



**Bell Laboratories**

subject: Apollo 17 Lunar Surface Experiments  
Summary - Case 40058

date: SEP 19 1972

from: G. K. Chang

MEMORANDUM FOR FILE

The attached "Apollo 17 Lunar Surface Experiments Summary" contains a brief description of each surface experiment including the scientific objectives, the parameters to be measured, and a very brief description of the instruments. In cases where the experiment has flown previously, some results of these prior missions are also included.

*G. K. Chang*  
G. K. CHANG

DC-3451-GKC-amd

Att.

## APOLLO 17 LUNAR SURFACE EXPERIMENTS

### ALSEP (Array E)

Central Station

Heat Flow (S-037)

Lunar Seismic Profiling (S-203)

Lunar Surface Gravimeter (S-207)

Lunar Atmospheric Composition (S-205)

Lunar Ejecta and Meteorites (S-202)

### Traverse Experiments

Surface Electrical Properties (S-204)

Traverse Gravimeter (S-199)

### Other Experiments

Lunar Geology Investigation (S-059)

Documented Sample

Drill Core Sample

Neutron Flux Monitor (S-229)

Soil Mechanics (S-208)

## CENTRAL STATION

The ALSEP Central Station (C/S) is the heart of the lunar surface experiment package. The C/S distributes power generated by a Radioisotope Thermoelectric Generator to the experiments and subsystems. The C/S consists of the communication subsystem transmitters and receivers (including antenna), the data subsystem, and the electronic subsystems for the experiments. It receives, decodes, and applies uplink commands to the experiments and collects, processes, and transmits scientific and engineering data from the experiments and subsystems to the MSFN (Figure 1). A switch panel is available by which the astronaut can activate the C/S if activation by ground commands fails.

The experiments which the Array E ALSEP C/S supports are the Lunar Heat Flow Experiment (S-037), Lunar Seismic Profiling Experiment (S-203), Lunar Surface Gravimeter Experiment (S-207), Lunar Atmospheric Composition Experiment (S-205) and the Lunar Ejecta and Meteorites Experiment (S-202). Each ALSEP experiment interfaces electrically with the central station by means of flat, ribbon-like conductor cabling.

The ALSEP C/S and experiments will be deployed 100 m west of the LM by the astronauts during EVA-I (Figure 2). The Apollo 17 ALSEP will collect scientific data on the lunar surface for a period over two years.

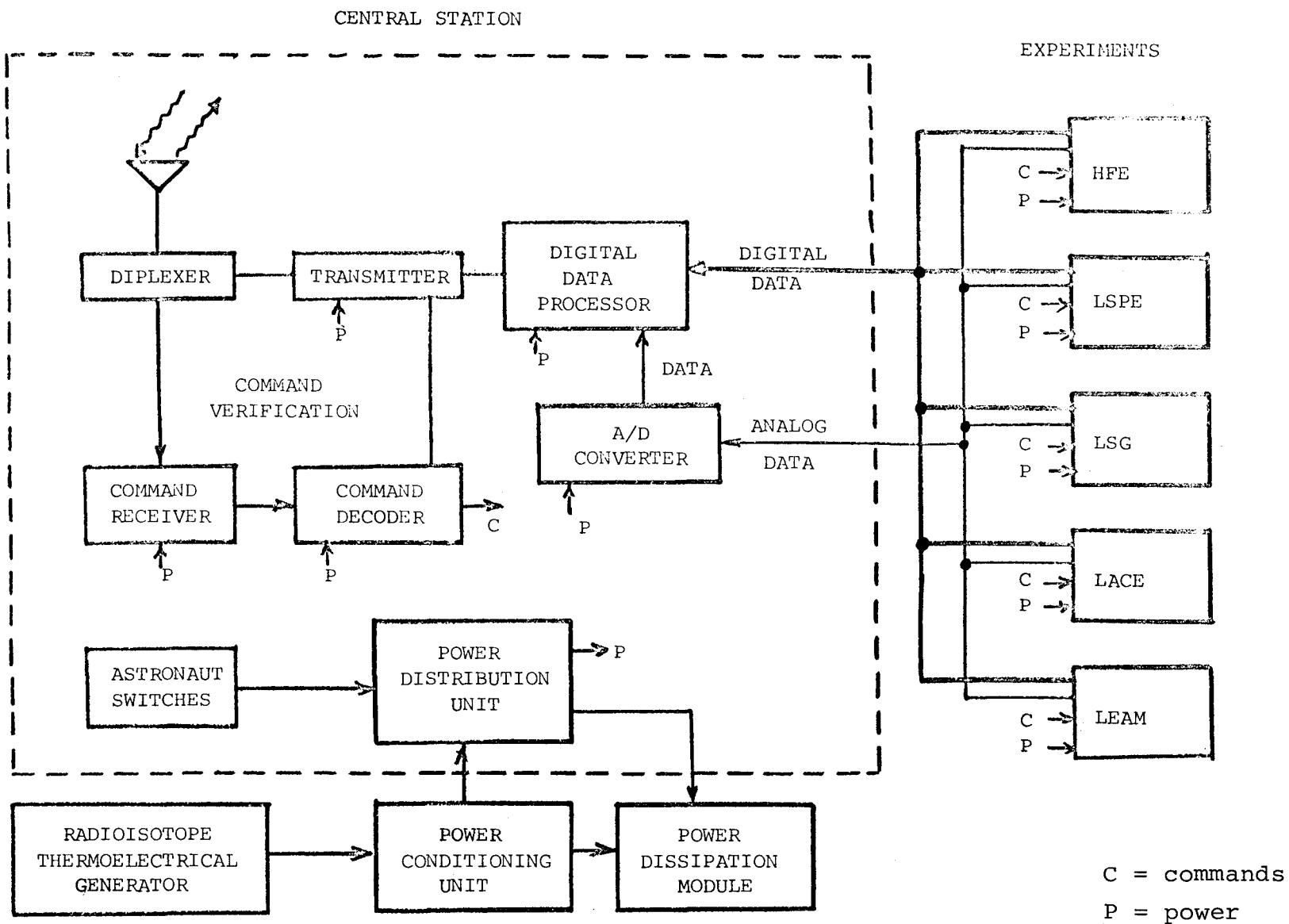


FIGURE 1 - ALSEP ARRAY E FUNCTIONAL BLOCK DIAGRAM

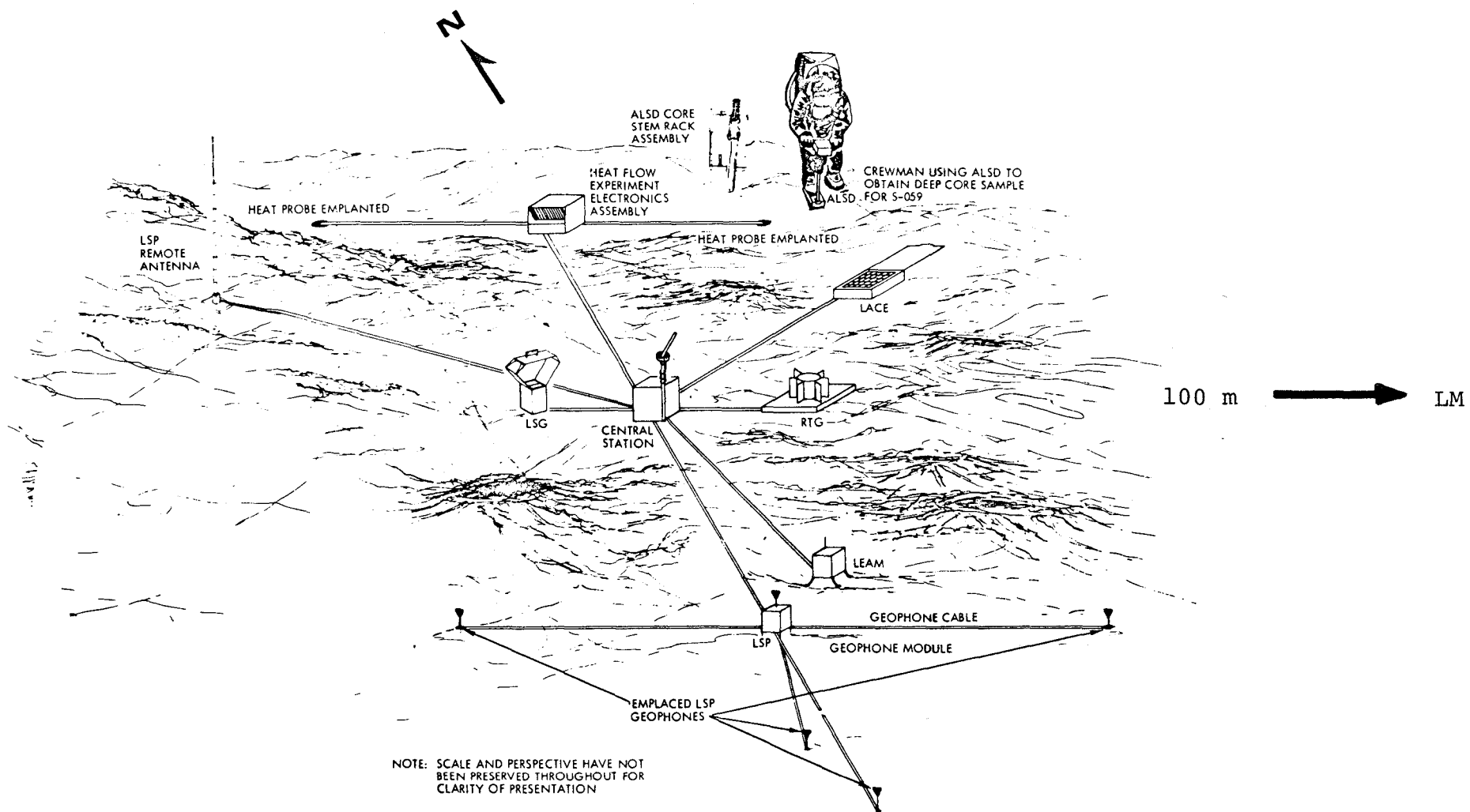


Figure 2 - APOLLO 17 ALSEP EXPERIMENT DEPLOYMENT

### HEAT FLOW EXPERIMENT (S-037)

Principal Investigator: Langseth/Lamont-Doherty Geological Observatory  
Co-Investigators: Clark/Yale; Simmons/MIT

The purpose of the Heat Flow Experiment is to determine the rate of heat flow from the lunar interior by temperature and thermal-property measurements in the lunar subsurface. Heat loss is directly related to the internal temperature and the rate of internal heat production. Measurements of these quantities enable limits to be set on long-lived radioisotopic abundances, the internal temperature, and the thermal evolution of the Moon.

The essential measurements for determining heat flow are made by two slender temperature-sensing probes that are placed in predrilled holes in the subsurface, spaced approximately 10 m apart. Each probe consists of two nearly identical 50 cm long sections (Figure 3). Each section of each heat flow probe has two accurate ( $\pm 0.001^\circ\text{K}$ ) differential thermometers that measure temperature differences between points separated by approximately 47 and 28 cm. Additional temperature measurements are provided by four thermocouple junctions in the cables that connect each probe to the electronics units. Conductivity measurements are made by means of heaters that surround each of the eight gradient bridge sensors. The temperature rise and the rate of temperature rise can be interpreted in terms of the conductivity of the surrounding lunar material.

Preliminary results from the Apollo 15 Heat Flow Experiment indicate that the heat flow from the interior of the moon outward is about  $3.3 \times 10^{-6}$  watts/cm, approximately one-half the average heat flow of the earth. Thermal conductivity of the regolith increases with depth and the values between  $1.4$  and  $2.5 \times 10^{-4}$  W/cm-K were determined at depths between 1 and 1.5 m; these values are a factor of 7 to 10 greater than the values of the surface conductivity.

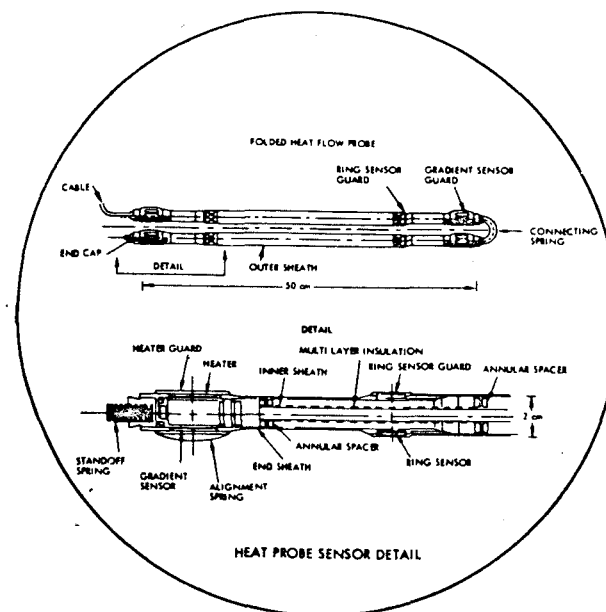
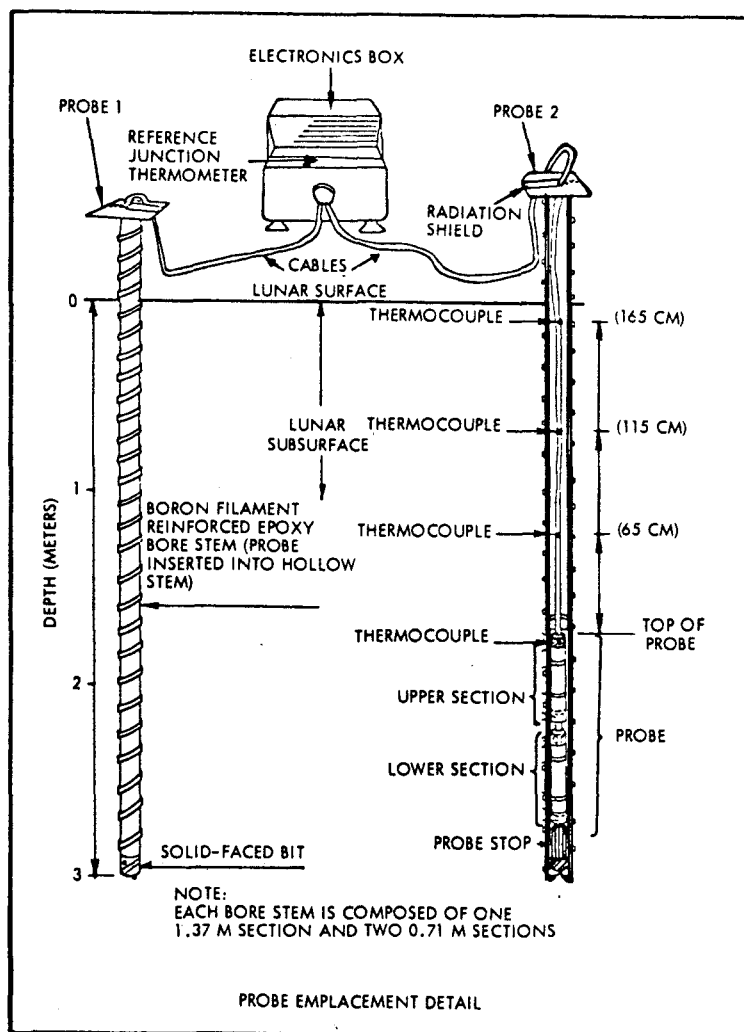


Figure 3 - HEAT FLOW EXPERIMENT -- FLOW PROBE EMPLACEMENT/SENSOR DETAILS

### LUNAR SEISMIC PROFILING (S-203)

Principal Investigator: Kovach/Stanford

Co-Investigator: Watkins/North Carolina

By means of seismic refraction, the Lunar Seismic Profiling Experiment (LSPE) will determine physical properties of lunar surface and near-surface material to depths of approximately 3 km. The LSPE has two modes of operation: (1) In the active mode, artificial seismic waves will be generated by a pre-set explosive package and be detected by geophones. (2) In the passive listening mode, the geophones will monitor micro-moonquakes and detect meteorite impact. Additionally, the LSPE will record seismic signals generated by LM ascent and the LM ascent stage impact on the lunar surface.

Eight explosive packages, four on each transport module (Figure 4), will be deployed on the lunar surface from the LRV at varying distances up to 2.5 km from the LM. Each explosive package contains safety devices, electronics, and a high explosive charge ranging in size from 1/8 to 6 lbs. The explosives will be detonated in a prescribed sequence after the astronauts leave the lunar surface by a coded command transmitted from the ALSEP central station. The artificially generated seismic signal will be detected by four geophones, deployed in a triangular array 300 feet on a side and with one geophone in the center (Figure 5), and the data transmitted to the earth.

Early versions of this experiment, the Active Seismic Experiment (ASE) (S-033), were deployed during Apollo 14 and Apollo 16. Preliminary results indicate that the near-surface material possesses a seismic-wave velocity of 104 m/sec. The velocity increases with depth, and at a depth of 8.5 m the lunar material has a velocity of 299 m/sec. The LSPE is expected to provide more accurate seismic wave velocities than the ASE. The geophone configuration set up in LSPE will permit determination of the approach azimuth of the seismic wave which was not possible on previous missions.



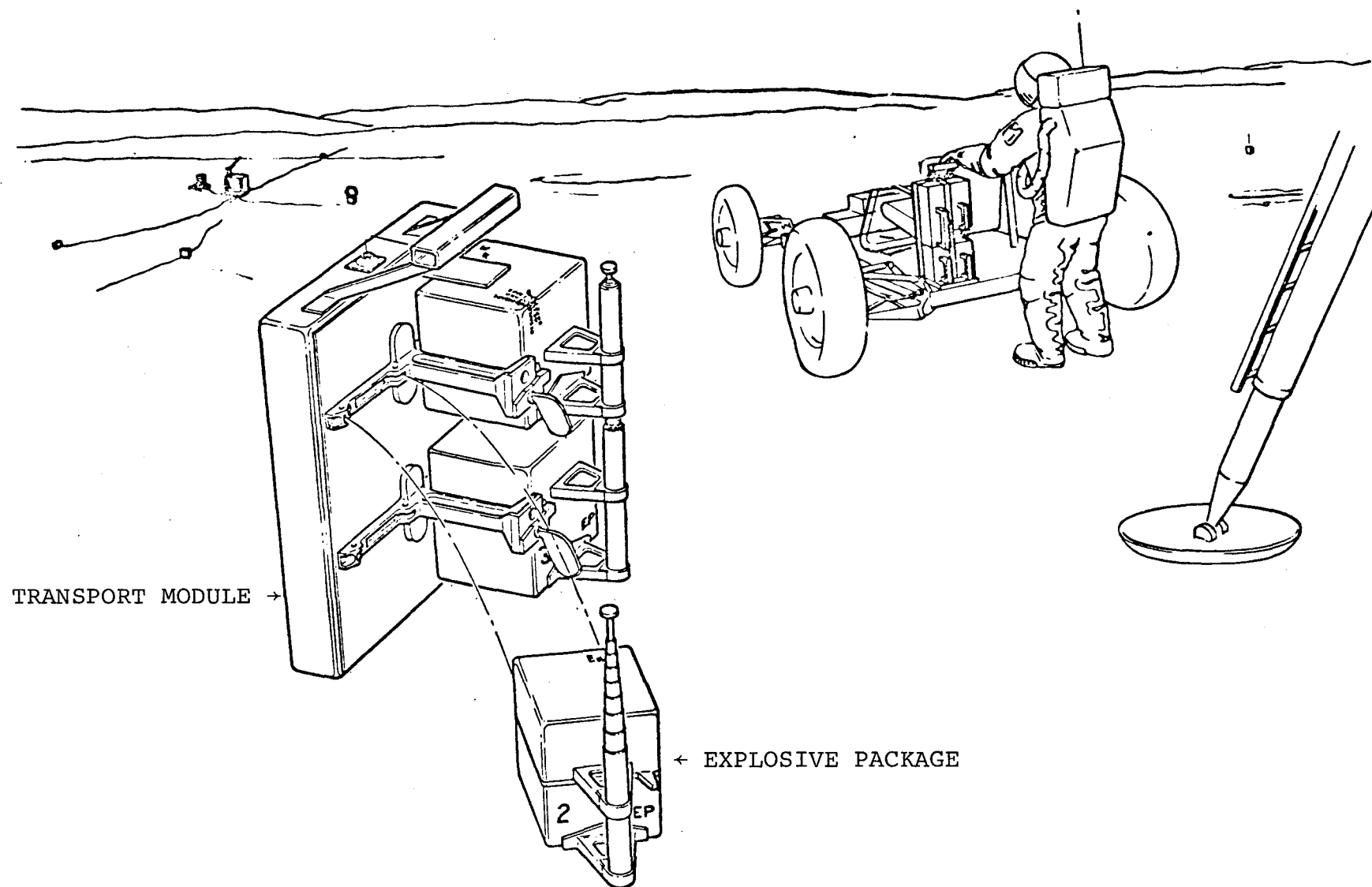


Figure 4 - EXPLOSIVE PACKAGE DEPLOYMENT

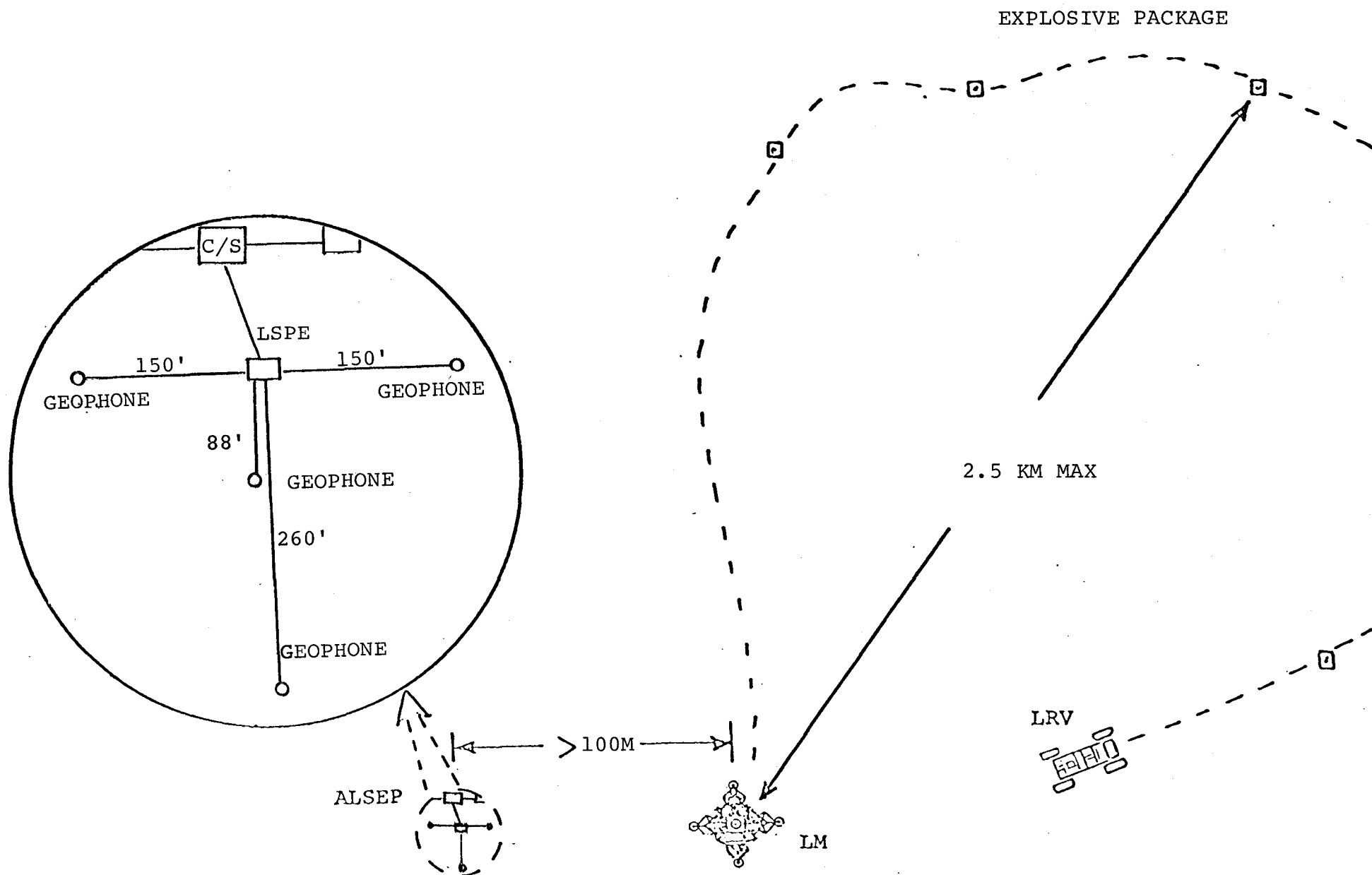


Figure 5 - GEOPHONE DEPLOYMENT

## LUNAR SURFACE GRAVIMETER (S-207)

Principal Investigator: Weber/Maryland  
Co-Investigators: LaCoste/ LaCoste-Romberg; MacDonald/Dartmouth;  
Phinney/Princeton

The purpose of the Lunar Surface Gravimeter (LSG) is threefold: (1) to detect gravitational waves by measuring free oscillations of the moon resulting from the interaction of a propagating gravitational field with the moon; (2) to measure local gravity changes due to lunar tides produced by the earth, the sun and other celestial bodies; (3) to detect lunar seismic activities. Additionally, the LSG will measure lunar gravity relative to earth gravity with an accuracy of approximately 1 part in  $10^5$ .

The most essential part of the experiment is the LaCoste-Romberg gravimeter sensor (Figures 6 and 7) operated at a constant temperature ( $\pm 0.001^\circ\text{C}$  over an hour;  $\pm 0.01^\circ\text{C}$  over one month). The constant temperature is set at the "inversion temperature" where the sensor spring is least sensitive to temperature change. An elaborate thermal control system (Figure 8) is designed to meet the stringent thermal requirements of the LSG sensor.

Recently, Weber reported detection of gravitational radiation apparently arriving from the direction of the Galactic center. Two large aluminum cylinders with frequency in the vicinity of 1660 Hz were used as the gravitational detectors. Coincidences have been observed on these detectors over a baseline of about 1000 km at Argonne National Laboratory and at the University of Maryland. The detection of the gravitational radiation on the Moon in coincidence with the detection on the earth should prove unequivocally the existence of the gravitational radiations in the universe.

Both the earth and the sun produce significant tides on the moon. Theoretical calculation shows gravity change due to earth effect is approximately 1 mgal peak-to-peak and about .02 mgal peak-to-peak due to solar effect. The data obtained from the tidal change and the free oscillation of the moon should yield important information about the internal constitution of the moon.

In conjunction with the Passive Seismic Experiment deployed on previous missions LSG data should also give valuable information about the lunar interior.

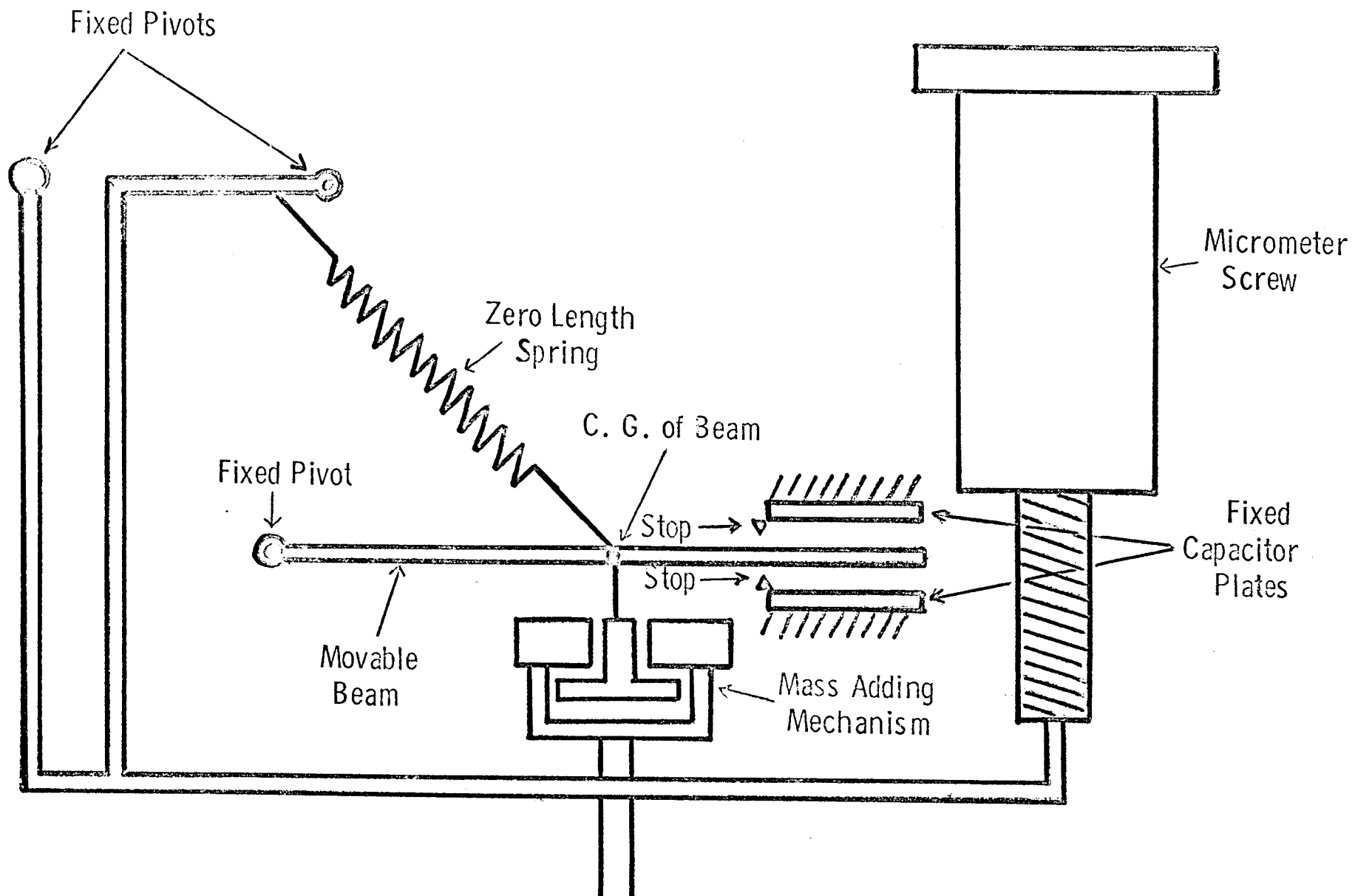


Figure 6 - LUNAR GRAVITY METER DIAGRAM

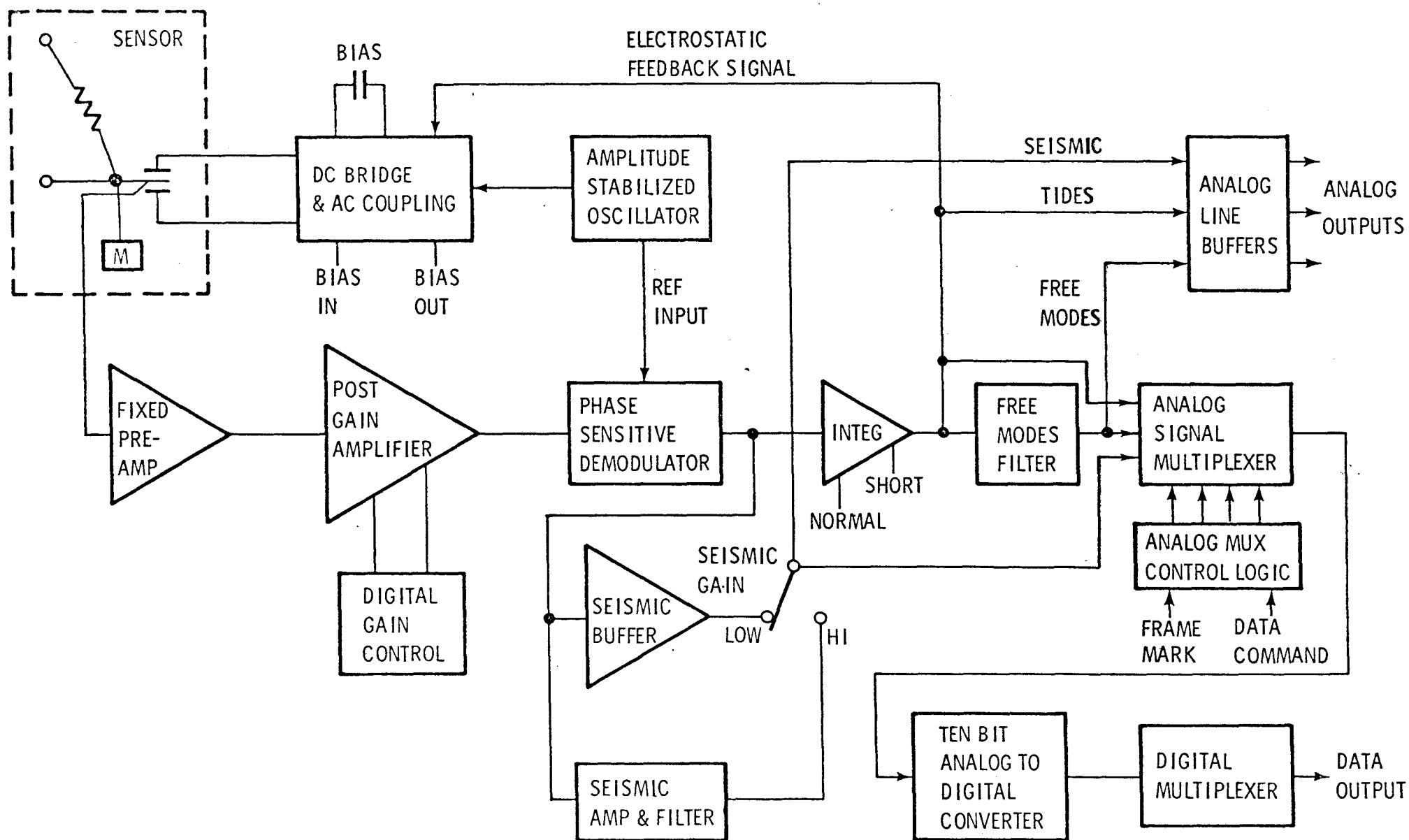


Figure 7 - LaCOSTE-ROMBERG GRAVIMETER SENSOR SYSTEM

# LSGE/CUTAWAY

9270-359

SUNSHADE  
OUTSIDE  $\epsilon = 0.9$   
INSIDE  $\epsilon = 0.9$

ELECTRONICS  
PACKAGE  
COVER  $\epsilon = 0.9$

THERMAL  
INSULATION

INNER CONTAINER  
INSIDE  $\epsilon = 0.9$

ALSEP  
CABLE

INSTRUMENT  
HOUSEING  
OUTSIDE  $\epsilon = 0.9$   
INSIDE  $\epsilon = 0.15$

RADIATOR  $\epsilon = 0.93$

GIMBAL LOCK

SUNSHADE TILT  
INDICATOR

BUBBLE LEVEL

UHT SOCKET

SUNSHADE  
TILT MECHANISM

HEATER BOX  
(SENSOR INSIDE)  
OUTSIDE  $\epsilon = 0.15$   
INSIDE  $\epsilon = 0.08$  (CONETIC FOIL)

GIMBAL  
RELEASE  
LANYARD

Figure 8 - LSG THERMAL DESIGN

## LUNAR ATMOSPHERIC COMPOSITION (S-205)

Principal Investigator: Hoffman/Texas  
Co-Investigators: Hodges and Johnson/Texas; Evans/MSU

The Lunar Atmospheric Composition Experiment (LACE) uses a mass spectrometer to measure the composition and density of neutral molecules present in the lunar environment. Long term variations of the lunar ambient gas and decay of man-made contaminants will also be determined. The data obtained by the LACE will be useful in understanding the geochemical process of the moon and further study of the gas transport process in the lunar environment.

The present lunar atmosphere (Figure 9) is assumed to be composed of remnants of the primordial atmosphere whose loss rates are very small (Kr, Xe), neutralized solar wind particles (H, He, Ne, Ar), volcanic effluents ( $\text{H}_2\text{O}$ ,  $\text{H}_2\text{S}$ ,  $\text{CO}_2$ , CO,  $\text{SO}_2$ ), gas produced by impact vaporization ( $\text{H}_2\text{O}$ ,  $\text{SiO}_2$ , etc.) and gases which are the products of radioactive decay (Ar, Kr, Xe, Ru). Additionally, some man-made contaminants may also be measured in the lunar environment.

The LACE is basically a magnetic sector mass spectrometer which consists of an entrance port, ionization source, accelerating grid,  $90^\circ$  sector permanent magnet, electron multipliers, and processing electronics (Figure 10). A neutral molecule entering the port is ionized by an electron beam. (The molecule becomes a positive ion.) The ion is then accelerated to a velocity,  $v$ , by a voltage,  $V$ , applied to the accelerating grid, giving the ion an energy  $E = eV$  ( $=1/2 mv^2$ ). The accelerated ion enters a magnetic field which will turn as the result of Lorentz force acting upon it. The radius of the ion's trajectory is determined by the ion's mass, energy (and hence the applied voltage), and the magnetic field. Since the magnetic field is steady, by adjusting the accelerating voltage ions of different mass will be recorded. Mass 1 to 4 amu will be recorded on Low Mass Collector, 12 to 48 amu on Mid Mass Collector and 27 to 110 amu on High Mass Collector. The LACE will measure partial pressures down to  $10^{-14}$  torr ( $\sim 10^3$  particles/cc).

A similar experiment, Lunar Orbital Mass Spectrometer Experiment (LOMSE) (S-165), was flown on Apollos 15 and 16. Due to a large amount of contaminant at the vicinity of the spacecraft, the LOMSE collected a limited amount of useful data. The LACE is designed to operate on the lunar surface over two years. In conjunction with data collected from the Cold Cathode Gauge Experiment (S-058), the LOMSE and the Far UV Spectrometer (S-169), the LACE will provide valuable data for understanding the origin of the lunar atmosphere and for studies of the transport processes in the lunar environment.

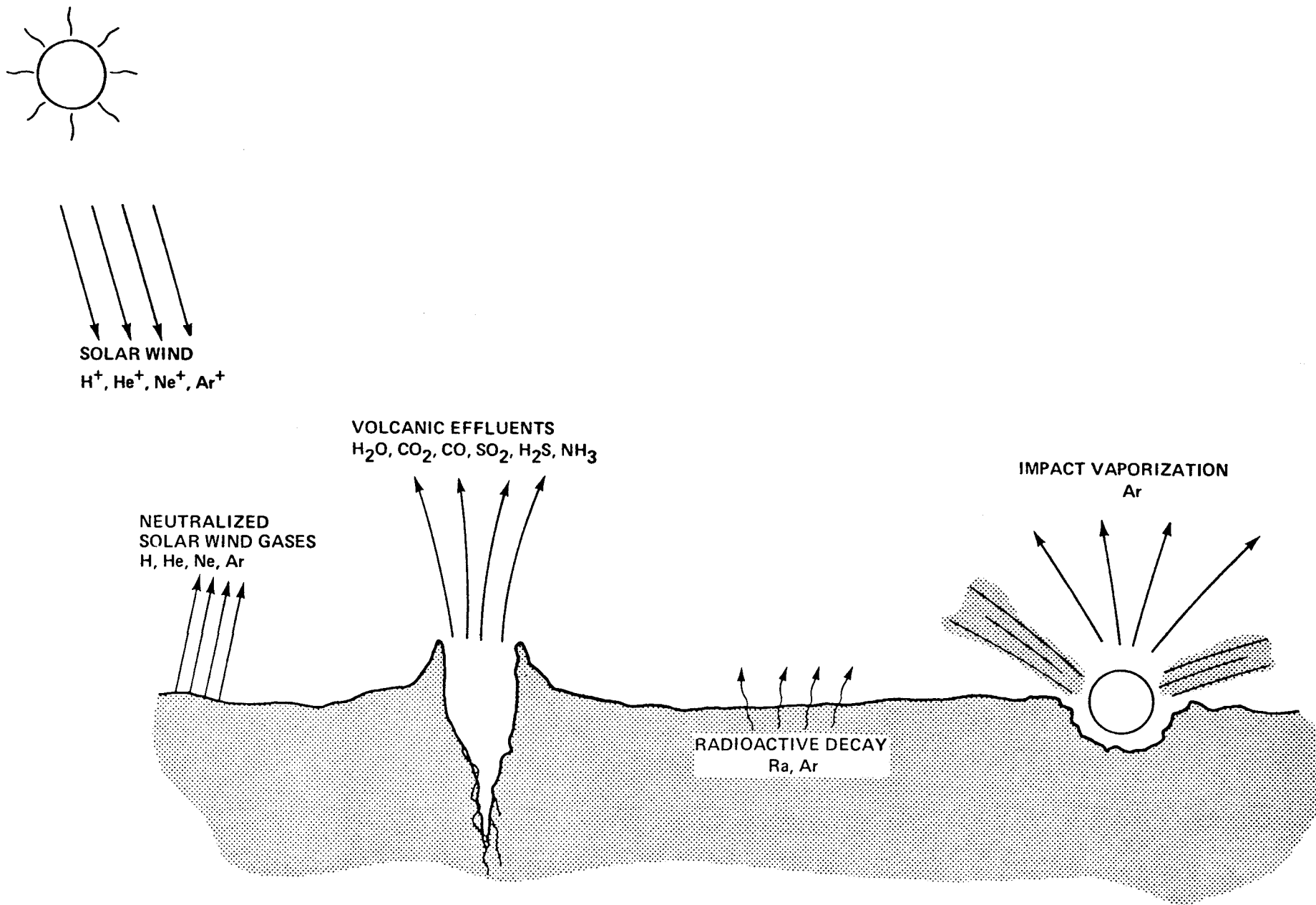


Figure 9 - SOURCES OF THE LUNAR ATMOSPHERE



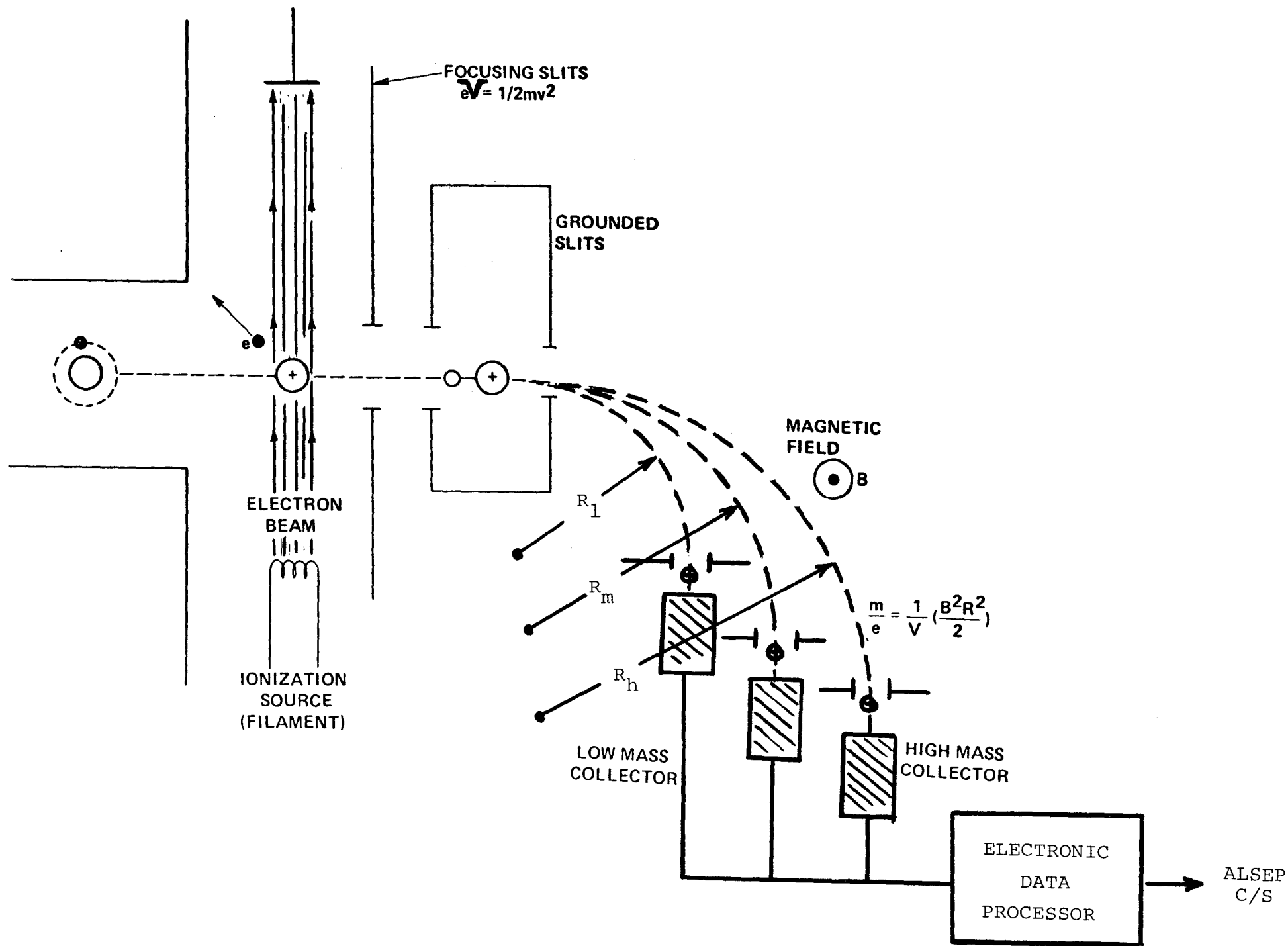


Figure 10 - THEORY OF MASS SPECTROMETER ANALYZER OPERATION

## LUNAR EJECTA AND METEORITES (S-202)

Principal Investigator: Berg/Goddard  
Co-Investigators: Gault and Farlow/Ames

The purpose of the Lunar Ejecta and Meteorites (LEAM) experiment is to measure the primary and secondary meteoroid fluxes on the lunar surface as a function of time and incoming direction of the particles. This would yield information on the spatial and temporal distribution of primary particles and the corresponding flux density of secondaries.

The basic sensor of the LEAM experiment is shown in Figure 11. It is designed to respond to two physical phenomena that occur whenever a hypervelocity particle impacts upon a surface: the production of an ionized plasma and the transfer of momentum. The plasma resulting from the particle impact is separated into ions and electrons and collected on the film and grid, respectively, producing the positive and negative pulses shown in the figure. If the particle has sufficient momentum after impacting front and rear film sensors, it will be recorded by the acoustical sensor. The speed of individual cosmic dust particles are measured by the time-of-flight between front and rear sensors, and the particle direction is determined by a particular combination of front and rear film matrix. The basic sensor shown in Figure 11 is one of 256 elements that comprise a LEAM sensor (Figure 12). There are three sensors in the LEAM experiment: the east, west, and up sensors. The east and up sensors utilize the entire five-coincidence sensor array, and they yield data for determining particle speed ( $\pm 5\%$ ), flight path ( $\pm 26^\circ$ ), kinetic energy and particle momentum. By assuming a particle density and by using the measured speed and kinetic energy, the mass and diameter of the cosmic dust particle can be obtained. The west sensor has no front film and, consequently, cannot measure particle speed. The specific function of the west sensor is to measure impact parameters of low-speed lunar ejecta particles.

The LEAM experiment is similar to those successfully flown in the Pioneer 8 and 9 satellites. The experiment will yield information on the cosmic dust impact flux rate on the lunar surface, the degree of "Earth focussing" effect on the dust particles, the effects of crossing the orbital planes of known comets and the source origin of the cosmic dust within and without the solar system. Additionally, the experiment will measure the extent and nature of the lunar ejecta which is crucial to the understanding of the origin and the nature of the lunar soil.

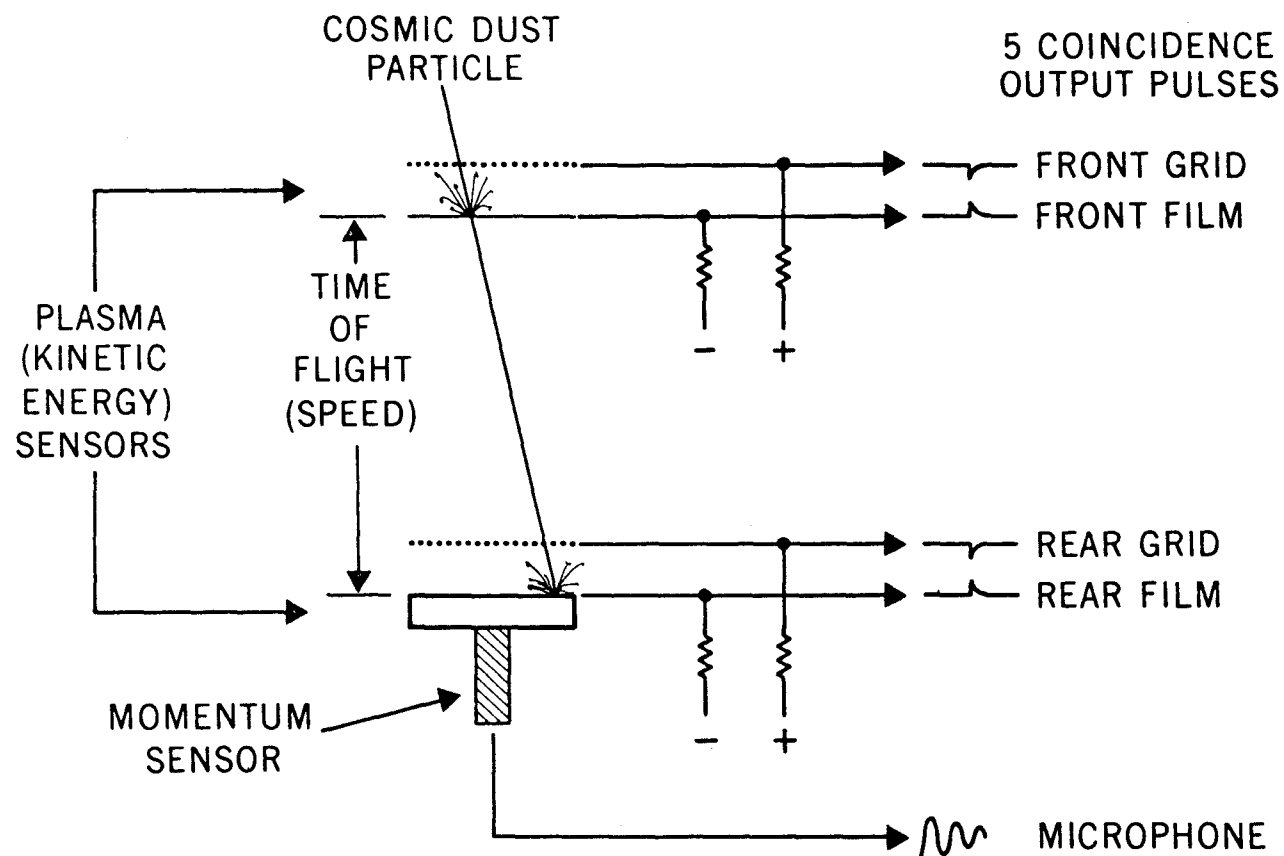


Figure 11 - BASIC SENSOR OF THE LEAM EXPERIMENT

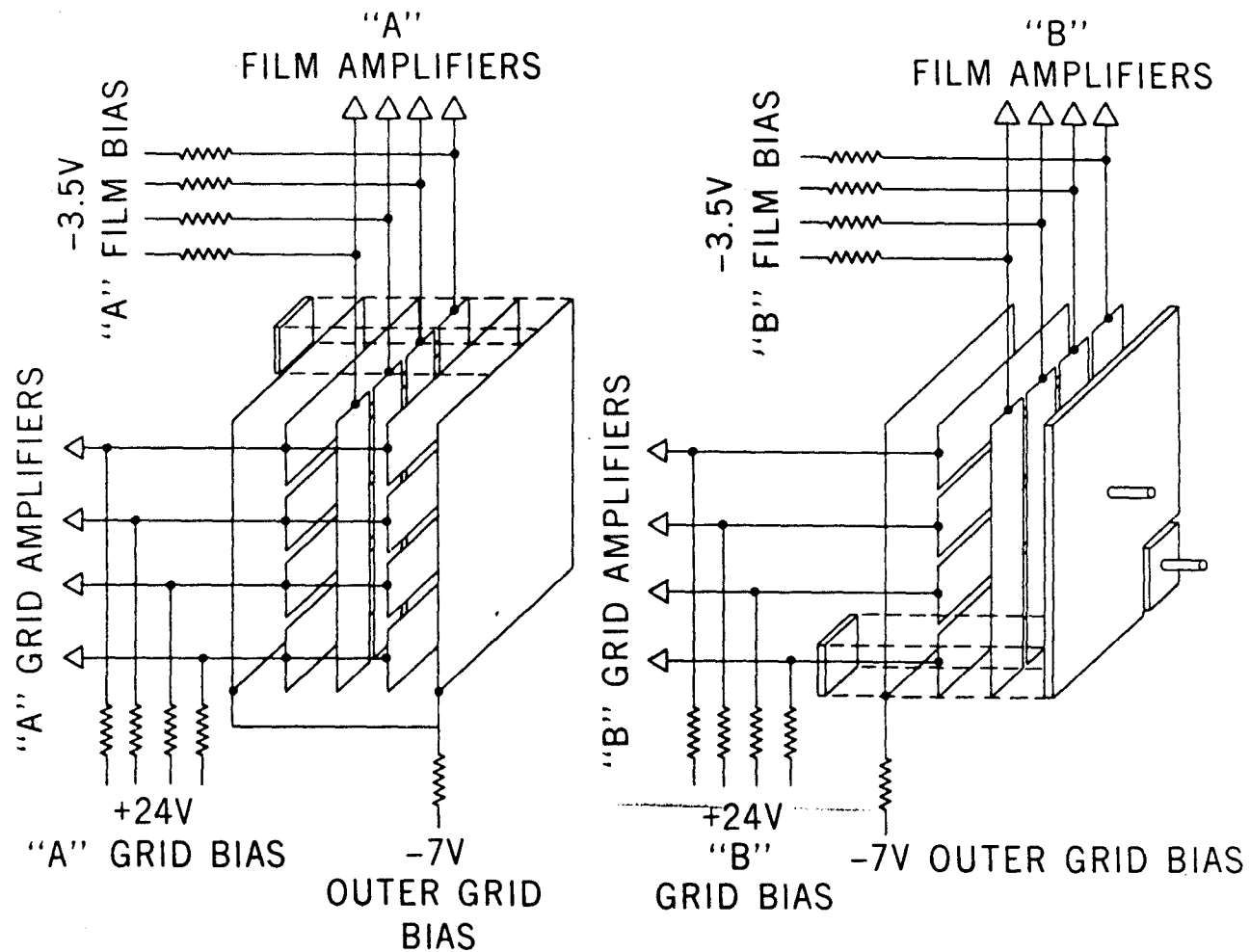


Figure 12 - FRONT AND REAR PORTIONS OF LEAM EXPERIMENT SENSOR ARRAY

## SURFACE ELECTRICAL PROPERTIES (S-204)

Principal Investigator: Simmons/MIT  
Co-Investigators: Strangway/Toronto; England/MSU

The primary objectives of the Surface Electrical Properties Experiment (SEP) are the search for subsurface layering and the detection of subsurface water on the moon. The first objective has obvious significance to our understanding of lunar geology and stratigraphy, while the second objective pertains both to discovery of a major geochemical factor and to the most significant natural resource one could find on the moon.

The SEP experiment consists of a transmitter, a receiver and a recorder (Figure 13). The electric dipole transmitter is laid on the surface and transmits frequencies ranging between 1 MHz and 32 MHz. Energy is propagated in three ways: a) above the surface with the speed of light, b) below the surface along the interface with the velocity of the medium, and c) by reflection from layering or other inhomogeneities in the subsurface. These various waves may interfere with each other as a function of position along the surface. The receiver/recorder is mounted on the rover and measures the field strength as a function of range so that interference frequency can be measured. Interference between the surface and subsurface wave gives a measure of the dielectric constant according to the formula  $\epsilon = (1 + \Delta K)^2$  where  $\Delta K$  is the interference frequency. The rate of decay of the interference gives a measure of the loss tangent. Transmission is done sequentially from a pair of orthogonal dipoles and the receiver consists of three orthogonal loops to measure the field strength of three independent components. Scientific data and rover navigational data are recorded on a DSEA recorder. Upon completion of the lunar traverses, the entire tape recorder (without receiver) will be returned to earth for data analysis.

Another experiment, the Lunar Sounder (S-209), will gather data from lunar orbits during the Apollo 17 mission. The Lunar Sounder will collect data on a global scale, whereas the SEP measures localized phenomena. Data obtained from both experiments should yield important information on the structure and nature of layering beneath lunar surfaces to a depth of about 3 km. In addition, the SEP data may find the presence of scattering bodies in the lunar subsurface.

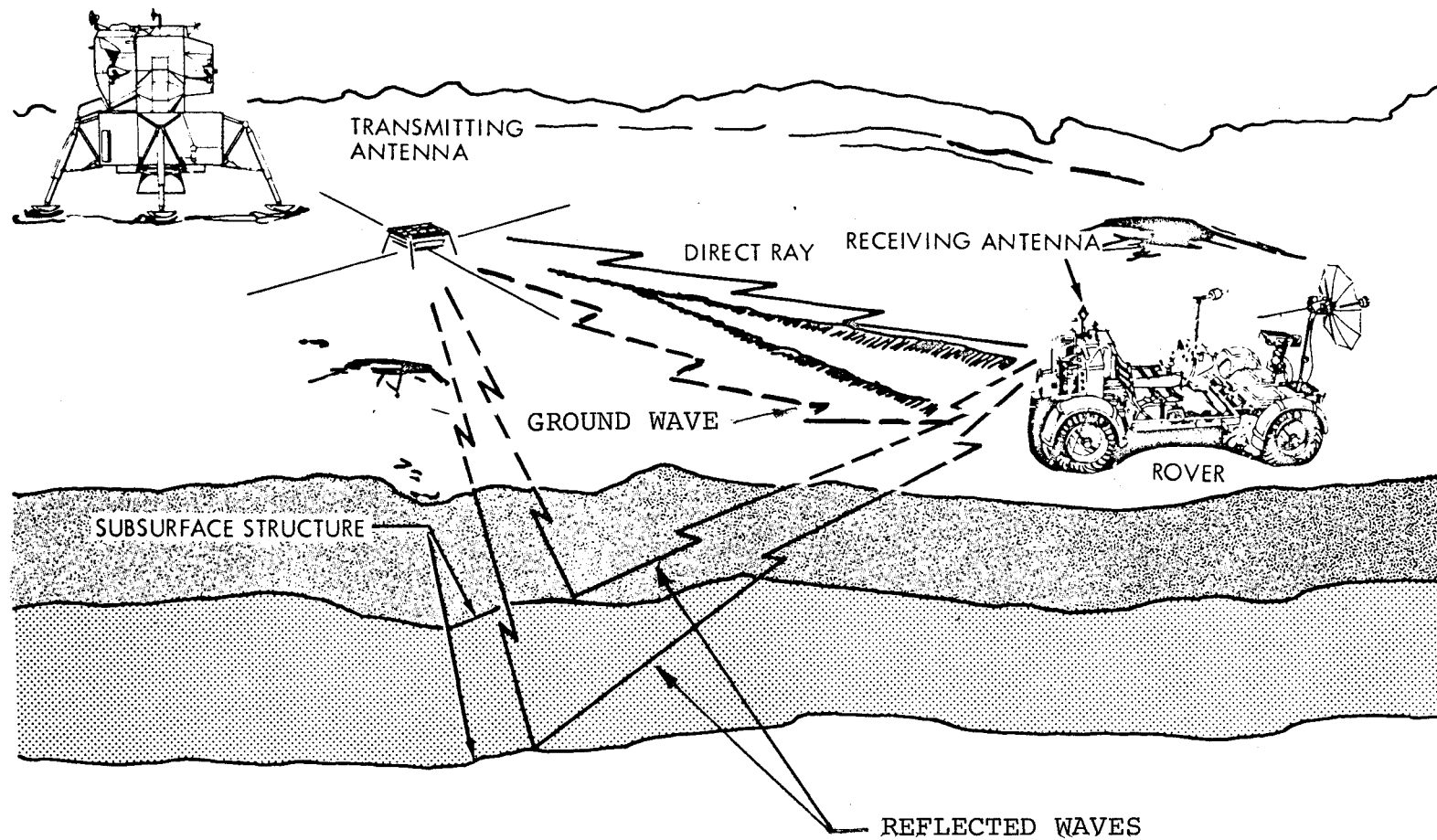


Figure 13 - SURFACE ELECTRICAL PROPERTIES EXPERIMENT

### TRAVERSE GRAVIMETER (S-199)

Principal Investigator: Talwani/Lamont-Doherty  
Co-Investigator: Wing/MIT

The purpose of the Traverse Gravimeter Experiment (TGE) is to measure gravity at various points on the lunar surface to obtain a gravity profile. The profile will be used to reveal subsurface information related to ridges, mascons, craters, rilles, scarps, thickness variations in the regoliths and lava flows, and density variations in the basement and maria highland borders. The gravity measurements will be made at predetermined stops along the LRV traverse. The measurement made by the TGE will, if possible, be related to an earth-based gravity station. Results of each measurement will be displayed digitally to the astronaut who will, in turn, transfer the measurement to earth by way of voice communication.

The gravimeter sensor of the TGE is a Vibrating String Accelerometer (VSA) which operates at a constant temperature ( $50^{\circ} \pm .01^{\circ}\text{C}$ ). To maintain this temperature throughout the mission, an elaborate thermal control oven was designed (Figure 14). The TGE will take a gravity reading in the vicinity of the LM and then it will be mounted on the LRV (Figure 15) to make gravity measurements along the LRV stops. The TGE will measure lunar gravity within the accuracy of 5 mgals.

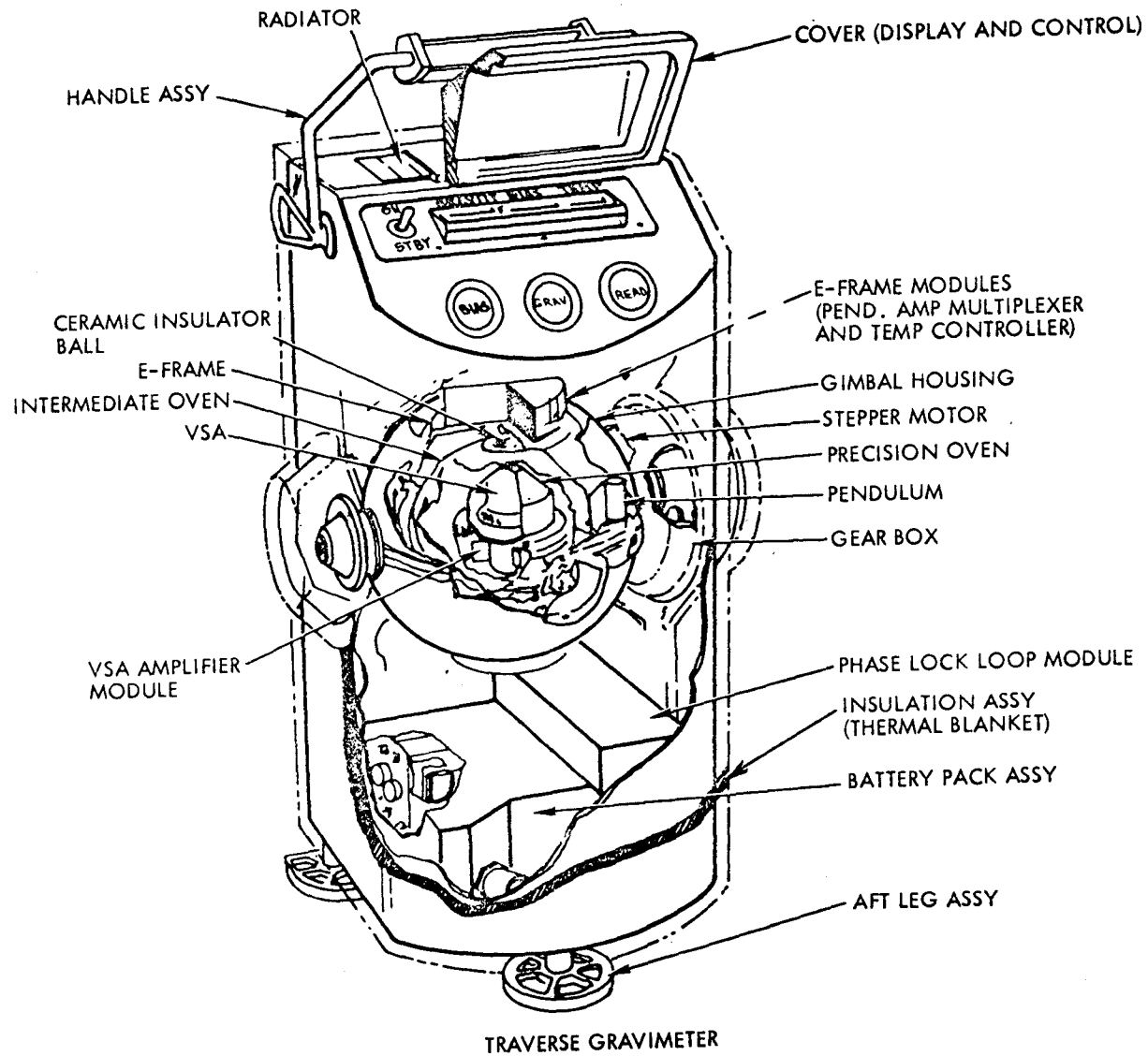


Figure 14 - TRAVERSE GRAVIMETER EXPERIMENT



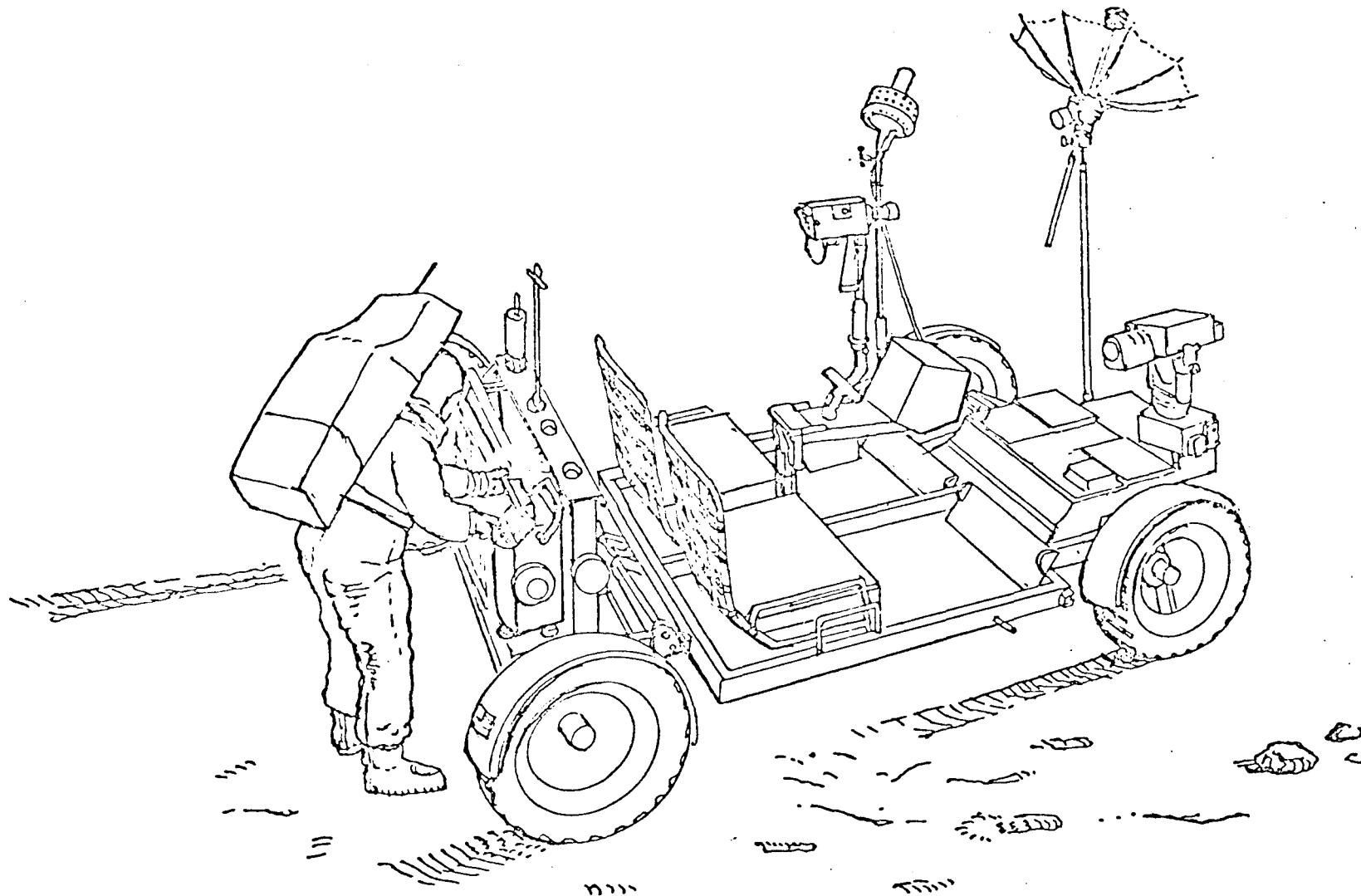


Figure 15 - TRAVERSE GRAVIMETER; STOWAGE CONFIGURATION ON THE LUNAR ROVING VEHICLE

## LUNAR GEOLOGY (S-059)

Principal Investigator: Muehlberger/USGS & Texas  
Co-Investigators: Silver/Cal. Tech.; McGetchin/MIT;  
Titley/Arizona; Page, Peck, Jackson, Ulrich, Masursky, Hodges,  
Milton, Elston, Schafer, Boudette, Freeman and Wolfe/USGS

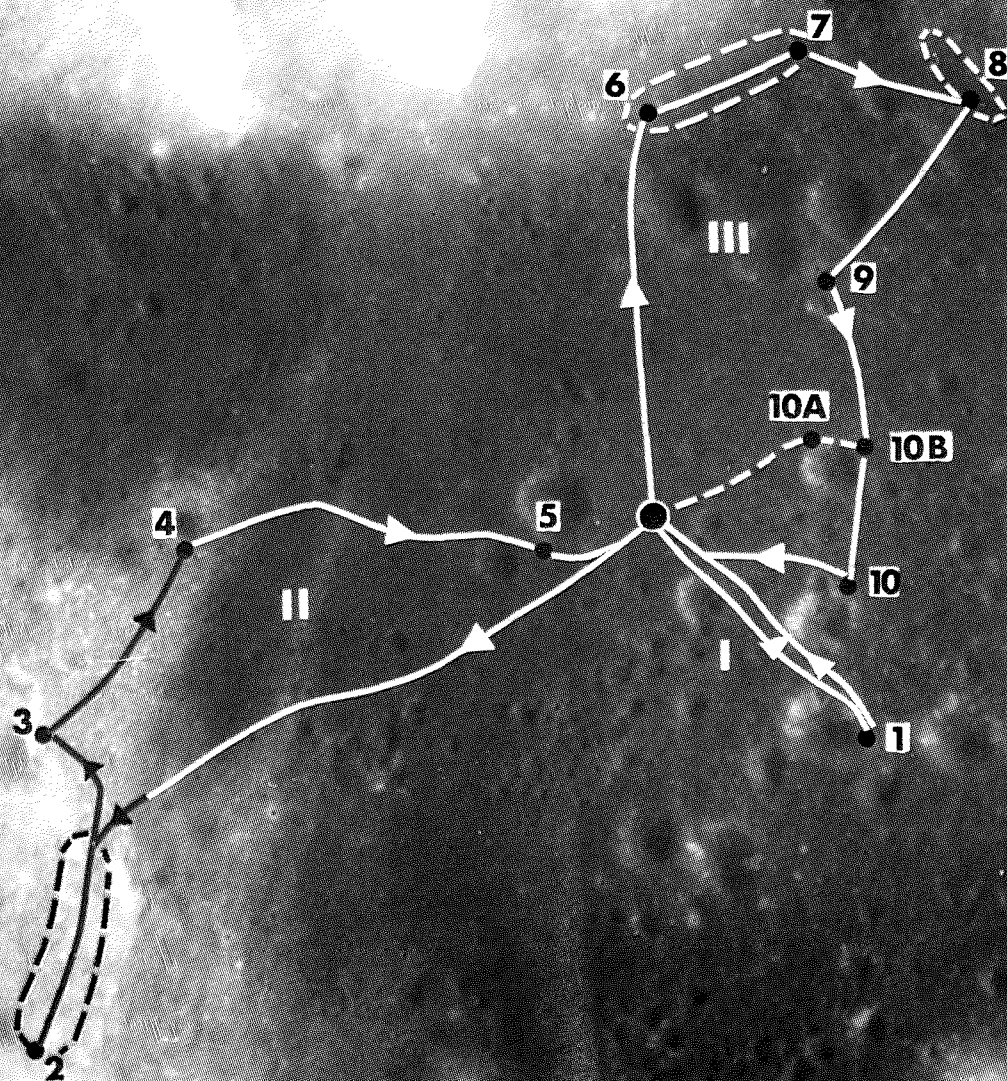
The purposes of the Lunar Geology Investigation Experiment are to obtain a better understanding of the Taurus-Littrow highlands area and the processes which have modified the highland surface through the study of documented lunar geological features and returned lunar samples.

The major equipment used for this experiment are: hammer; tongs; extension handle; large sampling scoop; rake; gnomon/photometric chart; sample scale (located in the LM ascent stage); core tubes/caps with follower tool; documented sample bags; LRV Sampler, sample collection bags; special sample containers (a nominal SESC and a CSVC); sample return bags; and sample return containers. A 3.3 meter core sample is obtained with the use of the Apollo Lunar Surface Drill.

Photography requirements for this experiment are satisfied with the use of the 70 mm Hasselblad electric data camera with 60 mm lens. The Ground-Commanded Television Assembly (GCTA) provides realtime ground and science support for the geology activities. Three traverses are planned for this mission (Figure 16).

The collection of geological samples, photography and verbal descriptions of geological features are planned to provide data for lunar geological studies that will increase the knowledge of the physical makeup of the moon, its history, the nature and history of the solar system, and the history of the earth. The samples and photographs obtained on this mission will augment the data obtained during Apollo 11, 12, 14, 15, and 16, and are expected to provide valuable information for use in the interpretation of the geological history of the moon.

# APOLLO 17 LRV TRAVERSES



### LUNAR NEUTRON PROBE EXPERIMENT (S-229)

Principal Investigator: Burnett/Cal. Tech.  
Co-Investigator: Woolum/Cal. Tech.

The purposes of the Lunar Neutron Probe Experiment are to measure neutron capture rates in the lunar regolith, measure variation of neutron capture rates as a function of depth beneath the lunar surface, and gain information on the lunar neutron energy spectrum.

The experiment equipment (Figure 17) consists of a cylindrical probe (metallic outside, track detector materials inside). The probe is 2.35 meters in length and 2 centimeters in diameter. The probe consists of two 1.2 meter sections for transport purposes. Each section is normally set to a "deactivates" condition (detector materials shielded). The sections are activated/deactivated by rotating the inner shield tube using a handle inserted at the top of each section. The crew will transport the probe sections to the experiment site, activate the sections, mate the sections, and insert the probe approximately 2 meters into the lunar surface, utilizing the hole remaining after the core stem sample (Lunar Geology Experiment, S-059) has been extracted. The lower section has a pointed end and the upper section has a cap capable of withstanding hammer blows to provide the capability of insertion to the required depth. The probe will be extracted after the required measurement period (minimum 24 hours), demated, both sections deactivated, and stored in the LM for return to earth.

This experiment will provide data that will permit interpretation of neutron dosage measurements based on the distribution of gadolinium isotopes in returned lunar samples. The lunar neutron flux is a very sensitive function of depth, the measured exposures would be a useful tool in interpreting the mixing history of lunar soil. The lunar neutron flux gradient is an important data for a thorough interpretation of the gadolinium isotopic data.

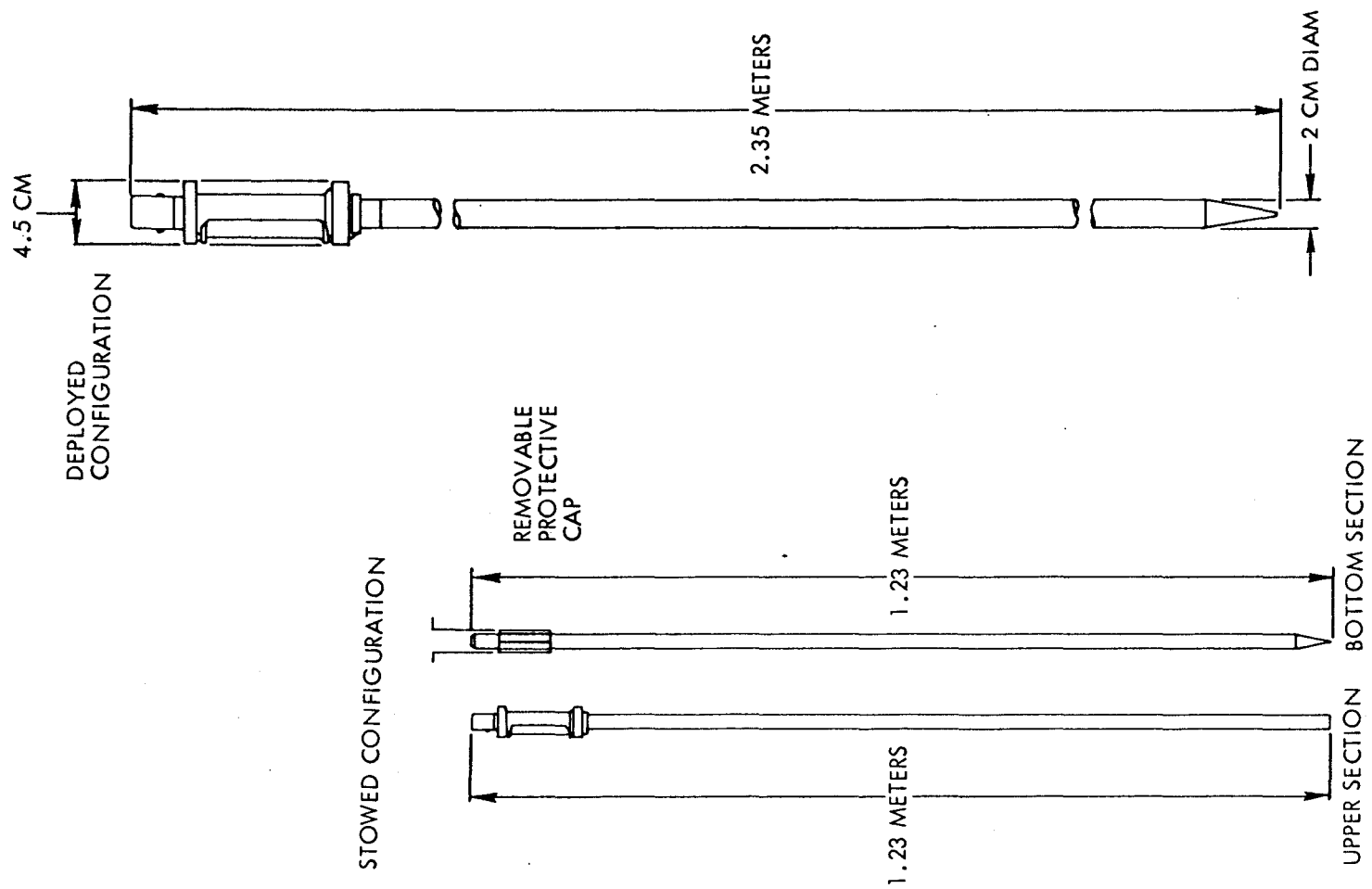


Figure 17 - LUNAR NEUTRON PROBE -- STOWED AND DEPLOYED CONFIGURATION

### SOIL MECHANICS (S-700)

Principal Investigator: Mitchell/Calif.  
Co-Investigators: Bromwell/MIT; Scott/Cal. Tech.;  
Costes/MSFC; Carrier/MSC; Houston/Calif.

The objective of the Soil Mechanics Experiment is to obtain data on the physical characteristics and mechanical properties of the lunar soil at the lunar surface and subsurface and their variations in a lateral direction.

The Soil Mechanics Experiment will provide data on the in-place physical properties of the soil in the vicinity of the landing site for use in the interpretation of lunar history and processes. Observational data on the lunar surface and information on soil grain size and grain-size distribution obtained from returned samples, will enable estimation of in-place density and porosity profiles in the upper few tens of centimeters.

The Soil Mechanics Experiment for the Apollo 17 Mission is to be completely passive and will require no experiment-unique equipment or activities as was done on the Apollo 15 and Apollo 16 Missions. Experiment data will be derived from visual observations of the crew, lunar surface photography of crewman/LRV/LM induced soil impressions and natural surface features, and returned lunar samples, especially core tube and soil samples.

Subject: Apollo 17 Lunar Surface Experiments Summary  
Case 40058

From: G. K. Chang

Distribution List

NASA Headquarters

R. J. Allenby/MAL  
D. A. Beattie/MAL  
L. J. Casey/MAE  
N. W. Hinnners/MAL  
J. K. Holcomb/MAO  
C. M. Lee/MA  
P. V. Mason/MAL  
W. T. O'Bryant/MAL  
R. A. Petrone/MA  
R. B. Sheridan/MAO  
W. E. Stoney/MAE

Boeing/MAB

J. DelGobo

BTL/Holmdel

I. M. Ross

BTL/Raritan River

A. P. Boysen, Jr.

BTL/Washington

F. El-Baz  
K. E. Martersteck  
P. E. Reynolds  
All Members, Dept. 3451