5 Enable/Disable | +5/±15 vdc |
| 5057 | Temperature, Camera Housing | A thermistor mounted on the +Z surface of the camera housing, centered on the X axis at approximately Station 79.2, monitors the internal temperature. The output is processed in the housing, producing a nonlinear signal from 30F (4.82 volts) to 100F (1.02 volts). | ±15 vdc |
| 5060 | Temperature, 5 Tilt Frame | A thermistor mounted on the outer side of the 5 tilt frame near the platen drive motor monitors the frame temperature. Processing circuitry is located in the camera housing. The output is linear from 60F (4.5 volts) to 80F (0.87 volt). | ±15 vdc |

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TABLE 3.2-6 (CONT'D)

| <u>IMP</u> | <u>TITLE</u> | <u>DESCRIPTION</u> | <u>POWER</u> |
|------------|---------------------------------------|---|--------------|
| 5061 | Temperature, 9 Tilt Frame | Similar to IMP 5060. The thermistor is mounted on the outer edge of the 9 tilt frame near the platen drive motor. | ±15 vdc |
| 5110 | Temperature, Corrector, Camera Spacer | A thermistor, mounted on the +Z surface of the RCFLA housing, monitors the temperature of the RCFLA assembly. Processing circuitry is located in the instrumentation processor, generating a linear signal from 60F (4.75 volts) to 80F (1.06 volts). | ±15 vdc |

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2.7 Command Summary

The following subsections summarize the commands controlling the 9 x 5 dual platen camera and film handling subsystem. For an explanation of command bit structure, refer to Part 3, Section 9.

2.7.1 CP Select Commands

CP A SELECT (N02663, N01663, N03663)

CP B SELECT (N02666, N01666, N03666)

Function: These commands choose the "A CHANNEL" or "B CHANNEL" electronics in the command processor for control of the crab servo and stereo servo. The commands also choose which CP channel will process the 9 OP and 5 OP commands.

Comments:

- (1) Both Channel A and Channel B circuits are completely capable of handling all servo and all 9 and 5 OP commands. They can be used interchangeably. Any combination of Decoder A or B, CP A or B, 9 FPLLE A or B, 5 FPLLE A or B, 9 Slit A or B and 5 Slit A or B may be used. There is no requirement to use all A's or all B's at the same time.
- (2) Erroneous instrumentation and reverse power control logic will result if the sides of the CP are switched while either 9 or 5 operational power is ON.

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2.7.2 Operational Power Commands

2.7.2.1 OP On

9 OP ON* (N12054, N11054, N13054)
 5 OP ON** (N12055, N11055, N13055)

Function: The OP ON commands switch camera operating power for the indicated camera systems. The following units receive power when the indicated commands are executed:

Stereo Servo (9 or 5 OP ON)
 Crab Servo (9 or 5 OP ON)
 9 FPLLE (9 OP ON)
 5 FPLLE (5 OP ON)
 Film Control Electronics (9 OP ON)
 Film Handling Electronics (5 OP ON)

If 9 SRC DISABLE or 5 SRC DISABLE have disabled an SRC mechanism, execution of OP ON for that system will reset the disabled SRC, allowing power application to the associated SRC, data track and interframe marker electronics.

Interlocks:

- (1) The OP ON command is required in a camera system to permit that system to operate; i.e., 9 OP ON for the 9 system and 5 OP ON for the 5 system.
- (2) Operational power for a system is required for take-up operation in that camera system. Film take-up requires 3.0 seconds (3.5 seconds for the 9 system when there is less than 500 feet, or more than 4000 feet of film on the spool, and the drive voltage is less than 24.5 vdc).

*9 OP ON will turn on the 9 T/U drive briefly. If the take-up loop is not empty, it will initiate a take-up cycle.

**5 OP ON will turn on the 5 supply drive briefly.

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- (3) Either the 9 or the 5 operational power must be ON for execution of crab or stereo angle changes commanded by a 13V WORD.
- (4) Commanding 5 OP ON will disable the 5 parking brake circuit. 5 OP OFF will remove the disable if the 5 parking brake power is OFF. Otherwise, the disable will not be removed until both 5 OP and 5 parking brake power are OFF.

2.7.2.2 OP Off

9 OP* OFF (N12050, N11050, N13050)
 5 OP** OFF (N12056, N11056, N13056)

Function: The indicated OP OFF commands remove camera operating power from:

9 FPLLE (9 OP OFF)
 5 FPLLE (5 OP OFF)
 Film Control Electronics (9 OP OFF)
 Film Handling Electronics (5 OP OFF)
 Stereo Servo (9 and 5 OP OFF)
 Crab Servo (9 and 5 OP OFF)

Interlocks: 5 OP OFF will enable the 5 parking brake circuit if the 5 parking brake power is OFF. Otherwise, the disable will not be removed until both 5 OP and 5 parking brake power are OFF.

2.7.2.3 Additional Commands Affecting Operational Power

The following commands, described in the subsections referenced, also control operational power in addition to other functions:

-
- *9 OP OFF will turn on the 9 T/U drive briefly, if 9 OP is already off.
 **5 OP OFF will turn on the 5 T/U drive briefly, if 5 OP is already off.

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| <u>Command</u> | <u>Subsection</u> |
|----------------|-------------------|
| 9/5 RUNOUT ON | 2.7.4.6 |
| 9 OFF | 2.7.4.7 |
| 5 OFF | 2.7.4.7 |
| 9/5 OFF | 2.7.4.7 |

2.7.3 5 Parking Brake

2.7.3.1 5 Parking Brake On

HEATER POWER AND 5 PARKING BRAKE ON (NO2661, NO1661, NO3661)

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

Interlocks: Commanding 5 OP ON or 9/5 RUNOUT ON will disable the 5 parking brake circuit. Removing 5 operational power (5 OP OFF; 9/5 OFF; 5 OFF) will remove the disable if the 5 parking brake power is OFF. Otherwise, the disable will not be removed until both 5 OP and 5 parking brake power are OFF.

2.7.3.2 5 Parking Brake Off

5 PARKING BRAKE OFF (NO2651, NO1651, NO3651)

Function: Removes power from the 5 parking brake.

Interlocks: 5 PARKING BRAKE OFF enables the 5 parking brake circuit if it was disabled by turning ON operational power and the 5 parking brake power was ON at the time 5 operational power was turned OFF.

2.7.3.3 5 Parking Brake On/Off (M6V WORD)

M6V002YZ (bits 35-37)

Function: This command controls the 5 parking brake, the DTU states, and the heater branch circuits.

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| <u>Bit No.</u> | <u>Function</u> |
|----------------|--|
| Implicit | Spare |
| 33-1 | DTU 1 ON |
| 33-0 | DTU 1 OFF |
| 34-1 | DTU 2 ON |
| 34-0 | DTU 2 OFF |
| 35-1 | 5 Parking Brake, and Heater Branches 1,2,4,5, and 6 ON |
| 35-0 | 5 Parking Brake, and Heater Branches 1,2,4,5, and 6 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: Commanding 5 OP ON or 9/5 RUNOUT ON will disable the 5 parking brake circuit. Removing 5 operational power (5 OP OFF, 9/5 OFF, 5 OFF) will remove the disable, if the 5 parking brake power is OFF. Otherwise, the disable will not be removed until both 5 OP and 5 parking brake power are OFF.

2.7.3.4 Additional Commands Affecting the 5 Parking Brake

The following commands, described in the referenced subsections also affect the 5 parking brake in addition to other functions:

| <u>Command</u> | <u>Subsection</u> |
|----------------|-------------------|
| 5 OP ON | 2.7.2.1 |
| 5 OP OFF | 2.7.2.2 |
| 9/5 RUNOUT ON | 2.7.4.6 |
| 9/5 OFF | 2.7.4.7 |
| 5 OFF | 2.7.4.7 |

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2.7.4 Film Drive Commands

2.7.4.1 FPLLE SELECT Commands

9 FPLLE A SELECT (N12037, N11037, N13037)
 9 FPLLE B SELECT (N12051, N11051, N13051)
 5 FPLLE A SELECT (N12052, N11052, N13052)
 5 FPLLE B SELECT (N12053, N11053, N13053)

Function: These commands assign subsequent commands for film-drive speed to two of the four frequency phase lock loop electronics channels for providing film drive and control when film drive is commanded by a 14V WORD.

Comments: Any combinations of Decoder A or B, CP CHANNEL A or B, 9 FPLLE A or B, 5 FPLLE A or B, 9 Slit A or B, and 5 Slit A or B may be used. There is no requirement to use all A's or all B's at the same time.

2.7.4.2 9/5 FPLLE NORMAL SPEED RANGE Command

(N12036, N11036, N13036)

Function: This command causes subsequent 14V WORD film drive commands to be executed within the low-speed ranges of the selected 9 and the selected 5 frequency phase lock loop electronics. This will result in film-drive speed commands being executed in the 3.37 to 11.8 inches per second range.

Comments:

- (1) The command may be given before or after the A or B FPLLEs are selected for each camera system.
- (2) Both the 9 and the 5 camera systems are set to the normal range by this command and will remain there until the HIGH SPEED RANGE is commanded.

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2.7.4.3 9/5 FPLLE HIGH SPEED RANGE Command

(N12034, N11034, N13034)

Function: This command causes subsequent 14V WORD film drive commands to be executed within the high-speed ranges of the selected 9 and the selected 5 frequency phase lock loop electronics. This will result in film-drive speed commands being executed in the 6.74 to 23.6 inches per second range.

Comments:

- (1) The command may be given before or after the A or B FPLLEs are selected for each camera system.
- (2) Both the 9 and the 5 camera systems are set to the high range by this command and will remain there until the NORMAL SPEED RANGE is selected.
- (3) The camera rate must not be allowed to exceed the take-up rate on long-strip photographs. Various combinations of film-drive speeds, supply voltages, and film quantities on take-ups can produce such a situation.

2.7.4.4 Film Drive ON/OFF (14V WORD)

14V WORD (14V4bbWXYZ, bits 25-38, Implicit)

Function: This command commences and terminates photography in the 9 and the 5 systems. Either system may be operated individually or both may be used simultaneously.

Only one film-drive speed (FDS) can be held in the CP at a given time. This FDS will be used by whichever system(s) is (are) operating. The command implicitly removes power from the 9 and 5 slit mechanism control electronics and inhibits both the 9 and the 5 take-up drives. The command also stores the stereo position to which the stereo mirror is to move upon receipt of a 13V WORD command.

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| <u>Bit No.</u> | <u>Function</u> | | | | | | | | | | | | | | | | | | |
|--------------------------------------|--|-------------------------------|-----------|-----------|------------------|--|--|-----------------|---|---|----------------|---|---|-------------|---|---|-------------|---|---|
| Implicit Bit | 9/5 Slit OFF, 9/5 Take-up Inhibit | | | | | | | | | | | | | | | | | | |
| 25-1 | 9 Film Drive (9 FPLLE) ON, 9 SRC ON, 9 Data Track and 9 Interframe Marker ON | | | | | | | | | | | | | | | | | | |
| 25-0 | 9 Film Drive (9 FPLLE) OFF, 9 SRC OFF, 9 Data Track and 9 Interframe Marker OFF | | | | | | | | | | | | | | | | | | |
| 26-1 | 5 Film Drive (5 FPLLE) ON, 5 SRC ON, 5 Data Track and 5 Interframe Marker ON | | | | | | | | | | | | | | | | | | |
| 26-0 | 5 Film Drive (5 FPLLE) OFF, 5 SRC OFF, 5 Data Track and 5 Interframe Marker OFF | | | | | | | | | | | | | | | | | | |
| 27-1 } 27-0 } 28-1 } 28-0 } | Stereo Position for the Stereo Mirror at Next 13V WORD: <table border="0" style="margin-left: 40px;"> <thead> <tr> <th style="text-align: left;"><u>Mirror Position Stored</u></th> <th style="text-align: center;"><u>27</u></th> <th style="text-align: center;"><u>28</u></th> </tr> <tr> <th style="text-align: left;"><u>(Degrees)</u></th> <th></th> <th></th> </tr> </thead> <tbody> <tr> <td>+8.65 (Forward)</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td>0.0 (Vertical)</td> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> </tr> <tr> <td>-8.65 (Aft)</td> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> </tr> <tr> <td>-8.65 (Aft)</td> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> </tr> </tbody> </table> | <u>Mirror Position Stored</u> | <u>27</u> | <u>28</u> | <u>(Degrees)</u> | | | +8.65 (Forward) | 0 | 0 | 0.0 (Vertical) | 0 | 1 | -8.65 (Aft) | 1 | 0 | -8.65 (Aft) | 1 | 1 |
| <u>Mirror Position Stored</u> | <u>27</u> | <u>28</u> | | | | | | | | | | | | | | | | | |
| <u>(Degrees)</u> | | | | | | | | | | | | | | | | | | | |
| +8.65 (Forward) | 0 | 0 | | | | | | | | | | | | | | | | | |
| 0.0 (Vertical) | 0 | 1 | | | | | | | | | | | | | | | | | |
| -8.65 (Aft) | 1 | 0 | | | | | | | | | | | | | | | | | |
| -8.65 (Aft) | 1 | 1 | | | | | | | | | | | | | | | | | |
| 29-1 } 29-0 } | Film-Drive Speed Bit 10 (LSB) | | | | | | | | | | | | | | | | | | |
| 30-1 } 30-0 } | Film-Drive Speed Bit 9 | | | | | | | | | | | | | | | | | | |
| 31-1 } 31-0 } | Film-Drive Speed Bit 8 | | | | | | | | | | | | | | | | | | |
| 32-1 } 32-0 } | Film-Drive Speed Bit 7 | | | | | | | | | | | | | | | | | | |
| 33-1 } 33-0 } | Film-Drive Speed Bit 6 | | | | | | | | | | | | | | | | | | |
| 34-1 } 34-0 } | Film-Drive Speed Bit 5 | | | | | | | | | | | | | | | | | | |
| 35-1 } 35-0 } | Film-Drive Speed Bit 4 and SRC Bit 4 (LSB) | | | | | | | | | | | | | | | | | | |

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| <u>Bit No.</u> | <u>Function</u> |
|------------------|--|
| 36-1 } 36-0 } | Film-Drive Speed Bit 3 and SRC Bit 3 |
| 37-1 } 37-0 } | Film-Drive Speed Bit 2 and SRC Bit 2 |
| 38-1 } 38-0 } | Film-Drive Speed Bit 1 (MSB) and SRC Bit 1 (MSB) |

Interlocks:

- (1) No film motion will occur unless 9 OP ON or 5 OP ON is provided for that system in which film drive is commanded. The stereo mirror position will be stored, however, and the SRC will function for the commanded system.
- (2) The 9/5 TAKE-UP INHIBIT will be overridden in a system if a low-tension condition is encountered or if the take-up side of a storage looper reaches electrically full. The 9/5 TAKE-UP INHIBIT will also be overridden by execution of a 9/5 TAKE-UP ENABLE command after execution of the 14V WORD.

Comments:

- (1) The film drive requires 0.30 second (nominal) after the command reaches the PPS/DP EAC to achieve acceptable drive smoothness. During this time, the SRC mechanism can move four steps. If a change of more than four steps in the SRC is required, it should be accomplished before the film motion begins or focus degradation will occur as the SRC is moving. This can be accomplished by leaving the operational power for a system OFF and requesting film drive for that system with a 14V WORD command. Another 14V WORD or 13V WORD command must then be used to request film drive OFF after the SRC move has been completed.
- (2) The 14V WORD is the only command which can be used to provide the stereo mirror position information to the PPS/DP EAC.
- (3) The 14V WORD is the only command which can be used to commence photography in either system.

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2.7.4.5 9/5 Camera Off (13V WORD)

13V WORD (13V2bWXYZ, bits 27-31, Implicit)

Function:

- (1) This command implicitly terminates photography in both the 9 and the 5 systems by resetting the 9 and 5 film-drive command memories to OFF. It also removes power from the 9 and 5 SRCs, and the 9 and 5 data tracks and interframe markers.
- (2) The stereo servo will move to the position stored by the last 14V WORD command and the crab servo will move to the crab angle specified. Bits 27-30 of the 13V WORD command specify the crab angle to be executed. Bit 31 provides the polarity of the desired crab angle.

13V WORD Command Bits

| <u>Bit No.</u> | <u>Function</u> |
|---------------------|--|
| Implicit Bit: | 9 and 5 Film Drive OFF 9 and 5 SRCs OFF 9 and 5 Data Track and Inter- frame Markers OFF Stereo Mirror Drive ON |
| 26 | No Function in PPS/DP EAC |
| 27 | Crab Angle (LSB) |
| 28 | Crab Angle |
| 29 | Crab Angle |
| 30 | Crab Angle (MSB) |
| 31 | Crab Polarity |
| 32 through 38 | No Function in PPS/DP EAC |

For crab angle vs command-bit pattern, refer to Table 3.4-2 in Part 3, Section 4.

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Interlocks:

- (1) This command requires either 9 OP ON or 5 OP ON for execution of crab and stereo positions.
- (2) The stereo mirror stereo angle position given in the last 14V WORD will be executed by this command.

Comments:

- (1) 3.0 seconds are required for stereo angle transitions between extremes (forward/aft), 2.0 seconds between adjacent positions (aft/vertical or forward/vertical).
- (2) Crab angle transition requires 3.0 seconds for one step. Each additional step requires 2.5 seconds.
- (3) Due to system design, it is possible to more accurately achieve a desired crab angle by approaching the desired crab step from a certain direction (reference Part 3, Section 4).
- (4) The 13V WORD is the only command which executes crab and stereo mirror changes.

2.7.4.6 9/5 RUNOUT ON Command (MCS)

(MP00046)

Function: This command provides power to the:

Stereo Servo

Crab Servo

9 FPLLE

Film Control Electronics

5 FPLLE

Film Handling Electronics

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It selects the normal speed range of film-drive speeds and selects "1" for the two most significant film-drive speed bits. It turns ON the 9 and the 5 FPLLEs producing film drive in both systems between step 768 (9.70 in./sec) and step 1023 (11.8 in./sec).

Interlocks:

- (1) Runout can be halted by commanding 9 OFF (MN00122) and 5 OFF (MN00124) or 9/5 OFF (MN00773).
- (2) Runout can also be negated by the ECS 13V WORD or 14V WORD commands together with 9 OP OFF and 5 OP OFF.
- (3) Application of power to the film handling electronics (5 operational power) disables the 5 parking brake circuitry. Removing 5 OP will remove the disable if the 5 parking brake power is OFF. Otherwise, the disable will not be removed until both 5 OP and 5 parking brake power are OFF.

Comment: The 9/5 RUNOUT ON command does not enable the SRC, data track, and interframe marker circuitry.

2.7.4.7 POWER OFF Commands (MCS)

9 OFF (MN00122)
 5 OFF (MN00124)
 9/5 OFF (MN00773)

Function: These commands remove power from the:

- Stereo Servo (9 OFF and 5 OFF, 9/5 OFF)
- Crab Servo (9 OFF and 5 OFF, 9/5 OFF)
- Focus Sensor Electronics (9 OFF, 5 OFF, 9/5 OFF)
- 9 FPLLE (9 OFF, 9/5 OFF)
- 5 FPLLE (5 OFF, 9/5 OFF)

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Film Control Electronics (9 OFF, 9/5 OFF)

Film Handling Electronics (5 OFF, 9/5 OFF)

S1-PRG (9 OFF, 5 OFF, 9/5 OFF)

Interlocks: Removing power from the film handling electronics (5 OP) enables the 5 parking brake circuitry, if the 5 parking brake power is OFF. Otherwise, the disable will not be removed until both 5 OP and 5 parking brake power are OFF.

2.7.5 Take-up Control Commands

2.7.5.1 9/5 TAKE-UP ENABLE Command

(N02653, N01653, N03653)

Function: This command allows both the film control electronics (9) and the film handling electronics (5) to transfer film from the take-up sides of the associated loopers to the take-ups and to refill the supply sides of the loopers from the supply spools. The transfer will only take place on a looper whose supply side is not electrically full of unexposed film. The take-up will again be inhibited when its looper is filled, or if any 14V WORD command is executed while the supply looper is filling.

If the supply side of a looper is in the electrically full state when 9/5 TAKE-UP ENABLE is commanded, the take-up associated with that looper will remain inhibited.

Interlocks:

- (1) 9 OP ON and 5 OP ON are required until completion of a take-up operation in the indicated camera system.
- (2) Each time a 14V WORD is executed, both the 9 and the 5 take-ups will be inhibited until a 9/5 TAKE-UP ENABLE command is executed. (The inhibit will be overridden in one camera system if the

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film tension is low, or if the take-up side of a looper reaches electrically full.)

- (3) In long strip activity, only the first 9/5 TAKE-UP ENABLE command following a 14V command will be effective; a 14V TAKE-UP INHIBIT is required between consecutive 9/5 TAKE-UP ENABLE commands.

Comments:

- (1) A take-up cycle requires a maximum of 3.0 seconds to completely fill the supply side of the looper from the electrically empty state with the film drive not operating (3.5 seconds for the 9 system when there is less than 500 feet or more than 4000 feet of film on the spool, and the drive voltage is less than 24.5 vdc).
- (2) If a 9/5 TAKE-UP ENABLE is not received before the take-up side of a looper reaches electrically full, the take-up associated with that looper will activate, emptying only that looper. Such a sequence may degrade high-resolution photography.

2.7.5.2 Splice and Cut Commands

9 SPLICE AND CUT (P02766, P01766, P03766)

5 SPLICE AND CUT (P02573, P01573, P03573)

Function: These commands fire the pyros which initiate the respective splicer mechanisms. They cut the film going into SRV 1 and splice the film coming from the loopers to the leaders going to SRV 2. They also connect the respective take-up control signals to SRV 2.

Interlocks: The commands enable 9 ROLL-IN TERMINATE and 5 ROLL-IN TERMINATE.

Constraints: The film must be stationary for execution of these commands. Tension should be removed from the splice shortly after command execution (typically within 10 minutes).

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After execution of the first SPLICE AND CUT, the loose tail of the film must be rolled into SRV 1 before any film is moved in the other system. The tail must also be rolled into SRV 1 prior to execution of the SPLICE AND CUT for the other system. These actions will prevent damage to either the 9 or 5 film strands in the tunnel where they move in close proximity to one another.

Comments: Since the take-up control signals are connected to both SRV 1 and SRV 2 by this command, roll-in of the cut film ends into SRV 1 is accomplished as the take-ups are operated in SRV 2.

2.7.5.3 Roll-in Terminate Commands

9 ROLL-IN TERMINATE (N02652, N01652, N03652)

5 ROLL-IN TERMINATE (N02752, N01752, N03752)

Function: These commands remove the indicated take-up control signals from SRV 1.

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

Comments: These commands are irreversible.

The commands should not be given until the cut ends of film have been run into SRV 1 after 9 or 5 SPLICE AND CUT. This will prevent cutting off the last length of film when CUT AND SEAL 1 is given to prepare SRV 1 for recovery. The lengths of film to be rolled in are approximately 8.5 feet of 9.5-inch wide film and 11 feet of 5-inch wide film.

2.7.5.4 Additional Commands Affecting Take-up Operation

The following commands, described in the subsections referenced also control or affect take-up operation in addition to other functions:

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| <u>Command</u> | <u>Subsection</u> |
|------------------------------|-------------------|
| 14V WORD (Film Drive ON/OFF) | 2.7.4.4 |
| 9/5 RUNOUT ON | 2.7.4.6 |
| 9 OFF | 2.7.4.7 |
| 5 OFF | 2.7.4.7 |
| 9/5 OFF | 2.7.4.7 |
| 9 OP OFF | 2.7.2.2 |
| 5 OP OFF | 2.7.2.2 |

2.7.6 Variable Exposure Mechanism (Slit Mechanism) Commands

2.7.6.1 Slit Select Commands

9 SLIT A SELECT (N12035, N11035, N13035)

9 SLIT B SELECT (N12033, N11033, N13033)

5 SLIT A SELECT (N12031, N11031, N13031)

5 SLIT B SELECT (N12027, N11027, N13027)

Function: These commands assign subsequent slit drive commands to two of the four slit control electronics circuits in the 9 and 5 camera electronics assemblies.

Comments: Any combinations of Decoder A or B, CP CHANNEL A or B, 9 FPLLE A or B, 5 FPLLE A or B, 9 Slit A or B and 5 Slit A or B may be used. There is no requirement to use all A's or all B's at the same time.

2.7.6.2 9 Slit Command

(4V0272bZ, 4V0172bZ, 4V0372bZ)

Function: This command implicitly provides power to the 9 variable exposure mechanism control electronics (A or B) and moves the slit to the position indicated by bits 35 to 38 of the command:

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| Bit | | | | Slit No. | Slit Width (Nominal) Inches |
|-------------|----|----|-------------|----------|--------------------------------|
| 35 (LSB) | 36 | 37 | 38 (MSB) | | |
| 0 | 0 | 0 | 0 | 1 | 0.0040 |
| 1 | 0 | 0 | 0 | 2 | 0.0054 |
| 0 | 1 | 0 | 0 | 3 | 0.0072 |
| 1 | 1 | 0 | 0 | 4 | 0.0094 |
| 0 | 0 | 1 | 0 | 5 | 0.0126 |
| 1 | 0 | 1 | 0 | 6 | 0.0168 |
| 0 | 1 | 1 | 0 | 7 | 0.0224 |
| 1 | 1 | 1 | 0 | 8 | 0.0300 |
| 0 | 0 | 0 | 1 | 9 | 0.0400 |
| 1 | 0 | 0 | 1 | 10 | 0.0534 |
| 0 | 1 | 0 | 1 | 11 | 0.0712 |
| 1 | 1 | 0 | 1 | 12 | 0.0948 |
| 0 | 0 | 1 | 1 | 13 | 0.1266 |
| 1 | 0 | 1 | 1 | 14 | 0.1686 |
| 0 | 1 | 1 | 1 | 15 | 0.2250 |
| 1 | 1 | 1 | 1 | 16 | 0.3000 |

Interlocks:

- (1) The execution of a 14V WORD command removes power from the 9 slit control electronics.
- (2) 9 OP ON is not required for execution of this command.

Comments: 1.0 second is required to attain the next wider or narrower slit. The execution of a 14V WORD will stop the variable exposure mechanism in transit if sufficient time has not been allowed for completion of the commanded move. The move can be continued while the camera is operating by giving the 4V command again.

2.7.6.3 5 Slit Command

(4V0262bZ, 4V0162bZ, 4V0362bZ)

Function: This command implicitly provides power to the 5 variable exposure mechanism control electronics (A or B) and moves the variable mechanism to the position indicated by bits 35 to 38 of the command:

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| <u>35</u> (LSB) | <u>Bit</u> | | <u>38</u> (MSB) | <u>Slit No.</u> | <u>Slit Width (nominal)</u> Inches |
|--------------------|------------|-----------|--------------------|-----------------|---------------------------------------|
| | <u>36</u> | <u>37</u> | | | |
| 0 | 0 | 0 | 0 | 1 | 0.0040 |
| 1 | 0 | 0 | 0 | 2 | 0.0054 |
| 0 | 1 | 0 | 0 | 3 | 0.0072 |
| 1 | 1 | 0 | 0 | 4 | 0.0094 |
| 0 | 0 | 1 | 0 | 5 | 0.0126 |
| 1 | 0 | 1 | 0 | 6 | 0.0168 |
| 0 | 1 | 1 | 0 | 7 | 0.0224 |
| 1 | 1 | 1 | 0 | 8 | 0.0300 |
| 0 | 0 | 0 | 1 | 9 | 0.0400 |
| 1 | 0 | 0 | 1 | 10 | 0.0534 |
| 0 | 1 | 0 | 1 | 11 | 0.0712 |
| 1 | 1 | 0 | 1 | 12 | 0.0948 |
| 0 | 0 | 1 | 1 | 13 | 0.1266 |
| 1 | 0 | 1 | 1 | 14 | 0.1686 |
| 0 | 1 | 1 | 1 | 15 | 0.2250 |
| 1 | 1 | 1 | 1 | 16 | 0.3000 |

Interlocks:

- (1) The execution of any 14V WORD command removes power from the 5 slit control electronics.
- (2) 5 OP ON is not required for execution of this command.

Comments:

1.0 second is required to attain the next wider or narrower slit. The execution of a 14V WORD will stop the variable exposure mechanism in transit if sufficient time has not been allowed for completion of the commanded move. The move can be continued while the camera is operating by giving the 4V command again.

2.7.6.4 9/5 Slit Off (Implicit)

Execution of any 14V WORD command (subsection 2.7.4.4) removes power from both the 9 and 5 variable exposure mechanism electronics.

2.7.7 Slant Range Compensation Commands

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2.7.7.1 SRC ON/OFF (14V WORD)

(14V4bbWXYZ, bits 25-26, 35-38)

Function: Refer to subsection 2.7.4.4 for the 14V WORD bit usage.

Slant range compensation platen adjustments are determined by the four most significant film-drive speed bits. This SRC adjustment is implicit with the 14V WORD CAMERA ON command. Both 9 and the 5 systems have their own SRC electronics. Only that camera system being commanded will make an SRC adjustment. The SRC has 16 discrete positions over a 4.5-mil range.

The nominal rate is four steps in 0.20 second. If more than four SRC steps are required prior to high-resolution photography, either the film drive may be turned ON early (using additional film), or the 14V WORD CAMERA ON word may be given while the operating power for that system is turned OFF (9 or 5 OP OFF). This will permit SRC adjustment without moving film.

SRC step 10 corresponds to the nominal platen position. From step 10, the moves programmed by the SRC system are as follows:

| <u>SRC Step No.</u> | <u>Relative Platen Position (Mils)*</u> | <u>Associated FDS Step No.</u> | <u>14V FDS Bits LSB-35 to MSB-38</u> |
|---------------------|---|--------------------------------|--------------------------------------|
| 1 | +2.7 | 0 through 63 | 0000 |
| 2 | +2.4 | 64 through 127 | 1000 |
| 3 | +2.1 | 128 through 191 | 0100 |
| 4 | +1.8 | 192 through 255 | 1100 |
| 5 | +1.5 | 256 through 319 | 0010 |
| 6 | +1.2 | 320 through 383 | 1010 |
| 7 | +0.9 | 384 through 447 | 0110 |
| 8 | +0.6 | 448 through 511 | 1110 |
| 9 | +0.3 | 512 through 575 | 0001 |
| 10 | Nominal Zero | 576 through 639 | 1001 |
| 11 | -0.3 | 640 through 703 | 0101 |
| 12 | -0.6 | 704 through 767 | 1101 |
| 13 | -0.9 | 768 through 831 | 0011 |
| 14 | -1.2 | 832 through 895 | 1011 |
| 15 | -1.5 | 896 through 959 | 0111 |
| 16 | -1.8 | 960 through 1023 | 1111 |

*Note: (+) is aft, toward the Ross Corrector

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Interlocks: 9 SRC DISABLE and 5 SRC DISABLE commands prevent operation of the SRC drive and the data tracks and interframe markers in their respective systems. 9 SRC DISABLE is removed by commanding 9 OP ON; 5 SRC DISABLE is removed by commanding 5 OP ON.

Comments: The SRC is designed to operate in the NORMAL SPEED RANGE. This fact must be accounted for when determining platen position during utilization of the 9/5 FPLLE HIGH SPEED RANGE.

2.7.7.2 9/5 SRC OFF (13V WORD)

(13V2bWXYZ, bits 27-31, Implicit)

Function: The 13V WORD implicit bit removes power from the 9 and 5 SRC circuits, and the 9 and 5 data tracks and interframe markers. Additional functions of the 13V WORD (camera off) command can be found in subsection 2.7.4.5.

2.7.7.3 SRC Disable Commands

9 SRC DISABLE (N02665, N01665, N03665)

5 SRC DISABLE (N02654, N01654, N03654)

Function: These commands prevent power application to the respective slant range compensation, data track and interframe marker electronics.

Interlocks: An SRC DISABLE command is reset by an OP ON command in the same camera system; i.e.,

9 OP ON resets 9 SRC DISABLE

5 OP ON resets 5 SRC DISABLE

Comments: In addition to the loss of slant range compensation, data track and interframe marker information from the camera concerned will also be lost when an SRC DISABLE is used.

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2.7.7.4 SRC Disable Reset

The operational power ON commands, 9 OP ON and 5 OP ON (subsection 2.7.2.1), reset the SRC DISABLE circuitry in the respective systems when executed. In so doing, the OP ON command also enables the data track and interframe marker circuitry in that system.

2.7.8 Focus Adjustment (NPA) Commands

2.7.8.1 NPA Prime Mode Select Commands

9 NPA PRIME MODE SELECT (N12017, N11017, N13017)

5 NPA PRIME MODE SELECT (N12015, N11015, N13015)

Function: These commands choose the prime mode for execution of platen motion commands. The prime mode electronics can handle all nominal platen adjustment (NPA) commands, both NSPCs and RTCs.

Comments:

- (1) The NPA mode (prime or backup) should be chosen prior to commanding 9 FOCUS DRIVE ENABLE or 5 FOCUS DRIVE ENABLE.
- (2) The NPA prime mode may be used as a backup in the event of an SRC failure, although the NPA prime mode movement rate is considerably slower than the SRC.

2.7.8.2 NPA Backup Mode Select Commands

9 NPA BACKUP MODE SELECT (N12016, N11016, N13016)

5 NPA BACKUP MODE SELECT (N12022, N11022, N13022)

Function: These commands choose the backup mode for execution of platen motion commands. Only real time commands (RTCs) can be handled by the backup mode electronics.

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Comments: The NPA mode (prime or backup) should be chosen or verified prior to commanding 9 FOCUS DRIVE ENABLE or 5 FOCUS DRIVE ENABLE.

2.7.8.3 Focus Drive Enable Commands

9 FOCUS DRIVE ENABLE (P02767, P01767, P03767)

5 FOCUS DRIVE ENABLE (P02564, P01564, P03564)

Function: These commands provide power to the 9 and 5 focus drive electronics, both prime and backup, in the respective camera electronics assemblies.

Interlocks: The 9 FOCUS DRIVE ENABLE command is required for execution of:

9 PLATEN PLUS (N12023, N11023, N13023)

9 PLATEN MINUS (N12025, N11025, N13025)

9 PLATEN STOP (N12026, N11026, N13026)

9 PLATEN PLUS (R12, R11)

9 PLATEN MINUS (R22, R21)

The 5 FOCUS DRIVE ENABLE command is required for execution of:

5 PLATEN PLUS (N12020, N11020, N13020)

5 PLATEN MINUS (N12021, N11021, N13021)

5 PLATEN STOP (N12024, N11024, N13024)

5 PLATEN PLUS (R02, R01)

5 PLATEN MINUS (R52, R51)

Comments: The mode (prime or backup) should be determined prior to enabling the drive.

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2.7.8.4 Focus Drive Inhibit Commands

9 FOCUS DRIVE INHIBIT (N12030, N11030, N13030)

5 FOCUS DRIVE INHIBIT (N12032, N11032, N13032)

Function: These commands remove power from the 9 and 5 focus drive electronics respectively, both prime and backup.

Interlocks: These commands prevent execution of any platen motion commands in the indicated systems.

2.7.8.5 Platen Plus Commands

9 PLATEN PLUS (N12023, N11023, N13023)

5 PLATEN PLUS (N12020, N11020, N13020)

Function: These commands initiate effective motion of the indicated film platen in the plus direction (positive reference: toward Ross Corrector). The movement is 0.1 mil for each 0.2 second the command is in effect (0.5 mil/second). The commands can only be executed in the prime mode.

Interlocks:

- (1) The 9 PLATEN PLUS command requires 9 NPA PRIME MODE SELECT and 9 FOCUS DRIVE ENABLE for execution. The 5 PLATEN PLUS command requires 5 NPA PRIME MODE SELECT and 5 FOCUS DRIVE ENABLE for execution.
- (2) Platen motion will continue until 9 PLATEN STOP or 5 PLATEN STOP are received. (9 FOCUS DRIVE INHIBIT and 5 FOCUS DRIVE INHIBIT will also stop the motion, but the motion will continue when the focus drives are again enabled.) PLATEN STOP must follow a PLATEN PLUS before motion can be initiated in the opposite direction.

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Comments: A platen is not protected from being driven to mechanical stops on either end of its 24-mil range. No catastrophic damage would result from such action.

2.7.8.6 Platen Minus Commands

9 PLATEN MINUS (N12025, N11025, N13025)

5 PLATEN MINUS (N12021, N11021, N13021)

Function: These commands initiate effective motion of the indicated film platen in the minus direction (away from the Ross Corrector). The movement is 0.1 mil for each 0.2 second the command is in effect (0.5 mil/second). The commands can only be executed in the prime mode.

Interlocks:

- (1) The 9 PLATEN MINUS command requires 9 NPA PRIME MODE SELECT and 9 FOCUS DRIVE ENABLE for execution. The 5 PLATEN MINUS command requires 5 NPA PRIME MODE SELECT and 5 FOCUS DRIVE ENABLE for execution.
- (2) Platen motion will continue until 9 PLATEN STOP or 5 PLATEN STOP are received. (9 FOCUS DRIVE INHIBIT or 5 FOCUS DRIVE INHIBIT will also stop the motion, but the motion will be continued when the focus drives are once again enabled.) PLATEN STOP must follow a PLATEN MINUS before motion can be initiated in the opposite direction.

Comments: A platen is not protected from being driven to mechanical stops on either end of its 24-mil range. No catastrophic damage would result from such action.

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2.7.8.7 Platen Stop Commands

9 PLATEN STOP (N12026, N11026, N13026)

5 PLATEN STOP (N12024, N11024, N13024)

Function:

- (1) These commands terminate motion of the 9 and 5 film platens.
- (2) The commands stop the platen motion which was initiated by 9 PLATEN PLUS, 9 PLATEN MINUS, 5 PLATEN PLUS, or 5 PLATEN MINUS commands in the prime mode.

Comments: The PLATEN STOP commands will reset the real time command receipt relays in the command processor, if set by an RTC. Execution of PLATEN STOP must follow a platen direction command before motion can begin in the opposite direction. However, the PLATEN STOP command should not be given when using RTC commands until all RTCs have been executed.

2.7.8.8 Platen Plus Commands (RTC)

9 PLATEN PLUS (R12, R11)

5 PLATEN PLUS (R02, R01)

Function: These commands initiate effective incremental motion of the indicated film planes in the plus direction (toward the Ross Corrector). Platen motion will continue as long as PLATEN PLUS command pulses are received. In the prime mode, each real time command will cause a 0.1 mil movement. In the backup mode, each real time command will move the platen 0.025 mil. Backup mode commands must be sent in groups of four, resulting in an adjust rate of one 0.1 mil step in 0.8 second (four command pulses).

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Interlocks: The commands require 9 FOCUS DRIVE ENABLE or 5 FOCUS DRIVE ENABLE for execution. They can be executed by either the prime or backup mode electronics, but adjustment rates are different in each mode. PLATEN STOP must follow a PLATEN PLUS before motion can be initiated in the opposite direction.

Comments: A platen is not protected from being driven to mechanical stops on either end of its 24-mil range. No catastrophic damage will result from such action.

Although each RTC pulse in the backup mode moves the platen 0.025 mil, ambiguous positioning can result if commands are given in other than multiples of four.

2.7.8.9 Platen Minus Commands (RTC)

9 PLATEN MINUS (R22, R21)

5 PLATEN MINUS (R52, R51)

Function: These commands initiate effective incremental motion of the indicated film planes in the minus direction (away from the Ross Corrector). Platen motion will continue as long as PLATEN MINUS command pulses are received. In the prime mode, each real time command will cause a 0.1 mil movement. In the backup mode, each real time command will move the platen 0.025 mil. Backup mode commands should be sent in groups of four, resulting in an adjust rate of 0.1 mil in 0.8 second (four command pulses).

Interlocks: The commands require 9 FOCUS DRIVE ENABLE or 5 FOCUS DRIVE ENABLE for execution. They can be executed by either the prime or backup mode electronics, but adjustment rates are different in each mode. PLATEN STOP must follow a PLATEN MINUS before motion can be initiated in the opposite direction.

Comments: A platen is not protected from being driven to mechanical stops on either end of its 24-mil range. No catastrophic damage will result from such action.

Although each RTC pulse in the backup mode moves the platen 0.025 mil, ambiguous positioning can result if commands are given in other than multiples of four.

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3.0 OPTICAL SUBSYSTEM

The PPS/DP EAC optical subsystem incorporates a lens (designated R-5) and a movable folding mirror (the stereo mirror) to produce a highly corrected image of a distant moving scene. The R-5 lens uses an aspheric mirror as the primary converging element and uses a set of five smaller refractive elements (the Ross corrector and field lens assembly (RCFLA)) to provide optical correction over an extended field. The stereo mirror is an elliptical shaped, reflecting element which is used to redirect the optical line-of-sight (LOS); it has no optical function other than redirection of the input light rays.

Additional optical elements are mounted in the dual platen camera housing but are not considered components of the optical subsystem. They include the stationary (5 folding) mirror (Part 3, Section 2) and the focus sensor assembly optics (Part 3, Section 6).

3.1 Optical Subsystem Configuration

The basic configuration of the lens and stereo mirror is illustrated in Figure 3.3-1. The folding mirror associated with the 5 film platen is included for reference purposes only.

The R-5 lens has a 175-inch effective focal length* with a nominal $f/4.02$ relative aperture. The telephoto ratio, which is the ratio of the overall length to the focal length, is 1.085. The back focal length, or the distance

*Due to the optical characteristics of the RCFLA, the effective focal length is considerably shorter than the physical length of the optical subsystem.

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from the -X surface of the number 5 Ross lens to the focal plane is 5.756 inches (infinity conjugate). Table 3.3-1 summarizes the R-5 lens formula characteristics. Refractive indices of the lens materials used are listed in Table 3.3-2.

3.2 Elements of the Optical Subsystem

To illustrate the contribution of each component of the optical subsystem, the characteristics and functions of the primary and stereo mirrors and of the RCFLA are treated individually in the following sections. A summary of the physical characteristics of the optical subsystem is presented in Table 3.3-3. The optical properties of the subsystem are summarized in Table 3.3-4.

3.2.1 Stereo Mirror

The stereo mirror is a flat, ultra-low-expansion (ULE), silica element with a highly reflective front surface coating of silver and lanthanum oxide. Because of its size, a honeycomb type of construction is used to save weight. The mirror is a movable optical element which has two degrees of freedom (crab and stereo), and provides the ability to redirect the line-of-sight (LOS) at approximate right angles to the lens axis. Movement in crab is used to align the image and film velocity vectors. Stereo movement provides the ability to acquire a stereoscopic image of a scene.

The mirror is suspended by lateral axles in spherical bushings so that bending stresses cannot be introduced into the mirror through the suspension. The axles (trunnions) are fixed to pillow blocks attached to a magnesium yoke as described in Part 3, Section 1. The crab servo, mounted on the aft face of the COA double bulkhead, is connected to the yoke by a lead screw and nut. Travel of the nut (which is attached to the yoke) causes the yoke

3.3-5

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TABLE 3.3-1
R-5 OPTICAL FORMULA

| Element | Surface* | Radius | Clear Aperture | | Glass** Type | Center* Thickness | Center* Spacing |
|---------|----------|--------------|----------------|-------|-----------------|----------------------|--------------------|
| | | | Y Dia | Z Dia | | | |
| Asphere | 1 | -383.7910(1) | 43.50 | - | - | - | 162.4660(S1) |
| Lens 1 | 2 | -188.4970 | 14.92 | 6.72 | SK-14 | 1.0569(T1) | |
| | 3 | +65.9500 | 14.86 | 6.60 | | | 0.0718(S2) |
| Lens 2 | 4 | -15.8105 | 14.07 | 6.48 | SK-14 | 1.9694(T2) | 0.0875(S3) |
| | 5 | +203.6580 | 13.95 | 5.99 | | | |
| Lens 3 | 6 | +141.6670 | 13.91 | 5.94 | LaKN-14 | 0.4400(T3) | 16.0660(S4) |
| | 7 | -13.0786 | 12.69 | 5.72 | | | |
| Lens 4 | 8 | +21.5360 | 10.33 | 3.02 | LaKN-14 | 0.4229(T4) | 0.1261(S5) |
| | 9 | -66.9137 | 10.46 | 2.99 | | | |
| Lens 5 | 10 | -31.1467 | 10.57 | 2.99 | SK-14 | 1.4071(T5) | 5.7560(S6) |
| | 11 | +19.6411 | 10.58 | 2.91 | | | |
| - | Image | - | - | - | - | - | |

3.3-6

*As defined on Figure 3.3-1.
**Glass types are Schott designations

$$(1) \text{ Aspheric Surface Sag} = \frac{CS^2}{1 + \sqrt{1 - (1 - E^2)C^2 S^2}} + 1.872098 \times 10^{-13} S^6$$

where C = $\frac{1}{\text{Radius}}$
S = Distance From Vertex
E² = 1.857249

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R-5 REFRACTIVE INDICESSchott Glass Type

| <u>Wavelength (nm)</u> | <u>SK-14</u> | <u>LaKN-14</u> |
|------------------------|--------------|----------------|
| 486.1 | 1.610029 | 1.705546 |
| 516.7 | 1.607513 | 1.702362 |
| 546.1 | 1.605482 | 1.699796 |
| 587.6 | 1.603108 | 1.696797 |
| 623.4 | 1.601412 | 1.694656 |
| 656.3 | 1.600073 | 1.692966 |
| 686.9 | 1.598978 | 1.691584 |

Note: Glass indices are Schott catalog values.

3.3-7

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TABLE 3.3-3
OPTICAL SYSTEM PHYSICAL CHARACTERISTICS SUMMARY

| | |
|--|--|
| Overall Length | 189.9 inches |
| Asphere to Ross Length | 162.466 inches |
| Back Focal Length | 5.756 inches |
| Aperture Diameter (nominal) | 43.5 inches |
| Measured Weight | |
| Ross Corrector and Field Lens Assembly | 96 pounds |
| Primary Mirror Assembly | 347 pounds |
| Stereo Mirror (including mounts) | 456 pounds |
| Stereo Yoke Mechanism | 44 pounds |
| Internal Structure (tube + box beams) | 473 pounds |
| Total | 1416 pounds |
| Stereo Mirror | |
| External Shape | Elliptical, 58-inch major axis by 46-inch minor axis |
| Central Hole | Rectangular, 17.0 inches long by 9.8 inches wide |

3.3-8

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OPTICAL PROPERTIES SUMMARY

| | | |
|--|--|------|
| Effective Focal Length | 175 inches | |
| Aperture Diameter (primary mirror) | 43.5 inches | |
| <u>f</u> -number* | 4.02 nominal 4.46 effective - forward 4.30 effective - nadir 4.22 effective - aft | |
| Type | Aspheric reflector with five-element Ross corrector | |
| Configuration | Optical path folded by stereo mirror; optical axis passes through stereo mirror | |
| Semi-field Angle | 1.45 degrees - 9 subsystem 0.74 degree - 5 subsystem | |
| Percent Obstruction* (central and edge) | 12.4 (nadir) | |
| Clear Aperture Transmittance | 84 percent | |
| Typical T-numbers* | 5.0 (forward) 4.8 (nadir) 4.7 (aft) | |
| Stereo Angle of Line-of-Sight (with respect to nadir) | -8.65, 0, +8.65 degrees | |
| Depth of Focus* | ±0.00072 inch (Rayleigh criterion) | |
| Crab-angle Range | -3.85 to +3.85 degrees | |
| Optical Quality Factor* | 85 percent (minimum) | |
| Peak Static Resolution* | <input type="text"/> lines/mm (geometric mean)** | 25X1 |

*Values are quoted with respect to the 9 subsystem image plane. Values at the 5 subsystem image plane differ slightly.

**Based on 2:1 contrast at film plane, 85 percent OQF; threshold modulation = $0.017 + 3.7 \times 10^{-4} \nu$.

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to rotate about the crab axis for crab adjustment over a nominal range of ± 3.85 degrees. This rotation of the stereo mirror relative to the film platen axis produces a rotation of the image velocity vector and a deviation of the line-of-sight in the cross-track direction. (See Figures 1.2-7 and 1.2-8 in Part 1, Section 2 of this document for illustrations of crab movements.)

Rotation of the mirror in stereo is accomplished by a servo motor attached to the mirror yoke and linked to the mirror through a hypocycloid mechanism. This drive provides shockless, precise positioning of the mirror at three discrete positions: nadir, forward, and aft. At zero crab angle, a $+4.325$ -degree rotation about the stereo axis causes a $+8.65$ -degree change in the line-of-sight with the result that the LOS is forward of the vehicle relative to nadir. For a -4.325 -degree rotation the LOS is aft by 8.65 degrees relative to nadir.

For a more detailed discussion of the crab and stereo mirror drives, refer to Part 3, Section 4.

3.2.2 Primary Mirror (Asphere)

The primary mirror is an aspheric converging element which accepts the light rays directed from the stereo mirror and reflects (and converges) them toward the Ross corrector. The mirror, which is 44.5 inches in diameter, is constructed of ultra-low-expansion, fused silica using a lightweight cellular core. A high reflectance front surface coating applied over a 43.5-inch diameter area defines the clear aperture of the PPS/DP EAC optical subsystem, and, based on a 175-inch effective focal length, results in the nominal R-5 lens f-number of 4.02. The aspheric shape of the mirror provides almost perfect correction to minimize aberrations at the edge of the field.

The mounting of the primary mirror is designed to provide strain-free support and thermal isolation. The mirror is potted to three mounts which in turn are supported in the end bell (aft end of the internal structure) by a three-point suspension called the flexure assembly (refer to Part 3, Section 1).

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3.2.3 Ross Corrector and Field Lens Assembly

The primary function of the RCFLA is the correction of field curvature arising from the aspheric primary mirror. However, introduction of the refractive Ross corrector elements produces chromatic aberration. As a result, the design and execution of the RCFLA in combination with the asphere are critical if acceptable levels of aberration are to be realized.

Each of the surfaces of the five RCFLA elements has an antireflection coating to reduce transmission losses. In addition, the Ross surface nearest the focal plane is coated with a minus blue filter that establishes a lower spectral transmittance figure of approximately 30 percent at 435 nanometers and, in conjunction with the film types used in the PPS/DP EAC results in an overall spectral range of approximately 435 to 720 nanometers.

A portion of the RCFLA protrudes into a hole in the stereo mirror. This position was deemed best considering the design trade-offs involved. The RCFLA housing is attached to the internal structure by a supporting framework forward of the double bulkhead and a double K-pad arrangement on the aft side of the double bulkhead. Within the housing, the two field lens elements are separated from the three-element corrector group by a 16-inch air space.

3.3 Optical Performance Parameters

The determination of the expected performance of the optical subsystem is directly affected by the limitations of the physical hardware. Factors such as surface irregularities, lens color, material inhomogeneity, and manufacturing tolerances in mounting and alignment directly affect the quality of the overall subsystem. Detailed analysis of the influence of these factors on optical quality is presented in Part 2, Section 12, with a discussion of such quality evaluation and performance prediction techniques as optical quality factor (OQF) calculations and modulation transfer function (MTF) analysis. The magnitude of thermally induced focus changes is also evaluated in Part 2,

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Section 12, with the shift due to each individual COA component, and the resultant shift due to all contributors summarized graphically. Other significant factors, specifically vignetting and spectral transmittance, are addressed in the following subsections.

3.3.1 Aperture Obstructions and Vignetting

Figure 3.3-2 is a view of the Ross corrector looking forward from the primary mirror. The effective opening in the stereo mirror defines the central obstruction, and also introduces a small amount of edge vignetting for the extreme stereo/crab position shown. The circles represent the unvignetted cross sections and the ellipses represent the vignetted cross sections of the beam at the front surface of the Ross corrector.* Note that all vignetting indicated by the shaded areas is caused by the stereo mirror.

The vignetting of the central and S-1 sensor obstructions is shown in the clear aperture view of Figure 3.3-3.

Vignetting by the stereo mirror causes the effective f -number (and T-number) to vary with stereo position (forward, nadir, or aft). Table 3.3-5 summarizes the vignetting as a percentage of the unvignetted aperture for several stereo mirror positions at the on-axis and extreme off-axis field positions. The worst-case, off-axis vignetting due to the stereo mirror is 24.9 percent and occurs in the forward position at a crab angle of 3.85 degrees. The relative illumination at the edge of the field is 84 to 89 percent, depending on the crab angle of the stereo mirror. (Note: Effective vignetting values at the 9 and 5 image planes will differ slightly.)

*Vignetting due to a malfunction in the viewport door subsystem is discussed in Part 3, Section 5.

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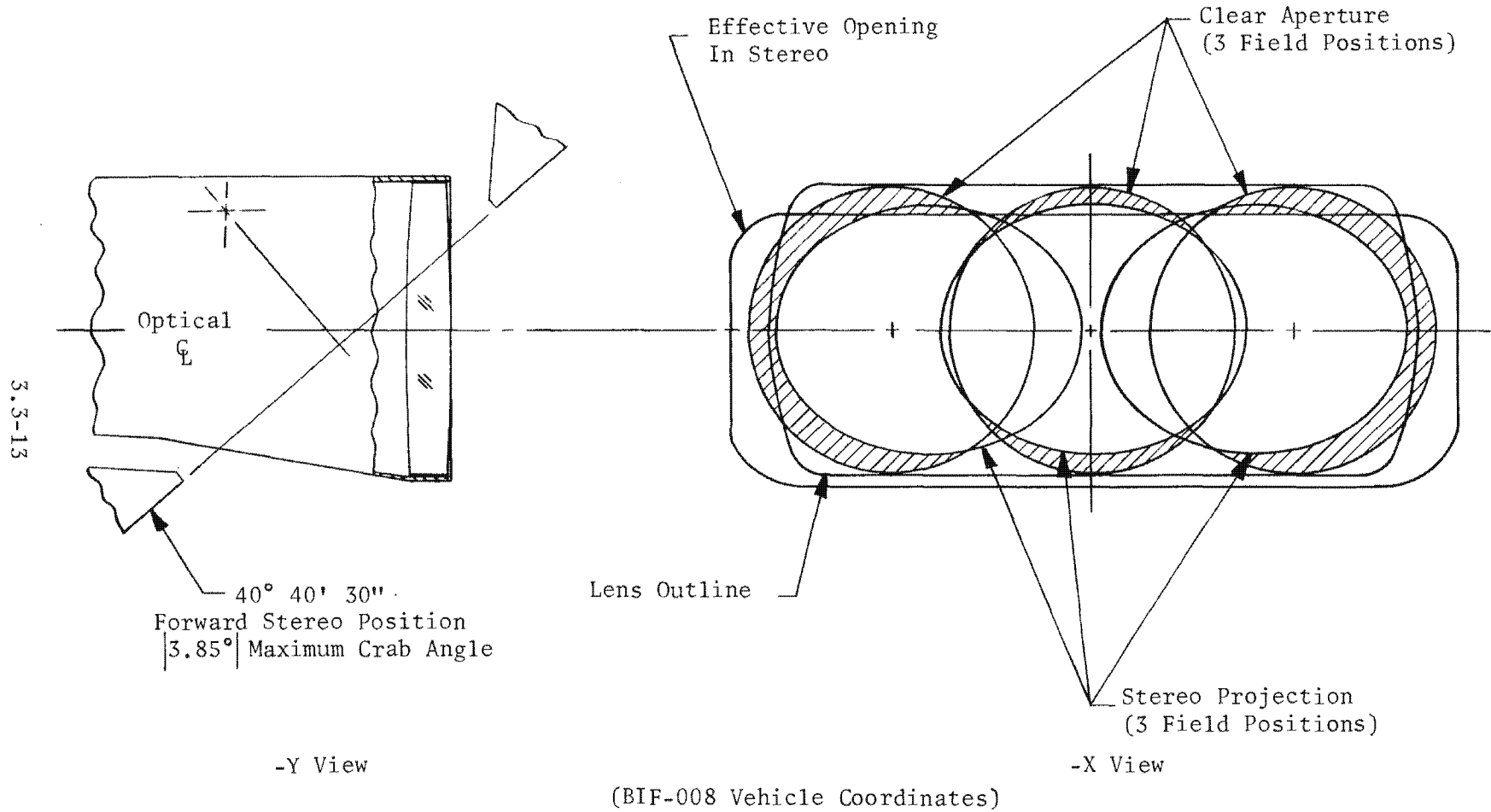
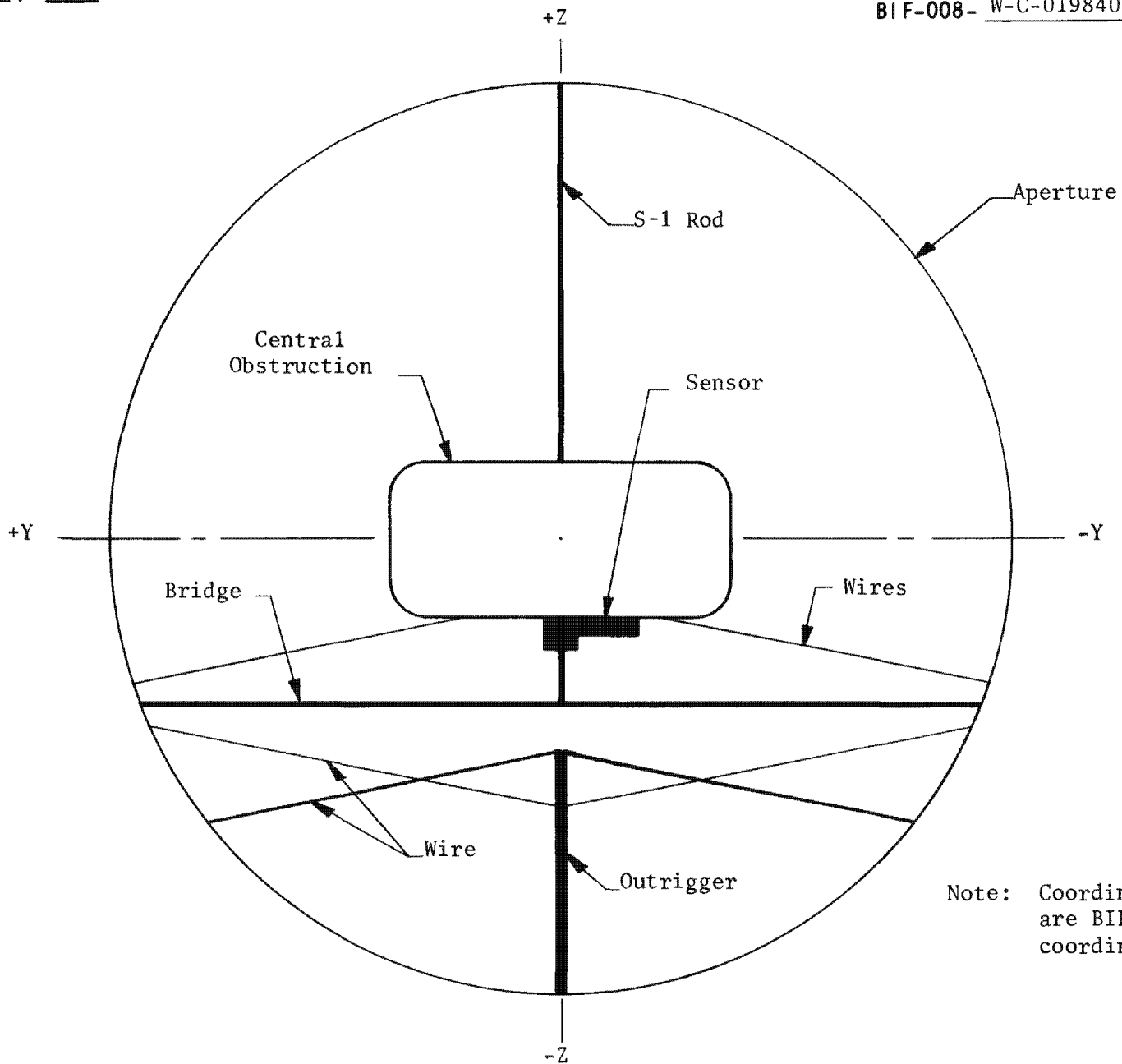


Figure 3.3-2. Stereo Mirror Vignetting



Note: Coordinates shown are BIF-008 vehicle coordinates.

Figure 3.3-3. Central And S-1 Sensor Vignetting

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TABLE 3.3-5
PERCENT OBSTRUCTION (Vignetting)

| Stereo Mirror Position | On Axis* | Off Axis* | | Central Obstruction | S-1 Sensor Obstruction |
|---------------------------|----------|-----------|------------|------------------------|---------------------------|
| | | 0° Crab | 3.85° Crab | | |
| Forward | 10.8 | 21.6 | 24.9 | 7.7 | 2.9 |
| Nadir | 4.0 | 15.5 | 18.9 | 8.4 | 2.8 |
| Aft | 0 | 11.7 | 16.1 | 9.0 | 2.7 |

*Central and S-1 sensor obstructions not included.

3.3.2 Lens Spectral Transmittance

The transmittance characteristic of a lens is best defined by its spectral transmittance, or transmitted energy plotted as a function of wavelength. In practice, the spectral transmittance of each optical assembly is obtained from a calculation based on spectral transmittance and reflectance data for the individual components. Transmittance values for the optical path length in glass (LaKN-14 and SK-14) are taken from the vendor's catalog. Transmittance values for the nine low reflectance multilayer coatings and the minus-blue cut-off filter are measured and supplied by the coating contractor. Reflectance values for the stereo and primary mirrors are also measured values. Figure 3.3-4 is a typical resultant curve.

3.4 Instrumentation

Table 3.3-6 is a list of the instrumentation specifically applicable to the optical subsystem.

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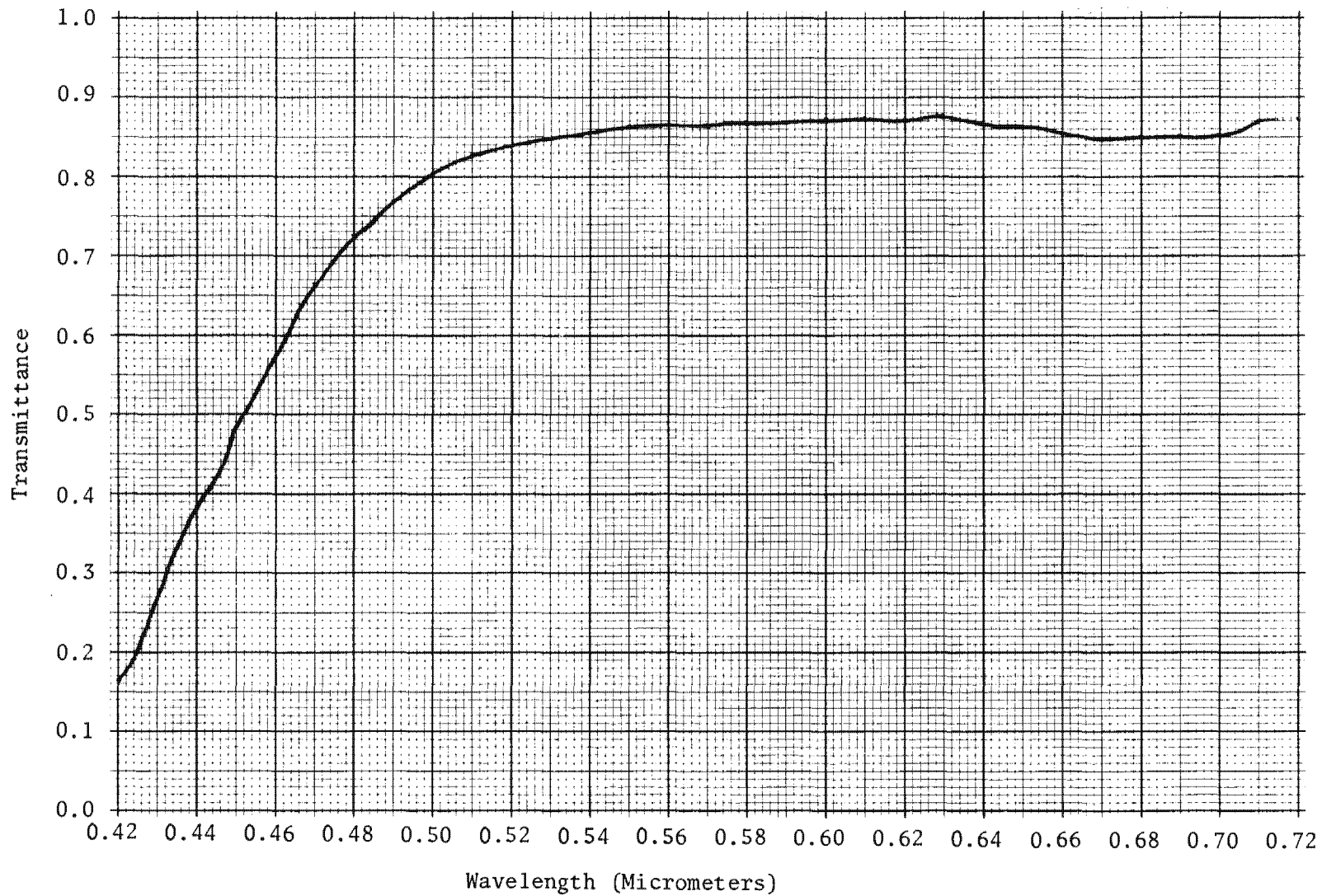


Figure 3.3-4. Typical Spectral Transmittance, R5 Optics (Unobstructed)

3.3-16

TABLE 3.3-6

OPTICAL SUBSYSTEM INSTRUMENTATION

| <u>IMP</u> | <u>Title</u> | <u>Description</u> | <u>Power</u> |
|------------|--|---|--------------|
| 5099 | Temperature, Stereo Mirror | A thermistor, mounted on the back surface of the stereo mirror, monitors the mirror temperature. The output is processed by an integrated circuit differential amplifier in the instrumentation processor, producing a linear signal from 60F (4.75v) to 80F (1.06v). | ±15 vdc |
| 5110 | Temperature, Corrector, Camera Spacer | Similar to IMP 5099; the thermistor is mounted on the top plate of the Ross Corrector at the +Y edge approximately 2 3/4 inches from the camera interface. | ±15 vdc |
| 5112 | Temperature, Lens Tube Forward, Sta 175, 279 Degrees | A thermistor located on the outer surface of the COA structure at Sta 175, 279 degrees, monitors the internal structure temperature. The output is processed in the instrumentation processor, producing a nonlinear signal from 40F (4.95v) to 100F (1.4v). | +15 vdc |
| 5113 | Temperature, Lens Tube Aft, Sta 244, 5 Degrees | Similar to IMP 5099, the thermistor is mounted on the outer surface of the COA at Sta 244, 5 degrees. | ±15 vdc |
| 5115 | Temperature, Lens Tube Forward, Sta 175, 99 Degrees | Similar to IMP 5099, the thermistor is mounted on the outer surface of the COA at Sta 175, 99 degrees. | ±15 vdc |

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| <u>IMP</u> | <u>Title</u> | <u>Description</u> | <u>Power</u> |
|------------|---|---|--------------|
| 5145 | Temperature Primary Mirror 2 (-Y) | A thermistor mounted on the front surface of the primary mirror, approximately 8 inches from the center along the -Y axis, monitors the primary mirror surface temperature. The output is processed in the instrumentation processor producing a nonlinear signal from 40F (4.5v) to 100F (1.25v). | ±15 vdc |
| 5150 | Temperature Primary Mirror 1 (+Y) | Similar to IMP 5099, the thermistor is mounted on the front surface of the primary mirror, approximately 8 inches from the center, along the +Y axis. | ±15 vdc |
| 5375 | Differential Temperature, Stereo Mirror Lower | Two matched thermistors are mounted in the front and back plates of the stereo mirror. The two outputs are processed by a differential amplifier in the instrumentation processor producing a differential temperature signal, Δt (front minus back), ranging linearly from -1.0F (0.5v) to +3.0F (4.98v). | ±15 vdc |
| 5009 | Crab Angle (Coarse) | A coarse and fine potentiometer (ratio 5:1) with their associated voltage divider networks are located in the crab servo and are mechanically connected through gears to the servo output shaft. Voltage output extends linearly from 0.5v to 4.5v, with the fine sensor cycling several times over the full range of crab drive. | +5 vdc |
| 5010 | Crab Angle (Fine) | | |

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| <u>IMP</u> | <u>Title</u> | <u>Description</u> | <u>Power</u> |
|------------|---------------------|---|--------------|
| 5148 | Crab Angle (Coarse) | A coarse and fine potentiometer (ratio 5:1), located in that portion of the load box mounted to the camera optics assembly, monitor directly the position of the stereo mirror yoke by means of lever arms and gears. This arrangement provides a redundant means of monitoring crab position. Associated processing circuitry is located in this portion of the load box. | +15 vdc |
| 5149 | Crab Angle (Fine) | | |
| 5127 | Stereo Angle | A potentiometer, located within the stereo servo, monitors the position of the stereo output shaft over the range of rotation required to establish the three mirror positions (forward, vertical, aft). The potentiometer is mechanically connected through gears to the output shaft. Output varies nonlinearly from 0.5v to 4.5v. | +5 vdc |
| 5147 | Stereo Angle | A potentiometer, located in that portion of the load box mounted to the stereo mirror yoke, monitors the stereo angle. Linkage arms connect the load box assembly to the stereo mirror and rotate the potentiometer as a function of mirror stereo position. The processing network is located in that portion of the load box containing IMPs 5148 and 5149. Output varies nonlinearly from 0.5v to 4.5v (aft to forward). | +15 vdc |

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4.0 MIRROR POSITIONING SUBSYSTEM

Acquisition of high-resolution photography requires that the photographic payload section/dual platen extended altitude capability (PPS/DP EAC) have three angular degrees of freedom. One degree of freedom is provided by the roll joint in the satellite control section (SCS), which rotates the entire PPS/DP EAC about its roll axis. The remaining two degrees of freedom are provided within the PPS/DP EAC by the crab and stereo rotations of the stereo mirror. Crabbing the stereo mirror orients the image-motion vector in the image plane so that it will coincide with the direction of film motion, minimizing cross-track smear (reference Part 3, Section 2). Stereo aiming provides stereo convergence by allowing the line-of-sight to be moved fore and aft with respect to the satellite nadir.

Figure 3.4-1 is a conceptual representation of the stereo-mirror yoke and its mount, showing the crab movement of the yoke and mirror, and the stereo movement of the mirror. Note that crabbing rotates the entire yoke, including the stereo mirror and stereo servo, such that the stereo mirror stereo axis lies wholly within a plane parallel to the Y-Z vehicle coordinate plane.

All hardware associated with both servo systems is mounted forward of the stereo mirror in the controlled environment of the camera optics module (see Figure 3.4.2). Removable panels are provided to allow access to both servos or, if need be, removal and replacement of both from the completed PPS/DP EAC.

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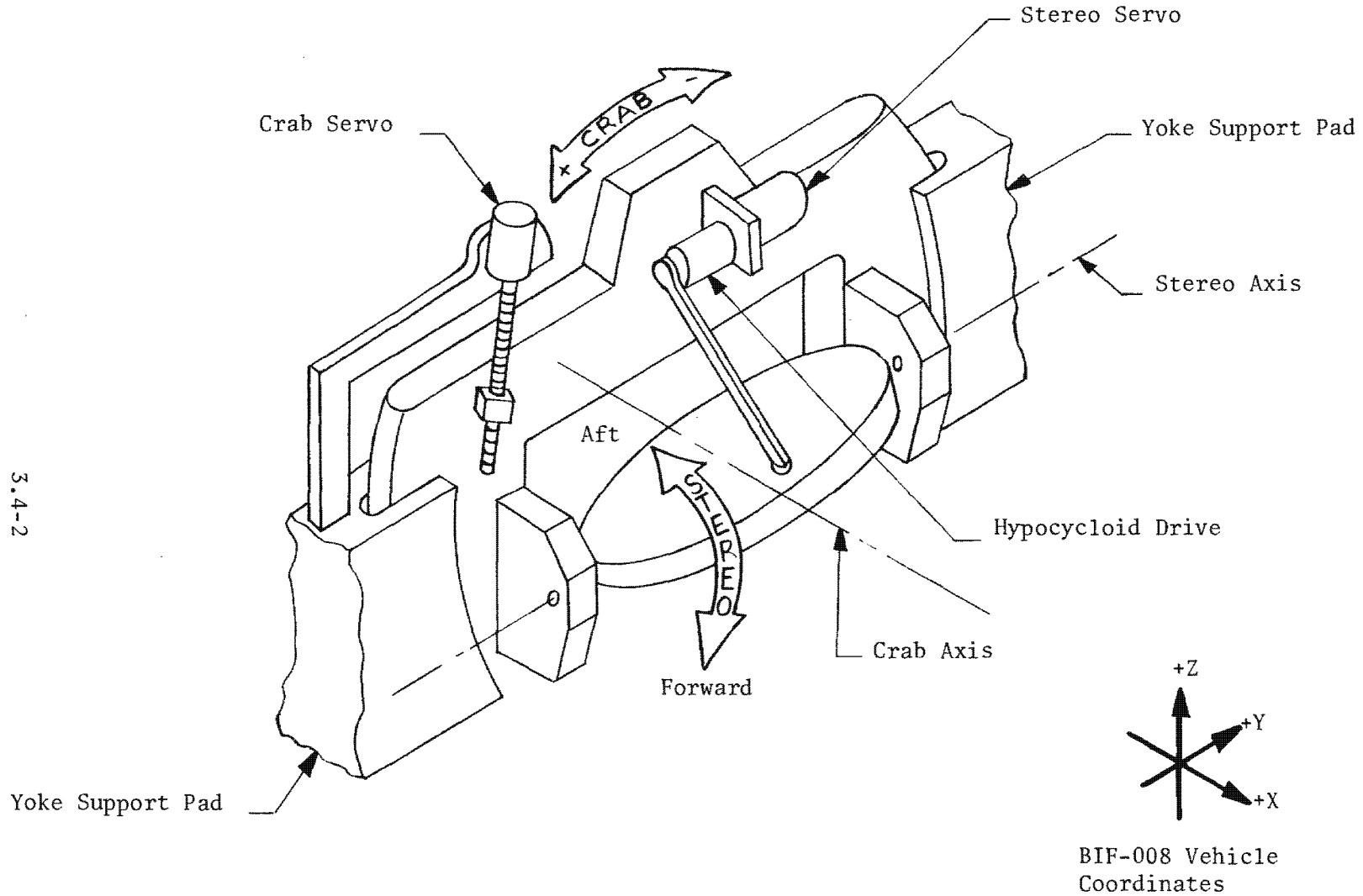
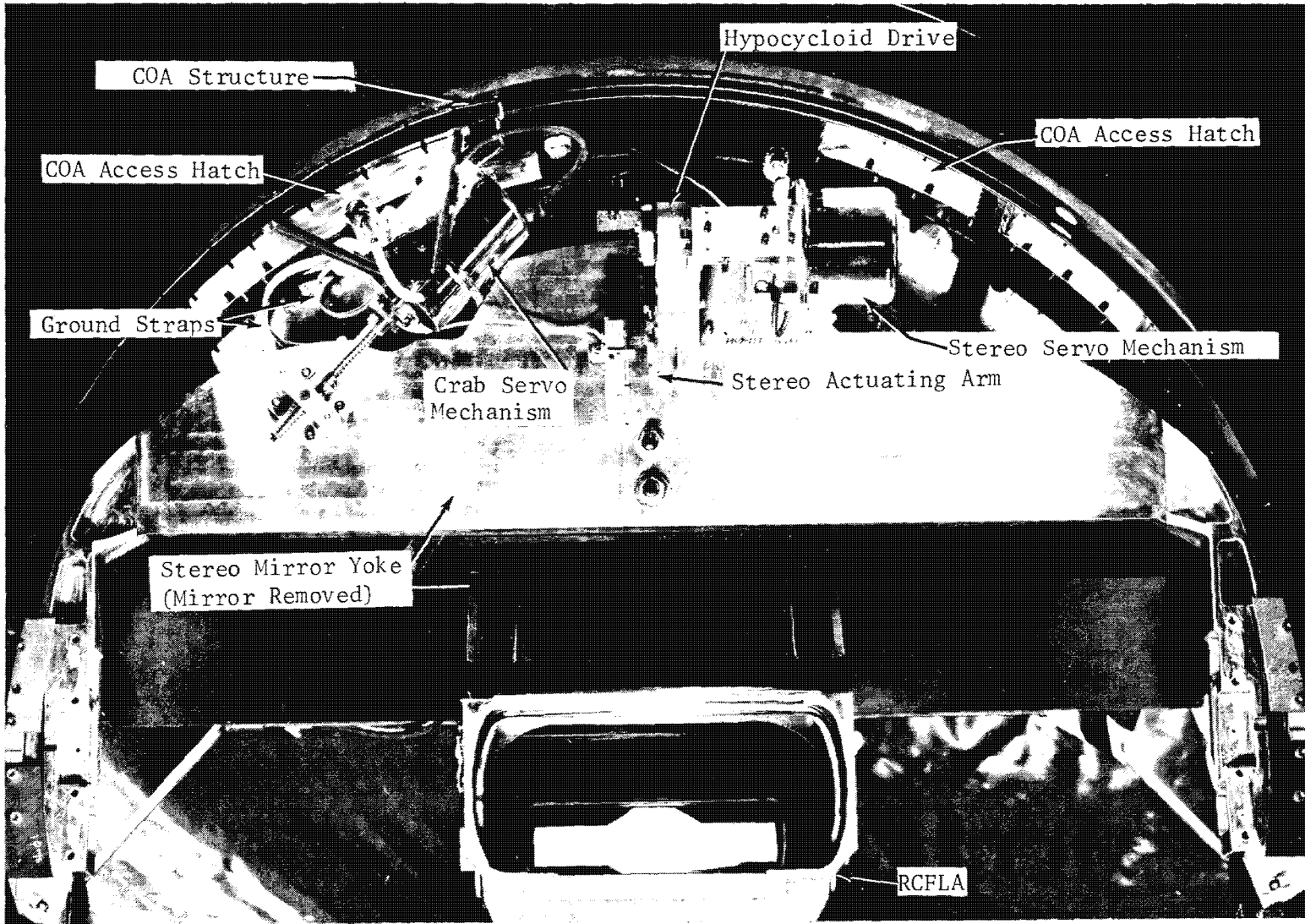


Figure 3.4-1. Stereo Mirror Movements (Conceptual Presentation)



Note: Photograph is representative of FM-47 configuration. FM-52 servos are identical.

Figure 3.4-2. Crab and Stereo Servos

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4.1 Stereo Servo Subsystem

The stereo servo provides the capability to reposition the line-of sight (LOS) deviating element (the stereo mirror) so that more than one "look" can be made at the same target during a single pass. In-track (stereo) aiming of the LOS is accomplished by rotating the stereo mirror to any of three positions (0 degree, +4.325 degrees, or -4.325 degrees) about an axis which is parallel to the camera optics module pitch axis (Y-axis) when the crab angle is zero degree. The LOS, therefore, rotates either +8.65 (forward) or -8.65 degrees (aft) from the zero-degree position (zero degree is parallel to the Z-axis of the PPS/DP EAC). The mirror will consistently reproduce the zero-degree position within ± 0.05 degree and the 8.65-degree stereo angles within ± 0.15 degree.

The stereo servo is capable of moving the mirror between extreme positions (forward/aft) and settling within three seconds after receiving a command, or within 2.0 seconds for transitions between adjacent positions (forward/nadir or aft/nadir). The servo can neither overshoot nor hunt for its commanded position. Experience has shown that the mirror oscillates briefly about its final position, with the oscillation decaying as a damped sinusoid. The mirror is considered "settled" when the amplitude of oscillation falls below a specified limit.

4.1.1 Stereo Drive Components

Stereo positioning of the mirror is accomplished by means of a servo motor mounted on the yoke which drives a hypocycloid mechanism connected to the mirror by a link (see Figure 3.4-3). The pressure-tight servo enclosure is fixed to the yoke by means of a mounting bracket such that rotation of the servo with respect to the yoke is prevented. Included in the enclosure is a dc motor which drives the servo output shaft through a reduction gear

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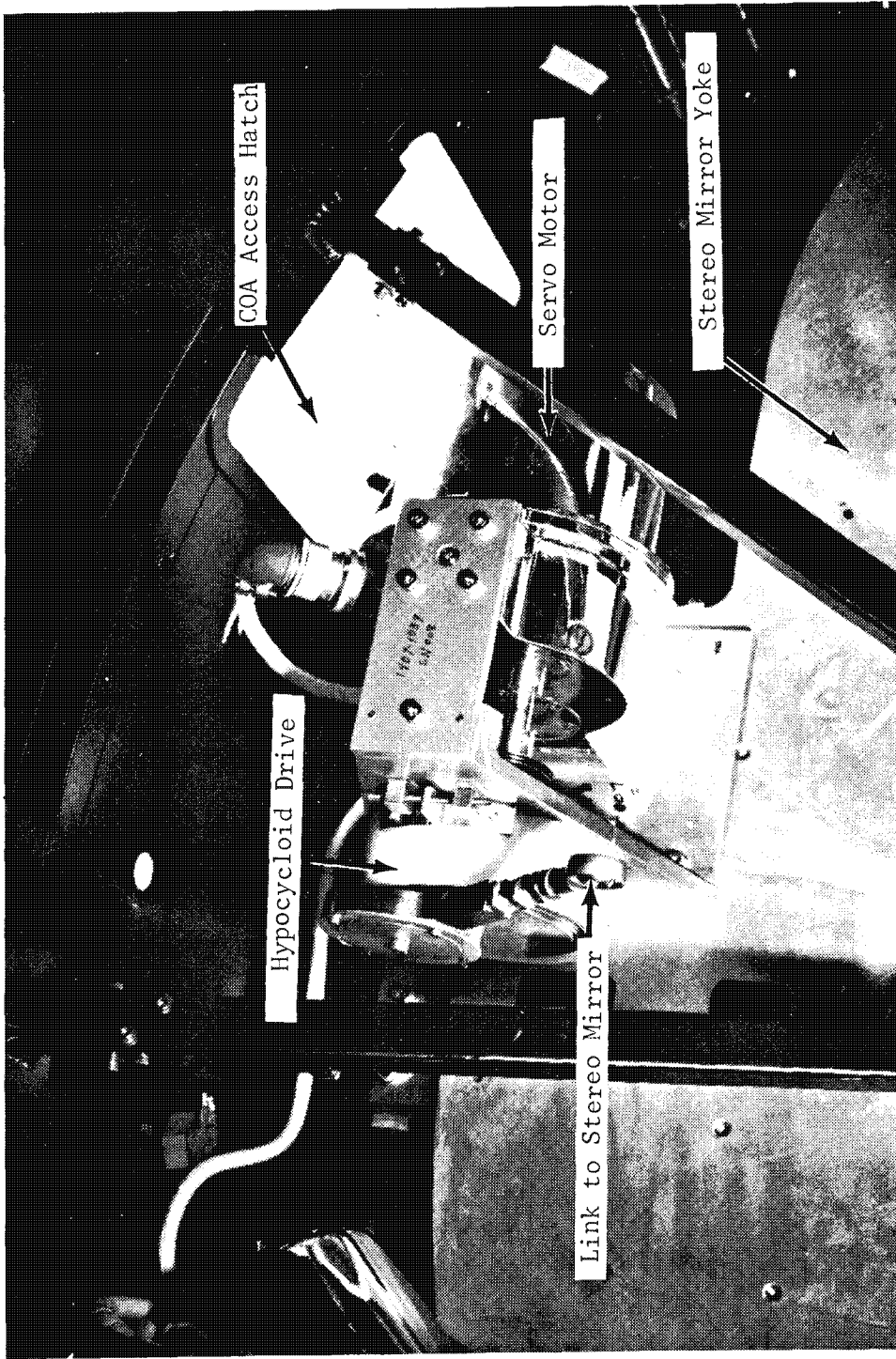


Figure 3.4-3. Stereo Servo and Drive

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train (270.4:1), thus providing the motor with a high torque advantage. Also mounted in the servo case are an encoder, and instrumentation potentiometers and associated circuitry. The hypocycloid mechanism is attached to the servo mounting bracket, and a flexible coupling is used to connect the output shaft of the servo to the input shaft of the hypocycloid.

4.1.1.1 Hypocycloid Drive Assembly. The hypocycloid drive assembly (see Figures 3.4-4 and 3.4-5) is a three-position indexing drive based on the hypocycloidal motion generated by a circle rotating inside another fixed circle. The pitch circle of a planet gear rotates on the pitch circle of a stationary internal gear. The gear teeth maintain the phase relation between input and output motions and also transfer forces. Because the ratio of the internal gear to the planet gear is 3:1, one revolution of the servo motor output shaft produces 3 revolutions of the planet gear and 3 cusps which are used as positioning points.

A mirror position vs time plot is shown in Figure 3.4-6. The shape of this curve shows why the hypocycloid drive was selected for stereo mirror positioning. The mechanical advantage and resulting high acceleration or deceleration near the cusps (rest positions) bring the mirror to a controlled stop or start with a minimum of "ringing" (oscillation). Ringing is further minimized by the maintenance of extremely tight part tolerances throughout the linkage assembly. When the mirror is commanded from one extreme position to the other, the servo drive direction is such that the planet gear passes through the zero-position cusp; hence the path directly between plus and minus is not used.

4.1.2 Stereo Servo Electronic Control

Figure 3.4-7 is an electrical block diagram of the stereo servo subsystem and associated instrumentation. Power is provided by the power monitor and control (PM and C) primary power circuit via the servo power switch, with two

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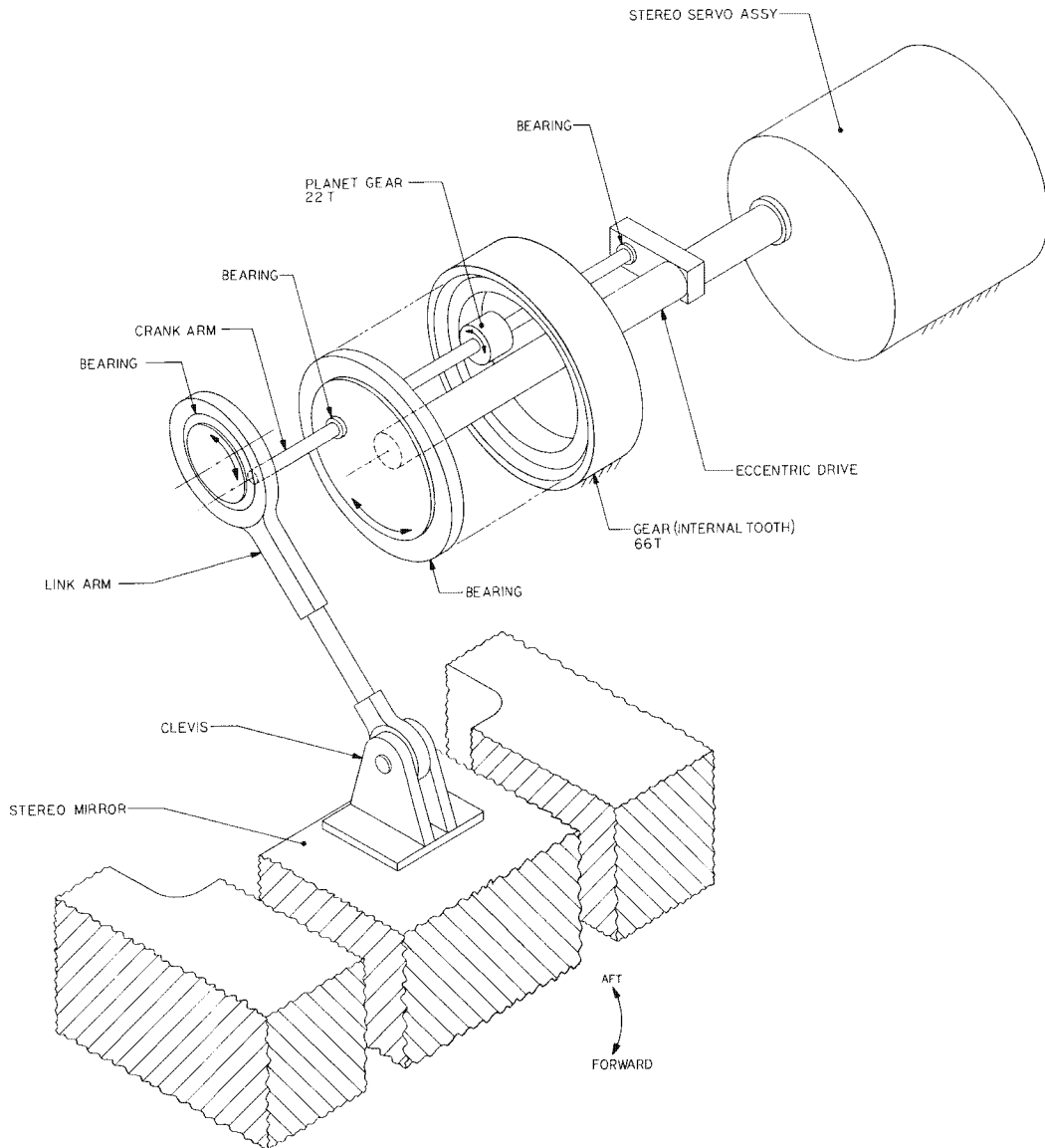


Figure 3.4-4. Hypocycloid Drive Assembly

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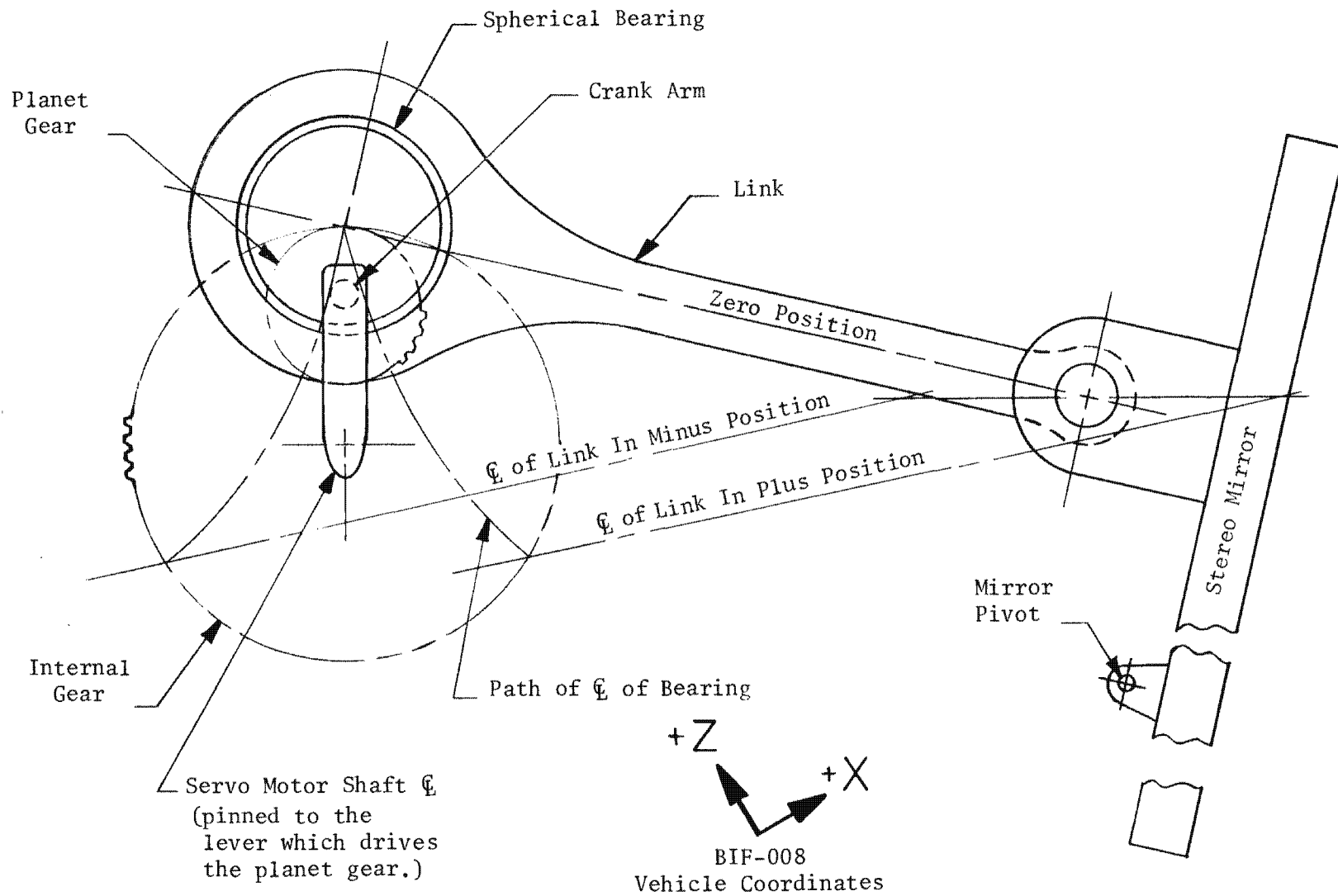


Figure 3.4-5. Hypocycloid Drive (Conceptual Representation)

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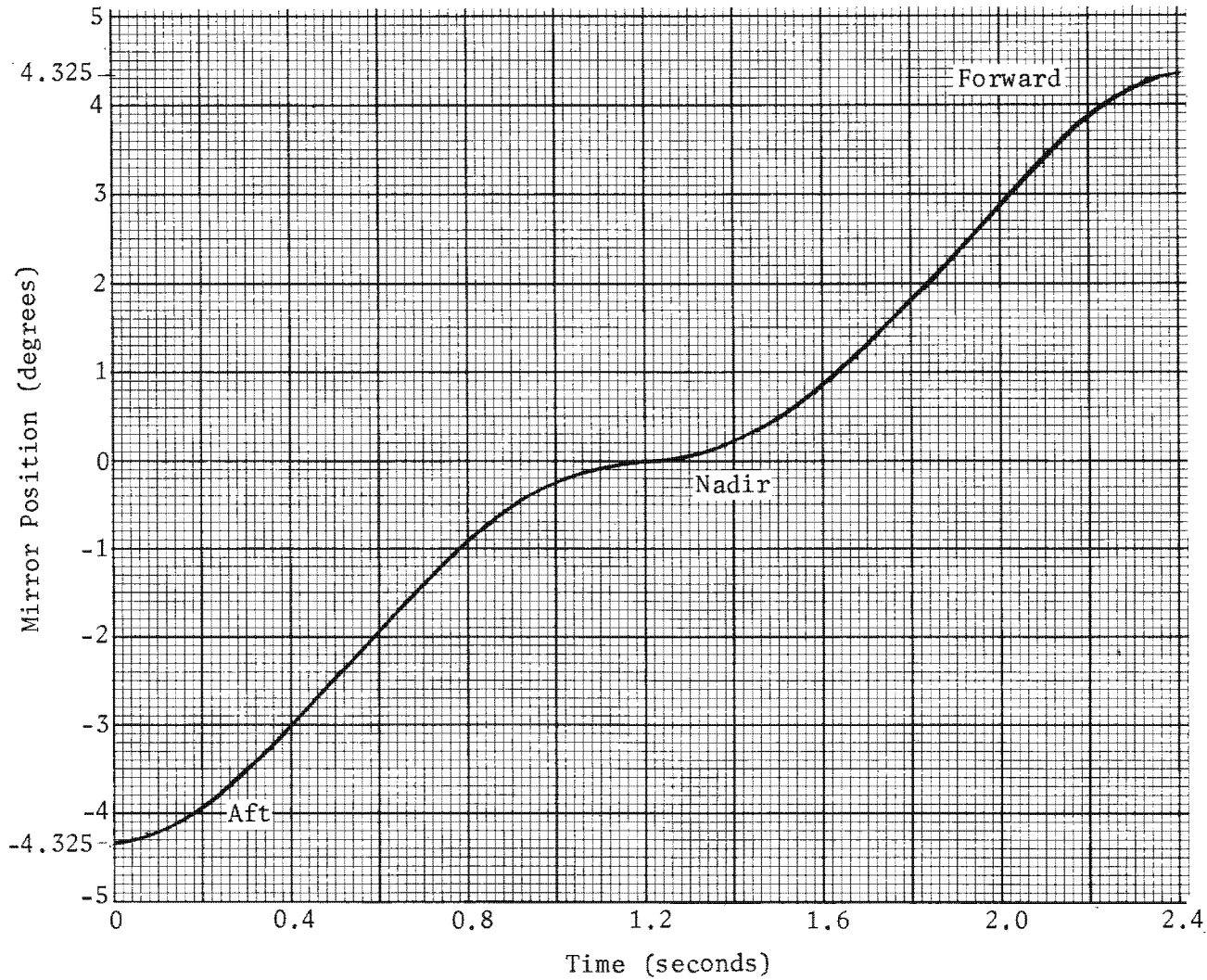


Figure 3.4-6. Typical Position-Time Curve For Stereo Mirror With Hypocycloid Drive

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3.4-10

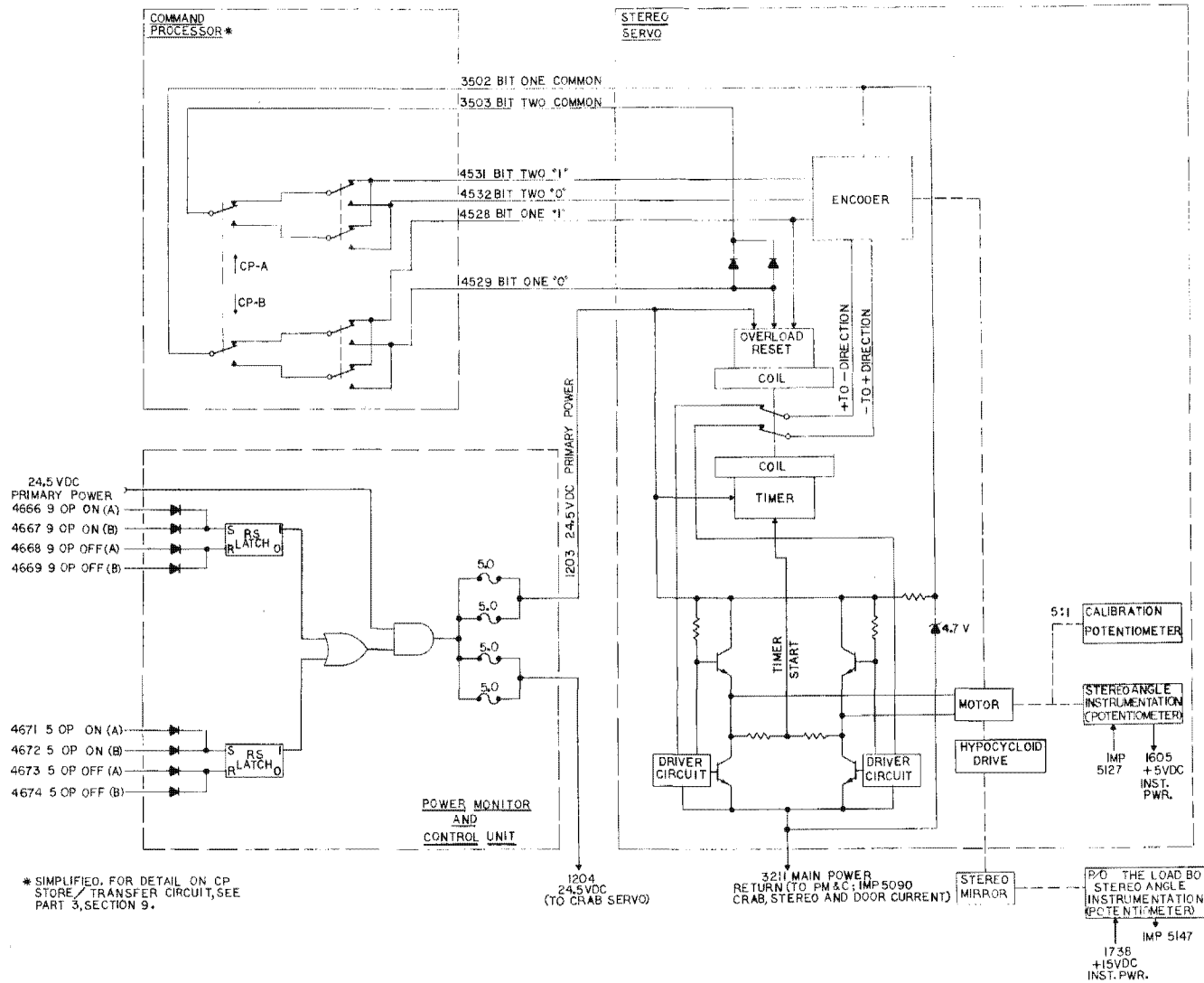


Figure 3.4-7. Stereo Servo Subsystem Electrical Block Diagram

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5.0-ampere fuses, in parallel, between the switch and servo to protect against short circuits. The power switch is controlled by the 9 and 5 operational power commands. The switch is closed (servo-drive powered) when either 9 OP ON or 5 OP ON is commanded.

The stereo servo drive consists of a motor bidrive circuit, a mechanical brush-type encoder, a permanent magnet dc motor, a time-out protection circuit, and two instrumentation potentiometers geared to the output shaft. The servo is commanded to each of its 3 positions by means of a 2-bit binary code word. The positions are separated by 120 degrees of output shaft rotation. An increasing binary number results in a counterclockwise shaft rotation when viewed from the load end of the shaft. Three wires are connected between the servo and command processor for each bit. Position command information is supplied to the servo by shorting each bit-common lead to either the bit "1" or bit "0" lead by means of latching relays in the command processor. Stereo position commanding is controlled by bits 27 and 28 of the 14V WORD command (see Table 3.4-1). Execution of a 14V WORD stores the position to which the stereo mirror is to move upon receipt of a 13V WORD command (9/5 Camera OFF).

4.1.2.1 Stereo Servo Motor Bidrive Circuit. The motor bidrive circuit is a standard "H" type drive with the motor in the center of the "H" and an NPN power Darlington transistor acting as a switch in each leg (reference Figure 3.4-7). The 2 top transistors in the bridge are self-biased on, but do not conduct until an emitter current path is provided by one of the bottom transistors. The direction of the motor current is determined by which of the lower power transistors is on. Information as to which bottom transistor is to be turned on is supplied by a voltage applied to one of 2 lines from the encoder. One line goes to the base of a driver transistor on each bottom side of the "H". The driver circuit on each side of the bridge turns the bottom power transistor on and the top one off. When the servo is in a command-satisfied position, there is no voltage on either line and both

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TABLE 3.4-1
STEREO POSITION VS EXECUTED COMMAND BIT STATE

| 14V WORD (1) | | Stereo Position (2) (Stereo Mirror Angle) | Stereo Position (2) (Line-Of-Sight) | Descriptor (Convention) |
|--------------|--------|--|--|----------------------------|
| Bit 27 | Bit 28 | | | |
| 0 | 0 | +4.325 degrees | +8.65 degrees | + or Forward |
| 0 | 1 | 0.00 degree | 0.00 degree | 0 or Vertical |
| 1 | 0 | -4.325 degrees | -8.65 degrees | - or Aft |
| (3) | 1 | -4.325 degrees | -8.65 degrees | - or Aft |

3.4-12

Notes:

- (1) 14V WORD Bit 27 corresponds to Stereo Bit 1
14V WORD Bit 28 corresponds to Stereo Bit 2
- (2) Assuming execution of a 13V WORD command
- (3) Not normally used

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bottom transistors are off. If the mirror drive is mechanically moved such that the servo position falls outside the tolerance range for its commanded position, it will return to the commanded position without being recommanded, provided servo power is available.

4.1.2.2 Stereo Servo Encoder. The function of the encoder is to compare the input binary command with actual shaft position and direct the bidrive circuit to run in the proper direction to satisfy the command. The encoder consists of 8 varying length, conductive segment tracks on a cylindrical drum. Electrical connection is made to each track by means of conductive brushes. This motor-encoder drive method is not a closed-loop system. Voltage is lost to the bidrive circuit when a command is satisfied by a brush breaking electrical contact with a segment. Coast is controlled by dynamic braking of the motor.

4.1.2.3 Stereo Servo Overload Timer. If the servo does not reach its commanded position within 3.5 to 8.7 seconds, latching relay contacts in series with the 2 encoder outputs to the bidrive circuit open, disabling the servo. This time is determined by an RC timing circuit which triggers a transistor switch after the voltage on a capacitor reaches a predetermined level. If the timer has timed out before the commanded position is reached, the overload protection device must be reset manually by changing bit 28 of the 14V WORD command or by removing and reapplying servo power. Before recommanding the servo to a new position after it has satisfied a previous command, a 0.5-second delay should be allowed for the timer to discharge; otherwise, any residual charge on the capacitor may result in the RC circuit reaching its trigger level in a shorter time than that needed to complete a normal mirror transition.

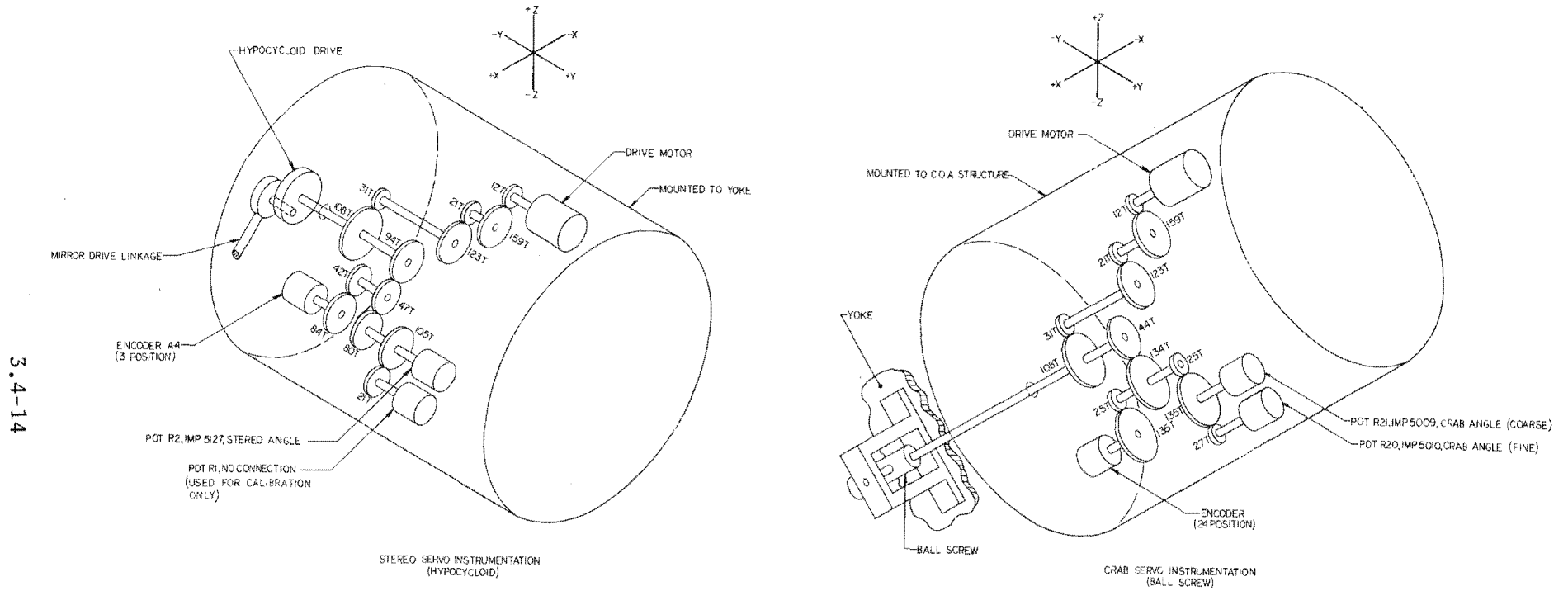
4.1.3 Stereo Angle Instrumentation

Two 10K Ω precision potentiometers are connected in parallel across the +5-volt instrumentation power line and geared to the output shaft (see Figure 3.4-8).

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NOTE: AXES SHOWN ARE BIF-008 VEHICLE COORDINATES



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Figure 3.4-8. Stereo and Crab Servo Instrumentation

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The wipers of both potentiometers are wired to the servo connector. The output of R2 is IMP 5127. The output of R1 is not wired into the system beyond the servo connector. R1 rotates five times for each rotation of R2 and is used solely for servo calibration.

A second instrumentation point (IMP 5147) is also provided. This output is derived from a potentiometer located in an assembly (part of the load box) which is mounted to the yoke (reference Figure 3.4-9). Linkage arms connect the load box assembly to the stereo mirror and serve to rotate the potentiometer as a function of mirror stereo position. Power is provided by the +15-volt instrumentation supply.

4.2 Crab Servo Subsystem

Crab is defined as rotation of the stereo mirror stereo axis about an axis parallel to the vehicle roll axis (reference Figure 3.4-1). Crabbing of the stereo mirror is controlled by the crab servo which is capable of positioning the mirror to within 0.10 degree of each of 24 crab positions between +3.85 and -3.85 degrees in uniform 0.35-degree increments (+0.0 degree and -0.0 degree are unique positions due to the mechanical encoder characteristics). In operation, the servo neither overshoots nor hunts for its commanded position. By choosing the direction of approach, it is possible to use the encoder deadband and motor deceleration characteristics to determine on which side of the nominal commanded position the mirror will actually stop. The magnitude of this hysteresis around any given point is typically 0.10 degree to 0.15 degree (excluding the zero-degree positions) and is essentially time-invariant for a given vehicle. The result is 46 unequally spaced, discrete crab positions which can be used to more accurately position the mirror in crab, if desired (see Figure 3.4-10).

Under conditions of maximum load and low supply voltage, the crab servo can drive the yoke (and thereby the stereo mirror stereo axis) from one crab

3.4-15

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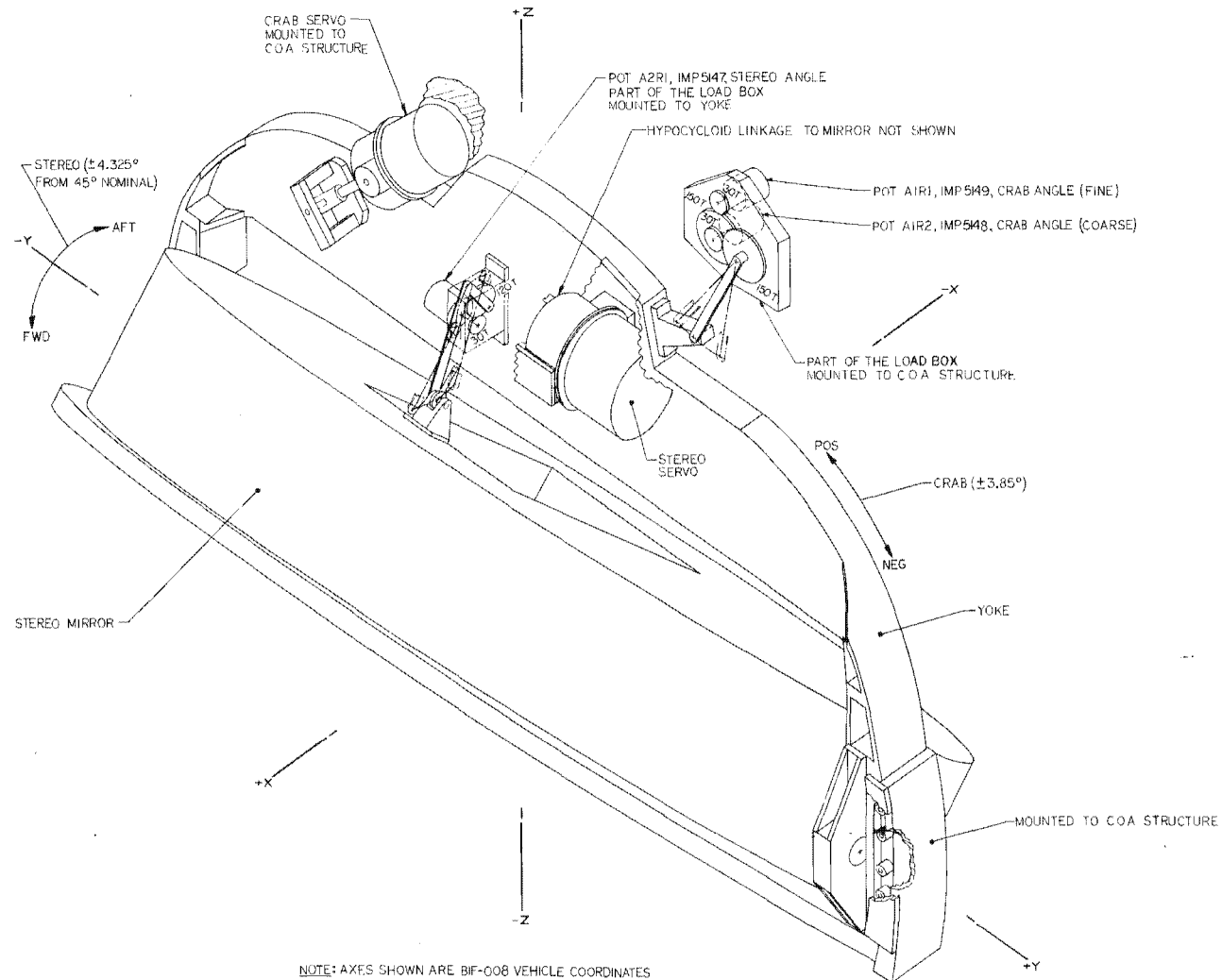


Figure 3.4-9. Stereo Mirror Servos and Instrumentation

3.4-16

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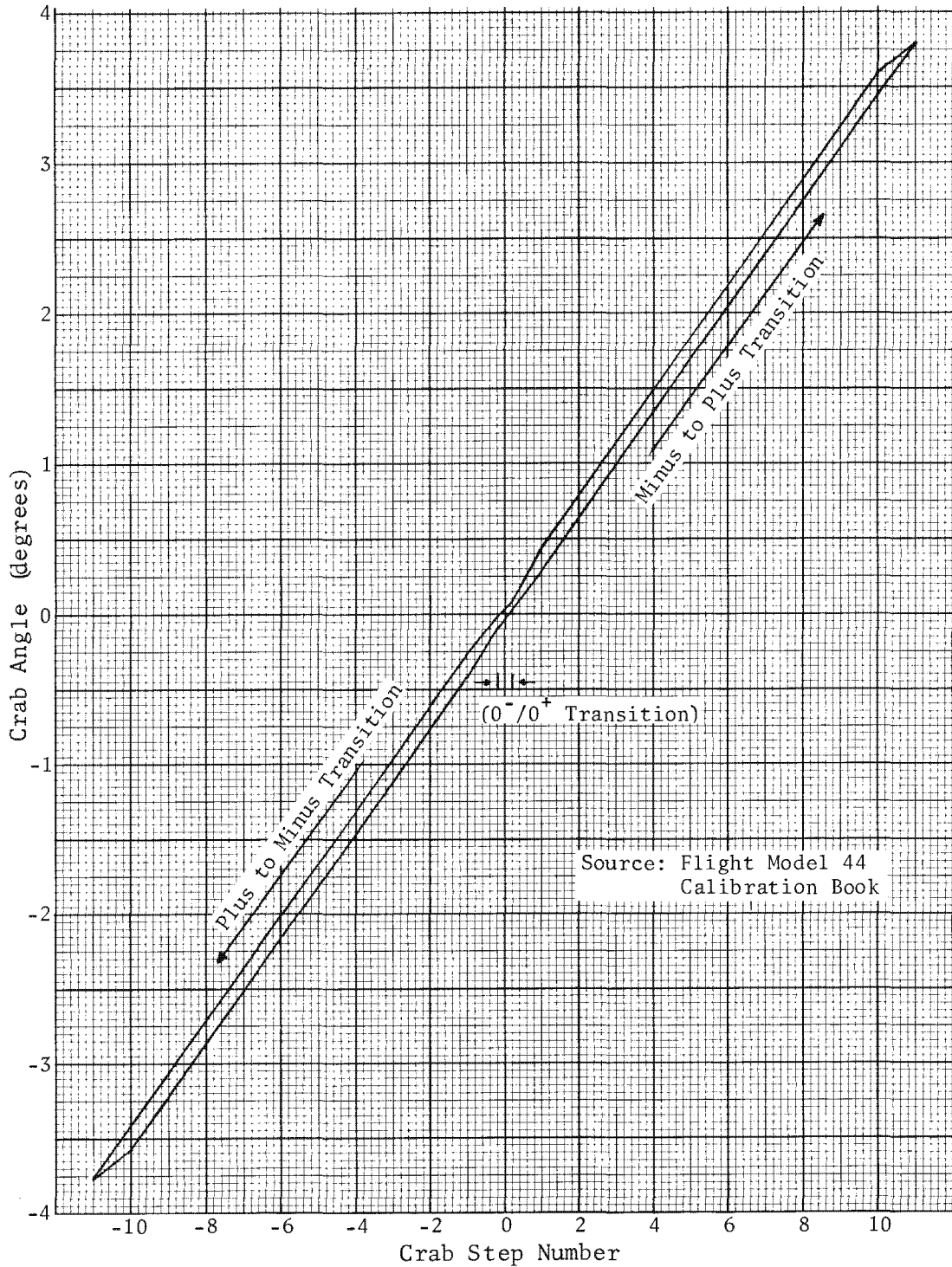


Figure 3.4-10. Crab Hysteresis Effect

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position to the next adjacent position (0.35 degree) and settle within three seconds after receiving a command. Each additional step moved requires 2.5 seconds. In addition, under minimum load and maximum supply voltage, the maximum angular velocity of the servo output shaft does not exceed 125 degrees-per-second. This requirement was established to limit the total angular momentum of the yoke-mirror combination to a level compatible with the SCS attitude-control system capability.

4.2.1 Crab Drive Components

The pressure-tight servo enclosure is fixed to an internal structure mounting frame by means of a mounting bracket (see Figure 3.4-11). The mount allows the servo to rotate about the crab axis, with respect to the internal structure, accommodating the yoke rotation. Included in the enclosure is a dc motor driving the servo output shaft through a gear train having a speed reduction of 270.4:1, providing the motor with a high torque advantage. Also mounted in the servo case are an encoder, and the instrumentation potentiometers and associated circuitry.

The output shaft of the servo drives the stereo mirror yoke by means of a lead screw and nut combination having a 0.1875-inch pitch per revolution. Beginning with Flight Model 50, the lead screw is protected from contamination by a dust cover composed of shields and a flexible bellows. The servo and ball screw are included in Figure 3.4-9.

4.2.2 Crab Servo Electronic Control

Figure 3.4-12 is an electrical block diagram of the crab servo subsystem and associated instrumentation. The crab servo is powered in parallel with the stereo servo via the PM and C servo power switch, with two 5.0-ampere fuses, in parallel, between the switch and each servo (four fuses total) for protection against short circuits. The servos are powered when either 9 OP ON or 5 OP ON is commanded.

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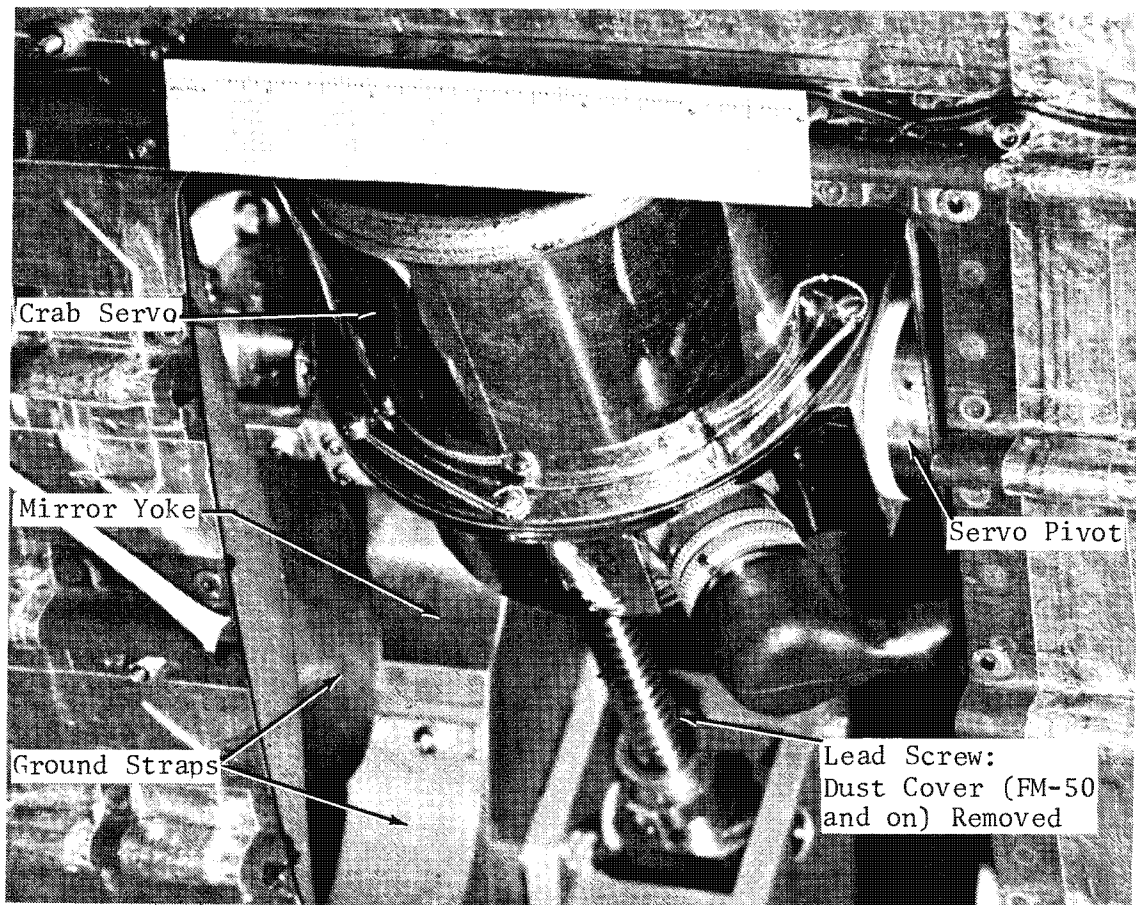
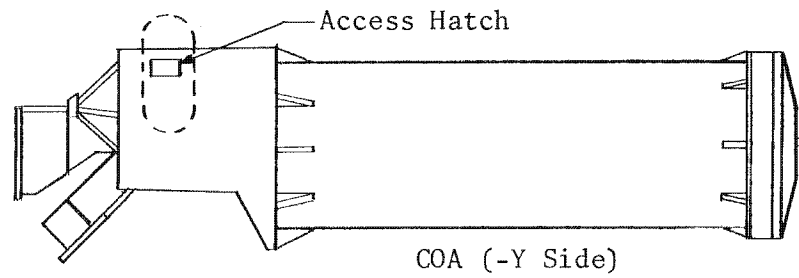


Figure 3.4-11. Crab Servo

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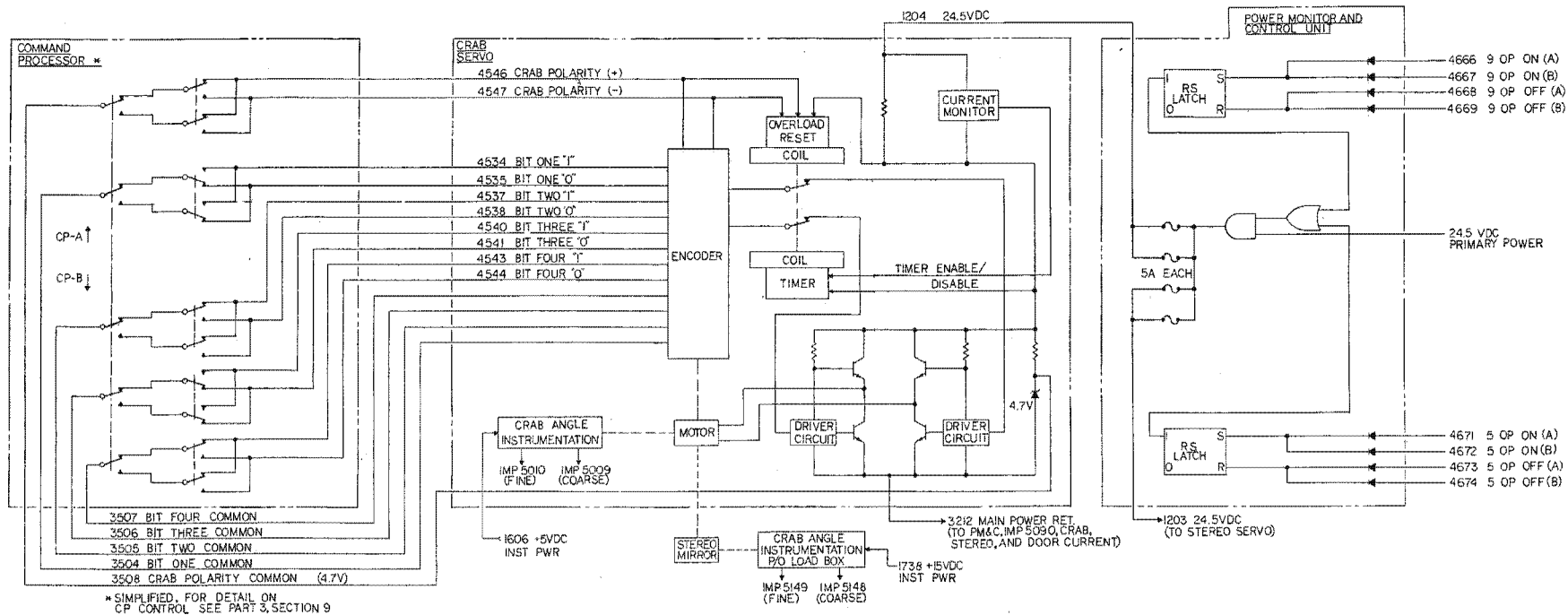


Figure 3.4-12. Crab Servo Subsystem Electrical Block Diagram

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3.4-21/3.4-22

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The crab servo consists of a motor bidrive circuit, a mechanical brush-type encoder, a permanent magnet dc motor, a time-out protection circuit, and two instrumentation potentiometers geared to the output shaft. The servo is commanded to each of its 24 nominal positions by means of a 5-bit binary code word. The positions, except for +0 and -0, are separated by 236.7 degrees of shaft rotation. Three wires are connected between the servo and command processor for each bit. Position command information is supplied to the servo by shorting each bit-common lead to either the bit "1" or bit "0" lead by means of latching relays in the command processor. Crab position commanding is controlled by the 13V WORD command (9/5 Camera OFF). Bits 27 through 30 specify the crab angle to be executed. Bit 31 indicates the polarity of the desired crab angle. Positioning control logic is based on the need for only 24 commands of the 32 possible from the 5 variable bits. The remaining 8 false or incorrect commands will drive the servo to either the extreme clockwise or counterclockwise discrete position, depending on the commanded crab polarity (see Table 3.4-2). Upon receipt of a 13V WORD command, the stereo servo will move to the position stored by the last 14V WORD, and the crab servo will move to the crab angle specified.

4.2.2.1 Crab Servo Motor Bidrive Circuit. The motor bidrive circuit is a standard "H" type drive similar to that used for the stereo servo, with the motor in the center of the "H" and an NPN power Darlington transistor acting as a switch in each leg. The 2 top transistors in the bridge are self-biased on, but do not conduct until an emitter current path is provided by one of the bottom transistors. The direction of the motor current is determined by which of the lower transistors is on. Information as to which bottom transistor is to be turned on is supplied by a voltage applied to one of 2 lines from the encoder. One line goes to the base lead of a driver transistor on each bottom side of the "H". The driver circuit turns its associated bottom power transistor on and the top one off. When the servo is in a command-satisfied position, there is no voltage on either line and both bottom

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CRAB POSITION VS COMMAND BIT STATE

| 13V WORD | | | | | | |
|-----------------|--------|--------|-----------------|--------|-------------------------|--------------------------|
| Bit 27 (LSB) | Bit 28 | Bit 29 | Bit 30 (MSB) | Bit 31 | Crab Angle (Degrees) | Crab Step (Numerical) |
| 1 | 1 | 0 | 1 | 1 | +3.85 | +11 |
| 0 | 1 | 0 | 1 | 1 | +3.50 | +10 |
| 1 | 0 | 0 | 1 | 1 | +3.15 | + 9 |
| 0 | 0 | 0 | 1 | 1 | +2.80 | + 8 |
| 1 | 1 | 1 | 0 | 1 | +2.45 | + 7 |
| 0 | 1 | 1 | 0 | 1 | +2.10 | + 6 |
| 1 | 0 | 1 | 0 | 1 | +1.75 | + 5 |
| 0 | 0 | 1 | 0 | 1 | +1.40 | + 4 |
| 1 | 1 | 0 | 0 | 1 | +1.05 | + 3 |
| 0 | 1 | 0 | 0 | 1 | +0.70 | + 2 |
| 1 | 0 | 0 | 0 | 1 | +0.35 | + 1 |
| 0 | 0 | 0 | 0 | 1 | + 0 | + 0 |
| 0 | 0 | 0 | 0 | 0 | - 0 | - 0 |
| 1 | 0 | 0 | 0 | 0 | -0.35 | - 1 |
| 0 | 1 | 0 | 0 | 0 | -0.70 | - 2 |
| 1 | 1 | 0 | 0 | 0 | -1.05 | - 3 |
| 0 | 0 | 1 | 0 | 0 | -1.40 | - 4 |
| 1 | 0 | 1 | 0 | 0 | -1.75 | - 5 |
| 0 | 1 | 1 | 0 | 0 | -2.10 | - 6 |
| 1 | 1 | 1 | 0 | 0 | -2.45 | - 7 |
| 0 | 0 | 0 | 1 | 0 | -2.80 | - 8 |
| 1 | 0 | 0 | 1 | 0 | -3.15 | - 9 |
| 0 | 1 | 0 | 1 | 0 | -3.50 | -10 |
| 1 | 1 | 0 | 1 | 0 | -3.85 | -11 |

Note: Any other combination of bits 27 through 30 (crab bits 4 through 1) will drive the crab servo to either the positive or negative extreme, depending on the commanded crab polarity.

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transistors are off. If the mirror drive is mechanically disturbed to such an extent that the servo position is moved outside the specified tolerance range for its commanded position, it will return to within tolerance without being recommanded, provided servo power is available. The motor terminal voltage is regulated to approximately 18 vdc with zener diodes.

4.2.2.2 Crab Servo Encoder. The function of the encoder is to compare the input binary command with actual shaft position and direct the bidrive circuit to run in the proper direction to satisfy the command. The encoder consists of 32 varying length, conductive segment tracks on a cylindrical drum. Electrical connection is made to each track by means of conductive brushes. This motor-encoder drive method is not a closed-loop system. Voltage is lost to the bidrive circuit when a command is satisfied by a brush breaking electrical contact with a segment. Coast is controlled by dynamic braking of the motor.

4.2.2.3 Crab Servo Overload Protection. If the servo current (motor plus electronics) exceeds approximately 1.4 amperes (overload), a timing circuit is activated. This circuit will energize a latching relay within 3.5 to 8.7 seconds of continuous overload. The latching relay opens the 2 encoder outputs to the bidrive circuit disabling the servo. The timer will automatically reset itself within 0.5 second after current returns to a normal level. If the latching relay has been activated by the timer circuit, it must be reset manually by reversing the polarity bit or by removing and reapplying servo power.

4.2.3 Crab Angle Instrumentation

Two 10K Ω potentiometers, a coarse and a fine output (IMPs 5009 and 5010, respectively), are connected through gears to the servo output shaft (reference Figure 3.4-8). These potentiometers are powered through resistor dividers by the +5-volt instrumentation power supply. The fine potentiometer rotates 5 times for each rotation of the coarse.

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A second set of instrumentation points (fine IMP 5149 and coarse IMP 5148, gear ratio 5:1) act as redundant position monitors. These outputs are derived from potentiometers located in that portion of the load box attached to the COA structure (reference Figure 3.4-9). A linkage arm connects the load box assembly to the yoke and rotates the potentiometers as a function of yoke position. Power is derived from the +15-volt instrumentation power supply.

4.3 Instrumentation Summary

Table 3.4-3 summarizes those instrumentation points associated with the mirror positioning servos.

4.4 Mirror Positioning Command Summary

4.4.1 CP Select Commands

CP A SELECT (NO2663, NO1663, NO3663)

CP B SELECT (NO2666, NO1666, NO3666)

Function: These commands choose the "A Channel" or "B Channel" electronics in the command processor for control of the crab servo and stereo servo. The commands also choose which CP channel will process the 9 OP and 5 OP commands.

Comments: (a) Both Channel A and Channel B circuits are completely capable of handling all servo and all 9 and 5 OP commands. They can be used interchangeably.

(b) Erroneous instrumentation and reverse power control logic will result if sides of the CP are switched while either 9 or 5 operational power is on.

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TABLE 3.4-3
MIRROR POSITIONING INSTRUMENTATION SUMMARY

| <u>IMP</u> | <u>Title</u> | <u>Description</u> | <u>Power</u> |
|------------|---------------------|---|--------------|
| 5009 | Crab Angle (Coarse) | A coarse and fine potentiometer (ratio 5:1) with associated voltage divider networks are located in the crab servo and are mechanically connected through gears to the servo output shaft (see Figure 3.4-8). Voltage output extends linearly from 0.5v to 4.5v, with the fine sensor cycling several times over the full range of crab drive. | +5 vdc |
| 5010 | Crab Angle (Fine) | | |
| 5148 | Crab Angle (Coarse) | A coarse and fine potentiometer (ratio 5:1) located in that portion of the load box mounted to the camera optics assembly monitor directly the position of the stereo mirror yoke by means of lever arms and gears (see Figure 3.4-9). This arrangement provides a redundant means of monitoring crab position. Associated processing circuitry is located in this portion of the load box. Voltage output extends linearly from 0.25v to 4.8v, with the fine sensor cycling several times over the full range of crab drive. | +15 vdc |
| 5149 | Crab Angle (Fine) | | |
| 5127 | Stereo Angle | A potentiometer, located within the stereo servo, monitors the position of the stereo servo output shaft over the range of rotation required to establish the three mirror positions (forward, vertical, aft). The potentiometer is mechanically connected through gears to the output shaft (reference Figure 3.4-8). Output varies nonlinearly from 0.5v to 4.5v. | +5 vdc |
| 5147 | Stereo Angle | A potentiometer located in that portion of the load box mounted to the stereo mirror yoke monitors the stereo angle. Linkage arms connect the load box assembly to the stereo mirror and rotate the potentiometer as a function of mirror stereo position (see Figure 3.4-9). The processing network is located in that portion of the load box containing IMPs 5148 and 5149. Output varies nonlinearly from 0.5v to 4.5v. | +15 vdc |

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TABLE 3.4-3 (CONT'D)

| <u>IMP</u> | <u>Title</u> | <u>Description</u> | <u>Power</u> |
|------------|--|--|--------------|
| 5090 | Crab, Stereo, and Door Current | A current sensing resistor in the power return line in the PM and C generates a voltage proportional to the combined currents for the crab and stereo servos, and the viewport door motor and electronics. The signal is amplified within the PM and C to produce a linear output ranging from 0.2v (0.0 amp) to 5.0v (6.0 amps). | +15 vdc |
| 5585 | Servo Voltage Monitor | A two-resistor voltage divider network connected across the servo power feed in the PM and C monitors the voltage output level. Output is digitized in the DTU to yield a binary signal (<u>On/Off</u>). "0" = <u>Off</u> "1" = <u>On</u> | Self |
| 5011 | Crab Bits 1,2,3,4 | 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 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 0.3-volt increments: Bit 1 (LSB) = Crab Bit 4-LSB (13V WORD Bit 27) Bit 2 = Crab Bit 3 (13V WORD Bit 28) Bit 3 = Crab Bit 2 (13V WORD Bit 29) Bit 4 (MSB) = Crab Bit 1-MSB (13V WORD Bit 30) | +5/±15 vdc |
| 5035 | Stereo Drive Transfer Bit 1,2, Viewport Door Open/Close, Crab Polarity +/- | Similar to IMP 5011: Bit 1 (LSB) = Stereo Drive Transfer Bit 1 (14V WORD Bit 27) Bit 2 = Stereo Drive Transfer Bit 2 (14V WORD Bit 28) Bit 3 = Viewport Door Open/Close Bit 4 (MSB) = Crab Polarity +/- | +5/±15 vdc |

3.4-28

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TABLE 3.4-3 (CONT'D)

| <u>IMP</u> | <u>Title</u> | <u>Description</u> | <u>Power</u> |
|------------|---|--|--------------|
| 5046 | Stereo Bit 1 Stored, Stereo Bit 2 Stored, CP Select A/B, FPLLE Speed Range High/Normal | Similar to IMP 5011: Bit 1 (LSB) = Stereo Bit 1 Stored (14V WORD Bit 27) Bit 2 = Stereo Bit 2 Stored (14V WORD Bit 28) Bit 3 = CP Select A/B Bit 4 (MSB) = FPLLE Speed Range High/Normal | +5/±15 vdc |
| 5029 | 9 Cam ON/OFF, 5 Cam ON/OFF, 9 OP ON/OFF, 5 OP ON/OFF | Similar to IMP 5011: Bit 1 (LSB) = 9 Cam ON/OFF Bit 2 = 5 Cam ON/OFF Bit 3 = 9 OP ON/OFF Bit 4 (MSB) = 5 OP ON/OFF | +5/±15 vdc |

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4.4.2 14V WORD Command

14V WORD (14V4bbWXYZ, bits 25 through 38, Implicit)

Function: Bits 27 and 28 of this command store the stereo position to which the stereo mirror servo is to move upon receipt of a 13V WORD command.

This command also commences and terminates photography in the 9 and 5 systems. Either system can be operated individually or both used simultaneously.

Only one film-drive speed (FDS) can be held in the CP at a given time. This FDS will be used by whichever system(s) is (are) operating. The command implicitly removes power from the 9 and 5 slit control electronics and inhibits both the 9 and the 5 take-ups.

14V WORD Command Bits

| <u>Bit No.</u> | <u>Function</u> |
|--------------------------------------|---|
| Implicit Bit | 9/5 Slit OFF, 9/5 Take-up INHIBIT |
| 25-1 | 9 Film Drive (9 FPLLE) ON, 9 SRC ON, 9 Data Track and 9 Interframe Marker ON |
| 25-0 | 9 Film Drive (9 FPLLE) OFF, 9 SRC OFF, 9 Data Track and 9 Interframe Marker OFF |
| 26-1 | 5 Film Drive (5 FPLLE) ON, 5 SRC ON, 5 Data Track and 5 Interframe Marker ON |
| 26-0 | 5 Film Drive (5 FPLLE) OFF, 5 SRC OFF, 5 Data Track and 5 Interframe Marker OFF |
| 27-1 } 27-0 } 28-1 } 28-0 } | Stereo position for stereo mirror at next 13V WORD: |

| Mirror Position Stored (Degrees) | <u>27</u> | <u>28</u> |
|----------------------------------|-----------|-----------|
| +8.65 (Forward) | 0 | 0 |
| 0.0 (Vertical) | 0 | 1 |
| -8.65 (Aft) | 1 | 0 |
| -8.65 (Aft) | 1 | 1 |

29 through 38 } Film-drive speed (LSB to MSB), and also for bits 35 through 38, SRC step (LSB to MSB)

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- Interlocks:
- (a) No film motion will occur unless 9 OP ON or 5 OP ON is provided for that system in which film drive is commanded. The stereo mirror position will be stored, however, and the SRC will function for the commanded system.
 - (b) The 9/5 Take-up INHIBIT will be overridden in a system if a low tension condition is encountered or if the take-up side of a looper reaches electrically full. The 9/5 Take-up INHIBIT will also be overridden by execution of a 9/5 TAKE-UP ENABLE command after execution of a 14V WORD.
- Constraints:
- (a) The film drive requires 0.30 second (nominal) to achieve acceptable drive smoothness.
 - (b) The SRC mechanism can move a maximum of four steps during the film drive start-up period.
- Comments:
- (a) The 14V WORD is the only command which can be used to provide the stereo mirror stereo position information to the PPS/DP. EAC.
 - (b) The 14V WORD is the only command which can be used to commence photography in either system.

4.4.3 13V WORD Command (13V2bWXYZ)

- Function:
- (a) The stereo servo will move to the position stored by the last 14V WORD command and the crab servo will move to the crab angle specified. Bits 27 (LSB) through 30 (MSB) of the 13V WORD command specify the crab angle to be executed. Bit 31 provides the polarity of the desired crab angle.
 - (b) This command implicitly terminates photography in both the 9 and the 5 systems by resetting the 9 and 5 film-drive command memories to OFF. It also removes power from the 9 and 5 SRCs, and the 9 and 5 data tracks and interframe markers.

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| <u>Bit No.</u> | <u>Function</u> |
|---------------------|--|
| Implicit Bit: | 9 and 5 Film Drive OFF 9 and 5 SRCs OFF 9 and 5 Data Track and Interframe Markers OFF Stereo Mirror Drive ON |
| 26 | No Function in PPS/DP |
| 27 | Crab Angle Bit 4 (LSB) |
| 28 | Crab Angle Bit 3 |
| 29 | Crab Angle Bit 2 |
| 30 | Crab Angle Bit 1 (MSB) |
| 31 | Crab Polarity |
| 32 through 38 | No Function in PPS/DP EAC |

See Table 3.4-2 for command bit pattern vs crab angle.

- Interlocks:
- (a) This command requires either 9 OP ON or 5 OP ON for execution of crab and stereo positions.
 - (b) The stereo mirror stereo angle position given in the last 14V WORD will be executed by this command.
- Comments:
- (a) 3.0 seconds are required for stereo angle transitions between extremes (forward/aft), 2.0 seconds between adjacent positions (aft/vertical or forward/vertical).
 - (b) Crab angle transition requires 3.0 seconds for one step. Each additional step requires 2.5 seconds.
 - (c) Due to system design, it is possible to more accurately achieve a desired crab angle by approaching the desired crab step from a certain direction (see Section 4.2).
 - (d) The 13V WORD is the only command which executes crab and stereo mirror changes.

4.4.4 Operational Power ON Commands

9 OP ON (N12054, N11054, N13054)
5 OP ON (N12055, N11055, N13055)

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Function: The OP ON commands switch camera operating power for the indicated camera system. The following units receive power when the indicated commands are executed:

Stereo Servo (9 or 5 OP ON)
 Crab Servo (9 or 5 OP ON)
 9 FPLLE (9 OP ON)
 5 FPLLE (5 OP ON)
 Film Control Electronics (9 OP ON)
 Film Handling Electronics (5 OP ON)

If 9 SRC DISABLE or 5 SRC DISABLE have disabled an SRC mechanism, execution of OP ON for that system will reset the disabled SRC allowing power application to the associated SRC, data track, and interframe marker electronics.

- Interlocks:
- (a) Either the 9 or the 5 operating power must be on for execution of crab or stereo angle changes commanded by a 13V WORD.
 - (b) The OP ON command is required in a camera system to permit that system to operate; i.e., 9 OP ON for the 9 system and 5 OP ON for the 5 system.
 - (c) Operational power for a system is required for take-up operation in that camera system. Film take-up requires 3.0 seconds (3.5 seconds in the 9 system when there is less than 500 feet or more than 4000 feet of film on the take-up spool, and the drive voltage is less than 24.5 vdc).
 - (d) 5 OP ON disables the 5 parking brake circuit.

4.4.5 Operational Power OFF Commands

9 OP OFF (N12050, N11050, N13050)
 5 OP OFF (N12056, N11056, N13056)

Function: The indicated OP OFF commands remove camera operating power from:

Stereo Servo (9 and 5 OP OFF)
 Crab Servo (9 and 5 OP OFF)
 9 FPLLE (9 OP OFF)
 5 FPLLE (5 OP OFF)
 Film Control Electronics (9 OP OFF)
 Film Handling Electronics (5 OP OFF)

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- Interlocks:
- (a) Either 9 or 5 operational power is required for crab and stereo servo power.
 - (b) 5 OP OFF enables the 5 parking brake circuitry if the 5 parking brake power is not on at the time of command execution. Otherwise, the 5 parking brake circuitry will not be enabled until both 5 OP and 5 parking brake power are off.

4.4.6 9/5 RUNOUT ON Command (MCS)

(MP00046)

Function: This command provides power to the:

- Stereo Servo
- Crab Servo
- 9 FPLLE
- 5 FPLLE
- Film Control Electronics
- Film Handling Electronics

It selects the normal speed range of film-drive speeds and selects "1" for the two most significant film-drive speed bits. It turns on the 9 and the 5 FPLLEs producing film drive in both systems between step 768 (9.70 in./sec) and step 1023 (11.8 in./sec).

- Interlocks:
- (a) Runout can be halted by commanding 9 OFF (MN00122) and 5 OFF (MN00124) or 9/5 OFF (MN00773).
 - (b) Runout can also be negated by the ECS 13V WORD or 14V WORD commands with 9 OP OFF and 5 OP OFF.
 - (c) 9/5 RUNOUT ON disables the 5 parking brake circuitry.

4.4.7 Power OFF Commands (MCS)

- 9 OFF (MN00122)
- 5 OFF (MN00124)
- 9/5 OFF (MN00773)

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Function: These commands remove power from the:

- Stereo Servo (9 OFF and 5 OFF, 9/5 OFF)
- Crab Servo (9 OFF and 5 OFF, 9/5 OFF)
- Focus Sensor Electronics (9 OFF, 5 OFF, 9/5 OFF)
- 9 FPLLE (9 OFF, 9/5 OFF)
- 5 FPLLE (5 OFF, 9/5 OFF)
- Film Control Electronics (9 OFF, 9/5 OFF)
- Film Handling Electronics (5 OFF, 9/5 OFF)
- S-1/PRG (9 OFF, 5 OFF, 9/5 OFF)

Interlocks: 5 OFF or 9/5 OFF enables the 5 parking brake circuitry if 5 parking brake power is off at the time of command execution. Otherwise, the 5 parking brake circuitry will not be enabled until both 5 OP and 5 parking brake power are off.

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