~~TOP SECRET~~ CORONA

[redacted]

[redacted]

TOTAL
PAGES 117

MURAL SYSTEM [redacted]

C [redacted]

PERFORMANCE EVALUATION

REPORT

24 January 1964

Handle Via [redacted] Controls Only

~~TOP SECRET~~ CORONA

FOREWORD

This PET Report includes an analysis of Missions 9056, 9057, 1001-1, and 1002-1. These flights occurred on 26 June, 18 July, and 24 August 1963, respectively. The several missions are incorporated into one report in order to compare one with another and to look at factors which are not universally present in all missions. For example, Mission 9056 had a yaw programmer and a Titanium/Invar Drum and Mission 1001-1 had a higher instrument temperature than the others. Mission 9057 is considered to be "typical" and the bulk of the analysis is concentrated on this mission, but loss of the Index camera on this mission precludes an analysis of system mapping capability on this mission. System mapping capability was therefore analyzed by ACIC using Stellar-Index photography from Mission 1002-1.

It should be noted that this report is to some degree afte the fact and system changes have since been incorporated which influence the team's recommendations concerning system improvements.

PUBLICATION REVIEW

This report has been reviewed and is approved.

Albert W Johnson
ALBERT W. JOHNSON
Captain, USAF
PET Chairman

ABSTRACT

An evaluation of the Corona M/J System was made using data from Mission 9056, 9057, 1001-1, and 1002-1. The bulk of the analysis is concentrated upon Mission 9057. Comparisons of one system with another were made, and isolated factors pertaining to individual missions were analyzed.

The evaluation was performed by representatives of AFSSD, LMSC, and ITEK assisted by personnel of the National Photographic Interpretation Center, Army Map Service, Aeronautical Chart and Information Center, and the 6594th Test Squadron (AFSPPL) (AFSC).

It is concluded that the photography collected by the M/J System is suitable for search intelligence and that it has considerable capability for mapping purposes.

Average ground resolutions were estimated to be 24 feet (12 foot object size) for Mission 9057, slightly greater than 24 feet for Mission 9056, and approximately 40 feet (20 foot object size) for Mission 1001-1.

The variations are attributed to temperature effects and to a light leak on Mission 9056. The Stellar-Index malfunctions appear to have been corrected by the changes made on the later missions.

Recommendations are included to further optimize the system performance.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

Page

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont'd)

LIST OF TABLES

PERFORMANCE EVALUATION TEAM

PARTICIPANTS

AFSSD

[redacted]

Captain Albert W. Johnson (Chairman)

6594TH TEST SQUADRON

[redacted] Commander

Technical Staff

NPIC

[redacted]

Technical Staff

ACIC

[redacted]

Technical Staff

LMSC

[redacted]

ITEK

[redacted]

Mr. Francis J. Madden

TEAM OBJECTIVES

The objective of this evaluation is to analyze Mural System performance and the degree to which the system meets design objectives. The PET evaluation includes an analysis of system malfunctions, attempts to correlate performance indicators with the various degrading factors, and makes recommendations for system improvements.

SECTION I

MURAL SYSTEM DESCRIPTION

The payload section of the Mural (J) System consists of the camera subsystem, space structure subsystem and recovery subsystem. The payload section is boosted into orbit by the Thor or Improved Thor with second stage propulsion and orbit injection performed by the Agena D vehicle.

1. Camera Subsystem

The M/J Camera System consists of two high-acuity panoramic cameras aligned for 30 degree convergent stereoscopic photography (Figures 1, 2, and 3). Each camera incorporates a constantly rotating, 24-inch focal length, f/3.5, Petzval lens system, the velocity of which is matched to a reciprocating scan head during film exposure. The basic operation of both cameras is the same, with one camera acting as a "Master" instrument and the other as a "Slave." The Master camera carries the double frame camera programmer and the V/h programmer, and is the forward-looking instrument in operation.

The power to operate each of the cameras is supplied by three motors; the supply and cassette torque motors, and the camera drive motor, all of which are energized simultaneously upon receipt of an "operate" signal. The M-System supply torque motor maintains constant film tension

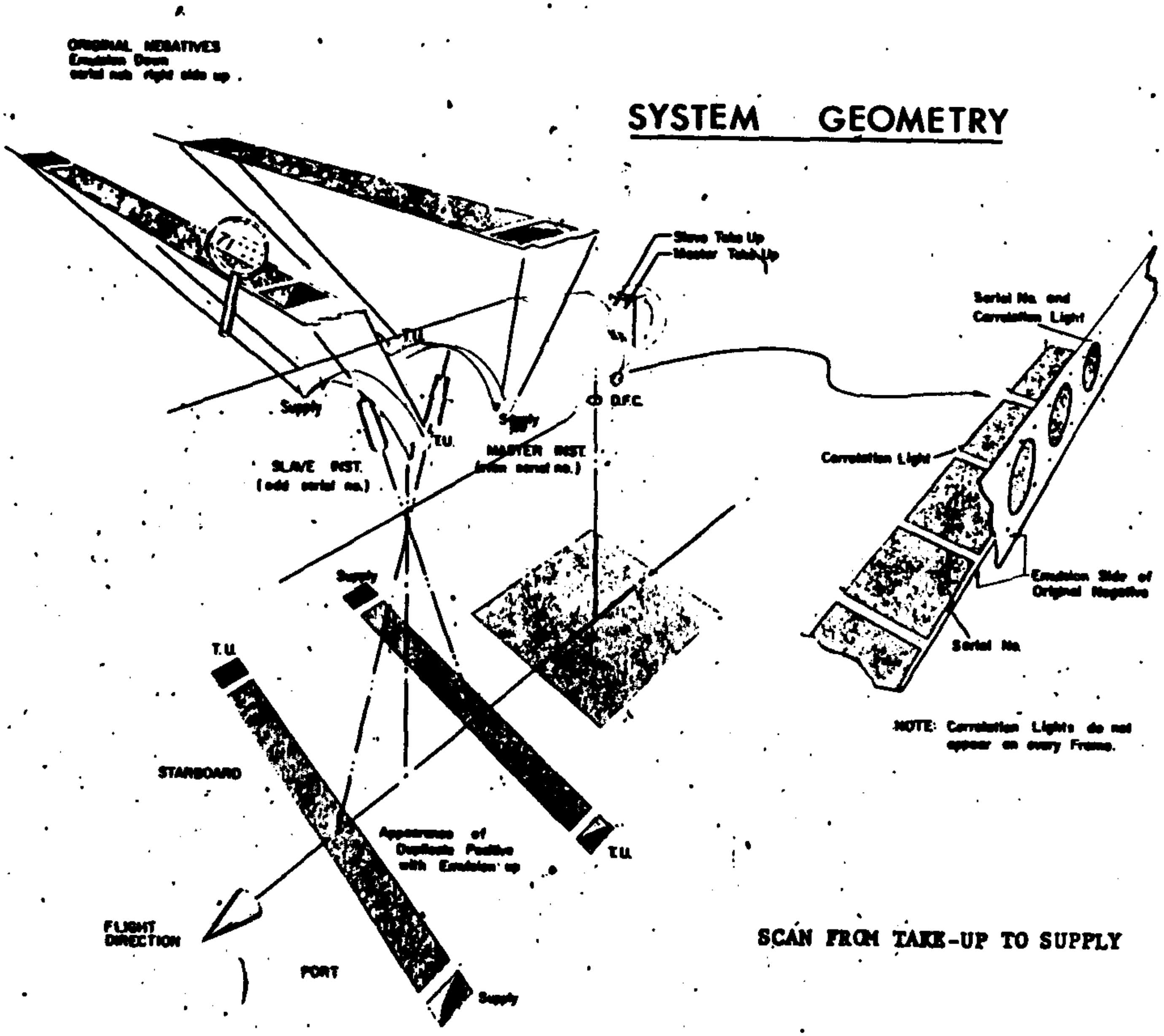
FIGURE 1

J SYSTEM CAMERA

FIGURE 2

MURAL PET REPORT/64

SYSTEM GEOMETRY



SCAN FROM TAKE-UP TO SUPPLY

FIGURE

on the supply side of the transport system by attempting rotation in a direction counter to film transport, and the cassette torque motor maintains constant film tension through the camera system beyond the input metering roller and provides the power required to take film out of the camera and onto the take-up spools. Power for all other camera functions is supplied by the camera drive motor.

When the camera drive motor is energized, the lens begins to rotate (one lens rotates in counter-direction to the other), the metering roller feeds film into the camera, and the scan arm begins its reciprocating motion (Figure 4). A timing belt linkage to the camera drive motor rotates the lens 360 degrees about the lens vacuum nodal point at a constant velocity (for a given V/h). At the same time, the camera drive motor supplies power to the scan arm through sector gears, a cam and cam follower, and another timing belt linkage. The scan arm cam, which provides the proper position and velocity relationships between the lens and the scan arm, is accurate to within 0.25 percent. While the lens is rotating and the scan arm oscillating, unexposed film is fed from the supply spools into the camera through a system of metering, pressure, idler, and shuttle rollers. Camera drive motor power is transmitted to the input metering roller through a timing belt linkage and one of two alternate gear trains. The resulting tension on the film up to the input

M/J CAMERA OPERATING SCHEMATIC

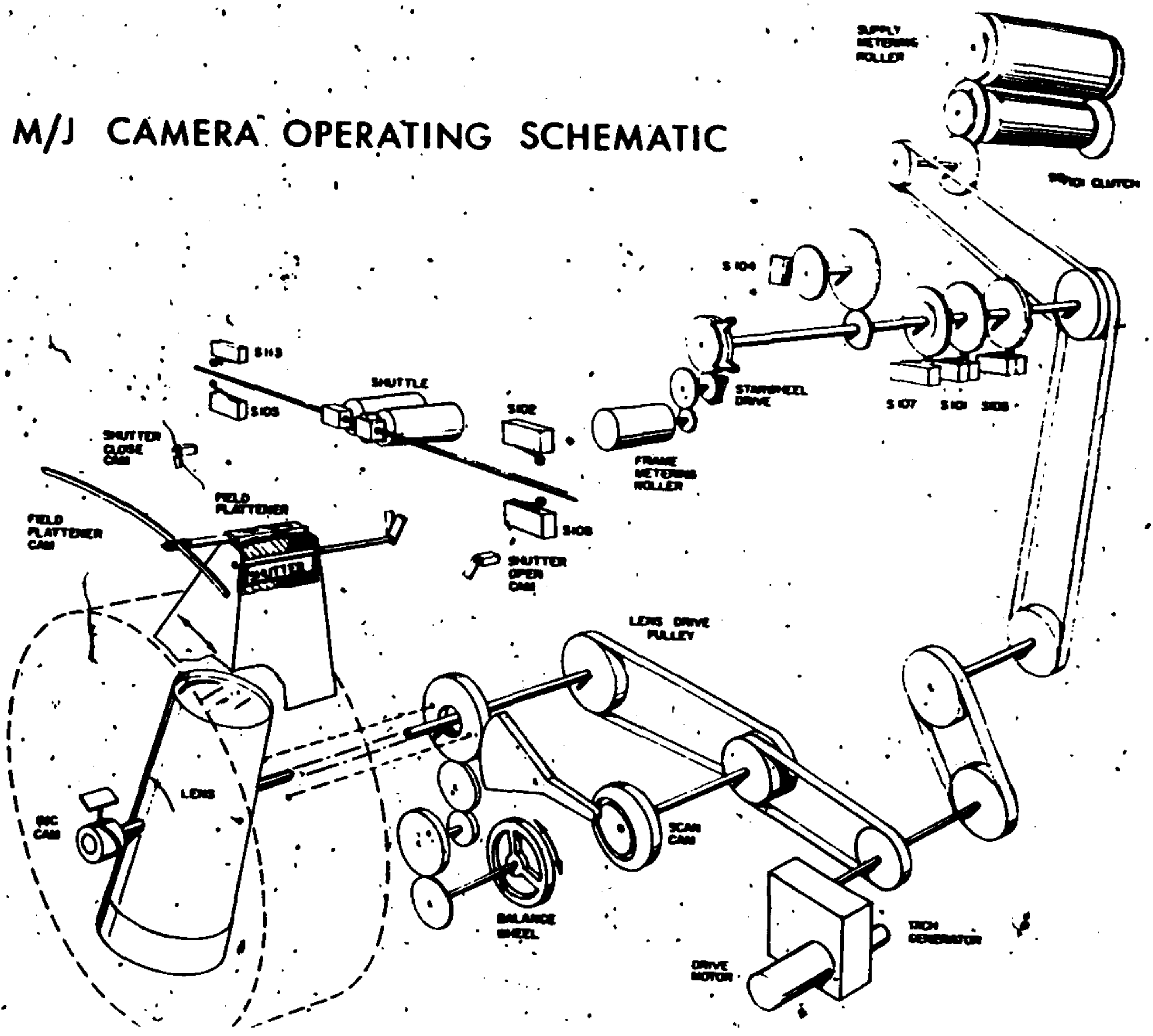
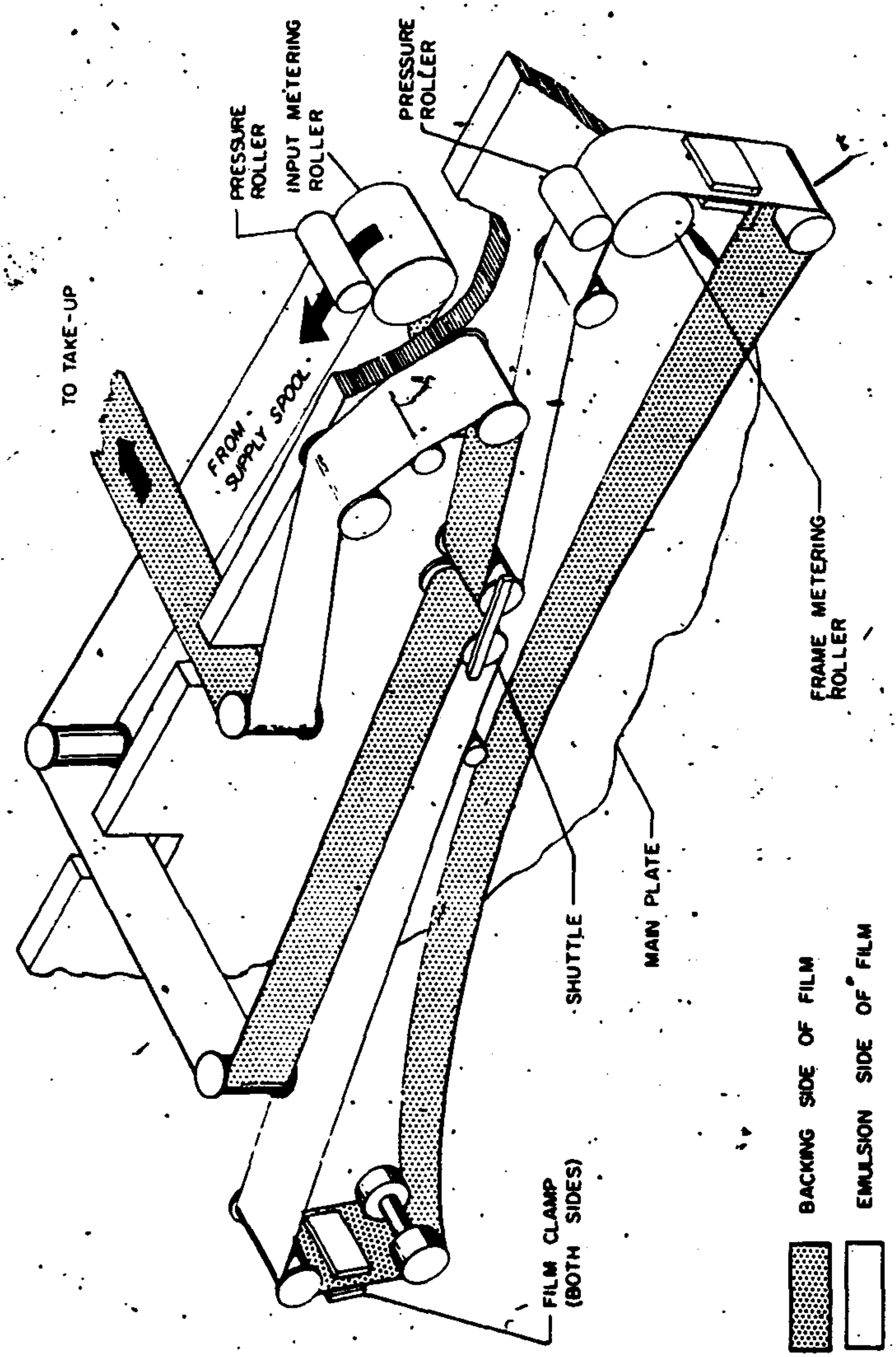


FIGURE 4

metering roller is applied by the supply torque motor, which is energized at less than full voltage throughout the operating cycle (the complete film path is shown in Figure 5). Thus, film is metered into the system while tension is maintained. Continuous input metering, as well as continuous film take-up, is made possible by the film shuttle system, which stores a "loop" of incoming film while giving up a "loop" of exposed film. The film loop is adjusted by engaging one or the other of two gear trains which drive the input metering roller. The two gear train values represent an input film speed of either 99 or 101 percent of the nominal film speed of 31-3/8 inches per lens revolution, a value established by the frame metering roller. By alternating gear trains as a function of shuttle position, the required average film speed is maintained throughout operation.

The frame metering roller is driven by the camera drive motor through a timing belt linkage and a "star-wheel" drive. This roller meters film through the guide rails; the film that is given up by the frame metering roller is transported through the remainder of the film path by the action of the take-up motor. The "star-wheel" drive imparts an intermittent rotation to the frame metering roller to limit roller rotation to the non-photographic portion of lens rotation. Slightly before, during, and slightly after the exposure portion of the cycle,



M/J CAMERA SYSTEM FILM PATH

FIGURE

the dwell period of the intermittent drive is in effect so that no film is metered; 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.

While a frame of film is being metered, the scan arm moves in a direction counter to continuous lens rotation. When the scan arm reaches the "start-scan" position, the shutter opens, and the arm reverses direction. The scan arm, which is now moving in the same direction as the lens, accelerates until it reaches the "start-exposure position"; the scan arm and the lens reach this position simultaneously. At this point, the scan arm and lens, the velocities of which are now identical, are mechanically coupled through a latching system. The coupled scan arm and lens then sweep, at a constant velocity, to expose the film which is being held motionless, until the "end-exposure" position is reached. The resulting exposure time is a function of the scan velocity as the camera contains a single, fixed slit. At the end of scan, the lens is uncoupled and the scan arm decelerates to the "end-scan" position. Lens rotation continues at a constant angular velocity, film frame metering resumes, the scan arm reverses direction and returns to the "start-scan" position, and the next cycle begins.

The film being exposed is supported in semi-circular guide rails which approximate the sweep of the scan head. The radius of this semi-circle is 0.010 to 0.012 inches less than the lens focal length. Ball bearing rollers in the scan head lift the film slightly as the head scan and positions the film such that the film is at the exact focal distance during exposure.

Camera cycle rates are a function of the exact V/h, which is matched through the selection of pre-programmed ramp functions for the expected vehicle orbit; 121 non-linear ramps are provided to cover a wide spectrum of possible orbit characteristics. Operational cycle rates range from 6.0 seconds per cycle to 2.15 seconds per cycle; a programmer limiter circuit assures that the cycle rate will be no greater than 2.15 seconds per cycle. The V/h programmer and transducer are set such that voltages to the camera drive motor maintain camera cycle rates to within 5% of the required rates; for a given command, cycle rates of the two cameras are within 3% of each other.

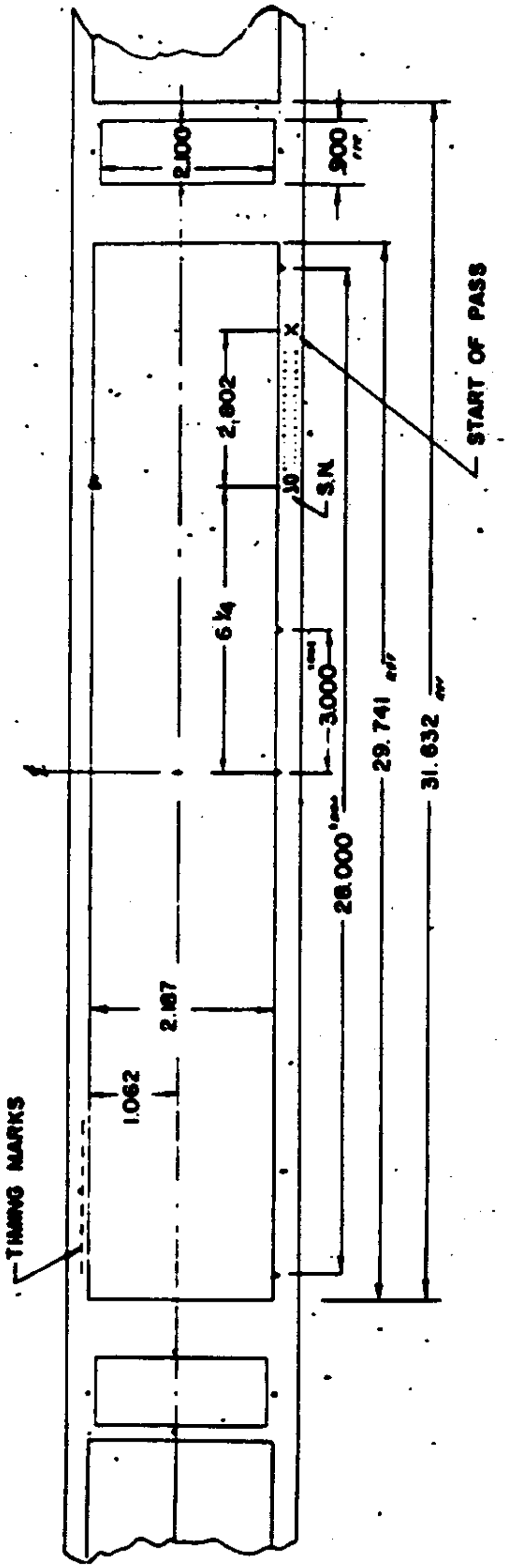
Image motion compensation is achieved through the IMC cam, which is attached to the lens shaft; this cam is accurate to within 0.25%. Lens shaft rotation causes the cam to translate the lens along the line of flight axis. During the exposure portion of lens rotation, the cam translates the lens at a changing velocity as a function of scan angle in a direction counter to the direction of flight. During the film transport period, the cam completes its revolution and returns the lens to its original position. Translational IMC velocity is directly proportional to the lens rotational rate, and therefore, to the required V/h.

The momentum of the oscillating scan arm and its associated components is of sufficient magnitude to affect vehicle flight characteristics in the event that one instrument is operated while the other is not, or in the event that the two scan arms are not in exact synchronization. Compensation is achieved through a balance wheel in each instrument, the $I\alpha$ product of which is equal to that of the scan assembly. Motion is transmitted through a gear train which changes rotational direction and velocity so that the $I\alpha$ product of the balance wheel is equal to and in the opposite direction from that of the scan arm assembly.

Exposed film is taken up and stored in the cassette, which is capable of storing 7800 feet of 70mm film on each of its main take-up spools. The exposed film is pulled into the cassette with approximately the same tension at all times regardless of the diameter of the film wrap on the take-up spools. Take-up tension is maintained at a constant value by varying torque to the spool as a function of the spool core radius. The take-up motor is provided with an anti-back-up mechanism to prevent reverse rotation of the spool. This mechanism maintains the tension in the film while the camera is not operating and thereby prevents the formation of slack loops in the take-up system.

Data recorded on the film includes clock readout time (relative to the start of the mission), camera serial number, start of pass indicator, 200 cps timing track, film shrinkage markers, center of format marker, and Stellar-Index camera operate indicator (Figure 6).

Time relative to the start of the mission is imposed directly on the film by the camera binary data lamps, which are energized by a series of pulses from the vehicle clock; at the same time, the camera serial number is exposed on the film. The 200 cps timing track makes it possible to check the instantaneous scan velocity rate in effect during each exposure. The timing mark projector is mounted in the scan head so that its light strikes the edge of the format; the marker is energized and de-energized at the same time as the film clamping solenoids. Because the pulse rate is a known constant (200 cps), the number of pulses imposed on a frame indicates scan head and lens velocity. The film shrinkage markers and center of format indicator are exposed through small v-shaped cutouts on the inboard film guide track. The light transmitted through the lens is masked from the edge of the film except where the cutouts allow it to pass through. Since the distance between the markers



REF. DRAWING J 44448

M/J SYSTEM FORMAT

FIGURE 6

on the film guide track is known, the measurement of the distance between the markers as developed on the film will indicate any shrinkage that may have occurred between time of exposure and the time of measurement. Each time the Stellar-Index camera shutters are fired, a 20 millisecond pulse is simultaneously transferred to the master panoramic camera's frequency lamp, thereby producing a smear on the Master camera film at that point.

The two Horizon cameras are mounted at either end of the film guide rails so as to focus on the port and starboard horizons when the vehicle is in the correct operational attitude. The cameras record the horizons on alternate frames during the mission, and this information is subsequently evaluated to determine the vehicle attitude at the time of eac exposure. Each of the two horizon cameras contains a 55mm f/6 Aerotar, wide-angle lens with a self-cocking shutter. Apertur and shutter speed can be varied and then set for optimum expos prior to flight. A Wratten No. 25 filter is used to penetrate haze and to improve contrast. Fiducials built into each camer expose pin-hole images at the ends of the two major axes of th horizon format. These fiducial markings, which are imposed on the film each time the horizon exposure is made, facilitate evaluation of the Horizon information. Power to energize the Horizon cameras is series-connected through two switches such that the cameras operate every other cycle. The shutters are fired through a spring connection between the shutter release lever and cam-energized solenoids. The exact relationship between the Horizon camera optics and Panoramic camera optics is determined through theodolite calibration.

For these missions, the Stellar-Index camera has been calibrated for distortion and alignment of the optical axis by photographing a stellar field and making precise measurements of the position of the recorded stellar images. This calibration is difficult and is dependent upon local weather conditions.

Itek is developing a goniometer technique to accomplish camera calibration. This approach has the virtue of providing measurement points at critical areas across the lens field and should result in improved distortion data. Cameras calibrated by the goniometer method should be available in March 1964.

In this Panoramic camera the focal distance depends upon the length of the scan arm and the distance the film rises above the scan head rollers during the scan cycle. This necessitates consideration of the dynamic effects of the scan arm rollers on the film. A technique (called the Dr. Aschenbrenner Test) has been developed which produces a contour map of the film position with relationship to the field flattener during the exposure scan.

The field flattener (optical element #6) is replaced with a glass plate having 9 transparent 25 micron wide lines in the direction of lens scan. A pair of bulbs are mounted approximately 3 inches apart, and 4 inches below the glass plate, and thus produce on the film a pair of line images corresponding to each line on the glass plate. The separation of this line pair is directly proportional to the height of the film above the field flattener. A calibration standard set of exposures are made on glass at .010 inch and .000 lift above the film lift rollers. Measurements are then made at 1/2 inch intervals of the spacing of each pair of lines on the 9 lines for each format developing the actual contour. The fundamental concepts of this technique are depicted in Figure 7, Aschenbrenner Test for Film Position.

2. <u>Space Structure Subsystem</u>

The space structure subsystem consists of the Aft conic adaptor providing the interface with the Agena D vehicle, the barrel section which provides the housing for the Panoramic camera, and the conic fairing which provides housing for the Stellar-Index camera and the digital clock, and mounting attachment for the recovery capsule. The space structure also contains cabling and junction boxes to supply electrical power and commands to the payload subsystem. The digital clock which provides system time to the Panoramic cameras is a part of the

Handle Via [redacted] Controls Only

~~TOP SECRET~~ CORONA [redacted]

MURAL PET REPORT/64

ASCHENBRENNER TEST FOR FILM POSITION

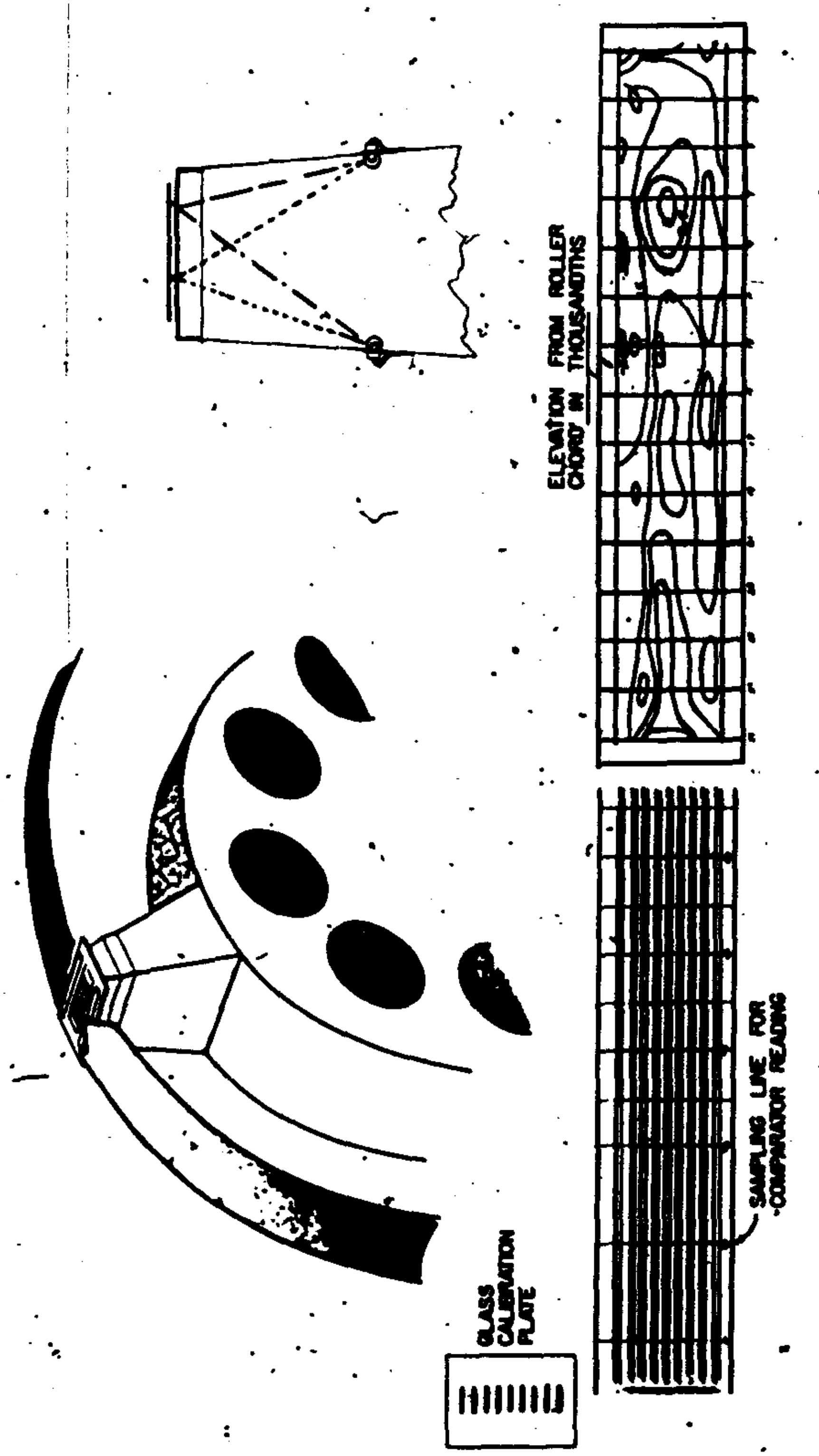


FIGURE 7

space structure. This clock is accurate to one millisecond in a 12-hour period and is related to real time by comparing telemetered system time to clocks at the tracking stations. The space structure also provides the signal conditioner to convert payload subsystem telemetry pickoff signals into the proper signal for the Agena D telemetry system and/or tape recorder. Other major functions of the space structure are to provide thermal control and light-tight housing for the cameras.

3. Recovery Subsystem

The recovery subsystem is the standard Mark 5A satellite recovery vehicle used throughout 1962 and 1963. It provides a light-tight container for the film take-up cassettes recovery aids in the form of tracking beacons and event telemetry, a parachute, and a de-orbiting rocket motor system. It also provides an ablative shield to protect the inner container from re-entry heat.

4. Vehicle System

The oribiting vehicle consists of the payload section and the Agena D vehicle modified to carry Program [redacted] peculiars The Agena D provides the second stage thrust to attain orbit, on orbit attitude control, electrical power to operate the vehicle and payload on orbit, and on-orbit programming of the payload on orbit. Initial thrust to attain the required attitu and velocity to attain orbit is provided by the Thor or improved Thor.

The attitude of the Agena vehicle is maintained by an inertial reference platform. The drift in the pitch and roll platform gyroscopes is continually corrected by infra-red horizon scanners. The yaw gyroscope is coupled to the roll attitude control segment; however, the drift cannot be actively corrected.

The error tolerances for the resulting attitude control at the time of Mission 9056, 9057, and 1001-1, based on a 90% probability, were:

Pitch	Error	±	1.64°
Roll	Error	±	1.64°
Yaw	Error	±	2.19°
Pitch	Rate	±	80°/hr
Roll	Rate	±	160°/hr
Yaw	Rate	±	160°/hr

Subsequent modifications and improvements to the Agena attitude control system have reduced to the allowable error tolerances, based on a 90% probability, to:

Pitch	Error	±	1.0°
Roll	Error	±	0.5°
Yaw	Error	±	1.1°

Pitch Rate	±	10°/hr
Roll Rate	±	30°/hr
Yaw Rate	±	10°/hr

5. Normal Expected Performance

When the camera is considered without regard to vehicle or natural parameters, the camera-film (type 4404) combination should be capable of performing dynamically within the range shown in Figure 8. This figure also illustrates the dependence of resolution image contrast.

The capability range was arrived at by noting the relationships between static lens bench tests, static simulator tests, and dynamic simulator tests, while taking into account the degradation by the simulator collimator of the original target contrast.

Handle Via [redacted]
Controls Only
MURAL PET REPORT/64

~~TOP SECRET~~ CORONA [redacted]

RESOLUTION VS CONTRAST

T-[illegible] SYSTEMS ON .4404

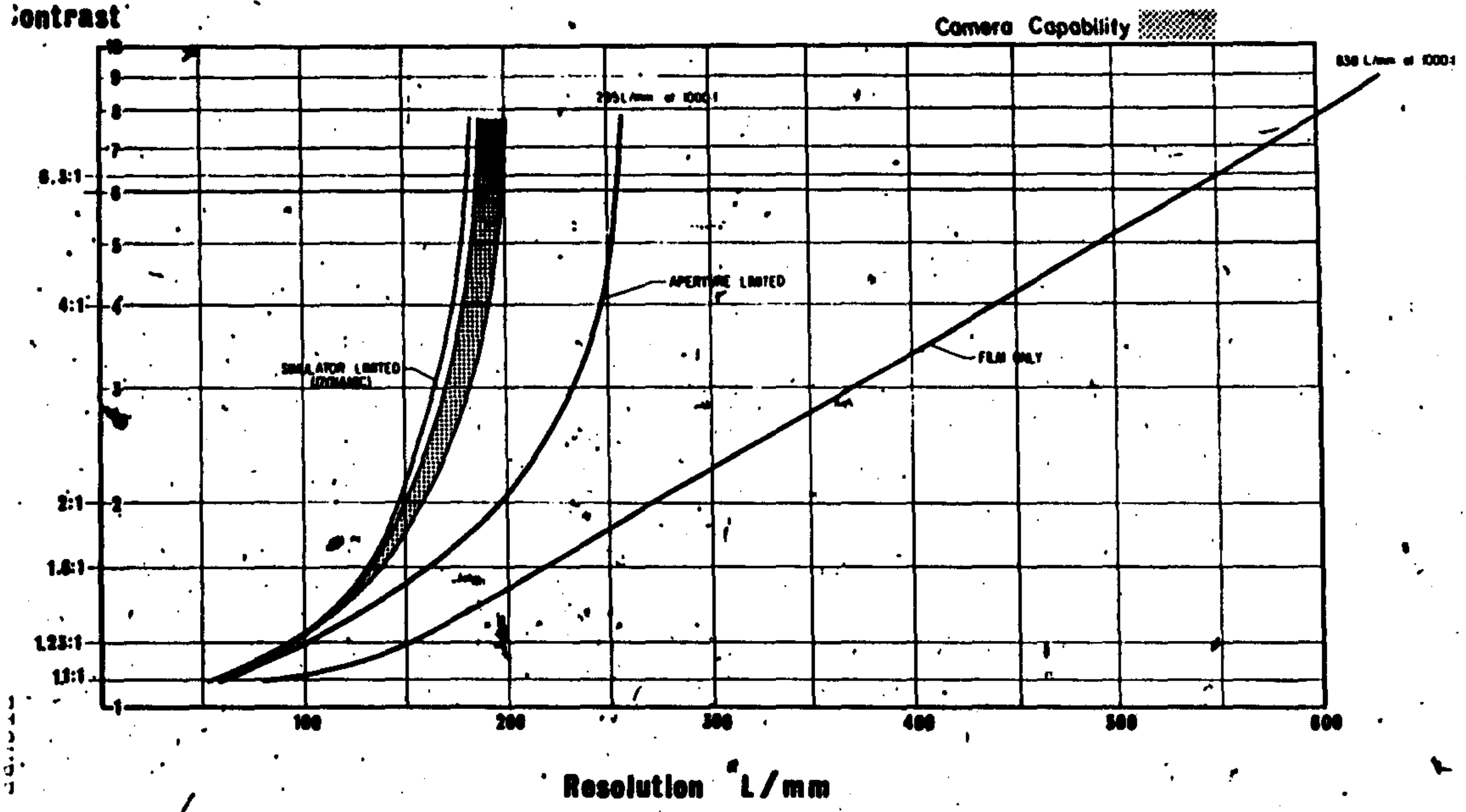


FIGURE 8

SECTION II

COMMAND SYSTEM

1. Command System Description

The Mural Command System used on Mission 9057 was the Type 7 Orbital Timer and a V/h Programmer controlling camera cycling rate. The Type 7 Orbital Timer is loaded before flight with commands as a function of elapsed time to turn the camera system on and off and to control certain system functions. The timer may be periodically reset by real time command transmitted by radio from the ground tracking stations to assure that desired operations are obtained. Real time commands are also used to select alternate programs, V/h ramps to adjust for orbit parameters, active lifeboat recovery mode, and similar functions.

Missions 9056 and 1001-1 were flown with the Type 8 Orbital Timer which replaces the Type 7. The same principles of operation are employed, but more timer tracks are provided on the tape which allows more alternate programs to be stored. This capability is particularly required for Corona J Missions where the second operation may occur a considerable time after the first operation resulting in shifts of the orbital parameters.

Inasmuch as Mural or J Systems are primarily employed for broad area coverage, targetting is not too difficult a problem. After selection of orbit parameters and designation of the areas to be photographed, the timer tape is prepared to turn the camera on at the proper time. It is standard practice to add a 25 second pad to both on and off times which reduces the need to make adjustments to the command system during flight. Recently the off time pad has been reduced to 15 seconds.

2. <u>Command System Response</u>

An examination of post flight records of Missions 9056, 9057, and 1001-1 shows that in all cases the command and control systems functioned satisfactorily and that desired operations were obtained. In the case of Mission 9057, a perigee shift of 18 degrees occurred which caused some difficulties in matching V/h ramps. Despite this, normal coverage was obtained.

SECTION III

ON-ORBIT OPERATIONS

The assurance of optimum satellite reconnaissance photography is dependent upon the acquisition of a quality latent image on the photographic emulsion and the ability to know where the photographed object is located on the surface of the earth. Some of the more paramount variables, beyond proper equipment operations, are exposure selection, image motion compensation and thermal control. These facets of the system as well as attitude determination are presented herein.

1. <u>Exposure Selection</u>

The exposure time for each frame of photography is, as noted in Section I, a direct function of the camera scan velocity. The width of the camera slit is selected based upon the range of solar angles that the system will be expected to be operating. Experience has shown that a 0.200 inch wide slit is optimum for operations during the major part of the year with a 0.250 inch wide slit used during operations near the winter solstice.

The camera scan velocity is controlled by the V/h programmer, hence, this velocity is essentially proportional to the latitude of the vehicle, since the vehicle altitude is usually higher over the poles than for the lower sunlit latitu for the Mural missions. The solar elevation for the day and time of launch is known for each terrestial latitude; therefore, the ephemeral parameters and launch time are selected to result in a best match of exposure time to solar elevation for the mission.

[redacted] has published curves which provide the optimum exposure time vs. solar elevation for various filter/emulsion conditions at three levels of processing time: Primary, Intermediate, and Full. The slit selection is based on the Intermediate processing curve to allow the underexposed and overexposed areas, resulting from exposure time - solar elevation mismatches, to receive proper processing.

2. Image Motion Compensation

The creation of quality photography made with a moving camera system requires some technique to stop the motion of the image during the time that the exposure occurs. This technique is called Image Motion Compensation (IMC). In Section I the method used within the camera system to accomplish IMC is described to compensate for the forward motion of the vehicle. This technique is predicted to correct IMC to a 90% probable error of 3%.

Other motion effects are, in some cases, compensated by airborne hardware. Mission 9056 contained equipment that would induce a programmed yaw error (horizontal deviation of the vehicle center line with respect to the orbital plane) to compensate for the velocity vector induced to the image by earth rotation. This feature has not been present on any mission since Mission 9056.

3. Thermal Control

Temperature variations of 30° to 40°F from nominal have been experienced during these missions. These changes from normal displace the film plane from the lens focal plane far in excess of the depth of focus. See Figure 9, Image Plane Shift with Temperature Change. The poor imagery was determined to be caused by the expansion or contraction of the magnesium drum-scan arm assembly. An invar titanium drum-scan arm assembly has been incorporated into the camera and now permits greater thermal variations before the film plane is displaced from optimum focus.

The effect of temperature variation on the resolution is shown on Figure 10, Lens System Thermal Response.

4. Attitude Determination

The post-flight determination of the geographical location of the center of each photographic frame is an established mission requirement. The Mural System contains Horizon cameras as a part of each panoramic instrument as described in Section I. The Horizon cameras photograph the

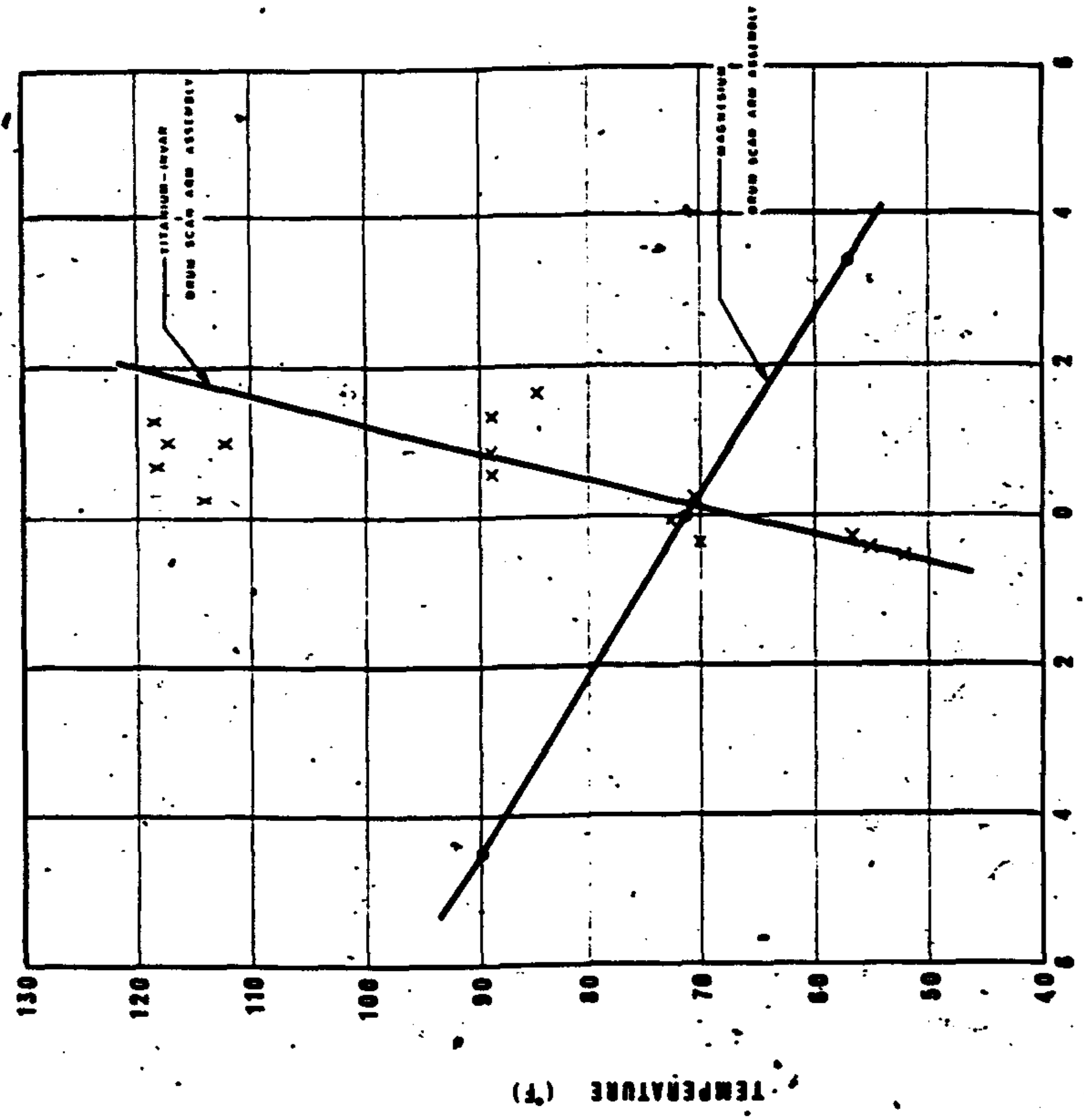
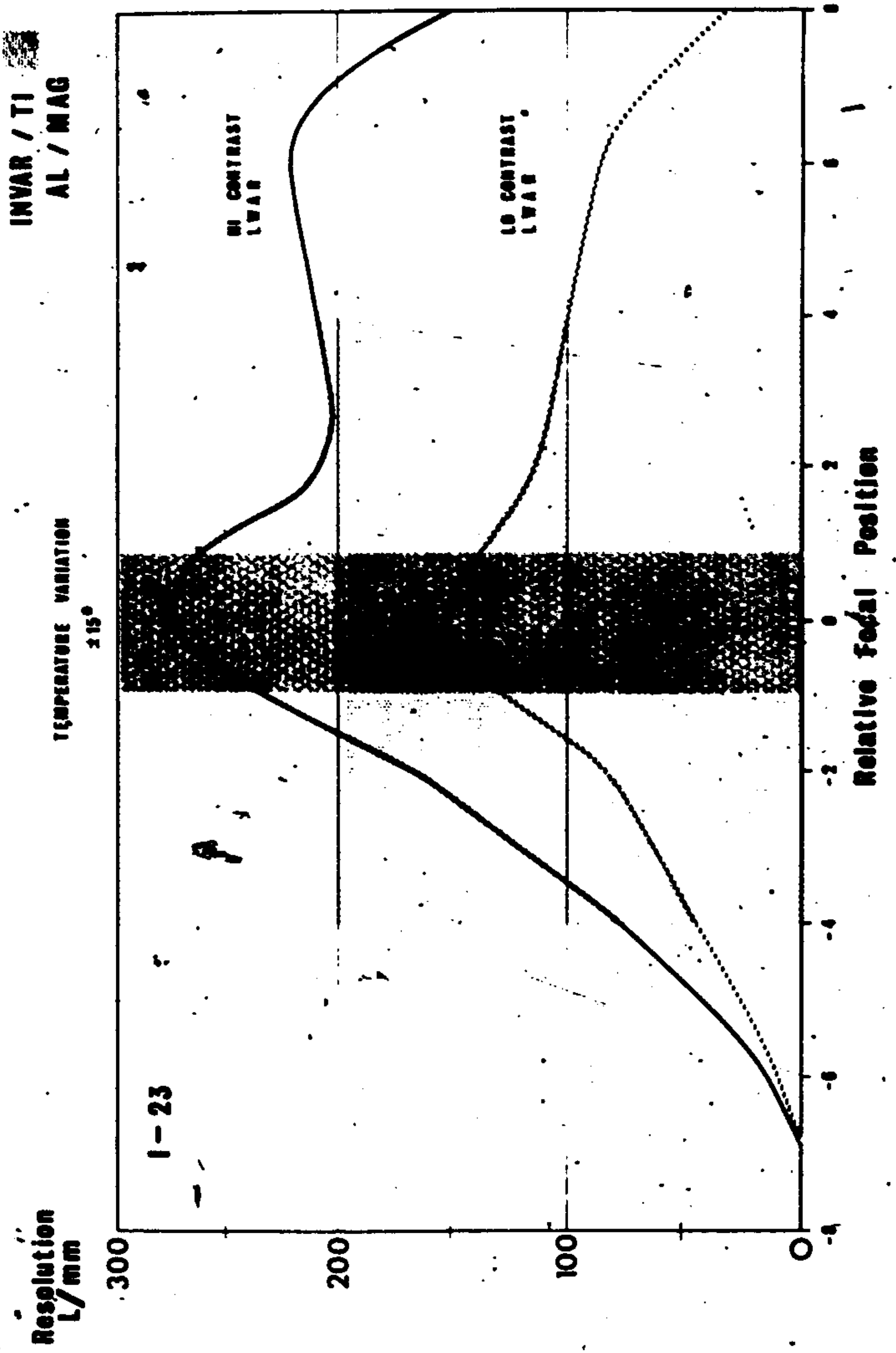


IMAGE PLANE SHIFT WITH TEMPERATURE CHANGE

FIGURE 9

MURAL PET REPORT/64



LENS SYSTEM THERMAL RESPONSE

FIGURE 1

port and starboard earth-space interface during every other cycle of the Panoramic camera. Coupled with pre-determined alignment data the pitch and roll position of the system can be determined. The center of format location of each frame is then determined with this attitude data and the normal tracking information.

A double frame (Stellar-Index) camera is installed in these systems which provides very accurate pitch and roll data and also permits measurements of the system yaw error.

SECTION IV

DATA PROCESSING AND MEASUREMENT

The quality of the intelligence information gathered by a system during operation is highly dependent upon the proper processing of the original negative as well as performance of the camera system. The evaluation of mission performance to ascertain the causes of reduction in intelligence gathering capability presents a difficult mensuration problem. Several techniques are now used to perform this evaluation.

1. Original Negative Processing

The control of the processing level imparted to the original negative is accomplished by a variable speed processor to achieve either the Primary, Intermediate, or Full processing conditions established as nominals by [redacted] [redacted]. The original material is given Primary processing and manually viewed with infra-red equipment to ascertain the degree of further processing required to optimize the density range of the ground images.

The operator of the processor is assisted by the estimated exposure time and solar elevation at the start and end of each camera operation. This data is prepared and transmitted by TWX to the processing facility prior to the receipt of the flight material.

2. Mission Information Potential

Satellite photographic reconnaissance missions are launched to record intelligence information. The determination of the degree of success of any given mission in recording information is a controversial topic and may vary depending upon the user, or evaluator, his objectives, experience and expectations. However, NPIC recognizes the need for some subjective measure for determining and expressing the "success" of a mission. Based upon the experience gained from a number of Mural missions, certain feasible expectations have been established, and a set of arbitrary values adopted to express the relative "success" of each mission with respect to photographic quality, not the "success" in regard to targets covered.

The Mission Information Potential (MIP) values are determined subjectively and reflect the best apparent photographic quality found within the mission, even though this quality may be limited to a few frames. This is considered the maximum potential of the mission, hence the Mission's Informati Potential. These arbitrary values are not limited to a termina value of 100, but can be increased as the system improves. Whe plotted, these values provide a graphic picture of the potentia of each individual mission as well as the relative potential or "success" of various missions.

3. Reciprocal Edge Spread

The determination of image quality by AFSPPL is accomplished by an alternate technique called Reciprocal Edge Spread (RES). An image subject is selected which has well-defined edges, parallel and perpendicular to the line of flight. Cultural features are selected where possible; however, natural features are used as secondary selections.

The subject is viewed with a microscope containing a precision Filar micrometer. The reticule edge is located on the edge of the subject. The reticule is then moved across the width of the spread or "fuzzy" area adjacent to the subject. This width is measured in millimeters and the reciprocal of this measurement is the recorded RES value.

The mission material is examined throughout on an every tenth frame sample. Originally the sample started with the first frame of every pass, as was the case for all missions through 1002-1; however, this procedure has recently been changed to start the sample with the fifth frame of all passes. Each frame is divided into five equal areas and a measurement made in each area; thus for each frame, with no cloud cover, a total of ten measurements are made.

4. Micro-Analyzer

Several of the best images in each mission are selected for micro-densitometer traces to provide additional information about these subjects. AFSPPL uses a Micro-Analyzer to perform this measurement.

The equipment uses a 1.58 micron round spot to scan the subject. This spot is created by a 40X reduction of a 0.0025 inch aperture. The subject is scanned at a speed of 0.5 millimeters per minute and a chart speed of 101.6 millimeters per minute giving a final scale of one inch on the plot equal to 25 microns. The informational output equals 1620 bits per millimeter recorded from high resolution film.

Samples of selected areas and the Micro-Analyzer traces are in Appendix E through H.

5. Density Measurement

The measurement of diffuse density is done with a Macbeth TD-100 Densitometer in the same frames where RES values have been recorded; however, one set of values is obtained for the entire frame rather than five sets in each frame.

The instrument is equipped with a 1.0 millimeter aperture and uses a white light source. Recently, after Missic 1001-1, the spot size was reduced to 0.5 millimeters and a Wratten 39B blue transmitting filter added by AFSPPL, as their prime mission is to produce duplicate positives which are made with a blue light source. In each selected frame values are obtained for the minimum and maximum image density, the maximu density of the cloud areas and the base plus fog density.

SECTION V

PERFORMANCE EVALUATION

The overall system performance has been examined and evaluated for Missions 9056, 9057, and 1001-1. Some areas could not be evaluated in detail due to the lack of pertinent data. Discrete portions of other missions have also been evaluated in order to present a more complete appraisal of the Mural system.

1. Thermal Effects

The available in-flight temperature data from sensors 11 and 13 (stove and drum) was examined for correlation with RES measurements since two of the three missions exceeded the design objective for camera temperature. Two missions (9057 and 1001-1) employed magnesium scan arms, while 9056 employed Titanium/Invar. Laboratory data shows that significant defocussing should occur over the temperature ranges encountered on 1001-1 with magnesium scan arm.

All three missions showed marked differences in temperature between the drum and stove on Forward and Aft cameras immediately after launch (Pass 0). This difference, due to exit heating, dropped rapidly even when the temperature at both positions rose sharply as it did in 9056 and 1001-1 by Pass 9. The following table shows the temperature of drum and stove immediately after launch for all three missions: