SPACE ASTRONOMY

OF THE

STEWARD OBSERVATORY

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA

SIX-MONTH STATUS REPORT

NASA CONTRACT NSR 03-002-163

Technical Support Systems for Manned Space Astronomy

S 68 - 18

6 MONTH STATUS REPORT

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Technical Support Systems for Manned Space Astronomy

Submitted by:

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INTRODUCTION

The contract divides into two main task areas. The first task concerns the development of a 35 mm film cassett for utilization in astronomical photography in the space environment. The second task deals with the development of image dissectors as control and display systems for astronomical experimentation from manned space vehicles.

FILM CASSETTE PROJECT

The starting point for the film cassette program was an engineering prototype model which had been constructed through the Marshall Space Flight Center during the development program for the Arizona 6-Inch Ultraviolet Camera under contract NAS8-20651. (A photograph of the prototype appeared in the proposal document for this contract.) An engineering support purchase order was placed with J. A. Maurer, Inc., for assistance in a design review of the prototype. The Maurer Company was selected for this study since they have extensive experience in designing and building cameras and film magazines for space applications. They have built 16 mm and 70 mm cameras for the Apollo Program and are currently designing a 70 mm film magazine for the ATM Program.

The design review has been completed. The Maurer Company has expressed the opinion that the present magazine design is deficient in several respects, such that it would have little chance of performing satisfactorily under the conditions expected in space. This conclusion is in agreement with that previously reached by Arizona personnel which had caused us to institute this advanced study. The areas in which the design was determined to be deficient included the following:

1. Light shielding was inadequate.
2. Various non space qualified components were utilized, including components which have little chance of being qualified.
3. The film was improperly protected from the space environment. It is the opinion of the Maurer Company that the film should not be exposed to the ultrahigh vacuum of outer space but should be in a cassette which is at least slightly pressurized. In addition to pressure control, the temperature control provided in the preliminary cassette was felt to be inadequate.
4. Improper metal-to-metal contact between moving members, such as the worm gear drive for advancing the film, must be corrected.
5. The system showed generally poor or inadequate design on mechanical details, including excessive wobble of film reels, improper length of sprocket teeth and non-flatness of the pressure plate.
6. Various materials had been used, especially various plastics, which are known to have excessive outgassing under vacuum conditions with gasseous products which could contaminate optical surfaces.

The Maurer Company demonstrated several of their cameras and film magazines to Arizona personnel as examples of what they feel to be proper designs for space applications. The 16 mm film magazine for the Apollo Program was of particular interest; it appears that a relatively simple scaling of this design would make it applicable to the Arizona camera program. This magazine is a rapid load film cassette which snaps onto the camera; the film drive motor is separate from the magazine with a flexible coupling disconnect between the magazine and the camera.

As a result of the Maurer study, the space astronomy group asked the company to quote on the effort required to build a 35 mm magazine based on the

16 mm design; this quote has not yet been received. If the cost of such a design effort is reasonable, it would appear desirable to allow the Maurer Company to handle the design. If the cost is prohibitive, Arizona personnel will perform a preliminary design of this type. Until the quotation from the Maurer Company is received and reviewed, further effort by the University of Arizona on the film magazine has been stopped. Until a design decision is reached, no fabrication effort of a new magazine can be started.

Several tests of the engineering prototype film cassette were carried out under modest vacuum conditions. The film was exposed to a vacuum of approximately 20 microns for periods of up to 72 hours. For these times and at these pressures, the film cassette worked satisfactorily and the film showed no significant degradation. The film used in these tests was 103a-0 with rem jet backing. Using this type of backing prevented static electrical problems.

IMAGE DISSECTOR CONTROL AND DISPLAY SYSTEM (IDCADS)

The key element of the IDCADS task consists of the design and fabrication of a prototype system for utilization on the University of Arizona 90-inch telescope. The system will demonstrate the feasibility and effectiveness of image dissectors for remote control of operations and data collection, both for astronomical imagery and photometry. This program provides basic technology necessary for a realistic approach to a man oriented photometric experiment from an ATM type space vehicle under the control of the scientist astronauts, such as previously proposed by the University of Arizona. The effort to date has concentrated in two main areas, mechanical design and electrical design.

Mechanical Design

The IDCADS system may be subdivided into four basic modules. The first unit is a base ring gear which provides an interface to the telescope and position angle orientation of the experimental package. The second module is the mounting plate which adapts to the ring gear and carries necessary guides and screws for radial positioning of the control and data collecting modules. The first of the modules carried on the base plate is the guidance and acquisition module denoted M1. The second unit is the principal data collecting module, M2, which provides for photoelectric, image dissector area scanning and photographic data acquisition.

The base ring gear assembly consists of an adapter plate to provide a mounting interface between the IDCADS instrument and the Boller and Chivens offset guider which is the mounting point to the 90-inch telescope. This adapter plate has been designed and fabricated. A main ring gear, which attaches to the adapter plate, provides position angle orientation of the data collecting modules. The gear has been ordered from the Messinger Bearing Company and is scheduled for delivery in mid-December. The main drive gear for positioning the ring gear has also been ordered from the Messinger Bearing Company for delivery in December. Figure 1 is a schematic drawing of the base ring gear and mounting plate system.

The main base plate provides the mounting for the guide rails along which modules M1 and M2 are shifted in radial position. This base plate mounts directly to the outer race of the gear adapter. The base plate also carries the drive mechanisms for the radial modules including the drive screws, motors and encoders. The base plate is approximately 50% designed with final completion awaiting the detailed layout of modules M1 and M2. The drive screws and precision nuts for module positioning have been ordered from Saginaw Steering Gear (GMC). Delivery is expected shortly.

Module 1, which provides guidance and field acquisition, has been completely designed and fabrication is approximately 60% complete. Figure 2 presents

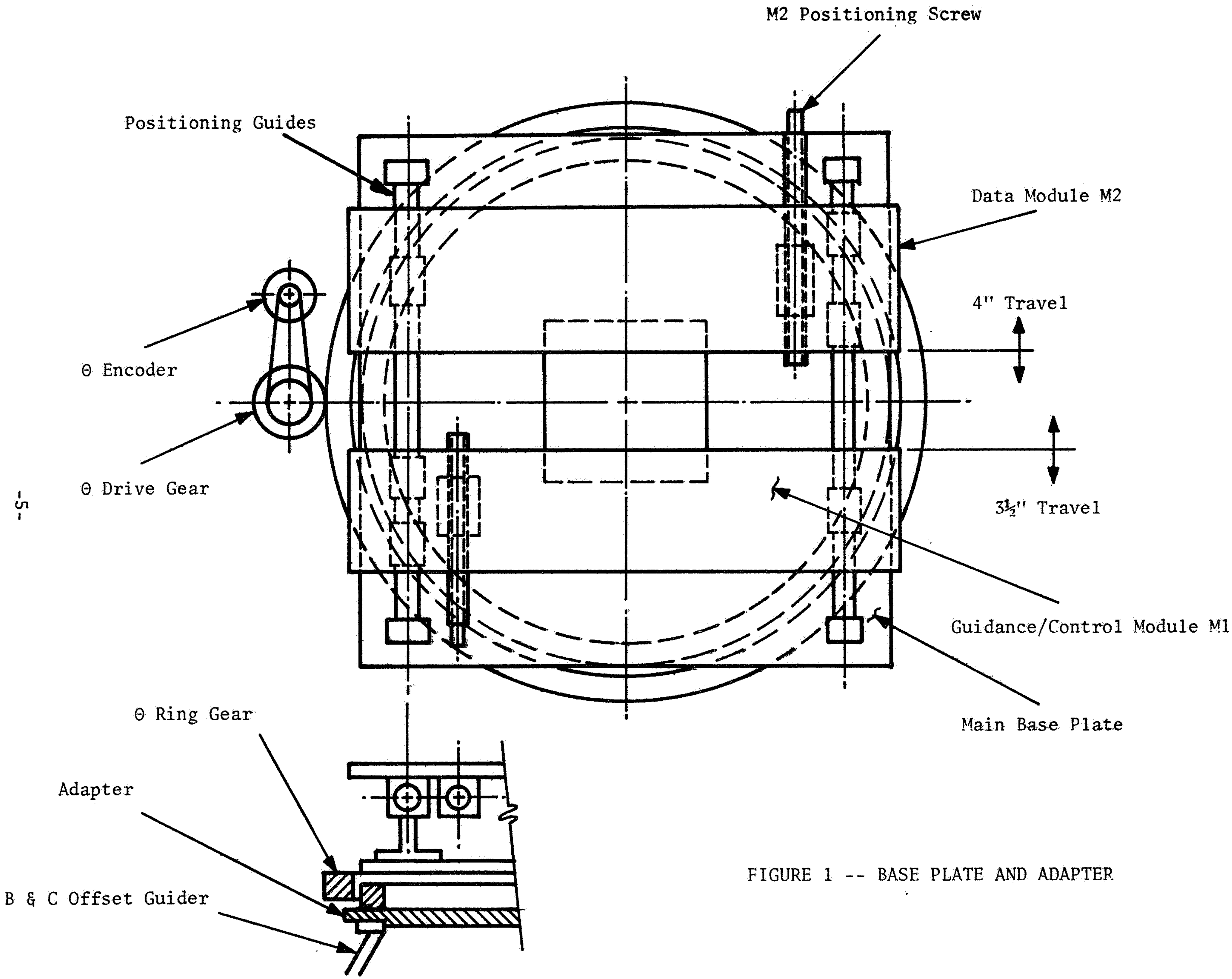


FIGURE 1 -- BASE PLATE AND ADAPTER

the optical schematic for Module 1. It consists of a mirror which may be turned to direct the telescope focal plane into either an acquisition field viewer image dissector or into the main guidance image dissector. Both image dissectors are ITT 4011 tubes; the guider having an 0.040 inch aperture and the viewer having either an 0.0025 or 0.006 inch aperture. The aperture dimensions are determined by the star image scale in the focal plane of the telescope. The guidance module will normally work with stars in the peripheral portions of the field of view.

Module 2, which provides data acquisition, divides into four parts. In the center a turret mirror directs the field being viewed into one of three subsections. The subsections are in turn a photoelectric cell assembly, a photographic film system and an image dissector area scanning system. Figure 3 shows schematically the locations of the subsystems with respect to the turret mirror.

The photoelectric cell assembly is shown schematically in Figure 4. The field being viewed is isolated with a focal plane aperture and is then relayed by the turret mirror through a series of filters and the fabry lens to the photocell. Originally an adjustable iris diaphragm was to be utilized as the focal plane aperture. This has now been replaced by a disc with a selection of apertures ranging from .5 mm to 10.0 mm. The aperture assembly is mounted on a precision x-y table which is positioned by high speed stepping motors under the control of the guidance system in Module 1. Any displacement in the position of the object being observed is compensated by repositioning of the aperture. The aperture may be shifted over a ±.1 inch range at a rate of .1 inch per second. This aperture positioning assembly is presently being designed.

The photocell and the image dissectors discussed below must be refrigerated

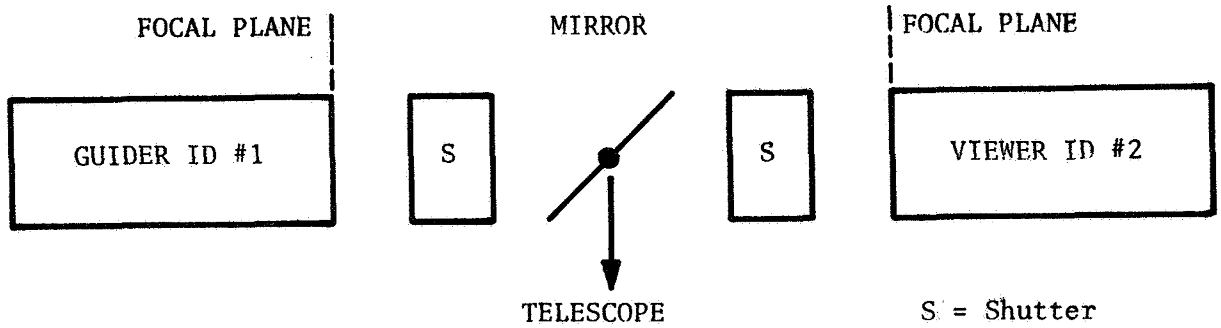


FIGURE 2 -- MODULE 1

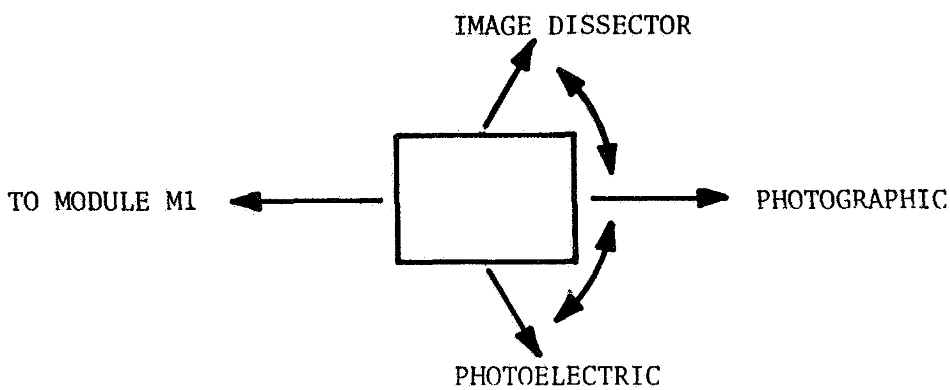


FIGURE 3 -- MODULE M2 TURRET MIRROR

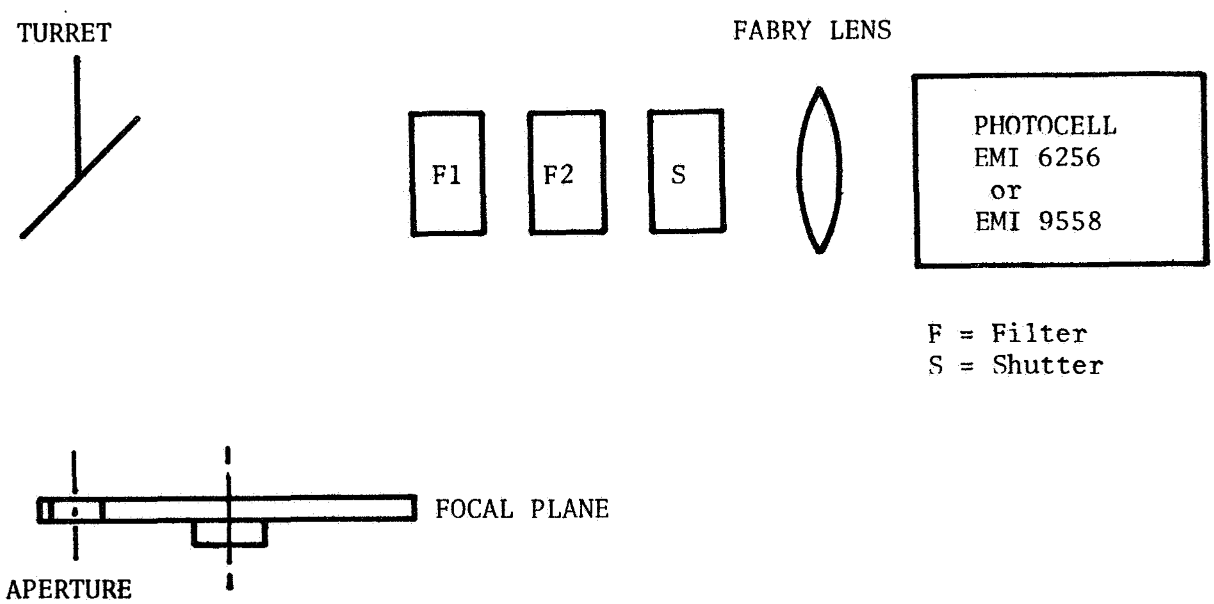


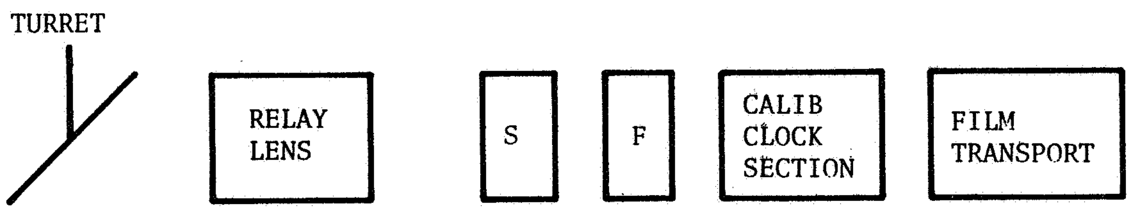
FIGURE 4 -- PHOTOELECTRIC SECTION

to obtain proper performance. The method of cooling which will be utilized consists of a closed loop two stage Freon 12 refrigeration system. This technique for cooling was selected as being the most compact and convenient for the particular system. Alternates, such as powdered dry ice or dry cold nitrogen gas systems, are either mechanically inconvenient or insufficiently developed for utilization at this time. Full details on the cooling system are now being researched in preparation for detailed design.

Figure 5 shows schematically the optical layout for the photographic film system. The focal plane is relayed via a transfer lens to the film transport mechanism. Guidance is accomplished by either translating the relay lens or the film transport mechanism in a manner very similar to the translation of the focal plane aperture for the photoelectric section. Techniques being used to position the transfer lens in the Princeton Stratascope experiment are being investigated for possible utilization with the transfer lens in the IDCADS system. Portions of the Arizona 6-inch camera design, specifically the calibration and clock systems, are being adapted for use with the film recording portion of IDCADS. The film transport mechanism utilized may be the Arizona camera 35 mm cassette or alternate available transports presently being researched.

The image dissector section of Module 2 is shown schematically in Figure 6. The focal plane image is relayed to a pair of image dissectors through a beam splitting system. Simultaneous observation in two fields is, therefore, possible. Guidance of the image dissectors is accomplished by direct deflection bias under the direction of Module 1. A calibration source may be directed into the image dissector system to provide regular calibration of the cathode sensitivity.

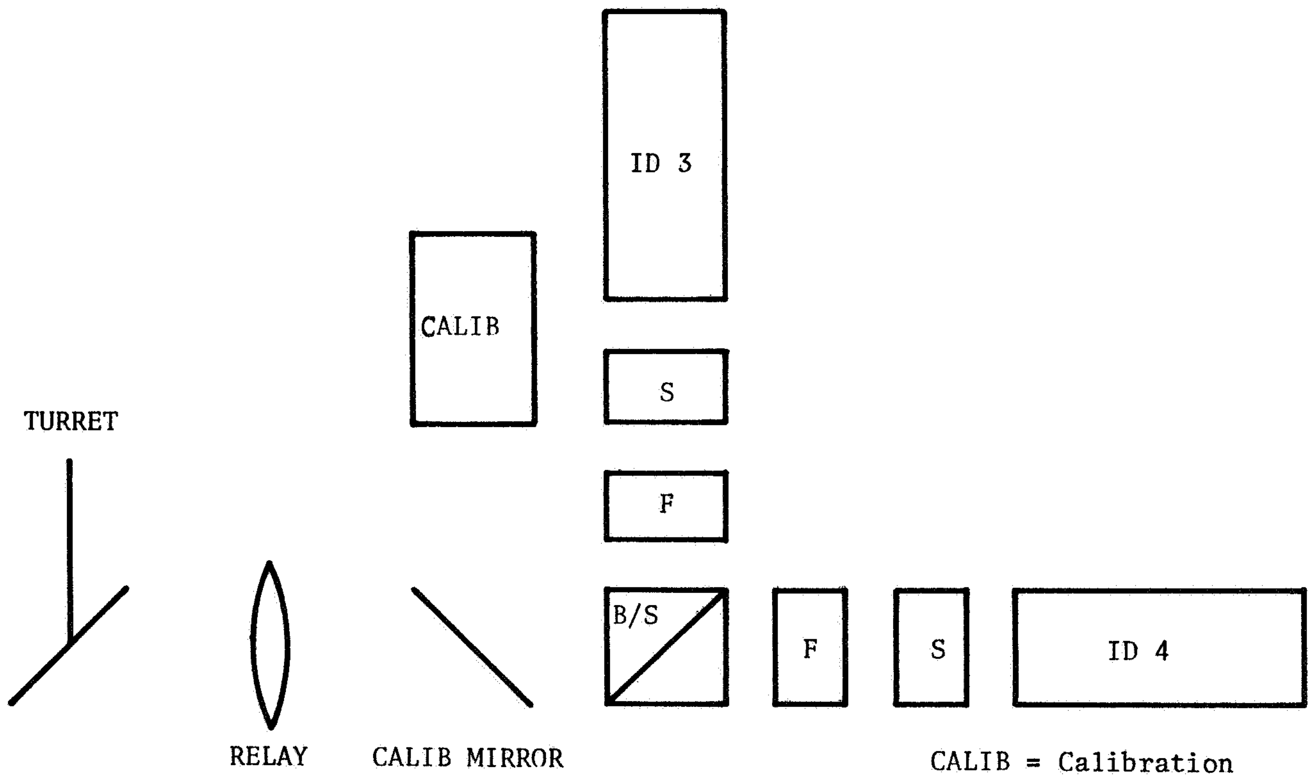
The first image dissector for the IDCADS project has been received. The



CALIB = Calibration
S = Shutter
F = Filter

----- FOCAL PLANE

FIGURE 5 -- PHOTOGRAPHIC SECTION



CALIB = Calibration
S = Shutter
F = Filter
B/S = Beamsplitter 50/50

----- FOCAL PLANE

FIGURE 6 -- IMAGE DISSECTOR SECTION

cells being utilized are ITT 4011 image dissectors with S11 cathodes. The dark current for this type of cell is in the vicinity of $.2 \times 10^{-9}$. The dark current appears to be primarily dynode dark current and is obviously of a magnitude which will require cooling for satisfactory astronomical operation. The principal complication with image dissector cooling is that the deflection and focus coils which closely surround the tube must also be cooled. They provide a constant source of heat, therefore, placing some load on the cooling system. Very little experience presently exists with regard to the cooling of image dissector cells; however, there appears to be no reason why these cells will not respond as any other normal photocell to the cooling process.

Design effort to date on Module 2 has consisted primarily of work with the focal plane aperture system and the photocell and image dissector cooling systems. Only preliminary details exist for the remainder of Module 2.

Electrical Design

The IDCADS electrical system includes control of the base frame for radial and angular positioning of Modules 1 and 2, functional control of the operations on Modules 1 and 2, and the processing and recording of data generated by Module 2. The image dissectors are used in three different ways--guidance, field viewing and direct photoelectric detection or area scanning. The entire IDCADS system is remotely controlled from a console approximately 60 feet distant from the assembly.

The base frame controls have been designed and partially constructed. All parts have been ordered and many have been received. Controls for filter selection, shutter operation, aperture selection, and various mirror and lamp controls are presently in the process of design.

Design of image dissector deflection circuitry for the guidance and viewing modes of operation is essentially complete. These circuits have been partially constructed. The guidance error detection and guidance control circuitry to correct errors in the telescope position or in the various data collecting modules have been designed and breadboarded as far as the error detection portion. The control circuitry is under investigation to determine which of several alternative modes is most practical. The viewing system operates by displaying the image dissector scan on a storage oscilloscope screen. The scan from any portion of three of the four image dissectors in the system can be displayed. The storage scope has been received.

Figure 7 shows schematically how the signals from the photocell or Module 2 image dissectors are processed and recorded. Pulse amplifiers and voltage to frequency converters are presently being investigated to determine whether to utilize commercial units or to build units in-house from circuits which have been developed at other institutions. Photometric controls to determine such factors as input selection, gain and prescale settings, integration time count direction, and general information recording have been defined and many of the parts selected. The principal reversing counters have been ordered. Circuitry to select and sequence information to be recorded is designed and most parts, including the incremental tape recorder, have been ordered. The control console panel layout has been completed and most of the components selected. Nearly all major items for the IDCADS electronic systems have been ordered. Some equipment is shared with other NASA programs, notably the NsG-732 grant.

It presently appears that the first assembly and operational tests of the IDCADS system can occur in January or February, 1969.

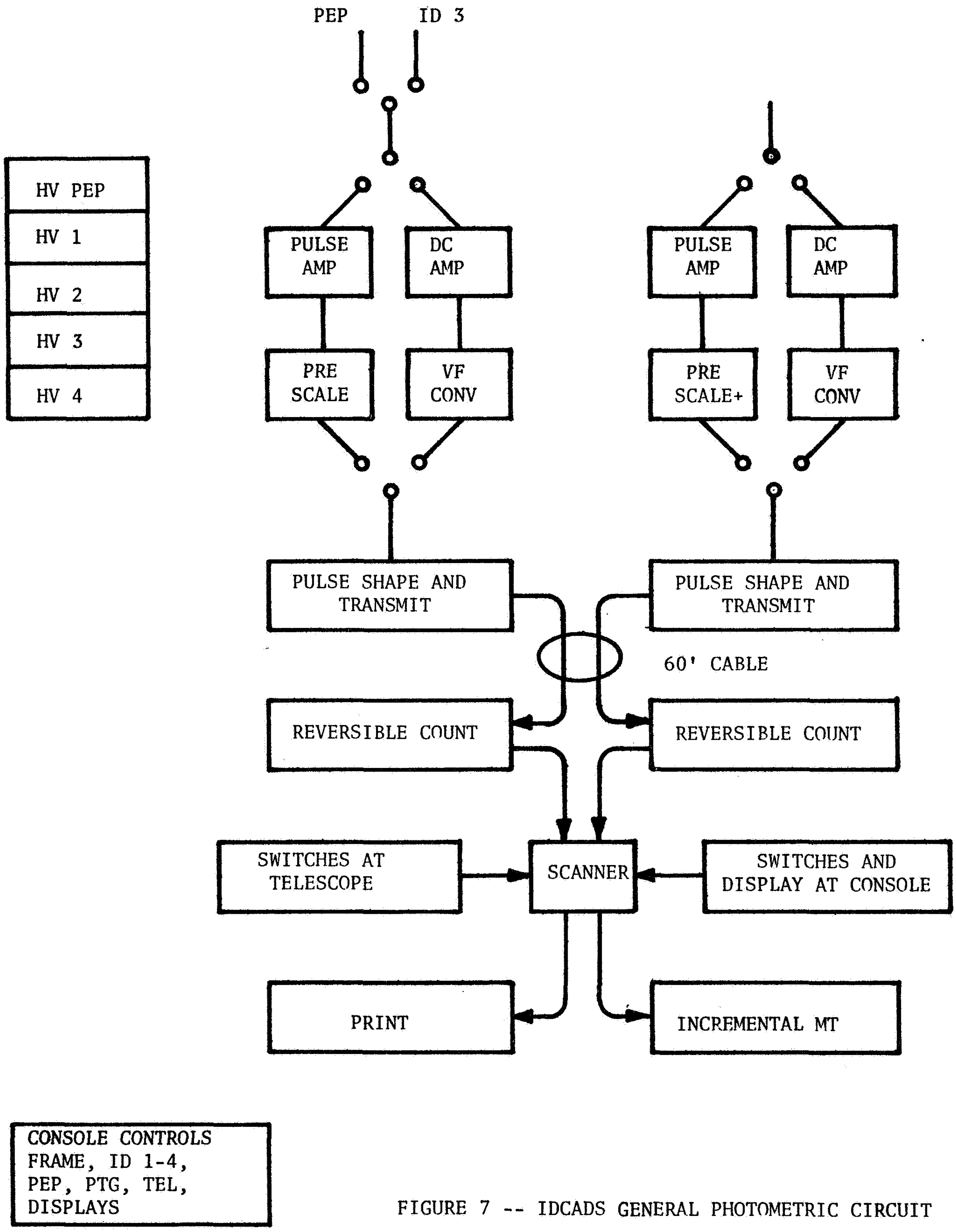


FIGURE 7 -- IDCADS GENERAL PHOTOMETRIC CIRCUIT