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DESCRIPTION AND OPERATION MANUAL

J-3 PANORAMIC CAMERA SYSTEM

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Itek

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LEXINGTON, MASSACHUSETTS 02173

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Notice of Missing Page(s)

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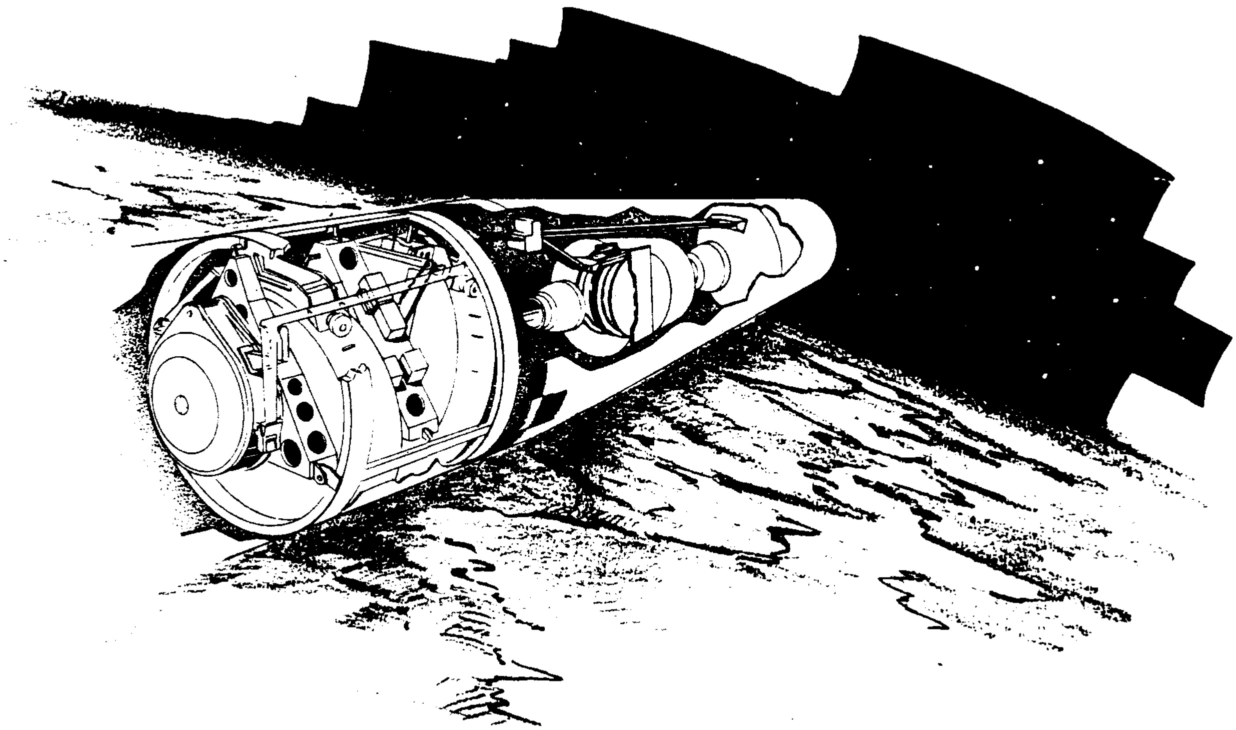

J-3 Camera System

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1. GENERAL DESCRIPTION

1.1 PURPOSE AND SCOPE OF MANUAL

The purpose of this manual is to provide instruction on the operation of the J-3 Stereoscopic Panoramic Camera System. The text of this manual is arranged so that a general description of the system is provided first, followed by successively more detailed sections on the system operation, and basic checkout and adjustment practices which must be performed to prepare the system for use. In general, this manual is designed to serve as a reference text for the user community and field service personnel, and an indoctrination text for those associate personnel who must have a basic knowledge of the camera operation.

Section 1 describes the system physically. Section 2 describes the system principles of operation in block diagram form. These sections are oriented towards engineering management personnel. Section 3, which breaks down and describes the electrical circuits and mechanical assemblies in more detail, is directed more towards the engineer who must work with the system and who must have a more detailed understanding of the inner workings of the system.

The front panels, controls, and indicators of the test and checkout console are illustrated and described in Section 4. This section also contains a brief description of the system startup and shutdown procedures.

Section 5 contains nonstandard adjustment and replacement procedures which must be performed to make the system ready for use.

Section 6 contains detailed electrical and electronic checkout procedures for all major electrical components.

Section 7 contains the electrical schematics of the J-3 system. These schematics were of the latest revision available at the time of printing, and are provided here for instruction only. When performing the actual troubleshooting operations, refer to the schematics which are supplied with each system (by serial number).

1.2 PURPOSE OF THE J-3 SYSTEM

The general role of the J-3 system is to provide stereoscopic photographic reconnaissance from a satellite. More specifically, the J-3 system has a dual purpose role in reconnaissance; namely, (1) intelligence acquisition, and (2) provisions to enable cartographic and geodetic evaluation of the photography and image points of interest.

1.2.1 Acquisition

The fundamental purpose of the J-3 system is to provide extensive stereoscopic photographic coverage of the ground with sufficient detail to allow a photointerpreter to recognize, evaluate, and monitor selected targets. Consequently, the J-3 system contains certain features which are designed specifically towards this end. First, the camera uses a high acuity, diffraction limited lens in such a way as to take advantage of the high resolution available over a narrow field angle. Secondly, auxiliary horizon recording cameras are mounted in a fixed relationship to the panoramic camera to provide an expeditious means for determining vehicle roll and pitch. A time reference system is provided which allows recovery of the time at which any point in the photographic format was recorded and also the time relationship of horizon optics exposure to panoramic exposure.

1.2.2 Cartography and Geodesy

The secondary purpose of the J-3 system is to provide photogrammetric control data having the required geometric accuracy to assist the cartographer in constructing accurate terrain maps from the photography obtained by the system. Of equal importance is the ability to assign accurate geodetic coordinates to the maps so constructed. The J-3 system can supply the required geodetic control, assuming the availability of accurate orbital and attitude information.

For cartographic purposes it is essential to establish the geometrical relationship between points on the film format and corresponding ground points. In order to accomplish this, it is necessary to calibrate the internal geometry of the camera. Generally, this involves the use of special equipment in preflight testing of the system and special data reduction techniques. The calibration information obtained from the tests is supplied to the cartographic community. Additional data is recorded on the film during inflight photography. This data permits the correlation of the photography with the previously obtained calibration information. Thus, for every point on the film, the cartographer can determine two angles, α (cross-track or scanning angle), and β (along-track angle), with an rms accuracy of 4 arc-seconds each.

1.3 SYSTEM DESCRIPTION

A summary of the basic physical features and operational parameters is provided in Table 1-1. The complete J-3 system payload consists of the following:

1. Two identical, 24-inch focal length, f/3.5 panoramic cameras, each having two integrated 55-millimeter focal length, f/6.3 horizon optics
2. One auxiliary structure (supports both panoramic cameras and the electronics packages to form the so-called camera module)
3. One supply cassette
4. One supply support structure

Table 1-1 — Summary of Physical Features and Operational Parameters

Physical Features	
Configuration	30-degree convergent stereo panoramic cameras
Lenses	24-inch focal length, f/3.5 Petzval design
Film capacity	15,750 feet of 70-millimeter, 3.0-mil, polyester-base film per camera
Film size	31.632 × 2.754 inches
Usable format	29.323 × 2.147 inches
Power	1620 watt-hours (24 vdc, unregulated, at 2.5 radians per second)
	270 watt-hours (115 vac, 400 cps, at 2.5 radians per second)
Weight (empty)	Approximately 437 pounds
Weight (with film)	Approximately 597 pounds
Cycle period	1.5 to 4.2 seconds per cycle
Exposure time	Variable
Overlap	Fixed at 7.6 percent
Filter	Variable (2 position)
Operational Parameters	
V/h range	0.0525 to 0.021 radians per second
Altitude	80 to 200 nautical miles
Cross-track coverage per frame	116 to 290 nautical miles
Along-track coverage per frame	7.73 to 19.33 nautical miles
Total along-track coverage	41,167 nautical miles at 80-nautical mile altitude
Total operating time	169 minutes at 80-nautical mile altitude

5. Two takeup cassettes
6. One intermediate roller assembly

The following ancillary equipment is used to support the system in the field:

1. Test and Checkout Console (see Section 4)
2. Camera module transit case
3. Single camera transit case
4. Camera module dolly
5. Single camera dolly
6. Spool assembly dolly

The general configuration is illustrated in the frontispiece and the geometric relationships of the system are shown in Fig. 1-1. The panoramic cameras are positioned on the auxiliary structure in a V-configuration to provide a 30-degree stereo angle. The auxiliary structure is three-point mounted to the vehicle so that the even serial numbered camera is located forward and views toward the rear (aft-looking), and the odd serial numbered camera is located aft and views forward (forward-looking). The auxiliary structure also provides the mounting surface for the system's electronic packages. The supply cassette, which contains the total film supply for both cameras, is located aft of the camera module. The supply cassette is fastened to its support structure which is, in turn, three-point mounted to the vehicle. Takeup A, located in recovery vehicle RV-1, and takeup B, located in RV-2, each take up half of the film of both cameras. The intermediate roller assembly is attached to the vehicle between takeup B and the camera module.

The system is basically designed to use 2.5-mil base, 3.0-mil thick, 70-millimeter, EK 3404 film. Either camera can also operate with a split load of any two of the following types of film: 3404, SO-121, SO-180, SO-230, SO-380. The supply cassette contains two 28 1/4-inch diameter spools, each capable of storing 16,000 feet of film. Each of the two takeup A spools is capable of storing 8,000 feet, and each takeup B spool is capable of storing 7,750 feet of film. The system's total film capacity, therefore, is limited by takeup B of 31,500 feet of the above film.

1.4 ELECTRICAL CHARACTERISTICS

The power requirements of the J-3 system are 24 vdc, unregulated, and 115 vac at 400 cps. Unregulated 24-vdc power is utilized for general service in the camera, supply control, and takeup control. The 115 vac, 400-cps power is utilized in the camera to develop regulated direct current power; plus and minus low voltages are developed for the camera drive servo and exposure control circuits, and high voltage direct current power is developed for the frequency marker lamp requirements.

The power supply returns are carefully segregated within the system to provide isolation between the 115 vac, 400 cps return and the 24-vdc unregulated return. Also, isolation is provided between power returns and all shielding and bonding requirements.

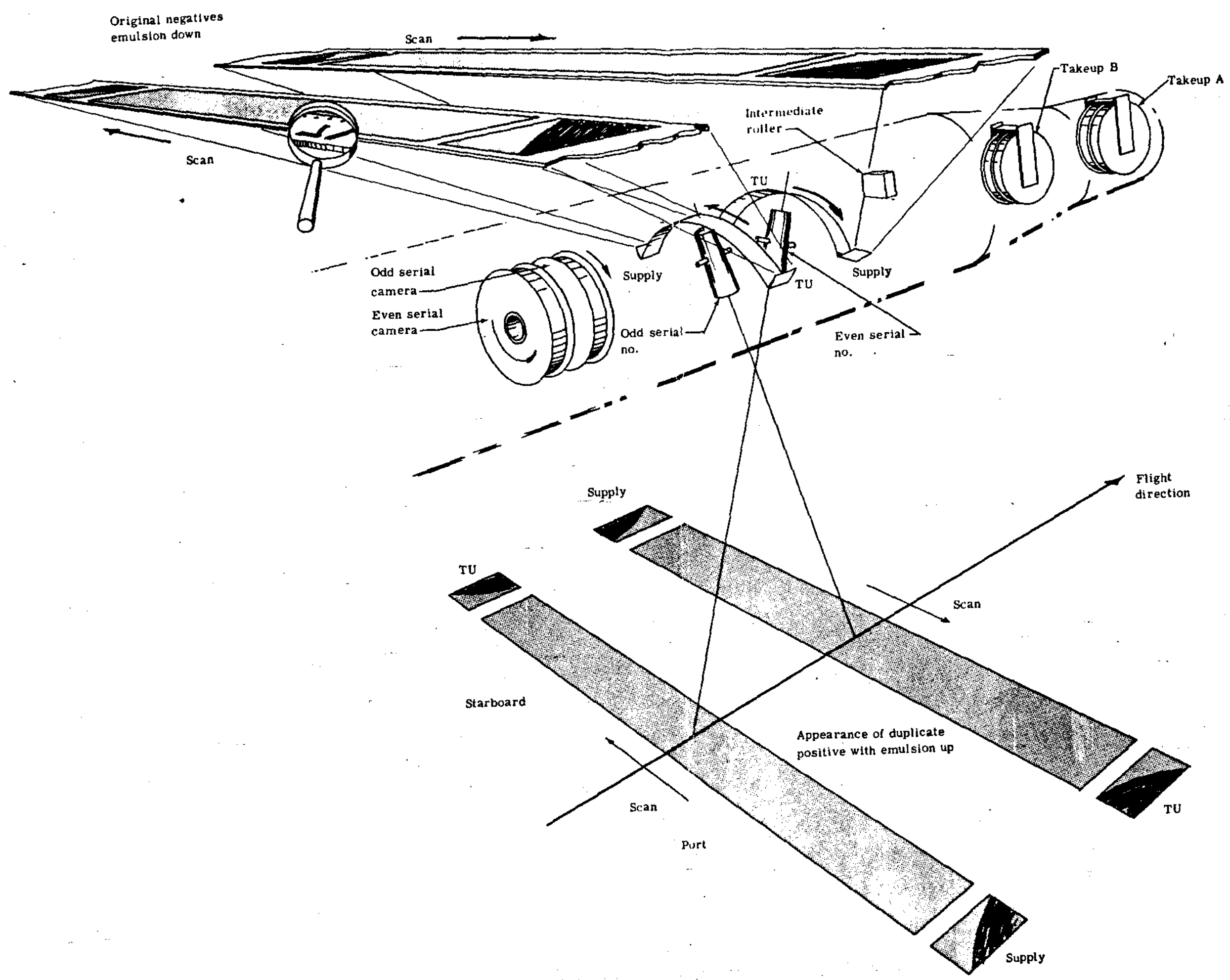


Fig. 1-1 — Configuration and orientation

In addition, regulated dc power returns are joined to the unregulated dc return at only one point (drive servo). This is required to maintain proper referencing of the V/h programmer signal to the tachometer feedback signal.

The no-load and average-load requirements of the J-3 system are as follows:

1. Unregulated direct current
   a. No-load +22 to +29.5 volts
   b. Average-load +21 to +28.5 volts
2. Alternating current
   a. No-load 113.7 to 117.3 volts rms
   b. Average-load 111.7 to 115.3 volts rms

The total system power consumption is nominally 1,890 watt-hours (based on 40 frames per pass at a 2.5 second per cycle rate, and 150 starts and stops per mission).

1.5 TELEMETRY

The J-3 system contains several component temperature and operation monitors which provide telemetric data during operation. In addition to the telemetry, monitor points which can be checked during ground testing are provided.

1.6 CAMERA MODULE

The camera module, shown in Figs. 1-2 and 1-3, consists of a triangular, riveted, sheet metal, auxiliary structure, on which are mounted two panoramic cameras and the system electronics boxes. The main electronics box contains the control package, the interface package, the data signal conditioner, and the ac-to-dc power supply. The auxiliary electronics box contains the main servo and the panoramic geometry electronics circuits.

1.7 CAMERA DESCRIPTION

The panoramic cameras are independent and similar but are not interchangeable. Each camera consists of its own machined frame upon which most of the camera components are mounted. Because some camera components are attached to the auxiliary structure, the structure must be considered as an integral part of the panoramic camera.

The primary components of the panoramic camera are: (1) drive system, (2) lens, (3) scan head assembly, (4) drum, (5) film transport mechanisms, (6) FMC mechanism, (7) panoramic geometry system, and (8) the horizon optics. The actions of these components are related and timed through a system of belts, pulleys, and special-function gear packages, all of which are driven from a single camera drive motor.

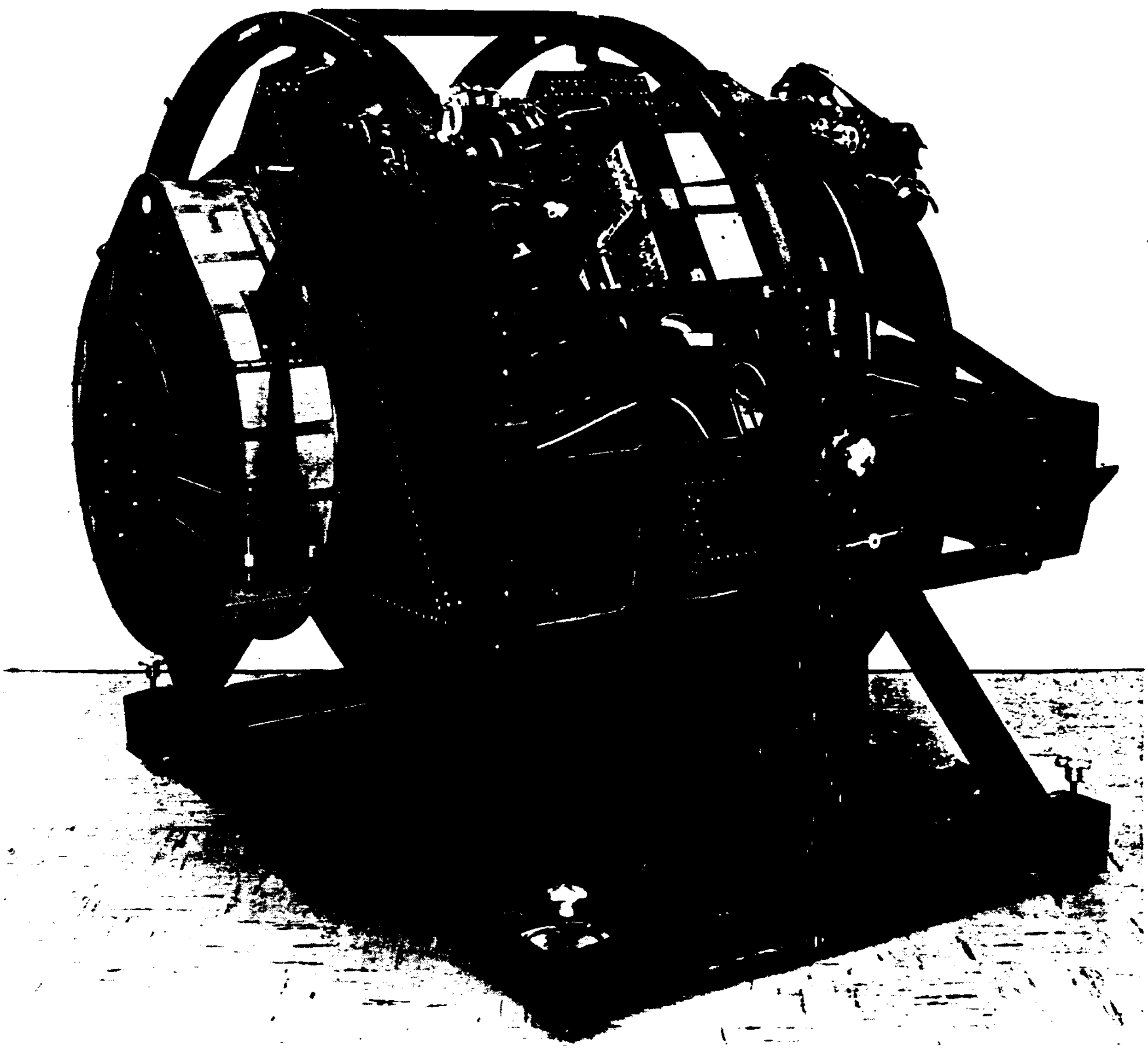


Fig. 1-2 — Camera module, supply end

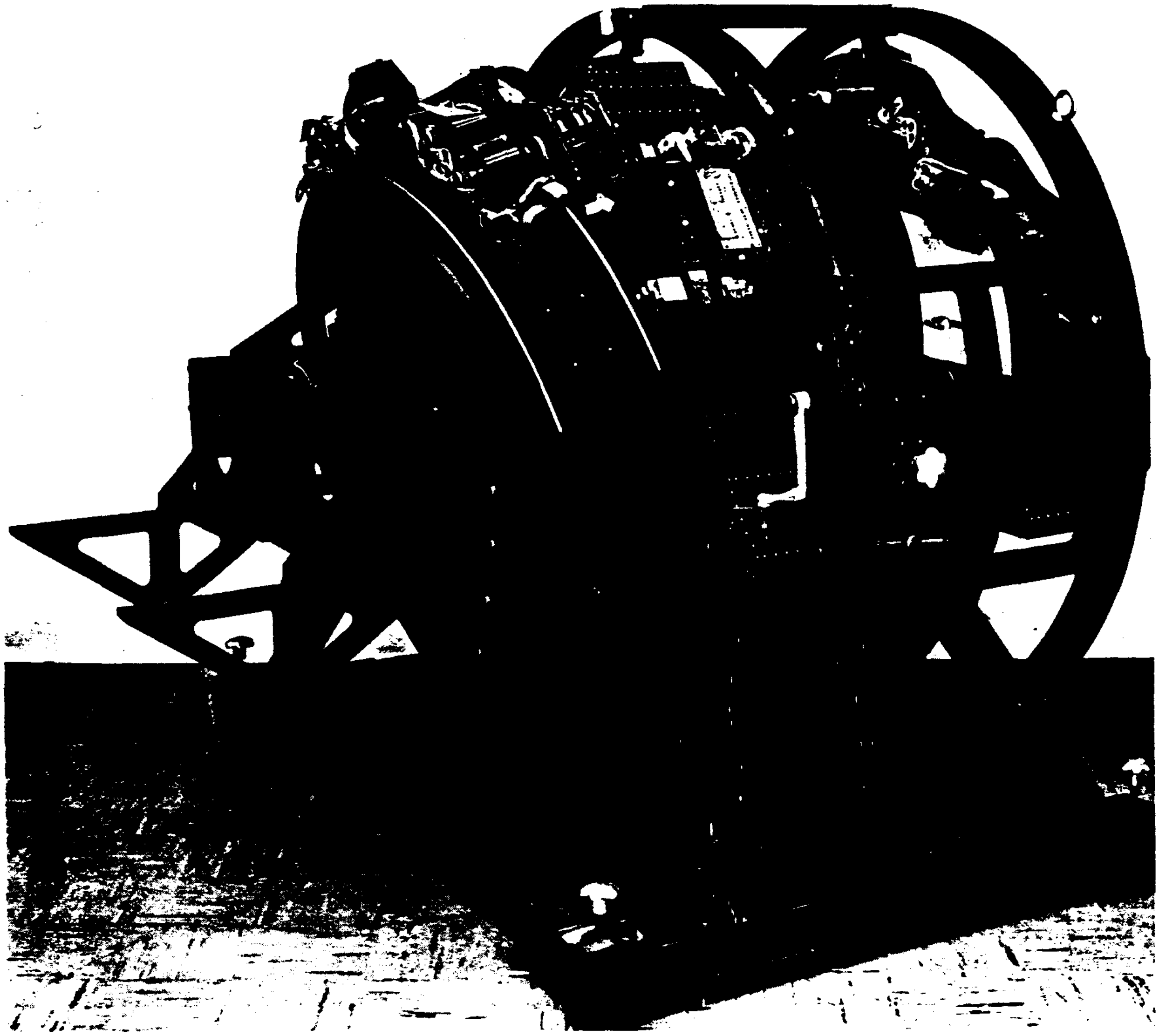


Fig. 1-3 — Camera module, takeup end

The 24-inch focal-length lens is a Petzval design consisting of five elements mounted within a cast magnesium cell. A sixth element, the field flattener, and the scan head assembly are mounted on the end of a titanium tail cone which is, in turn, secured to the lens cell at the nodal point.

The scan head assembly, which contains the slit width and filter change devices and the focal plane rollers, is mounted on the end of the lens cone. This device consists of a bidirectional, four-position slit width changer and a two-position filter changer. A slit width failsafe mode or nominal slit width position is also provided. The slit blades are driven through a clutch and a dual potentiometer, by a servo motor. The filter is driven by a stepper motor and a dual potentiometer. During the exposure portion of the scan, the focal plane rollers lift the film from the guide rails into the exact focal plane.

In order to prevent light from entering the vehicle compartment through the vehicle/camera interface, a drum housing the lens rotates within a network of non-rotating light shields that nod with the drum. The drum itself is lighttight except for the clear aperture end and a smaller opening for the scan head access cover. Two formed pieces of sheet metal, which are attached to the drum around its periphery, rotate inside a labyrinth preventing light from entering alongside the drum. The inside diameter of the light shields are slightly larger than the diameter of the drum, and the shields encompass the drum over a sufficient portion of the circumference to prevent light from passing around the drum itself. The drum assembly also serves as a thermal shield for the lens when the camera is inoperative.

A series of rollers, located around the circumference of the drum and placed parallel to the lens rotation axis, revolve with the drum just beneath the film guide rails to prevent film from being pulled through the rails. These rollers do not contact the film under normal operation.

The camera film transport system comprises an input metering roller which is geared through a 99/101-percent clutch to provide continuous input metering at a nominal rate. Film guide rails guide the film over the 70-degree format and film clamps located at either side of the format are actuated during exposure. A frame metering roller pulls one frame of exposed film out of the format area during the non-exposure portion of the cycle. A shuttle mechanism stores extra loops of film arising from continuous film input and output and intermittent frame metering. The shuttle also is used to control the 99/101-percent clutch.

Each camera contains its own FMC mechanism. The FMC mechanism is comprised of a cam, which is driven by the camera drive motor, and a four-bar linkage which is driven by the cam. The linkage is fixed at one point such that the action of the cam against the linkage causes the cameras to rock about an axis parallel to the vehicle pitch axis.

The panoramic geometry subsystem contains the equipment which is required to record a sufficient amount of data on each panoramic frame to enable a calibration of the panoramic camera. The elements of the panoramic geometry subsystem include the following:

1. Holes in the film guide rails which are spaced about 1 degree apart, angularly, and two incandescent lamps which are mounted on the scan head of the lens and are exposed through the rail holes
2. A subsystem consisting of an accurate optical encoder, electronic circuits, xenon flashtube, two sections of optical fiber bundles, a rotating optical coupling, and a lens, all of which combine to expose dots on the film to represent the nod angle of the camera
3. An accurate pulse generator which triggers a neon tube and exposes timing marks on the film to permit the determination of the time difference between the exposure of two different points of the format
4. Two lights mounted on the scan head which provide the panoramic geometry traces

Each panoramic camera contains two horizon camera assemblies that allow the photointerpreter to quickly determine the pitch and roll attitude of the panoramic camera during exposure. The horizon camera consists of a 55-millimeter, f/6.3 lens, a between-the-lens leaf shutter, a shutter-trip solenoid, a filter change mechanism, and an assembly housing. The horizon camera assemblies are mounted on each end of the film transport bridge. This facilitates the sharing of a common film supply and path with the panoramic camera. The optical axes of the horizon lenses are nominally, but not exactly, coplaner with the optical axis of the panoramic camera.

The horizon camera uses an integral filter equivalent to a Wratten no. 25. The lens provides a format of 2.1 by 0.9 inches. The corresponding half angles are 26 and 12 degrees, respectively.

The horizon camera housing provides a support structure for the lens, shutter mechanism, lens cone, lens hood, and filter change mechanism. The filter change mechanism, mounted in front of the lens, consists of a sliding filter on a track, a drive motor, and connecting linkage. An attenuating filter may be slid in front of the lens when films faster than the basic 3404 are used.

1.8 SUPPLY AND STRUCTURE

The supply cassette, which remains integral with its support structure after final assembly, contains the supply spools for both panoramic cameras, a torque motor for each spool, radius sensor arms which control the output of each torque motor, a set of tension rollers for each spool, and brakes for each spool.

The triangular-shaped support structure is a riveted, magnesium skin construction with machined fittings. It has a support ring centrally located to which the rear cover of the supply cassette is mounted.

The supply cassette is composed of three individual machined magnesium castings (two end covers and a center section) which are lightened by chemical-milling. The cassette assembly is lighttight except in the area of the tension rollers located on each side of the center section where the film exits from the cassette. They can be temporarily sealed to prevent light leaks during testing.

The supply spools consist of a 6-inch outside diameter machined magnesium hub and two 28 1/4-inch diameter by 3/8-inch thick aluminum honeycomb and magnesium skin flanges.

Tension is provided by torque motor output to a gear attached to the hub of each supply spool. A brake on each torque motor prevents rotation of the spools when the power is off.

1.9 TAKEUP CASSETTE

The takeup cassettes consist of a structure, spools, spindle, sensor arm, and component boards and cable. An additional assembly, the roller carriage, is used in takeup B.

The structure consists of two magnesium honeycomb side plates which are aligned, bonded, and secured to two shear plates. Mounted on this structure are the cable, component board, resistor plates, transistors, RFI covers, heaters, and thermostat (takeup A only).

The spools are of lightweight magnesium construction. The B takeup spool has a larger core diameter which results from having three hub rollers and a set of wrap-around plates installed.

The spindle assemblies consist of a three-piece magnesium housing into which are assembled two torque motors, the necessary drive gearing, and two antibackup systems for the A takeup (or two brakes for the B takeup). The antibackup unit consists of a ratchet wheel coupled to the motor shaft through a one-way clutch, a pawl, suitable linkage, and a release solenoid. The brake used in the B spindles is keyed to the motor shaft and is released electrically.

The sensor arm assembly consists of a magnesium frame into which are assembled two potentiometers, antibacklash gearing, and a spring-loaded sensor arm and puck assembly.

The roller carriage assembly, contained only on B takeups, consists of two magnesium side plates into which are mounted the input and output rollers, deflection roller, roller shafts, and film guard.

2. GENERAL PRINCIPLES OF OPERATION

2.1 INPUTS AND COMMANDS

As shown in Fig. 2-1, the J-3 system receives its power from the Agena vehicle and its command signals from the LMSC control package via the vehicle interface harness which interfaces with the J-3 system's main electronics box. Inputs to the main electronics box interface are as follows:

1. Plus 24 vdc, unregulated, 115 vac, 400 cps power
2. Control commands
   a. Launch mode
   b. Orbit (standby) mode
   c. Operate
   d. V/h
   e. A to B transfer
3. Other commands
   a. Exposure slit position
   b. Clock signal
   c. Slit width failsafe
   d. Filter change
   e. Slit width failsafe reset

All commands and signals required to operate the components internal to the J-3 system (supply, cameras, and takeups) are generated (basically) in the J-3 main and auxiliary electronics boxes.

2.2 CAMERA SYSTEM CONCEPT

The J-3 camera system, like most camera systems, has a lens which images information onto the film, a means for storing the film prior to exposure, a method of moving the exposed film from the exposure area (format), and a storage system for receiving the exposed film. Unlike most cameras, however, the J-3 camera has supply and takeup systems which are physically separated from the camera proper. In the case of the supply cassette, this separation is made to allow location of the spools at a position in the vehicle where there is room to carry large amounts of film and yet have good access for loading. The takeup, on the other hand, has been

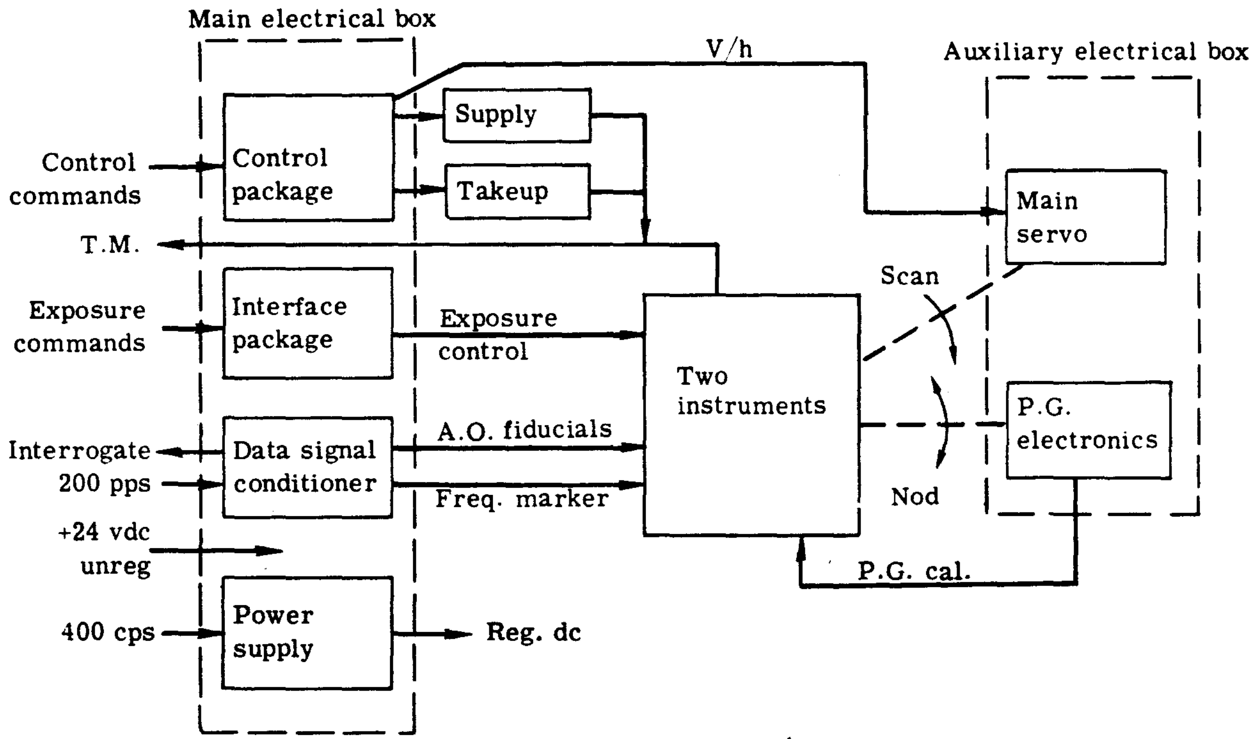


Fig. 2-1 — System power and control block diagram divided into two parts, since the available area in the recovery section is not sufficient to accommodate all of the film on one set of recovery spools. The dual takeups also allow early recovery of the first half of the exposed film of both cameras.

Another camera requirement, a lighttight box, is in this case provided by the vehicle itself in order to save the weight that would otherwise be necessary if the camera was completely self contained.

2.3 MODES OF OPERATION

A camera system which is utilized in a satellite is necessarily subjected to a wide variation of environments which affect the original design and also affect the manner of operation. This variation arises from the different phases of system operation which are: powered flight (launch mode), orbital flight without operation (standby mode), orbital flight with operation (operate mode), and recovery (A to B transfer).

2.3.1 Launch

During launch, the camera system is subjected to a variety of simultaneous stresses arising from acceleration, random mechanical vibrations, pulsating shock, and acoustical loading. Concurrently, there is likely to be, due to structural deflections, a considerable motion of one part of the camera system relative to another, particularly between comparatively widely spaced items such as the supply cassette, camera proper, and takeups. Since the film connects these components, damage could be incurred if the film became too taut or if the film lifted from the rollers (causing subsequent mistracking) due to slack. To obviate these failures, the film transport system, with the exception of the supply side, is programmed to maintain a low level of tension throughout the film path during launch. This is accomplished by energizing the takeup spools at less than full power and deactivating the antibackup device in takeup A. Since the camera remains inoperative during this period of time, the torque motor in takeup A supplies reduced film tension from the input metering roller through the camera and forward to the takeup A film spool. The second takeup (takeup B) is held stationary by a brake, and the film is simply routed around an idler roller in its hub on the way to takeup A. The supply is energized at full power and the torque motor supplies full film tension from the supply spool up to the camera input metering roller by pulling backwards.

In this condition, therefore, there is an allowance for relative movement between the basic system components without an occurrence of either excessively high or low tensions.

At injection, the doors which cover the camera viewing ports are blown off, exposing a portion of the camera to the external environment. In order to prevent undue thermal disturbance of the lens elements, the lenses are stored in an approximate horizontal position (along the vehicle pitch axis). Following injection into orbit, the camera system enters the phase of nonoperational flight.

2.3.2 Standby

In general, all power is removed from the camera system in the standby mode. In this power-off condition, brakes restrain any motion of the supply spools or spools in takeup B. A ratchet type antibackup device in takeup A is also operative. The cycle rate (V/h) and exposure command can be applied to the J-3 system interface at any time; however, the camera system does not react until an operate command is received.

2.3.3 Operate

At receipt of an operate signal to the brakes on the supply spools, the brake on the B takeup remains ON. (The action of the B takeup will be discussed later.) Power is simultaneously fed to the supply and takeup torque motors which then provide operational film tension throughout the system.

At this time, an electrical ground connection which existed at the input to the camera drive servo is removed and replaced with the V/h voltage. This V/h voltage provides a control to the camera drive servo motor which in turn brings the camera up to a cycle speed which is directly proportional to the V/h voltage. The servo motor is the only drive source in the camera, and the energy necessary for the other camera functions, such as film metering and framing, are derived from this source by the use of gears, pulleys, and timing belts.

To terminate operation, the operate command is removed from the interface. The electrical circuitry is such that no internal camera action takes place until the completion of a camera cycle. At this time, the system is programmed down from the operational speed to a creep velocity. This creep velocity is maintained until the lens is brought into the storage position, at which time the servo motor stops and the lens is held in the stowed position for 2 to 3 seconds. The supply and takeup motors remain energized for 3 seconds after the storage position is reached to maintain system tension. After this 3-second delay, the system is fully shut down and is in the standby mode.

2.3.4 A to B Transfer

When the photographic operation has reached the point where the A takeup spools are full, it is necessary to initiate the action which brings takeup B into operation. This operation, called the A to B transfer, takes place during some convenient non-operational period of the orbit. The A to B transfer sequence is illustrated in Fig. 2-2.

A real time command actuates mechanical cutters which are located close to the A takeup. The film of each camera is cut, leaving loose ribbons of film, about 8 feet long, between the cutter and the idler rollers in the hubs of the takeup B spools. The camera then receives a 30-second command signal from the vehicle programmer which starts the sequence of the A to B transfer. A V/h signal calling for a low cycle

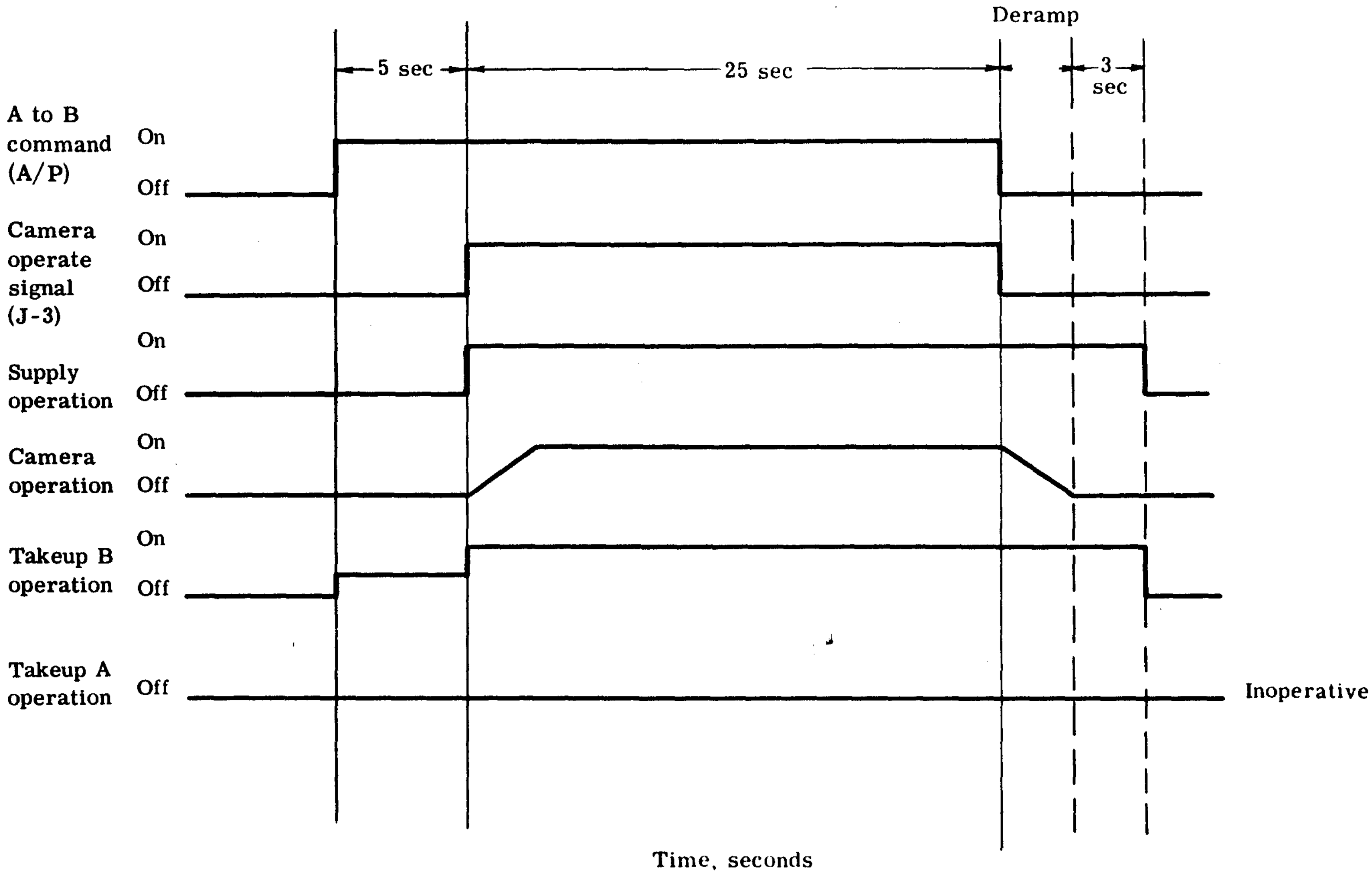


Fig. 2-2 — A to B transfer sequence

rate is applied to the J-3 interface, but the camera does not react at this time. During the first 5 seconds of the 30-second command, the takeup B spool torque motors are energized at less than full power, thereby producing reduced film tension to wrap and cinch the slack film onto the takeup B spools. At the end of the 5-second period, the supply and takeup B spool torque motors are energized at full power and an internal camera operate signal is generated, causing the cameras to operate at the commanded low cycle rate for 25 seconds. This cycle rate is such that a minimum of four camera cycles is completed in the 25-second period. At the end of the 30-second period, the A to B transfer command and the internal camera operate signal are de-energized and the J-3 system comes to its normal (ramp down) stop, and the camera is once again in a standby mode.

2.4 J-3 PANORAMIC CAMERA

The general configuration and functional characteristics of the J-3 panoramic camera are depicted in Fig. 2-3.

2.4.1 Basic Concept

The J-3 camera is an evolution of the J-1 camera and is based on the same fundamental design concepts. The first of these is based on the fact that a lens specifically designed to achieve high acuity has that acuity restricted to a narrow angular field close to the optical axis. If such a lens is to be used to cover a wide angle, a means must be found to successively expose small sections of the format. Fortunately, an axis of rotation which is perpendicular to the optical axis can be positioned such that rotation about this axis produces no movement of an image point (for reasonable angles of rotation). This axis of rotation must pass through the point on the optical axis which is termed the rear nodal point or nod of emission. Hence, if exposure is made by means of a narrow exposing slit located at the focal plane, there is no motion of the image point while this exposure is made and, in turn, a wide angle of view, at least in one direction, can be obtained by rotating the lens' exposing slit over a wide angle.

When used in a satellite, wide coverage across the line of flight can be achieved by this scanning process. Coverage along the line of flight is achieved by making successive exposures at a rate which ensures overlap. This is the second design concept common to both the J-1 and J-3 cameras.

In order to exploit the high resolution capabilities of the lens itself, it is very important that the film be located in the exact focal plane. However, an attempt to simultaneously position all points of a wide-angle cylindrical section of film at an exact radius from the lens' rotational axis would require that extremely tight tolerances be maintained over a very wide area during the occurrence of significant structural and thermal disturbances. The panoramic concept provides a solution to this problem which, again, is a carryover from the J-1 concept. Since the narrow slit

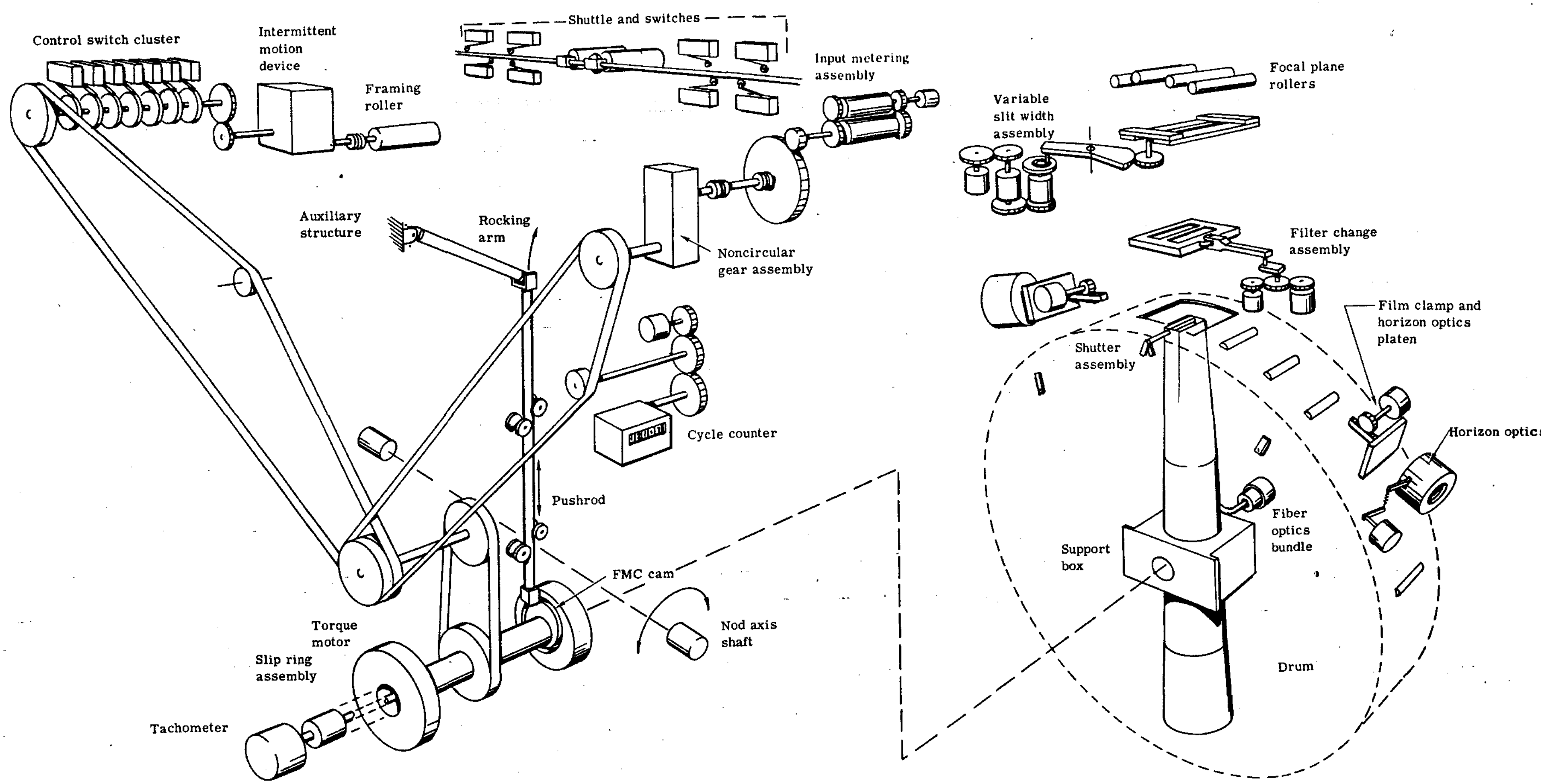


Fig. 2-3 — Camera functional schematic

exposes only a very small section of the total format at one time, only that small section need be located at the exact focal radius while it is being exposed, the remainder can be positioned at the approximate focal radius. If, therefore, the exposing slit is placed between rollers mounted rigidly to the end of the lens cone, it is possible to very accurately define the position of this small section of film and content with only the tolerances which exist in a single assembly.

2.4.2 Scanning Lens System

Since rotation about the nodal point produces no image motion due to lens scan, the film can remain stationary during exposure. Rotation about any axis other than one through the nodal point would produce an image motion and would require that a compensating velocity be imparted to the film during exposure. Such a compensating motion would, of necessity, require extreme accuracy, since motions of a magnitude greater than a few microns will deteriorate a high resolution image.

In the J-3 system, the larger vehicle diameter, as compared to the J-1, allows the lens and integral scan elements to make a full rotation, as opposed to the reciprocating motion of the J-1 scanner. This has two advantages: (1) once up to speed, it is simple to accurately maintain a fairly high rotational rate and consequently a high cycle rate which permits low altitude operation, and (2) a continuous rotation produces smoother operation with lower inherent vibration characteristics. The camera, therefore, is built around a continuously rotating high acuity lens (scan) system.

The lens has five elements which are housed in a magnesium lens cell and a small field flattener element located close to the focal plane. The field flattener, film positioning rollers, exposing slit, filter holder, and a capping shutter are mounted in an assembly on the end of a titanium cone, the other end of which mates with the lens cell at the nodal point. This combination of metals makes the lens system relatively insensitive to temperature variations of up to 30 °F on either side of the nominal design temperatures. In common with most lens systems, it is more sensitive to gradients than to changes in level.

The lens is rigidly mounted within a drum which serves three basic purposes. First, it prevents light, other than image forming light, from entering the camera. This is accomplished by the use of labyrinth seals at the periphery of the drum, and a closefitting stationary cylindrical section close to the drum cylindrical surface. Second, the drum provides a protective thermal housing for the lens when the camera is inoperative. The lens drum system is programmed to a storage position such that an aluminum surface faces the open viewing port, thus protecting the lens from the earth's albedo. The third purpose of the drum is to prevent the film from being pulled through the guide rails during transport of the ultra-thin-base film. This is performed by placing a series of rollers around the circumference of the drum with the roller axes parallel to the lens rotational axis. The rollers rotate with the drum through a position just below the film rail such that, in normal operation, they are not in contact with the film. Therefore, if an excessive tension transient occurs and the film tends to buckle through the curved film guide rails, the film will contact the rollers and be forced to remain in the rails.

The basic elements of the J-3 camera are: (1) a drive system, (2) a film transport system, (3) a method of compensating for the forward motion of the vehicle, (4) an exposure control technique, (5) a reference framework to make the photography suitable for cartographic purposes, (6) data presentation which is needed to make full use of the panoramic photography, and (7) structures to relate the various components.

2.4.3 Camera Drive System

The lens/drum system is rigidly fastened to a beryllium box section which is in turn fastened directly to the rotor of a torque motor. This torque motor, in addition to lens drive, provides the camera with the power necessary to operate all mechanical functions, such as the film transport, the frame-counter drive, and the control switch cluster. The power is transmitted by gears, pulleys, and toothed timing belts. Since the lens is driven directly by the motor, gear noise is eliminated, and any high frequency noises generated in the other mechanisms are filtered by the timing belts which drive the mechanisms. The timing belts also precisely relate the phases of the operational functions of the camera. It should be pointed out that a vibration which produces a ripple on the lens rotational rate would not, because of the nodal axis rotation, cause image smear in the scan direction. The only effect would be to cause a variation in exposure and possible banding. Therefore, the main concern is to prevent vibrations which could cause motions of the lens in directions other than scan, or motions of the film in any direction.

The torque motor is a component of a servo system which is commanded by a reference voltage received from the vehicle programmer. This input signal is varied as a function of orbital velocity-to-height ratio. The servo follows this command and drives the camera at a cycle rate such that proper forward motion compensation and proper overlap is achieved. The J-3 camera can compensate for V/h values from 0.0198 to 0.055 radian per second, and the nominal forward overlap per frame is 7.6 percent at the center of format. The V/h ratios correspond to altitudes of 250 and 80 nautical miles, respectively.

2.4.4 Film Transport System

A discussion of the film transport for the J-3 camera must include the functions of the supply and takeup systems as well. In a nodal rotation camera, the film remains stationary during the period of exposure. As previously noted, this is an advantage from the photographic viewpoint but it does require that a means be provided for intermittently moving the exposed film from the exposure areas. At all times, film tension control must be such that a well defined tension level is maintained throughout the system. Also, the supply and takeup spools are so large that it is not feasible to start and stop them at a rate consistent with the camera cycle rate. Therefore, the transport system must be designed to allow continuous motion of the film into and out of the camera and yet provide a means for holding the film stationary in the exposing arc while it is being exposed.

Five basic components of the transport system make this possible. Starting from the supply these are: the supply spool control system, a camera input metering assembly, a storage shuttle, a framing or intermittent drive device, and the takeup control system.

The camera input metering assembly divides the complete film transport system into two separate tension regions. On the supply side of the camera input drive roller, the supply spool control system dictates the tension in the film path. On the takeup side of the input drive roller, the takeup control system defines the film tension. This latter region includes the areas of shuttle storage and, importantly, the exposing area.

The two supply spools are individually connected to torque motors such that they attempt rotation in the direction opposite to film motion. The current flow to the torque motors is controlled as a function of the spool radii to maintain the film tension within allowable limits. A small tension loop is also in each supply path to minimize transients during operation. The takeup spools are controlled in basically the same way as the supply except that they are, of course, driving in the direction of film motion.

From the above it can be seen that the two sides of the panoramic system are completely independent and also that the functioning of one camera does not affect the other. Since two takeups (A and B) are used, the B is inactive while the A is being filled, then the B takeup takes over.

The camera input metering assembly pulls film continuously from the supply spool and feeds it into a storage shuttle. The framing system intermittently moves the exposed material out of the format and also feeds it into the storage shuttle. The direction of shuttle motion depends on the cycle phase: while the format film is motionless, the shuttle moves away from the input toward the output; during framing, the opposite is true. At all times, film is moving out of the camera to the active takeup at essentially a constant rate.

It would appear possible to select the speeds of the input roller and framing roller such that an average film speed through the camera would be achieved, with the shuttle storing film during output roller inactivity. However, since it is impossible to manufacture drive rollers with a zero tolerance on diameters, the slightest deviation from the specified diameter, if uncompensated, would cause a long term drift of the shuttle in one direction and eventually cause a film transport failure. To compensate for this, the input roller is purposely made about 1 percent smaller than the framing roller, and a 2-percent speed increase transmission is incorporated into the input assembly. Thus, when the input is in the direct drive mode, it moves film into the shuttle at about

99 percent of the average framing speed. When the 2-percent transmission is clutched-in, the input film speed is about 101 percent of the average framing velocity. The required input mode is programmed by switches on either end of the shuttle which are spaced to allow a reasonable number of cycles to take place before the drift (due to metering and framing roller diameter differences) causes switch actuation. So in one case the input velocity is too high as compared to the average framing velocity, and in the other case the input velocity is too slow, but the long term average is identical.

Film clamps are situated at either end of the exposing arc to assist in the isolation of the film in the format during exposure. The clamps serve a dual purpose since they also act as the horizon optics pressure platens.

2.4.5 Forward Motion Compensation

The method used in the J-3 camera to compensate for the image motion resulting from the forward motion of the vehicle is fundamentally different from the method used in the J-1 camera. The J-1 camera moves the lens relative to the film to produce an image velocity equal in magnitude but opposite in direction to the vehicle-induced image motion. This technique requires that the lens slide along its rotational axis, and a sliding interlock is needed to relate the axes of the drum/scan-arm assembly, which supports the film positioning rollers, and the lens optical axis.

To avoid any relative motion and possible vibrations in the critical lens/film system, it was decided to rock the entire camera about on axis parallel to the vehicle pitch axis to compensate for forward motion. This effectively puts the compensation in object space rather than image space, as was the case in J-1. This means that the photographic scale has no bearing on the rocking rate, but what is required is that the line of sight from an object point to an image point be maintained during the exposure period. Exact compensation is made only for a central line along the format since, due to the oblique stereo angle, other points along the exposing slit would require different angular rocking rates.

The mechanism utilized to produce the rocking motion consists of a cam, pushrod, and rocking arm. The nod axis shaft is located at the bottom of the camera, parallel to the pitch axis of the vehicle, and is supported in bearing blocks mounted to the auxiliary structure. One end of the rocking arm is attached to the structure, the other to the pushrod. The pushrod is mounted on the camera structure and is parallel to the lens axis when the lens is in the center of scan. The cam is mounted on the shaft of the torque motor which drives the lens. As the pushrod is pushed up by the cam, the rocking arm rotates about its fixed axis on the auxiliary structure and the top of the camera is, in turn, pushed away from the auxiliary structure resulting in a rocking motion of the camera about the nod axis pivot. The required constant angular motion is provided during exposure. The acceleration, deceleration, and return portions of the cam cycle are designed to keep perturbations to a minimum.

2.4.6 Exposure Control

The camera incorporates a means for varying the period of exposure and a means for changing filters during operation. The exposure time for an increment of film is a function of both the slit width and the slit velocity. Since the slit is located on the end of the rotating scan arm close to the focal plane, the rotational velocity of the lens defines the slit velocity. There are physical limitations, due to the location of the slit mechanism, to both the maximum slit width and the minimum slit width. The maximum available slit is 0.340 inch while the minimum slit is 0.134 inch. These limits, when combined with the scan rates needed to provide proper overlap and forward motion compensation at the upper and lower operating altitudes, define the extent of variation of the exposure period. These limits are illustrated in Fig. 2-4.

A cam which is driven by a servo motor provides the means for varying the slit width. The servo motor takes its command from a signal from the vehicle programmer. The vehicle programmer has a capability of providing four reference voltages and, therefore, the normal exposure control is accomplished by using four slit width positions. An additional position, called failsafe mode, is obtained by sending a real time command which opens a clutch between the servo motor and the slit mechanism to allow a spring to pull the slit to a nominal width. A reset command is provided to override the slit width failsafe.

NOTE

Reset action must be performed following the initial application of 24-vdc unregulated power to the system.

The control cam can easily be changed to provide any combination of slit widths within the limits stated above.

The J-3 camera is capable of handling several different basic film materials in combinations of two at a time. For example, assuming that the forward-looking camera has film types A and B on the supply spool, it could be divided into several different lengths of the two materials in sequence (A, B, A, B). At the same time, the rear-looking camera could have film types C and D on its supply spool. Of course the various film types would most likely require different exposure periods for a given solar altitude and also require a different filter. Within one camera it would be necessary to provide a cam which would select slit widths that would be the best compromise for the two films. A filter change mechanism is available which allows a choice of one of two filters. If there is a large exposure difference between the two films, it is possible to add a neutral density filter to one of the positions to reduce the light input to the faster film such that the same exposure slits could be used for the slower film.

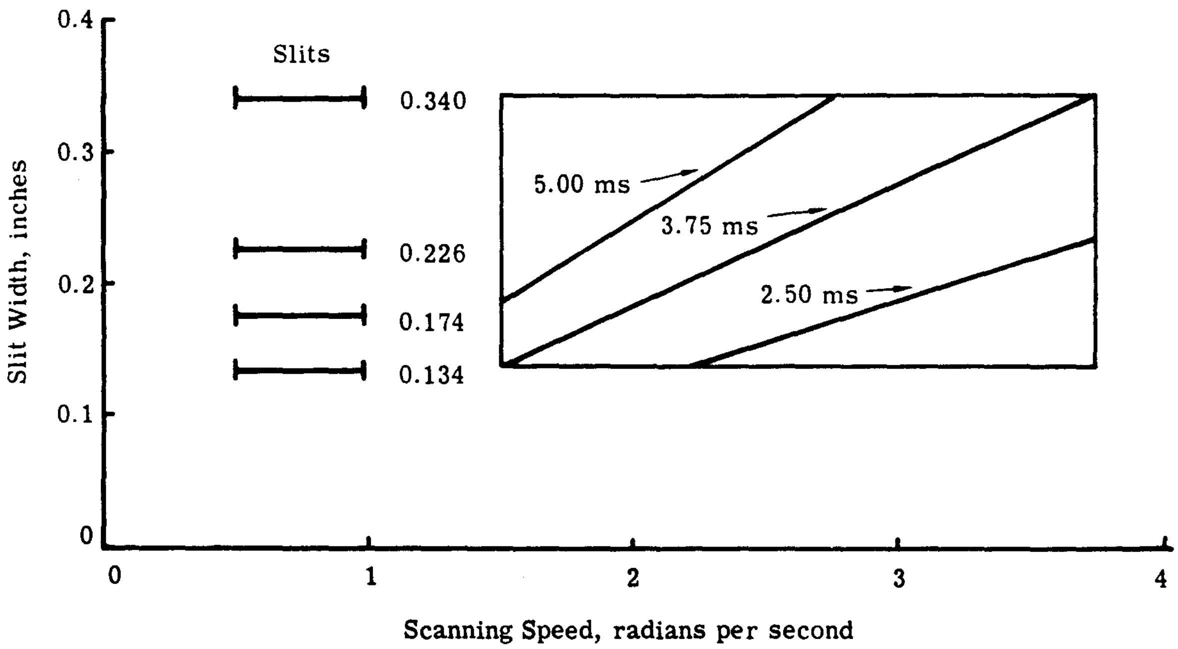


Fig. 2-4 — Slit width versus scanning speed for various exposure times

There are two methods available for activating the filter change. One is by real-time command from the ground, and the other is by command from an internal device called the material change detector. The material change detector utilizes an infrared detector which looks at a pattern of marks near the edge of the material adjacent to the splice between the two films. When these marks interrupt the infrared wavelength, a signal is fed from the material change detector which activates the filter change mechanism. Other necessary actions take place at this time, such as modification of the data presentation lamp outputs, and reduction of the light filter in front of the auxiliary optics lens. The material change detector incorporates a safeguard against being triggered by normal splices between similar films.

2.4.7 Panoramic Geometry

The camera incorporates the means by which a calibration framework can be developed that allows the panoramic photography to be utilized for cartographic purposes. The components of this panoramic geometry framework internal to the camera are: (1) a series of holes spaced along each film guide rail, (2) a pair of lamps fastened rigidly to the upper end of the lens scan arm which produce traces on either side of the format and which represent the locus of the path of the principle axis of the lens, (3) a nod angle to scan angle calibration system which, by means of a xenon flash triggered by an optical encoder mounted on the nod axis, images a series of small dots along the edge of the format, and (4) a series of timing pulses also imaged on the edge of the format to provide a time reference.

During laboratory testing, data is acquired which allows calibration of the angular relationship of the rail holes, the angular relationship of nod angle to scan angle, and the angular and positional relationship of the principal axis of the lens to the lamps which provide the scan traces.

To make proper use of the material for cartographic purposes, it is also necessary to know the attitude of the vehicle during exposure. This information is provided by a separate camera system (not a part of the J-3 panoramic camera) which simultaneously records stellar and terrestrial imagery and therefore allows for a determination of the vehicle attitude at that instant. In addition to the internal geometry for each camera, it is necessary to know the relative orientation of one panoramic camera to the other, as mounted in the vehicle. This will be established after vehicle installation by means of an external array of calibration collimators.

Related to cartography, but not specifically required for cartographic purposes, are the horizon optics. One of these is mounted on either end of each panoramic format and provides a comparatively coarse but readily available means for determining vehicle attitude. They are useful in the intelligence application of the photography. The external collimator array, mentioned previously, will also provide information as to the relative orientation of the horizon optics to the panoramic cameras.

2.4.8 Data Presentation

The data which is required for panoramic geometry calibration has been previously described. In summary, this consists of two lens locus traces, one on either side of the format, a 200-cycle-per-second time pulse record, nod to scan calibration dots along one side of the format, and rail hole images on both margins of the film.

In addition to this material, certain other data appears on the film. The vehicle clock is read out to a semiconductor light pulse block (SLP) which exposes the time on the film in binary form. The binary spot size is about 0.007 inch in diameter. There are actually six columns of 32 bits available, but only three columns of 30 binary bits are used. The columns are parallel to the edge of the film and are read from left to right as seen from the side of the film away from the emulsion when the SLP is on the edge of the film nearest the viewer. The column nearest the edge of the film is no. 1, and all 30 bits are illuminated to provide a registration for mechanical readout. Column two presents the time word in rows 1 through 29 with the 30th bit being the parity bit. Column three presents reciprocated time, again with the 30th bit being the parity bit.

To properly image the SLP, it is necessary to firmly clamp the film to the block during exposure. Since this is not possible in the film format area, the SLP block is located on the takeup side of the framing roller. This means that any time readout as seen on the film is associated with the following (next higher number) frame, or conversely, when ascertaining the time a particular frame was taken, it is necessary to look at the SLP readout block on the previous or lower numbered frame.

Determination of the instant during scan when the time was recorded is made by noting the position of a smear pulse in the 200-cycle-per-second timing marks. This is a variance on the J-1 technique where clock interrogate was referenced by a blanked pulse.

A serial number is located on the margin opposite to the data block. A cross is at this same position which is illuminated at the initiation of camera operation.

The margin of the horizon camera format contains fiducial hole images which are used to reference the position of the principal point of autocollimation of the horizon lens.

2.4.9 Camera Structures

The J-3 camera consists of four basic structural sections. The lens and drum assembly has been discussed.

The film transport or shuttle assembly consists basically of a pair of aluminum faced honeycomb plates spaced to accommodate the film rails, input metering assembly, framing assembly, shuttle, and grid rollers. The horizon optics are also supported at either end of the shuttle assembly.

Both the lens and drum assembly and the shuttle assembly are supported by an anchor-shaped magnesium main structure. This structure forms the backbone of an individual camera, and in addition to supporting the two noted assemblies, also carries the main drive assembly, the forward motion compensation mechanism, control switch complex, and various pulleys, counters, etc. The main structure is milled from a solid billet of magnesium to achieve the maximum physical characteristics of the material. Each end of the lower cross of the anchor carries a shaft. These shafts are in line with each other and form the nod axis of the camera when mounted in bearing blocks carried on the auxiliary (delta) structure.

The auxiliary structure is an integral part of, but shared by, each panoramic camera of the stereo pair. This aircraft-type sheet metal structure carries the bearing blocks for the nod axes of both panoramic structures and also provides the fixed tie points for the rocking links of the FMC mechanisms. Additionally, it carries all electronic packages needed for the operation of both cameras. The auxiliary structure interfaces with the vehicle at three points to minimize the effect of any vehicle distortions on the camera.

3. PRINCIPLES OF OPERATION

3.1 SCOPE

This section describes the function and operation of the important elements (hardware and subsystems) of the J-3 system. Where appropriate, the interrelationship of various elements is discussed.

3.2 CAMERA SYSTEM

The major elements of the camera are: (1) the drive system, which includes the mechanical drive and the servo control subsystems; (2) the acquisition system, including the lens assembly, drum assembly, slit width and filter system, forward motion compensation system, and the horizon optics; (3) the panoramic geometry calibration system, including the xenon flash module, rail holes, shaft encoder, and the other data presentation elements; (4) film transport system; (5) telemetry; and (6) miscellaneous electrical circuits.

3.3 DRIVE SYSTEM

3.3.1 Mechanical Drive

A single driving assembly in each instrument supplies all the mechanical motion requirements except those associated with exposure control and material change. This drive assembly, shown in Fig. 3-1, directly drives the lens and drum, FMC cam, and its own controlling tachometer. Rotational power and timing of the cycle counter, switch cluster, FMC, and material supply compensating device (noncircular gears) is accomplished by a timing belt drive. The power unit of the drive assembly is a direct-drive, dc torque motor. The high torque and uniform low speed of this motor makes it ideal for this application. A tachometer is coupled directly to the drive shaft through the slip ring assembly to ensure maximum accuracy. Resolution loss due to gear noise is eliminated by mounting the lens and its light-sealing drum directly on the drive shaft. The shaft is made of beryllium to ensure light weight and rigidity and is supported on preloaded bearings that ensure a system stiffness consistent with the resolution capabilities of the lens.

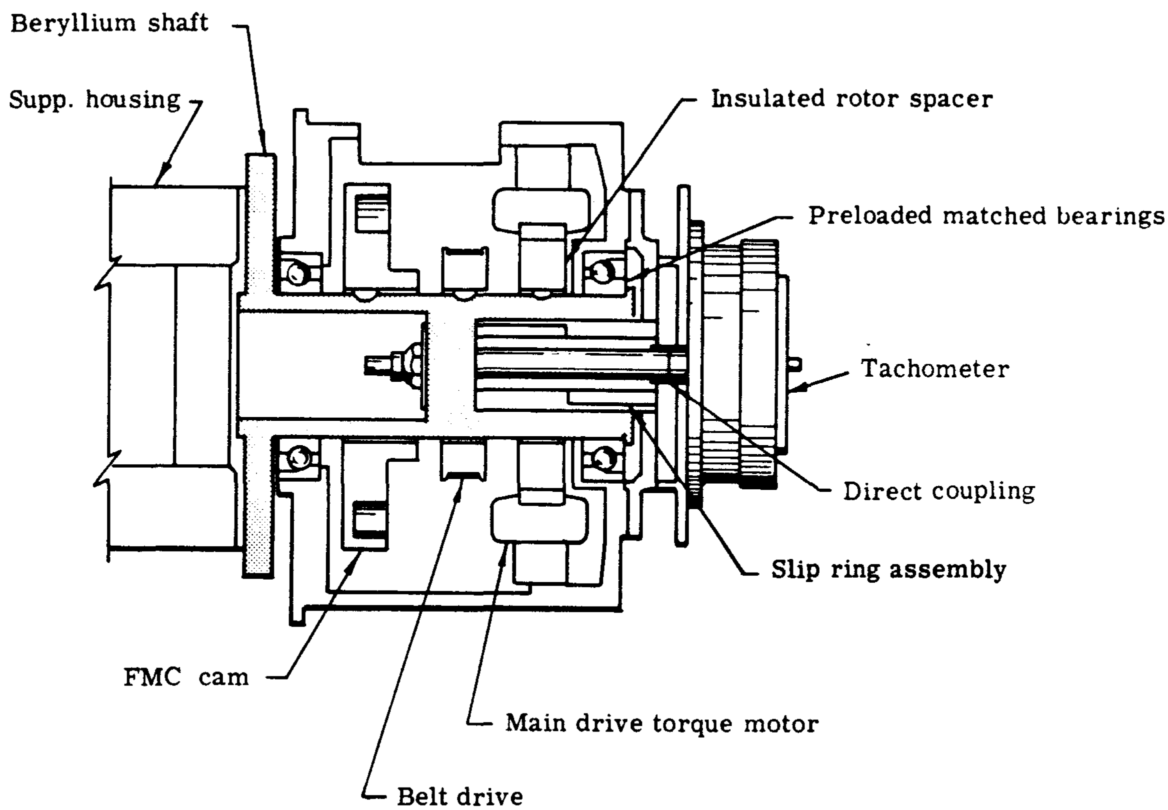


Fig. 3-1 — Main drive assembly

3.3.2 Main Drive Servo

The main drive servo consists of an electronics assembly, motor, tachometer, and related wire harnesses. This is illustrated schematically in Fig. 3-2 and is described in the following paragraphs. The electrical and electronic checkout procedures for these components are found in Section 6.

The servo electronics consist of semiconductor circuits located in amplifier assemblies within the auxiliary electronics box. Interconnections are routed through the main instrument harness.

The torque motor (P/N 79125) is rated at 7 foot-pounds at 20 vdc stalled. It consists of a permanent magnet stator and a wound rotor with associated brushes and commutating segments. The rotor is mounted directly on the main drive shaft while the stator and brush assembly is mounted on the drive housing assembly. The torque constant of this motor is 0.53 foot-pound/ampere.

The tachometer assembly (P/N 85639) also includes a permanent magnet stator and wound rotor, as well as an integral shaft and bearings. This assembly is attached to the drive housing assembly and is connected to the main shaft through the slip-ring rotor shaft. The tachometer gain is nominally 1.0 vdc per radian per second.

The main drive servo is energized during OPERATE and A TO B TRANSFER. This occurs when K9 and K12 are energized in the control assembly. Upon being energized, the servo follows the velocity (voltage) commands applied through K9 and K10 in the control assembly. These relays select a reference input from stow (0 volts), creep (0.7 volt), or the programmed V/h.

This reference input signal is passed to the error detection circuit where it is compared with the negative sense of the tachometer voltage, utilizing an operational amplifier in a summing configuration. The tachometer signal is adjusted for proper gain through the tachometer gain potentiometer and filtered prior to summing in the error detection circuit. The existing error is amplified and operated on by the servo compensation and gain electronics which utilize operational amplifier characteristics for transfer function generation. These circuits determine the precision and stability characteristics of the main drive servo. The amplified version of the error signal is applied to the power output electronics which include a bridge of power transistors. These power transistors are energized to switch the current from the +24 vdc unregulated power supply through the motor in a forward or reverse sense as indicated by the polarity of the error signal. The amount of current applied is proportional to the torque required to maintain the error signal below the desired levels.

NOTE

In this description the relay K numbers refer to the no. 1 main instrument relays. No. 2 main instrument relay numbers equal the no. 1 main instrument relay number plus 12.

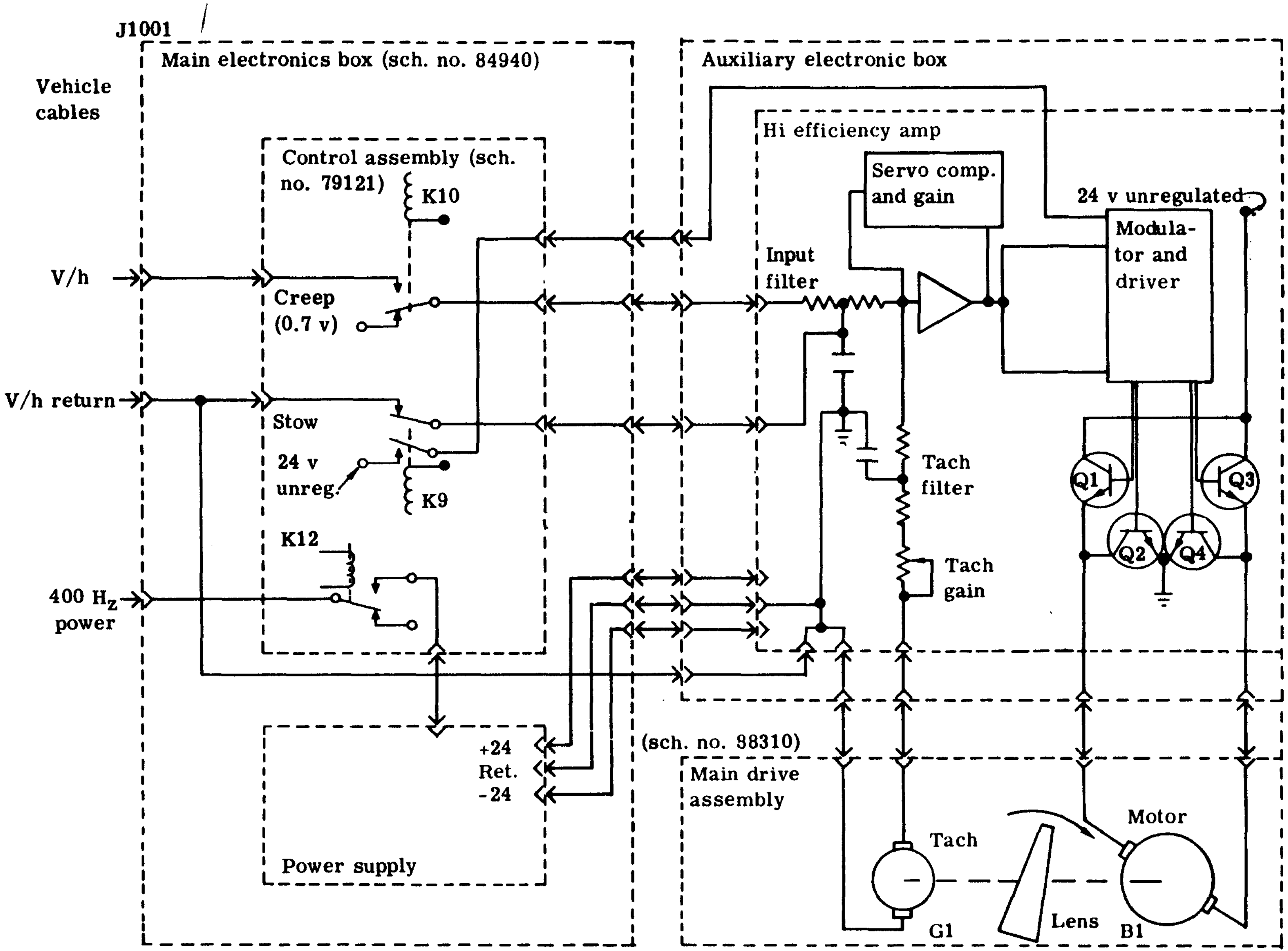


Fig. 3-2 — No. 1 main drive servo

The servo electronics (Fig. 3-3) consists of five basic groups contained in one complete electronics package and installed on the auxiliary junction box (refer to schematic no. 88286). Two such amplifiers are required for each system, one for each camera. These basically consist of the input stage, modulator, driver, power stage, and the 2-volt power supply.

The input stage is a dc preamplifier, the input of which is the summing point of the reference and tachometer signals, and two additional operational amplifiers that phase split the output. This provides two dc signals of equal amplitude and opposite polarity. These signals are fed directly to the modulator stage that has a quiescent -6.8-volt level at each input. Servo response characteristics are compensated by associated circuitry in the preamplifier stage.

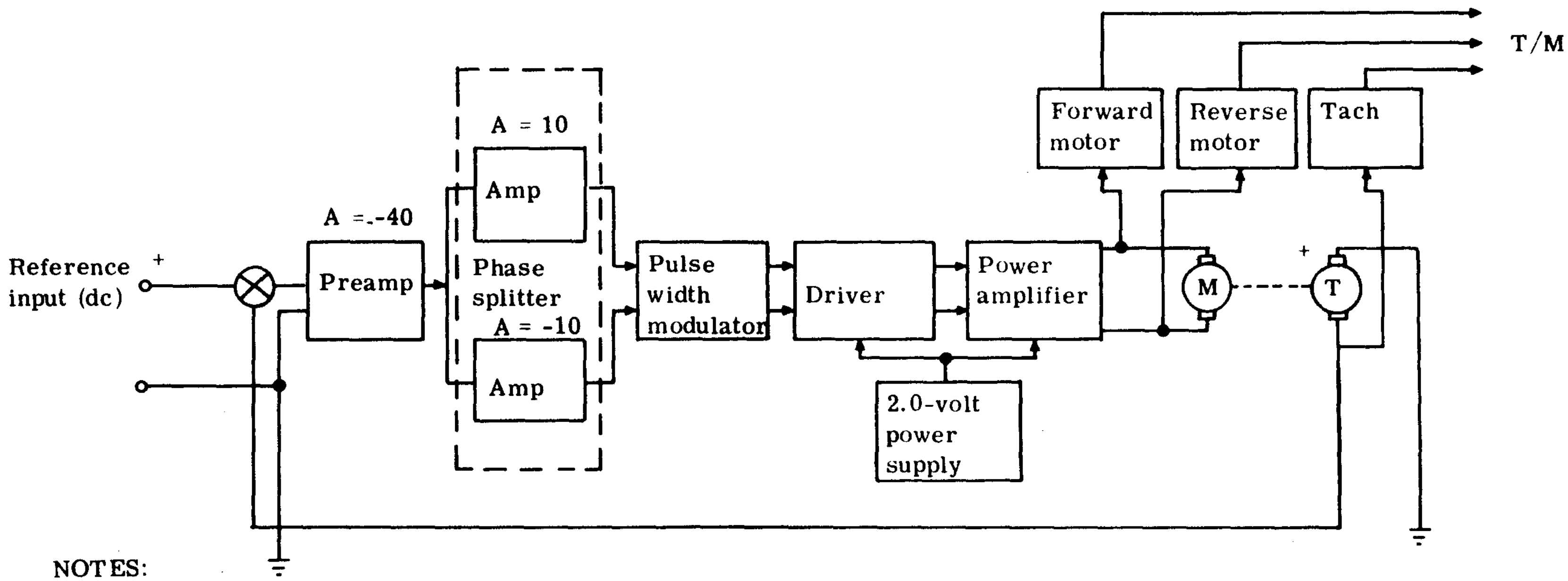
The modulator is an astable multivibrator with constant current generators in both coupling circuits that furnish linear charging waveforms into the bases of each half of the multivibrator. This provides a linear change in duty cycle for a related change in input signal. With a zero input signal, the duty cycle of the circuit is 50 percent. With a nonzero input signal, the discharged levels of the coupling capacitors are changed. This makes one side of the multivibrator conduct longer than the other, as determined by the polarity of the input signal. Under these conditions, the duty cycle is different than 50 percent. The output of the modulator is taken from two emitter follower stages, which switch between + 24 and 0 vdc. These complimentary signals are fed directly into the driver stage.

The driver stage is an intermediate amplifier that receives complimentary square wave signals from the modulator. This stage passes these signals with additional drive to the power amplifier.

The power amplifier is a bridge configuration of four power transistors with the system drive motor connected across it. This stage, like the stage that precedes it, has complimentary switches. It is here that the applied voltage is switched on and off across the motor. The duty cycle established in the modulator stage determines the average dc driving voltage, and the polarity of the input signal to the modulator determines the direction of rotation. The switching frequency in the motor and the driver is the same as that of the modulator, 7 kilocycles.

The 2.0-volt power supply is used to furnish base drive to the two return-path, power stage transistors. This is a more efficient technique than developing the drive from the unregulated +24-vdc power supply. This stage is so configured in the system that a positive shut down control of the power stage is provided.

Following the removal of the OPERATE signal, K9 and K10 remain energized until the end of scan cam switch in the switch cluster is actuated, at which time K10 drops out causing the creep voltage (0.7 vdc) to be impressed at the input of the servo electronics. This causes the lens to decelerate to approximately 0.7 radian per second in a deramp slope. The drive continues through scan, activating the center-of-format



NOTES:

1. The preamp and phase splitter amplifiers are located on subassembly board A-4.
2. Modulator and T/M circuits are located on subassembly board A-3.
3. 2.0-volt power supply is located on subassembly A-1.
4. Driver is located on subassembly board A-2.
5. Final amplifiers are located on heat sink assembly.
6. Refer to schematic no. 88286.

Fig. 3-3 — High efficiency servo

cam switch and the stow cam switch. This de-energizes K9 and causes the stow signal (0.0 volts) to be impressed on the servo electronics, bypassing the input filter circuit. K12 is de-energized 3 seconds later, turning off the power supply and removing the regulated dc power from the servo.

3.3.3 Power Supply

The 400-cps power supply block diagram is shown in Fig. 3-4. (See schematic no. 88416.) This power supply is located in the main electronics box and provides the required dc voltages to the following electronics packages: the dual data signal conditioner; the two high efficiency amplifier packages; the dual interface package; the two xenon modules; and the two nod encoders and their electronic packages.

The power supply is actuated by the control package. When the system is in the OPERATE mode, a 400-cps voltage is passed through a transformer and rectified to provide the following unregulated voltages: ±40, ±20, and ±12 vdc. These voltages are then regulated to supply ±24 and ±12 vdc, +5 and +8 vdc. The 150 vdc required by the neon lamps is obtained by rectifying the line voltage and charging a filter capacitor.

3.3.4 Control System

The J-3 system is operated by applying an OPERATE signal which energizes the operate relay and the decelerate relay (see Fig. 3-5 and schematic no. 79121). The decelerate relay contacts provide the V/h voltage to the analog servo reference input.

The operate relay removes the stow signal from the servo and energizes the operate-plus-3-second relay, supplying power to the supply spool torque motor and brake and the A takeup motor (or the B motor and brake) as well as supplying 400 cps to the power supply package.

To shut down normal operation, the OPERATE signal is removed. The decelerate relay is locked up by its contacts in series with the end-of-scan switch. This allows the camera to complete a scan before it starts to ramp down. At the completion of the scan, the end-of-scan switch contacts are tripped open by a cam, de-energizing the decelerate relay. The contacts in this relay transfer from the V/h voltage to a small creep voltage feeding the input to the analog servo causing the drum to decelerate.

During deceleration, the operate relay remains locked up via its contacts in series with the parallel combination of the stow switch and the prepare-to-stow relay contacts. The decelerate relay, when de-energized, also provides a path for the center-of-format switch to reset the prepare-to-stow relay at the center-of-format position. This leaves only the stow switch contacts in series with the operate relay contacts, keeping the operate relay energized. When the velocity determined by the creep voltage is reached, it is maintained until the scan head reaches the stow position, when the cam-tripped stow switch de-energizes the operate relay. The operate relay contacts ground the input to the analog servo, causing the drive motor to servo quickly to zero velocity.

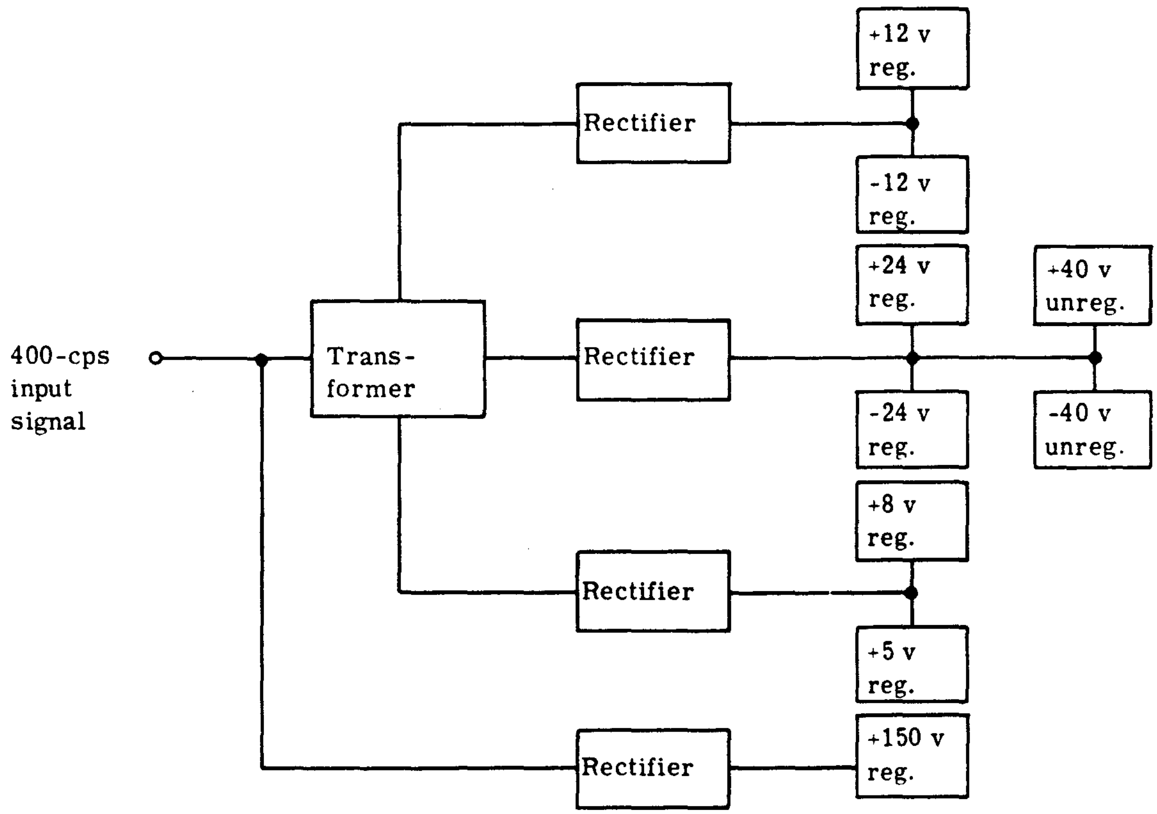


Fig. 3-4 — Power supply (400 cps)

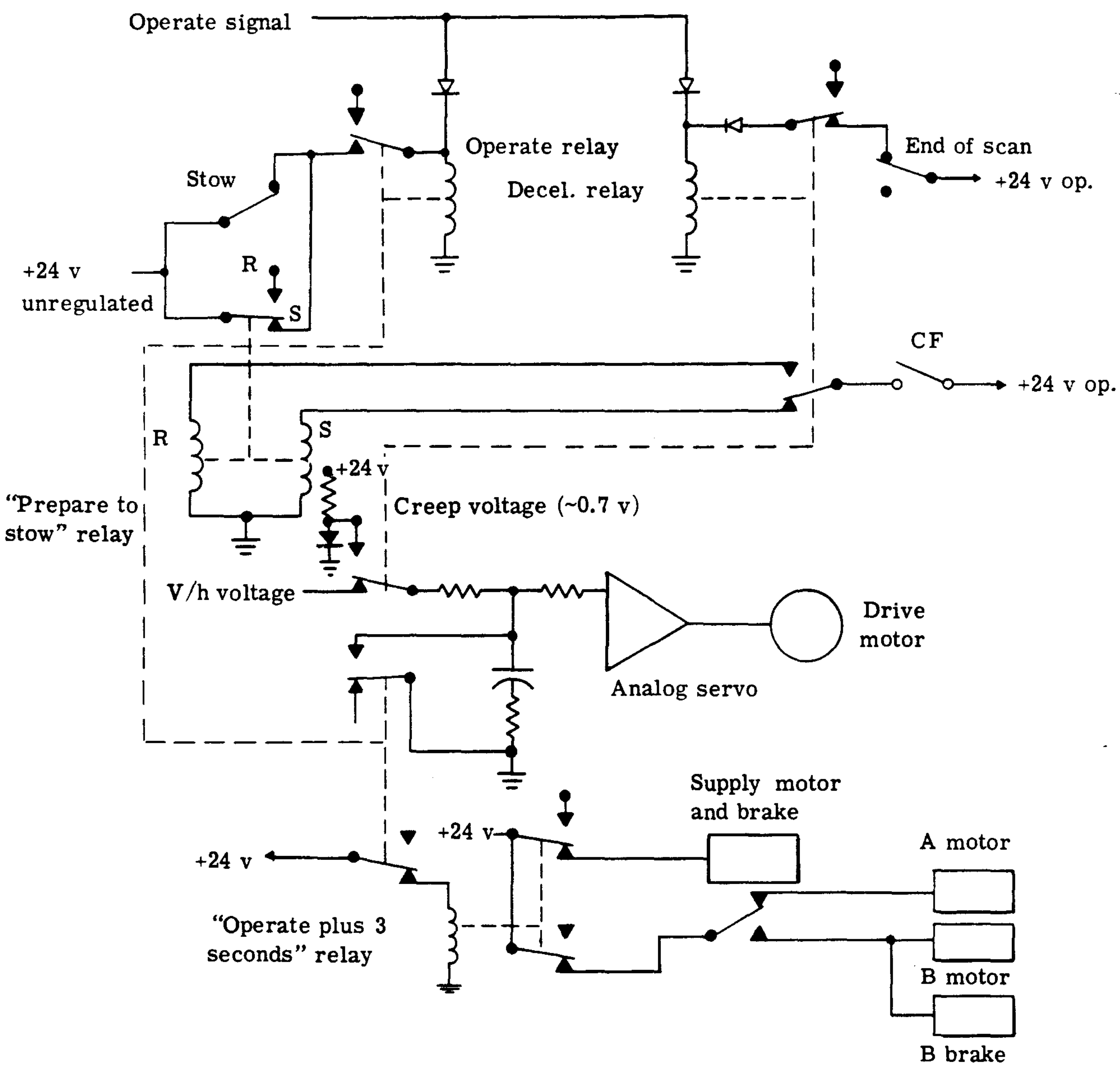


Fig. 3-5 — Operate circuit

The operate-plus-3-second time delay relay contacts allow the supply and takeup torque motors to remain powered for an additional 3 seconds before dropping out, holding the film taut.

The launch mode command (Fig. 3-6) resets relays K6 and K7 in the control package. K6 applies power to the supply cassette motor and brake, and to the A takeup motor, shunt, and antibackup. A closed set of contacts on K7, the launch mode monitor, provides an indication that the system is in the launch mode.

Upon receipt of an orbit mode command, K6 and K7 change to the set position. The launch mode monitor contacts open and the A takeup and the supply cassette are de-energized. The system is then in the standby condition.

The 30-second A to B transfer command (Fig. 3-7) energizes relays K2, K3, and K4 in the control package. K2 applies power to the B takeup and brake through the K4 contacts and power to the B shunt, for 5 seconds, through the K3 contacts. During this time, the B takeup, operating at a reduced tension, cinches the film. K3 pulls in after 5 seconds, supplying an operate command and removing the B shunt which in turn provides full takeup tension. After 30 seconds, the transfer command is removed and K2 and K3 released; this removes the operate command, allowing for a normal instrument shutdown.

3.4 ACQUISITION SYSTEM

3.4.1 Lens System

The lens system consists of a lens and tail cone which contains the major optical elements and a scan head which contains the slit width device, filter, and focal plane rollers.

3.4.1.1 Lens Cell and Tail Cone

The lens is a 24-inch, focal length Petzval design consisting of five elements mounted in a cast magnesium cell. A sixth element, a field flattener, and an exposure/filter device are mounted on the end of a titanium tail cone which is secured to the lens cell at the nodal point. The purpose of the combination of magnesium cell and titanium cone is to maintain coincidence between the focal plane and the film surface during temperature change. The lens is designed to use a Wratten no. 21 filter with black and white film which is inserted below the field flattener. The lens has a 6-degree field, a 0.250-inch back vacuum focus, and a spectral range of 0.5461 to 0.6900 micron.

3.4.1.2 Scan Head Assembly

The scan head assembly, mounted on the end of the tail cone, consists of the following: capping shutter, field flattener, filter change mechanism, scan rollers, panoramic geometry data sources, and variable slit width device with its servo drive system.

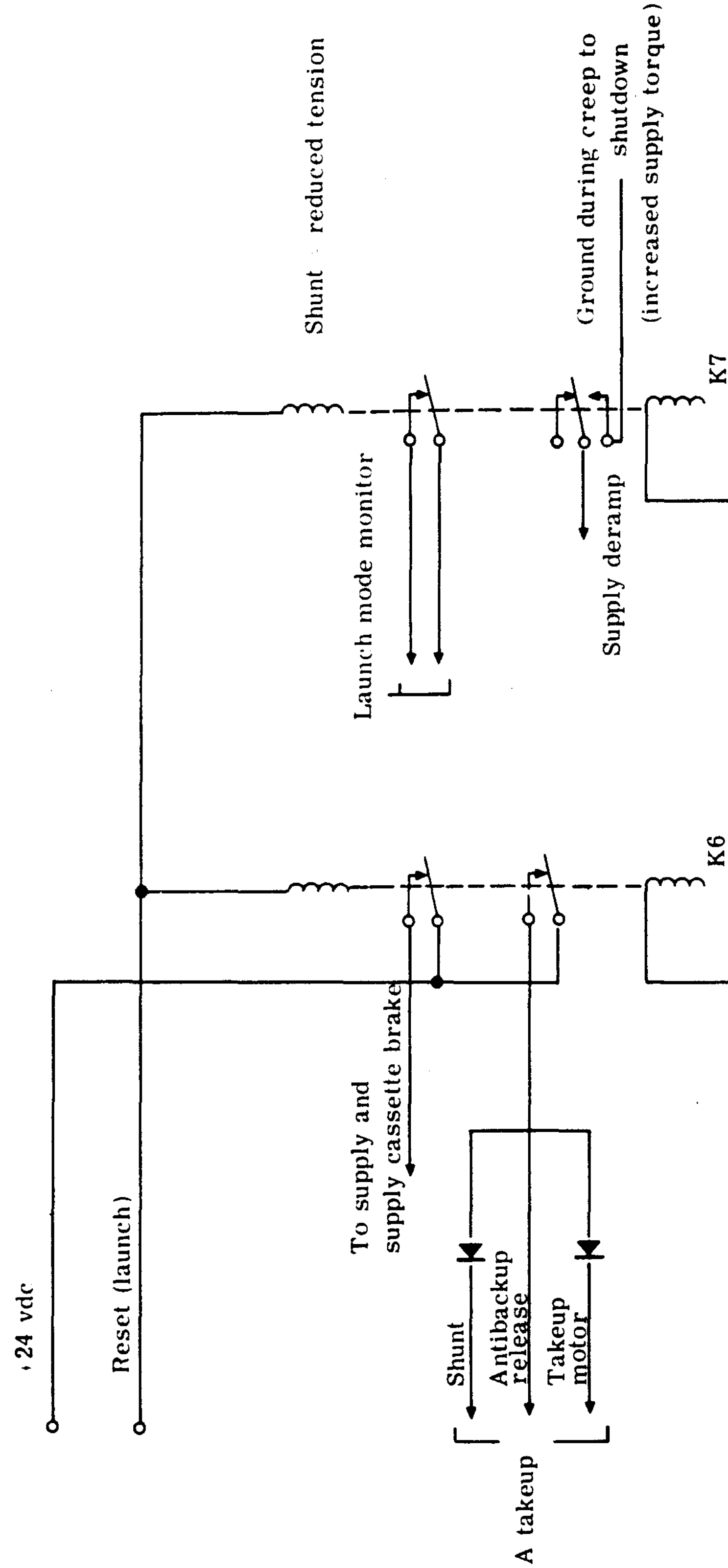


Fig. 3-6 — Launch mode command

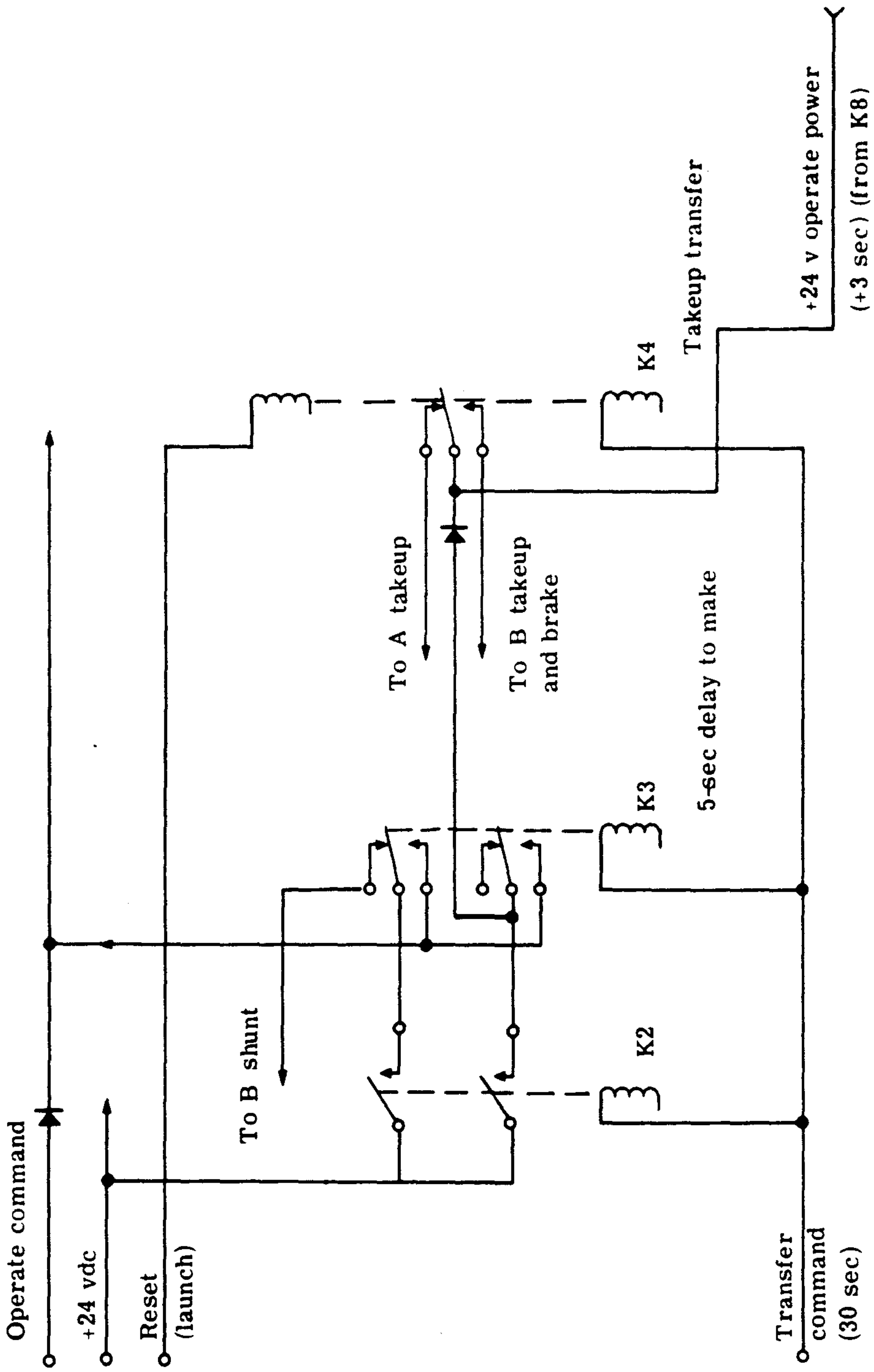


Fig. 3-7 — A to B transfer command

As the lens rotates, the scan head (focal plane) rollers contact the material which is stationary in the format area. The rollers locally raise the material off the rails to the proper focal plane as they traverse the format area. The rails are used to support the material in the approximate focal plane throughout the format area, and are set nominally 0.006 to 0.008 inch below the focal plane.

The capping shutter allows light to pass through the lens only during the actual exposure. The shutter is actuated by cam surfaces mounted externally to the drum.

Provision is made for two filters to be mounted in the filter slide. The proper selection of filters to match the film is made prior to flight, and these filters are installed in the slide assembly in the scan head.

The variable slit width assembly has provisions for four different slit settings between 0.134 and 0.340 inch. In addition, there is a failsafe position of 0.200 inch. The four positions and the failsafe position may be changed by preflight selection of the slit width control cam.

The panoramic geometry data components consist of a lamp between the format area and the rails on the inboard and outboard side, a lamp for frequency marks on the outboard side only, and a fiber optics bundle for nod dots on the outboard side.

3.4.1.3 Slit Width Control

The following is a list of slit width components, with their drawings and schematics, for camera no. 1.

Component	Assembly	Schematic	Location
Servoamplifier	Part of no. 88020	No. 85491 (zones 4G, 4F)	Interface package
Motor	No. 79135	No. 88310 (zone 17D)	Scan head
Clutch	No. 79135	No. 88310 (zone 17D)	Scan head
Automatic exposure control servo potentiometer	No. 79135	No. 88310 (zone 17D)	Scan head
Failsafe pulse shaper	Part of no. 88020	No. 85491 (zone 5H)	Interface package

The slit width device (Fig. 3-8) is controlled by the vehicle programmer which provides a 24-volt (unregulated) command on any one of four channels corresponding to four different slit widths as follows:

Position	Slit width, inches
1	0.134
2	0.174
3	0.226
4	0.340
Failsafe	0.200

The slit width servo amplifier (AR-1, Q5, and Q6 in the interface package) drives the slit width motor (B1) in the scan head until the feedback potentiometer (R1) voltage nulls the servo.

NOTE

The servo is nulled when the voltage at the inverting input of the AR-1 operational amplifier is zero.

In case of a servo failure, a real-time command may be used to set the slit width to a nominal operating width of 0.2 inch (the failsafe slit width position). Receipt of the failsafe command causes the failsafe pulse shaper (three-stage transistor network in the interface package) to put out a 24-volt, 2-second pulse. This pulse sets the latching relay (K3) opening the slit width servomotor control line. At the same time, this pulse energizes the slit width clutch (L1) in the scan head disengaging the motor shaft from the slit width cam, allowing a spring to return the slit to failsafe position. The slit width control may be returned to normal operation by a slit width failsafe reset command.

NOTE

The slit width failsafe reset must be actuated after each application of +24 vdc unregulated to the system.

3.4.2 Filter and Readout Control

The filter and readout control system (Figs. 3-9 and 3-10) alters the intensity of the readout lamps and changes the scan and horizon camera filters automatically when the film changes or by an RTC filter control backup command.

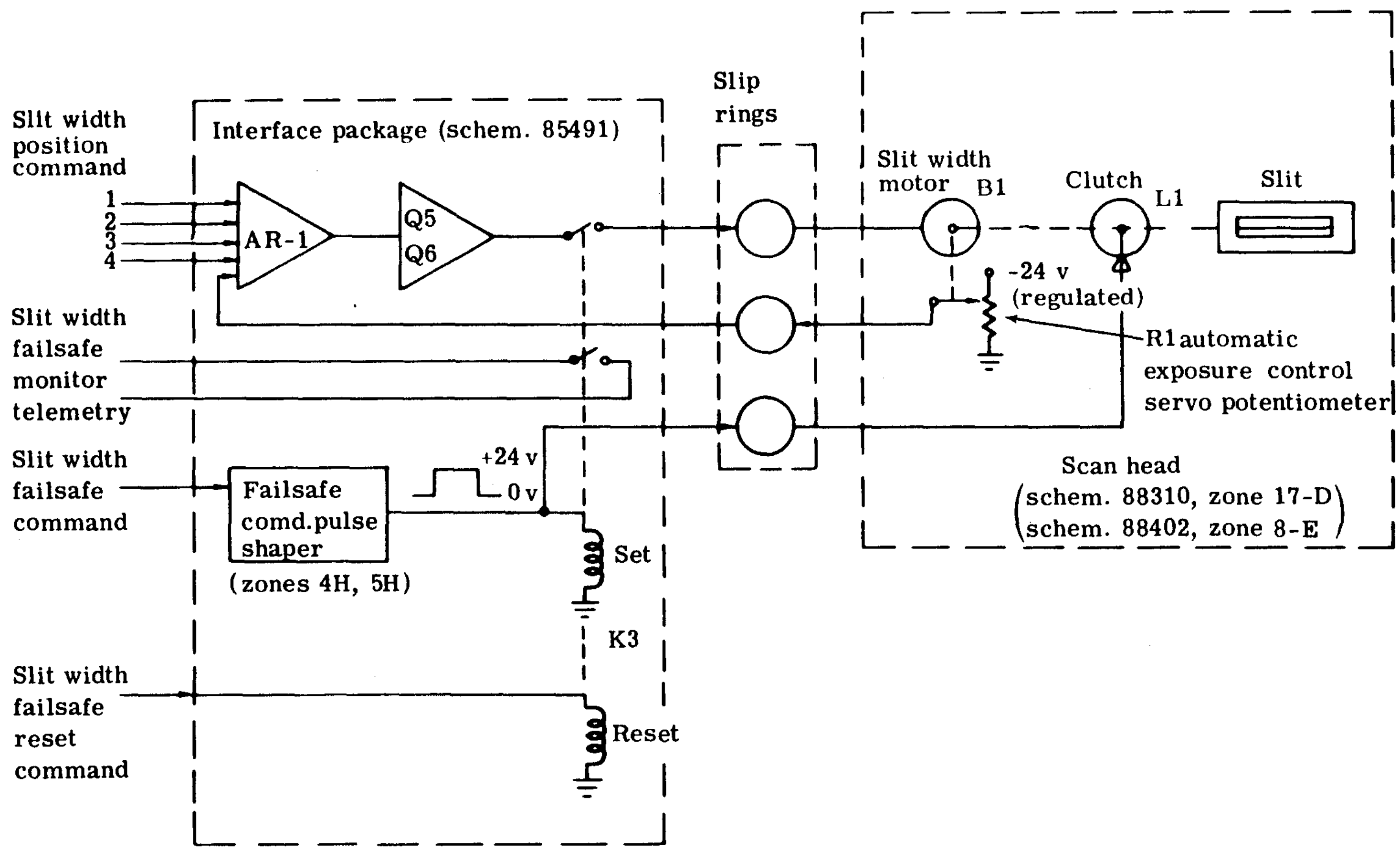


Fig. 3-8 — Slit width control

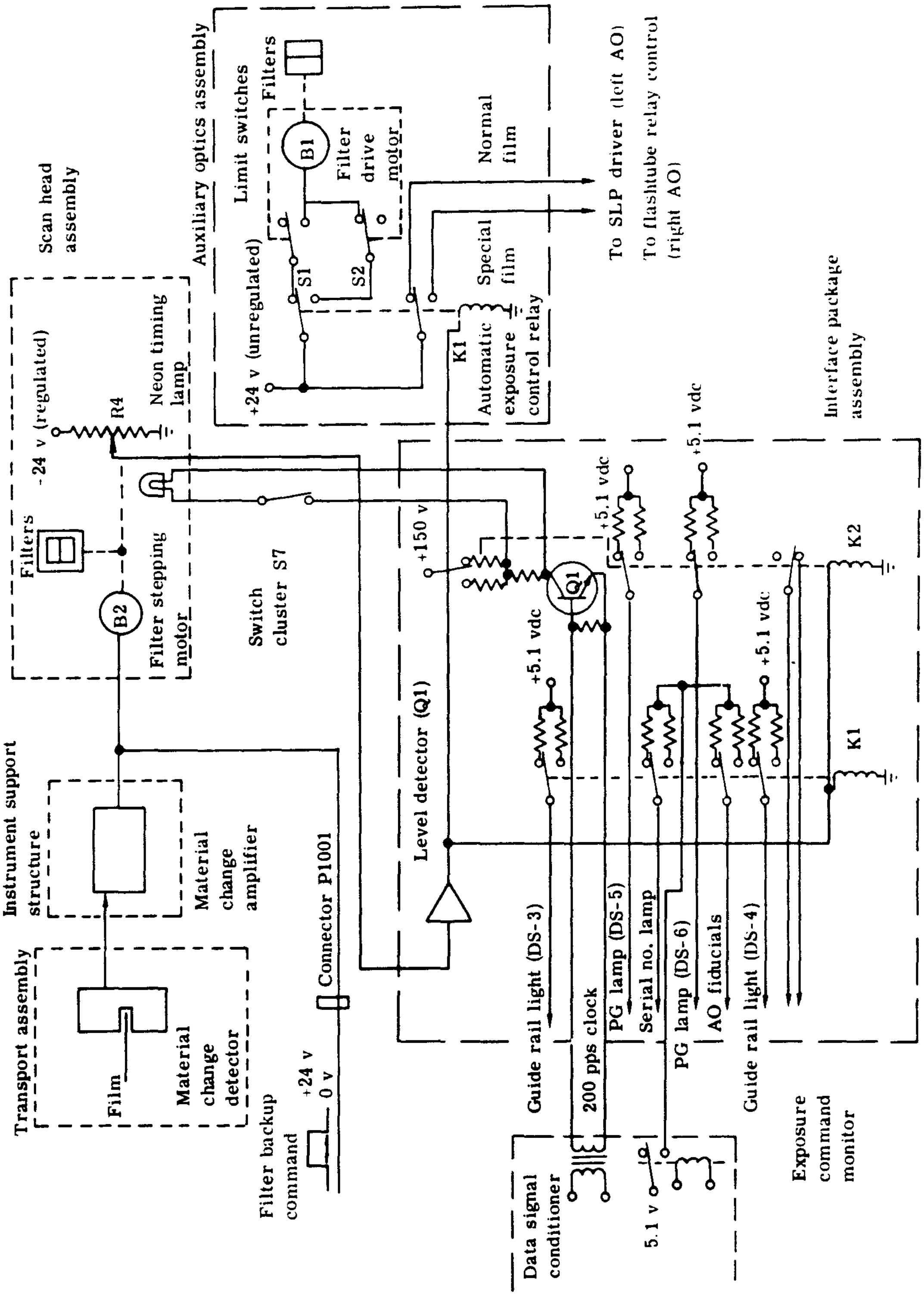


Fig. 3-9 — Filter and readout control

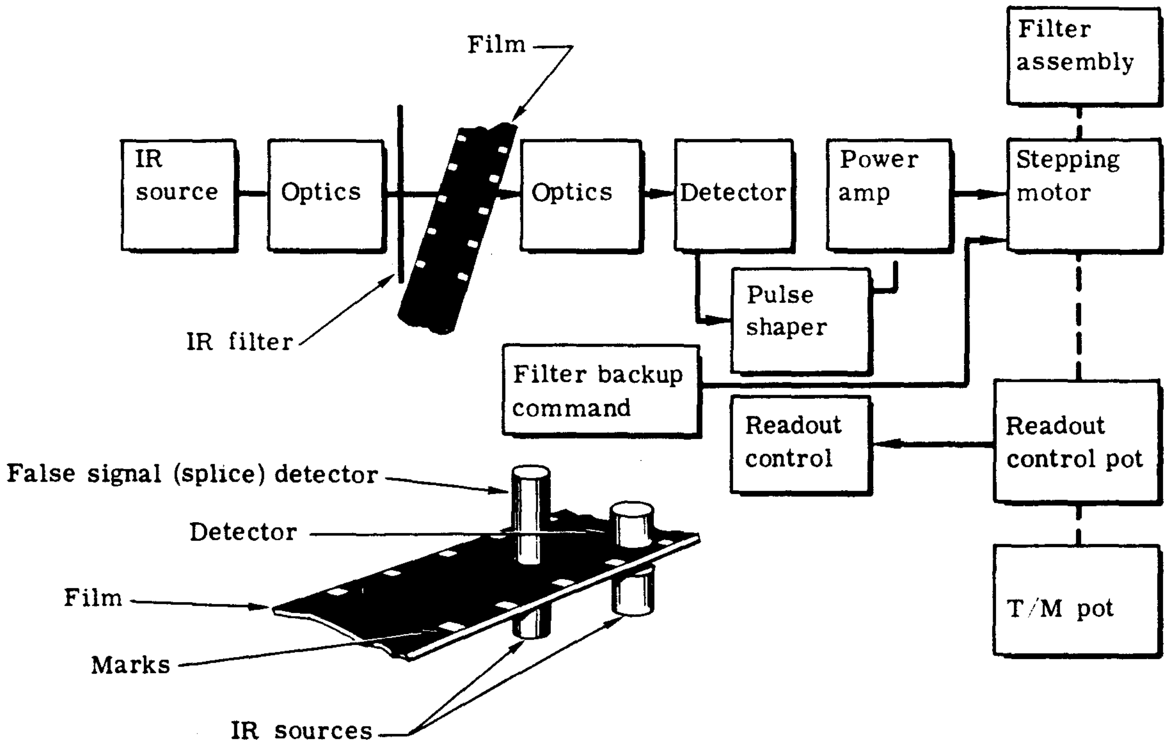


Fig. 3-10 — Material change detector

The components of the filter and readout system are as follows:

Component	Assembly	Schematic	Location
Material change detector	88258	88402	Transport
Material change detector electronics	107633	107631	Instrument support structure
Filter stepping motor	79135	88310 (zone 17D)	Scan head
Readout exposure control	79135	88310 (zone 17D)	Scan head
Relay driver (Q1)	Part of 88020	85491 (zone 10F)	Interface package
Readout intensity control relays (K1 and K2)	Part of 88020	85491 (zones 9F and 7F)	Interface package
Timing lamp driver (Q1)	Part of 88020	85491 (zone 5F)	Interface package
AEC relay (horizon optics)	78667	88310 (zones 7B and 8B)	Horizon optics
Horizon optics filter motor	78667	88310 (zones 7B and 8B)	Horizon optics
Lamps			
Timing (DS-1)	84911	88310 (zone 15G)	Scan head
Guide rail (DS-3, -4)	84911	88310 (zone 17F)	Scan head
Panoramic geometry	84911	88310 (zone 15G)	Scan head
Serial number	78507	88310 (zone 7H)	Transport
Start of pass	78507	88310 (zone 7H)	Transport
Horizon optics fiducial	78667	88310 (zones 7B and 8B)	Horizon optics assembly
Material change detector	88258	88310 (zone 12H)	Material change detector

A material change detector, consisting of an infrared source on one side of the film and a detector on the opposite side, generates five pulses when five marks on the film pass. These pulses are generated each time the transmission of infrared increases, i.e., a low to a high transmission region. The material change detector electronics amplify and shape these pulses to drive a stepping motor. The stepping motor shaft rotates 180 degrees for every five pulses, automatically changing the filter. A readout exposure control potentiometer (R4, 2.5K) with -24-volt excitation is geared to the motor, and the wiper voltage is applied to a 2N1132 (Q1) transistor in the interface package. When the wiper voltage is -11 volts or more, Q1 conducts, setting relays K1 and K2. The relays switch in a different resistor in series with the lamps of the guide rail, serial number, horizon optics fiducial, and panoramic geometry readout, altering their intensity. A collector resistor in the +150-volt timing circuit is changed, modifying the intensity of the lamp.

NOTE

> All lamp intensity adjustments should be made in accordance with the electrical and electronic check-out procedures (see Section 6).

Transistor Q1 also sets the automatic exposure control (AEC) relay, (K1) driving the auxiliary optics filter motors (B1) until the limit switches remove the voltage when the new filter is in position. Another contact in this relay supplies a +24-volt signal on either the normal or special film line to the SLP driver which changes the intensity of the data block.

The material change amplifier is a six-stage wave shaper and amplifier used to interface between a germanium phototransistor and a stepping motor. The input signal from the phototransistor is a low amplitude pulse (1 volt) with an extremely slow rise time (1/2 the pulse width). A differentiator (C2, R6) and a common emitter amplifier (Q1), driven to saturation, are used to decrease the rise time and increase the signal level. The output of Q1 is a rectangular pulse (24-volt peak nominal) which is used to drive the succeeding stage, Q2. Q2 is a unijunction transistor, one-shot multivibrator with an NPN transistor output stage, Q3. The output of Q3 is a rectangular pulse of predetermined pulse width (50, +5, -0 milliseconds). The pulse width is determined by the selection of R13 and C6 and the unijunction transistor parameters. The output of Q3 is inverted by Q5 which drives the power output stage Q6. The load presented to Q6 is a Ledex size 11 stepping motor which has an 11-ohm coil resistance. The stepping motor requires a pulse of 50 milliseconds minimum duration with a minimum amplitude of 18 volts to step. Since the phototransistor cannot detect the difference between a splice and a mark on the material, a second phototransistor is used to sense only the splices (located away from the marks). The output of this second phototransistor drives Q4 which shorts the output of Q3 to ground, keeping the stepping motor from stepping.

3.4.3 Drum Assembly

This assembly prevents light from entering the vehicle except through the lens. It consists of a drum that rotates with the lens in a network of nonrotating light shields that nod with the drum. The drum is lighttight except for the clear aperture end and a smaller opening for the scan head. Two formed pieces of sheet metal are attached to the drum around its periphery and rotate inside a labyrinth, preventing light from entering alongside the drum. The inside diameter of the light shields is slightly larger than the diameter of the drum. These shields encompass the drum from the clear aperture up to and beyond the drum centerline, preventing light from passing around the drum itself.

The drum is constructed of two honeycomb panels separated by an inner structure of formed beams that allow attachment to the support box and shaft. A thin sheet of metal, wrapped around the honeycomb panels, forms the outside diameter and has provisions for mounting 32 roller assemblies. These rollers prevent the film from pulling out of the rails under normal operating conditions. Two panels on one side of the drum permit access to the lens and cone.

3.4.4 Forward Motion Compensation System

In this system, each camera is independently nodded about an axis parallel to the pitch axis of the vehicle to accomplish forward motion compensation (FMC) (see Fig. 3-11). It can be shown mathematically that the compensation for any given combination of altitude and ground speed (V/h) requires a constant angular rotation during the photographic scan. Since the cycle rate required to maintain constant overlap is also a function of V/h, the nod rate has a fixed relation to the scan rate. The overlap of this system is 7.6 percent. The required nod is accomplished by a cam-driven linkage, with the pivot point of the camera being located as close to the center of gravity as practical, to keep the inertia forces to a minimum.

The FMC cam and linkage form the equivalent of a planar 4-bar linkage, with the extensive link (cam pushrod) restrained at a constant angle with the driven link (scan shaft), one link fixed (delta), and one member (upper rod) rotatable at each end. The nod axis bearings are offset from each side of the central plane, while all other links are restrained in the center plane by clevis attachments and grooved rollers. The FMC cam and linkage are designed to give a specified ratio of nod angle rate to scan angle rate, and a specified stereo half angle at midscan (15.23 degrees).

Photographic mission requirements determine the angular rate ratio between nod (FMC) rate and scan rate during the active scan section of the cycle. This ratio is constant and positive for the rear viewing camera and constant and negative for the forward viewing camera.

Even though the FMC cam is nearly symmetrical, there is a 180-degree phase difference of nod angle to scan position for the two cameras, making it impossible to

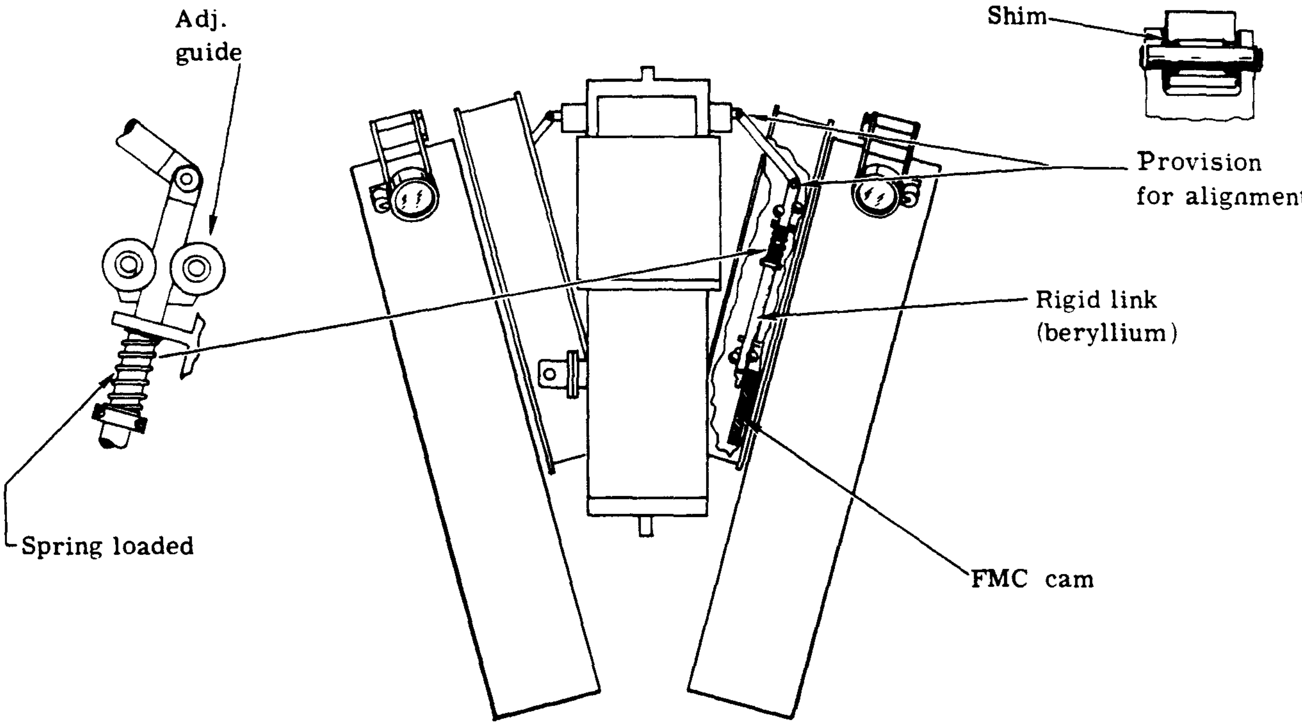


Fig. 3-11 — Forward motion compensation mechanism interchange the cameras within a system. A camera assembled as no. 1 (rear-looking) must remain as such in order to get proper FMC. The cam pushrod assembly is preset and pinned at assembly for proper spring preloading. This assembly is shimmed, aligned, and pinned to a given camera structure and must remain with that structure. The upper rocking link is carefully shimmed to ensure that it (the pushrod) and the scan shaft are coplanar.

3.4.5 Horizon Optics

A horizon camera is mounted on each end of the film transport bridge of each camera. The exposure is made by a single action, self-cocking, between-the-lens, leaf-type shutter. The shutter is actuated by a rotary solenoid on alternate camera cycles when the panoramic camera lens is in the center of format. The solenoid is energized by the HO shutter command relay which is itself energized by the center-of-format switch and the 1/2-revolution-per-cycle switch. The exposure control system consists of a motor-driven attenuating filter that slides in front of the lens for films faster than the basic 3404. The filter change drive motor is actuated by a command from the filter control potentiometer on the scan head.

During scan, the film is clamped to prevent it from moving. A solenoid-operated platen behind the film clamps the film against the format frame attached to the horizon lens cone.

The format includes five fiducials which register as 0.007-inch diameter dots. These dots are formed by four 1.5-volt incandescent lamps which contact print through small holes in the format frame when the panoramic camera is in the center of format. The fiducials are nominally positioned to provide the basis for a coordinate reference system for calibration. The intersection of imaginary lines joining opposite fiducials represents the origin of the coordinate system. (This intersection does not represent a photogrammetric point.) Horizon cameras are individually calibrated prior to being mounted on the panoramic camera. This individual calibration consists of determining the principal point of autocollimation and the equivalent focal length, and checking the lens distortion characteristics. Subsequent to this, each camera system is calibrated to determine the position of the horizontal cameras in relation to their respective panoramic camera lens.

3.5 PANORAMIC GEOMETRY

The panoramic geometry subsystem records a sufficient amount of accurate data on each panoramic frame to enable the cartographic community to determine, at every point on the frame, the following parameters:

1. α (scanning) and β (along track) angles with an accuracy of 4 arc-seconds, 1σ (rms).

2. The absolute time of exposure at the center of format with an accuracy of a few microseconds. (This is necessary since all the images in the panoramic format are not photographed simultaneously.)

3. The time of exposure relative to the center of format with an accuracy of 1 millisecond, 3σ.

4. The change in the nod angle of the camera, at the time of exposure of the image point, from a predetermined nod angle with an accuracy of 4 arc-seconds, 1σ.

These parameters can be obtained for each image point by making linear measurements between the image point and the data which are recorded at the edge of the film adjacent to the format. A row of rail hole images and solid traces are recorded along the length of the format (scanning direction) at one edge of the film. At the other edge of the film, a row of rail hole images, a solid trace, a row of timing marks, and a row of nod angle dots are recorded. The panoramic format and the location of the data are more fully described in Fig. 3-12.

3.5.1 Rail Hole Images

The rail hole images are about 75 microns across the major axis of the elliptical image. They are the images of 0.0015-inch diameter holes in the rails. The rails support the edges of the film on an arc of 70 degrees. There are 73 holes in each rail spaced about 1 degree apart angularly and approximately 1 centimeter apart linearly.

Two incandescent lamps (called rail lamps) are mounted on the scanning head of the lens. Each lamp directs a small beam of light towards the rail and the rails interrupt this light except where the rail holes are located. When a light beam passes through a hole, a spot on the film is exposed. The result is a dense spot that is slightly larger than the corresponding rail hole diameter, depending on the distance of the film from the rail (film lift).

The rail holes are calibrated metrically so that their expected position on the film is known to about 6 microns, 1σ, (4 microns in each of two orthogonal directions). This information, when used in conjunction with focal length measurements, allows determination of the α angle (scan angle) of each hole. The accuracies of the rail hole calibration vary slightly between cameras but are specified in the calibration report provided with each camera.

In each rail, the rail holes are exposed one at a time as the lens rotates about its nodal point. The rail lamps are positioned in such a way that the rail holes and the ground images are exposed simultaneously. The zero scan angle is set arbitrarily by an additional rail hole at the center of the rails (see drawing no. 78600).

3.5.2 Panoramic Geometry Traces

The solid traces, usually referred to as the panoramic geometry traces, are useful in locating the principal point of the lens. The position of the principal point must be known so that linear measurements in the x-direction of the film (along-track) can be correctly converted to β angles. The distances of the two light spots which produce the solid traces from the principal point will be measured and given as x,y coordinates. The principal point will have (0,0) coordinates. The panoramic geometry traces are about 50 microns wide. The x,y coordinates of the two light spots that produce the solid traces will be given with respect to the principal axis from measurements made on an optical bench.

3.5.3 Nod Dots

The nod dots are round spots about 50 microns in diameter. They are produced by a separate subsystem consisting of an accurate optical encoder, electronic circuits, a xenon flashtube, two sections of optical fiber bundles, a rotating optical coupling, and a lens.

An optical encoder is mounted on the nod shaft of the camera to measure the nod angle. At certain fixed nod angle positions (every 19.78 arc-seconds), the encoder and its associated electronics generate electrical pulses. These pulses trigger the xenon flashtube which flashes for 2 microseconds into the fiber optics bundles through the rotary optical coupling to the scan head where the fiber bundle is masked except for a very small hole. The light emerges from this hole and is projected by a small lens onto the film.

In this manner, dots which can be identified with definite nod angles are recorded on the film. The position of the nod dot along the film (y coordinate of a frame) depends on the location of the scan head with respect to the rails (in other words, the scan angle) when the xenon flashtube was triggered. This provides sufficient information to obtain the calibration of the nod versus the scan angle. The zero nod position is arbitrary and it is normally defined by an additional nod dot.

3.5.4 Time Marks

The time marks are short lines 0.005 inch wide by 0.045 inch long. Their main purpose, as part of the scanning function, is to facilitate the determination of the time of exposure of the format. The time marks are generated by an accurate pulse generator (200 pulses per second) which triggers a neon tube. The light of the neon tube is focused on the film by the same lens which focuses the nod dots. The time marks permit the determination of the time difference between the exposures of two different points on the format with an accuracy of 1 millisecond (3σ).

A vehicle clock provides the basic time reference for the system. This clock is interrogated at the approximate center of format. The absolute time of the next timing pulse is recorded in binary form on the previous frame by the SLP block. The timing mark, which occurs as the clock is being interrogated, is purposely elongated so that it shows the relation between the time marks and absolute time. Thus, the absolute time a point on the format was exposed can be determined with an accuracy of a few microseconds depending on the accuracy of the clock.

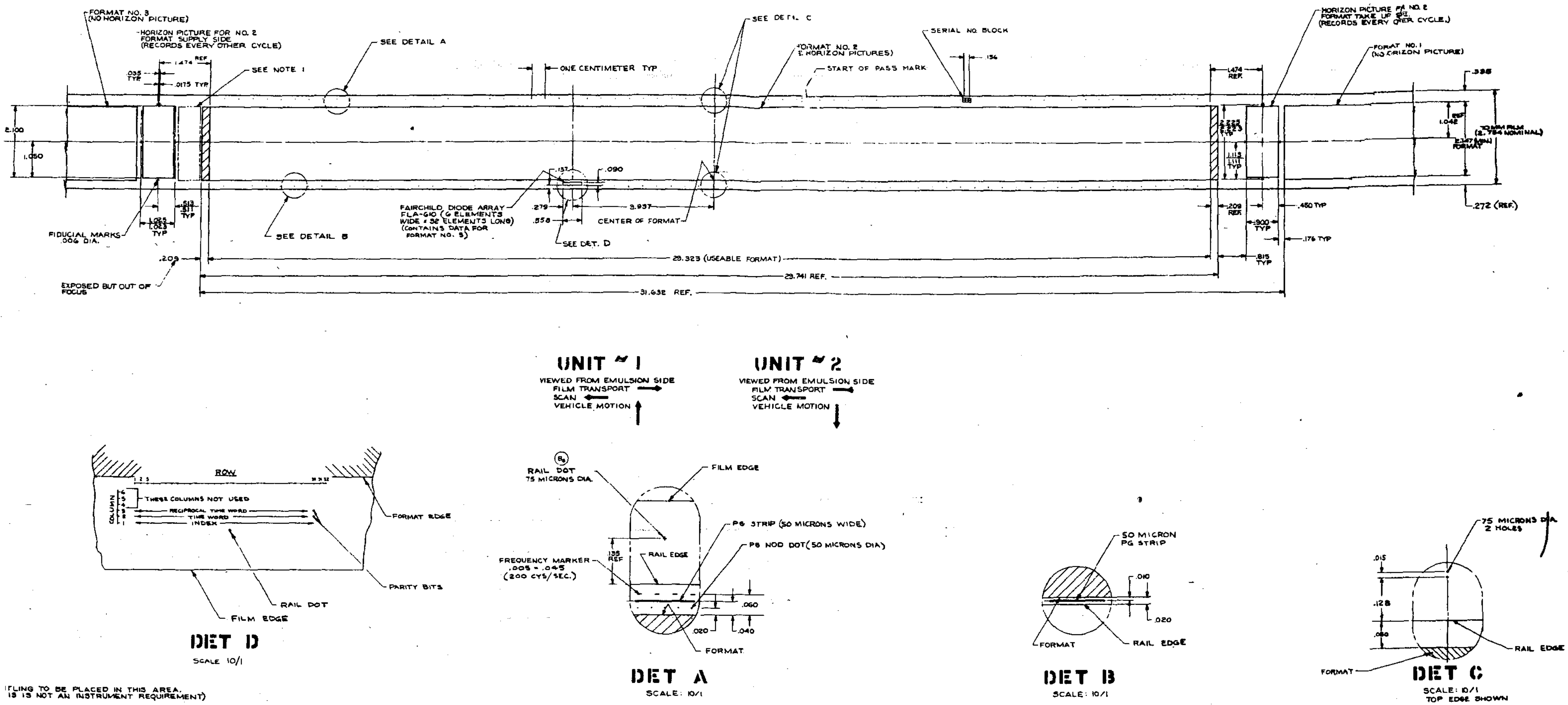


Fig. 3-12 — Film format

3.5.5 Nod to Scan Electrical System

The nod to scan electrical system (see Fig. 3-13) provides a means of relating camera scan angle to camera nod angle. This is accomplished by triggering a xenon tube with an optical encoder mounted on the nod axis. These tube flashes are imaged on the film format by a lens mounted rigidly on the lens scan head assembly. The major components of this system are listed below.

Component	Assembly	Schematic	Location
Nod encoder	84867	88310 (zone E20) 88402 (zone E5)	Nod shaft
Nod encoder electronics module	84867	107519	Auxiliary box
Encoder signal conditioner	107656	107643	Auxiliary box
Xenon tube circuit	107865	107790	Auxiliary box
Fiber optics			Lens cone

The encoder pulse is applied to the xenon tube circuit which generates a 5.0-volt, 2-microsecond pulse to fire the xenon flashtube. The flash is delivered to the scan head via a fiber optics bundle where a lens projects it onto the film format.

The nod encoder (Dynamics Research Corporation Theodosyn) generates a 5-volt, 5-microsecond-wide pulse every 20 arc-seconds. These pulses are spaced to an accuracy of 2.5-arc-second peak to peak over the 360-degree rotation of the encoder. The spacing on the film is determined by the following constants:

1. The ratio of nod to scan motion = 0.01321 degree/degree
2. The film plane radius (R) = 24 inches

Therefore, the pulse spacing relative to the nod shaft is,

$$\Delta\theta = \frac{19.775 \text{ arc-secs}}{0.01321} = 1{,}495 \text{ arc-secs} = 0.007225 \text{ radian}$$

The approximate spacing on the film is,

$$d = R\Delta\theta = (24)\ (0.007225) = 0.174 \text{ inch}$$

The encoder signal conditioning package (ESC) interfaces between the encoder electronic package and the xenon unit. The encoder signal conditioning package can be divided into three areas as follows: (1) the input or buffer stage, (2) the pulse shaping stage, and (3) the output or driver stage. An input signal of 5.0 ± 1 volt is applied to

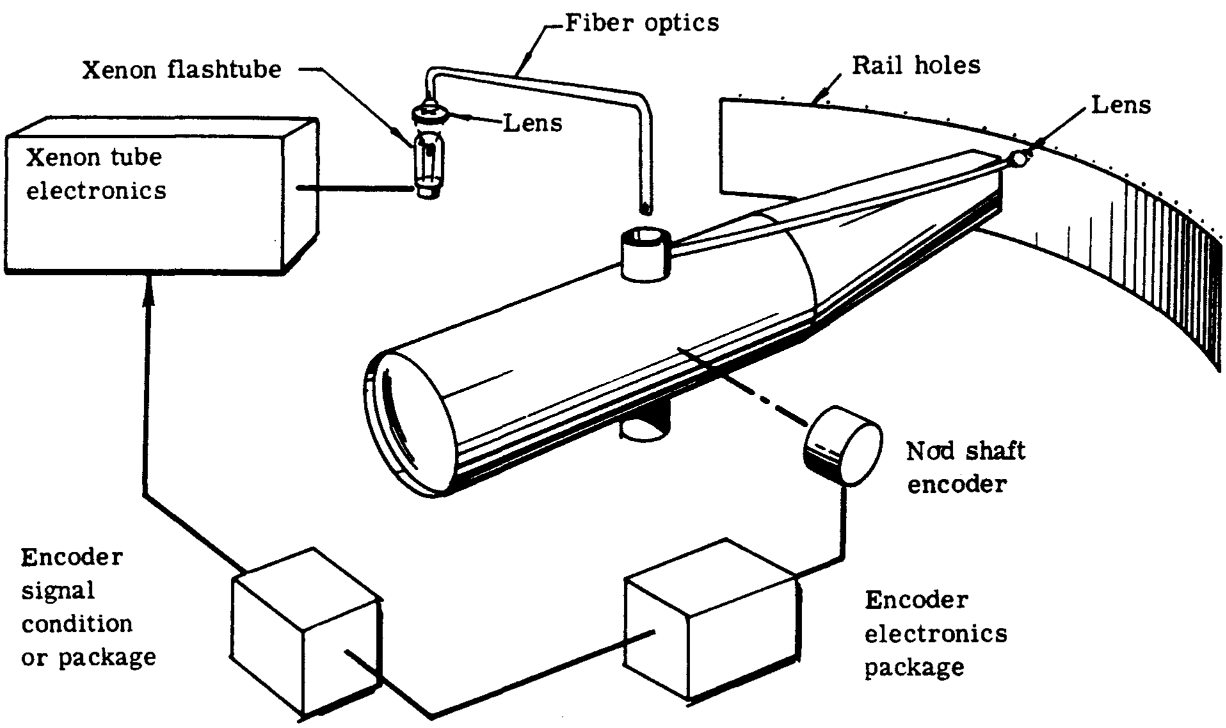


Fig. 3-13 — Nod to scan system

the buffer stage. The output from the buffer stage is applied to the pulse shaping circuit to provide a pulse of proper amplitude and duration. The driver stage increases the signal to a power level acceptable by the xenon circuit.

The xenon tube module contains the tube triggering circuits, the high voltage power supply, and RC control circuits.

A pulse from the encoder signal conditioning unit activates a transistor switch which discharges a 1.0-microfarad capacitor through the primary of the triggering transformer firing the xenon tube. After the tube has been triggered, the RC control circuit determines the amount of light energy delivered to the film.

The fiber optics in this system are used as a "light pipe." They consist of fine drawn glass filaments which are grouped together at each end in an epoxy cast. Each loose bundle is incased in either a polyvinyl or aluminum cover. The bundles act as an optical transmission wave guide and transport light from the xenon flashtube to the object plane of the panoramic geometry lens. This is accomplished by using two bundles of different lengths. The first one, from the xenon tube to the drum assembly has an aluminum casing and is 6 feet in length. This bundle transmits approximately 30 percent of its introduced light to a rotary couple. The second fiber bundle, located 0.007 inch away, transmits the light to the object plane of the panoramic geometry lens. Extreme care must be taken in handling the second bundle since the minimum bend radius is 3/4 inch, and if this is exceeded, the glass filaments may break, significantly decreasing the light transmission.

3.5.6 Data Signal Conditioner

The data signal conditioner (Fig. 3-14, schematic no. 85492) drives the frequency marker lamp, provides the smear pulse synchronizing the center of format with the 200-pulse-per-second clock input, turns on the fiducial and serial number lights, and provides the interrogate pulse that triggers the vehicle clock to read out to the SLP data block.

The first five stages A1 (dual stage), Q1, A2, and A3 accept the 200-pulse-per-second clock input from the vehicle clock, condition the signal, shape the waveform, and set the 100-microsecond ON time for the frequency marker light. This pulse supplies NPN transistor drive for the frequency marker light via the OR gate, emitter follower, and an isolation pulse transformer.

The closing of S3 in the switch cluster applies a 24-volt pulse signal to the center-of-format trigger circuit. The output pulse sets A4; at the next clock pulse, resets flip-flop A4. When reset, the next two stages (A5 and A6) set the time of the fill-in pulse. This pulse goes through the OR gate and fills in 1 pulse for 3 milliseconds at the first clock pulse after the center of format.

The output of A5 and A6 also feeds A7 which controls the time for the interrogate pulse and the relay ON time. The interrogate output is a 70-millisecond pulse which

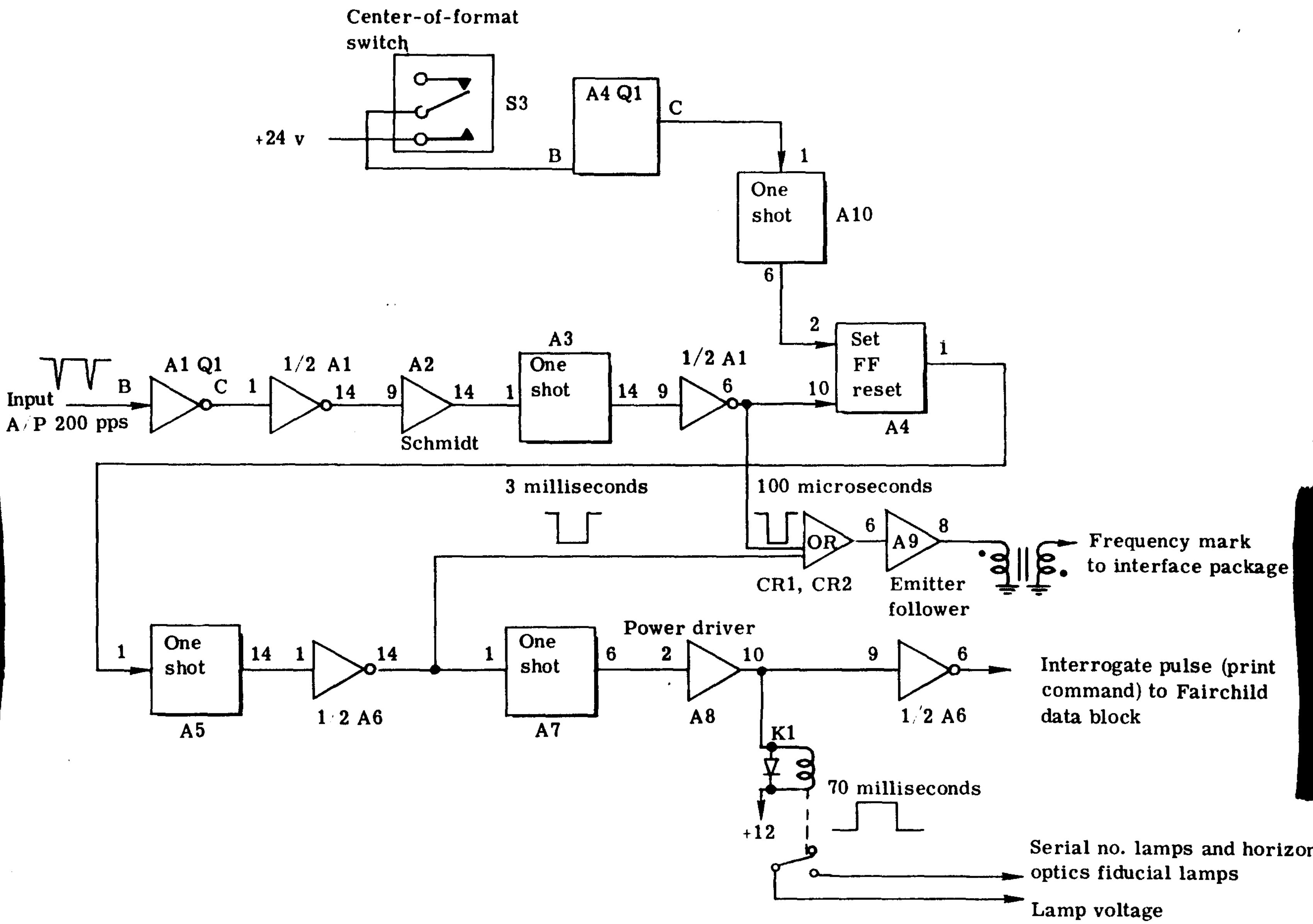


Fig. 3-14 — Data signal conditioner

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is sent back to the vehicle clock. On receipt of this signal, the clock commands the SLP data block to record pertinent time information on the film.

The interrogate pulse also drives a relay through a power driver to supply voltage for the serial number block and the fiducial lamps. This voltage is applied for 70 milliseconds and occurs just after center of format. The serial number light is driven directly by the data signal conditioner. The fiducial lights are turned on by a 1/2-revolution-per-cycle switch every other cycle.

The frequency marker light is driven by an NPN transistor circuit in the interface package (see Fig. 3-15) and its output is gated on during scan through switch S7 in the switch cluster.

The rail hole and panoramic geometry trace lights are driven directly from the power supply through limiting resistors. The return is gated on during scan by S6 in the switch cluster.

3.6 FILM TRANSPORT SYSTEM

3.6.1 General Discussion

The film transport system is illustrated in Fig. 3-16. The important elements of the transport system include the supply torque motors, the supply constant tension rollers, the input metering roller, the shuttle system, the film framing roller, the intermediate roller assembly, and the takeup torque motors.

Film is pulled continuously from the supply spool by the camera input metering roller and is fed through one half of the shuttle system, across the film support rails and around the framing roller, through the output side of the shuttle, through the intermediate roller assembly to takeup B, and back through the intermediate roller assembly to takeup A. Continuous input metering as well as continuous film takeup is made possible by the film shuttle system which, during film exposure, stores an amount of incoming film in the form of a loop while giving up a loop of exposed film. The length of film stored by the shuttle is sufficient to allow the film in the exposure area to be held still during exposure. In order to compensate for differences in input metering roll and framing roll diameters, a two-speed input metering drive is provided. The input metering roller operates alternately from one of two clutch-operated gear trains depending upon the position of the film shuttle system at a given time. The two gear train ratios represent an input film speed of either 99 or 101 percent of the nominal film speed, a speed established by the cycle rate. By alternating gear trains as a function of shuttle position, the required average film speed is maintained.

Film tension on the supply side of the input metering roller is maintained by the supply torque motor, which attempts rotation in the direction opposite to film transport,

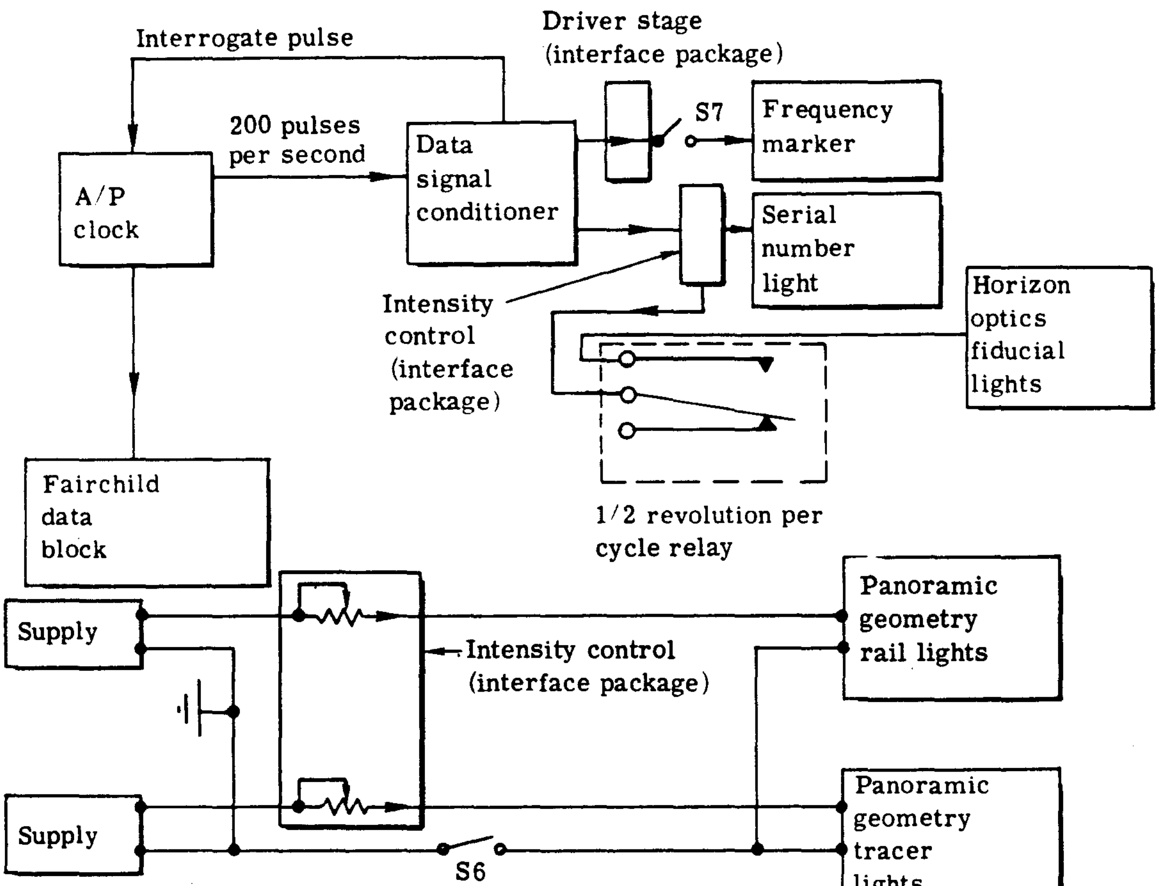


Fig. 3-15 — Readout system

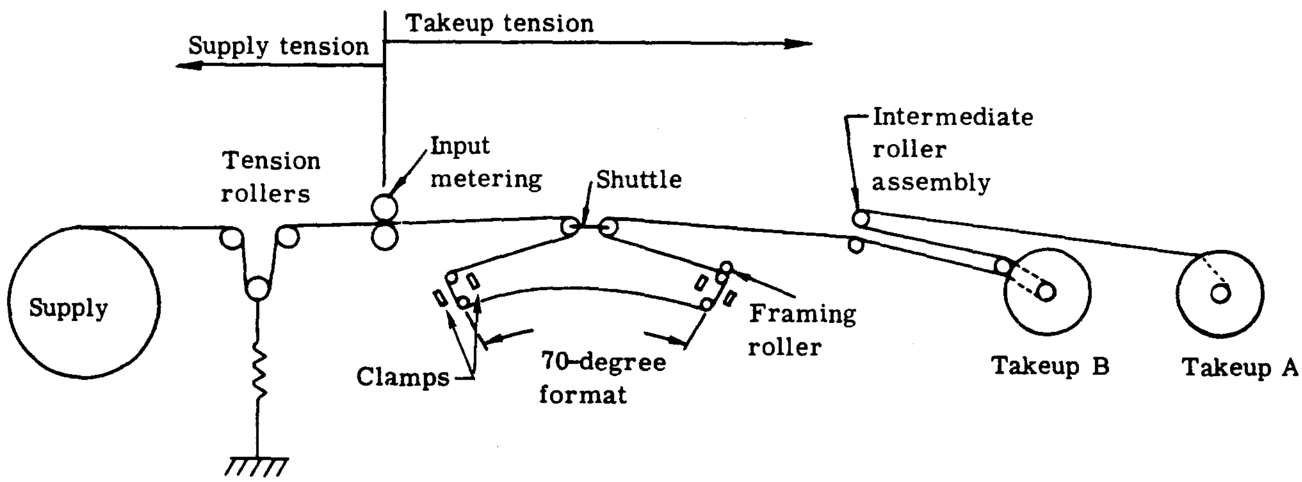


Fig. 3-16 — Film transport system schematic and the constant tension rollers. The torque motor corrects for the overall tension changes, and the constant tension rollers nullify small variations or ripples in the film transport. The constant tension rollers also compensate for the inertial effect generated by the full supply during camera start and shutdown. Each spool in the supply cassette contains a friction type brake which is released when power is applied to the supply spools. Film tension on the takeup side of the input metering roller, including the exposure area and the shuttle system, is maintained by a takeup torque motor driving in the direction of film takeup. To maintain a reasonably constant film tension, the output power of the supply and takeup motors is controlled by a potentiometer which is linked to film radius sensor arms located in each spool. Film is passed through the B takeup before the A takeup to allow recovery of the A takeup after a cut and wrap sequence transfers the film to the B takeup. The B takeup is then filled and recovered.

Each spool in the takeup cassettes contains a method of preventing reverse rotation. The A takeup antibackup device utilizes a one-way clutch and a ratchet and pawl mechanism. The A takeup torque motor operates the one-way clutch which is linked to the ratchet and pawl mechanism. When the film is being taken up, the clutch slips. If the motor begins to reverse direction, the clutch locks and engages the ratchet which is locked by its pawl, preventing reverse rotation of the spool. To release the antibackup feature, power is applied to a solenoid thereby releasing the pawl and allowing the ratchet and spool to turn. The B takeup does not use an antibackup device. Instead it uses a friction type brake similar to that of the supply cassette. The B takeup brake is also operated by a solenoid and is released upon the application of power.

During camera operation, power is supplied to the supply tension motor, the takeup drive motor, and to the camera. The input metering roller pulls film from the supply spool as the frame metering roller, directed by the intermittent motion device, pulls film through the camera and the takeup spools begin reeling in film. Before, during, and slightly after the exposure cycle, the dwell period of the intermittent drive is in effect. During this period, film clamps located at either end of the film guide rails are activated to ensure that there is no film creep over the rails. The film is exposed over a 70-degree scan angle and is supported by two fixed guide rails. After exposure is completed, the clamps are released and the film framing roller meters enough film for the next exposure cycle.

3.6.2 Supply Spool Tension Control

The sensor arm drives the wiper of variable resistor A5R1, which is a part of voltage divider A1R2, A5R1, and A1R3 (see Fig. 3-17). A voltage regulator circuit (A1R1 and A1CR1) maintains a constant regulated voltage across the voltage divider. As the sensor arm moves from a full spool to an empty spool, the wiper of A5R1 impresses a lesser voltage on the bases of the power transistors (Q1 and Q2). This same voltage, minus the V_{BE} drop, appears across the emitter resistance, which is a parallel combination of A3R1 and A3R2 in series with A4R1. This forces a current to

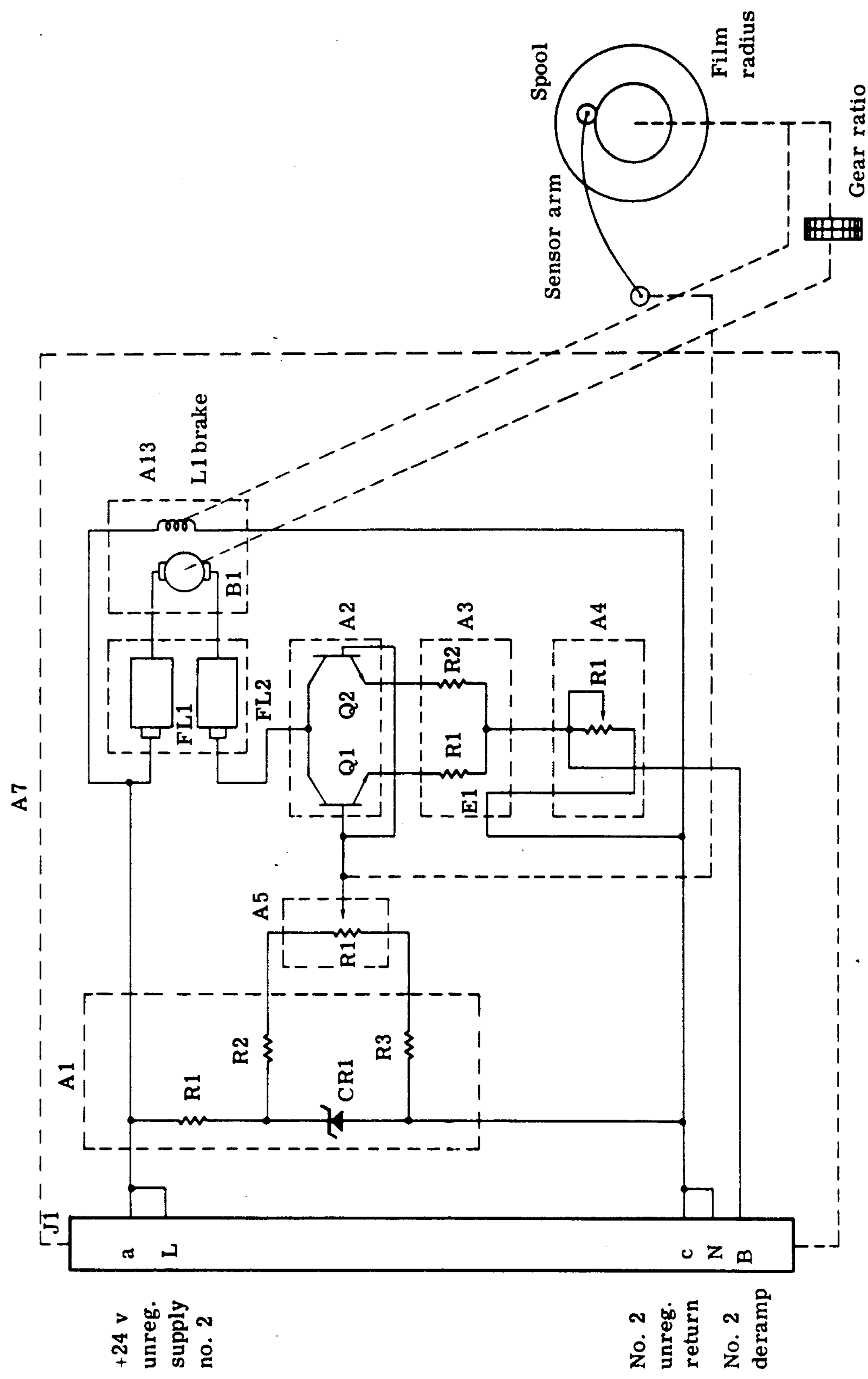


Fig. 3-17 — Supply spool tension control flow through the transistors and through the armature of the torque motor (A13B1). Torque and film tension are directly proportional to the current. A family of film tension curves can be generated with the proper values of the voltage divider resistors. The slope of these curves are adjusted for a programmed current to the motor; this will provide constant dynamic tension throughout the complete range of full to empty condition. The brake (A13L1) is released when the motor is operating. No. 2 deramp places a ground in parallel with A4R1, forcing more current through the motor and thereby increasing tension during the shutdown operation.

3.6.3 Takeup Tension Control

The takeup tension control sensor arm drives the wiper of the variable resistor A5R1 which is a part of voltage divider A1A1R1, A5R1, and A1A1R14 (see Fig. 3-18). A voltage regulator circuit (A1A1R13 and A1A1VR2) maintains a constant regulated voltage across the voltage divider. As the sensor arm moves from an empty spool to a full spool, the wiper of A5R1 impresses a greater voltage on the bases of the power transistors (Q1 and Q2). This same voltage, minus the V_{BE} drop, appears across the emitter resistance which is the parallel combination of A1A2R2 and A1A2R3 in series with A1A2R1. This forces a current to flow through the transistor and through the armature of the torque motor (A4A3B1). Torque and film tension are directly proportional to the current. With the proper values of the voltage divider resistors, a family of film tension curves can be generated. The slope of these curves are adjusted for a programmed current to the motor which will provide dynamic tension throughout the complete range of empty to full condition.

The film tension range can be raised or lowered without changing the empty to full linearity by adjusting the current with potentiometer A1A2R1. No. 1 takeup antibackup control voltage releases the antibackup solenoid (A4A1L1). A2FL1 and A2FL2 are RF1 filters. The takeup A shunt (A1A1R2) causes reduced tension by lowering the base voltage of Q1 and Q2.

3.6.4 Film Clamping

The film is clamped at the right and left horizon camera during the scan period. These clamps, which also serve as platen pressure plates for the horizon cameras, are actuated by rotary solenoids which are energized by the clamping switch in the switch cluster. This clamping switch also energizes the clamping solenoid on the SLP time block to keep the film firmly against the time block during the clock readout period. The clamping switch is timed to cause clamping after the film stops framing and to unclamp just prior to the next film framing cycle.

3.6.5 Shuttle Electrical System

The 99/101-percent input metering speed is obtained by energizing and de-energizing the 99/101-percent clutch assembly solenoid. When film is metered at the 101-percent rate, it is stored in the shuttle during the clamping period causing the

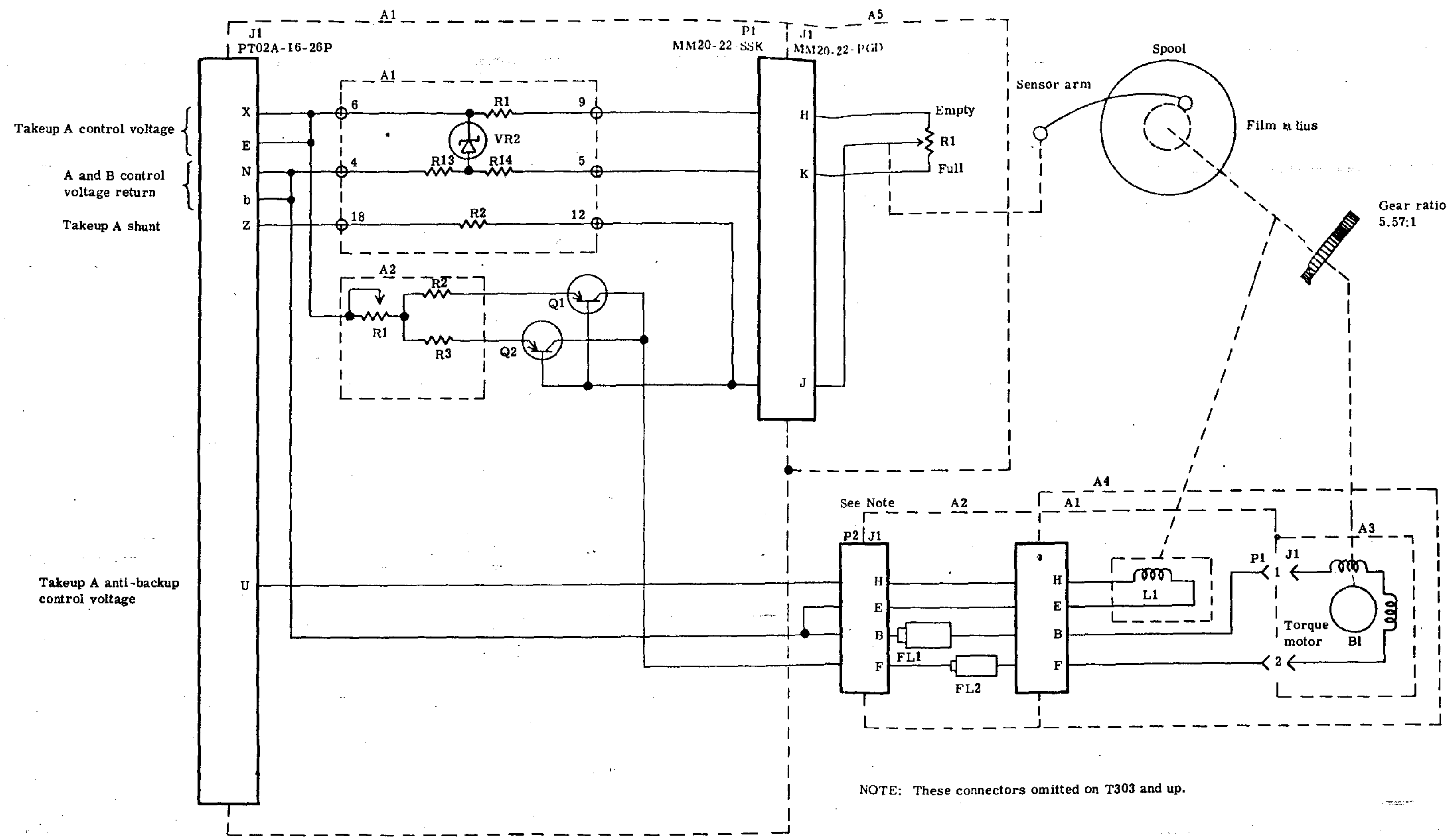


Fig. 3-18 — Takeup A film tension control shuttle to move toward the right (when viewed from the drum side). After clamping and during framing, the film is removed from the shuttle and the shuttle moves to the left. Because the film is metered to the shuttle at 101 percent, shuttle excursions to the right are greater than those to the left. After four to six right-hand excursions, the shuttle will actuate the right limit switch. The right limit switch in turn, trips a latch relay de-energizing the 99/101-percent clutch solenoid. This places the clutch in the 99-percent mode. The shuttle continues to make right and left excursions during clamping and metering; however, the metering speed is now only 99 percent, so the left excursions are greater than those to the right. After a few cycles, the left limit switch is activated, resetting the latching relay and returning the 99/101-percent clutch to the 101-percent metering condition.

3.6.6 Shuttle Failsafe Circuit

A failsafe circuit is incorporated to prevent possible damage to the framing system gears that might be caused by the shuttle reaching its mechanical limits. The circuit consists basically of overtravel switches mounted near the right and left limits of shuttle travel. If the shuttle overtravels far enough to actuate either of these switches, electrical circuits will cause the main servo drive system to come to a quick stop, preventing any further film metering and possible damage.

When operating with an A/P test and checkout console, a pair of jumpers are inserted between test jacks on the control package and those on the main electronics box. The tripped switch energizes the failsafe relay (K5 or K17) in the control package which gives the servo a stow command. The switch also provides a ground signal to the test and checkout console which is used to give the other instrument a normal shutdown command and then turns off all instrument power.

The jumpers are removed when operating with a Boston test and checkout console. The ground signal to the test and checkout console is used to replace the V/h voltage to the instrument with a ground (zero volts).

In the event the circuit is activated, normal camera operation may be resumed by resetting the failsafe system from the test and checkout console after clearing the shuttle problem. (The possibility of a failsafe occurring during normal operation is very remote. However, it is possible to induce this condition during ground testing or debugging.)

3.6.7 Noncircular Gear Drive

The nodding motion of the camera required for FMC introduces several perturbations in the material handling system. The most severe of these is associated with the supply spool. For any given cycle rate, the nod motion adds or subtracts approximately 6 percent to or from the required nominal film transport rate as seen by the supply and takeup system. This variation is seen by both the supply and takeup spools as a tension change, hence, these spools would be required to speed up and slow down once every cycle during FMC. Because of the mass and diameters involved, this is not possible. Therefore, both the supply and takeup spools are tension corrected for the diameter changes associated with film passage. Each has a tension sensing and modulating actuator to correct for minor variations. In the case of the takeup spools, the tension modulating device combined with the lower inertia characteristic eliminates the need for further correction for variations resulting from nodding. In the case of the supply spool, however, further correction must be added to the system. A set of noncircular gears are introduced which, during the course of a cycle, add and subtract from the average film input metering rate required at a given cycle rate. This approach is satisfactory since the input metering roller is supplying a storage loop controlled by a shuttle.

The noncircular gear assembly, or material speed compensating device (Fig. 3-19), is belt driven from the main drive and, in turn, drives the input metering roller through a pair of flexible couplings (see Fig. 3-20). Once the device is properly timed it cannot get out of phase with the rest of the drive system, barring pin shearing or disassembly to remove one or more of the belts.

The device consists of two pairs of gears, one the eccentric set and the other a set of idlers, to obtain proper direction of rotation. The eccentric, or shaped gears, are first phased with each other to mesh properly and then synchronized with the nod motion so that the output speed is increased for the half cycle when the camera nods toward the supply spool and decreased as it nods away from the supply. Because one camera looks forward and the other looks aft, care must be taken that the timing of the noncircular gear assembly is in relation to the camera (not the same for both cameras).

The eccentricity is accomplished by taking regular circular gears and mounting them eccentrically on their respective shafts. The gears are marked by a hole through the web at the high point. The pair is phased by meshing them with both holes aligned with the shafts and toward the output shaft. This phasing should be set with the lens in the 270-degree position (scan head rotated 180 degrees from center of format).

If for any reason a camera is disassembled or if one or more parts in the drive system are changed, the noncircular gear assembly must be synchronized with the nod motion either by repinning the hub or by adjusting the hobbed section of the input pulley.

3.7 TELEMETRY

3.7.1 Command Monitors

The launch mode monitor consists of relay K7 in camera no. 1 and relay K19 in

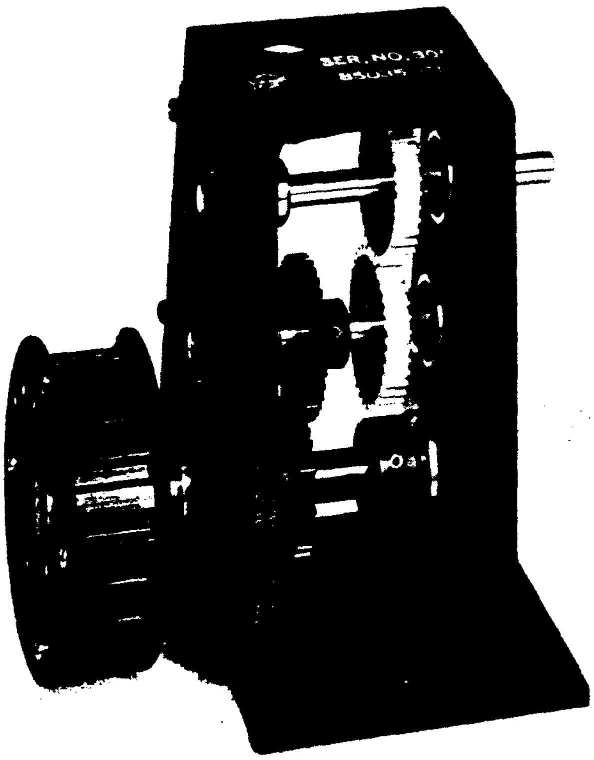


Fig. 3-19 — Noncircular gear assembly

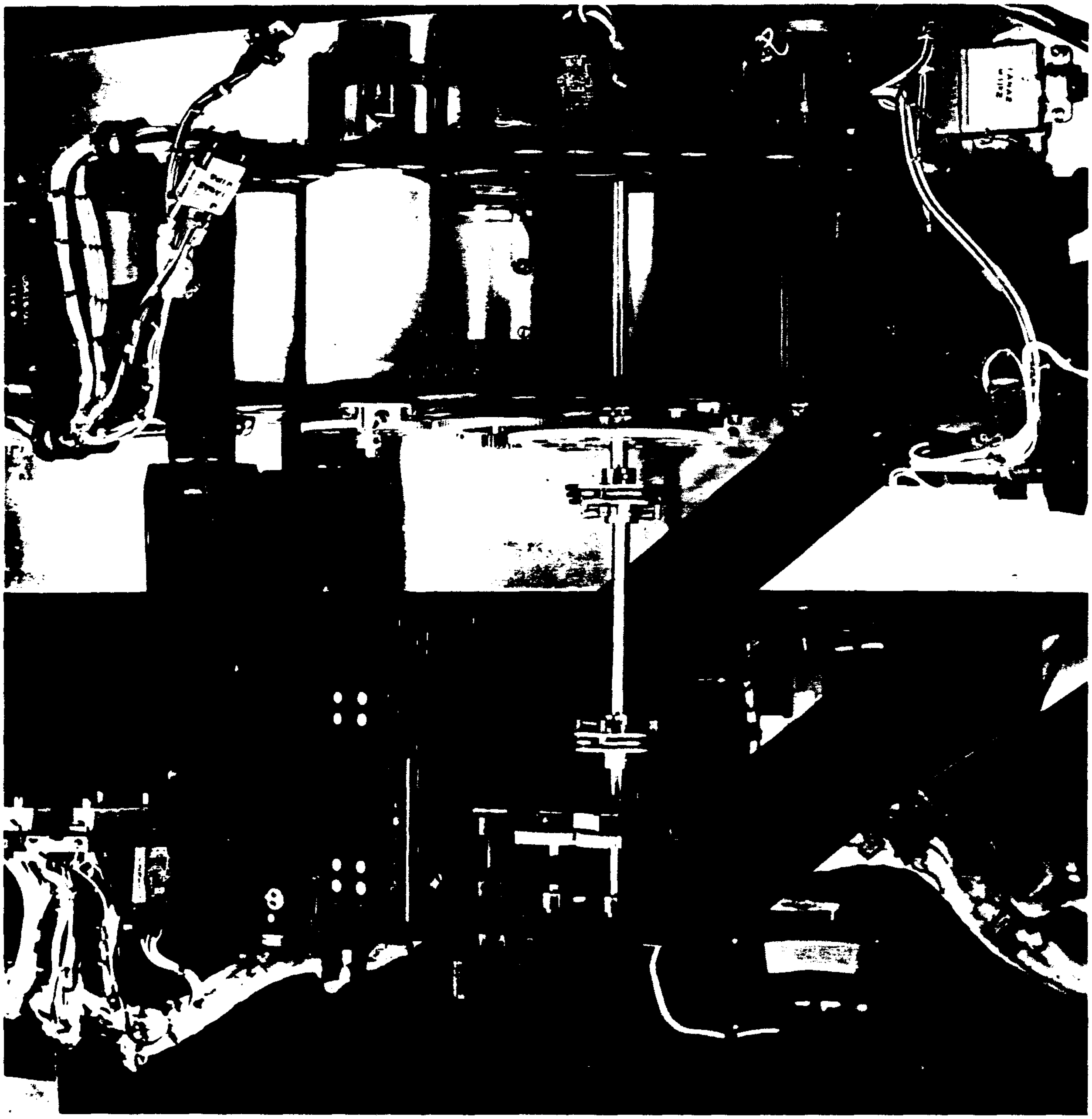


Fig. 3-20 — Flexible couplings

camera no. 2. When the system is in a launch ready condition (after receipt of the relay reset command), the relay contacts close. The contacts open upon receipt of the orbit mode signal. Relays K7 and K19 are in the control package (reference schematic no. 79121, zones 6A and 6C).

The operate voltage monitor (P1004 and P1005, pin T) is an unconditioned signal monitor (see Fig. 3-21) and provides output to the telemetry channels by means of a low output impedance Darlington amplifier located in the interface package (reference schematic no. 85491, zones H7 and A7).

The center-of-format command monitor (P1004 and P1005, pin f) consists of a nominal +24-vdc output pulse generated by a microswitch closure during 90 to 110 degrees of scan (see Fig. 3-22).

3.7.2 Scan Servo

Forward motor voltage (P1004 and P1005, pin U) is approximately +20 vdc during servo startup. The average steady-state voltage during operation is approximately 5 vdc. The creep mode voltage on a shutdown should be approximately 3.5 vdc.

NOTE

> These voltages fluctuate considerably during a cycle because of nonconstant loads from the film transport, etc.

The telemetry voltage is taken from the output of a Darlington amplifier circuit in the main servoamplifier package.

The reverse motor voltage (P1004 and P1005, pin S) is approximately +20 vdc during servodeceleration and will be approximately zero at all other times. This telemetry voltage is also taken from the output of a Darlington amplifier circuit in the main servoamplifier package.

The tachometer feedback voltage (P1004 and P1005, pin R) is the output of a Darlington amplifier circuit in the main servoamplifier package and will be between 0 and +5 volts.

The lens assembly rotation voltage (P1004 and P1005, pin z) is the 0- to 5-vdc output from a potentiometer located on the scan shaft. It is set for 3 vdc at the stow position (180 degrees).

3.7.3 Supply Cassette

The supply spool motor voltage (P1004 and P1005, pin V) is taken from the collectors of the two paralleled 2N3474 transistors, which drive the supply tension motor. The voltage is within the 0- to 24-vdc range (unregulated) and increases with decreasing film radius. The telemetry voltage is taken from the output of a Darlington emitter follower circuit within the supply cassette.

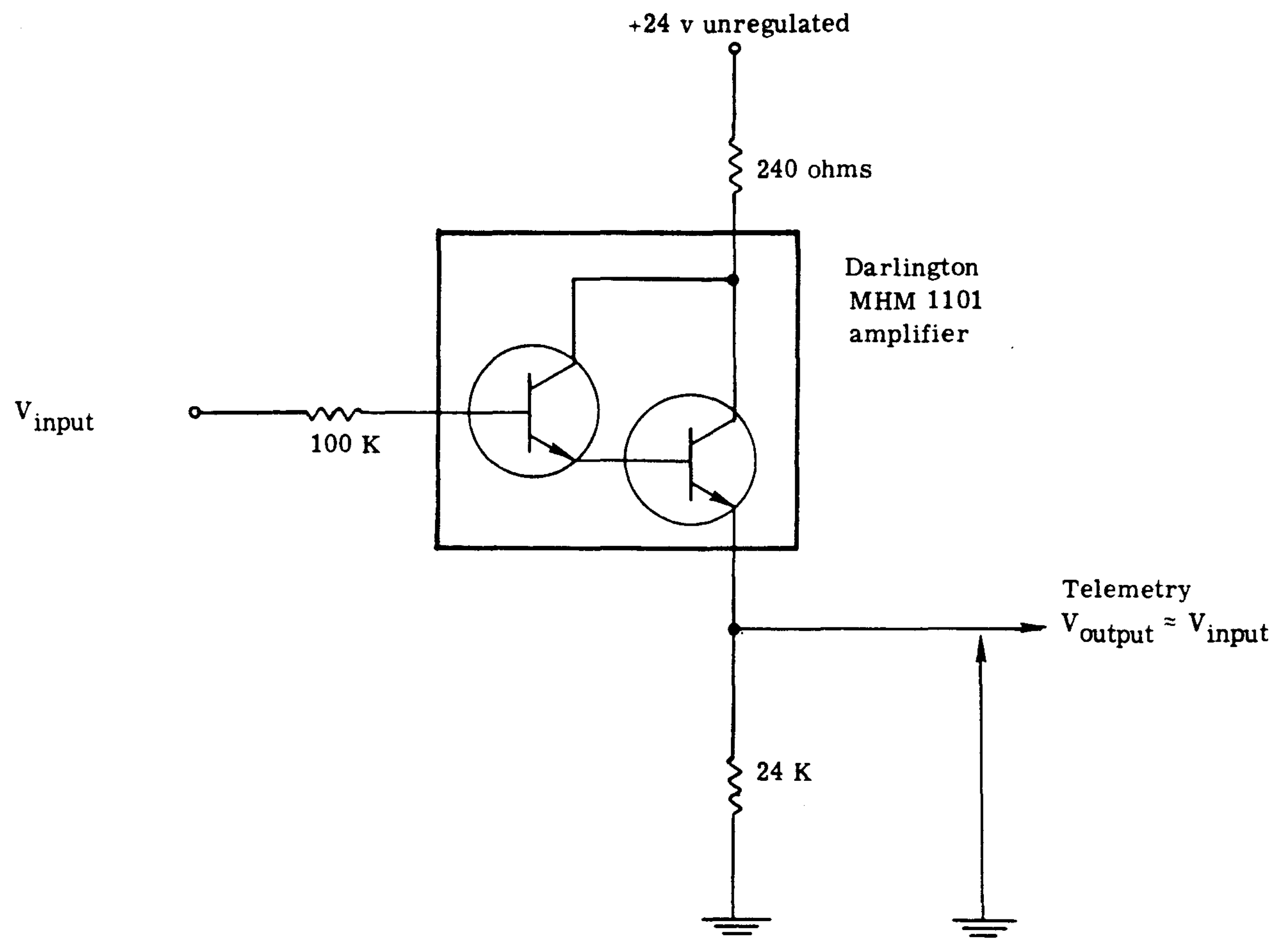


Fig. 3-21 — Operate voltage monitor circuit

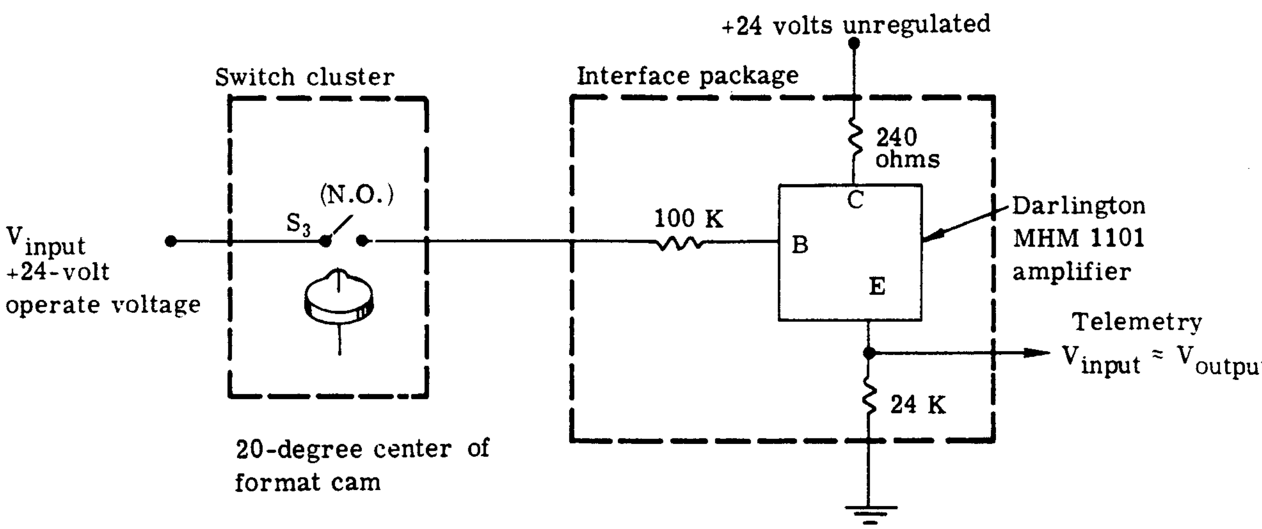


Fig. 3-22 — Center of format command monitor circuit

3.7.4 Film Transport

The 99/101 clutch command (P1004 and P1005, pin W) is +24 vdc when the higher speed gear ratio is engaged. It is generated by the voltage applied to the clutch on the transport assembly, and the output is through a Darlington amplifier circuit in the interface package.

The input metering roller (P1004 and P1005, pin p) is a 0- to 5-volt sawtooth waveform generated by a 5 K ± 10 percent, 1-percent linearity potentiometer on the roller shaft.

The input film idler (P1004 and P1005, pin r) is a 0- to 5-volt sawtooth waveform generated by a 5 K ± 10 percent, 1-percent linearity potentiometer on the roller shaft. The waveform will dwell at a constant voltage during the scan portion of an instrument cycle. This voltage level will change from cycle to cycle.

The output framing roller (P1004 and P1005, pin v) is a 0- to 5-volt sawtooth waveform generated by a 5 K ± 10 percent, 1-percent linearity potentiometer on the roller shaft. The waveform will dwell at a constant voltage during the scan portion of an instrument cycle.

The output film idler (P1004 and P1005, pin x) is a 0- to 5-volt sawtooth waveform generated by a 5 K ± 10 percent, 1-percent linearity potentiometer on the roller shaft.

The shuttle position left and right (P1004 and P1005, pins AA and BB) are momentary switch closures to the unregulated return as the shuttle passes to the left or right of center. During exposure the shuttle is moving to the right and after exposure the shuttle moves to the left.

3.7.5 Takeup

The takeup motor voltage monitor (W2P8A and W2P8B, pins G and P) voltage is measured across a resistive voltage divider which represents 1/6 of the actual motor voltage.

The film footage monitor (W2P8A and W2P8B, pins L and D) output voltage increases from 0 vdc for an empty spool to + 5 vdc at an 8-inch radius and then decreases to 0 vdc at a 115 percent full spool.

3.7.6 Intermediate Rollers (P1010 and P1011, pin B)

The intermediate roller voltage is from the wiper of a 5 K ± 1-percent linearity potentiometer on the rollers, and varies from 0 to 5 vdc for one revolution of the roller.

3.7.7 Exposure Control

The slit width monitor (P1004 and P1005, pin g) is a 5 K potentiometer excited by +5 vdc. The telemetry output is as shown below.

Position	Slit Width, inches	Telemetry, volts
Failsafe	0.200	2.00
No. 1	0.134	0.43
No. 2	0.174	1.48
No. 3	0.226	2.54
No. 4	0.340	3.59

Regarding the slit width failsafe monitor (P1004 and P1005, pin P), when the slit width servo control is in the failsafe condition there will be open relay contacts from pins P to e of P1004 or P1005. These will be closed contacts in the nonfailsafe condition. This relay is located in the interface package (schematic no. 85491, zones 3G and 3C).

The filter position (P1004 and P1005, pin DD) monitor consists of a 5 K potentiometer excited by +5 vdc. The motor steps five times when moving from the normal film filter to the special film filter and vice versa. The nominal telemetry readouts versus filter positions are shown below.

Filter Position	Telemetry, volts	Motor Steps	Remarks
Full in	4.000	0	Special film filter
	4.528	1	
	5.00	2	
	0.278	3	
	0.795	4	
Full out	1.300	5	Normal film filter
	1.831	6	
	2.38	7	
	2.92	8	
	3.45	9	
Full in	4.000	10	Special film filter

Regarding the film change monitor (P1004 and P1005, pin HH), when the scan head filter is in the normal film position a relay contact closure is seen from pin HH to pin e of P1004 or P1005. The contacts are open when the filter is in the special film position. This relay is located in the interface package (reference schematic no. 85491, zones 7F and 7D) and is activated by the pickoff voltage of the readout exposure control potentiometer (R4) geared to the filter stepper motor (B2) on the scan head.

3.7.8 Auxiliary Optics

The auxiliary optics shutter command (P1004 and P1005, pin Y) is a +24-vdc output which occurs every other scan cycle at 90 to 110 degrees of scan position. It is generated by a relay contact closure (K1, schematic no. 88310, zone D8) in the auxiliary optics assembly. The telemetry voltage is taken from the output of a Darlington amplifier circuit in the interface package.

The auxiliary optics platen command (P1004 and P1005, pin X) is a +24-vdc output which occurs every cycle from 45 to 130 degrees of scan position. It is generated by switch S4 in the switch cluster assembly. The telemetry voltage is taken from the output of a Darlington amplifier circuit in the interface package.

The input and output auxiliary optics platen position monitors (P1004 and P1005, pins h and i to j) are switch contact closures when the platen is clamped and are opened when it is released. They are located on the film transport assembly (schematic no. 88310, zone G7).

3.7.9 Cycle Counter (P1004 and P1005)

The counter is mechanically activated once every scan revolution. The output is as follows:

Count	Telemetry Voltage, vdc
0	0.5
1	1.0
2	1.5
3	2.0
4	2.5
5	3.0
6	3.5
7	4.0
8	4.5
9	5.0

The P1004 and P1005 pin connections are as follows:

Pin	Function
Z	Units
a	Tens
b	Hundreds
c	Thousands
d	+5-vdc excitation
e	Return

3.7.10 Temperature Sensors

The temperature sensors have the following characteristics:

Nominal resistance	2,000 ohms ±2 percent at a nominal temperature of 78 °F.
Coefficient of resistance	90 ± 2 percent in resistance with a 200 °F change in temperature from nominal.
Operating range	-100 to +350 °F.
Leakage resistance	Room temperature leakage resistance with a 50-volt excitation shall be greater than 50 megohms.
Power dissipation	Nominal resistance value shall remain within ±2 percent when power is applied (10 to 50 milliwatts) and through resistance stabilization.
Calibration	A four or five point vendor calibration shall be furnished with each temperature sensor. The calibration shall cover the range from -50 to +150 °F, if possible.

The temperature monitoring circuit is as shown in Fig. 3-23.

The resistor has the following characteristics:

Resistance	1.5 K ohms ± 0.1 percent (to be 1.6 K as soon as feasible after CR-1)
Power	1/4 watt
Temperature coefficient	Less than 100 ppm/°C

The nominal output curve is shown in Fig. 3-24.

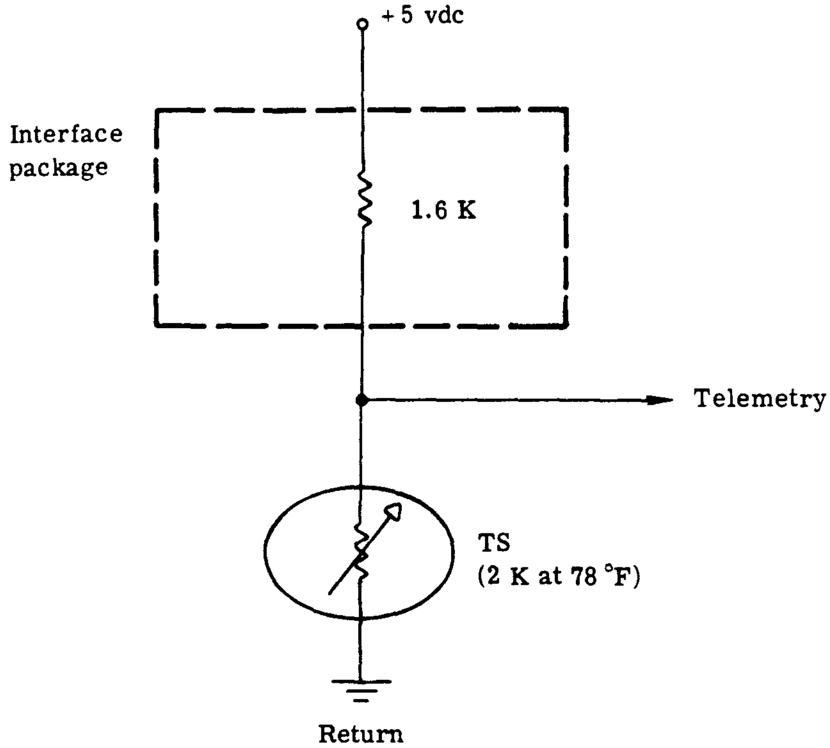


Fig. 3-23 — Temperature monitoring circuit

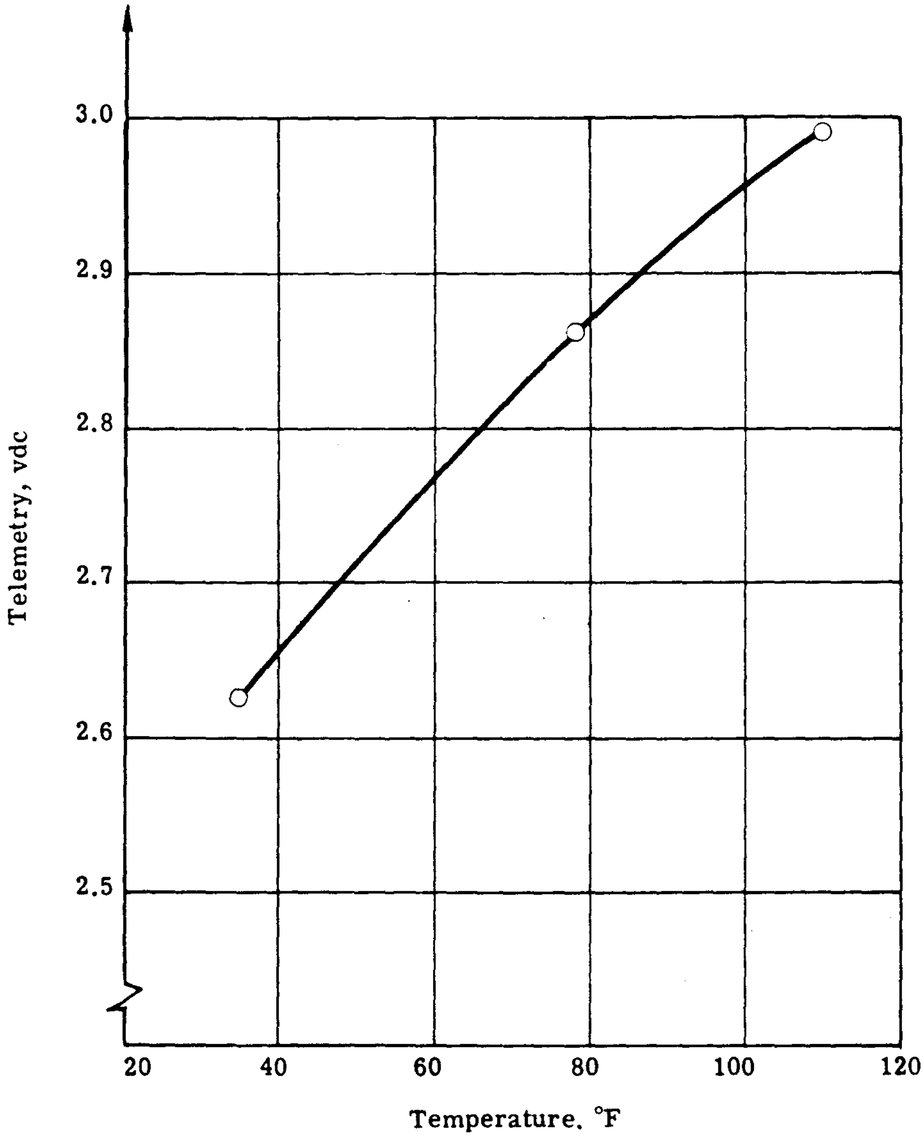


Fig. 3-24 — Temperature sensor output

Temperature sensor locations are indicated in the following listing:

Temperature Sensor No.	Location	Output Connector Pin
1	Lens	P1004, P1005, pin B
2	Scan head	P1004, P1005, pin C
3	Inboard rail	P1004, P1005, pin D
4	Right auxiliary optics	P1004, P1005, pin E
5	Drive housing	P1004, P1005, pin F
6	Outboard rail	P1004, P1005, pin G
7	Delta (Delta Apex)	P1004, pin H
8	Delta (vehicle starboard)	P1004, pin J
7	Supply cassette	P1005, pin H
8	Main electrical box	P1005, pin J
	Takeup A*	W2P8(A), pin A
	Takeup B*	W2P8(B), pin A
	Pad* (vehicle port)	P1005, pins EE and FF

* 1.6 K divider resistor not on Boston side of interface.

3.8 ELECTRICAL PACKAGING AND MISCELLANEOUS CIRCUITS

3.8.1 Electrical Packaging

J-3 system electrical assemblies are distributed throughout the payload as shown in electrical block diagram no. 85196; this drawing provides symbol designations referenced in the following discussion.

1. A takeup (1-A1) has self-contained electronic assemblies and associated harnesses. The main groups are the electronics component boards (1-A1-A1), spindle assembly (1-A1-A4), and the sensor arm assembly (1-A1-A5); refer to assembly drawing no. 78548.

2. B takeup (1-A2) is electrically similar to the A takeup; refer to assembly drawing no. 78549 for further details.

3. On the intermediate roller assembly (1-A3), electrical signals are provided by continuously rotating potentiometers connected to rollers; refer to assembly drawing no. 79025.

4. Main instrument assembly electrical equipment is grouped in three major subdivisions: (1) the no. 1 instrument assembly (1-A4) (mounted on the side nearest the takeups), (2) the main support assembly (1-A5), and (3) the no. 2 instrument assembly (1-A6) (mounted on the side nearest the supply). The two instrument assemblies are electrically similar, consisting mainly of the following:

	Drawing No.
Transport assembly	78507
Auxiliary optics assemblies	78667
Material change detector and amplifier assemblies	88258 107633
Lens cell assembly	84911
Main drive assembly	85069 85750
Switch cluster	107549

Interconnections between the above assemblies and the main support assembly are provided through main instrument harnesses 1 and 2 (1-A4-A1-W1) and (1-A6-A1-W1). The main support assembly includes the main electronics box (1-A5-A1) (drawing no. 85486) and the auxiliary electronics assembly (1-A5-A4) (drawing no. 88127). These two assemblies comprise the major portion of the J-3 system electronics. The main electronics box contains the following:

	Drawing No.
Dual control system assembly	88382
Dual power supply assembly	88443
Dual interface circuit assembly	88020
Dual data signal conditioner	87983
MEB harness	88125

5. The supply spool assembly (1-A7) has self-contained electronic assemblies and associated harnesses. These include electronic assemblies, motor and brake assembly, the sensor arm potentiometer, and associated harnesses (refer to assembly drawing no. 78550).

3.8.2 Miscellaneous Electrical Circuits

Linear potentiometers are coupled to the input metering roller shaft, input film idler shaft, output film idler shaft, framing roller shaft, and the lens rotation system. These potentiometers are used for telemetry and are energized by the 5-volt telemetry buss. The output waveform of these potentiometers is a sawtooth of approximately 5-volt peak. This waveform can be used to obtain positional, velocity, and directional information concerning each shaft.

Two microswitches are located at the shuttle assembly, one on either side of the center-of-shuttle travel. When actuated, these switches complete an electrical circuit to the 24-volt return buss and are designated the telemetry left and telemetry right shuttle switches.

Four fiducial lamps are located in the two horizon camera housings. These lamps, exposed on each horizon frame, provide the required calibration framework. The exposure control for the lamps is derived from the data signal conditioner (DSC). The exposure is approximately 70 milliseconds and occurs at the time of center-of-format switch actuation. One temperature sensor is located on each rail to provide rail temperature information. These sensors are located at the center of each rail and are identified as T.S. no. 6 for the outboard rail and T.S. no. 3 for the inboard rail.

The shaft driven cycle counter is coupled to the drum drive system via timing belts and gears. The counter is a four digit visual/electrical readout device. The electrical readout is a 0- to 5-volt readout in 0.5-volt steps from 0 to 9 on each of the four channels. These electrical readouts are wired directly to the telemetry connector and provide a telemetry readout capability of the number of camera cycles in units, tens, hundreds, and thousands.

4. TEST AND CHECKOUT CONSOLE

4.1 PURPOSE

The Test and Checkout Console (T&C) is a piece of ground support equipment designed to simulate inflight operational conditions which enables engineers and technicians to test and evaluate the J-3 panoramic camera system.

4.2 SCOPE

The Test and Checkout Console is capable of performing the following functions:

1. Supply electrical power necessary to operate the J-3 system
2. Place the system in the launch mode
3. Place the system in the orbit or standby mode
4. Operate either or both cameras
5. Provide V/h voltage
6. Provide A to B transfer command
7. Change the slit width
8. Place the slit width in the failsafe position
9. Monitor slit width position, 5-volt T/M, and V/h voltage
10. Change the filter
11. Release and engage the brakes and antibackups
12. Stop the camera quickly
13. Indicate shuttle bottoming
14. Count cycles
15. Time any number of cycles from 1 to 10 using electrical pulses
16. Start or stop clock with external switch or pulse
17. Reset clock manually
18. Reset slit width from failsafe position

19. Automatically or manually multiplex two groups of 11 signals
20. Indicate which signal is being sampled
21. Provide Visicorder sensitivities of 1/2, or 1 volt per inch
22. Deflect unwanted Visicorder input beams
23. Supply telemetry signals to the digital voltmeter, Visicorder, or an external recorder by use of patch panels
24. Multiplex 11 signals on one Visicorder channel or 22 signals on two channels

4.3 PHYSICAL DESCRIPTION

The Test and Checkout Console is a two-bay metal cabinet housing the following:

1. Two 0- to 36-vdc, 0- to 20-amp power supplies
2. One 115-vac, 400-cps power supply
3. Control panel
4. Patch panel
5. Junction box
6. Power panel
7. Deflection control
8. Timer
9. Visicorder and takeup
10. Seven interconnecting cables and one power cable
11. Utility panel

The controls and indicators for each front panel of the Test and Checkout Console are described in Figs. 4-1 through 4-12, and Tables 4-1 through 4-11.

4.4 INITIAL CAMERA OPERATION

To initially operate the camera, proceed as follows:

Caution

Do not rotate the drum by hand or permit it to be rotated electrically in other than the scan direction since damage to the shutter actuating mechanism may occur.

Caution

Do not cause the drum to stop in the scan sector with power on or to run continuously below 1.4 volts (V/h signal) since damage to the solenoids may occur.

1. Verify that all external cables are disconnected and that the circuit breaker is off.

2. Turn on the three power supply switches.

3. Connect the power cable from the junction box to a 115-vac, 60-cps outlet that has at least a 20-ampere capacity.

4. Turn on the circuit breaker and verify that the CONSOLE POWER OFF button is lit.

5. Press CONSOLE POWER ON button, verify that the three power supplies are operating, adjust both dc supplies to read 24 volts on the meter, and adjust the 400-cps supply for 115 volts.

6. Turn CYCLE RATE knob fully counterclockwise to zero and verify that the voltage is zero by observing the digital voltmeter (DVM).

7. Connect cable W8 from the camera to the supply spool assembly.

8. Connect cables W1 through W5 from the junction box to the camera.

9. Connect cable W6 to the A takeup.

10. Connect cable W7 to the B takeup and the two IR receptacles.

11. Verify that the camera is in stow position. If film is to be transported, verify that the shuttle is in position and that the plugs within the camera are connected.

12. Press the INSTRUMENT POWER ON button.

13. Observe whether A or B is lit on the TRANSFER COMMAND button. If the A takeup is to be used and the B light is on, press the round RESET button. This will transfer from B to A. If the B takeup is to be used and the A light is lit, press the TRANSFER COMMAND button. This will transfer from A to B. Wait 30 seconds before proceeding to the next step.

14. Press the MODE SIGNAL. (This establishes a standby-ready condition.)

15. Press the OPERATE COMMAND ON button for the no. 1 camera and gradually turn the CYCLE RATE knob clockwise until the camera starts to operate slowly. When satisfied that the film is tracking properly, push the OPERATE COMMAND ON

button for the no. 2 camera. When satisfied that both cameras are operating satisfactorily, the cycle rate voltage, as observed on the DVM, may be increased incrementally, but not in excess of 3.75 volts.

16. Press the OPERATE COMMAND OFF button for no. 1 camera and observe that the shutdown is normal. Do the same for no. 2 camera.

4.5 OPERATING INSTRUCTIONS

Camera operation is accomplished by following the procedure listed below.

Caution

Do not rotate the drum by hand, or permit it to be rotated electrically, in other than the scan direction, since damage to the shutter actuating mechanism may occur.

Caution

Do not stop the drum in the scan sector with power on or run continuously below 1.4 volts (V/h signal), since damage to the solenoids may occur.

1. Connect the cables as shown in Fig. 4-12.

2. Connect the T&C power cable to 115-vac, 60-cps outlet, and turn on the circuit breaker.

3. Press the CONSOLE POWER ON button and adjust the CYCLE RATE knob to the desired voltage (shown on the digital voltmeter).

4. Press the INSTRUMENT POWER ON button and press the PG LAMPS button.

5. Observe the +5 VDC meter and adjust to 5 volts, if necessary.

6. Observe the AUTO EXPOSURE meter for the desired slit width and press the AUTO EXPOSURE CONTROL button to change the slit command (1 volt on the meter is minimum width and 4 volts is maximum width.

NOTE

The slit width servo follows the commands only during OPERATE ON operations.

7. The filter may be changed by pulsing the FILTER switch five times.

8. The slit may be placed in the noncontrollable nominal opening by pressing the slit width failsafe (F-S) switch.

9. To return to the auto exposure control, press the slit width failsafe RESET switch.

NOTE

The slit width failsafe RESET must be actuated after each INSTRUMENT POWER ON action.

10. If either lamp on the FAILSAFE button is lit, the cycle rate voltage will remain at zero and the camera will not operate. To reset, press the lighted button. If the light does not go out, a limit switch on the camera is still tripped; troubleshoot as necessary.

11. Press the MODE SIGNAL button to put the system in the standby condition.

12. Press the OPERATE COMMAND ON button for either or both cameras.

13. To shut down either instrument, press the OPERATE COMMAND OFF button.

14. To transfer from the A to B takeup, turn off both cameras and press the TRANSFER COMMAND button. To transfer from the B to the A takeup, turn off both cameras and press the RESET button. To return to the standby condition, press the MODE SIGNAL button.

15. To release the takeup brake or antibackup device, turn off both cameras and press the appropriate button.

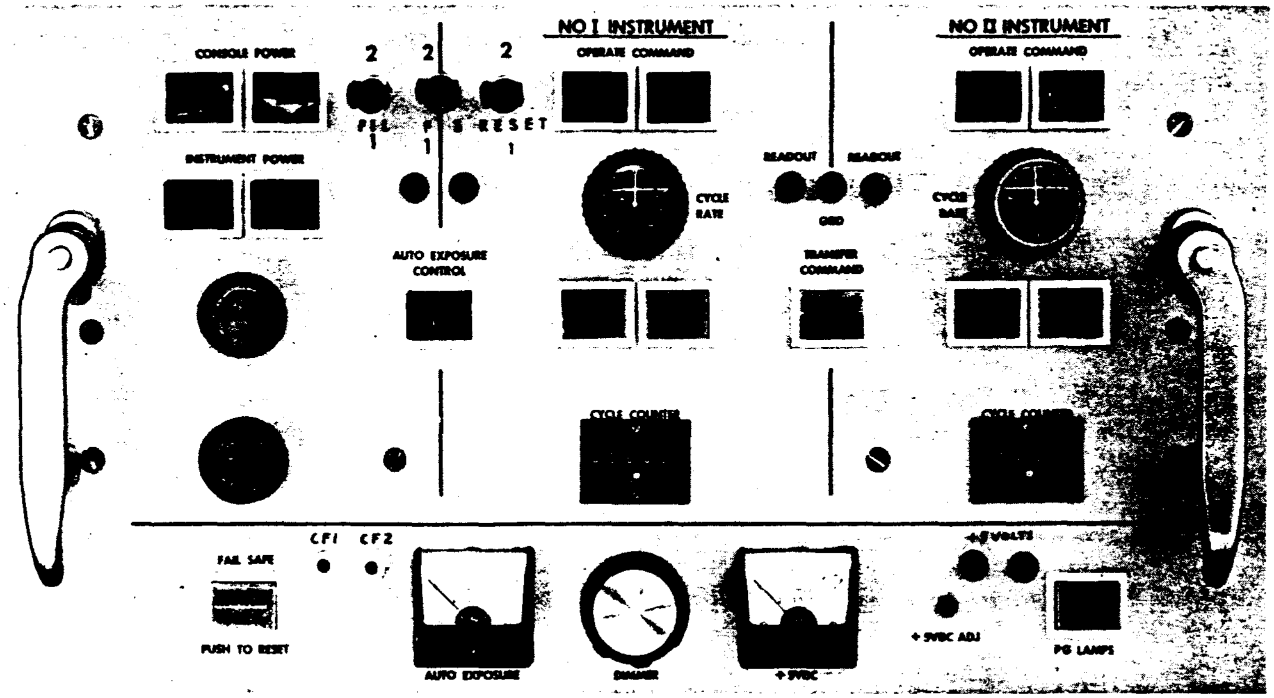


Fig. 4-1 — Instrument control panel

Table 4-1 — Instrument Control Panel

Control/Indicator	Function
CONSOLE POWER, OFF	Lights when circuit breaker is on, turns off power supplies
CONSOLE POWER, ON	Turns on power supplies
INSTRUMENT POWER, OFF	Turns off power to camera
INSTRUMENT POWER, ON	Turns on power to camera
RESET (button)	Puts camera in L (launch) mode. Also switches from B to A takeup
MODE SIGNAL	Puts camera in 0 mode (standby)
FAIL SAFE (instrument)	Warning signal from camera, indicating that a device has exceeded its limit, lights lamp and instantly replaces velocity command voltage with zero volts, causing both cameras to decelerate to a quick stop; when trouble is corrected, the button is pushed and both cameras again begin operating

Table 4-1 — Instrument Control Panel (Cont.)

Control/Indicator	Function
CF1, CF2	External jacks, pulses from CF switch in each camera
AUTO EXPOSURE CONTROL	Each push changes the slit width to 1 of 4 positions
AUTO EXPOSURE	Indicates which of the four slit widths is being used; 1 volt is position 1, 2 volts is position 2, etc.; does not change with failsafe command
DIMMER	Dims panel lights
+ 5 VDC	T/M voltage meter
+ 5 VOLTS	T/M voltage external jacks
+ 5 VDC ADJ	Not used
PG LAMPS	Controls power to three switches used as: (1) filter change, (2) slit width failsafe, and (3) slit width fail-safe reset

NOTE

The PG LAMPS switch does not control the PG lamps. Its only function is to control power to the following three switches.

Control/Indicator	Function
FIL	Changes filter in either camera
F-S (exposure control)	Causes slit to assume a predetermined width
RESET	Resets above so that four slit widths are again available
CYCLE COUNTER	Counts cycles of each camera manual reset
TRANSFER COMMAND	A to B transfer command
ANTIBACKUP	Releases holding devices in the A takeup
BRAKE	Releases holding devices in the B takeup
STOP	External cord plugs into banana jacks and serves as a stop signal; it simulates failsafe signal
OPERATE COMMAND, OFF	Causes camera to come to a normal shutdown
OPERATE COMMAND, ON	Causes camera to go into operation
CYCLE RATE (left knob)	Provides a voltage to operate the camera at the desired velocity
CYCLE RATE (right knob)	T/M voltage adjustment
READOUT	External jacks for reading out the cycle rate voltage

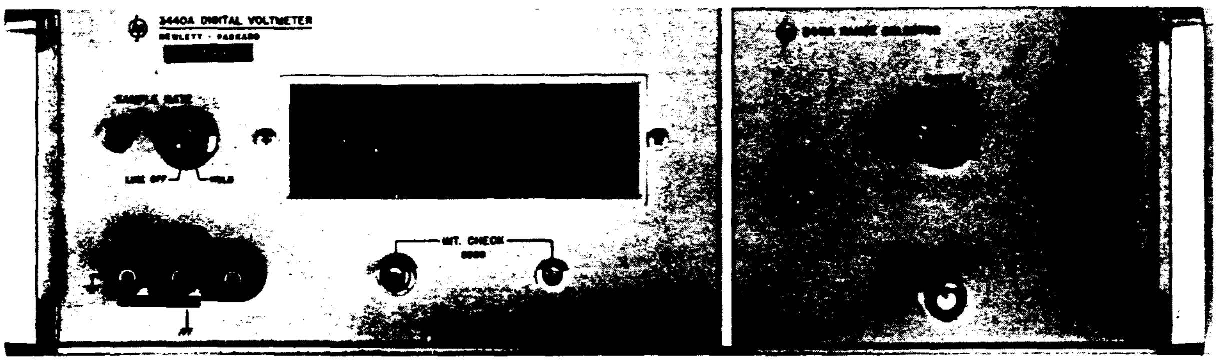


Fig. 4-2 — Digital voltmeter

Table 4-2 — Digital Voltmeter

Control/Indicator	Function
SAMPLE RATE	Lamp pulses at the rate that the incoming signal is being sampled; power switch and sample rate control
INPUT	Input jacks to digital voltmeter
INT CHECK	Calibration check for digital voltmeter
RANGE	Changes position of decimal point

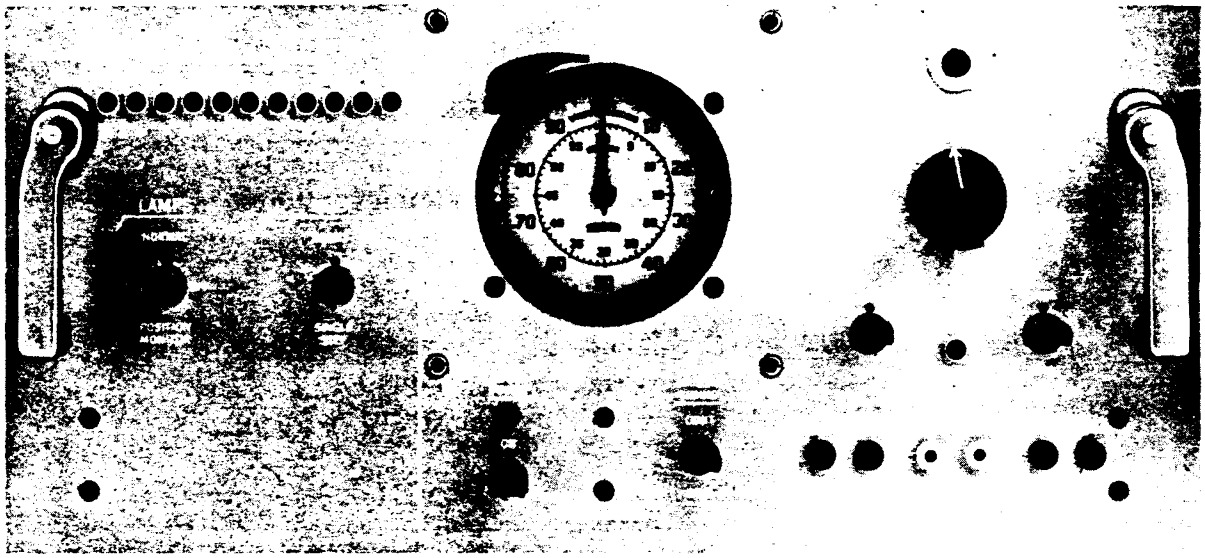


Fig. 4-3 — Timer panel

Table 4-3 — Timer Panel

Control/Indicator	Function
PATCH BOARD SIGNAL	Lamps light sequentially with action of stepping switch; 11 signals may be patched into one Visicorder channel and observed sequentially
Manual reset	Zeros clock
TIMER	Clock timer indicates in hundredths of a second
RESET	Reset after each timing cycle
CYCLES	Sets number of cycles to be timed
LAMPS	"Normal" is for sequential observation; position monitor is for observing which lamp is lit when sequential operation is off
MODE	For either automatic, sequential sampling or single step
CLOCK POWER	Power indicator lamp and power ON switch
MANUAL TIMING	Manual timing control
EXT POWER	24 vdc external power
EXTERNAL CONTROL SWITCH	External switch closure times clock continually
EXTERNAL CONTROL, 24-VOLT PULSE	External 24-volt pulses for external timing
CF 1	Up or down when timing CF pulses
CF 2	Center off position when using manual or external pulses
Pulse	Pulse indicator light
START-RUN	Allows pulse to start clock

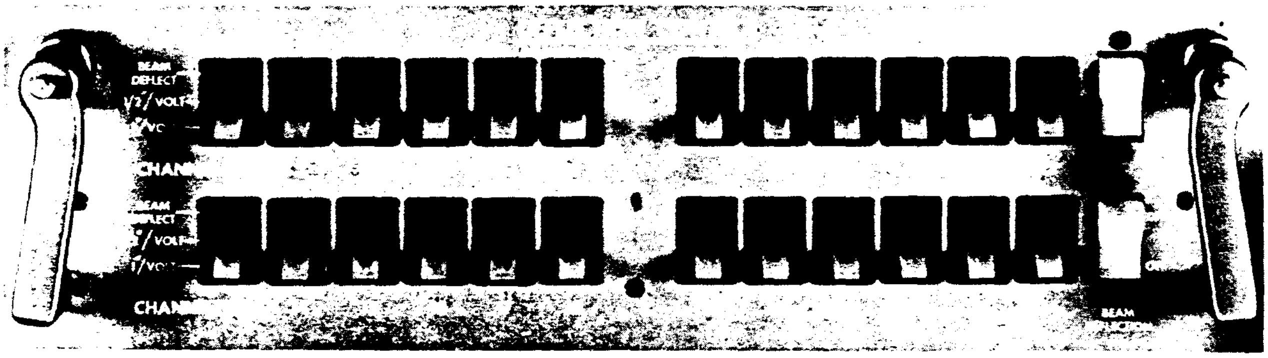


Fig. 4-4 — Deflection control panel

Table 4-4 — Deflection Control Panel

NOTE

The deflection control panel controls the sensitivity of signals to the Visicorder. There are 24 switches, one for each channel of the Visicorder. Each switch has three positions. The down position provides a sensitivity of 1-inch deflection per volt. The middle position is 1/2 inch per volt, and the up position deflects the beam off the paper. Each switch has three lighted colors.

Control/Indicator	Function
LAMPS	Controls lamps in the switches (on-off)
BEAM DEFLECT	Controls the beam deflection voltage (on-off)

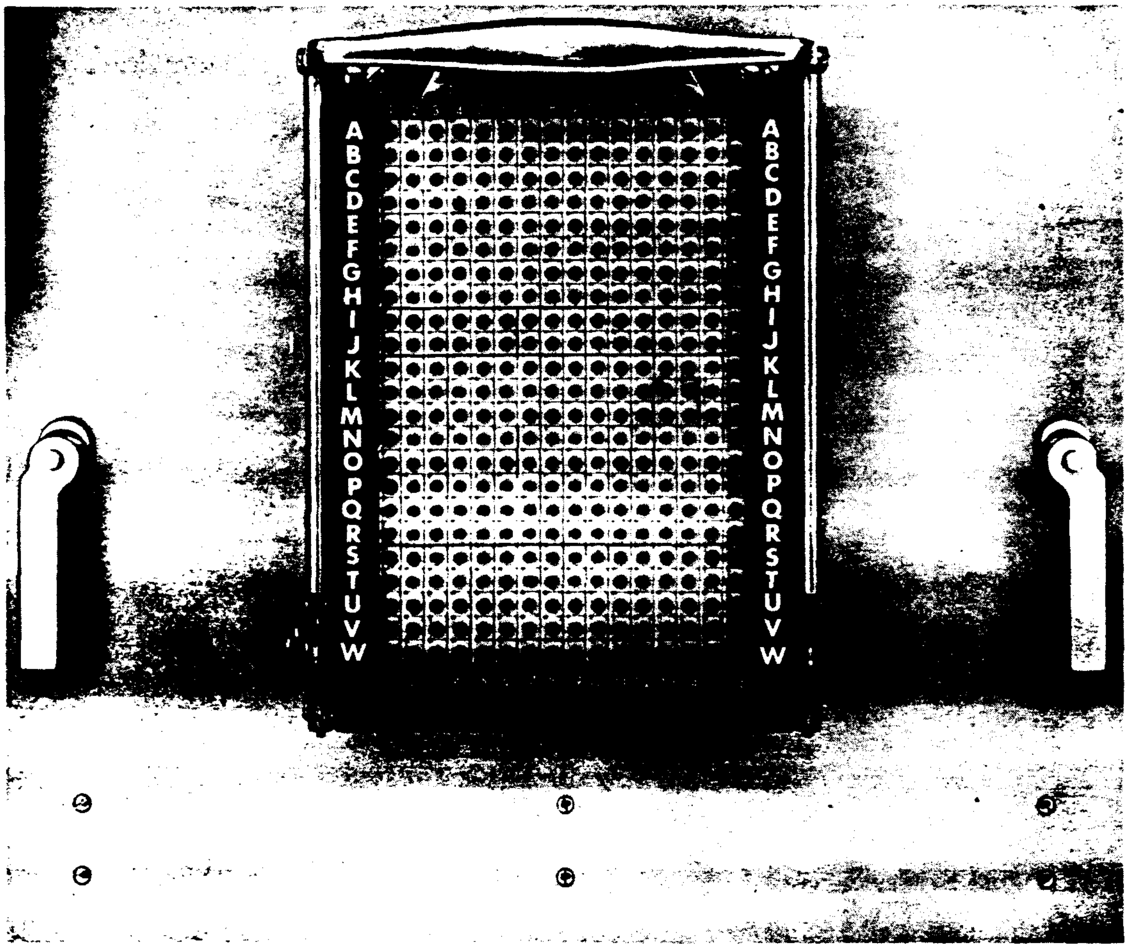


Fig. 4-5 — Patchboard panel

Table 4-5 — Patchboard Panel

Control/Indicator	Function
Patchboard labeled A through W vertically and	Removable patchboard; patchboard cords plug into holes in board for routing of signals
1 through 16 horizontally	Rear frame and spring assembly; incoming and outgoing signals are connected here

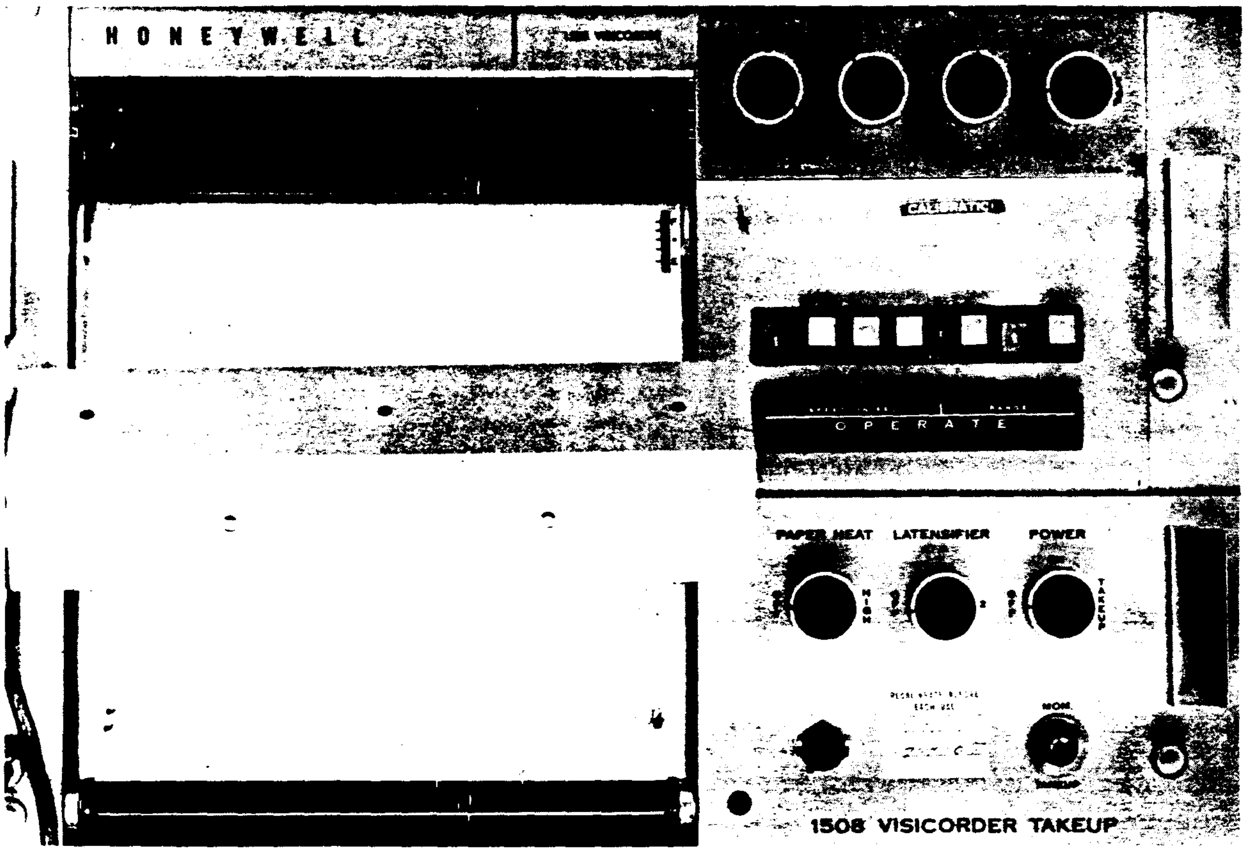


Fig. 4-6 — Visicorder

Table 4-6 — Visicorder

Control/Indicator	Function
F and E	Paper remaining indicator
GRID	Grid lines intensity control
GALV	Galvanometer dot intensity control
TIMER	Puts timing lines on paper
POWER	Main power and lamp control
1, 2, 4, 8, X, 0.1, 1, 10	Paper speed control
OPERATE	Operate and stop paper drive
(Latensifier lamp)	Lamp brings out latent image quickly
PAPER HEAT	Controls the temperature of the heated platen
LATENSIFIER	Controls latensifier lamps
POWER	Power to the takeup
(Jack)	Jack for the heated platen
TAKEUP	Momentary power to the takeup

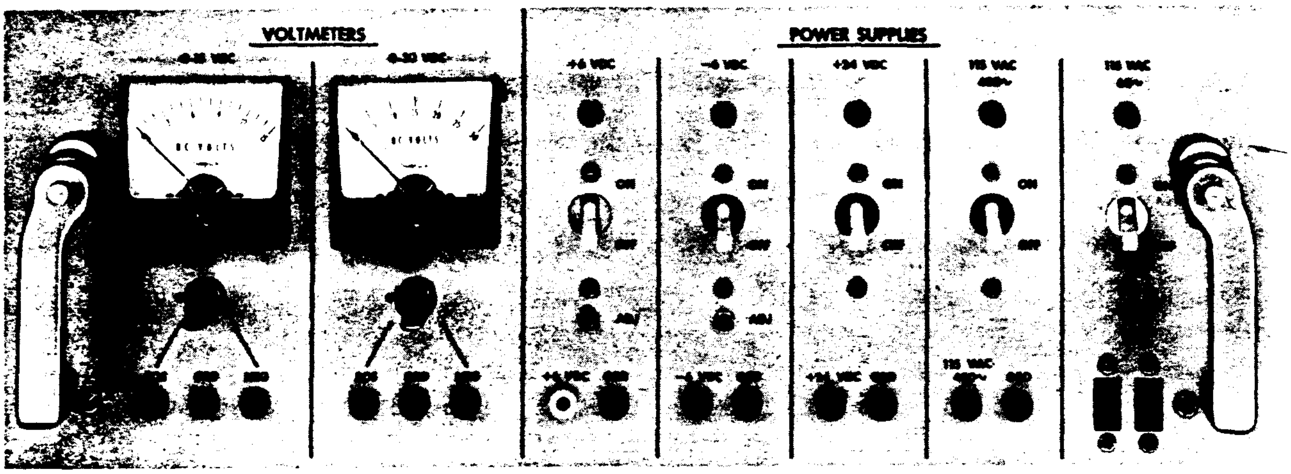


Fig. 4-7 — Power supply control panel

Table 4-7 — Power Supply Control Panel

Control/Indicator	Function
VOLTMETERS	Indicates output voltage
(Switches)	Polarity switches
POS, GRD, NEG	Input jacks
+6 VDC, -6 VDC, +24 VDC, 115 VAC, 400~, 115 VAC, 60~ (at top of panel)	Indicators
ON, OFF (five switches)	Circuit breakers
ADJ	Voltage adjust
+6 VDC GRD, -6 VDC GRD, +24 VDC GRD, 115 VAC 400~ GRD	Output jacks
(Jacks)	Output jacks

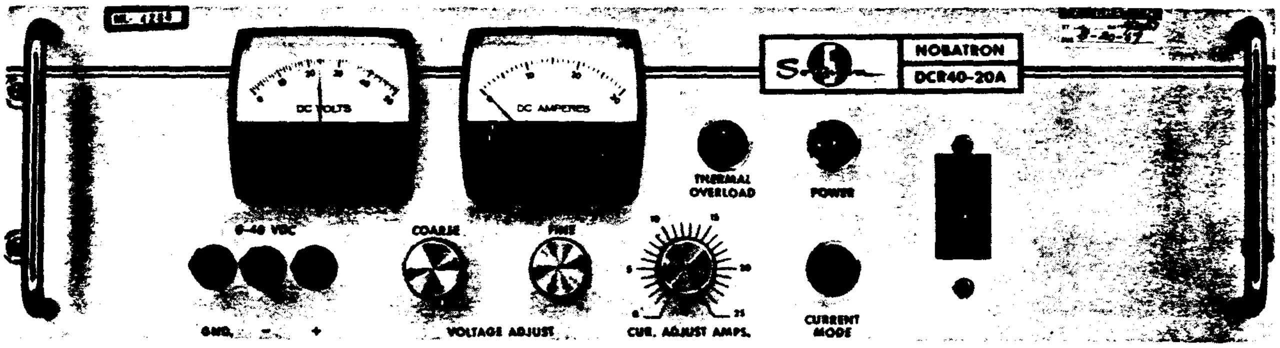


Fig. 4-8 — DC power supply

Table 4-8 — DC Power Supply

Control/Indicator	Function
DC VOLTS	Indicates dc voltage
0 to 40 VDC GND./–/+	Output jacks
DC AMPERES	Indicates dc amperage
VOLTAGE ADJUST COARSE FINE	DC voltage adjustments
THERMAL OVERLOAD	Indicates overtemperature condition
CUR. ADJUST AMPS.	Current limiter adjustment
POWER	Indicates power ON
CURRENT MODE	Indicates current in excess of limiter setting
ON/OFF	Circuit breaker

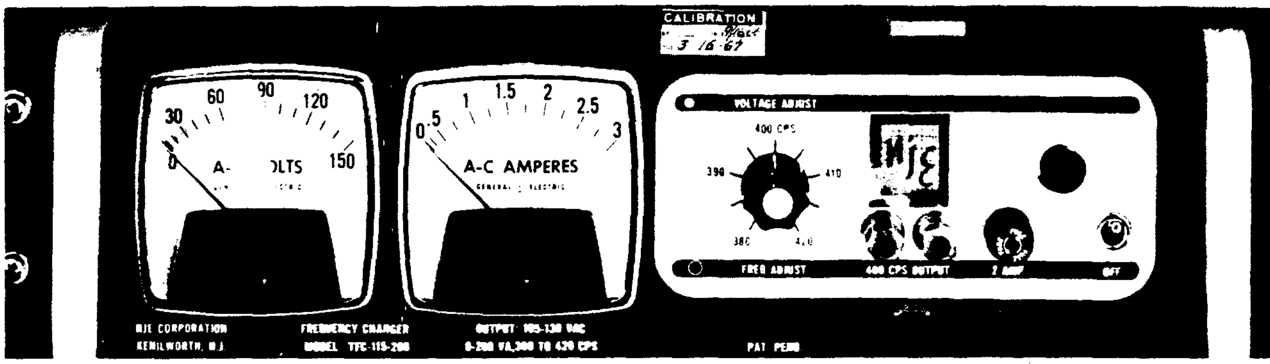


Fig. 4-9 — AC power supply

Table 4-9 — AC Power Supply

Control/Indicator	Function
AC VOLTS	Indicates ac voltage
AC AMPERES	Indicates ac amperage
FREQ ADJUST	Frequency adjustment
VOLTAGE ADJUST	Voltage adjustment
400 CPS OUTPUT	400-cps output jacks
OFF	Power switch
(Lamp)	Power on indicator lamp
2 AMP	Fuse

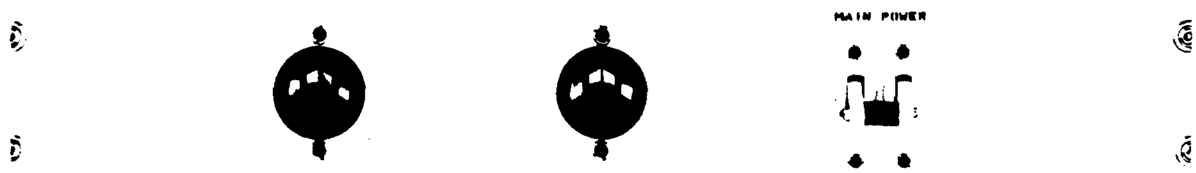


Fig. 4-10 — Circuit breaker panel

Table 4-10 — Circuit Breaker Panel

Control/Indicator	Function
(Outlets)	115-vac, 60-cps outlets
MAIN POWER	Circuit breaker for 115 vac, 60 cps coming into the Test and Checkout Console

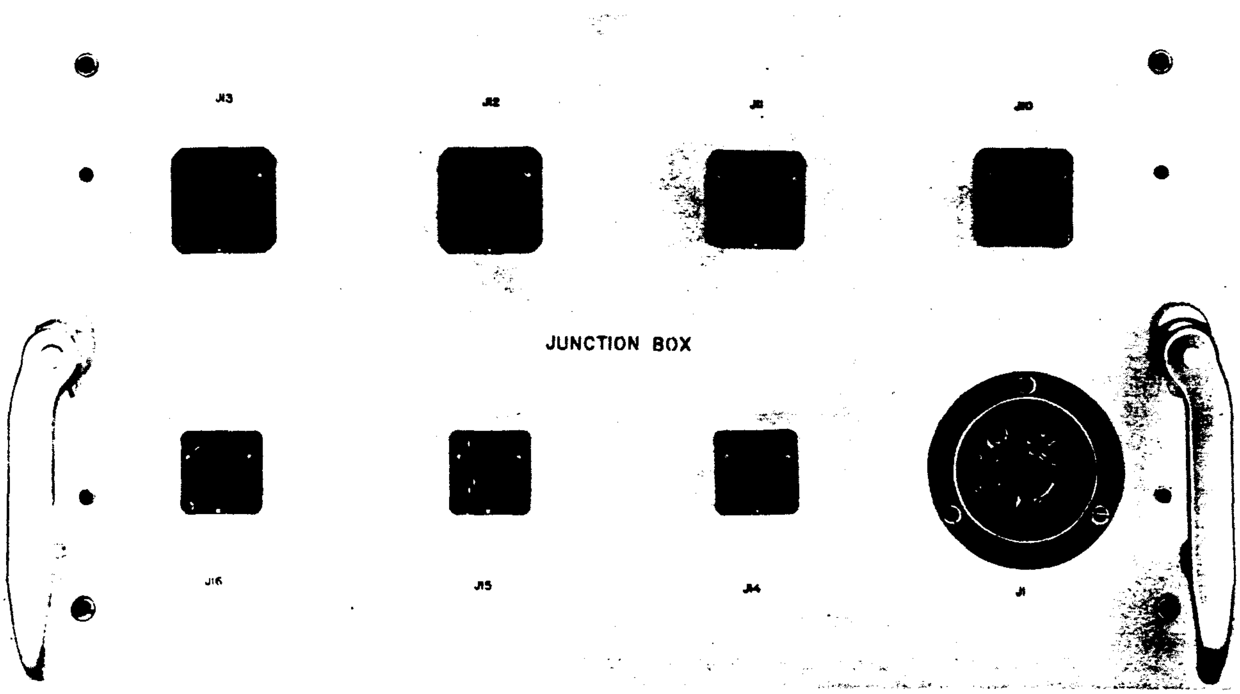


Fig. 4-11 — Junction box

Table 4-11 — Junction Box

NOTE

Interconnecting cables mate between the junction box connectors and those on the camera and takeups.

Control/Indicator	Function
J13, J12, J11, J10, J14	To camera
J16	To takeup B
J15	To takeup A
J1	Main power flush-plug power cable mates with this plug

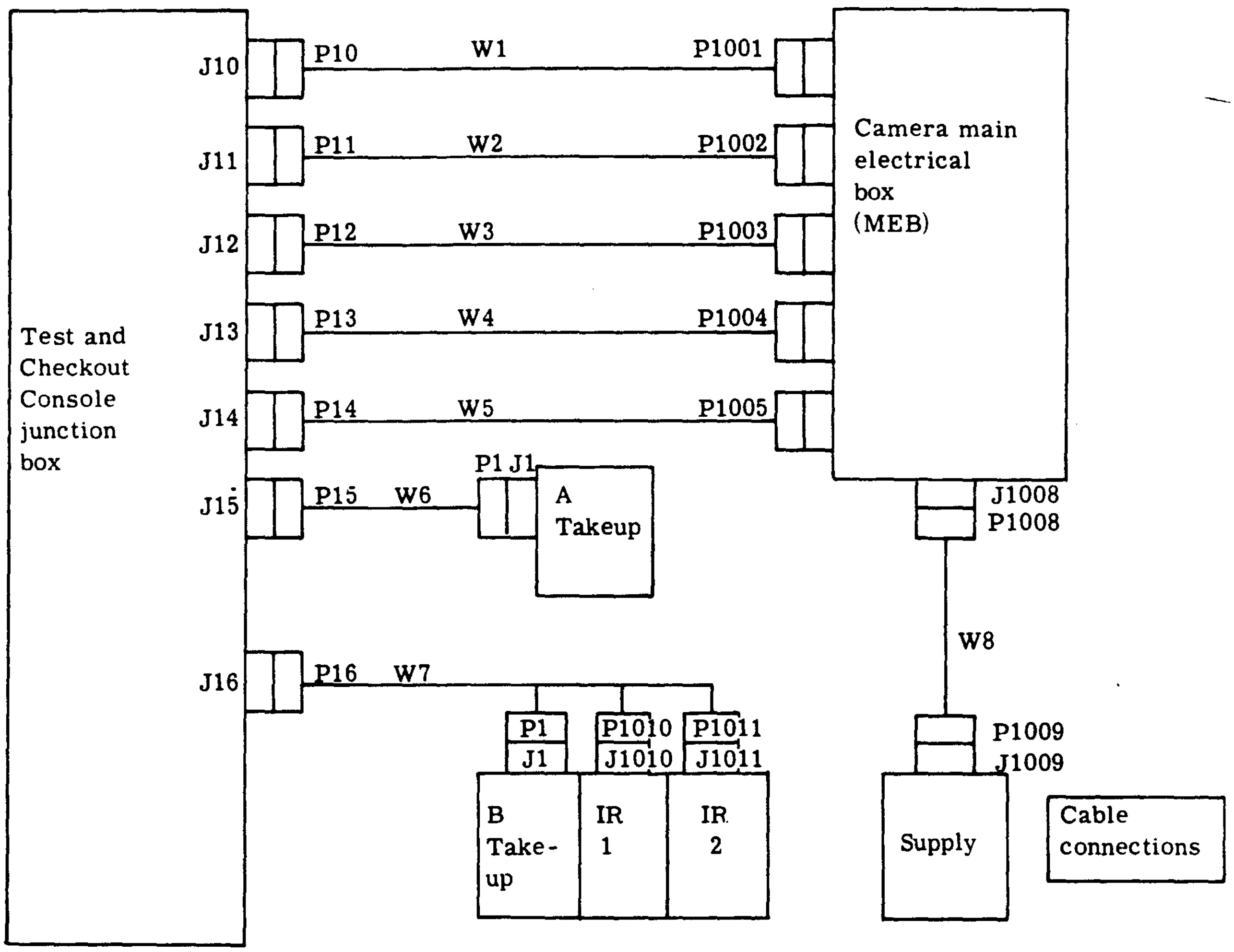


Fig. 4-12 — Interconnecting diagram

5. MAINTENANCE

5.1 SCOPE

This section contains instructions and information on nonstandard maintenance and calibration required in the field.

Caution

Do not rotate the drum by hand or permit it to be rotated electrically in other than the scan direction since damage to the shutter actuating mechanism may occur.

Caution

Do not cause the drum to stop in the scan sector with power on or to run continuously below 1.4 volts (V/h signal) since damage to the film clamp solenoids may occur.

5.2 REPLACEMENT OF ELECTRONIC PACKAGES

If necessary, the electronic packages may be unplugged and replaced with spare units, providing the adjustments and checks described in Table 5-1 have been accomplished.

5.3 RAIL LAMPS REPLACEMENT

To replace the rail lamps, refer to drawing nos. 84838 and 84911, and proceed as follows:

1. Turn off all power and rotate the drum to the 31-degree (approximate) position, and remove the top access cover.

2. Remove the three screws holding the shaft follower assembly and the four screws holding the adjustable aperture assembly. Care must be taken to note the location and quantity of shims under the aperture assembly.

Table 5-1 — Electronics Package Replacement Checks

Unit	Part No.	Electrical Adjustments	Checks After Readjustments
Control Logic Assembly	88382	None	Verify correct launch, standby, operate, and A to B transfer functions for both instruments.
Dual Power Supply Assembly	88443	None	Verify overall system operability including lamp readout intensities.
Dual Data Signal Conditioner Assembly	87983	None	Verify correctness of interrogate pulses, frequency marks, and fiducial readouts.
Interface Circuit Assembly	88020	Adjust all potentiometers to obtain correct slit widths and lamp readouts.	Verify correct slit widths and proper lamp readouts.
High Efficiency Amplifier Assembly	88271	Adjust balance and tach gain potentiometers for proper cycle rates.	Recheck cycle rates, and T/M readout points.
Material Change Detector Assembly	88258	None	Verify proper filter stepping operation and check film tracking.
Component Board Assembly, Material Change Amplifier	107633	None	Verify proper filter stepping operation.
Signal Conditioner, Nod Encoder Assembly	107656	None	Verify correct nod dot readout.
Encoder Incremental, 16 Bit	84867	None	Verify correct nod dot readout.
Xenon Flash Tube Assembly	107865 88294	None	Verify correct nod dot readout.

3. Remove the screws from the defective lamp assembly, cut the harness lacing, and remove the lamp assembly.

NOTE

Care must be taken to replace the lamp assembly with one of the same type as removed.

NOTE

If lamp assembly DS-3 was removed, the wires must be reinstalled in their original position and cemented with RTV 103 (glue).

NOTE

Care must be taken to properly mesh the follower assembly and blade drive gear to ensure a proper slit width when the cam is in the failsafe position.

4. Replace and secure the aperture assembly, making sure that the shims are replaced in their original location. Replace and secure the follower assembly shaft. Verify that the slit width is still in the proper position when the cam is in the failsafe position.

5.4 PREFLIGHT FILTER CHANGE

To make preflight filter change, refer to drawing no. 79070 and proceed as follows:

1. Turn all power off, rotate the drum to the 31-degree (approximate) position, and remove the top access cover.
2. Remove the retaining rings, pins, and link.

NOTE

Both pins have one or more spacers (approximately 0.004 inch thick) between the retaining ring and the bearings. Thrust bearings are located between the rotating surfaces on both ends of the link. These spacers and bearings must be reassembled in the same location.

3. Remove and replace the filter slide assembly.

NOTE

Care must be taken to avoid damaging the filter.

4. Slide the link, thrust bearings, pins, and spacers in place.
5. Install new retaining rings and rotate the crank arm by hand to check for free operation.

5.5 PREFLIGHT CHANGE OF APERTURE CAM

To make a preflight change of the aperture cam, refer to drawing nos. 79135 and 84911, and proceed as follows:

1. Turn off all power, rotate the drum to the 31-degree (approximate) position, and remove the top access cover.
2. Remove the three screws and the gear on top of the failsafe clutch.
3. Loosen, but do not remove, the four screws holding the adjustable aperture assembly.
4. Remove the screw in the shaft clevis on the cam end of the spring extension. Rotate the cam until the follower is at the point of least cam rise.
5. Tilt the slit assembly and swing the cam follower out of the cam track. Remove the retaining ring and shim from the cam shaft and remove the cam.
6. Install the new cam and shim to ensure tight sealing of the retaining ring.

NOTE

A new retaining ring must be used.

7. Rotate the cam to the minimum rise position and insert the follower in the cam track.
8. One at a time, remove the screws holding the aperture assembly, apply Glyptal, and replace. Tighten all four screws.
9. Rotate the cam to ensure free operation, replace the clevis screw in the cam, and recheck for free operation.
10. Replace the gear on top of the failsafe clutch and reinstall the three screws.

5.6 REPLACEMENT OF PANORAMIC GEOMETRY LAMPS

To replace the panoramic geometry lamp assembly, refer to drawing no. 84911 and proceed as follows:

1. Turn off all power, rotate the drum to the 90-degree (approximate) position, and remove the large access door.

Caution

Mark the leads to ensure proper positioning when reconnecting since damage to the instrument may result.

Caution

Care must be taken not to kink or sharply bend the fiber optics bundle since damage to the system may result.

2. Unsolder the leads to the defective lamp, remove the mounting screws and washers, and remove the defective assembly.

NOTE

The lock screw for the fiber optics clamp must be released if the outboard assembly having the fiber optics is to be removed.

Caution

Do not attempt to repair defective lamp assemblies in the field, since optical recalibration is required.

3. Remove and return the defective lamp assembly to the factory for repair. Replace the repaired assembly, reinstalling the shims as removed.

Caution

Do not kink or sharply bend the fiber optics bundle since damage to the system may result.

4. If the fiber optics have been removed, the bundle must be reinserted in the lamp assembly and the lock screw retightened.
5. Replace screws and tack-solder the leads to the proper terminals.
6. Rotate the drum by hand to the 31-degree (approximate) position.
7. Check lamp operation, location, and focus by energizing the proper circuits.
8. Turn off all power, final solder all tacked connections, and replace the access door.

5.7 FILM THREADING

Thread the film in accordance with the film threading diagram, Fig. 5-1.

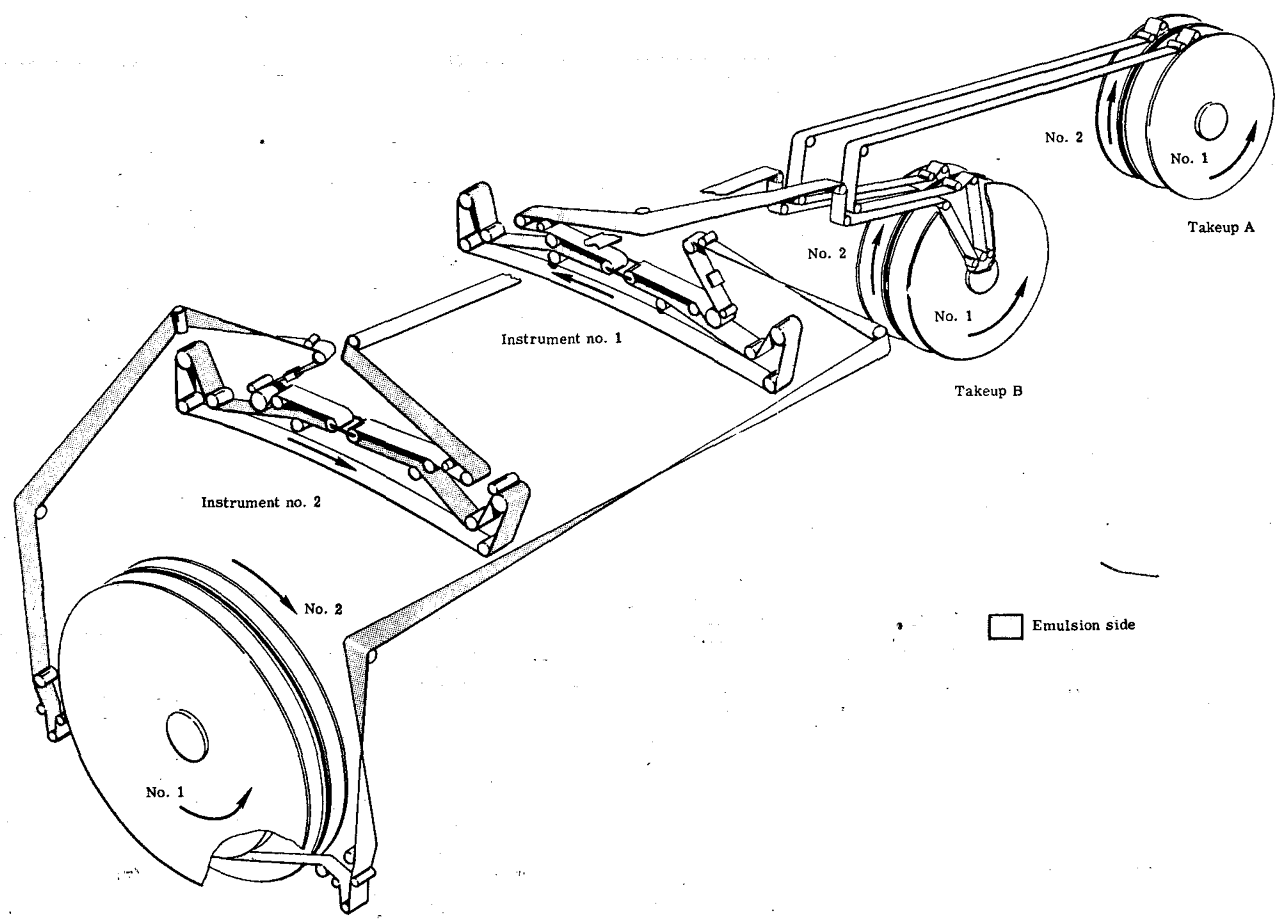


Fig. 5-1 — Film threading diagram

6. ELECTRICAL AND ELECTRONIC TEST AND CHECKOUT PROCEDURES

6.1 MAIN DRIVE TORQUE MOTOR ASSEMBLY

6.1.1 Test Equipment

The following test equipment is required:

1. DC power supply, 0 to 5 vdc, 0 to 2 amps
2. Ammeter, 0 to 5 amps
3. Torque wrench, 0 to 15 inch-pounds, and adapter
4. Test fixture to hold motor assembly
5. Multimeter, Simpson 260 or equivalent

6.1.2 Procedure

Test the main drive torque motor as follows:

1. Make continuity and insulation checks with the multimeter.

2. Connect the power supply through the ammeter and, using caution not to exceed 4 volts, increase the voltage until the shaft starts to rotate (from the stow position). Record the current necessary to overcome friction noted on the data sheet (see Fig. 6-1).

3. Allow the motor to rotate at slow speed operation for several revolutions. Note the performance.

4. De-energize the motor and attach the torque wrench. While restraining the shaft with the torque wrench, increase the current to 2 amps. Record the average torque magnitude and the direction, which is observed from the support box side. Repeat this procedure for the opposite motor polarity.

The average torque is computed from the following equation:

$$\text{Average torque} = \frac{(T_{\text{avg ccw}} + T_{\text{friction}}) + (T_{\text{avg cw}} - T_{\text{friction}})}{2}$$

6.1.3 Data

Record the test data as shown in Fig. 6-1.

6.2 TACHOMETER GENERATOR SUBASSEMBLY

6.2.1 Test Equipment

The following equipment is required:

1. Pulse generator, variable from 900 to 3,000 pulses per second
2. Power supplies:
   a. +30 vdc, 2 amps
   b. -30 vdc, 2 amps
   c. +4.8 vdc, 1 amp
3. Digital counter, five digits at 1 megacycle or four digits at 100 kilocycles
4. Oscilloscope with high grain preamp (such as a Tektronix type D)
5. Precision VTVM (±1/2 percent) (Fluke 801B or equivalent)
6. Tachometer calibration servo assembly (reference schematic no. SK107669)
7. Resistor, 27 K, 1/4 watt, ±5 percent
8. Torque wrench, 40 inch-ounces
9. Oscilloscope camera

6.2.2 Equipment Connection

Connect the equipment as shown in Fig. 6-2.

6.2.3 Procedure

Test the tachometer generator as follows:

1. Measure the dc tachometer output voltage with the VTVM at the shaft velocities listed in Table 6-1. The peak-to-peak variation in tachometer gain shall not be greater than 0.3 percent. Note any voltage variation which occurs in synchronism with shaft rotation. The gain should be 1.0 ± 0.1 volt radian per second.

2. Measure the ac tachometer voltage ripple at the shaft velocities listed in Table 6-1. Take photographs of the ripple waveforms to verify that the peak ripple voltage does not exceed 2.5 percent of the dc output voltages measured by the VTVM.

3. With tachometer assembly not assembled on wheel, measure breakaway torques in both clockwise and counterclockwise directions.

4. Record the following data:

   Counter reading (microseconds)
   Volts output, vdc
   Breakaway torque, clockwise and counterclockwise (inch-ounces)

Current to overcome friction ___ (0.8a) max	Comments on rotational operation:
T_{avg} at 2 amps ___ in.-lb. (12.7 ± 1) (With terminal c and d positive, the shaft should tend counterclockwise)	T_{avg} at 2 amps ___ in.-lb. (12.7 ± 1) (With terminal b and f positive, the shaft should tend clockwise)

Fig. 6-1 — Main drive torque motor test data sheet

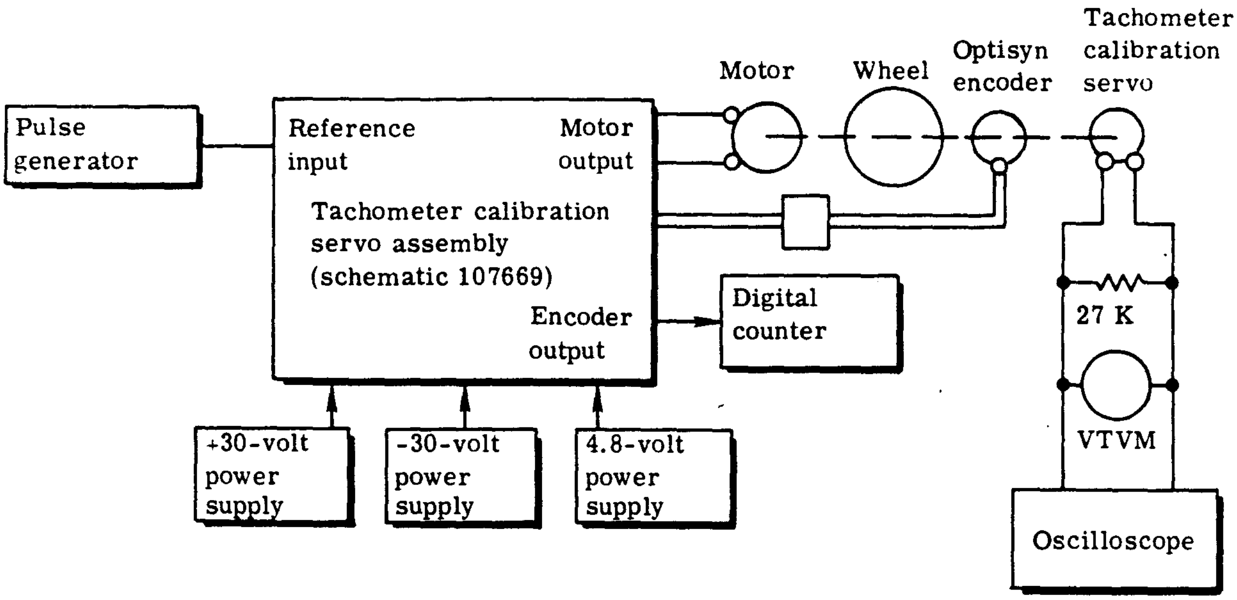


Fig. 6-2 — Tachometer/generator test setup

Table 6-1 — Shaft Velocities

Shaft Velocity ($\dot{\theta}$), radians per second	Counter Reading (T_S), seconds
1.2	40,906
2.0	24,544
2.8	17,531
3.6	13,635
4.4	11,156

6.2.4 Operation Checkout

To operate, refer to drawing no. 85639 and proceed as follows:

1. Turn on the pulse generator, 4.8-volt power supply, and all other test equipment (except ±30-volt power supply).

2. While monitoring the servo error detector output with the oscilloscope, turn on the ±30-volt power supply. The wheel should turn clockwise (looking at optisyn) and should come up to speed and "sync-in" within 2 to 3 minutes. (The servo is synchronized when the error detector output is a stable square wave.)

3. Measure the shaft velocity with the digital counter using the following equation:

$$\dot{\theta} = \frac{2\pi \times 10^6}{\frac{T_S}{32} \times 4{,}096} = \frac{49{,}087.5}{T_S} \text{ rad/sec}$$

If the counter reading varies, use the average value (verify that the servo is synchronized). If the variation is difficult to average, measure the time period of the pulse generator output. In this case, $\dot{\theta} = 1{,}533.98/T_S$ rad/sec, which is accurate as long as the servo is synchronized.

6.2.5 Calculations

To compute linearity, use the following equation:

$$\text{Gain} = \frac{\text{voltage output (vdc)}}{\text{shaft velocity } (\dot{\theta}) \text{ (rad/sec)}}$$

$$\text{Percent peak-to-peak variation} = \frac{\text{maximum gain - minimum gain}}{\text{average gain}} \times 100$$

NOTE

These values should be worked out to six places on a calculator.

To compute ripple, use the following equation:

$$\text{Percent peak ripple} = \frac{1/2\ (\text{peak-to-peak voltage})}{\text{voltage output}} \times 100$$

NOTE

Peak voltage is measured from the photographs.

NOTE

Slide rule accuracy is adequate for ripple calculations.

6.3 MAIN DRIVE SERVO, CLOSED LOOP OPERATIONAL CHECK

6.3.1 Test Equipment

The following equipment is required:

1. +24-vdc power supply (15 amps)
2. Digital velocity readout equipment
3. 0 to 5 vdc (V/h input simulator)
4. Digital voltmeter or John Fluke dc meter
5. Tektronix scope 535 or equivalent

NOTE

A three-bay test and checkout console with counter, buffer, and printer is necessary to accomplish this check.

6.3.2 Procedure

Test the main drive servo as follows:

1. With the servo electronics disconnected from the main torque motor and tachometer, and with the input and tachometer signals grounded, verify that a zero torque output signal exists. If it does not, adjust the signal processing or biasing as required.

Caution

If the servo does not function properly, de-energize the system immediately.

2. With the power off, connect the servo electronics to the motor and tachometer, and set in a zero V/h signal input. With the drum firmly stalled, energize the electronics, adjust the input to 0.5 vdc, and verify that the torque is in the proper direction.

3. Release the drum and verify that the servo operates with stability and that the drum speed is approximately 0.5 radian per second.

4. Utilizing the digital velocity readout equipment, adjust the tachometer gain to give the correct wheel velocity at 3.0 radians per second. Vary the input signal between 1.0 and 4.5 vdc to determine that response to commands is correct.

6.4 SLIP RING ASSEMBLY, POSTASSEMBLY CHECKOUT

NOTE

This check should be performed with the slip ring in the main drive assembly and the tachometer installed.

6.4.1 Test Equipment

A Simpson 260 multimeter or equivalent is required.

6.4.2 Procedure

Test the assembly as follows:

1. Using the multimeter, verify that continuity is in accordance with drawing no. 85143.
2. Using the multimeter, verify that each ring circuit is isolated from the adjacent ring circuits and from the housing.

NOTE

Multimeter readings greater than 10 megohms are considered adequate isolation for this test.

6.5 POLARITY CHECKS, DC TORQUE, AND DC TACHOMETER

NOTE

Perform this procedure during torque motor and tachometer wiring to ensure proper signal polarity at the connector.

6.5.1 Test Equipment

The following equipment is required:

1. Simpson 260 multimeter or equivalent
2. Power supply, 0 to 5 vdc, 2 amps

6.5.2 Procedure

Test the equipment as follows:

1. Connect the positive lead of the multimeter to pins h and j, and the negative lead (no. 2) to pins g and k. With the wheel rotating in the normal direction (counterclockwise when viewed from the lens side), verify that the polarity of the tachometer signal is correct.

2. Connect the positive lead (no. 1) of the power supply to pins c and d, and the negative lead (no. 2) to pins b and f. Verify that the wheel is connected and the torque motor turns in the right direction.

3. Verify that the motor leads are twisted together and sleeved over sharp bends and are properly dressed and secured. Verify that the tachometer leads are twisted together and dressed away from the motor leads except at the points where they enter the connector.

6.6 DUAL DATA SIGNAL CONDITIONER

6.6.1 Test Equipment

The following test equipment is required:

1. Power supplies:

   a. 12 vdc, 1 amp
   b. -12 vdc, 1 amp
   c. 24 vdc, 1 amp
   d. 6 vdc, 1 amp

2. Pulse generator, variable to 500 cps
3. Oscilloscope, Tektronix 656A, type M plug-in
4. Test fixture (breadboard cable, tie points)

6.6.2 Equipment Connection

Interconnect the equipment as shown in Fig. 6-3.

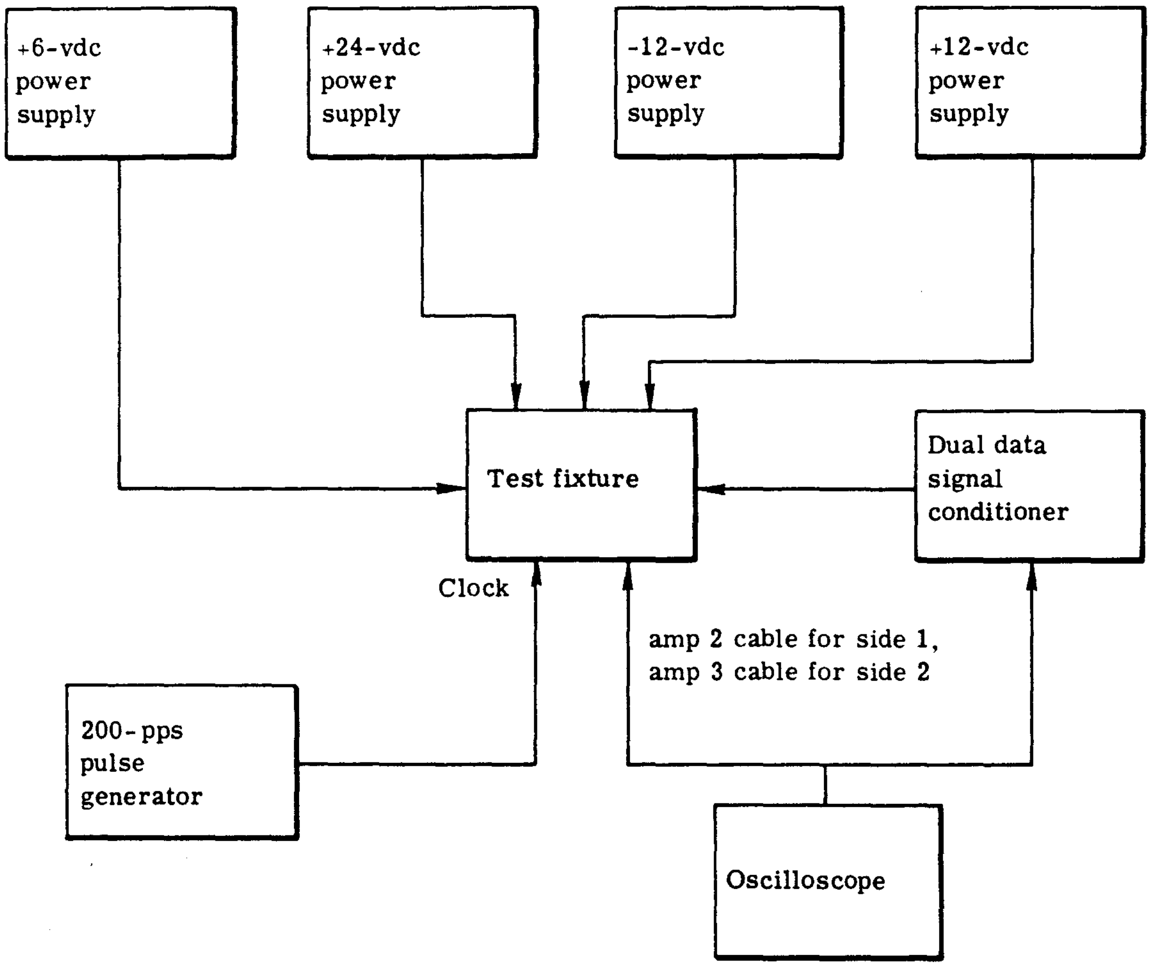


Fig. 6-3 — Dual DSC test setup

6.6.3 Procedure (Side 1)

Refer to drawing no. 87983 and test side 1 as follows:

1. Adjust the pulse generator for 200 pps (0 to -10 volts peak-to-peak, 10-microsecond pulse duration) and connect it to the clock input.

2. With the oscilloscope probe on test point 2, adjust A2-R1 to obtain a 100-microsecond pulse of 0 to +8 volts.

NOTE

Readings are obtained by triggering the center-of-format pulse switch.

3. Reposition the probe on test point 3 and adjust A2-R2 to obtain a 250-millisecond pulse of 0 to +12 volts.

4. Reposition the probe on test point 4 and adjust A2-R3 to obtain a 4-millisecond pulse of 0 to +8 volts.

5. Reposition the probe on test point 5 and adjust A2-R4 to obtain a 70-millisecond pulse of 0 to +10 volts.

6. Trigger the oscilloscope at the Interrogate pulse input and verify that the no. 1 instrument out pulse is 70 milliseconds at 0 to 12 volts (+3 volts, -1 volt).

NOTE

Pulse rise time must be 3 microseconds or less.

7. Trigger the scope on the Interrogate pulse input. Verify that the no. 1 frequency marker output is 200 pps (one pulse filled in when the CF pulse is triggered for 4 milliseconds) and that the no. 1 lamp voltage ON time is 70 milliseconds (connect 6 volts to lamps).

6.6.4 Procedure (Side 2)

Refer to drawing no. 87983 and test side 2 as follows:

1. Disconnect the amp no. 2 cable and replace it with the amp no. 3 cable.

2. With the oscilloscope probe on test point 7, adjust A3-R1 to obtain a 100-microsecond pulse of 0 to +8 volts.

NOTE

Readings are obtained by triggering the center-of-format pulse switch.

3. Reposition the probe on test point 8 and adjust A3-R2 to obtain a 250-millisecond pulse of 0 to 12 volts.

4. Reposition the probe on test point 9 and adjust A3-R3 to obtain a 3-millisecond pulse of 0 to 8 volts.

5. Reposition the probe on test point 10 and adjust A3-R4 to obtain a 70-millisecond pulse of 0 to 10 volts.

6. Trigger the oscilloscope at the Interrogate pulse input and verify that the no. 2 instrument out pulse is 70 milliseconds at 0 to 12 volts (+3 volts, -1 volt).

NOTE

Pulse rise time must be 3 microseconds or less.

7. Trigger the scope on the Interrogate pulse input. Verify that the no. 2 frequency marker output is 200 pps (one pulse filled in when the CF pulse is triggered for 4 milliseconds) and that the no. 2 lamp voltage ON time is 70 milliseconds (connect 6 volts to lamps).

6.6.5 Data

Record the data shown in Fig. 6-4.

6.7 SCAN HEAD LAMP ADJUSTMENT

6.7.1 Test Equipment

The following equipment is required:

1. Digital voltmeter
2. Oscilloscope, Tektronix 585A (with type D plug-in), or equivalent
3. Test fixture (breadboard cable with tie points)
4. Light meter and adapters, drawing no. 107835

6.7.2 Procedure

Refer to drawing no. 85491 and test as follows:

1. Break the P2-J1 connection and insert the test fixture cable.

2. Set the resistors listed in Table 6-2 for the voltages listed.

3. Using the equipment described on drawing no. 107835, determine the intensity of the rail and panoramic geometry trace lamps. The "C3" view shows the required

Side 1		
Test Point	Pulse Width	Amplitude
TP2		
TP3		
TP4		
TP5		
Int. pulse		
F. M.		
Lamps: ON time		
Int. rise time		

Side 2		
Test Point	Pulse Width	Amplitude
TP7		
TP8		
TP9		
TP10		
Int. pulse		
F. M.		
Lamps: ON time		
Int. rise time		

Fig. 6-4 — Dual DSC test data recording form

Table 6-2 — Scan Head Checks

	Lamp		Camera 1 Resistors	Camera 2 Resistors	Voltage	Test Points
Normal	DS-3 Guide rail	Outboard lamp	R_1	R_{14}	4.8	J-H
Auxiliary	DS-3 Guide rail	Outboard lamp	R_2	R_{15}	4.8	J-H
Normal	DS-4 Guide rail	Inboard lamp	R_7	R_{20}	4.8	F-H
Auxiliary	DS-4 Guide rail	Inboard lamp	R_8	R_{21}	4.8	F-H
Normal	DS-5 P. G.	Outboard lamp	R_9	R_{22}	1.5	K-H
Auxiliary	DS-5 P. G.	Outboard lamp	R_{10}	R_{23}	1.5	K-H
Normal	DS-6 P. G.	Inboard lamp	R_{11}	R_{24}	1.5	P-H
Auxiliary	DS-6 P. G.	Inboard lamp	R_{12}	R_{25}	1.5	P-H
Normal	A.O. fiducials		R_5	R_{18}	1.5 pulses	A.O. assembly A3, terms 3 and 2
Auxiliary	A.O. fiducials		R_6	R_{19}		
Normal	Serial no.		R_3	R_{16}	1.5 pulses	Shuttle TB1, terms 7 and 10
Auxiliary	Serial no.		R_4	R_{17}		

	Lamp	Camera 1 Resistors	Camera 2 Resistors	Current	Test Points
Normal	DS-1 Neon	R_{28}	R_{30}	0.200	D-1
Auxiliary	DS-1 Neon	R_{27}	R_{29}	0.030	D-1

position of the adapter when measuring the intensity of the panoramic geometry trace lamps. (The rail lamp intensity is determined by placing this adapter over the rail lamps.)

4. Verify that the intensity of the outboard and inboard lamps is approximately equal. If necessary, equal intensity may be obtained by maintaining one lamp at the recommended voltage (4.8 volts for the rail lamps or 1.5 volts for the panoramic geometry lamps) and reducing the voltage to the other lamp. If greater voltage is required to increase image density, do not exceed 5.3 volts for rail lamps or 1.55 volts for panoramic geometry lamps.

6.8 DUAL POWER SUPPLY

6.8.1 Test Equipment

The following equipment is required:

1. 400 cps, 115-volt power supply NJE Corp., model TFC-115-200 or equivalent
2. Differential voltmeter, J. Fluke, model 823A or equivalent
3. Oscilloscope, Tektronix model 535A or equivalent
4. Plug-in, Tektronix type CA or equivalent
5. Oscilloscope camera
6. Power supply load simulator

6.8.2 Test Connections

Connect the equipment as shown in Fig. 6-5.

6.8.3 Test Procedure (Side J_1)

Refer to drawing no. 85432 and test as follows:

1. Turn on the 400-cps power supply and adjust the output voltage to 115 vac. Turn the supply off and connect it to the load simulator.

2. Turn all the switches and pots on the load simulator to the OFF position and connect P1 of the simulator to the J_1 of the power supply under test.

3. Turn on the 400-cps power supply and read and record the current supplied.

Caution

If current exceeds 0.25 ampere, discontinue the test.

4. Using the differential voltmeter, read and record all "no-load" voltages (VNL).

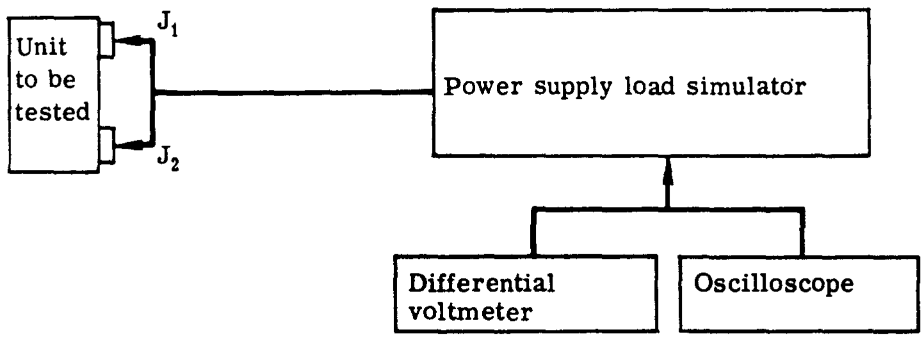


Fig. 6-5 — Dual power supply test setup

5. Connect the differential voltmeter to the +40-volt (xenon) terminal, turn on the +40-volt (xenon) load switch, and read and record the "single load" (VSL) voltage. Turn off the +40-volt load switch. Repeat this procedure for each terminal on the load simulator in the following sequence.

a. + 40 volts
b. -40 volts
c. + 24 volts
d. + 12 volts
e. -24 volts
f. -12 volts
g. + 5 volts
h. + 8 volts
i. + 150 volts

6. Turn on all the load switches, except ±40 volts, and, using the differential voltmeter, read and record all "full load" voltages (VFL). Read, record, and note as shown in Fig. 6-6.

7. Turn off the 400-cps supply and disconnect the oscilloscope and differential voltmeter from the simulator lead.

6.8.4 Test Procedure (Side J_2)

To test side B repeat the procedure described in paragraph 6.8.2, except connect P1 of the load simulator to J_2 of the power supply under test.

	No Load (VNL)		Reading (VSL)		Full Load (VFL)	
	Actual	Limits	Actual	Limits	Actual	Limits
+40 (Xenon)		+40 ± 3		+40 ± 13		+40 ± 13
+40 volts		+40 ± 13		36 ± 3		36 ± 3
-40 volts		-40 ± 13		31 ± 3		31 ± 3
+24 volts		+24 ± 2		VNL ± 0.5		VNL ± 0.5
+12 volts		+12 ± 1		± 12 ± 1		± 12 ± 1
-24 volts		-24 ± 2		VNL ± 0.5		VNL ± 0.5
-12 volts		-12 ± 1		-12 ± 1		-12 ± 1
+5 volts		+5 ± 1		+5 ± 1		+5 ± 1
+8 volts		+7.5 ± 1		+7.5 ± 1		+7.5 ± 1
+150 volts		+140 ± 5		+130 ± 5		+ 130 ± 5

400-cps Current	Actual Reading	Limits
No load		0.25 ± 0.1
Full load		0.60 ± 0.1

Ripple		
	Actual	Limits
+24		75 mv p-p
-24		75 mv p-p
+12		125 mv p-p
-12		125 mv p-p
+ 5		125 mv p-p

Fig. 6-6 — Power supply test data recording form

6.9 DUAL INTERFACE ELECTRONICS PACKAGE

6.9.1 Test Equipment

The following equipment is required:

1. Power supplies:
   a. 24 ± 1 vdc, 500 ma
   b. 24 ± 1 vdc, 500 ma
   c. 40 ± 2 vdc, 500 ma
   d. 40 ± 2 vdc, 500 ma
   e. 5 ± 1 vdc, 500 ma
   f. 150 ± 10 vdc, 100 ma
2. Differential voltmeter, J. Fluke model 823A or equivalent
3. Interface test console
4. Resistance bridge, Becco model 312A or equivalent
5. Oscilloscope, Tektronix 565A with type CA plug-in or equivalent
6. Oscilloscope camera

6.9.2 Test Procedure (Side A1)

6.9.2.1 Interconnection

Connect as follows:

1. Connect the power supplies to the points as indicated on the interface test and checkout (T&C) console chassis (power supplies to be preset and off).
2. Turn all potentiometers and switches on the T&C unit off. Connect J1 of the dual interface package to P1 of the T&C chassis and connect J2 of the dual interface package to P2 of the T&C chassis.

6.9.2.2 AEC Relay Test

Test as follows:

1. Turn on the -40-volt power supply and the +5-volt power supply. Both PG lamps should light to some intensity. If not, adjust R1 and R9 of TB-1 until they both do and adjust for minimum intensity.
2. Depress the AEC relay switch (a change in intensity of both PG lamps indicates that both AEC relays are operating) and adjust R2 and R10 of TB-1 for minimum lamp intensity.

6.9.2.3 Level Detector Test

Test as follows:

1. Adjust the COMMAND IN potentiometer until both PG lamps change in intensity.
2. Press the PUSH TO READ COMMAND IN switch. The voltage indicated on the meter should be -12.0 volts. Record this reading.
3. Decrease the COMMAND IN signal voltage until both PG lamps change in intensity.
4. Repeat step 2 except that the voltage indicated should be -11.0 ± 1 volt.
5. Turn off all voltages.

6.9.2.4 T/S Measurement

Test as follows:

1. Connect the resistance bridge to the T/S OUT terminals and accurately measure and record the resistance reading.
2. Measure and record for each setting of the T/S SELECTOR switch.
3. Disconnect the bridge from the T&C unit.

6.9.2.5 Timing Lamp Test

Test as follows:

1. Turn on the +24- and +150-volt power supplies.
2. Rotate the TIMING LAMP ADJ clockwise. The timing lamp should increase in intensity.
3. Turn off the +24- and +150-volt supplies.

6.9.2.6 Telemetry Measurements

Test as follows:

1. Turn on the +24-volt power supply and set the T/M SELECTOR switch to the 1 position.
2. Rotate the T/M ADJ potentiometer clockwise to the +10-volt position. Press the T/M OUT switch and record the reading.
3. Repeat step 2 for all settings of the T/M SELECTOR switch.
4. Repeat steps 2 and 3 with the T/M ADJ potentiometer at the +24-volt position.

6.9.2.7 70-Millisecond Pulse Test

Test as follows:

1. Connect the oscilloscope to the 70-millisecond out monitor and set the oscilloscope on INTERNAL TRIGGER with a sweep of 10 milliseconds per centimeter and an amplitude of 2 volts per centimeter.
2. Set T/M SELECTOR to position no. 5 and T/M INPUT to the 24-volt position.
3. Open the camera shutter, press the 70-millisecond on switch, and close the shutter.
4. Attach the picture to the data sheet.
5. Turn off the +24-volt power supply.

6.9.2.8 Slit Width (S/W) Servo Test

Test as follows:

1. Attach the differential voltmeter to the output of the amplifier module (located in the dual interface package).
2. Turn on both 24-volt power supplies.
3. Press the S/W POT disconnect and adjust R13 until the output of the amplifier is 0.00 ± 0.01 volt. Release the S/W POT switch.
4. Disconnect the differential voltmeter from the interface and connect it to the S/W position terminals. Turn on ±40-volt supplies.
5. Press the S/W RESET switch, set the S/W SELECTOR to OPEN, and record the reading of the S/W position.
6. Set the S/W SELECTOR to position no. 1 and adjust R31 for 22 volts.
7. Set the S/W SELECTOR to position no. 2 and adjust R32 for 20 volts.
8. Set the S/W SELECTOR to position no. 3 and adjust R33 for 18 volts.
9. Set the S/W SELECTOR to position no. 4 and adjust R34 for 16 volts.

6.9.2.9 S/W Failsafe Test

Test as follows:

1. Set the S/W SELECTOR to position no. 1.
2. Press the S/W FAILSAFE switch. (Clutch simulator should light for about 2 seconds and then go out.)

3. Set the S/W SELECTOR to position no. 2. The S/W position should not change.
4. Press the S/W RESET. The S/W position should change to 20 volts.
5. Shut off all power supplies and disconnect the differential voltmeter.

6.9.3 Procedure (Side A2)

Connect and test side 2 as follows:

1. Turn all potentiometers and switches of the T&C unit off (counterclockwise). Connect J1 of the dual interface package to P2 of the T&C chassis.
2. Connect J2 of the dual interface package to P1 of the T&C chassis.
3. Repeat paragraphs 6.9.2.2, 6.9.2.3, 6.9.2.4, 6.9.2.5, 6.9.2.6, 6.9.2.7, 6.9.2.8, and 6.9.2.9 with the following exceptions:
   a. In paragraph 6.9.2.2:

      Change R1 to R14
      Change R9 to R22
      Change TB-1 to TB-2
      Change R2 to R15
      Change R10 to R23
      Change TB-1 to TB-2

   b. In paragraph 6.9.2.8 steps 3, 6, 7, 8, and 9:

      Change R13 to R26
      Change R31 to R35
      Change R32 to R36
      Change R33 to R37
      Change R34 to R38

6.9.4 Data

Record the results of the preceding tests as shown in Fig. 6-7.

6.10 HIGH EFFICIENCY AMPLIFIER

6.10.1 Test Equipment

1. System test fixture (brassboard)
2. Oscilloscope, Tektronix 531 or equivalent
3. Simpson meters, models 260 and 269
4. 2-channel recorder, Brush no. RP2522-20 or equivalent
5. Buffer storage and printer system

	Actual Reading		
	Side A_1	Side A_2	Should Read
Level detector test			
Level On			-12 ± 1 v
Level Off			-11 ± 1 v
T/S resistance			
No. 1			1.6 k ± 0.1%
2			1.6 k ± 0.1%
3			1.6 k ± 0.1%
4			1.6 k ± 0.1%
5			1.6 k ± 0.1%
6			1.6 k ± 0.1%
7			1.6 k ± 0.1%
8			1.6 k ± 0.1%
Telemetry measurements			
+10 v In No. 1			9.0 → 10 v
+10 v In 2			9.0 → 10 v
+10 v In 3			9.0 → 10 v
+10 v In 4			9.0 → 10 v
+10 v In 5			9.0 → 10 v
+24 v In No. 1			23.0 → 24 v
+24 v In 2			23.0 → 24 v
+24 v In 3			23.0 → 24 v
+24 v In 4			23.0 → 24 v
+24 v In 5			23.0 → 24 v
70 ms pulse			
Measured pulse			
-3 db pts.			70 ± 7 ms
S/W servo measurements			
Pos. Open			0 v
No. 1			22 v ± 1
2			20 v ± 1
3			18 v ± 1
4			16 v ± 1

Fig. 6-7 — Dual interface package test data recording form

6.10.2 Initial Power Check

Test as follows:

1. With power off, plug the amplifier into the brassboard.

2. Turn on the 24-vdc regulated power supplies. Observe and record their readings. The output of the regulated power supplies must not noticeably differ from the following values: +24 vdc—90 to 100 milliamps, -24 vdc—25 to 30 milliamps.

3. With the regulated power supplies on, connect pins d, e, and g together (brought out to a terminal board). These are ground, reference input, and tachometer input respectively. Connect the Simpson meter to TP1 and ground and adjust potentiometer R2 for 0.0 volts output from amplifier A1. Remove and connect the meter to TP2 and ground. Adjust potentiometer R3 for 0.0 volts output from amplifier A3. Remove and connect the meter to TP3 and ground and adjust potentiometer R4 for 0.0 volts output from amplifier A2. Recheck the above three adjustments to eliminate interaction between the stages.

4. Disconnect pins d, e, and g and remove the meter. With the brassboard main power switch off, turn on the +24-vdc unregulated power supply. Observing the ammeter on the 24-vdc unregulated supply, turn on the brassboard main power switch. The 24-vdc unregulated current must not noticeably exceed 400 milliamperes. Record the current.

5. Connect the Simpson meter to TP6 and ground. The meter should read between +1.45 and +1.65 volts. Record this value.

6. Turn the V/h switch on and turn the V/h potentiometer fully counterclockwise. Press the OPERATE button on and slowly turn the V/h potentiometer to full clockwise, then to full counterclockwise. During this operation the wheel must be under servo control.

7. With all power supplies on and the brassboard power switch off, perform the following:

a. Set the unregulated 24-vdc supply to 20 vdc. Set the V/h potentiometer for an output of 3.75 vdc (read on the digital voltmeter). Observe and record with operate button on.

(1) TP6 (Simpson reading)
(2) Turn on current (surge)
(3) Current at velocity
(4) Turn off current (surge)

NOTE

(2), (3), and (4) above refer to unregulated power.

b. Repeat step a with the unregulated power set to 24 vdc.

c. Repeat step a with the unregulated power set to 29 vdc.

6.10.3 Modulator Evaluation

Test as follows:

1. Connect pins d, e, and g together, with the V/h switch off, the power supplies on, and the OPERATE button on.

2. Attach the oscilloscope probes to TP4 and TP5. Set the oscilloscope preamplifier sensitivity to 20 microseconds per centimeter, and 10 volts per centimeter. Verify that the square waves are equal and of opposite polarity (an external synchronization signal taken from either test point is suggested).

3. Measure and record the amplitude, frequency, and duty cycle of the square waves. These readings should not vary from the following nominal values:

Amplitude: 22 volts ±10 percent
Frequency: 7 ± 1 kilocycles
Duty cycle: 50 percent

6.10.4 Tachometer Adjustment and Input Limiting Measurement

Test as follows:

1. With the power supplies on and the OPERATE switch off, set the V/h switch to 3.14 volts (read on the digital voltmeter). Verify that the wheel turns one complete revolution in 2 seconds (±1 percent). Adjust R1 if necessary.

2. With the OPERATE switch off, connect the digital voltmeter across the input of the V/h amplifier (Union Carbide U6000) located in back of the test panel. Connect the digital voltmeter to the V/h test jack on the front of the test panel. Press the OPERATE button on, set the V/h to 0.5 volt on the digital voltmeter, and record the input to the Union Carbide H6000 amplifier. Repeat this operation in 0.25-volt steps until the voltage reading on the digital voltmeter does not increase with increases in input voltage. Plot the tabulated data (typically about 4.2 volts).

6.10.5 Efficiency and Reverse Current Check

Test as follows:

1. With the wheel locked, turn system power on and press the OPERATE switch on.
2. Verify that there is no current to the motor by adjusting potentiometer R2, (preamplifier balance) for zero current in the motor.

3. Connect a Simpson meter to the motor current test jacks and record the value (in millivolts); repeat this step for the system current test jacks.

4. Remove and connect the Simpson meter to the motor volts test jacks, and record the value (in volts).

5. Using the Simpson meter, verify that the unregulated supply is 24 vdc. Compute the input power as follows:

System power = (system current) (system voltage)
Load power = (motor current) (motor voltage)

NOTE

There should be no load power (motor power) at all. There will be a slight dc voltage across the motor but no load current.

6. Repeat steps 1 through 5 with potentiometer R2 (preamplifier balance) adjusted to give +3 amps through the motor. After the load power and system power have been computed, compute and record the efficiency using the following formula:

$$\frac{\text{Load power (motor current)(motor voltage)}}{\text{System power (system current)(system voltage)}} \times 100 = \text{Eff (percent)}$$

7. Repeat step 6 with potentiometer R2 adjusted for maximum positive current.

8. Repeat step 6 with potentiometer R2 adjusted for maximum negative current.

6.10.6 Operational Checkout

Test as follows:

1. With 24-vdc regulated power on, rebalance amplifiers A1, A2, and A3.

2. Turn on the unregulated 24-vdc power. Set the V/h voltage to 3.75 volts, turn the V/h switch on, and set the unregulated voltage to 20 vdc.

3. Connect the motor current test jacks to one channel of the brush recorder, and system current test jacks to the other channel. Set the sensitivity of each channel to 0.1 volt/line. With the recorder on, and the signal leads disconnected, adjust the pen bias for center scale zero on both channels.

4. Press the OPERATE button on and record approximately 5 to 10 cycles of data.

5. Repeat step 4 with the unregulated voltage adjusted to +24 vdc.

6. Repeat step 4 with the unregulated voltage adjusted to +29 vdc.

7. Disconnect the recorder leads from the test panel, and connect them to the forward and reverse motor jacks. Set the sensitivity on both channels for 0.5 volt/line and set the unregulated power to 24 vdc.

8. Turn the recorder on, press the OPERATE switch on, and record approximately 5 to 10 cycles of data.

9. Disconnect either the forward or reverse motor test jack, and plug it into the tachometer test jack. Set the sensitivity of the respective channel to 0.2 volt/line.

10. Turn the recorder on, press the OPERATE switch on, and record approximately 5 to 10 cycles of data.

NOTE

Steps 7 through 10 are included for T/M testing.

6.11 MATERIAL CHANGE DETECTOR

6.11.1 Test Equipment

The following equipment is required:

1. Pulse generator, Intercontinental Instrument, Inc., model PG-2 or equivalent
2. Oscilloscope, Tektronix model 531 or equivalent
3. Power supply, +24 volts, 3 amps
4. Resistance decade box
5. Scope, plug-in, Tektronix model 1A1 or equivalent
6. Material change test rack
7. Material carriage fixture
8. Power supply +5 volts at 225 milliamps
9. Power supply, +18 volts at 3 amps
10. Power supply, variable 0 to 18 volts at 3 amps

6.11.2 Equipment Connection

Verify that all test equipment switches are in the OFF position and connect the equipment as shown in Fig. 6-8.

6.11.3 Detector Head Test

Refer to drawing no. 107631 and test as follows:

1. Mount the detector head on the material carriage test fixture and connect it to the test rack.

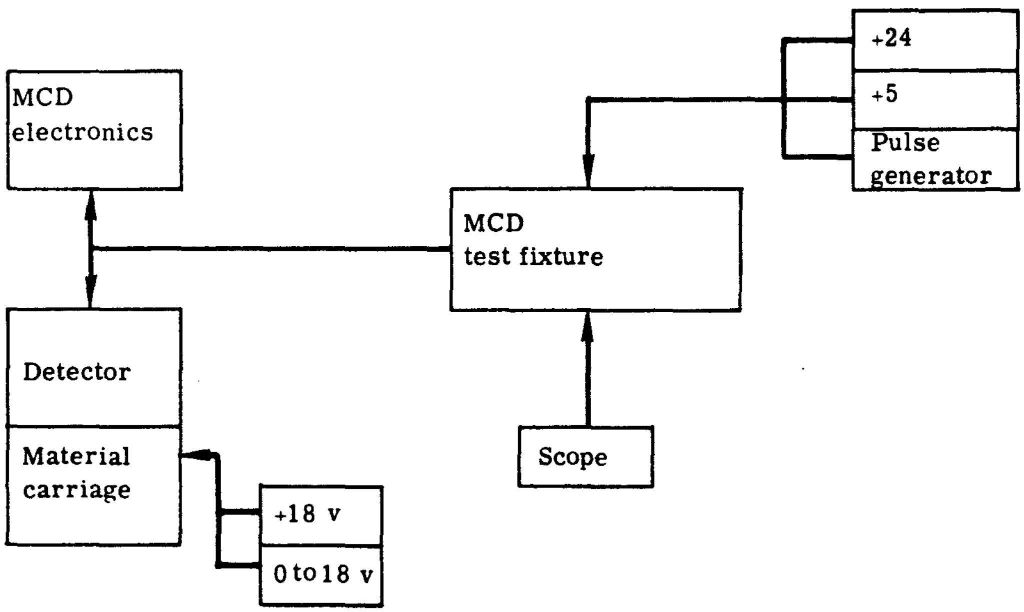


Fig. 6-8 — Material change detector test setup

2. Connect the detector amplifier to the test rack amplifier simulator.
3. Connect the +18-volt power supply and the 0- to 18-volt power supply to the material carriage and turn them on. Adjust the material speed for 7 inches per second.
4. Turn on the +24- and +5-volt power supplies.
5. Read and record the detector output pulse and the inhibit output pulse.
6. Repeat step 5 with the material speed at 21 inches per second.

6.11.4 Detector Amplifier Test

Test as follows:

1. Verify that all test rack switches are in the OFF position.
2. Connect the detector amplifier to the test rack.
3. Connect the detector head to the DETECTOR SIMULATOR connector on the front panel of the test rack.
4. Adjust the pulse generator to obtain the following:
   a. Pulse repetition rate: 3 pulses per second
   b. Pulse width: 30 milliseconds
   c. Pulse amplitude: 1.0 volt (0 to peak)
5. Connect the resistance decade box in place of R13 on the component board and turn on the +24-volt supply (preset the decade box to 5.1 K).
6. Place the SIGNAL ON switch in the ON position.
7. Connect the scope to the motor monitor and adjust the decade box for a 50-millisecond output pulse. Read and record the output pulse and resistor value.
8. Place the INHIBIT SIGNAL ON switch in the ON position and press the INHIBIT button. (This will blank out 1 to 3 of the output pulses.)
9. Turn all power supplies off and return all switches to the OFF position.
10. Replace the resistance decade box with a fixed resistance as specified on drawing no. 107631.

6.11.5 Amplifier and Detector Operational Test (Optional)

Test as follows:

1. With all switches off, connect the amplifier and the detector head to the test rack and mount the detector on the material carrier.

2. Turn on the +18-volt and the 0- to 18-volt power supplies and adjust for 7 inches per second.

3. Turn on the +5- and +24-volt power supplies and verify that the step motor in the test rack operates and inhibits properly.

4. Decrease the 5-volt power until the circuit ceases to function properly. Read and record the voltage of the 5-volt power supply and the detector and inhibit outputs.

5. Repeat steps 2 through 4 with the material traveling at 21 inches per second with the 5-volt supply set at 5 volts.

6.11.6 Debug Test Procedure

Test as follows:

1. With the material change detector installed in an operating system, splice an insert (drawing no. 107808) onto the 3404 film.

2. Energize the supply and wrap about 20 feet of film, after the insert, on the supply spool. Repeat this so as to have two inserts with 20-foot leaders.

3. Operate the system at 3.75 radians per second and stop it immediately after the MCD has actuated the scan head filter. Determine that the AO and scan head filters have changed position (5 steps of motor). The intensity of the lights (rail, S/N, AO, PG, SLP) must be altered when the scan head filter changes position.

4. Operate the system at 1.5 radians per second and stop it after the MCD has actuated the scan head filter. Verify that the filters and lights have returned to their original condition.

5. Turn instrument power on and off. Check the scan head filter position to make sure the motor did not step.

6. Critically inspect the film used during a photographic test. Light streaks caused by the MCD are not acceptable.

6.12 CONTROL LOGIC ASSEMBLY

6.12.1 Test Equipment

The following equipment is required:

1. Special test setup
2. Stopwatch

6.12.2 Procedure

Test as follows:

1. Connect the side 1 test cable to the control package and verify that the side 1 light on the test console comes on.
2. Actuate the following controls and record the result of each:

   RESET button
   SET button
   OPERATE switch (ON)
   OPERATE switch (OFF)

3. Ground TP1 (or TP2 for side 2). The STOW SIGNAL light should come on. All other lights should remain the same. Remove the ground from TP1. The STOW SIGNAL light should go out.
4. Actuate the following controls and record the results:

   No. 1 button
   No. 2 button
   No. 3 button

5. Hold the A TO B TRANSFER switch in the ON position for at least 5 seconds and return it to the OFF position.
6. Repeat step 4.
7. Repeat steps 2 through 4.
8. Connect the side 2 test cable to the control package and repeat steps 2 through 7.

6.12.3 Data

Record the results of the preceding tests on the data sheet (see Fig. 6-9)(one sheet for each side).

6.13 XENON FLASH TUBE SYSTEM

6.13.1 Test Equipment Required

1. Pulse generator, E. H. model 132A or equivalent
2. Oscilloscope, Tektronix model 535A, or equivalent
3. Plug-in, Tektronix type CA, or equivalent
4. Power supply, +40 volts at 200 milliamps, Harrison Laboratories model 800A or equivalent
5. Power supply, +24 volts at 10 amps, Harrison Laboratories model 800A or equivalent

Time delay data recording form

Camera	Time Between "Stow" and 400 Hz Power Off (~ 3 seconds)	Time between "A to B Transfer" and 400 Hz Power On (~ 5 seconds)
No. 1		
No. 2		

Mode	L-Mode	Supply Motor	Supply Tension	A Takeup Motor	A Takeup Anti	A Takeup Shunt	B Takeup Motor	B Takeup Shunt	24 Volts Operate	400 Hz Operate	V/h Signal, meters	Stow Signal
L-Mode											0.7	
O-Mode											0.7	
Operate On											~1.5	
Operate Off											~1.5	
No. 1 (EOS)											0.7	
No. 2 (CF)											0.7	
No. 3 (Stow)		3 sec	3 sec	3 sec						3 sec	0.7	
A to B Transfer		After 5 sec						For 5 sec	After 5 sec	After 5 sec	After 5 sec 1.5 v	For 5 sec
No. 1 (EOS)											0.7	
No. 2 (CF)											0.7	
No. 3 (Stow)		3 sec	3 sec				3 sec			3 sec	0.7	
Operate On											~1.5	
Operate Off											~1.5	
No. 1 (EOS)											0.7	
No. 2 (CF)											0.7	
No. 3 (Stow)		3 sec	3 sec				3 sec			3 sec	0.7	

NOTE: Check (√) the lights that are on after each step. They should correspond to the shaded blocks.

Fig. 6-9 — Control logic assembly test data recording form (one sheet for each side)

6. Xenon tube test fixture with detector adapter

7. Itek type G_1, G_2, and G_3 adapter plugs (see drawing no. 85794)

6.13.2 Test Arrangement

Connect equipment as shown in Fig. 6-10.

6.13.3 Procedure

Test as follows:

1. Set the intensity switch to LOW, place the signal input and 400-cps switches in the OFF position, mount the detector fixture on the flash module, and set the signal generator for a 3.0-microsecond pulse of +4.0-volt amplitude with a repetition rate of 100 pulses per second.

2. Connect the G_3 mating plug to J-2 and turn on the +40-volt power supply.

3. Set the input switch to position no. 1 and turn on the +24-vdc power supply.

4. Monitor the detector output with the oscilloscope and align the detector with the flash tube for maximum output.

5. Read and record the amplitude, frequency, and pulse width of the detector output.

NOTE

Output pulses should be constant with no spurious pulses.

6. Repeat steps 4 and 5 with the input selector in the nos. 2 and 3 position.

7. Switch the intensity control to the HIGH position. Read and record the output of the detector. There should be an increase in intensity.

8. Turn the +24- and +40-vdc power supplies off. Return the intensity relay switch to the LOW position.

9. Repeat steps 2 through 8 using G_2 and G_1 connectors.

NOTE

There will be no change in intensity when G_1 connector is used.

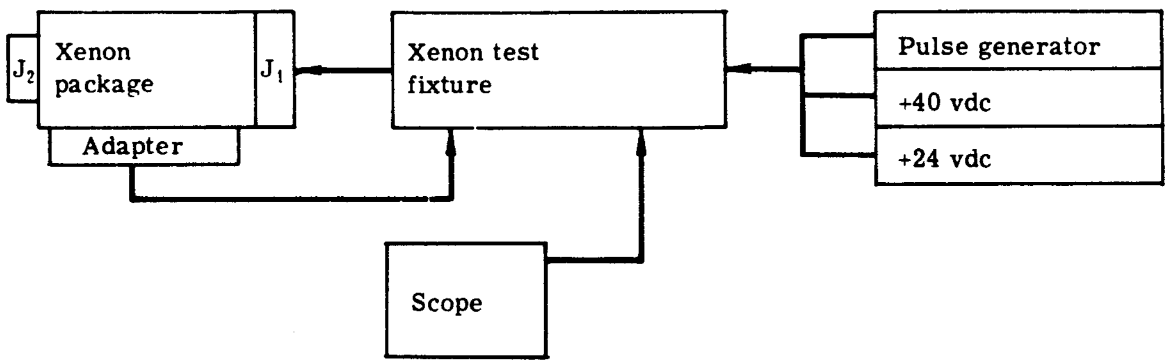


Fig. 6-10 — Xenon tube test setup

6.14 AUXILIARY OPTICS ASSEMBLY CHECKOUT

6.14.1 Test Equipment

The following test equipment is required:

1. DC power supply, 0 to 30 vdc, 0 to 2 amps
2. Multimeter, Simpson model no. 260 or equivalent

6.14.2 Procedure

Test as follows:

1. Turn on the dc power supply and adjust the output voltage for 24 ± 1 vdc.

2. Turn off the supply and connect the return lead to pins C and R of the connector (see schematic nos. 88310 and 88402).

3. Connect the +24-vdc lead to pin N and turn on the +24-vdc supply.

4. Pulse pin B with +24 vdc several times. The pulse duration should be 1 second or less. The shutter solenoid should actuate.

5. Connect +24 vdc to pin F. The motor should move the aperture in the filter tray over the aperture in the A.O. housing. The motor should stop when both apertures are aligned and the tray linkage is approximately 0.020 inch from its fully extended position. If it does not, adjust the microswitch as necessary. Verify that +24 vdc appear between pins C and D when the apertures are properly aligned.

6. Remove the voltage from pin F. The filter tray should move completely from in front of the A.O. aperture. The motor should stop with the tray linkage approximately 0.020 inch from its fully extended position. If it does not, adjust the microswitch as necessary. Check between pins C and H for +24 vdc.

7. Alternately apply and remove +24 vdc from pin F and verify proper filter tray action.

8. Apply 1.5 volts maximum between pins A and E and verify that all four of the fiducial lamps are lit.

6.15 SCAN HEAD POTENTIOMETER ALIGNMENTS

6.15.1 Test Equipment

The following equipment is required:

1. Fluke meter, model no. 823A or equivalent
2. DC power supply, 0 to 5 vdc, regulated to ±5 millivolts

6.15.2 Slit Width Potentiometer Adjustment Procedure

Test as follows:

1. Using the digital voltmeter, set the power supply to 5 volts ± 5 millivolts.

2. Put the positive side of the supply on terminal no. 1 of R2 (outboard potentiometer) and the negative side (ground) on no. 3.

3. Monitor the potentiometer voltage, terminal no. 2 (the arm) to ground.

4. With the slit width and cam in the failsafe position and its coupling loose, rotate the potentiometer shaft until the potentiometer voltage is 2.005 volts ± 5 millivolts.

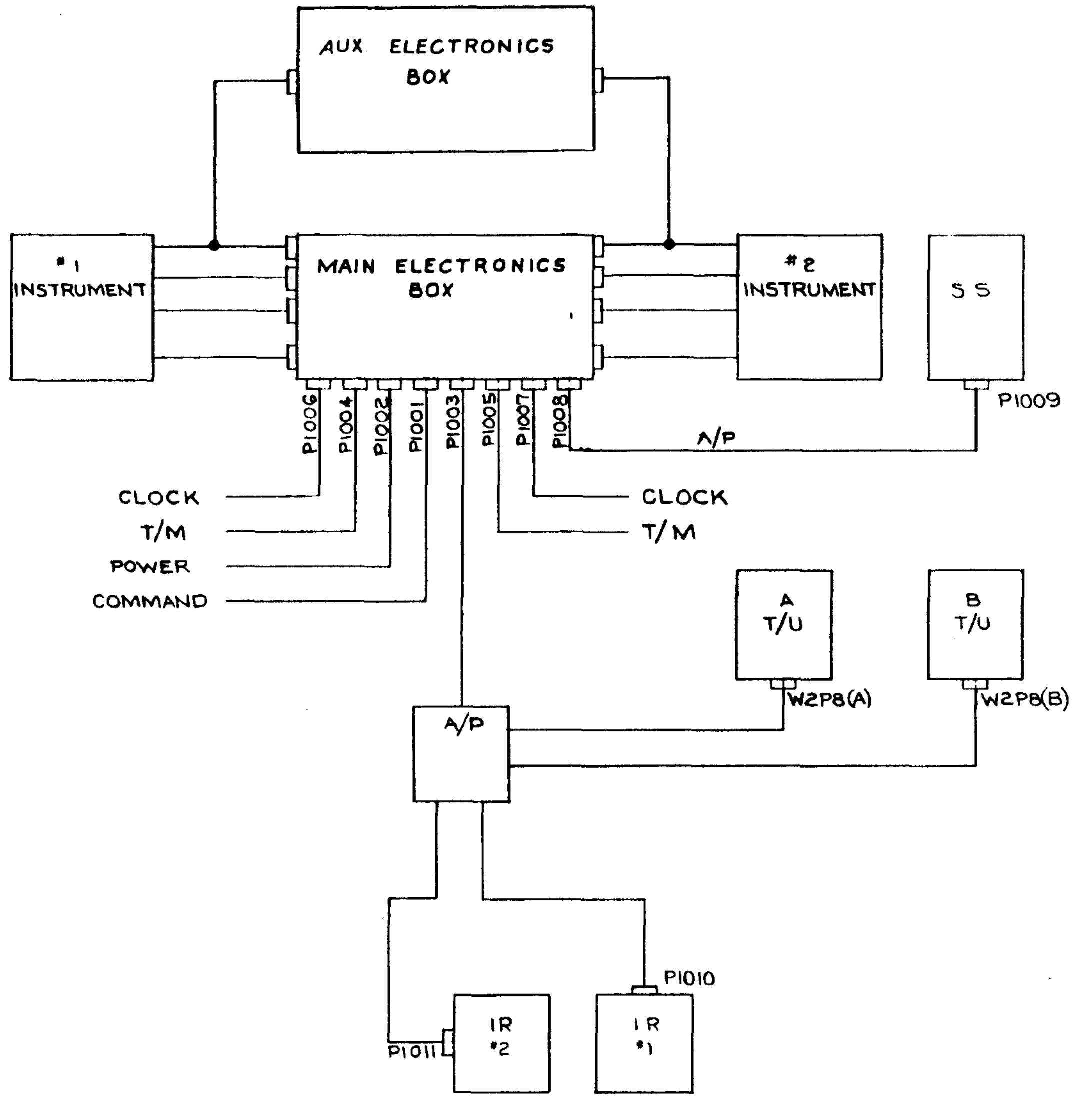
5. If this accuracy cannot be obtained, get as close to 2.005 volts as possible, tighten the coupling, loosen the servo clamps holding the potentiometer, and adjust to the voltage by rotating the potentiometer body. Tighten the servo clamps.

6. Turn the slit width cam and release, allowing the spring to return the cam to the failsafe position. Repeat several times; the potentiometer voltage should be fairly evenly distributed about 2.005 vdc when in the failsafe position.

6.15.3 Filter Potentiometer Adjustment

1. Using the digital voltmeter, set the power supply to 5 volts ± 5 millivolts.
2. Put the positive side of the supply on terminal no. 1 of R3 and the negative side (ground) on no. 3.
3. Monitor the potentiometer voltage, terminal no. 2 (the arm) to ground.
4. Loosen the set screw holding the filter tray linkage to the motor shaft.
5. Place the filter tray in the IN position.
6. Rotate the motor shaft until the potentiometer voltage is 4 ± 0.4 volts.
7. Loosen the servo clamps holding the potentiometer and rotate the potentiometer body until the potentiometer voltage is 4 volts ± 5 millivolts. Tighten the servo clamps.
8. Rotate the motor shaft 360 degrees and check that the voltage returns to 4 volts.

7. ELECTRICAL SCHEMATICS



P1001	PTO6SE-20-41S-011
P1002	PTO6SE-20-16S-011
P1003	PTO6SE-16-26P-011
P1004	PTO6SE-22-55P-011
P1005	PTO6SE-22-55PW-011
P1006	PTO6SE-22-55S-011
P1007	PTO6SE-22-55SW-011
P1008	PTO6SE-16-26PW-011
P1009	PTO6SE-16-26S-011
P1010	PTO6SE-10-6S-SR
P1011	PTO6SE-10-6S-SR
W2P8(A)	PTO6SE-16-26S-011
W2P8(B)	PTO6SE-16-26S-011

Fig. 7-1 — Block diagram A/P to CR, dwg. no. 85157

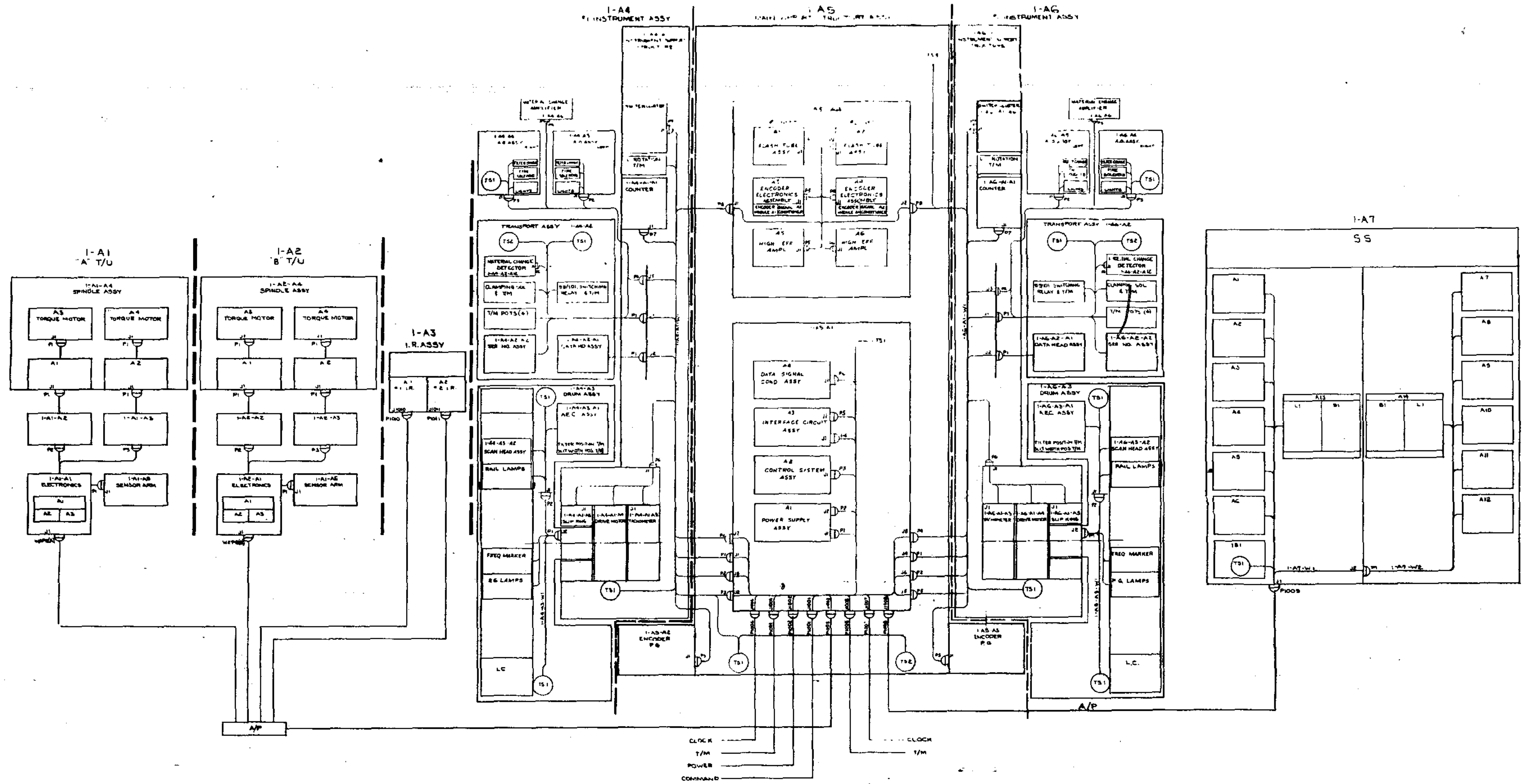


Fig. 7-2 — Electrical block diagram, dwg. no. 85196

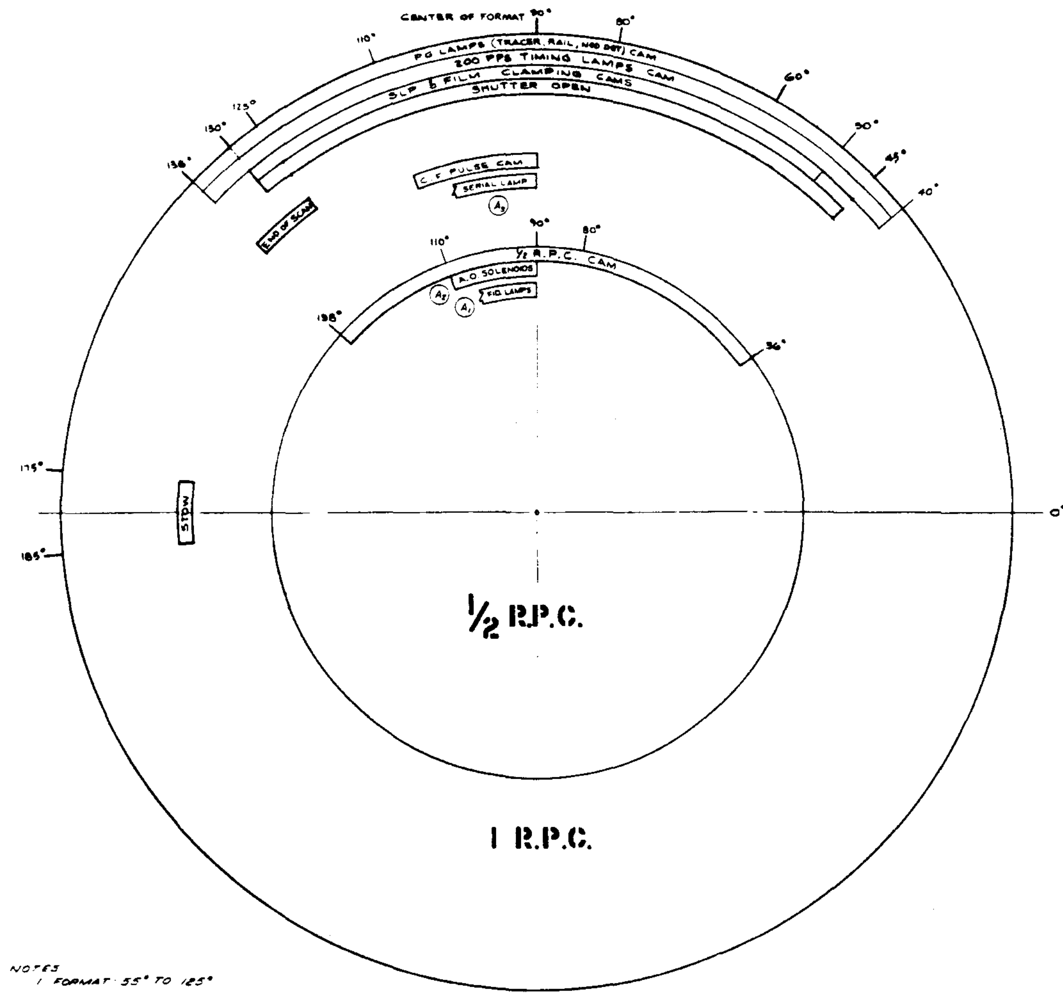


Fig. 7-3 — Timing diagram, dwg. no. 85427

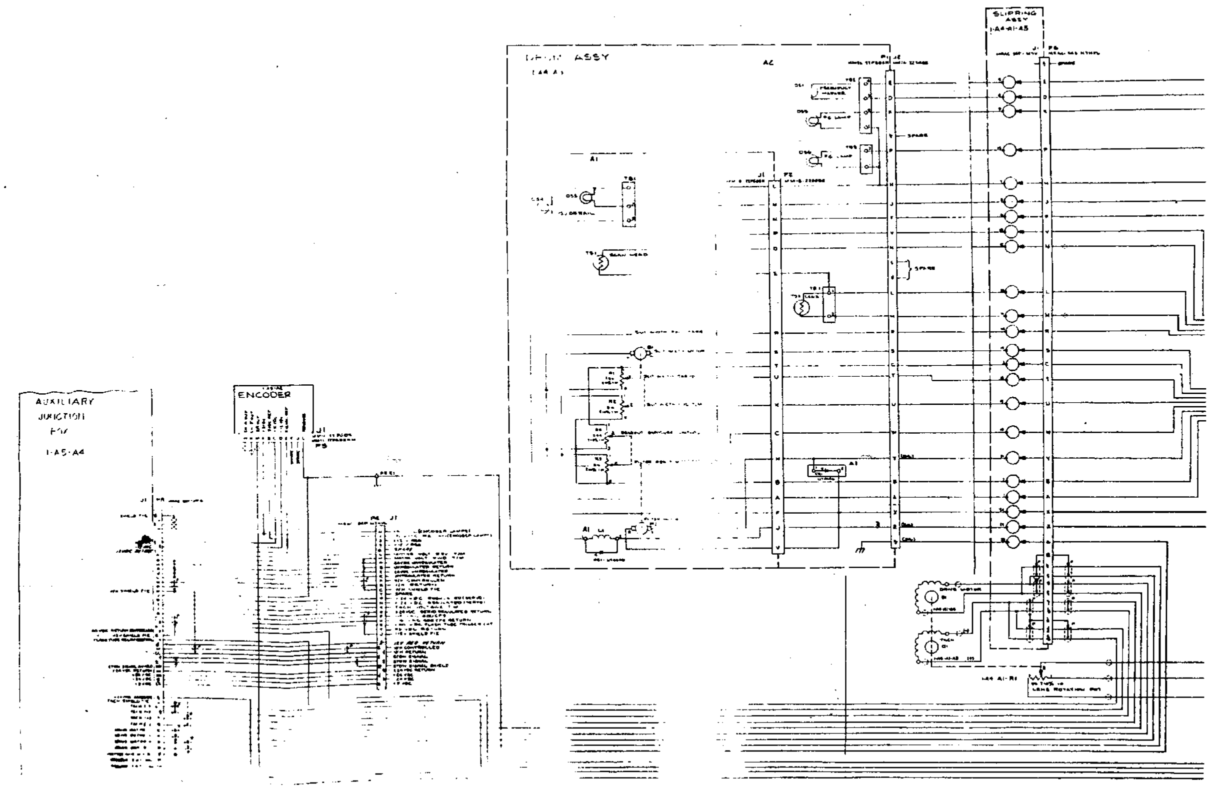


Fig. 7-4 — Instrument schematic no. 1, dwg. no. 88310

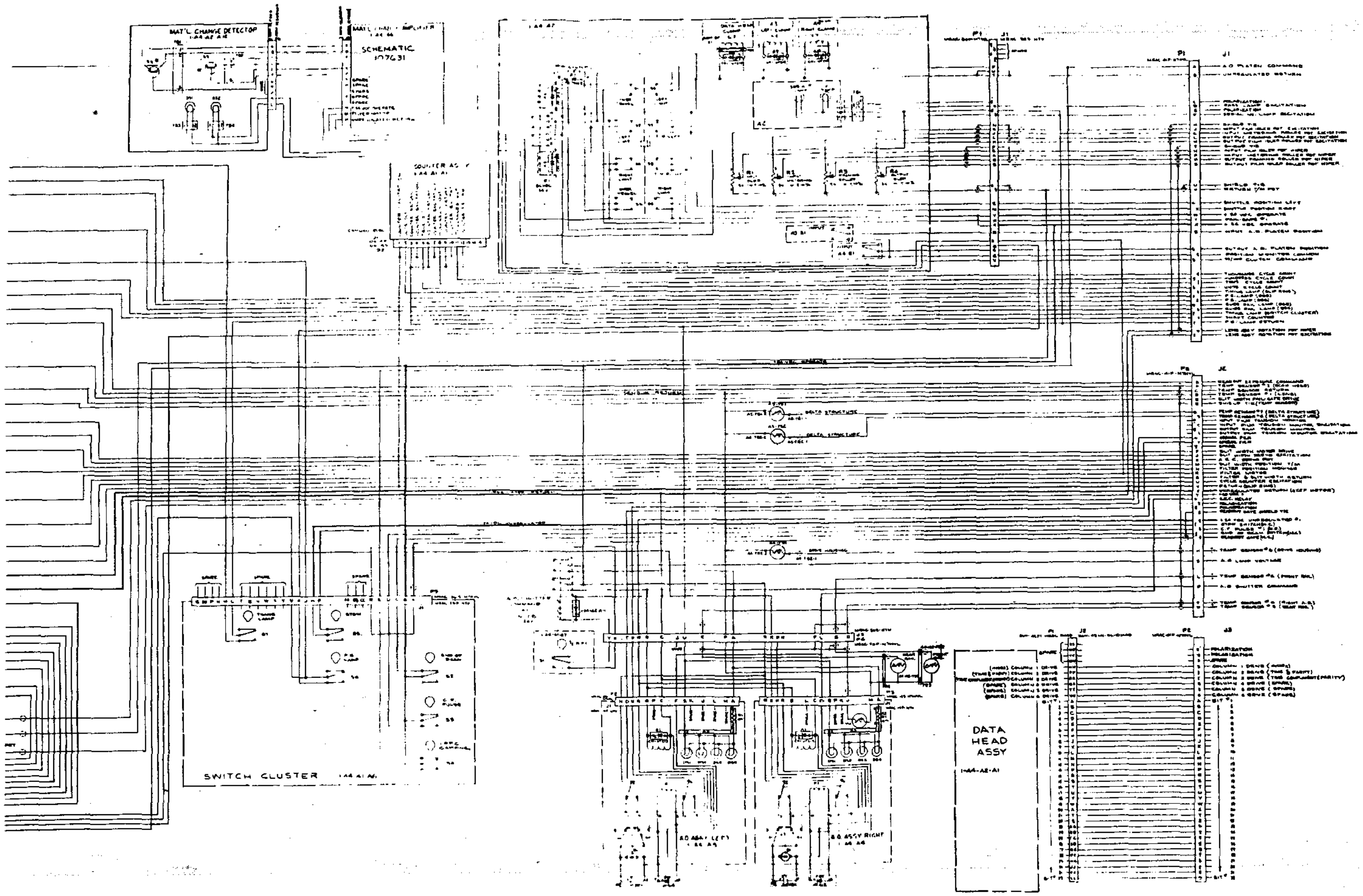


Fig. 7-4 — Instrument schematic no. 1 (Cont.)

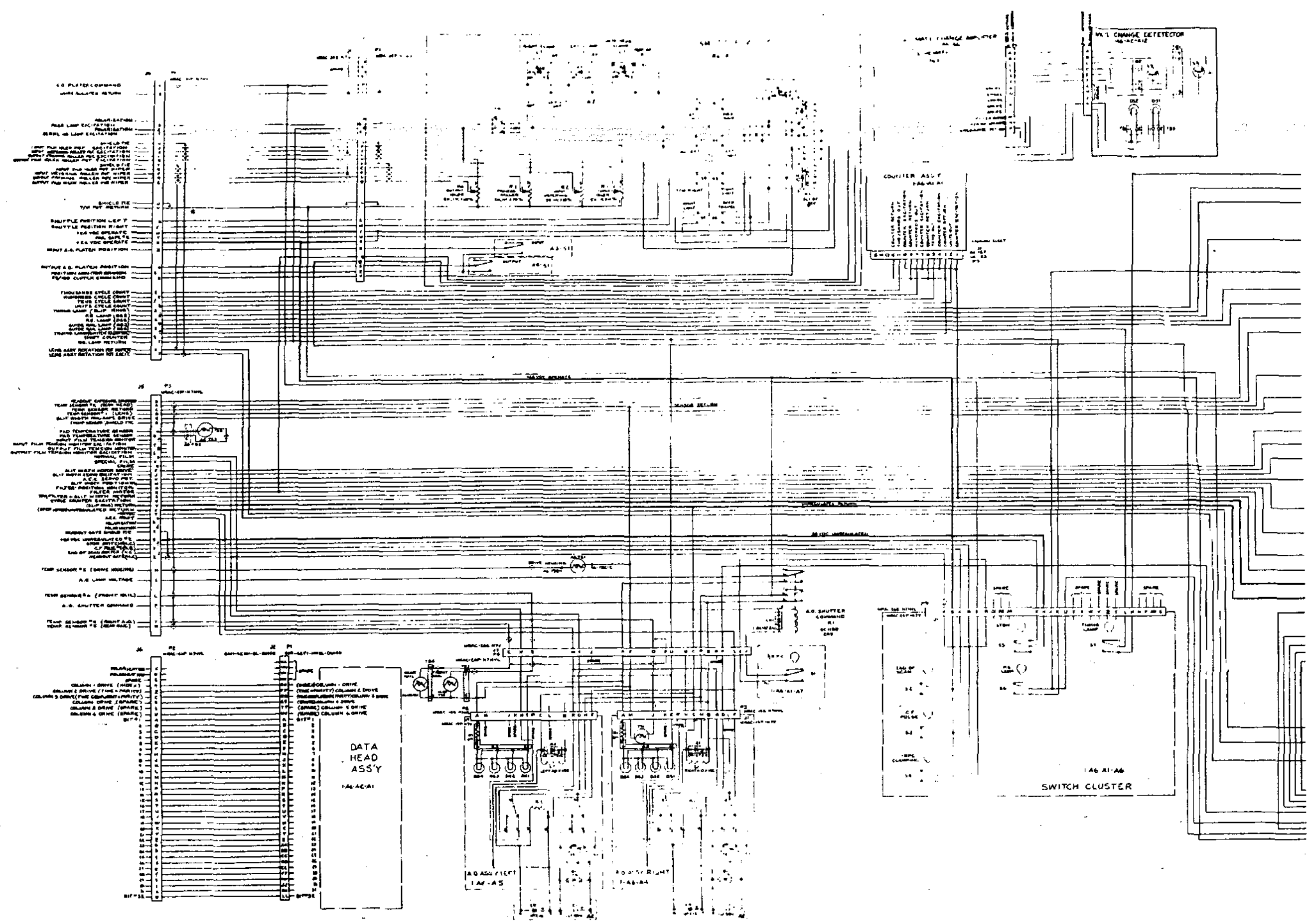


Fig. 7-5 — Instrument schematic no. 2, dwg. no. 88402

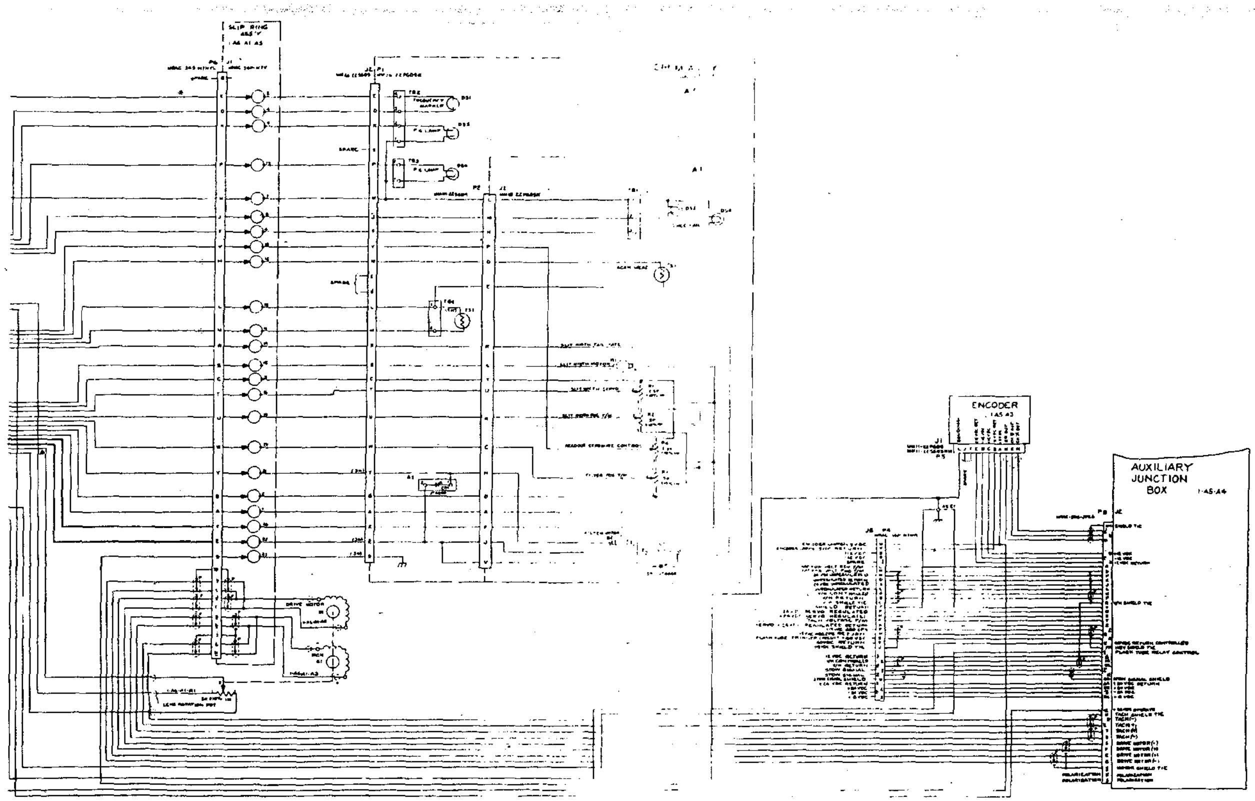


Fig. 7-5 — Instrument schematic no. 2 (Cont.)

TOP SECRET/C/[redacted]

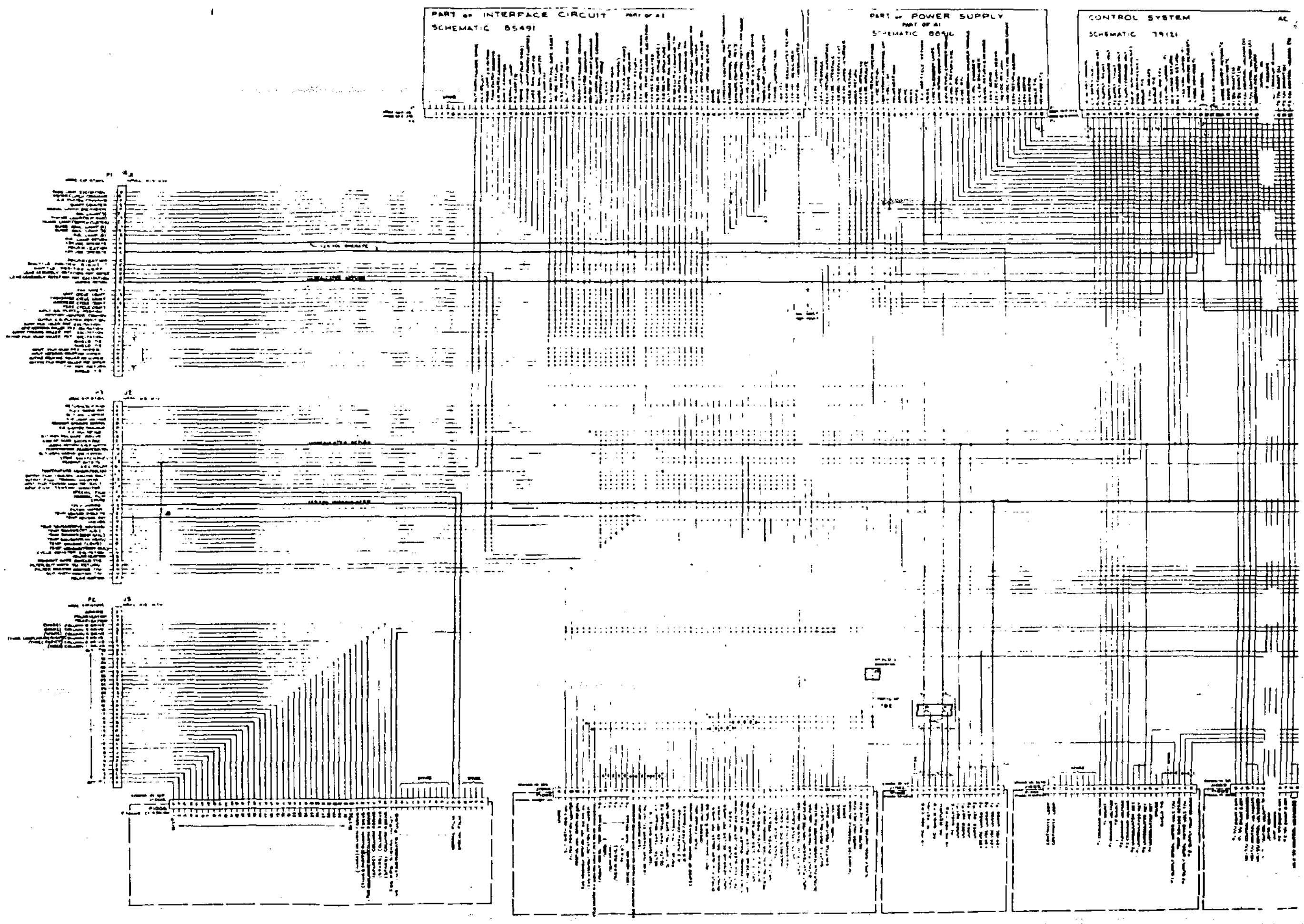


Fig. 7-6 — Schematic main electronics box, dwg. no. 84940

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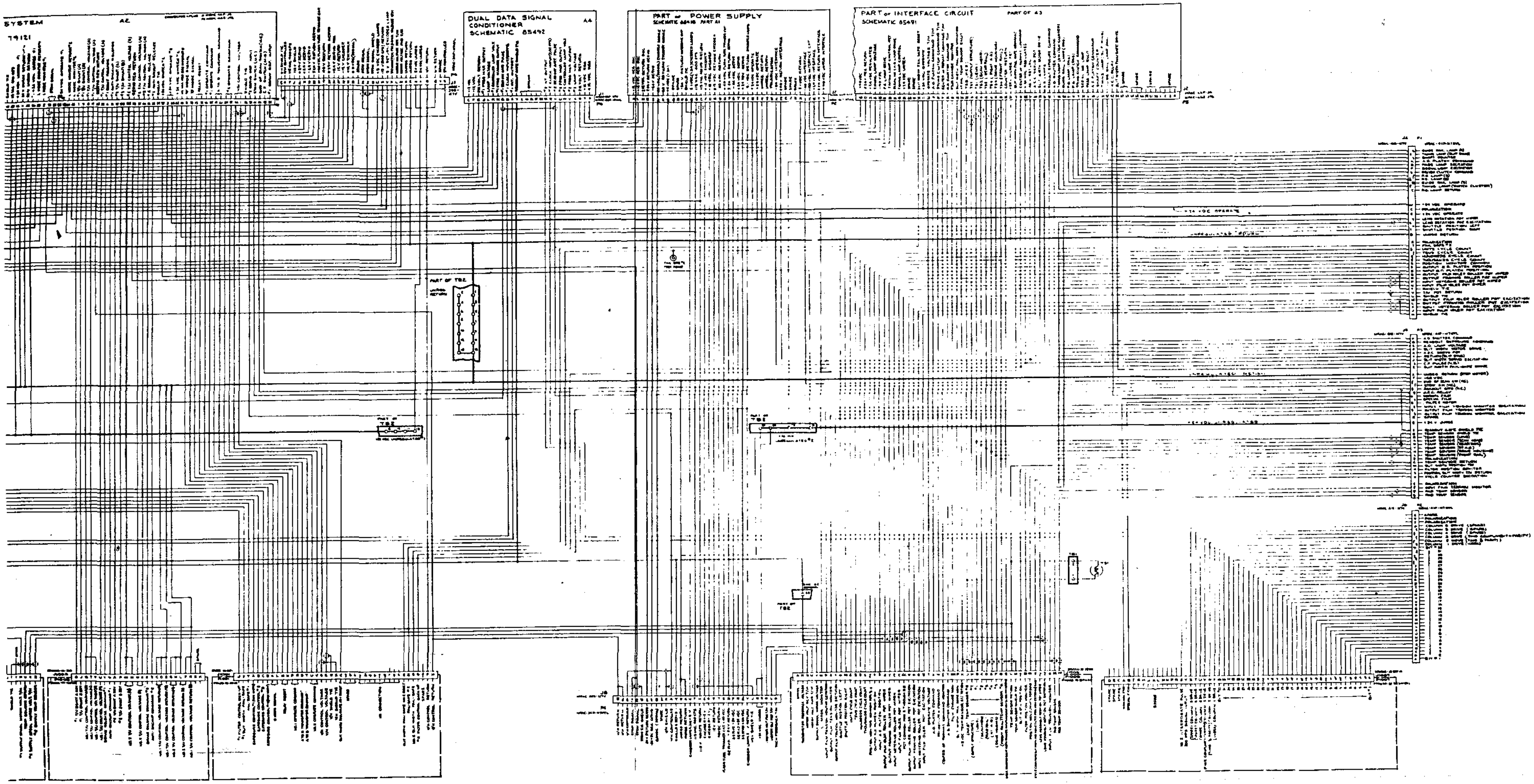


Fig. 7-6 — Schematic main electronics box (Cont.)

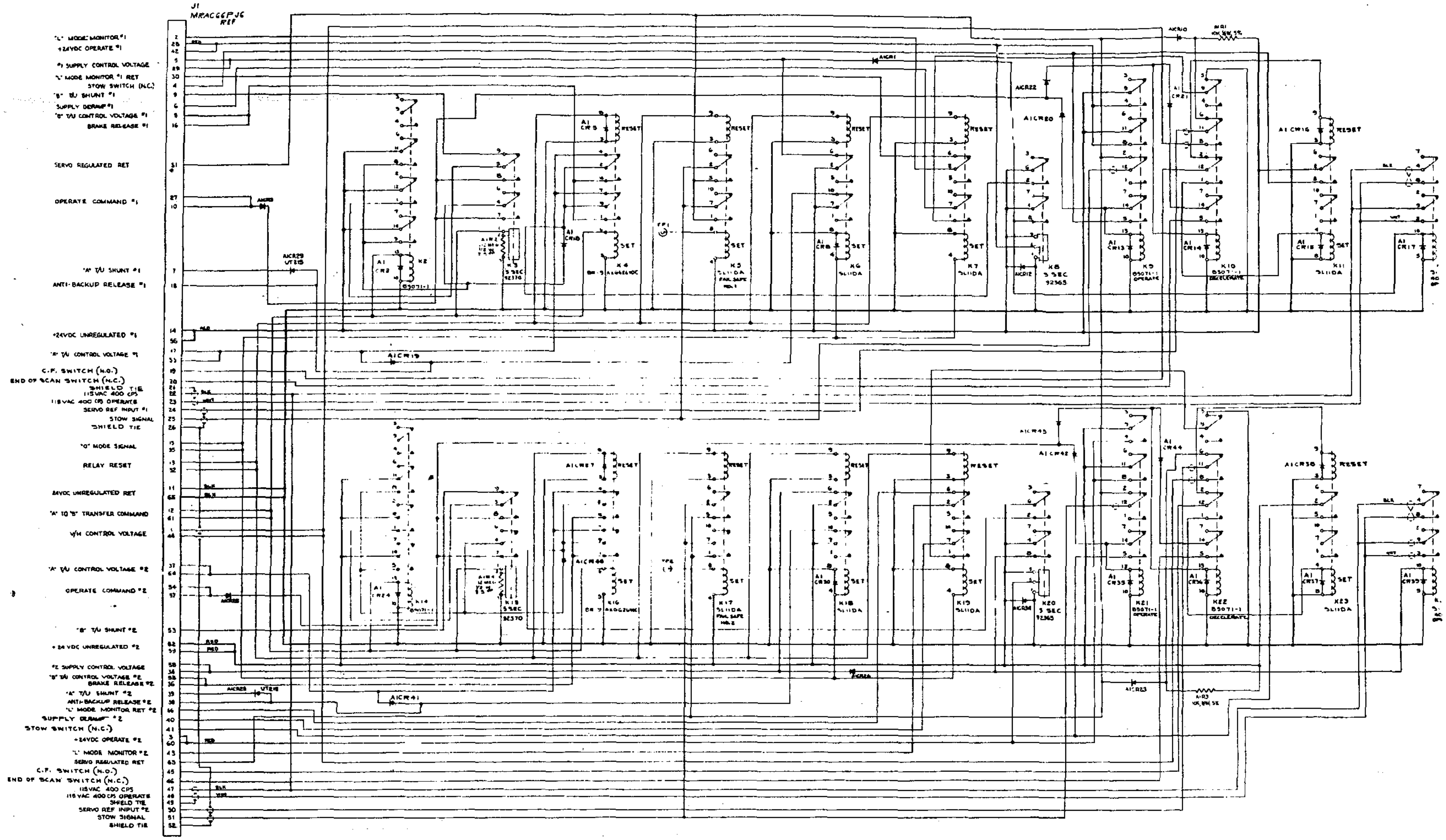


Fig. 7-7 — Electrical schematic control system, dwg. no. 79121

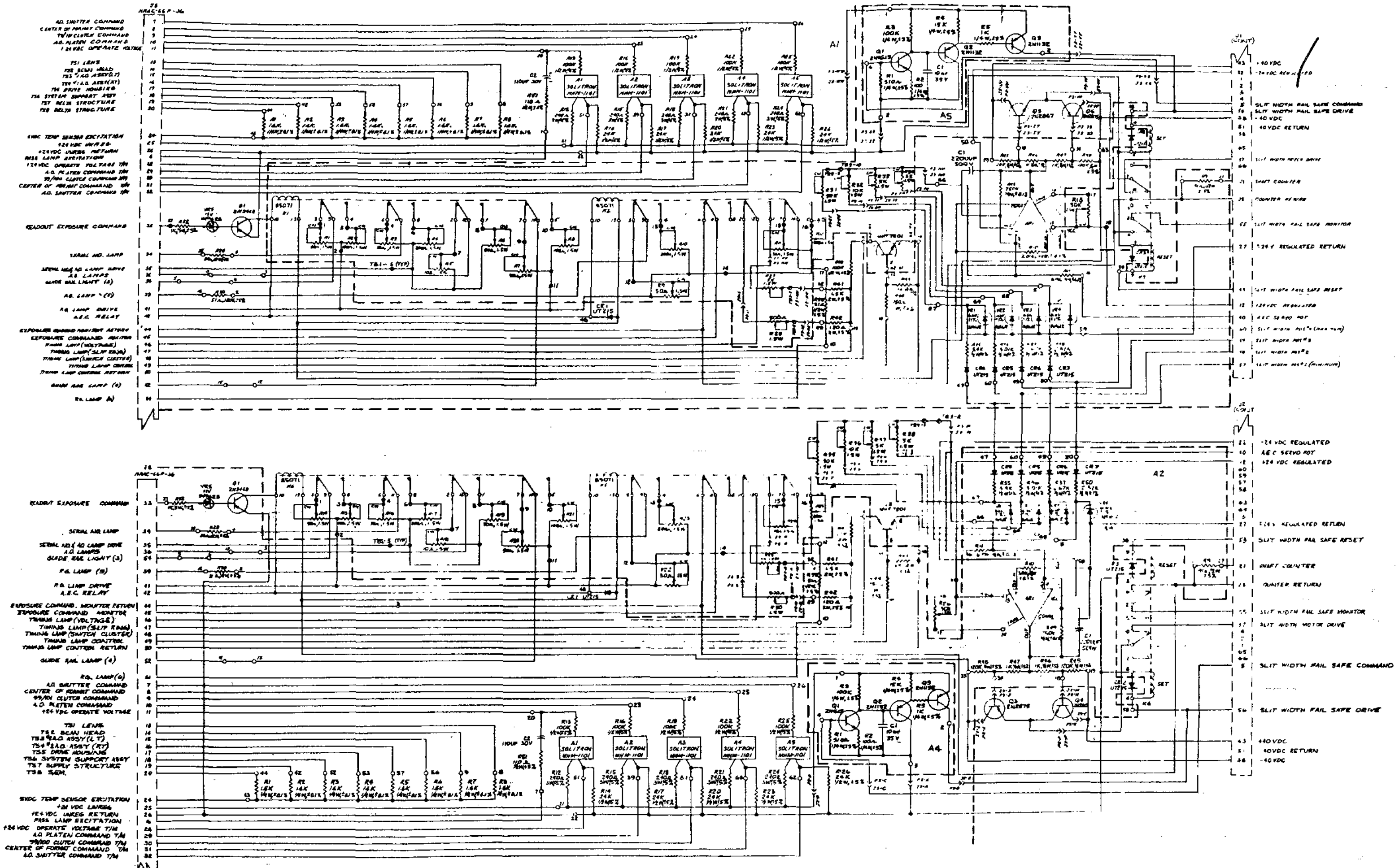
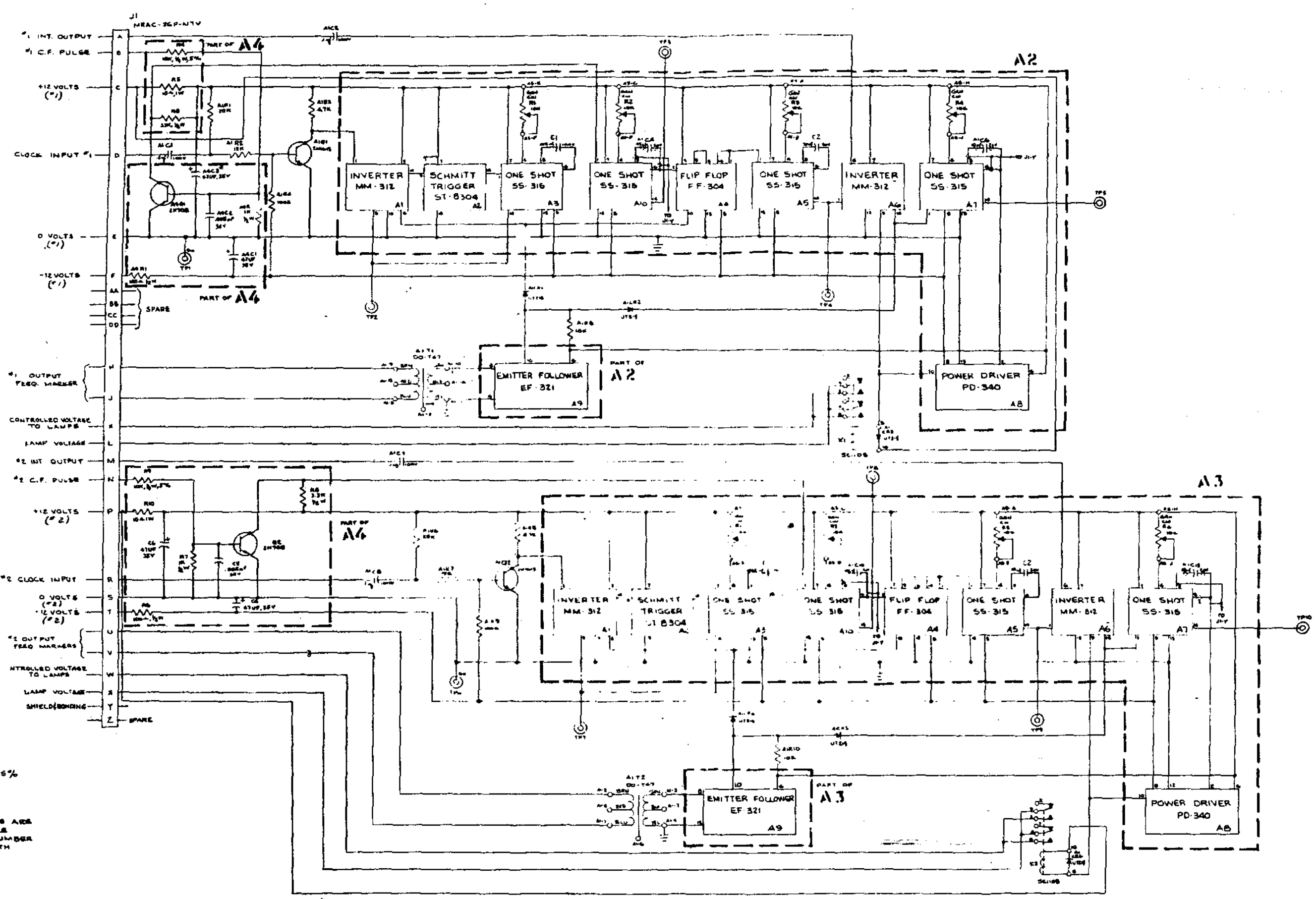
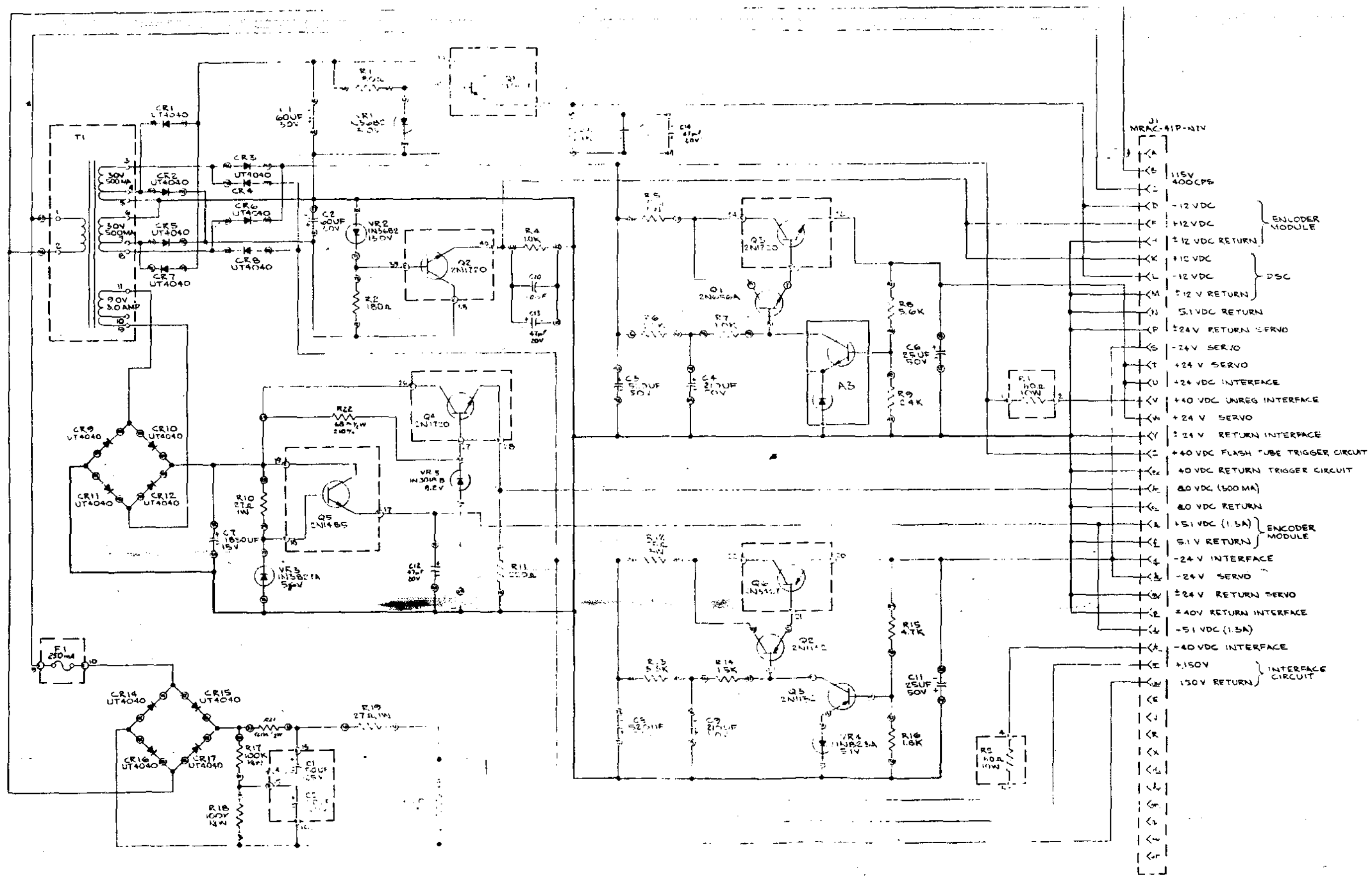


Fig. 7-8 — Schematic interface circuit, dwg. no. 85491



NOTE
1. ALL RESISTOR VALUES ARE 1/2 W ± 5% UNLESS OTHERWISE SPECIFIED
2.
3. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. FOR COMPLETE REFERENCE DESIGNATION PREFIX WITH UNIT NUMBER OR SUBASSEMBLY NUMBER OR BOTH

Fig. 7-9 — Schematic dual data signal conditioner, dwg. no. 85492



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/2 W, ±5%

Fig. 7-10 — Schematic power supply no. 1, dwg. no. 88416-1

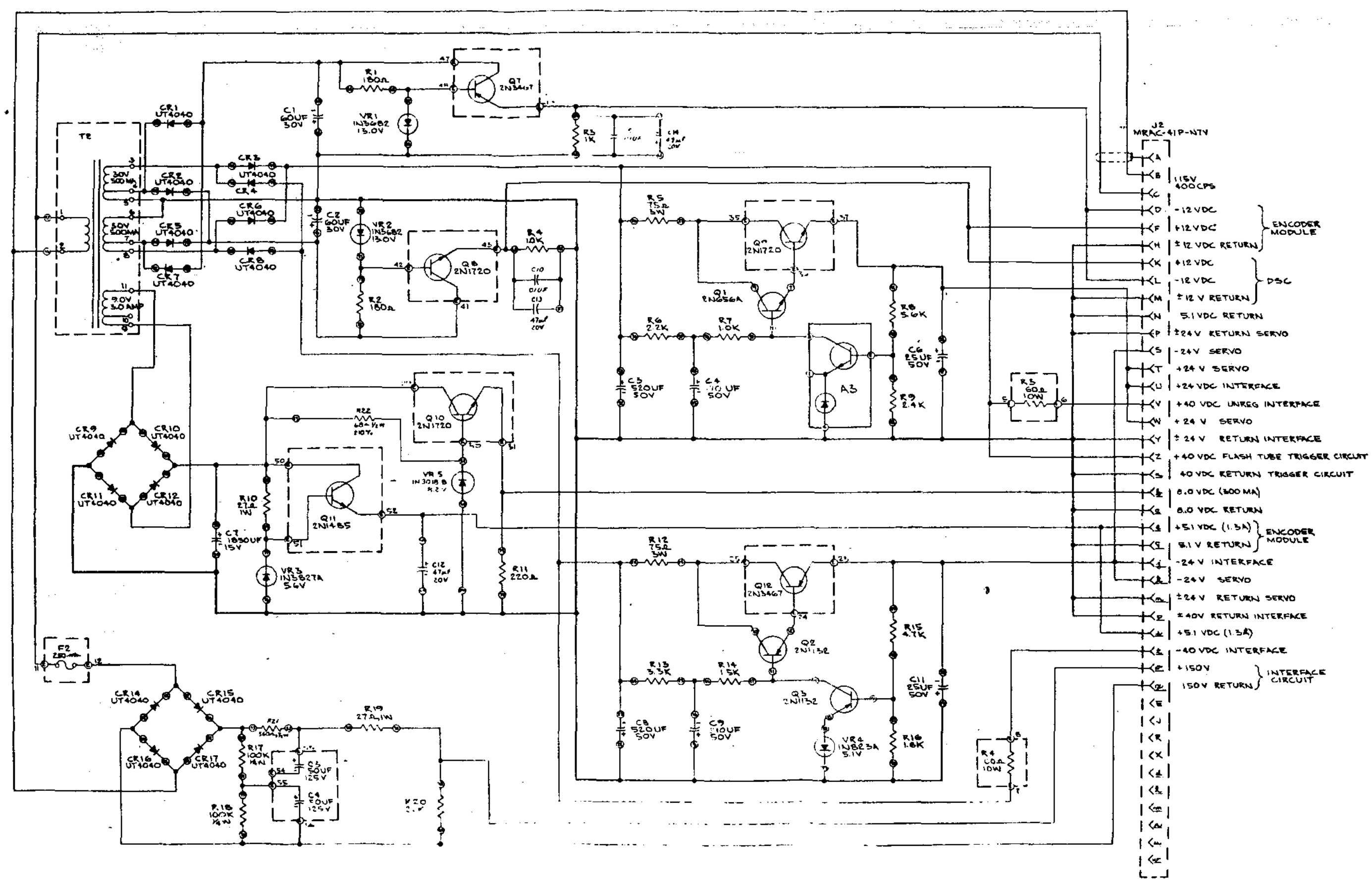


Fig. 7-11 — Schematic power supply no. 2, dwg. no. 88416-2

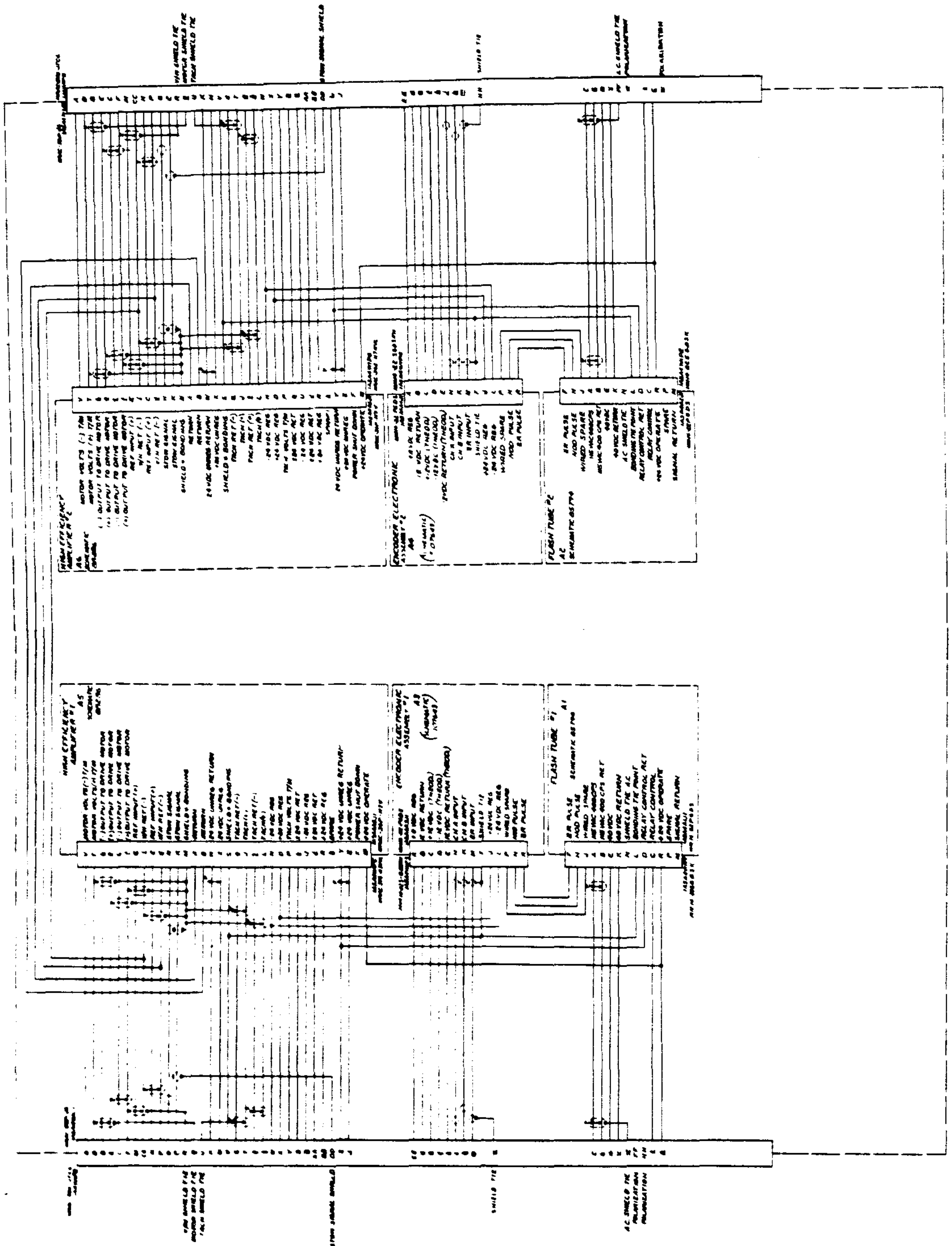


Fig. 7-12 — Auxiliary electronics box schematic, dwg. no. 107519

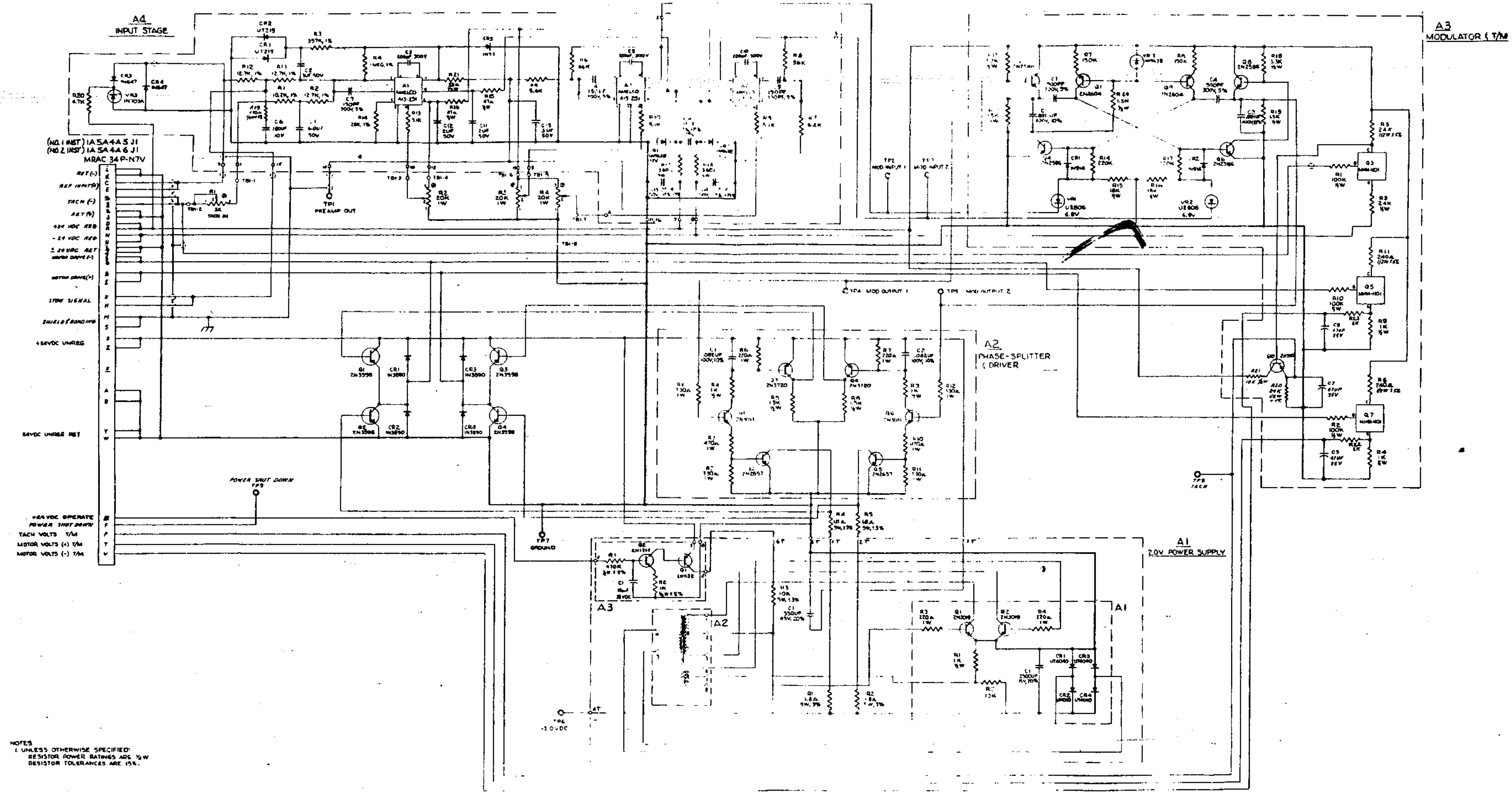


Fig. 7-13 — Electrical schematic, high-efficiency amplifier, dwg. no. 88286

SPECIFICATIONS:

1.0 GENERAL:
THIS DRAWING DEFINES THE REQUIREMENTS FOR A SERVO AMPLIFIER MODULE UTILIZING SOLID STATE ELECTRONICS COMPONENTS. THE MODULE CONSISTS OF TWO BASIC STAGES:
A1 - SERVO COMPENSATION STAGE
A2 - HIGH EFFICIENCY STAGE

2.0 ELECTRICAL REQUIREMENTS:
CONNECTIONS SHALL BE PROVIDED AS SHOWN IN FIGURE 2. SIGNALS AND POWER PROVISIONS SHALL MEET THE FOLLOWING SPECIFICATIONS:

2.1 INPUT POWER. ——— +24 VDC UNREGULATED (+29 TO +19)
±24 VDC ±1% REGULATED, 2 WATTS MAX
2.2 LOAD: ——— D.C TORQUE MOTOR, SEE ITEK DWG NO. 79125.
2.3 EFFICIENCY: ——— 90% @ 40 WATTS OUTPUT
2.4 OUTPUT VOLTAGE: ——— ±20 VDC EFFECTIVE (AT 24 VDC UNREG)
OUTPUT CURRENT (MAX) — CONTROLLED BY 33% TO 100% PULSE WIDTH LIMIT ADJUSTMENT.
2.5 DC GAIN STAGE A1 40% ±5%, STAGE A2: 30% ±10%
2.6 FREQUENCY RESPONSE: — STAGE A1. (SEE FIGURE 1)
STAGE A2: ±3DB TO 100 HZ
GAIN, PHASE, AND PULSE WIDTH LIMIT SETTING COMPONENTS MUST BE ACCESSIBLE FOR REPLACEMENT
2.7 COMMON RETURNS: ALL POWER AND SIGNAL RETURNS SHALL BE COMBINED WITHIN THE MODULE IN SUCH A MANNER THAT ERROR DETECTION IS ACCURATELY ACHIEVED
2.8 ERROR DETECTION: ERROR DETECTION SHALL BE ACCURATE TO WITHIN ±10 MILLIVOLTS REFERRED TO THE INPUT WHEN THE MODULE IS SUBJECTED TO THE OPERATING ENVIRONMENT
2.9 POWER SHUTDOWN: PROVISION SHALL BE MADE TO DIRECTLY TURN OFF THE SEMICONDUCTOR SWITCHES IN THE POWER STAGE BY THE APPLICATION OF GROUND POTENTIAL ON TP5
2.10 MONITORED POINTS: ISOLATED MONITORING PROVISIONS SHALL BE MADE FOR BOTH MOTOR LEADS AND FOR THE FEEDBACK SIGNALS IN A MANNER SIMILAR TO THAT SHOWN IN FIGURE 1. A3, A4 AND A5 SHOULD HAVE CHARACTERISTICS SIMILAR TO HONEYWELL P/N MHM 101
2.11 TEST POINTS: TEST POINTS SHALL BE PROVIDED AS SHOWN AND AS OTHERWISE REQUIRED FOR EXTERNAL ADJUSTMENTS. TEST POINTS SHALL BE ACCESSIBLE FROM THE TOP
2.12 POTENTIOMETERS: THE USE OF POTENTIOMETERS SHALL BE KEPT TO A MINIMUM. POTENTIOMETERS EMPLOYED SHALL BE ADJUSTABLE FROM THE TOP

3.0 MECHANICAL SPECIFICATIONS:
3.1 DIMENSIONS: ——— AS SHOWN
3.2 WEIGHT: ——— 3.25 LB MAX REF
3.3 THERMAL: DESIGN SHALL BE SUCH AS TO OPTIMIZE HEAT DISSIPATION BY RADIATION FROM THE OUTER SURFACES

4.0 CONSTRUCTION REQUIREMENTS:
4.1 MATERIAL:
4.1.1 TERMINALS: ——— BRASS, GOLD OR ELECTRO-TIN FINISH
4.1.2 TERMINAL BOARD: — PER MIL-P-997, TYPE GEG, CL H, SI GLS LAM
4.1.3 METAL PARTS: — MIL SPEC ALUMINUM ALLOYS
4.1.4 WORKMANSHIP: — PER ITEK QA WORKMANSHIP STD (QAWS) NO. 50
4.1.5 WIRE: — EXTRUDED TFE INSULATED WIRE PER MIL-W-16878/4
4.1.6 SOLDER: ——— PER QQ-S-571, COMP SN60, FORM W
4.1.7 POTTING MAT'L: — EMERSON (CUMING, INC, CANTON MASS, STYCAST 1090
4.1.8 COMPONENTS TO BE SECURED TO BOARD PER QAWS-50 SECTION 1.6 USING EMERSON (CUMING INC STYCAST 1264
4.2 FINISH: — BLACK ANODIZE PER MIL-A-8625 TYPE II
[4.3] MARKING: ——— APPLY MARKINGS PER ITEK SPEC S-1006-1 OR S-1006-5, .12 HIGH CHARACTERS
4.4 LOCKING: GENERAL ELEC. CO., PITTSFIELD, MASS. GLYPTAL, PURPLE CEMENT. APPLY TO ALL THREADED HARDWARE WHICH DOES NOT HAVE A LOCKING DEVICE. APPLY GLYPTAL RED ENAMEL TO INDICATE THREAD HAS A LOCKING DEVICE
GLYPTAL, RED ENAMEL

5.0 ENVIRONMENTAL REQUIREMENTS: (DESIGN REQUIREMENTS)
5.1 SHOCK: ——— MIL-E-5272C, 30G, 11 MILLISEC.
5.2 VIBRATION: ——— MIL-E-5272C, PROCEDURE XIV
5.3 OPERATIONAL TEMPERATURE: 25°C 120°C
5.4 STORAGE TEMPERATURE ——— -55°C TO 120°C

6.0 SUGGESTED SOURCE OF SUPPLY:
NORTHERN ELECTRONIC SYSTEMS
RANDOLPH, MASSACHUSETTS
(VENDOR MODEL A100 MODIFIED AS REQUIRED)

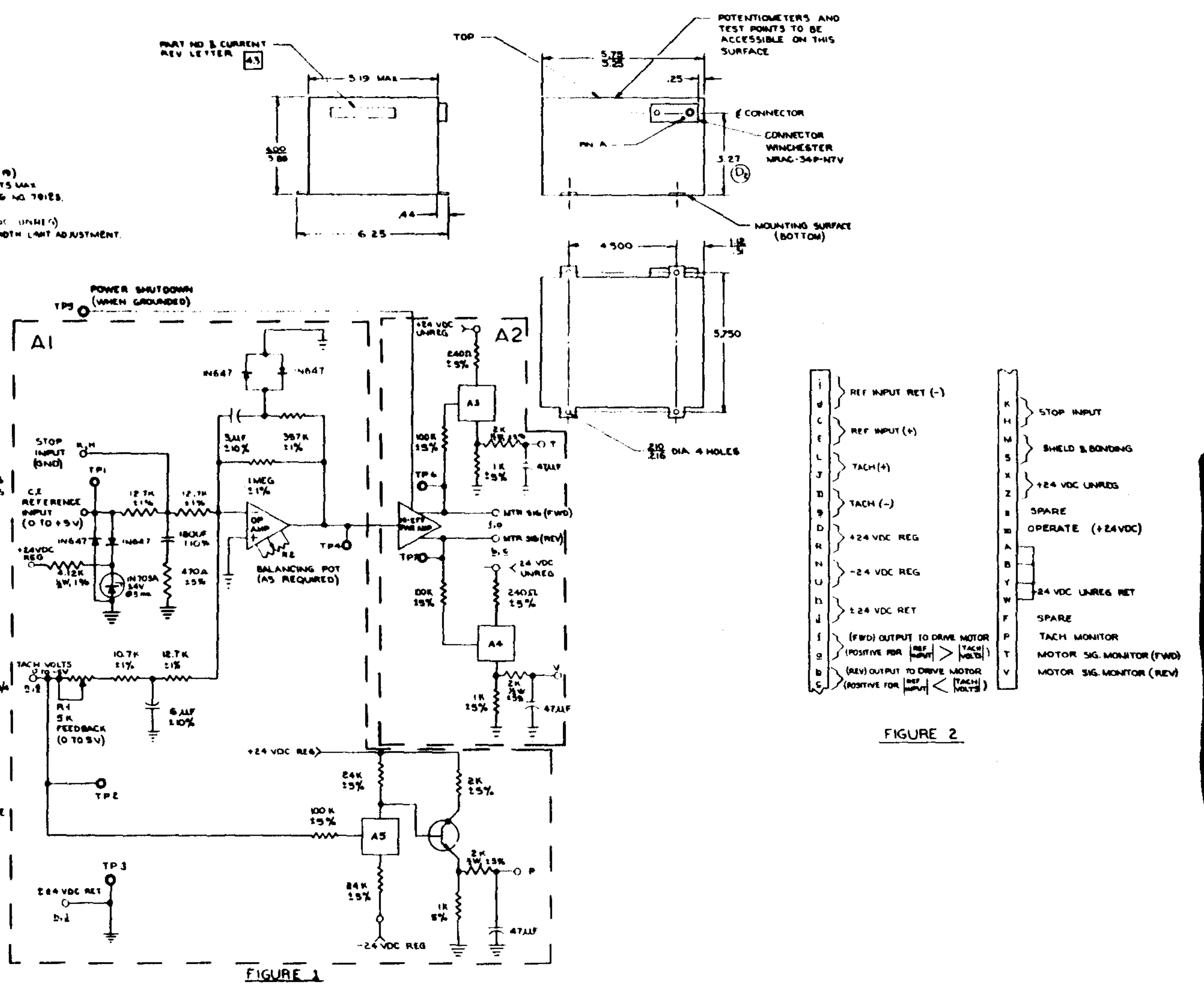


Fig. 7-14 — Amplifier, servo, high-efficiency, dwg. no. 88433

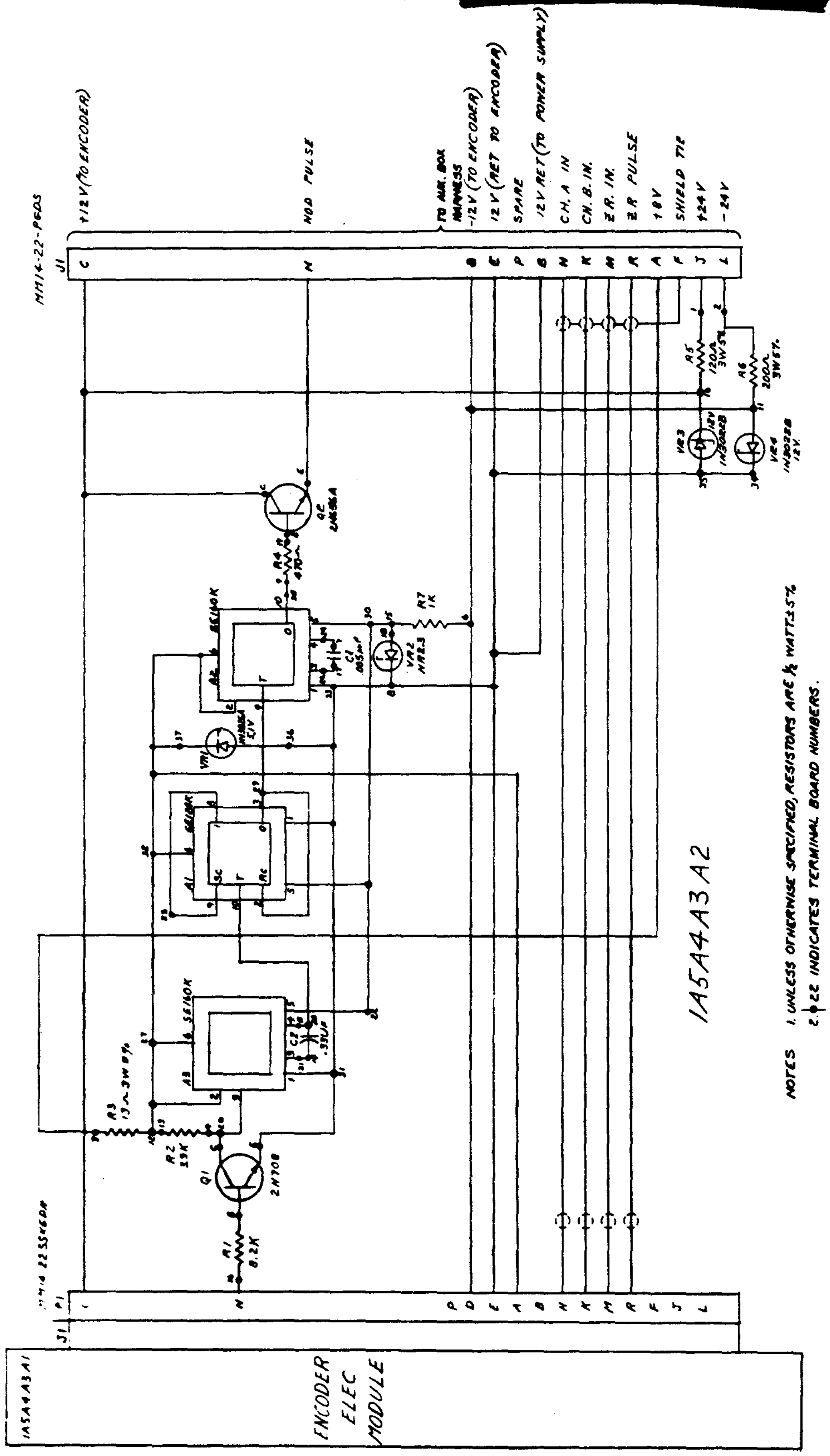


Fig. 7-15 — Schematic, signal conditioner nod encoder no. 1, dwg. no. 107643

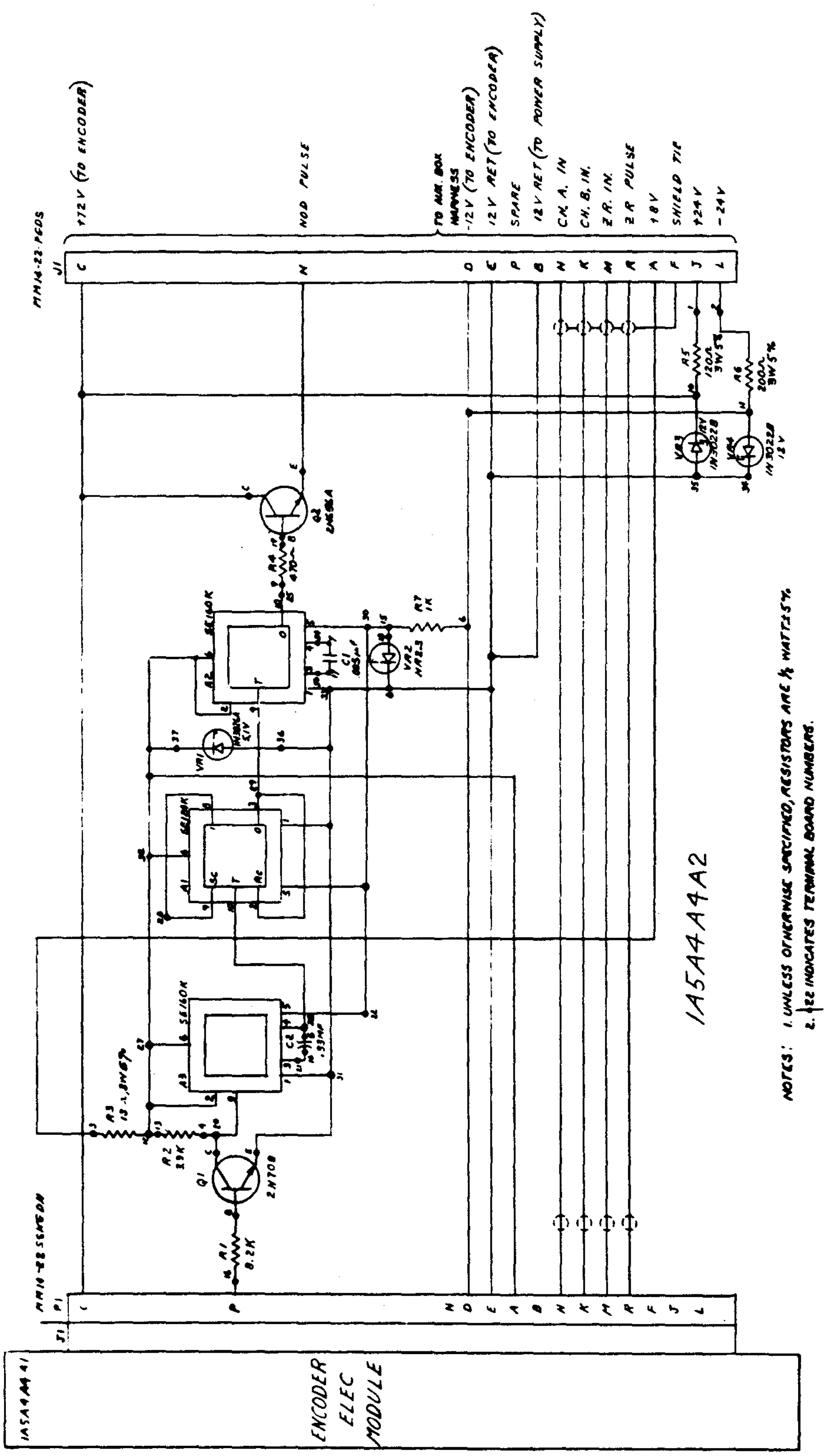


Fig. 7-16 — Schematic, signal conditioner nod encoder no. 2, dwg. no. 107748

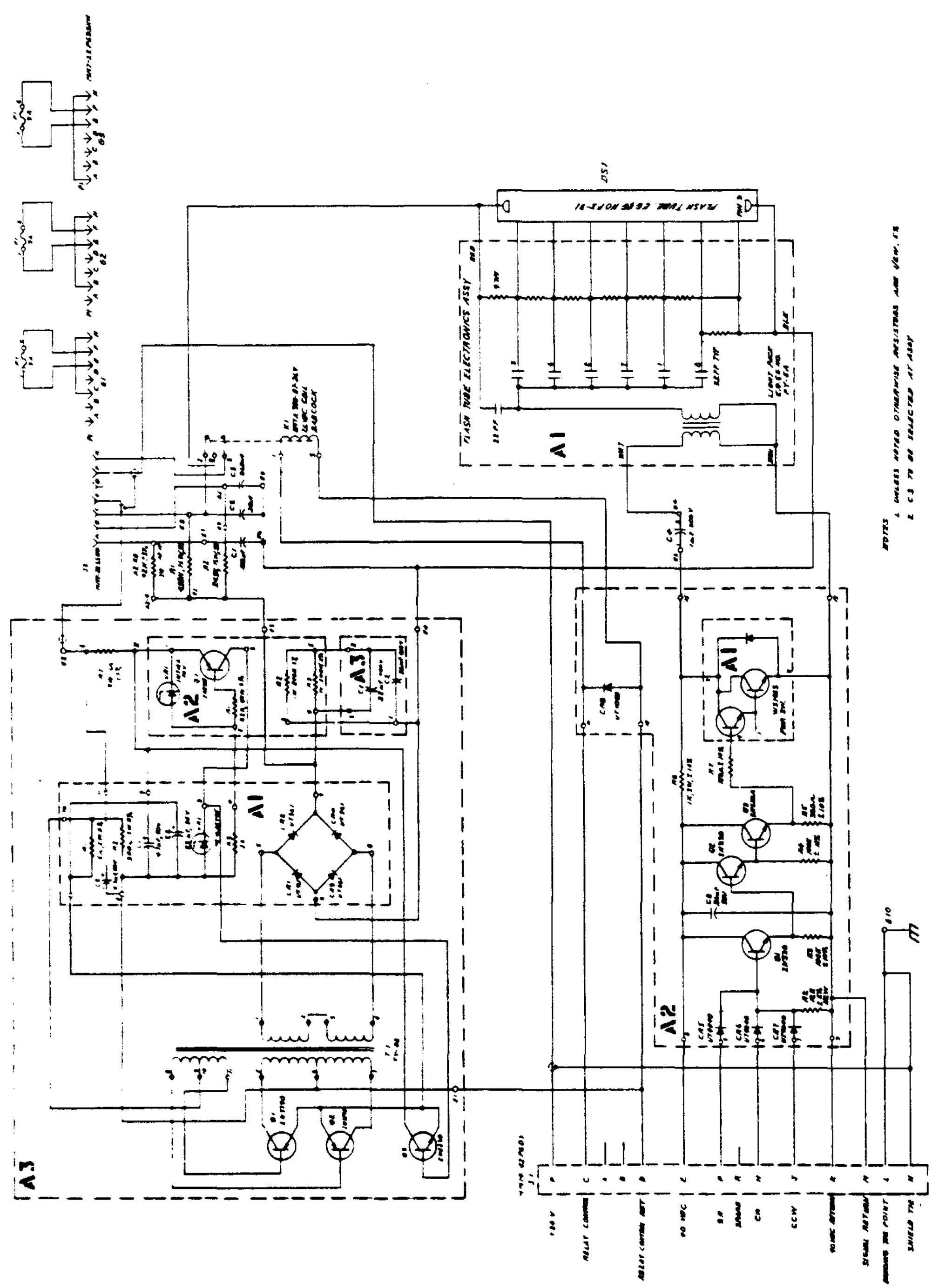
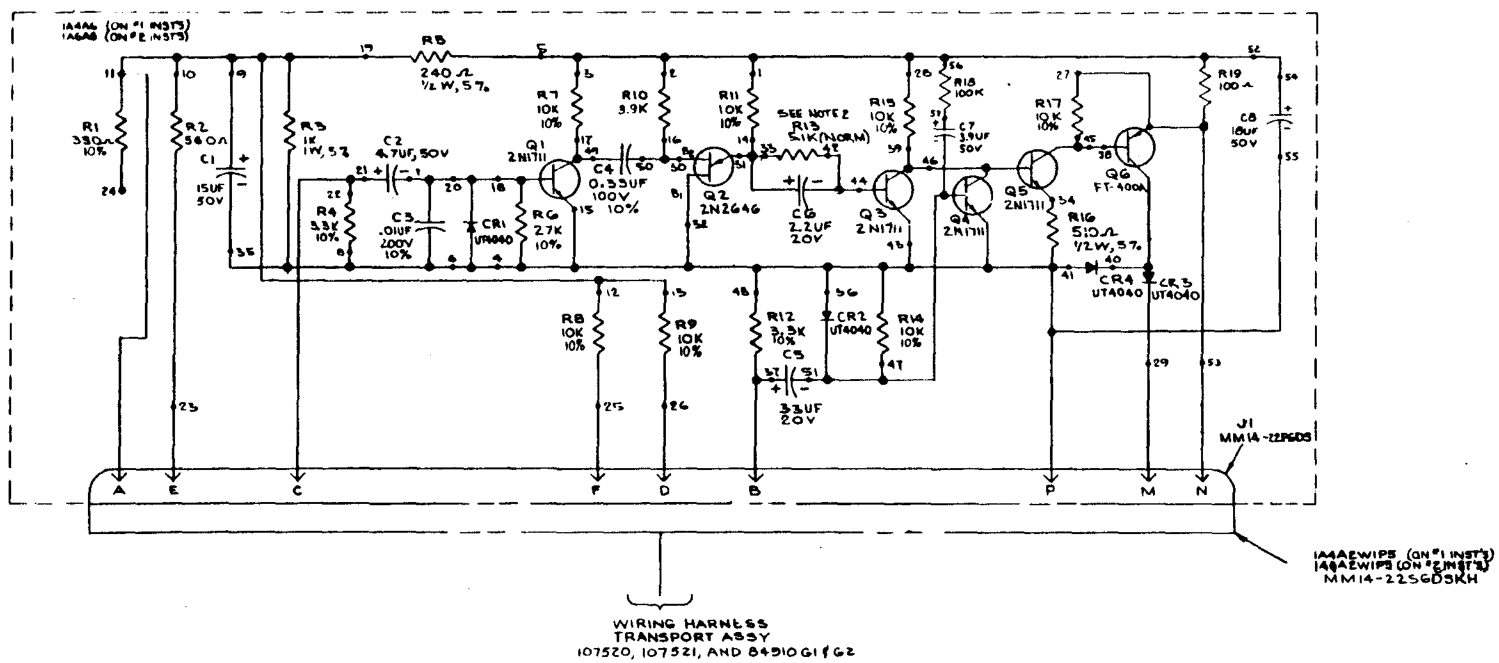


Fig. 7-17 — Schematic xenon tube, dwg. no. 107790



NOTES:
1. UNLESS OTHERWISE SPECIFIED:
   RESISTORS 1/4 W, 5%.
2. R13 IS A SELECTED VALUE.
3. •23 INDICATES TERMINAL BOARD NUMBERS

Fig. 7-18 — Electrical schematic (material change amplifier), dwg. no. 107631

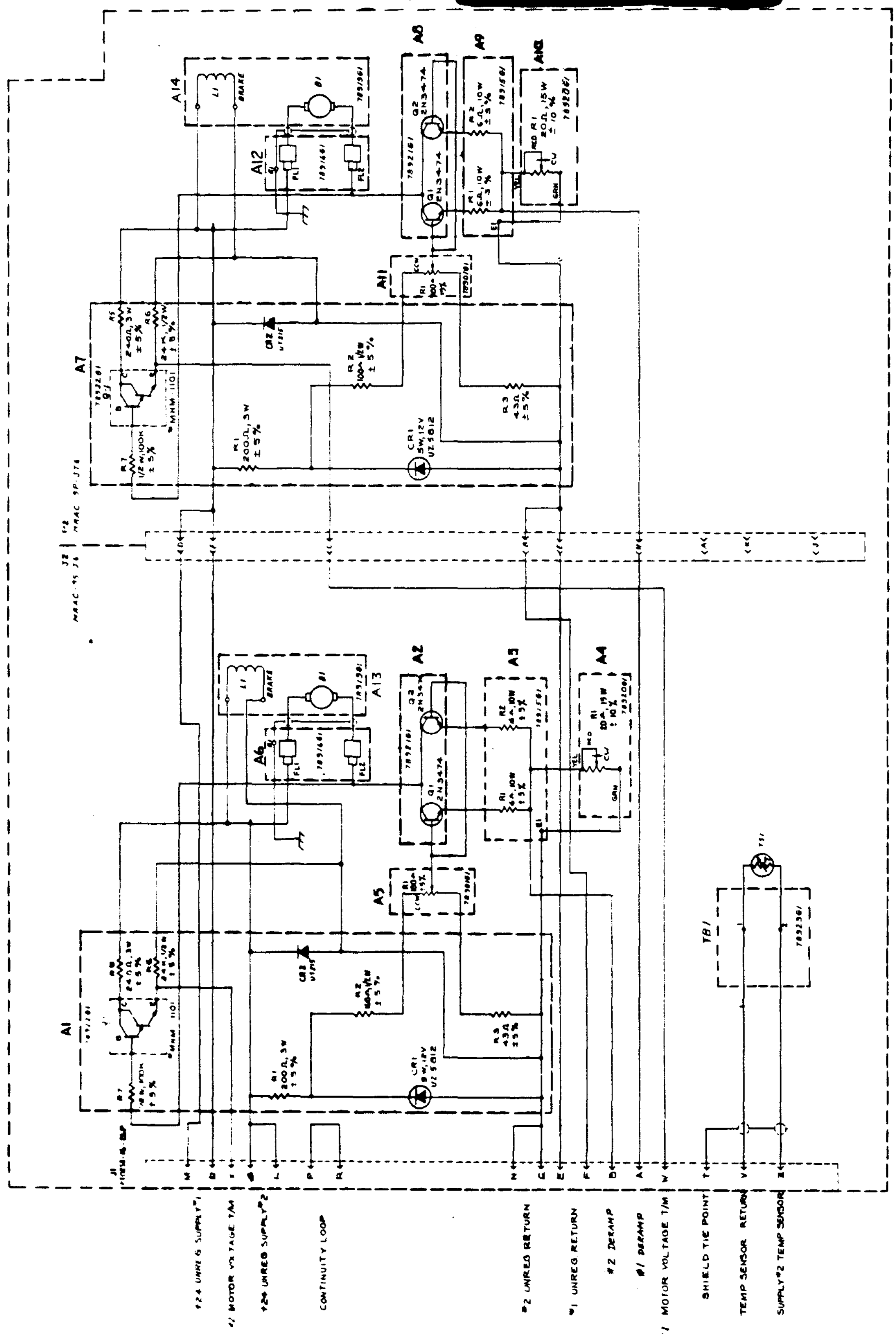


Fig. 7-19 — Schematic supply spool (support structure), dwg. no. 78943

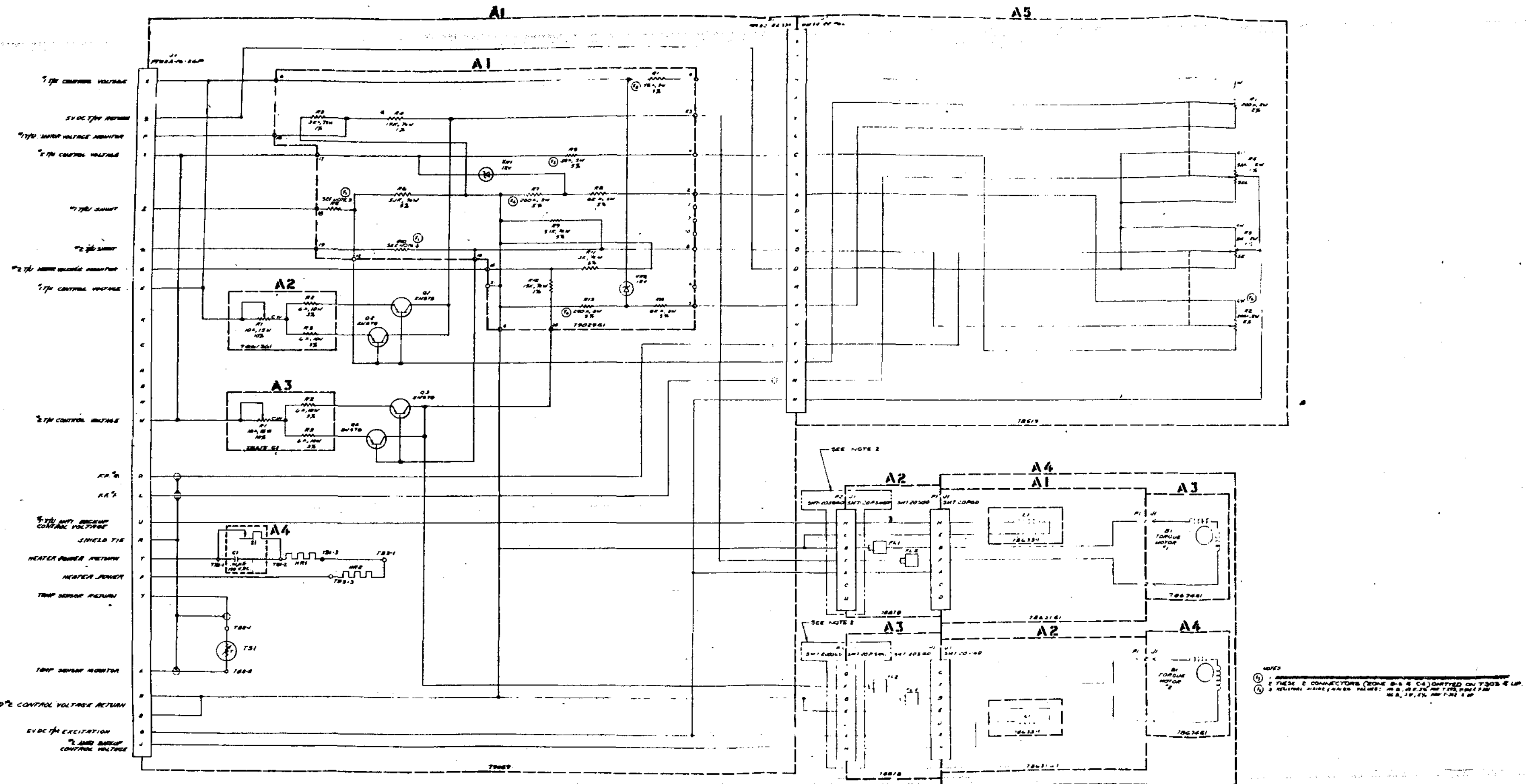


Fig. 7-20 — Schematic takeup A, dwg. no. 84827

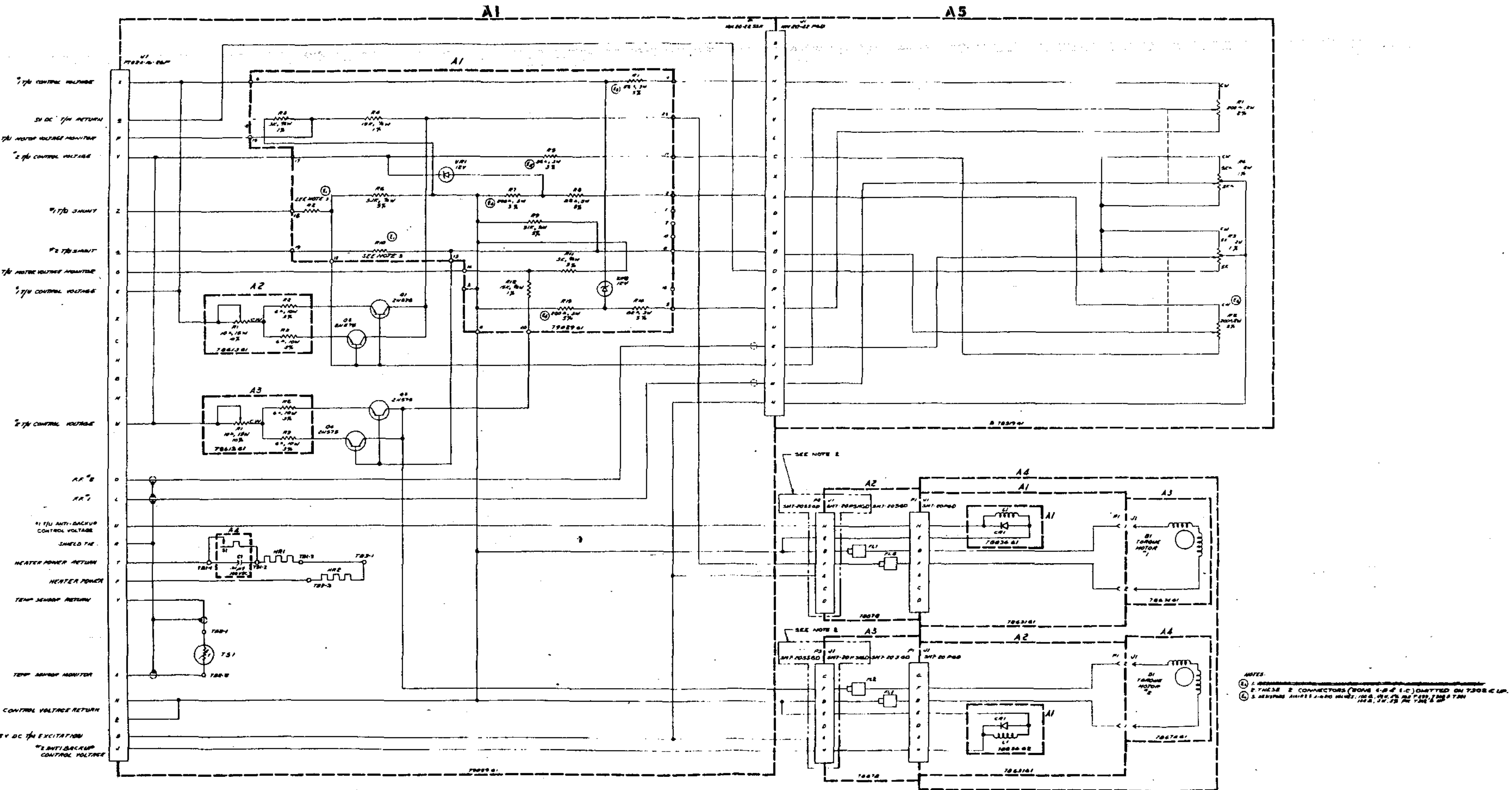


Fig. 7-21 — Schematic takeup B, dwg. no. 84828