

UNITED STATES GOVERNMENT

2-Way Memo

Subject:

July 7 HHSEP Interface
Conference

To:



Jim Ragg

#283

DATE OF MESSAGE	6/23/66
DATE OF REPLY	
INSTRUCTIONS Use routing symbols whenever possible. SENDER: Forward original and one copy. Conserve space. RECEIVER: Reply below the message, keep one copy, return one copy.	

5027-101

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USE BRIEF, INFORMAL LANGUAGE

FOLD

Enclosed is a list of typical areas of interest on the HHSEP program which some of your words in this Preliminary Report on Surveyor Results might answer.

Enclosed is a not-too-absolute Formulation Manual about us.

I'll send you a copy of the agenda when it's printed (2-3 days).

From:

Jim Church
HHSEP Project Office - EX 22
X 5243

Data Bank
ALSEP papers
#2

BENDIX HOU

BENDIX SYSTEMS DIV ANN ARBOR MICH 313-665-6687 6-21-66 10/44 AM

BENDIX CORPORATION
HOUSTON, TEXAS

ATTENTION... M. E. DONNELLY
TWX NUMBER S-1471

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J. CHURCH

IN ACCORDANCE WITH YOUR REQUEST LAST WEEK THESE ARE THE SUBJECTS
WE WOULD LIKE DISCUSSED ON JULY 7 FROM SURVEYOR.
GENERAL CONFIGURATION AND LOCATION OF ALL TEMPERATURE SENSORS.
SPECIFIC DESIGN CONFIGURATION OF ALL THERMALLY CONTROLLED COMPART-
MENTS - INCLUDING DESIGN DETAILS AND BACK UP DESIGN ANALYSIS.
TIME/TEMPERATURE PROFILE OF ALL TEMPERATURE SENSORS /INCLUDING
CALIBRATION DATE/ FROM INITIAL ACTIVATION THROUGH TWILIGHT AND INTO
NIGHT AS LONG AS DATA IS AVAILABLE.

LIST OF ALL OTHER SCIENTIFIC AND ENGINEERING DATA AVAILABLE.

ADDITIONAL DATA WILL BE REQUESTED AFTER EXAMINATION OF THIS LIST:

- CLOSE UP PHOTOGRAPHS OF LANDING PAD IMPACT AREA.
- ROCK SIZE AND DISTRIBUTION.
- PHOTOGRAPHS AND ANALYTICAL RESULTS SHOWING BOTH SHORT AND LONG
PERIOD SLOPE CHARACTERISTICS.
- ESTIMATE OF BEARING STRENGTH AND DEPTH OF UNCONSOLIDATED SURFACE
MATERIAL.
- ESTIMATE OF DEGREE OF SURFACE MATERIAL CONSOLIDATION/NEEDED TO
ESTIMATE SETTLING CHARACTERISTICS OF CENTRAL STATION/.
- ESTIMATE OF STATIC ELECTRIC CHARGE EFFECTS, IF ANY.
- CONSOLIDATED PHOTOGRAPH OF HORIZON.
- ESTIMATE OF BEST MATERIAL FOR SURFACE SIMULATION.

J. F. CLAYTON
BENDIX SYSTEMS DIVISION
ANN ARBOR, MICHIGAN

END PLS ACK

BENDIX HOU
✓

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PREFACE

The end products of Phase I of the ALSEP Program consist of detailed equipment design and a program plan for the future design verification, manufacture, test, delivery, and operational support of the equipment. The design of the ALSEP, including all of the selected experiments, is described elsewhere in drawings, specifications, mockups, and the Familiarization Manual. The program plan is a series of 18 separate plans which describe all of the tasks, schedules, facilities, manpower, vendors, and all other resources required to deliver ALSEP.

The plans for Phase II are divided into three classes. The first class is the Functional Plans. These describe, via master schedules and brief accompanying narrative, what each of the functional subdivisions of the Bendix ALSEP organization will accomplish in Phase II. In general, the functional plans bear a one-to-one relationship with the Bendix organization. These plans are essentially an expansion of the Phase II work statement. They describe what will be done and when. They also describe what will not be done and why, in areas where there may be potential uncertainty or ambiguity. The functional plans are:

Integrated Test Plan

Test Plan

Qualification Test Plan

Ground Operations Plan

GSE Development and Test Plan

Reliability Plan

Quality Plan

Support Plan

Training Plan

Facilities Plan

Manufacturing Plan

Configuration Management Plan

Engineering Plan

Mission and Crew Engineering Plan

The second class of plans is the Management Control Plans. There are 16 of these corresponding to the 16 organizational subdivisions one level below the ALSEP Department Managers. Management control plans describe all of the tasks of Phase II, their end products, and the manpower and materials required to accomplish the tasks, all spread over time. There is a specific individual in the Bendix ALSEP organization responsible for each Management Control Plan. The Management Control Plans can be related to the functional plans and consist of:

System Engineering

Mechanical and Thermal Design Engineering

Experiments Engineering

Data Subsystem Engineering

GSE Engineering

Development Test Support - Test Department

Test Plans and Procedures - Test Department

Factory and KSC Operations - Test Department

Electronics Manufacturing

Mechanical Manufacturing

GSE Manufacturing

Program Control

Mission and Crew Engineering

Support and Crew Engineering

Support Engineering

Quality Assurance

Reliability Engineering

The third class of plans is management documents, which include the procedures and methods by which Bendix will produce the Phase II end products. They include program costs and other matters of business management. These are:

Program Plan

Management Plan

Phase II Incentive Proposal

PERT and Companion Cost Plan

Make or Buy Plan

Documentation Plan

The functional plans have been prepared as handbooks for all levels of supervision in the Bendix ALSEP program organization in Phase II. The management control plans contain the final work statements and Project Work Orders for the complete Phase II program. Project Work Orders are Bendix internal financial management authorizations which fund project engineers.

Preparation of these plans was begun in the first month of the six-month ALSEP Phase I program. The preparation was itself controlled

by a management control plan. Over 100 specific planning tasks were defined. The tangible end products of these tasks were collected for this final publication. In all cases, these plans were prepared by the supervisors who will have responsibility for carrying them out in Phase II.

During Phase I, Bendix has given substantial weight to the planning tasks and especially to the management control aspects of them. The program management procedures preferred by the MSC Experiments Project Office are identical to those which are standard within Bendix Systems Division.

Bendix believes that the ALSEP program does not require a large organization in terms of number of people and square feet of plant area; rather it is ideally suited to an experienced but smaller and well organized team with plant and test facilities commensurate with the quality requirements of the experiment package. These plans describe the Bendix Systems Division personnel, procedures, and facilities which meet these criteria.

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FOREWORD

Much of what is known about the continental regions of the earth today is a product of field geology techniques supplemented by geochemical studies of rock samples which have been returned to the laboratory. The geologist goes into the field and studies the layering of the rocks and the layer variations. Samples of these rocks are returned to the laboratory for more detailed study. In the laboratory the geochemist and the petrologist can determine, by the study of thin rock samples, the mineral content of the rocks, their orientation, and something of their origin.

When the astronaut explores the lunar surface, he will obtain rock samples in a similar fashion and return them to the earth for detailed examination. One of the most interesting questions to be answered will be the degree of differentiation, that is, to what extent has a presumably homogeneous body separated into rocks of different types. On the earth we have rocks that are more or less basic, the granite-type rocks and the basaltic-type rocks, with an almost bewildering variety of mineral combinations. The astronomical information we have, so far, does not permit us to determine to what extent such differentiation has taken place on the moon. Another question of great scientific interest to the geologist is the degree of layer exposure that exists on the moon. On earth this exposure is readily available from erosion or by man's intervention in nature. The same sort of exposure may occur on the moon in regions of faulting. Whatever the cause, these exposures provide the geologist an opportunity to study the layering of the rocks as it occurs in depth and it is only with this exposure or with drill samples that geologists can directly obtain samples for measurement.

The Apollo program provides the opportunity for these advanced scientific studies of the moon. The primary areas of interest in this program are geology, geophysics, and geochemistry, as they relate to the moon itself, and the use of the moon as a base for the study of interplanetary space and interplanetary space travel.

As part of the Apollo Program for manned lunar landing and exploration, the Manned Spacecraft Center of the National Aeronautics and Space Administration has issued contracts for the design of a package of scientific instruments, known as the Apollo Lunar Surface Experiments Package (ALSEP), to be transported to the moon aboard the Lunar Excursion Module (LEM) and emplaced by the astronaut.

The geological aspects of the lunar surface will be partially determined by a study of the lunar soil and rock samples which will be obtained by the crew with the aid of the Apollo Lunar Geological Equipment (ALGE). These samples will be stored in the LEM ascent stage for return to the earth for detailed laboratory analysis. The ALGE is packaged and stowed in the same area as that provided for ALSEP.

The ALSEP will supply the long-term scientific measurements necessary to achieve the scientific objectives of the Apollo Program. The ALSEP is comprised of seven scientific experiments and the supporting subsystems required to effectively collect scientific data in the lunar environment.

The data obtained by the ALSEP experiments, particularly the active and passive seismic experiments, will provide supplemental data for the geological studies in addition to providing scientific data which will stand on their own merits.

SECTION 1

INTRODUCTION

This Manual is submitted in compliance with Section 11.1 of Exhibit C of the contract, which states: "The contractor shall provide a Familiarization Manual which describes the complete ALSEP and its GSE. Each item of equipment shall be described in general terms but with sufficient detail to convey a clear understanding of the ALSEP including the operation of each item of equipment and the earth receiving stations".

SECTION 2

SYSTEM DESCRIPTION

The ALSEP System is comprised of a set of experiment and supporting subsystems which are deployed and emplaced by an Apollo astronaut on the lunar surface to collect, format, and transmit geophysical and other scientific data to the earth. Seven separate experiments have been selected by NASA and grouped into two primary combinations: Array A and Array B. Table 2-1 presents the flight assignments for the two experiment arrays.

The ALSEP is designed to operate in conjunction with the Manned Space Flight Network (MSFN), and contains in addition to the scientific experiments the following supporting subsystems: (1) Data Subsystem, (2) Structure/Thermal Subsystem, (3) Electrical Power Subsystem, and (4) Ground Support Equipment (GSE).

Since ALSEP systems will be placed at various sites on the lunar surface during the early stages of the Apollo program, provision has been made for the simultaneous operation of three ALSEP systems without communications interference.

TABLE 2-1

ALSEP EXPERIMENT FLIGHT ASSIGNMENTS

Experiment	Array A	Array B	Array A Backup	Array B Backup
Magnetometer	x			x
Suprathermal Ion Detector	x	x		
Passive Seismometer	x	x		
Solar Wind	x			x
Heat Flow		x	x	
Electron/Proton		x	x	
Active Seismometer		x	x	

The ALSEP/ALGE scientific equipment bay in the LEM descent stage is shown in Figure 2-1, with Compartments 1 and 2 identified. Compartment 1 contains all experiments and the data subsystem. Compartment 2 contains the power subsystem and the Apollo Lunar Geological Equipment (ALGE). The separate cask used for fuel shipment is carried on struts mounted to LEM hard points adjacent to Compartment 2.

Figure 2-2 shows the equipment as it is packaged and installed in Compartments 1 and 2 during lunar transit. The ALGE is accessible for independent removal.

Figure 2-2 also shows the mounting tabs through which "pip" pins secure the compartment in the LEM. There are two pairs of bullet pins in the rear of the compartments and the tab "pip" pin arrangement in the front of the compartments.

The weights in the two compartments are approximately 92 and 95 lb with 22 lb of external equipment (this is for Array A, but does not change appreciably for Array B). In all cases, the center of gravity location is within the GAEC requirement.

Figure 2-3 shows the method of mounting the separate fuel cask. Struts are provided to pick up GAEC-designated LEM hard points. Included in the cask mounting structure is the rotation/tilt mechanism. This cask rotation (see Figure 2-4) is the first unloading step. It places the thermal insulation originally used to reduce the heat load into the LEM between the cask and the astronaut during ALSEP unloading. The cask tilt mechanism provides the proper cask attitude for extracting the fuel capsule during fuel transfer, regardless of the LEM attitude.

Figure 2-5 shows Compartment 2 with the ALGE tool box and Lunar Drill. This equipment has a volume of 3 cu ft and weighs 60 lb. These boxes are attached to the ALSEP mounting pallet using the same bullet pin-tab approach employed for the total compartment. These boxes represent a volume allocation only and may be reconfigured when the ALGE is fully defined. Figure 2-6 shows Compartment 2 with the ALGE removed. The RTG and PCU once installed at the factory are never removed from their pallet.

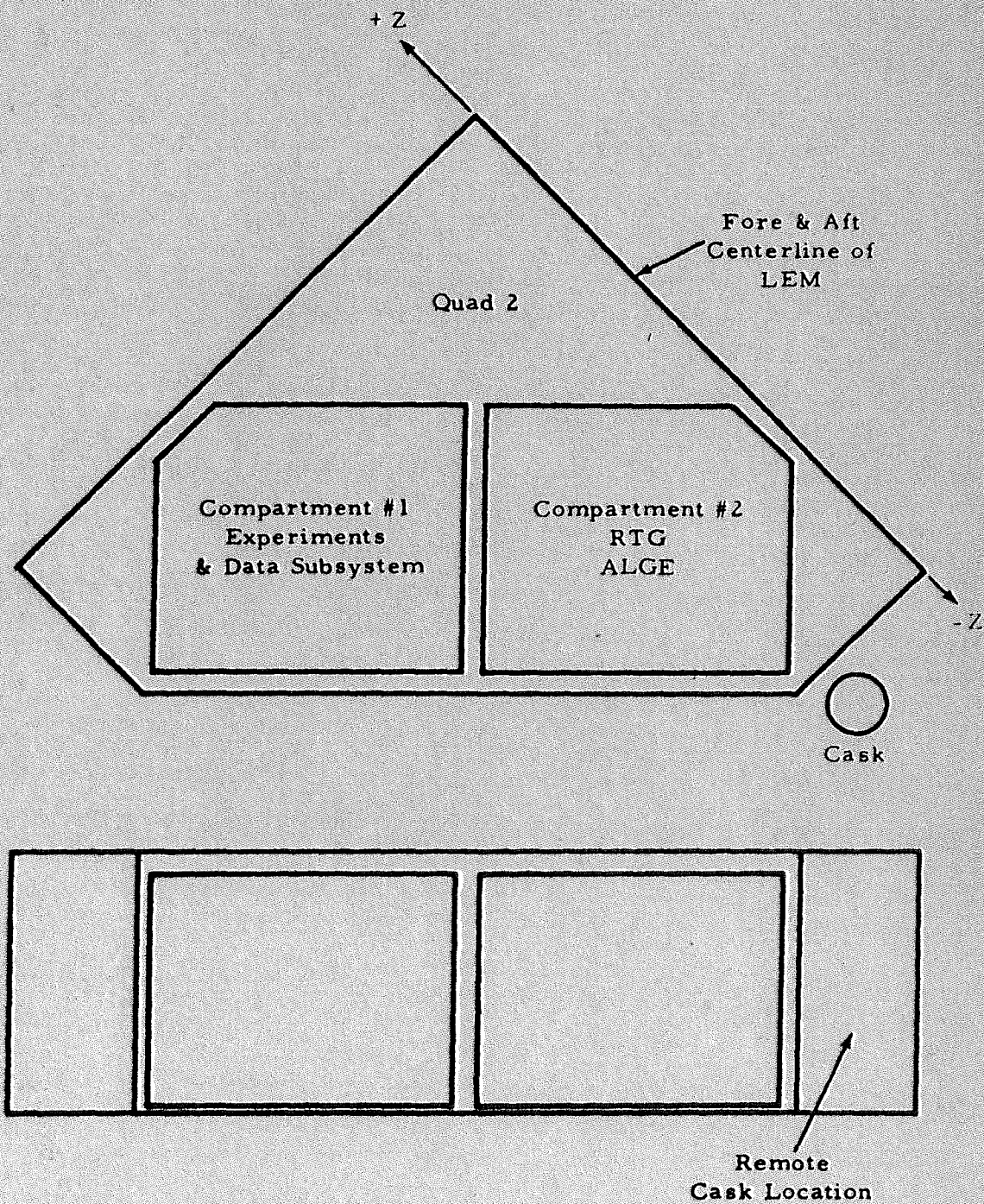


Figure 2-1 ALSEP Location in LEM

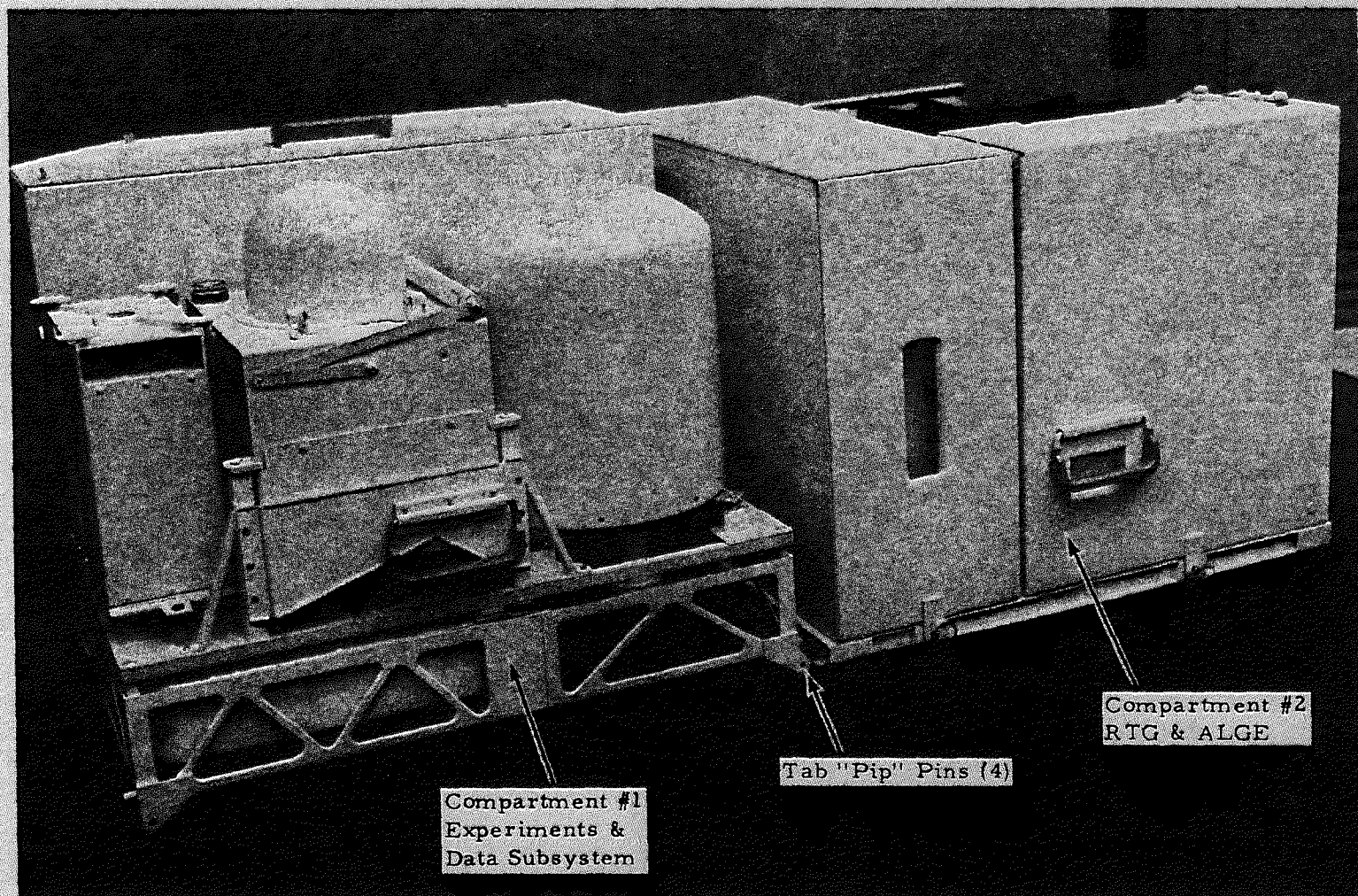


Figure 2-2 Stowed Configuration-Array "A"

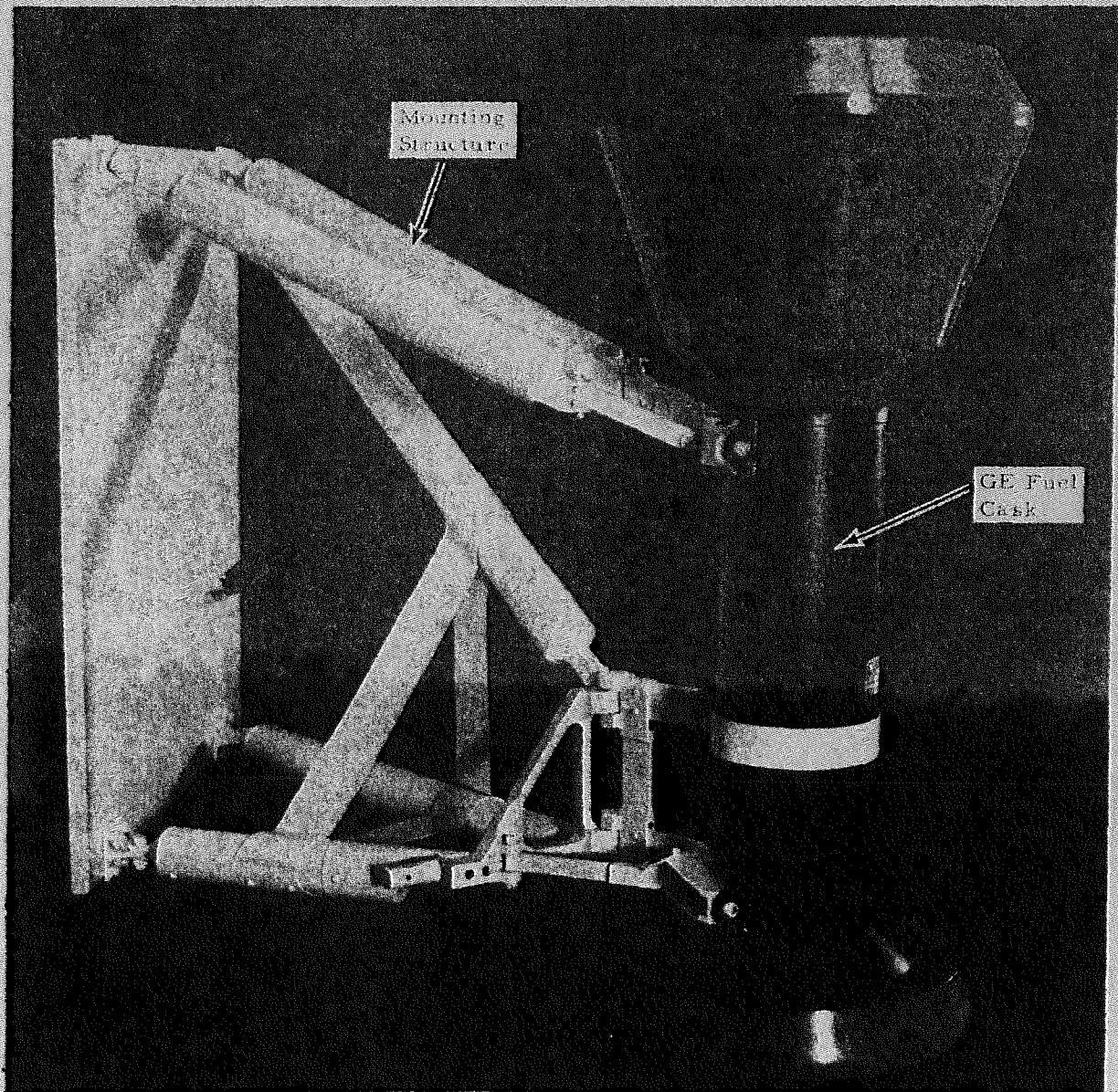


Figure 2-3 Fuel Cask Mounting

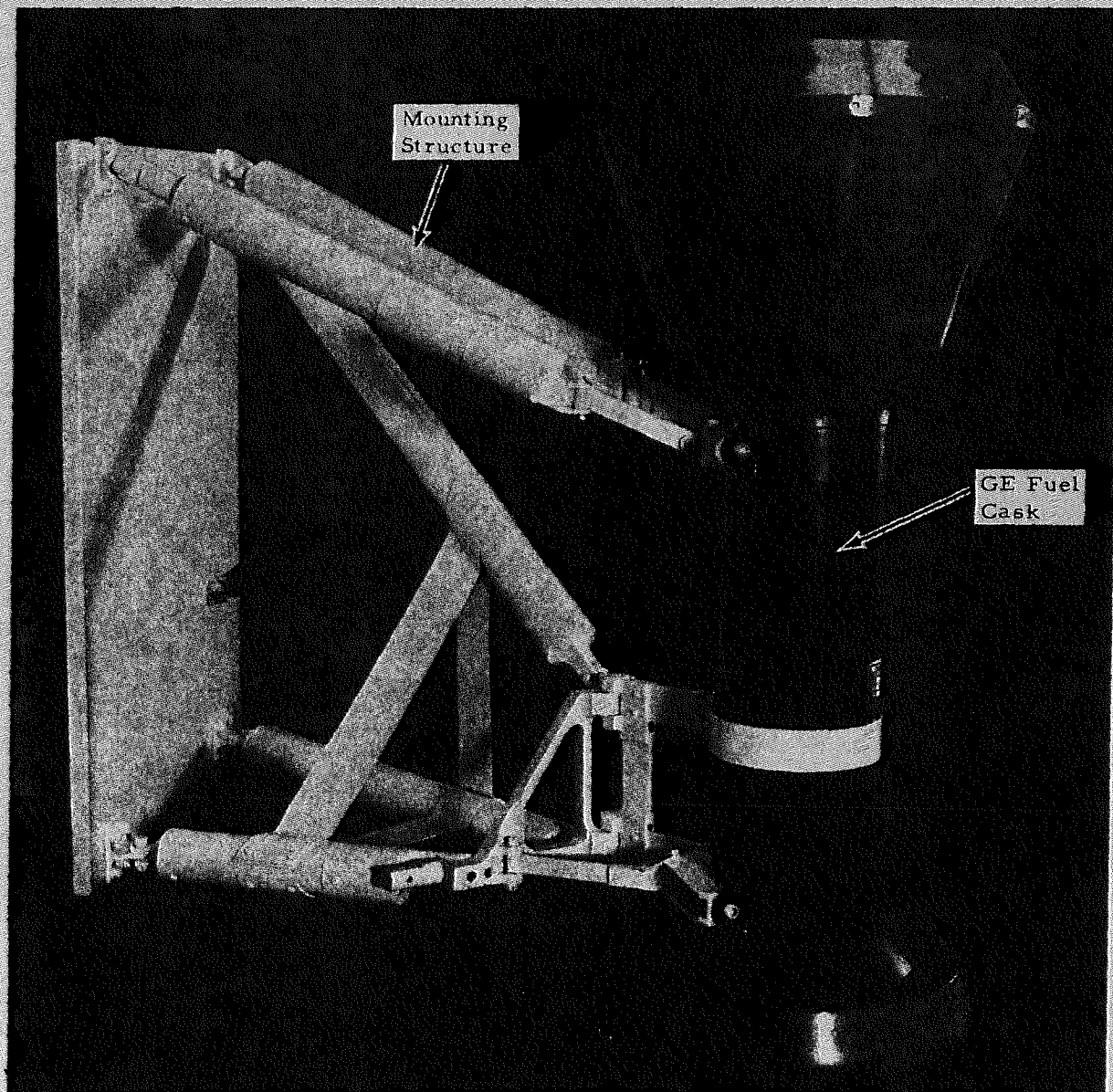


Figure 2-3 Fuel Cask Mounting

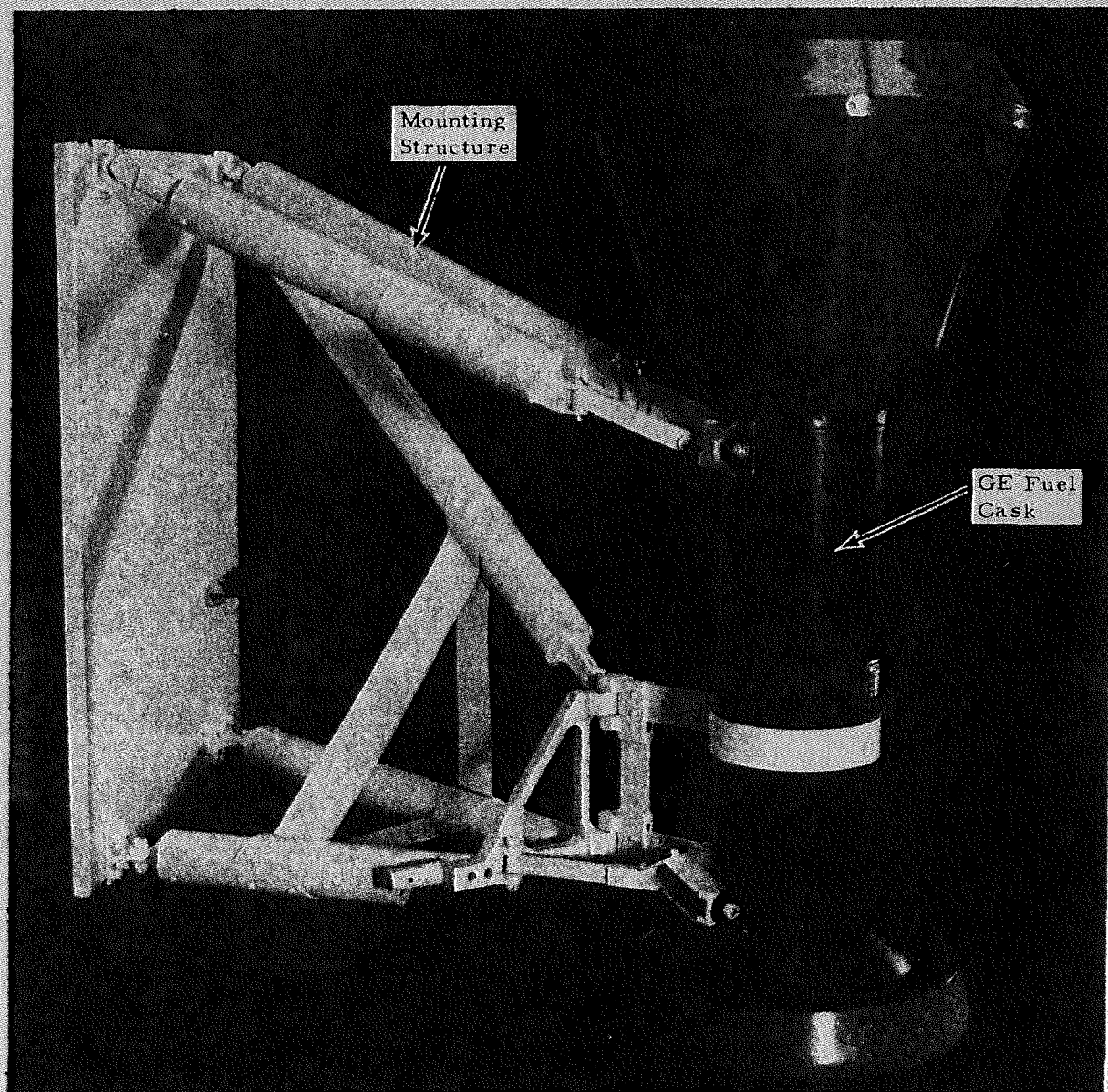


Figure 2-3 Fuel Cask Mounting

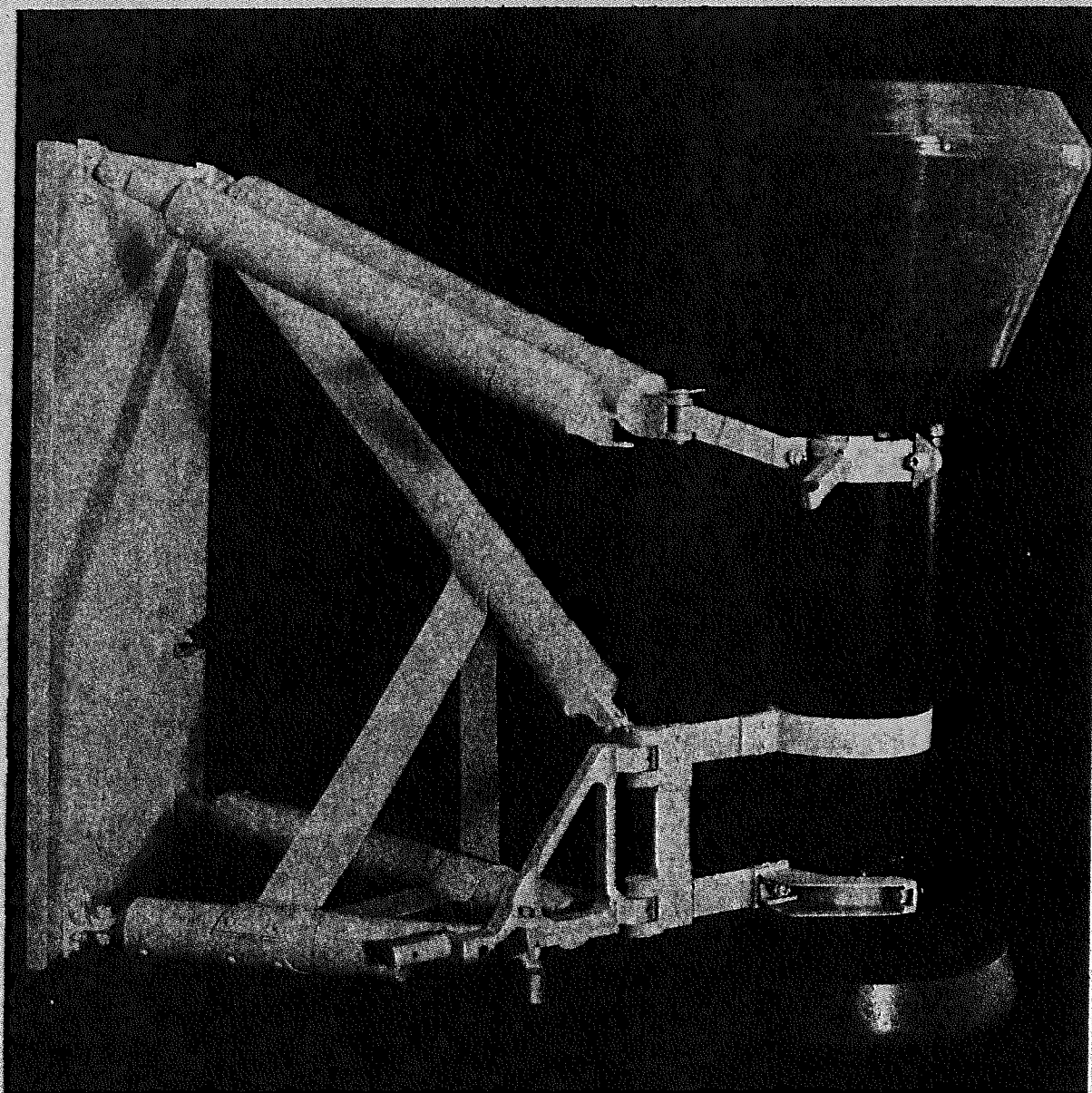


Figure 2-4 Fuel Cask Rotated for Thermal Protection

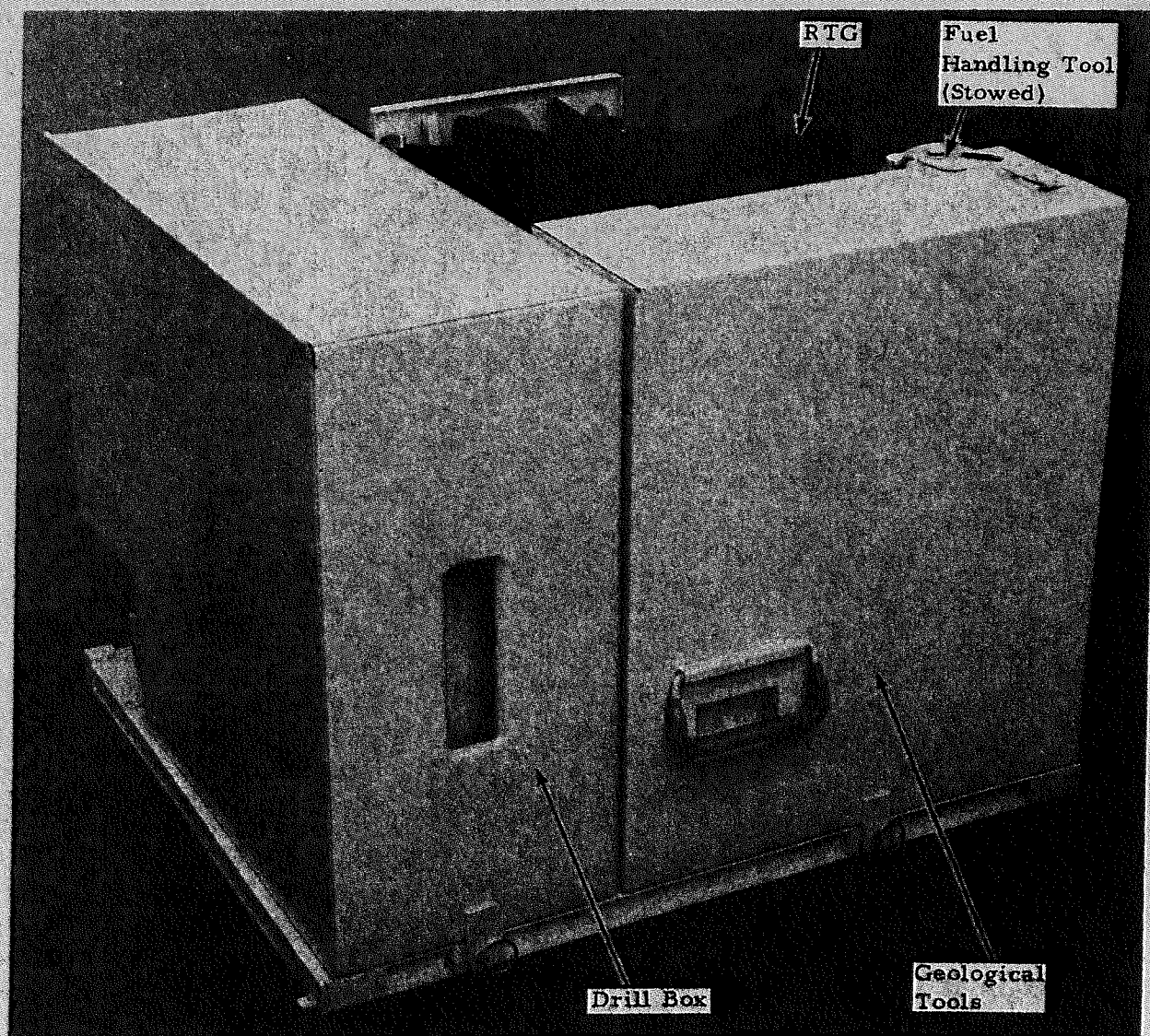


Figure 2-5 Compartment No. 2, RTG/ALGE

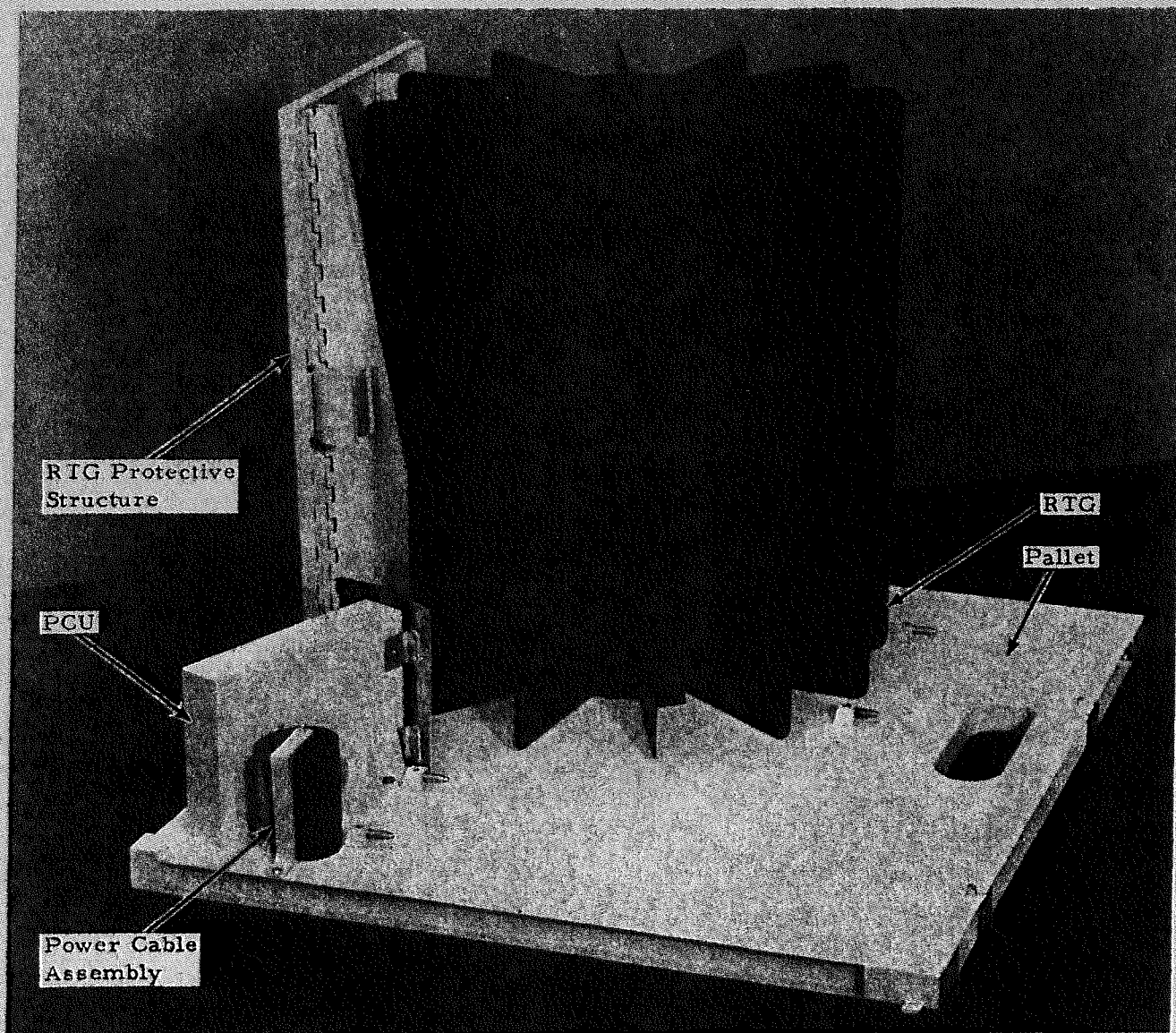


Figure 2-6 RTG-Pallet Compartment No. 1

The ALSEP/ALGE equipment can be extracted from Compartment 2 as a complete unit, if desired, by means of the handle on the ALGE tool box. Alternatively, the ALGE can be removed separately. The mounting pallet has a hand hold for independent removal in the event the ALGE has been previously removed.

The arrangement of experiments shown in Figure 2-7 is Array A. Except for the passive seismometer, which is mounted on the primary structure through shock mounts, the experiments are tied to a pallet with tie-downs at their own hardpoints. Tie-downs are released by applying a 1/4 turn to the fasteners. Release is accomplished by the astronaut from a standing position using a special tool which does not apply a reaction torque to the total package.

The Solar Wind and Suprathermal Ion Detector experiments incorporate dust covers which are released on command after the ascent stage departs. The release mechanism is a mousetrap-type spring. The large box at the rear is the Magnetometer, the data system antenna, and the optical sight. The magnetometer, antenna, and optical sight are enclosed in foam under compression. The foam-restraining box structure is tied to the mounting structure in a manner similar to the other experiments.

The basic structure carrying the flight loads in Compartment 1 is a simple tray and truss configuration. All structural members are aluminum and are riveted throughout. In addition the structure supports the electronics package and provides a base for the antenna mast on the lunar surface.

Mounted permanently to the structure is a central electronic package including all of the data subsystem electronics and all experiment electronics which are not deployed with the experiment. These electronic packages are hard mounted to the underside of the thermal control plate. Connections between the data subsystem and the experiments are permanently made inside the data system. All experiment connections are made prior to LEM installation. Between the thermal plate and the main structure there is a thin enclosure to protect the superinsulation from handling damage either on the ground or on the lunar surface. The structure which supports the experiments in flight serves later as a sunshield for the data subsystem. Extraction of Compartment 1 from LEM is readily accomplished by the handle located in line with the equipment center of gravity.

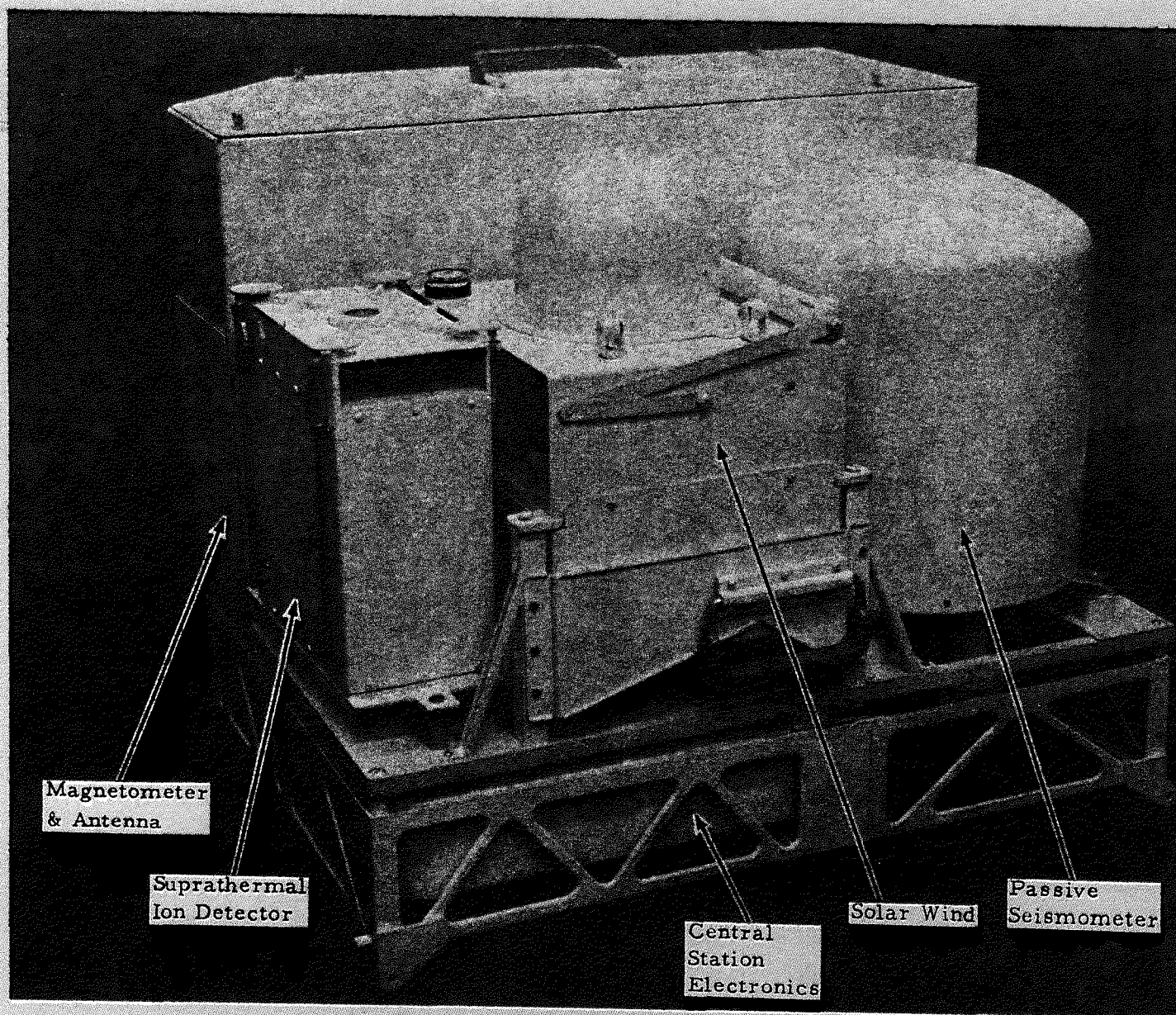


Figure 2-7 Compartment No. 1 - Array "A" Stowed Configuration

Following deployment by the astronaut, the ALSEP station appears as in Figure 2-8 (Array A) or Figure 2-9 (Array B). In both cases the Central Station which contains the data subsystem and undeployed experiment electronics is located about 10 feet away from the RTG and Power Conditioning Unit. This separation distance is necessary to ensure an adequate thermal radiation path to space for the RTG. After the experiments have been removed, the sunshield on the Central Station is automatically raised to its proper position for thermal control. The Central Station is then aligned in azimuth to prevent direct solar illumination of the thermal radiator plate. The antenna is mounted on its mast, and pointed in a direction determined by the earth line of sight and the moon's libration position.

The functional system block diagram is shown in Figure 2-10. Prime power from the RTG is converted and regulated at the Power Conditioning Unit and supplied as required at +29 v, ± 12 v, and +4.5 v to the Data Subsystem and Experiments. A timer in the PCU will interrupt prime power after a predetermined period of one to five years to automatically terminate the ALSEP operation. This timer is a backup to the command link which may not be operative when the system is to be deactivated.

A helical antenna serves for both uplink commands and downlink telemetry through a diplexer to the command receiver and to either of two redundant transmitters.

The command receiver accepts a 2119 Mc phase-modulated signal and produces a composite biphasic-modulated subcarrier and sync subcarrier which is the input to the Command Decoder. The Command Decoder demodulates the data and sync and verifies and decodes the commands.

The selected uplink frequencies for the three flight ALSEPs are 2276.799 Mc, 2227.263 Mc, and 2278.255 Mc.

The Data Processor accepts scientific and engineering data from the experiments and other subsystems, converts analog data, formats the data, and produces a modulated subcarrier. The Data Processor operates in five modes: normal (1060 bps), degraded (530 bps), active seismic short array (10,600 bps), active seismic long array (10,600 bps), and heat flow (1060 bps).

Electrical heaters are incorporated for thermal control during lunar night. Additional heaters are provided to simulate the energy dissipated

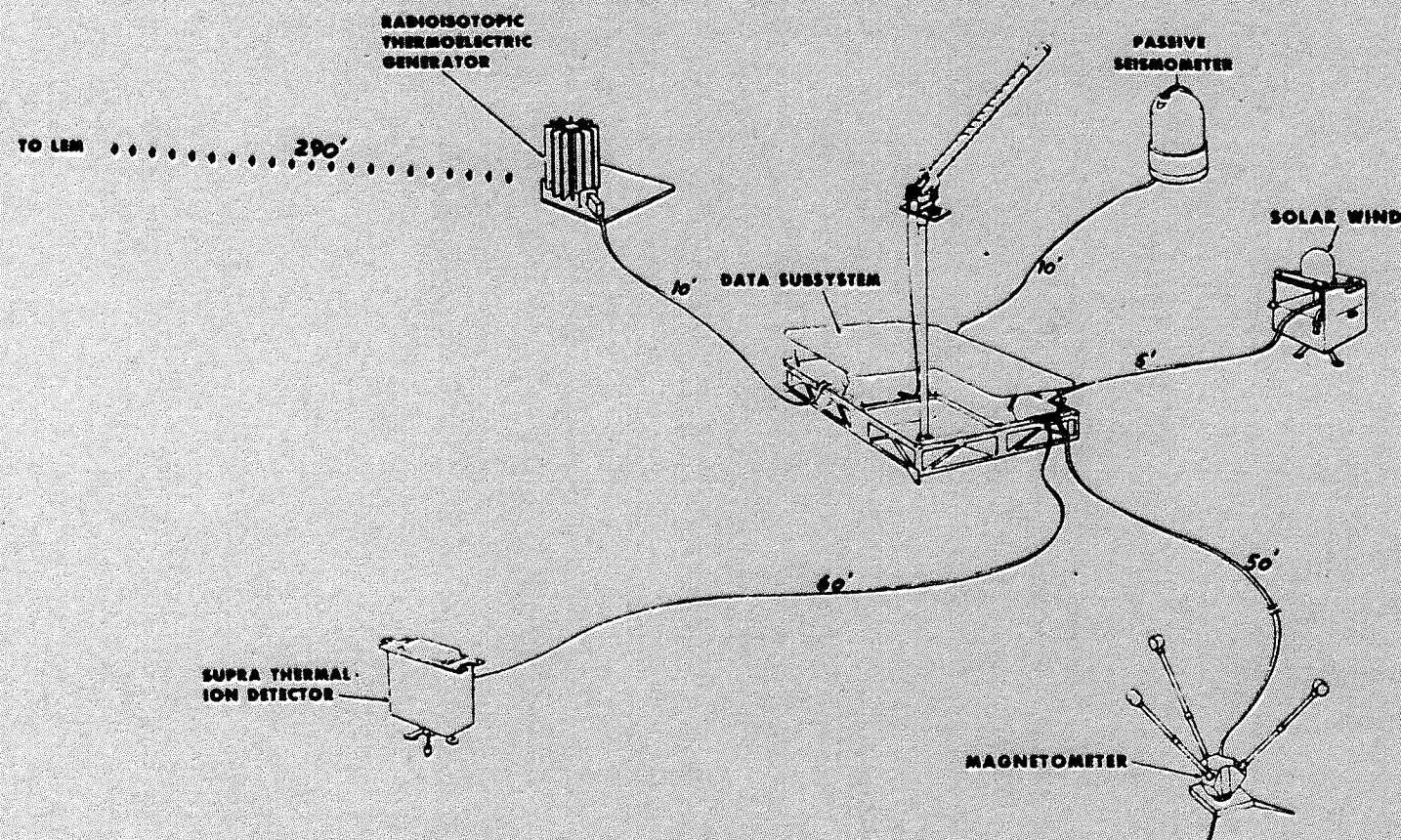


Figure 2-8 Experiment Array "A" Deployed

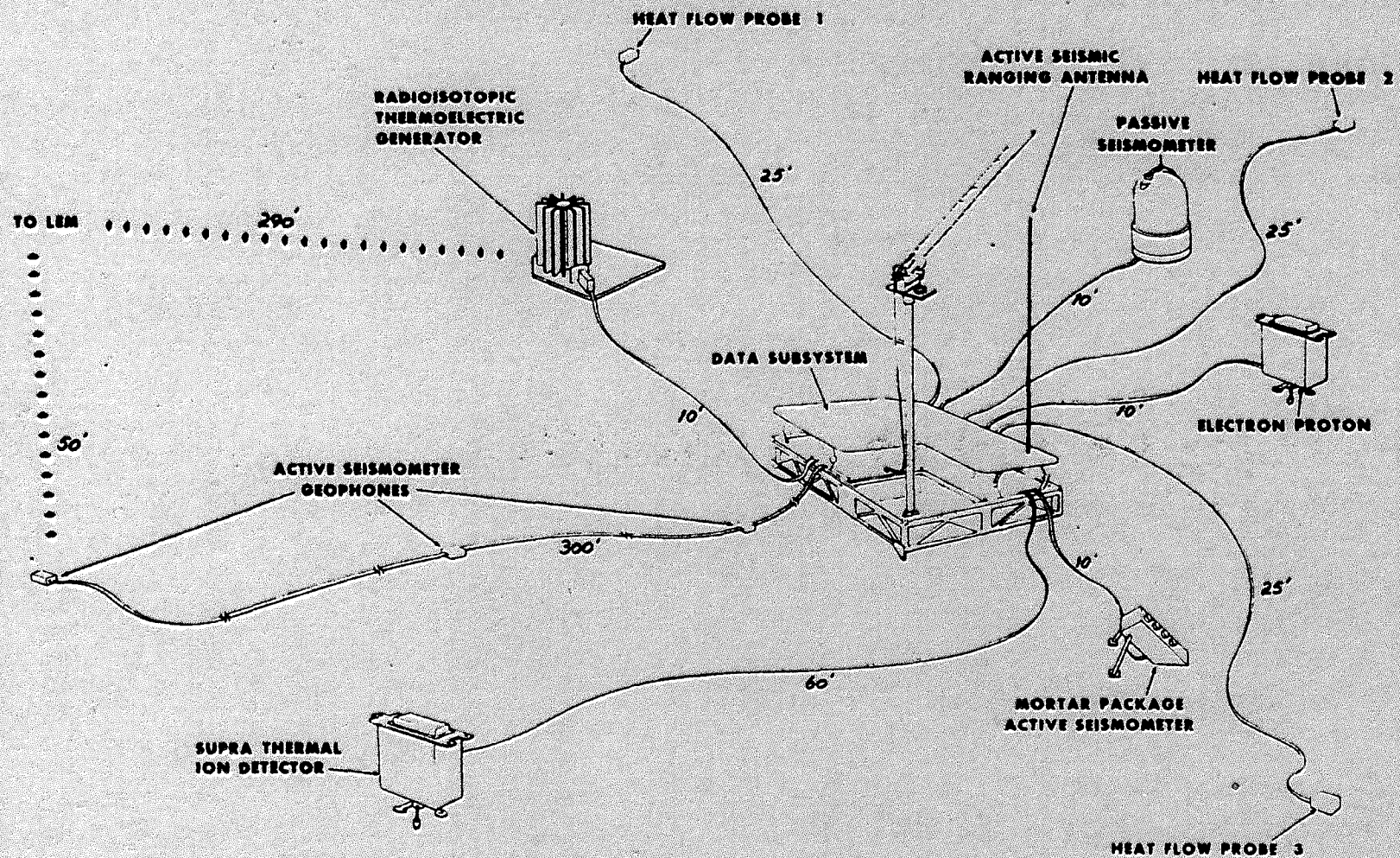


Figure 2-9 Experiment Array "B" Deployed

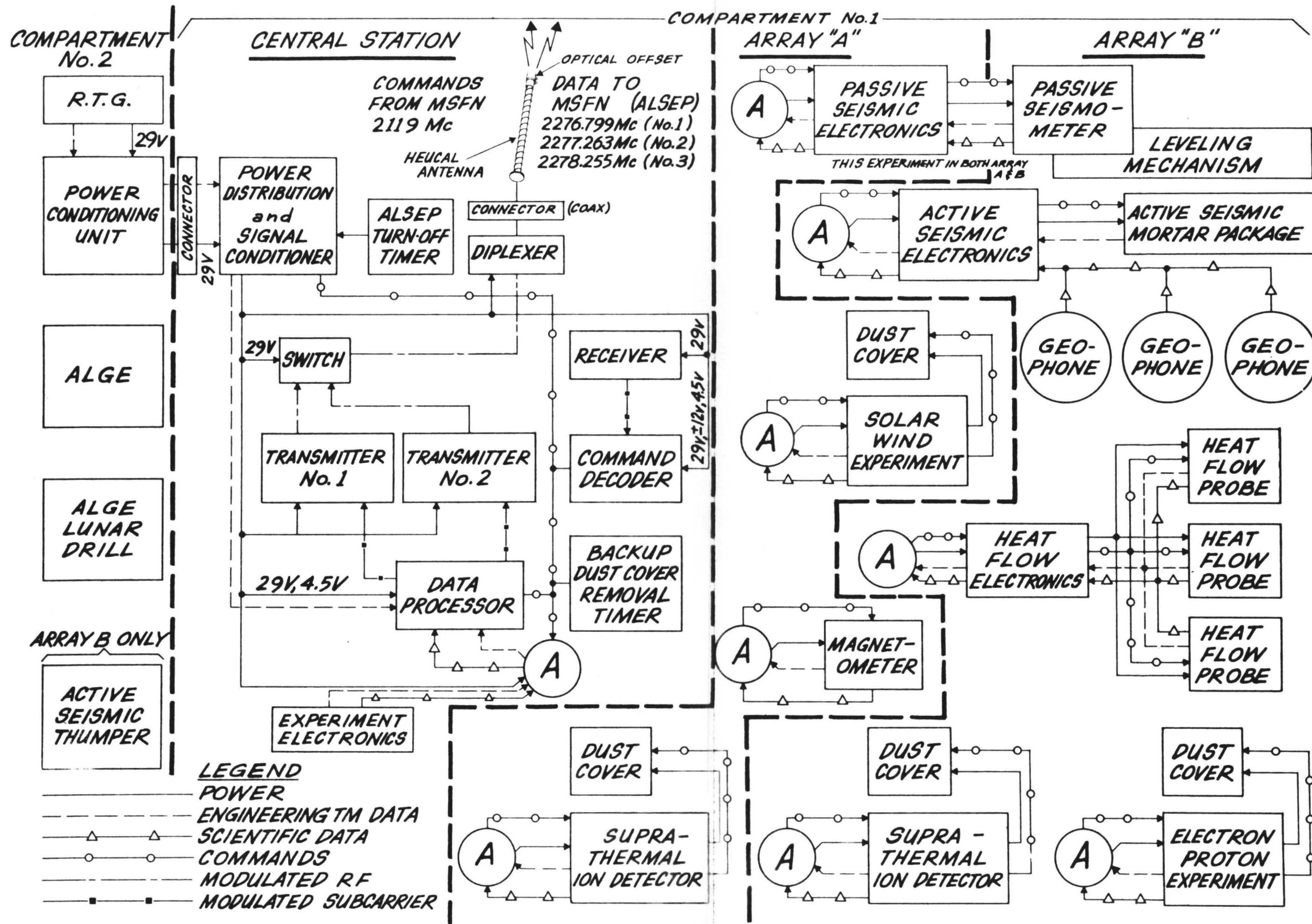


Figure 2-10 System Block Diagram

by various components whose failures would not render the system totally inoperative but would adversely affect the thermal balance since this equipment is no longer dissipating energy. The heaters are automatically actuated to simulate the heat normally dissipated by the inoperative component. These heaters may also be activated by command if the automatic mode fails.

The ALSEP equipment will be tested at the system level prior to assembly into the LEM descent stage. No testing of the ALSEP system after installation is required.

Preinstallation testing is initiated by manual turn-on of the Receiver and Command Decoder. External power and RF commands are inserted into the power and coaxial connectors to test all components except the basic experiment sensors.

Through the RF Command link, the remaining equipments are turned on and "built in" single point calibration circuits are activated. All command functions are then exercised while monitoring the demodulated RF output.

After fuel cask rotation, as shown in Figure 2-4, the LEM compartment thermal covers are removed. Compartment 1 (Experiment/Data Subsystem Package) is unloaded and placed on its side, magnetometer/antenna box down, carrying handle up. Compartment 2 is then unloaded, and placed on the lunar surface with the RTG axis vertical. If suitcase carry is elected, the antenna mast is attached to Compartment 1 for transport. If barbell carry is elected, the mast is assembled and attached to Compartment 1.

Unloading of the ALSEP packages is accomplished by removing the compartment covering and thermal blanket, pulling the pip pins, and grasping the suitcase type handle which is attached to each of the two ALSEP packages. After each package is pulled out to the edge of its compartment, the astronaut uses a second handle on the side, or appropriate handholds in the structure, to lower it to the surface in the proper position for subsequent operations.

The fuel transfer tool is released and in the nonextended position is used for rotation of the cask to the desired angle (see Figure 2-11). The tool is then extended to its full length and functionally checked by the astronaut.

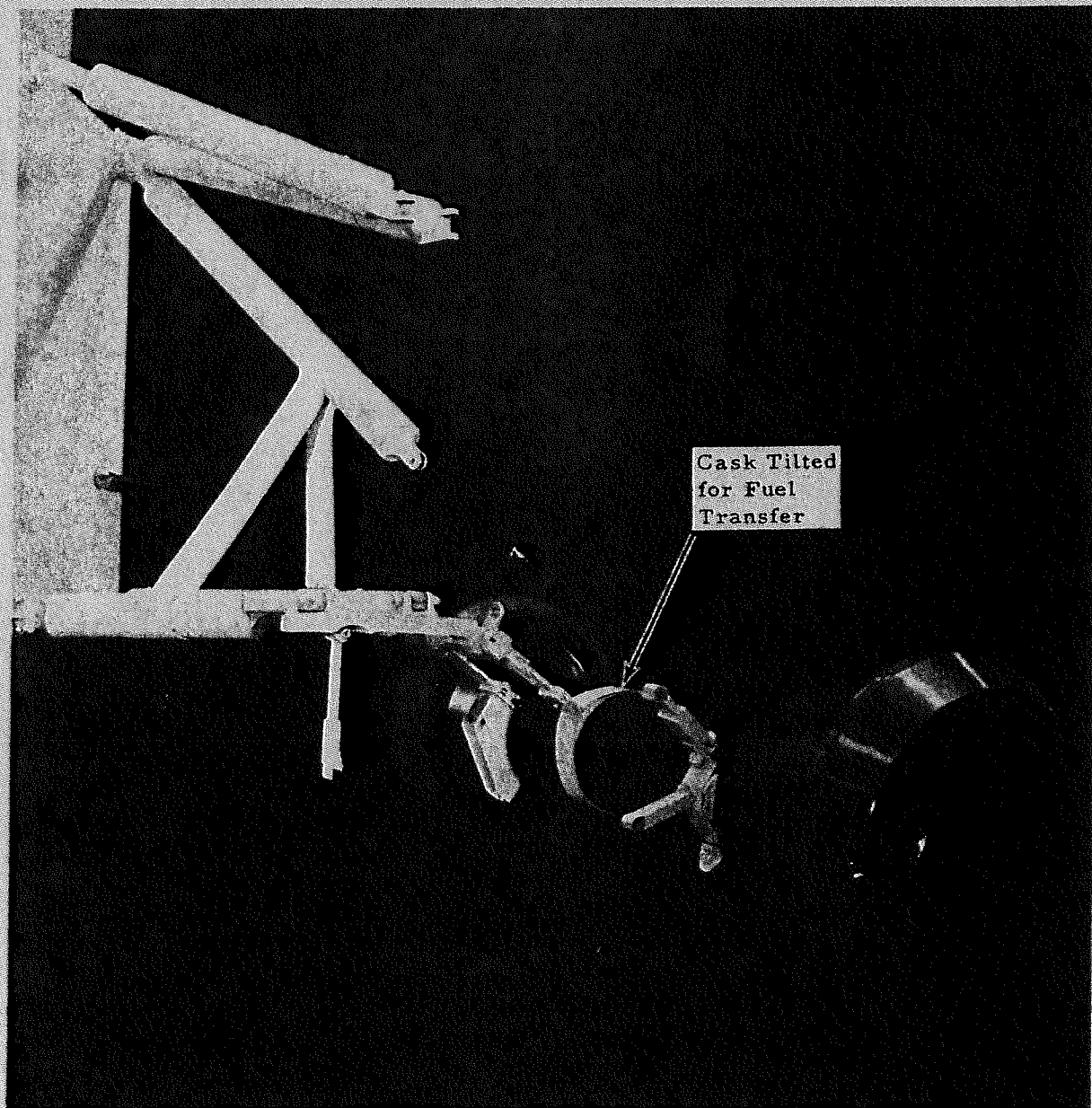


Figure 2-11 Cask Mounting Showing Tilt for Full Transfer

Using the fuel transfer tool, the astronaut positively engages the tool with the fuel capsule, and withdraws the fuel capsule. The capsule is then lowered into the RTG. The tool then disengages and locks the capsule into the RTG. The capsule handling tool is hinged to provide maximum separation between the fuel and astronaut during the capsule insertion into the RTG.

The ALGE is mounted for easy removal from the pallet structure. This feature provides an astronaut option to use the geological tools in the vicinity of LEM or to carry them to the selected ALSEP site.

The astronaut reinstalls the thermal blanket on Compartments 1 and 2 to maintain thermal integrity of the LEM descent stage after ALSEP unloading.

For human factors reasons, the normal procedure is to transfer the fuel as the final unloading operation so that the RTG is relatively cool during the time it is being carried by the astronaut.

Compartment 2, after fuel transfer, is tipped so that it rests on the structure at the back of the compartment (see Figure 2-12). The astronaut can now pick up the two packages and move out on the traverse.

The ALSEP is carried to a point 300 ft from LEM for deployment. This distance is selected to provide a safety margin against the disturbances caused by the departure of the ascent stage (exhaust shock, blast, and heating). Potential lunar surface debris thrown out by the exhaust should be minimal at this distance and the design allows for it. Specifically, critical experiments sensitive to dust have dust covers (removed later) and thermal surfaces such as the sunshade are compatible with superimposed dust.

Two carrying modes are provided and the astronaut can select the one best suited to the local surface characteristics: (1) a handle on each package for a suitcase mode, and (2) a bar, which later serves as an antenna mast, for a barbell carry mode (see Figure 2-13).

The antenna alignment is accomplished using a simple optical sighting mechanism. Using an ephemeris table, and having a general knowledge of the time and LEM landing position on the moon, the astronaut adjusts the optics to obtain a proper offset so that the antenna will be pointed to the

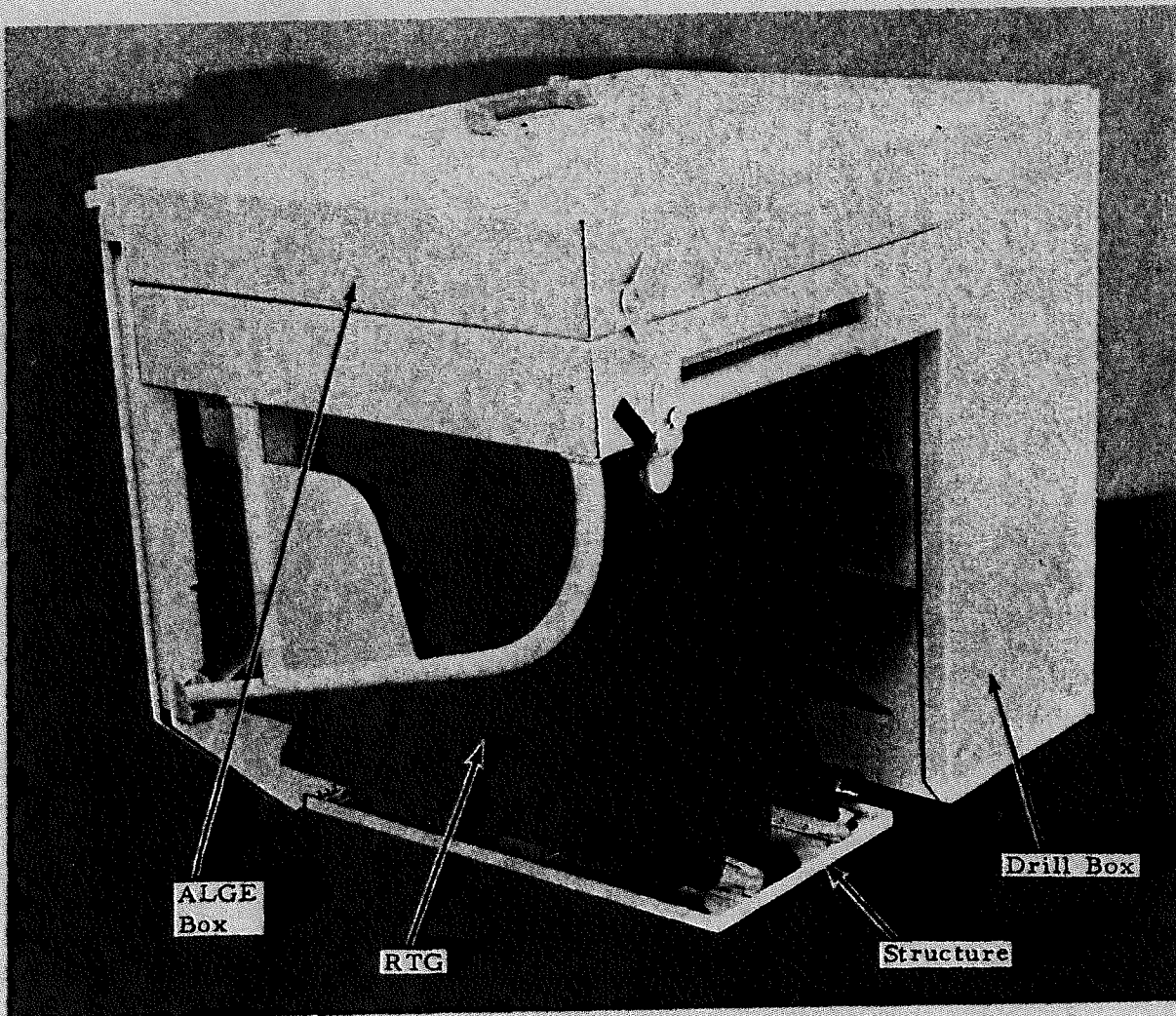


Figure 2-12 Compartment No. 2 - Carry Position

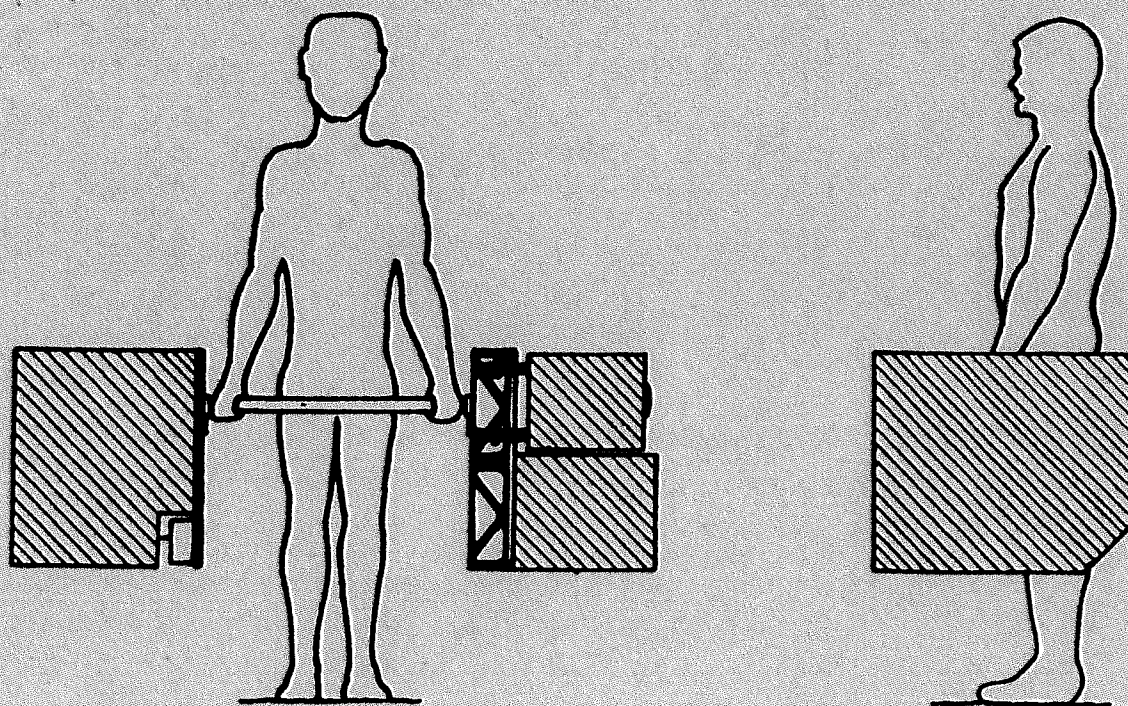


Figure 2-13 Barbell Carry Mode

center of the earth's apparent motion. The astronaut then centers the earth in the sight. Since the optics and its housing are nonmetallic, they are left attached to the end of the antenna after the alignment procedure, thereby precluding any possibility of the antenna being disturbed after its initial positioning.

System turn-on is achieved as follows:

1. Astronaut turns on power to command receiver and decoder
2. Astronaut initializes decoder logic.
This sets decoder logic to receive earth commands.
3. Astronaut sets experiment enable switch to permit commands to the experiments to be executed
4. System is activated by earth command and monitored by MCC and MSFN Ground Stations.

The Active Seismic Experiment requires a data rate of 10,600 bps (ten times the normal data rate). However, this activity is scheduled for the 85 ft MSFN antenna. For all other operations, the ALSEP requires only the 30 ft MSFN antenna.

The approximate times required to accomplish each step of deployment are as follows:

	<u>min</u>
LEM exit and ALSEP unloading (approx.)	12.5
Fuel transfer	2.3
300-ft traverse (one way)	9.3
RTG and Central Station Deployment	3.5
Antenna deployment	11.0
Experiment deployment (Array A)	32.0
Experiment deployment (Array B)*	52.0

* Does not include time required to drill holes for heat flow experiment.

Turn on (normal mode) and confirm	1.5
Return to LEM	<u>9.3</u>
Total time—Array A (approx.)	81.4 min
Total time—Array B (approx.)	101.4 min

The normal mode of operations will be for the MSFN stations to tape record the ALSEP data for shipment to MSC. However, during the early phases of the mission, or at any other time the MCC requests, MSFN stations with a data link to MSC will send the ALSEP data directly to MCC for real time display.

The experimental data will be sorted by the data processor and the output of each experiment will be recorded on separate channels of the tape recorder. A separate recorder channel will be used for engineering data. The recording of all three ALSEPs on a single tape is required to facilitate correlation of data from the separate ALSEP systems—primarily the passive seismic. These tape records will be forwarded to MCC for processing, copying, and dissemination.

This operational concept provides a central facility where NASA, Principal Investigators, and Bendix can monitor and evaluate experiment and system performance and initiate command functions as appropriate.

The requirements for real-time data display at MSC Mission Control can be divided into (1) Engineering Data and (2) Experimental Data.

Approximately one hundred channels of engineering data must be processed and displayed in real time. The display can be sequential so that only a single display console is required. Provision should be made to display any channel on demand. Real-time display of engineering data is required so that immediate corrective action can be taken as the need arises—turn on heaters, turn off experiment, etc—and to evaluate system performance during initial turn-on and periodically throughout the program. This real-time display of engineering data will also satisfy the requirements for command verification.

With the exception of the active seismic long array, no requirement for real time display and monitoring of experiment data exists. Tape

playback is adequate. Display equipment using tape playback should be available at MSC to monitor and evaluate the experiment data and evaluate experiment operation prior to distribution of the experimental data.

SECTION 3

DATA SUBSYSTEM DESCRIPTION

The data subsystem is the focal point for the collection of the ALSEP experimental and engineering data. This system (see Figure 2-6) conditions, stores, formats, etc, the collected data, and transmits the modulated RF signal to the earth receiving stations of the Manned Space Flight Network (MSFN). Earth commands are also received and processed by the data subsystem.

The components of the data subsystem include the command receiver, command decoder, transmitter, data processor, diplexer and switch, helical antenna, cabling harness, and associated packaging.

Figure 3-1 shows Compartment 1 after the experiment deployment and antenna erection. The "L" shaped thermal box under the sunshield contains all the electronic components of the Data Subsystem. A plan view of this container showing the arrangement of components is seen in Figure 3-2.

In addition, the Data Subsystem includes the cabling harness. The connectors between experiments and the Data Subsystem are located at the Data Subsystem, so that when an experiment is replaced it is removed with its interconnecting cable.

Data will be accepted by the subsystem in both analog and digital form. These data are processed and transmitted in a normal mode of 1060 bps. A command link is provided for ground control of the system. The command decoder processes command subcarrier information from the receiver, converts the command information into digital form, and decodes the digital information into discrete commands. Each discrete command will be transmitted and received as a 47-bit message and upon correct decoding will be routed to the various ALSEP elements. The command decoder is capable of accepting 128 different command words. Figure 3-3 is a block diagram of the Data Subsystem.

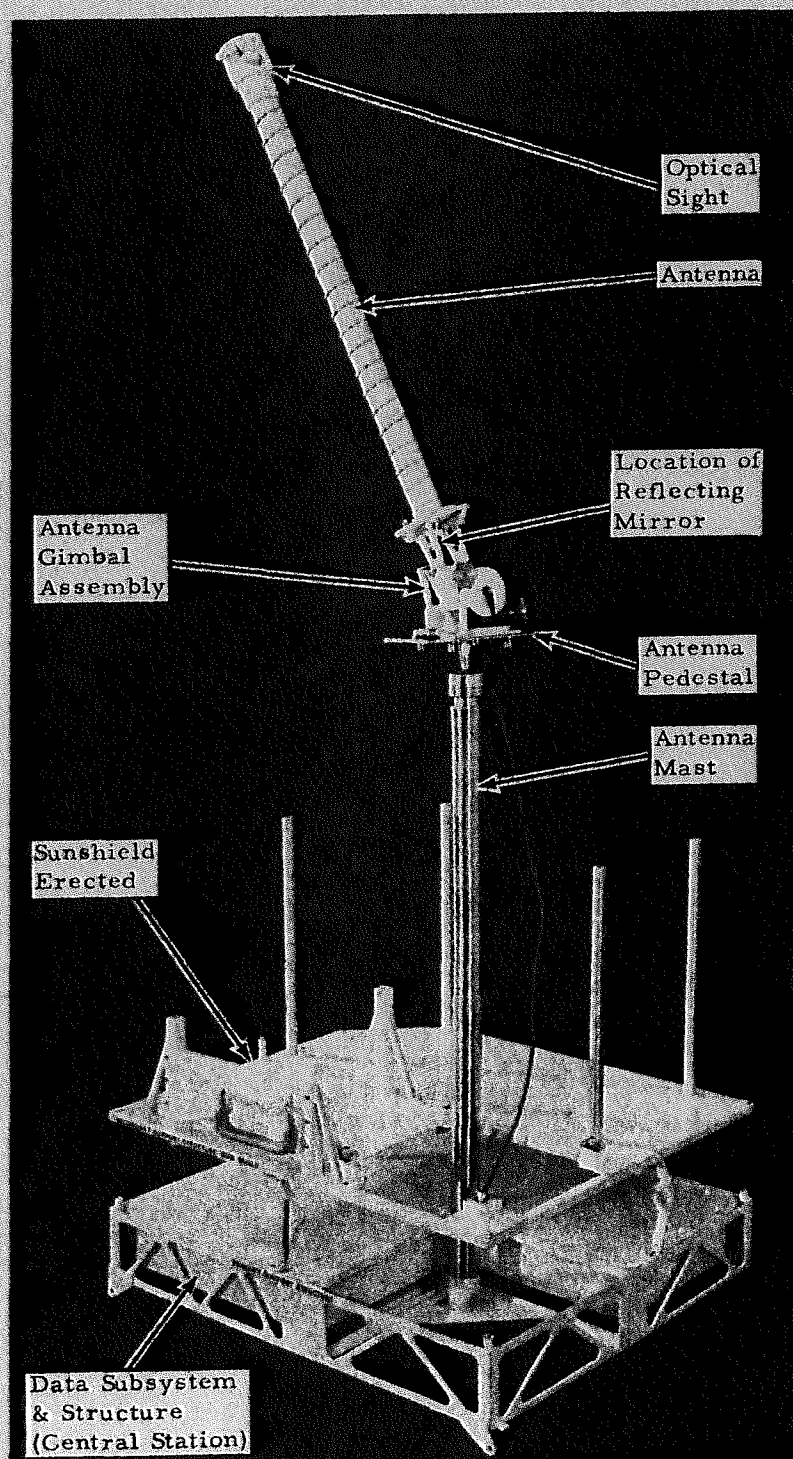


Figure 3-1 Central Station and Antenna Emplaced

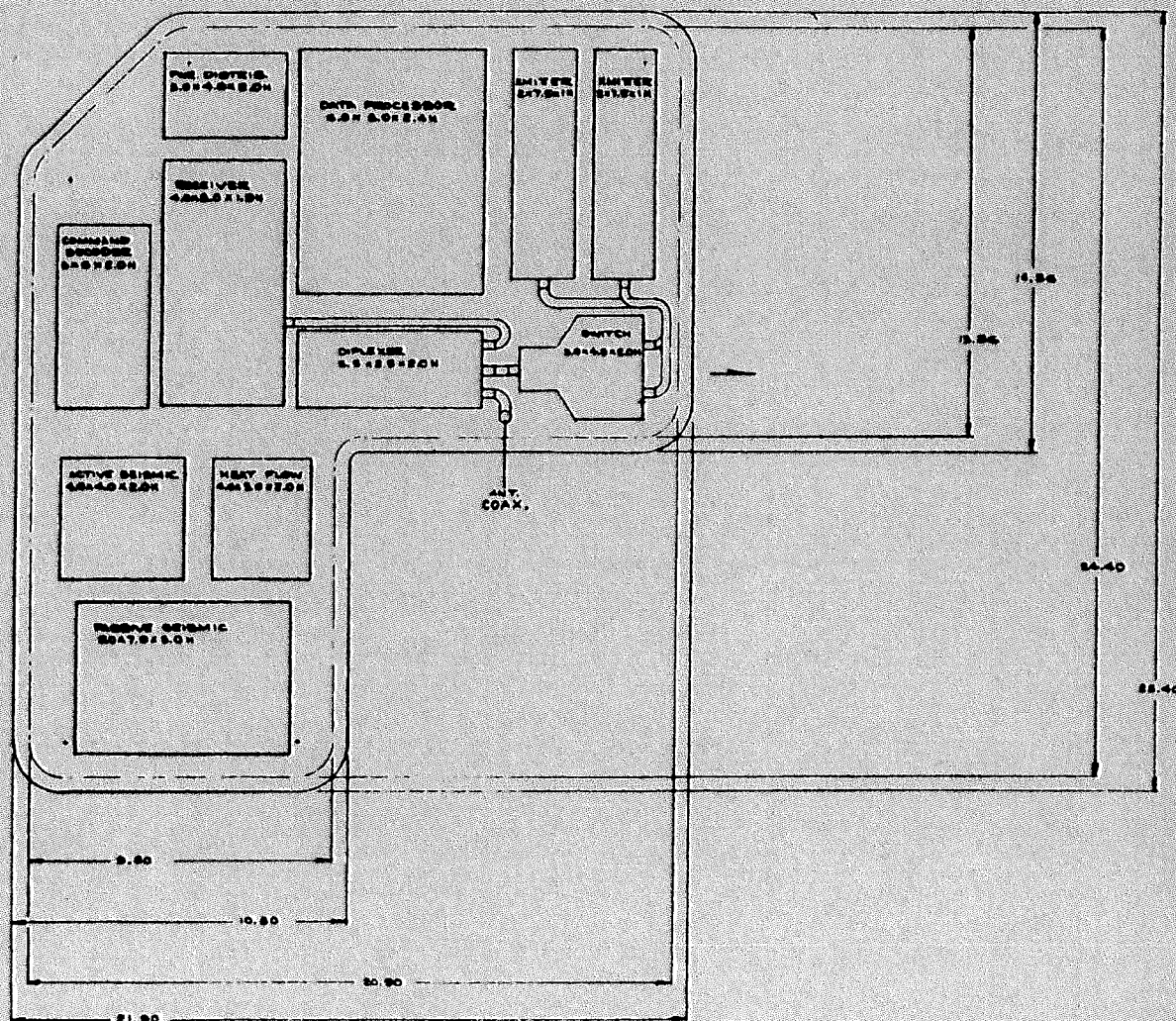


Figure 3-2 Component Arrangement of Data Subsystem

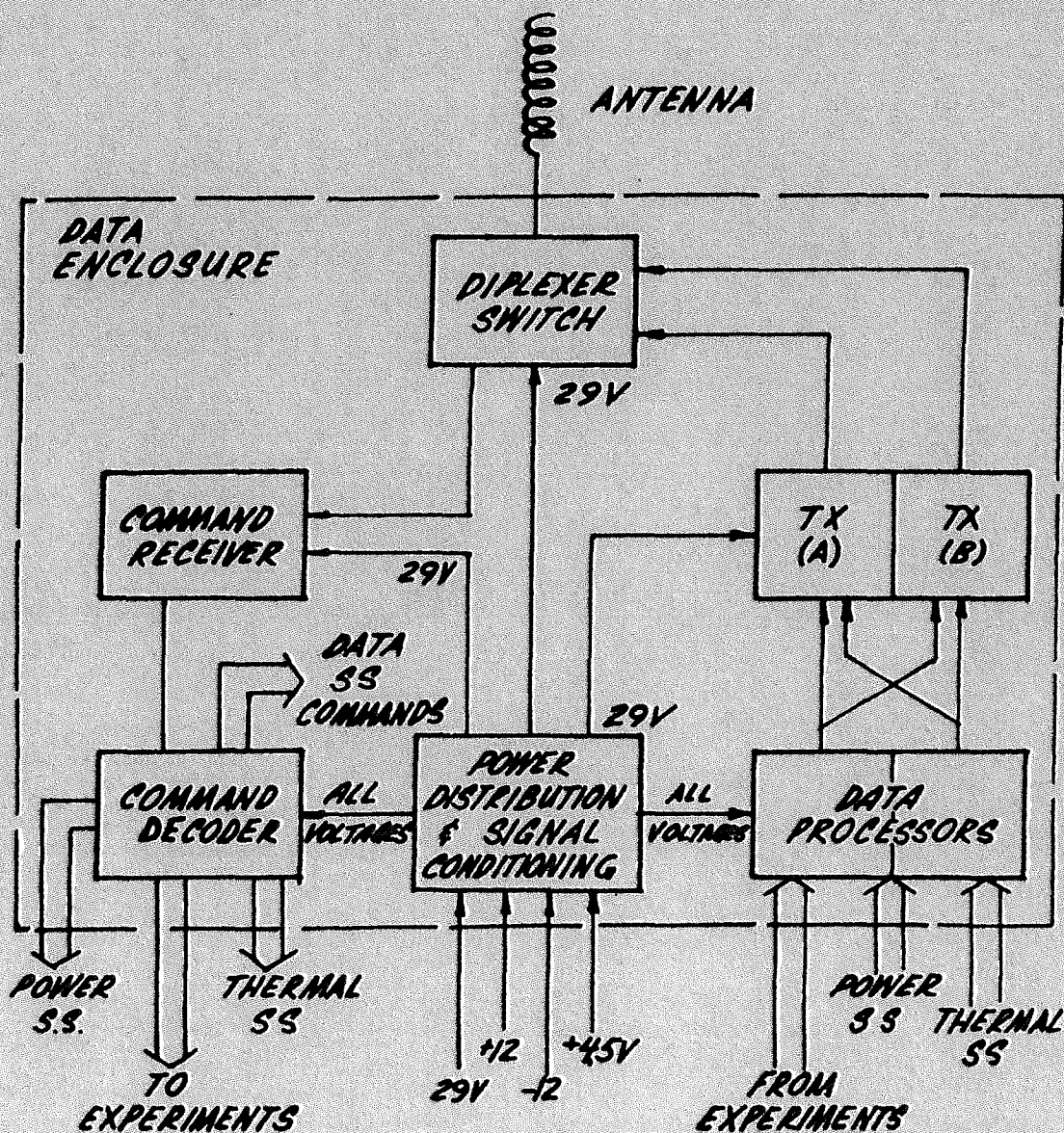


Figure 3-3 Data Subsystem Block Diagram

A helical antenna is used for both the up- and downlink. Both the helix and ground plane are constructed of aluminum, while the tube around which the helix is wound is an epoxy fiberglass. This antenna has a right circular polarization with a maximum loss due to ellipticity of 0.5 db. The 3 db beam width is 26° . Peak gain is 15.8 db nominal with a minimum of 15.2 db. The pointing mechanism has a $\pm 50^{\circ}$ movement in one plane, and $\pm 15^{\circ}$ in the normal plane.

The downlink frequency allocations for the three ALSEPs are presented in Figure 3-4. Downlink modulation is PCM/PM/PM. The system operates at three bit rates: 10, 600, 1060, and 530 bps. The normal operating rate is 1060 bps. The uplink utilizes PCM/PM/PM modulation and operates at a frequency of 2119 Mc.

The command data are biphase modulated on a 2 kc sine wave sub-carrier. A 1 kc tone is added to the signal for synchronization purposes, and the combined signal modulates the S-band carrier. This technique is compatible with the existing Apollo Unified S-Band System.

In the normal mode the data processor will accept data from all experiments except the active seismic in accordance with preprogrammed instructions. Each analog housekeeping input will be sampled once every 90 telemetry frames. The data will be formatted into a 1060 bps serial bit stream.

In the heat flow mode the operating procedure is the same as in the normal mode except the heat flow analog housekeeping data are read every frame rather than every 90th frame. Housekeeping inputs from other experiments are not read during this mode.

In the active seismic mode the data processor will accept fully formatted seismic data in serial form which will occur at either a 1060 bps or 10, 600 bps. No other experimental data are collected in this mode.

The basic data format is an 8×8 matrix of 10-bit words. The format is repeated every $53/32$ sec, thus the 640 bit format is performed at the rate of $(53/32 \times 640)$ 1060 bps. This format is compatible with all experiment data requirements.

(Shaded area shows limits of center frequency assignment)

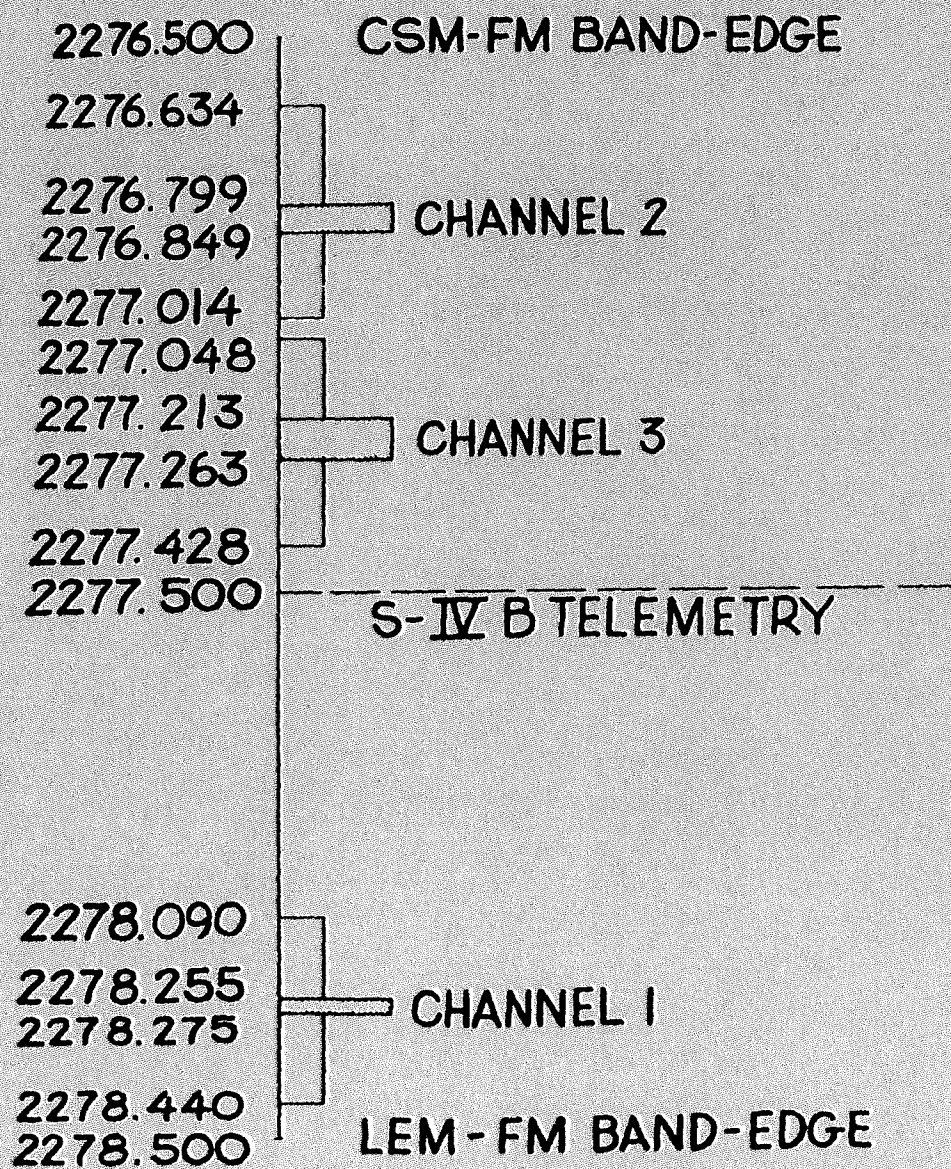


Figure 3-4 Channel Frequency Allocation

After the astronaut has reached the ALSEP emplacement site and has positioned the RTG, he will make the connection between the PCU and Data Subsystem. This connector is located on the front face of Compartment 1. The connection is made with this compartment in the upright position (same as during transportation).

Figure 3-5 shows the antenna assembly. After placing the antenna support post in its socket, the astronaut attaches the antenna pedestal. The optical sight (Figure 3-6) is then adjusted to the proper off-set (if adjustment is required). A leveling bubble and sun compass are provided so that the astronaut can level and align the antenna pedestal in azimuth. Leveling and alignment requirements are both $\pm 4^\circ$. The antenna then can be pointed to any position in a rectangle $\pm 45^\circ$ of the zenith by $\pm 15^\circ$ of the zenith.

The astronaut makes the coaxial connection and attaches the antenna to its gimbal which is mounted on the pedestal. Two adjustments are provided for the antenna pointing. The worm gear which controls motion about the axis having the $\pm 45^\circ$ freedom will be disengageable so that the astronaut can make coarse, rapid alignment without looking through the optics. Final adjustment of the antenna position is made by sighting through the optics via the mirror at the base of the antenna tube. Normally the astronaut will use the earth to sight on. If, however, the earth and sun are near conjunction, this will not be possible. In this case the astronaut will sight on the sun using a filter for eye protection. The off-sets in the optics are of course different in this case.

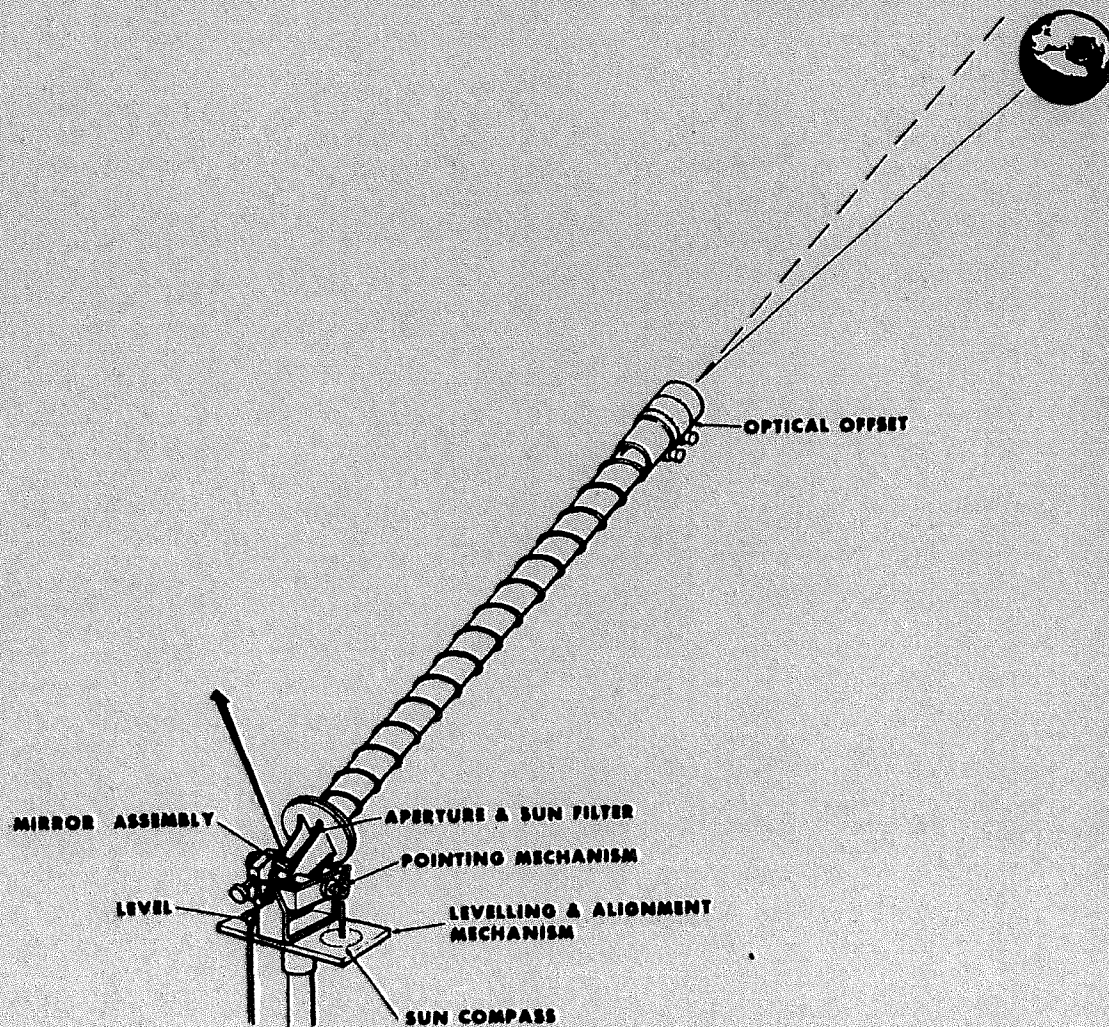


Figure 3-5 Antenna Assembly

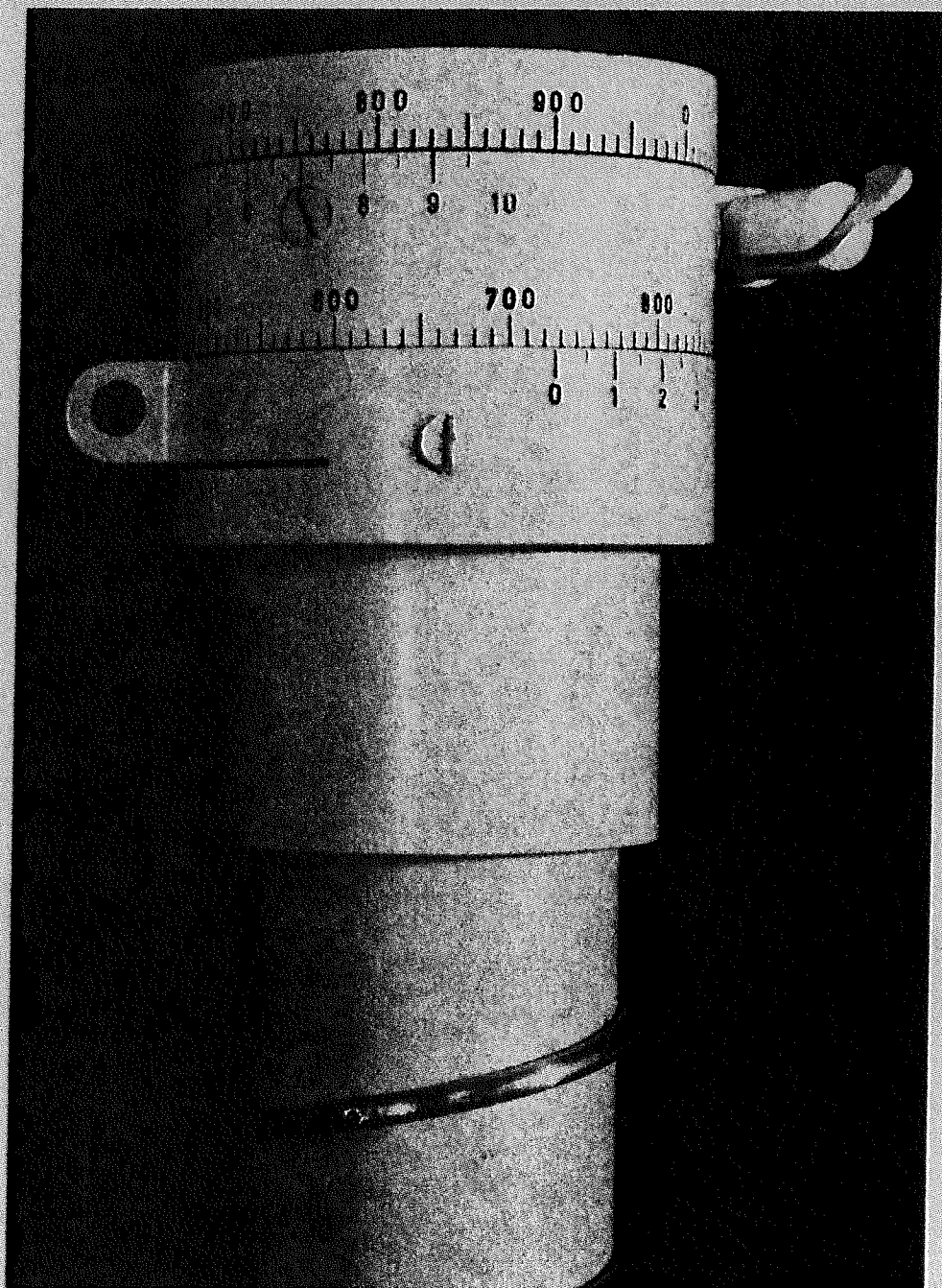


Figure 3-6 Optical Sight

SECTION 4

STRUCTURAL/THERMAL SUBSYSTEM

The structural/thermal subsystem has the dual purpose of holding the ALSEP functional equipment within the confines of a predetermined space allocation in the LEM and providing the necessary thermal control for the data subsystem and those experiment electronics not deployed with the experiment. The structural elements of this subsystem include the enclosing support structure of ALSEP, environmental protection of ALSEP, the LEM attachments, the lunar surface bearing contacts, the mounting for subsystem components and other required mechanisms

The structural subsystem contains two enclosures designated as Compartment 1 and Compartment 2. Housed in Compartment 1 are the experiments and the central station electronics while Compartment 2 holds the unfueled RTG and the Apollo Lunar Geological Equipment (ALGE).

Nonmagnetic materials, primarily aluminum, are used for the structure and a simple load path from the equipment hard points to the LEM tie points is provided. The basic LEM/ALSEP structural interface consists of six LEM fittings around the bottom in each of the ALSEP compartments:

- Two bullet pins in the rear to carry vertical and side loads

- Two tie points in the front for pip pins to carry vertical and side loads

- Two tabs along the edges near the front to carry radial (outboard) loads

- Inboard radial loads are carried by the flanges around the pip pins.

Figure 2-7 shows the Compartment 1 structure with the Array A experiments mounted. The primary structure of this compartment is a riveted aluminum truss which is supported in the LEM bay on the Grumman hard points. The primary support structure supports the Central Station and the sunshield, with all of the experiments attached during flight and after deployment on the lunar surface. After the experiments have been deployed, it then serves as the base for the antenna in addition to supporting the Central Station and sunshield. The sunshield also serves a dual purpose in that it is an essential element in the design of the thermal control system.

The equipment stowed in Compartment 2 is comprised of the integrated power unit (IPU), RTG fuel transfer tool, and the ALGE.

The IPU consists of the unfueled radioisotope thermoelectric generator (RTG), the power conditioning unit (PCU), and associated electric cables and cable storage.

The equipment is supported on a 1-in. -thick structural honeycomb pallet that interfaces with the hard points in LEM. The honeycomb pallet provides the primary structural support for the stowed configuration, and serves as a mounting base for the IPU in the deployed configuration. In addition, the honeycomb pallet serves as a temperature barrier between the astronaut and the fueled RTG while he is deploying ALSEP.

As is seen in Figure 2-6 a structural member normal to the pallet is mounted adjacent to the RTG. This structure protects the RTG during surface transportation and also is used to mount the antenna support bar during flight.

The five-element fuel cask support truss structure, adapted to the new cask configuration as well as protecting the astronaut and providing easy manipulation of the cask and extraction of the fuel element, is shown in Figure 2-3.

Because of the sensitivity of the passive seismometer to high-level g loadings which occur during transport to the lunar surface, this instrument has been vibration isolated. Vibration isolation has been effected by installation of vibration mounts having a natural frequency of 11 cps and a deflection of ± 0.20 in. at the mount. The isolation mounts are located at four corners of the experiment with the horizontally oriented plane of the vibration mounts vertically located near its cg.

The temperature of each subsystem and experiment is controlled as an independent unit to allow flexibility for changing experiments. In the severe lunar environment, effective thermal control is obtained by decoupling the instruments from surface radiation with super insulation. In addition a reflecting sunshield is erected over the Central Station.

After deployment of the experiments, the self-erecting sunshield, which served as a structural support for the experiments during transit, is raised and locked about 5 in. above the thermal radiator. The sunshield, in conjunction with the thermal radiator and super insulation, provide the major components of the passive thermal control system.

The data subsystem electronics are mechanically mounted to the thermal radiator plate. The energy dissipated by these electronics is conducted into the thermal radiator. Radiative heat transfer downward or laterally is precluded by superinsulation which surrounds the electronics on five sides. Heat is dissipated from the top of the radiator directly to space around the sides of the sunshield. The thermal coating on the radiator, the coating on the underside of the sunshield, and the height of the sunshield above the radiator, together control the thermal state of the compartment. The sunshield limits the solar energy which can strike the thermal plate and limits the view of space seen by the thermal plate. This shield is a thermal insulator, and its coating has a high solar reflectivity. The design of this system is such that complete coverage of the sunshield with dust, assumed to be a flat reflector, will not compromise the design temperature range of the data subsystem electronics.

A sunshield is used on the Solar Wind and Heat Flow Experiments.

Temperature ranges for the experiments are:

Passive Seismometer	50° to 104° F
Active Seismometer	-58° to 302° F
Solar Wind	-4° to 194° F
Heat Flow	14° to 144° F
Electron-Proton	0° to 122° F
Magnetometer	32° to 122° F
Suprathermal Ion Detector	-4° to 176° F

SECTION 5

ELECTRICAL POWER SUBSYSTEM

A radioisotopic thermoelectric generator (RTG) and a power conditioning unit (PCU), together with an interconnecting cable and connector, comprise the Integrated Power Unit (IPU) which provides all electrical power for the ALSEP Lunar Surface operation. The power generation subsystem supplies 50 w of electrical power at a regulated bus voltage of 28 vdc $\pm 1\%$. The RTG rejects as waste heat 1000 to 1500 thermal watts.

The Electrical Power Subsystem also includes a cask, mounted externally to the LEM for transporting the fuel capsule (i. e., radioisotopic fuel source) to the moon, associated thermal insulation, and a handling tool for transferring the fuel capsule from the cask to the RTG by the astronaut on the lunar surface.

The power generation system warm-up characteristic is such that it will deliver full output power and voltage in 25 to 53 min depending on the fuel and RTG temperature at the time of fuel transfer.

Thermal input from the fuel cask to the LEM is reduced by insulation, which controls the heat input to less than 100 Btu/hr during translunar flight.

SECTION 6

EXPERIMENTS DESCRIPTION

6.1 MAGNETOMETER

The objectives of the magnetometer experiment are:

1. Measurement of the lunar surface vector magnetic field and its temporal variations
2. Measurement of the magnetic field gradient at the magnetometer site.

The lunar measurement is made with a tri-axis flux gate magnetometer. This instrument differs from typical flux gates in that each axis sensor is mounted on a three-foot boom. These booms have a common base and relative angles that form an orthogonal set of axes. Each sensor is attached via a drive cord to a bimetallic flipping motor mounted at the base of the sensor boom.

This motor will allow each sensor to be rotated in 90° and 180° steps about an axis normal to its sensing direction. Each boom is connected to a flipping motor which allows the boom to be rotated 90° about its longitudinal axis. The boom rotation and 90° sensor flipping will allow a determination to be made of the magnetic field gradient at the magnetometer site. This measurement will reveal any local field anomalies. The 180° sensor flipping will allow the removal of zero drift effects in any of the sensors. Flipping motors are located at the apex of the axes in a star-shaped box called the Gimbal Flipping Unit. Figure 6-1 shows the general arrangement of the instrument in its deployed configuration.

Thermal control is accomplished through the use of a coating on all exposed surfaces, and a heater is used for night operation.

To relate the field vector as measured in this local frame to the inertial frame, three angles are required. Two of the angles are obtained

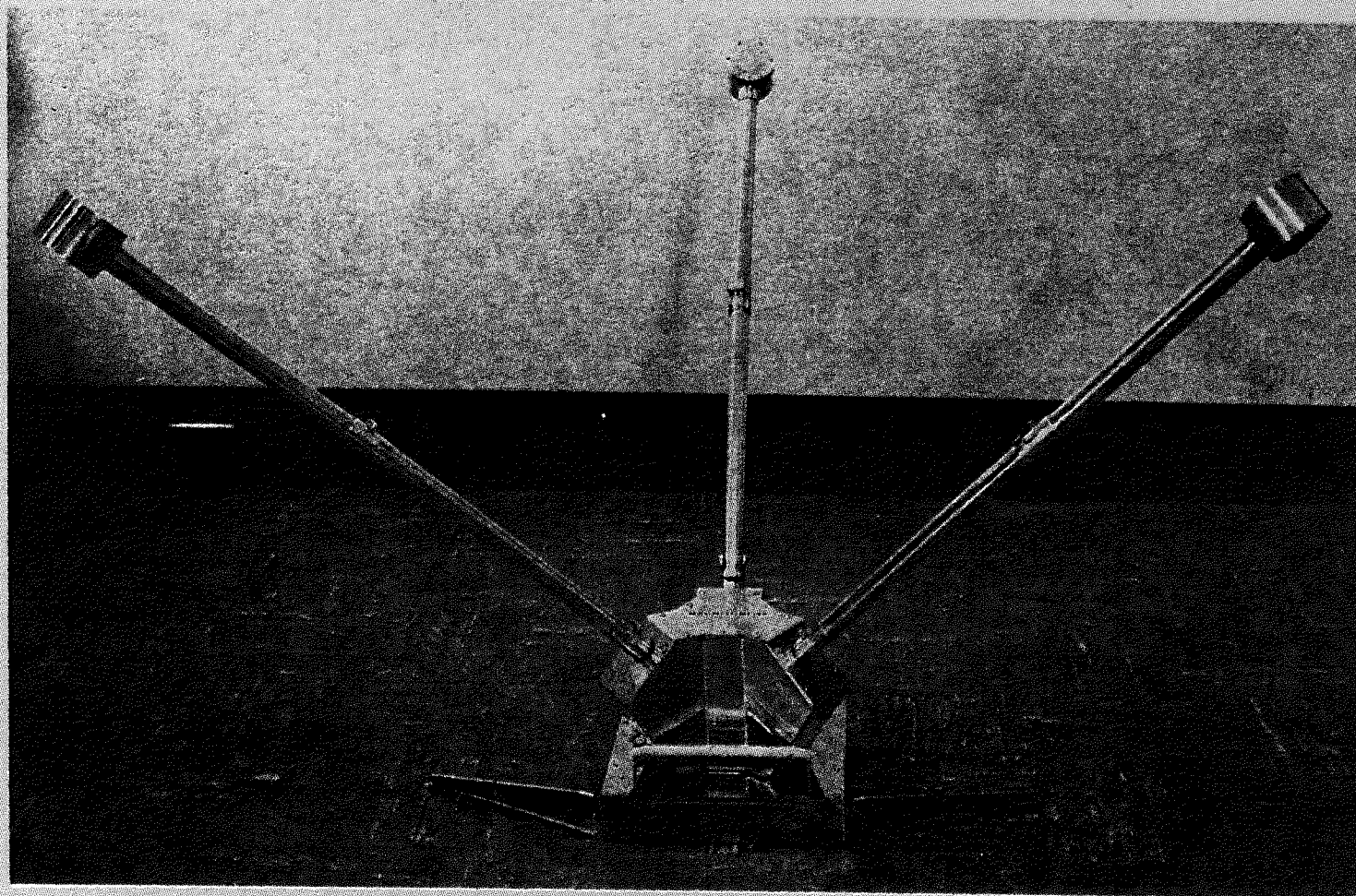


Figure 6-1 Deployed Magnetometer

from two tilt angle sensing elements in the instrument which will give the angle, in two planes, between the instrument vertical and the local vertical. The third angle is obtained by the astronaut aligning one boom along the Magnetometer/LEM line. These automatic angle sensing elements will simplify what would otherwise be an involved deployment task for the astronaut.

The three components of the magnetic field are sampled simultaneously four times per 0.6 sec periodically. Each sensor readout is converted to a 10-bit digital word and placed, along with the other two sensor words, in a 30-bit shift register. Between each field sample the ALSEP data subsystem clears the register and transmits the data.

In performing the magnetometer deployment tasks, the astronaut carries the instrument 50 ft from the central station, deploying the interconnecting cable enroute. When the distinct marking appears on the cable, the correct distance has been traversed. At that point, the astronaut manually extracts the base struts from their stowed position and grasps the sensor arms by which the instrument is lowered to the ground. The folded sensor arms are extended to their full length and the designated arm is oriented to a reference mark on the LEM. The astronaut then returns 50 ft to the central station to deploy the next experiment.

6.2 SUPRATHERMAL ION DETECTOR

The primary objective of this experiment is to measure the flux, energy, and velocity of the positive ions in the lunar ionosphere. The information derived will be used to investigate the ion density, temperature, and composition of the cold lunar ionosphere. The ion energy spectrum will also be investigated for ambient electric field effects by looking for non-Maxwellian components of the energy spectrum. Additional objectives are to measure the characteristics of the raw and thermalized solar wind at the lunar surface. These measurements all consist of independent determinations of particle velocities and energies using a multistage analyzer.

In the instrument designed for this experiment, the velocity analysis is accomplished by a crossed magnetic-electric field region in which the electric field is swept to provide the velocity selection. Positive ions transmitted by the velocity selector next enter a retarding potential analyzer of conventional design which acts as a "high-pass" energy

analyzer. A curved Channeltron® multiplier serves as the detector. The Channeltron detector is a small hollow tube which is coated on the inside with a special semiconducting material. It acts as an electron multiplier. Directional characteristics of the charged particles to be analyzed will be determined by using three complete analyzer systems, each oriented to accept only particles with trajectories within a defined solid angle. The individual analyzers will be monitored sequentially.

The energy and velocity ranges of interest are covered by stepping the voltages applied to the velocity selector and the retarding potential analyzer. An internal calibrator is also included to provide occasional calibration data on the detectors.

The experiment includes a dust cover which protects the entrance apertures to the detectors during deployment of the experiment by the astronaut and LEM ascent stage departure. Figure 6-2 shows the physical configuration of this instrument.

The Suprathermal Ion Detector is emplaced 60 ft from the central station with the interconnecting cable deployed enroute. At the deployment location, the astronaut lowers the instrument to the lunar surface, levels the entrance aperture to within $\pm 5^\circ$ of vertical (using the bulls-eye level) and aligns the wide entrance aperture to the ecliptic plane. Upon completion of this task he returns 60 ft to the central station.

6.3 PASSIVE SEISMOMETER

The ALSEP Passive Seismic Experiment will fulfill two objectives. First, it will determine the seismic activity of the moon. Seismic energy is expected to be produced on the moon by quakes, meteoroid impacts, and tectonic disturbances. Knowledge of the statistics of quakes is essential for definition of the strain regime of the moon during its evolution. It is also important to know the location of quake epicenters, permitting correlation of seismic events with surface features. In this way insight into the origin of visible features on the moon may be achieved. Second, analysis of the form and characteristics of seismic waves themselves will provide data on the physical properties of the lunar interior. Subsurface materials will differ in density, compressibility, rigidity, pressure, and temperature. These differences will impart variations to seismic wave velocities and character, from which the materials may be inferred. Structure of the lunar crust, mantle, and the presence or absence of a

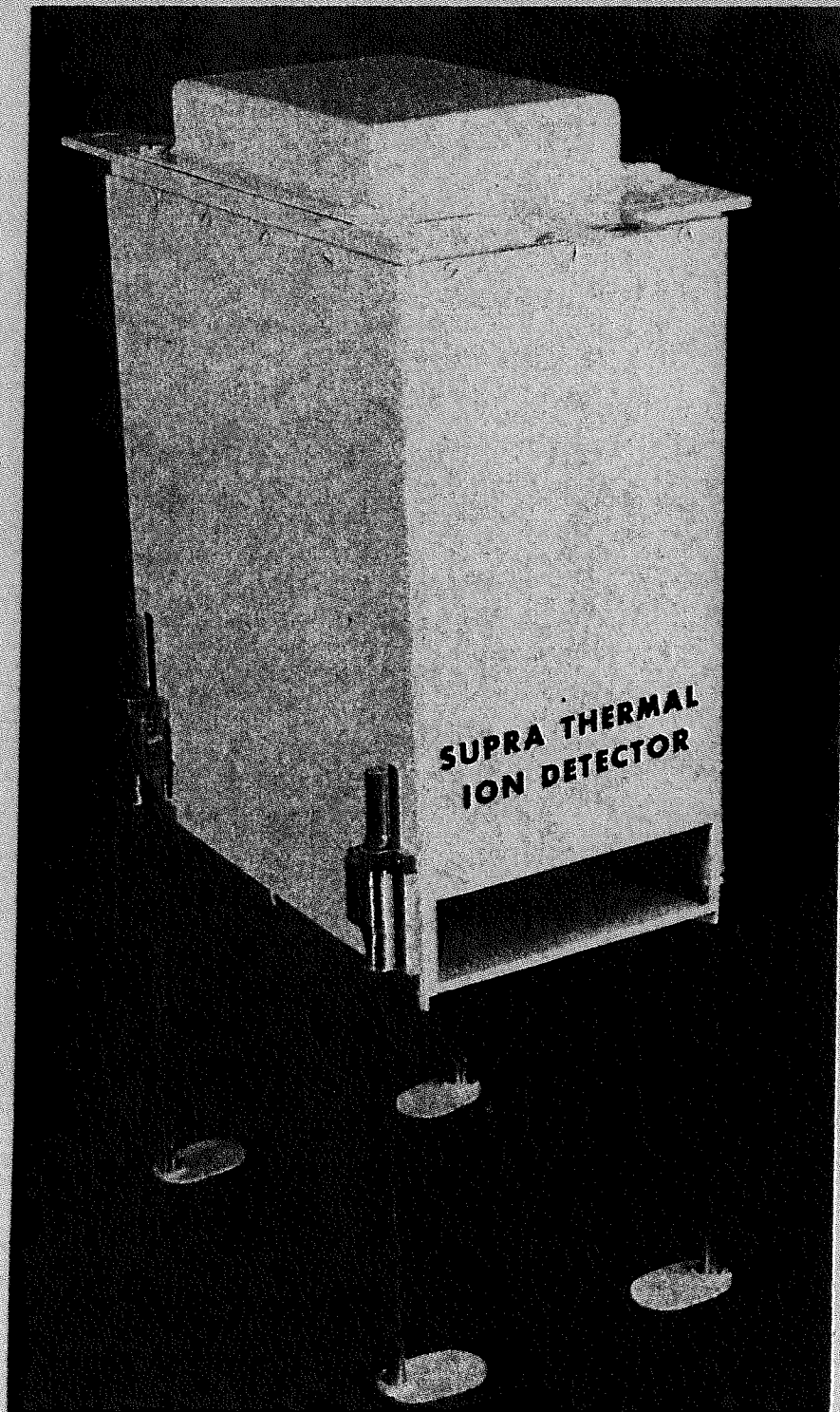


Figure 6-2 Suprathermal Ion Detector Configuration

core can be investigated by this means. Finally, the experiment will permit study of the free oscillations and tidal deformations at the moon to provide data on the physical properties of the moon as a whole.

The instrument proposed for the ALSEP Passive Seismic Experiment is comprised of two parts mounted in the same package. First, a 10-15 sec period, 3-axis, orthogonal seismometer is employed to monitor long-period, low-frequency energy. In addition, this instrument indicates azimuth and distance to seismic epicenters as well as monitoring long-term tidal deformations of the solid moon. Second, a short-period (1/2 to 1 sec), high-frequency (20 cycles per second) instrument is employed to monitor high-frequency energy with high sensitivity. It also serves as a backup for the long-period instrument. The instrument functions by monitoring the displacement of inertial masses from their zero positions relative to sensitive displacement transducers.

The mechanical design of the passive seismometer is that defined by the Principal Investigator, Dr. George Sutton of Columbia University. The description which follows is based on the prototype design which was developed to his specifications.

The mechanical structure is designed to accommodate both the long-period and the short-period seismometer. The long-period seismometer is comprised of two horizontal, hinge-type swinging gate components and one vertical LaCoste spring suspension component mounted orthogonally. These elements are sensitive to shock and vibration, and must be caged during launch. Each has a natural period of from 10 to 15 sec and uniform magnification, damping, and inertial masses. The three long-period components are mounted in a motor-driven gimbaled assembly attached to a support frame. The gimbal provides leveling resolution to two seconds of arc over a 15° span. The long-period instrument support frame and gimbal are mounted to trunions fixed to a central support plate. This plate also serves as primary structure for the entire unit, and provides hard points for mounting to the ALSEP structure. Figure 6-3 shows the external configuration of the Passive Seismometer. The short-period instrument has a natural period of 1/2 to 1 sec. It is attached to the lower side of the central structural plate, and it serves as a structural member for the lower part of the system. The instrument electronic circuits have been retained in the central station package for more efficient thermal control. The instrument is installed in a sealed enclosure to provide a predictable environment.



Figure 6-3 Passive Seismometer External Configuration

The programmer is a digital component that includes a binary pulse counter that is stepped by successive pulses from the ALSEP telemetry subsystem and a diode matrix that sets appropriate voltage levels in accordance with the number stored in the counter so that the required operations occur in the proper order. It controls (1) the seven miniature magnetic reed switches that connect any or all of the collector segments to the input of the current measurement chain, (2) the voltage applied by the high-voltage modulator to the modulator grid to select the proper polarity and energy band of particles to be measured, and (3) circuit connections so that the gain of the current measuring chain and the magnitude of critical voltages can be read into the telemetry from time to time to test for changes in calibration. In addition, it accepts command pulses from the earth to establish the desired measurement mode.

The passive seismometer is emplaced approximately 10 ft from the central station with the cable deployed enroute. It is placed on the lunar surface and rough leveled to within 10° of vertical, leveling legs are locked, and the return trip of 10 ft is made to the central station.

6.4 SOLAR WIND

This instrument will be used to investigate the temporal, spectral, and directional characteristics of the solar wind at the lunar surface.

The primary purpose of the solar wind experiment is to analyze the solar plasma as it exists on the lunar surface. The character (spectral and directional) of the solar plasma is dependent upon whether the measurement is made in the unperturbed interplanetary space or in the geomagnetic field shock front region. The solar plasma measurement will aid in determining the electromagnetic properties of the moon.

A knowledge of the radiation exposure experienced by the lunar surface is a key factor in determining layer characteristics. Since the solar plasma represents the primary source of high energy radiation, a measurement of its spectral and temporal characteristics is important.

In the area of geophysical research this experiment will yield the first clear-cut measurement of the spatial extent of the earth's magnetic tail at 60 earth radii. Such data will represent a significant advancement in our knowledge and understanding of the interaction of the geomagnetic field and the solar plasma.

Besides the lunar and geophysical areas, this experiment will yield information about the solar plasma itself. By comparing the arrival times and spectral character of plasma disturbances at the moon, the earth, and any deep space probes which are active at that time, the structure and propagation velocity of these disturbances can be investigated.

This instrument consists of a 5-in.-diam hemispherical Faraday Cup and a vertical charge collection cup surrounded by six equally spaced collection cups mounted at some angle to the vertical. The normal Faraday Cup grid structure is in the form of a hemispherical cover over these seven cups. By the impression of proper voltages on the grid structure the sensor is made sensitive to electrons in seven narrow energy bands and protons in 14 bands. The charge collectors can detect currents from 10^{-12} to 10^{-8} amp. The time required to sweep the grid voltages through a complete sequence is 24 sec.

The general configuration of the Solar Wind Experiment is shown in Figure 6-4. This experiment consists of a single package. The charge collection cups and grids protrude through the top of a 9 x 11 x 9 in., 10-lb cube which contains the instrument electronics and thermal control system. Up to the time the ascent rocket dust settles, the sensors are protected by a dust cover. After the dust has settled, this cover is removed by ground command.

The solar wind experiment requires no specific distance separation from the central station; however, it is emplaced on a directional quarter opposite the RTG. This is performed to ensure the instrument a clear field-of-view of 2π steradian. The experiment is lowered to the surface with the built-in handle, leveled, and positioned relative to the ecliptic plane. The astronaut then returns to the central station.

6.5 HEAT FLOW

The objective of this experiment is to measure lunar heat flow. The phenomenon of planetary heat flow has been receiving increased attention in recent years. Early measurements were made primarily on the continents where the continental crust is of the order of 30 km deep. Since the radioactive materials, such as uranium, thorium, and potassium, are concentrated in the crust, it was expected that the heat flow through the continents would be much larger than that on the ocean floor, where the crust is only a few kilometers thick. Contrary to expectation, it turned

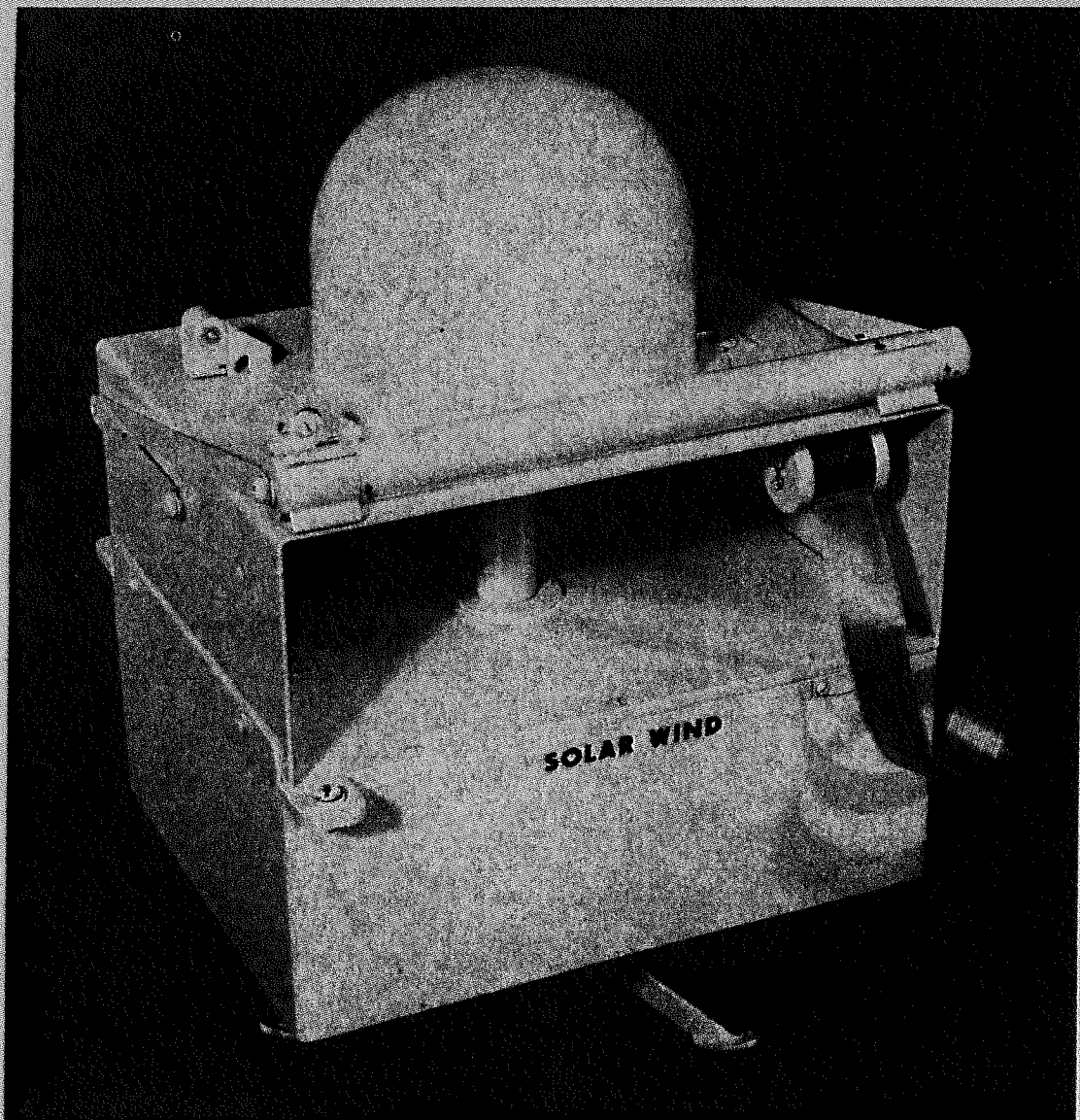


Figure 6-4 Solar Wind Experiment Configuration

out that averaging over the continents and over the oceans resulted in about the same amount of heat flow per square kilometer in the ocean as it was in the continents. There were anomalies in the situation, particularly in such areas as the North Atlantic Ridge where the heat flow is much larger than the average value for the earth. It has been suggested that this excess of the North Atlantic Ridge is due to a convection current carrying hot material up from the center of the earth toward the surface, thus allowing a convective transport of heat as well as a conductive one. Heat flow measurements on the moon would aid in determining the existence of a liquid core as well as possible convective motion and perhaps some information on the uniformity of distribution of radioactives.

The technique to be employed in this experiment is to measure the temperature of the moon as a function of depth and to determine the steady state vertical temperature gradient. In situ conductivity measurements are to be made at several depths. The steady state heat flow is then obtained as the product of the gradient and the conductivity.

The desired measurements will be obtained by placing a total of three probes each in a predrilled hole. These probes will obtain measurements to a depth of one meter (this figure represents the anticipated drilling depth capability for the early Apollo missions). The lower portion of the probe, approximately the bottom 80 cm of the probe, measures the expected small temperature gradient. Sensors are widely spaced at the bottom and closer together at the top in accordance with predicted thermal gradients. The upper 20 cm measures the wide temperature extremes of the diurnal temperature variation using platinum resistor sensors at close separations.

Physically, each probe is a $5/8 \times 1$ meter long cylinder which is inserted into a sleeved, predrilled hole. The sleeve is removed after the probe is emplaced. The probe contains a restraining device, which, when released, causes the probe to fold open through the diameter about a pivotal axis located near the circumference of the cylinder. This action is obtained by the use of specially designed springs located every two inches in the vertical plane. These springs are designed to provide a positive contact between the sensors (and heaters) and the lunar soil.

The basic structure of the probe is composed of rigid polyurathane foam, for low thermal conductivity, and flexible tape cable. The cable,

in addition to its primary function of electrically interconnecting the sensors and control circuits, serves to reinforce the foam structure. The rigid foam used as the primary structural material in this design has a low thermal conductivity which is as low as is obtainable for practical structural materials. The sensors and portions of their respective control circuits are embedded in the foam structure. Other electronics are contained in the ALSEP Central Station. A thermally conductive epoxy is used to complete the thermal conduction path from the sensor to the external surface of the probe.

After the probe is emplaced and the drill hole casing is removed, a small 3-1/2 cu in. electronics package (complete with temperature control) is attached to the top of the probe by means of a small bayonet lock type electrical connector. This electronics package is connected electrically to the central electronics package by means of a flexible tape cable containing seven interconnection wires.

The probe heaters will be switched on only upon command since they are used only after three months of operation. Each heater will be commanded off when prime power is applied to ensure that all heaters are off. These commands are in addition to the holding circuit on the reset of each input flip-flop. Also, if more than one heater is commanded on at any one time, no heaters will operate. Heat flow is independent of the probe heating control and can be operated indiscriminately during probe heating.

Housekeeping data, central electronics package ambient temperatures, will be taken continuously. Central package thermal control is independently powered and thermostatically controlled. To improve reliability, there is an additional heater which can be turned on upon command powered from the central package prime power.

The heat flow experiment requires the emplacement of three probes into 1-meter-deep holes 120° apart and at a distance of 25 ft from the central station. The procedure for emplacement of one probe is given here with the same procedure repeated for the other probes.

A portable drill and 1-meter-deep bit are carried to the correct distance along with the probe, sheath, and the electronics package. The interconnecting cable is laid enroute to the emplacement location. At this point, the drilling operation is started with the sheath being emplaced as drilling occurs. At the correct depth, the drill bit is removed, the heat

flow probe is inserted and the sensors released by a trigger action in the probe head. The sheath is removed and cable interconnection between the probe and the electronics package is completed. The electronics package is rough levelled on the lunar surface with a sunshield installed over it. The package is then oriented so that optimum thermal protection is afforded by the shield. The astronaut then returns to the central station, carrying the drill and bit, and repeats the procedure for installation of the remaining probes on bearings approximately 120° apart and 25 ft from the central station.

6.6 ELECTRON/PROTON

The purpose of the Electron/Proton Experiment is to measure particles in interplanetary space. Basically these particles, coming from the sun, are to be measured by number and energy spectrum.

Scientific studies have shown that an interface, known as the magnetopause, exists between the interplanetary magnetic field and the magnetic field of the earth. Whether or not such a shock front and interface exists around the moon is not known. As a result, measurement of the particles on the lunar surface may be divided into three possible situations:

1. No shock front exists and the moon can act as a point site in space away from the earth's magnetic field.
2. A shock front does exist and measurements made during new moon times will be primarily those of thermalized solar wind protons.
3. During the new moon period it will be possible to search for a turbulent wake of the earth at the distance of the moon's orbit.

In the presence or absence of a shock front, measurements of particles from the lunar surface would produce better data than if measurement were taken from an orbiting satellite. The turbulent wake search would utilize the moon primarily as a platform.

The objective of this experiment is therefore to measure protons and electrons over the energy ranges necessary to define the particle environment.

Two individual instruments are used, each having five Channeltron detectors for measuring protons and electrons. Incident particles pass through an entrance slit followed by a pair of deflection plates, where a voltage is impressed across the plates. The particles are deflected by the electric field into one of the five Channeltron detectors.

One of the instruments is oriented with its entrance axis toward the earth. Assuming the ALSEP is located near the center of the lunar disk, this will place its axis nearly vertical with respect to the lunar surface. The wide dimension of the entrance slit is oriented along the lunar equator. The other instrument is oriented with its axis pointing roughly toward the lunar horizon ($\sim 30^\circ$ above the horizontal) with the wide dimension of the slit parallel to the other entrance slit.

The voltages applied to the deflection plates are stepped between +35, +350, and +3500 v for protons, and -35, -350, and -3500 v for electrons. The counts from each Channeltron detector are read out (for each voltage on the deflection plates) about once every 1.2 sec. Thus, a complete data cycle takes $(6 \times 1.2) = 7.2$ sec.

The size of the basic instrument is $3\frac{1}{4} \times 6\frac{3}{4} \times 7\frac{1}{4}$ in. This unit contains the two instruments, all of the instrument electronics, thermal control heaters, and sensors. The unit is enclosed in an outer box, whose over-all dimensions are $4\frac{1}{2} \times 9 \times 10\frac{1}{2}$ in. This box contains $\sim 1\frac{1}{2}$ in. of thermal insulation on all sides and the bottom; the top of this box contains a dust cover which is removed by command after the ascent stage blast.

The top of the experiment (after removal of the dust cover) is the thermal control surface. This thermal plate has two slits which are the entrance apertures to the two detector units. The electrical leads are brought out to a connector to the junction box. The cable is folded above the dust cover before deployment.

The electron/proton spectrometer requires no specific separation from the central station. It is placed on the lunar surface so that it has a clear field of view and is aligned with the ecliptic plane. It is levelled to within 5° of vertical, completing the deployment tasks.

6.7 ACTIVE SEISMOMETER

The active seismic experiment measures the characteristics of the lunar subsurface material. The experiment objectives are to determine the structure, thickness, physical properties, and elastic constants of the surface and shallow depth materials on the moon. Seismic energy will be artificially produced by explosive devices, transmitted through the lunar rocks, and detected by a geophone array. The velocity of propagation of compressional waves, the frequency spectra, and the attenuation of seismic energy are each functions of the physical constants of the near surface rocks, and permit the rock type and character to be inferred. In addition, the experiment will provide data on the bearing strength of the surface materials and surface information necessary for planning of future lunar missions. Finally, the experiment will allow determination of the thickness and fine structure of the surface layers. These data, together with the variations in physical properties among the layers, are required for a full interpretation of the history of the lunar surface and the processes which led to its formation.

The Active Seismic Experiment apparatus is comprised of two parts, the seismic energy sources and the detection system. Two energy sources will be employed. One is a mortar device from which four explosive grenades will be launched to detonate at various distances up to one mile from the geophone detectors. The mortar package, including grenades and the explosives, will be armed and activated after about one year by earth command. The second energy source is a "thumper" device containing 20 explosive squibs which will be activated by the astronaut at specified locations along the geophone line as he returns to the ALSEP. The detection system will be a linear array of three geophones together with amplifier systems and necessary electronics.

The mechanical design of the Active Seismic Experiment is based on inputs from both Drs. Kovach and Watkins. The design concerns two areas, the seismic energy sources and the common detection system. The thumper device is for investigation of the materials within about a 75-ft depth of the lunar surface. This device will be about 4 ft long, and stored in two sections for transportation. The upper section will contain necessary electronics for the firing mechanism, the squib barrel, and contact points. The lower section will be a hollow cylinder which will be bayonet-connected to the squib barrel. It will serve to couple the energy source to the lunar surface, and impart seismic waves to the surface materials for detection by the geophones.

The mortar device contains four explosive grenades which will be activated by earth command after one year stay time on the lunar surface. This device will be a package about 15 in. long, and comprised of fiberglass grenade launching tubes packaged in rigid polyurethane foam, together with necessary electronics and grenade launching squibs. The mortar package contains supports to minimize the effects of recoil. Since it is necessary to know the distance from the geophone array at which the grenade is detonated as well as the time of detonation, the mortar package design provides for measurement of grenade launch angle, grenade launch velocity, and time of flight, from which quantities the range can be calculated.

To deploy the active seismic experiment, the astronaut first emplaces the mortar adjacent to the central station. The mortar is aimed away from the LEM location and is levelled to within $\pm 5^\circ$ of vertical. A geophone is then placed adjacent to the central station and cable deployment of a 300 ft sensor cable, roughly in line with and away from the mortar's line of fire, is begun. Along this traverse, the astronaut carries a squib-activated thumper. At a distance of 150 ft from the central station, the astronaut emplaces a second geophone and continues to the end of the cable. At this point, the third and final geophone is emplaced and the 300 ft excursion to the central station is started. The thumper is activated every 20 ft (15 times) along the return trip. The 20 ft intervals back to the central station are determined by distinct marks on the sensor cable.

SECTION 7

GSE DESCRIPTION

The GSE consists of the following:

1. System test set
2. Data subsystem test set
3. Experiments test set
4. Experiments simulator
5. Experiments sensor simulator
6. Power test set
7. Peripheral test set
8. Mechanical equipment.

The system test set will be used to perform final testing on the complete ALSEP system. This will include dynamic testing under the various environmental and life test conditions. During these tests, the system test set will interface with the sensor simulators and/or experiment simulators as well as the ALSEP itself. Under these conditions of dynamic testing all functions will be exercised and checked. Experiment electronics will be accurately checked over the complete operating ranges, all house-keeping data will be continuously monitored and checked to verify operations within expected limits. Uplink commands will be exercised and checked for performance. Wherever possible, the environmental conditions imposed upon ALSEP will be continuously monitored and changes noted as they occur. The system test set is shown in Figure 7-1.

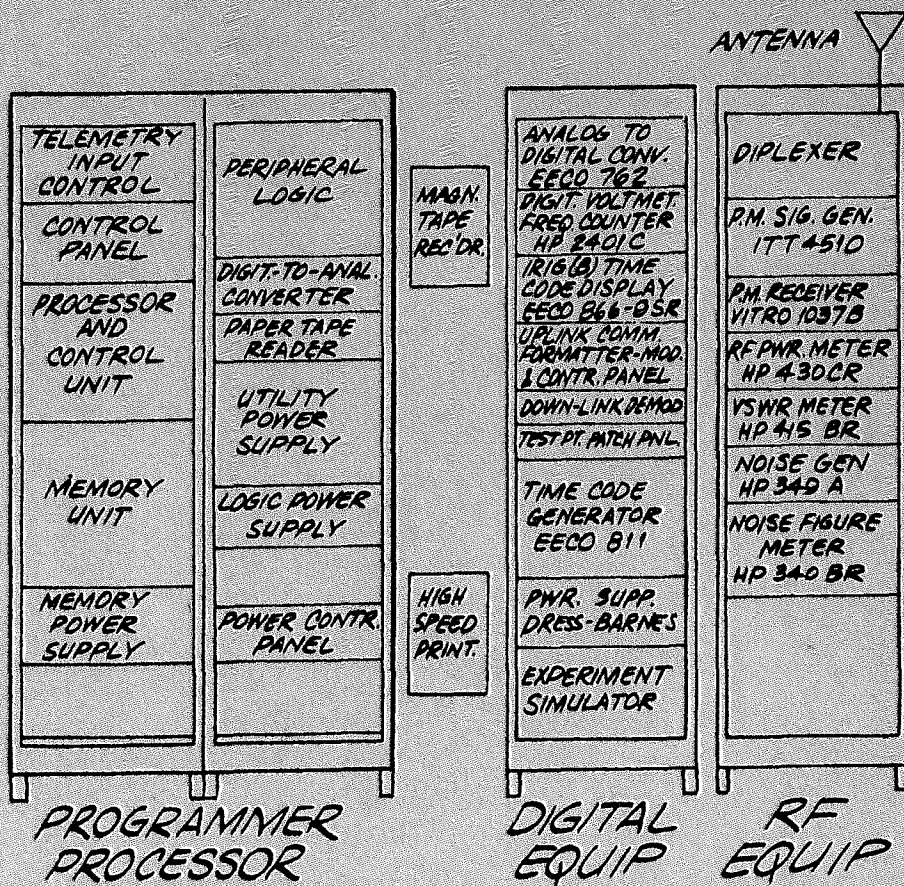
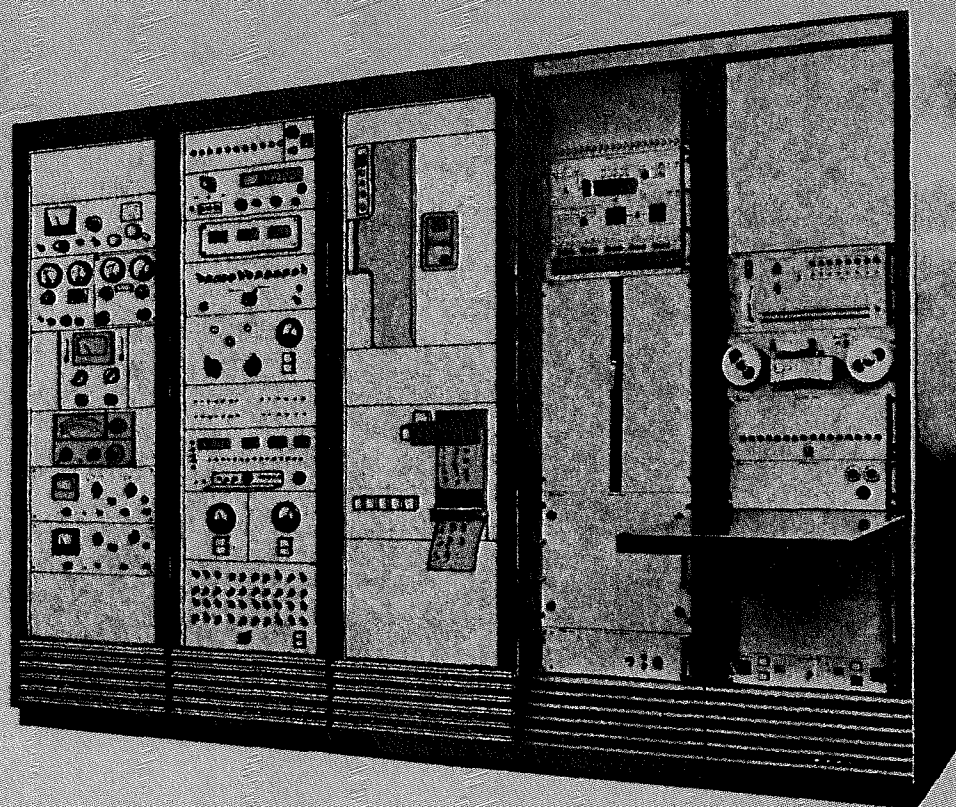


Figure 7-1 System Test Set Physical Arrangement

The data subsystem test set is made up of two sections: RF equipment and digital equipment. The purpose of the equipment is to provide a flexible and detailed testing capability at all stages of buildup of the ALSEP data subsystem. At any time, should it become necessary, sections and even units may be separately tested to efficiently locate and correct interface problems as well as unit malfunctions.

Experiment test sets are provided for the following experiments:

1. Active Seismic
2. Passive Seismic
3. Electron/Proton
4. Heat Flow.

The Magnetometer, Solar Wind, and Suprathermal Ion Detector Experiments and their test sets are GFE.

The experiments simulator will be designed to simulate digital experiment data for unit test of the data processor. It will also be used for data unit subsystem or system tests when any or all of the experiments are unavailable.

Sensor simulators are not provided for the Magnetometer or Solar Wind experiments. Discussion with the primary investigator indicates they will generate a calibration signal internally in their GFE equipment. This calibration signal will be used in place of a separately furnished sensor simulator.

Each experiment sensor simulator will be capable of generating a signal to simulate the experiment when the true sensor environment is not available. Each sensor simulator will be used in the manual mode in connection with the experiment test sets for individual subsystem tests on the appropriate experiment. They will also be used in the automatic mode for complete system test when the true sensor environments are unavailable.

The test set associated with functioning the RTG is GFE and will not be discussed here. The PCU test set is designed to test the power conditioning unit electrically. The RTG simulator will provide all inputs

to the PCU which would normally come from the RTG. The PCU test set will monitor and properly load all power outputs. These power outputs will be monitored for voltage, current, regulation, ripple, transient response, and other characteristics using standard laboratory test equipment. All housekeeping outputs will be monitored by an external digital voltmeter.

The RTG simulator will be capable of supplying 14 v to the power conditioning unit for all system and subsystem tests.

The J Box and cable checker will be capable of checking continuity and isolation on each wire and connector in the ALSEP distribution system. The J Box and cable checker will scan each wire or connection in any cable or J Box. Each wire will be checked for continuity of less than one ohm at the rated current, not to exceed one ampere. Also isolation of 10 megohms will be checked between each wire and all others. The tester will advance automatically to the next wire if a go decision is made and will stop on a no-go indication.

The ordnance test set will be capable of electrically functioning the mortar device and thumper staff of the Active Seismic Experiment. It will also be capable of making continuity checks on the squibs before they are installed. The current for these tests will be very low level to avoid accidental discharge of the squib. The test set will be battery powered to allow operation in a test area where the mortars and thumper squibs may be discharged. Safety switches will be installed to avoid accidental discharge.

The mechanical GSE consists of special tools, special handling fixtures, and shipping container. Special tools are required to assemble and disassemble experiments and subsystems to the ALSEP structure. ALSEP handling fixtures are required to fulfill the following functions:

1. Transportation at the contractor's facility and KSC
2. Antenna alignment
3. Hoisting
4. Installation of ALSEP into LEM
5. Measurement of ALSEP mass properties.

Shipping containers will provide suitable protection for ALSEP compartments, subsystems, and spare parts during transit from the contractor's facility to KSC and will also be used for protective storage of these items.

7.1 ALSEP/MSFN/MISSION CONTROL CENTER INTERFACE

Essentially all command origination and monitoring of the ALSEP will take place at the Mission Control Center. Displays for complete experiment and housekeeping data will be located in the MCC for use as appropriate. Each MSFN station will have, however, an emergency command capability and limit light displays.

With the exception of the early phases of the mission and certain particular instances, such as during some Heat Flow Experiment operations, the normal operating mode will be to record the ALSEP data on magnetic tape at the MSFN stations for subsequent shipment to MSC and appropriate distribution and interpretation. Each station will require an 18-channel tape recorder, six per each ALSEP. The ALSEP/MSFN interface is shown schematically in Figure 7-2. The MSFN 30-ft antenna is used for all ALSEP operations except the Active Seismic Experiment mortar firing and data recovery sequence, which requires use of the 85-ft antenna.

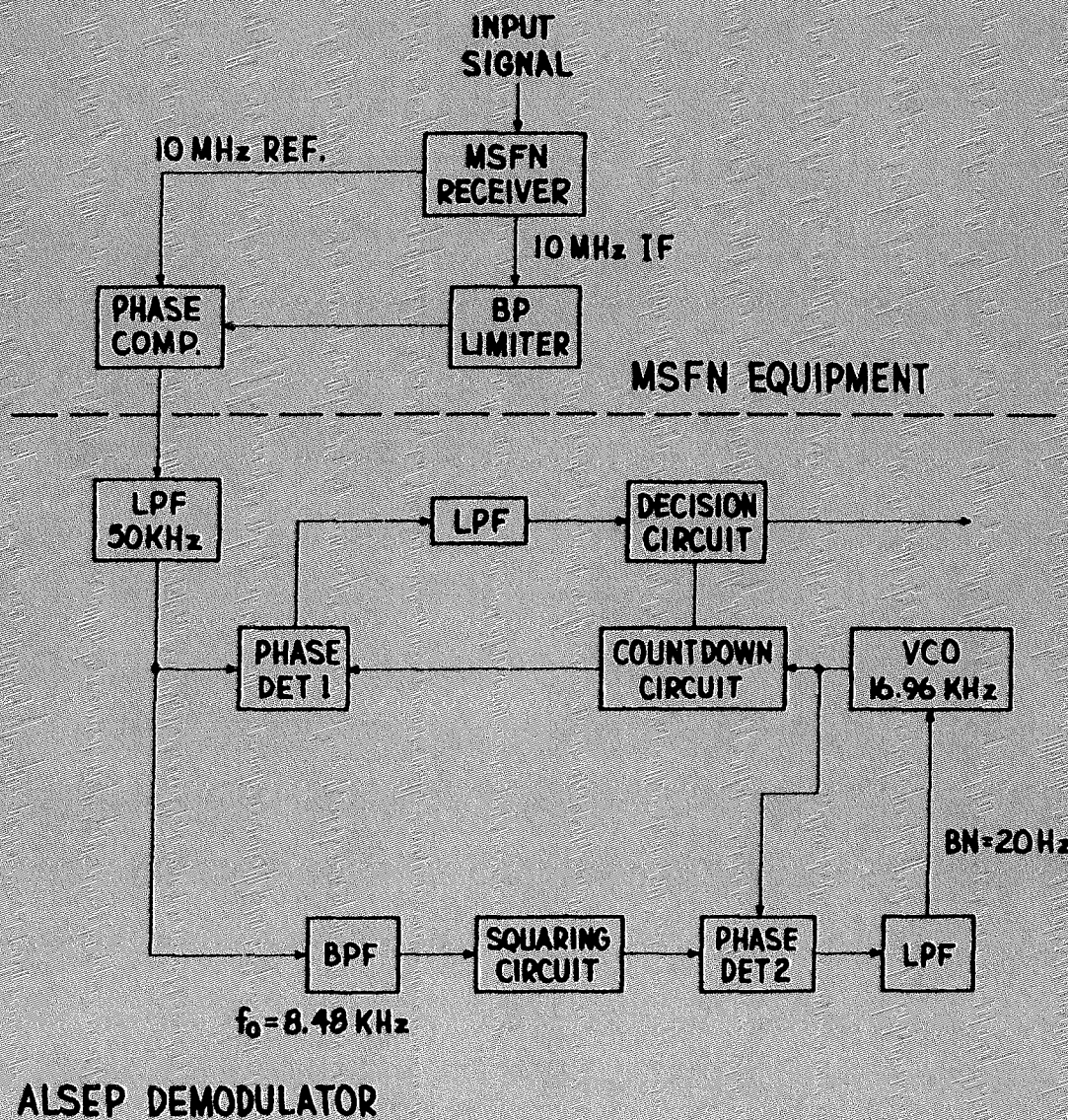


Figure 7-2 MSFN/ALSEP Interface