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FAIRCHILD

SPACE AND DEFENSE SYSTEMS

NASA CR 108414

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A Division of Fairchild Camera and Instrument Corporation
300 Robbins Lane, Syosset, New York

3-INCH MAPPING CAMERA

STUDY REPORT

Contract No. NAS 9-10201

FAIRCHILD SPACE AND DEFENSE SYSTEMS

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FAIRCHILD SPACE AND DEFENSE SYSTEMS

SECTION 1

INTRODUCTION

The objective of the Apollo Lunar Exploration Program is to conduct scientific experimentation from Lunar orbit with various remote sensing instruments located in the Service Module (SM),

The objective of this study was to identify those requirements peculiar to the installation of the Mapping Camera Subsystem (MCS) in the SM.

This study was conducted in accordance with Exhibit A, Statement of Work (SOW), Contract NAS 9-10201 which is presented in Table I. Table II presents a summary of the documentation in this report corresponding to the tasks required by the SOW.

Initial interfacing with North American Rockwell was accomplished. This consisted of three Interface Working Group Meetings, the establishment of eight required Interface Control Documents (ICD's), and the sign-off of the Electrical ICD, MH01-12502-234.

No problems were uncovered that would preclude installation of the MCS, as defined in this report, in the SM.

TABLE I

EXHIBIT A STATEMENT OF WORK

- 1.0 Purpose: The purpose of this statement of work is to define the tasks necessary for completion of this study by the contractor.
- 2.0 Background: The objective of the early Apollo Lunar Exploration Program is to conduct scientific experimentation from Lunar orbit with various remote sensing instruments located in the Scientific Instrument Module (SIM) of the service module.

Objective: The objective of this study is to identify at an early date those requirements peculiar to the installation of a mapping camera system in the SIM.
- 3.0 Contractor tasks: The contractor shall complete the following tasks during the course of the study.
 - 3.1 Define the envelope dimensions of the mapping camera system (MCS).
 - 3.2 Define the electrical power requirements for the MCS.
 - 3.3 Define the MCS measurement requirements. This should include both operational housekeeping measurement and required test measurements.
 - 3.4 Develop an implementation plan for incorporation of spacecraft time. IRIG B time format is presently available in the Command Module from the Central Timing Equipment.
 - 3.5 Define the method for synchronization of MCS experiment data with other scientific experiment systems.
 - 3.6 Define stowage requirements including any special environmental requirements for the stowed film.
 - 3.7 Define the MCS weight requirements both at launch and entry of the spacecraft.
 - 3.8 Define the ground support equipment (GSE) requirements necessary to support the MCS checkout both at North American Rockwell (NR), Downey, California, and at the Kennedy Space Center (KSC), Florida.
 - 3.9 Define the handling fixtures necessary to support the MCS both at NR and KSC.
 - 3.10 Define the shipping container requirements to insure that the MCS will not be damaged during shipment to NR or KSC.
 - 3.11 Define any special mechanical installation in the SIM necessary for the proper performance of the MCS during a Lunar mission including environmental considerations.

- 3.12 Develop schedules necessary to provide MCS flight hardware by December 1, 1970.
- 3.13 Define the qualification tests necessary to insure that the MCS will meet the design goals.
- 3.14 Develop detailed technical specifications for the development of an MCS.
- 4.0 Reporting: The contractor shall submit a written weekly report to the appropriate NASA-MSD Scientific Experiment Manager. This report is due on Friday of each week.
- 5.0 Deliverable items: Upon completion of the study, the contractor shall prepare and deliver to MSD a final report including any recommendations. In addition, the contractor shall submit the appropriate documentation, as it becomes available, for the tasks outlined under 3.0, above.

TABLE II

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FAIRCHILD SPACE AND DEFENSE SYSTEMS
A Division of Fairchild Camera and Instrument Corporation
300 Robbins Lane, Syosset, New York

1231-DB-1

MCS
END ITEM SPECIFICATION
16 February 1970

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1.0 SCOPE - This specification covers one type of equipment designated Mapping Camera (MC) Subsystem. The MC Subsystem is a photographic device consisting of two precisely oriented frame cameras. The optical system of each frame camera and their orientation relative to one another are fixed and calibrated. One frame camera is used for terrain photography and the other is used for simultaneous stellar photography. Terrain imagery is recorded on 5-inch film and stellar imagery is recorded on 35mm film. The MC Subsystem is intended to be used to satisfy the cartographic and spacecraft-attitude-definition requirements of the Apollo lunar exploration missions.

2.0 APPLICABLE DOCUMENTS

2.1 Government Specifications - The following government documents, of the issue in effect on the date of invitation for bids, forms a part of this specification to the extent specified herein.

Specifications

MIL-C-4150	Case, Carrying and Storage, Shock and Waterproof
MIL-E-5400	Electronic Equipment, Aircraft, General Specification for
MIL-E-8189	Electronic Equipment, Guided Missiles, General Specification for
MIL-Q-9858A	Quality Program Plan

Standards

MIL-STD-16	Electrical and Electronic Reference Designations
MIL-STD-129	Marking for Shipment and Storage

MIL-STD-130	Identification Marking of U. S. Military Property
MIL-STD-143	Specification and Standard Order of Precedence for the Selection of
MIL-STD-785	Requirements for Reliability Program (for Systems and Equipments)
USAF Bulletin 515	Control of Nonconforming Supplies

2.2 Non-Government Specifications - The following non-government documents, of the issue in effect on the date of invitation for bids, form a part of this specification. Where no issue date or revision is indicated, the most recent issue shall apply.

NR Interface Control Documents

—MH01-12500-134	CSM/Mapping Camera Envelope
MH01-12501-134	CSM/Mapping Camera Installation
MH01-12502-234	CSM/Mapping Camera Electrical Requirements
MH01-12503-234	CSM/Mapping Camera Functional Requirements
MH01-12504-434	CSM/Mapping Camera Environmental Requirements
—MH01-12505-434	CSM/Mapping Camera Ground Requirements
MH01-12507-434	CSM Record Container MC Envelope

Contractor Specifications

QAP 2528	Quality Assurance Plan
1231-AC-1	Reliability Program Plan
1231-AC-4	System Safety Plan MC System
1231-DO-1	Cartographic Lens
1231-DO-2	Stellar Lens
1231-DR-1	EMI Control and Test Requirements for MC Subsystem and BME
1231-EB-5	Environmental Qualification Test Specification MC Subsystem
1231-EB-7	MC Subsystem Acceptance Test Specification
1231-ER-1	Preliminary EMI Qualification Test Specification for MC Subsystem
1231-ER-2	Preliminary EMI Acceptance Test Specification for MC Subsystem

Contractor Drawings

1231L57	Mapping Camera Format
1231L58	Stellar Camera Format

3.0 REQUIREMENTS

3.1 Preproduction - This specification makes provision for prototype acceptance and qualification testing.

3.2 Components - The MC Subsystem shall consist of a Mapping Camera, a Stellar Camera, associated Camera Controls, a detachable Record Container, Lens Glare Shades, and a Deployment Device.

3.2.1 Mapping Camera - The Mapping Camera shall consist of the following major components and/or subassemblies:

- 1) Camera Body
- 2) Camera Lens Cone Assembly
- 3) Lens Shutter
- 4) Auxiliary Data Array
- 5) Film Transport and Forward Motion Compensation (FMC) Mechanism
- 6) Automatic Exposure Control (AEC) Light Sensor

3.2.2 Stellar Camera - The Stellar Camera shall consist of the following major components and/or subassemblies:

- 1) Camera Lens Cone
- 2) Lens Shutter
- 3) Auxiliary Data Array
- 4) Film Transport Mechanism

3.2.3 Camera Controls - Camera controls shall consist of all those components, subassemblies, and parts necessary to perform the electrical functions and to fulfill the electrical requirements of the complete Camera Subsystem. Major items of camera controls shall include the following:

- 1) Stellar Lens Shutter Control
- 2) Mapping Lens Shutter Control
- 3) Auxiliary Data Signal Converter
- 4) Camera Logic and Switching Circuitry
- 5) Film Drive Servo
- 6) AEC Servo
- 7) DC Voltage Supplies

3.2.4 Record Container - The camera Record Container shall consist of the following major components and/or subassemblies:

- 1) Housing
- 2) Film Spools
- 3) Film Spool Drives
- 4) Film Roll Sensors

3.2.5 Lens Glare Shades - The stellar lens glare shades shall consist of light baffles, support structures, articulated extensions, and mounting flanges as required.

3.3 General Specification - The requirements of MIL-E-8189 shall apply as a guide for the design and manufacture of the equipment covered by this specification whenever such design and manufacturing requirements are not explicitly specified herein.

3.4 Selection of Specifications and Standards - Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-143 as a guide, except as provided in paragraphs 3.4.1, 3.4.2, 3.4.3, and 3.4.4.

3.4.1 Commercial Parts - Commercial parts having suitable properties may be used where, on the date of invitation for bids, there are no suitable standard parts. In any case, commercial utility parts like screws, bolts, nuts, cotter pins, etc., having suitable properties may be used provided:

- 1) They can be replaced by the standard parts (MS or AN) without alteration.
- 2) The corresponding standard part numbers are referenced in the parts list and, if practical, on the contractor's drawings.

3.4.2 Where applicable, purchased components shall be procured using component Procurement Specification QRPS 1231-1 as a guide.

3.4.3 Use of Previously Accepted Design Data - To avoid unwarranted and costly changes in references to specifications and standards, design data previously accepted for similar equipment by any NASA activity shall be acceptable in connection with further procurement by the same or any other NASA requiring activity without change relative to provisions of paragraph 3.4.

3.4.4 Standard Parts - With the exception of paragraph 3.4.1, AN and MS standard parts shall be used where they suit the purpose. They shall be identified on the drawings by their part numbers.

3.5 Design - The MC Subsystem shall be designed to obtain photographic performance of the highest quality and precision. Resulting stellar and lunar images should be capable of providing information necessary to meet the primary photographic mission objectives. It shall meet the specific performance requirements described in paragraph 3.7 when operating under the specified environmental conditions. It shall be designed to have the functional characteristics and to meet the detail design requirements described in the following paragraphs.

3.5.1 Mapping Camera

3.5.1.1 Lens - The Mapping Camera lens shall be a cartographic lens with a 3-inch focal length and an f/4.5 relative aperture. Detail optical design requirements and other characteristics are covered in Document No. 1231-DO-1.

3.5.1.2 Film - The Mapping Camera shall be designed to accept standard 5-inch wide, thin base unperforated film, Type 2.5 mil or 4 mil polyester 3400 or similar.

3.5.1.3 Format - The Mapping Camera film format and frame length shall be designed using Drawing No. 1231L57 (Figure 1) as a guide.

3.5.1.4 Angular Coverage - The angular field of view of the Mapping Camera shall be $74^{\circ} \times 74^{\circ}$.

3.5.1.4.1 Endlap - Forward endlap of the photographic coverage shall be nominally 78%, with provision for adjustment, prior to MCS installation, over the range of 55% - 78% in discrete steps.

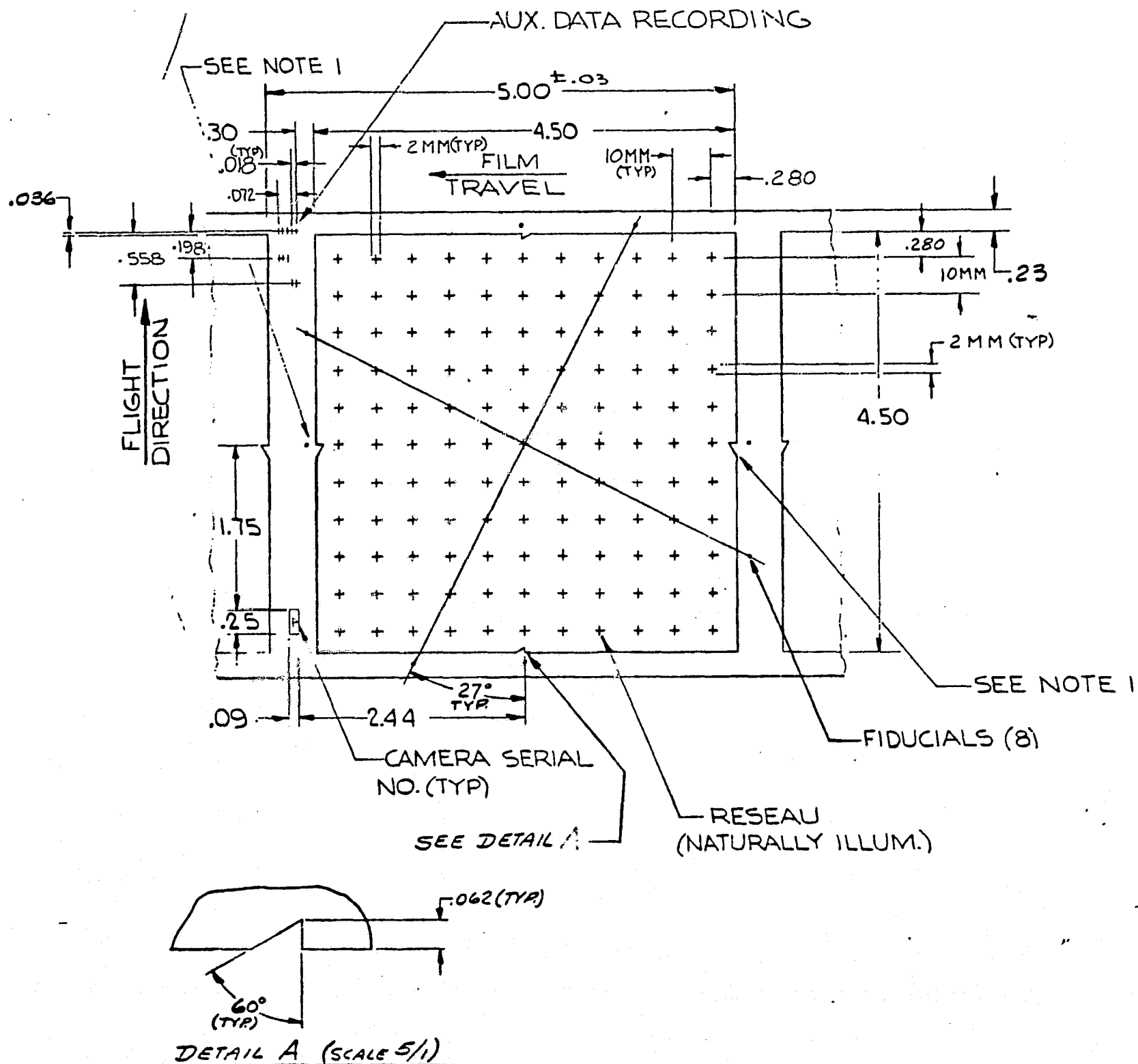
3.5.1.5 Film Flattening - Film flattening in the focal plane shall be accomplished by means of a glass focal plane platen and a moveable pressure plate. The pressure plate will maintain the emulsion side of the film in intimate contact with the focal plane plate during exposure.

3.5.1.6 Data Recording - Each frame of terrain photography shall contain photographically recorded data consisting of reference data and dynamic auxiliary data. Reference data includes a calibrated reseau, fiducial marks and the camera serial number. Dynamic auxiliary data includes an index word, coded time, altitude, and shutter speed.

3.5.1.6.1 Reseau - The reseau shall consist of a series of crosses, spaced 10 millimeters apart, which shall be recorded on each frame as a pattern of unexposed line segments. The reseau pattern and its orientation shall be designed using Figure 1 as a guide. The distance from the center of each cross to the end of each cross arm shall be 1 millimeter. The line width shall be 5 to 8 microns on the reseau plate. Reseau

NOTES:

1. THESE FIDUCIALS INDICATE DIRECTION OF ORBITAL FLIGHT WITH RESPECT TO FORMAT OF MAPPING CAMERA
2. FORMAT VIEWED FROM BASE SIDE OF FILM



MAPPING CAMERA FORMAT

FIGURE 1

cross intersections shall be calibrated to an accuracy of 0.001 millimeter (1σ error) in a single reseau plate coordinate system. The reseau pattern shall be naturally illuminated.

3.5.1.6.2 Fiducials - Two sets of artificially illuminated fiducials shall be recorded on each frame around the perimeter of the format using reference Figure 1 as a guide. One set of four fiducials shall be located respectively at the center of each side of the format, and a second set of four fiducials shall be located as indicated in Figure 1. The artificial fiducials shall be between 25 and 50 μ in diameter.

3.5.1.6.3 Serial Number - The camera serial number shall be recorded on each photographic frame in the form of a single line arabic numeral array using reference Figure 1 as a guide.

3.5.1.6.4 Time - Real time coincident with the center of exposure shall be recorded on each photographic frame. The information shall be recorded, using reference Figure 1 as a guide, in the form of a coded binary time word with one millisecond resolution. Absolute time shall be recoverable post flight to an accuracy of 5 milliseconds. Knowledge of the time between successive exposures shall be accurate to 1.5 milliseconds.

3.5.1.6.5 Altitude - Altitude information, coincident in time within 10 milliseconds of center of exposure, shall be recorded on each photographic frame. The altitude data measured from the lunar surface with a resolution of 8 feet shall be recorded, using reference Figure 1 as a guide, as a binary coded word.

3.5.1.6.6 Shutter Speed - The exposure time of the Mapping Camera shall be recorded with a resolution of 0.1 millisecond. The exposure time information will be recorded on the film as a binary coded word.

3.5.1.7 Operation Mode - The Mapping Camera shall be capable of continuous operation in an autocycle mode at cycling rates consistent

with orbital altitude, endlap, format and lens characteristics specified herein. Camera operation shall be controlled by external commands as detailed in ICD No. MH01-12503-434. The cycling rate change $\Delta R / \Delta t$ shall not exceed 0.01 cycle/second². The Mapping Camera mechanism shall return to a home position after the operate command is turned "OFF".

3.5.1.8 Forward Motion Compensation (FMC) - Provision shall be made for rectilinear motion of the platen and film in the camera focal plane during exposure to compensate for image motion in the direction of flight. Forward Motion Compensation (FMC) shall be provided for a V/H range of 0.01 to 0.04 radian/second and shall be accurate to within 3%. Provision shall also be made for disabling the FMC during the mission.

3.5.1.9 Exposure Control - Effective exposure time shall be automatically controlled over a range of sixteen to one by a between-the-lens-shutter. Exposure time control shall be variable over the specified range. The maximum stop-change rate shall be 1.0 stop/minute.

3.5.1.10 Film Handling - The Mapping Camera shall be designed to transport the specified 5-inch film throughout the entire internal camera and cassette film path without causing detrimental scratch marks in the film base, backing or emulsion; without crushing the edges of the film; and without causing objectionable electrostatic discharge marks. Lateral film control shall be provided wherever necessary to minimize side wander and to insure proper film tracking. The film shall be positively constrained in the focal plane area during FMC platen motion. In any acceptance conducted in vacuum, 90% of the formats from either camera may have corona marks whose density is less than 0.1 above the base plus processing fog level, 10% of the formats may have corona marks whose density is between 0.1 and 0.4 above base plus processing fog density, and no format shall have corona marks whose density exceeds 0.4 above base plus processing fog density; processing of test film shall be consistent with the practices used in processing flight film. The camera shall not cause corona marks on the film during operation in sea level ambient conditions.

3.5.2 Stellar Camera

3.5.2.1 Camera Lens - The Stellar Camera lens shall be a 3-inch focal length with an $f/2.8$ relative aperture. Detail optical design requirements are covered in Specification No. 1231-DO-2.

3.5.2.2 Film - The Stellar Camera shall be designed to accept standard 35mm wide, unperforated thin base film, type 3401.

3.5.2.3 Format - The Stellar Camera film format and frame length shall be designed using Drawing No. 1231L58 (Figure 2) as a guide.

3.5.2.4 Coverage - Angular field of view of the Stellar Camera shall be a 23.6° cone with 18.2° flats.

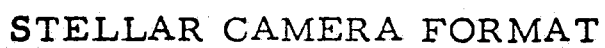
3.5.2.5 Film Flattening - Film flattening in the focal plane shall be accomplished by means of a glass focal plane platen and a movable pressure plate. The pressure plate will maintain the emulsion side of the film in intimate contact with the focal plane plate during exposure.

3.5.2.6 Data Recording - Reference and dynamic auxiliary data shall be photographically recorded on each frame of stellar photography. The reference data shall include a calibrated reseau and the lens serial number. The dynamic data shall include an index word and coded time and altitude words.

3.5.2.6.1 Reseau - The reseau shall consist of a series of crosses, spaced 10 millimeters apart, which shall be recorded on each frame as a pattern of unexposed line segments. The reseau pattern and its orientation shall be designed using Figure 1 as a guide. The distance from the center of each cross to the end of each cross arm shall be 1 millimeter. The line width shall be 5 to 8 microns ~~on the reseau plate~~. Reseau cross intersections shall be calibrated to an accuracy of 0.001 millimeter (1 σ error) in a single reseau plate coordinate system. The reseau pattern shall be artificially illuminated.

3.5.2.6.2 Time Data - Real time data in the format of a binary time word shall be recorded on each photographic frame of stellar photography. The time word data shall be recorded outside the format area using

1. THESE FIDUCIALS INDICATE DIRECTION OF ORBITAL FLIGHT WITH RESPECT TO FORMAT OF STELLAR CAMERA
2. FORMAT VIEWED FROM BASE SIDE OF FILM



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reference Figure 2 as a guide. Each record time word shall be identical with the time word recorded by the Mapping Camera for any given pair of simultaneous Stellar/Mapping exposures.

3.5.2.6.3 Serial Number - The lens serial number shall be recorded on each photographic frame in the form of a single-line arabic number array, using reference Figure 2 as a guide.

3.5.2.7 Operation Mode - The Stellar Camera shall operate in an autcycle mode at the same cycling rates as the Mapping Camera. Stellar Camera start/stop operation and other internal functions shall be a nominal - 1.5 seconds for stellar photography.

3.5.2.8 Exposure Control - Exposure time shall be controlled by a between-the-lens shutter. The effective exposure time shall be a nominal 1.5 seconds for stellar photography.

3.5.2.9 Film Handling - The Stellar Camera shall be designed to transport the specified 35mm film throughout the entire camera and cassette film path without causing detrimental scratch marks in the film base or emulsion; without crushing the edges of the film; and without causing objectionable electrostatic discharge marks. Lateral film control shall be provided wherever necessary to minimize side wander and to insure proper film tracking. The film shall be positively constrained in the focal plane during photographic exposure. In any acceptance conducted in vacuum, 90% of the formats from either camera may have corona marks whose density is less than 0.1 above the base plus processing fog level, 10% of the formats may have corona marks whose density is between 0.1 and 0.4 above base plus processing fog density, and no format shall have corona marks whose density exceeds 0.4 above base plus processing fog density; processing of test film shall be consistent with the practices used in processing flight film. The camera shall not cause corona marks on the film during operation in sea level ambient conditions.

3.5.3 Camera Controls

3.5.3.1 Camera Cycle Timing - The camera controls shall

provide the electrical and mechanical devices required for establishing the correct camera cycle time consistent with the parameters outlined in paragraph 3.5.1.7 of this specification.

3.5.3.2 Stellar Lens Shutter Timing - The camera controls shall provide the necessary electronic devices to time and operate the Stellar lens shutter. These devices shall operate the shutter once every camera cycle at the proper time in the cycle and shall provide the correct stellar exposure time. Stellar shutter efficiency shall be greater than 95%.

3.5.3.3 Mapping Lens Shutter Timing - The camera controls shall provide the timing mechanism and electronic circuitry required to perform the following functions:

- 1) provide one exposure per camera cycle
- 2) maintain the center of exposure of Mapping Camera coincident with the center of exposure of the Stellar Camera
- 3) generate a data request signal coincident with the center of exposure of the Mapping Camera

3.5.3.4 Fiducial Firing - The camera controls shall provide the electronic circuitry required to fire the fiducial lamps on the Mapping Camera. These lamps shall be fired coincident with the center of exposure of the Mapping Camera.

3.5.3.5 Automatic Exposure Control (AEC) Servo - The AEC mechanism shall be a servo which drives the Mapping Camera shutter blades. This servo shall be controlled by a light sensor in such a manner that the exposure time is varied as a function of scene brightness. The output of the light sensor shall have the provision for pre-flight adjustment to accommodate films with an Aerial Exposure Index (AEI) of between 6 and 80.

3.5.3.6 Forward Motion Compensation (FMC) Servo - The FMC servo shall be a velocity servo controlled in such a manner that the speed of the servo motor is a function of the spacecraft V/H ratio. This servo drives the FMC mechanism of the Mapping Camera and the film handling and film flattening mechanisms of the Mapping and Stellar Cameras. The FMC servo establishes the camera cycling rates. Refer to paragraphs 3.5.1.5, 3.5.1.7, 3.5.1.8, 3.5.1.10, 3.5.2.5, 3.5.2.7, and 3.5.2.9 of this specification.

3.5.3.7 Auxiliary Data Conversion - Electronic circuitry shall provide the capability of driving the Data Recording arrays to display the dynamic auxiliary data.

3.5.3.8 Power Requirements - The Camera Subsystem shall operate on electrical power supplied by the spacecraft as described in ICD No. MH01-12502-234.

3.5.3.9 Interconnection Cables - All electrical connections between the camera and film cassettes shall be made by means of internal electrical connectors (no SIM interface).

3.5.3.10 Instrumentation and Test Points - The Camera Subsystem shall be instrumented to provide a means of monitoring its functional operation through the GSE. The GSE will receive sufficient instrumentation information to ascertain the operational status of the subsystem. The monitored information will be electrical signals transmitted from the MC to the GSE by way of the test connector 1231-J4. ICD No. MH01-12505-434 describes the MCS ground requirements.

3.5.3.11 Camera Telemetry - The MC Subsystem telemetry instrumentation is provided to permit preflight and in flight measurements for subsystem checkout. The MC data will be routed to signal conditioners within the camera. The telemetry signals will be transmitted from the MC Subsystem via the T/M connector 1231-J3.

3.5.3.12 Control Requirements - MC Subsystem operation is controlled by external commands. The MC control interface is described in detail in ICD No. MH01-12503-434.

3.5.4 Film Take-Up Cassette - The MC Subsystem shall include a film take-up cassette to store the exposed film from both Mapping and Stellar Cameras. A portion of the cassette shall be separable from the camera proper in a manner which will satisfy the need for EVA retrieval of the exposed record. The cassette shall meet the detail functional requirements described in the following subparagraphs.

3.5.4.1 Film Spools - The take-up cassette shall contain a 510 foot capacity spool for the specified 35mm film and a 1,500 foot capacity spool for the specified 5-inch film for purposes of conveniently storing the recorded data.

3.5.4.2 Record Container - The film spools shall be enclosed in a light-shielded protective container of minimum size and weight. The container shall be manually separable from the cassette and shall be suitable for handling by spacecraft personnel. It shall be constructed in a manner which is compatible with storage requirements aboard the spacecraft. When properly stowed, the record container will have sufficient structural integrity to protect the film throughout the recovery operation.

3.5.4.3 Take-Up Drive - The take-up cassette shall include two separate spool drive mechanisms for individually tensioning and winding exposed film. Each drive mechanism shall include a non-reversing device to prevent unspooling of film.

3.5.4.4 Cassette Detachment - The cassette shall be designed for separation from the rest of the MC Subsystem for purposes of film loading and data retrieval by test personnel prior to flight. The separation shall be quick, physically complete, and generally convenient.

3.5.4.4.1 Electrical Disconnect - Provision shall be made for quick disconnect of all electrical connections between the cassette and the rest of the MC Subsystem.

3.5.4.4.2 Film Cutting - The cassette shall include devices for cutting the film and for light shielding the film entrance port after film cutting.

3.5.4.5 Film Motion Sensor - A film motion sensor for each film path shall be included.

3.5.5 Camera Structure - The Mapping Camera Subsystem shall be an integral structure. Provision for mounting in the vehicle shall be in accordance with requirements of ICD No. MH01-12501-134.

3.5.6 Pressurization - Pressure relief valves or other devices for pressure equalization purposes shall be provided in the Mapping/ Stellar Camera enclosure. In addition, a slight positive pressure in the range of 10 to 200 microns of Hg, may be maintained within the MC enclosure to suppress static marking of the film.

3.5.7 Film Supply Spools - A 510 foot capacity supply spool shall be provided for the specified 35mm film and a 1,500 foot capacity supply spool shall be provided for the specified 5-inch film. Removal and insertion of the supply spools shall be accomplished with ease and convenience without the use of special tools. Both spools, when mounted in the Camera Subsystem, shall be capable of independent motion in response to film demand from the respective transport systems. Both spools shall be rotationally constrained during the launch and ascent phases to prevent excessive unspooling of film.

3.5.8 Film Loading - Unexposed film, of the specified types, shall be loaded in the MC supply cassette in a darkroom. Film leader threading through the platen areas, over metering rollers and onto the take-up spools, may be performed in illuminated areas.

3.5.9 Film Feed - A common film transport drive shall be used to power separate film metering rollers to draw unexposed film from the supply spools into the platen areas. Both films shall be fed through the respective cameras without forming objectionable loops, accumulating excessive slack, or causing any of the degrading characteristics specified in paragraphs 3.5.1.10 and 3.5.2.9.

3.5.10 Lens Interlock Angle - The pointing angle of the Stellar Camera relative to the Mapping Camera shall be 96° . The angular coordinate relationship between the Stellar Camera lens and the Mapping Camera lens, defined in terms of Tilt, Swing, and Azimuth angles in accordance with Figures 3A and 3B, shall be measured and recorded for each MC Subsystem. Deviations from the calibrated values, for any given MC Subsystem, shall not exceed the following 3 sigma limits:

Tilt ± 37 seconds of arc

Swing ± 30 seconds of arc

Azimuth ± 85 seconds of arc

NOTE: These values reflect error limits of the calibration fixture used for initial testing. Residuals resulting from stellar calibration will probably be less than about 15 seconds of arc. A method for simultaneous stellar photography with the two cameras will be provided for ground test only.

3.5.11 Cycle Counter - A counter shall be provided for displaying the total number of MC Subsystem operating cycles. The counter shall be removed prior to flight.

3.5.12 Thermal Design - The MC Subsystem shall be designed as part of a thermal system which will also include its surrounding environment when installed in the vehicle. Provision shall be made for implementation of the thermal control requirements of ICD MH01-12504-434.

3.6 Construction - With the possible exception of the stellar lens glare shade, all components of the MC Subsystem specified in paragraph 3.2 shall be assembled together by means of mechanical fastening to form a single "package". The outline configuration of this unit device shall be determined by internal subsystem functional requirements, good design practices, and installation integration specifications. The latter are covered in ICD No. MH01-12500-134. The stellar lens glare shade may be a separate assembly with mechanical and/or electrical connections to the camera-cassette

DEFINITION OF SYSTEM GEOMETRY

The positive X axis of the cartographic camera shall be defined as being approximately in the direction of the vehicle velocity vector. The Z axis shall be perpendicular to the X-Y plane and positive in the direction of the terrain to vehicle radius vector. The cartographic camera Y axis shall be approximately perpendicular to the orbit plane and positive in such a direction as to conform to a right hand Cartesian Coordinate System. The positive X axis of the Stellar Camera shall be approximately in the direction of the vehicle velocity vector. The negative Y axis shall be in the approximate direction of the terrain to vehicle radius vector. The Z axis of the Stellar Camera shall be perpendicular to the X-Y plane and positive in such a direction as to conform to a right hand Cartesian Coordinate System.

Within each focal plane, the X and Y axes shall be defined as follows:

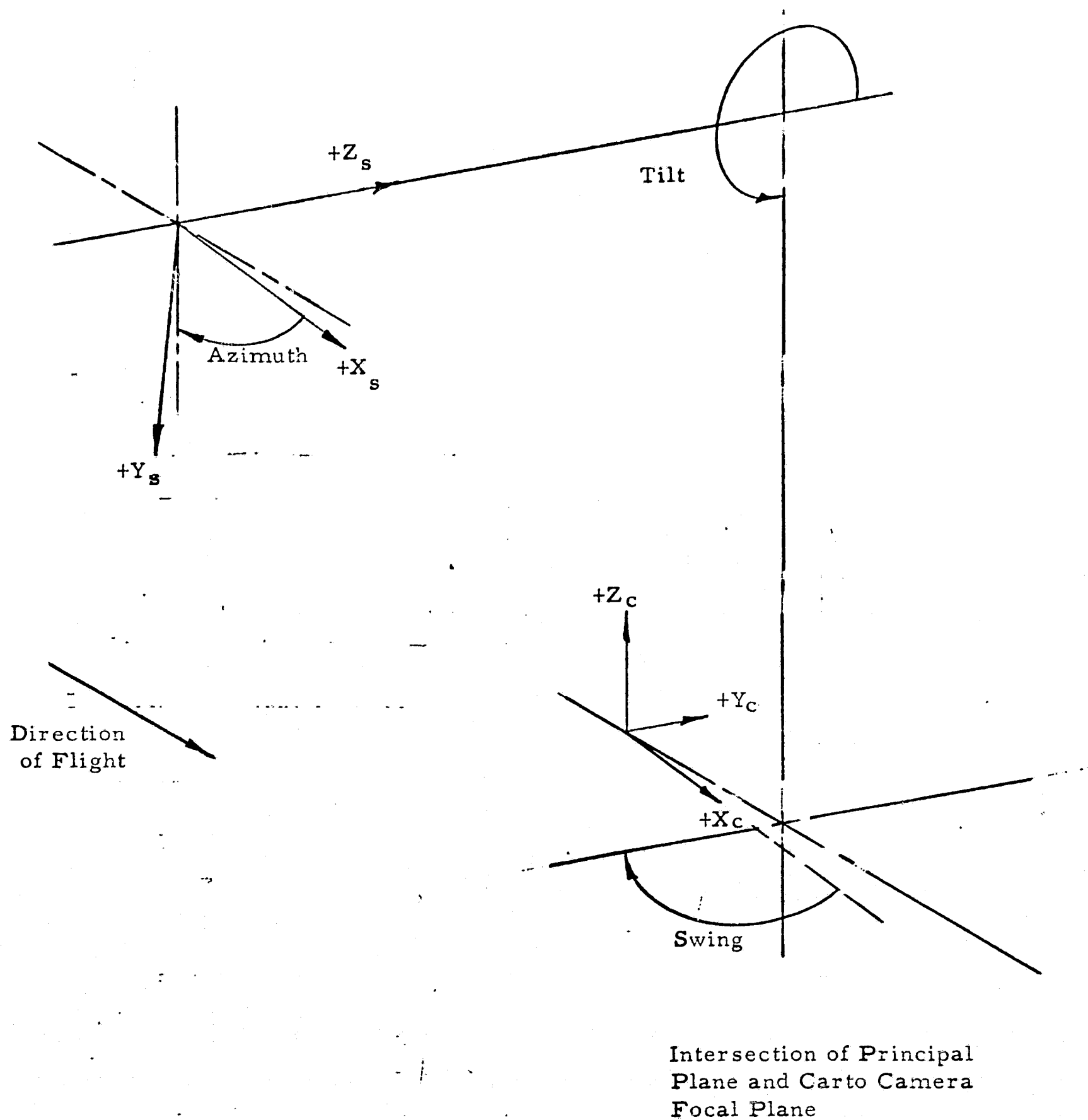
The Y axis shall be defined as the line determined by the two fiducial marks which are approximately perpendicular to the vehicle velocity vector. The X axis shall be defined as a line which is perpendicular to the Y axis, but passes through the indicated principal point. The Z axis is then defined as being perpendicular to the intersection of X and Y.

The principal plane shall be defined as that plane which contains Z_g and is parallel to Z_c .

The three angles defining the system geometry are defined as follows:

TILT	The clockwise angle measured from Z_g to the projection of Z_c on the principal plane (looking in the direction of flight). This angle shall be $264^\circ \pm 30$ minutes.
SWING	The angle measured from $+X_c$ to the trace of the principal plane in the $-Y$ direction on the cartographic camera focal plane. This angle shall be $90^\circ \pm 30$ minutes.
AZIMUTH	The angle measured in the clockwise direction from $+X_g$ to the trace of the principal plane (looking in the $-Z_g$ direction). This angle shall be $90^\circ \pm 30$ minutes.

FIGURE 3A



NOTES: (a) Carto Camera Coordinate System Rotated Slightly About Z_c Axis for Clarity

(b) Stellar Camera Coordinate System Rotated Slightly About Z_s Axis for Clarity

FIGURE 3B

unit. The overall size and weight of the MC Subsystem shall be held to a minimum and shall be consistent with the requirements of paragraphs 3.10 and 3.12. Light-weight materials shall be used wherever practicable for structural elements.

3.6.1 Structural Integrity - The level of structural strength and stiffness of mechanical elements shall be established on the basis of the service conditions and functional criteria specified herein. Design factors of safety shall be incorporated in consideration of stress concentrations, fatigue, self-induced loads, vibration amplification, and combinations of environmental conditions.

3.7 Performance Characteristics - The MC Subsystem shall meet the performance characteristics described herein under the environmental conditions given in paragraph 3.7.4.1 of this specification provided that all external signals and commands are in accordance with applicable interface specifications. Performance characteristics shall apply only after completion of at least two cycles after initiation of each camera start operation.

3.7.1 Photographic

3.7.1.1 Mapping Camera - The minimum static photographic resolution and the maximum distortion characteristics of the Mapping Camera lens shall be in accordance with Specification No. 1231-DO-1. Camera operation shall not degrade on-axis resolution by more than 10%.

3.7.1.2 Stellar Camera - The minimum static photographic resolution and the maximum distortion characteristics of the Stellar Camera lens shall be in accordance with Specification No. 1231-DO-2. Camera operation shall not degrade resolution by more than 10%.

3.7.1.3 Calibration - The MC Subsystem shall be calibrated as described in paragraph 3.5.10.

3.7.2 Electrical

3.7.2.1 Camera Subsystem Cycle Time - The camera cycle time shall be from 8.5 to 34 seconds. The time shall vary inversely with the V/H input signal. It shall be correct to within 3% of the theoretical value required by the input V/H signal for a nominal 78% photographic forward endlap at the input V/H.

3.7.2.2 Forward Motion Compensation - The FMC movement of the platen shall be accurate to within $\pm 3\%$ of any set value within the V/H range of 0.01 to 0.04 radian/second.

3.7.2.3 Stellar Camera Exposure Time - The Stellar Camera exposure time shall be $1.5 \pm 15\%$ seconds.

3.7.2.4 Mapping Camera Exposure Time - The error in exposure time shall not be greater than 1/2 stop over the exposure time range of 1/15 second to 1/240 second.

3.7.2.5 Exposure Synchronization - The center of exposure of the Mapping Camera shall be coincident with the center of exposure of the Stellar Camera to within 20 milliseconds (3 sigma).

3.7.2.6 Fiducial Lamp Firing - The Mapping Camera fiducial lamps shall be fired coincident with the center of exposure of the Mapping Camera to within the greater of 10% of the exposure time or one (1) ms.

3.7.2.7 Auxiliary Data Recording - The request pulse for auxiliary data to be recorded on the Mapping and Stellar Camera film shall be initiated coincident with the center of exposure of the Mapping Camera to within the greater of: 10% of the Mapping Camera exposure time, or one (1) ms.

3.7.3 Operating Life - The MC Subsystem shall be designed for a minimum operational life of 100,000 cycles with scheduled maintenance. The MC Subsystem shall be designed for a minimum operational life of 10,000 cycles without scheduled maintenance, provided this operation is not interrupted with periods of extended storage requiring reconditioning or environments not specified for Apollo missions.

3.7.4 Environmental - The MC Subsystem shall be designed and constructed so that no degradation in performance below that specified herein shall be caused by exposure to the ambient conditions described in the following subparagraphs.

3.7.4.1 Operating

3.7.4.1.1 Temperature - The operating temperature range of the MC Subsystem shall be $70^{\circ} \pm 10^{\circ}\text{F}$.

3.7.4.1.2 Altitude - The subsystem shall operate at lunar orbital altitudes of 30 - 80 nautical miles (circular).

3.7.4.1.3 Pressure - The MC Subsystem shall operate in the natural pressure environments corresponding to the altitudes specified in paragraph 3.7.4.1.2.

3.7.4.1.4 Humidity - The operating humidity range of the MC Subsystem shall be 0 to 50% RH.

3.7.4.2 Explosive Conditions - The subsystem shall not cause ignition of an ambient-explosive-gaseous mixture when operating in such an atmosphere.

3.7.4.3 Non-Operating

3.7.4.3.1 Temperature - The non-operating humidity range for the subsystem shall be $+40^{\circ}$ to $+120^{\circ}\text{F}$ without film load and $70^{\circ} \pm 20^{\circ}\text{F}$ with film load.

3.7.4.3.2 Humidity - The non-operating humidity range for the subsystem shall be 0 to 50% RH with or without film load.

3.7.4.3.3 Acceleration - The MC Subsystem shall withstand an acceleration of 5.0 g in the X-X direction and 0.75 g in any direction normal to the X-X axis for a period of 140 seconds.

3.7.4.3.4 Shock - The MC Subsystem shall withstand shock impulses of 5.0 g applied along the principal axes of a half sine wave of 6 milliseconds duration.

3.7.4.3.5 Vibration - The MC Subsystem shall withstand a random vibration level of 10.6 g's total rms acceleration for a period of 120 seconds. The acceleration density distribution shall be over a frequency range as follows:

20	200 Hz	3 db/octave rise to 0.05 g ² /Hz
200	- 2,000 Hz	0.05 g ² /Hz constant

The MC Subsystem shall withstand a sinusoidal acceleration of 0.25 g peak from 4 to 35 to 4 Hz at a sweep rate of 3 octaves/minute for 120 seconds.

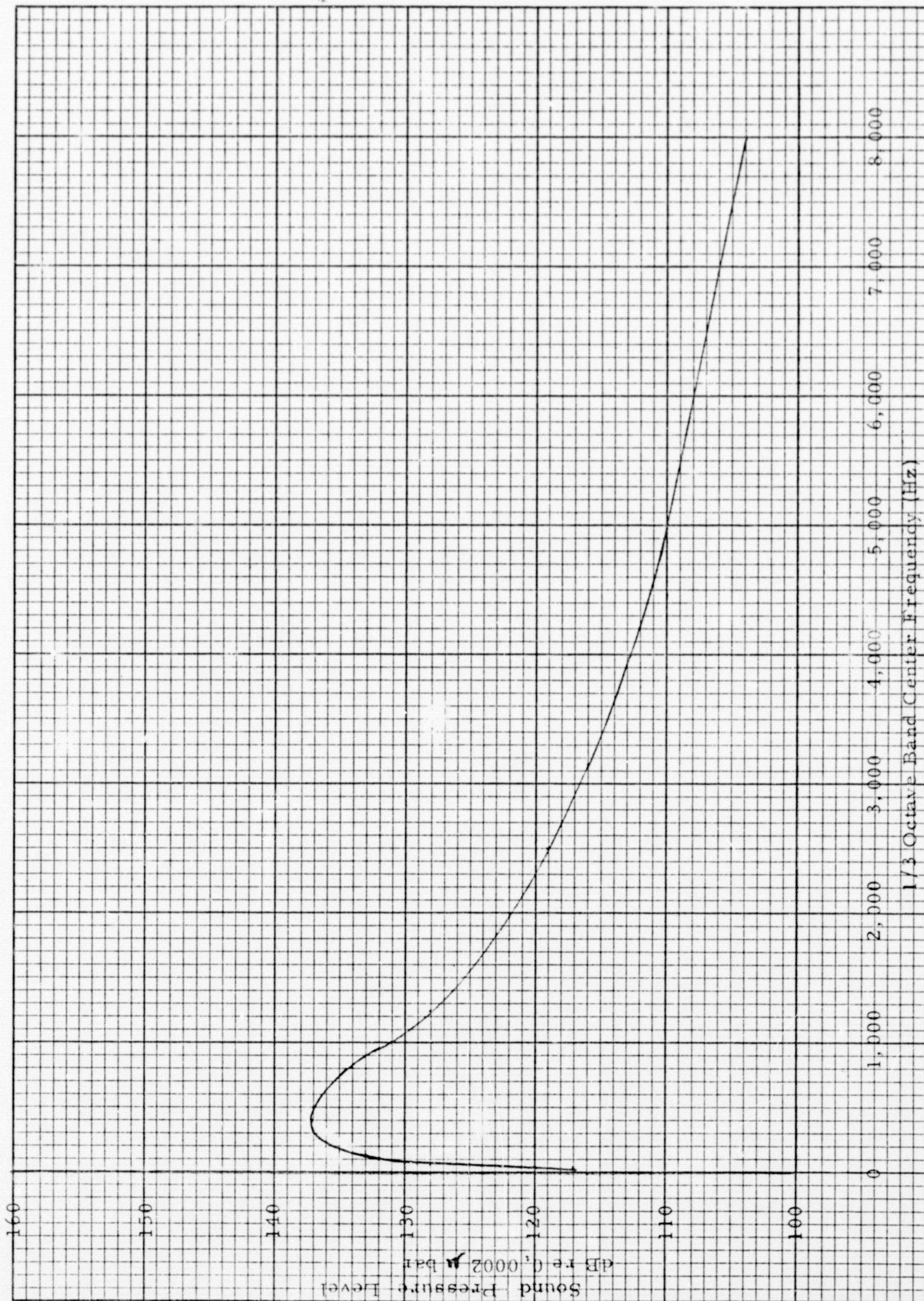
The subsystem shall also withstand a random vibration level of 5.4 g total rms acceleration for a period of 700 seconds. The acceleration density distribution for this level shall be over a frequency range as follows:

20	100 Hz	3 db/octave rise to 0.015 g ² /Hz
100	- 2,000 Hz	0.015 g ² /Hz constant

3.7.4.3.6 Acoustics - The MC Subsystem shall withstand an overall sound intensity level of 147 db for a period of 120 seconds. The spectral distribution of sound intensity shall be in accordance with Figure 4.

3.7.4.3.7 The MC Subsystem shall be tested in Class 100,000 clean room environment.

3.7.4.4 Transportation, Ground Handling and Storage - When properly packaged in its shipping container, the MC Subsystem shall be designed to withstand the extreme conditions of natural and induced environment specified in ICD MH01-12504-434.



ACOUSTICS SIM INTERNAL

FIGURE 4

3.8 EMI Suppression - The MC Subsystem shall be designed and fabricated to satisfy the EMI Control Requirements of Specification No. 1231-DR-1.

3.9 Reliability Requirements - The FSDS reliability program shall be in accordance with the plan described in Document No. 1231-AC-1.

3.10 Dimensions - The configuration and overall outline dimensions of the MC Subsystem shall be in accordance with the requirements of ICD MH01-12500-134 and ICD MH01-12507-434 . Dimensions and tolerances not specified, including all internal subsystem elements, shall be consistent with good manufacturing practices. When dimensions and tolerances affect the interchangeability, operation or performance of the equipment, they shall be held or limited accordingly.

3.11 Workmanship - The MC Subsystem, including all parts and accessories, shall be constructed and finished in a thoroughly workman-like manner. Particular attention shall be paid to neatness and thoroughness of soldering, wiring, part marking, plating, painting riveting, screw fastening, welding, brazing and deburring.

3.12 Weight - The MC Subsystem and/or components thereof, less thermal insulation and radiation shielding, shall, as a design goal, not exceed the weight values specified herein.

- Camera Subsystem with Film	125 pounds
- Lens Glare Shades	6 pounds
- Stowable Film Record Container with Film	24 pounds
- Deployment Mechanism	25 pounds

3.13 Finish - All parts, including items of hardware, shall be finished in accordance with the applicable paragraphs of MIL-E-5400 provided that such finishes are compatible with other MC Subsystem requirements specified and/or referenced herein. Special characteristics must be obtained.

3.14 Identification of Product - Equipment, assemblies and parts shall be marked for identification using Standard MIL-STD-130 as a guide. Reference designations for electrical connectors, cables, parts and assemblies shall be in accordance with the applicable paragraphs of MIL-E-5400 and MIL-STD-16.

3.14.1 Nomenclature and Type Designation - Nomenclature and type shall be established by the procuring activity.

3.15 Safety Requirements - The design, material, manufacturing testing, and operation of the MCS shall be in accordance with the System Safety Plan, Document No. 1231-AC-4.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 General - This section of the specification establishes the general test and inspection requirements to be followed during the test program. The requirements of the Quality Assurance Plan, Document No. QAP 2528, shall apply to all program activities. The program shall consist of the following test categories:

- 1) Acceptance Tests
- 2) EMI Tests
- 3) Reliability Tests
- 4) Qualification Tests
- 5) Post-Shipping Receiving Inspection and Test

4.1.1 Standard Environmental Conditions - Unless otherwise specified, the tests shall be conducted at the ambient temperature humidity, and pressure conditions as follows:

- | | |
|-------------------------|-------------------|
| 1) Temperature | 60°F to 80°F |
| 2) Relative Humidity | 0 - 50% RH |
| 3) Ambient Air Pressure | Local Atmospheric |

4.1.2 Instrument Calibration - All inspection measuring and test equipment shall be calibrated against certified secondary standards which have been calibrated against primary standards of the Nation Bureau of Standards by an accepted test organization. Records shall be maintained indicating the date of last calibration and due date. The due date shall be displayed on each item of inspection, measuring, and test equipment.

4.1.3 Tolerances

- 1) Test Equipment - All inspection and test measurements shall be made with test equipment that has calibration and resolution error which are approximately 1/10 of the specified performance tolerance or test condition tolerance of the parameter or condition being measured unless limited by the state-of-the-art. Performance parameters and test conditions which are specified as allowable ranges with no tolerances on the extreme limits shall be measured with test equipment that will read within 1% of the true value. When oscillographic or other time-based recording of a parameter is required, the measurement error shall be no greater than 5% of the full scale value of the maximum rate of change of the signal being measured.
- 2) Test Conditions - Unless otherwise specified, each condition as indicated by the measuring equipment during each test shall

be held within the following tolerance limits for each extreme limit or normal value of the specified condition.

- | | | |
|----|---|------------|
| a. | High Temperature | +5°F, -0°F |
| b. | Low Temperature | +0°F, -5°F |
| c. | Sine Vibration Amplitude | +20%, -0 |
| d. | Vibration Frequency | ±2% |
| e. | <u>Random Vibration</u> - The vibration acceleration density applied to the test item shall be within ±2db of the specified test level over broad regions of the spectrum between 20 and 1,000 cps and ±4 db between 1,000 and 2,000 cps. | |
| f. | Shock Amplitude | +20%, -0 |
| g. | Acceleration Amplitude | +10%, -0 |
| h. | Humidity | ±5% |
| i. | Time | +5%, -0 |
| j. | Pressure | +5% |
| k. | Voltage | ±1% |
| l. | Current | ±1% |
| m. | Transient Duration | ±2% |
| n. | <u>Waveform</u> - Maximum distortion limit specified for normal service shall be the minimum value for testing. | |

4.2 Tests

4.2.1 Test Inspection Requirements - The following test inspection requirements shall be applicable for each group of tests unless otherwise specified.

- 1) Pre-Test Inspection Requirements - Pre-test inspection shall consist of all visual examination necessary to determine conformity to the requirements of the approved design of the camera subsystem, including the dimensions and weight requirements of this specification.
- 2) Post Test Inspection Requirements - Post-test inspection shall consist of all visual examinations necessary to determine that no seal was disturbed and that part was dislocated, damaged, deformed or defaced at the conclusion of the test and that the dimensions, finish, identification or marking was not affected by the test. In addition, the subsystem shall be subjected to an operational test to assure that the subsystem satisfies the performance requirements.
- 3) Test Equipment Inspection Requirements - Test equipment inspection shall consist of all examinations necessary to determine that the accuracy and calibration requirements of paragraphs 4.1.2 and 4.1.3 are satisfied prior to initiating the applicable test.

4.2.2 Acceptance - An acceptance test shall be made on each deliverable camera subsystem. This testing is detailed in Document No. 1231-EB-7, MC Subsystem Acceptance Test Specification, and Document No. 1231-ER-2, EMI Acceptance Test Specification for MC Subsystem. The acceptance inspection and test procedure shall make provisions for detail inspection requirements of paragraph 4.2.1 and shall include the performance tests required to demonstrate compliance with the applicable requirements of Section 3 under the environmental conditions of paragraph 3.7.4.1.

4.2.3 EMI Qualification Tests - EMI qualification tests shall be performed on one camera subsystem in accordance with Qualification Test Specification No. 1231-ER-1. These tests shall demonstrate that the prototype design satisfies all the requirements of this specification.

4.2.4 Qualification Tests - Qualification tests shall be performed on one camera subsystem. The qualification test shall demonstrate that the prototype design will satisfy all the requirements of this specification under the environmental conditions of paragraph 3.7.4. An operational test shall be performed before and after exposure to each test environment and during the test environment when so specified. Prior to the start of the qualification test program, the test unit shall successfully complete the acceptance tests in accordance with paragraph 4.2.2. All parts or elements which have been subjected to these tests, either individually or as a part of a larger assembly, shall be distinctively marked as qualification tested parts. Specification No. 1231-EB-5 will be the applicable test document.

4.2.5 Post-Shipping Receiving Inspection and Test - After shipment and before operation, the MC Subsystem shall be inspected in accordance with ICD MH01-12505-434.

5.0 PREPARATION FOR DELIVERY - The preparation for delivery shall render the MC Subsystem capable of shipment and extended storage without degradation of reliability due to corrosion, contamination or physical damage. Preparation for delivery shall include preservation and packaging, packing and marking of shipments.

5.1 Preservation and Packaging - The MC Subsystem shall be cleaned and packaged in shipping container of MIL-C-4150 type.

5.2 Packing - Where overpacking of the shipping containers is required, they shall be packed in exterior type containers or minimum cube and tare consistent with the protection required. Cushioning, blocking, bracing and strapping shall be in accordance with good commercial practice.

5.3 Marking of Shipment - Interior and exterior containers shall be durably and legibly marked in accordance with MIL-STD-129. Shipping information and shipment nomenclature shall be as specified in the procurement contract.

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1231-DO-1

CARTOGRAPHIC LENS
Revision A

24 February 1970

1.0 SCOPE - This specification covers the design and performance requirements for a 3-inch focal length, f/4.5 cartographic lens to cover a 4-1/2 x 4-11/16 inch format. The lens shall be supplied as an integral unit with a glass focal plane plate with the rear surface plane.

2.0 APPLICABLE MILITARY DOCUMENTS

Specifications

MIL-F-32	Film, Photographic, Aerial, Black and White
MIL-M-3171	Magnesium Alloy, Processes for Corrosion Protection of
MIL-A-8625	Anodic-Coatings, for Aluminum and Aluminum Alloys
MIL-C-675	Films, Reflection-Reducing, for Class Optical Elements

Standards

MIL-STD-130	Identification Marking of U. S. Military Property
MIL-STD-150A	Photographic Lenses
MIL-STD-152	General Environmental Requirements Testing Procedures and Sampling for Aerial Photographic Reconnaissance

3.0 REQUIREMENTS

3.1 Materials - Every effort shall be made to select materials which will result in a lens of minimum size and weight within the performance con-

straints specified below. Materials which are not covered by applicable specifications or which are not specifically described herein shall be of a quality consistent with other requirements.

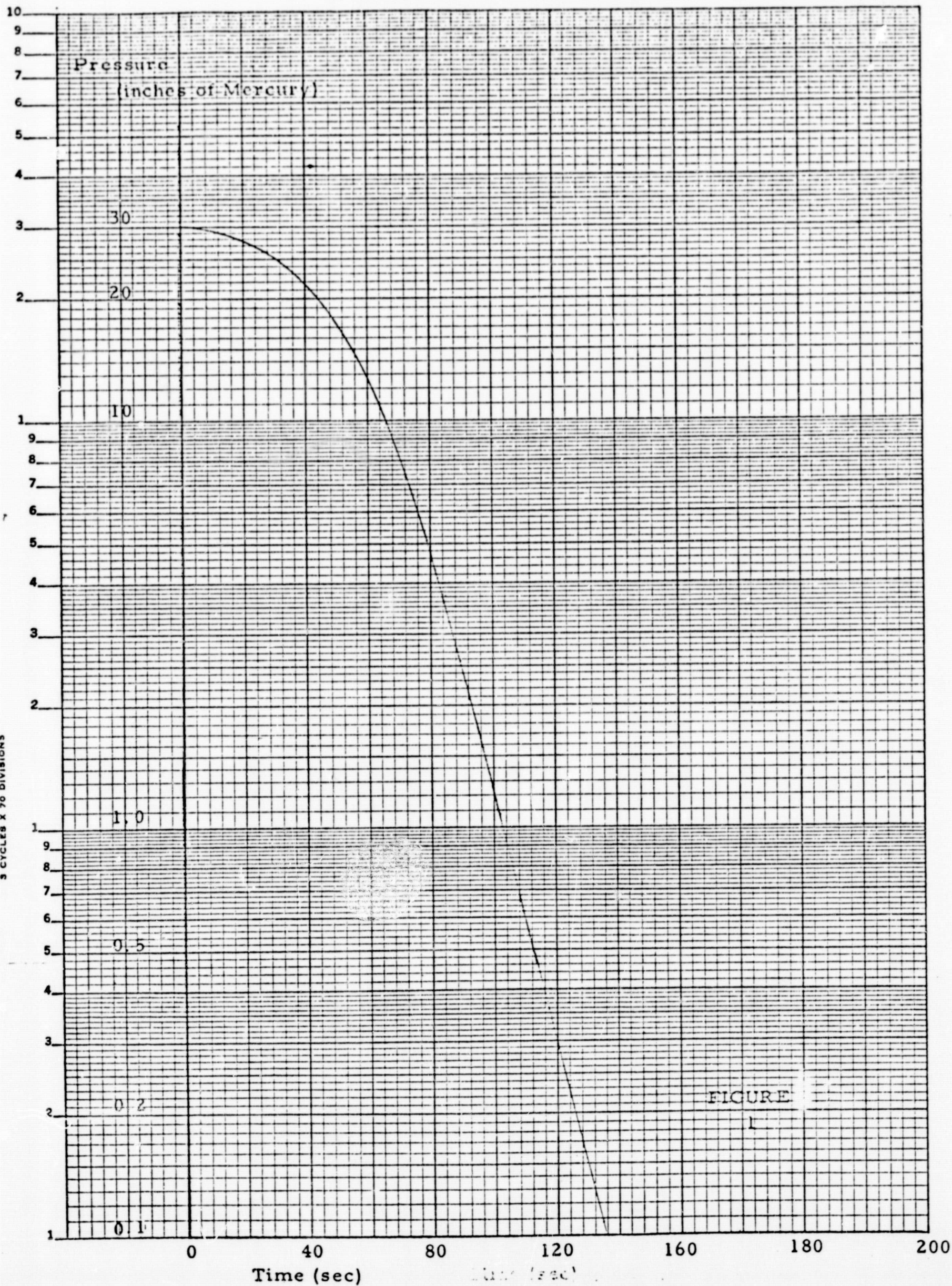
3.1.1 Metals - Metals shall be of the corrosion resistant type, unless suitably protected to resist corrosion during normal service life. Where aluminum and magnesium alloys are used, they shall be protected in accordance with Specifications MIL-A-8625 and MIL-M-3171.

3.1.2 Protective Treatment - When materials are used that are subject to deterioration when exposed to climatic and environmental conditions likely to occur during service usage as defined in paragraph 3.4, they shall be protected against such deterioration in a manner that will in no way prevent compliance with the performance requirements of this specification. The use of any protective coating that will crack, chip or scale with age or extremes of climatic and environmental conditions shall be avoided.

3.1.3 Fungus Proof Materials - Materials which are nutrients for fungi shall not be used.

3.2 Design and Construction

3.2.1 Mechanical - The detail design of the lens barrel envelope configuration and shutter mechanical interface shall be subject to mutual agreement between the purchaser and the lens manufacturer. However, the lens shall be supplied with a glass plane-parallel focal plane plate, which is perpendicular to the optical axis and adjustable to the plane of best definition. The plane of best definition shall be defined in accordance with the performance requirements set forth below. It shall be the responsibility of the lens manufacturer to insure that mounting provisions for each element shall result in a minimum deterioration of performance of the lens when subjected to the specified environmental conditions. Provisions shall be made for venting each air space within the lens assembly at a rate commensurate with Figure 1. Venting shall not permit light leaks to reach the focal plane. The preferred orientation of the vent holes shall be such that, radially outward from the optical axis, they slope away from the focal plane.



3.2.1.1 Motion Compensation - To permit film movement relative to the lens in order to compensate for image motion, the focal plane plate shall be movable in an X-Y plane (refer to Figure 2). This plate shall be so configured and maintained as to permit the requisite motion without degrading the optical performance specified in Section 3.3.

3.2.2 The material to be used for the upper and lower cells and the shutter housing shall be beryllium; the glass retainer rings shall be stainless steel.

3.2.3 Exposed external and internal surfaces of the metallic members shall have a durable firmly bonded, black matte, low reflecting surface sufficiently dull to minimize light reflections. In addition, ground surfaces of any element shall be blackened or dyed, wherever mounting provisions will permit. Lens seats and mechanical mounting surfaces are excepted from this requirement, where appropriate.

3.2.4 The serial number of the lens shall be marked on the front of the lens barrel or retainer.

3.2.5 Except where pre-empted by other special coatings, each glass-air surface of the lens shall be coated with a reflection reducing coating in accordance with Specification MIL-C-675, with the exception of the focal surface.

3.2.6 The inclusion of a thermal coating on the front surface of the first lens element shall be subject to mutual agreement between the purchaser and the lens manufacturer.

3.2.7 Beauty defects as defined in MIL-STD-150A shall not be a cause for rejection.

3.2.8 The lens shall be provided with a fixed aperture stop at $f/4.5$.

3.2.9 Front and rear caps shall be provided. Lens caps shall have a soft plastic exterior. The front lens cap shall be designed so that it can be affixed in the assembled camera configuration.

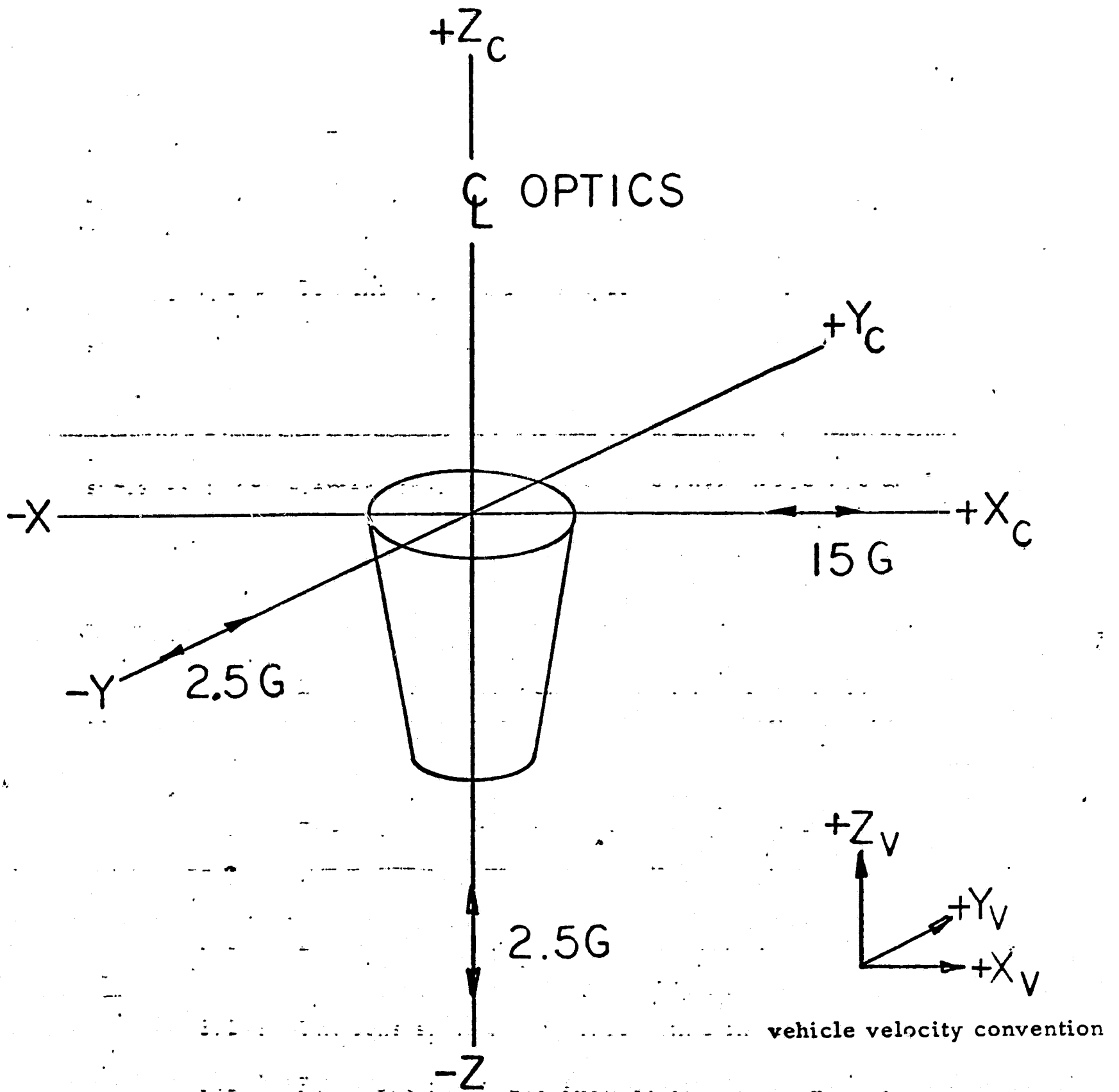


FIGURE 2

3.2.10 The total weight of the lens, lens caps shall not exceed 11.5 pounds.

3.3 Optical Characteristics

3.3.1 Color Correction - The lens shall be corrected to provide maximum performance with white light, filtered through a Wratten 12 filter, exposed on panchromatic emulsion. The filter shall be in the form of a coating on one element of the lens system.

3.3.2 Focal Plane Plate - A glass plate suitably figured for use as a focal plane shall be included as the last element of the lens. The focal surface shall have deposited upon it a reseau registration system consisting of a series of crosses spaced 10mm apart which shall be recorded on each frame as a pattern of unexposed line segments. Line width shall be 5 - 8 microns on the reseau plate. Cross intersections shall be calibrated to an accuracy of 0.001mm (1 σ -error) in a single reseau-plate coordinate system. The characteristics of the deposit made on the focal plane shall be in accordance with Drawing No. 1231-1152.

3.3.2.1 The focal plane plate shall be positioned so that the focal surface is correct for an operating pressure of from 0 to 1.0 mm of Hg.

3.3.3 Distortion - The radial distortion referred to the calibrated focal length in the focal plane of best definition shall not exceed ± 50 microns out to a half field angle of 42.5 degrees. The tangential distortion of the lens shall be 5 microns or less. A radial distortion of less than ± 30 microns shall be a design goal.

3.3.4 Relative Aperture - The relative aperture of the lens shall be f/4.5.

3.3.5 Relative Illumination - A vignetting correction coating shall be applied to the lens in order to provide a focal plane illumination which is uniform to within 50% (i.e., the corners of the field shall not be less than 50% of the axis).

3.3.6 Transmission - The axial transmission of the lens without filters or vignetting correction shall not be less than 75%. With vignetting coating but not including Wratten 12 film filter factor nor possible thermal coating, the axial transmission of the lens shall not be less than 35% and the AWAT shall not exceed 8.3.

3.3.7 Resolution - The minimum photographic resolution at the focal plane over the full 4-1/2 x 4-11/16 inch format shall be as follows on EK 3404 film properly exposed and processed at the specified target contrast; and at any focal plate position within the IMC travel:

Target Contrast Ratio

2:1

AWAR

90 lines/millimeter

3.3.8 Focal Length - The equivalent focal length of the lens shall be 76.2 ± 1.5 mm in vacuum. This value shall be determined to an accuracy of 0.010 mm. The focal length shall be computed to 0.001 mm.

3.4 Environmental Range

3.4.1 The lens shall be designed to meet the following environmental conditions:

- 1) Operating temperatures of $70^{\circ} \pm 20^{\circ}\text{F}$ at a pressure to 1×10^{-6} mm Hg and relative humidity from 0% to 60%. The lens must operate over a total range from $+40^{\circ}\text{F}$ to $+120^{\circ}\text{F}$ with minimum photographic performance degradation outside of the $70^{\circ} \pm 20^{\circ}\text{F}$ operating range.
- 2) Indefinite storage at any temperature in the range -65°F to $+120^{\circ}\text{F}$ when properly packaged for shipment or storage.
- 3) Prolonged accelerations of 10 minutes duration in direction and "g" levels shown in Figure 2. All accelerations to be in plus and minus directions.

- 4) Mechanical shocks of 20 g's for a duration of 6 milliseconds in each of 3 mutually perpendicular planes.
- 5) Vibration - The lens shall withstand a random vibration level of 21.2 g's total rms acceleration for a period of 120 seconds. The acceleration density distribution shall be over a frequency range as follows:

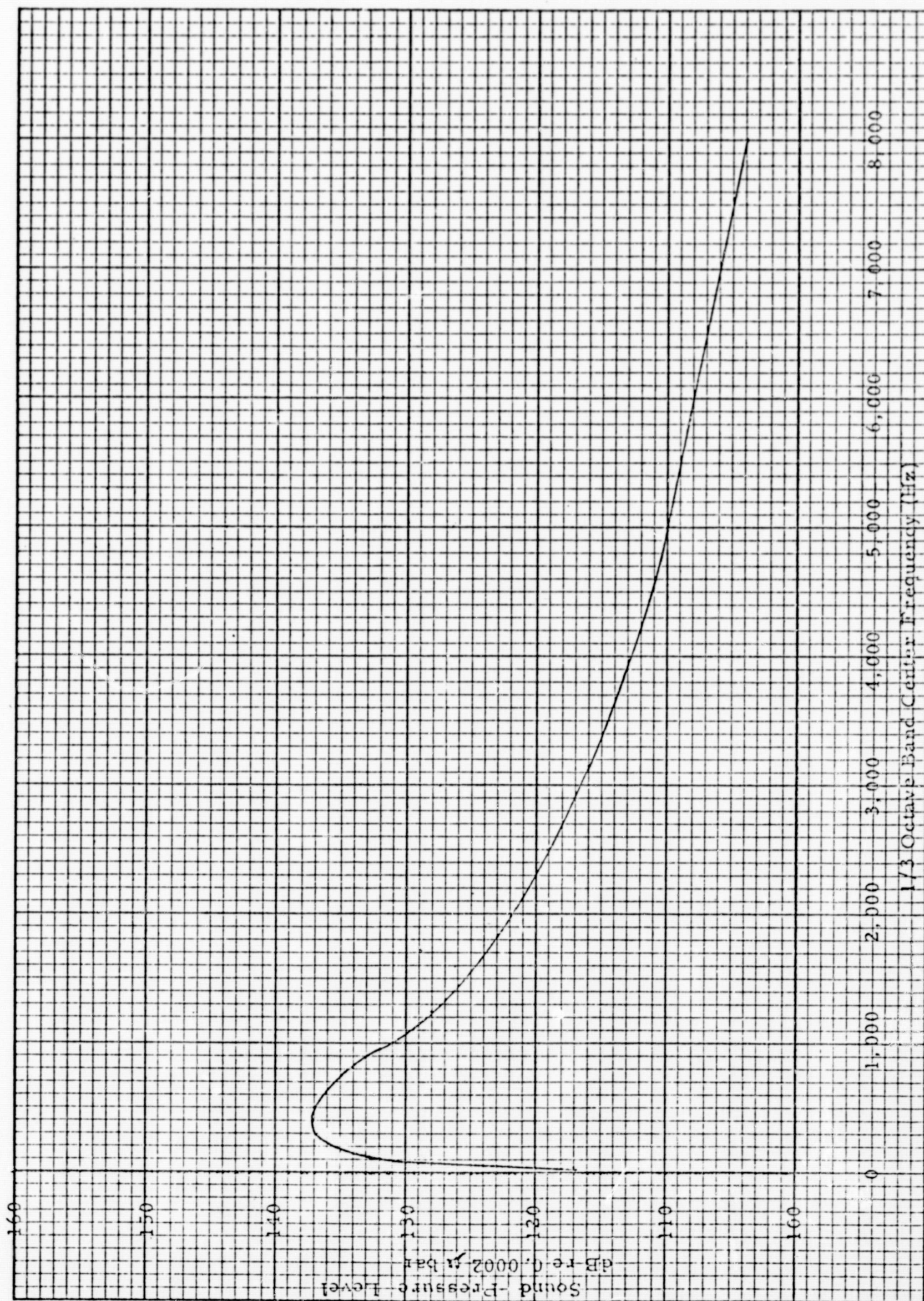
20 - 200 Hz	3 db/octave rise to $0.24 \text{ g}^2/\text{Hz}$
200 - 2,000 Hz	$0.24 \text{ g}^2/\text{Hz}$

The lens shall withstand a sinusoidal acceleration at 0.5 g peak from 4 to 35 to 4 Hz at a sweep rate of 3 octaves/minute for 120 seconds.

The lens shall also withstand a random vibration level of 10.8 g total rms acceleration for a period of 700 seconds. The acceleration density distribution for this level shall be over a frequency range as follows:

20 - 100 Hz	3 db/octave rise to $0.06 \text{ g}^2/\text{Hz}$
100 - 2,000 Hz	$0.06 \text{ g}^2/\text{Hz}$ constant

- 6) Acoustics - The lens shall withstand an overall sound intensity level of 147 db for a period of 120 seconds. The spectral distribution of sound intensity shall be in accordance with Figure 3.
- 7) Explosive Conditions - The lens shall not cause ignition of an ambient explosive-gaseous mixture when operating in such an atmosphere.



ACOUSTICS SIM INTERNAL

FIGURE 3

4.0 INSPECTION AND TEST PROCEDURES

4.1 General - Records of all inspection work and tests, giving the results of tests required to determine compliance with the standards, requirements and tests specified herein, shall be kept complete and shall be available to any of the purchaser's authorized personnel at any time.

4.1.1 Information shall be compiled, summarized, and presented with each lens operated in a vacuum (1mm Hg or less), as follows:

- 1) The tangential and radial resolution values obtained along two mutually perpendicular diagonals in the focal plane of best definition at low contrast.
- 2) A film sample corresponding to each data item in Item (1) above.
- 3) The values of the distortion along two mutually perpendicular diagonals in the focal plane.
- 4) The measured values of relative aperture, transmission and relative illumination.
- 5) The coordinates of the principal point of autocollimation shall be given with respect to the indicated principal point. The indicated principal point is defined by the intersection of the grid axes extending from the artificial fiducial marks.

4.2 Individual Inspection Test Methods - Each lens shall be subjected to the following tests:

4.2.1 Examination of Product - Each lens shall be inspected to determine compliance with this specification for requirements for which tests are not specified, such as workmanship, mounting, marking, reflection-reducing coatings, beauty defects, serial numbers, and finish.

4.2.2 Photographic Plane of Best Definition - A photographic test in accordance with Method 11 of MIL-STD-150A shall be made with the lens at maximum aperture. A test target with patterns varying by no more than the sixth root of two shall be exposed in maximum intervals of 7.5° from 0° to 45° . All lenses shall be tested at both high and low contrast by the lens manufacturer. Low contrast is nominally 2:1, however, the limits of acceptable contrast are 1.78:1 to 2.24:1. For all photographic testing, 3404 emulsion shall be used, and it shall be processed in accordance with the recommended procedures. Through focus tests shall be conducted over a range adequate to establish the focal plane depth, in and out from the best plane. Curves of these data shall be prepared.

4.2.3 Distortion - The distortion shall be determined by Method 26 of MIL-STD-150A, except that the angular location of the targets shall be known to an accuracy of 2 seconds of arc, and they shall be placed at angular intervals of 7.5° or less. Photographic plates or stable base film shall be used to make the exposures. The emulsion surface shall be as flat as practical and in no case shall it introduce more than 2 micron displacement of the image from its true planar position. Distortion shall be measured with sufficient accuracy to insure a calibration accuracy of ± 3 microns. As an alternate, Method 29 of MIL-STD-150A may be used in conjunction with the calibrated maseau grid. If Method 29 is selected, then the grid intersections used for measurement purposes shall be those which most nearly correspond to the following angles: 0° , 10° , 20° , 29° , 37° , and 43° .

4.3 Optical Tests - All lenses submitted on the order shall be subjected to the following tests by the lens manufacturer and the data submitted to the purchaser's Quality Assurance Department for approval.

4.3.1 Relative Aperture - Relative aperture shall be computed by the ratio of the measured EFL to the diameter of the effective aperture. The effective aperture shall be measured by Methods 3 or 4 of MIL-STD-150A.

4.3.2 Transmittance - The transmittance of the lens shall be measured by Methods 5 or 6 of MIL-STD-150A.

4.3.3 Relative Illumination - The relative illumination of characteristics of the lens shall be measured by Method 7 of MIL-STD-150A.

4.4 Environmental Tests - At least one lens shall be subjected to the tests listed below, with the lens secured to the test equipment by its normal mounting means. After each test, the lens shall be inspected for damage and subjected to suitable photographic tests to determine if there has been any alteration of optical performance. The testing shall be the responsibility of the camera subcontractor, however, the lens manufacturer shall be responsible for lens performance. The lens optical characteristics, as defined in paragraph 3.3, shall not be degraded as a result of these tests.

4.4.1 Acceleration - Prolonged accelerations of 10 minutes duration in direction and "g" levels shown in Figure 2. All accelerations to be in plus and minus directions.

4.4.2 Shock - Mechanical shocks of 20 g's for a duration of 6 milliseconds along X-X, Y-Y, and Z-Z axes in plus and minus direction.

4.4.3 Vibration - The lens shall withstand a random vibration level of 21.2 g's total rms acceleration for a period of 120 seconds. The acceleration density distribution shall be over a frequency range as follows:

20 - 200 Hz	3 db/octave rise to $0.24 \text{ g}^2/\text{Hz}$
200 - 2,000 Hz	$0.24 \text{ g}^2/\text{Hz}$

The lens shall withstand a sinusoidal acceleration at 0.5 g peak from 4 to 35 to 4Hz at a sweep rate of 3 octaves/minute for 120 seconds.

The lens shall also withstand a random vibration level of 10.8 g total rms acceleration for a period of 700 seconds. The acceleration density distribution for this level shall be over a frequency range as follows:

20 - 100 Hz	3 db/octave rise to $0.06 \text{ g}^2/\text{Hz}$
100 - 2,000 Hz	$0.06 \text{ g}^2/\text{Hz}$ constant

If the lens has any resonant points between 1Hz and 15 Hz, it shall be capable of withstanding a 1 g sinusoidal vibration at those frequencies for a period of five minutes.

4.4.4 Acoustics - The lens shall withstand an overall sound intensity level of 147 db for a period of 120 seconds. The spectral distribution of sound intensity shall be in accordance with Figure 3.

5.0 SHIPMENT - The lenses shall be packed and wrapped for domestic shipment.

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A Division of Fairchild Camera and Instrument Corporation
300 Robbins Lane, Syosset, New York

1231-DO-2

STELLAR LENS
Revision A

24 February 1970

1.0 SCOPE - This specification covers the design and performance requirements for a 3-inch focal length, f/2.8 lens to cover a 1.25 inch diameter format. The lens shall be supplied as an integral unit with a glass focal plane plate, with the rear surface plane and precisely perpendicular to the optical axis.

2.0 APPLICABLE MILITARY DOCUMENTS

Specifications

MIL-F-32	Film, Photographic, Aerial, Black and White
MIL-M-3171	Magnesium Alloy, Processes for Corrosion Protection of
MIL-A-8625	Anodic-Coatings, for Aluminum and Aluminum Alloys
MIL-C-675	Films, Reflection-Reducing, for Glass Optical Elements

Standards

MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-150A	Photographic Lenses
MIL-STD-152	General Environmental Requirements Testing Procedures and Sampling for Aerial Photographic Reconnaissance

3.0 REQUIREMENTS

3.1 Materials - Every effort shall be made to select materials which will result in a lens of minimum size and weight within the performance con-

constraints specified below. Materials which are not covered by applicable specifications or which are not specifically described herein shall be of a quality consistent with other requirements.

3.1.1 Metals - Metals shall be of the corrosion resistant type, unless suitably protected to resist corrosion during normal service usage, as defined in paragraph 3.4. Where aluminum and magnesium alloys are used, they shall be protected in accordance with Specifications MIL-A-8625 and MIL-M-3171.

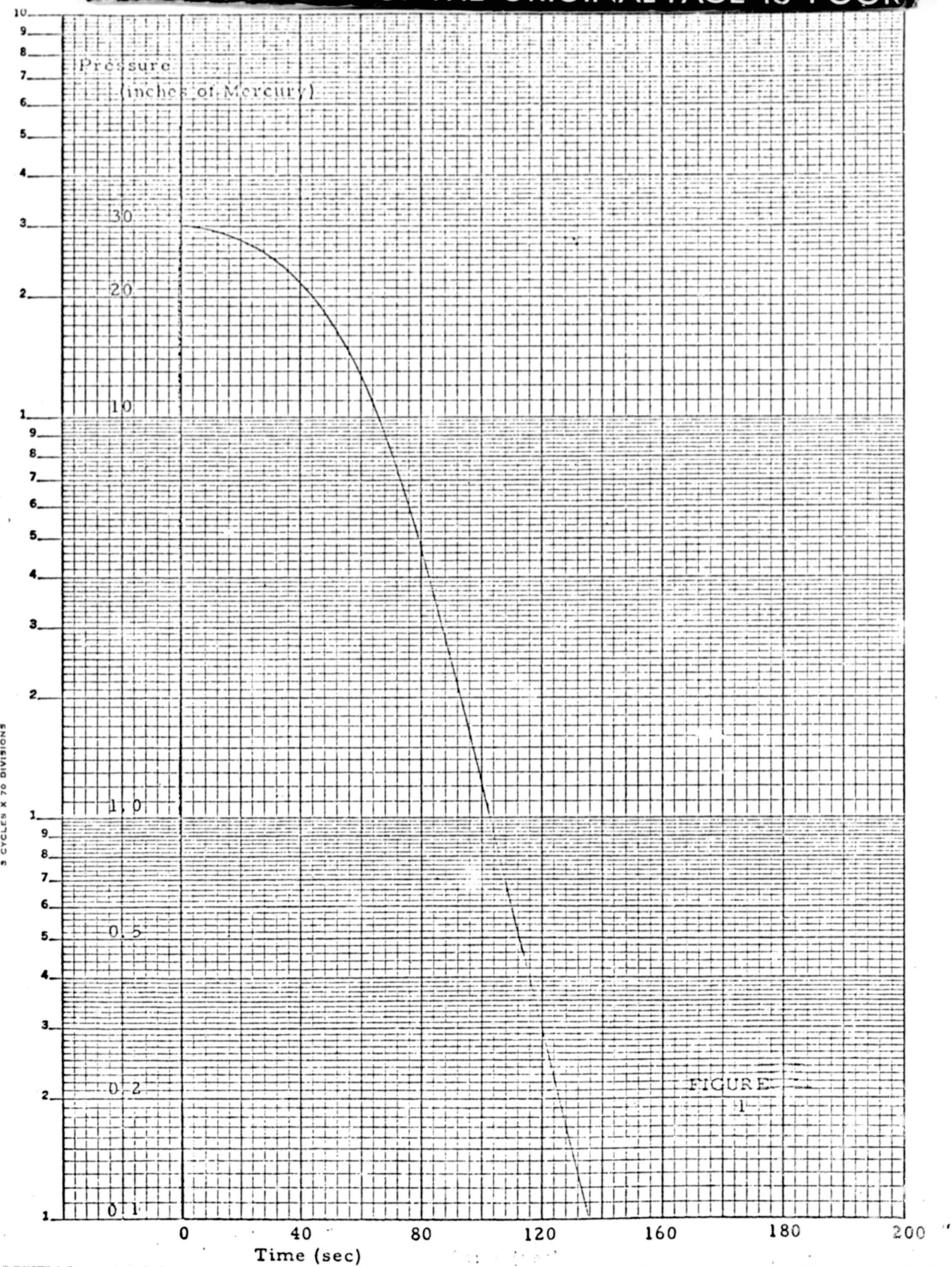
3.1.2 Protective Treatment - When materials are used that are subject to deterioration when exposed to climatic and environmental conditions likely to occur during service usage, they shall be protected against such deterioration in a manner that will in no way prevent compliance with the performance requirements of this specification. The use of any protective coating that will crack, chip or scale with age or extremes of climatic and environmental conditions shall be avoided.

3.1.3 Fungus Proof Materials - Materials which are nutrients for fungi shall not be used.

3.2 Design and Construction

3.2.1 Mechanical - The detail design of the lens barrel shall be subject to mutual agreement between the purchaser and the lens manufacturer. However, the lens shall be supplied with a glass focal plane plate, which is precisely perpendicular to the optical axis, and adjustable to the plane of best definition. The plane of best definition shall be defined in accordance with the performance requirements set forth below. It shall be the responsibility of the lens manufacturer to insure that mounting provisions for each element shall result in a minimum deterioration of performance of the lens when subjected to the specified environmental conditions. Provision shall be made for venting the entire lens assembly, at a rate commensurate with Figure 1. Vents shall not permit light leaks to reach the focal plane. The preferred orientation of the vent holes shall be such that, radially outward from the optical axis, they slope away from the focal plane.

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3.2.2 The materials to be used for the upper and lower cells and shutter housing shall be beryllium; the glass retainer rings shall be stainless steel.

3.2.3 Exposed external and internal surfaces of the metallic members shall have a durable firmly bended, black matte, low reflecting surface sufficiently dull to minimize light reflections. In addition, ground surfaces of any element shall be blackened or dyed, wherever mounting provisions will permit.

3.2.4 The serial number of the lens shall be marked on the front of the lens barrel or retainer.

3.2.5 Each glass-air surface of the lens shall be coated with a reflection reducing coating in accordance with Specification MIL-C-675, with the exception of the focal surface.

3.2.6 Beauty defects as defined in MIL-STD-150A shall not be a cause for rejection.

3.2.7 The lens shall be provided with a fixed aperture stop at $f/2.8$.

3.2.8 Front and rear lens caps shall be provided.

3.2.9 The total weight of the lens, less lens caps shall not exceed 50 pounds.

3.3 Optical Characteristics

3.3.1 Color Correction - The lens shall be corrected to provide maximum performance with white light, exposed on panchromatic emulsion. (EK 3400 or 3401).

3.3.2 Focal Plane Plate - A glass plate suitably figured for use as a focal plane, shall be included as the last element of the lens. The focal

surface shall have deposited upon it a reseau registration system consisting of a series of crosses spaced 5mm apart which shall be recorded on each frame as a pattern of unexposed lines. The line width shall be 5 - 8 microns on the reseau plate. Cross intersections shall be calibrated to an accuracy of 0.001mm (1 σ error) in a single reseau plate coordinate system. The characteristics of the deposit on the focal plane plate shall be in accordance with Drawing No. 1231-1153.

3.3.2.1 The focal plane plate shall be positioned so that the focal surface is correct for an operating pressure of from 0 to 1.0 mm of Hg.

3.3.3 Distortion - The radial distortion referred to the calibrated focal length in the focal plane of best definition shall not exceed ± 15 microns with ± 10 microns being the design goal. The tangential distortion of the lens shall be 5 microns or less.

3.3.4 Relative Aperture - The relative aperture of the lens shall be f/2.8.

3.3.5 Relative Illumination - The relative illumination across the full field of the lens shall not be less than $\cos^4$ of the half field angle.

3.3.6 Transmission - The axial transmission of the lens shall not be less than 75%.

3.3.7 Resolution - The minimum photographic resolution at the focal plane over the full format as shown in Drawing 1231-1153 shall be 80 lines/mm AWA, with a target contrast ratio of 1,000:1 when properly exposed and processed on 3400 emulsion.

3.3.8 Focal Length - The equivalent focal length of the lens shall be 76.2 ± 1.5 mm. This value shall be determined to an accuracy of 0.010mm. The focal length shall be computed to 0.001mm.

3.4 Environmental Range

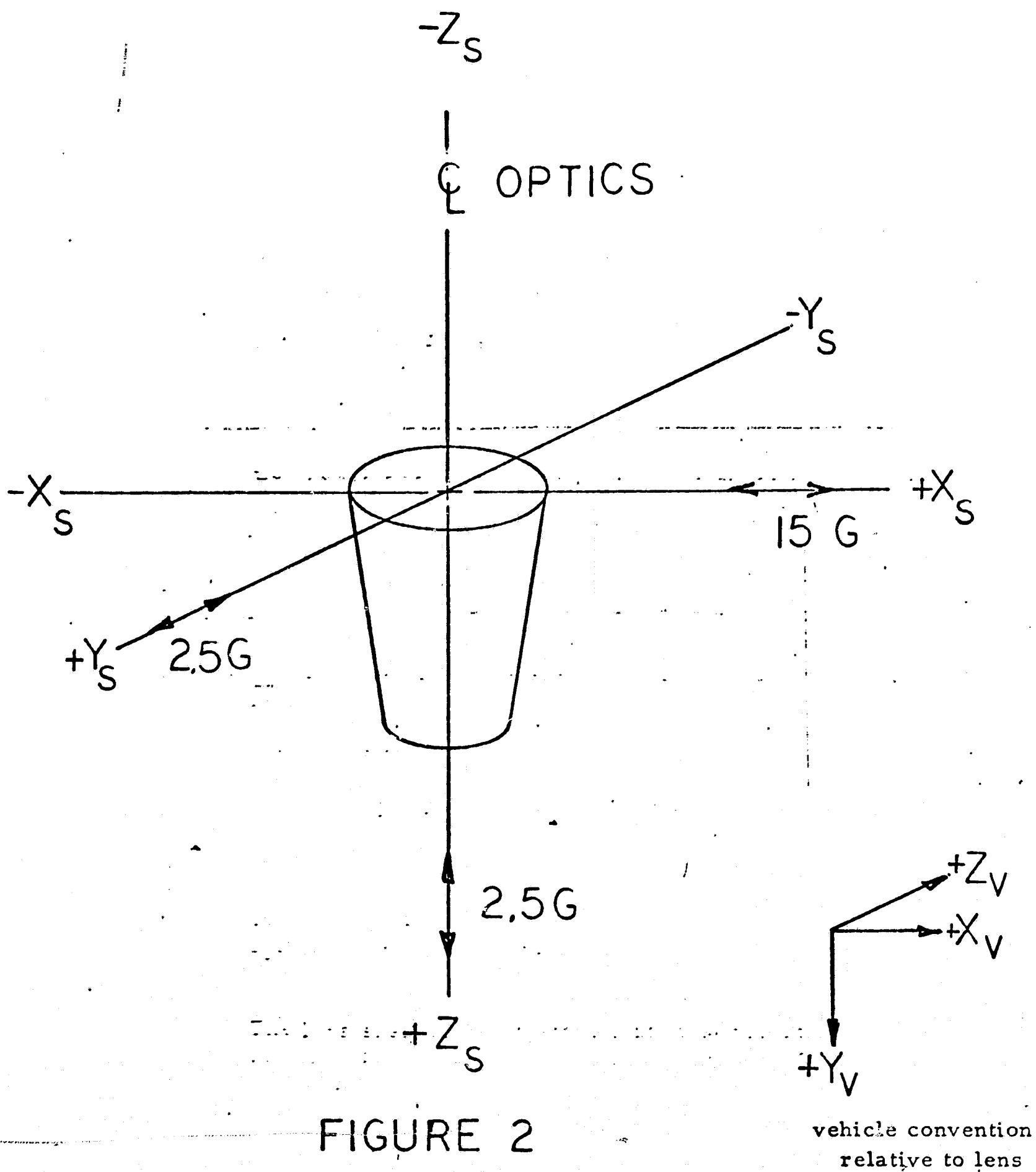
3.4.1 The lens shall be designed to meet the following environmental conditions:

- 1) Operating temperatures of $70^{\circ} \pm 20^{\circ}\text{F}$ at 1×10^{-6} mm of Hg and relative humidity from 0% to 60%. The lens must operate over a total range from $+40^{\circ}\text{F}$ to $+120^{\circ}\text{F}$, with minimum photographic performance degradation outside of the $70^{\circ} \pm 20^{\circ}\text{F}$ operating range.
- 2) Indefinite storage at any temperature in the range -65°F to $+120^{\circ}\text{F}$ when properly packaged for shipment or storage.
- 3) Prolonged acceleration of 10 minutes duration in direction and "g" levels shown in Figure 2. All accelerations to be in plus and minus directions.
- 4) Mechanical shocks of 20 g's for a duration of 6 milliseconds in each of 3 mutually perpendicular planes.
- 5) Vibration - The lens shall withstand a random vibration level of 21.2 g's total rms acceleration for a period of 120 seconds. The acceleration density distribution shall be over a frequency range as follows:

20 - 200 Hz	3 db/octave rise to $0.24 \text{ g}^2/\text{Hz}$
200 - 2,000 Hz	$0.24 \text{ g}^2/\text{Hz}$

The lens shall withstand a sinusoidal acceleration at 0.5 g peak from 4 to 35 to 4 Hz at a sweep rate of 3 octaves/minute for 120 seconds.

The lens shall also withstand a random vibration level of 10.8 g total rms acceleration for a period of 700 seconds. The acceleration density distribution for this level shall be over a frequency range as follows:



20 - 100 Hz 3 db/octave rise to $0.06 \text{ g}^2/\text{Hz}$ constant

100 - 2,000 Hz $0.06 \text{ g}^2/\text{Hz}$ constant

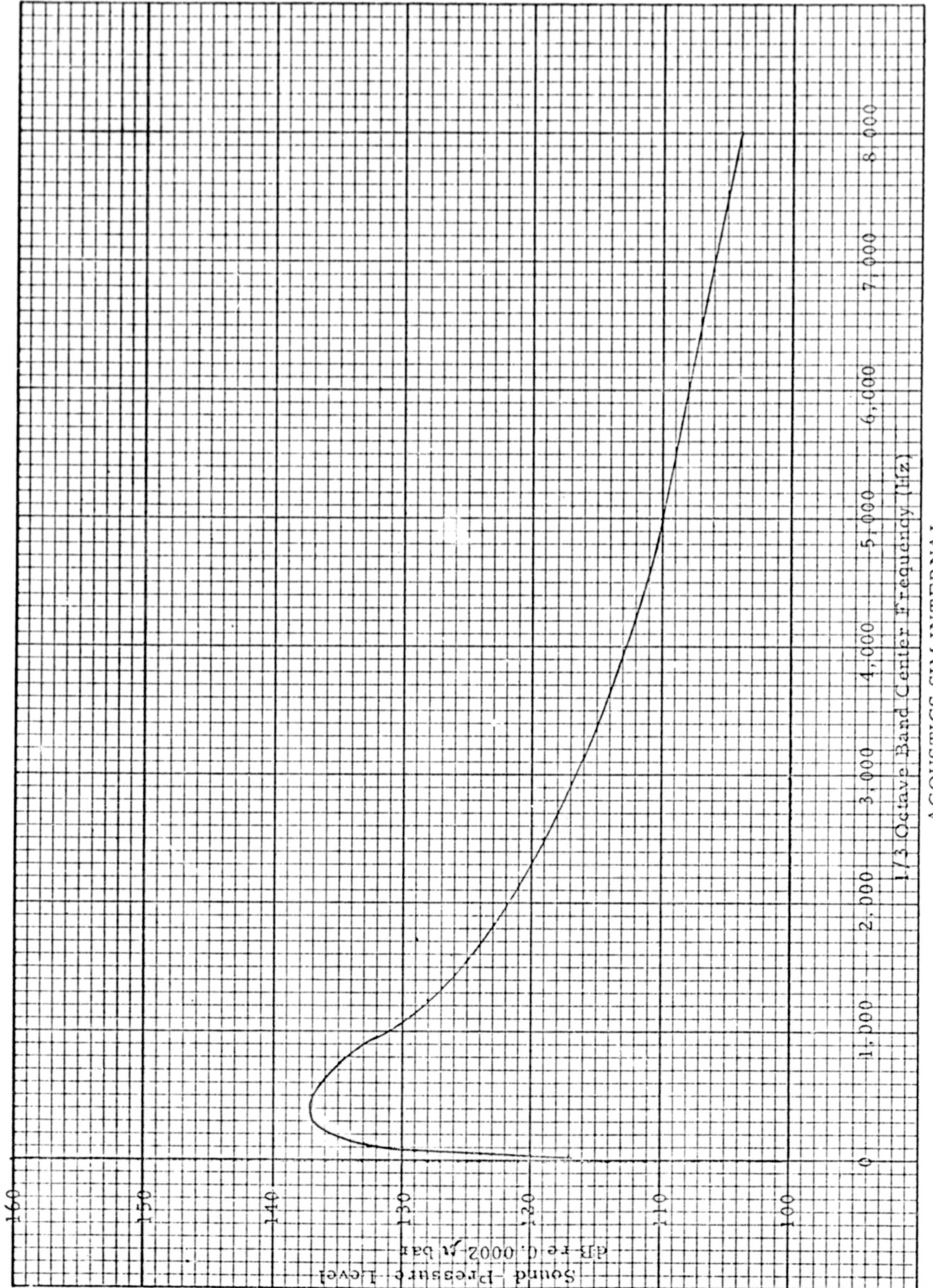
- 6) Acoustics - The lens shall withstand an overall sound intensity level of 147 db for a period of 120 seconds. The spectral distribution of sound intensity shall be in accordance with Figure 3.
- 7) Explosive Conditions - The subsystem shall not cause ignition of an ambient-explosive-gaseous mixture when operating in such an atmosphere.

4.0 INSPECTION AND TEST PROCEDURES

4.1 General - Records of all inspection work and tests, giving the results of tests required to determine compliance with the standards, requirements and tests specified herein, shall be kept complete and shall be available to any authorized personnel at any time.

4.1.1 Information shall be compiled, summarized and presented with each lens, operated in a vacuum, as follows:

- 1) The tangential and radial resolution values obtained photographically along two mutually perpendicular diagonals in the focal plane of best definition.
- 2) A film sample corresponding to each data item in Item (1), above.
- 3) The values of the photographic distortion along two mutually perpendicular diagonals in the focal plane, as defined by the natural fiducials.
- 4) The measured values of relative aperture, transmission and relative illumination.



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FIGURE 3

4.1.2 The coordinates of the principal point of autocollimation shall be given with respect to the indicated principal point. The indicated principal point is defined by the intersection of the grid axes extending from the natural fiducial marks.

4.2 Individual Inspection Test Methods - Each lens shall be subjected to the following tests:

4.2.1 Examination of Product - Each lens shall be inspected to determine compliance with this specification for requirements for which tests are not specified, such as workmanship, mounting, marking, reflection-reducing coatings, beauty defects, serial numbers and finish.

4.2.2 Photographic Plane of Best Definition - A photographic test in accordance with Method 11 of MIL-STD-150A shall be made with the lens at maximum aperture. A high contrast (3.0) test target with patterns varying by no more than the sixth root of two shall be exposed in maximum intervals of 2.5° from 0° to 12.5° . For all photographic testing, 3,400 emulsion shall be used, and it shall be processed in accordance with the recommended procedures.

4.2.3 Distortion - The distortion shall be determined by Method 26 of MIL-STD-150A, except that the angular location of the targets shall be known to an accuracy of 2 seconds of arc, and they shall be placed at angular intervals of 2.5° or less. Photographic plates or stable base film shall be used to make the exposures. The emulsion surface shall be as flat as practical and in no case shall it introduce more than 2 microns displacement of the image from its true planar position. Distortion shall be measured with sufficient accuracy to insure a calibration accuracy of ± 3 microns. As an alternate, Method 29 of MIL-STD-150A may be used in conjunction with the calibrated reseau grid. If Method 29 is selected, then the grid intersections used for measurement purposes shall be those which most nearly correspond to the following angles: 0° , 5° , 10° .

4.3 Optical Tests - All lenses submitted on the order shall be subjected to the following tests by the lens manufacturer and the data submitted to the purchaser's Quality Assurance Department for approval.

4.3.1 Relative Aperture - Relative aperture shall be computed by the ratio of the measured EFL to the diameter of the effective aperture. The effective aperture shall be measured by Methods 3 or 4 of MIL-STD-150A.

4.3.2 Transmittance - The transmittance of the lens shall be measured by Methods 5 or 6 of MIL-STD-150A.

4.3.3 Relative Illumination - The relative illumination of characteristics of the lens shall be measured by Method 7 of MIL-STD-150A.

4.4 Environmental Tests - At least one lens shall be subjected to the tests listed below, with the lens secured to the test equipment by its normal mounting means. After each test, the lens shall be inspected for damage and subjected to suitable photographic tests to determine if there has been any alteration of optical performance. The testing shall be the responsibility of the camera subcontractor, however, the lens manufacturer shall be responsible for lens performance.

4.4.1 Acceleration - Prolonged acceleration of 10 minutes duration in direction and "g" levels shown in Figure 2. All accelerations to be in plus and minus directions.

4.4.2 Shock - Mechanical shocks of 20 g's for a duration of 6 milliseconds along X-X, Y-Y, and Z-Z axes in plus and minus direction.

4.4.3 Vibration - The lens shall withstand a random vibration level of 21.2 g's total rms acceleration for a period of 120 seconds. The acceleration density distribution shall be over a frequency range as follows:

20 -	200 Hz	3 db/octave rise to $0.24 \text{ g}^2/\text{Hz}$
200 -	2,000 Hz	$0.24 \text{ g}^2/\text{Hz}$

The lens shall withstand a sinusoidal acceleration at 0.5 g peak from 4 to 35 to 4Hz at a sweep rate of 3 octaves/minute for 120 seconds.

The lens shall also withstand a random vibration level of 10.8 g total rms acceleration for a period of 700 seconds. The acceleration density distribution for this level shall be over a frequency range as follows:

20 - 100 Hz	3 db/octave rise to $0.06 \text{ g}^2/\text{Hz}$
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100 - 2,000 Hz	$0.06 \text{ g}^2/\text{Hz}$ constant
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If the lens has any resonant points between 1 Hz and 15 Hz, it shall be capable of withstanding a 1 g sinusoidal vibration at those frequencies for a period of five minutes.

4.4.4 Acoustics - The lens shall withstand an overall sound intensity level of 147 db for a period of 120 seconds. The spectral distribution of sound intensity shall be in accordance with Figure 3.

5.0 SHIPMENT - The lenses shall be packed and wrapped for domestic shipment.

1

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A Division of Fairchild Camera and Instrument Corporation
300 Robbins Lane, Syosset, New York

1231-DR-1

**EMI CONTROL AND TEST REQUIREMENTS
FOR MC CAMERA SUBSYSTEM
AND
GROUND SUPPORT EQUIPMENT
15 February 1970**

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1.0 SCOPE - This specification covers the design requirements and interference test plan and limits that will govern EMI control for the MC Subsystem and Ground Support Equipment in accordance with the requirements of MC999-0002. The design requirements are applicable to both MC and GSE. The test plan is applicable to MC only.

1.1 Classification - The test procedures and test limits which are specified cover the following type of tests:

- a) Interference Tests - Conducted and radiated tests which measure the magnitude of the interference signals emanating from the equipment under test.
- b) Susceptibility Tests - Conducted, radiated and transient tests which determine whether an equipment will operate satisfactorily when exposed to external interference signals.

All equipment tested for compliance with this specification shall conform to the interference control requirements set forth in Figure 1 for the appropriate equipment class. For the purposes of this specification, all unwanted signals shall be considered as broadband impulsive interference or CW interference.

1.1.1 Class I - The MC Subsystem will comply with the interference control requirements set forth in Figure 1, Class I. This includes all equipment that is supplied by the camera contractor that is directly used with the MC while airborne.

1.1.2 Class II - All Ground Support Equipment (GSE), i.e., equipment that is used for calibrating or checking the operation of the Camera Subsystem, will comply with the interference control requirements set forth in Figure 1, Class II.

2.0 APPLICABLE DOCUMENTS

Requirement	Limit	Test Method	Class I	Class II
A. Conducted Interference 1. Using wide band oscilloscope 2. Using current probe	Fig. 2	Para. 4.3.1	Yes	Yes
	Fig. 3	Para. 4.3.1.1	Yes	Yes
	Fig. 4	Para. 4.3.1.1	Yes	Yes
	Fig. 5	Para. 4.3.1.1		
B. Radiated Interference-RH 1. Measured at 1 foot 2. Measured at 3 feet	Fig. 6, 8	Para. 4.3.2	Yes	No
	Fig. 7	Para. 4.3.2	Yes	No
C. Susceptibility 1. RF conducted 2. AF conducted 3. Transient conducted 4. RF radiated 5. Front end rejection 6. AF induced-equipment 7. AF induced-cable	Para. 4.3.3.2	Para. 4.3.3.2	Yes	No
	Para 4.3.3.3	Para. 4.3.3.3	Yes	No
	Para. 4.3.3.4	Para. 4.3.3.4	Yes	No
	Para. 4.3.3.5	Para. 4.3.3.5	Yes	No
			Yes	No
	Para. 4.3.3.6	Para. 4.3.3.6	Yes	No
	Para. 4.3.3.6.1	Para. 4.3.3.6.1	Yes	No

FIGURE 1

INTERFERENCE CONTROL REQUIREMENTS

2.1 Government Specifications - The following government document form a part of this specification to the extent specified herein.

Specifications

MIL-B-5087A	Bond, Electrical for Aircraft
MIL-C-45662A	Calibration System Requirements
MIL-F-15733D	Filters, Radio Interference, General Specification for
MIL-STD-831	Test Reports, Preparation of

Standards

MIL-STD-220A	Method of Insertion Loss Measurement
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Air Force Drawings

62J4040 21 May 1963	Antenna Connical Logarithmic Spiral 100 - 1,000 MHz
62J4041 21 May 1963	Antenna Connical Logarithmic Spiral 1 - 10GHz

2.2 Non-Government Specifications - The following non-government documents form a part of this specification to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

North American Rockwell Publications

MC 999-0002	Electromagnetic Interference Control for the Apollo Space System 12 July 1969.
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Contractor Specifications

1231-DR-2

Electromagnetic Interference Requirements,
MC Subsystem Flight Hardware

3.0 REQUIREMENTS

3.1 General3.1.1 Documentation

3.1.1.1 Interference Control Plan - The EMI Compatibility Section shall prepare a detailed plan within 30 days ARO describing the interference control program and the engineering design procedures, selection of interference free components, techniques and philosophy that will be used in the camera and GSE in complying with this specification. The design aspects of the interference control program shall be emphasized. Inasmuch as, it is not specified in the SOW, the Control Plan will be a Type III document.

Specific information such as a table of potential interference sources and susceptible circuits, circuits to be filtered and shielded, grounding procedures, thickness of case material required to provide adequate shielding, methods of eliminating spurious emanations and responses, selection of interference-free components, and any other pertinent information shall be included to the depth of the design, development, and available circuit schematics at the time the control plan is initiated. The control plan will also describe and explain any switch or control that will be waived in any manner the limits set forth in this specification.

3.1.1.2 Camera Subassembly Test Report - Each major electrical subassembly will be tested as a breadboard. This test will include applicable portions of conducted and radiated interference and susceptibility as determined by review of the application of the particular breadboard. Tests may also be performed to evaluate shielding effectiveness and bonding impedance. The test procedures will follow the general methods outlined later in this plan for qualification testing. Upon completion of each subassembly breadboard

tests, a test report shall be generated. This report will include such information as; test performance, test setup, test results with graphic data and EMI control recommendations.

3.1.1.3 Qualification Test Plan - A Type II qualification test plan for the MC will be submitted for approval to the procuring activity two weeks before interference testing is started. This plan will show the means of implementation and application of the test procedures in this specification to the equipment being procured. Included shall be the proposed method of testing for the requirements in Figure 1 and additional data such as:

- a) Nomenclature and serial numbers of test equipment to be used.
- b) Methods of calibration to be used.
- c) Detector functions to be used during measurements
- d) Methods of loading and triggering
- e) Operation of test sample
- f) Control settings on test sample
- g) Frequencies at which interference might be expected, local oscillator, intermediate frequencies, multipliers, etc.

3.1.1.4 Qualification Test Report - A Type I test report for the MC, conforming to Mil-Std-831, shall be submitted for approval to the procuring activity 30 days after completion of tests. In addition, to the requirements of Mil-Std-831, the test report shall include such details of testing as:

- a) Nomenclature of interference measuring equipment
- b) Serial number of interference measuring equipment

- c) Data of last calibration of interference measuring equipment
- d) Detector functions used on interference measuring equipment
- e) Internal noise level of instrument used on detector function at each test frequency
- f) Description of procedures used (methods of loading and triggering, etc., operation of and control settings on test sample, etc)
- g) Measured line voltages to test sample
- h) Test frequencies
- i) Method of selection of test frequencies
- j) Type of interference measured
- k) Measured level of interference at each test frequency
- l) Specification limit at each test frequency
- m) Graphs showing items e, h, k, and l
- n) Photographs of the test setup and test sample
- o) Sample calculations (showing how item k was obtained for all antennas used)
- p) Description and size of screened enclosure
- q) Ground plane used if test is not performed in screened enclosures

- r) Description of open space area, if used
- s) Ambient interference levels, unless the ambient plus item interference are not above the specified limits

Examples of Sample Calculation

a)	Interference measuring equipment	NF-105
	Frequency of cw measurement	460 mc
	Antenna factor (DM Antenna)	+8 db
	Cable loss correction factor at 460 mc	+3 db
	Meter reading	+40 db

Interference level = meter reading + cable loss + antenna factor = 40 + 3 + 8 = 51 db

b)	Interference measuring equipment	NM-20B
	Frequency of broadband radiated measurement	500 kc
	Antenna factor	0 db or 1
	Cable loss correction factor	0 db or 1
	Meter reading	9 microvolts
	Effective random bandwidth	3,400 cps
	Impulse bandwidth = $1.4 \times 3,400 = 4,760$ cps = 4.760 kc	

Interference level = $\frac{\text{meter reading} + \text{antenna factor} + \text{cable loss}}{\text{impulse bandwidth}}$

$$= \frac{9 \times 1 \times 1}{4.76} = 1.89 \frac{\text{Antenna induced microvolts}}{\text{kc}} = 65.5 \text{ db above } 1 \text{ microvolt per mc (antenna induced)}$$

The test sample shall be completely identified in the test report with complete nomenclature, manufacturer, and serial number. All suppression work performed on the test sample during the interference tests shall be fully described in words as well as by the test data in the test report.

3.1.2 Definitions

3.1.2.1 Interference - Interference is defined as any electrical or electromagnetic disturbance, phenomenon, signal or emission, man-made or natural, which causes or can cause undesired response, malfunctioning or degradation of performance of electrical and electronic equipment.

3.1.2.2 Susceptibility - As used herein, susceptibility is defined as that characteristic which causes an equipment to malfunction or exhibit an undesirable response in excess of the system design control specification tolerance when its case or any external lead or circuit is subjected to the specified radio or audio frequency voltage or field.

3.1.2.3 Ambient interference, for the purpose of this specification, is the interference level emanating from sources other than the test sample, including the internal background noise of the interference measuring equipment.

3.1.2.4 Antenna Induced Microvolts - Antenna induced microvolts is that voltage which exists across the open-circuit antenna terminals.

3.1.2.5 Impulsive Interference - For the purposes of this specification, all broadband noise, including random noise, is considered to be impulsive interference.

3.1.2.6 Octave - An octave is a frequency ratio of 1 to 2, i. e., from 1 to 2mHz, 2 to 4mHz, 500 to 1,000mHz, etc.

3.1.2.7 Microvolts per MHz - The nearest approach to a standard unit of measurement of broadband radio interference is in terms of microvolts per megacycle. Interference intensity in microvolts per megacycle is equal to the number of root mean square sine wave microvolts (unmodulated) applied to the input of the measuring circuit at its center frequency that will result in detector peak response in the circuit equal to that resulting from the interference pulse being measured, divided by the impulse bandwidth of the circuit in megacycles. The impulse bandwidth is the area divided by the height of the voltage response versus radio frequency selectivity curve from antenna through the peak detector.

3.1.3 Short Duration Interference - Short duration transient interference resulting from manual or remote operation of switches and associated relays on controls may exceed the limits specified herein by 40 db. This exemption does not apply to recurring switching events which are initiated by the control function. Transient less than one nanosecond are exempt. Each deviation shall be submitted to the procuring activity for approval.

3.2 Design

3.2.1 Interference control shall be considered in the basic design of all electronic and electrical equipment, components, assemblies, and systems. This design shall be such that, before interference control components are applied, the amount of interference inherently generated and propagated is the minimum achievable. The application of interference control components that must be used, such as filtering, shielding, and bonding, shall conform to good engineering practice and, wherever possible, shall be an integral part of the system. Whenever additional interference control components are necessary, the use of miniaturized components is preferred.

3.2.2 Susceptibility - The equipment shall be designed to minimize susceptibility to interference from other sources. The enclosing case construction shall be designed not only to minimize interference propagation, but also to minimize interference pickup from external sources. Where conducted energy on the power leads or any external leads might cause interference, the leads shall be isolated from other leads to avoid coupling, and, where necessary, shall have line filters at their entry into the enclosing case. Receiving antenna inputs, or any other low-level signals circuits shall be low impedance, or of balanced design, so that coaxial or other shielded transmission lines can be used to insure an interference-free installation. Routing of receiving antenna input or any low-level signal circuit within the equipment shall be so designed and installed that interference is not picked up from power or control leads due to circuit coupling. Antenna or low-level signal circuit return paths or ground paths shall be so arranged that interference will not occur due to common conductive paths with other circuits, or with the enclosing case grounding path.

3.2.3 System Enclosures

3.2.3.1 Case Shielding - The number of mechanical discontinuities in the case (such as covers, inspection plates and joints) shall be kept to a minimum. All necessary mechanical discontinuities in the case shall be electrically continuous across the interface of the discontinuity so as to provide low impedance current path. Multiple-point spring-located contacts are suggested as a desirable method of obtaining low impedance continuity. Ventilation openings shall be designed to permit conformance to the radiated interference limits. Electrical bonding shall be provided where access doors or cover plates form a part of the shielding. Hinges, in themselves, are not considered satisfactory conductive paths.

Any opening in the case will be so designed that (1) radiation from external sources (not exceeding the requirements of paragraph 4.3.3.5 in this text) will not malfunction or disturb the equipment operation, and (2) radiation from the case will not exceed the specified limits.

3.2.3.2 Magnetic Shields - Magnetic shielding against DC and audio frequency fields may be applied directly to the susceptible component or to the field source where this proves to be an effective interference control measure.

3.2.3.3 Chassis, Case, and Mounting Continuity - The mating surface of the chassis case and mounting shall be free of all insulating finishes in order to provide a continuous electrical bond between these items and to enable the installing activity to accomplish bonding contact to the basic structure. Electrically conductive protective coating should be applied to reduce corrosion after assembly. This includes those surfaces that mate with EMI filters that are enclosed in metal. This requirement shall take precedence over any conflicting requirements in specification on finishes.

3.2.3.4 Component Placement - Components shall be placed and circuitry arranged to obtain minimum undesired coupling and to require a minimum number of filter components.

3.2.3.5 Interference Control Components - When additional interference control components are required after careful design in accordance with the foregoing paragraph, components shall be used that conform to the environmental requirements for the equipment. Hermetically sealed interference control components shall be used unless the equipment is hermetically sealed.

3.2.4 Bonding - The requirements of MIL-B-5087A shall be used as a design guide for compliance with the bonding requirements of this specification.

3.2.4.1 Purposes of Bonding - The bonding shall be so designed and so executed as to achieve the following results:

- a) Prevent the accumulation of static charge which would produce radio interference or explosion hazard by periodic spark discharge or would constitute a shock hazard.

- b) Prevent the development of r - f potentials on conducting frames and enclosures of electrical and electronic equipment.
- c) Provide sufficient homogeneity and stability of conductivity for r - f currents affecting radio transmission and reception.
- d) Provide fault-current return paths.
- e) Protect personnel from the shock hazard resulting from equipment internally power faulted. Shock hazard may be considered nonexistent for system voltages of less than 50 volts. This consideration shall in no way obviate the other requirements for bonding, if and when applicable.

3.2.4.2 Structure Bonding - All primary structure and all secondary structure supporting electrical/electronic equipment shall be bonded. This requirement is considered as being met by permanent metal-to-metal joints, as those made by bolting, riveting, pinning, or clamping provided the mating surfaces are free of all resistive film and normally immovable after installation.

3.2.4.3 Spacecraft - In keeping with established bonding practices, all metallic parts shall be properly bonded to maintain a continuous electrical contact.

3.2.4.4 Bonding Impedance - All metal parts within the MC Sub-system shall be bonded so that there will be less than 100 milliohm resistance between the parts.

3.2.4.5 Bonding Jumpers - Bonding jumpers shall be flat, unbraided beryllium copper or phosphor-bronze, silver plated metal strips. Where vibration or installation requirements preclude the use of unbraided strips, braid may be used, provided the requirements of paragraph 3.2.4.4 are met.

Bonding jumpers shall be installed in such manner as not to interfere in any way with the operation of movable components of the vehicle.

Unless otherwise specified, a minimum of one bonding jumper, preferably located at each corner of the mounting base, will be provided.

Bonding paths across the vibration isolators shall be continued and completed to the basic structure. Thin metal strips furnished with shock mounts, when connected at one end only, shall have the other end attached as directly as possible without sharp bends to the supporting structure.

3.2.4.6 Equipment Bonding - Equipment containing electrical circuits which may produce radio frequencies, either desired or undesired, shall be so installed that there will be a continuous low impedance path from the equipment enclosure to the vehicle structure.

3.2.5 Conductor Shielding - Any external line shielding used shall be prescribed as an installation requirement. Conductor shields shall be insulated from ground conductors, chassis, or structure except at the required ground point or points. A conductor shield shall not be used as a return for any prime power cable or audio frequency conductor. Shields shall be woven copper or tinned copper braid with at least 90% coverage. Double or triple shielding shall be used where required to reduce interference. No conductor shield shall be used for low-impedance audio frequency circuits where conductor separation or twisting of conductors is deemed to be more effective. Multiple signal leads and multiple power leads, when referenced to a common return, will employ one return lead rather than multiple return leads. This will reduce the number of leads and radiating sources. Audio frequency signals may be carried in twisted pairs and shielded as required. Interconnections between rf circuits, other than waveguide, shall use shielded coaxial cable or balanced shielded rf cable with a characteristic impedance equal to or less than 100 ohms. The shields of audio frequency circuit leads that connect the Ground Support Equipment (GSE) to the spacecraft may employ an rf bypass capacitor for grounding purposes where direct electrical connection is prohibited.

3.2.5.1 Shielding of Audio Frequency Sensitive Circuits - The following design requirements shall apply to circuits sensitive to frequencies from 0 - 50kHz or above if designated by the procuring activity. Interconnecting line load termination impedances shall be at least 50 ohms, unless otherwise specified by the procuring agency, and ideally between 150 and 660 ohms and, except for special instrumentation circuits, shall not exceed 100,000 ohms. The line source impedance is not restricted. Equipment interconnections shall be designed so that for each interconnecting circuit the signal current and signal return current (equal and opposite currents) may everywhere be routed together in the same bundle using a twisted pair, where this proves to be an effective means of reducing susceptibility or interference. Individual interconnecting circuits shall pass through connectors via adjacent pins. Internal wiring design shall employ wire twisting as necessary and wire routing control so as to minimize the formation of magnetic field pickup loops. All shields shall be covered by a layer of insulation.

3.2.5.2 Shield Discontinuities - When cable shields are routed through connectors, the shields may be connected in common at the cable connectors and carried through two (2) or more pins. When the cable shields are not routed through the connector, the cable shields shall be grounded at the equipment side of the discontinuities. All shields except coaxial cables, will be grounded at one end. Coaxial cables will be grounded at both ends. The grounding wire shall not be more than 1-inch in length.

3.2.5.3 Shield Returns - Shield returns, including rf shields, shall not carry any signal current, and may in general be combined whenever convenient to reduce the number of conductors and connector contacts required. This requirement does not apply to coaxial cables. The AF shield shall be referenced to a local chassis ground for isolated AF circuitry where the AF circuitry ground is made at the chassis.

3.2.5.4 Line Shielding - It is preferred that interference reduction be accomplished inside the equipment when such means give results equal to or better than the use of a shielded line. Any line shielding used shall be recommended to the procuring activity and shall be prescribed as an installation requirement.

3.2.6 Grounds - A multipoint ground system will be used for all circuits including circuits operating below 50kHz. All circuits will be internally compatible and meet the susceptibility requirements specified herein. An accessible and clearly labeled ground point shall be provided for all GSE cabinets or major enclosures. All metal parts shall be bonded so that there is less than 10 milliohms resistance across any joint. A bonding strap shall connect the GSE equipment ground point to the facilities ground buses.

3.2.6.1 Ground and Return Types - Separate buses shall be installed in the individual equipment for the following types of ground or returns (if the ground is required for equipment operation):

- a) Alternating Current Return (power line)
- b) Direct Current Return (power line)
- c) Signal Return
- d) Shield Common

3.2.6.2 Returns - Separate conductors shall be carried to vehicle ground point (VGP) for each of the types of returns defined above.

3.2.6.3 Radio Frequency Sensitive Circuits - Equipment intentionally operated in frequency range above 50 kHz may have signal and secondary power supply circuit ties to the unit case. If such ties exist, the following grounding and isolation requirements apply:

- a) Wire shields, including coaxial outer conductors, shall be multiple grounded; they must be continuous and tie to chassis ground.
- b) Secondary power supplies, such as static inverters and dc transformers, may be employed to isolate the dc power.

4.0 QUALITY ASSURANCE

4.1 Instrumentation - The instruments used to perform the measurements required by this specification shall be the best commercial equipment available that are capable of peak and field intensity measurements.

Table I lists the approved instruments that will be used for interference measurements.

TABLE I

<u>Frequency Range</u>	<u>Commerical Nomenclature</u>	<u>Manufacturer</u>
30 cps to 30 kcs	NM-40A	Stoddart
15 kcs to 150 kcs	T-X/NF-105	Empire
0.15 to 30 mc	T-A/NF-105	Empire
20 to 200 mc	T-1/NF-105	Empire
200 to 400 mc	T-2/NF-105	Empire
400 to 1,000 mc	T-3/NF-105	Empire
1,000 to 10,000 mc	FIM	Polarad
Transient conducted	Model 6254-4	Solar

All antennas, cables, probes, and ancillary items used will be those supplied by the manufacturer for the particular instrument or as specified in North American Document No. MC 999-0002.

4.1.1 Operation of Measuring Instruments - For both conducted and radiated interference measurements, the instruments used shall be calibrated and operated as indicated in their respective instruction manuals.

4.1.2 Calibration - Interference measuring instrumentation shall be maintained in a known condition of accuracy. Periodic checks on the calibration accuracy shall be made with laboratory generators. Recalibration shall be accomplished when the standardized gain setting fails to reflect a meter reading within plus or minus 20 percent of the known input signal. Substitution type measurements can be used in lieu of the calibrated method. Calibration shall comply with MIL-C-45662 requirements.

4.1.3 Generator Accuracy - Laboratory-type signal generators and impulse generators capable of an output voltage accuracy of at least 20 percent shall be used to calibrate interference measuring instruments and for substitution measurements.

4.1.4 Correction Factors - Where correction factors are used, i.e., antennas and current probes, they will be those factors called out by the instruction manual for the particular instrument or as specified in MC-999-0002.

4.2 Testing

4.2.1 Test Conditions

4.2.1.1 Ambient Interference Level - The ambient interference level during testing, measured with the test sample de-energized will be at least 6 db below the allowable specified interference limit. However, in the event that at the time of measurement the levels of ambient interference plus test item interference are not above the specified limit, the test item shall be considered to have met the specified requirements. This requirement shall apply equally to both radiated and conducted ambient interference levels.

A shielded enclosure will be used for all EMI testing. The minimum length shall be such that a 35mc tuned dipole can be placed in the room with at

least 12 inches clearance between the antenna extremities and the shielded enclosure.

4.2.1.2 Ground Plane - A copper or brass ground plane, 0.01 inch thick minimum for copper, 0.025 inch thick minimum for brass, 12 square feet or more in area with a minimum width of 30 inches, shall be used. In a screen room, the ground plane shall be bonded to the shielded room at intervals no greater than 3 feet and at both ends of the ground plane. The ground plane and screen room walls may be considered equivalent to a vehicle for purposes of simulating a normal installation. For large equipment systems mounted on a metal test stand, the test stand may be considered, for testing purposes, to be a part of the ground plane and shall be bonded accordingly.

4.2.1.3 Bonding - Only the provisions included in the design of the equipment and specified in the installation instructions shall be used to bond units, such as equipment case and mount, together or to the ground plane. Where bonding straps are required to complete the test setup, they shall comply with the requirements of paragraph 3.2.4. Connections made with such bond straps shall have clean metal-to-metal contact.

4.2.1.4 Shock and Vibration Isolators - Test samples shall be secured to mounting bases incorporating shock or vibration isolators, if such mounting bases are used in the installation. The bonding straps furnished with the mounting base shall be connected to the ground plane. Where mounting bases do not incorporate bonding straps, bonding straps shall not be used in the test setup.

4.2.1.5 External Ground Termination - When an external terminal or connector pin is available for a ground connection on the test sample, this terminal shall be connected to the ground plane if the terminal is normally grounded in the installation. If the installation conditions are unknown, the terminal shall not be grounded.

4.2.1.6 Portable Equipment - When tested, portable equipment shall be tested while bonded to the ground plane and also when not bonded to the

ground plane. Portable equipment that is intended to be grounded through a power cord shall not be bonded to the ground plane by other means.

4.2.1.7 Power Supply Voltage - The power supply voltages shall be within the tolerance specified in the detail specification for the test sample. The voltages shall be measured at the power line terminals. The test sample shall be operated at the line voltage, within the specified tolerance, which causes maximum conducted interference or susceptibility at 0.15MHz.

4.2.1.8 Arrangement and Operating Conditions - The general arrangement of equipment, interconnecting cable assemblies, and supporting structures shall be such as to simulate actual installation and usage as practicable. The front surface of each unit shall be located 4-inches $\pm 1/2$ -inch from the edge of the ground plane; interconnecting cables shall be routed between the units and the edge of the ground plane. In those cases where equipment size exceeds the ground plane dimensions, or where more than two 10 microfarad feed throughs are required, the above instructions shall be adhered to as closely as possible.

4.2.1.9 Test Sample Leads - The test sample leads to the power line 10 microfarad feed throughs shall be 24 inches ± 1 inch in length and shall be so arranged that the distance between the leads and from each lead to ground or grounded enclosure is approximately 2 inches. In those cases where more than two power line 10 microfarad feed throughs are required, the above instructions shall be adhered to as closely as possible.

4.2.1.10 Interconnecting Leads - Interconnecting leads between boxes comprising a test sample shall not be less than 2 feet and not more than 5 feet long. Leads between the test sample and external leads shall be 5 feet long. Cables supplied with the equipment, not meeting the above criteria, may be used if their length is suitable for the purpose of tests.

4.2.1.11 Antenna Orientation and Positioning in Shielded Enclosure - Those interference measuring instruments which use a rod antenna shall be so placed that the rod antenna is in a vertical position and the instrument

panel or counterpoise is 6-inches below the level of the ground plane. The rod antenna shall be located at the point where maximum interference or susceptibility indications are obtained when it is moved along a line parallel with the edge of the ground plane. Those interference measuring instruments which use a resonant dipole antenna shall have the dipole positioned parallel with the front edge of the ground plane. Its height shall be 12-inches ± 1 -inch above the level of the ground plane and its center shall be adjacent to the geometrical center of the units under test. The rod or the dipole antenna shall be located at the distance from the test sample specified in Figure 1 and the typical test setups. When the dimensions of the dipole or directive antenna become smaller than the test layout, the antenna shall be moved parallel to the edge of the ground plane to keep its sensitive elements adjacent to the point of maximum leakage or susceptibility. At frequencies from 25 up to and including 35 megacycles, the measurements shall be taken with the dipole antenna adjusted to 35 mc. The dipole antenna shall be adjusted to the proper length at all frequencies above 35 mc.

4.2.1.12 Bonding Measuring Instrument - Interference measuring instruments utilizing dipole antennas shall be bonded to the ground plane or shielded enclosure with the ground clip on the power cord.

The interference measuring instruments shall be physically grounded with only one connection. If the copper strap is used, neither the ground clip, the ground terminals, nor the power supply shall be connected to ground.

4.2.1.13 Bonding Rod Antennas - The counterpoise on rod antennas shall be bonded to the ground plane with a strap of such length that the rod antenna can be positioned correctly. The strap shall be as wide as the counterpoise. This applies to rod antennas utilizing the interference measuring instrument as a counterpoise and to rod antenna mounted on a separate counterpoise.

4.2.1.14 Loads - The equipment under test shall be loaded with the full mechanical and electrical load, or equivalent, for which it is designed. This requirement specifically includes electrical loading of the contacts of

mechanisms which are designed to control electrical loads even though such loads are physically separate from the equipment under test. The loads used shall simulate the actual load currents, and the resistance, inductance and capacitance where these values are known.

4.2.1.15 Power Line 10 Microfarad Feed Through Capacitors - The power line stabilization network is shown in Figure 2. On capacitor shall be inserted in each ungrounded power supply lead supplying power to the test sample and shall be used for the complete radio interference tests. The capacitor enclosure shall be bonded to the ground plane.

The current carrying capacity of the capacitor is 100 amperes dc to 800 cycles ac. The maximum voltage drop characteristics of this device will permit measurements of test items at the following maximum voltage ratings:

dc	600 volts
60 cycles	440 volts
400 cycles	230 volts
800 cycles	115 volts

4.2.2 Measurements

4.2.2.1 Monitoring - The interference measuring instrument shall be monitored with a headset, loudspeaker, oscilloscope, or other indicating devices, during all measurements. Precaution shall be taken to ensure that the monitoring does not influence the meter reading on the interference measuring equipment.

4.2.2.2 Test Frequencies - The interference measuring instrument shall be slowly turned through each frequency octave and the frequencies at which maximum interference or susceptibility is obtained shall be selected as test frequencies. Test frequencies shall not be selected prior to the interference test. A minimum of three measurements shall be made in each band of the measuring instrument.

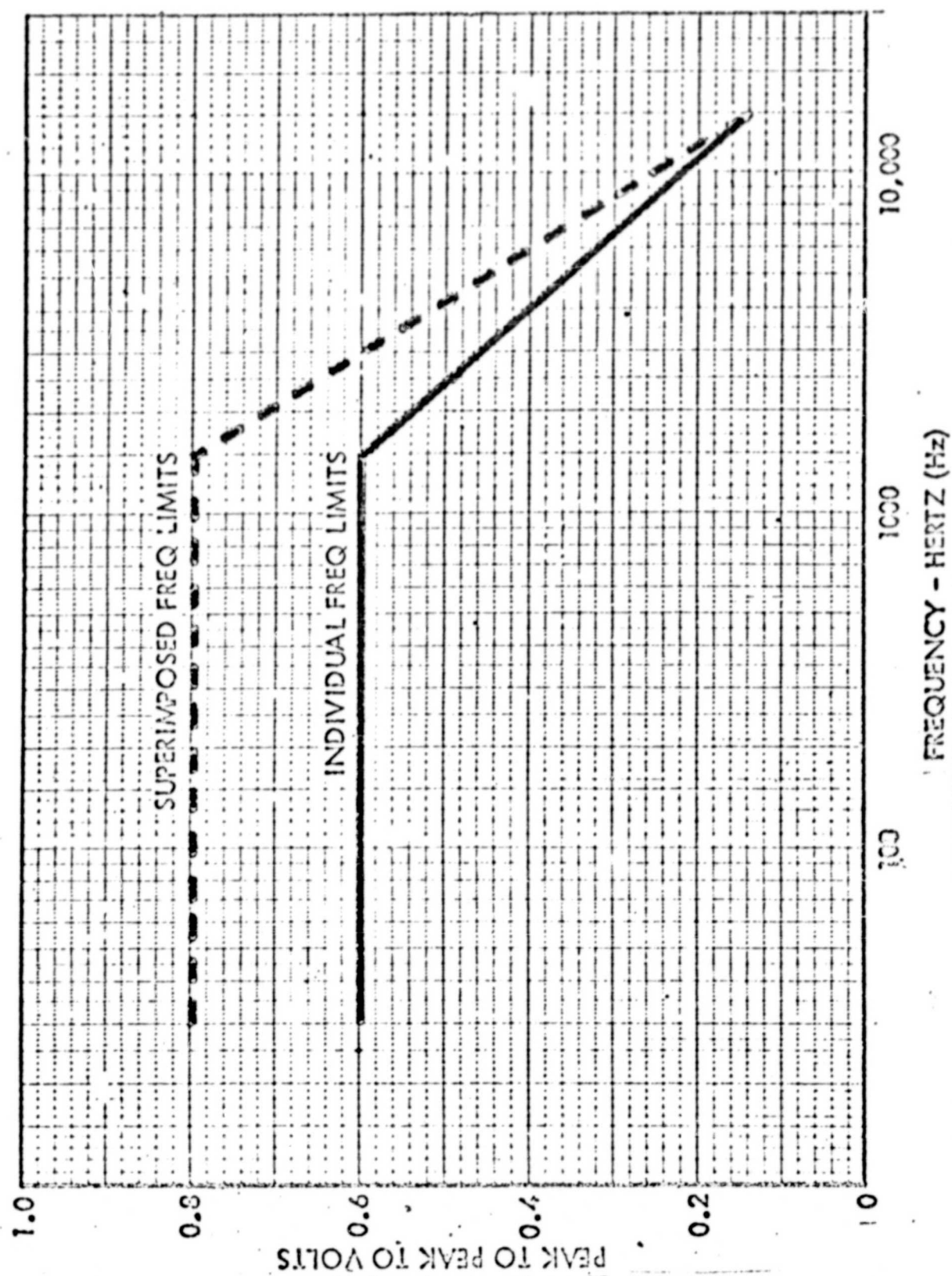


Figure 2. Narrowband (CV) Conducted Interference Limits (Permissible DC Power Ripple Voltages)

4.2.2.3 Tuning - The interference measuring instrument shall be turned to and measurements made at the fundamental frequency and all harmonics of equipment containing oscillator circuits. Additional checks shall be made by scanning for and measuring any signal or spurious response that can be anticipated.

4.2.2.4 Broadband Interference Measurement - Broadband interference shall be measured by using an impulse generator with the substitution technique, or by calibrating the interference measuring instrument so that it reads directly in decibels above one microvolt per unit bandwidth. The peak detector function on the interference measuring instrument shall be used for broadband and pulse cw measurements.

4.2.2.4.1 CW Interference Measurement - CW interference shall be measured by calibrating the interference measuring instrument so that it reads directly in decibels above one microvolt.

4.3 Test Methods

4.3.1 Conducted Interference - Electromagnetic interference voltages in the frequency range of 30 Hertz (Hz) to 25 megaHertz (MHz) generated by equipment in excess of the values indicated in Figures 3, 4, and 5 shall not appear on any external power conductor except narrowband (CW) interference on the DC power lines to the CSM power bus (0 to 15,000Hz). The test setup shall conform to Figure 12. For CW interference (0 to 15,000 Hz) on the DC power lines, the interference shall be within the limits of Figure 2. For broadband and PCW interference (30Hz to 15,000Hz), the level shall not exceed 100db above one microampere per 20KHz. The AC power lines shall be exempted from the power frequencies and its second, third, and fourth harmonics.

4.3.1.1 Conducted Interference Using Current Probe - Conducted interference measurements on input power leads. Measurements may be required on shielded leads in some cases (i.e., the probe will enclose the entire cable diameter). Where measurements are required on shielded external power lines, the shields will be stripped back and measurements will be performed on the individual hot leads. The hot lead and its return will not be grouped together.

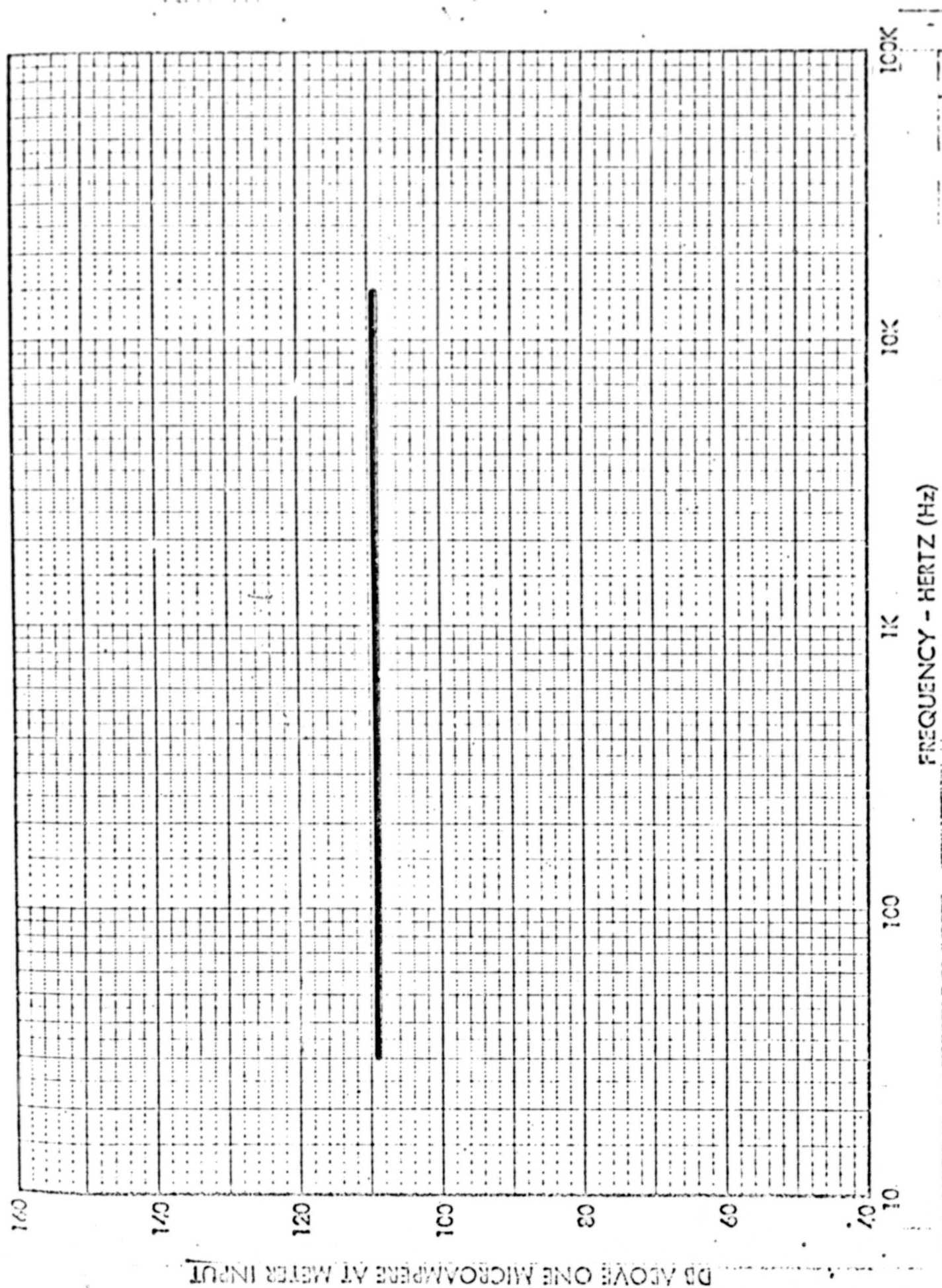


Figure 3. Narrowband (CW) Conducted Interference Limits Using Current Probe (AC Power)

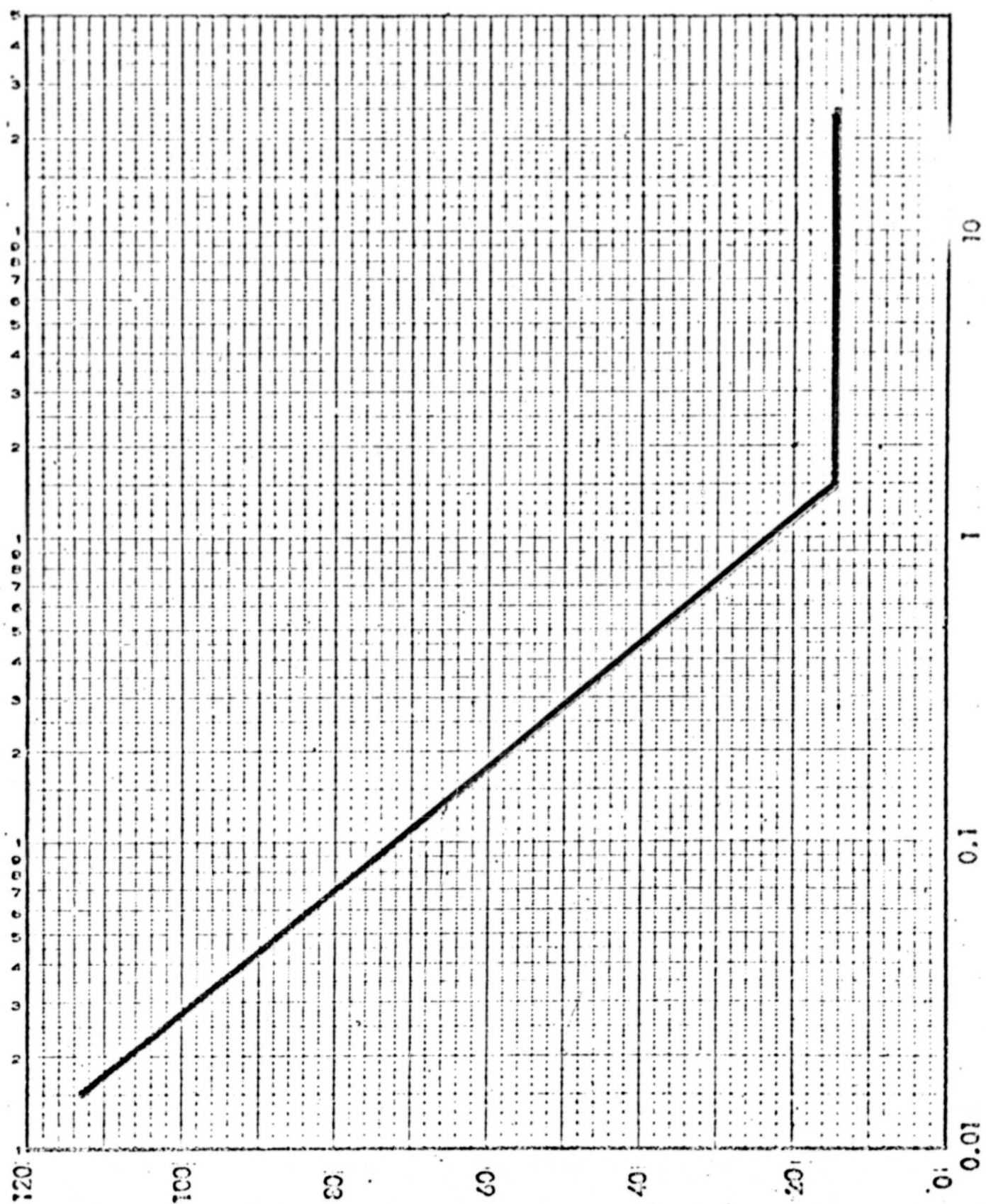


Figure 4. Narrowband (CW) Conducted Interference Limits Using Current Probe

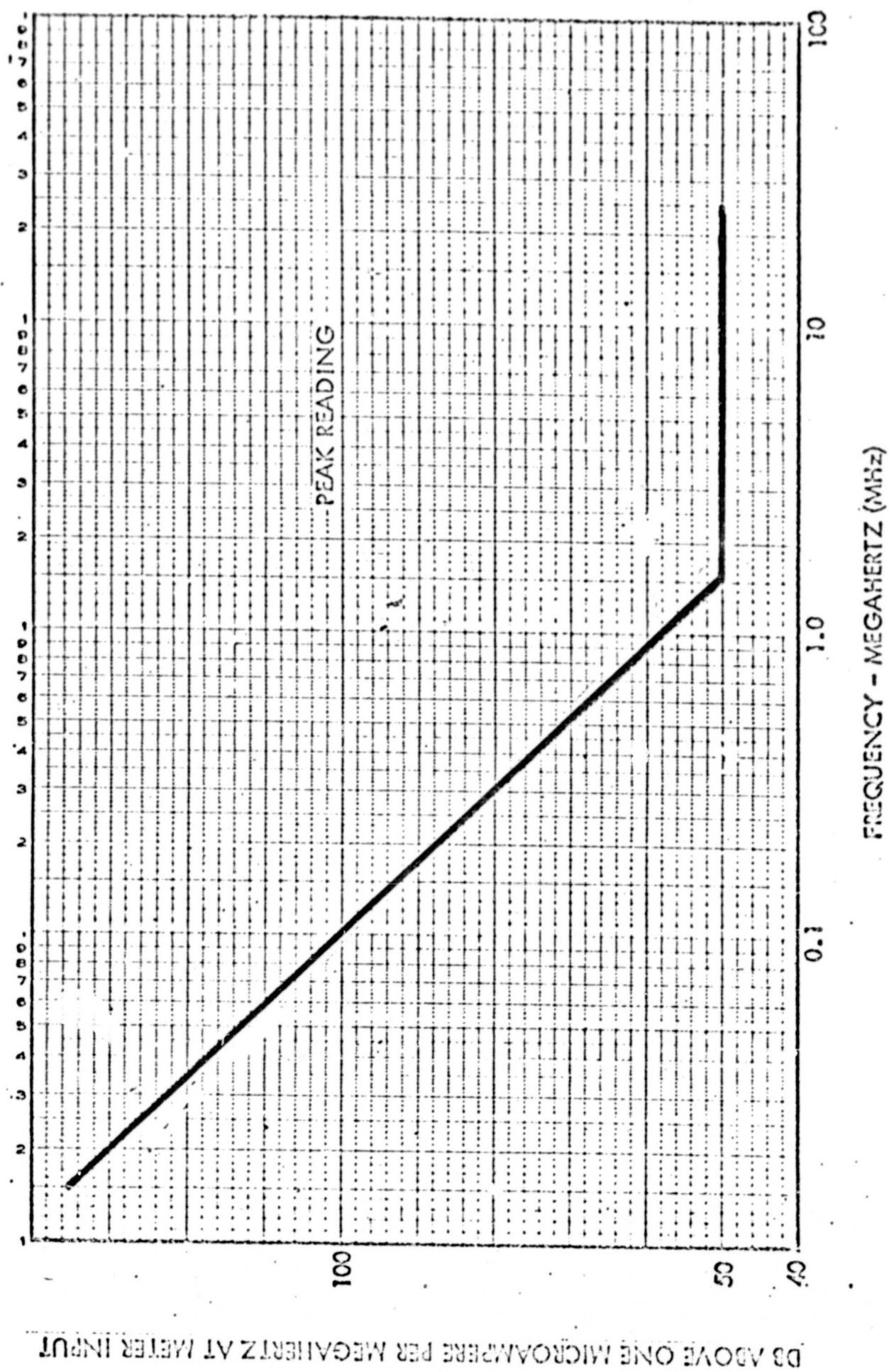


Figure 5. Broadband and Pulsed (CW) Conducted Interference Limits Using Current Probe

4.3.1.1.1 Position of Probe - The current probe shall be positioned at the point of maximum interference on the lead to be tested. This maximum interference point shall be located at each test frequency. The location of the current probe shall be fully described in the test report.

4.3.1.2 DC Line CW Conducted, 30Hz to 15,000 Hz - Measurements shall be made using a wideband (20MHz) oscilloscope with a differential input and high frequency pickup probe.

4.3.1.3 Transient Interference - Radiated interference fields in excess of the values given in Figure 6, 7, and 8 shall not radiate from any unit, cable (including control, pulse, IF, video, antenna transmission and power cables), or interconnecting wiring over the frequency range of 0.015-10,000 MHz for CW and 0.015 mc for broadband impulsive interference. Test setups are illustrated in Figures 9, 10, and 11. Equipment which does not utilize electronic circuits and which is incapable of producing oscillations, either intentional or unintentional, are exempt from measurements above 400 MHz.

4.3.2.1 Operator and Observer Positions - In those cases where the operator's or observer's location seems to vary a measurement reading, a minimum distance of 3 feet should be maintained between his body and the antenna; the operator should change position slightly until a maximum reading is obtained. In all cases, as few people as possible should be present in the screen room during the radiated measurements.

4.3.3 Susceptibility - All external and internal controls shall be set for maximum indication of susceptibility, or, if these cause an equipment to malfunction or to become inoperable as a result of such a control setting, the critical control shall be adjusted as directed in the instruction manual. The radio frequency signal shall be modulated

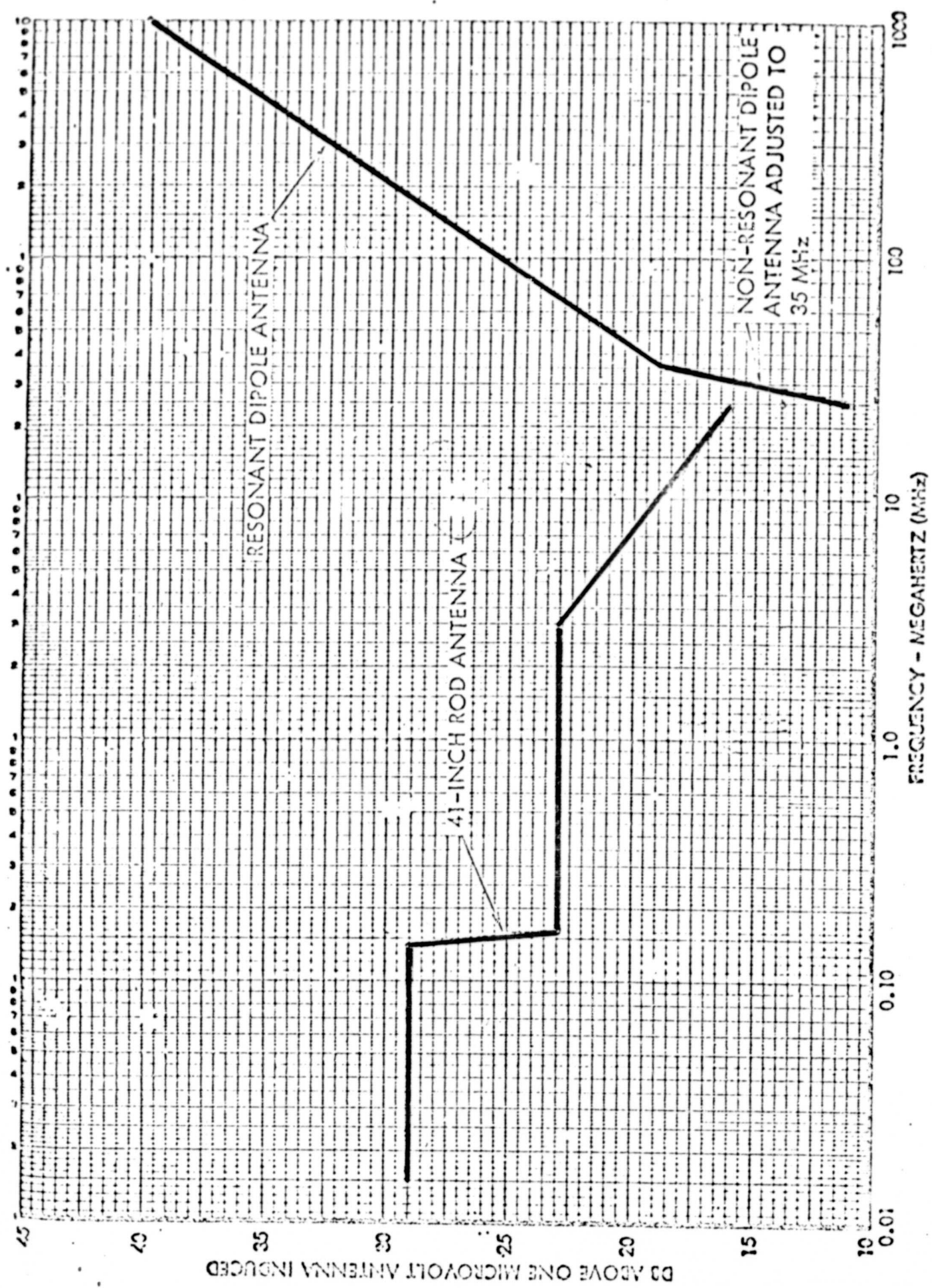


Figure 6. Narrowband (CW) Radiated Limits

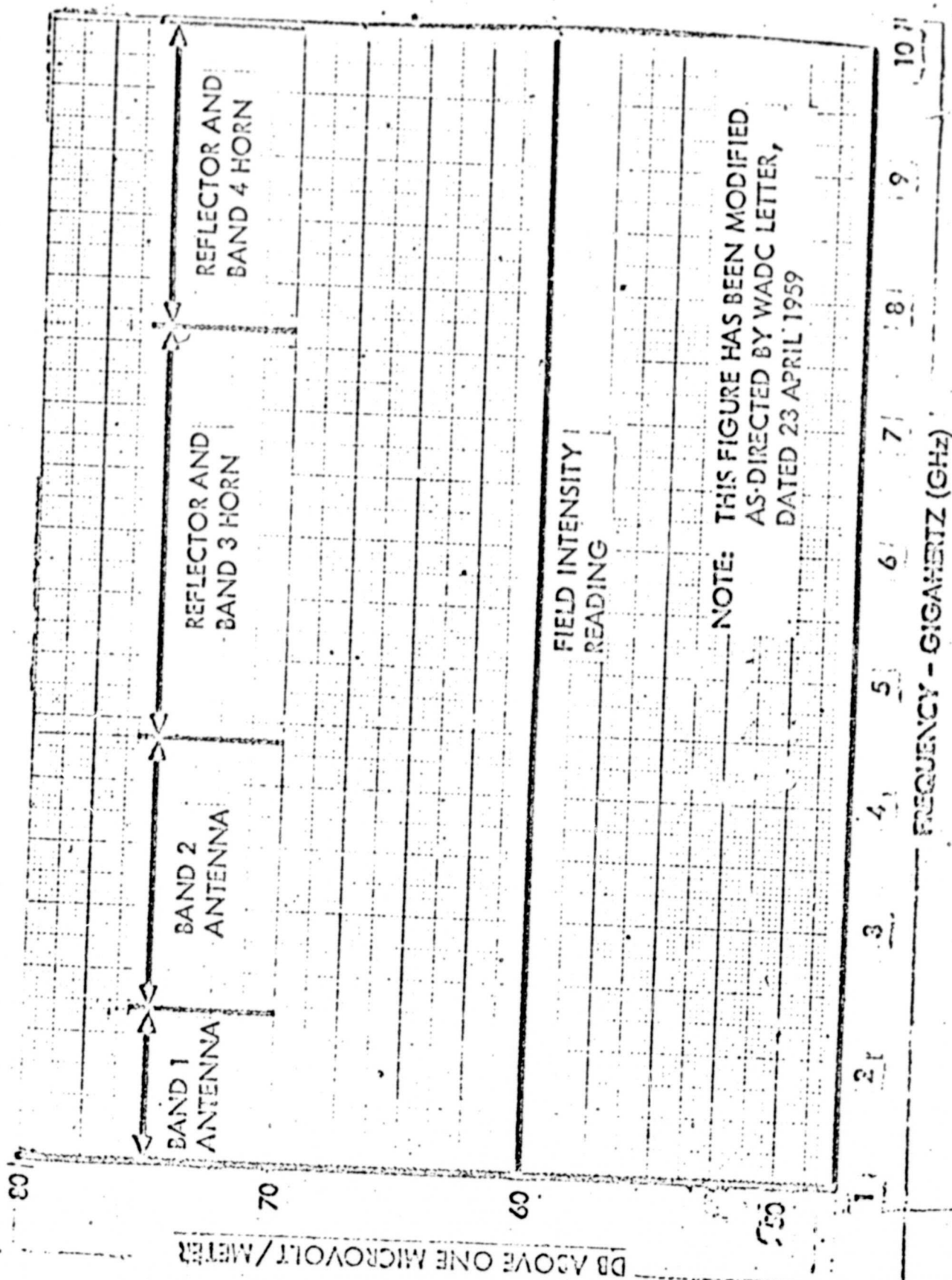


Figure 7. Narrowband (CW) Radiated Interference Limits

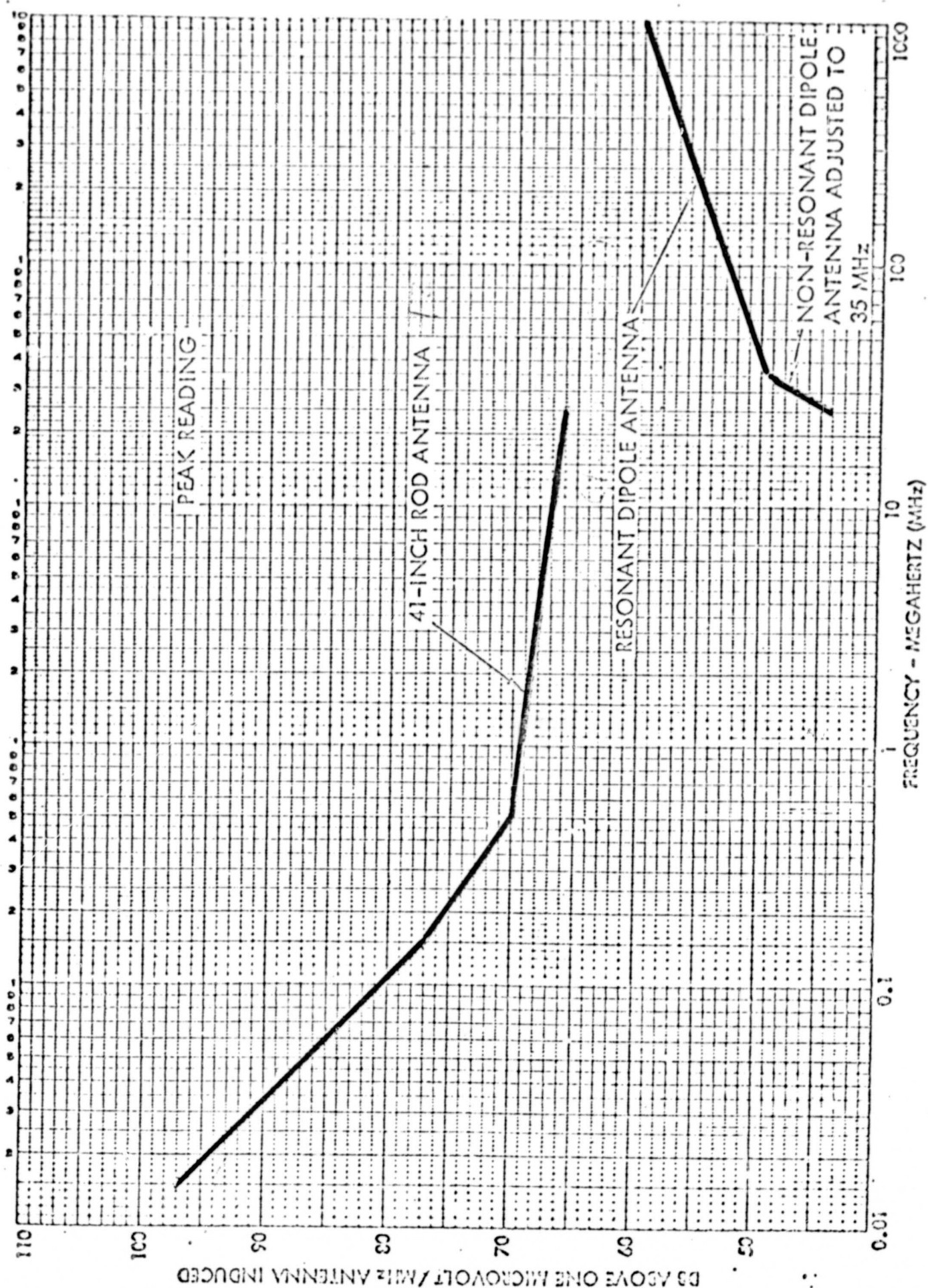


Figure 8. Broadband and Pulsed (CW) Radiated Interference Limits

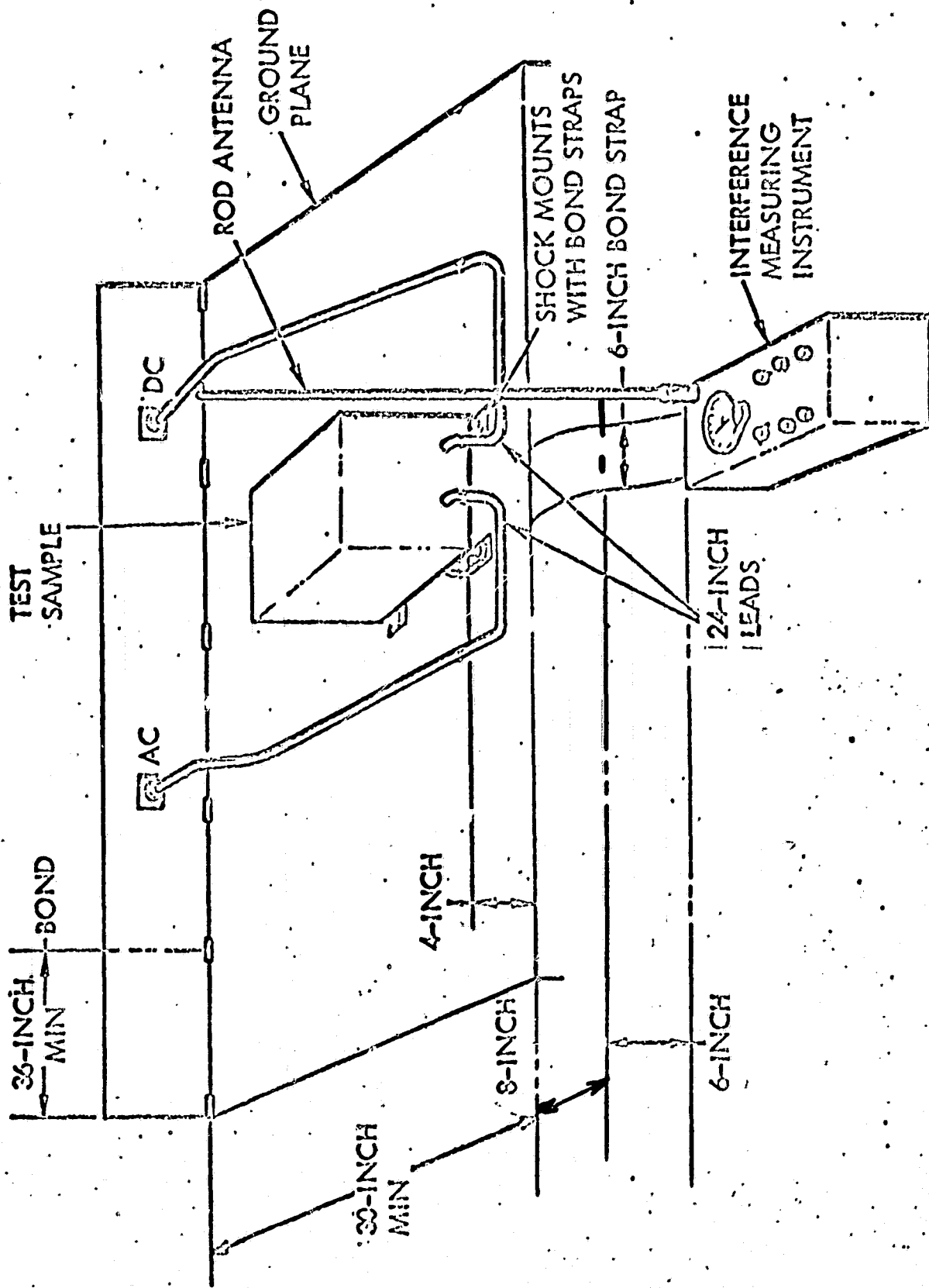


Figure 9. Test Setup for Radiated Interference Measurement (Rod Antenna) Class I Equipment (Typical)

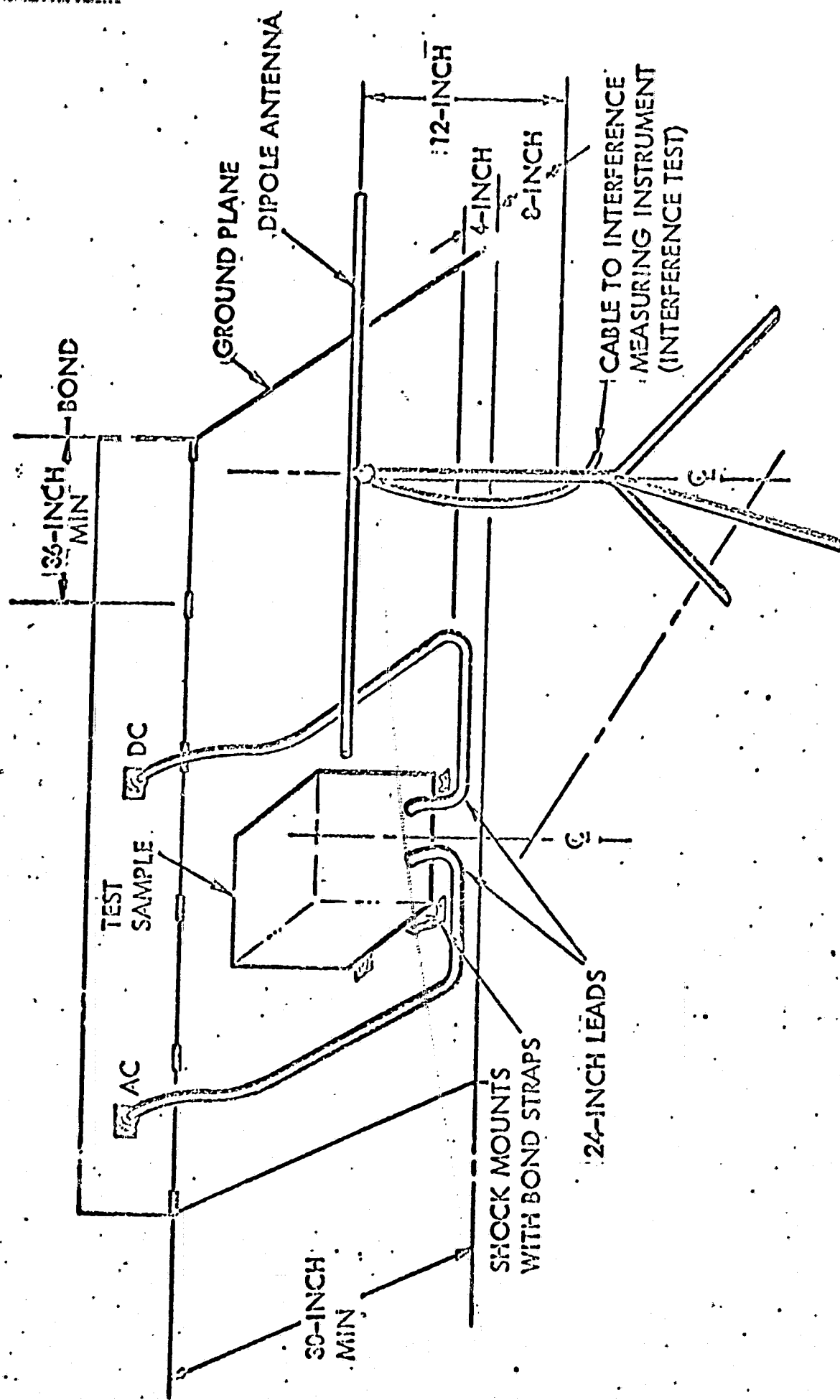


Figure 10. Test Setup for Radiated Interference Measurement (Dipole Antenna) Class I Equipment (Typical)

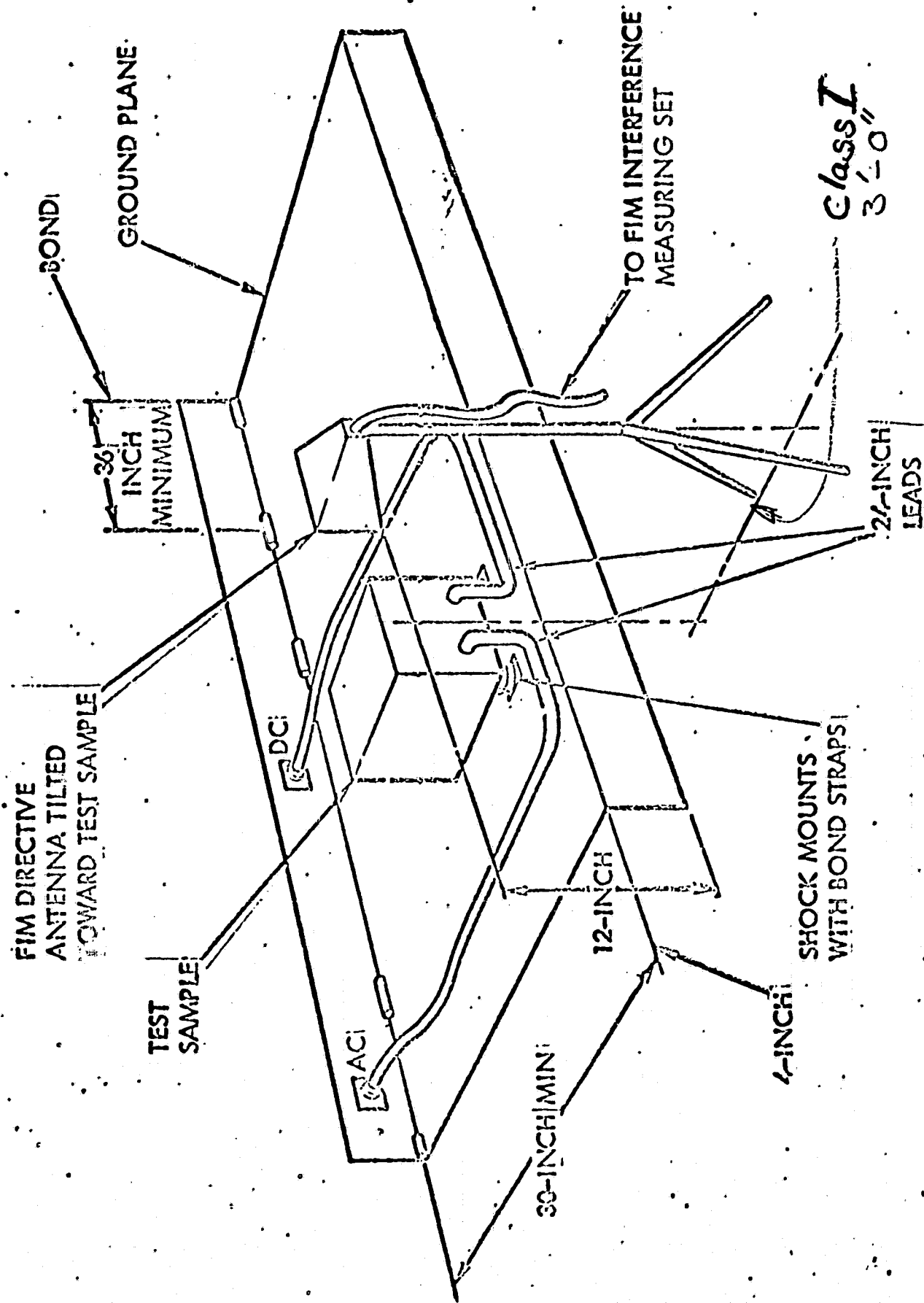


Figure 11. Test Setup for Radiated Interference Measurement
(Microwave-Directive Antenna) Class I Equipment (Typical)

30 percent, 400, or 1,000 Hz, on equipments that are not designed for other modulation frequencies or for special forms of modulation. When testing other equipment, the modulation frequency or any other special form of modulation shall be used to modulate the radio frequency.

4.3.3.1 Conducted Susceptibility - The voltages specified shall be those voltages which are calculated to exist across the output terminals of the signal source when no load other than that necessary to meet the requirements as to source impedance is connected to the signal generator. A matching network suitable for use at required test frequencies and voltages shall be used to obtain the proper source impedance. Blocking capacitors having negligible impedance at the test frequency may be inserted in the leads from the signal source to the equipment under test if required for the protection of the signal source.

4.3.3.2 Radio Frequency Conducted - No malfunction or degradation of performance shall be produced in any equipment when an rf signal of 100,000 microvolts from a source having an impedance of 50 ohms is applied to the test sample as shown in Figure 13. Tests shall be made over the frequency range of 0.05 MHz to 400 MHz.

4.3.3.3 Audio Frequency Conducted - No malfunction or degradation of performance shall be produced in any equipment when a sine wave audio frequency signal of 1.0 volt peak to peak (closed circuit) is applied between each ungrounded power lead and ground as shown in Figure 14. Measurements at 1.0 volt shall be made over a frequency range of 20 to 1,500 Hz. The 1.0 volt shall drop logarithmically to 0.1 volt (rms) at 50 kHz.

4.3.3.4 Transient Conducted - The environment in which equipment must operate will determine expected transient conditions to which the equipment will be subjected. Unless otherwise defined in the detailed specification, equipment shall meet the transient requirement as follows:

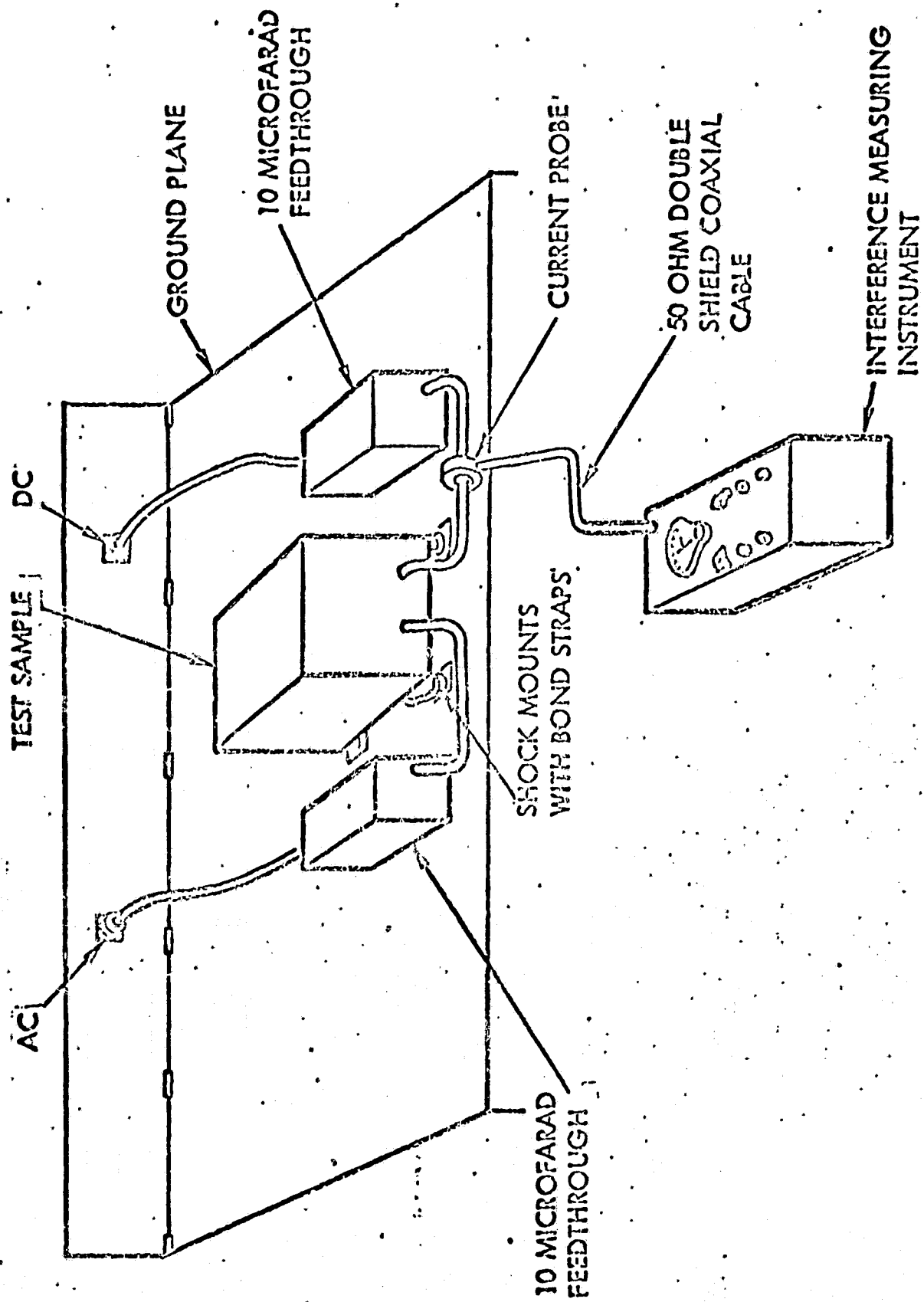


Figure 12. Test Setup for Conducted Interference Measurement (Typical)

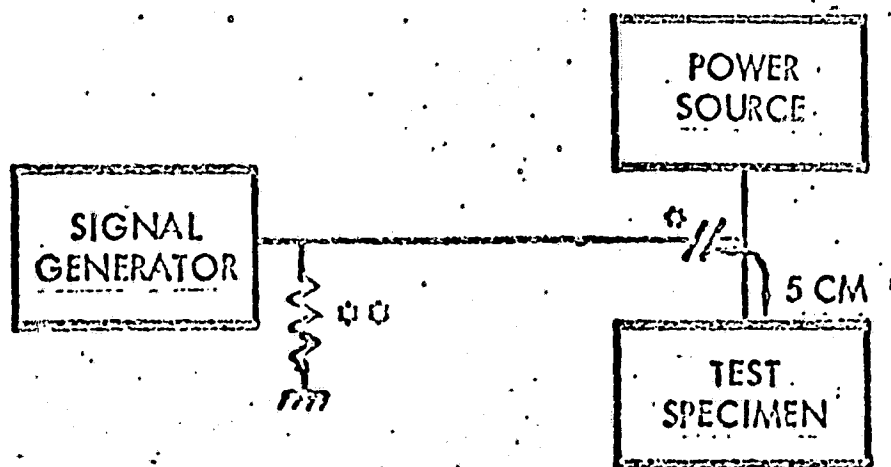
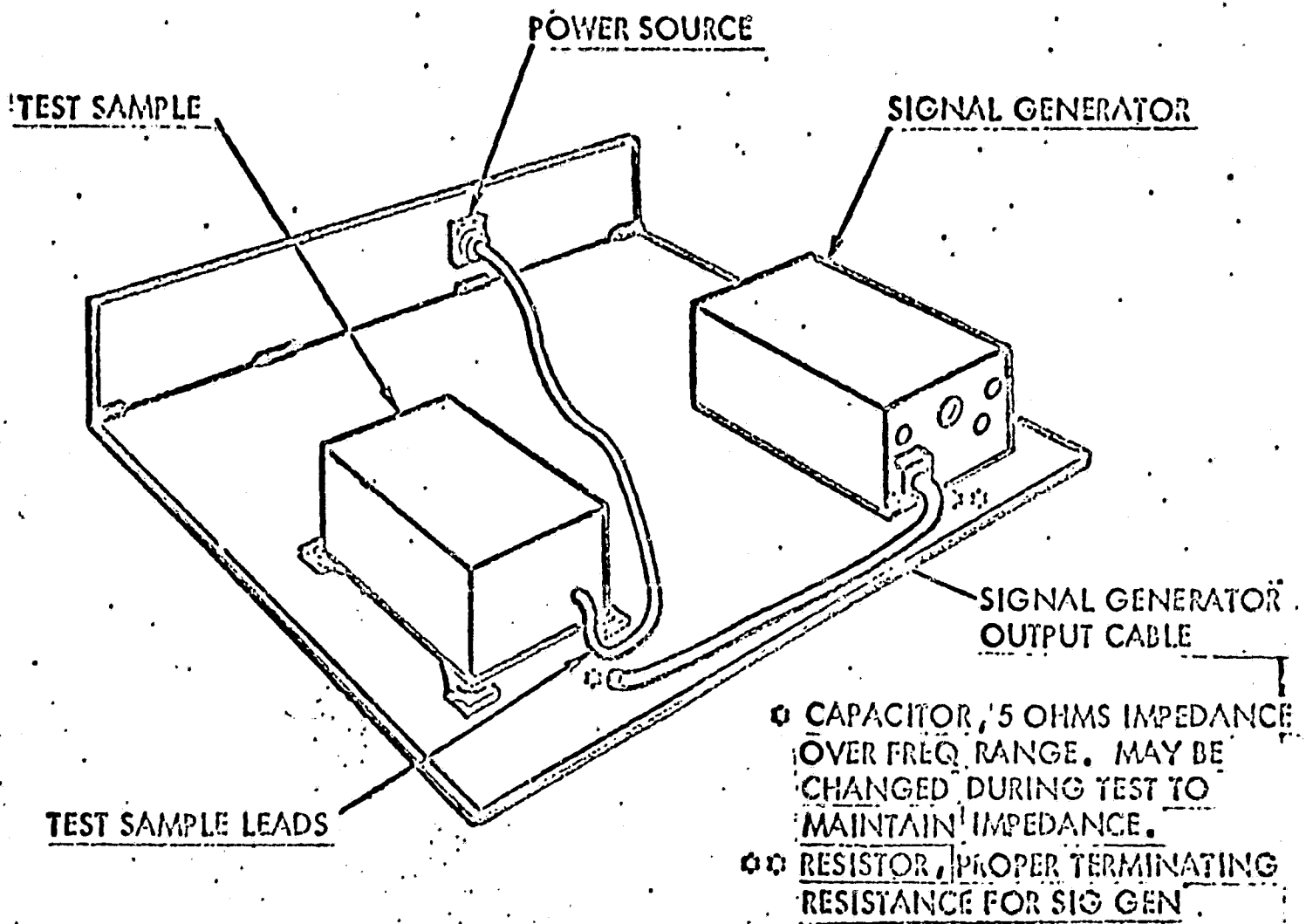
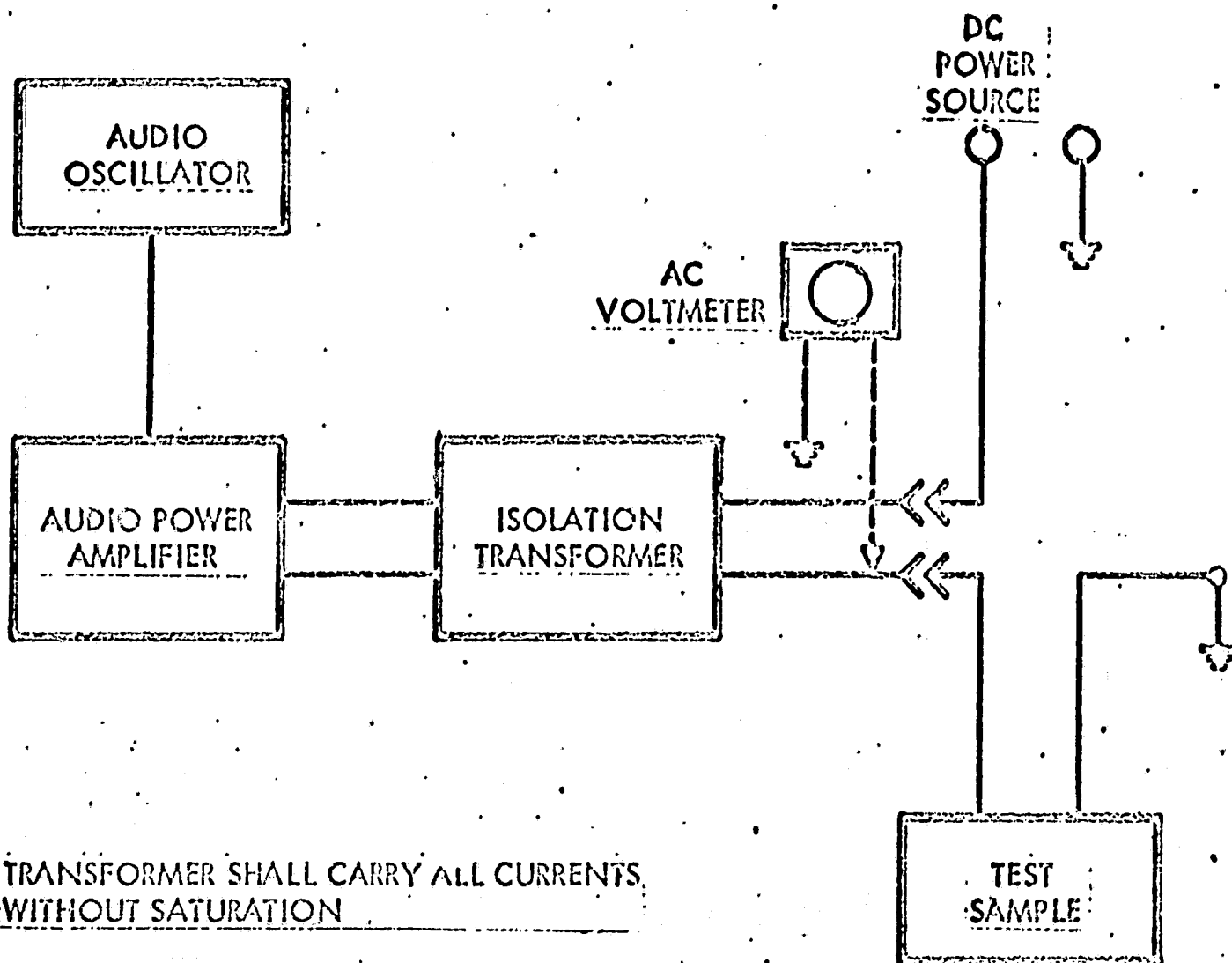


Figure 13. RF Susceptibility Test Setup (Conducted)



TRANSFORMER SHALL CARRY ALL CURRENTS
WITHOUT SATURATION

SERIES CONDENSER ON AC VOLTMETER SHALL HAVE
REACTANCE NOT GREATER THAN $1/10$ METER IMPEDANCE

Figure 14.1 AF Susceptibility Test Setup

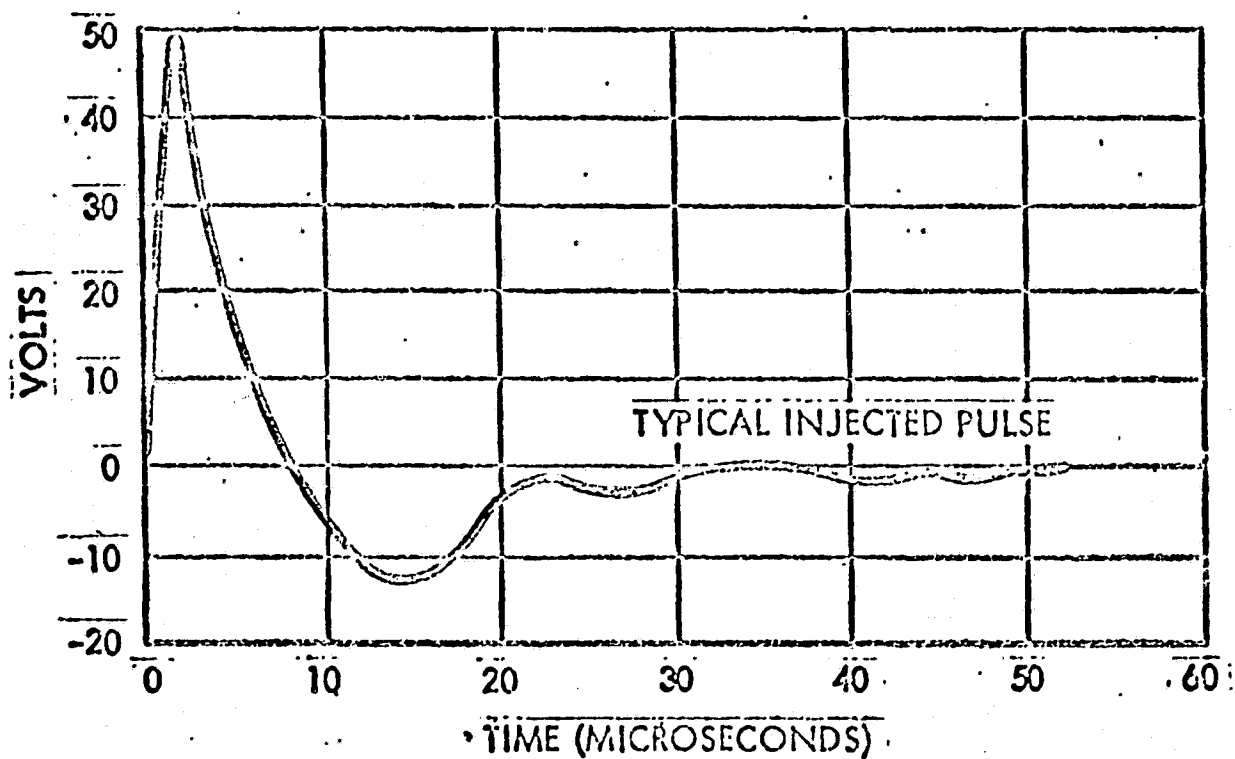
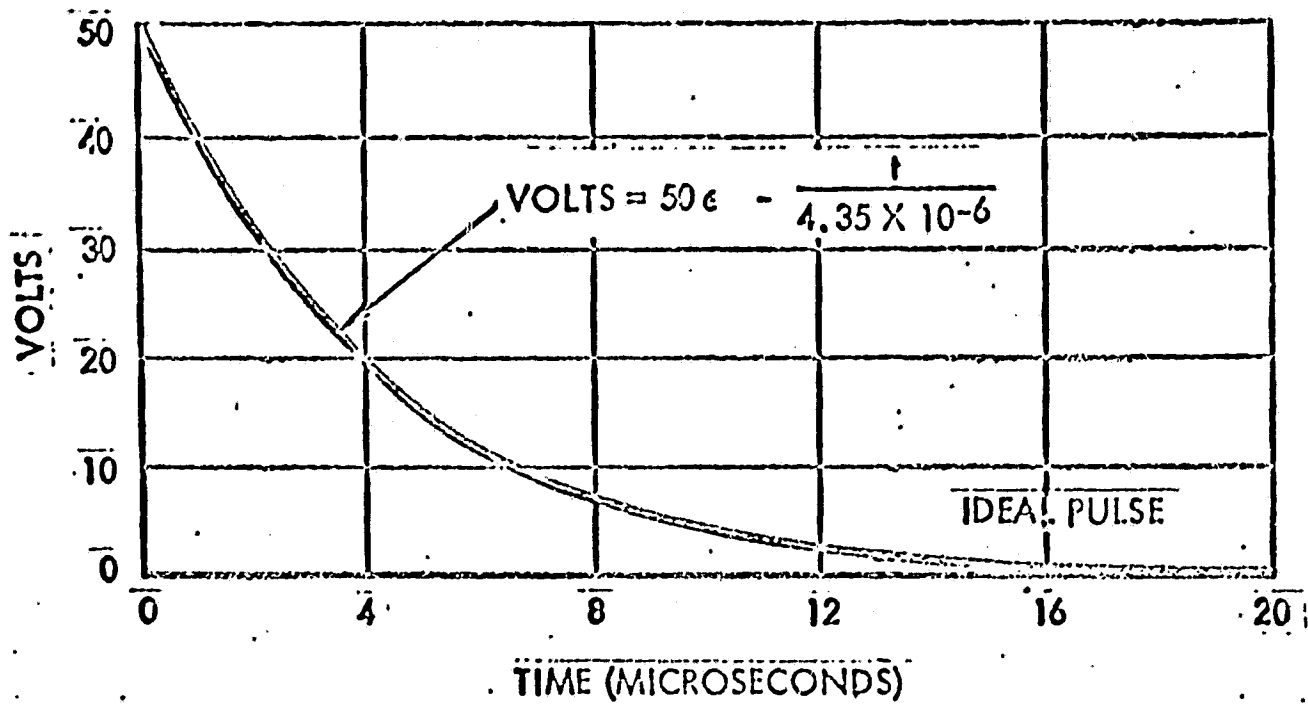
- a) No temporary or permanent damage shall be produced in any equipment when a fifty volt positive or negative pulse, with a width of 10 microseconds and a repetition rate of 10 pulses per second, is induced on each 28 volt (nominal) dc supply lead. Figure 15 specifies the transient shape and Figure 16 diagrams a typical circuit to be used to generate and couple the pulses into the required leads.

In regard to Figure 16, the dc charging voltage (V_c) may be changed to adjust the amplitude of the injected transient. The transient decay time may be adjusted by varying R and C.

- b) The equipment shall perform within the applicable specification tolerances when a plus or minus 0.5 volt transient, with a time width of 10 microseconds and a repetition rate of 10 pulses per second is induced between each return circuit and chassis ground. The return circuit resistance to spacecraft simulated VCP shall exceed 1.0 ohms for this test.

4.3.3.5 Radio Frequency Radiated - The equipment shall perform within the applicable specification tolerances when exposed to an RF field. This field shall be established with a 50-ohm signal generator driving the antenna listed below. Care shall be taken to use matching networks when required. The test setup is shown in Figure 17 for the rod antenna, Figure 18 for the bi-conical antenna, and Figure 19 for the log spiral antenna. Figure 20 shows a general test setup for measuring the generated field.

<u>Frequency</u>	<u>Field Intensity</u>	<u>Antenna</u>
0.14 to 20 MHz	1.0 volt per meter (V/M)	41-Inch Rod
20 to 200 MHz	1.0 V/M	Bi-Conical
200 to 1,000 MHz	1.0 V/M	Low Freq Log Spiral
1 GHz to 10 GHz	1.0 V/M	High Freq Log Spiral



TOLERANCES:

AMPLITUDE:

50 ± 2 VOLTS

RISE TIME:

ONE MICROSECOND (MAX) FROM 5 VOLTS TO 45 VOLTS

PULSE WIDTH:

10 ± 4 MICROSECONDS AT THE 5 VOLT LEVEL

Figure 15. Transient Shape

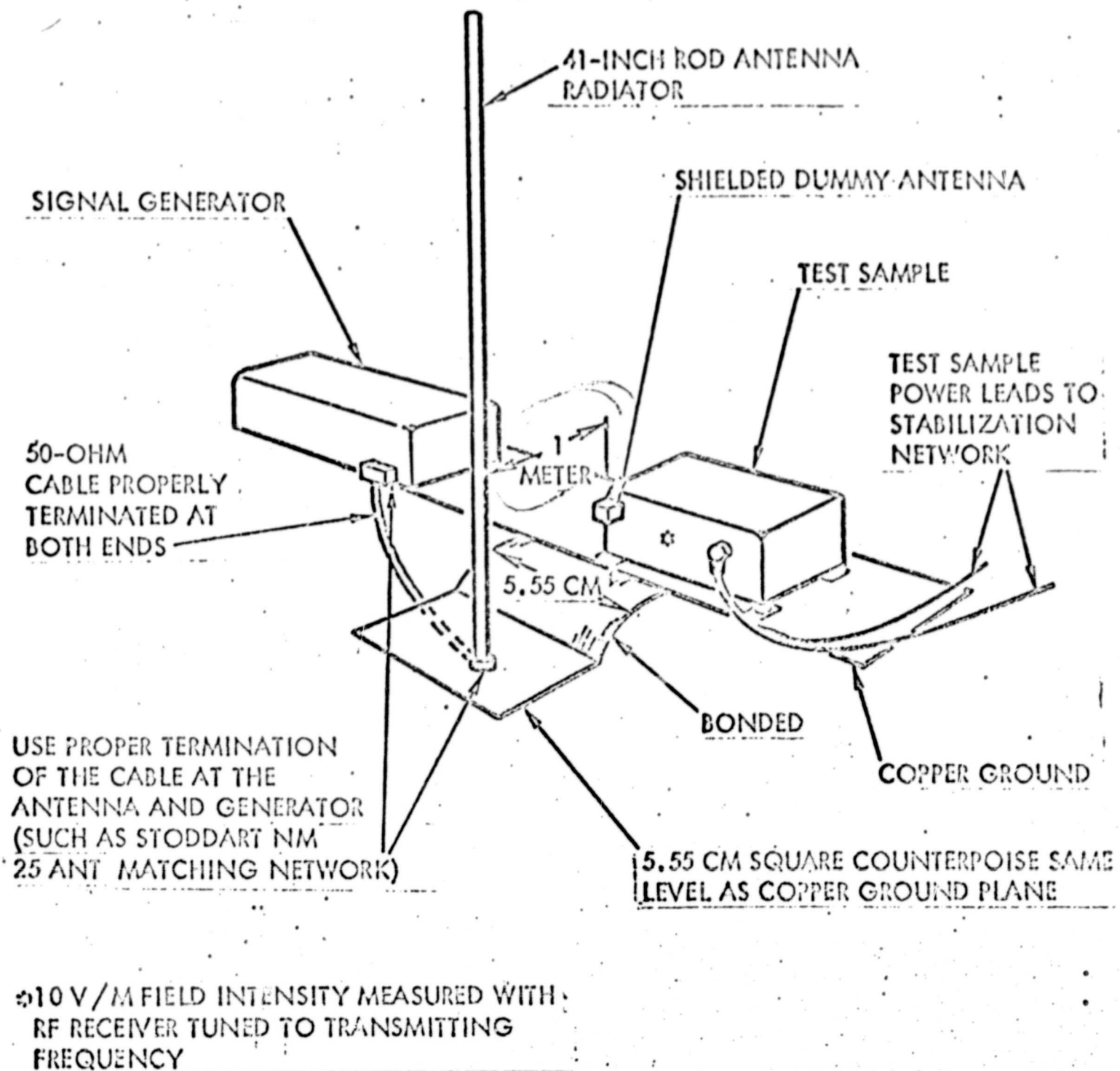


Figure 17. Susceptibility Radiated Test Setup (Red Antenna)

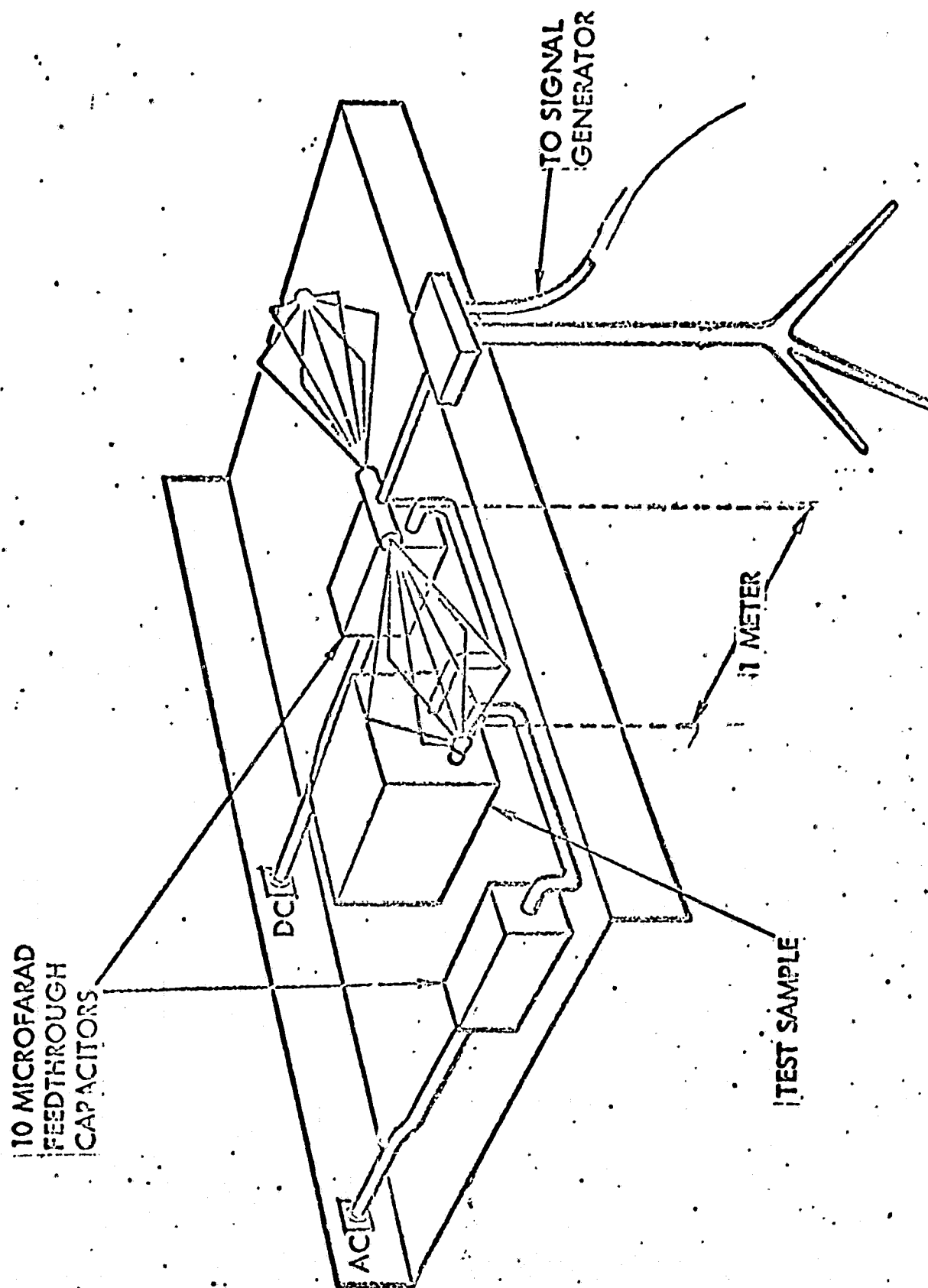


Figure 18. Test Setup for Radiated Susceptibility (Bi-conical Antenne) (typical)

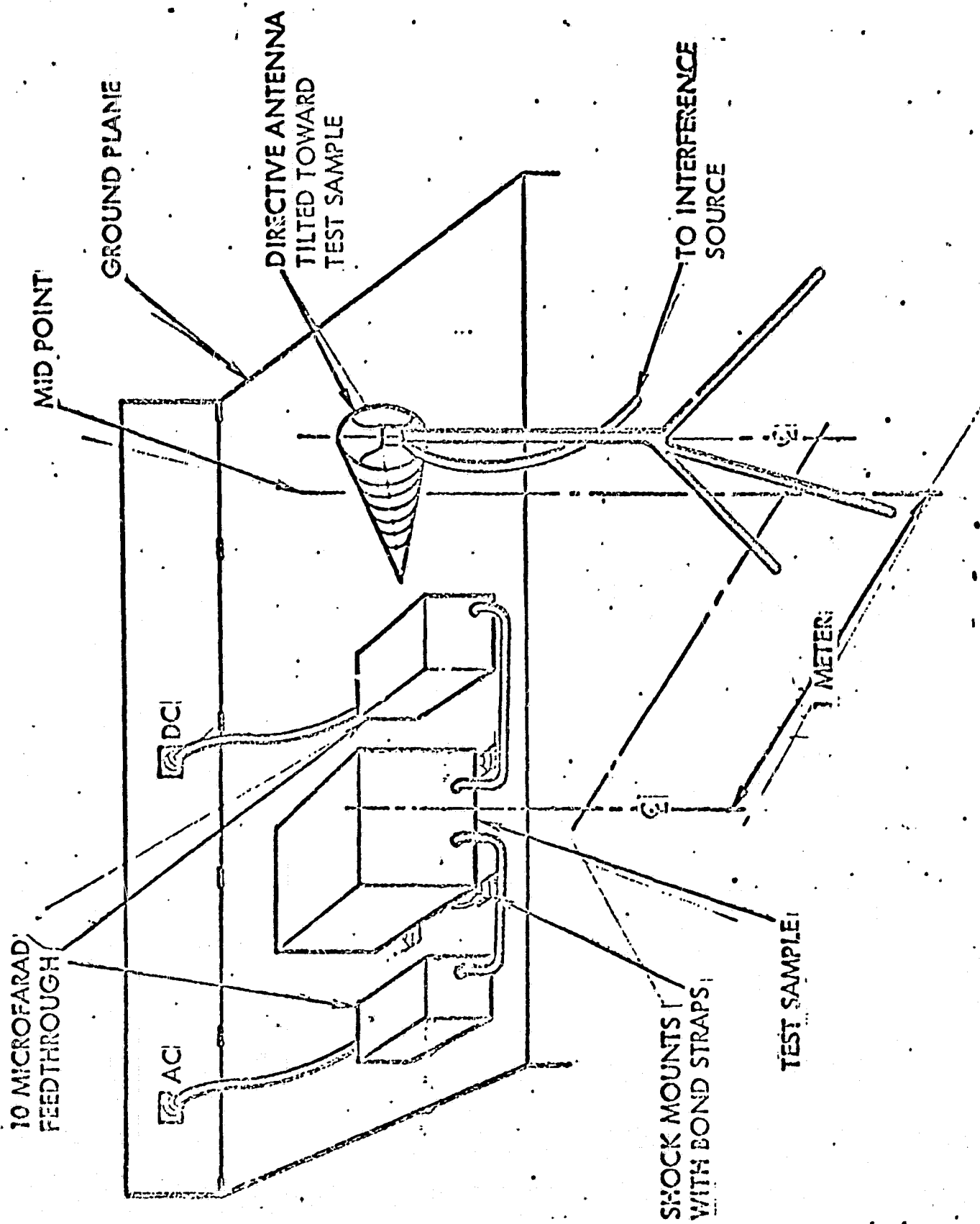


Figure 19. Test Setup for Radiated Susceptibility (Conical, Log Spiral Antenna) (Typical)

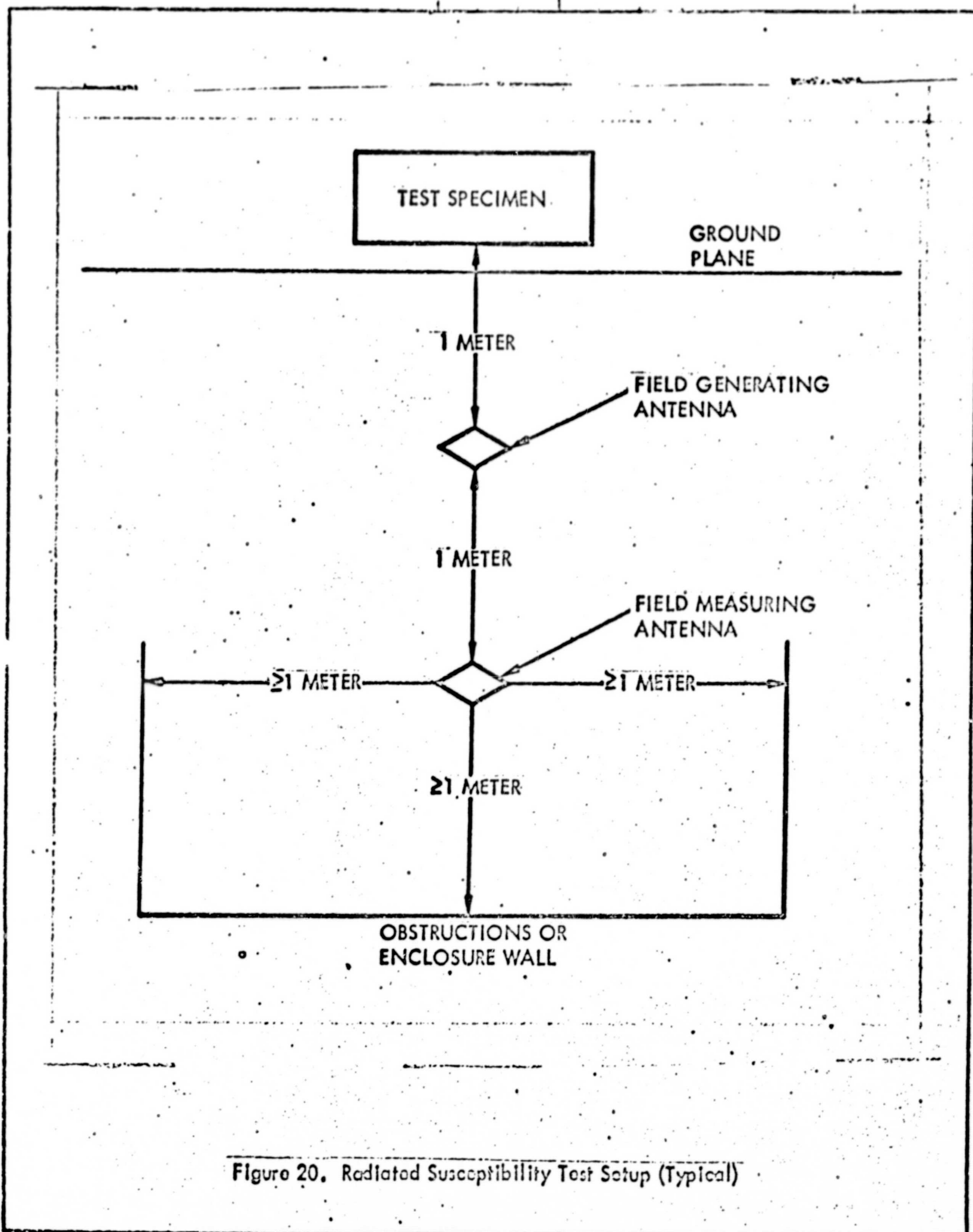


Figure 20. Radiated Susceptibility Test Setup (Typical)

In addition to the above, one frequency will be selected from each one of the following bands:

250-300 MHz	2V/M	Bi-Conical
2270-2290	15V/M	Log Spiral
9800-9850	7V/M	Log Spiral

4.3.3.6 Audio Frequency Induced Susceptibility - The equipment shall perform within the applicable specification tolerances when subjected to a 400Hz magnetic field. The applied magnetic field shall be generated by a current of 10 amperes rms in a straight wire segment located 1 foot from the test sample unit periphery and from sample interconnecting cables. The segment shall be oriented as necessary to probe throughly each unit for susceptibility. The length of the segment shall extend 2 feet past the unit under test at each end. The leads supplying current to the segment shall be routed at least 2 feet from any portion of the sample and from the segment (that portion of the segment directly opposite the unit under test).

4.3.3.6.1 Cables - Interconnecting cables shall withstand, without evidence of equipment performance degradation, the application of magnetic field equivalent to that caused by a wire carrying 40 ampere (rms) feet at 400Hz routed adjacent to the cable under test. The length of the test sample interconnecting cables shall be the RF test arrangement. Cabling of the test sample shall be routed at least 2 inches away from the ground plane or equipment rack. The current carrying wires shall break away from the test sample at least 6 inches short of the cable connectors. The wire return leads shall be kept at least 2 feet from the cable under test and from all other cables of the test samples. The product of current carrying wire length (that section which is parallel to the cable) and rms current shall be equal to the required number of ampere-feet. The current shall not be less than 5 amperes rms.

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A Division of Fairchild Camera and Instrument Corporation
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1231-DC-1

INTERFACE SPECIFICATION
MC SUBSYSTEM

Revision A

9 March 1970

1.0 SCOPE - This specification defines the interfaces for integration of the MC Subsystem in the Scientific Instrument Module (SIM). It identifies the interface areas, describes pertinent Mapping Camera (MC) Subsystem requirements, and establishes contractor responsibility assignments for the performance of interface tasks. It is based on interface agreements jointly developed by the MC contractor and associated contractors.

1.1 Purpose - The purpose of this specification is to establish the interface guidelines necessary to insure complete compatibility between the MC and the SIM. It is intended that the provisions of this specification be incorporated in respective equipment development programs.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-3	Installation Requirements, MC Subsystem Flight Hardware
1231-DB-4	Electrical Power Requirements, MC Subsystem Flight Hardware
1231-DB-6	BME Interface Requirements, MC Subsystem Flight Hardware
1231-DB-7	P/L Space Requirements, MC Subsystem Flight Hardware
1231-DB-8	Thermal Interface Requirements, MC Subsystem Flight Hardware
1231-DB-9	Instrumentation Interface Requirements, MC Subsystem Flight Hardware
1231-DB-10	Installed P/L Test Requirements, MC Subsystem Flight Hardware

1231-DB-12	Environmental Interface Requirements, MC Subsystem Flight Hardware
1231-DB-13	Auxiliary Data Recording Requirements, MC Subsystem Flight Hardware
1231-DB-14	Command and Control Interface Requirements, SIM Flight Hardware
1231-DB-15	Telemetry Interface Requirements, MC Subsystem Flight Hardware
1231-DB-18	MSFN Interface Requirements, MC Subsystem Flight Hardware
1231-DR-1	EMI Control and Test Requirements for MC Camera Subsystem and Ground Support Equipment

2.2 Contractor Drawings

1231L46

MC Payload Stowage Outline

3.0 INTERFACE REQUIREMENTS - This section establishes the interface criteria for integration of the MC Subsystem Flight Hardware in the SIM, and for integration of MC Bench Maintenance Equipment (BME) in operational, checkout, and test facilities associated with Scientific Instrument Module (SIM) ground testing and flight operations. In addition, it includes interface criteria for integration of MC simulators, models, and related hardware in SIM development test vehicles.

3.1 MC Subsystem Flight Hardware - Interface criteria for integration of MC flight hardware in the SIM configuration are summarized in the following subsections with references being made, where necessary, to documents which further define characteristics, requirements, responsibility or concept. They are described in terms of those functional, mechanical,

electrical, environmental, thermal, and test characteristics of the MC Subsystem flight hardware which affect development of the Apollo SIM configuration.

3.1.1 Functional

3.1.1.1 Orbital Parameters - The MC Subsystem is designed for operation at lunar orbital altitudes of 30 to 80 nautical miles. Orbital inclinations for the lunar missions shall be up to 45° . Orbital plane changes during any given mission should be subject to ground coverage limitations of 10% minimum side overlap.

3.1.1.2 Flight Altitude - During photographic operation in flight, the MC Subsystem shall be oriented so that the principal axis of the mapping lens is aligned parallel to the local vertical and the principal axis of the stellar lens is aligned perpendicular to the vehicle velocity vector. With the MC Subsystem installed as specified in paragraph 3.1.2.3, the velocity vector must point in the Spacecraft (S/C) $\pm X$ direction. The orientation error when referred to the principal axis of the mapping lens shall not exceed $\pm 2^{\circ}$.

3.1.1.3 Attitude Control - Within the pointing accuracy limits established in paragraph 3.1.1.2, the Command and Service Module (CSM) attitude control system shall provide vehicle stabilization rates not to exceed 1.2 arc minutes/second in pitch, roll, and yaw. No stabilization is required during camera-off periods.

3.1.1.4 Checkout and Ground Operations - For operation during pre-launch checkout activities and other ground operations involving integrated systems, the MC Subsystem will be powered, controlled, and monitored by BME. Prior to electrical mating with the S/C, electrical power and commands will be received from, and responses transmitted to, MC BME. After electrical mating with the S/C, control and monitoring will be accomplished via the Acceptance Checkout Equipment (ACE) S/C integration.

3.1.1.5 Film Loading - Flight-film loading for any specific mission will be accomplished at a point in time as close to the launch date as possible.

3.1.1.6 Access Port - A clear opening shall be provided in the SIM panel. The opening shall be of sufficient size and shape to permit access for loading film in the camera. The opening shall be covered and sealed-off by a cover or door during all pre-photographic-orbit phases of the mission.

3.1.1.7 RCS Plumes - Exhaust plumes from the CSM Reaction Control System (RCS) engines shall not interfere with photographic performance of the MC Subsystem. Whenever the possibility of condensation of reaction products on camera lenses exists, either the RCS engines shall not be operated or the SIM shall be sealed-off during such engine operation.

3.1.1.8 Useful Life - The MC Subsystem is designed for photographic operation in lunar orbit. MC equipment, including recoverable portions, shall not be designed for repeated mission use.

3.1.1.9 Record Retrieval - Exposed film shall be returned to earth in the S/C command module. Record transfer from the service module to the command module shall be accomplished after completion of all photography. The retrieval sequence shall commence with the separation of the record container from the MC Subsystem take-up cassette.

From the time the exposed record leaves the controlled environment of the SM Sector I until earth recovery and return to controlled environment, it shall not be subjected to environmental conditions exceeding those specified in section 3.1.4.

The record retrieval concept and the implementation thereof shall be the responsibility of the S/C contractor. The MC contractor shall be responsible for insuring MC Subsystem compatibility with the retrieval concept described herein.

3.1.1.9.1 Record Storage - The enclosed record container shall be stowed in the CM in a manner which affords optimum protection of the contents during transearth trajectory, re-entry, and earth-recovery phases of the mission.

3.1.1.9.2 Post Landing - The MC contractor shall not be responsible for removal of the record container from the CM after descent or for any other post-landing activity relating to the handling, storage, or developing of the exposed record.

3.1.1.10 Command and Control - For operation in flight, the MC Subsystem is powered and controlled in accordance with the requirements described in Document No. 1231-DB-14.

3.1.2 Mechanical

3.1.2.1 Physical Characteristics

3.1.2.1.1 MC Subsystem Configuration - Configuration details of the MC Subsystem shall be in accordance with the information presented in Figure 1 and in Document No. 1231-DB-3. The delineation shown in the figure represents preliminary subsystem design definition of actual hardware limits, and the dimensions specifying these limits shall be considered nominal dimensions only. Configuration changes as a result of continuing design development shall be permissible provided that such changes do not affect existing interface agreements. Furthermore, the configuration outline depicted does not include insulation blankets, heaters, sinks, or related items enclosing or fastened to external surfaces of the MC Subsystem for purposes of thermal control.

3.1.2.1.2 MC Subsystem Size

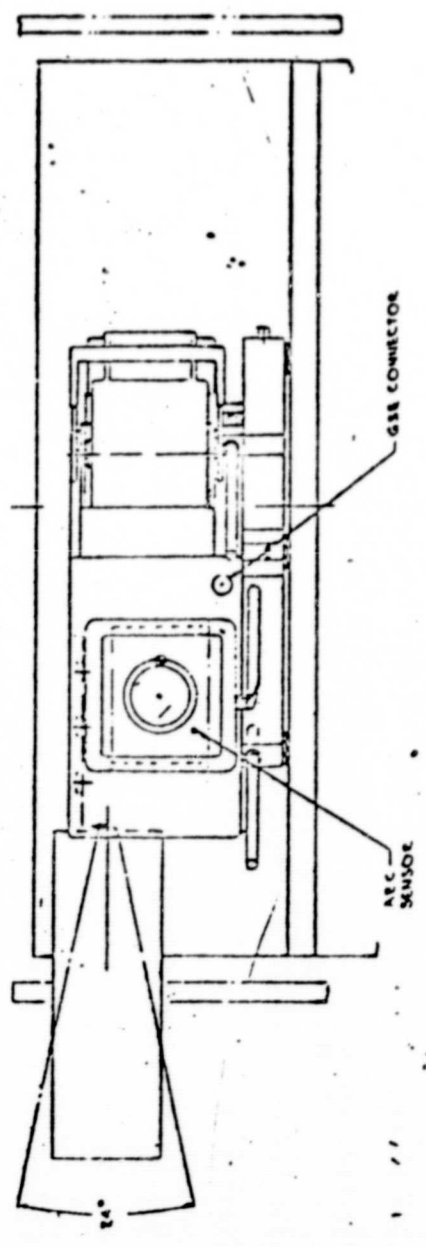
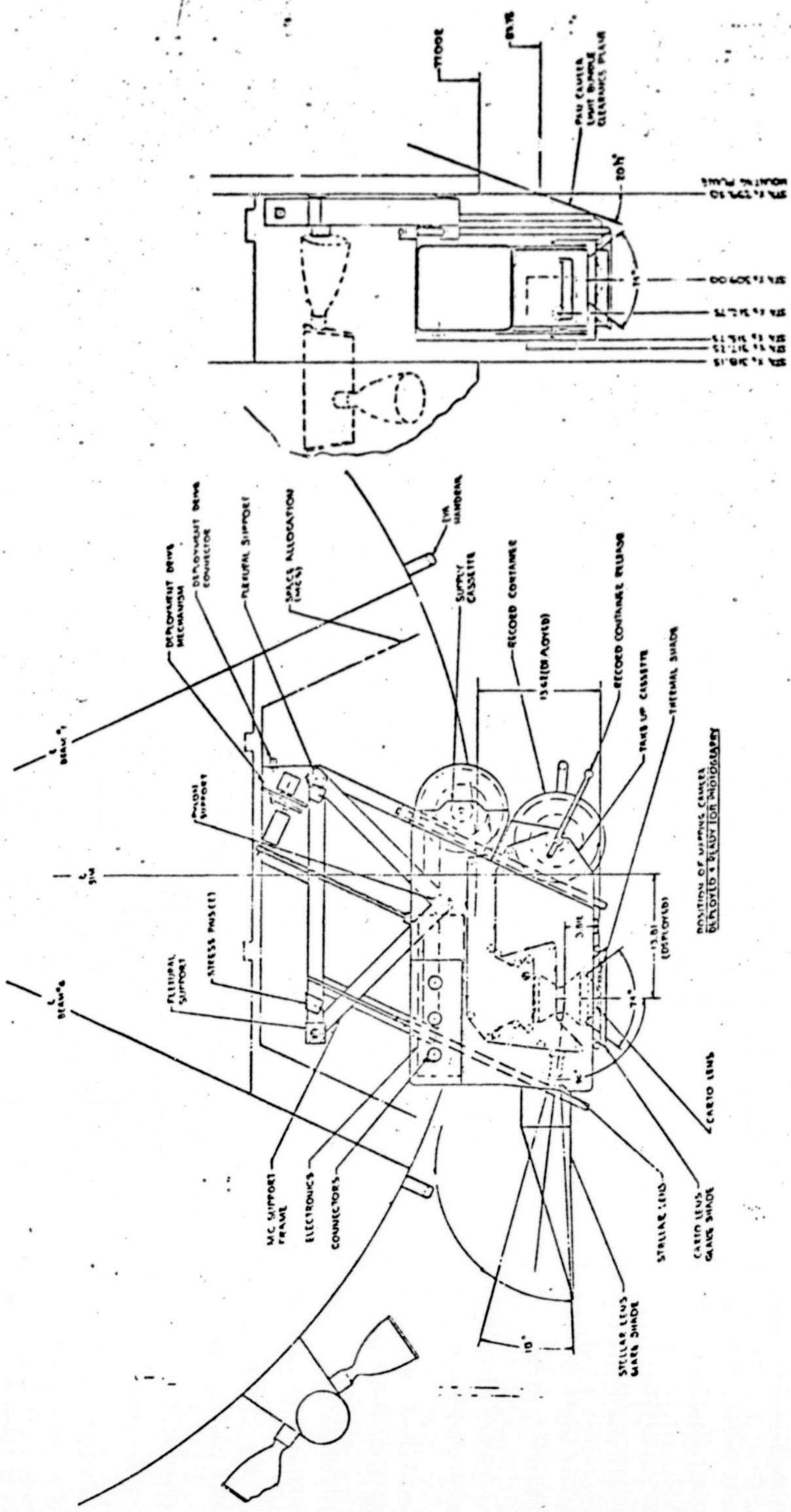
- Complete MC Subsystem 24"(H) x 36"(W) x 17"(L)
- Record Container 10.75" Dia. with projecting
 handle x 11"(L)

The first item above includes the latter.

3.1.2.1.3 MC Subsystem Weight

- Complete Subsystem with 156 pounds
 full film load
- Record container with 24 pounds
 full film load

3.1.2.1.4 MC Subsystem CG - Approximate CG locations for the complete subsystem, deployment device, and record container shall be in accordance with the information presented in Figure 1.



3.1.2.2 Space Allocation - Space allocations for integration of MC Subsystem flight hardware in the Apollo SIM configuration shall be in accordance with Document Nos. 1231-DB-3 and 1231-DB-7.

3.1.2.3 Installation and Mounting - Integration of the MC Subsystem in the Apollo S/C will require mounting points for flight hardware in the S/C SIM and the Command Module. The complete MC Subsystem shall be hard-mounted to the SIM in Sector I. Installation of the MCS and mounting requirements, characteristics, and responsibility assignments shall be in accordance with Document No. 1231-DB-3.

3.1.2.4 Take-Up Cassette - The take-up cassette is that portion of the MC Subsystem which houses the record container and mechanisms relating to the handling of exposed film. It is designed as an integral part of the complete Subsystem, structurally as well as functionally. However, provision is made for detaching the record container in its entirety, from the take-up cassette for purposes of transfer to the CM. Separation from the complete MC Subsystem shall be mechanically and electrically complete and shall be sufficiently non-accelerative so as to result in a minimum net-displacement of affected elements.

3.1.2.5 Record Container - The record container is that portion of the take-up cassette which houses the exposed film. It is designed for quick-release from the cassette to facilitate crew operations and expedite the jettisoning of expendable thermal insulation. It affords protection to its contents during handling and storage but is not waterproof or completely light-tight. Configuration details of the record container are given in Drawing No. 1231L46 and stowage requirements are described in Document No. 1231-DB-3.

3.1.2.6 Glare Shades - For purposes of thermal control and lens shading, glare shades surrounding income light-ray bundles shall be provided as part of the MC Subsystem compartment in the SM Sector I Bay. The shades shall be configured to extend from the MC Subsystem body.

3.1.2.6.1 Stellar Lens Glare Shade - The glare shade for the stellar lens shall be a separate part which will be assembled to the camera. The MC contractor shall be responsible for the design and manufacture of the stellar lens glare shade, and the vehicle contractor shall be responsible for its installation in the vehicle, along with the rest of the MCS. Installation and interface requirements are given in Document No. 1231-DB-3.

3.1.3 Electrical - This section of the interface specification document describes the electrical interfaces and defines the responsibility for the current design and hardware configuration as related to the interface issues not apparent. The division of responsibility between each contractor for the electrical interface requirements imposed by the MC Subsystem shall be in accordance with Document No. 1231-DB-9. The following paragraphs briefly describe additional documents which define the essential requirements and constraints relating to the electrical interfaces.

3.1.3.1 Power - The electrical power required for MC Subsystem operation is 28V DC. This power will be transmitted via the SM wiring harness to a single connector, 1231-1, on the MC Subsystem. The Electrical Power Requirements, Document No. 1231-DB-4, details the subsystem interfacing and power utilization.

3.1.3.2 Instrumentation - The MC Subsystem will be instrumented internally to generate all of the information necessary to evaluate the MC performance. The instrumentation will also allow diagnostic analysis for isolation of malfunctions. The information generated will be in the form of electronic signals which are fed through a separate test connector, 1231-J4, on the MC Subsystem. A detailed description is given in the MC Instrumentation Interface Requirements, Document No. 1231-DB-9.

3.1.3.3 Telemetry - The MC Subsystem shall be instrumented to provide pre-flight checkout and perform in flight measurements which are necessary for performance evaluation. The MC telemetry output will be interfaced with the SIM through the T/M connector, 1231-J3, on the MC Subsystem. The MC Telemetry Interface Requirements, Document No. 1231-DB-15, describes the MC T/M capabilities and interfacing.

3.1.3.4 ADR - The Auxiliary Data Recordings registered on each exposed frame will be utilized as an aid in the subsequent reduction of photographic information. The auxiliary data will be transmitted to the MC Subsystem through the command connector, 1231-J2, as described in the following

paragraph 3.1.3.5. All essential requirements and constraints relating to the ADR are found in Document No. 1231-DB-13, Auxiliary Data Recording Requirements.

3.1.3.5 Command and Control - All commands and control signals for functional operation of the MC Subsystem, the temperature warning system, and the auxiliary data signals will emanate from the S/C. These signals will be transmitted to or from the MC through a single connector, 1231-J2, on the MC Subsystem. The MC/S/C interface is described in detail in the Command and Interface Requirements, SIM Flight Hardware Document No. 1231-DB-14, Section III.

3.1.3.6 MSFN - The Manned Space Flight Network (MSFN) will provide the means for monitoring and controlling the MC Subsystem during mission operations. The T/M data downlink and any command uplink will be transmitted via the network. The procedures utilized between the MSFN and the MC are detailed in the MSFN Interface Requirements Document No. 1231-DB-18.

3.1.3.7 EMI - The EMI electrical and mechanical parameters which must be controlled at the MC Subsystem interfaces are described in the Electromagnetic Interference Requirements Document No. 1231-DR-1.

3.1.3.8 Cables and Harnesses - The MC Subsystem will have four (4) bulkhead receptacles as described in the Installation Requirements Document No. 1231-DB-3. The vehicle contractor shall have the responsibility for producing the cables, harnesses and connectors which mate with three (3) of the MC receptacles. The wiring information for each receptacle can be obtained from the documents referenced in each of the above paragraphs, 3.1.3.1 (Power Receptacle 1231-J1), 3.1.3.3 (T/M Receptacle 1231-J3), and 3.1.3.5 (Command Receptacle 1231-J2).

3.1.4 Environmental - The natural and induced environmental design criteria for MC Subsystem flight hardware shall be in accordance with the levels summarized in this section and described in detail in Document Nos. 1231-DB-8 and 1231-DB-12. Wherever the specified levels are more

restrictive than the respective environmental levels that may be encountered during the various SIM mission phases and/or during normal operational flow sequences, it will be necessary to provide environmental control. The vehicle contractor shall be responsible for providing such control.

3.1.4.1 Operational Flight - The following represent the natural and induced environmental extremes which can be tolerated by the MC Subsystem during photographic operation in lunar orbit.

- 1) Temperature $70^{\circ} \pm 10^{\circ}\text{F}$
- 2) Gas Pressure $< 10^{-13}\text{mm Hg.}$
- 3) Humidity 0 - 50% RH
- 4) Nuclear Radiation $< 2.0\text{ rads total absorbed by}$
photographic emulsion

3.1.4.2 Non-Operational Flight - The following represent the natural and induced environmental extremes which can be tolerated by the MC Subsystem in a non-operating condition during SIM mission phases from Launch Ascent through photographic Orbit Insertion and Orbital Coast. The MC Subsystem shall be capable of meeting applicable performance specifications after exposure to these extremes.

- 1) Temperature $70^{\circ} \pm 20^{\circ}\text{F}$
- 2) Gas Pressure 760 nominal to $< 10^{-13}\text{mm Hg}$
- 3) Humidity 0 - 50% RH
- 4) Nuclear Radiation See paragraph 3.1.4.1
- 5) Random Vibration The MC Subsystem shall withstand a random vibration level of 10.6 g's total

rms acceleration for a period of 120 seconds. The acceleration density distribution shall be over a frequency range as follows:

20 - 200 Hz 3 db/octave rise to
0.05 g^2/Hz

200 - 2,000 Hz 0.05 g^2/Hz

The MC Subsystem shall withstand a sinusoidal acceleration at 0.25 g peak from 4 to 35 to 4 Hz at a sweep rate of 3 octaves/minute for 120 seconds.

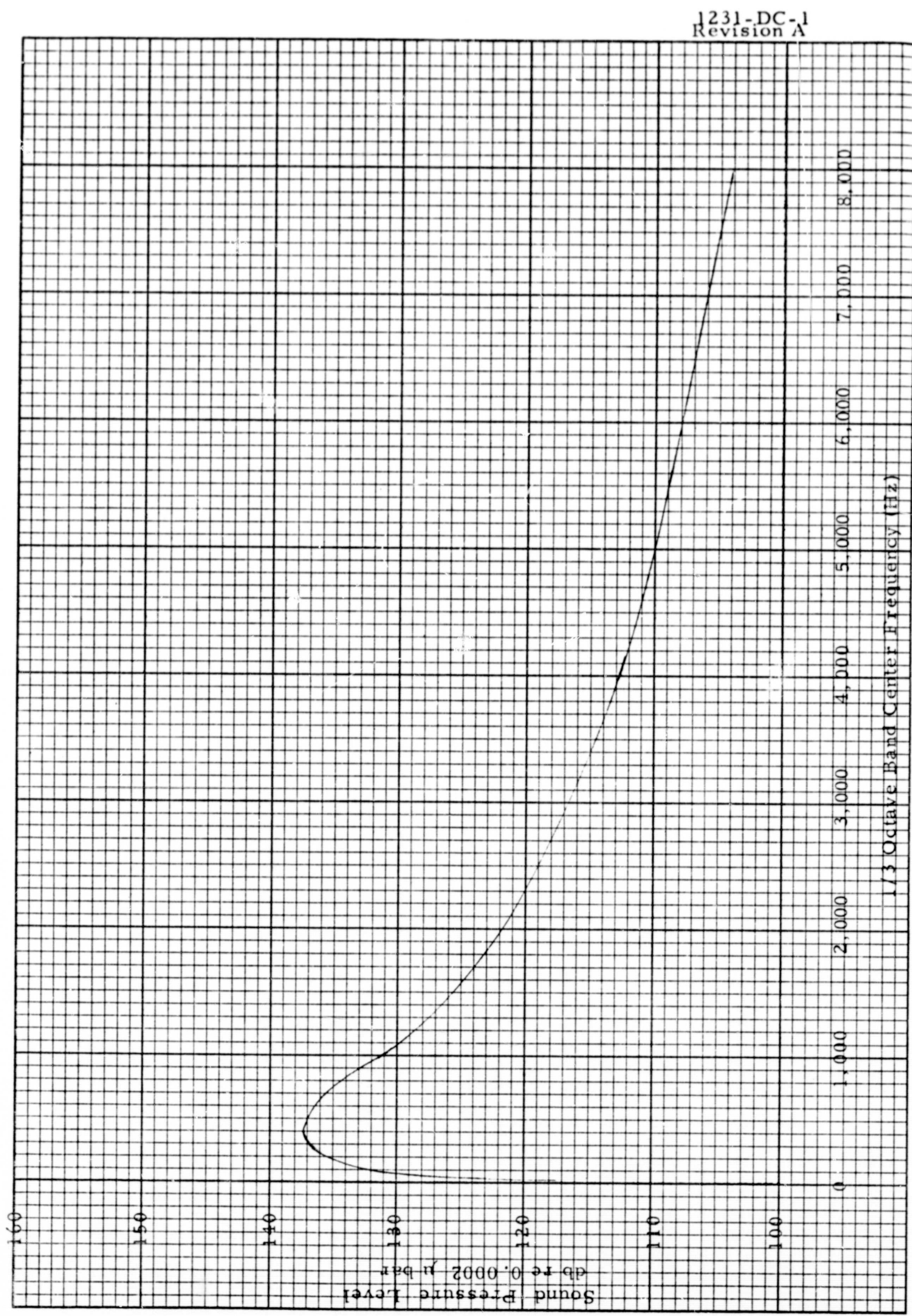
The subsystem shall also withstand a random vibration level of 5.4 g total rms acceleration for a period of 700 seconds. The acceleration density distribution for this level shall be over a frequency range as follows:

20 - 100 Hz 3 db/octave rise
to 0.015 g^2/Hz

100 - 2,000 Hz 0.015 g^2/Hz constant

6) Acoustics

The MC Subsystem shall withstand an overall sound intensity level of 147 db for a period of 120 seconds. The spectral distribution of sound intensity shall be in accordance with Figure 2.



ACOUSTICS SIM INTERNAL
FIGURE 2

- | | | |
|----|--------------|---|
| 7) | Shock | 5.0 g's along principal axes - 1/2 sinewave
6 milliseconds duration |
| 8) | Acceleration | 5.0 g's along X-X axis 0.75 g's any
direction normal to X-X axis. Duration
140 seconds. |

3.1.4.3 Ground Operations - The natural and induced environmental extremes which can be tolerated by the MC Subsystem during flight readiness SIM integration, and prelaunch checkout and testing shall not exceed the limits specified in paragraphs 3.1.4.1 and 3.1.4.2 for the operating and non-operating conditions except as amended or augmented as follows:

- 1) Gas Pressure - Local Atmospheric
- 2) Relative humidity 40 - 50%
- 3) Air cleanliness levels in accordance with Class 100,000 of Federal Standard No. 209

3.1.4.4 Record Container - From MC cassette separation, deployment, SM/CM transferral and stowage in the CM through re-entry, recovery, and post-landing phases; the film in the record container shall not be exposed to environmental conditions exceeding the following:

- | | | |
|----|-------------|---|
| 1) | Temperature | No greater than 125°F, temperature-time accumulation over 90°F not to exceed 4,000 hours based on the integral expression specified in paragraph 3.2.10.1 of Document No. 1231-DB-12. |
| 2) | Humidity | No greater than 50% RH |
| 3) | Shock | 40 g's X-X Axis
5 g's along any axis normal to X-X axis |

The shock levels specified shall apply only when the loaded record container is stowed in the CM in accordance with the arrangement described in paragraph 3.2.5.2 of Document No. 1231-DB-3 and as noted in Drawing No. 1231L46.

3.1.4.5 Transportation, Ground Handling and Storage - The MC Subsystem shall be packaged for protection during transportation, ground handling, and storage in MIL-C-4150 type carrying cases.

The protective packaging shall be designed to attenuate extreme conditions of natural and induced environment so that the non-operating equipment inside will not be exposed directly to levels exceeding those specified in paragraph 3.1.4.3. Extreme levels of natural and induced environment applicable to the protective packaging, in sheltered areas, shall be in accordance with Document No. 1231-DB-12.

3.1.5 Thermal - MC temperatures shall be controlled during pre-flight and mission phases to insure satisfactory subsystem performance. The vehicle contractor shall develop and implement a thermal control system capable of maintaining MC temperatures in accordance with Document No. 1231-DB-8.

Thermal analyses of the MC shall be performed to support the development of the thermal control plan. Evaluation of and modifications to the MC thermal design will be effected through extensive thermal-vacuum and optical performance testing of a thermal model at the MC contractor's facility. The equipment will be tested under simulated operational conditions in order to verify the effectiveness of the thermal control system.

3.1.6 Checkout and Test Requirements - The following paragraphs briefly describe the requirements imposed upon the spacecraft and facilities during the ground checkout test phases of the MC Subsystem and spacecraft.

3.1.6.1 MC Subsystem Receiving, Inspection and Health Checkout - The MC Subsystem and associated BME will be shipped directly to the Kennedy facility. NR furnished handling equipment will transport the MC Subsystem

and BME from the receiving area to the MC airlock. The equipment will be unpacked and transported to the MC Test and Maintenance Area using MC handling equipment. Any units not required for immediate support of spacecraft operations will be stored in an area adjacent to the MC test area. The MC Subsystem will undergo a series of tests to verify MC Subsystem health prior to installation into the S/C. The MC BME will completely exercise and monitor MC Subsystem responses during these tests. Upon satisfactory completion of these tests, the MC Subsystem and BME will be transported to the integration area using MC contractor furnished handling equipment for integration checkout in the spacecraft. Document No. 1231-DB-10 describes in detail the MC Subsystem receiving, inspection and health checkout requirements that are imposed upon the spacecraft and facilities.

3.1.6.2 Installed Payload Requirements - Prior to installing the MC Subsystem into the S/C for integration checkout, spacecraft wiring will be verified utilizing a substitute test unit which is to be supplied by NR. This unit shall checkout all MC Subsystem interface wiring. Upon completion of this check, the MC Subsystem shall be installed in the spacecraft. Document No. 1231-DB-3 describes in detail the installation requirements for the MC Subsystem. MC BME will exercise and monitor the MC Subsystem to verify MC health after integration in the S/C. Upon completion of this check, ACE will exercise the MC Subsystem. MC Subsystem responses will be monitored by ACE T/M and MC BME.

After the SIM cover has been installed at the Kennedy facility, payload health will be verified at regular intervals. During these health checks, the MC Subsystem will be exercised by ACE and MC Subsystem responses will be monitored by ACE T/M.

Document No. 1231-DB-10 describes in detail the test requirements and S/C requirements required for support of the MC Subsystem test phases at the Kennedy facility.

3.1.6.3 Facility Requirements - Facility support requirements at Kennedy shall be provided by the spacecraft contractor prior to pre-installation checkout and integration testing of the MC Subsystem. The MC Subsystem will require approximately, TBD, square feet of area at the Kennedy facility for equipment and operating personnel.

3.2 MC BME - The following paragraphs briefly describe the requirements imposed upon the spacecraft and facilities to ensure proper support and maintenance of the MC Subsystem during the ground checkout test phases of the MC Subsystem at the Kennedy facility. Document No. 1231-DB-6 describes these requirements in greater detail.

3.2.1 Functional Test Set Console - One test set console and associated cables will be delivered directly to the KSC facility. The test set console is approximately 5' x 6' x 2.5' in size and weighs approximately 1,300 pounds. Input power requirements are 115V, 60 cps, 30 amperes.

3.2.2 Handling Fixture - Two test stands will be shipped directly to the Kennedy facility. The test stand is approximately 6' x 5' x 4' in size and weighs approximately 450 pounds.

3.3 Development Support Hardware - Several items of MC Subsystem related hardware will be designed and manufactured in support of the vehicle contractors SIM development testing program.

3.3.1 Interface Substitute Set - An interface substitute set will be furnished by the vehicle contractor for test purposes in the verification and checkout of the SIM installation. The test set will simulate MC Subsystem electrical interface characteristics to the extent necessary to accomplish test

objectives. The MC contractor will supply the vehicle contractor with all MC Subsystem electrical interface data necessary to design and construct the substitute test set.

3.3.2 Form, Fit and Function Model - One MC Subsystem prototype model will be furnished by the MC contractor for purposes of integration testing. This model shall be a complete EMI qualified acceptance tested subsystem with all interface characteristics representative of MC Subsystem flight hardware as specified in section 3.1 of this document.

3.3.3 Mass and Inertia Simulator - The MC contractor shall furnish the vehicle contractor with an MC Subsystem Mass and Inertia Simulator. The simulator shall be designed to approximate the weight and inertia characteristics of a typical MC Subsystem flight unit. The simulator shall include, wherever possible, structural components which conform exactly with respective elements of MC Subsystem flight hardware. The simulator shall be non-operative.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Quality Control - The MC contractor shall be responsible for the quality control provisions required to insure that the MC Subsystem meets the requirements established by the contract.

4.2 Integration Assurance Testing - In support of the integration systems testing, the MC Quality Control personnel, in joint effort with NASA, will witness the integration tests to insure proper operation of the MC Subsystem during integration procedures.

In preparation for operational use of the MC Subsystem, a logical evolution and demonstration of the interface compatibility with the associate contractors must be performed by NR and witnessed by MC personnel. This demonstration will be verified by using the SIM Interface Substitute Unit prior to initiating the integration tests. Integrated systems testing will demonstrate and validate the MC Subsystem readiness for flight testing.

4.3 Integration Compatibility Tests - Integration tests for the MC Subsystem shall be conducted for mechanical, electrical and optical compatibility. The testing will be under ambient conditions, conducted to verify the MC Subsystem compatibility with the associate contractors and the Apollo SIM. The following tests will be accomplished in conjunction with the SIM Ground Test Program.

Document No. 1231-DB-10 describes in more detail the interface test requirements for supporting the MC Subsystem during integration testing.

4.3.1 Mechanical Compatibility - Install MC Subsystem in Command Module (CM) and check for:

- 1) Mounting Fit and Structural Integrity
- 2) Envelope Conformance

4.3.2 Electrical Compatibility

- 1) Inter Cabling Check
- 2) Power Requirements
- 3) Signal Source Requirements
- 4) Operational Functions
- 5) EMI Interference from other Subsystems

4.3.3 Optical Compatibility

- 1) Optical Ray Path Clearance
- 2) Optical Alignment

The above subsystem integration test will be participated in and monitored by the MC contractor's Engineering and Quality personnel.

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1231-DB-3

INSTALLATION REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE

Revision A

9 March 1970

1.0 SCOPE - This document defines the installation requirements for integration of the MC Subsystem Flight Hardware in the Scientific Instrument Module (SIM). It identifies the interface areas, describes pertinent subsystem characteristics and defines equipment mounting requirements. In addition, information is presented representing MC contractor/NR agreements for assignment of responsibilities and performance of interface tasks. This document does not include those requirements relative to space allocations in the SIM which are described in Document No. 1231-DB-7.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-4	Electrical Power Requirements, MC Subsystem Flight Hardware
1231-DB-7	Payload Space Requirements, MC Subsystem Flight Hardware
1231-DB-8	Thermal Interface Requirements, MC Subsystem Flight Hardware
1231-DB-9	Instrumentation Interface Requirements, MC Subsystem Flight Hardware
1231-DB-10	Installed P/L Test Requirements, MC Subsystem Flight Hardware
1231-DB-12	Environmental Interface Requirements, MC Subsystem Flight Hardware
1231-DB-15	Telemetry Interface Requirements, MC Subsystem Flight Hardware

2.2 Contractor Drawings

1231L46

MC Payload Stowage Outline

3.0 REQUIREMENTS - The MC Subsystem will be installed initially in the SIM. On completion of photographic operation, the record container portion will be separated from the MC and transferred extravehicularly to the CM. The record container portion of the take-up cassette will be stowed in a locker in the CM for return to earth. Installation requirements for integration of the MC Subsystem in the SIM configuration are described herein and include those related to functional characteristics as well as those associated with mechanical, electrical, thermal or environmental characteristics.

3.1 Functional Requirements

3.1.1 Camera Attitude - During periods of active photography, the MC Subsystem shall be oriented so that the principal optical axis of the mapping lens is aligned parallel to the local vertical and the principal axis of the stellar lens lies in the plane formed by the orbital velocity vector and the local vertical. The orientation error referred to an orthogonal coordinate system formed by the vehicle orbital velocity vector and the local vertical shall not exceed 2° from local vertical.

3.1.2 Direction of Flight - During periods of active photography with the camera installed as specified herein, the S/C velocity vector must point in the vehicle $\pm X$ direction.

3.1.3 Mounting Plane - The parallelism error between the principal axes of the lenses and the camera mounting plane, as defined by the surfaces of the mounts at the mounting plane, as defined by the surfaces of the mounts at the mounting interface, shall not exceed 30 minutes of arc (2σ) in each of 3 axes.

3.1.4 Deployment - During all periods of active photography, the MC Subsystem shall be deployed out of the SIM and Sector I Bay in such a

manner that no portion of the CSM shall interfere with the stellar lens field-of-view. Deployment shall be along a line at 25° to the radial bisector of Sector I of the SM and shall be accomplished in a manner compatible with other functional requirements specified herein.

Deployment shall include all functional and operational requirements associated with moving the MC Subsystem from its stowed position in the SIM to an extended position external to the Sector Bay.

3.1.5 Lens Glare Shades - Glare shades surrounding both light bundles will be required for purposes of glare attenuation and/or thermal shielding.

3.1.6 Exhaust Plumes - Exhaust plumes from the Reaction Control System (RCS) engines must not interfere with photographic performance. Whenever the possibility of condensation of reaction products on camera lenses exists, either the engines shall not be operated or the SIM bay must be sealed off during engine operation. NR shall be responsible for SIM bay sealing.

3.2 Mechanical - Installation of the MC Subsystem will require, at some point in the SIM ground operations and checkout sequence, clear access to the interior forward end of the SIM. Access space shall be large enough to accommodate the entire MC plus handling and support equipment or devices. During actual insertion or removal operations, the SIM cover shall not be in place. A port or door shall be provided in the SIM cover for access to the camera for film loading and periodic test operations after the SIM cover has been installed.

3.2.1 Integration - Installation of the MC Subsystem in the SIM shall be performed at SIM integration site in accordance with Document No. 1231-DB-10. At this location the MC contractor shall be responsible for transporting the MC to the integrating area, and the vehicle contractor (NR) shall be responsible for actual MC insertion and electrical integration. All MC integration functions performed by the vehicle contractor shall be witnessed by the MC contractor.

3.2.1.1 Insertion - Insertion of the MC Subsystem will involve the attachment of a yoke/sling assembly to the MC; the use of an overhead crane for lifting the MC off its transport cart and placement on an Inserter; the use of the Inserter to move the MC into bolting position in the SIM; and the attachment of mounting bolts and electrical connectors. An inserter adapter will be required to accept and support the MC at the interface with the Inserter. The inserter, adapter, special slings, and hoisting crane shall be provided by the vehicle contractor (NR). Insertion of the MC will take place along a line parallel to the SIM center line at an elevation slightly forward of its installed position.

3.2.1.2 Thermal Insulation - Prior to and/or after mechanical integration, it may be necessary to install thermal insulation blankets around the MC Subsystem. Thermal insulation may be attached to the MC at certain selected locations to facilitate installation. The points of attachment and details of the fastening devices will be determined at a future date. Thermal insulation shall not interfere with MC cassette separation/deployment, or occlude any portion of the incoming light-ray bundles during photography. Other thermal interface requirements are given in Document No. 1231-DB-8.

3.2.1.3 Lens Glare Shades - The cartographic lens glare shade shall be an integral part of the MC Subsystem. It may include a thermal door or shutter for capping the lens in accordance with the overall thermal control plan. Sufficient clearance between the shade and the SIM cover must be provided to prevent damage to the shade during and after installation of the cover. The stellar lens glare shade will be part of the MC Subsystem. However, some connection from the shade to the camera deploying mechanism may be necessary, not only for additional support, but also for satisfying deployment requirements. Sufficient clearances must be provided in the SIM for installation access to the support point.

3.2.2 Removal - Removal of the MC Subsystem from the SIM for purposes of bench test operations, fault isolation or repairs shall involve a reversal of the installation procedures outlined herein. Contractor responsibility assignments for removal and disassembly functions shall be the same as those delineated for the respective installation functions.

3.2.3 Physical Characteristics - Information on those physical characteristics of the MC Subsystem which impact installation aspects of the SIM is presented in this section.

3.2.3.1 Configuration - Configuration details of the MC Subsystem are given in Figure 1. That portion of the MC Subsystem which will be stowed in the CM for record protection and earth-recovery purposes is depicted in Drawing No. 1231L46.

3.2.3.2 Weight and CG Data (with out thermal insulation and heaters)

- MC Subsystem with full film load 156 pounds
- Record Container (stowable portion of MC with full film load) 24 pounds

Approximate CG locations are given in the respective configuration drawings specified herein.

3.2.4 Mounting Provisions

3.2.4.1 MC Subsystem - The MC Subsystem will be hard mounted to the SIM shelf at station X_s 299.50 via a deployable structure. Three points of attachment are provided at the aft end of the MCS for mounting purposes. It will be necessary to have three mating points of attachment, located correspondingly, on the SIM shelf. At the interface, the attachment points on the shelf shall consist of three pads, the surfaces of which are coplaner at station X_s 299.50 and which are machined to accept the MC mounting bolts. Bolt size, attachment point locations, and other mounting details shall be subject to interface agreements. The points of attachment shall be strong enough to support the MC during all phases of the mission in a manner consistent with camera/vehicle alignment requirements specified herein.

3.2.4.2 Record Container - The loaded record container shall be stowed in the CM after extravehicular transferral from the SIM. It shall be placed in an opaque plastic sheath for protection against ambient illumination, humidities in excess of 50% RH and contamination by sea water. The encased container shall then be secured inside the stowage locker. A support inside the locker shall be provided with a shock attenuator, suitably contoured to accept the record container, and a clamping device shall be fitted with a screw-type mechanism to load the record spools against the bottom of the container. The screw clamp shall act axially against the container center-spindle and shall be torque limited to prevent excessive loading. The stowage arrangement shall meet the environmental requirements of Document No. 1231-DB-12.

3.2.4.3 Glare Shades - The cartographic lens shade will be mounted directly to the camera. The stellar lens shade will be a light-weight sheet-metal and/or fabric assembly that will be deployed out of the SIM along with the camera prior to photographic operation. It is anticipated that one end of the shade will be fastened to the camera, and the other end supported by the deploying mechanism structure. The location of the mounting points and other mounting details are shown on Figure 1.

3.3 Electrical

3.3.1 Power Requirements - Electrical power requirements are given in Document No. 1231-DB-4.

3.3.2 Instrumentation - Instrumentation interface requirements are given in Document No. 1231-DB-9.

3.3.3 Telemetry - Telemetry interface requirements are given in Document No. 1231-DB-15.

3.3.4 Electrical Connectors - The MC Subsystem has three bulk-head-mounting type electrical connectors located on the forward end. These connectors are required for mission operation. A fourth connector is located

facing radially outward near the skin line. It is used for ground test purposes only and will be capped prior to mission. A fifth connector is mounted to the deployment frame near the inboard SIM bulkhead. It is used for powering the deployment device. It will be necessary for combined-systems interconnection cabling to be harnessed with appropriate breakouts for MC electrical connection. The breakouts shall terminate with pendant connectors that will mate with MC Subsystem receptacles. It shall be the responsibility of the vehicle integrator to design the pendant cable interconnections with three operational connectors so as to accommodate the MC Subsystem deployment requirement.

3.4 Thermal - Thermal partitions, insulation blankets, heaters, or other devices for thermal control in the MC compartment of the SIM shall not interfere with installation and/or operation of the MC by limiting accessibility or by imposing stress loads of significant magnitude.

3.5 Environmental - Environmental requirements for installation of the MC Subsystem in the SIM are given in Document No. 1231-DB-12.

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1231-DB-4

ELECTRICAL
POWER REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE

Revision A

28 March 1970

1.0 SCOPE - This document describes the requirements imposed upon the spacecraft power supply by the MC Sub system.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-9	MC Ground Test Interface Requirements MC Subsystem Flight Hardware
1231-DB-13	Auxiliary Data Recording Requirements MC Subsystem Flight Hardware
1231-DB-14	Control Interface Requirements MC Subsystem Flight Hardware
1231-DB-15	Telemetry Interface Requirements MC Subsystem Flight Hardware
1231-DR-2	EMI Interface Requirements MC Subsystem Flight Hardware

2.2 Contractor Drawings

1231L18	CSM/MC Wiring Interface
1231L200	MC - SC Interface Control Drawing

3.0 REQUIREMENTS

3.1 Spacecraft Power Supply - The MC Subsystem shall be designed to operate on electrical power supplied by the spacecraft fuel cells. The characteristics of the spacecraft power supplies are as follows:

3.1.1 DC Power Characteristics (at MC Interface)

Steady-State Voltage Limits	25 to 30 volts
Transient Voltage Limits	21 to 32 volts, recovering in 1.0 second
Ripple Voltage (peak to peak)	1.0 volt p/p

3.2 MC Subsystem Power

3.2.1 DC Power (less Thermal Control Heaters) - The average DC power required by the MC will not exceed 100 watts. The maximum peak DC power will not exceed 300 watts. Standby power will not exceed 10 watts. Standby power will be required whenever the system requires active thermal control produced by internal heaters.

3.2.2 DC Thermal Control Power

TO BE DETERMINED

3.2.3 Film Cut Power - An electro-mechanical film cutter must be operated prior to EVA cassette recovery. 28V DC power at 10A will be required for a maximum of 200 milliseconds.

3.2.4 Power During Engine Firing - DC power to the supply spools will be required during perioding of engine firing. Power will not exceed 10W(DC).

3.3 Wiring Interface

3.3.1 MC Subsystem Power Connector - The MC will be equipped with a connector (J1 on Drawing No. 1231L200) which will accept the power connector from the SM wiring harness. The power connector type and pin connections will be determined by MC/vehicle integrator mutual agreement.

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1231-DB-6

BME INTERFACE REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE

Revision A

28 March 1970

1.0 SCOPE - This document describes the Bench Maintenance Equipment (BME) that is required for MC Subsystem operation to ensure proper performance of the MC Subsystem.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-10

Installed Payload
Test Requirements
MC Subsystem Flight Hardware

SD 69-315

Interface Specification
Block II
CSM (ALEM)

2.2 Contractor Drawings

1231L50

MC Test Console Outline

1231L51

MC Calibration Fixture Outline

1231L52

MC Test Stand Outline

1231L201

MC Portable Test Set Outline

3.0 REQUIREMENTS

3.1 General - The MC-BME will be used for MC contractor in-plant acceptance, reliability, and qualification testing of the MC Subsystem. In addition, the MC-BME will be utilized at out-of-plant facilities for confidence testing, integration checkout, and fault isolation tests of the MC Subsystem. This document describes the MC-BME that is required to support these tests and defines the quantities required at the in-plant and out-of-plant facilities. The MC-BME will be comprised of the following equipment.

- 1) Functional Test Set Console
- 2) Portable Test Set
- 3) Calibrated Light Source
- 4) Resolution and Calibration Fixture
- 5) Camera Test Stand
- 6) Interconnecting Cables

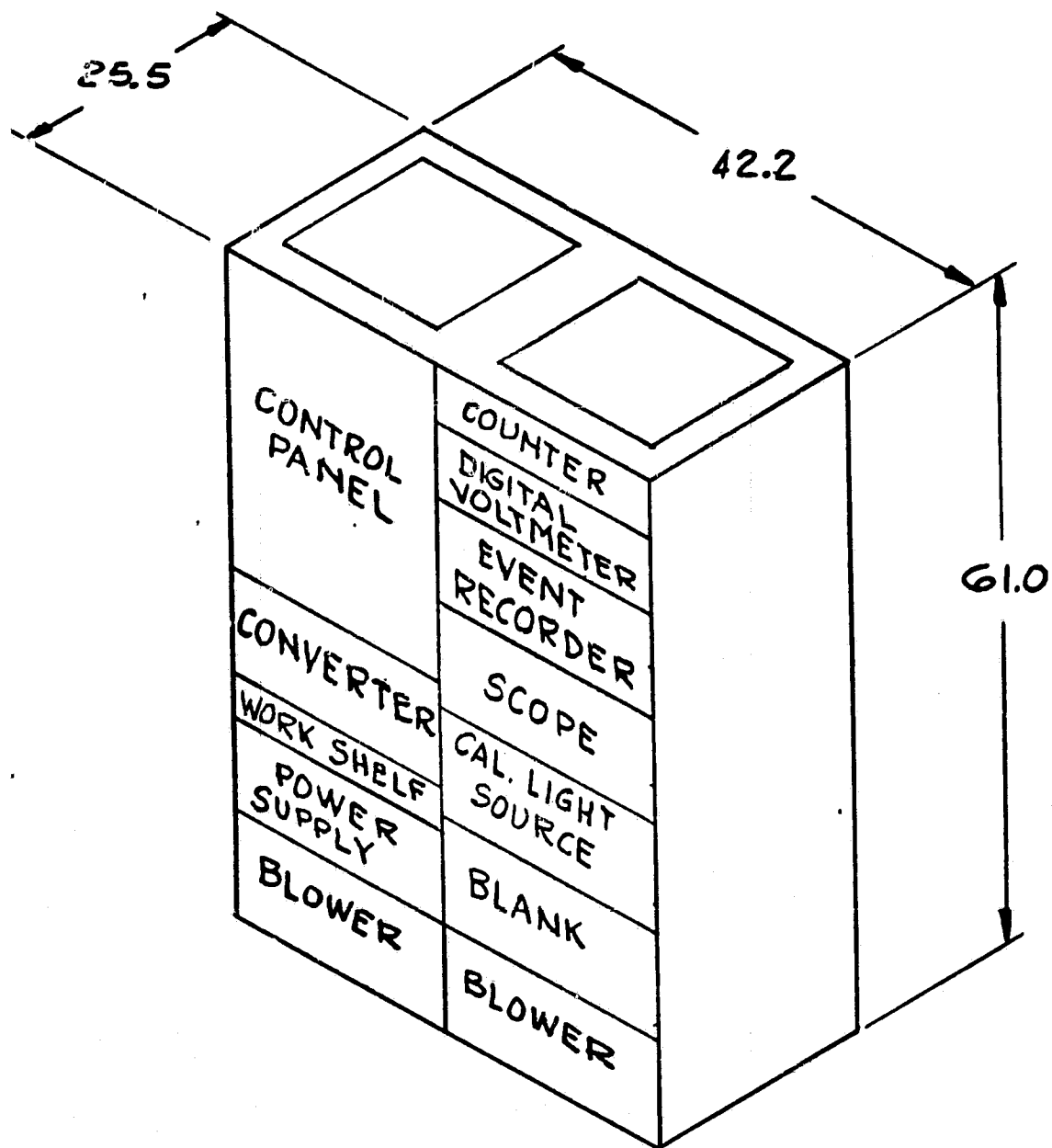
3.2 BME Description

3.2.1 Functional Test Set Console - Drawing No. 1231L50 is the outline drawing of the functional test set console. The console will be mounted on swivel casters for mobility of transport and will consist of a group of rack mounted test equipment approximately 5' high x 6' long x 2.5' deep, weighing approximately 1,200 pounds. The unit will be self-contained, requiring only 115V, 60 cps, 30 ampere power. The test set will have the capability of electrically aligning, operating, and testing the MC Subsystem and will contain MC Subsystem power and command simulators, and the necessary circuitry and recording devices to evaluate the instrumentation signals generated by the MC Subsystem.

The functional test set console will be used for MC contractor in-plant testing of the MC Subsystem and for out-of-plant confidence testing, integration check-out, and fault isolation tests. Visual indication as well as recorded data will be available for analysis of the MC Subsystem performance during these tests.

The functional test set will be comprised of the following equipment:

- 1) Counter
- 2) Digital Voltmeter



MC TEST CONSOLE OUTLINE

- 3) Recorder
- 4) Oscilloscope
- 5) Power Supply
- 6) Calibrated Light Source
- 7) Functional Test Set Control Panel

The counter is a universal electronic counter capable of measuring time interval, frequency, period, multiple period average, ratio, and multiple ratio. The maximum counter rate of the instrument is 2 megacycles. Resolution of the instrument is six (6) digits with a reading accuracy of ± 1 count.

The digital voltmeter is a four (4) digit electronic instrument capable of measuring AC and DC voltages. The accuracy of DC measurement is $\pm 0.05\%$ of reading ± 1 digit while the accuracy of AC measurement is $\pm 0.1\%$ of reading.

The recorder is a 30 channel event recorder with the capability of monitoring the ON/OFF status of multiple events simultaneously. The time resolution of the instrument is 1 millisecond. The recording system accuracy is $\pm 1\%$.

The oscilloscope bandwidth is DC to 300KC and its sensitivity is 5mv/division to 10 volts/division. The sweep rate range is from 50 nanoseconds/division to 2 seconds/division, calibrated to an accuracy better than 3%.

The power supply is a continuously adjustable DC supply over the range from 0 volt to 36 volts. Maximum current capability is 25 amperes. Load and line regulation is 0.1%.

The functional test set control panel will contain the simulators that generate the specific commands and power to the MC Subsystem which are normally supplied by associated external subassemblies during operation. Lamp indicators will be employed in the control panel to provide visual indication of command

and response functions which can best be displayed in this manner. Self-checking test points and their associated circuitry will be provided in the control panel to permit evaluation of functional test set performance. The major units comprising the control panel will be:

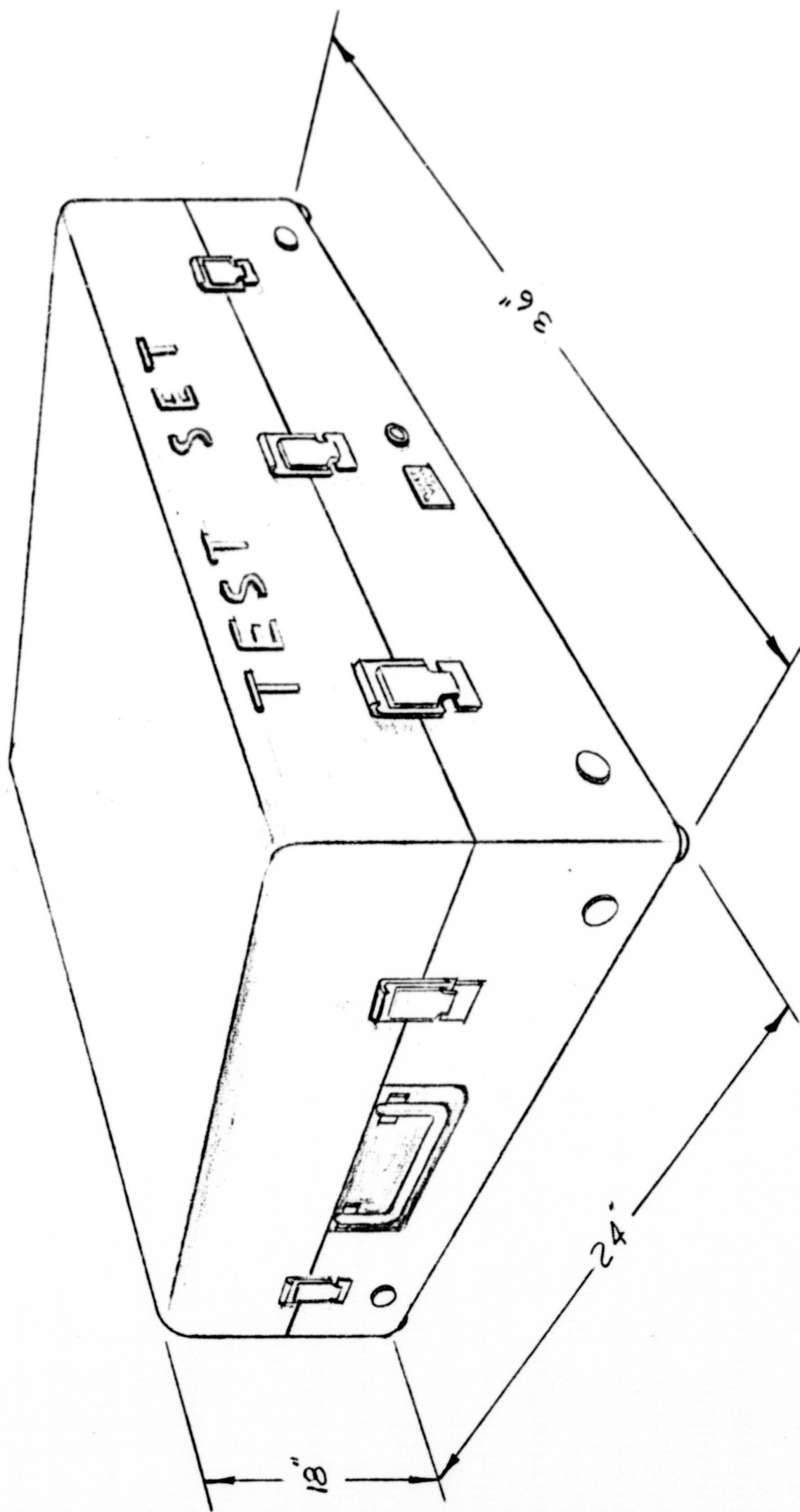
- 1) V/H Simulator
- 2) Command Simulator
- 3) ADR Simulator
- 4) Power Simulator
- 5) Command and Response Indicators

3.2.1.1 Functional Test Set Console Environmental Design - The functional test set console shall be designed to withstand ground environment extremes using the natural and induced environmental criteria defined in SD 69-315 as a guide.

3.2.2 Portable Test Set (PTS) - Drawing No. 1231L201 is the outline drawing for the PTS. The PTS is self-contained in a transit case no larger than 18" x 24" x 36", will weigh no more than 60 pounds, and will require 115V, 400 cps, 3 phase, 10 ampere power. The PTS will have the capability of operating the MC Subsystem via the test connector only. It will exercise the MC Subsystem with fixed, defined combinations of inputs and evaluate MC responses as "go-no-go" indications.

The PTS will be used at the launch site for normal operation of the MC in connection with film loading and for periodic "go-no-go" testing after the MC Subsystem is integrated into the SIM.

3.2.2.1 PTS Environmental Design - The PTS shall be designed to withstand ground environment extremes using the natural and induced environmental criteria defined in SD 69-315 as a guide.



PORTABLE TEST SET
1231 L201

3.2.3 Calibrated Light Source - The calibrated light source is a light generator which will simulate several scene brightness conditions by emitting light of spectral quality approximately that of sunlight. The light source will be used to excite the automatic exposure control circuitry in the MC Subsystem. The light source will be designed as a portable unit with the capability of being mounted in the functional test set console.

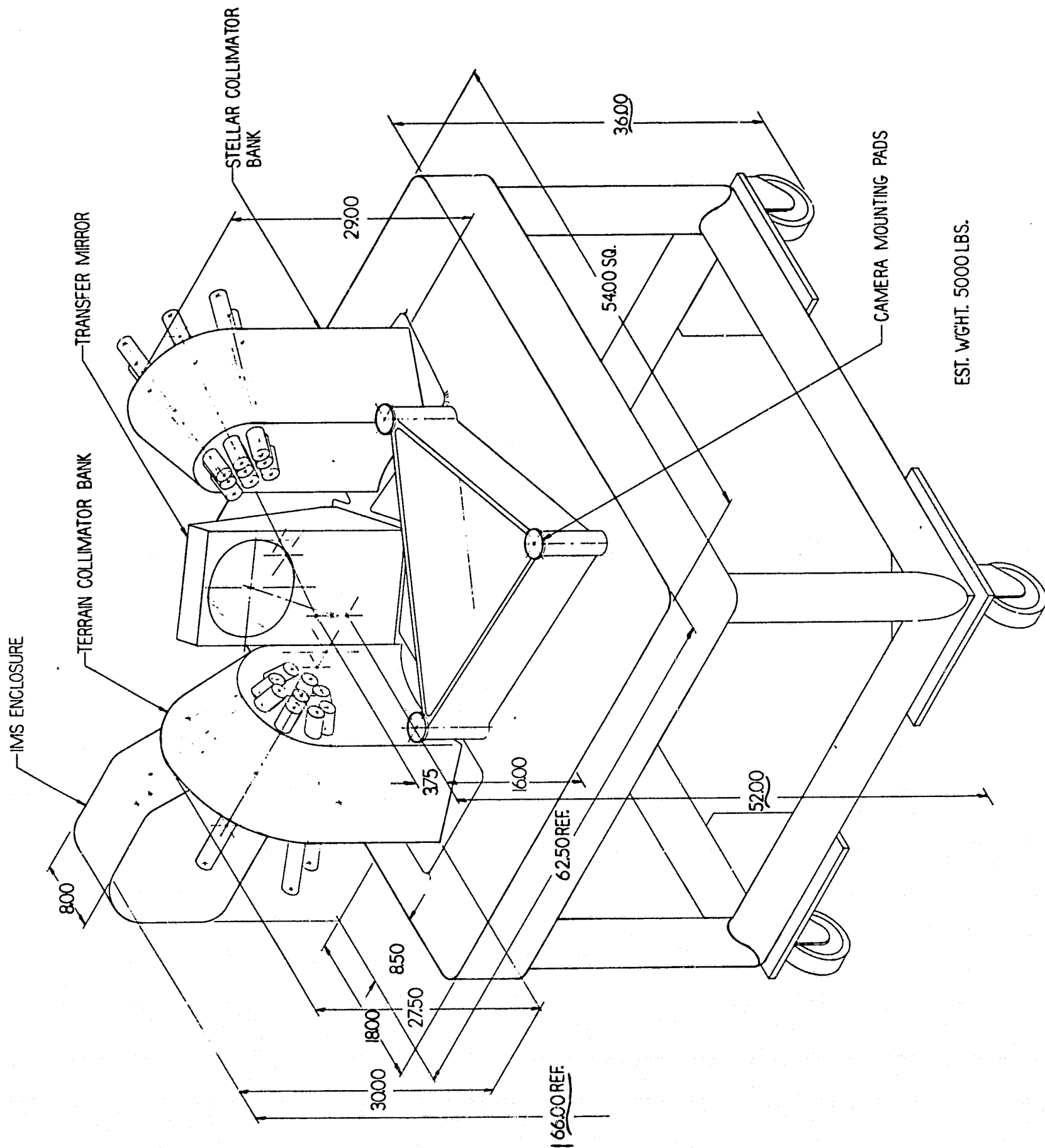
3.2.4 Resolution and Calibration Fixture - The resolution and calibration fixture will be used for photographic testing and for optical calibration of the relative orientation of the combined MC Subsystem. The fixture will contain an array of collimators mounted in a sturdy frame in a manner suitable for such testing. The collimators will have provision for the inclusion of resolution targets to permit photographic checking of the static and dynamic resolution of the camera. The resolution and calibration fixture will be used in MC contractor in-plant testing of the MC Subsystem.

Drawing No. 1231L51 specifies the weight and size requirements of the resolution and calibration fixture.

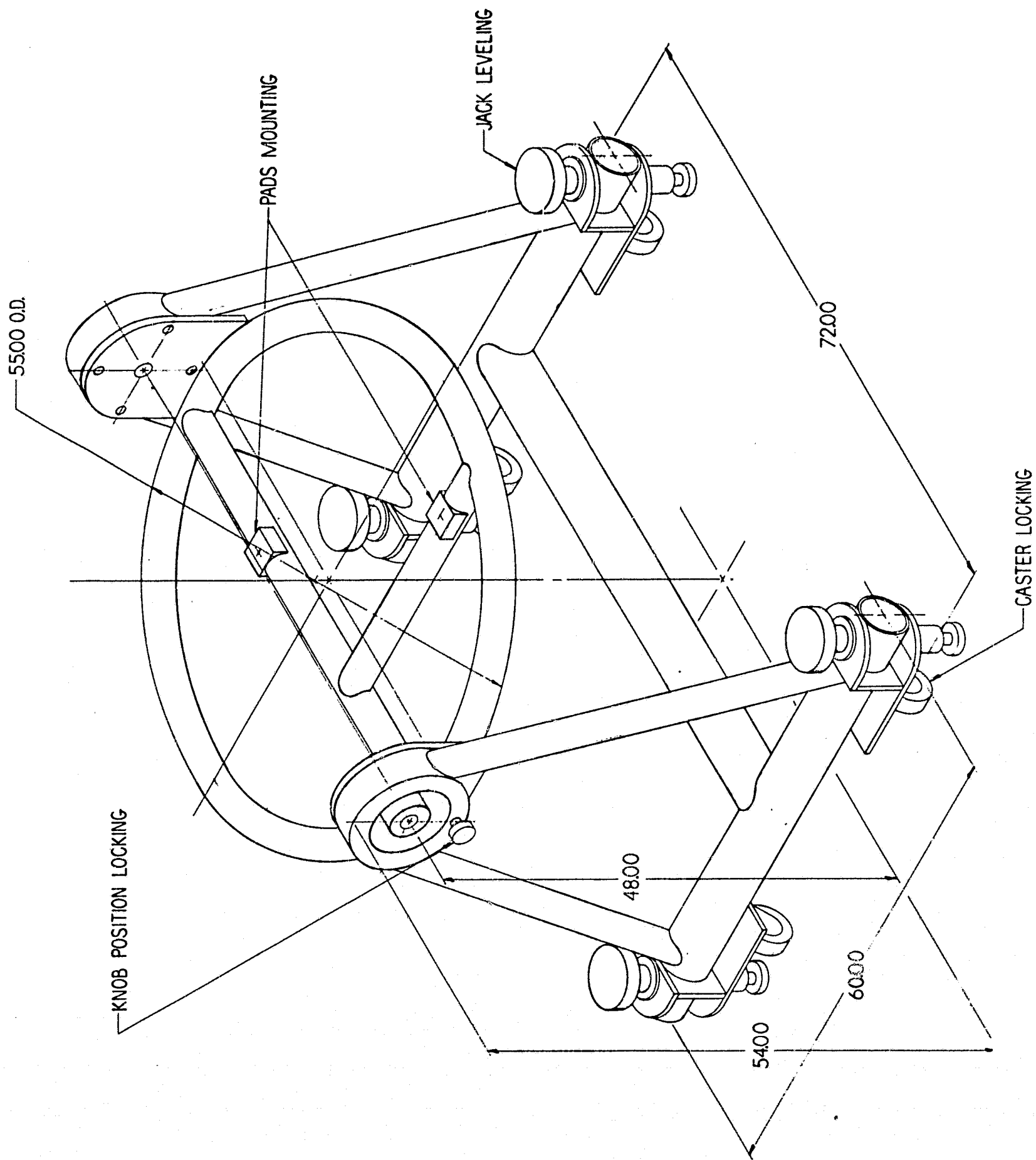
Operation of the resolution and calibration fixture requires 115V, 60 cps, 20 ampere power.

3.2.5 Camera Test Stand - The camera test stand is a fixture that simulates the arrangement of the MC Subsystem in the spacecraft. The test stand will mount on swivel casters for ease of transport. The MC Subsystem will be mounted on the fixture for handling and testing. The test stand will be used in MC contractor acceptance, reliability, and qualification testing of the MC Subsystem. The test stand will be approximately 6' x 5' x 4' and will weigh approximately 450 pounds. Drawing No. 1231L52 depicts the MC Subsystem test stand.

3.2.6 Interconnecting Cables - Test cables will be supplied by the MC Subsystem contractor and will be used to perform confidence, integration, and fault isolation tests on the MC Subsystem. Two sets of cables will be provided. One cable set, approximately 70' in length, will be used during confidence and integration checkout procedures.



EST. W'GHT. 5000 LBS.



3.2.7 Quantity and Location of BME

3.2.7.1 Quantity of BME - The quantities of BME required are as follows:

<u>BME TYPE</u>	<u>QUANTITY</u>
Functional Test Set	3
Portable Test Set	2
Calibrated Light Source	1
Resolution and Calibration Test Fixture	1
Test Cables	3 sets of 30' cables 2 sets of 70' cables
Test Stands	5

3.2.7.2 Location of BME

- 1) The following BME will be located at the MC contractor facility:

<u>BME TYPE</u>	<u>QUANTITY</u>
Functional Test Set	1
Calibrated Light Source	1
Resolution and Calibration Test Fixture	1
Test Stands	2
Cables	2 sets of 30' cables

- 2) The following BME will be located at remote stellar calibration facilities as required:

<u>BME TYPE</u>	<u>QUANTITY</u>
Portable Test Set	1
Test Stand	1
Cables	1 set of 70' cables

- 3) The following BME will be located at the KSC facility:

<u>BME TYPE</u>	<u>QUANTITY</u>
Functional Test Set	1
Portable Test Set	1
Test Stands	2
Cables	1 set of 30' cables 1 set of 70' cables

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300 Robbins Lane, Syosset, New York

1231-DB-7

P/L SPACE REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE
Revision A

9 March 1970

1.0 SCOPE - This document defines the space allocations necessary for integration of the MC Subsystem hardware in the Scientific Instrument Module (SIM). It includes space requirements for subsystem storage, assembly and test, for integration in the SIM, and for data retrieval and post-flight operations. It does not include space allowances for MC Subsystem installation which are covered in Document No. 1231-DB-3.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-3

Installation Requirements,
MC Subsystem Flight Hardware

2.2 Contractor Drawings

1231L9

MC - SC Space Allocation

1231L46

MC Payload Stowage
Outline

3.0 REQUIREMENTS

3.1 General - Integration of the MC Subsystem hardware in the SIM will require certain space allocations in the SIM and Command Module. In addition, it will be necessary to provide sufficient space for the MC Subsystem hardware in storage, checkout and test areas for use during SIM ground operations, as well as space for the recovered record container during all pertinent post-flight activities.

3.2 Physical Characteristics - In order to allocate sufficient space, information covering subsystem size and configuration is presented in the following subparagraphs.

3.2.1 Size - The complete MC Subsystem including detachable record container but without lens glare shades is approximately 24" high x 36" wide x 17" long. The dimensions given refer to distances measured along coordinate axes corresponding to the S/C Z, Y, and X axes respectively, when referred to the flight attitude of the MC Subsystem.

3.2.2 Configuration - The outline configuration of the MC Subsystem is largely a result of fitting the equipment into a preselected location in the SIM without interfering with basic SIM structure or other equipments located in the same sector bay. Equipment outline details are shown on Figure 1. The dimensions given therein, wherever applicable, represent actual hardware limits and do not include insulation blankets, insulation attachment fasteners, or other related items which may be required for thermal control purposes.

3.3 Space Allocation in SIM - It will be necessary to provide sufficient space in the SIM for installation and operation of the MC Subsystem. The location of the space allocation shall be compatible with operational and mission requirements of the MC. The amount of space and the configuration of the space envelope shall be in accordance with the requirements specified herein.

3.3.1 Location - The space envelope or compartment shall be located in the SIM between stations X_s 299.5 and X_s 318.5. It shall include the internal area of the SIM between the specified stations, as noted in Figure 1.

3.3.2 Size - The space envelope shall be large enough to prevent physical interference between the MC and other equipment or structures. It shall be configured so that the MC Subsystem can be installed and properly oriented relative to the spacecraft coordinate axes. The compartment shall be large enough to allow for thermal partitioning, electrical connector mating, and installation access. Installation requirements are given in Document No. 1231-DB-3, and compartment configuration requirements shall be in agreement with Drawing No. 1231L9.

3.3.3 MC Integration within SIM

3.3.3.1 Mechanical Integration - During insertion of the MC Subsystem into the SIM, it may be necessary for the inserting device to project or extend into the MC compartment. Furthermore, it will be necessary for installing personnel to make use of certain regions of the MC compartment for access to mounting fasteners and electrical connectors. Installation requirements are given in Document No. 1231-DB-3.

3.3.3.2 Electrical Integration - It will be necessary to allocate certain regions within the MC compartment for deployable electrical interconnection cabling including those pendant connectors which mate the MC connectors. Combined systems cable runs and harnessing breakouts within the MC compartment shall be positioned so as to occupy a minimum amount of space and shall not interfere with installation, checkout, and/or operation of the MC Subsystem.

3.3.3.3 Thermal Integration - It may be necessary to allocate certain regions within the MC compartment for the installation of insulation blankets, insulation fasteners, and related items for thermal control purposes. The blankets and the fastening means shall be designed to occupy a minimum amount of space and shall not interfere with installation, checkout, and/or operation of the MC Subsystem.

3.4 Space Allocation in CM - It will be necessary to provide sufficient space in the CM for stowage of the MC record container after transfer from the SM.

3.4.1 Stowage Requirements

3.4.1.1 Location - The space allotted for stowage of the MC record container shall be established by the S/C contractor.

3.4.1.2 Size and Configuration - The amount of space required shall be sufficient to stow the MC record container in the attitude specified in Document No. 1231-DB-3. It shall be large enough to prevent physical

interference between the record container and other equipment. It shall include space for clamps, straps, and other items used for securing the record container to CM structure. In addition, it shall be large enough to permit clear access for removal during post landing operations. Dimensional characteristics of the record container without the sealing sheath are given in Drawing No. 1231L46.

3.5 Space Allocations for Post-Flight Operations - Space allocations for handling the record container during post-flight activities shall be consistent with the dimensional characteristics given in Drawing No. 1231L46.

3.6 Space Allocations in Assembly and Test Areas - In assembly and test areas, space allocations for handling the MC Subsystem hardware shall be in accordance with the facilities requirements specified in Interface Control Documents.

3.7 Space Allocations for Storage and Transport - In storage and during transport, all MC Subsystem hardware will be installed in metal carrying cases. It is anticipated that the maximum case size will be approximately 24"(H) x 34"(W) x 48"(L).

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1231-DB-8

THERMAL INTERFACE REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE
Revision A

10 March 1970

1.0 SCOPE - This document defines the thermal requirements necessary for satisfactory performance of the MC in the Scientific Instrument Module (SIM). In addition, temperatures at which exposed film must be maintained during retrieval and stowage are specified. It defines areas of responsibility for the vehicle and MC - S/C contractors in the development and implementation of the thermal control plan.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-9	Instrumentation Interface Requirements, MC Subsystem Flight Hardware
1231-DB-12	Environmental Interface Requirements, MC Subsystem Flight Hardware
1231-DB-15	Telemetry Interface Requirements, MC Subsystem Flight Hardware

3.0 REQUIREMENTS - The MC Subsystem shall be maintained at the temperatures specified herein.

3.1 Operating Temperatures - During MC Subsystem operation, major components shall be maintained within the temperature range indicated:

- Lenses, Platen, Shutter Mechanisms,
Drive Mechanisms, Film 60°F to 80°F
- Motor Housings 60°F to 200°F
- Electromechanical Clutch-Brake Housing 60°F to 150°F
- Photocells 15°F to 160°F
- Electronic Subassemblies 40°F to 150°F

Electronic subassembly temperatures shall be measured at the chassis or surfaces to which the electronic components are mounted. The MC contractor shall use good design practice to provide adequate thermal paths from heat sources to chassis or mounting surfaces to insure that components do not exceed rated operating temperatures. Verification of the electronic subassembly thermal design shall be made during the In-House Test Program described in paragraph 5.1 of this document.

3.2 Non-Operating Temperatures - The non-operating temperature of the MC Subsystem shall be maintained in accordance with Document No. 1231-DB-12 except that photocells may vary between -65°F to 250°F.

3.3 Exposed Film Temperature - During the mission interval extending from separation from the camera to post landing phases, the film record temperatures shall be maintained in accordance with paragraph 3.2.10 of Document No. 1231-DB-12.

4.0 CONTRACTOR RESPONSIBILITIES - The vehicle contractor shall provide the MC Subsystem contractor with the mission thermal environment profile. This information shall be supplied in two (2) parts.

The first part shall include the SIM compartment wall temperatures as a function of time from launch to and including lunar orbit insertion.

The second part shall define the thermal environment corresponding to the entire period in lunar orbit. This information shall include the total radiant thermal flux, consisting of solar, lunar and lunar albedo, which falls on the external surface areas of the MC. Sink temperatures including, but not limited to, the SIM itself and deep space shall also be defined. All the data in the second part shall be generated for five (5) distinct sun line to lunar orbit plane angles, namely, 0° , 5° , 10° , 20° , and 45° .

The MC Subsystem contractor shall employ the above information to develop and implement a thermal control system. This system shall be capable of maintaining the non-operating and operating temperatures of paragraphs 3.2 and 3.1 respectively.

The thermal control system designed by the MC Subsystem contractor shall employ no active elements with the exception of lens thermal doors, baffles to mask and unmask radiating panels along with their associated thermal-electrical control systems, and heaters and their corresponding thermostatic elements.

4.1 MC Thermal Analysis - The MC Subsystem contractor shall construct an analytical thermal nodal network to be used by the MC Subsystem contractor as a thermal design aid for the development of the MC. The network shall contain a sufficient number of nodal points to depict the thermal behavior of the temperature sensitive elements defined in paragraph 3.1 of this document. Further, the nodal network shall include all inter-nodal thermal coupling modes (conduction and radiation), thermal inertia of nodal points (capacitance), heat dissipation within the MC, and the external thermal fluxes defined in paragraph 4.0.

4.1.1 Interface Thermal Analysis - A thermal nodal network shall be configured by the MC Subsystem contractor to represent the thermal behavior of the MC when integrated into the SIM. This model will be restricted to a maximum number of nodal points defined by the vehicle contractor. As in the MC Thermal Analysis (paragraph 4.1), this model shall contain the thermal coupling modes internal to the MC, the thermal inertia of nodal points, and the heat dissipation internal to MC. The MC Subsystem contractor shall supplement the above information with data describing the emissivities and areas of the MC surfaces which couple the MC to the ambient and the SIM.

The vehicle contractor shall incorporate the nodal network of the MC into the overall thermal model of the SIM. The vehicle contractor, upon completion of transient thermal analysis, shall deliver to the MC Subsystem contractor the time temperature history produced by the vehicle contractor's computer program for those nodal points supplied by the MC Subsystem contractor.

5.0 MC SUBSYSTEM TESTING - The MC Subsystem shall be tested by the MC Subsystem contractor under simulated space thermal-vacuum environmental conditions to evaluate thermal control system performance.

5.1 In-House Testing - The MC Subsystem contractor shall subject an operating prototype camera to a series of thermal design checks under an approximately simulated thermal-vacuum mission environment. The thermal environment shall be simulated by controlled heating devices or sinks which shall maintain the camera surfaces at the temperatures derived from the updated thermal analysis described in paragraph 4.1.1 of this document. Test results shall be used to evaluate the MC Subsystem thermal design and shall serve as a basis for thermal design modifications as may be required.

6.0 FLIGHT THERMAL SENSORS - Four (4) temperature sensors, as described in Document No. 1231-DB-15, shall be located within the MC Subsystem. Installation and location of these sensors shall be the responsibility of the MC contractor.

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1231-DB-9

MC GROUND TEST
INTERFACE REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE
Revision A

28 March 1970

1.0 SCOPE - This document defines the ground test interface requirements of the MC Subsystem.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-4	Electrical Power Requirements MC Subsystem Flight Hardware
1231-DB-13	Auxiliary Data Recording Requirements MC Subsystem Flight Hardware
1231-DB-14	Control Interface Requirements MC Subsystem Flight Hardware
1231-DB-15	Telemetry Interface Requirements MC Subsystem Flight Hardware
1231-DR-2	EMI Interface Requirements MC Subsystem Flight Hardware

2.2 Contractor Drawings

1231L18	CSM/MC Wiring Interface
1231L200	MC - SC Interface Control Drawing

3.0 REQUIREMENTS

3.1 General - The MC Subsystem will be instrumented to generate all the necessary signals which will be used to indicate MC performance.

The instrumentation will also provide acceptance checkout responses for analyzing operation of the MC mechanisms and components.

The instrumentation will be so arranged that diagnostic analyses of isolated faults or failures can be traced to malfunctions within the MC Subsystem during integration with the spacecraft.

3.2 MC Checkout - The instrumentation and response information will be in the form of electrical signals which will consist of pulse trains and changes in voltage levels. These signals will be fed through a separate test connector J4 (Drawing Reference: 1231L200), which is located on the body of the MC Subsystem.

This connector will provide a compatible means to support the MC Subsystem during pre-flight preparation and spacecraft interface verification by use of the MC BME (refer to Document No. 1231-DB-6).

3.3 Test Connector - One receptacle shall be provided for electrical connections to all input and output signals for the instrumentation requirements. The connector will be miniature, quick disconnect, high temperature type with the environmentally sealed removable crimp type contacts. The connector type and pin connections will be determined by MC/vehicle integrator mutual agreement.

3.4 Signal Characteristics - The instrumentation signals will be in the form of pulse trains and changes in voltage levels. The description of the input and output signals, and the final form for these signals and possible additional signals will be determined concurrent with the MC design and interface determination. It shall not be possible to apply MC operating power via the test connector.

3.5 Prelaunch Checkout (ACE) - At T minus (TBD) days the MC Subsystem will be integrated into the SIM and the SIM cover will be secured. Between T minus (TBD) and T minus (TBD), (TBD) pre-flight operational

tests will be accomplished which will involve the complete checkout of the MC Subsystem.

The MC Subsystem will be tested to meet the above requirements by a joint test team utilizing the G&N ACE console. The MC Subsystem will time share the G&N ACE console for all ground checkout operations. The MC checkout measurements will be transmitted to the G&N ACE console via the MC telemetry data link. All control stimuli required for checkout will come from the CM experiments control panel.

If a malfunction occurs, which requires further isolation than provided by ACE, the MC Functional Test Set (BME) will be brought to the test station and appropriate tests performed from the test connector (J4). Interconnecting cabling between the test connector (J4) and the Functional Test Set shall be provided by NR. MC power shall be applied via the normal SM busses during these tests.

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1231-DB-10

INSTALLED PAYLOAD
TEST REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE
Revision A

28 March 1970

1.0 SCOPE - This document describes the installed payload (P/L) test requirements imposed upon the spacecraft (S/C) and facilities to ensure proper performance of the MC Subsystem.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-3	Installation Requirements MC Subsystem Flight Hardware
1231-DB-6	BME Interface Requirements MC Subsystem Flight Hardware
1231-DB-12	Environmental Interface Requirements MC Subsystem Flight Hardware
1231-DB-13	Auxiliary Data Recording Requirements MC Subsystem Flight Hardware
1231-DB-14	Control Interface Requirements MC Subsystem Flight Hardware
1231-DB-15	Telemetry Interface Requirements MC Subsystem Flight Hardware

2.2 Standards

Federal Std. 209	Clean Room and Work Station Requirements, Controlled Environment
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2.3 Reference Documents - The following non-government contractor documents are not part of this specification. They are listed as a guide only in performing the requirements of this specification.

Contractor Specifications

1231-EB-8	Receiving Inspection and Test Specification (Downey Facility)
1231-EB-9	Receiving Inspection and Test Specification
1231-EB-10	Receiving Inspection and Test Specification (Florida Facility)
1231-DO-6	Stellar Calibration Procedure

3.0 REQUIREMENTS

3.1 General - Acceptance testing of the MC Subsystems will be performed at the MC contractor facility. Accepted subsystems will be shipped to the Downey facility. This document defines the MC Subsystem operations flow and defines the ground rules, criteria, and requirements for use of the MC Bench Maintenance Equipment (BME) and Acceptance Check-out Equipment (ACE) that are required to support the MC Subsystem operations flow.

3.2.1 Equipment, Size and Weight - The approximate sizes and weights of the MC Subsystem and associated Bench Maintenance Equipment (BME) are as follows:

		<u>SIZE</u>	<u>WEIGHT</u>
1)	MC Subsystem and Shipping Container	2' x 3' x 4'	200 pounds
2)	Test Stand	6' x 5' x 4'	450 pounds
3)	Test Console	6' x 5' x 2.5'	1,200 pounds
4)	Test Cables	3' x 3' x 3'	150 pounds
5)	Portable Test Set	2' x 3' x 1-1/2'	60 pounds

3.2.2 Receiving and MC Test - The MC will be uncrated in the receiving area and visually inspected for any damage sustained during shipping and handling operations. Following receipt in bonded storage, it will be requisitioned for MC Subsystem personnel controlled functional test. The MC Subsystem will be unpacked and mounted in the test stand.

The MC will then be subjected to electrical and mechanical baseline tests using the Receiving and Test Specification No. 1231-EB-8 as a guide. After completion of these tests, the subsystem will be inspected and inserted in a plastic bag. Elapsed time for MC Subsystem test is estimated at 3 working days. This time estimated is based on 2 eight-hour shifts per day. A film processing facility or service will be required.

A detailed description of the Bench Maintenance Equipment (BME) is given in the BME Interface Requirements Document No. 1231-DB-6.

3.2.3 Scientific Instrument Module (SIM) Integration

3.2.3.1 SIM Wiring - Before the installation of the MC Subsystem in the SIM, North American Rockwell (NR) will checkout all SIM/MC Subsystem interface wiring with an interface substitute test set (supplied by NR). These tests will be witnessed by MC Subsystem engineering personnel.

3.2.3.2 MC Subsystem Mechanical Integration - The MC Subsystem enclosed in a plastic bag and mounted on a transportation dolly (supplied by MC contractor) will be transported to the SIM/MC integration area by MC Subsystem personnel. The subsystem will then be installed in the SIM by NR personnel in accordance with Installation Requirements Document No. 1231-DB-3. The installation of the subsystem will be accomplished under Class 100,000 or better clean room conditions as defined in Federal Standard 209. Installation will be witnessed by MC Subsystem personnel. The subsystem will be checked for mechanical compatibility with the Service Module (SM) by NR personnel.

3.2.4 CSM/SIM/MC Electrical Integration

3.2.4.1 CSM Integration Tests - The MC Subsystem will be exercised from the CM experiments control panel. The PCM telemetry data will be monitored by ACE, and additional test signals from the test connector on the subsystem will be monitored by the BME. This data will then be analyzed to check the proper operation of the S/C control functions, S/C telemetry system, and the MC Subsystem. Exposed film will be processed as part of the MC operation verification.

A test plan for the combined spacecraft will be prepared by NR with the assistance of MC Subsystem personnel. Tests will be conducted on the spacecraft under the direction of the NR test director with support from MC Subsystem personnel as required.

3.3 Preparation for Shipment

3.3.1 Special Film Leaders

3.3.2 Plastic Bags

3.4 Transportation from Downey to Kennedy - During the transportation phase, the MC environment must be maintained in accordance with the requirements of Document No. 1231-DB-12.

3.5 Kennedy Facility

3.5.1 Integration Tests

TO BE DETERMINED

3.5.2 Periodic Health Tests on Pad

TO BE DETERMINED

3.5.3 Flight Film

- 1) Installation of Flight Film
- 2) Installation Tests
- 3) Periodic MC Operation

TO BE DETERMINED

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1231-DB-12

ENVIRONMENTAL
INTERFACE REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE
Revision A

9 March 1970

1.0 SCOPE - This document establishes the environmental requirements for integration of the MC Subsystem in the Scientific Instrument Module (SIM). It covers those conditions pertaining to the environment during assembly, test, transportation, installation and actual mission.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Military Specifications

Fed. Std. 209	Clean Room and Work Station Requirements Controlled Environment
MIL-STD-810B	Environmental Test Methods for Aero- space & Ground Equipment

3.0 REQUIREMENTS

3.1 Operating - The MC Subsystem is capable of operating under the environmental conditions specified herein without degradation in photographic performance.

3.1.1 Temperature - The critical items of the MC Subsystem such as the film, platen, shutter mechanism and lenses will be maintained at a temperature of $70^{\circ} \pm 10^{\circ}\text{F}$.

3.1.2 Altitude - The MC Subsystem will operate at lunar altitudes of 30 to 80 nautical miles.

3.1.3 Pressure - The MC Subsystem will operate in the SIM at a pressure environment of $1.0 \times 10^{-6}\text{mm Hg}$.

3.1.4 Nuclear Radiation - Based on allowable background density of base plus fog of 0.4, the total radiation absorbed by the photographic emulsion shall not exceed 2.0 rads.

Radiation at the MC Subsystem from all sources shall not exceed 2.0 rads for a total mission.

3.1.5 Vehicle Attitude Control - During periods of active photography, the MC Subsystem will require pointing accuracy and attitude hold to be within $\pm 2^\circ$ (each axis; roll, pitch, yaw) measured between subsystem principal optical axes and the orthogonal coordinate system defined by the local vertical and flight velocity vector. Within these limits, the CSM attitude control system shall provide vehicle stabilization rates not to exceed 1.2 arc minutes/second (95%) in pitch, roll, and yaw. No stabilization is required during camera-off periods.

3.1.6 Humidity - The MC Subsystem will be capable of operating under conditions of relative humidity between 0 and 50% during all photographic phases of the flight mission. For all checkout and test operations, a controlled humidity environment shall be maintained between 40% and 50% RH.

3.2 Non-Operating - The MC Subsystem will withstand a random vibration level of 10.6gRMS for a period of 120 seconds. The random vibration density distribution shall be over a frequency range as follows:

20	200 Hz	3 db/oct rise to $0.05 \text{ g}^2/\text{Hz}$
200 - 2,000 Hz		$0.05 \text{ g}^2/\text{Hz}$ constant

The MC Subsystem shall withstand a sinusoidal acceleration of 0.25 g peak from 4 to 35 to 4 Hz at a sweep rate of 3 octaves/minute for 120 seconds.

In addition to the above, the MC Subsystem will also withstand a random vibration level of 5.4 g total RMS for a period of 700 seconds. The random vibration density distribution shall be over a frequency range as follows:

20 - 100 Hz 3 db/oct rise to $0.015 \text{ g}^2/\text{Hz}$
100 - 2,000 Hz $0.015 \text{ g}^2/\text{Hz}$ constant

3.2.2 Shock - The MC Subsystem will be capable of withstanding shock impulses of 5.0 g's applied along the principal axes as a half sine-wave of 6 millisecond duration.

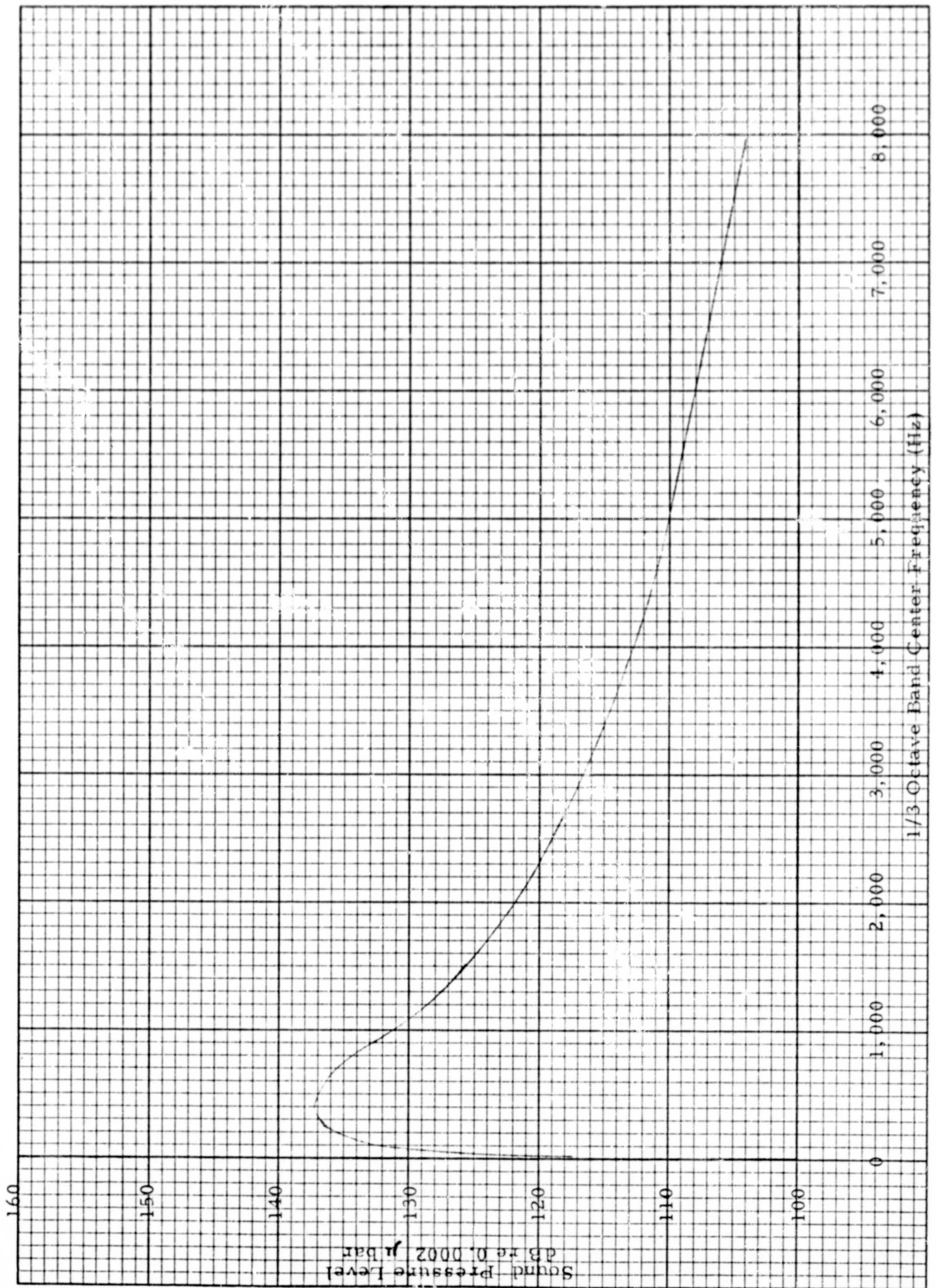
3.2.3 Acceleration - The MC Subsystem will withstand a sustained acceleration of 5.0 g in X-X direction and 0.75 g in any direction normal to the X-X direction for a period of 140 seconds.

3.2.4 Acoustics - The MC Subsystem will withstand an overall sound intensity level of 147 db for a period of 120 seconds. The spectral distribution of sound intensity shall be in accordance with Figure 1.

3.2.5 Assembly and Test - The MC Subsystem will be assembled and bench tested in a Class 100,000 clean room environment as defined in Federal Standard No. 209. The temperature will be maintained at $70^\circ \pm 10^\circ\text{F}$.

3.2.6 Ground Handling, Transportation and Storage - The MC Subsystem will be designed to withstand extreme conditions of natural and induced environment as specified below when protected by its normal packaging. The protective packaging shall attenuate extreme levels so that the equipment inside will not be exposed directly to conditions exceeding those specified in the equipment specification.

- | | | |
|----|----------|---|
| 1) | Pressure | Minimum of 16.9 in. Hg for 8 hours
(air transportation) |
| 2) | Humidity | 0 - 60 $\pm$ RH nominal
60 to 80% RH for 48 hours |
| 3) | Fungus | As experienced in Florida climate. Camera materials will not support or be damaged by fungus. |



ACOUSTICS SIM INTERNAL

FIGURE 1

- 4) Shock 3 g 0.11 millisecond rise time
- 5) Vibration Sinusoidal as experienced in any direction, 0.75 g peak, 35 - 70 Hz, 1 oct/min scan for 15 min.

3.2.7 Installation - Installation of the MC Subsystem in the S/C service module will be done under Class 100,000 or better clean room conditions as defined in Federal Standard No. 209.

3.2.8 Temperature

3.2.8.1 Ground Handling, Transportation and Storage - The MC Subsystem shall not be exposed to temperature extremes exceeding the range of 40°F to 120°F without film load and 70°F ±20°F with film load.

3.2.8.2 Non-Operating Flight - The temperature of the MC Subsystem shall not exceed the range of 70°F ±20°F during non-operational flight.

3.2.9 Vehicle Checkout - During vehicle checkout, the MC Subsystem will not be exposed to any environmental conditions that are more stringent than those specified herein.

3.2.10 Film Record Stowage in CM - During pre-entry, re-entry, recovery and post landing phases, the film record shall not be subjected to extremes of temperature, humidity, and shock which are greater than those specified herein.

3.2.10.1 Temperature - The maximum temperature of the film record shall not exceed 125°F; and, in addition, the time-temperature accumulation at temperatures over 90°F shall not exceed 4,000 hours.

The time-temperature accumulation shall be given by the following expression:

$$2 \left[\frac{T(t) - 90}{5} \right] dt$$

where t_0 is the time corresponding to the start of the period when the temperature exceeds 90°F and t_r is the time corresponding to the end of the period when the temperature exceeds 90°F . This accumulation shall be in effect.

3.2.10.2 Humidity - The film record will require protection against exposure to water immersion and relative humidity to excess of 50%.

3.2.10.3 Shock - The film record, as stowed in the CM, will withstand impact shock conditions of 62 g's along the X-X axis and 5 g's along any axis perpendicular to the X-X axis. The specified levels shall apply to the CM stowage locker container in which the film record is placed and/or to the CM structure which supports the film record. Shock absorbing material shall be placed between the film record and the container to attenuate extreme levels so that the former will not be exposed to more than 40 g's in the X-X direction.

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A Division of Fairchild Camera and Instrument Corporation
300 Robbins Lane, Syosset, New York

1231-DB-13

AUXILIARY DATA RECORDING REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE
Revision A

28 March 1970

1.0 SCOPE - This document defines the Auxiliary Data Recording Requirements of the Mapping Camera (MC) Subsystem.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-4	Electrical Power Requirements MC Subsystem Flight Hardware
1231-DB-9	Auxiliary Data Recording Requirements MC Subsystem Flight Hardware
1231-DB-14	Control Interface Requirements MC Subsystem Flight Hardware
1231-DB-15	Telemetry Interface Requirements MC Subsystem Flight Hardware
1231-DR-2	EMI Interface Requirements MC Subsystem Flight Hardware

3.0 REQUIREMENTS

3.1 General - This section describes all essential requirements and constraints relating to the auxiliary data to be recorded as an aid in the subsequent ground reduction of photography and compilation of charts or maps.

3.2 Auxiliary Data to be Recorded

3.2.1 Real Time - The real time coincident within one (1) ms of the center of exposure of the Mapping Camera shall be recorded on both the Mapping and Stellar photographs.

3.2.2 Altitude - The vehicle altitude taken with reference to the surface of the earth or of the moon (dependent upon the mission) coincident within 10 milliseconds of the center of exposure of the Mapping Camera shall be recorded on the Mapping Camera photographs.

3.2.3 Mapping Exposure Time - The Mapping Camera exposure time shall be recorded to a resolution of 0.1 ms.

3.3 Responsibility Designations

3.3.1 Data Request Signal - It shall be the responsibility of the Mapping Camera to generate a data request signal, more fully described in succeeding sections, to the Scientific Instrument Module (SIM) Command and Control System coincident in time with the center of exposure of the Mapping Camera.

3.3.2 Auxiliary Data Signals - It shall be the responsibility of the SIM Command and Control System to supply the time and altitude signals, more fully described in succeeding sections, to the MC interface upon receipt of the data request signal.

3.4 Data Signal Characteristic at MC Interface

3.4.1 Data Request Signal

- | | | |
|----|-----------------------|-----------------|
| 1) | Waveform Type | Pulse |
| 2) | Repetition Period | 8 to 34 seconds |
| 3) | Pulse Characteristics | See Figure 1 |
-
- | | | | |
|----|-------------------------------------|-----|--|
| a) | Amplitude | (A) | 8 $\pm$ 2 volts |
| b) | Pulse Width | (B) | 50 - 200 μ s |
| c) | Backswing | (C) | 1 volt (maximum) |
| d) | Droop | (D) | 20% |
| e) | Rise Time | (E) | 10 μ second
(maximum) |
| f) | Impedance | | |
| | 1. Load Impedance | | 200 ohms (nominal) |
| | 2. Source Impedance | | 100 ohms (nominal) |
| g) | Noise | | |
| | 1. Noise During Pulse Transmission: | | |
| | | | The signal plus noise shall remain within the envelope of amplitude defined in Figure 1. |
| | 2. Noise During Pulse Absence: | | |
| | | | +0.4 volt maximum, - 2.0 volts maximum, measured with respect to the amplitude reference (see Figure 1). |

PULSE CHARACTERISTICS

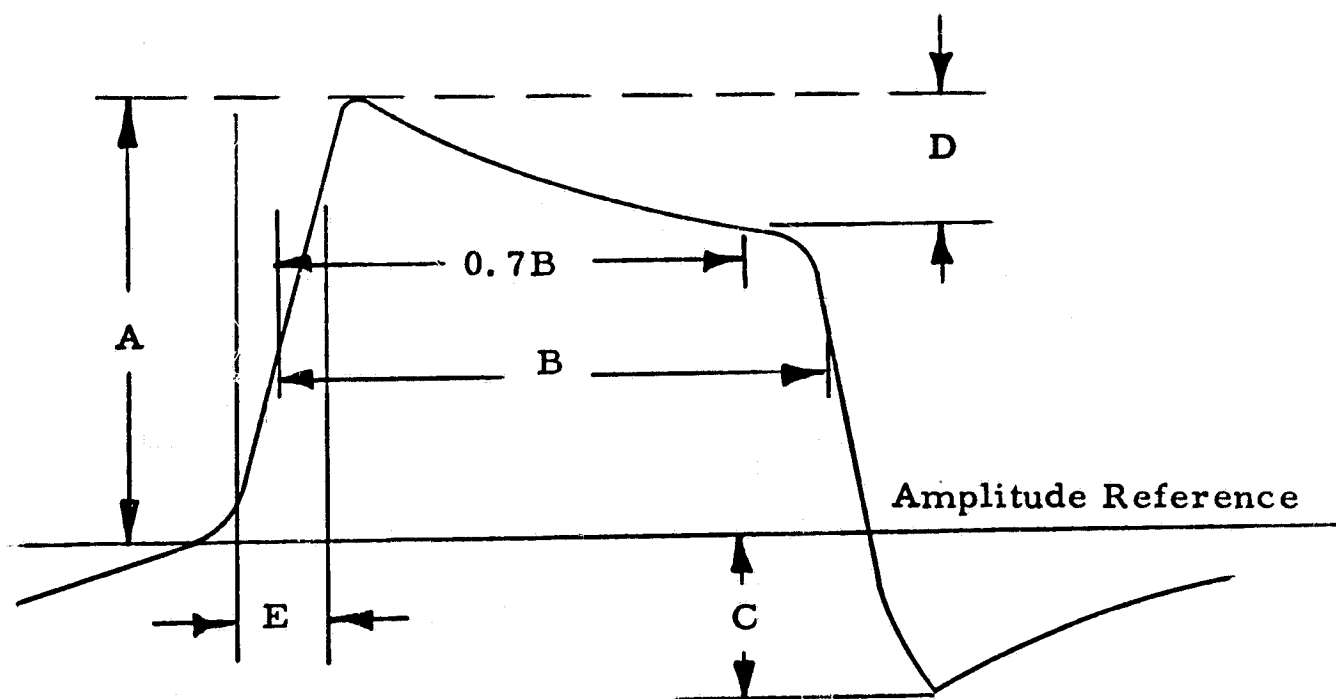


FIGURE 1

PULSE WAVEFORM NOMENCLATURE

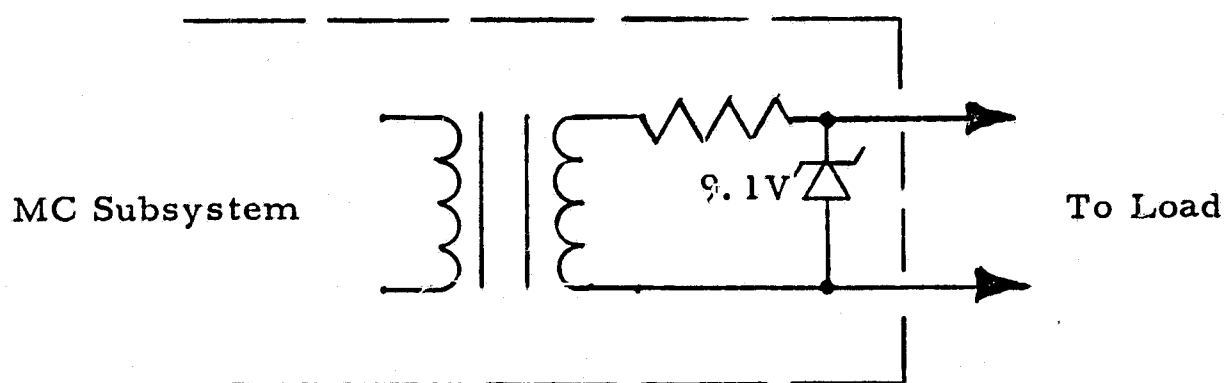
- | | | |
|----|-------------|---|
| A. | Amplitude | - measured to pulse maximum positive level |
| B. | Pulse Width | - measured at $A/2$ level |
| C. | Backswing | - measured to pulse maximum negative level |
| D. | Droop | - measured from pulse maximum positive level to level at $0.7B$ |
| E. | Rise Time | - time required for pulse to rise from 10% to 90% of A |

h) Definition of ON/OFF

1. Presence of Pulse ON Condition
2. Absence of Pulse OFF Condition

i) Miscellaneous

1. Source electrically isolated (transformer coupled).
High and return lines to be provided to load. Probable
transformer secondary configuration:

3.4.2 Time Data Signals

- | | | |
|----|----------------------|---|
| 1) | Waveform Type | Width Coded Pulse |
| 2) | Word Repetition Rate | once/second |
| 3) | Code Type | IRIG, Format B, Unmodulated
(See Figure 2) |

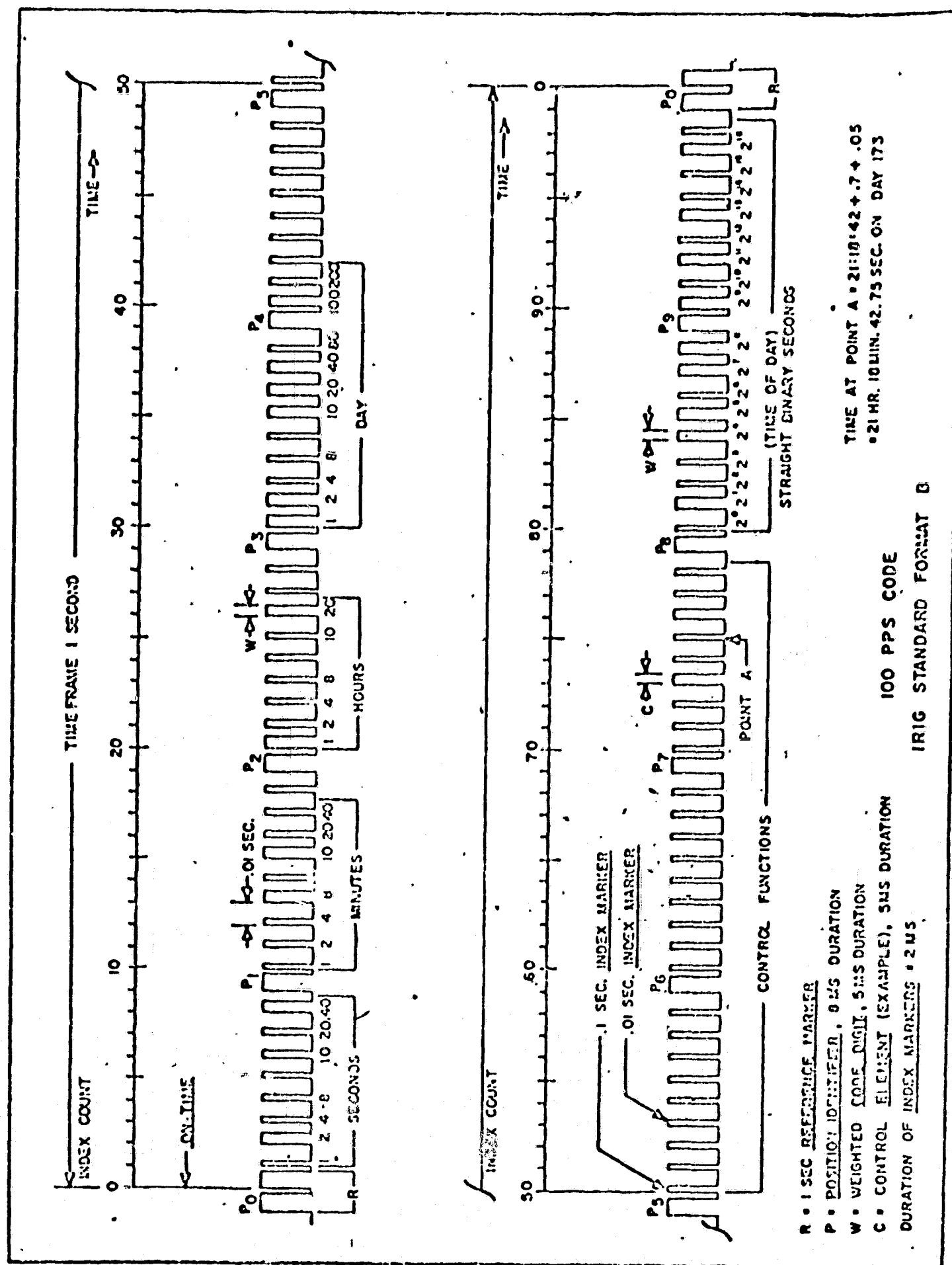


FIGURE 2

- | | | |
|----|-----------------------|---|
| 4) | Transmission Form | Serial (least significant digit
bit first) |
| 5) | Time Accuracy | 5ms absolute* |
| 6) | Pulse Characteristics | See Figure 3 |
- | | | | |
|----|-------------------------------------|-----|---|
| a) | Amplitude | (A) | 8 $\pm$ 2 volts |
| b) | Pulse Width | (B) | 2, 5, or 8ms $\pm$ 5% |
| c) | Backswing | (C) | 2 volts (maximum) |
| d) | Droop | (D) | 1 volt maximum |
| e) | Rise Time | (E) | 10 μ sec. (maximum) |
| f) | Fall Time | (F) | 10 μ sec. (maximum) |
| g) | Impedance | | |
| | 1. Load Impedance | | 200 ohms (nominal) |
| | 2. Source Impedance | | 100 ohms (nominal) |
| h) | Noise | | |
| | 1. Noise During Pulse Transmission: | | |
| | | | The signal plus noise shall remain within the
envelope of amplitude defined in Figure 3. |
| | 2. Noise During Pulse Absence: | | |
| | | | +0.4 volt maximum, -2.0 volts maximum,
measured with respect to the amplitude
reference (see Figure 3). |
| i) | Definition of ON/OFF | | |
| | 1. Presence of Pulse | | ON Condition |
| | 2. Absence of Pulse | | OFF Condition |

*Accuracy required post-flight

PULSE CHARACTERISTICS - IRIG B TIME

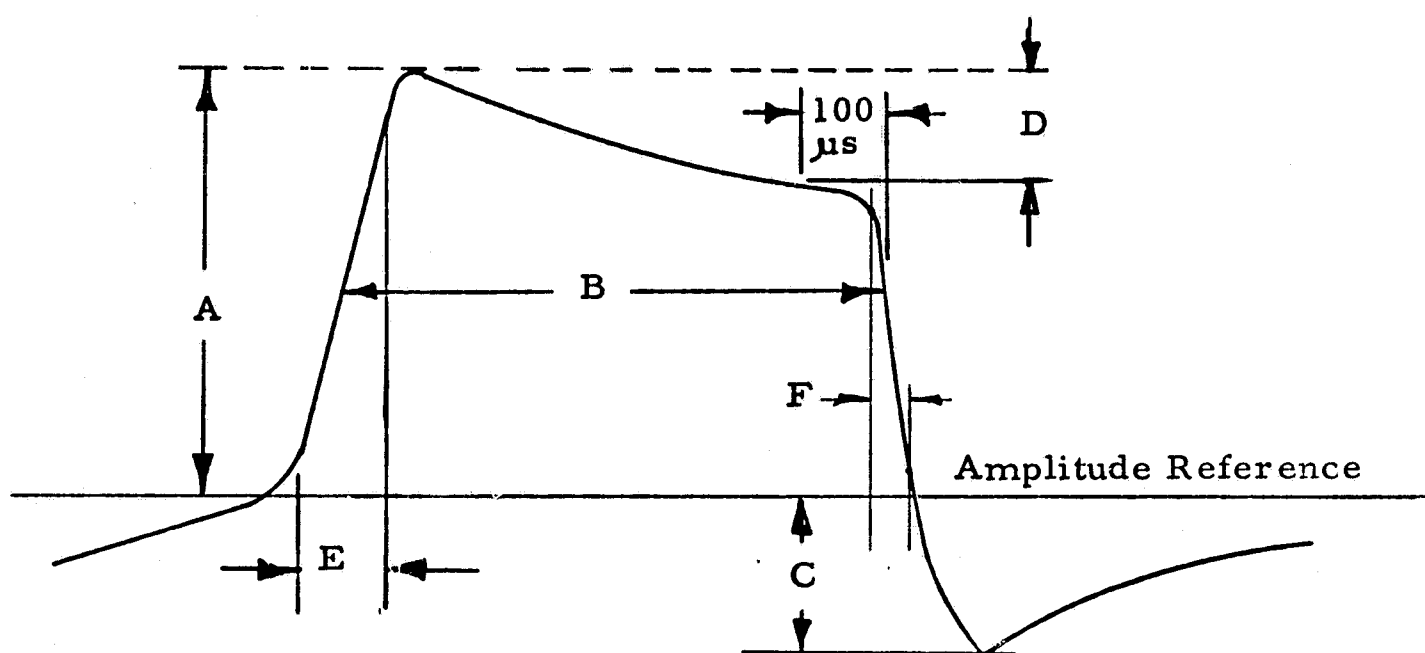


FIGURE 3

PULSE WAVEFORM NOMENCLATURE

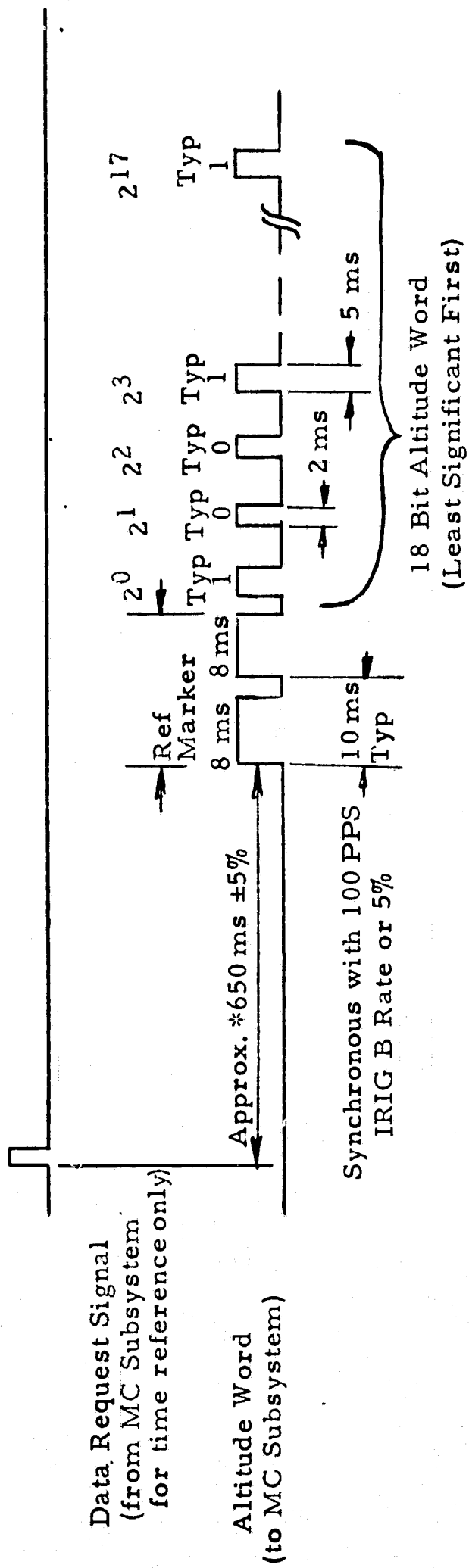
- | | | |
|----|-------------|--|
| A. | Amplitude | - measured to pulse maximum positive level |
| B. | Pulse Width | - measured at A/2 level |
| C. | Backswing | - measured to pulse maximum negative level |
| D. | Droop | - measured from pulse maximum positive level to level at B - 100μs |
| E. | Rise Time | - time required for pulse to rise from 10% to 90% of A |
| F. | Fall Time | - time required for pulse to fall from 90% to 10% of (A-D) |

3.4.3 Altitude Data Signals

- | | | |
|-----|--|---|
| 1) | Waveform Type | Width Coded Pulse |
| 2) | Word Repetition Rate | once/camera cycle (8-34 seconds) |
| 3) | Code Type | Natural Binary-See Figure 4(A) |
| 4) | Transmission Form | Serial (least significant digit bit first) |
| 5) | Number of Bits | 20 (2 reference markers + 18 information) |
| 6) | Resolution | 8 feet |
| 7) | Accuracy | 50 feet or less |
| 8) | Transmission Rate | 1 bit/10ms |
| 9) | Pulse Characteristics | See Figure 4 (B) |
| | a) Load Impedance | 200 ohms (nominal) |
| | b) Source Impedance | 100 ohms (maximum) |
| | c) Noise | |
| | 1, Noise During Pulse Transmission: | |
| | | The signal plus noise shall remain within the envelope of amplitude defined in Figure 4(B). |
| | 2. Noise During Pulse Absence: | |
| | | +0.4 volt maximum, -2.0 volts maximum, measured with respect to the amplitude reference- see Figure 4(B). |
| 10) | Miscellaneous | |
| | a) High and return lines to be provided. | |

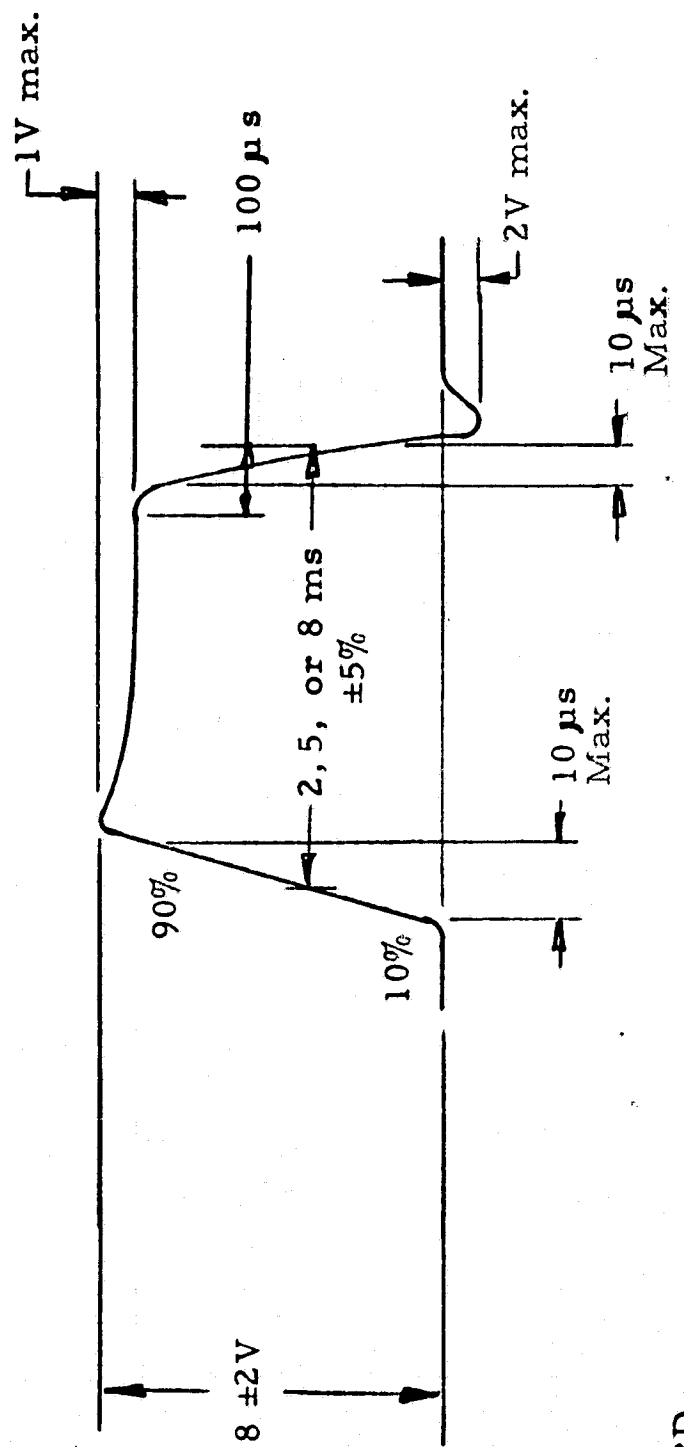
ALTITUDE WORD CHARACTERISTIC

(A)



(B)

TYPICAL ALTITUDE WORD PULSE (into 200 ohm load)



*Actual Value TBD

FIGURE 4

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300 Robbins Lane, Syosset, New York

1231-DB-14

CONTROL INTERFACE
REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE
Revision A
28 March 1970

1.0 SCOPE - This document defines the control interface requirements of the MC Subsystem.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-4	Electrical Power Requirements MC Subsystem Flight Hardware
1231-DB-9	MC Ground Test Interface Requirements MC Subsystem Flight Hardware
1231-DB-13	Auxiliary Data Recording Requirements MC Subsystem Flight Hardware
1231-DB-15	Telemetry Interface Requirements MC Subsystem Flight Hardware
1231-DR-2	EMI Interface Requirements MC Subsystem Flight Hardware

2.2 Contractor Drawings

1231L18	CSM/MC Wiring Interface
1231L200	MC - SC Interface Control Drawing

3.0 REQUIREMENTS

3.1 General - The control functions are required for flight operation of the MC when mated in the SIM configuration. They are also required for

mated ground operation when the BME (reference Document No. 1231-DB-9) is not connected.

The control requirements are met by a combination of manual and automatic signals. Several of the manual controls permit system failures to be overridden.

3.2 Connector Interface - One standard wall mounting receptacle shall be provided for electrical connections for all control functions. This connector shall also provide for the data annotation interface connections in accordance with the requirements of Document No. 1231-DB-13. The connector type and pin designations will be determined by MC/vehicle integrator mutual agreement.

3.3 Manual Control - Manual control is obtained from the CM. It consists of the control switches listed in Table I and the talk-back indicators listed in Table II. Note that control switch No. 5, "Supply Spool Lock", could be shared by any other experiment requiring a signal occurring during high vibration periods of the mission (most notably launch). Refer to Drawing No. 1231L18 for interface wiring implementation.

3.3.1 Switching Characteristics - All switches shall be break before make. Maximum switching voltage will not exceed 30V DC. Maximum switching and carrying current will not exceed 100 MADC per switch. Inductive switch loads in the MC will be diode suppressed.

3.3.2 Talk-Back Characteristics

TO BE DETERMINED (see Table II for functions to be covered)

3.4 Automatic Control - An analog signal proportional to vehicle V/H is required to an accuracy of 3%.

NEED TO BE DETERMINED

TABLE I

COMMAND AND CONTROL

	CONTROL SWITCH	ACTIVE POSITIONS	POSITION	FUNCTION	REMARKS
1	Operate Command	3	Up Center Down	Operate On Operate Off & Film Cut Enable Standby & Heaters Only	
2	Film Cut Command	2	Up Down	Film Cut Off	Switch Guard Required
3	Exposure Control	3	Up Center Down	Automatic Manual-High Light Manual-Lo Light	
4	V/H Control	3	Up Center Down	Automatic Manual-Hi Manual-Lo	NEED TBD
5	Supply Spool Lock	2	Up Down	Lock Supply Spool Unlock Supply Spool	

1231-DB-14
Revision A

TABLE II

TALK - BACK

	TALK-BACK	FUNCTION
1	Temperature	OR'd - Terrain and Stellar Lenses, Body, and Cassette Temperatures
2	Fail and Film Cut	OR'd - Auto Exposure, Ext. V/H Failure; Film Cut Complete

3.4.1 V/H Signal Characteristics

NEED TO BE DETERMINED

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300 Robbins Lane, Syosset, New York

1231-DB-15

TELEMETRY
INTERFACE REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE

Revision A

28 March 1970

1.0 SCOPE - This document defines the telemetry interface requirements for the MC Subsystem.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-4	Electrical Power Requirements MC Subsystem Flight Hardware
1231-DB-9	MC Ground Test Interface Requirements MC Subsystem Flight Hardware
1231-DB-13	Auxiliary Data Recording Requirements MC Subsystem Flight Hardware
1231-DB-14	Control Interface Requirements MC Subsystem Flight Hardware
1231-DR-2	EMI Interface Requirements MC Subsystem Flight Hardware

2.2 Contractor Drawings

1231L18	CSM/MC Wiring Interface
1231L200	MC - SC Interface Control Drawing

3.0 REQUIREMENTS

3.1 General - The MC Subsystem shall be instrumented for telemetry purposes to: provide pre-flight checkout; perform in-flight measurements essential for analyzing the MC Subsystem at the Mission Control Center in

Houston during the scheduled mission; and permit post-flight evaluation of performance.

3.2 Interface Signal Characteristics - All signals provided to the PCM T/M system shall be normalized as follows:

3.2.1 Source Impedance - Source impedance of all T/M channels shall be 5K maximum.

3.2.2 Analog Signal Voltage Level - Analog signal voltage level shall be conditioned between 0 and +5V DC for the full range of scale measurement.

3.2.3 Digital Signal Voltage Level - Digital signal voltage level shall be 0 $\pm$ 0.5V DC for a binary zero, and +3.5 to +10.0V DC for a binary one.

3.3 Connector Interface - One standard wall mounting receptacle shall be provided for electrical connections to all telemetry output signals from the MC Subsystem. The connector type and pin connections will be determined by MC/vehicle integrator mutual agreement.

3.4 Wiring Interface - It shall be the responsibility of the spacecraft contractor to supply the cables and interface wiring.

3.5 Telemetry Signal Description - Telemetry signal description is shown in Table I. For each signal, the following information is provided:

1) Category of Usage - Six (6) categories are provided:

Cat. I (A) - Needed for basic intelligence or scientific data

Cat. I (B) - Needed to determine if EVA recovery should be performed.

Cat. I (C) - Needed for pre-flight ground test to determine if MC is malfunctioning

Cat. I (D) - Malfunction capable of correction via CSM control

Cat. II - Data required to refine basic data

Cat. III - Diagnostics for post-flight evaluation of performance

- 2) Type of Channel Required - Event or Analog - An analog channel of equal minimum sampling rate can be substituted for an event channel, if desired.
- 3) Required Sampling Rate - Minimum required rate is given.

TABLE I

TELEMETRY SIGNAL DESCRIPTION

No.	Signal Description	CATEGORY							Type E = Event A = Analog	Minimum Sample Rate (per second)
		I (A)	I (B)	I (C)	I (D)	II	III			
01	Metric Film Motion		x	x				E	10	
02	Stellar Film Motion		x	x				E	10	
03	Metric Film Remaining (T/U)	x	x	x				A	1	
04	Stellar Film Remaining (T/U)	x	x	x				A	1	
05	Metric Capping Blade		x	x				E	10	
06	Stellar Capping Blade		x	x				E	10	
07	Metric Exposure Sensor		x	x				E	1	
08	Metric Shutter Speed	x		x	x			A	1	
09	Cycling Rate	x		x	x			A	1	
10	Stellar Fogging					x		E	10	
11	Data Request Pulse	x		x		x		E	50	
12	Metric Lens Temp				x	x		A	1	
13	Stellar Lens Temp				x	x		A	1	
14	Cassette Temp				x	x		A	1	

1231-DB-15

TABLE I

TELEMETRY SIGNAL DESCRIPTION

No.	Signal Description	CATEGORY					Type E = Event A = Analog	Minimum Sample Rate (per second)
		I (A)	I (B)	I (C)	I (D)	II	III	
15	Altitude Word Input	x		x			E	10
16	Time Word Input	x		x			E	10
17	115V, 400Hz Σ A, B, C			x				
18	28V DC			x				
19	V/H Input Signal	x		x	x		E	10
20	Operate Command			x			E	10
21	Manual Exposure Control			x			E	10
22	Manual V/H Control			x			E	10
23	Film Cutter Latched			x			E	10
24	Film Cut Complete						E	10
25 ^{*1}	Supply Spool Locked		x	x			E	10
26	Heater ON			x				10

NOTE: ^{*1} Not Cat. I if launch power and CM "supply spool lock" is provided

1231-DB-15

TABLE I

TELEMETRY SIGNAL DESCRIPTION

No.	Signal Description	CATEGORY						Type E = Event A = Analog	Minimum Sample Rate (per second)
		I (A)	I (B)	I (C)	I (D)	II	III		
27	MC Body Temp				x			A	1
28	Σ One Rev. Shaft Timing						x	A	1
29	1 Σ DC Power						x	A	1
30	2 Σ DC Power						x	A	1
31	1 Σ Data Annotation						x	A	1
32	2 Σ Data Annotation						x	A	1
33	Metric Expos. Register Input						x	E	10
34	Photocell Output						x	A	1
35	AEC Up/Down Register Clock						x	E	10
36	AEC Up/Down Register Input						x	E	10
37	Film Metering Solenoid						x	E	10
38	V/H Backup Signal						x	A	1
39	Metric T/U Motor Drive						x	A	1
40	Stellar T/U Motor Drive						x	A	1

1231-DB-15

FAIRCHILD SPACE AND DEFENSE SYSTEMS
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1231-DB-18

MANNED SPACE FLIGHT NETWORK
INTERFACE REQUIREMENTS
MC SUBSYSTEM FLIGHT HARDWARE
13 November 1969

1.0 SCOPE - This document establishes the specific technical requirements and defines the agreements for performance and design of the interface between the Manned Space Flight Network (MSFN) and the MC Subsystem.

2.0 APPLICABLE DOCUMENTS - Documents and drawings of the specified issue listed in the following subparagraphs form a part of this document to the extent specified herein. Where no issue date or revision is indicated, the most recent issue shall apply.

2.1 Contractor Specifications

1231-DB-14	Control Interface Requirements MC Subsystem Flight Hardware
------------	--

1231-DB-15	Telemetry Interface Requirements MC Subsystem Flight Hardware
------------	--

3.0 REQUIREMENTS

3.1 General - The primary function of the Manned Space Flight Network (MSFN) is to provide a means for communicating with and controlling the spacecraft's (S/C) equipment from the complex at the Mission Control Center in Houston, Texas. The MSFN is composed of the Mission Control and integrated remote sites and launch facilities, ship facilities, and aircraft required for real time mission support. It also includes all communications circuits required for data and voice transmission between all facilities.

The remote site facilities provide the intermediate links which receive the data from the S/C by means of telemetry, voice and radar and forward this data to the Mission Control Center. Voice and command data will be sent from the Mission Control Center to the S/C via the remote site facilities.

In general, the computing centers at the Mission Control Center will be receiving telemetry data from the MC Subsystem via the downlink Pulse Code Modulation (PCM) telemetry system. This data will be monitored by

the MC Subsystem support personnel in order to analyze and determine if any command action is necessary to correct the flight operation of the MC Subsystem.

The basic Pulse Coded Modulation (PCM) telemetry system must be capable of supporting the MC Subsystem during prelaunch test, preflight countdown, and all flight phases of the mission as outlined in the MC Telemetry Interface Requirements, Document No. 1231-DB-15. The Mission Control Center will monitor and display the MC telemetry data for flight controller analysis and action. A detailed analysis of the telemetry data will be made by MC Subsystem support personnel during the mission in order to advise and technically support the flight controller.

3.2 Interface Criteria - The primary purpose of this document is to establish the initial interface and define the additional MSFN requirements imposed by the MC Subsystem.

3.3 Interface Design - The Manned Space Flight Network (MSFN) will have the capability of receiving the MC downlink data from the PCM telemetry as necessary and inputting the data to the MC Subsystem support team for evaluation. The MSFN will also be required to up link commands to the MC Subsystem.

3.3.1 Mapping Camera Telemetry Data - The MC telemetry system contains signal conditioning equipment necessary to convert the MC data outputs into signals compatible with the Service Module (SM) telemetry system. These signals will be present at the telemetry connector on the MC Subsystem.

3.4 Support Area - A support area will be required to analyze the mission and support the command functions which are initiated from flight-control consoles. An office area should be provided for three MC Subsystem personnel selected for the specific task of supporting the preparation and execution of the mission.

3.5 Communication - A voice communications systems will be needed in the support area with talk-listen and monitor capabilities so that MC Subsystem personnel can communicate with the flight controllers.

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A Division of Fairchild Camera and Instrument Corporation
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1231-EB-5

ENVIRONMENTAL QUALIFICATION
TEST SPECIFICATION
MC SUBSYSTEM
18 December 1969

1.0 SCOPE - The procedures for testing the MC Subsystem, to determine that the camera will be qualified to withstand its anticipated environment, are presented in this specification. The MC Subsystem qualification test program will consist of the following:

- 1) Vibration Tests
- 2) Shock Tests
- 3) Acceleration Tests
- 4) Acoustic Tests
- 5) Record Container Shock Test
- 6) Vacuum (Altitude) Test

2.0 GENERAL INFORMATION

2.1 Standard Conditions - The conditions for conducting the environmental testing unless otherwise specified shall be as follows:

- 1) Temperature 60°F - 80°F
- 2) Relative Humidity 0 - 50% RH
- 3) Barometric Pressure Local Atmospheric

2.2 Measurements - All measurements shall be made with instruments, the accuracy of which conforms to acceptable laboratory standards, which are appropriate for measurement of the environmental condition concerned.

2.3 Definition of System Geometry - For definition of the system geometry, including definition of axes, reference should be made to Figures 1A and 1B of this specification.

DEFINITION OF SYSTEM GEOMETRY

The positive X axis of the cartographic camera shall be defined as being approximately in the direction of the vehicle velocity vector. The Z axis shall be perpendicular to the X-Y plane and positive in the direction of the terrain to vehicle radius vector. The cartographic camera Y axis shall be approximately perpendicular to the orbit plane and positive in such a direction as to conform to a right hand Cartesian Coordinate System. The positive X axis of the Stellar Camera shall be approximately in the direction of the vehicle velocity vector. The negative Y axis shall be in the approximate direction of the terrain to vehicle radius vector. The Z axis of the Stellar Camera shall be perpendicular to the X-Y plane and positive in such a direction as to conform to a right hand Cartesian Coordinate System.

Within each focal plane, the X and Y axes shall be defined as follows:

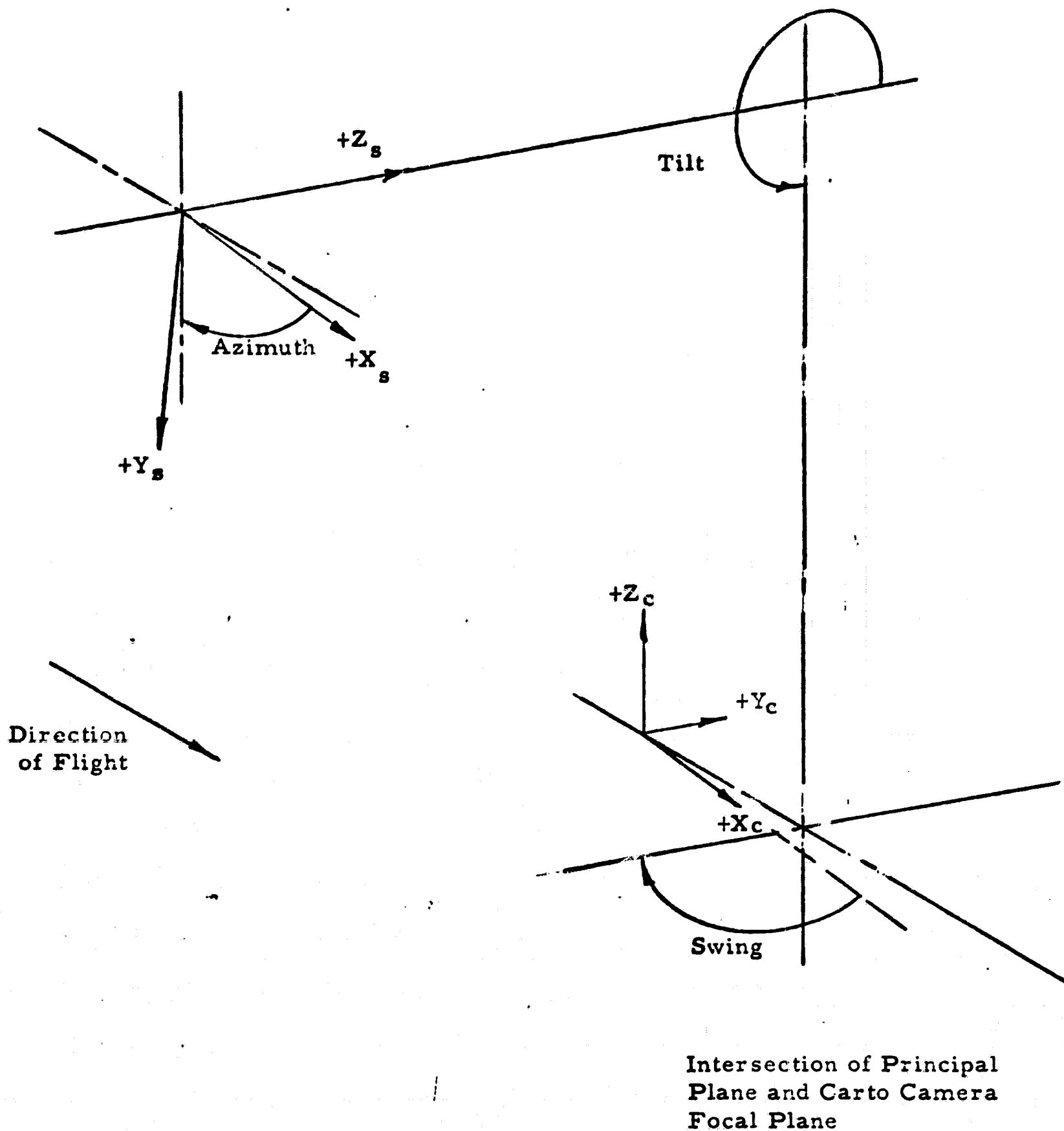
The Y axis shall be defined as the line determined by the two fiducial marks which are approximately perpendicular to the vehicle velocity vector. The X axis shall be defined as a line which is perpendicular to the Y axis, but passes through the indicated principal point. The Z axis is then defined as being perpendicular to the intersection of X and Y.

The principal plane shall be defined as that plane which contains Z_S and is parallel to Z_c .

The three angles defining the system geometry are defined as follows:

TILT	The clockwise angle measured from Z_S to the projection of Z_c on the principal plane (looking in the direction of flight). This angle shall be $264^\circ \pm 30$ minutes.
SWING	The angle measured from $+X_C$ to the trace of the principal plane in the $-Y$ direction on the cartographic camera focal plane. This angle shall be $90^\circ \pm 30$ minutes.
AZIMUTH	The angle measured in the clockwise direction from $+X_S$ to the trace of the principal plane (looking in the $-Z_S$ direction). This angle shall be $90^\circ \pm 30$ minutes.

FIGURE 1A



NOTES: (a) Carto Camera Coordinate System Rotated Slightly About Z_c Axis for Clarity

(b) Stellar Camera Coordinate System Rotated Slightly About Z_s Axis for Clarity

FIGURE 1B

3.0 VIBRATION QUALIFICATION TEST - MC SUBSYSTEM

3.1 Object - To determine that the structural integrity and performance of the MC Subsystem is satisfactory with respect to the random vibration environment.

3.2 Applicable References

1231-EB-7

MC Subsystem
Acceptance Test Specification

3.3 Equipment and Facilities Required

- 1) Vibration System, MB Electronics, Model C 210
- 2) Spectrum Equalizer Control, MB Electronics, Model N 300
- 3) Random Noise Generator, MB Electronics, Model N 80
- 4) Spectral Density Voltmeter, MB Electronics, Model N 122
- 5) Multiple Channel Scanner, MB Electronics, Model N 280
- 6) X-Y Recorder, F. L. Moseley Co., Model 135
- 7) Accelerometers, MB Electronics, Type 300 series or equivalent
- 8) Visicorders, Honeywell, Type

3.4 Procedure - Prior to performance of any vibration testing on the system, the vibration fixture shall be evaluated for resonance and cross talk. All resonance and cross talk of the fixture shall be removed by re-working the fixture wherever possible.

Prior to vibration testing, the MC Subsystem shall be subjected to the acceptance tests given in Sections 3.1, 3.2, and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7.

The MC Subsystem shall then be mounted to the vibration fixture which in turn is mounted on the vibration equipment. An accelerometer located at one of the mounting locations will monitor the input vibration. The system shall be equalized using automatic equalizing equipment (80 filters) to within ± 3 DB over the spectrum from 20 to 2,000 Hz. The spectrum equalization will be analyzed by means of a spectrum analyzer and X-Y recorder. The spectrum will be applied in a single frequency band from 20 to 2,000 Hz.

The MC Subsystem shall be non-operating during vibration testing. The random vibration shall be applied over the spectrum as indicated below:

1)	First 120 seconds	10.6 g RMS overall vibration
	20 - 200 Hz	3 db/octave rise to $0.05 \text{ g}^2/\text{Hz}$
	200 - 2,000 Hz	$0.05 \text{ g}^2/\text{cps}$ constant
2)	Next 700 seconds	5.4 g RMS overall vibration
	20 - 100 Hz	3 db/octave rise from 0.003 $0.015 \text{ g}^2/\text{Hz}$
	100 - 2,000 Hz	$0.015 \text{ g}^2/\text{Hz}$ constant

The spectrum will be analyzed during the test period to verify proper equalization.

The MC Subsystem shall be subjected to this vibration test in each of three mutually perpendicular axes. At the conclusion of vibration in each axis, the test unit shall be examined for evidence of damage. After completion of the vibration test in three axes, the subsystem shall be subjected to the acceptance tests given in Sections 3.1, 3.2, and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7.

4.0 SHOCK QUALIFICATION TEST - MC SUBSYSTEM

4.1 Object - To determine that the structural integrity and performance of the MC Subsystem is satisfactory with respect to the shock environment.

4.2 Applicable Reference

1231-EB-7

MC Subsystem
Acceptance Test Specification

4.3 Equipment and Facilities Required

- 1) Shock Machine, Barry Controls, Model 15,000 or equivalent
- 2) Accelerometer, Endevco, Model 1214
- 3) Oscilloscope, Hewlett Packard, Model 150A

4.4 Procedure - A dummy load shall be mounted in the shock fixture which in turn shall be mounted on the shock machine. An accelerometer shall be mounted adjacent to a mounting point of the test unit. The shock machine shall then be calibrated for the proper waveshape and time duration.

Prior to shock testing, the MC Subsystem shall be subjected to the acceptance tests given in Sections 3.1, 3.2, and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7.

The MC Subsystem shall then be mounted to the shock machine in the X-X axis. The test unit shall be non-operating during the shock test. The system shall be subjected to a total of six impact shocks in the X-X axis, which shall include shock in both the plus and minus directions along the principal axis. The shock pulse shall be 5.0 g's $\pm 10\%$ half sinewave with a total time duration of 6 milliseconds. This shock test shall be repeated along the other two principal axes (Y-Y and Z-Z).

At the conclusion of each shock test, the MC Subsystem shall be inspected for evidence of damage as a result of the test. After testing in all three axes, the subsystem shall be subjected to the acceptance tests given in Sections 3.1, 3.2, and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7.

5.0 ACCELERATION QUALIFICATION TEST - MC SUBSYSTEM

5.1 Object - To determine that the structural integrity and performance of the MC Subsystem is satisfactory with respect to the acceleration environment.

5.2 Applicable Reference

1231-EB-7

MC Subsystem
Acceptance Test Specification

5.3 Equipment and Facilities Required

- 1) Centrifuge, 24 foot boom or equivalent
- 2) Frequency Counter, Hewlett Packard, Model 523

5.4 Procedure - Prior to the acceleration test, the MC Subsystem shall be subjected to the acceptance tests given in Sections 3.1, 3.2 and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7. The subsystem shall then be mounted in the acceleration fixture which shall be non-operating during this test. The test may be conducted outdoors in natural environment.

The acceleration tests will be conducted in plus and minus direction along each of the principal axes and the acceleration shall be applied as follows in each axis of the unit:

X-X	±5.0 g's
Y-Y	±0.75 g's
Z-Z	±0.75 g's

The MC Subsystem shall be subjected to a translational acceleration in each of the above axes for a period of 140 seconds each. The total time shall be 840 seconds.

At the conclusion of the acceleration test, the MC Subsystem shall be removed from the fixture and inspected for evidence of damage. The subsystem shall then be subjected to the acceptance tests given in Sections 3.1, 3.2, and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7.

6.0 ACOUSTICS QUALIFICATION TEST - MC SUBSYSTEM

6.1 Object - To determine that the structural integrity and performance of the MC Subsystem is satisfactory with respect to the acoustic environment.

6.2 Applicable Reference

1231-EB-7

MC Subsystem
Acceptance Test Specification

6.3 Equipment and Facilities Required

- 1) Acoustic Chamber
Avco Corp, or equivalent
Model TE 1562
- 2) Multiple Band Equalizer
Allison, or equivalent
Model 30 Man - 8
- 3) True RMS Meter
Ballantine Labs, or equivalent
Model 320 M
- 4) Microphone System
Altec - Lansing, or equivalent
Model 21BR150

6.4 Procedure - Prior to acoustics test, the MC Subsystem shall be subjected to the acceptance tests given in Sections 3.1, 3.2, and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7.

The acoustic spectrum shall be adjusted over the specified frequency spectrum prior to the installation of the MC Subsystem. After the spectrum has been adjusted, the subsystem shall be installed in the acoustic chamber. The spectrum shall again be analyzed and adjusted as required. After final adjustment, the spectrum shall not be re-analyzed but the overall level shall be monitored throughout the test period. The subsystem shall be non-operating during this test.

The subsystem shall then be subjected to an acoustic noise level of 147DB overall for a period of 120 seconds. The spectral distribution of sound intensity shall be in accordance with Figure 4 of Document No. 1231-DB-1.

At the conclusion of the acoustic test, the MC Subsystem shall be removed from the chamber and inspected for evidence of damage. The subsystem shall then be subjected to the acceptance tests given in Sections 3.1, 3.2, and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7.

7.0 SHOCK QUALIFICATION TEST - RECORD CONTAINER

7.1 Object - To determine the ability of the record container to protect the stowed film against damage due to its shock environment.

7.2 Applicable References -

Specification

1231-DB-3

Installation Requirements,
MC Subsystem Flight Hardware

Drawing

1231L46

Payload Stowage Outline

7.3 Equipment and Facilities Required

- 1) Shock Machine, Barry Controls, Model 15,000 or equivalent
- 2) Accelerometer, Endevco, Model 1214
- 3) Oscilloscope, Hewlett Packard, Model 150A

7.4 Procedure - A dummy load shall be mounted to the record container shock fixture which in turn shall be mounted on the shock machine. An accelerometer shall be mounted adjacent to a mounting point of the test unit. The shock machine shall then be calibrated for the proper waveshape and time duration. The shock fixture for holding the record container shall be designed to simulate the CM structural support as described in paragraph 3.2.5.2 of the Installation Requirements Document No. 1231-DB-3.

Two full spools of live film shall be installed in the record container and the record container mounted to the shock fixture. The complete assembly shall be mounted on the shock machine. The system shall be subjected to one impact shock in each direction for a total of 5 shocks. The shock impacts shall be half sinewaves with a total time duration of 6 milliseconds. The amplitude and direction of the shock pulses shall be as follows:

X-X Axis	40 g's $\pm 10\%$
Y-Y Axis	5 g's $\pm 10\%$
Z-Z Axis	5 g's $\pm 10\%$

The X-X axis of the record container is shown on Drawing No. 1231L46.

At the conclusion of the shock test, the film spools shall be removed from the record container and the film developed. The developed film and the film spools shall be inspected for evidence of damage as a result of this test.

8.0 VACUUM QUALIFICATION TEST - MC SUBSYSTEM

8.1 Object - To demonstrate that the MC Subsystem will perform in accordance with the MC Subsystem Equipment Specification No. 1231-DB-1 when subjected to a high vacuum environment.

8.2 Applicable References

1231-DB-1	Equipment Specification, MC Subsystem
1231-DB-6	BME Interface Requirements, MC Subsystem Flight Hardware
1231-DB-15	Telemetry Interface Requirements, MC Subsystem Flight Hardware
1231-EB-7	MC Subsystem Acceptance Test Specification

8.3 Equipment and Facilities Required

- 1) Altitude Chamber, NRC
- 2) MC Functional Test Set

8.4 Test Measurements - The telemetry outputs of the MC Subsystem shall be monitored during this qualification test each time the subsystem is operated. These outputs are described in the Telemetry Interface Requirements Document No. 1231-DB-15.

8.5 Procedure

8.5.1 Base Line Tests - Before the start of the vacuum test, the MC Subsystem shall be subjected to the acceptance tests given in Sections 3.1, 3.2, and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7.

8.5.2 Set Up Procedure - After the acceptance tests have been completed, proceed in the following manner:

- 1) Load subsystem with full spools of live film
- 2) Mount subsystem on calibration fixture and place in altitude chamber
- 3) Connect subsystem to the functional test set
- 4) Check the subsystem for proper operation
- 5) Evacuate the chamber to a maximum pressure of 1×10^{-5} mm of Hg and adjust the chamber to a temperature of $70^{\circ} \pm 10^{\circ}$ F.

8.5.3 Vacuum Test - This test shall approximate a typical four (4) day lunar photographic mission. The operation of the MC Subsystem will be programmed in accordance with TBD. During the operating periods, fogging lamps will be used to expose the film. During non-operating periods, static dynamic resolution tests will be made on the subsystem. These resolution tests will be made at least 3 times during the test. During this test, the chamber temperature shall be varied between 60° F and 80° F.

After completion of the vacuum test, the altitude chamber shall be returned to ambient conditions and the film removed from the subsystem for processing and evaluation.

8.5.4 Base Line Tests - After completion of the vacuum tests, the MC Subsystem shall be subjected to the acceptance tests given in Sections 3.1, 3.2, and 3.4 of the MC Subsystem Acceptance Test Specification No. 1231-EB-7.

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A Division of Fairchild Camera and Instrument Corporation
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DATA REDUCTION COMPATIBILITY

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EQUIPMENT SUPPORT REQUIREMENTS

1. EQUIPMENT COMPATIBILITY

In order to satisfy the optimum cartographic requirements for the Lunar Mapping Mission, it is essential that the ground data processing facilities at NASA Manned Spacecraft Center be geared to handle the precision cartographic and stellar imagery that will be obtained from the Mapping Camera Subsystem. All precautions must be taken to insure that complete compatibility exists between the Mapping Camera Subsystem and the related data processing and reduction equipments at NASA/MSC. Correspondingly, if equipment compatibility does not presently exist in certain MSC data processing areas, it is necessary to identify specific existing and/or new equipment requirements in order to insure for optimum processing and reduction of the Mapping Camera image data. In addition, it is also necessary to identify and recommend specific data handling techniques that would allow the output Mapping Camera image data to be compatible with standard available cartographic equipments.

During the course of the preliminary compatibility investigation, a visit was made to NASA Manned Spacecraft Center for the purpose of surveying and evaluating existing NASA/MSC data reduction techniques. Since the NASA charter specifically states that the "Manned Spacecraft Center must handle and process all original film", it was considered pertinent to commence the investigation with an evaluation of existing data processing and reduction facilities at the Manned Spacecraft Center's Photo Technology and Mapping Sciences Laboratories.

It is the purpose of this report to summarize the findings and identify some of the problem areas pertaining to the preliminary equipment investigation at NASA/MSC. The MCS final report, presently in the process of preparation, will present a comprehensive review and evaluation of the pertinent data reduction equipments/techniques currently in use at the major map support and compilation agencies such as Aeronautical Chart and Information Center, U.S. Geological Survey, U.S. Coast and Geodetic Survey, and U.S. Army Topographic Command. It should be emphasized that visits to ACIC and

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TOPOCOM have not been made to date, pending an initial visit to Department of Defense Mapping, Charting and Geodesy (DOD MC&G). Since this agency oversees all DOD mapping activities, it was considered essential that they be contacted first with regard to the MCS equipment compatibility evaluation. A meeting with DOD MC&G personnel has been scheduled for 4 February 1970. Meetings with ACIC and TOPOCOM personnel will be scheduled immediately thereafter. A meeting with USGS(Fred Doyle), on the other hand, has been scheduled for 28 January 1970.

As a result of these discussions with the various agencies, concrete recommendations will be made pertaining to MCS compatibility with existing NASA/MSC data reduction techniques and to the identification and justification of possible new equipment development requirements for handling the Mapping Camera image data.

2. SURVEY OF EQUIPMENTS IN PHOTO TECHNOLOGY LABORATORY

Although the Photo Technology Laboratory has a large volume motion picture capability, it is not presently geared to handle, process and convert the large quantities of high order original negative metric and stellar inputs that will be acquired from the Lunar Mapping Mission. The laboratory, at present, is not equipped to perform the precision high resolution processing and reproduction that is required of metric photography.

Table 1 lists the photographic processing, printing, enlarging and miscellaneous photographic support equipments presently in the Photo Technology Laboratory. Some of the equipments listed do not appear to be compatible with the requirements of the Mapping Camera Subsystem and, in addition, are currently used rather extensively in the Earth Resources Program.

2.1 PHOTOGRAPHIC PROCESSING

The Photo Technology Laboratory is presently equipped with two Black and White Versamat Model 11C Processors which are continuously being used for the Earth Resources Program. Although the Versamat provides rapid processing and drying, it appears that this type of processor is not capable

TABLE 1

EQUIPMENTS IN PHOTO TECHNOLOGY LABORATORY

- PHOTOGRAPHIC PROCESSORS

- 2 - Eastman Kodak Black & White Versamats, Model 11C
- 2 - Eastman Kodak Color Versamats, Model 1411C
- 1 - Eastman Kodak Color Processor, Model 30
- 1 - Eastman Kodak 4A Print Processor
- 1 - Eastman Kodak 4C Print Processor
- 1 - Pako Type RC Color Print Processor

- PHOTOGRAPHIC PRINTERS

- 1 - LOG-E Model SP 10/70B Continuous Strip Printer
- 2 - Eastman Kodak Niagara Printers
- 1 - Eastman Kodak Rainbow Printer (on order)
- 1 - LOG-E Mark II Electronic Contact Printer
- 1 - Morse 10" x 20" Contact Printer
- 1 - Douthitt 30" x 40" Vacuum Printer

- PHOTOGRAPHIC ENLARGERS AND COPY CAMERAS

- 1 - Princeton 11" x 14" Copy Camera
- 1 - LOG-E Model 10B Enlarger
- 1 - Beseler 4" x 5" Enlarger
- 1 - Super-Chromega 4" x 5" Enlarger
- 1 - Durst 9" x 9" Color Enlarger
- 1 - Zeiss SEG-V Rectifier

- MISCELLANEOUS PHOTOGRAPHIC SUPPORT EQUIPMENTS

- 1 - Eastman Kodak 1B Sensitometer
- 1 - Herinfeld Sensitometer
- 1 - Eastman Kodak Control Sensitometer
- 1 - each Macbeth Quanta Log Models TD-203, TD-204, and OP-10
Densitometers
- 1 - Joyce Micordensitometer, Model MK 111CS, with Tech Ops
Isodensitracer.

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of handling the metric quality or precision of the original Lunar Mapping Photography. In addition, the MSC Photo Laboratory has never processed more than 200 feet of film in the Versamat at any given time. This is considered inadequate since in order to process the original lunar mapping photography, it is required that the recommended processor be capable of handling and processing original roll film inputs up to 1,500 feet in length with precision metric quality. Consequently, Photo Technology Laboratory processing requirements must be specified for a continuous deep tank photographic processing machine capable of handling the high quality lunar metric photography with provisions for the following:

- a) Adequate film drying and tension controls to limit affects of film distortion
- b) Replenishment of chemicals
- c) Agitation
- d) Maintain solution temperature control
- e) Control of processing time

On the basis of preliminary investigation, it appears that the Fultron Processor, manufactured by Eastman Kodak, will satisfy the pertinent requirements for handling and processing large quantities of original metric photography. The pertinent performance characteristics of this particular processor will be obtained from Eastman Kodak. Recommendations as to specific processing equipments, however, should not be considered final since all pertinent metric photographic processing requirements are currently being reviewed with the appropriate government map compilation and research agencies. All results, including recommendations, will be presented in the final report.

It is suggested that the highest priority item in the entire program be given to the development of a capability for producing quality-controlled photo-

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graphic products for the lunar mapping mission. Research has proven that dimensional stability, image density, edge gradients and resolution often become random variables in the processing of metric photography, particularly when handling original input materials in an uncontrolled processing environment. Consequently, in order to insure for the high quality control processing of the original lunar mapping photography, an environmentally controlled, clean room facility is recommended as a necessary adjunct to the existing Photo Technology Laboratory. The clean room must provide capabilities for environmental control, particularly from the standpoint of temperature, humidity, dust filtration and static electricity (atmosphere, clothing, materials). In addition, provisions for decontamination entrances and exits must also be made available. These should be the minimum specified requirements for handling the original negative lunar mapping photography.

2.2 CONTACT, ENLARGEMENT AND DIAPOSITIVE PRINTING

From the standpoint of contact printing capabilities, the Photo Technology Laboratory is equipped with two Niagara Printers which are capable of handling the original negative metric roll film inputs from the Lunar Mission. This printer can handle up to 1,000 feet of duplicating film at a printing rate of 100 feet/minute. The Niagara Printer is also capable of providing an output resolution of greater than 350 lines/mm at 1,000:1 contrast. An adjustable exposure control enabling the operator to compensate for individual density variations from frame to frame is also provided. In addition to the Niagara Printer, high resolution contact prints of specific image frames can also be produced by using either the Log E SP 10/70 Continuous Strip Printer and/or the Log E Mark II Electronic Printer.

It appears, however, that the Photo Technology Laboratory does not possess adequate capabilities for producing controlled high quality/precision photogrammetric enlargements and/or diapositives for use in comparators and stereo plotting instruments. Since most standard double projection plotting instruments, such as the Multiplex, Nistri, Balplex and Kelsh Plotters, are designed for operation with 6-inch focal length, 9 x 9 inch mapping photography, adequate means must be taken to insure that the 3-inch focal length lunar

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metric photography is converted (enlarged) and corrected to the proper acceptable focal length prior to insertion into the appropriate plotting instrument.

In order to adequately satisfy the requirements for precision enlargement printing, it is recommended that the Photo Technology Laboratory be provided with a high resolution, precision photogrammetric enlarger which will provide the required output format of 9 x 9 inches. The particular enlarger that is used must incorporate special lenses which are essentially distortion free. Moreover, the input and output planes must incorporate precision adjusting mechanisms which will permit easy and accurate alignment of these planes to the optical axis. Fairchild Space and Defense Systems has developed an enlarger of this type under contract to Rome Air Development Center. The instrument is presently in operational use at a major government map making facility.

The generation of diapositives, i. e., positive prints on glass plates, from 9 x 9 inch aerial negatives are also required prior to insertion into most standard stereo plotting instruments. The diapositive must duplicate the information contained in the original or enlarged negative as completely as possible. Therefore, it is essential that all geometric, optical and photographic conditions governing diapositive preparation be controlled to a great degree of accuracy.

Most diapositive plates are made either by contact or, when required, by reduction printing. Standard diapositive printers, such as the Balplex Printer, for example, are equipped with aspheric correction plates to compensate for radial distortion in the taking camera lens. Once the radial distortion has been corrected, the diapositive is ready for insertion into the appropriate stereoplotting instrument. The Multiplex and Belfort Stereoplotters also operate in the same fashion, i. e., the effects of radial lens distortion are corrected in the diapositive printer prior to stereo compilation. Stereoplotters such as the Kelsh Plotter, on the other hand, compensate for radial distortion during the map compilation process. This compensation is accomplished by varying the principal distances of the projection lenses in accordance with a definite pattern that is established by the

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radial distortion to be corrected. Contact size (9 x 9 inch) diapositives that are produced for use in the Kelsh Plotter, therefore, need not be corrected for distortion during diapositive printing.

The requirements for optimum diapositive generation, including diapositive compatibility with standard available stereoplotting instruments, will be discussed with the appropriate map support agencies during the course of the MCS equipment evaluation. Pertinent recommendations will be summarized in the final report.

The Photo Technology Laboratory is also equipped with a Zeiss SEG V Rectifier. This instrument is used to correct geometric distortions that are present in photographs taken in oblique angles. The instrument provides magnifications ranging from 0.5X to 6.5X, and accepts film formats up to 12 x 12 inches. The easel-tilt range for the SEG V is $\pm 13^{\circ}$ in X and Y.

It is important to emphasize, however, that the Photo Technology Laboratory has done very little with regard to rectification printing. Correspondingly, there are few trained and/or knowledgeable technicians who can operate SEG V Rectifier at the present time.

2.3 MISCELLANEOUS PHOTOGRAPHIC SUPPORT EQUIPMENTS

The Photo Technology Laboratory can satisfy all the sensitometric requirements for the analysis of lunar mapping film materials. With the aid of the Eastman Kodak 1B Sensitometer, precision sensitometric readings can be obtained. This sensitometric instrument contains a precision light source for imaging a density step tablet onto film. Under existing operating conditions, sensitometric exposures are placed on the film, both before and after the mission, by the sensitometer. The densities of the sensitometric exposures are examined after the mission film has been developed in order to determine the effects of environmental and handling aspects of the mission on the sensitometric properties of the film. The results of this examination are used to optimize the quality of any subsequent hard copy produced from the original mission film.

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Titling information should be placed on the emulsion side of each frame of original lunar and stellar negative imagery once it has been processed by the Photo Laboratory. Minimum titling data to be placed on each frame should include mission number, revolution number and sequential negative number.

In order to implement the film titling requirements, the Photo Technology Laboratory should be equipped with a Film Titler which can automatically apply titles to each frame of mapping and stellar roll film imagery. Included should be the capability for longitudinal or lateral titling, bi-directional film transport (providing speeds up to 60 feet per minute) and frame sensing circuitry which allows fully automatic titling. Fairchild Space and Defense Systems has recently developed a Film Titler of this type (Model BS-12) under contract to Rome Air Development Center.

No apparent problems are anticipated in the titling of the MCS 5-inch terrain frame format. There appears to be sufficient space in the margin between the outer image border and the edge of the film. The 35mm stellar imagery, on the other hand, could present problems due to the lack of adequate titling space within the margins of each frame format. Techniques for solving this problem are presently being investigated.

2.4 CURRENT PHOTO LABORATORY DATA HANDLING PROCEDURES

Figure 1 presents a simplified flow diagram of the current data handling procedures at the MSC Photo Technology Laboratory. These handling procedures are currently being used to process the Earth Resources image data.

After a particular mission is flown and its output products (film, magnetic tape, flight logs) are logged in and inspected by the Data Management Group, the original mission film is delivered to the Photo Laboratory where it is processed, used to generate the desired output products, and placed in controlled storage. After inspection and editing, copies of the desired output products are released to the various NASA (and outside) working groups for data reduction and analysis.

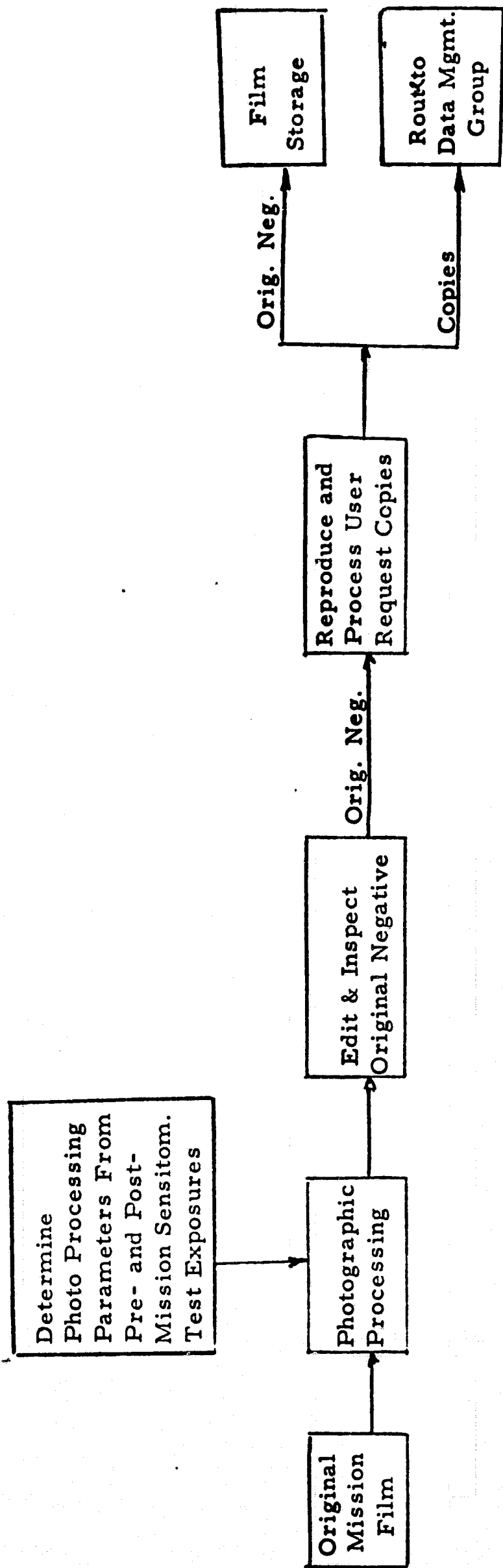


Figure 1 - CURRENT MSC PHOTOGRAPHIC HANDLING FLOW

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Depending upon specific user requests for image data, film processing by the Photo Technology Laboratory can result in the generation of the following output product forms:

- B&W Duplicate Negative
- B&W Duplicate Positive Transparency
- B&W Paper Prints
- B&W Rectified Paper Prints
- B&W Glass Plates
- Duplicate Positive Color Transparency
- Color Prints

It is anticipated that the procedures for handling the lunar metric and stellar imagery will be somewhat different from those procedures currently in use for the Earth Resources Program. Major procedural changes will occur primarily in the production, control and routing of required high precision metric output products to the wide variety of user experimentors (e. g. , NASA Mapping Sciences Laboratory, major government map compilation/research agencies, related university researchers, etc).

3. SURVEY OF EQUIPMENTS IN MAPPING SCIENCES LABORATORY

In general, the Mapping Sciences Laboratory should encounter little or no difficulty with regard to reducing and analyzing the terrain and stellar data acquired from the Lunar Mapping Mission. Specifically, the Mapping Sciences Laboratory will utilize the lunar photography for the primary purpose of performing the following operational task analyses:

- 1) landing site location

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- 2) define relative location of landmarks with respect to the specific landing sites selected
- 3) define the topography along approach path to potential landing sites
- 4) provide control for the high resolution 24-inch panoramic camera (flown concurrently with MCS)
- 5) detailed scientific interpretation and analysis of selected landing site areas

It appears that the implementation of MSL's five major task objectives can be satisfied by existing (and requisitioned) equipments in the Photogrammetric Laboratory. It should be emphasized, however, that lunar map compilation will not be accomplished by the Mapping Sciences Laboratory, but by agencies such as U.S. Army TOPOCOM, U.S. Geological Survey and USAF Aeronautical Chart and Information Center.

Table 2 lists the photogrammetric equipments currently in the Mapping Sciences Laboratory. The capabilities of some of the more important MSL instruments such as the Automated Stereoplotters, Comparators and Point Marking and Transfer Devices will be briefly summarized in the following sections.

3.1 AUTOMATED STEREOPLOTTERS

The Bendix/OMI AS-11A Analytical Stereoplotter should be used extensively during photogrammetric reduction of the lunar mapping photography. Basically, this instrument uses a digital computer to mathematically simulate the geometry of the original photography. The computer contributes to overall accuracy by correcting for known or predictable factors such as lens distortion, film shrinkage, and systematic model deformation. The AS-11A is a versatile system in that it provides for the handling of a wide range of camera focal lengths, frame or panoramic photographs, and vertical or convergent types

TABLE 2

EQUIPMENTS IN MAPPING SCIENCES PHOTOGRAMMETRIC LABORATORY

- AUTOMATED STEREOPLOTTERS

AS-11A, Analytical Stereoplotter
B-8 Stereomat, Automated Plotter

- STEREOPLOTTERS

Wild B-8 Stereoplotter

- COMPARATOR SYSTEMS FOR COORDINATE MENSURATION

Mann 1210 Comparator (in clean room)
Mann 1205 Stellar Comparator (on order)

- POINT MARKING AND TRANSFERRING DEVICES

B&L Multi-scale Point Transfer Device (on order)
Wild PUG-3 Point Transfer Device (in clean room)
Zeiss Snap Markers

- RECTIFIERS

High Tilt Photogrammetric Rectifier

- IMAGE INTERPRETATION EQUIPMENTS

Richards Multisensor Light Table with Stereoscope

- COMPUTER/CALCULATORS

Olivetti-Underwood Programma 101 Calculator

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of photography. Semi-automatic interior, relative, and absolute orientation procedures are employed to simplify the problem of initial model setup.

With the use of automation modules, automatic stereo perception and automatic contouring/profiling modes can be provided which reduce the need for manual system operations. Automatic operation is effected by use of an electronic image scanning and correlation system controlled by the digital computer.

The B-8 Stereomat Automatic Plotter, on the other hand, is not quite as versatile as the AS-11A since it can handle only 6-inch focal length, 9 x 9 inch photographic inputs. In order for this instrument to accommodate the 3-inch focal length lunar metric photography, an appropriate 2X precision enlargement to the 9 x 9 inch image format would be required. Briefly, the Stereomat employs flying spot scanning with a random scan. The size of the pattern is controlled by a signal indicating with a random scan. The size of the pattern is controlled by a signal indicating the magnitude of terrain slope. The Stereomat is capable of automatic contouring, automatic profiling and automatic relative orientation. An important feature of the B-8 Stereomat is its capability to produce orthophotographs. Orthophoto prints can be obtained in approximately 1-1/2 to 2 hours, while the average time for an automatic relative orientation of a stereo model is from 3 to 4 minutes.

3.2 COMPARATOR SYSTEMS FOR COORDINATE MENSURATION

Comparators will be used extensively by MSL, particularly during the coordinate measurement and reduction of stellar photographic data. A Mann-type 1205 Stellar Comparator, in particular, will be a vital adjunct to the presently available equipments in MSL. This equipment is presently on order.

Basically, the Mann 1205 Comparator is a versatile two-coordinate semi-automatic stellar comparator used principally for high precision measurements of star and satellite images contained on photographic glass plates and cut film. The slewing speed, continuously variable to 360mm/minute, and

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the automatic determination of the photocentric position of the images enable the determination of image positions with a four-fold increase in speed over measurements made on conventional comparators. Precise coordinate measurement over a 10 x 10 inch area is accomplished by movement of precision screw driven stages.

Since the Mann 1205 Comparator is a semi-automatic instrument, a basic question could arise relative to its capability for distinguishing between stellar images and reseau crosses. Due to the fact that a reseau pattern (series of crosses spaced 10mm apart on terrain and 5mm apart on stellar) will be recorded on each stellar and terrain frame, precautions must be taken to insure that there will be no interference with the instrument's reading capabilities. This specific problem will be discussed with the various government map support agencies and industry representatives familiar with automated mensuration techniques. Pertinent conclusions and/or recommendations will be presented in the final report.

3.3 POINT MARKING AND TRANSFER DEVICES

The point marking and transfer functions can be satisfied with existing equipments in MSL (refer to Table 2). The B&L Multiscale Point Transfer Device (presently on order), in particular, will provide the laboratory with added capabilities by enabling precision identification, selection, and marking of conjugate image points on the lunar terrain photography. It can transfer points from one photograph to corresponding imagery on the second photograph of the same terrain. One or both photographs of the stereo pair can be marked. Marking system accuracy is within 1 micron standard error. The instrument is also equipped with both visual readout and an automatic card punch system to record point coordinates along with other data pertinent to each photograph and to make this data available for rapid retrieval at a later time.

The Wild PUG is a device consisting of two movable glass tables, a binocular stereoscopic viewing system with a reference half-mark in each optical path, and a pair of mechanical drills collinear with the half-marks. The tables are illuminated from above for stereoscopic marking and from below for

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general examination of the diapositives. The instrument provides a precision of 2 to 3 microns, well within the requirements of the lunar mapping mission.

3.4 DYNAMIC AUXILIARY DATA BLOCK READING

Each photographic frame of MCS terrain and stellar photography will contain dynamic auxiliary data in the form of binary coded words which record the variables of time, altitude, index word and shutter speed (terrain camera only). The matrix format for the terrain camera data block will be 4 x 32, whereas the format of the stellar camera data block matrix will be 3 x 32. Binary coded data presented in this format will be of little value to the user unless it can be read and translated into human readable form. The Mapping Sciences Laboratory, at present, does not have equipments capable of automatically reading binary coded data formats of this type. Fairchild Space and Defense Systems is presently examining the MCS data block reading problem in detail.

4. MCS COMPATIBILITY STUDY IMPLEMENTATION PLAN

In a recent paper on lunar photogrammetry, F. Doyle* stated the following:

"Studies of plotting equipment adaptability should be carried out in parallel with the development of camera systems and mission plans to provide the basis for selection of available instrumentation, or the justification for new development. It is apparent that the future course of lunar exploration will depend heavily upon photogrammetric scientists taking a leading and active role in the development of camera systems and data reduction systems".

The above statement concisely outlines the purpose of the MCS Compatibility Study. The results presented in this report represent only the first phase of

*Doyle, F.J., 1968, Photogrammetric geodesy on the moon: Annual Meeting, American Society Photogrammetry, March 1968.

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the compatibility evaluation. Investigations are currently in progress which will lead to further recommendation pertaining to MCS compatibility with existing NASA MSC data reduction techniques and with existing and/or new equipment development requirements.

The implementation plan for completing the MCS compatibility evaluation is presented in Table 3. The plan identifies, in an orderly progression, the series of objectives whose major tasks will lead to the fastest, most efficient achievement of the desired results. Specifically, the three major objectives of the study are:

- Continuing review of existing data reduction techniques/
equipments
- Define MCS equipment support requirements
- Prepare final report

TABLE 3
IMPLEMENTATION PLAN
MCS COMPATIBILITY STUDY

OBJECTIVE	TASK	RESULTS
I. Continuing Review of Existing Data Reduction Techniques/Equipments	1.1 Contact the following government map compilation and research support agencies relative to discussing MCS equipment compatibility requirements. a) ACIC b) U. S. G. S. c) U. S. Army TOPOCOM d) U. S. C. and G. S. e) NASA Headquarters f) DOD M. C. and G. 1.2 Review current data reduction techniques/equipments for: a) Photographic processing b) Reproduction/conversion (1) Contact printing (2) Enlargement printing (3) Diapositive printing (4) Rectification printing c) Coordinate mensuration (1) Mono comparators (2) Stereo comparators (3) Automated comparators	1. Summary of data reduction techniques/equipments currently used for photogrammetric and map compilation. 2. Delineation of user data requirements relative to MCS photography 3. Selected flow diagrams summarizing current user data handling procedures. 4. Identification of special problems relative to handling/reducing 3-inch focal length metric photography.

TABLE 3
IMPLEMENTATION PLAN
MCS COMPATIBILITY STUDY
 (continued)

OBJECTIVE	TASK	RESULTS
I. Continuing Review of Existing Data Reduction Techniques/Equipments	d) Plotting (1) Stereoplotters (2) Automated analytical stereoplotters e) Auxiliary data reading f) Film titling 1.3 Review user data requirements such as desired input product forms, format sizes, etc. 1.4 Determine current user data flow models. 1.5 Coordinate results with NASA PTL and MSL.	
II. Define MCS Equipment Support Requirements (Insure Equipment Compatibility)	2.1 Correlate all user equipment/requirement data acquired during Phase I. 2.2 Analyze user requirement data in terms of MCS equipment compatibility.	5. Recommendations pertaining to specific equipments/techniques to be used in reducing MCS data, including new equipment development required to insure NASA MCS compatibility.

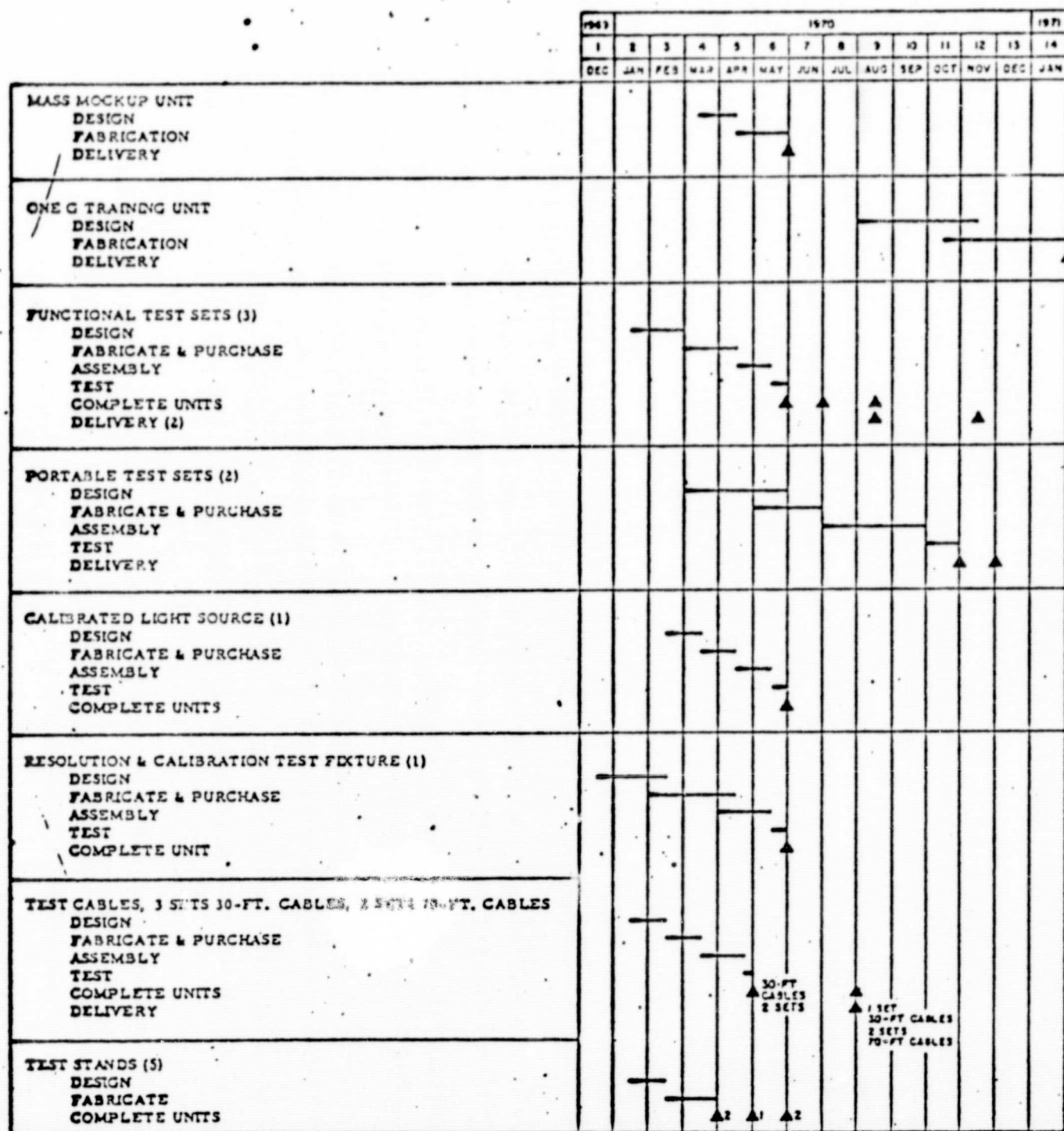
TABLE 3

IMPLEMENTATION PLAN

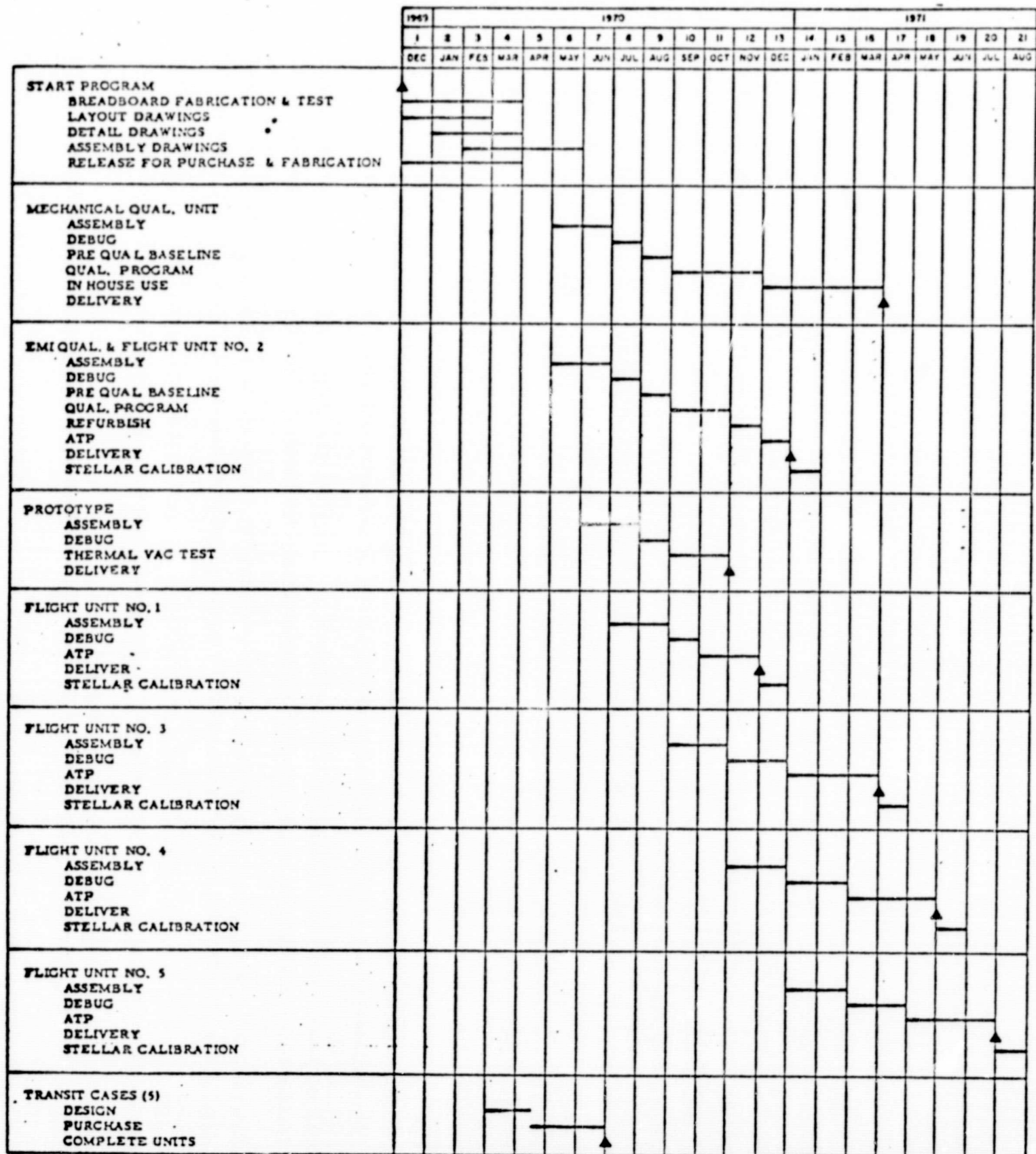
MCS COMPATIBILITY STUDY

(continued)

OBJECTIVE	TASK	RESULTS
II. Define MCS Equipment Support Requirements (Insure Equipment Compatibility)	2.3 Identify specific existing and/or new equipments required to reduce MCS image data. 2.4 Coordinate results with NASA, MSL and PTL.	
II. Prepare Final Report	3.1 Organize all previous study findings (reports, tabulations, flow diagrams, etc.) pertaining to Phases I and II. 3.2 Publish final report. 3.3 Submit final report to customer.	6. Final Report summarizing all technical efforts relating to MCS equipment support requirements, including recommendations.



MAJOR MILESTONE CHART - AGE



MAJOR MILESTONE CHART - CAMERA

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APPENDIX D

SYNCHRONIZATION OF MCS EXPERIMENT DATA WITH OTHER EXPERIMENT SYSTEMS

To obtain lunar photography that provides the maximum mapping information possible, it is necessary to operate at cycling rates that provide a fixed photo end lap. One operating mode of the MC results in stereo models consisting of photo pairs covering 22 percent of the format. This results in a base-height ratio of about 1.0 and a stereo model end lap of about 10 percent. This mode of operation precludes random time synchronization of the center-of-exposure of the MC to commands furnished by other experiments.

Selenographic ties between the MC and other experiments can be obtained by commanding the MC to operate during the time other experiments are in progress. If these experiments are tied to the same vehicle time that is recorded at the center of MC exposure, a basis for post flight correlation would be established.

A data request signal is provided, as an MC output, that corresponds to the MC center-of-exposure. This can be used as synchronization signals by other experiments. The characteristics of the data request signal are described in Document No. 1231-DB-13.