

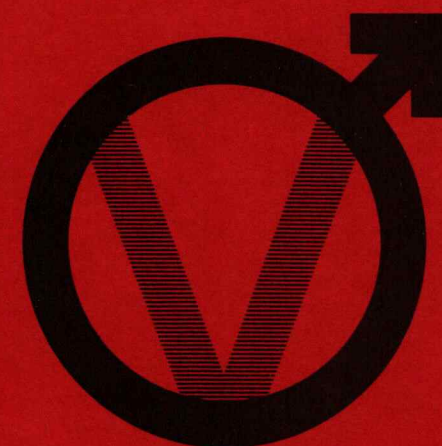
HB-3720311
VOLUME IV



**Viking'75
Project**

SPACECRAFT
OPERATIONS
HANDBOOK

HB-3720311
VOLUME IV



**Viking'75
Project**

SPACECRAFT OPERATIONS HANDBOOK

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Langley Research Center

Viking Project Office

MARTIN MARIETTA

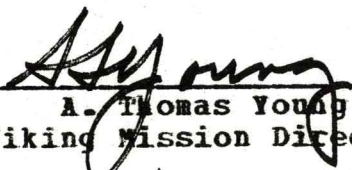
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VIKING 75 PROJECT
SPACECRAFT OPERATIONS HANDBOOK
VOLUME IV
VIKING LANDER CAPSULE

Rev. E 8-3-76

APPROVED



A. Thomas Young
Viking Mission Director

Date

3/20/76

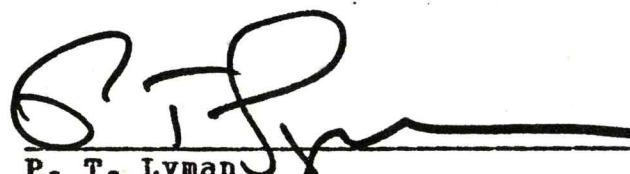
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VIKING 75 PROJECT SPACECRAFT OPERATIONS HANDBOOK

TBD/OPEN ITEMS
STATUS AS OF 03-26-76

<u>ITEM</u>		<u>RESPONSIBILITY</u>
1)	Section 4.3.2.4, Magnetic Properties Investigation (entire section)	C. Spitzer, LSG
2)	Section 4.3.2.10, Physical Properties Investigation (entire section)	C. Spitzer, LSG

4.8.1 Entry Science

4.8 Science Instruments Subsystems

4.8.1 Entry Science

4.8.1 ENTRY SCIENCES

The overall objective of the Entry Sciences investigations is to define the present physical and chemical state of the Martian atmosphere and its interaction with the Solar Wind.

In the Upper Atmosphere the composition and abundance of neutral species will be determined by the Upper Atmosphere Mass Spectrometer (UAMS). The ion concentration and ion and electron energy distributions will be determined by the Retarding Potential Analyzer (RPA).

In the Lower Atmosphere, pressure, temperature, density and mean molecular weight, will be determined by pressure and temperature measurements together with data from the VL Guidance System.

4.8.1.1 Upper Atmosphere Mass Spectrometer

4.8.1.1 UPPER ATMOSPHERE MASS SPECTROMETER

4.8.1.1.1 PURPOSE

The function of the Upper Atmosphere Mass Spectrometer (UAMS) is to determine the natural components in the upper atmosphere of Mars and the variations in their relative abundances as a function of altitude.

4.8.1.1.2 FUNCTION

The UAMS is mounted on the V-S/C Aeroshell and is operated during the descent phase of the mission. The instrument sealing cap will be severed after the termination of deorbit burn. Data gathering on a continuous basis will be initiated at Entry (E)-40 minutes (approximately 5000 KM altitude) and terminated at sensing .05g + 7 seconds (approximately 100 KM altitude).

The UAMS scans through the mass range m/e approximately 0.9 to m/e approximately 50 every 5 seconds.

The UAMS consists of three major functional assemblies; Sensor assembly, Electronics assembly, and the Cutter assembly.

a. Sensor Assembly (Figures 4.8.1.1-2 and 4.8.1.1-8 Zone 19E)

The instrument is a double focussing mass spectrometer of the Mattauch-Herzog geometry with a semi-open ion source and two Faraday Cup ion collectors. The basic geometry is shown in Figure 4.8.1.1-2.

Once the sealing cap has been cut off, the ion source will be exposed at the front of the aeroshell and neutral particles in the Mars atmosphere will enter the ion source (ion box). Electrons will be prevented from entering the source by the potential on the electron repeller grid and ions will be prevented from entering the source by the potential on the ion box. A narrow beam of electrons passes through the ion source in front of the ion exit slit and this electron beam will ionize a small fraction of the neutral particles in the ion source. The potential gradients in the ion source are such that the ions formed in the electron beam are drawn through the ion exit slit and then accelerated into the analyzer section of the sensor by the potential difference between the ion box and the grounded object slit plate. Ion transmission through the object slit is optimized by the voltage trimming on the J-plates which are used to focus the ions and obtain optimum ion transmission through the analyzer.

The ions which enter the analyzer region are dispersed and focussed on the instrument focal plane as a result

of the interaction between the moving ions and the electrostatic and magnetic fields. The position at which a given m/e value is focussed depends upon the potential difference between the ion box and the object slit plate. The scanning of the mass spectrum is accomplished by varying the potential differences between the ion box and the object slit plate, thus sweeping the m/e values across the image slit of each of the two Faraday cup ion collectors. Ions which are focussed on an image slit pass through it, are collected, and form the current source which is then passed to the electronics assembly for amplification and processing. The scanning potentials of the instrument result in m/e values between approximately 0.9 and approximately 7 being swept across the "Low Mass" collector slit and m/e values between approximately 7 and approximately 50 being swept across the "High Mass" collector slit. The number of ions of a particular component which are formed in the ion source will be a function of the component's partial pressure in the source and hence the intensity of the current from the collector will be proportional to the partial pressure in the ion source.

An ion pump is mounted on the end of the sensor assembly. The pump is designed for a nominal pumping speed of 0.3 liters per second and pumps from the analyzer region. It performs the following basic functions:

- 1) Maintains the instrument vacuum prior to separation of the sealing cap;
- 2) Extends the useful measurement range during entry by keeping the analyzer pressure lower, thus reducing internal ion scattering.

b. Electronics Assembly

The Electronics Assembly consists of three major functional elements; data acquisition, data processing and power conversion. The basic functions of each element are as follows:

- 1) Data Acquisition
 - a) Preamplifiers (Figures 4.8.1.1-1 and 4.8.1.1-8 Zone 17D)

The current from each ion collector is passed to a separate preamplifier which provides a voltage output proportional to the current input.

The high mass ion collector preamplifier consists of an amplifier feedback which provides a voltage output given by: $V_{\text{sub (out)}} = R_{\text{sub f}} \times I_{\text{sub (in)}}$. A gain changing relay forms a part of the preamplifier and the relay allows a value of 4×10^{10} ohms or 6.24×10^8 ohms for the feedback resistance $R_{\text{sub f}}$.

The low mass ion collector preamplifier is similar to the high mass preamplifier except that the gain changing relay is not present and only a 4×10^{10} ohm feedback resistor is used.

- b) Electrometer (Figures 4.8.1.1-1 and 4.8.1.1-8 Zone 15.16D) - The Electrometer has the following characteristics:

- (1) An automatic gain ranging amplifier;
- (2) 14 separate gains, where each gain is a X2 factor different;
- (3) A rezero circuit that nulls out any offset voltage present at the beginning of each 5 second scan.
- (4) Preamplifier - Electrometer combination can detect the following input currents:
 - (a) High mass: 1.5×10^{-14} amps to 4×10^{-9} amps
 - (b) Low mass: $.75 \times 10^{-14}$ amps to 3×10^{-11} amps

2) Data Processing and Timing

- a) Analog Multiplexer (Figures 4.8.1.1-1 and 4.8.1.1-8 Zone 14D)

The Analog Multiplexer multiplexes 13 channels of data, 11 of which are housekeeping, 2 of which are science data.

- b) Analog to Digital (A/D) Converter

The A/D Converter is an 8 bit dual slope design. Housekeeping is converted to 8 bits, science data to 5 bits.

- c) Digital Multiplexer

All digital data is multiplexed together in proper order for storage in memory.

- d) Buffer Memory (Figures 4.8.1.1-1 and 4.8.1.1-8 Zone 13D)

The Buffer Memory consists of five separate 9-bit storage registers and sends digital data to Data Acquisition and Processor Unit (DAPU).

- e) Sequencer and Control Unit (Figures 4.8.1.1-1 and 4.8.1.1-8 Zone 12, & 13F)

The Sequencer and Control Unit generates synchronous instrument timing, control signals, etc. and receives Enable and Clock pulses from DAPU.

3) Power Conversion

- a) Low Voltage Power Supply (Figures 4.8.1.1-1 and 4.8.1.1-8 Zone 33, 34 E & F)

The low Voltage Power Supply provides ± 5 Vdc and ± 15 Vdc for operation of the unit and provides 30 VAC, 20 KHz for operation of Emission Regulator and Ion Accelerator Supply.

- b) Emission Regulator (Figures 4.8.1.1-1 and 4.8.1.1-8 Zone 28B)

The Emission Regulator provides power to filaments which produce the electron beam that ionizes the neutral gas molecules.

- c) Ion Accelerator Power Supply (Figures 4.8.1.1-1 and 4.8.1.1-8 Zone 28E)

The Ion Accelerator provides an exponential sweep (150 volts to 1200 volts) that provides all of the voltages required by the sensor. The sweep consists of 360 discrete voltage steps, each lasting 13.5 milliseconds.

- d) Ion Pump Power Supply (Figures 4.8.1.1-1 and 4.8.1.1-8 Zone 28G)

The Ion Pump Power Supply provides -3500 volts to the Ion pump.

c. Cutter Assembly (Figure 4.8.1.1-8 21D)

The Cutter Assembly has the task of cutting the sealing cap which vacuum seals the sensor. In order to prevent contamination of the sensor and also allow the filaments to be powered-up for testing in the Earth environment, the sensor internal pressure must be kept in the 10^{-9} to 10^{-5} torr pressure range. This pressure is maintained by periodic use of the Ion Pump. In order to operate during Mars entry, the sealing cap must be cut off so that the sensor is exposed to the atmosphere. (See Figures 4.8.1.1-3 and 4). Once the cutter has severed the sealing cap, it is ejected from the Aeroshell by two springs. The mechanical power required to cut the cap is supplied by two Standard Viking Initiators (VSI's). The electrical power required to fire the VSI's is supplied by the Lander Pyrotechnic Control Assembly (LPCA), on command from the Guidance Control and Sequencing Computer (GCSC). (See Section 4.3.2).

4.8.1.1.3 OPERATING MODES

When power is applied to the UAMS it powers up to an inactive state which is used primarily for permitting instrument warmup. When the DAPU is commanded into Format 2A by the GCSC and starts sending shift and enable pulses to the UAMS, the instrument resets (on the first enable pulse) and then starts continuous scanning. With the normal 4 KHz clock, each scan of the mass range takes 5 seconds. However, since the scanning is clocked from the shift and enable pulses the scan takes 10 seconds during preseparation (also prelaunch and cruise) checkout since the clock is only 2 KHz.

The instrument ion pump has separate input power from the rest of the instrument so that the ion pump can be powered without having to turn on the complete instrument.

The UAMS makes a complete operational cycle in 8 scans of the mass range. Each scan consists of a 5 second time period, and is called a frame. Frames # 1, 3, 4, 5, 6, and 7 are for an electron accelerating potential of 75 Vdc, while Frames # 2 and 8 are for a value of 25 Vdc. During each scan of the mass range, ion beam current measurements are made at a high mass and a low mass collector. Samples from the high mass channel are separated by equal mass steps, as are the low mass samples. To accomplish this for the low mass scan, the low mass current is sampled every fifth time that the high mass current is sampled. For each scan of the mass range, the set of sample point locations is indexed one quarter sample step along both the high and low mass scales. After four scans of the mass range, the mass offset is returned to the starting point. Mass offset sampling is used to provide improved definition of mass peak shape and amplitude.

Each 5 second frame consists of a housekeeping minor frame and a science data minor frame. Before each scan of the mass

range, the Sequencer and Control Unit provides a zero command to the Ion Accelerator Supply and to both Electrometers. In response to this signal, the Ion Accelerator Supply unbalances the electrostatic analyzer plate potentials cutting off the ion beam from both the high and the low mass collectors. This signal also puts the Electrometers in an automatic zeroing mode which lasts 140 msec. Meanwhile the Sequencer and Control Unit processes the instrument identifier word and the housekeeping data through the Analog Multiplexer, Analog to Digital Converter, Digital Multiplexer and Buffer Memory. After this 140 msec of housekeeping data, the instrument begins a scan of the mass range which lasts 4,860 msec. At this time the Electrometers are taken out of the automatic zeroing mode, and the electron energy and mass offset are selected according to the major frame within the current operational cycle. The Sequencer and Control Unit provides commands to the Ion Accelerator Supply to sweep the instrument in discrete steps over the mass range. During the 13.5 msec period of each step, the Electrometer's automatic ranging adjusts for proper gain and the Electrometer outputs settle to their final value before the signal is converted by the A/D Converter. The science and housekeeping data is held in a Data Buffer until Transmission to the VL DAPU. An example of the type of science data received after decommutation is shown in Figure 4.8.1.1-5.

4.8.1.1.4 OPERATIONAL SEQUENCE

The UAMS operation is controlled by the GCSC. Immediately after the completion of deorbit burn the GCSC commands the LPCA to sequentially fire the VSIs which energize cutting off the UAMS cap. Two seconds later the ion pump is powered on.

At nominal "Entry" minus 60 minutes the GCSC commands the PCDA to apply power to the UAMS. At nominal "Entry" minus 40 minutes the GCSC commands the DAPU to send shift and enable pulses to the UAMS and data is taken continuously until termination of the sequence at the sensing of $0.05g \pm 7$ seconds. At this time power is removed from the UAMS and the ion pump.

4.8.1.1.5 INTERFACES

The UAMS interfaces with the DAPU, the PCDA, the LPCA, and the VLC Aeroshell.

a. Electrical Interfaces

The electrical/signal interfaces are shown in Figure 4.8.1.1-6. The types of signals corresponding to these interfaces are listed in Table 4.8.1.1-1.

1) Discretes

This signal is used to perform the enable functional, and is generated by the DAPU.

2) Shift Pulses

This signal is used to clock formatted data from UAMS to DAPU. It also provides the basic timing for the UAMS. The format is Return to Zero Level (RZL) at a bit rate of 4 Kbps ± 0.1 percent.

b. Mechanical Interface

The UAMS mechanical interface location on the Aeroshell is shown in Figure 4.8.1.1-7.

4.8.1.1.6 POWER REQUIREMENTS

The power requirements are as follows:

a. UAMS Power

The application of power is controlled by commands from the GCSC to the PCDA. The PCDA bus supplies the UAMS with a nominal steady state input voltage of +30 Vdc (+24 Vdc minimum to +37 Vdc maximum) at a maximum current of 5.0 amps. This voltage is then converted to the voltages required by the UAMS electronics as shown in Figure 4.8.1.1-8. The average power consumption level is 11.75 watts maximum.

b. Ion Pump Power

The application of power is controlled by commands from the GCSC to the PCDA. The PCDA bus supplies the Ion Pump Power Supply with a nominal steady state input voltage of +30 Vdc (+24 Vdc minimum to +37 Vdc maximum) at a maximum current of 5.0 amps. This voltage is converted to -3500 Vdc in order to power the Ion Pump. The average power consumption level is 1.5 watts maximum.

c. Release Cover Power

The application of power is controlled by commands from the GCSC to the LPCA. The LPCA bus supplies the energy necessary from its capacitor bank to fire the VSIs on the UAMS sealing cap cutter assembly. The sequencing is such that power is applied to the VSIs one at a time. If the first VSI fires the cap will be severed and the fire charge will not be received by the second VSI.

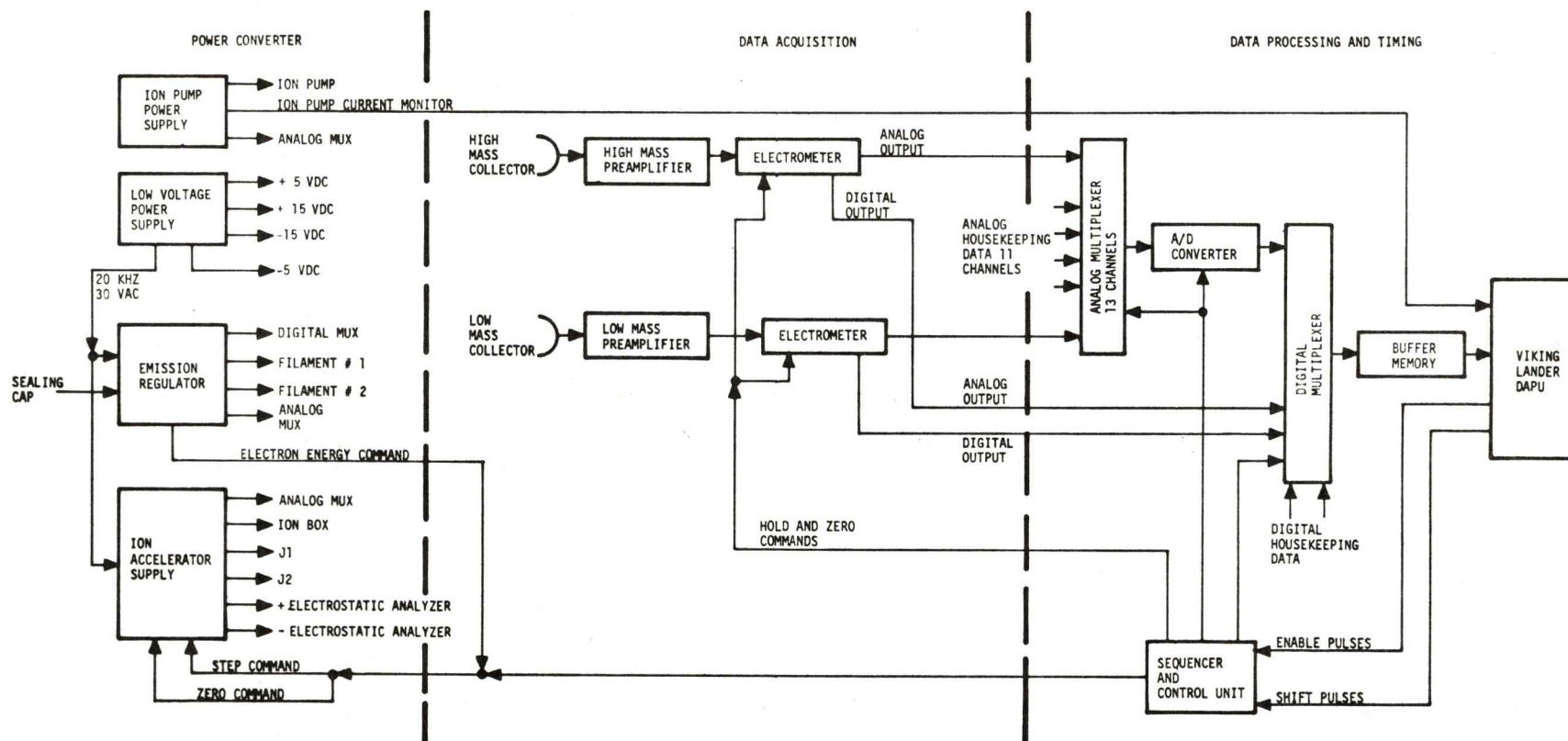


FIGURE 4.8.1.1-1 ELECTRONICS BLOCK DIAGRAM

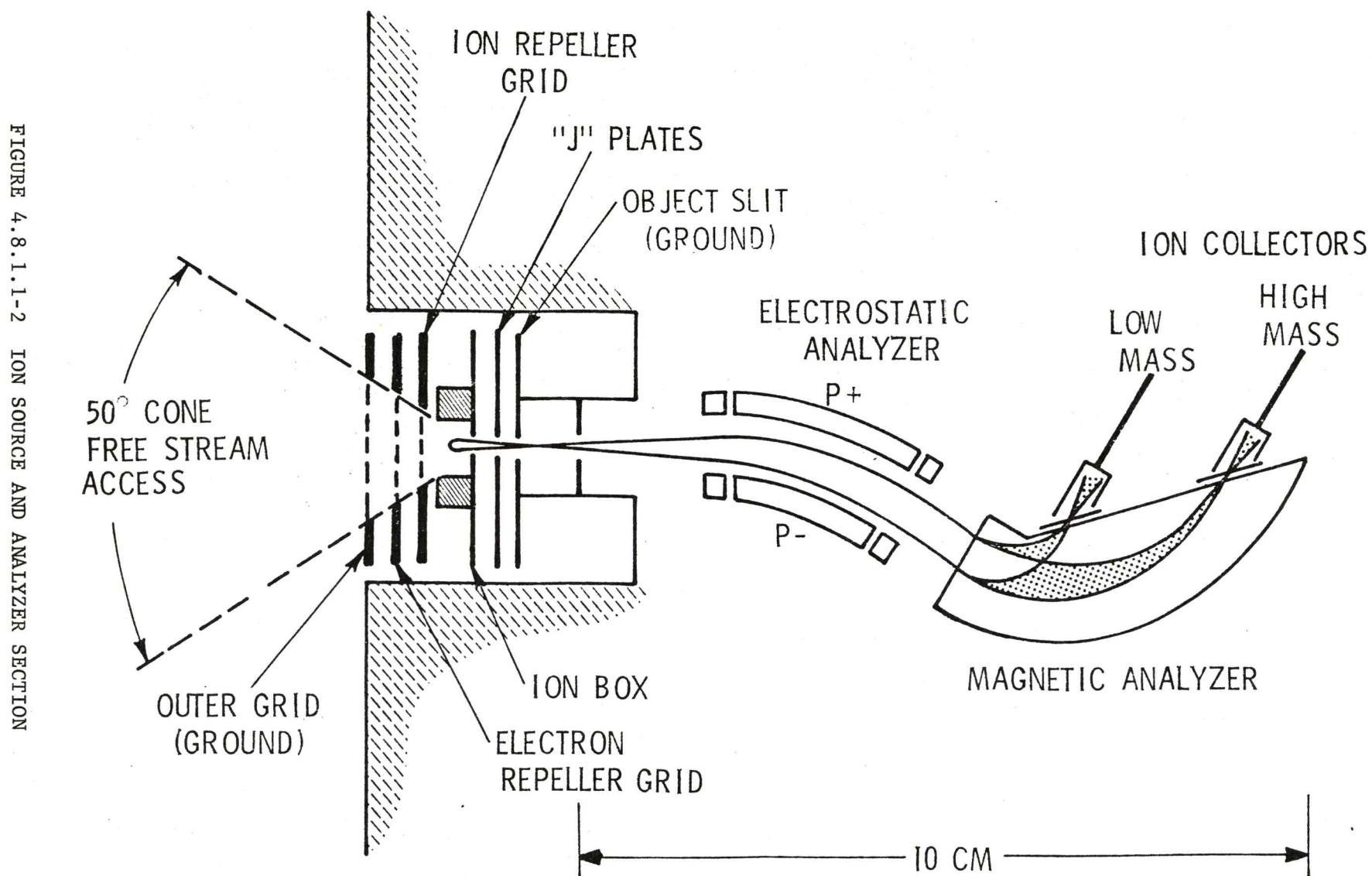
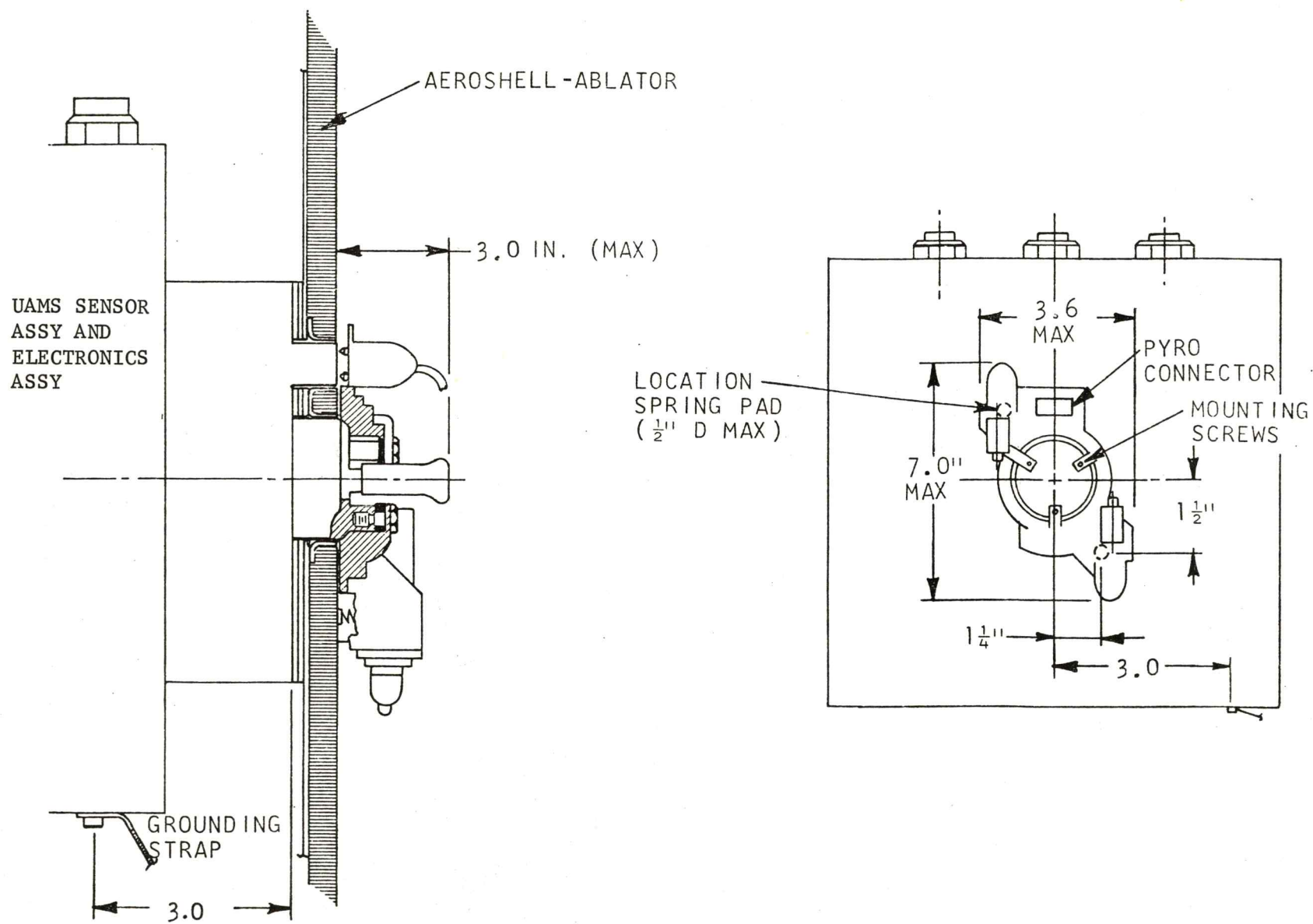


FIGURE 4.8.1.1-3 UAMS CUTTER ASSEMBLY INTERFACES



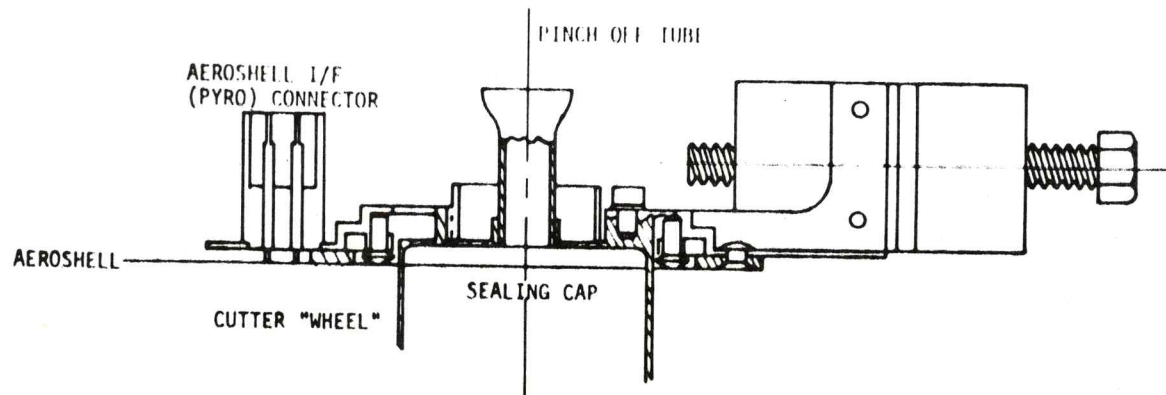
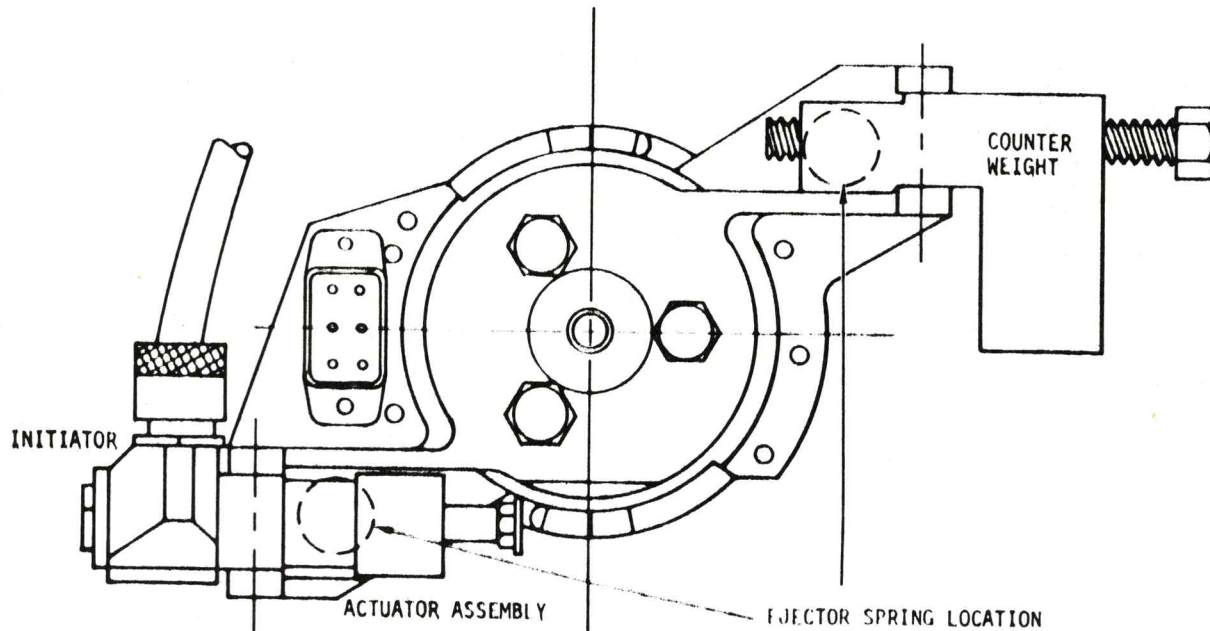


FIGURE 4.8.1.1-4 UAMS CAP OPENER

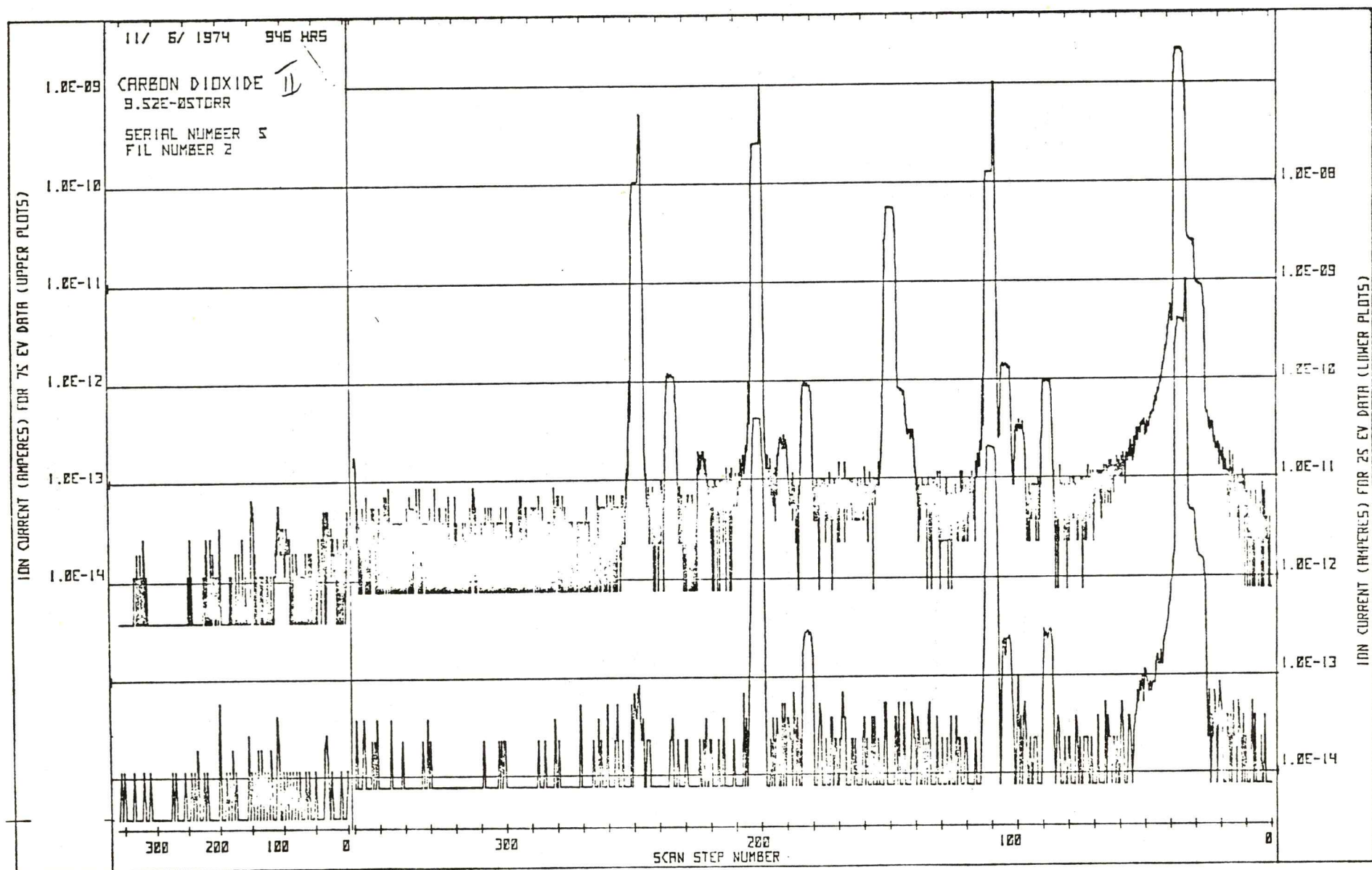


FIGURE 4.8.1.1-5 EXAMPLE OF SCIENCE DATA

**TABLE 4.8.1.1-1
UAHS INTERFACE SIGNALS**

<u>FUNCTION</u>	<u>FROM</u>	<u>TO</u>	<u>TYPE OF SIGNAL</u>
UAHS Data Enable	DAPU	UAHS	Discrete Control
UAHS Data Shift Pulse	DAPU	UAHS	Digital Control
UAHS Digital Data	UAHS	DAPU	Digital Monitor
UAHS Power	PCDA	UAHS	Power
UAHS Power Return	UAHS	PCDA	Power Return
UAHS Case & Signal Ground	UAHS	Aeroshell Structure	Signal Return
UAHS Ion Pump Power	PCDA	UAHS	Power
UAHS Ion Pump Current	UAHS	DAPU	Analog Monitor
UAHS Ion Pump Current Return	UAHS	DAPU	Analog Monitor
Release UAHS Cover VSI A	LPCA	UAHS	Power
Release UAHS Cover VSI A Return	UAHS	LPCA	Power Return
Release UAHS Cover VSI B	LPCA	UAHS	Power
Release UAHS Cover VSI B Return	LPCA	Power Return	

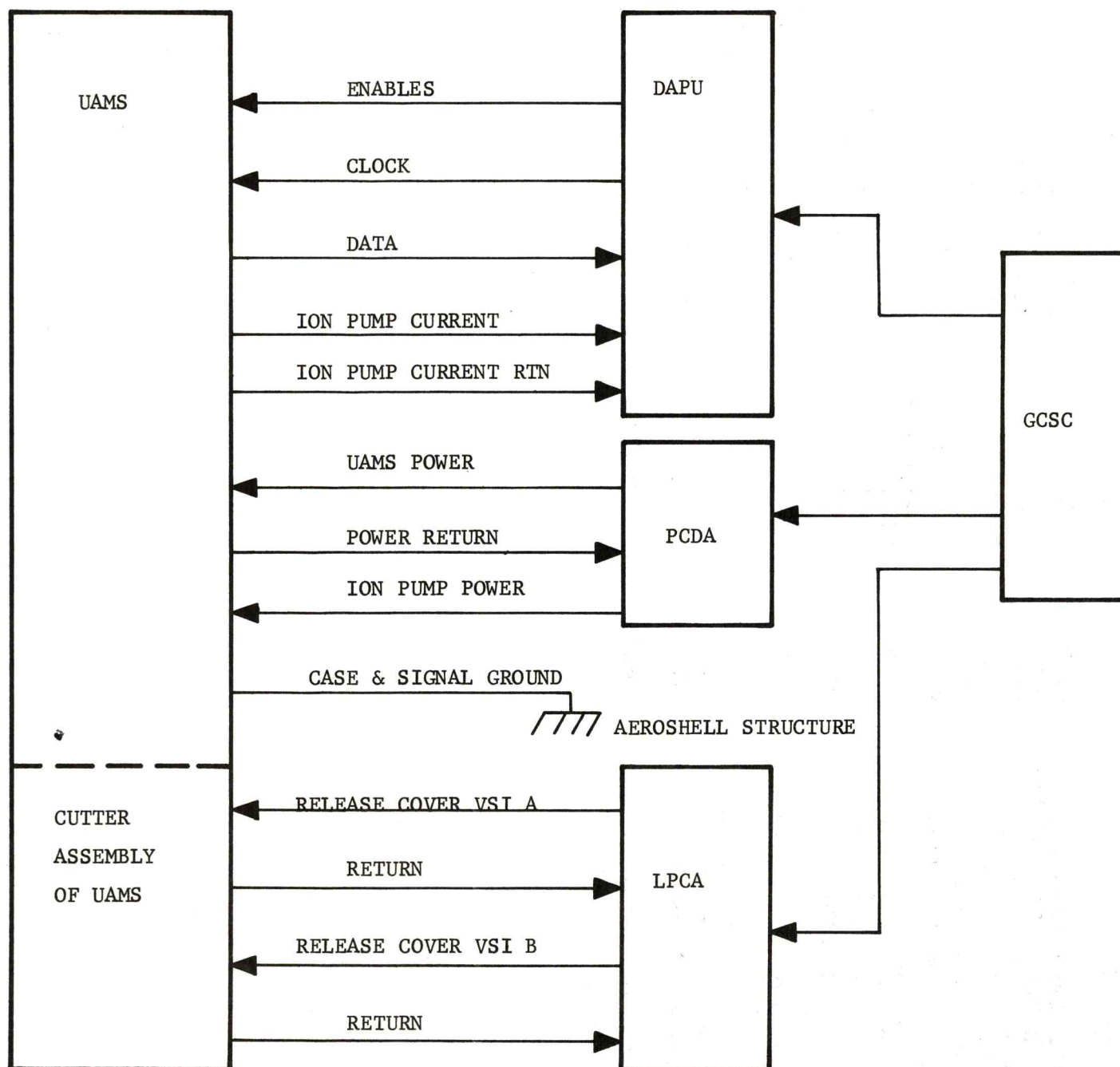


FIGURE 4.8.1.1-6 UAMS ELECTRICAL INTERFACES

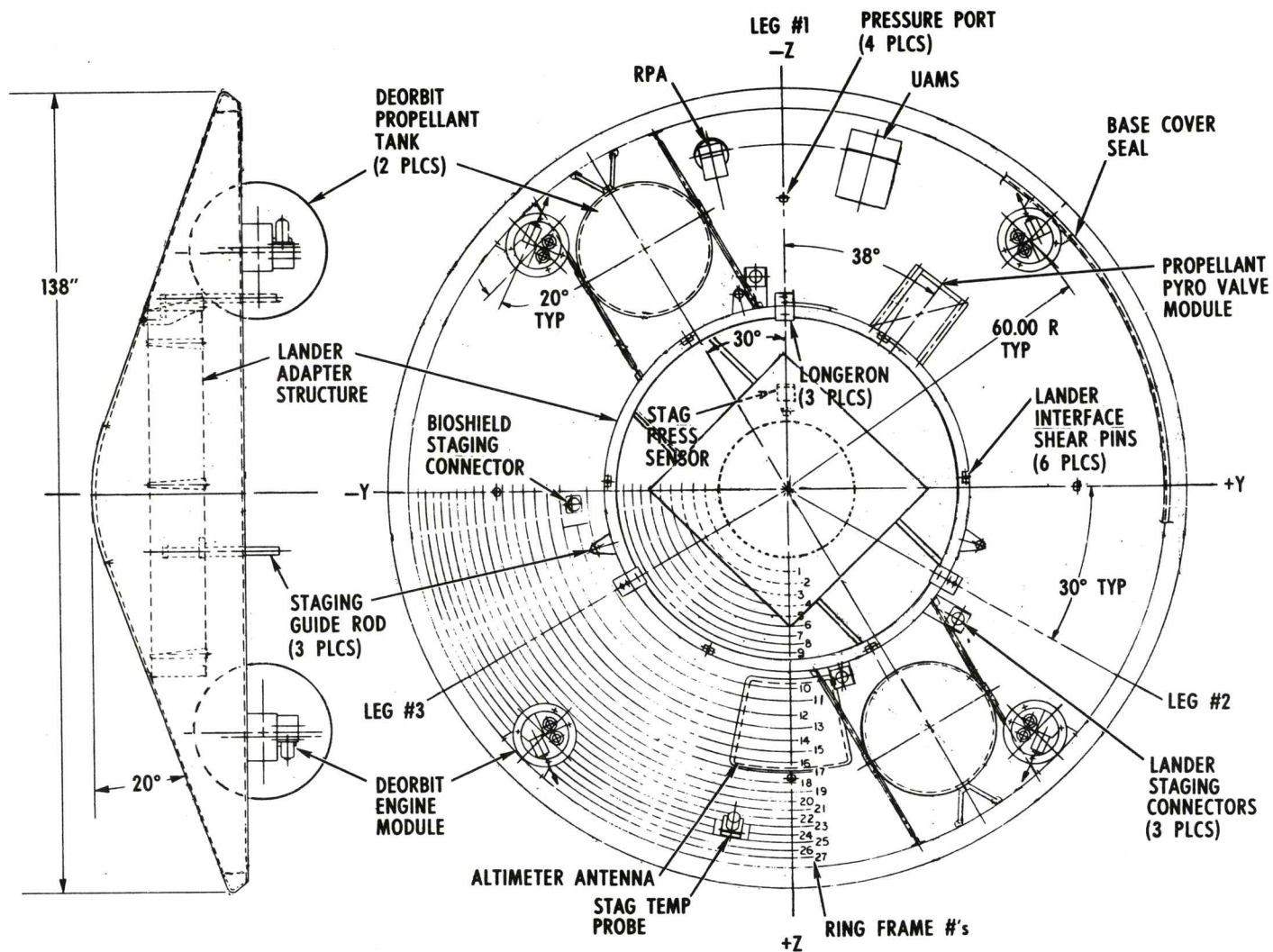
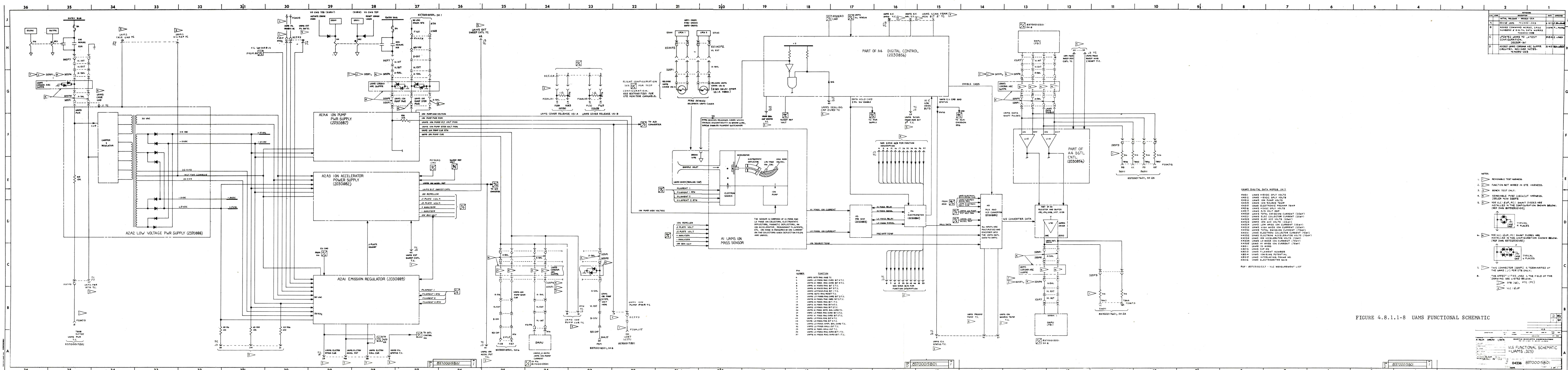


FIGURE 4.8.1.1-7 AEROSHELL ASSEMBLY CONFIGURATION



4.8.1.2 Retarding Potential Analyzer

4.8.1.2 RETARDING POTENTIAL ANALYZER

4.8.1.2.1 PURPOSE

The Retarding Potential Analyzer (RPA) is designed to measure the concentrations and energy distributions of ions and electrons in the Mars upper atmosphere. The measurements to be made during the descent of the V-S/C will determine the following:

- a. Ionic species and ion concentration profiles as a function of altitude.
- b. Ion and electron temperature profiles as a function of altitude.
- c. Characteristics of the Solar Wind/Mars atmosphere interaction.

4.8.1.2.2 FUNCTION

The RPA will operate from soon after the termination of deorbit burn until 7 seconds after the sensing of 0.05g, at which time power will be permanently removed from the instrument. During the deorbit coast period, data will be gathered on a periodic basis (every 10% altitude change, or less) and transmitted to the VO. At "Entry" minus 40 minutes, data gathering becomes continuous; all data gathered between "Entry" minus 6 minutes and power removal will be stored on the VL tape recorder as well as being transmitted in real time. The RPA data output is sampled only, and whenever, the Data Acquisition and Processor Unit (DAPU) is operating in Format 2A.

The RPA consists of two functional assemblies, both mounted in the same housing (Figure 4.8.1.2-1). These assemblies are:

- a. Sensor Assembly
- b. Electronics Assembly.
 - 1) Sensor Assembly

The sensor assembly is composed of seven wire grids. (See Figure 4.8.1.2-2). As the voltages on the grids are swept through a range of positive and negative potentials, varying portions of the population of the ions and electrons in the Mars atmosphere will penetrate the grid structure. (See Figure 4.3.1.2-3 for these time-varying voltages). Those charged particles which traverse all seven grids are collected by a "collector". This produces a current which flows into an electrometer that provides amplification. In essence, the seven grids act as an electrical

filter, which admits only those particles possessing selected ranges of energies and electrical charge.

2) Electronics Assembly

The electronics assembly consists of three major functional elements, namely: data acquisition, data processing, and power conversion. (See Figure 4.8.1.2-5). The function of each is as follows:

a) Data Acquisition

(1) Preamplifier:

A current amplifier where an amplifier-feedback resistor combination transforms an input current to produce an output voltage $V_{out} = (1 \times 10^{10} \text{ ohms}) \times I_{in}$.

The preamplifier contains a relay that can change the current to voltage multiplier from $1 \times 10^{10} \text{ ohms}$ to $3.9 \times 10^7 \text{ ohms}$.

(2) Electrometer:

Is an automatic gain changing amplifier that has 8 separate gains, with each a factor of X4 different. Once the Electrometer has switched into the less sensitive gains, i.e., range 5 thru 8, it cannot drop back down to the more sensitive gains (1 thru 4) until the completion of that particular phase.

The rezero circuit nulls out any offset voltage present at the beginning of each 4 second scan.

The Preamplifier/Electrometer combination measures currents from $8 \times 10^{-14} \text{ amps}$ to $2.67 \times 10^{-8} \text{ amps}$.

b) Data Processing and Timing

(1) Analog Multiplexer

Multiplexes 3 channels of data, two housekeeping and one science data.

(2) A/D Converter

Is an 8-bit successive approximation R-2R ladder design.

(3) Digital Multiplexer

Multiplexes all digital data together in proper order before it is sent to the DAPU.

(4) Sequencer and Control Unit

Receives Enable and Clock pulses from the DAPU, and generates synchronous instrument timing, control signals, etc.

c) Power Conversion

(1) Low Voltage Power Supply

Provides $\pm 5\text{Vdc}$, -12Vdc , $\pm 15\text{Vdc}$, $\pm 20\text{Vdc}$, and -80Vdc for operation of the unit.

(2) Suppressor Grid Voltage Generator

Provides voltage to the suppressor grid (See Figure 4.8.1.2-3).

(3) Retarding Grid Voltage Generator

Provides voltage to the retarding grid (See Figure 4.8.1.2-3).

4.8.1.2.3 OPERATING MODES

When power is applied to the RPA by the Power Control and Distribution Assembly (PCDA), it resets and remains in a passive state. When the shift and enable pulses are sent from the DAPU, the instrument starts its scanning and the instrument cycling is slaved to the shift and enable pulses. In normal operation, power is applied five minutes before the shift and enable pulses are sent to allow instrument warmup.

The RPA makes a complete operational cycle in 4 scans or 16 seconds. Each scan takes 4 seconds and is repeated with minor variations in the Suppressor grid voltages. During one scan out of every four, the gain control relay in the Preamplifier is switched to low sensitivity mode and is maintained throughout the scan.

Each 4 second scan consists of a housekeeping portion and a science portion. For the first 40 msec of every scan, the Electrometer is in the automatic zeroing mode. At the same time, the retarding grid is a -75Vdc and the suppressor grid is at $+15\text{Vdc}$ in order to prevent all ions and electrons from entering the

collector head. During this 40 msec period, the RPA is transmitting the 24 bit Source ID word and the Preamplifier temperature data to the DAPU. The science portion consists of three separate sequences, and each sequence analyzes a different characteristic of the Mars "atmosphere". The three sequences are as follows:

a. Phase I - Energetic Electron Flux

Performs analysis of high energy electrons. The analysis period is for 960 msec and 89 separate science samples are taken. The retarding grid is swept incrementally from -75 Vdc to 0 V and the suppressor grid is either +15 Vdc or -4 Vdc. (See Figure 4.8.1.2.3).

b. Phase II - Thermal Electron Flux

Performs analysis on thermal energy of electrons. The analysis period is one second and 92 separate science samples are taken. The retarding grid is swept incrementally from -1.5 Vdc to 0 V, the suppressor grid is +15 Vdc. (See Figure 4.8.1.2-3).

c. Phase III - Ion Concentration

Performs analysis on ions present. The analysis period is two seconds and 187 separate science samples are taken. The retarding grid is swept incrementally from +15 Vdc to 0 V, the Suppressor grid is -15 Vdc. (See Figure 4.8.1.2-3).

An example of the type of data received is shown in Figure 4.8.1.2-4. This is for data received from the Phase III sequence, i.e., ion concentration. Periodically during Phase I, II, and III, the retarding grid voltage is sampled to provide a reference for the science data being collected. (Refer to Figure 6 of RPA PD6400459 if these times are desired).

The actual operation of the electronics is as follows (Figure 4.8.1.2-5 & 8). After the zeroing period, the retarding grid and the suppressor grid are switched to the correct starting value for the collection of science data. (See Figure 4.8.1.2-3). The Electrometer is taken out of the zeroing mode and the automatic ranging adjusts for proper gain. The Electrometer output settles, and then a conversion is made by the A/D Converter. Next, the Sequencer and Control Unit steps the retarding grid voltage to its new value. Again, the Electrometer adjusts to the correct gain, and an A/D conversion is made. Each "step" period lasts for 10 milliseconds. The "incremental step" mode continues until the retarding grid has swept from its maximum value to its minimum value, and the next Phase begins.

During the 4 second scan, a total of 3200 bits of data is sent. The data is shifted out in eight bit words at 4 Kbps during each enable pulse. The enable pulse goes "high" for two msec with time spacings of 8 msec followed by 12 msec (i.e., an averaging spacing of 10 msec). The 3200 bits of data is equivalent to 400 eight bit words. Of these words, 32 words are for housekeeping data and 368 words are for science data.

The 32 housekeeping words consist of 3 words for Source ID, one word for preamplifier temperature, one word for electrometer range, and 27 retarding grid potential samples.

During Prelaunch Cruise and Preseparation Checkouts, each scan will take 8 seconds since the clock rate in Format 2A will be 2 Kbps instead of 4 Kbps.

4.8.1.2.4 OPERATIONAL SEQUENCE (FIGURE 4.8.1.2-5 & 8)

The RPA operation is controlled by the Guidance Control and Sequencing Computer (GCSC). Shortly after deorbit burn, the first RPA data acquisition sequence is begun. This consists of a warmup period (+30 Vdc from the PCDA), and then a 1 minute and 12 second data collection run. To collect data, the DAPU enters Format 2A and begins sending Enable and Shift pulses to the RPA. The RPA is then powered down by removal of the +30 Vdc PCDA power. The "RPA Data Acquisition Sequence" is repeated several times. The amount of off time between data runs is dependent upon which coast trajectory (maximum, nominal, or minimum) that the Aeroshell, etc., is following.

4.8.1.2.5 INTERFACES

The RPA interfaces with the DAPU, the PCDA, and the Aeroshell.

a. Electrical Interfaces

The electrical/signal interfaces are shown in Figure 4.8.1.2-6. The types of signals corresponding to these interfaces are listed in Table 4.8.1.2-1.

1) Discretes

This signal is used to perform the enable function and is generated by the DAPU.

2) Shift Pulses

The signal is used to clock formatted data from RPA. It also provides the basic timing for the RPA. The format is RZL at a bit rate of 4 Kbps \pm 0.1 percent.

3) Serial Digital Signals

This signal transfers data from RPA to DAPU. The format is PCN, NRZ-L, and the bit rate is 4 Kbps \pm 0.1 percent.

b. Mechanical Interface

The RPA mechanical interface location on the Aeroshell is shown in Figure 4.8.1.2-7.

4.8.1.2.6 POWER REQUIREMENTS

The application of power is controlled by commands from the GCSC to the PCDA. The PCDA bus supplies the RPA with a nominal steady state voltage of +30 Vdc (+24 Vdc, min to +37 Vdc max) at a maximum current of 5.0 amps. This voltage is then converted to the voltages required by the RPA electronics as shown in Figure 4.8.1.2-5 & 8. The power consumption is 3.5 watts maximum.

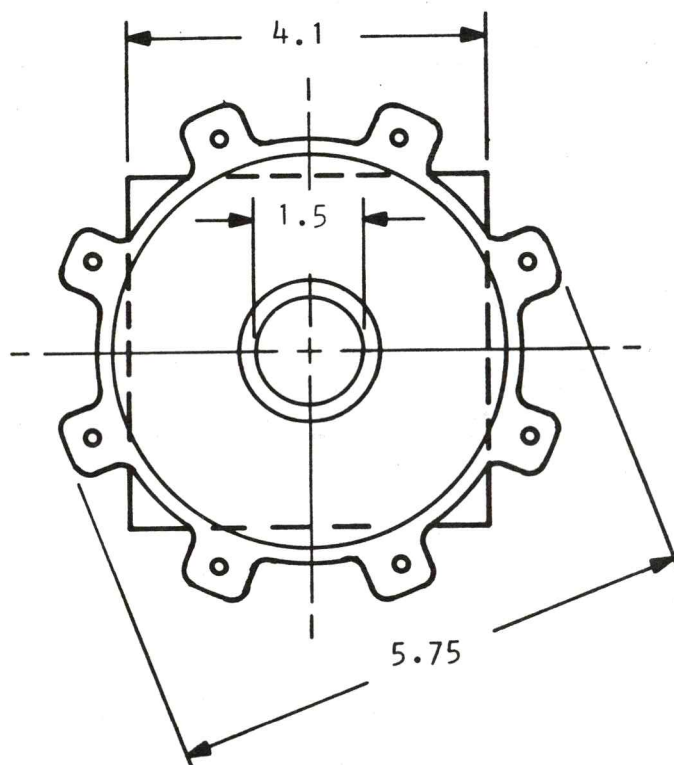
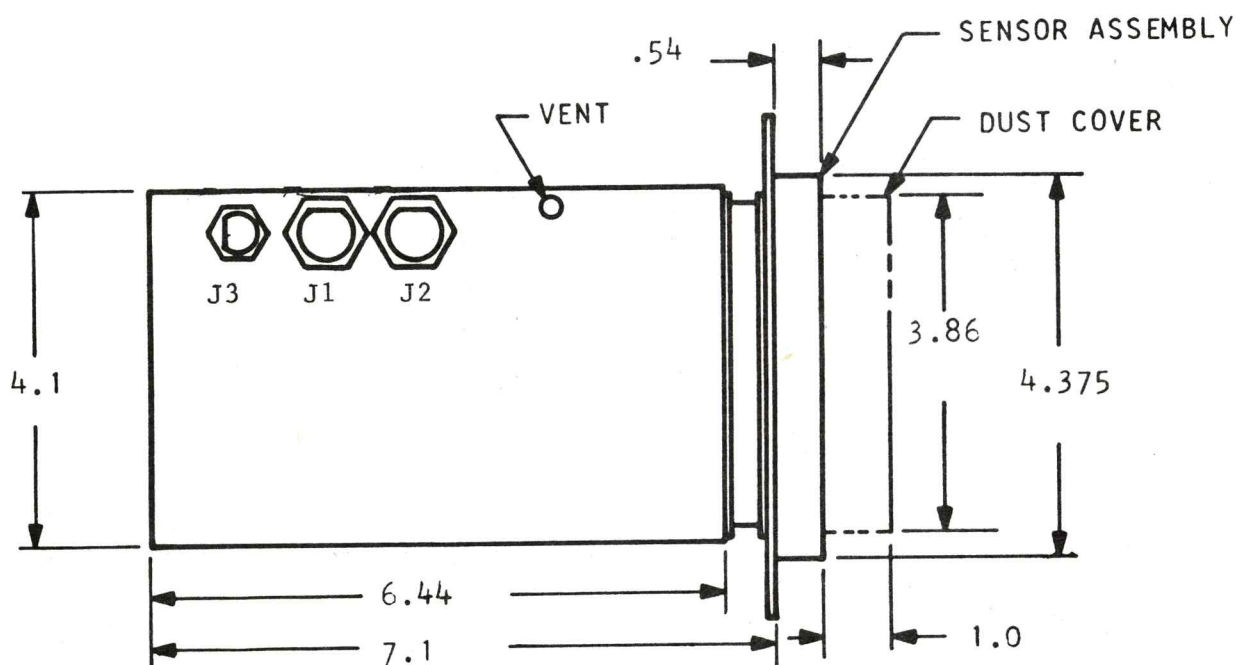


FIGURE 4.8.1.2-1 RPA ASSEMBLY

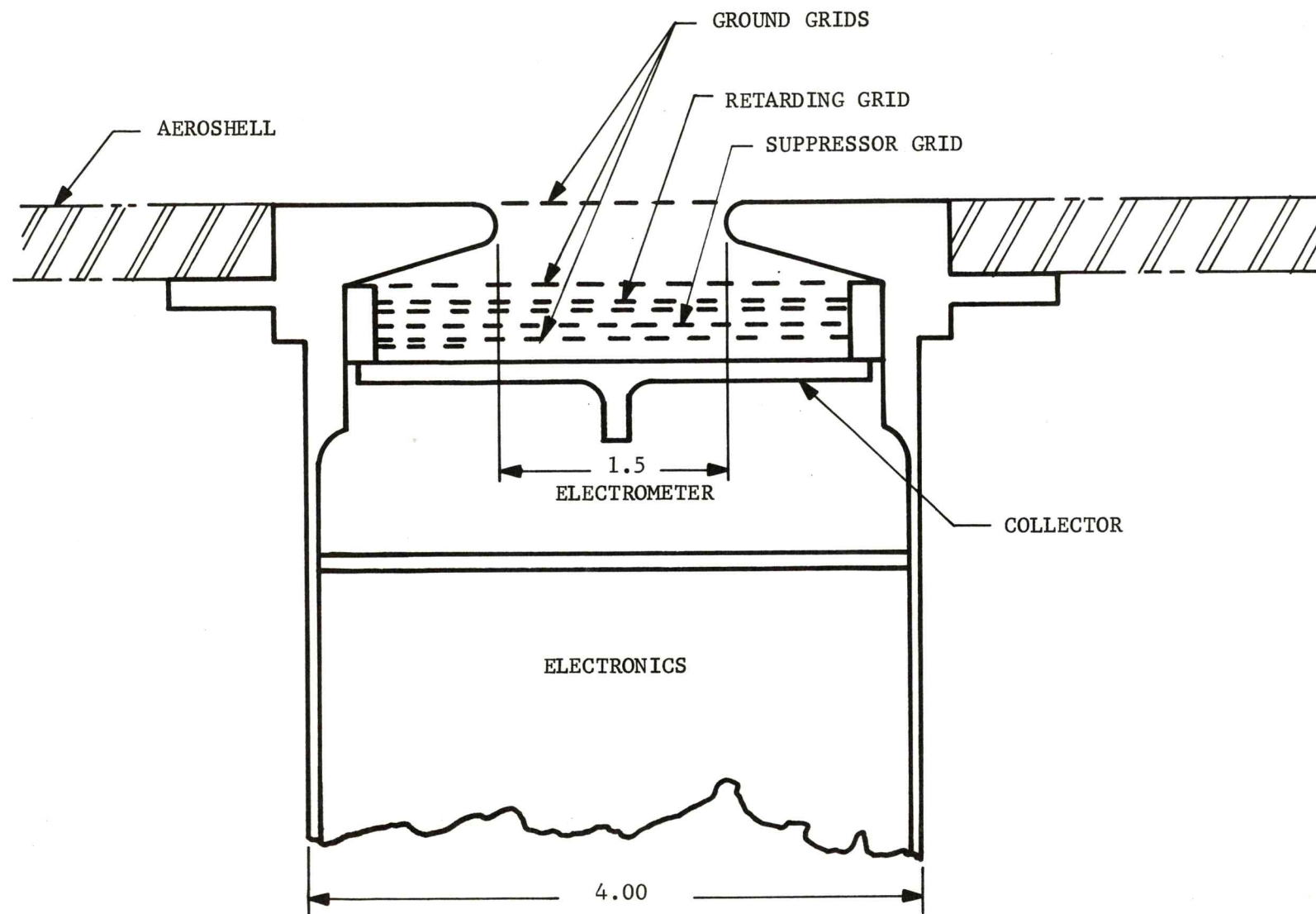


FIGURE 4.8.1.2-2 RPA SENSOR ASSEMBLY

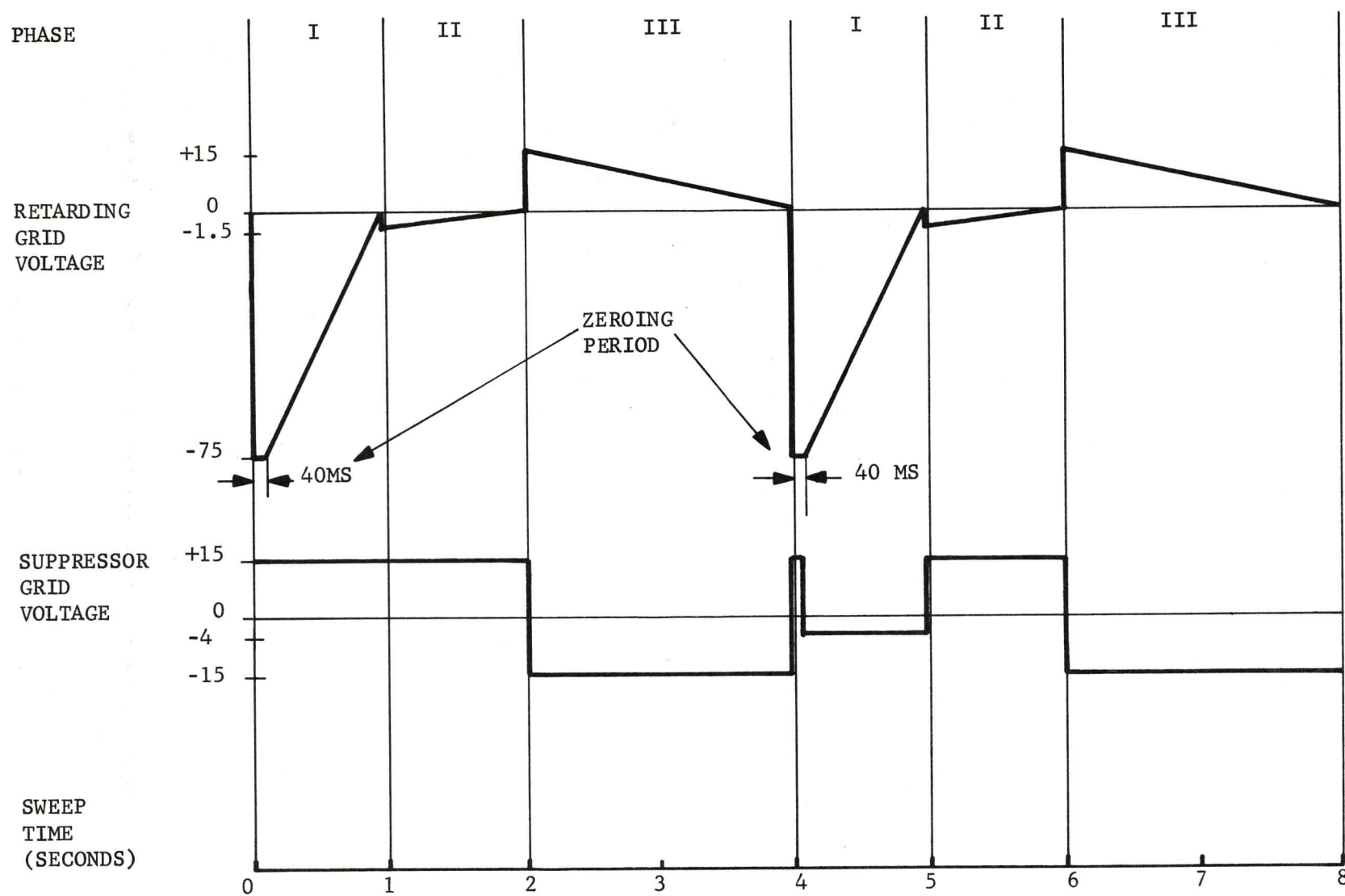


FIGURE 4.8.1.2-3 RPA GRID VOLTAGE SWEEPS

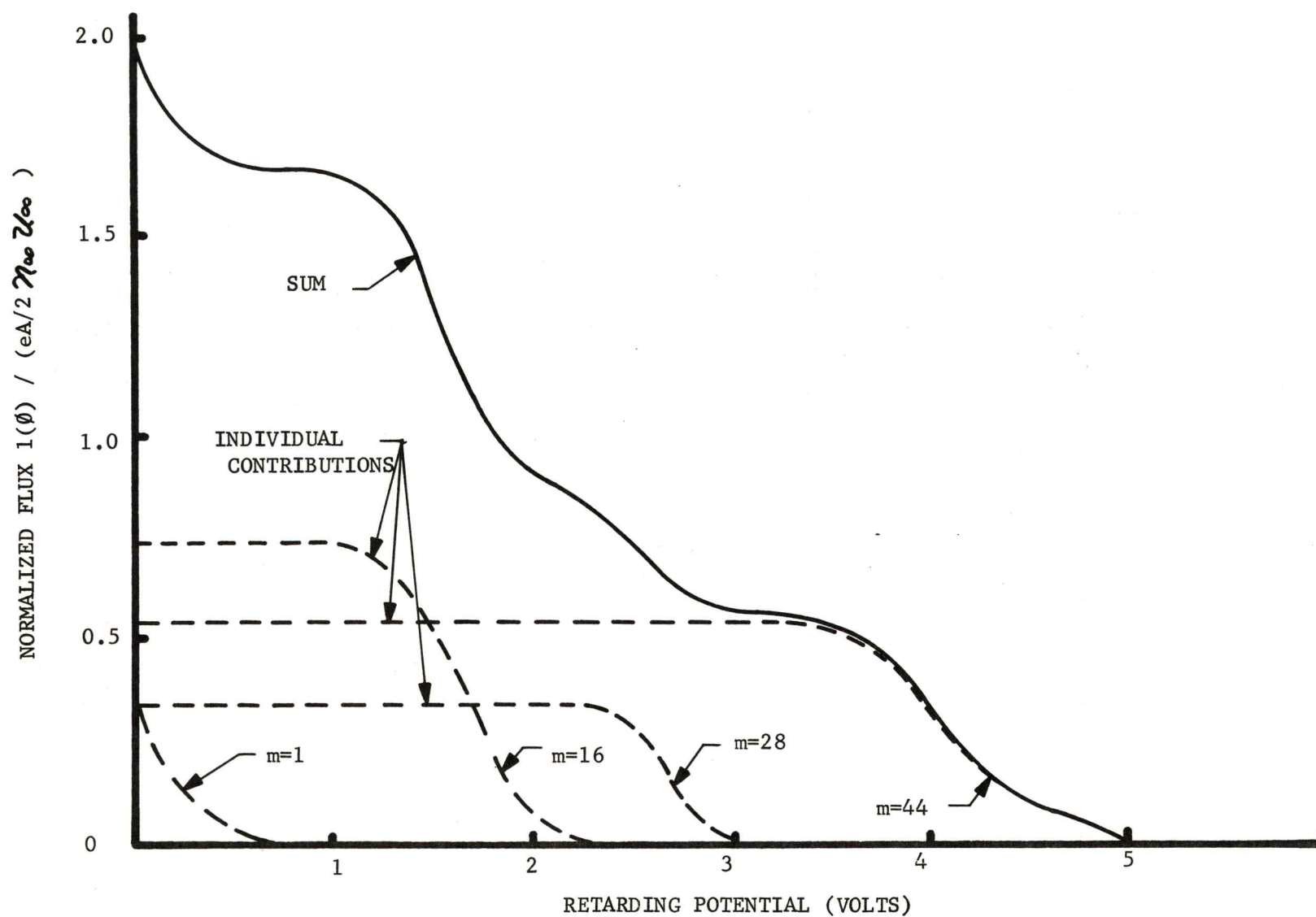
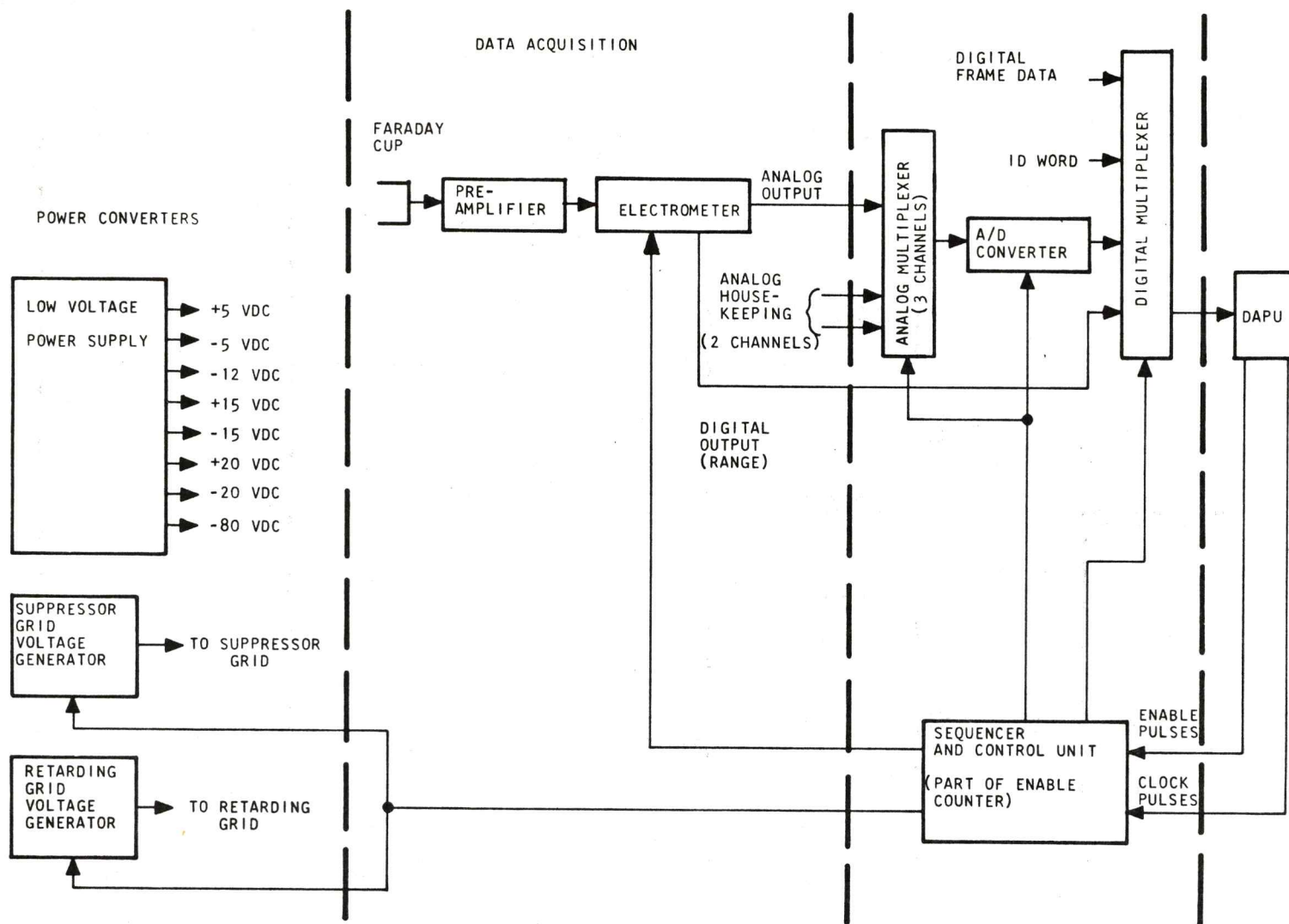


FIGURE 4.8.1.2-4 EXAMPLE OF SCIENCE DATA RECEIVED (FOR IONS)

FIGURE 4.8.1.2-5 RPA ELECTRONICS BLOCK DIAGRAM



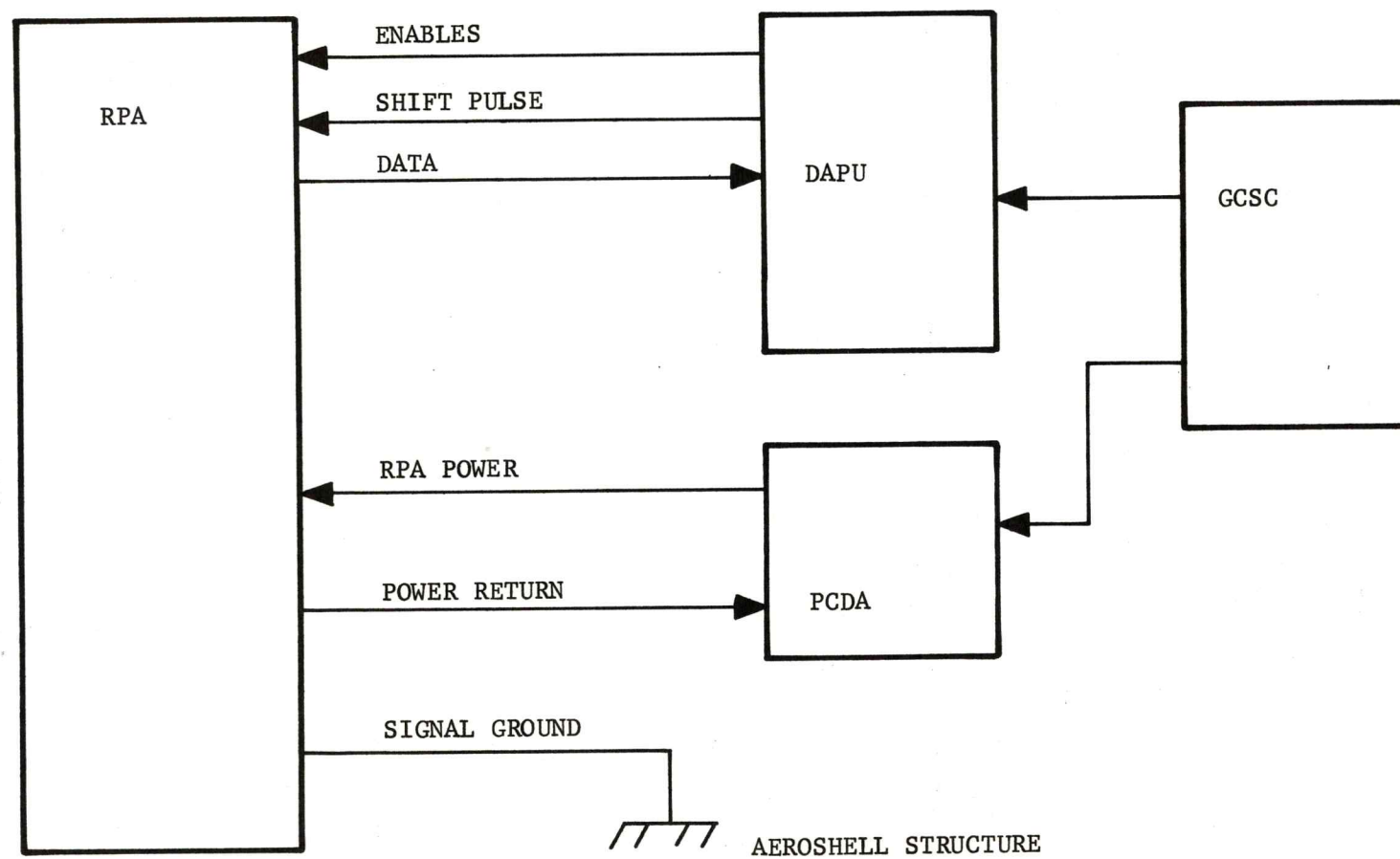


FIGURE 4.8.1.2-6 RPA ELECTRICAL INTERFACES

TABLE 4.8.1.2-1
RPA INTERFACE SIGNALS

<u>FUNCTION</u>	<u>FROM</u>	<u>TO</u>	<u>TYPE OF SIGNAL</u>
RPA Data Enable	DAPU	RPA	Discrete Control
RPA Data Shift Pulse	DAPU	RPA	Digital Control
RPA Digital Data	RPA	DAPU	Digital Monitor
RPA Power	PCDA	RPA	Power
RPA Power Return	RPA	PCDA	Power Return
RPA Case & Signal Ground	RPA	Aeroshell Structure	Signal Return

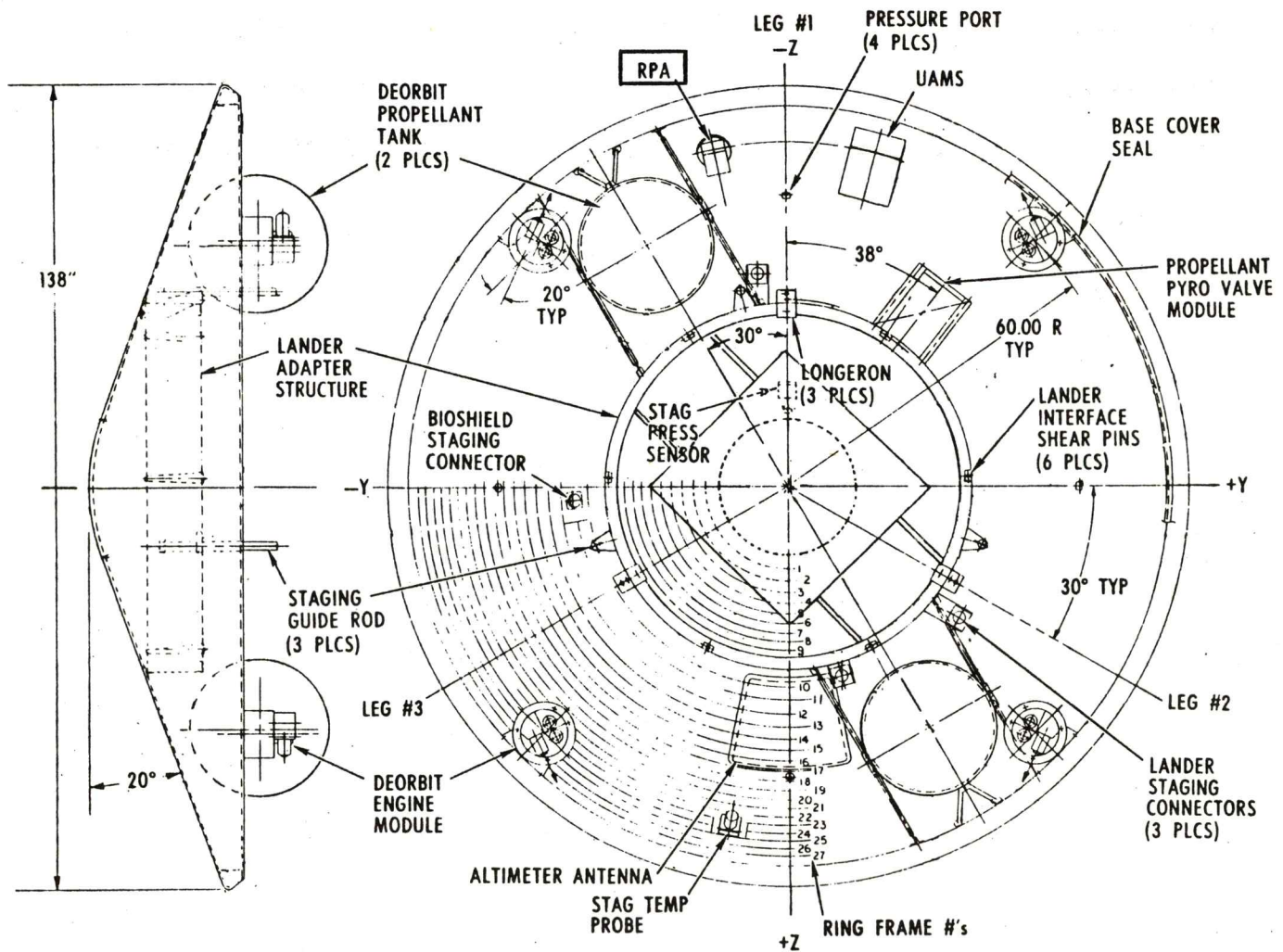
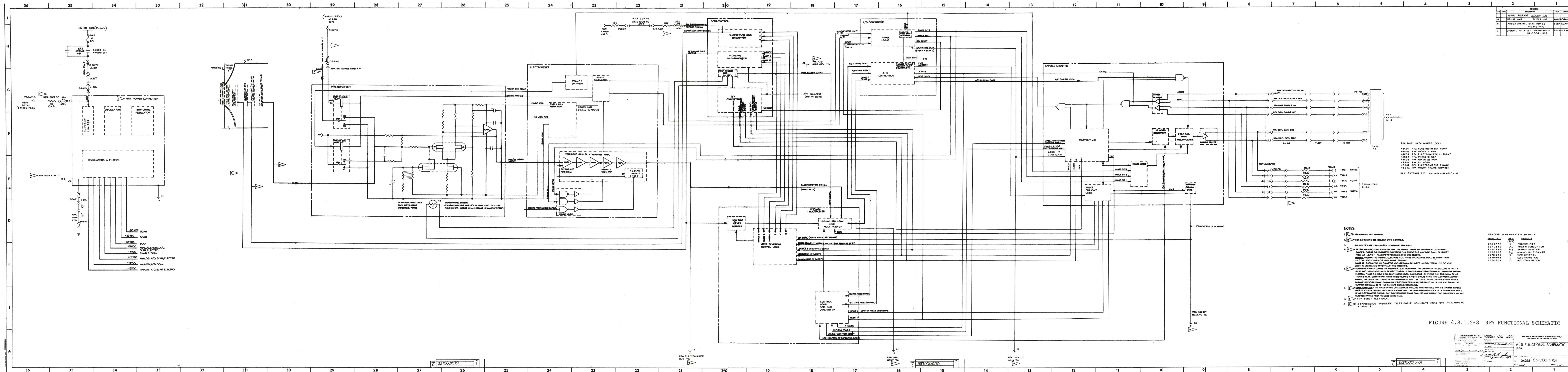


FIGURE 4.8.1.2-7 AEROSHELL ASSEMBLY CONFIGURATION

REVISIONS				
SYN	ZONE	DESCRIPTION	DATE	APPROV
		INITIAL RELEASE DE 0324-023		
A		REVISE PINS TC2528-005	8-17-75	A. Baez
B		ADDED DIGITAL DATA WORDS TA 8443-007	2-23-76	F.L. PO.
C		UPDATED TO LATEST CONFIGURATION DE 0324-123	7-19-76	W.P. RE



4.8.1.3 Stagnation Pressure

4.8.1.3 STAGNATION PRESSURE

4.8.1.3.1 PURPOSE

The Entry Sciences Stagnation Pressure Instrument is intended to provide data from which the vertical pressure profile of the Martian atmosphere can be determined from as high an altitude as possible down to the point of Aeroshell separation (an altitude of approximately 18,000 feet). The instrument is mounted on the inside of the Aeroshell with a sampling port on the front of the Aeroshell at the stagnation point at the trim angle of attack.

The location of the instrument is shown in Figures 4.8.1.3-1 and 4.8.1.3-2.

Due to the high velocity of the VLC during this phase of the mission, the stagnation pressure will be significantly higher than the ambient pressure; therefore, VLC velocity and orientation data will be required to correct the instrument measurements. Figure 4.8.1.3-3 shows the relationships between the relevant parameters for a "typical" entry into a "typical" atmosphere.

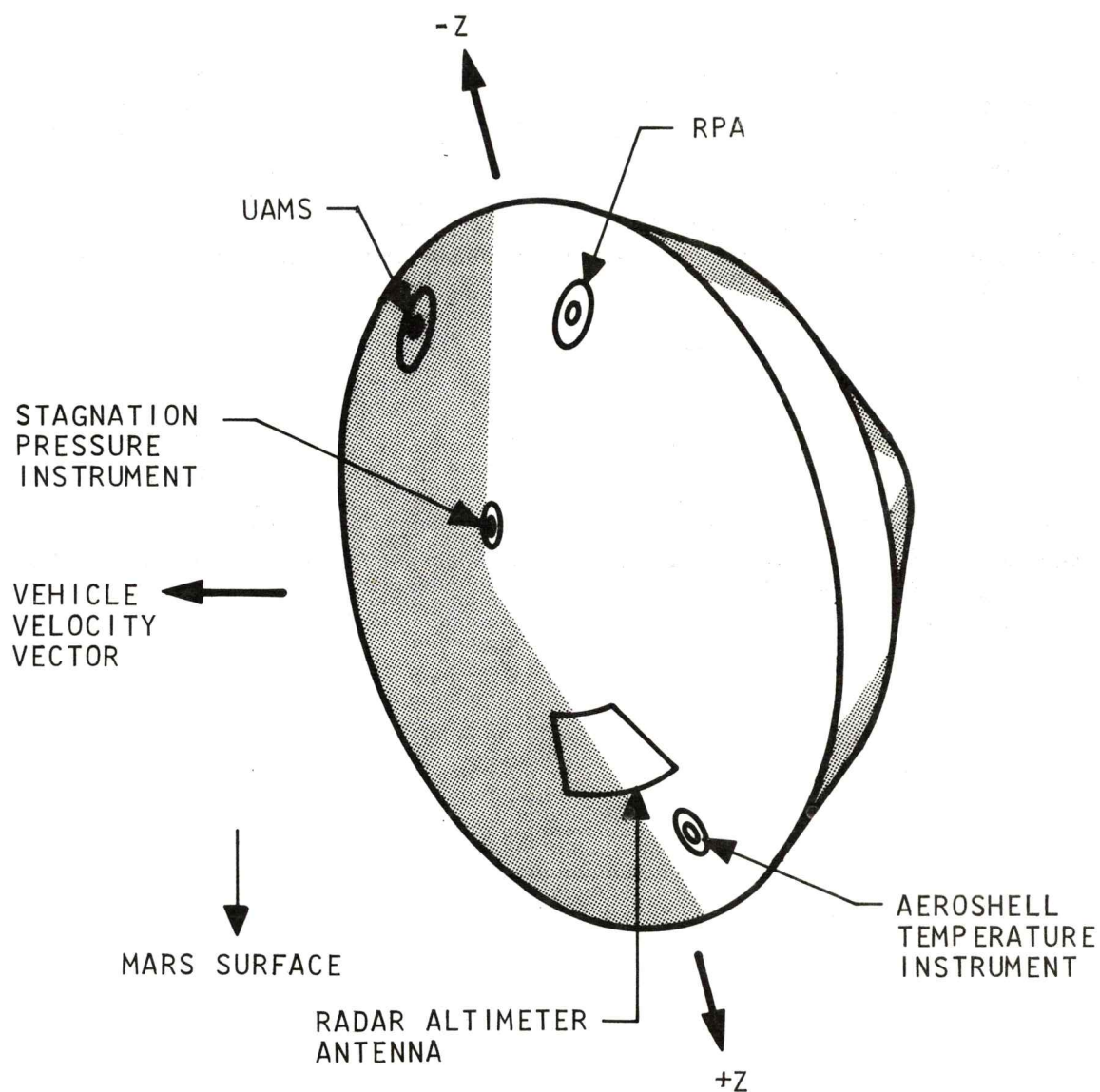


FIGURE 4.8.1.3-1
STAGNATION PRESSURE INSTRUMENT INLET LOCATION

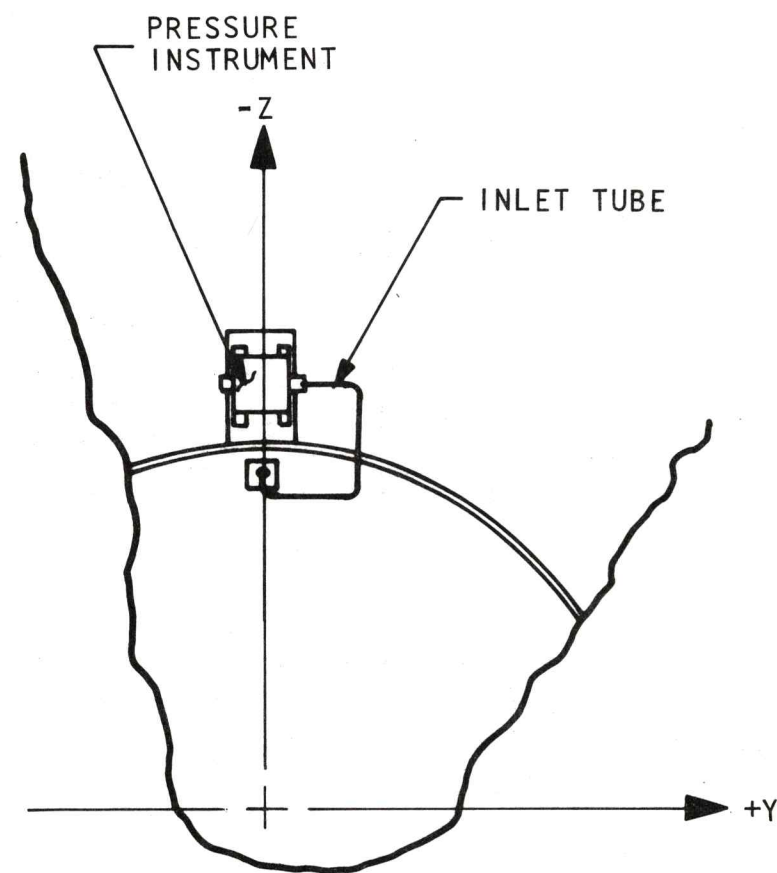
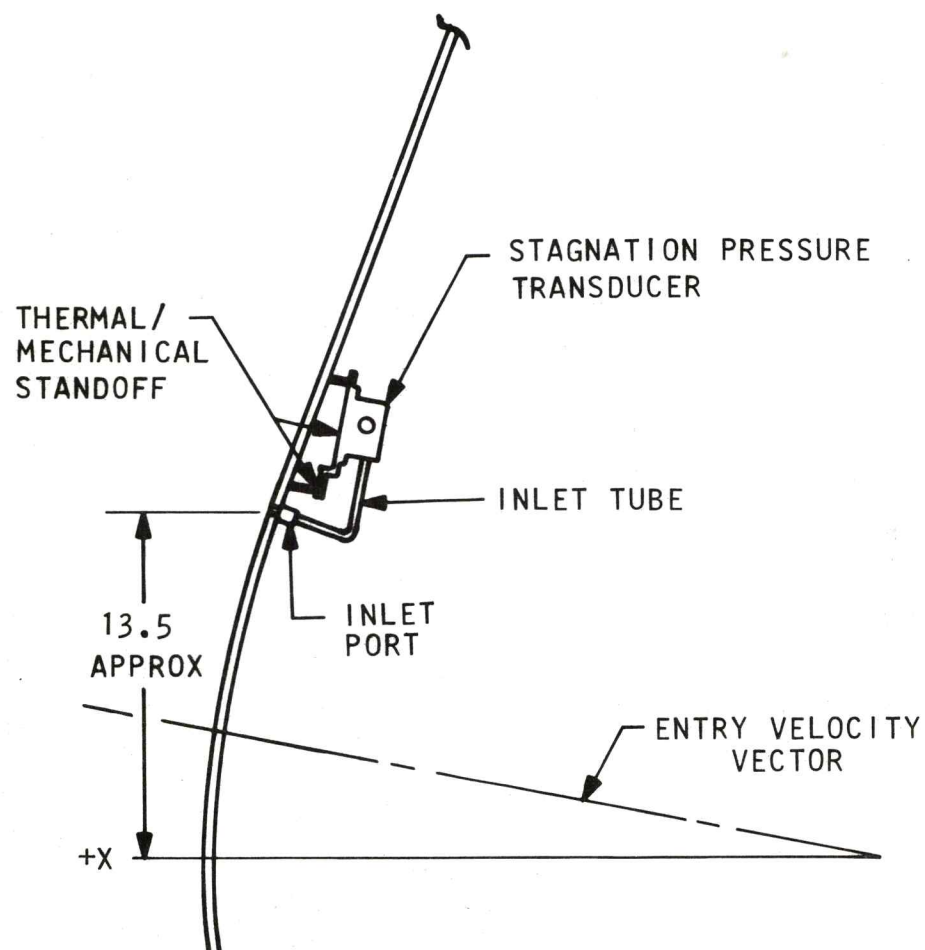


FIGURE 4.8.1.3-2 STAGNATION PRESSURE INSTRUMENT LOCATION

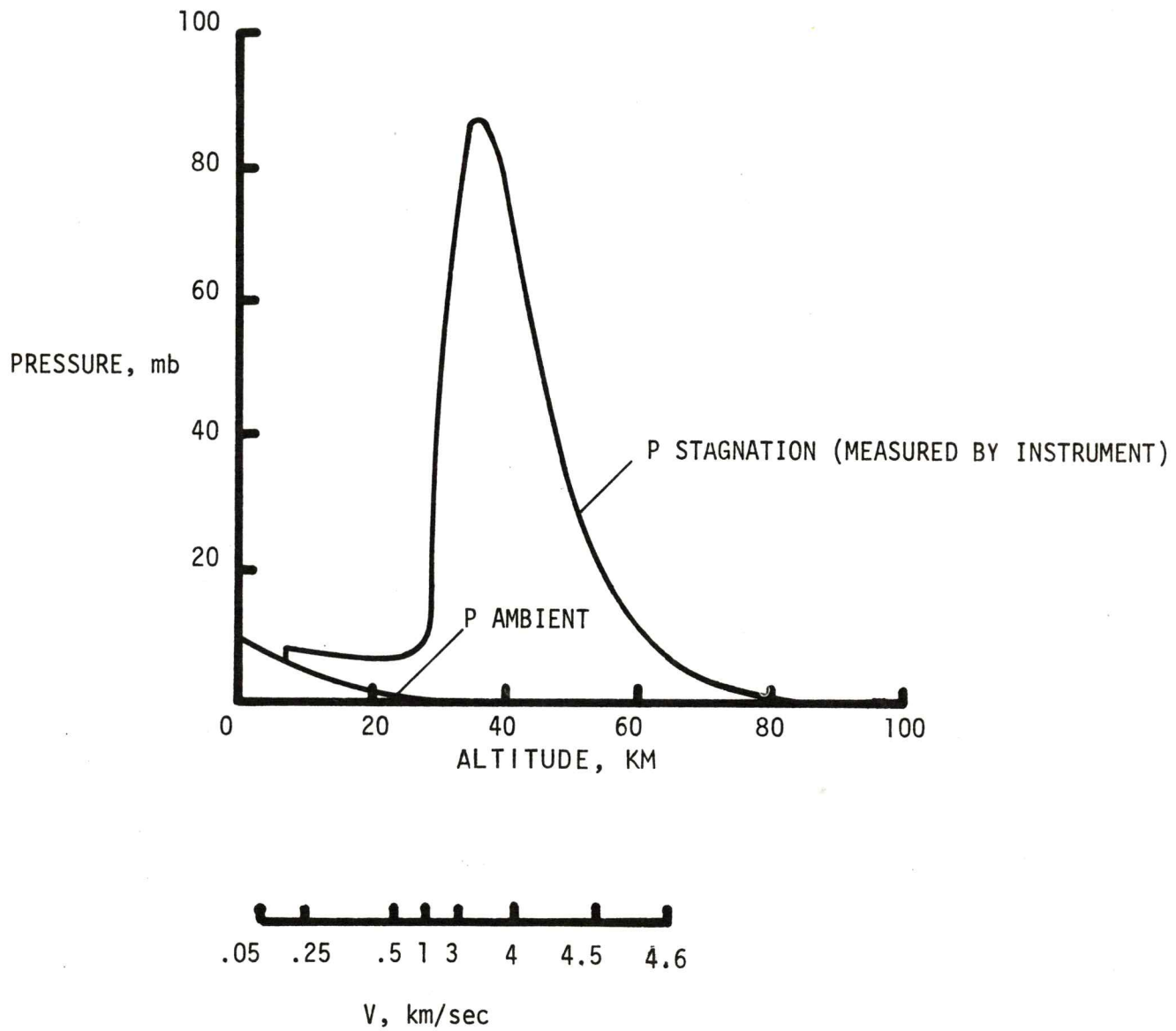


FIGURE 4.8.1.3-3 TYPICAL ENTRY DATA

4.8.2.3.2 FUNCTION

The input pressure in the Stagnation Pressure Transducer acts on one side of a thin stretched diaphragm. The other side of the diaphragm is referenced to a hard vacuum chamber. In this chamber is a capacitance electrode parallel to the diaphragm. At zero absolute pressure the diaphragm is flat and the sensor capacitance is minimum. The tension of the diaphragm is set so that under full scale pressure, the capacitance doubles. At twice full scale pressure, the diaphragm contacts the backplate, providing an overpressure stop. The electronic circuit consists of an input Electromagnetic Interference (EMI) filter, pre regulator, DC-DC converter which provides a square wave signal as well as filtered supply voltages, charge amplifier, rectifier, and buffer amplifiers. The capacitance of the sensor is used as the feedback element of the charge amplifier whose input is a square wave. Therefore, the square wave output varies from a maximum voltage at zero input pressure to a lower value at full scale pressure, and a minimum value under overpressure. The amplitude of the charge amplifier output is measured by the rectifier and the DC output is reversed so that increasing pressure produces increasing output. Buffer amplifiers set zero and gain and low pass filtering. A temperature sensor (platinum resistance type) is connected in a bridge circuit operating from the unit supply voltage. The output of this sensor bridge is used to supply unit temperature data to allow for the correction of pressure data for temperature shifts. The instrument consists basically of two parts: the sensor sub-assembly and the electronics sub-assembly. The two subassemblies are mounted within the same hermetically sealed case.

a. Sensor Sub-Assembly

A cross-section of the sensor sub-assembly is shown in Figure 4.8.1.3-4 and the instrument Functional Schematic in Figure 4.8.1.3-5. Changes in absolute pressure result in changes in the capacitance between the diaphragm and fixed capacitor plate.

b. Electronics Sub-Assembly

The electronics Functional Schematic for the Electronics Sub-assembly is shown in Figure 4.8.1.3-5. The electronics consists of the following basic elements:

1) Power Supply

The power supply operates from the VLC bus and provides regulated plus and minus 10 Vdc power to the rest of the electronics and also a 10 KHz square wave supply. The power supply consists of an EMI filter, pre-regulator, chopper circuit,

converter and low pass filter to smooth the DC outputs.

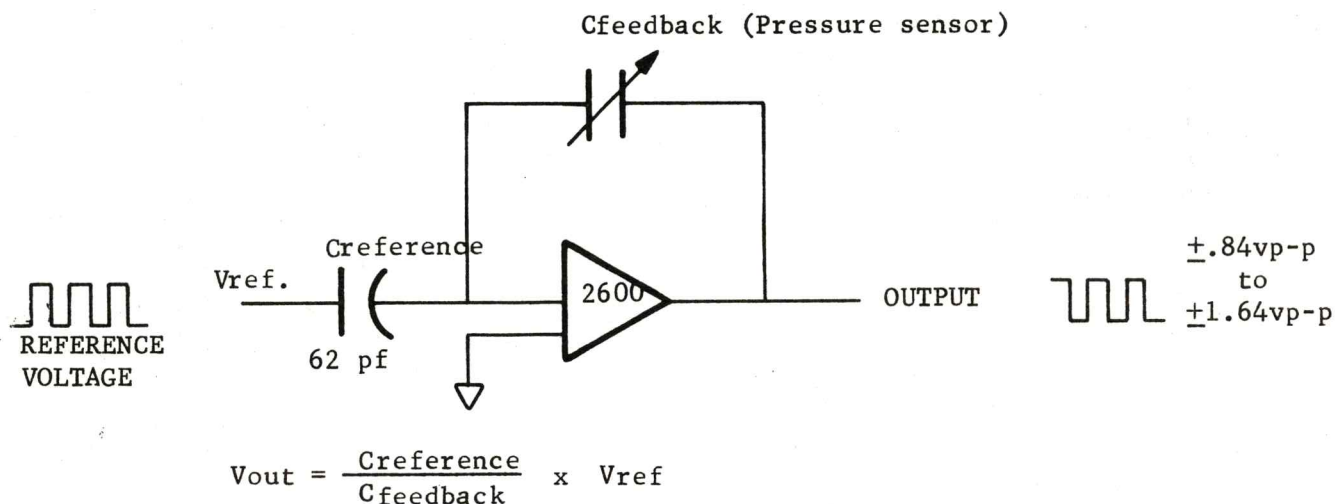
2) Reference Signal Circuit

This circuit generates a precision amplitude controlled square wave with no overshoot. It is used as the reference voltage and input to the charge amplifier.

3) Charge Amplifier

The capacitive sensing element is in the feedback loop of the charge amplifier. The charge amplifier provides a square wave output voltage which is a function of changing pressure due to changes in capacitance of the sensor (capacitance changes from about 40 pf at zero pressure to 80 pf at full scale).

The simplified schematic is as follows:



4) Active Rectifier

The active rectifier accepts the square wave output from the charge amplifier, provides an offset and rectifies the signal to provide a DC output.

5) DC Amplifier

The DC amplifier amplifies the active rectifier output to provide the instrument 0-5 Vdc analog outputs. It has an amplifier with a nominal gain of about 2.5 for the high range output and of about 20 for the low range output. The amplifier also contains low pass filtering to reduce ripple on the outputs.

6) **Temperature Sensor**

The temperature of the pressure sensor is measured by a platinum resistance sensor. The resistance is in a bridge circuit and the bridge output varies over a 0 to 40 mv span.

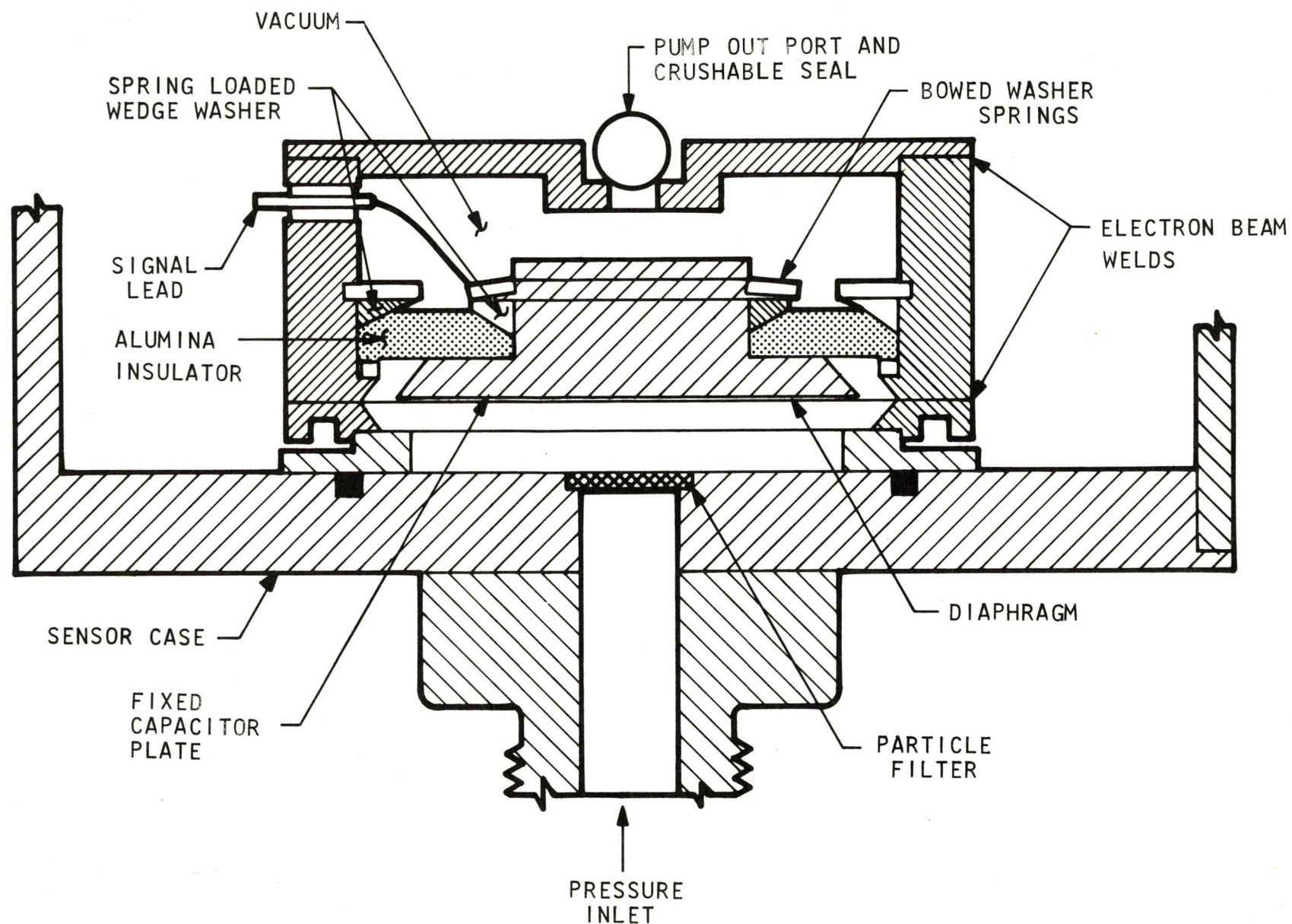


FIGURE 4.8.1.3-4
STAGNATION PRESSURE INSTRUMENT SENSOR SUBASSEMBLY

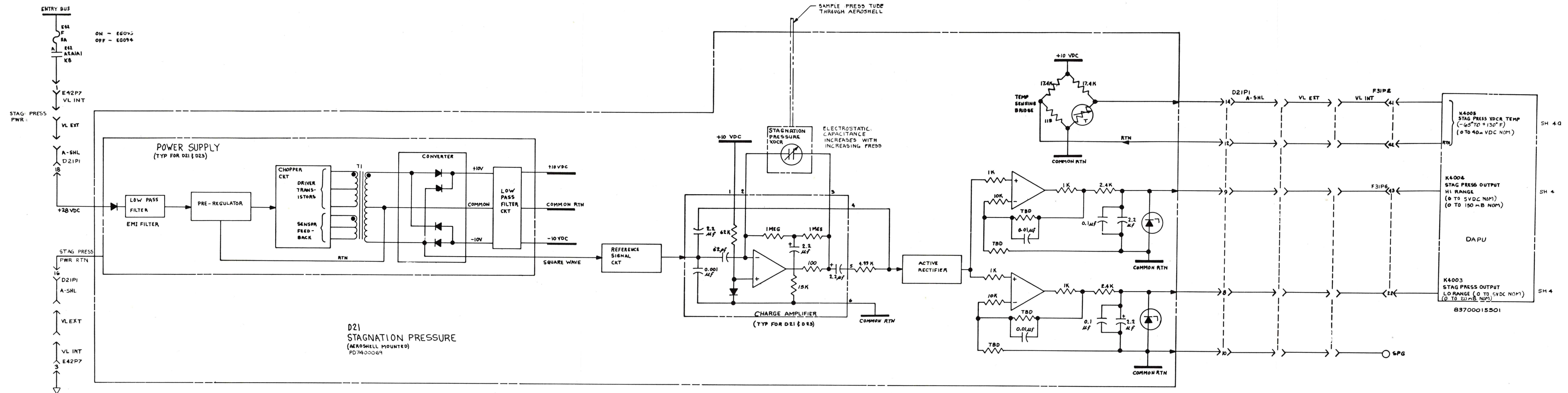


FIGURE 4.8.1.3-5
STAGNATION PRESSURE INSTRUMENT
FUNCTIONAL SCHEMATIC

4.8.1.3.3 OPERATING MODES

The instrument has only the one operating mode. When power is applied the output signals appear on the output lines as analog voltages.

4.8.1.3.4 OPERATIONAL SEQUENCE

Power is applied to the instrument ten minutes before "Entry" to allow sufficient time for the instrument to warm up and establish the zero pressure output and drift. Once power has been applied, the outputs appear on the output lines to the VL Data Acquisition and Processor Unit (DAPU) and the data is digitized and inserted into the VL data stream whenever the DAPU is in the appropriate format. The sampling formats and rates are as follows:

<u>Measurement</u>	<u>Format</u>	<u>Samples Per Second</u>
K4003	2	5
0-20mb	2A	2
(Low Range)	2P	5
K4004	2	5
0-150mb	2A	2
(High Range)	2P	5
K4005	2	0.25
-65/130°F	2A	2
(Transducer Temperature)	2P	0.25
	3	0.5

Sampling during the warm-up time (in Format 2A) establishes the zero pressure reference point and the drift in zero pressure point as a function of time as the instrument warms up. The bulk of the science data will be obtained in Format 2.

4.8.1.3.5 INTERFACES

The instrument interfaces mechanically with the Aeroshell structure and pressure port inlet (Figures 4.8.1.3-1 and 4.8.1.3-2) and electrically with the Power Conditioning and Distribution Assembly (PCDA) and DAPU (Figure 4.8.1.3-6).

Instrument sequencing is controlled by the Guidance Control and Sequencing Computer (GCSC) with power on/off commands to the PCDA and format commands to the DAPU.

4.8.1.3.6 POWER REQUIREMENTS

The instrument operates on the 24 Vdc to 37 Vdc power bus. Power consumption under worst case conditions is less than 1.1 watts.

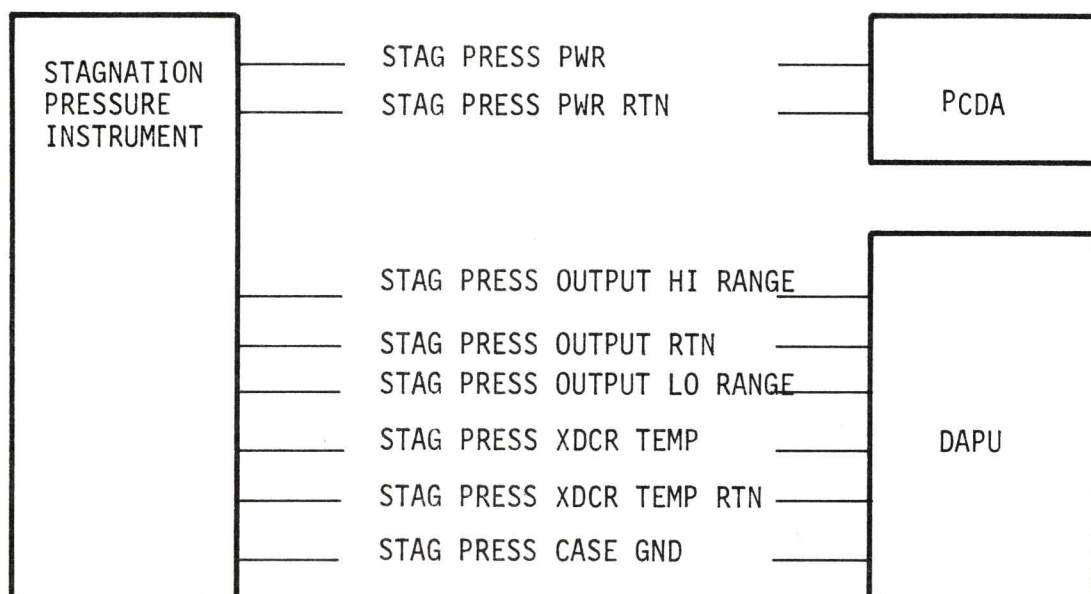


FIGURE 4.8.1.3-6 ELECTRICAL INTERFACE

4.8.1.4 Ambient Pressure

4.8.1.4 AMBIENT PRESSURE

4.8.1.4.1 PURPOSE

The Ambient Pressure instrument is intended to provide data from which the vertical pressure profile of the Martian Atmosphere can be determined during the Parachute and Terminal phases of descent to the Martian surface. In addition, it will be used to measure atmospheric pressure during the Post-Landed portion of the mission.

The location of the instrument and inlet on the VLC are shown in Figures 4.8.1.4-1 and 4.8.1.4-2.

4.8.1.4.2 FUNCTION

The instrument is the same as the low range engineering pressure sensors provided by the Tavis Corporation except for more extensive screening. An instrument functional schematic is shown in Figure 4.8.1.4-3.

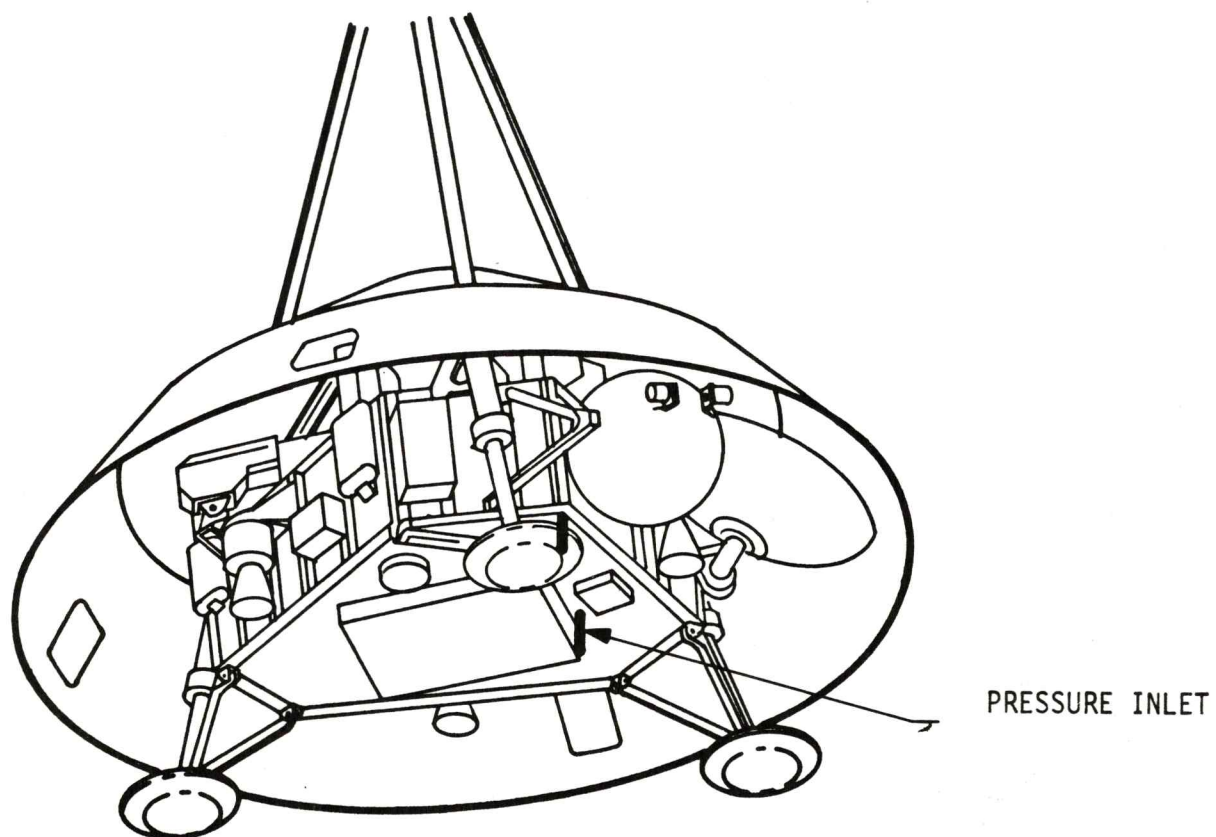
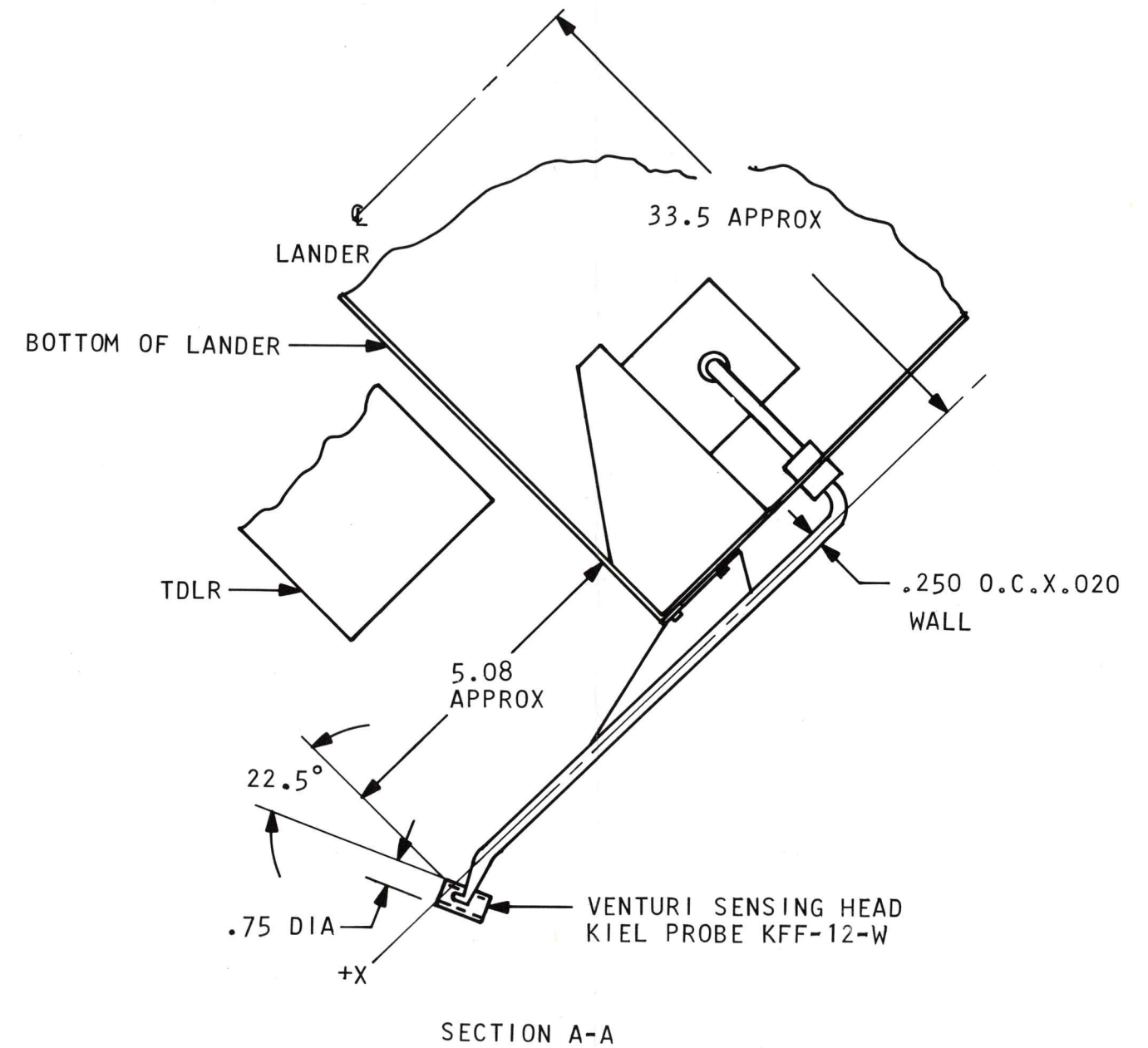


Figure 4.8.1.4-1 AMBIENT PRESSURE INSTRUMENT INLET



NOTES:

1. ALL DIMENSIONS IN INCHES
2. LENGTH OF TUBE FROM PROBE TO INSTRUMENT SHALL BE 22.0 MAX.

FIGURE 4.8.1.4-2 AMBIENT PRESSURE INSTRUMENT AND INLET LOCATIONS

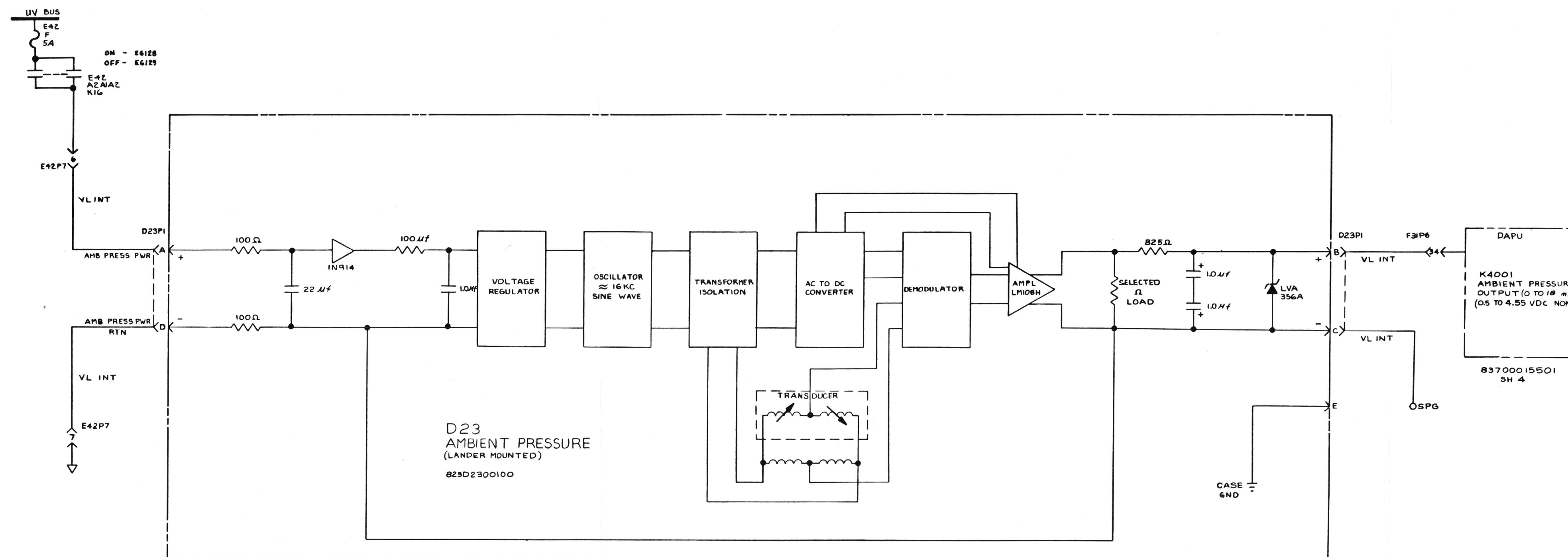


FIGURE 4.8.1.4-3 AMBIENT PRESSURE INSTRUMENT
FUNCTIONAL SCHEMATIC

4.8.1.4.3 OPERATING MODES

When power is applied to the instrument by the Power Conditioning and Distribution Assembly (PCDA) an analog voltage appears on the instrument output lines. This is sampled by the Data Acquisition and Processor Unit (DAPU) and digitized at a rate depending upon the format. The sampling formats and rates are as follows:

<u>Measurement</u>	<u>Format</u>	<u>Sampling</u>
K4001 (0-18mb.)	1	1 sample per frame
	2	1 sample per second
	2A	2 samples per second.
	2P	1 sample per second.
	3	2 samples per second.
	4	1 sample per frame
	5	1 sample per frame

4.8.1.4.4 OPERATING SEQUENCE

During the Entry phase of the mission the instrument power will be applied at "Entry" minus 10 minutes to allow an adequate warm-up period and also to obtain an instrument output at essentially zero pressure. This measurement will enable an assessment of instrument long-term zero drift.

During the Post-Landed phase of the mission acquiring format 4 engineering data format provides instrument power-on (shorter warm-up time than during Entry) and data collection.

4.8.1.4.5 INTERFACES

The instrument interfaces mechanically with the VLC structure and inlet port (Figures 4.8.1.4-1 and 4.8.1.4-2). The design and location of the Kiel Probe venturi sensing head resulted from analytical studies and tests with the intent that during Entry, correct pressure measurements will be obtained within the large angles of attack that may be experienced when swinging on the parachute.

The instrument interfaces electrically with the PCDA and DAPU. The electrical interfaces are shown in Figure 4.8.1.4-4.

Instrument sequencing is controlled by the Guidance Control and Sequencing Computer (GCSC) with power on/off commands to the PCDA and format commands to the DAPU.

4.8.1.4.6 POWER REQUIREMENTS

The instrument operates on the 24 Vdc to 37 Vdc power bus. Power consumption under worst case conditions is less than 0.25 watts.

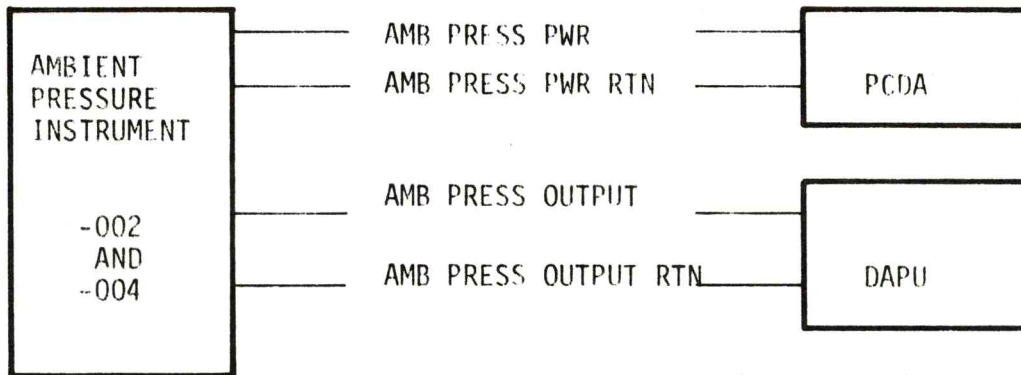


Figure 4.8.1.4-4 - ELECTRICAL INTERFACES

4.8.1.5 Science Temperature Sensors

4.8.1.5 SCIENCE TEMPERATURE SENSORS

4.8.1.5.1 PURPOSE

The Entry Science Temperature Sensors are intended to measure the vertical temperature profile of the Martian atmosphere over as large an altitude range as possible. In order to accomplish this, there are two instruments. One instrument, the Stagnation Temperature Instrument, is mounted on the Aeroshell and will take measurements during the latter part of the ballistic entry. The other instrument, the Ambient Temperature Instrument, is mounted on Footpad No. 2 and will take measurements after the Aeroshell has been jettisoned and the landing legs have been deployed. The useful measurement ranges of the instruments is shown in Figure 4.8.1.5-1 for a typical entry trajectory. The locations of the instruments is shown in Figures 4.8.1.5-2 and 4.8.1.5-3.

4.8.1.5.2 FUNCTION

Both instruments are essentially similar in basic design concept, being based upon multiple thermocouples. The major outputs are derived from the output of three thermocouple elements in series. In order to provide redundancy against breakage, each of the three thermocouples has two other thermocouples in parallel with it. The electronics associated with each instrument are essentially passive, being merely resistance bridge networks using the 5 Vdc Data Acquisition and Processor Unit (DAPU) transducer excitation voltage as reference.

Functional schematics of both instruments are shown in Figure 4.8.1.5-4.

Three pairs of posts are used to hold the thermocouple away from the bulk of the instruments and in the gas flow. The thermocouples themselves are butt welded and mounted to the posts so that the weld is half way between the posts. The thermocouple wires are slightly corrugated to allow post movement without overstressing the weld.

4.8.1.5.2.1 STAGNATION TEMPERATURE INSTRUMENT (PD74600086-001)

The Stagnation Temperature Instrument is designed to measure temperatures over the range of 100°K to 750°K, with an accuracy of $\pm (3.5^\circ\text{K} + 1\% \text{ of reading})$.

In order to accomplish this, the output has been divided into two outputs. One, Measurement, K4009, covers the range from 100°K to 475°K and the other, Measurement K4010, covers the range from 425°K to 750°K. It is necessary to know the temperature of the electronics and thermocouple reference junction and this is provided (Measurement K4012) from a platinum resistance element and covers the range of approximately 160°K to 350°K. Additional

redundancy is obtained with another output, Measurement K4011, which is derived from the front set of redundant thermocouples. This redundant measurement covers the full range from 100°K to 750°K but the digitization accuracy does not meet the overall accuracy requirement.

The Stagnation Temperature Instrument is mounted on the inside of the Aeroshell. It incorporates a pyrotechnic actuated deployment mechanism for its protective cover. When the pyros are fired by the Lander Pyrotechnic Control Assembly (LPCA) on command from the Guidance Control and Sequencing Computer (GCSC), the protective cover (ejectable plug) on the front face of the Aeroshell is pushed away and the sensing elements are deployed out into the gas flow ahead of the Aeroshell. The mechanical configuration of the Stagnation Temperature Instrument is shown in Figure 4.8.1.5-5. Deployment of the sensors into the flow field is programmed to occur when the VLC velocity, relative to the rotating atmosphere, is 1.1 Km per second. If the sensing elements were to be exposed at velocities significantly in excess of 1.1 Km per second the heat load would be sufficient to burn out the thermocouples.

All measurement outputs have a 0 to 40 mv range and are digitized by the Data Acquisition and Processor Unit (DAPU). The sampling format and rates are as follows:

<u>Measurement</u>	<u>Format</u>	<u>Samples/Second</u>
K4009	2	1
100°K-475°K	2A	2
	2P	1
K4010	2	1
425°K-750°K	2A	2
	2P	1
K4011	2	0.25
100°K-750°K	2A	2
(Front Post TC)	2P	0.25
	3	0.5
K4012	2	1
(Reference	2A	2
Temperature)	2P	1

The DAPU transducer excitation voltage is applied to the instrument prior to any sampling and hence data is always obtained whenever the DAPU is in the appropriate format. The calibration curves for deriving sensing element temperatures are relatively complex as a result of the temperature compensating element in the bridge circuitry. The curves for each individual instrument are contained in its acceptance data package.

4.8.1.5.2.2 AMBIENT TEMPERATURE INSTRUMENT (PD7400086-020)

The Ambient Temperature Instrument is designed to measure temperatures over the range of 100°K to 400°K, with an accuracy of $\pm (1.3^\circ\text{K} + 2.1\% \text{ of reading})$.

The instrument has three measurement outputs:

- a. Measurement K4006, which is the prime thermocouples output covering the range of 100°K to 400°K;
- b. Measurement K4007, which is the electronics and thermocouple reference junction temperature. This platinum resistance measurement covers the range of about 160°K to 350°K;
- c. Measurement K4008, which is the output from the front set of thermocouples and covers the range 100°K to 400°K.

The Ambient Temperature Instrument is mounted in the inside of Footpad No. 2. This location was chosen as a result of flow field studies which showed that the gas mass flow over the sensing elements was acceptable over a wide range of angle of attack (this being necessary to obtain good data when the VLC is swinging on the parachute).

The mechanical configuration of the instrument is shown in Figure 4.8.1.5-6.

All measurement outputs have a 0 to 40 mv range and are digitized by the DAPU. The sampling formats and rates are as follows:

<u>Measurement</u>	<u>Format</u>	<u>Sample Rate</u>
K4006	3	2 per second
100°K-400°K	4	1 per frame
K4007	3	2 per second
(Reference Temperature)	4	2 per frame
K4008	2	1 per second
100°K-400°K	2P	1 per second
(Front Post)	3	2 per second
	4	1 per frame
	5	1 per frame

The DAPU transducer excitation voltage is applied to the instrument prior to any sampling and hence data is always obtained whenever the DAPU is in the appropriate format.

The calibration curves for deriving sensing element temperatures are relatively complex as a result of the temperature compensating element in the bridge circuitry. The

wires for each individual instrument are contained in its acceptance data package.

The instrument will be sampled during the Post-Landed phase of the mission and if the thermocouple sensing elements survive landing, near surface atmospheric temperature measurements will be made.

4.8.1.5.3 OPERATING MODES

Both the Stagnation and Ambient Temperature Instruments are essentially passive. An output will appear on the measurement lines to the DAPU whenever the DAPU 5 Vdc transducer excitation voltage is applied. This excitation voltage is applied by the DAPU just prior to sampling each channel and measurements will be obtained whenever the DAPU is operating in an appropriate format.

The two ranges of the Stagnation Temperature transducer always provide outputs. If the temperature is less than 425°K, the high range will provide a negative output to the DAPU and this will be digitized as 0DN. If the temperature is greater than 475°K the low range will provide an output in excess of +40 mv to the DAPU and this will be digitized as 255 DN, i.e. full scale.

4.8.1.5.4 OPERATIONAL SEQUENCE

The sequencing of taking data from the Stagnation and Ambient Temperature Instruments is determined by the DAPU mode sequencing. These data will be of value only when the sensing elements are exposed to an adequate flow of Martian atmosphere over the thermocouples.

Figure 4.8.1.5-1 shows the useful range of measurements.

The Stagnation Temperature sensors are deployed through the front of the aeroshell when the VLC velocity has been reduced to $1.1 \pm .1$ Km/sec. The deployment is initiated by the GCSC which computes velocity from the VLC initial conditions and Inertial Reference Unit (IRU) data and commands the LPCA to fire the pyros at the appropriate time. Useful measurement will be obtained until parachute deployment (mortar fire at altitude of approximately 18,200 feet) with data being obtained for another 6 seconds (7 seconds for K4011 measurement). These last data may be difficult to analyze, due to transients caused by parachute deployment.

The Ambient Temperature sensors will not see an adequate flow of Martian atmosphere until after the landing legs have been deployed. Useful measurements will be obtained starting at approximately 20 seconds after parachute deployment and will continue until the Descent Engine fires at an altitude of 4,574 feet.

4.8.1.5.5 INTERFACES

The Stagnation Temperature Instrument interfaces directly with the DAPU, LPCA and Aeroshell structure. The electrical interfaces are shown in Figure 4.8.1.5-7. The instrument interfaces indirectly with the GCSC which controls the DAPU modes and commands the LPCA to fire the deployment pyros.

The Ambient Temperature Instrument interfaces directly with the DAPU and Footpad No 2 structure. The electrical interface is shown in Figure 4.8.1.5-8.

4.8.1.5.6 POWER REQUIREMENTS

Both the Stagnation and Ambient Temperature Instruments use the 5 ± 0.015 Vdc transducer excitation voltage supplied by the DAPU.

Maximum power drawn is about 9 milliwatts for each of the instruments.

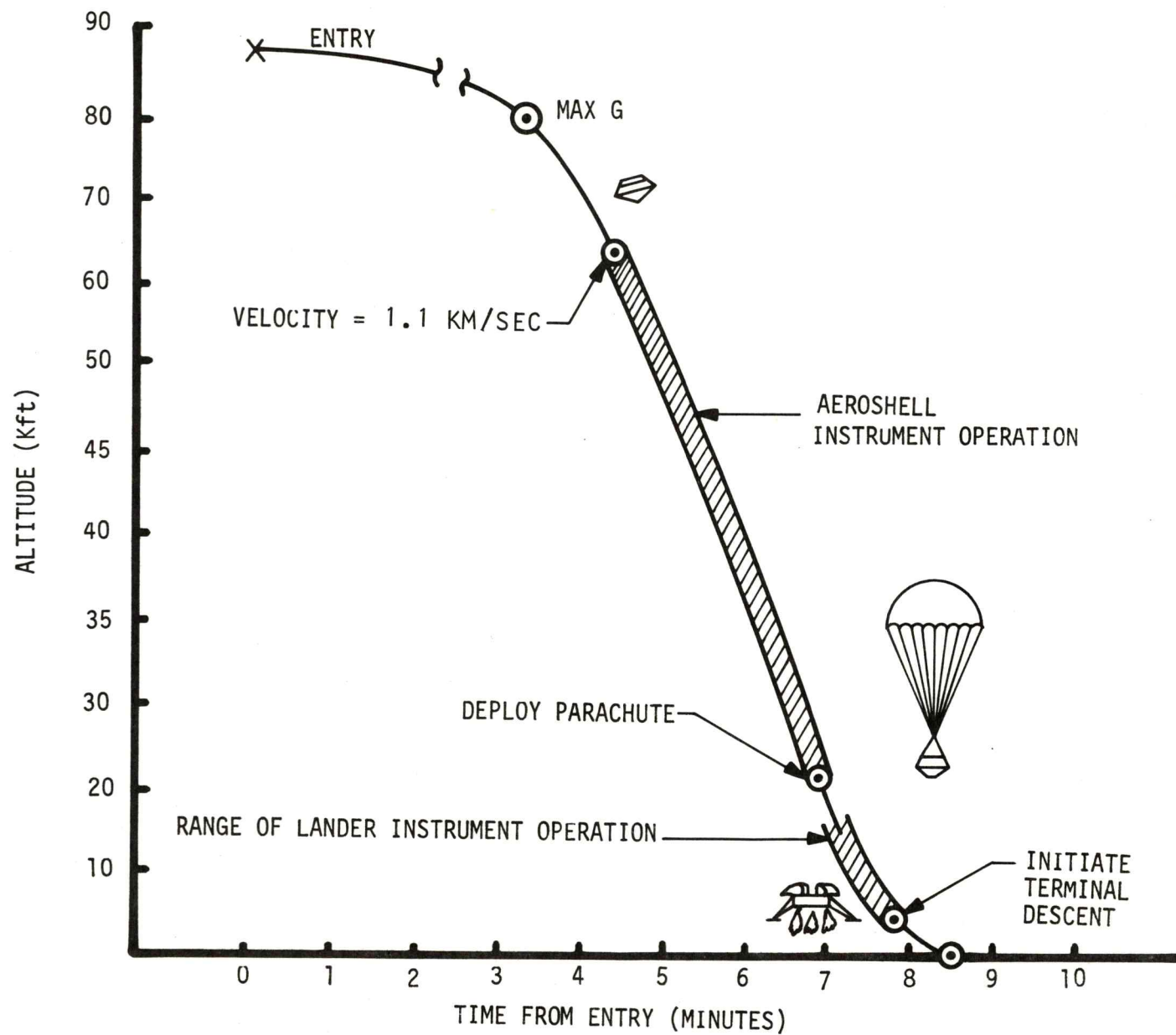


FIGURE 4.8.1.5-1 TEMPERATURE INSTRUMENTS MEASUREMENTS PROFILE

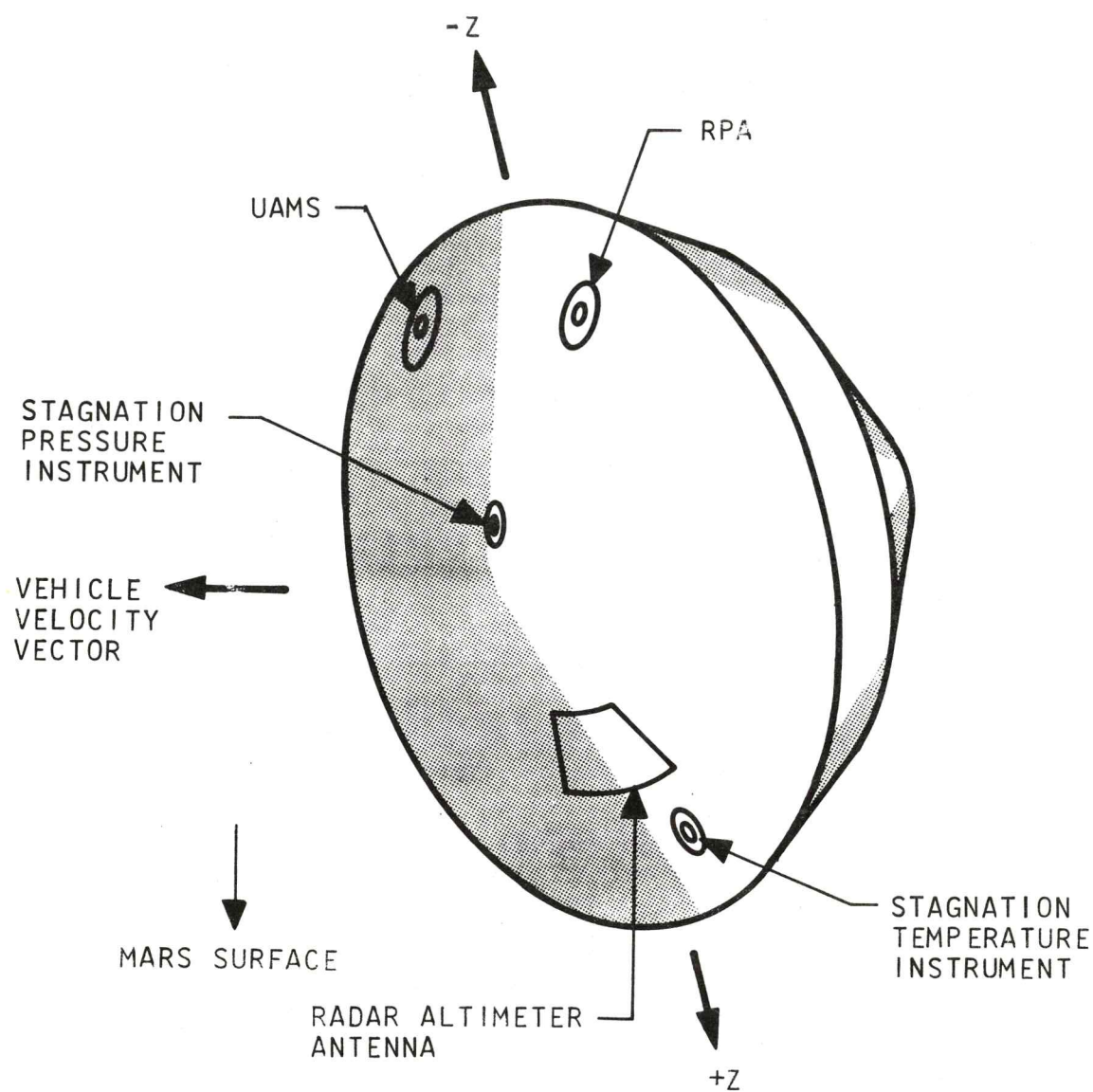


FIGURE 4.8.1.5-2
STAGNATION TEMPERATURE INSTRUMENT LOCATION
ON AEROSHELL

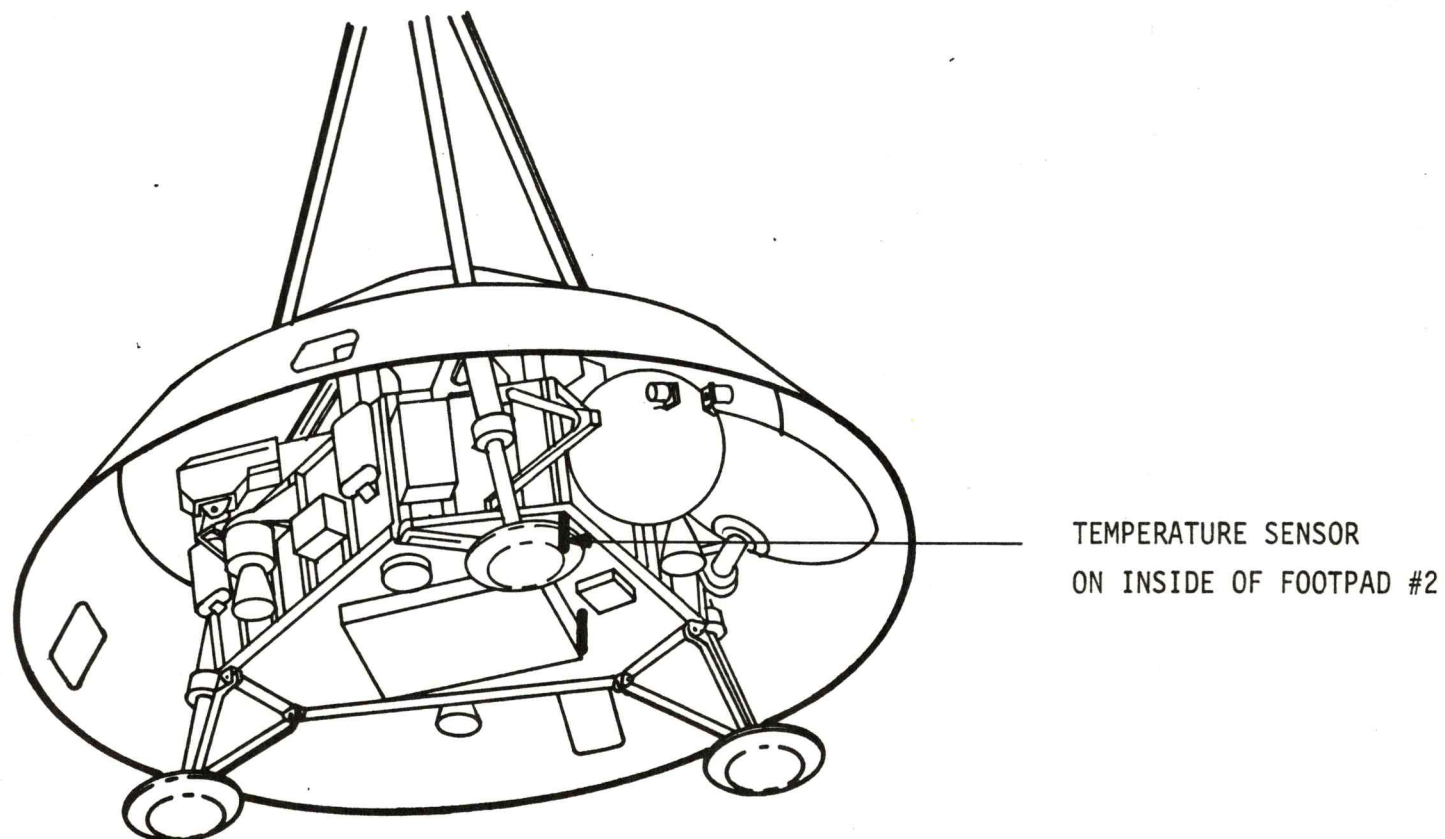
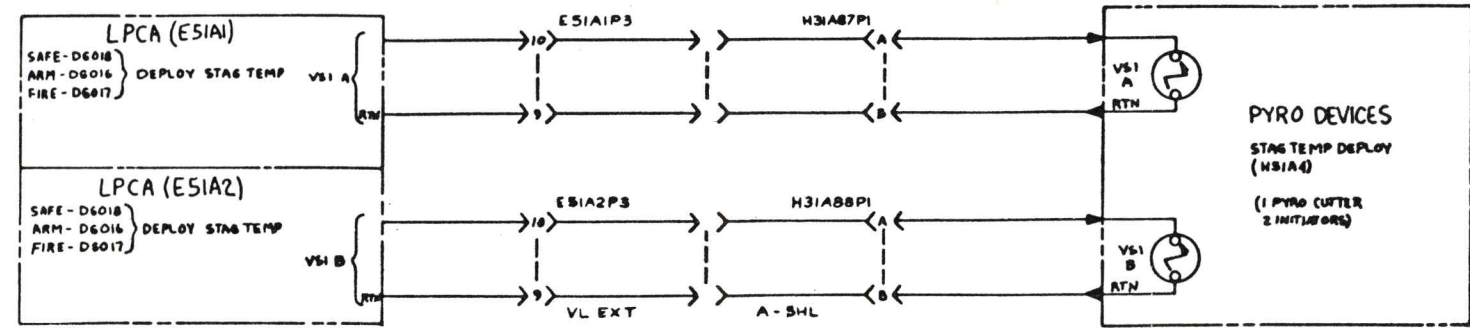
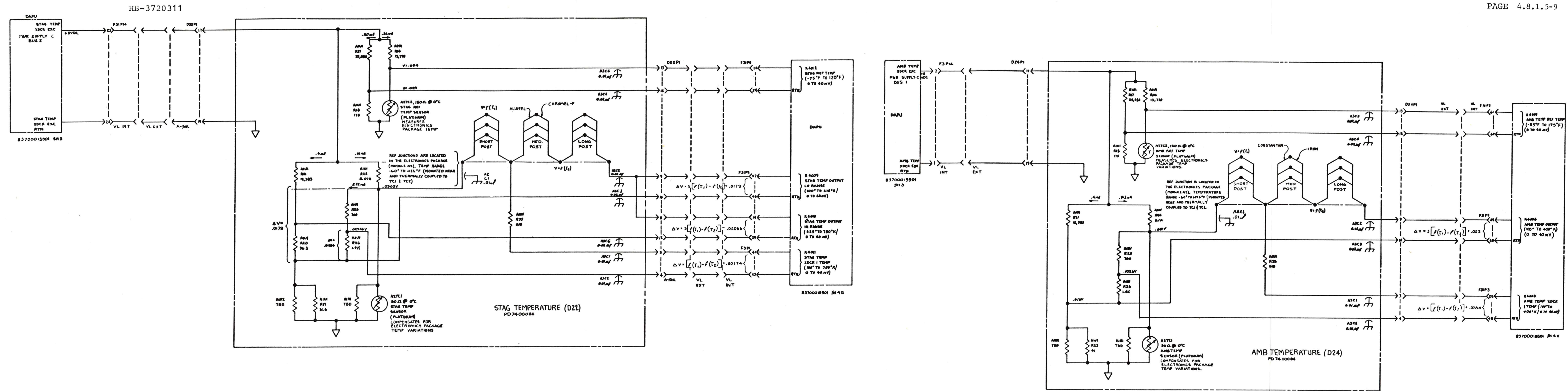
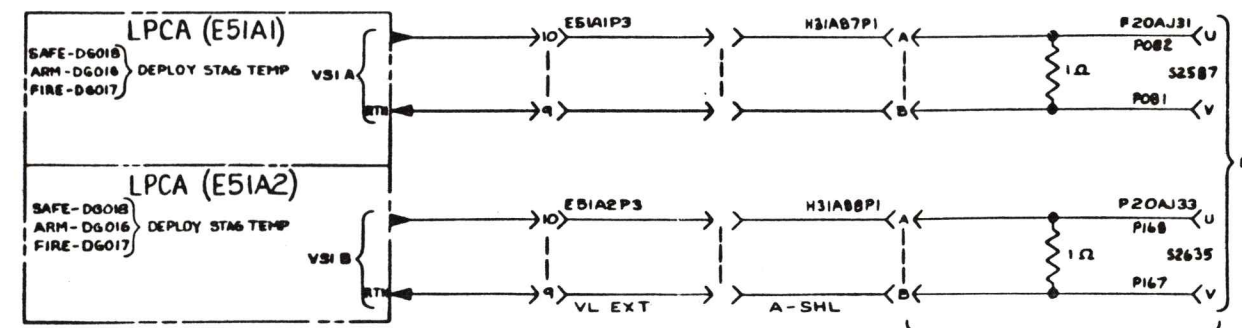


Figure 4.8.1.5-3 AMBIENT TEMPERATURE INSTRUMENT LOCATION ON LANDER



837E4400012
PG 6.7
STAGNATION TEMPERATURE (D22)
(AEROSHELL MOUNTED) (FLIGHT CONFIGURATION SHOWN)
TEST CONFIGURATION SHOWN AT ZONE 24-21/B4C



837E4400012
PG 6.7
STAGNATION TEMPERATURE (D22)
(AEROSHELL MOUNTED) (FLIGHT CONFIGURATION SHOWN)
TEST CONFIGURATION SHOWN AT ZONE 24-21/B4C

FIGURE 4.8.1.5-4 FUNCTIONAL SCHEMATICS
TEMPERATURE INSTRUMENT

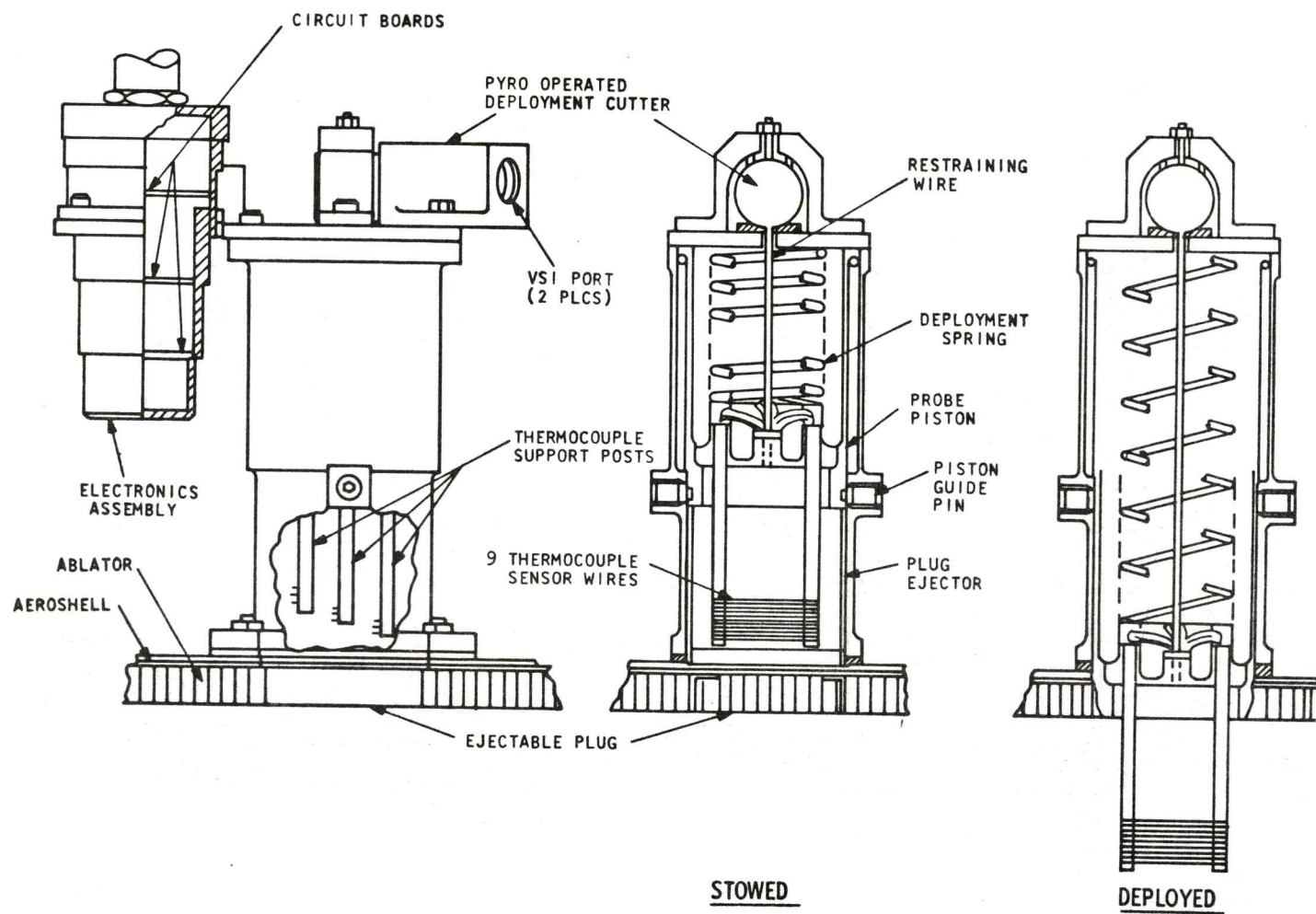


FIGURE 4.8.1.5-5 STAGNATION TEMPERATURE INSTRUMENT

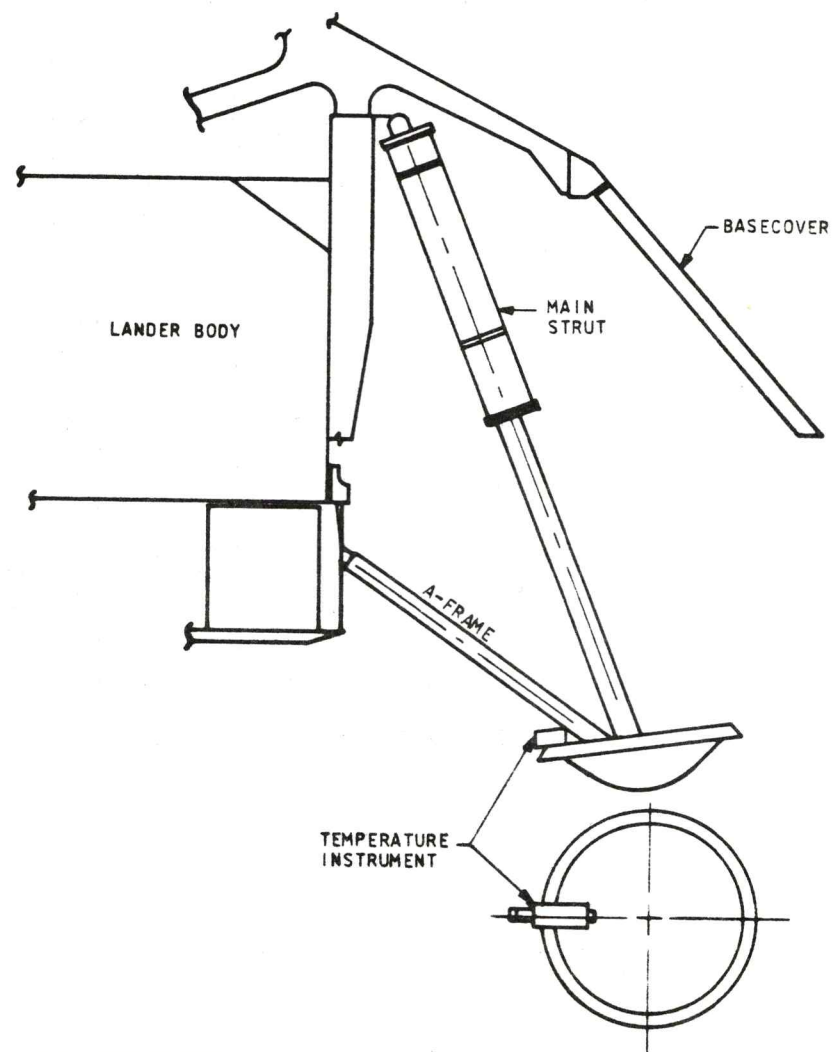
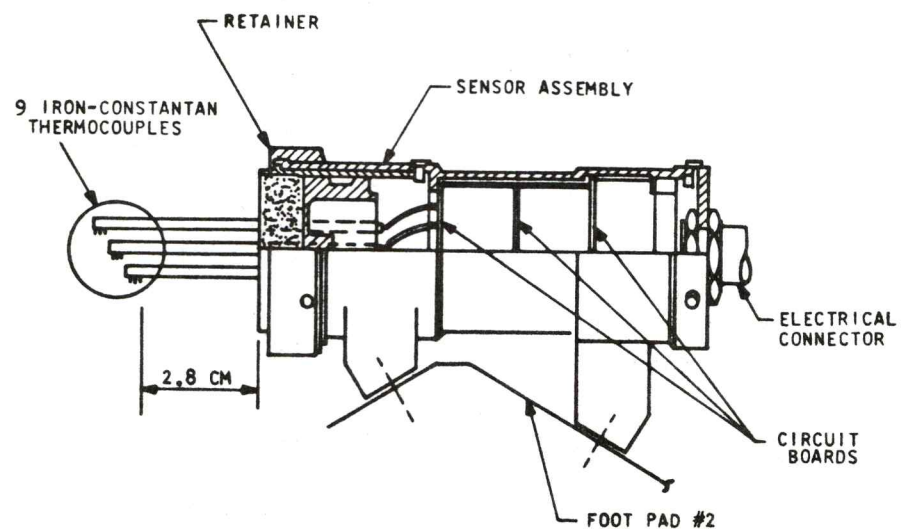
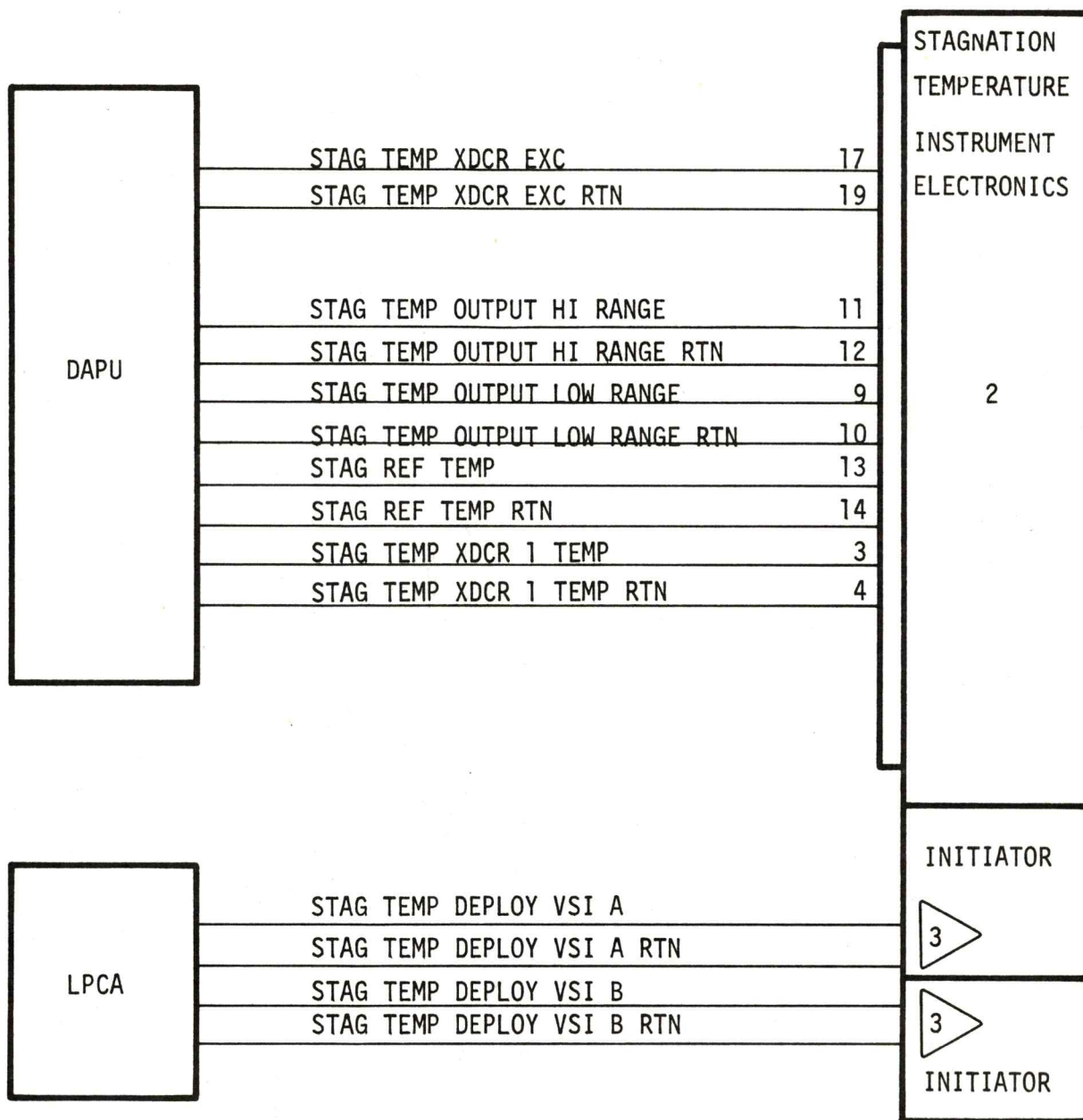


FIGURE 4.8.1.5-6 AMBIENT TEMPERATURE INSTRUMENT

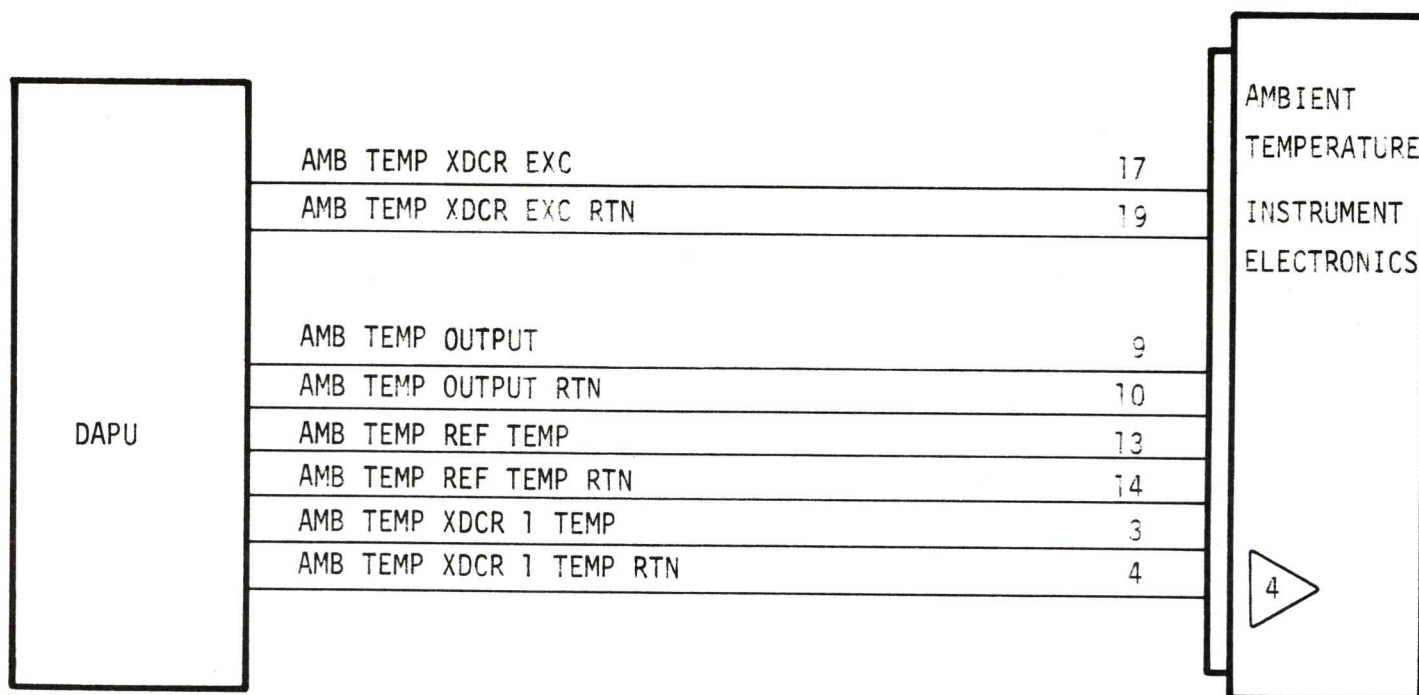


CONNECTOR SV81DMD63RA2PN
ALL SIGNALS ARE LOW LEVEL ANALOG -PINS NOT LISTED ARE UNUSED



CONNECTOR INTEGRAL TO INITIATOR (PD5000006)

FIGURE 4.8.1.5-7 STAGNATION TEMPERATURE INSTRUMENT
ELECTRICAL INTERFACE



CONNECTOR SV81DMD63RA2PN
ALL SIGNALS ARE LOW LEVEL ANALOG - PINS NOT LISTED ARE UNUSED

FIGURE 4.8.1.5-8 AMBIENT TEMPERATURE INSTRUMENT
ELECTRICAL INTERFACE

ing Mission is on gathering
environmental
for extraterrestrial
future. In
and

4.8.2 Landed Science

4.8.2 LANDED SCIENCES

The primary emphasis of the Viking Mission is on gathering information on biological, chemical, and environmental characteristics most relevant to the search for extraterrestrial life—either past, present, or potential for the future. In addition, investigations of the interior, surface, and meteorology of Mars will be carried out.

A listing of Scientific goals and the investigations performed by instrumentation on the Viking Lander (VL) is as follows:

<u>Scientific Goals</u>	<u>Investigations (Instruments)</u>
Visually examine the landing Site.	Visual Imaging (2 cameras).
Search for evidence of life.	Direct biology (3 metabolism and growth detectors).
Search for and study organic and inorganic compounds.	Molecular Analysis (gas chromatograph and mass spectrometer).
Determine atmospheric composition and its variations with time.	X-ray Spectrometer.
Determine temporal variations of pressure, temperature, and wind velocity.	Meteorology (pressure, temperature, and wind sensors).
Determine seismological characteristics.	Seismology (3-axis seismometer).
Determine magnetic properties of surface.	Magnetic properties (2 magnet arrays and magnifying mirror).
Determine physical properties of surface.	Physical properties. Surface Sampler System

The general location of the science instrumentation on the VL is shown in Figure 4.8.2-1.

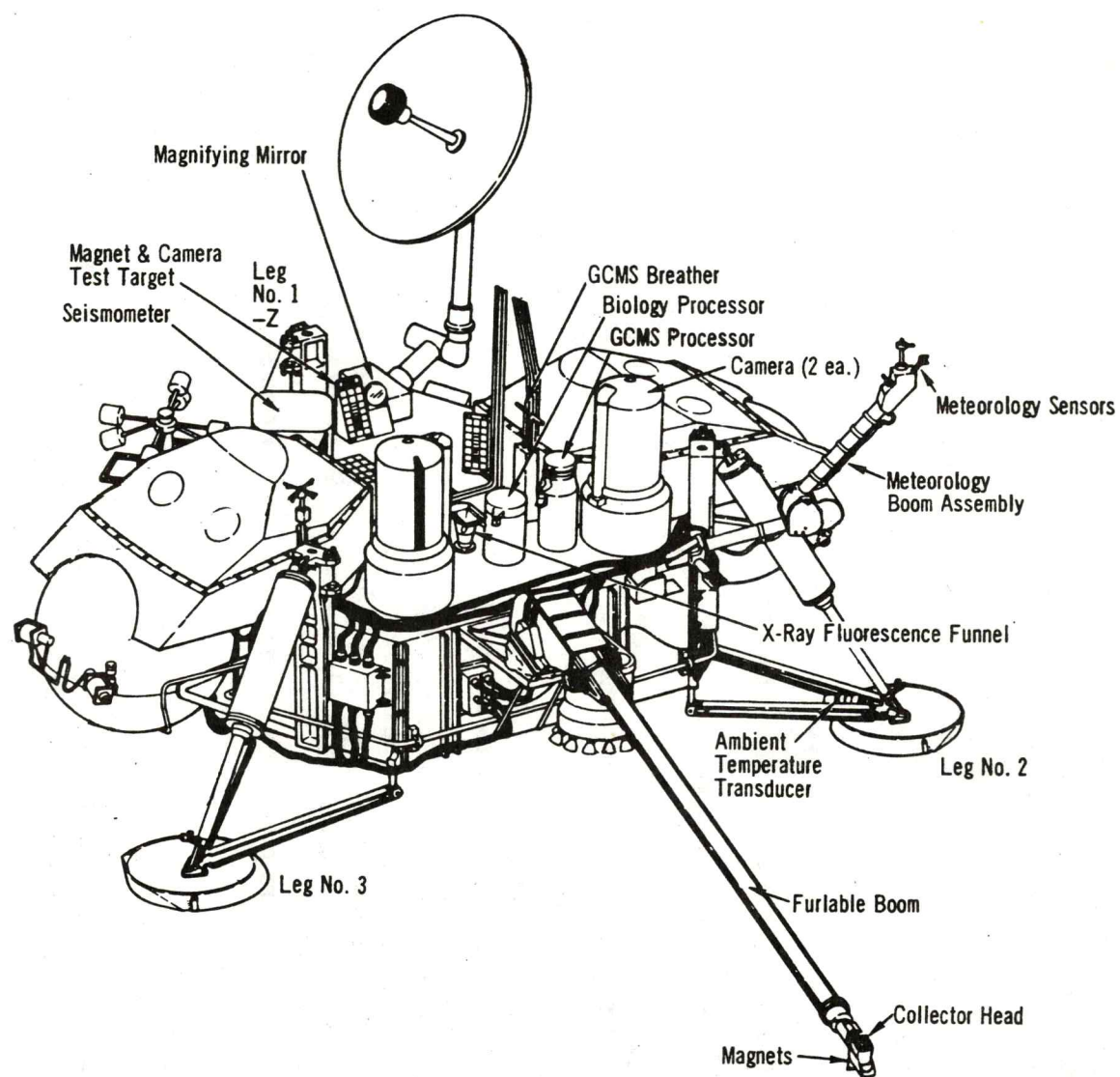


FIGURE 4.8.2-1

VL INSTRUMENT LOCATION

4.8.2.1 Biology

4.8.2.1 BIOLOGY

4.8.2.1.1 PURPOSE

The objective of the Biology Investigation is to measure evidence or conversely lack of evidence for metabolism of micro-organisms that are present in samples of the Martian surface that are deposited in the Biology instrument's test chambers. The Biology instrument provides a test chamber environment that is conducive to metabolism and/or growth of life forms similar to those that probably evolved early in Earth's history. The instrument contains three complete biological experiments, each operating on a different principle, along with the electronics to operate them and to record their findings for transmission to Earth.

a. Gas Exchange (GEX) Experiment

The GEX experiment operates on a simple principle: living organisms alter their gaseous environment as they live, respire, eat, and reproduce. Gaseous changes can indicate that life processes are going on. In this experiment, a Mars surface sample inside a sealed cup is either humidified with water vapor or is partially submerged in a complex aqueous nutrient medium.

The surface sample is repeatedly incubated for up to 17 days (typically) in an atmosphere of helium, krypton, and carbon dioxide. Gases within the experiment cell are sampled periodically by gas chromatography. The GEX experiment looks for evidence of metabolism by checking for concentration changes in molecular hydrogen (H_2), molecular nitrogen (N_2), molecular oxygen (O_2), methane (CH_4), or carbon dioxide (CO_2).

Metabolism occurs as living organisms process food to maintain and reproduce themselves. A common example of metabolism on Earth is man's ingestion of carbon-based organic matter (food), and his use of the energy from changing the food to CO_2 , and other products.

The complete experiment, involving up to four cycles using the same surface sample, can be performed once. If desired, a second soil sample can be analyzed on top of the first, but within the total of four cycles.

b. Labeled-Release (LR) Experiment

The LR experiment also searches for signs of metabolic activity in the Mars surface sample. It is based on the following four assumptions:

- 1) If life exists on Mars, micro-organisms are probably present to recycle organic matter, although life on Mars may not be limited to micro-organisms;
- 2) Biochemical reactions can be carried on in a fluid or damp milieu (on Earth it is water);
- 3) Micro-organisms assimilate compounds from their environment and produce gas;
- 4) Compounds assimilated could include relatively simple carbon-containing molecules.

A sample of the Martian surface will be loaded into a test cell, barely moistened by a nutrient labeled with radio-active carbon-14, and allowed to incubate at 47° F for up to 11 days. If there are any micro-organisms which consume the nutrient they could release gases that contain radioactively labeled wastes (the carbon-14). The LR experiment will detect any volatile carbon products such as carbon-14 dioxide (^{14}CO sub 2), carbon-14 monoxide (^{14}CO) or methane (^{14}CH sub 4).

The LR experiment can be performed up to four times.

c. Pyrolytic Release (PR) Experiment

The PR experiment has a primary goal of detecting photosynthetic organisms under normal, arid Martian conditions. The experiment will detect the presence of organisms capable of assimilating and forming organic material from ^{14}CO sub 2 and ^{14}CO . A 1/4 cc surface sample will be incubated in a test cell with a mixture of ^{14}CO sub 2 and ^{14}CO under simulated Martian sunlight for a period of 5 days. Following the removal of the incubation atmosphere, the surface sample will be pyrolyzed by heating to 625° C. During this process, the unincorporated ^{14}CO sub 2/ ^{14}CO gas released from the sample will be passed through an Organic Vapor Trap (OVT), collected at a radiation detector and counted as the first peak. The heavier organic molecules identified with organisms are collected in the OVT. Following the collection of the first peak, this organic material will be eluted from the OVT by heating to 650° C, collected in the detector and counted as the second peak.

4.8.2.1.2 FUNCTIONAL DESCRIPTION

An initial understanding of the Viking Biology Instrument (VBI) functional performance may be ascertained in a broad sense from examination of the VBI operational system block diagram shown in Figure 4.8.2.1-1. Operationally, the VBI functions through its interface for commands and power from the VL, while

providing both engineering and scientific data to the VL for transmission to earth. This interface is carried out within the VBI in the electrical subsystem. The other significant operational interface between the VBI and the VL provides for a supply of Martian surface sample to the VBI from the VL's Surface Sampler Control Assembly (SSCA). This interface is implemented in the VBI Soil Distribution Assembly (SDA) for distribution to the three experiment modules. Internal functions of the VBI are performed through a complex system of pneumatics which provides for the use of pressurized helium as a working medium, storage of certain nutrients for biological experiment functions, and a waste management system which ensures removal of spent fluids and gases from the working areas. Scientific results which can be derived from the Biology experiment are totally dependent on data which are produced by the ^{14}C detectors in the PR and LR modules and the gas chromatograph in the GEX module.

Following are operational process descriptions for the five major instrument subsystems; the SDA, three experiment modules, and the common services module.

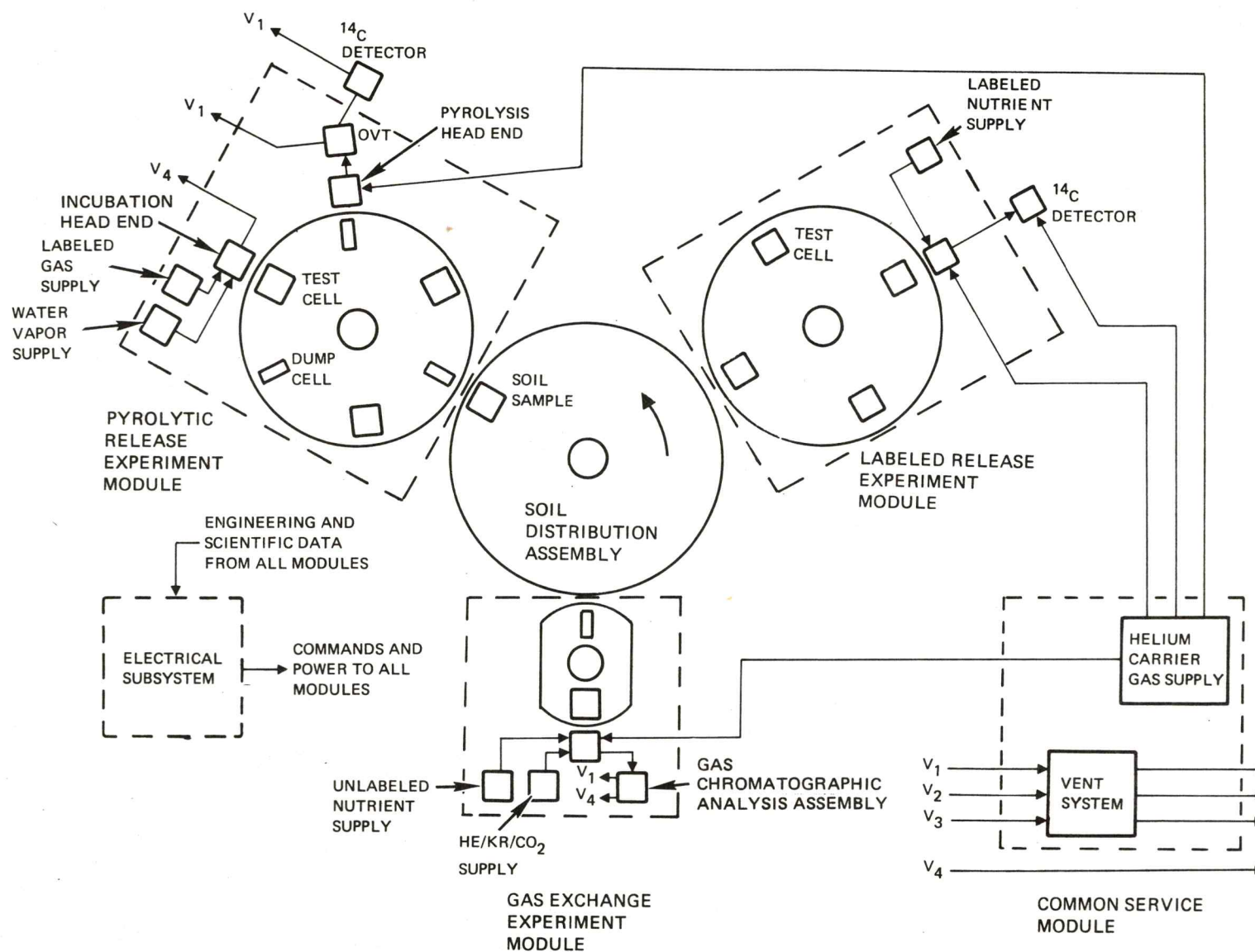


Figure 4.8.2.1-1 - VBI SYSTEM OPERATIONAL BLOCK DIAGRAM

a. Soil Distribution Assembly (SDA)

The SDA is located above the three experiment modules and serves to receive the surface sample from the Surface Sampler PDA, to accept, deliver, and meter the surface samples for each experiment test chamber and to store sufficient quantities of each surface sample delivered such that a second distribution may be made to the PR, LR and GEI experiments. When not required, the excess surface sample is transferred to soil dump cavities which are part of each experiment module, prior to accepting the subsequent sample. The SDA will accept and distribute a nominal surface sample size of 6.0 cc and is capable of accepting, delivering, and metering surface sample with particle sizes up to 3870 microns.

The instrument surface sampler hopper is in position to receive a surface sample from the VL at all times except during surface sample distribution. The instrument meters and delivers the active surface samples to the individual experiments following a distribute surface sample command from the Guidance, Control and Sequencing Computer (GCSC).

The functional steps in each SDA cycle are shown in Figure 4.8.2.1-2 and are described below.

1) Step 1

While in the rest position, the hopper receives 6.0 cc of surface sample from the Surface Sampler PDA. During this operation the hopper is oscillated approximately 0.020 inch at 20 cps continuing for 5 seconds after the Surface Sampler PDA shuttle vibrator stops. This is to insure that, when tilted 25 degrees, the full surface sample drops into the hopper. In the rest position the bottom of the hopper is blanked off by the metering plate. The three metering cavities are aligned with the three module feed tubes in the base, which are also aligned with one of the dump cavities or test cells in each of the three modules as programmed.

2) Step 2

During this step the surface sampler hopper plate is rotated 25 degrees as indicated while the metering plate assembly is locked in position such that the metering cavities will not permit the surface sampler to pass into the test cells or dump cavities.

3) Step 3

With all metering cavities blanked off by the base, the hopper is rotated an additional 330 degrees Counter Clockwise (CCW), thereby filling each cavity as it passes over.

4) Step 4

A Clockwise (CW) rotation of 330 degrees of the hopper returns it to the position shown, with the metering cavities and the surface sample hopper not aligned.

5) Step 5

Unlocking the metering plate accompanied by CW rotation of 25 degrees dumps the measured soil into a dump cavity or test cell as programmed.

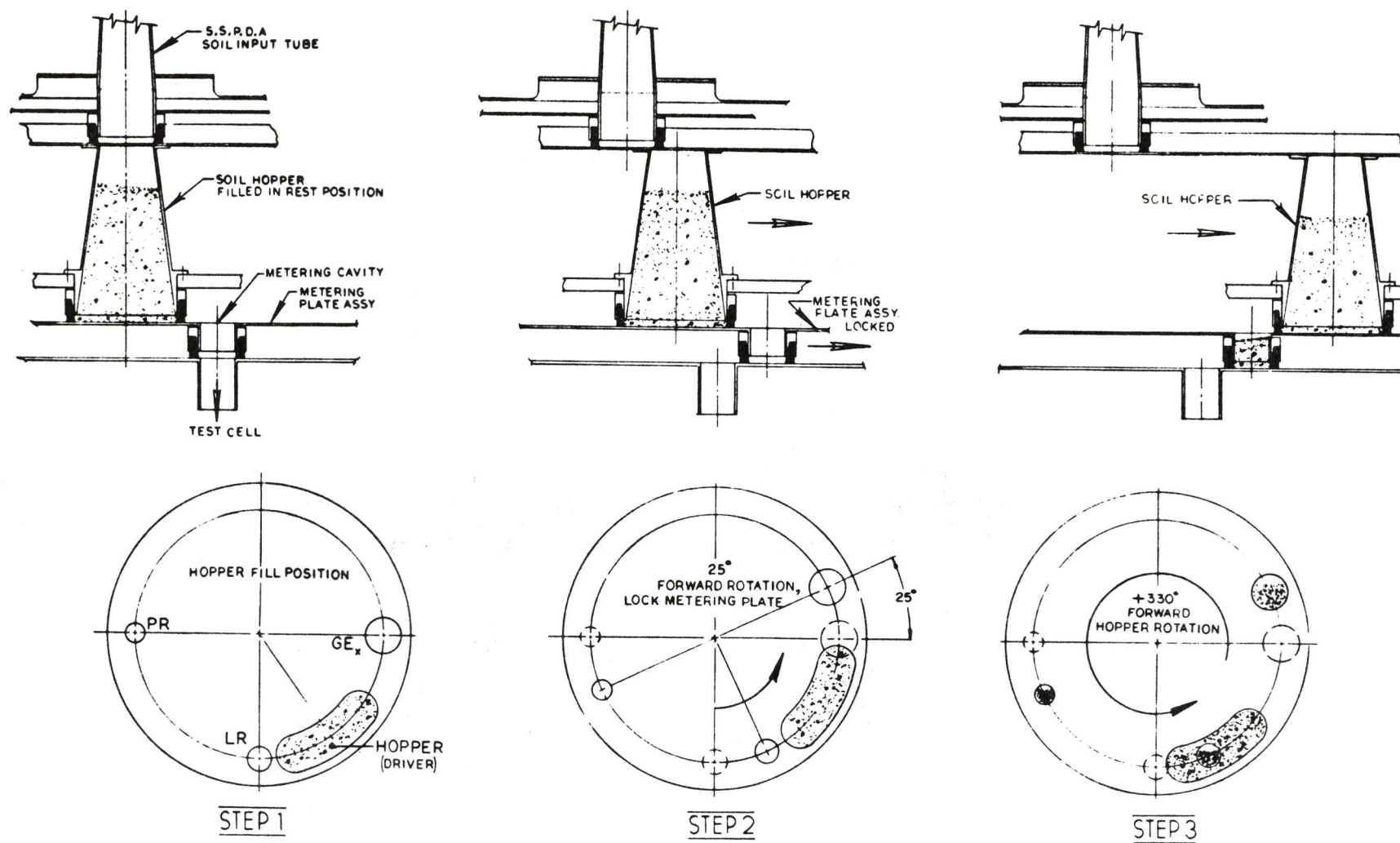


Figure 4.8.2.1-2 - SDA Functional Operation

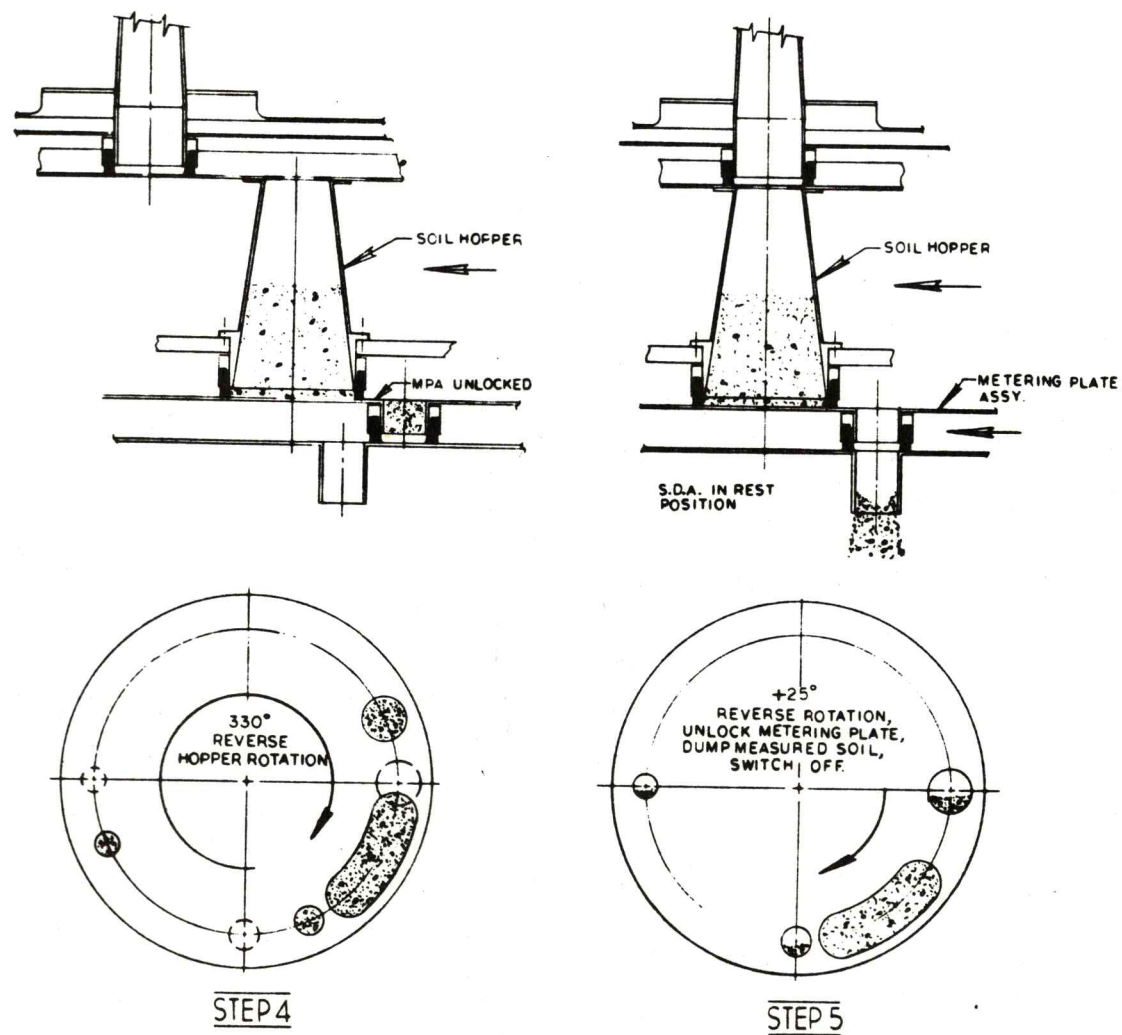


Figure 4.8.2.1-2 - SDA Functional Operation (Cont)

b. Common Services Module (CSM)

The CSM contains the helium reservoir and instrument waste management system. Helium is used in the three experiments for pneumatic actuation, as a carrier gas for the gas chromatograph, and as a carrier pressurant and purge gas for the LR and PR experiments. Waste is effluent purge gases and spent biological liquid nutrients which are exhausted through an activated charcoal trap to remove organics.

The helium supply and vent pneumatics between the CSM and the three experiments are shown in Figure 4.8.2.1-3. The CSM flow diagram is in Figure 4.8.2.1-4.

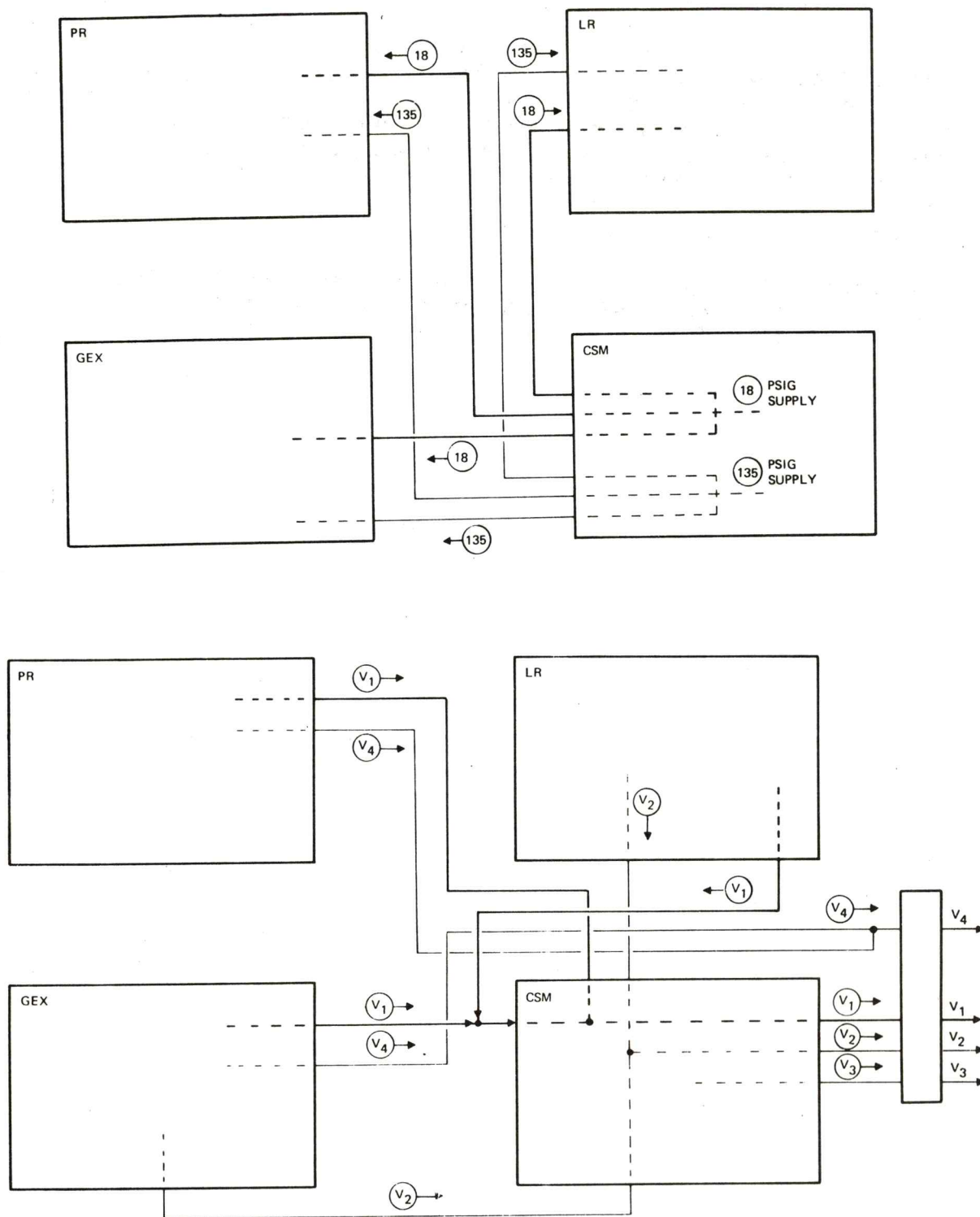
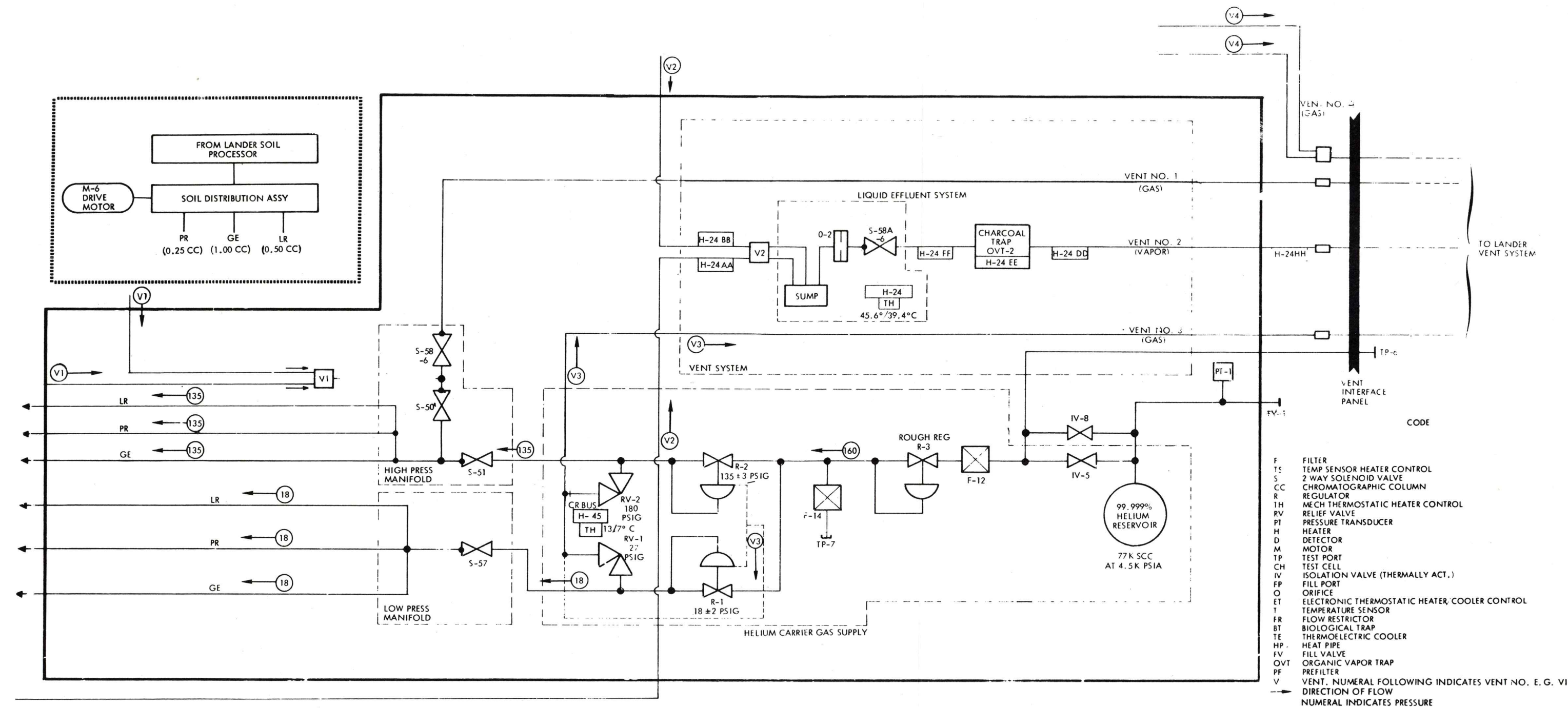


Figure 4.8.2.1-3 - CSM PNEUMATICS



c. Pyrolytic Release

The general functioning of the PR is shown in Figure 4.8.2.1-5.

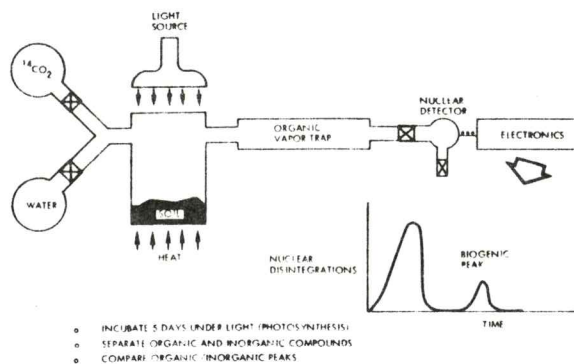


Figure 4.8.2.1-5 Pyrolytic Release Experiment

The specific functions will be described while referring to the mechanical arrangement of the module, Figure 4.8.2.1-6, and the flow diagram of Figure 4.8.2.1-7.

The PR module consists primarily of test and dump cells and two head ends, one for incubating the surface samples and one for pyrolyzing them. A water vapor supply, a labeled gas supply and a lamp are ancillary to the incubation head end while an organic vapor trap and ^{14}C detector assembly provide the equipment needed for the pyrolysis, elution and measurement functions of the experiment. The surface sample is loaded into the cells from a SDA and helium gas is provided by the CSM.

The three test cells can be used to perform the fixation of ^{14}C experiment with active surface sample or to perform a control experiment with sterilized soil. When loading of surface sample into a test cell is undesirable, the three dump cells shown provide capacity for accepting surface samples. The test and dump cells are mounted on a carousel which can be indexed in 60 degree increments by a positioning mechanism consisting of a stepping motor and geneva star wheel.

Prior to starting the sequence, the OVT, and the pyrolysis system in general, are backfilled with Martian gases. The test sequence is initiated by loading a 0.25 cc soil sample into one of the three test cells. The vertical actuator assembly is pressurized which removes the loaded cell from contact

with the surface sample loader and the test cell is indexed 180 degrees to the incubation head end assembly. Next, the vertical actuator is depressurized and the actuator return spring seals the test cell to the head end assembly.

Water vapor and labeled gas are injected into the test cell. The lamp is turned on and the surface sample is exposed to approximately 15% of the normal Martian sunlight level for the 5-day incubation period.

On about the third day of incubation, the OVT is prepared for the following set of sequences to be performed when the test cell is moved under the pyrolysis head end. First the pyrolysis head end, the OVT and detector are purged with helium, and the OVT is heated to 700° C for a 3-minute clean-up period. The ¹⁴C compounds, if any, contained in the OVT column are purged with helium into the ¹⁴C detector and counted. After OVT clean-up, the helium purge is stopped and the vent valves are reopened to allow re-equilibration with Martian atmosphere.

Incubation is terminated at the end of the fifth day by turning the lamp assembly off, heating the test cell to 120° C, and venting the residual incubation gases.

During the fifth day, a radiation background measurement is carried out by the ¹⁴C detector assembly. The OVT is then heated to 700° C in the Martian atmosphere to saturate the OVT with ¹²CO sub 2 before exposure to ¹⁴CO sub 2 from the pyrolysis, and is then allowed to cool to 120° C to prepare the pyrolysis system for its sequence.

The pyrolysis sequence is initiated by employing the vertical actuator assembly to remove the test cell from contact with the incubation head end. The test cell is then indexed 60 degrees to the pyrolysis head end assembly. Depressurization of the vertical actuator permits the actuator return spring to seal the test cell to the pyrolysis head end. A helium purge is then made of the OVT and detector using the low-pressure helium gas supply to remove entrapped gases. The head end and test cell-to-OVT plumbing is then heated to 200° C while maintaining the OVT at 120°C, completing the preparation of for pyrolysis.

Pyrolysis is initiated by heating the test cell to 625° C. The test cell is then purged with low-pressure helium to force the mixture of helium and volatile pyrolysis products from the test cell to the OVT. The light gases of helium and labeled gas that did not combine organically pass through the OVT while the

heavy organic products are trapped in the OVT. The gases that pass through the OVT are trapped in a 6 cc holding chamber and a known sample is backfilled into and counted by the ^{14}C detector assembly. The remainder of the gases in the holding chamber are vented.

This level of ^{14}C is called the first peak or "non-biogenic peak," because it is a measurement of the residual, unincorporated ^{14}C released from the surface sample during heating. The head end and OVT heaters are then turned off, and the OVT and detector purged clean with helium which exits from the detector assembly vent.

The test cell is next rotated 60 degrees and an empty dump cell is placed at the head end position to provide a clean cell for the entire pyrolysis system while the detector is heated to 110°C for 2 hours while being purged with helium to remove residual gases. After the detector has cooled down, it is pressurized with helium and another radiation background count is made to determine if the count within the detector assembly has returned to the original background level. The OVT is then heated to 120°C for 2 hours, and purged with helium to remove residual ^{14}C gases that are in the OVT. A background count is then carried out at Martian pressure at the end of this heating cycle to determine the state of the OVT. Martian pressure is subsequently established in the detector and the unit is ready for removal of the trapped biogenic material from the OVT, which will provide the measurements for determining if Martian surface sample organisms metabolized the labeled CO_2 either photosynthetically or chemotrophically.

To remove this organic material, the OVT is heated to 120°C and purged with helium for a few minutes to remove the last residual gaseous ^{14}C material from the OVT. This is followed by a heating of the OVT to 650°C to vaporize and oxidize the trapped materials and to release them mainly as $^{14}\text{CO}_2$. The released gases are flushed into the ^{14}C detector assembly and the ^{14}C content of these gases is determined. This biogenic or "second peak" beta particle count determines the ^{14}C absorbed by the Martian organisms. The head end assembly, OVT, and detector assembly are then purged and the background count established.

Two OVT clean-up cycles are then performed by heating the OVT to 700°C while purging with helium. A sample is collected in the detector in both cases and the background count is obtained after each heating cycle.

To verify that the above findings were valid, the above procedure is repeated in a control sequence using a sterile surface sample.

Upon completion of each experiment sequence the OVT is opened to Martian atmosphere exposure during power off between sequences.

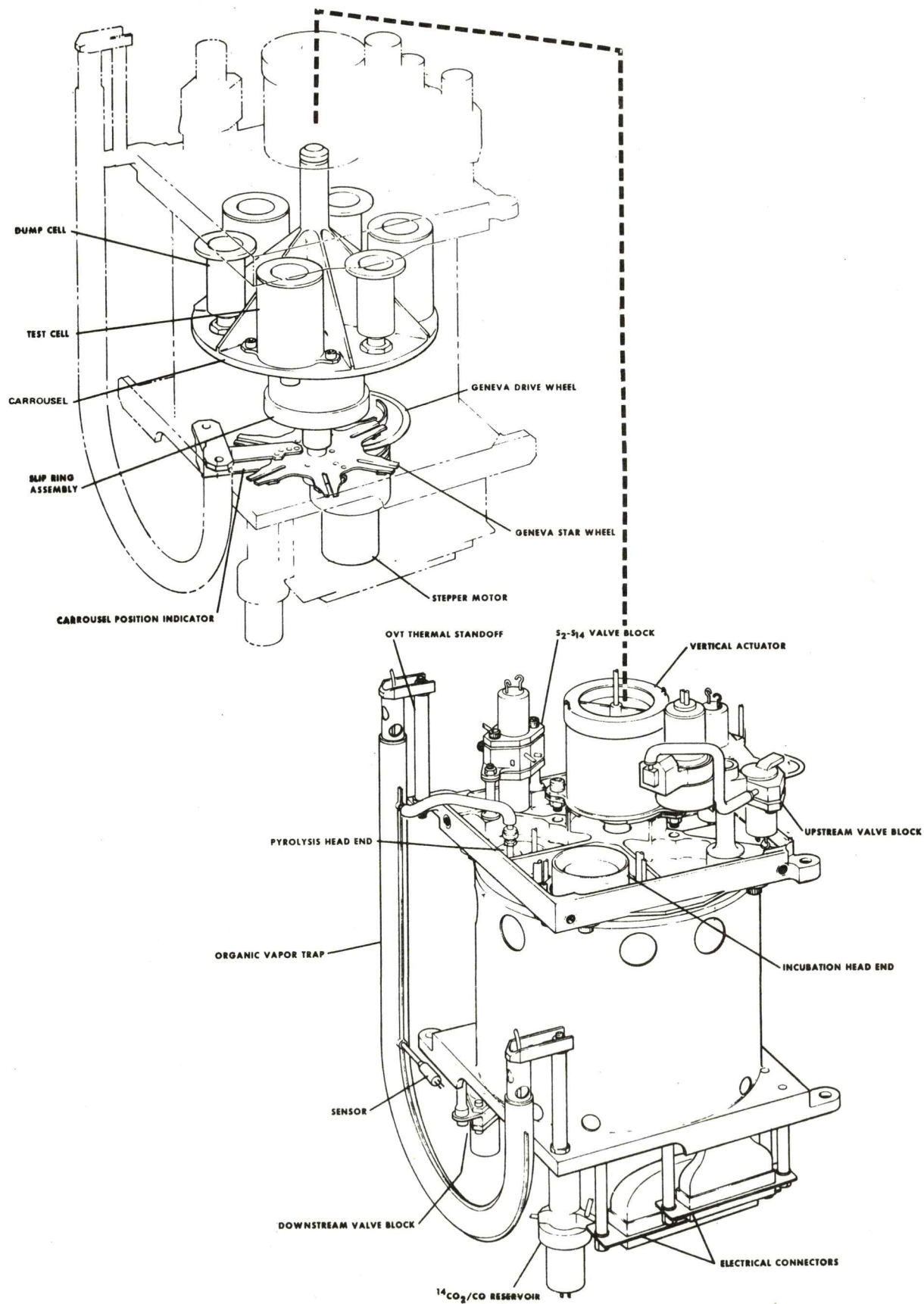


Figure 4.8.2.1-6 - PR Module

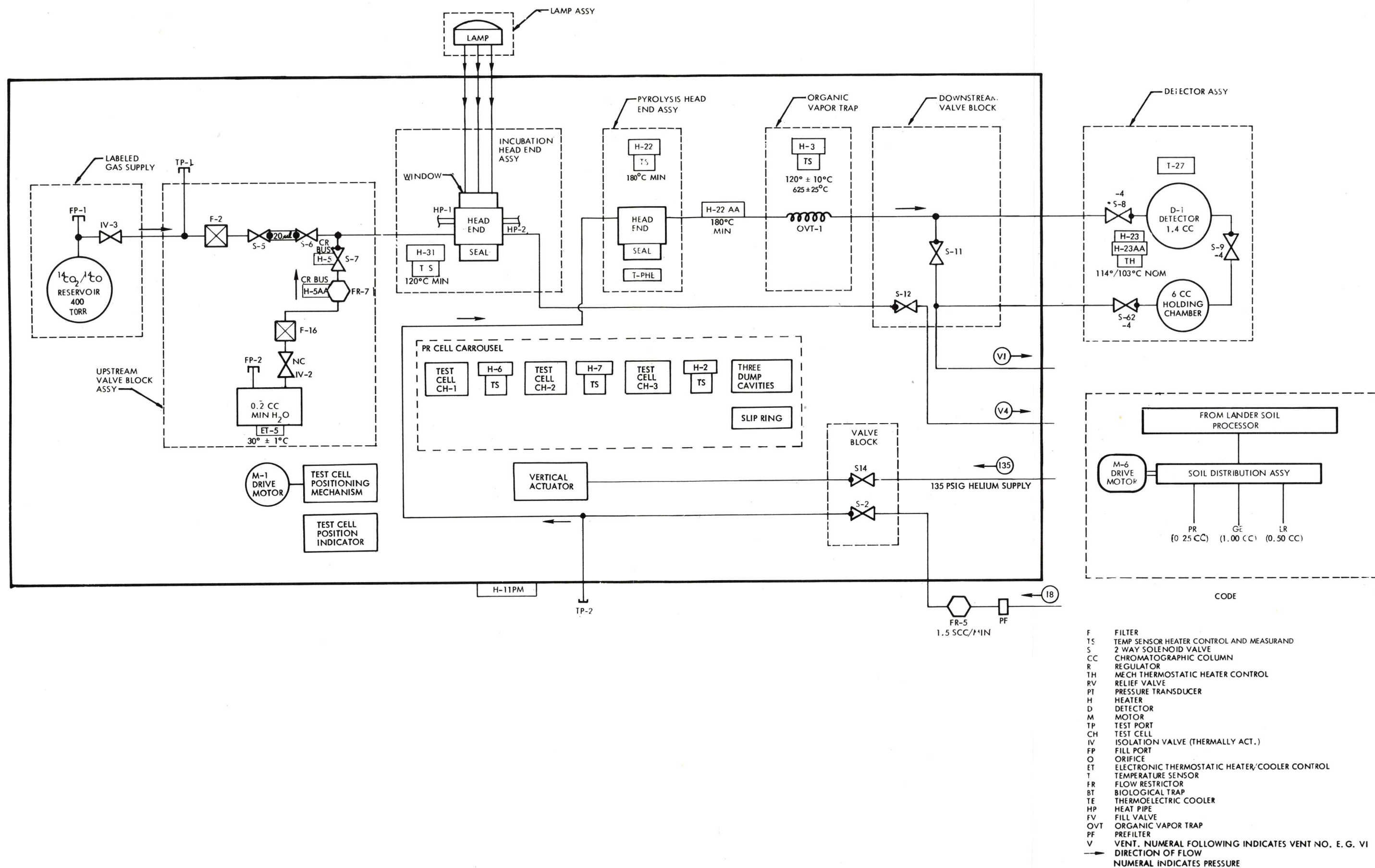


Figure 4.8.2.1-7 - PYROLYTIC RELEASE
EXPERIMENT MODULE
FLOW DIAGRAM

d. Labeled Release

The general functioning of the LR is shown in Figure 4.8.2.1-8.

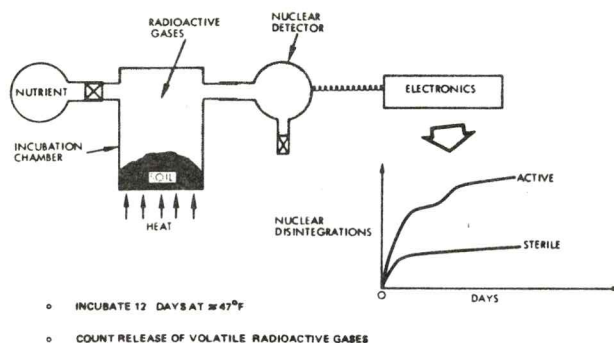


Figure 4.8.2.1-8 Labeled Release Experiment

The specific functions will be described while referring to the mechanical arrangement of the module, Figure 4.8.2.1-9, and the flow diagram, Figure 4.8.2.1-10.

The LR module consists primarily of four test cells for receiving surface samples; a head end assembly for maintaining the environment for incubation of organisms in the surface sample and injecting the nutrient into the test cell; a detector for measuring the results of incubation, and a supply of labeled nutrient for injection into the surface sample.

Four test cells provide a means of performing multiple experiments; three for active surface samples, and one for a control analysis of a sterilized surface sample to verify that activity took place or for a fourth active sample.

The test cells are mounted on a carrousel which can be indexed CW every 60 degrees by a mechanism consisting of a stepping motor and a geneva star wheel. A cell can be positioned by the carrousel under the head end assembly, under the surface sample loader, or in the open.

During the initialization sequence on Post-Landed Sol 2, the nutrient storage ampoule is broken using high-pressure helium. Low-pressure helium is then used to de-gas the nutrient, driving off radioactive gases. The helium and entrained gases flow through the CSH sump and into the V-2 vent to the Martian environment.

After 5 hours of de-gassing, the low pressure helium flow is terminated.

The test sequence is initiated by loading a 0.5 cc soil sample into the test cell that is positioned under the surface sample loader. The vertical actuator is pressurized to lower the test cell. The test cell is then rotated 180 degrees to the head end assembly for incubation. The vertical actuator is depressurized, and the return spring raises the test cell and seals it to the head end.

The ^{14}C detector and test cell are purged with low pressure helium to remove any residual gases. The purge stream is discharged through the V-2 vent to the Martian environment, having passed through the sump and the charcoal trap (OVT-2) of the CSM. When the purge is over, the test cell is lowered for 18 minutes so that a Martian atmosphere is re-established for subsequent incubation. A 24-hour detector background count is made, and the experiment is ready for the nutrient injection and incubation.

During the injection sequence, the nutrient reservoir is repressurized with high pressure helium, the injection cavity is twice filled with nutrient and discharged into the V-2 vent, and the test cell is pressurized with low pressure helium to prevent surface sample splattering upon injection. A volume of about 0.125 cc of nutrient is then injected onto the surface sample. For the next 10 days, the ^{14}C detector monitors the test cell head space for evolved radioactivity. An optional second injection is scheduled to occur after 8 Sols incubation.

At the end of incubation, the detector and test cell are purged with helium and the test cell is heated briefly to remove radioactive gases and to dry the surface sample to prevent surface sample eruption when the cell is lowered. The carrousel is lowered, and a clean test cell is rotated and sealed to the head end. A detector background count is taken to determine if any change in background has occurred.

A cleanup cycle terminates the experiment. During the cleanup, the head end assembly and test cell are heated to 160°C for 2 hours; the detector is heated to 100°C for 3 hours; and the detector, head end, and test cell are purged with helium for 3.5 hours. The test cell is vented. The nutrient injection cavity is then twice filled and discharged into the V-2 vent to remove any heat decomposed nutrient.

If evidence of metabolic activity is obtained, another experiment may be performed on a heat sterilized surface sample to verify that the released radioactivity was the result of metabolic activity and not caused by some abiogenic process. To perform this verification, the control analysis experiment command table is uplinked to the VL.

In the control analysis, a surface sample is taken and the test cell is rotated and sealed to the head end. The detector and test cell are purged with helium to remove any residual gases. After the purge, the carrousel is lowered for 18 minutes to re-establish Martian atmosphere for incubation. A 25-hour detector background is taken. The surface sample is then heat sterilized by turning on the head end (160° C), detector (100° C), and valve block heaters (125° C), for 3.8 hours. The nutrient injection cavity is then twice discharged into the V-2 vent to remove any heat decomposed nutrient. The test cell is vented to discharge any gases from the surface sample that were not reabsorbed upon cooling. The experiment is now ready for nutrient injection and incubation.

During the injection sequence, the nutrient reservoir is repressurized with high pressure helium, the nutrient injection cavity is twice filled with nutrient and discharged into the V-2 vent, and the test cell is pressurized with low pressurized helium to prevent the surface sample from splattering upon injection. A volume of about 0.125 cc of nutrient is then injected onto the surface sample. For the next 10 Sols, the ¹⁴C detector monitors the test cell head space for evolved radioactivity. An optional injection is scheduled to occur after 8 Sols incubation.

The control analysis is terminated in the same way as an active analysis: purge and dry the surface sample, rotate to the head end a fresh test cell, detector background, and heat, cleanup, and purge.

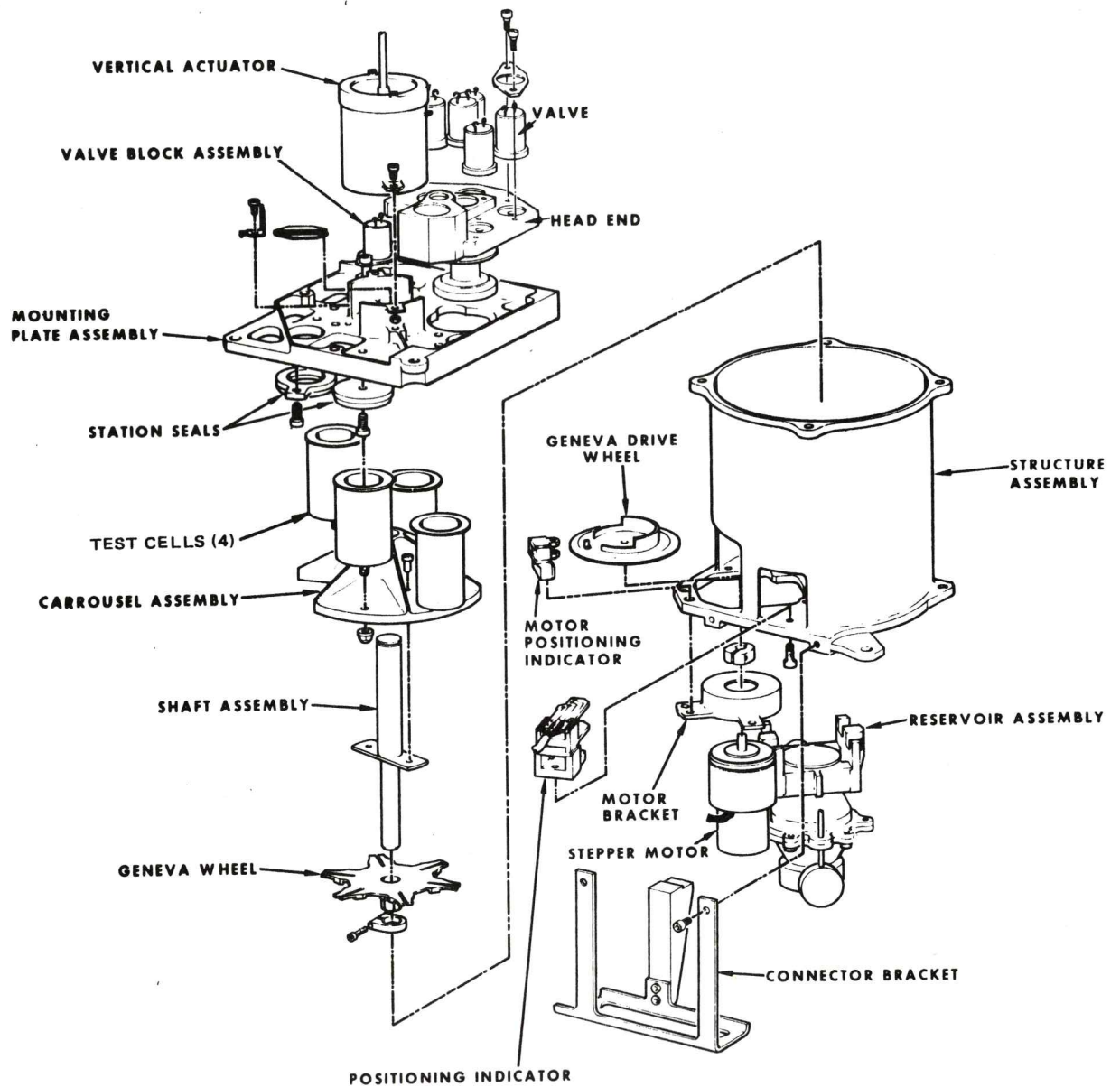


Figure 4.8.2.1-9 - LR MODULE ASSEMBLY

e. Gas Exchange

The general functioning of the GEX is shown in Figure 4.8.2.1-11:

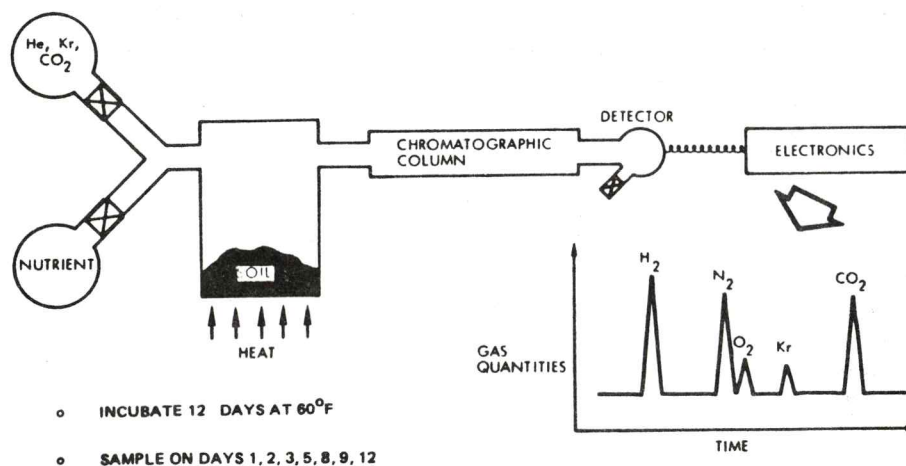


Figure 4.8.2.1-11 Gas Exchange Experiment

The specific functions will be described while referring to the mechanical arrangement of the module, Figure 4.8.2.1-12, and the flow diagram, Figure 4.8.2.1-13.

The GEX module consists primarily of two cells (one for receiving surface samples for analysis and one for receiving surplus surface samples), a head end assembly for incubation, a nutrient reservoir containing the liquid nutrient supply, another reservoir for the incubation and internal standard gas, a gas sample valve assembly for metering and injecting a sample of head-space gas into the chromatograph column, the duplex chromatographic column assembly consisting of matched active and reference columns, and a duplex thermal conductivity detector for measuring the separate gas components as they emerge from the active and reference columns. Also part of the GEX system is a reservoir of He/CO sub 2/O sub 2 gas which is used to precondition the active column prior to the experimental sequences. The active Gas Chromatograph (GC) column is pre-conditioned by an exposure to a helium-carbon dioxide-oxygen mixture so that quantities of the experimental sample components will not be removed from the first by absorption within the column. A chromatogram of trapped preconditioning gas is taken to diagnose the absorptive state of the column, and the column is then purged for two hours. High pressure helium is admitted to the nutrient reservoir pistons during the initialization sequence to break the nutrient ampoule and pressurize the reservoir.

The first operational sequence begins by receipt of a surface sample from the SDA. After receipt of the surface sample in the test cell, the test cell is placed under the head end assembly by actuating the vertical actuator via helium gas from solenoid valve S-30 and indexing the test cell to the head end using the stepper motor and geneva drive.

The vertical actuator is then deactivated and the actuator return spring seals the test cell to the head end assembly. Subsequently a helium purge followed by an injection of He/Kr/CO sub 2 gas is initiated. An amount of nutrient can be injected under the surface sample through a restrictor capillary tube from the liquid nutrient reservoir in accordance with the sequence which is to be run. The experiment is designed to first conduct either Sequence 1A or 1B followed by Sequences 2 and 3, the sequences differing in the timing and amount of nutrient used as follows:

<u>Number</u>	<u>Sequence</u>
1A	Humidify soil only - 0.5 CC injection
1B	Humidify initially - add 2.0 CC on day 8
2	Inject 2.5 CC initially
3	Inject 2.5 CC initially

Prior to each chromatographic measurement the gas chromatogram detector and column heaters are turned on to stabilize the gas chromatogram temperatures. Helium flow is started and the sample loop is purged twice. After purging the sample tube and chromatographic column, gas in the test cell head space is sampled. Chromatograms are obtained at periodic intervals of 1, 1, 2, and 4 days plus the last day of the analysis cycle and prior to draining and purging the test cell in the next cycle.

At test cell pressure, 100 microliters of gas is removed by the gas sample tube and is placed in a stream of pure helium flowing into the active chromatographic column. Flow through the active column and the reference column is controlled by restrictors such that the flow rates and pressure drops across the columns are compatible with column performance requirements.

Each gas of interest is detected and its concentration determined by the Thermal Conductivity Detector (TCD). Each gas is eluted from the chromatographic column and is identified by its predetermined retention time. The system has a dynamic range of greater than 1000, and the maximum precision is better than 5 percent. Because the Kr peak has an predictable amplitude because the inert gas does not diminish with biological

activity, its identification in the data returned serves to check proper operation of the experiment. In addition, neon is added to the nutrient as a tracer and its detection in the chromatogram verifies nutrient injection. The liquid nutrient is left in the test cell and incubation temperature are maintained as usual between analysis cycles.

At the beginning of subsequent cycles a gas analysis is made, the test cell is drained, and fresh medium and gas are injected. Surface material may be added to material already present on command if a termination has been carried out. If a positive result is obtained after the first two analysis cycles, the surface sample may be heat treated and tested as a control. The control analysis is initiated by VL command. The control analysis has the same sequence as described for an active analysis cycle except that the surface sample is heated at 160°C for 3 hours prior to injection of incubation gas.

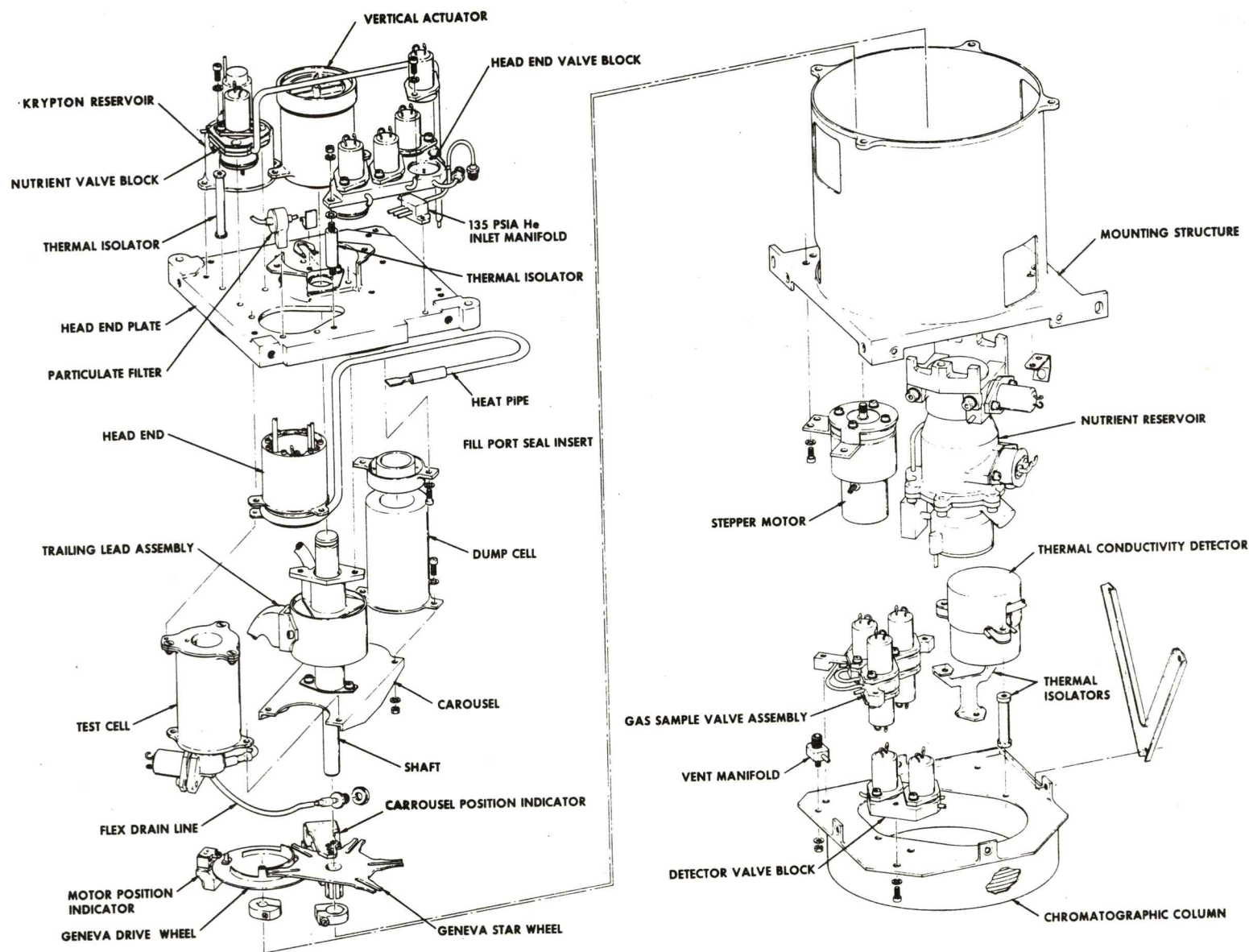


Figure 4.8.2.1-12 Gas Exchange Module

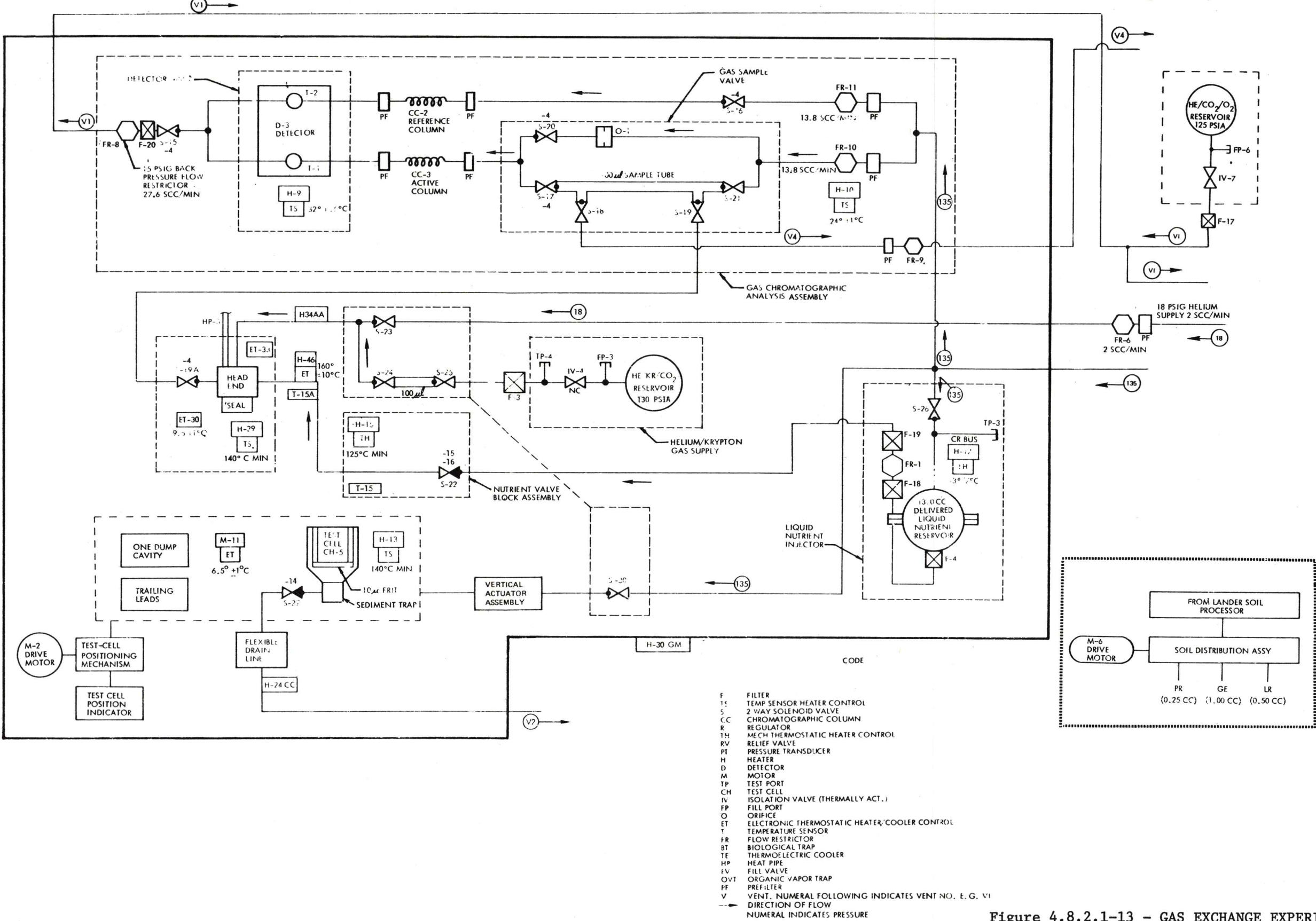


Figure 4.8.2.1-13 - GAS EXCHANGE EXPERIMENT MODULE FLOW CHART

4.8.2.1.3 OPERATIONAL SEQUENCES

Biology sequences differ from other science instrument sequences because each sequence is continuous over twelve Sols and must be developed using computer software. The uplink commands are produced using the same software. The process of sequence development is described briefly herein and in detail in the Biology User's Guide, SD-3700012. The essential steps are as follows:

- a. Selection of desired "mini sequence elements" from the block dictionary;
- b. Use BIOL-C program to shift blocks to satisfy internal instrument constraints;
- c. Manual time manipulation of preliminary sequence to satisfy thermal and VL constraints;
- d. Use BIOL-C program to produce final sequence as a file for direct use of LSEQ and LPWR.

1) Block Dictionary

The Biology instrument functions that must not be interrupted have been defined in a Block Dictionary contained as a file in BIOL-C. Each block has a specific function which was verified during pre-launch testing. A summary of the block contents appears in Table 4.8.2.1-1. A detailed explanation is available in the TRW document "VLBI Mission Sequencing Constraints Criteria and Block Definitions", NMC-842C, dated 10 July 1975.

2) Constraints

A primary use of the BIOL-C computer program is to time shift the designated blocks to satisfy the automatic constraints incorporated in the logic. These constraints are identified in Section 4.8.2.1.7. The resulting output is a detailed instrument sequence of events which is reviewed to identify VL and thermal constraints (also identified in Section 4.8.2.1.7). The modified command timing required for a constraint free sequence is run through a BIOL-C option that produces the required uplink data for LSEQ and LCON.

3) BIOL-C Output

The principle output products are described in SD-3700012 and consist of listings and files. These are summarized below.

<u>Product</u>	<u>Description</u>	<u>Use</u>
List	Time tagged internal instrument sequence of events (valves, heaters, etc.)	Manual constraint checking
File	Time tagged predicted measurement sequence	Comparison by BIOL-A to received data
File	Predicted helium consumption	Comparison to Format 4 data
List	Internal Valve position Status	Contingency planning
List	Lamp and motor position	Contingency planning
List	Heater settings	Contingency planning
File	Significant events at MMT	LSEQ sequence of events
File	Frame length and MMT Occurrence	Data management
File	Octal commands at MMT occurrence	LSEQ and LCOM/LTRAN uplink preparation

4) Typical Sequences

Shown in Figures 4.8.2.1-14 through 4.8.2.1-19 are blocks for each experiment for both an active and control sequence. When the designated blocks from all three experiments are combined using BIOL-C into an overall sequence, the result is overlapping and time-staggered blocks. A method for displaying the significant events in a combined sequence is shown in Figure 4.8.2.1-20 which represents a test sequence performed during instrument qualification.

TABLE 4.8.2.1-1
BLOCK DICTIONARY SUMMARY

<u>EXPERIMENT</u>	<u>TITLE</u>	<u>USE</u>	<u>COMMANDS</u>	<u>ELAPSED TIME (MIN)</u>
LR	TC to HEA	Move test cell to head end assembly after receiving soil	2	12
LR	Open BKGD Count	Second block in all active sequences	5	1059
LR	24-Hr BKGD Count	Second block in control sequence	5	1551
LR	Sterilization	Third block in control sequence	5	227
LR	PEEQUILB + BKGD	Fourth block in control sequence	6	6
LR	Double Bleed	Fifth block in control	14	25
LR	1st Bleed + Inj.	First injection in first active sequence	33	164
LR	Normal Bleed +Inj.	Third block in active; sixth block in control	31	162
LR	COM Bleed + Inj.	Fourth block in active; seventh block in control	21	35
LR	Dry Cycle+ DET BKGD-ACT	Fifth block in active	9	824
LR	Dry Cycle + DET BKGD-CON	Eighth block in control	12	825
LR	Termination	Last block in all sequences	25	282
GEX	TC to HEA	Move test cell to head end assembly after receiving soil	1	26
GEX	TC to Load Port	Move test cell from head end to receive soil	1	26
GEX	Normal Injection	Inject 2.5cc nutrient	4	433
GEX	Purge + Inject	First mission injection	4	103
GEX	2cc Inject	2cc nutrient inject	5	398
GEX	Post Inj.Analysis	First analysis after 2 or 2.5cc injection	5	91
GEX	2nd Post Inj.Anal.	Second analysis after injection	5	91
GEX	Analysis	Alternate ROM sequence	5	91
GEX	Recycle Analysis	Analysis before draining spent nutrient	5	91
GEX	Column Purge	Contingency sequence	2	159

TABLE 4.8.2.1-1 (Cont)
BLOCK DICTIONARY SUMMARY

<u>EXPERIMENT</u>	<u>TITLE</u>	<u>USE</u>	<u>COMMANDS</u>	<u>ELAPSED TIME (MIN)</u>
GEX	Sterilization	Control heating of soil	3	211
GEX	60-Deg.Rotation	Contingency sequence	1	24
GEX	Termination	Drain spent nutrient	3	176
PR	TC to INC HEA	Move test cell to incubation station after receiving soil	3	28
PR	Sterilization	Control heating of soil	3	269
PR	INC+PYRO-ACT	Incubates through first peak count	29	8231
PR	INC+PYRO-CON	Incubates through first peak count	37	8232
PR	Purge & BKGD	First block following pyrolysis	9	2078
PR	Elution	Second peak count	2	1532
PR	BKGD Count	Follows elution	2	772
PR	1st OVT Cleanup	Second block after elution	2	816
PR	TC Cleanup	Test cell cleanup	2	851
PR	2nd OVT Cleanup	Follows 1st as close as possible	2	777
PR	OVT Conditioning	Last block all sequences	5	309
PR	Water Res Degas	During initialization sequences	11	33

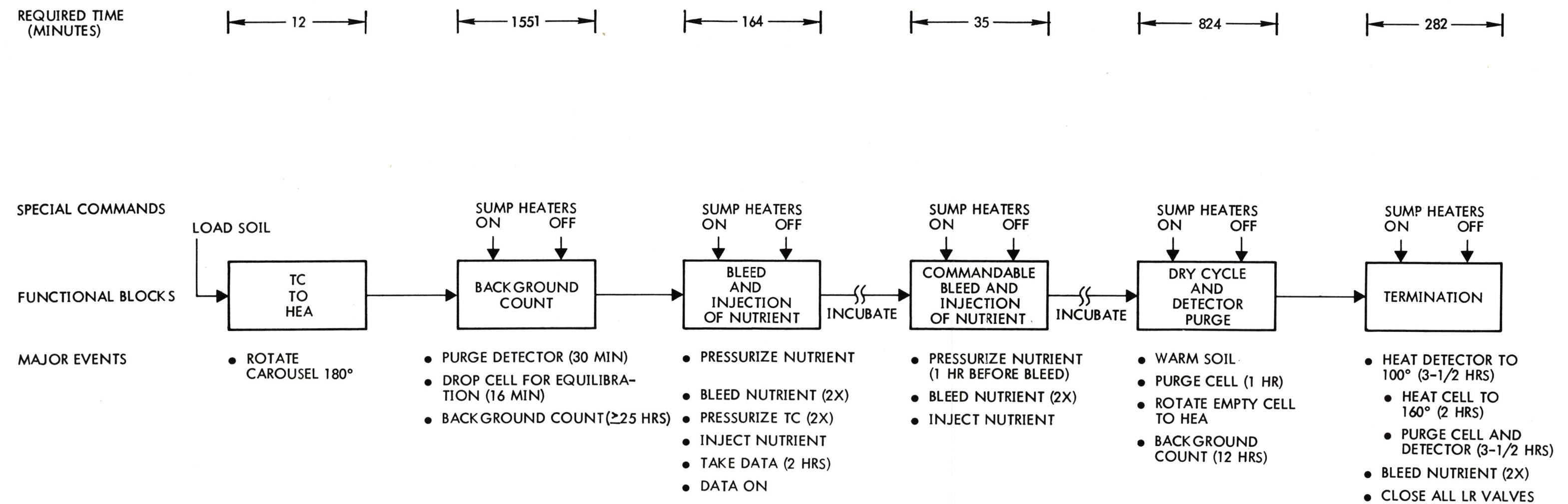


Figure 4.8.2.1-14 - FUNCTIONAL BLOCK DIAGRAM
LR SEQUENCE 1: FIRST ACTIVE

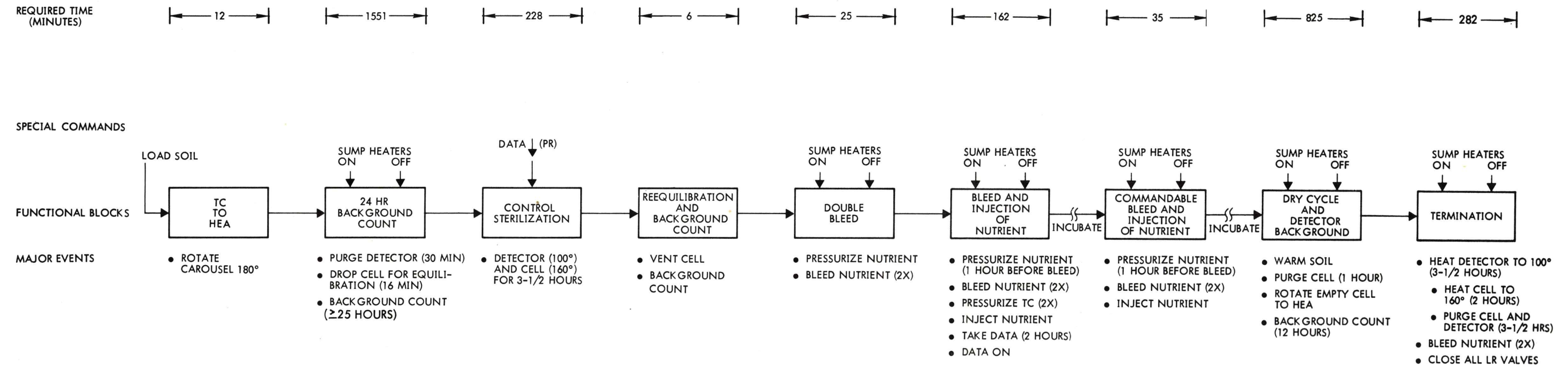


Figure 4.8.2.1-15 - FUNCTIONAL BLOCK DIAGRAM
LR SEQUENCE II: CONTROL STERILIZATION

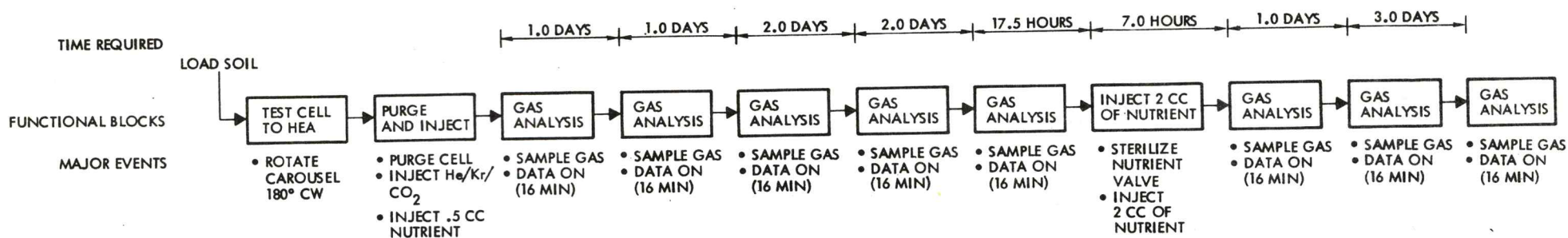
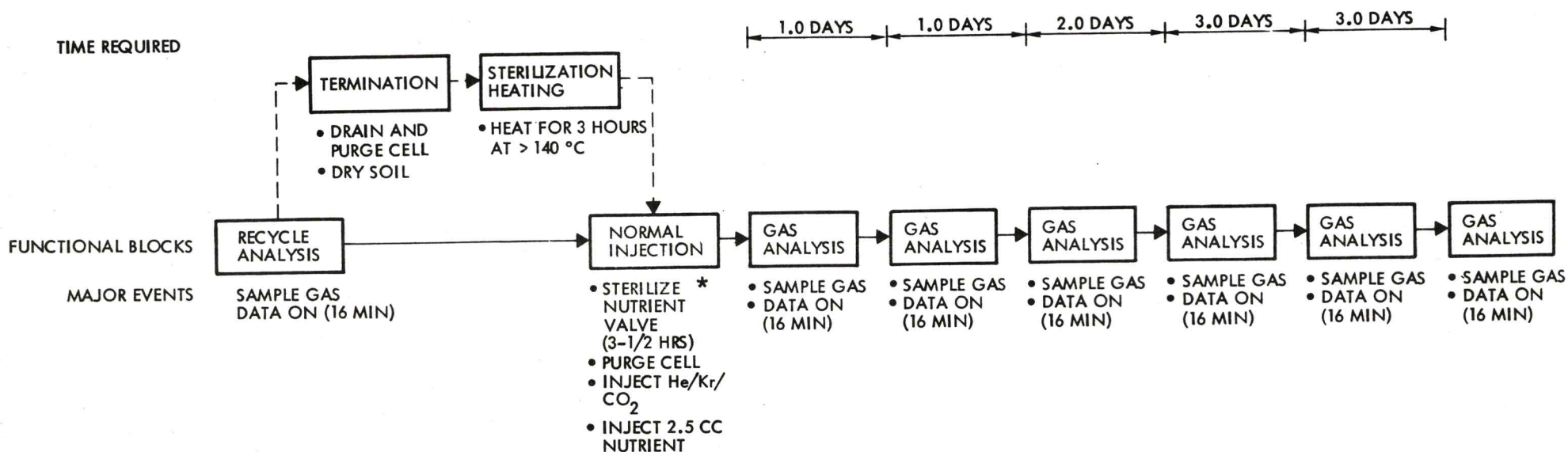
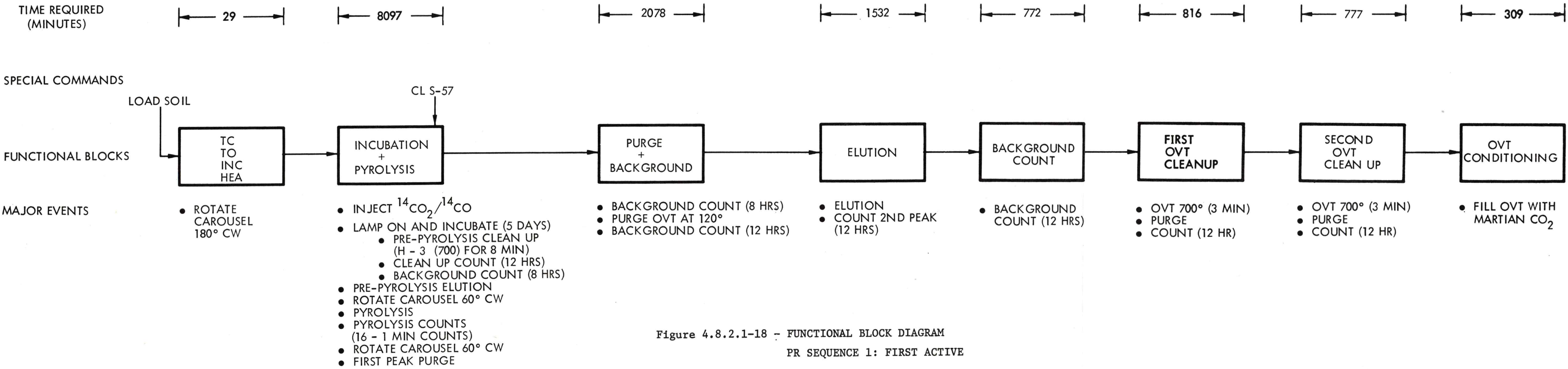


Figure 4.8.2.1-16 - FUNCTIONAL BLOCK DIAGRAM GEX SEQUENCE 1:
FIRST ACTIVE



*Included as part of the sterilization heating in a control cycle.

Figure 4.8.2.1-17 - FUNCTIONAL BLOCK DIAGRAM GEX SEQUENCES
RECYCLE AND CONTROL



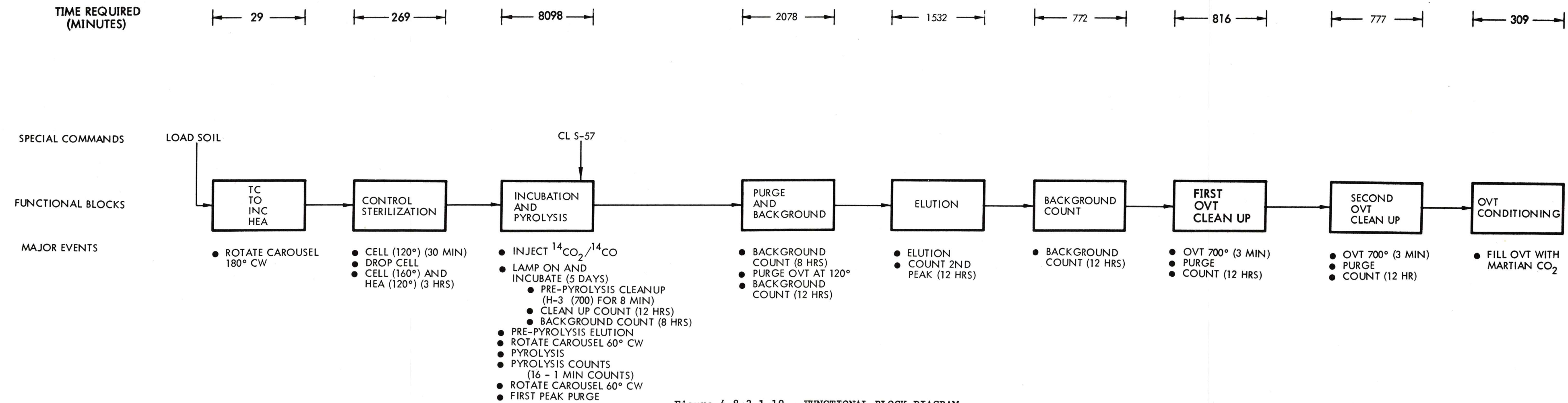


Figure 4.8.2.1-19 - FUNCTIONAL BLOCK DIAGRAM

PR SEQUENCE II; CONTROL STERILIZATION

BIOLOGY SEQUENCE NO. 5
INSTRUMENT 103

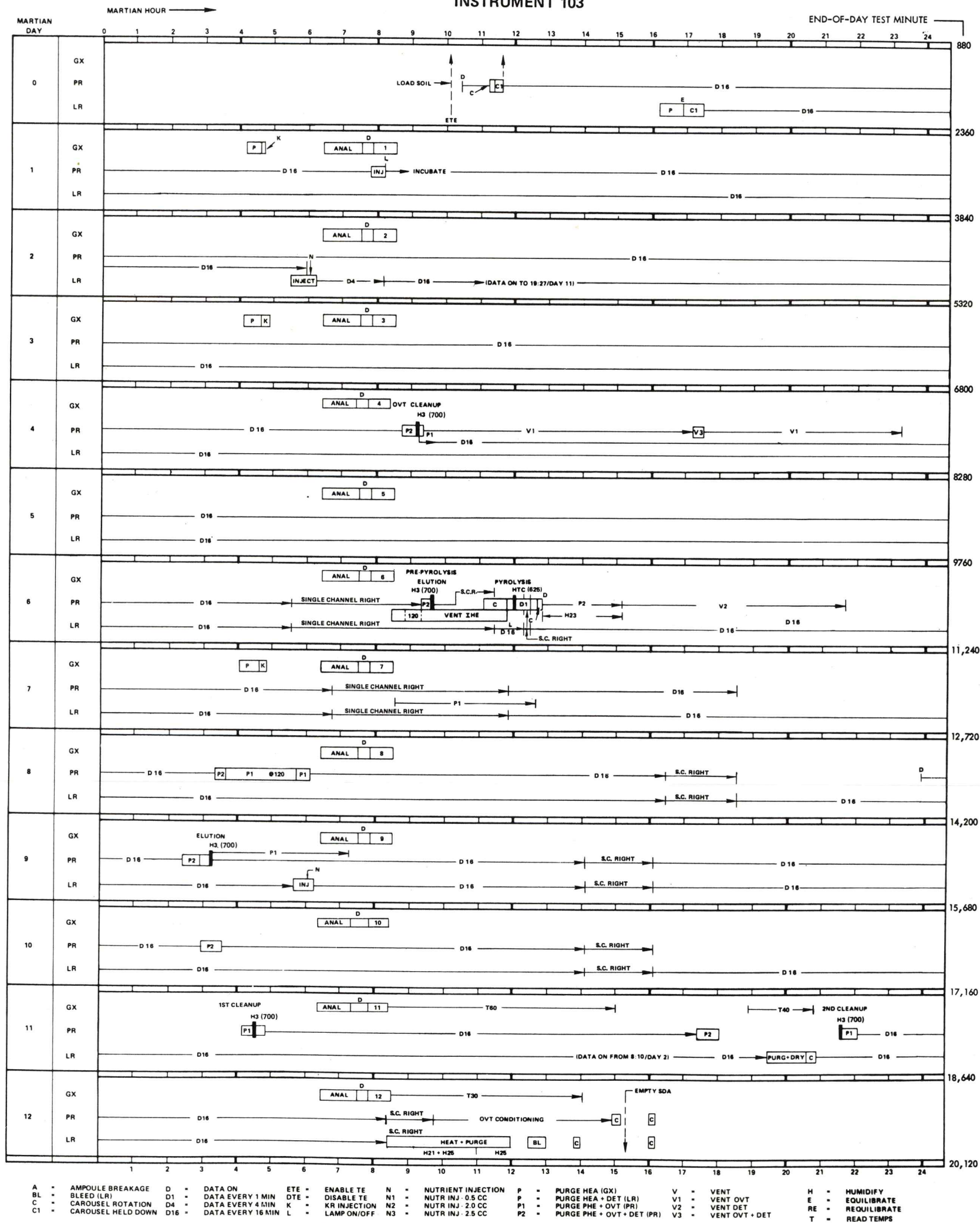


Figure 4.8.2.1-20 - S/N 103 BIOLOGY TEST - BIOLOGY SEQUENCE NO. 5,

4.8.2.1.4 INTERFACES

The principle Bio interfaces are: Power, Command Control, Data, Surface Sampler, Atmosphere Venting, Gas and Vapor Vents, and Thermal. The details of all electrical interfaces are depicted in the Biology Functional Schematic at the end of this section. The data interface is described in 4.8.2.1.6. Figures 4.8.2.1-21 through 4.8.2.1-23 inclusive depict some features of interfaces which are described below.

a. Power

- 1) Power consumption is shown in Section 4.8.2.1.5.
- 2) Biology Operate Bus from PCDA:
 - a) Supplies all sequenced event power;
 - b) Must be turned on after Biology Thermal Bus turned on, and off before Bio Thermal Bus off;
 - c) Turned off during Emergency Mode.
- 3) Biology Thermal Bus from PCDA:
 - a) Supplies thermo electric coolers, nutrient reservoirs, and module heaters;
 - b) Cycled on/off during Emergency Mode, 70% on duty cycle with off periods not to exceed 5 minutes to prevent freezing;
- 4) Biology Emergency Bus from PCDA:
 - a) Turns off thermo electric coolers;
 - b) Closes CSM valves S-50, S-51, and S-57 which stop flow of low and high pressure helium.

b. Command Control

- 1) Command structure and description shown in VLC Command List, HMC Drawing 83703021228, Sheet 139;
- 2) Command timing window is from 0.5 to 30.0 seconds after the multiple minute from the HG001 command throughout any continuous sequence.

c. Data

Data is described in Section 4.8.2.1.7.

d. Surface Sampler

- 1) Provides atmospheric vent path described later;
- 2) SSPDA and Bio Table B sequence require time synchronization to start the Surface Sampler PDA shuttle start moving to "Deliver" coincident with Biology SDA start vibrate (Command MG-013).

e. Atmosphere Venting:

- 1) Venting prior to Post-Landed mission is through Surface Sampler PDA bypass tube and through activated charcoal filter in the lid clamped on the Surface Sampler PDA;
- 2) Post-Landed mission venting of instrument interior is by diffusion through the Surface Sampler PDA bypass tube.

f. Gas and Vapor Vents:

- 1) Exhausted dry purge gases exit through three 1/16 inch ID plastic lines extending through the VL bottom plate.
- 2) Exhausted water vapor is through a six foot 3/8 inch ID plastic line laid at the bottom of the VL side wall and exiting near leg 1.

g. Thermal:

- 1) Interior instrument temperatures are largely controlled by the VL equipment mounting plate;
- 2) Test cell cooling is through ammonia heat pipes into multistage thermo electric heat pumps attached directly to the VL equipment mounting plate;

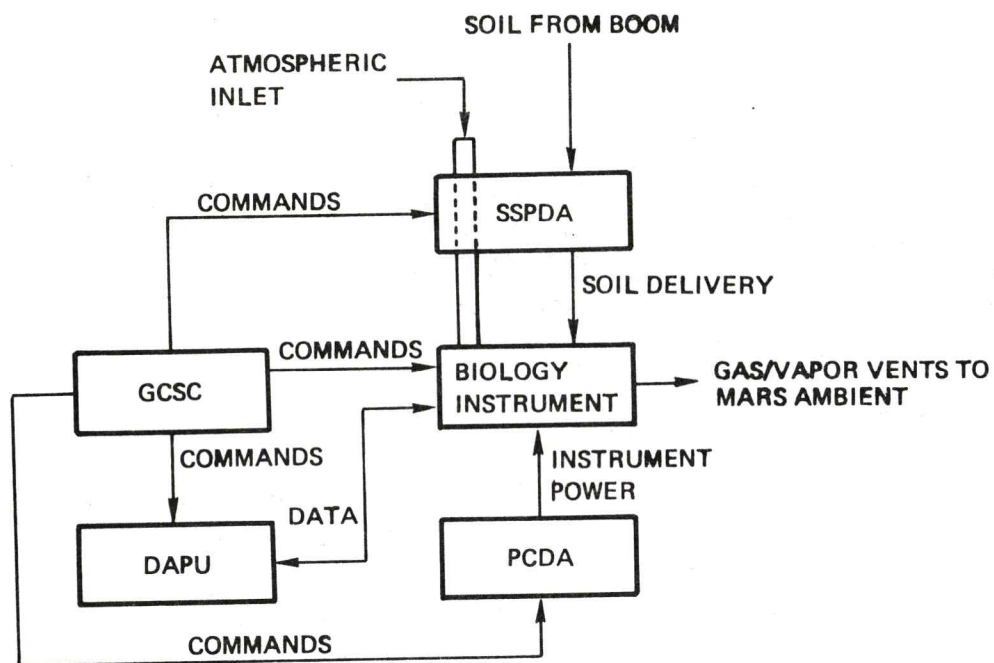


Figure 4.8.2.1-21 - BIO INTERFACES

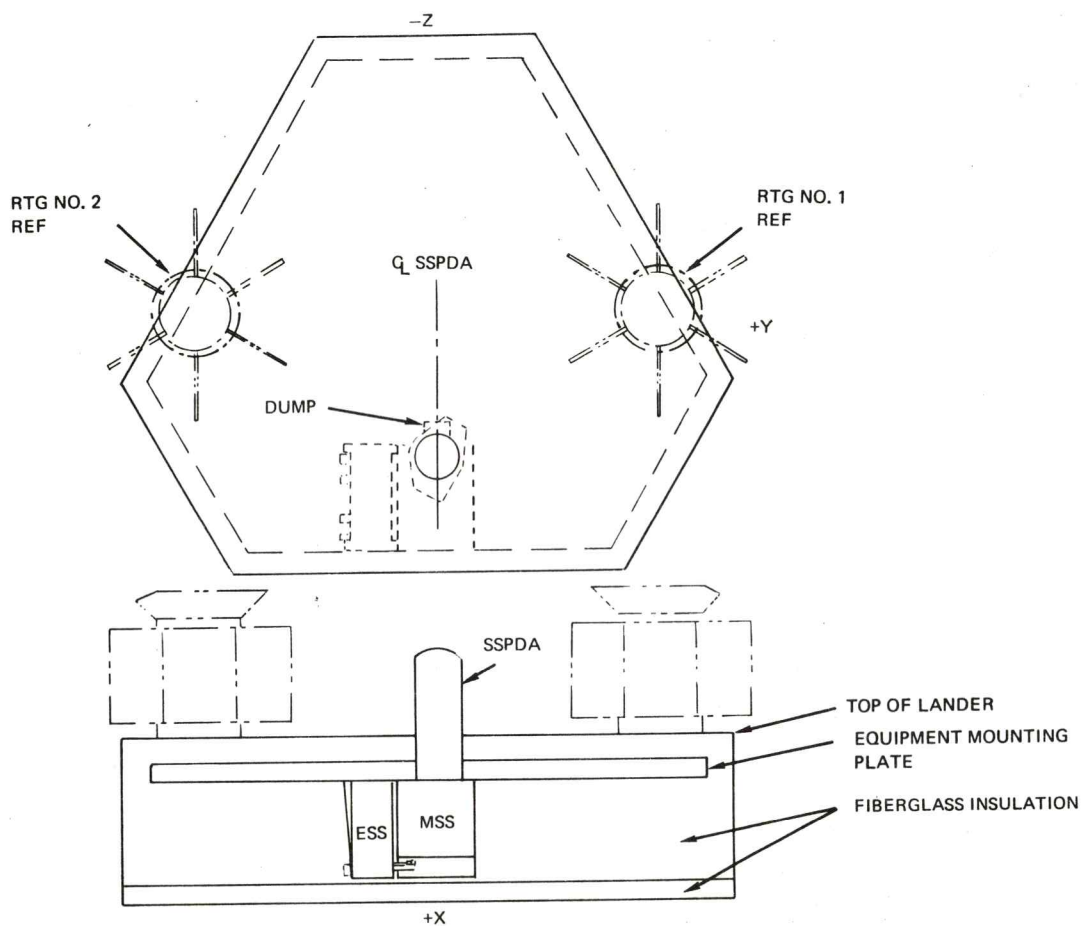


Figure 4.8.2.1-22 - PHYSICAL LAYOUT

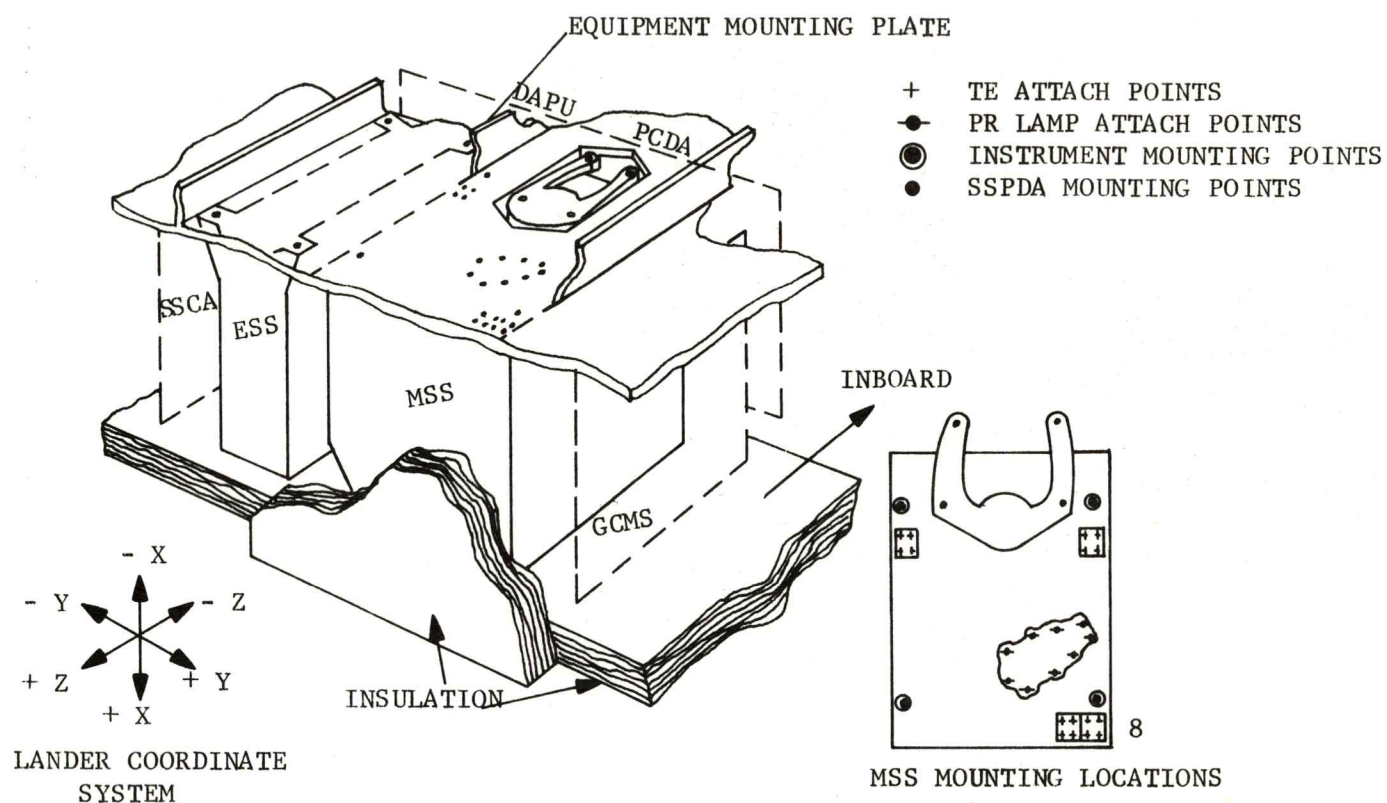


FIGURE 4.8.2.1-23 BIO THERMAL INTERFACE

4.8.2.1.5 POWER REQUIREMENTS

Instrument power is dissipated in either the electrical subsystem or mechanical subsystem and is supplied from both the Biology Operate Bus and Biology Thermal Bus. Biology operate power is used for all sequenced events while Biology Thermal power is used for temperature control required while the instrument is inactive during Cruise and between Post-Landed mission experiment analysis cycles. Total power consumption is expressed by the equation,

$$P \text{ sub } T = P \text{ sub } E + P \text{ sub } M$$

$$= [A(P \text{ sub } STBY + P \text{ sub } REG) + P \text{ sub } RAW] + P \text{ sub } M$$

Where:

$P \text{ sub } T$ = total power
 $P \text{ sub } E$ = ESS power
 $P \text{ sub } M$ = HSS power
 A = power regulation losses
 $P \text{ sub } STBY$ = standby (idle) power
 $P \text{ sub } REG$ = regulated bus power when event sequenced on
 $P \text{ sub } RAW$ = unregulated bus power when event sequenced on

A listing of all power events at 31 VDC is shown in Table 4.8.2.1-2. Use of the table requires a detailed knowledge of the instrument sequence and a time correlated temperature of the equipment mounting plate. This is due to extensive thermostatic control which produces the instantaneous power equation,

$$P \text{ sub } M = P \text{ sub } O + ST \text{ sub } P$$

Where:

$P \text{ sub } O$ = power at 0°F
 S = power demand change per degree F change
 $T \text{ sub } P$ = Lander equipment plate temperature (B4004)
 in degrees F above 0°F

Additionally, sequenced power in some events is approximated by time intervals which represent delay times in reaching the controlled temperature set point. Precise power prediction requires using the warmup intervals because of some significant delay times on higher power heaters.

Power estimates can be made if the VL equipment mounting plate temperature variation is known. During prelaunch instrument testing power data was collected using the four diurnal temperature cycles defined below.

Cycle Name	HOT	WARM	COOL	COLD
Minimum Temp	45°F	32°F	5°F	-15°F
Median temp	70°F	57°F	15°F	- 5°F
Maximum temp	96°F	83°F	25°F	5°F

Table 4.8.2.1-3 lists the major additive power events as a function of the temperature cycle at 31 VDC. Each power value was derived by integrating instantaneous power over the entire diurnal cycle and then averaging over one Sol of 24.6 hours.

Table 4.8.2.1-4 lists the total daily average power for reasonably predictable sequences. The Table B all active sequence does include sequenced power for the xenon lamp, one LR termination, and one GEX valve block sterilization but does not include any control sterilizations.

Power Event		ESS POWER, P _E						MSS POWER, P _M							
		ESS Slice	BIO OP BUS			BIO TH BUS		MSS Module	BIO OP BUS			BIO OP OR BIO TH BIO TH BUS			
			Stby	ON RegRaw		Stby	On		Set ③ Point, °C	P _O , W	S, W/°F	Internal, min WarmupAt Temp		P _O , W	S, W/°F
Power Regulation Losses		A1	44.6%	44.6%	0%										
Regulator Logic		A3	0.19												
Master Reset		A1	0.03												
A/D Converter		A2	0.16												
Temperature Monitors		A2	0.08												
GEX Detector (LLE)		A2	0.01	0.36											
TCPM Monitor		A2	0.10												
Xenon Lamp: Logic Drive		A2 A1	0.01		1.78		PR	N/A	6.50	0	All	All			
Sequencers		A2	0.75												
Solenoid Valve: Logic		A2	0.01												
Auto Control		A2	0.07												
Drive		A3	0.04 ④												
Command Processor		A2	0.08												
Master Clock		A2	0.33												
14C Data Processing		A2	0.23	0.11(PR)			LLE	N/A	0.8	0	All	All			
14C Detector (LR+PR)		N/A	0.80												
Buffer Memory		A2	0.64 ⑤ 0.90 ⑥ 1.09 ⑦												
Shutdown		A3	0.03												
TE Collers		A1				0.08	0.03*P _M	All	12°			All	All	-15.4 ⑨	+0.297
Motors: Driver Logic		A3	0.17	1.3 ④ 1.3 ④ 1.3 ④			Carousel Soil Distr SDA Vibr		2.00 ④ 4.00 ④ 8.00 ④	0 0 0	1 1 1	N/A N/A N/A			
Isolation Valve		A3	0.04	1.0 ④ 1.0 ④ 1.0 ④			2 + 3 4 + 7 5 + 8		19.00 ④ 19.00 ④ 19.00 ④	0 0 0	4 4 5	N/A N/A N/A			

Table 4.8.2.1-1 - BIO-POWER

Power Event	ESS POWER, P _E				MSS POWER, P _M									
	ESS Slice	BIO OP BUS			BIO TH BUS		BIO OP BUS			BIO OP OR BIO TH BIO TH BUS				
		Stby	ON		Stby	On	MSS Module	Set ③ Point, °C	P _o , W	S, W/°F	Interval, min		P _o , W	S, W/°F
			Reg	Raw							Warmup	At Temp		
HTC, PR Test Cell	A3	0.07	-0.03 ⑧	0.05*P _M		PR	HTC(90)	4.11	-0.222	1				
							HTC(120)	1.41	-0.0076		A11			
							(Incl H31)	4.90	-0.0205	1	A11			
							HTC(160)*	2.36	-0.0099	4	A11			
								15.90	-0.0530		A11			
								9.89	-0.0265	1	A11			
							HTC(625)	81.00	-0.0700	1	A11			
								19.00	-0.0164		A11			
							HTC(700)	87.00	-0.0651	1	A11			
								44.00	-0.0329		A11			
H-3, OVT	A3	0.07	-0.03 ⑧	0.05*P _M		PR	H3(120)	9.00	-0.0363	2				
								3.20	-0.0129		A11			
							H3(700)	90.00	-0.0673	2	A11			
								38.00	-0.0284		A11			
H-5, PR H ₂ O	A3				0.06	0.05*P _M	PR	30°			A11	A11	1.32	-0.0146
H-9, GEX Column	A3	0.07	-0.03 ⑧	0.05*P _M		GEX	H9(32)	12.00	-0.1339	3				
								2.50	-0.0279		A11			
H-10, GEX Detector	A3	0.07	-0.03 ⑧	0.05*P _M		GEX	H10(24)	4.00	-0.0532	4				
								1.00	-0.0133		A11			
H-11 + H-30, Module Heaters	A3				0.05	0.05*P _M	A11	10°			A11	A11	12.89	-0.2525
H-12 + H-20, Nutrient Reservoir	N/A				N/A	N/A	GEX + LR	10°			A11	A11	3.6	-0.0860
H-13, GEX Test Cell	A3	0.07	-0.03 ⑧	0.05*P _M		GEX	H13(140)	15.91	-0.0560	5				
								7.30	-0.0257		A11			
H-15 + H-46, GEX Nutr Block + Line	A3	N/A	0.05	0.05*P _M		GEX	H15(140)	22.11	-0.0732	5				
								10.41	-0.0344		A11			
H-21, LR Head End	A3	0.07	-0.03 ⑧	0.05*P _M		LR	H21(160)	21.00	-0.0656	6				
								14.00	-0.0437		A11			
H-22, PR Head End	A3	0.07	-0.03 ⑧	0.05*P _M		PR	H22(200)	21.46	-0.0510	4				
								9.66	-0.0229		A11			
H-23, PR Detector	N/A	N/A				LLE	H23(110)	26.72	-0.1087	10				
								11.76	-0.0478		A11			
H-24, GEX Heaters	N/A	N/A				GEX + CSM	H24(42)	11.49	-0.0501	1				
								7.94	-0.0171		A11			
H-25, LR Detector	N/A	N/A				LLE	H25(100)	24.58	-0.1000	10				
								12.82	-0.0522		A11			

*Incl H31(120)

Table 4.8.2.1-1 - BIO-POWER (Cont)

Power Event	ESS POWER, P _E						MSS POWER P _M							
	ESS Slice	BIO OP BUS			BIO TH BUS		MSS Module	BIO OP BUS			BIO OP OR BIO TH BIO TH BUS			
		Stby	ON		Stby	On		Set Point, °C	P _o , W	S, W/°F	Interval, min		P _o , W	S, W/°F
			Reg	Raw							Warmup	At Temp		
H-29, GEX Head End	A1	0.07	-0.03 ⑧	0.05*P _M			GEX	H29(140)	19.90	0.0701	5	All		
H-35, LR Valve Block	A1	N/A	0.05	0.05*P _M			LR	H35(125)	6.95	-0.0244	28	All		
									7.96	-0.0280		All		
									3.74	-0.0132		All		
H-42 + H-44, LR Line	N/A	N/A					LR	17°			All	All		
H-45, CGS	N/A				N/A	N/A	CSM	10°	3.05	-0.0468	All	All	0.32	-0.0063

Note:

1. N/A, not applicable.
2. Expressed at W except for fractional product such as $0.05 * P_M$.
- (3) Sequence commanded set point shown in parentheses.
- (4) Typical sequence average of low duty cycle event.
- (5) Average power at 70°F median diurnal temperature.
- (6) Average power at 57°F median diurnal temperature.
- (7) Average power at 4°F median diurnal temperature.
- (8) Electronics saturated on standby, reduced power when sequenced on.
- (9) Standby power only below 12°C (53.6°F).

Table 4.8.2.1-1 - BIO-POWER (Cont)

TABLE 4.8.2.1-3
BIOLOGY POWER EVENTS DAILY AVERAGE

<u>POWER EVENT</u>	<u>HOT</u>	<u>WARM</u>	<u>COOL</u>	<u>COLD</u>	<u>TYPICAL DURATION</u>
Additive elements:					
ESS idle	6.52	6.52	6.78	6.95	-
Module Heaters, Bio Op Off . . .	0.78	2.18	8.37	14.11	-
Module Heaters, Bio Op On . . .	0.89	2.54	9.72	16.13	-
(Nutrient Heaters, included in Mod heaters, Bio Op on)	(0.00)	(0.17)	(1.49)	(3.21)	-
Sequenced Events	See below				
Major Sequenced Events:					
Thermo Electric Coolers	6.24	3.25	0.08	0.08	Sol 8 to EOM
PR Xenon Lamp .	7.78	7.78	7.78	7.78	120 Hrs.
LR Control Sterilization .	23.61	25.07	29.77	32.01	225 Min
LR Termination .	17.71	18.85	22.53	24.28	218 Min.
GEX Control Sterilization .	20.48	21.68	25.57	27.42	210 Min.
GEX V Blk Sterilization .	8.40	8.87	10.39	11.11	210 Min.
PR Control Sterilization .	8.03	8.38	9.49	9.76	182 Min.
Sump Heaters, B/24/42 to ETS Off	6.74	6.97	7.68	8.03	Variable

TABLE 4.8.2.1-4
BIOLOGY TYPICAL SEQUENCE DAILY AVERAGE POWER

	<u>HOT</u>	<u>WARM</u>	<u>COOL</u>	<u>COLD</u>	<u>DURATION</u>
Cruise to Sol 2					
Nutrient Heaters Only	0.00	0.17	1.49	3.21	-
Table A-Sol 2 Only					27.45 Hrs.
ESS Idling . . .	6.52	6.52	6.78	6.95	
Module Heaters, Bio Op On	0.89	2.54	9.72	16.13	
All sequenced Events	1.46	1.71	2.23	2.43	
Total average power	8.87	10.77	18.73	25.51	
Table B-All Active Only					12 Sols
ESS Idling . . .	6.52	6.52	6.78	6.95	
Module Heaters, Bio Op on	0.89	2.54	9.72	16.13	
Thermo Electric Coolers	6.24	3.25	0.08	0.08	
All Sequenced Events	5.16	5.43	6.07	6.32	
Total Average Power	18.81	17.74	22.65	29.48	
Downmode, Between Tables B and A					7 Sols
Module Heaters, Bio Op Off . . .	0.78	2.18	8.37	14.11	
Thermo Electric Coolers	6.24	3.25	0.08	0.08	
Total Average Power	7.02	5.43	8.45	14.19	
Table A-After Sol 20					3.5 Hrs.
ESS Idling . . .	6.52	6.52	6.78	6.95	
Module Heaters, Bio Op On	0.89	2.54	9.72	16.13	
Thermo Electric Coolers	6.24	3.25	0.08	0.08	
All Sequenced Events	4.98	4.98	4.72	4.55	
Total Average Power	18.63	17.29	21.30	27.71	

4.8.2.1.6 BIOLOGY DATA AND DATA PROCESSING

The types of data used in the Biology investigation, the data structure, the measurement list, and a description of data processing are discussed below.

a. Data Types

Telemetry data comes from either the Biology buffer memory or from Data Acquisition and Processor Unit (DAPU) formatted frames. The memory data sources are shown in Figure 4.8.2.1-24 which lists the various types of measurements taken by sequencer control.

The DAPU data contains three types of measurements, as follows:

- 1) Helium reservoir pressure, monitored through Cruise and Post-Landed operations, no dependence on Biology power;
- 2) Instrument mounting plate temperature, (part of Lander Performance Analysis Group (LPAG) data);
- 3) Three internal instrument temperatures, added after instrument design was completed, monitored during specific sequence times in Format 4.

All measurements are more fully described in the Measurement List, Table 4.8.2.1-5

b. Data Structure

The structure of the buffer memory data words is shown in Table 4.8.2.1-6. The measurement number is that identified in the VLC Measurement List.

c. Measurement List

The Biology Measurement List is shown in Table 4.8.2.1-5. Figure 4.8.2.1-25 shows the orientation of test cells corresponding to specific test cell position data words.

d. Data Processing

The processing of Biology data is described in the following documents:

SD-37R0012 Software Requirements Document
SD-37P0012 Program Description Document
SD-37U0012 Biology Users Guide

An overall view of the Biology software system is shown in Figure 4.8.2.1-26. The major software programs are as follows:

BIOL-C Command Generation and Verification
BIOL-A Data Decalibration
BIOL-B Data Processing

The BIOL-A software system, shown in Figure 4.8.2.1-27, produces the data in an ordered form suitable for a variety of presentations by BIOL-B. The BIOL-A inputs are as follows:

VBIRN1 - The predicted measurement sequence and time of occurrence from BIOL-C
VBIRN2 - Predicted helium consumption from BIOL-C
DECSET BIOF - Received telemetry data including Biology buffer memory data and time tagged DAPU formatted data
LTEMP THERMAL - Predicted nodal temperature of the helium reservoir

The BIOL-A outputs are as follows:

BWDF3 - File containing each received measurement time tagged by comparison to the predicted measurement
Printout - Chronological list of received and time tagged measurements in engineering units.
BIOS - File for LSEQ constraint checking

4.8.2.1.7 OPERATIONAL CONSTRAINTS

Instrument operation is controlled by the GCSC commands in an operational sequence, as discussed in 4.8.2.1.3. The constraints used in developing an instrument sequence are listed in the Biology Software Requirements Document, SD-37R0012, Appendix C. These can be summarized as general instrument, intramodule, thermal, and VL constraints.

The BIOL-C program contains the constraint logic in two different run options that provide the following:

SHIFT OPTION - Automatically adjusts block sequence timing to satisfy intramodule constraints; alert messages for operator checking of thermal, Lander, and general instrument constraints.

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SEQOUT OPTION -

Alert messages for some constraints
noted above.

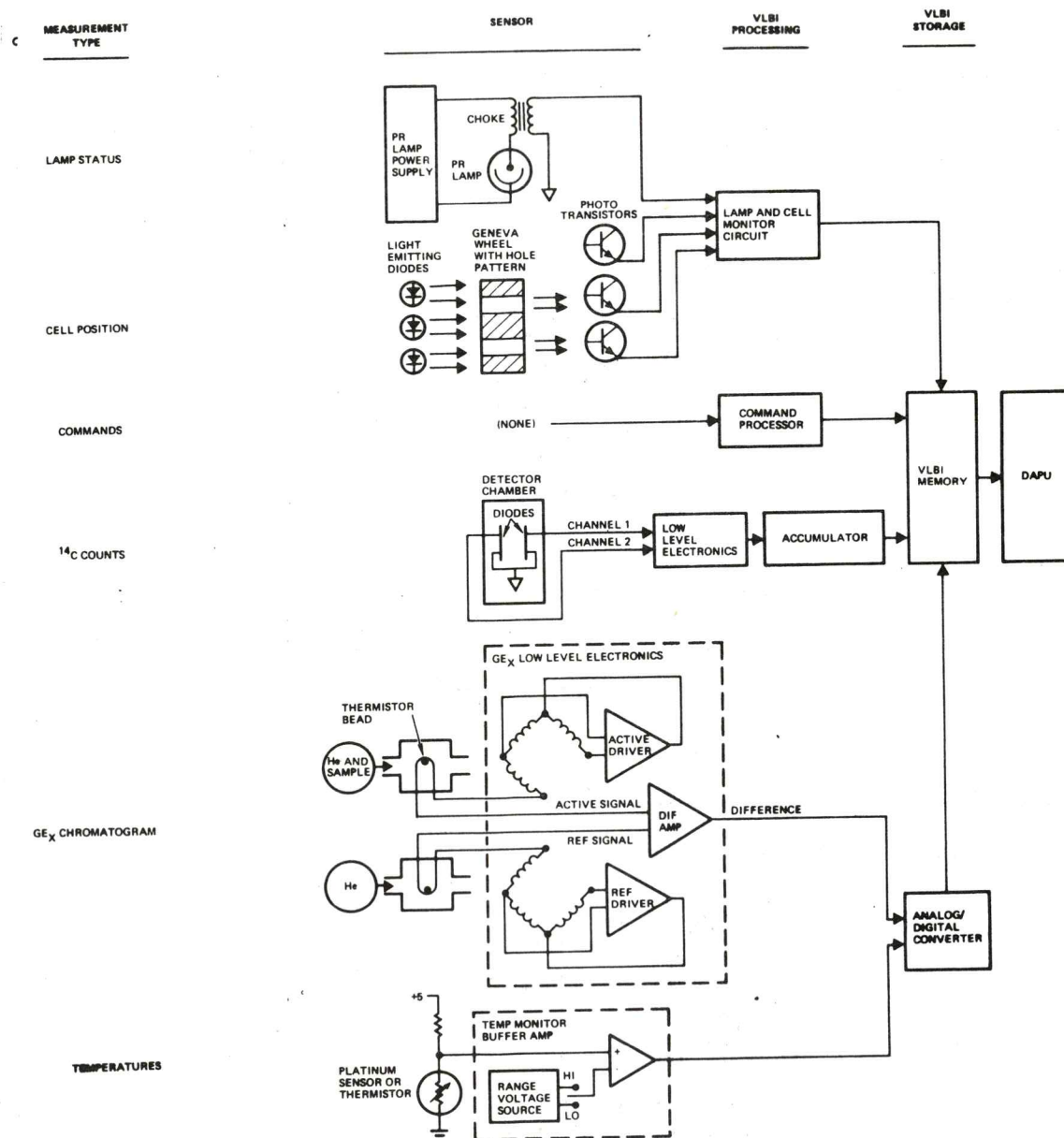


Figure 4.8.2.1-24 - BIOLOGY MEMORY DATA

Meas No.	Title	MNEMONIC	Function	Sample Rate	Range Units	V/Code	Accuracy	Precision	Resolution, °C/bit	Comments
M4001	Helium Pressure	BIOHEP	Indicates Helium Reservoir Pressure	Once per FMT-4	0 to 6500 psig	0 to 15 mV	10%	5%	N/A	VAIF Decalibration by DECSET
M4002	GEX Nutrient Valve Block Temp	BIOGXVBT	Indicates Temperature of Valve Block during Preinjection Sterilization	Once per FMT-4, Typical Every 30 min during Sterilization	+80° to +180°C	0 to 40 mV	±3°C	N/A	0.39°C	VAIF Decalibration by DECSET
M4003	GEX Nutrient Line Temp	BIOGNLT	Indicates Temperature of Nutrient Line during Preinjection Sterilization	Once per FMT-4, Typical Every 30 min during Sterilization	+105° to +205°	0 to 40 mV	±3°C	N/A	0.39°C	VAIF Decalibration by DECSET
M4004	PR Pyrolysis Head End Temp	BIOPHYET	Indicates Pyrolysis Head End Temp during Pyrolysis	Once per FMT-4, Typical Every Minute during Pyrolysis	+135° to 230°C	0 to 40 mV	±3°C	N/A	0.37°C	VAIF Decalibration by DECSET
B4004	Instrument Equipment Plate Temp	COMPT4	Indicates Instrument Mounting Plate Temp	Once per FMT-1, 2A, 2P, 3, 4, and 5	-50 to +150°F	N/A	2.2%	N/A	0.78°F/bit	VAIF Decalibration by DECSET
M8503	Frame Number	BIOFRNO	Indicates Sequential Frame Number	Once per Bio-frame	0 to 127	N/A	N/A	N/A	N/A	Consecutive While Power Uninterrupted; Rollback to 0 at Frame 128
M8504	Frame Length	BIOFRLN	Indicates Number of Words in Bioframe	Once per Bio-frame	0 to 127	N/A	N/A	N/A	N/A	128 Words Maximum Capacity Composite Word
M8505	Lamp Status and Test Cell Position	LMPSTAT	(See Below)							
			Indicates PR Xenon Lamp Status	a) When Bio Op Bus Turned On b) At Least Every 6 hr during PR Incubation c) Every Operation of any Test Cell Motor	ON OFF	1 0	N/A	N/A	N/A	
			Indicates Position of LR Test Cells	Same as above	Cell 1 Cell 2 None Cell 3 Cell 4 None	001 010 011 100 101 110	N/A	N/A	N/A	Position of Cell at Incubation Head End. See Figure 4.8.2.1-B+3
			Indicates Position of PR Test Cells	Same as above	Cell B Dump 2 Cell C Dump 3 Cell A Dump 1	001 010 011 100 101 110	N/A	N/A	N/A	Position of Cell or Dump Cavity at Incubation Head End. See Figure 4.8.2.1-B+3
			Indicates Position of GEX Test Cell	Same as above	Cell B Dump 120° ccw 60° ccw	001 100 101 110	N/A	N/A	N/A	Position of Cell or Dump Cavity at Incubation Head End. See Figure 4.8.2.1-B+3
M8506	Biocommand 1	BIOCMD1	Provides Code of all GCSC Commands Received by the Instrument	When GCSC Command Received	N/A		N/A	N/A	N/A	Two Data Words per GCSC Command.
M8507	Biocommand 2	BIOCMD2								
M8508	PR Radioactivity 1	PRRAD1	Accumulated Count of Radioactive Disintegrations during (a) Pyrolysis (First Peak)	(a) One Sample per min	0 to (2 ²⁴ -1) Counts, 24 bit Binary	N/A	N/A	N/A	N/A	Two Data Words per Sample, bits 24 through 13 in Word 1, bits 13 through 1 in Word 2.
M8509	PR Radioactivity 2	PRRAD2	(b) Elution (Second Peak)	(b) One Sample per 16 min						
			(c) Background	(c) One Sample per 16 min						
M8510	LR Radioactivity 1	LRRAD1	Accumulated Count of Radioactive Disintegrations (a) After Nutrient Injection (120 min)	(a) One Sample per 4 min	0 to (2 ²⁴ -1) Counts, 24 bit Binary	N/A	N/A	N/A	N/A	Same as M8508, M8509
M8511	LR Radioactivity 2	LRRAD2	(b) During Incubation	(b) One Sample per 16 min						
			(c) During Background	(c) One Sample per 16 min						

Table 4.8.2.1- 5

BIOLOGY MEASUREMENT LIST

Meas No.	Title	MNEMONIC	Function	Sample Rate	Range		Accuracy	Precision	Resolution, °C/Bit	Comments
					Units	V/Code				
M8512	GEX Chromatogram LO Gain	GEXLOGN	Indirect Measurement of Quantity of Each Gas Species during a Gas Analysis	One Sample per second for 16 min during the Chromatogram	LO Gain	0 to 5 V	N/A	N/A	N/A	10:1 Attenuation of M8513, Automatic Range Switching at LO Gain at 5 Vdc
M8513	GEX Chromatogram Hi Gain	GEXHIGN	Same as M8512	Same as M8512	Hi Gain	0 to 5 V	N/A	N/A	N/A	Two M8515 and Two M8516 Measurements Taken in Lieu of Four M8513 during Each Chromatogram
M8514	GEX Test Cell Temp	GEXTCTMP	Indicates (a) Incubation Temp (b) Sterilization Temp	(a) Two Samples per Day (b) One Sample per 30 min	(a) -20° to +200°C (b) -20°C to +200°C	0 to 5 V 0 to 5V	±3.4°C at 6°C ±12°C at 170°C	±1.1°C at 6°C ±7.7°C at 170°C	0.24°C at 6°C 0.34°C at 170°C	
M8515	GEX Chromatograph Column Temp	GEXCOLT	Indicates Chromatograph Column Temp	Two Samples per 16 min Chromatogram Plus One before and after Chromatogram	-20° to +200°C	0 to 5V	±4.0°C at 24°C	±1.4°C at 24°C	0.23°C at 24°C	Two Measurements per Chromatogram in Lieu of Two M8513
M8516	GEX Detector Temp	GEXDETT	Indicates Chromatograph Detector Temp	Same as M8515	-20° to +200°C	0 to 5 V	±3.3°C at 32°C	±1.1°C at 32°C	0.26°C at 32°C	Same as M8515
M8517	PR OVI Temp	OVITEMP	Indicates OVI Temp (a) Between Pyrolysis and Elution (b) During Elution (c) During Cleanup	(a) One Sample Every 120 min (b) One Sample per min (c) Five Samples	-20° to +200°C +500° to +780°C +500° to 780°C	0 to 5 V 0 to 5 V 0 to 5 V	±9.7°C at 110°C ±24°C at 725°C ±24°C at 725°C	±5.8°C at 110°C ±12°C at 725°C ±12°C at 725°C	0.29°C at 110°C 0.59°C at 725°C 0.59°C at 725°C	Two Commandable Set Points; 120° and 700°C. Two Readout Ranges Are Used.
M8518	PR Test Cell Temp	PRCTEMP	Indicates (a) Incubation Temp (b) Pyrolysis Temp (c) Sterilization (d) Cleanup Temp	(a) At Least Every 6 hr during Incubation (b) One Sample per min (c) One Sample Every 30 min (d) Once Only	-20° to +200°C +500° to +780°C -20° to +200°C +500 to +780°C	0 to 5 V 0 to 5V 0 to 5V 0 to 5 V	±5.7°C at 9°C ±16°C at 625°C ±8.9°C at 170°C ±13°C at 725°C	±2.8°C at 9°C ±6.3°C at 625°C ±4.5°C at 170°C ±4.2°C at 725°C	0.27°C at 9°C 0.51°C at 625°C 0.36°C at 170°C 0.58°C at 725°C	Four Commandable Set Points; 90°, 120°, 160°, and 625°C. Two Readout Ranges Are Used.
M8519	PR Radioactivity Detector Temp	PRRADT	Indicates Detector Temperature	One Sample Every 16 min during Background and Elution	-20° to +200°C	0 to 5 V	±2.5°C at 25°C	±2.1°C at 25°C	0.1°C at 25°C	
M8520	LR Test Cell Temp	LRCTEMP	Indicates (a) Incubation Temp (b) Sterilization Temp (c) Cleanup Temp	(a) One Sample Every 16 min (b) One Sample Every 30 min (c) One Sample Every 30 min	-20° to +200°C -20° to +200°C -20° to +200°C	0 to 5 V 0 to 5 V 0 to 5 V	±3.3°C at 9°C ±13°C at 175°C ±13°C at 175°C	±1.1°C at 9°C ±7.9°C at 175°C ±7.9°C at 175°C	0.25°C at 9°C 0.34°C at 175°C 0.34°C at 175°C	One Commandable Set Point; 160°C. One Readout Range Used.
M8521	LR Radioactivity Detector Temp	LRRADT	Indicates Detector Temperature	One Sample Every 16 min	-20° to +200°C	0 to 5 V	±2.5°C at 25°C	±2.1°C at 25°C	0.1°C at 25°C	

Table 4.8.2.1- 5 BIOLOGY MEASUREMENT LIST
(Cont)

TABLE 4.8.2.1-6 - DATA WORD STRUCTURE

MEAS. NO.	REF.	TITLE	DATA WORD															SEQUENCE	NOTE REF.	
			SOURCE CODE BITS	DATA WORD DATA BITS																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14			15
M8505	1	PR Lamp Status	0	0	0	X	Y	Y										First		
	2	LR Test Cell Position					S	X	L									Second	1	
	3	GEX Test Cell Position									S	X	L					Third		
	4	PR Test Cell Position											S	X	L			Fourth		
M8506	5	Instrument Commands	0	0	1	S	X								X	L	First			
			0	0	1	X	X	X	L	Y						Y	Second	2		
M8508	6	PR Radioactivity	0	1	0	S	X								X	L	First			
M8509			0	1	0	S	X								X	L	Second	3		
M8510	7	LR Radioactivity	0	1	1	S	X								X	L	First			
M8511			0	1	1	S	X								X	L	Second	3		
M8512	8A	GEX Chromatogram	1	0	0	0	1	S	X						X	L	Not Applicable			
M8513	8B	GEX Chromatogram (High Gain)	1	0	0	0	0													
M8514	9	GEX Test Cell Temp	1	0	0	1	0													
M8515	10	GEX Chromatograph Column Temp	1	0	0	1	1													
M8516	11	GEX Detector Temp	1	0	1	0	0													
M8517	12	PR OVT Temp	1	0	1	0	1											4		
M8518	13	PR Test Cell Temp	1	0	1	1	0													
M8519	14	PR Radioactive Detector Temp	1	0	1	1	1													
M8520	15	LR Test Cell Temp	1	1	0	0	0													
M8521	16	LR Radioactive Detector Temp	1	1	0	0	1													

Notes:

- Measurements 1 through 4 will occur in the sequence shown to form one data word. Three measurements are direct digital.
- Measurement 5 will consist of two successive data words in the sequence shown. Data bits map with Lander command bits:

Data Word	Bit	Lander Command Bit
First	4	9
	15	20
Second	4	21
	7	24

- Measurements 6 and 7 will consist of two successive data words in the sequence shown. The measurement data is obtained from a 24 bit binary counter.
First Word: Most significant half of counter (data bit 4 corresponds to counter bit 2^{23}).
Second Word: Least significant half of counter (data bit 4 corresponds to counter bit 2^{11}).
- Measurements 8A through 16 are analog-to-digital converted to 10 bit binary with most significant bit first.
- The 16th data word bit is odd parity and is not shown.
- Code bits and data bits occur in the output format as read from left to right.
- S = most significant bit of data.
- L = least significant bit of data.
- X = data bit (binary 1 or 0).
- Y = bits of no significance.
- Sequence applies only to the order of measurements and data words as stated in the above notes. The sequence of data words in the output format is variable.

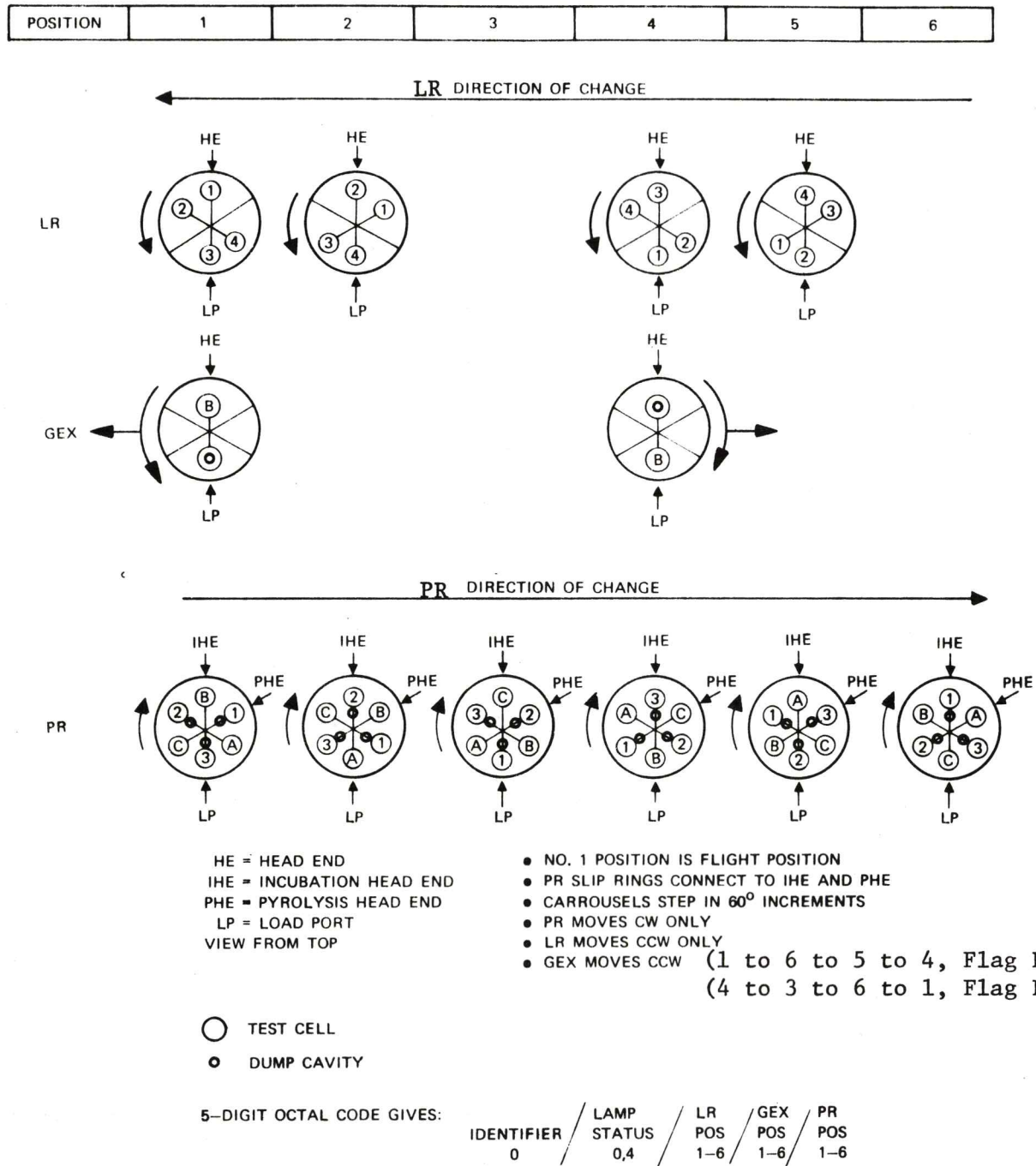


Figure 4.8.2.1-25 - BIOLOGY TEST CELL POSITIONS

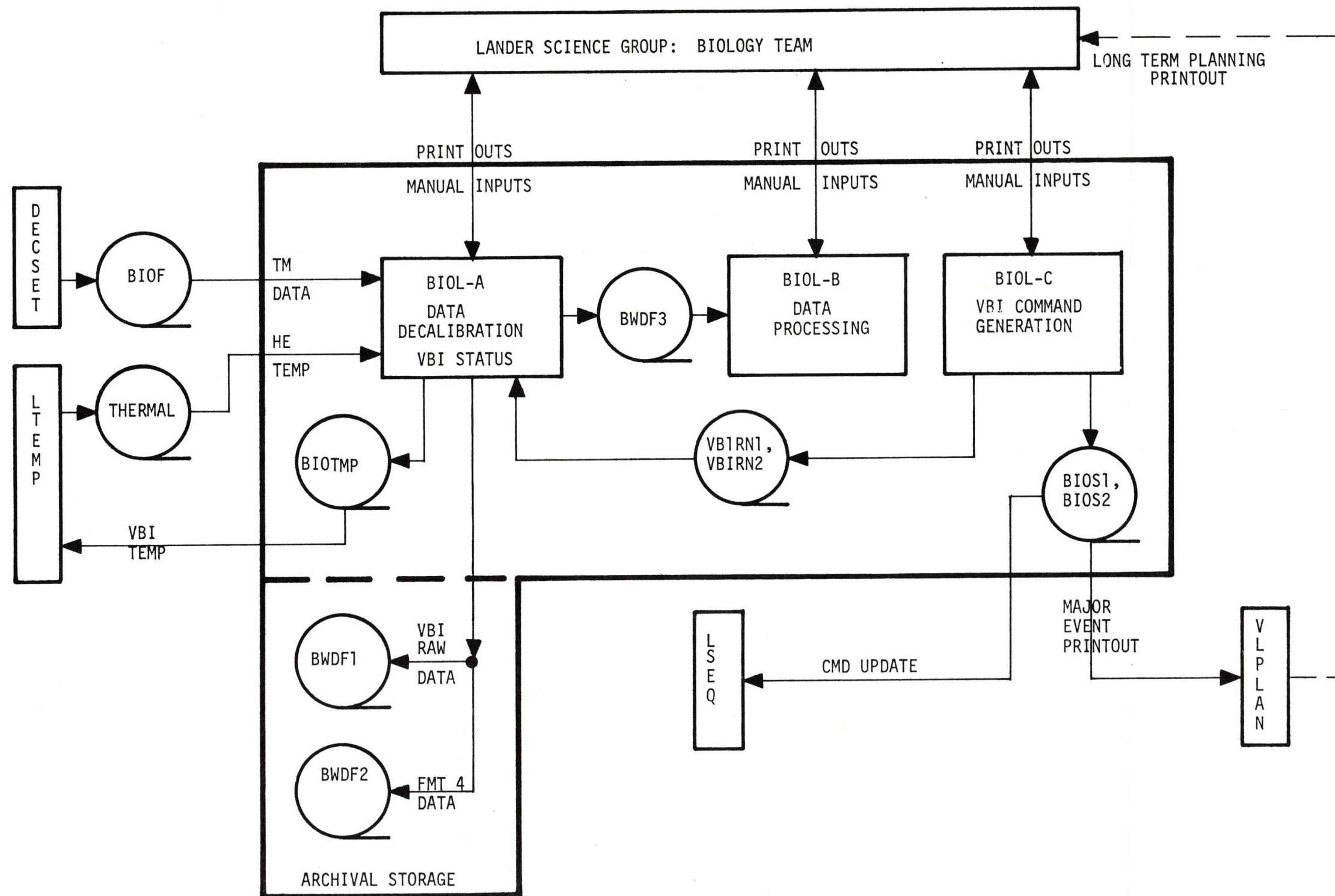


Figure 4.8.2.1-26 BIOLOGY SOFTWARE SYSTEM

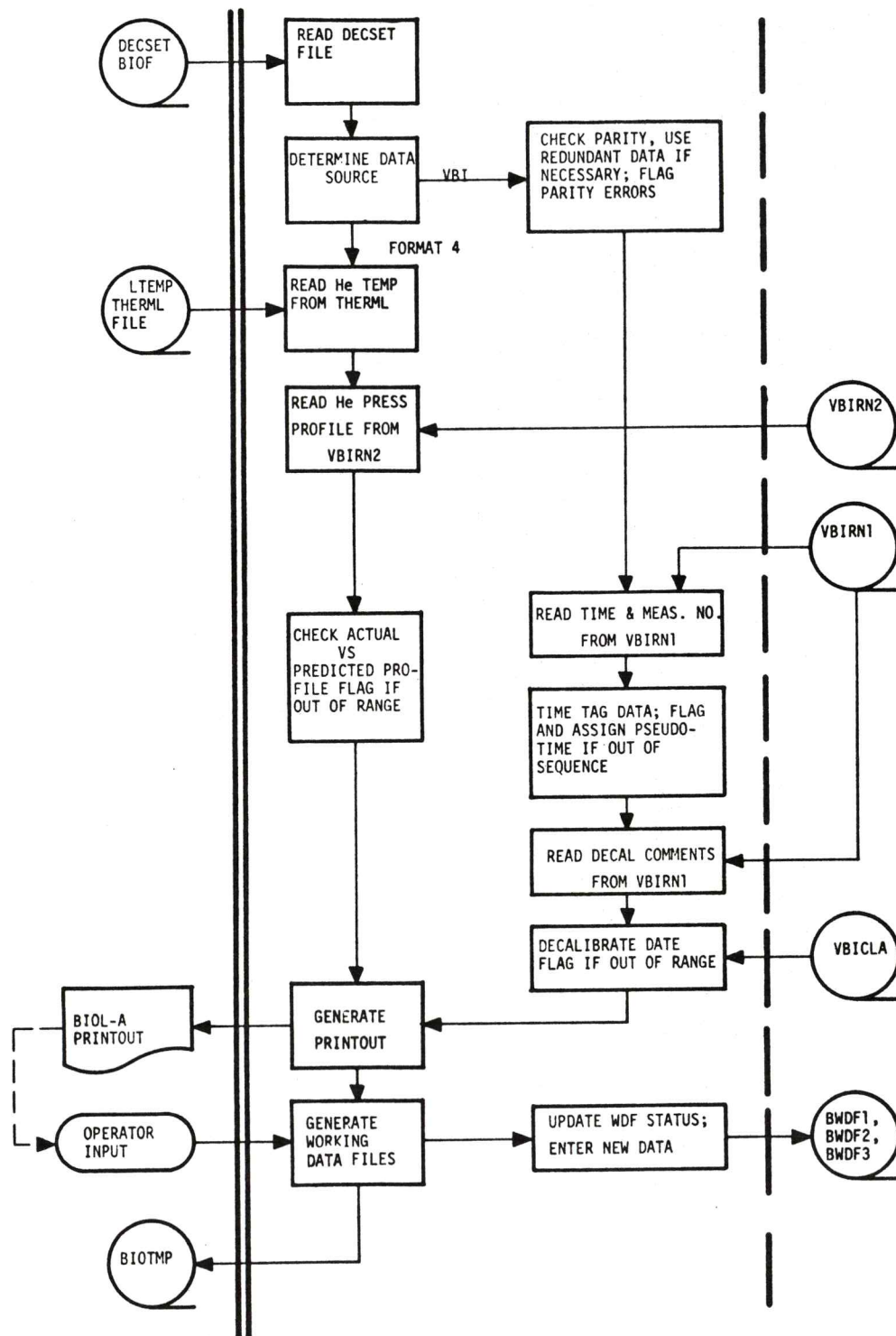
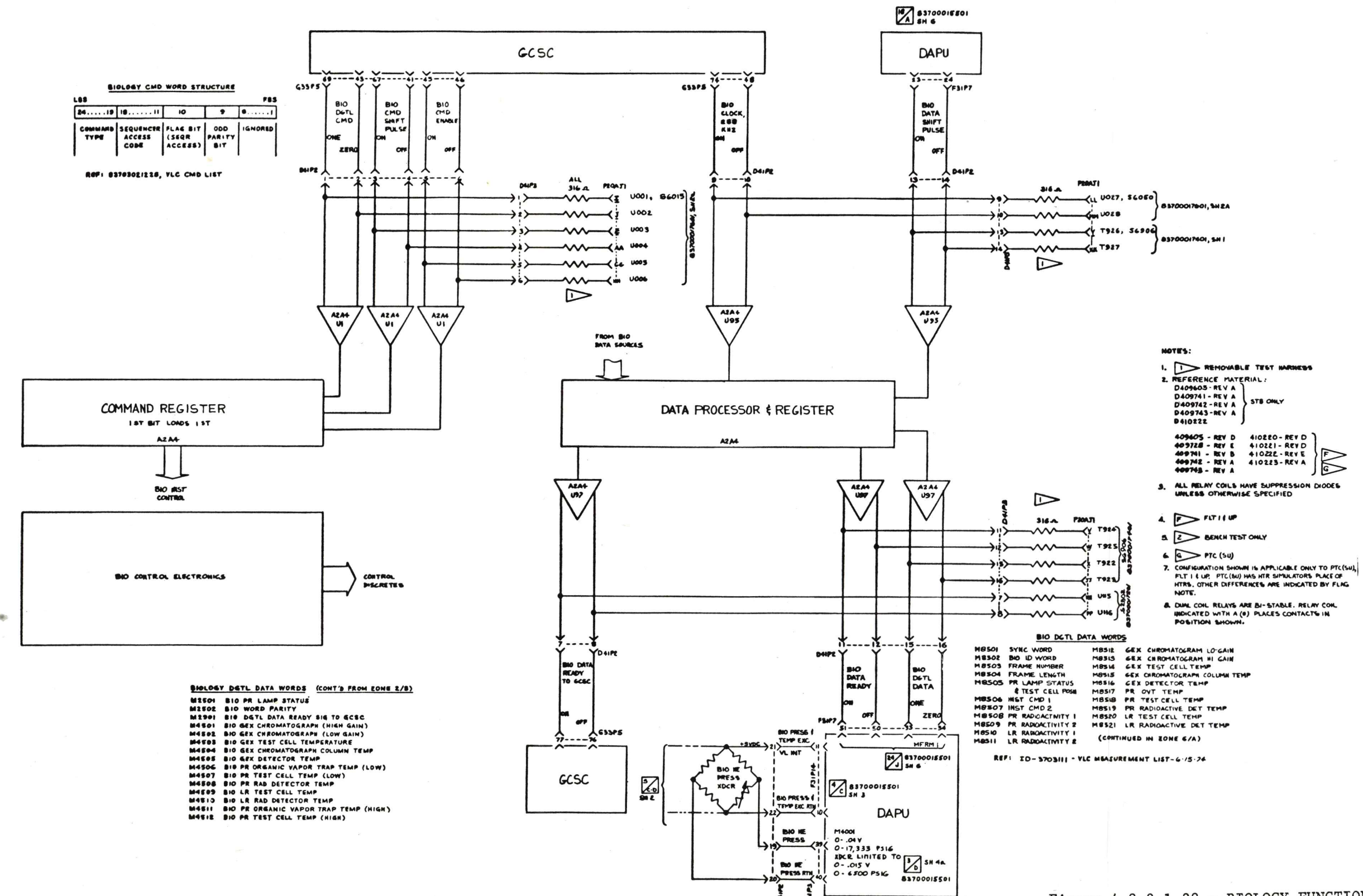


Figure 4.8.2.1-27 - BIOL-A SYSTEM



SHEET 1 of 5

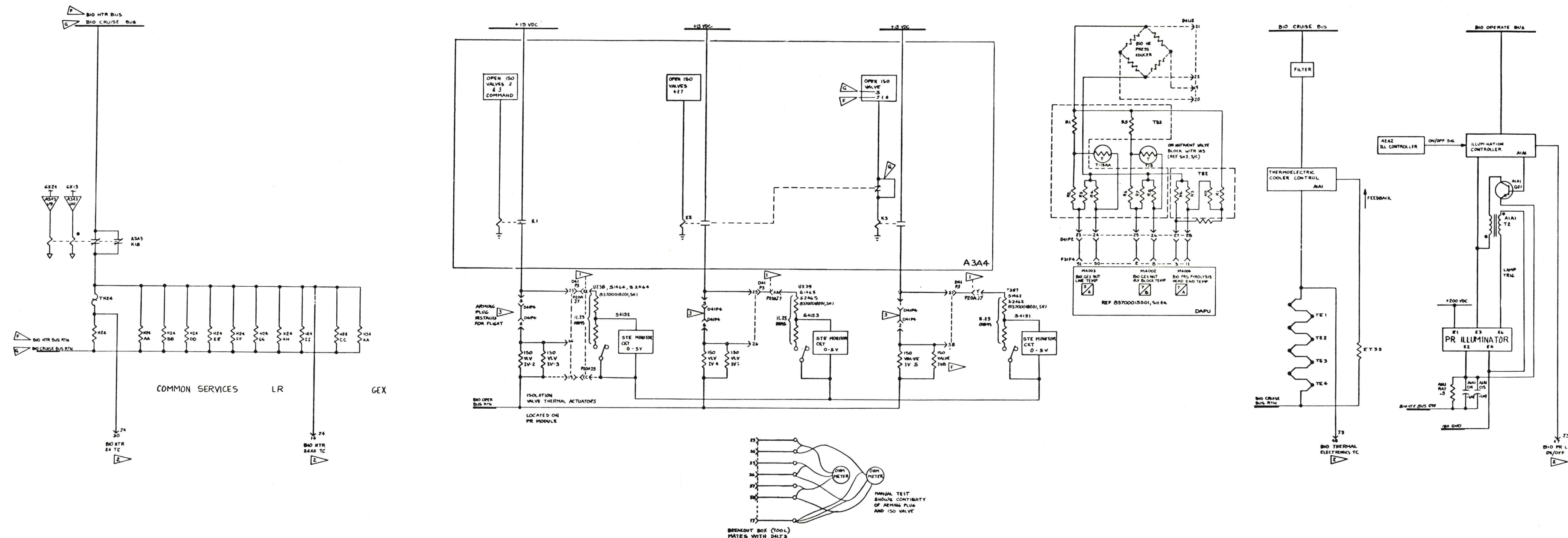


Figure 4.8.2.1-28 - BIOLOGY FUNCTIONAL SCHEMATIC

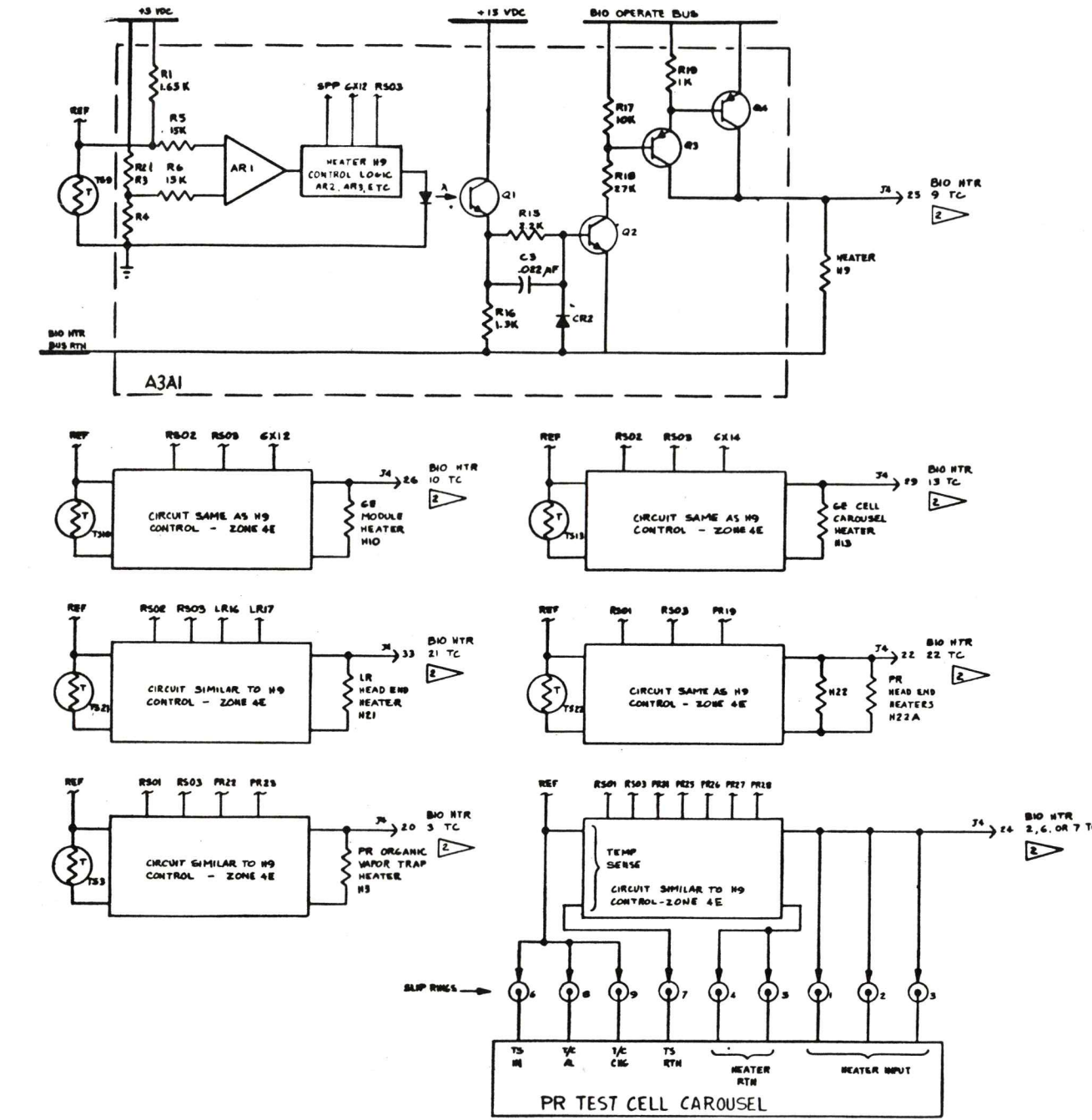
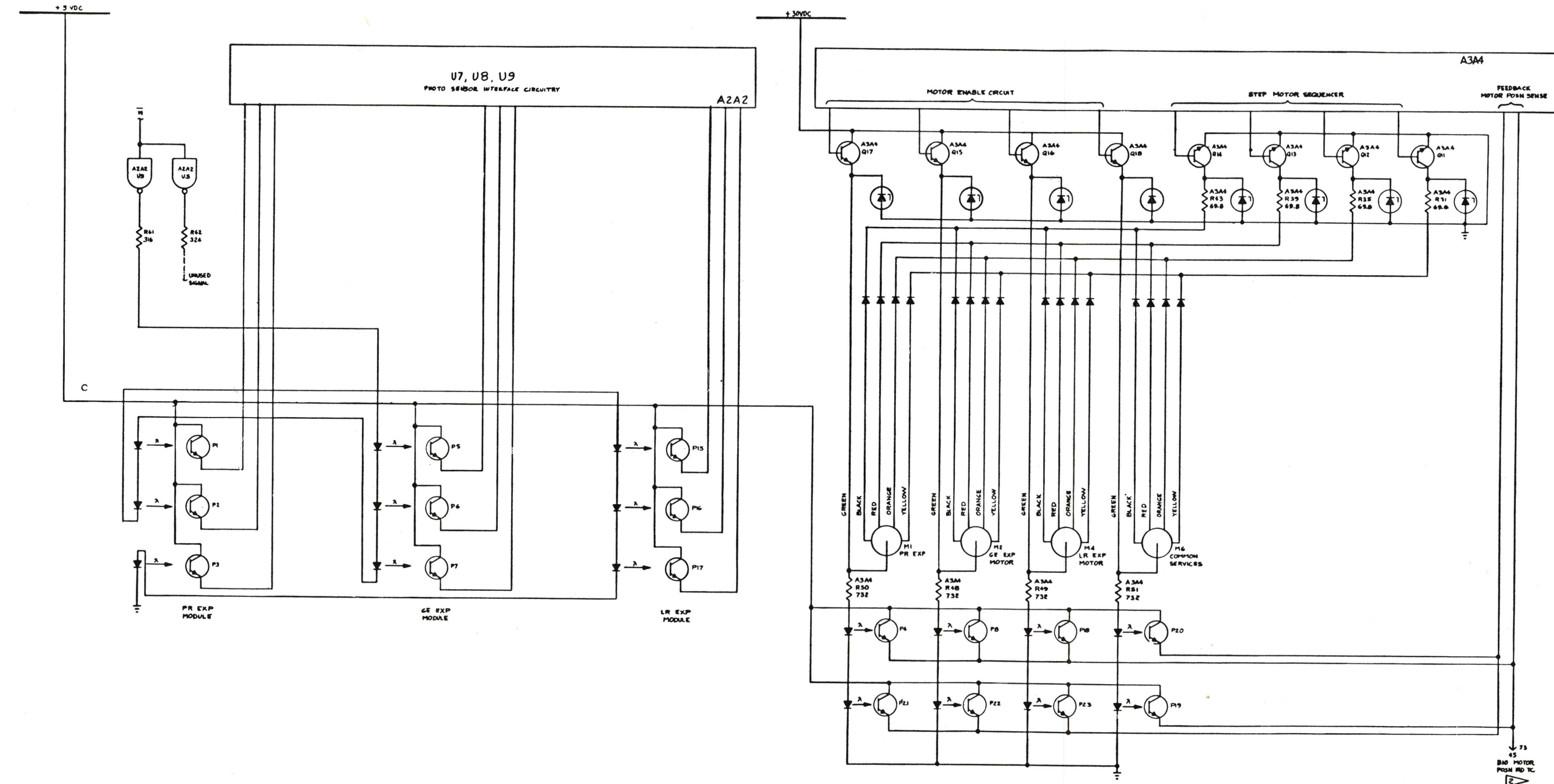
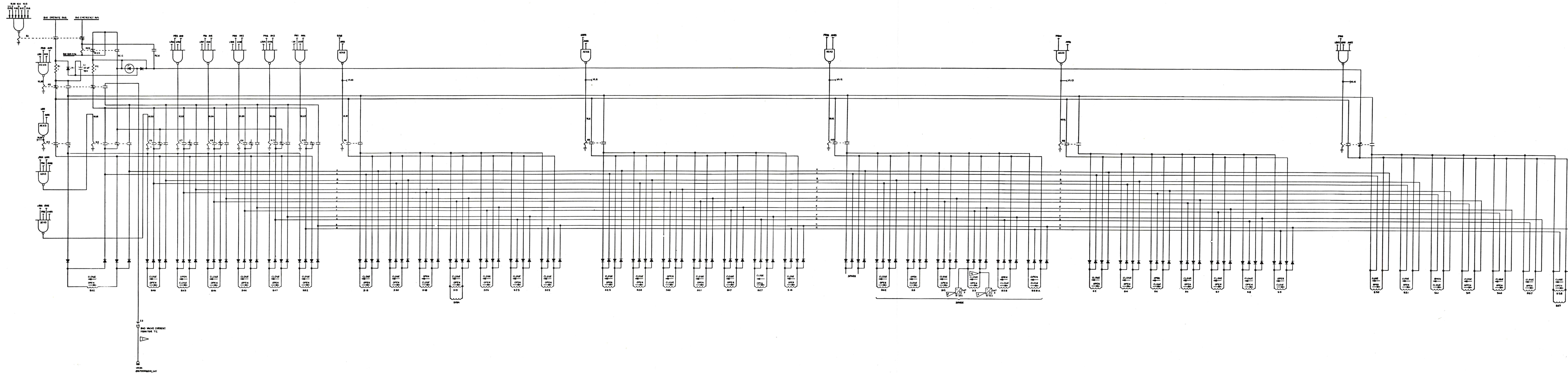


Figure 4.8.2.1-28 - BIOLOGY FUNCTIONAL SCHEMATIC



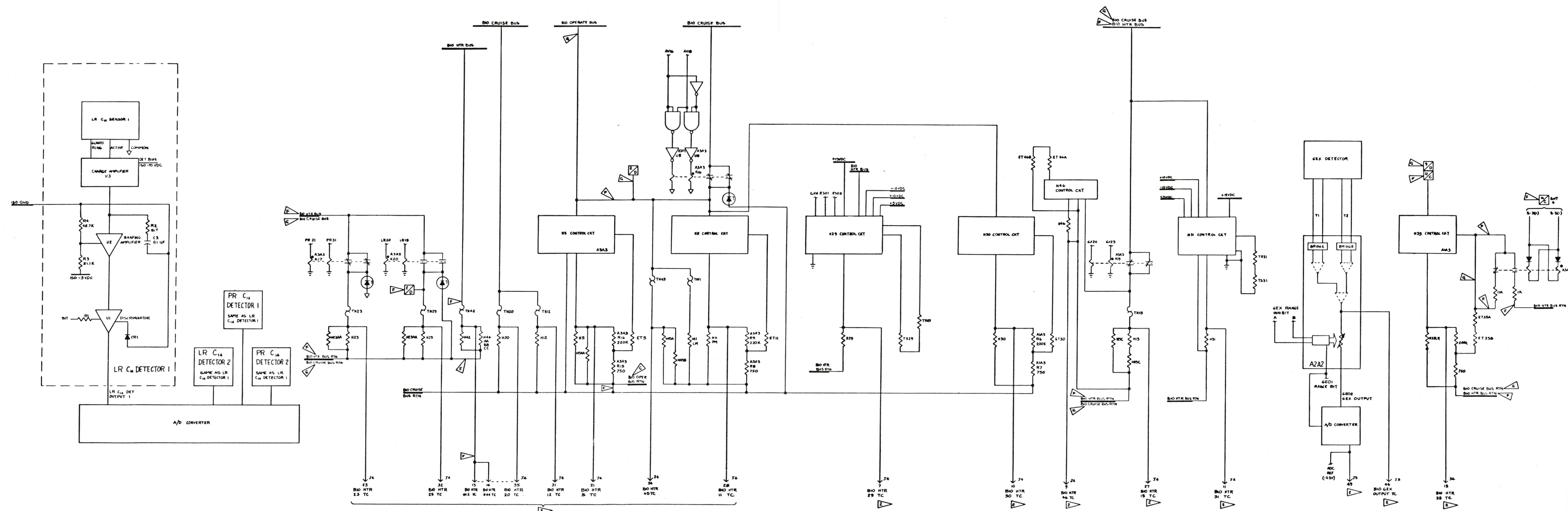


Figure 4.8.2.1-28 - BIOLOGY FUNCTIONAL SCHEMATIC

4.8.2.2 Gas Chromatograph Mass
Spectrometer (GCMS)

4.8.2.2 GAS CHROMATOGRAPH MASS SPECTROMETER (GCMS)

4.8.2.2.1 PURPOSE

The Gas Chromatograph Mass Spectrometer (GCMS) performs atmospheric and organic analyses on the Martian surface.

The primary purpose of the atmospheric analysis is the identification of constituents of the Martian atmosphere and the determination of their abundances, including possible variations, that are not detectable using remote optical spectroscopy. Of special interest are the abundances of the noble gases and their isotopes, particularly Argon. The abundance of Nitrogen and other minor constituents, some of considerable significance to the biological exploration of Mars, will also be investigated. Finally, an isotopic analysis of the major constituent, CO sub 2, will be carried out to complement existing spectroscopic determinations.

The purpose of the organic analysis investigation is to analyze samples of the Martian surface and subsurface for its organic content through gas chromatographic and mass spectral methods. The molecular analysis system is capable of analyzing compounds which constitute between 0.1 PPM and 2500 PPM by weight of the samples.

4.8.2.2.2 FUNCTION

The GCMS Functional Schematic is shown in Figure 4.8.2.2-32.

a. Atmospheric Analysis

One of the two prime functions of the GCMS is to analyze the Martian atmosphere. The instrument will first acquire an atmospheric sample. This is done by opening an atmospheric inlet valve (V9) for some finite period of time and allowing the Martian atmosphere to equilibrate in the GCMS Atmospheric Filter Assembly (AFA) equilibration volume, after which an atmospheric analysis may be commanded. CO/CO sub 2 filtration may be commanded prior to initiation of the atmospheric analysis to implement investigation of minor constituents in the Martian atmosphere. The atmospheric analysis sequences are not planned for the Cruise mission but are available for contingency planning.

b. Organic (Molecular) Analysis

The other prime function of the GCMS is to perform molecular analyses of Martian surface samples. Finely ground samples of Martian surface material are delivered to the GCMS by the Processing and Distribution Assembly (PDA) which is affixed to the GCMS Loading and Pyrolyzing Assembly (LPA). Upon

command, the LPA will be sequenced to load a portion of the sample into one of three ovens contained within the LPA. During an organic analysis, a selected sample oven is heated to drive off organic vapors contained in the sample within the oven. The vapors are deposited on the packing material within the gas chromatographic column in the Gas Chromatograph Assembly (GCA). During the remainder of the organic analysis, molecular compounds which have been deposited in the column will be carried to the mass spectrometer where mass spectra are generated. As with the atmospheric experiment, the organic analysis and the operation of each portion of the GCMS will be discussed in greater detail later in this section.

4.8.2.2.3 GCMS INSTRUMENT DESCRIPTION

Figure 4.8.2.2-1 is a photograph of the GCMS/PDA ready for installation in the Viking Lander. The GCMS is built up on three trays in a layer-like fashion as shown in Figure 4.8.2.2-2. The sensor tray contains the Mass Spectrometer Assembly (MSA), the GCA, the APA, and all the MSA electronic assemblies. The IES tray contains what is commonly called the Instrument Electronics Subsystem (IES). This consists of the Power Conditioning Subsystem (PCS), valve driver modules, heater controller modules, and motor and clutch controllers. The IDS tray contains the two multilayer laminates which comprise the instrument command and control logic, and data processing capability. This is called the Instrument Data Subsystem (IDS). The GCMS block diagram, Figure 4.8.2.2-3, and the GCMS gas flow block diagram, Figure 4.8.2.2-4 are a simplified representation of the interrelationship of the various portions of the GCMS.

4.8.2.2.4 GCMS FUNCTIONAL DESCRIPTION

The GCMS consists of two major assemblies, the Sensor Subset and the Instrument Data System Assembly.

a. Sensor Subset

The Sensor Subset contains the following subassemblies:

1) Hydrogen Supply Assembly (Figure 4.8.2.2-5)

The Hydrogen Supply Assembly (HSA) consists of a hydrogen tank containing H sub 2 at approximately 750 psig, a "one-shot" valve (VO), a pressure transducer, and two high pressure valves (V1 & V2). Associated with the HSA is the CO sub 2 cartridge which provides pressurant for a pyrolyzed sample. After pyrolysis, the hydrogen carrier gas is provided through valve V2. The "one-shot" valve (VO) contains the hydrogen within

the tank until such time as carrier gas is required.

2) Loading and Pyrolyzing Assembly (Figure 4.8.2.2-6)

The LPA receives a portion of a surface sample from the integrated PDA. The LPA then loads the sample into one of three ovens in response to command and control by the IDS and Instrument Electronics Assembly (IEA). During an organic analysis, the sample oven is heated to one of four, selectable temperatures in order to drive off the organic compounds within the sample. This, too, is in response to command and control (Figure 4.8.2.2-7). Figure 4.8.2.2-8 shows the Pyrolyzer Functional Flow Diagram.

3) Gas Chromatograph Assembly (GCA)

The GCA serves to control the flow of the vapor products of the sample of interest as they travel from the pyrolysis oven to the mass spectrometer. Referring to Figure 4.8.2.2-9 the GCA is made up of the GC Column and a heated assembly (Thermal Zone) which contains valves and restrictors (Effluent Divider) and a Hydrogen Separator. A brief description of these components follows:

a) Gas Chromatograph Column

The GC Column is a packed/capillary column with a configuration as shown in Figure 4.8.2.2-10. The purpose of the column is to elute, or give off, organic compounds which have been deposited on the column packing as a result of pyrolysis of a surface sample. The column is subjected to a linear temperature increase from 50C to 200C over an 18 minute period which causes the organics to elute selectively, lightest compounds first.

b) Effluent Divider

The Effluent Divider consists of high temperature valves and restrictors manifolded such that all, or a selected portion of the GC Column effluents, may be directed into the mass spectrometer for analysis. The Effluent Divider valves and manifolding are thermally controlled at approximately 200C to assure that effluents pass through into the mass spectrometer and are not deposited in the valves or manifolds. The Effluent Divider valves are operated in response to control

logic (Ref. Figure 4.8.2.2-18) in the IDS to allow as much effluent as possible to pass into the mass spectrometer. There are five possible effluent division ratios available -- 8000:1, 400:1, 20:1, 1:1, and 0:1. Each ratio is indicative of the quantity of effluent directed toward the mass spectrometer vs. the quantity vented from the GCMS. e.g. a 400:1 ratio would direct 1/400th of the effluent toward the mass spectrometer and the remainder would be vented. The most desirable state is that of 0:1 wherein all the effluent is directed toward the mass spectrometer.

c) **Hydrogen Separator**

The function of the Hydrogen Separator is to remove as much hydrogen as possible from the effluent stream. Hydrogen is used as a carrier or transporting gas in the GCMS, but must be removed prior to entry of the sample gas into the mass spectrometer. The Hydrogen Separator is an electrochemical cell made of precious metal which encapsulates an electrolyte. When power is applied to the separator during an analysis, the electrochemical action removes virtually all of the hydrogen from the sample gas stream.

4) **Atmospheric Filter Assembly (AFA) (Figure 4.8.2.2-11)**

The AFA consists of an atmospheric inlet valve (V9), an equilibration volume (approx. 10 cc), a CO/CO sub 2 filtration chamber and valve (V10) and an H sub 2 O absorber chamber and valve (V11). An atmospheric sample is admitted to the GCMS through valve V9 and allowed to equilibrate in the storage chamber. It is then analyzed by the Mass Spectrometer either before or after filtration. These sequences will be discussed in subsequent paragraphs.

5) **Mass Spectrometer Assembly (MSA)**

The MSA is the "heart" of the GCMS in that it is the assembly wherein analysis takes place and mass spectral are generated. A block diagram of the MSA is shown in Figure 4.8.2.2-12. The Mass Spectrometer Analyzer, which mounts to the Sensor Tray, is shown in Figure 4.8.2.2-13. During an atmospheric or organic analysis, the sample of interest enters the ionizing chamber of the mass

spectrometer ion source. The MSA contains the following components:

a) Mass Spectrometer Ion Source

In the ion source, a collimated beam of electrons ionizes the entering gas molecules. The electrons are produced by heating one of two selectable redundant tungsten-rhenium filaments to emitting temperature. The emitted electrons are focused electrostatically on the entrance aperture of the ionizing chamber. The electrons are collimated by a magnetic field as they traverse the ionizing region and leave via an exit aperture. The ions, which are produced in the electron beam column, are extracted from the ionizing region by an electric field and are focused on the exit aperture of the ion source, i.e., the object slit.

(1) Total Ion Current Collector

A fraction of the ion beam in the region of the object slit is intercepted by a collector, which is called the total ion current collector. The intercepted current is representative of the total ion current of unresolved ions.

(2) Ion Source Electronics

The potentials required by source electrodes to focus electrons and ions and extract the ions are supplied by the ion source electronic circuits. These also control the emitted electron current.

(3) Scan Control Electronics

The Scan Control Electronics vary appropriate potentials in the ion source in such a way that the energy of ions emerging from the object slit decreases exponentially with time from a maximum to a minimum value approximately every 10 seconds. In addition, these electronics provide a positive and negative voltage to the electric sector which is proportional to the ion energy. These voltages deflect the ions properly as they traverse the electric sector.

(4) Temperature Controller

The Temperature Controller provides power to heaters in the ion source to maintain the ion source temperature at approximately 200°C during analysis of gas from the Gas Chromatograph Column (GCC). An ion source temperature control circuit is provided to maintain a pre-set, fixed temperature of the ion source. Sensing elements will be located on the ion source to provide signals to the controller circuit.

b) Electric Sector

The ions of all masses that emerge from the object slit and enter the electric sector have a small spread in angle and energy. The electric sector focuses the ions in angle and disperses the ions in energy along its image plane. This plane becomes the object plane for the magnetic sector.

c) Magnetic Sector

Ions from the magnetic sector object plane are focused to second order in angle at the magnetic sector image plane. In addition, the magnetic field produces a mass dispersion along the image plane and simultaneously corrects for the small energy dispersion to produce first order energy or velocity focus. The scan voltage determines which ion follows the optical axis and passes through the mass resolving slit. As the scan voltage is continuously decreased, ions of increasing mass are swept across the resolving slit and a mass spectrum is generated, characteristic of the gas in the ion source.

d) Ion Pump and Ion Pump Supply

An ion pump is incorporated into the magnetic sector and supplied with high voltage by the ion pump supply. Gas that enters the Mass Spectrometer, or which appears in the Mass Spectrometer because of outgassing, is pumped by the ion pump.

Unregulated power is supplied to the ion pump power supply by the VL. Continuous power is applied to the ion pump at all times. Peak power demands will be required during organic

analysis and atmospheric composition analysis.

e) Ion Pump Auxiliary Supply

An auxiliary ion pump power supply operates during the sterilization period of the instrument to provide power to the ion pump. During this period when the temperature of the instrument is 139°C maximum the regular ion pump power supply is not operated. The ion pump auxiliary supply is not part of the flight system.

f) Electron Multiplier (EM) and EM Supply

The ion currents through the resolving slit are amplified by an electron multiplier to increase the currents to a level suitable for an electrometer amplifier. The electron multiplier supply provides high voltage to the electron multiplier.

g) Resolved Ion Current (RIC) Electronics

The electrometer amplifier amplifies the current output from the electron multiplier and converts it to a voltage signal. This signal is supplied to the RIC Post Amplifier where it is re-scaled, sampled, and transmitted to the IDS for digitization and transmission to the VL data acquisition system.

6) Instrument Electronics Assembly (IEA)

The IEA consists of valve driver modules, temperature controller modules, engineering data modules, and a separate power conditioning module housed in the Instrument Electronics Tray assembly.

a) Power Conditioning Subsystem (PCS)

The PCS provides the regulated voltages required by the Instrument Data Subsystem logic, the mass spectrometer electronics, and the hydrogen separator. A block diagram of the PCS is shown on Figure 4.8.2.2-14.

b) Instrument Data Subsystem (IDS) Figure 4.8.2.2-15.

The IDS functions is the "brain" of the GCMS in that it receives commands from the VL GCSC, initiates and controls GCMS sequences in response to commands and digitizes both engineering and mass spectral data and transmits these data to the VL data acquisition system. The IDS is made up of two multilayer laminate assemblies, the command processor assembly and the data processor assembly. These are interconnected and mounted in the IDS tray assembly. A block diagram of the IDS is shown on Figure 4.8.2.2-16.

(1) Command Processor Assembly

The IDS Command Processor Assembly receives a coded command from the VL system and controls GCMS functions in response to the command. See Figure 4.8.2.2-17. The GCMS Master Control Program is contained in this assembly in Programmable Read Only Memories (PROMS). Also included is the Effluent Divider/MS Overload Control Program which controls the behavior of the effluent divider during organic analysis or conditioning sequences. The effluent divider control - logical relationships are shown on Figure 4.8.2.2-18. Litton document 7861130-112, "GCMS Master Control Program", gives a complete listing of the GCMS sequences.

(2) Data Processor Assembly

The IDS Data Processor Assembly converts analog engineering and MS data to a digital data output compatible with the VL data acquisition system. Figures 4.8.2.2-22 and 4.8.2.2-23 show the IDS data format and the engineering data subcommutated words.

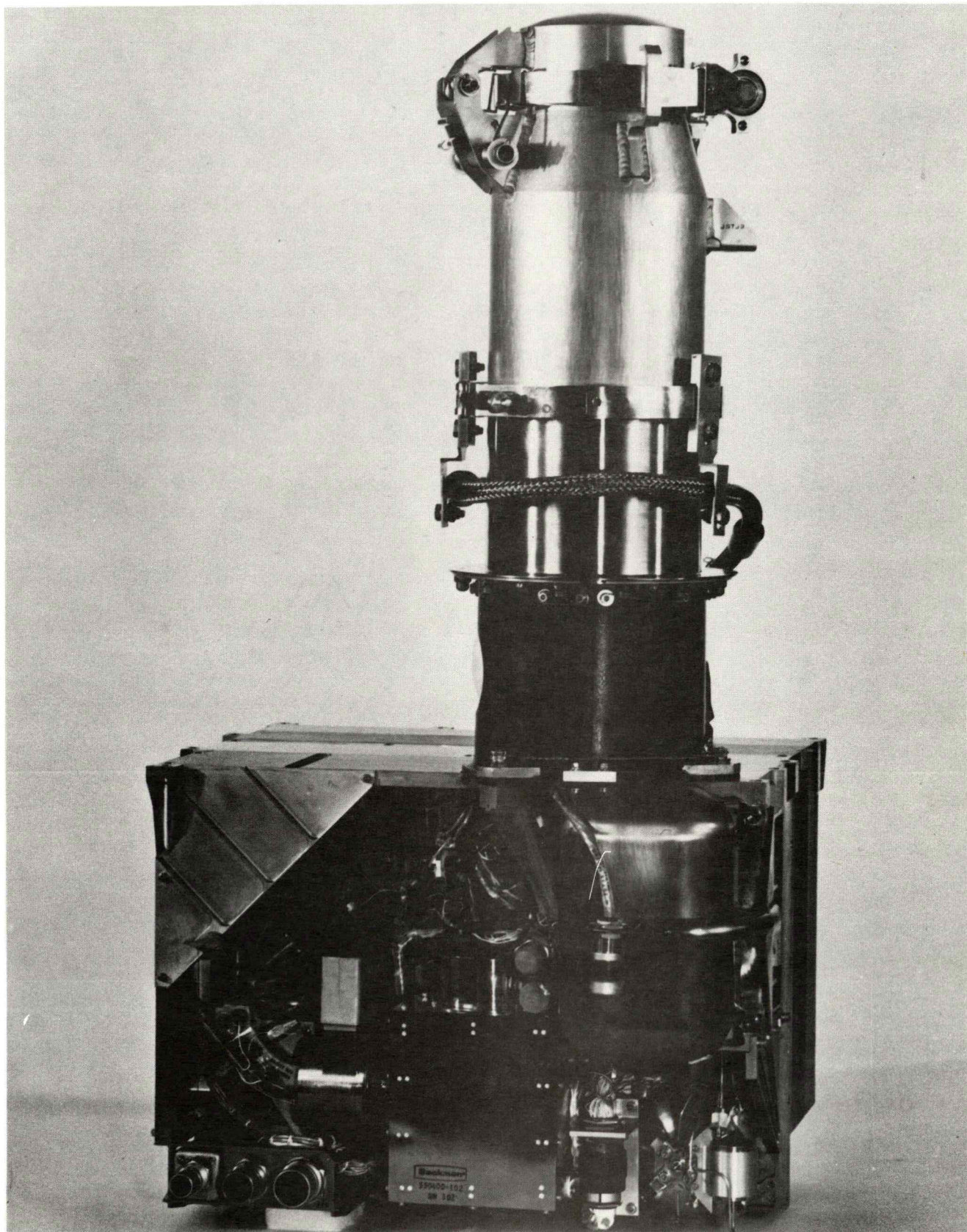


FIGURE 4.8.2.2-1 PHOTOGRAPH-GCMS/PDA

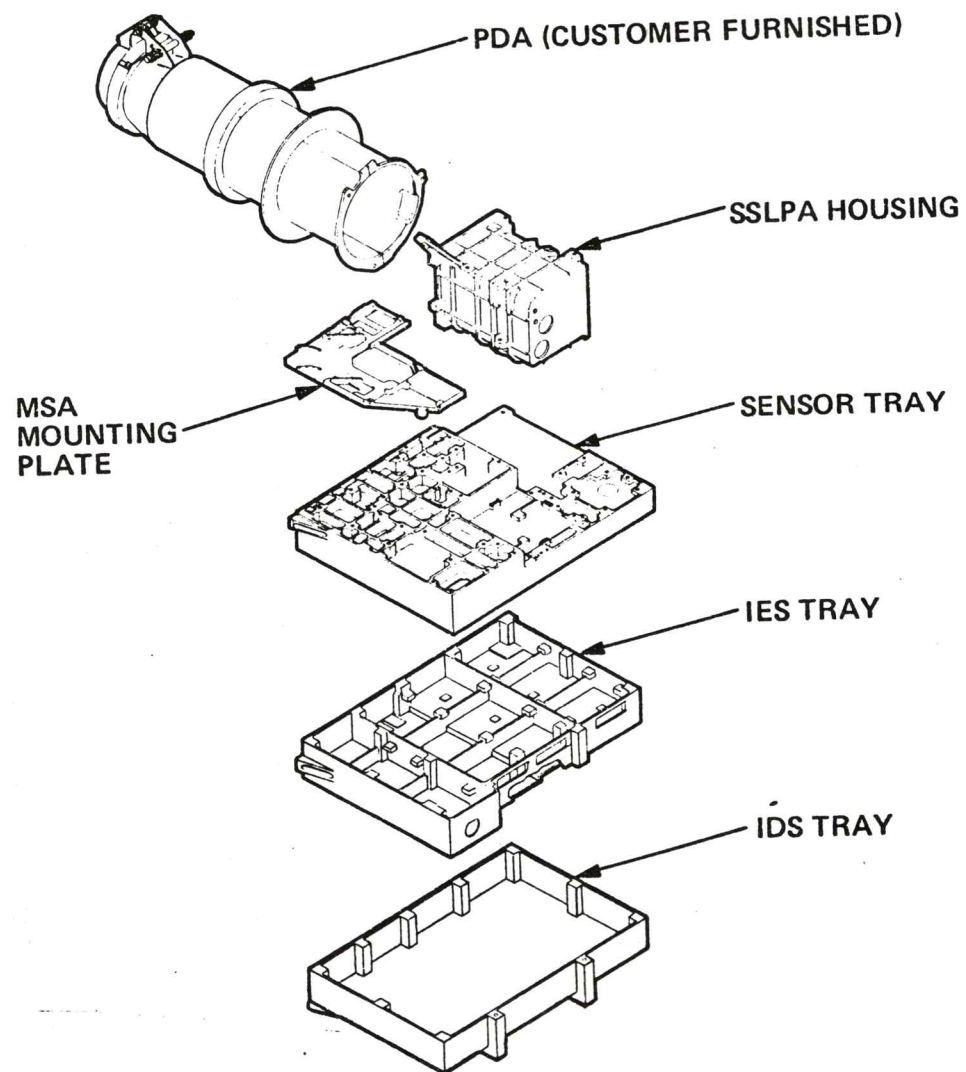


Figure 4.8.2.2-2 - INSTRUMENT CASE ASSEMBLY

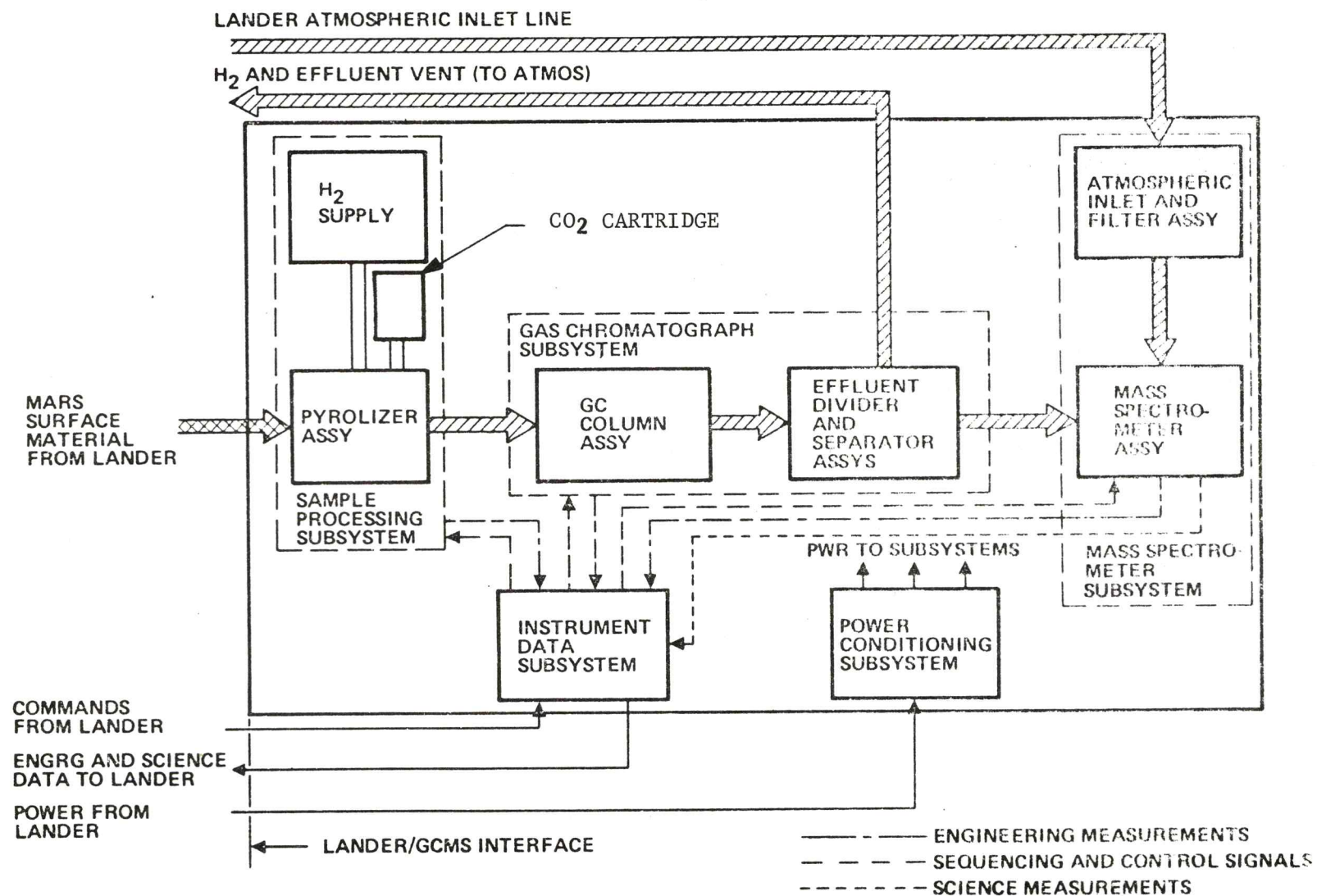


Figure 4.8.2.2-3 - GCMS INSTRUMENT BLOCK DIAGRAM

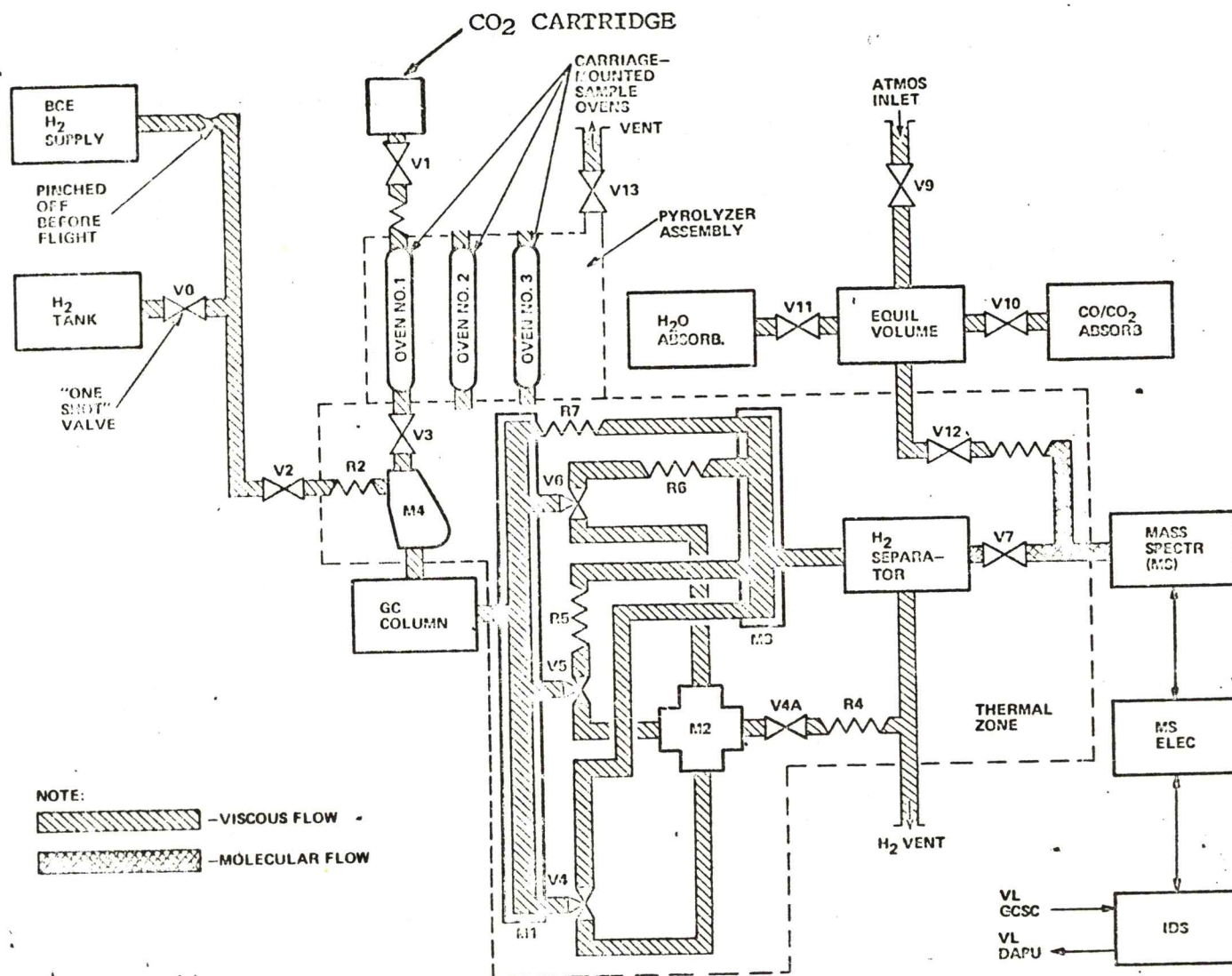


Figure 4.8.2.2-4 - GCMS GAS FLOW BLOCK DIAGRAM

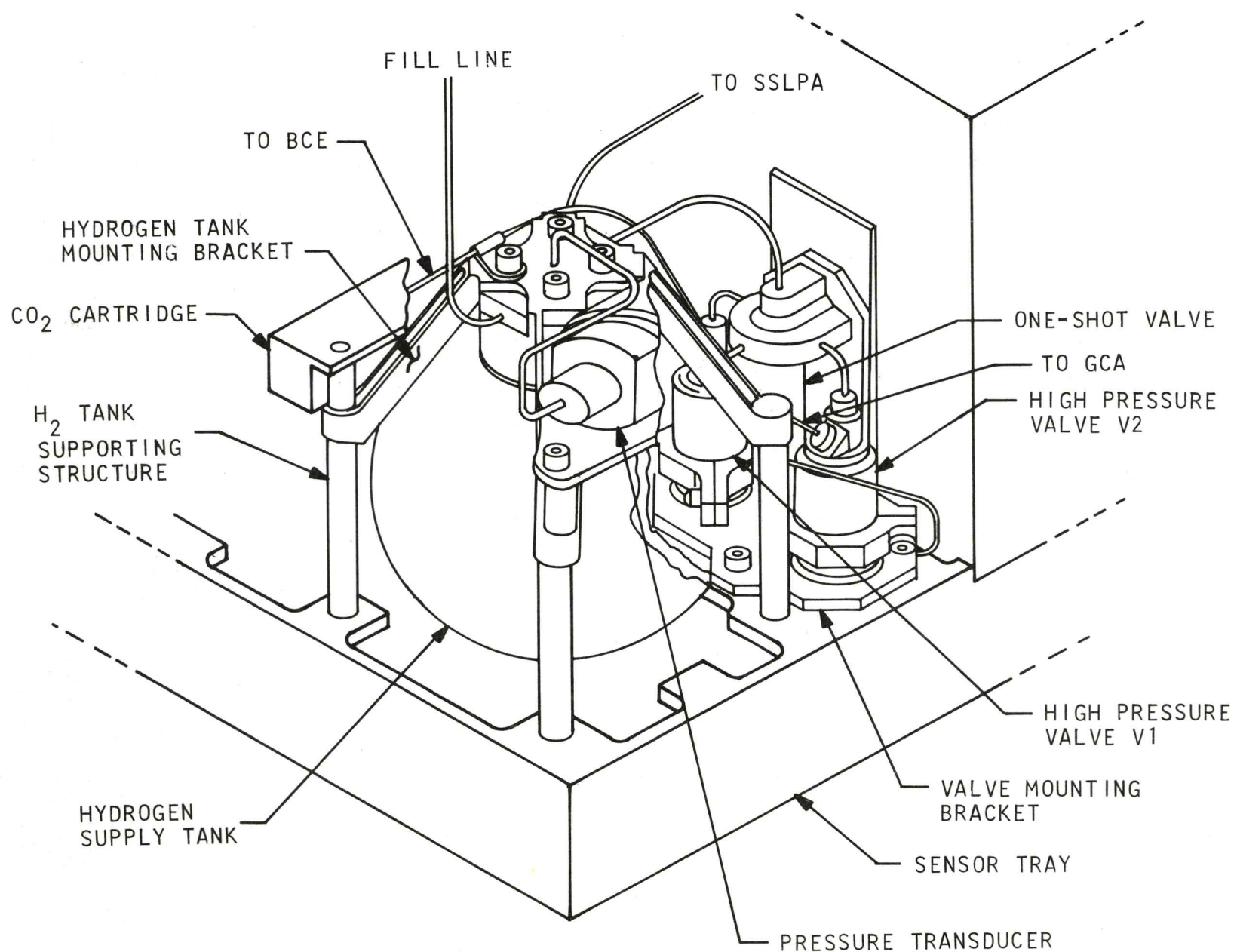


Figure 4.8.2.2-5 - HYDROGEN SUPPLY ASSEMBLY (HSA)

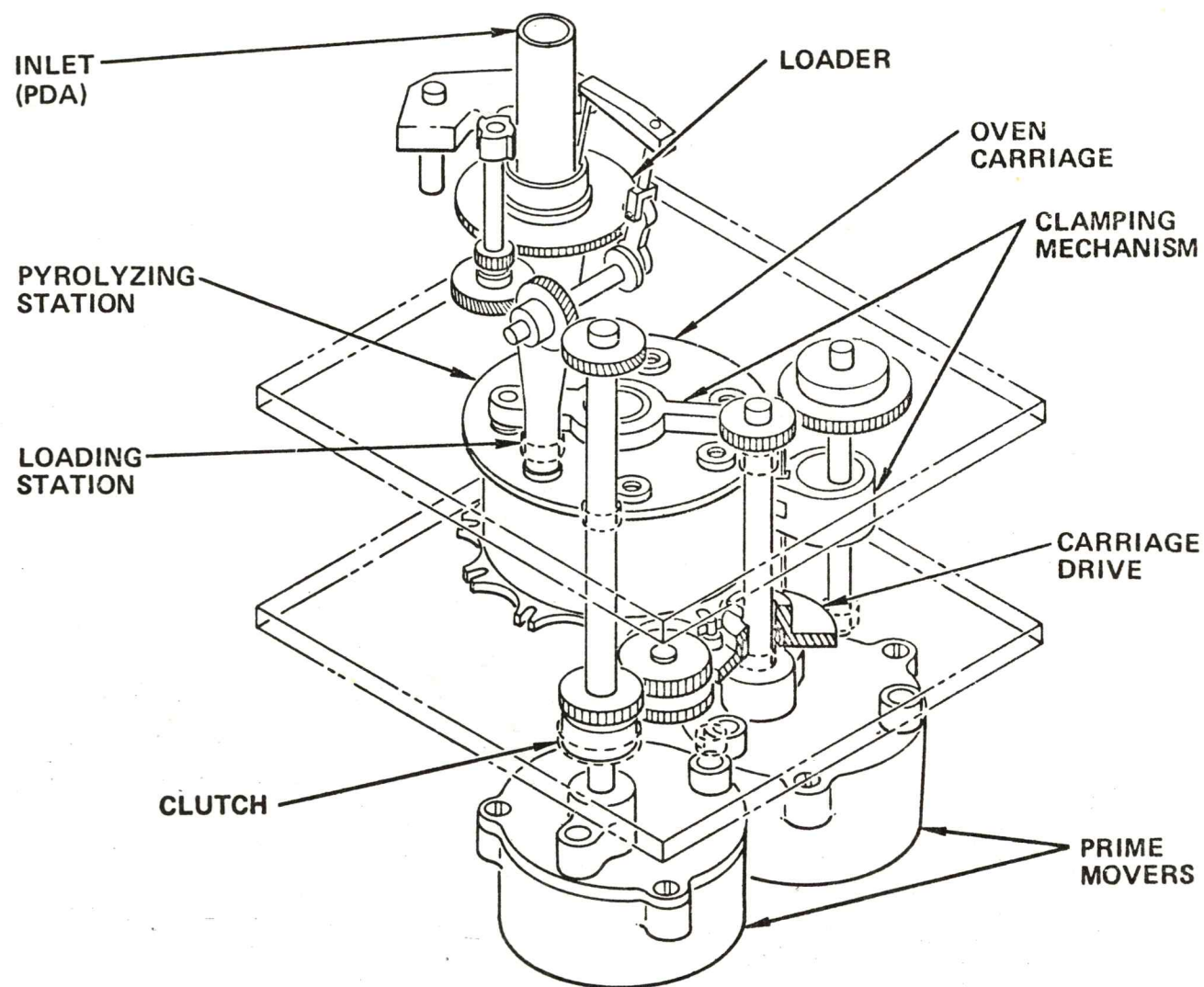
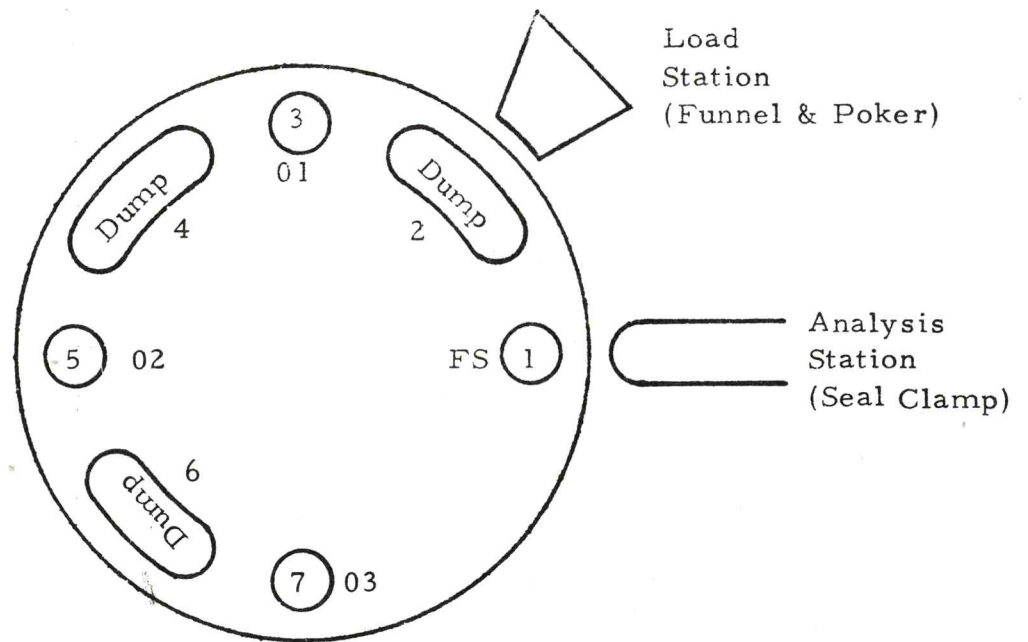


Figure 4.8.2.2-6 - PYROLYZER ASSEMBLY, BASIC LAYOUT



- | | |
|--------------|-------------------------------------|
| Position # 1 | Flight Station in Analysis Position |
| | Dump under Load Station |
| Position # 2 | Oven # 1 under Load Station |
| Position # 3 | Oven # 1 in Analysis Position |
| | Dump under Load Station |
| Position # 4 | Oven # 2 under Load Station |
| Position # 5 | Oven # 2 in Analysis Position |
| | Dump under Load Station |
| Position # 6 | Oven # 3 under Load Station |
| Position # 7 | Oven # 3 in Analysis Position |

Notes: Any Oven may be preheated in any position but must be heated before soil is dumped into funnel if preheated in Load position

All standard flight sequences move carriage one position (forward or reverse) at a time

Flight Station oven is non-heatable blank oven

No Dump after oven # 3

Figure 4.8.2.2-7 - LPA CARRIAGE/OVEN STATION DETAIL

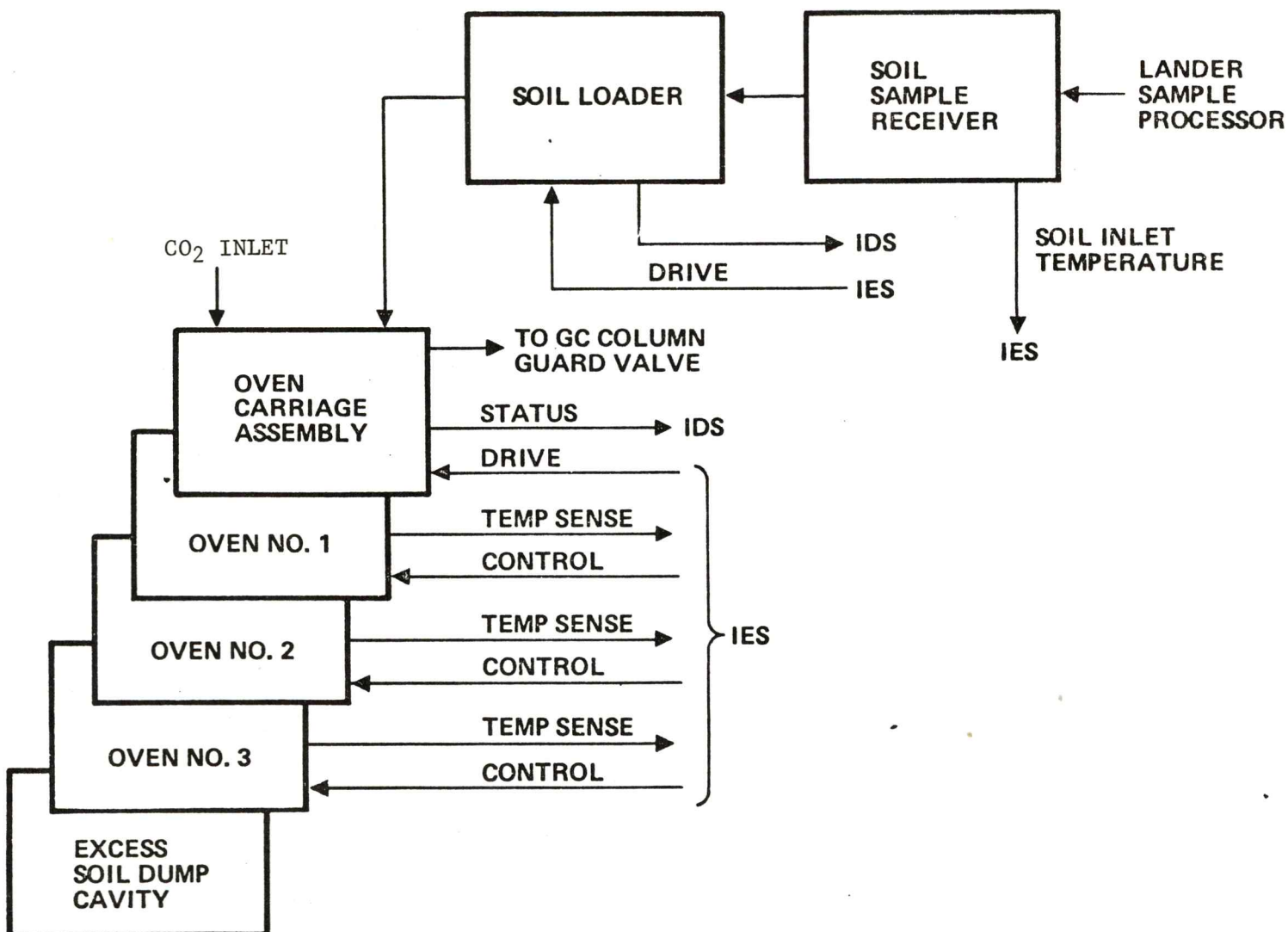


Figure 4.8.2.2-8 - PYROLYZER FUNCTIONAL FLOW DIAGRAM

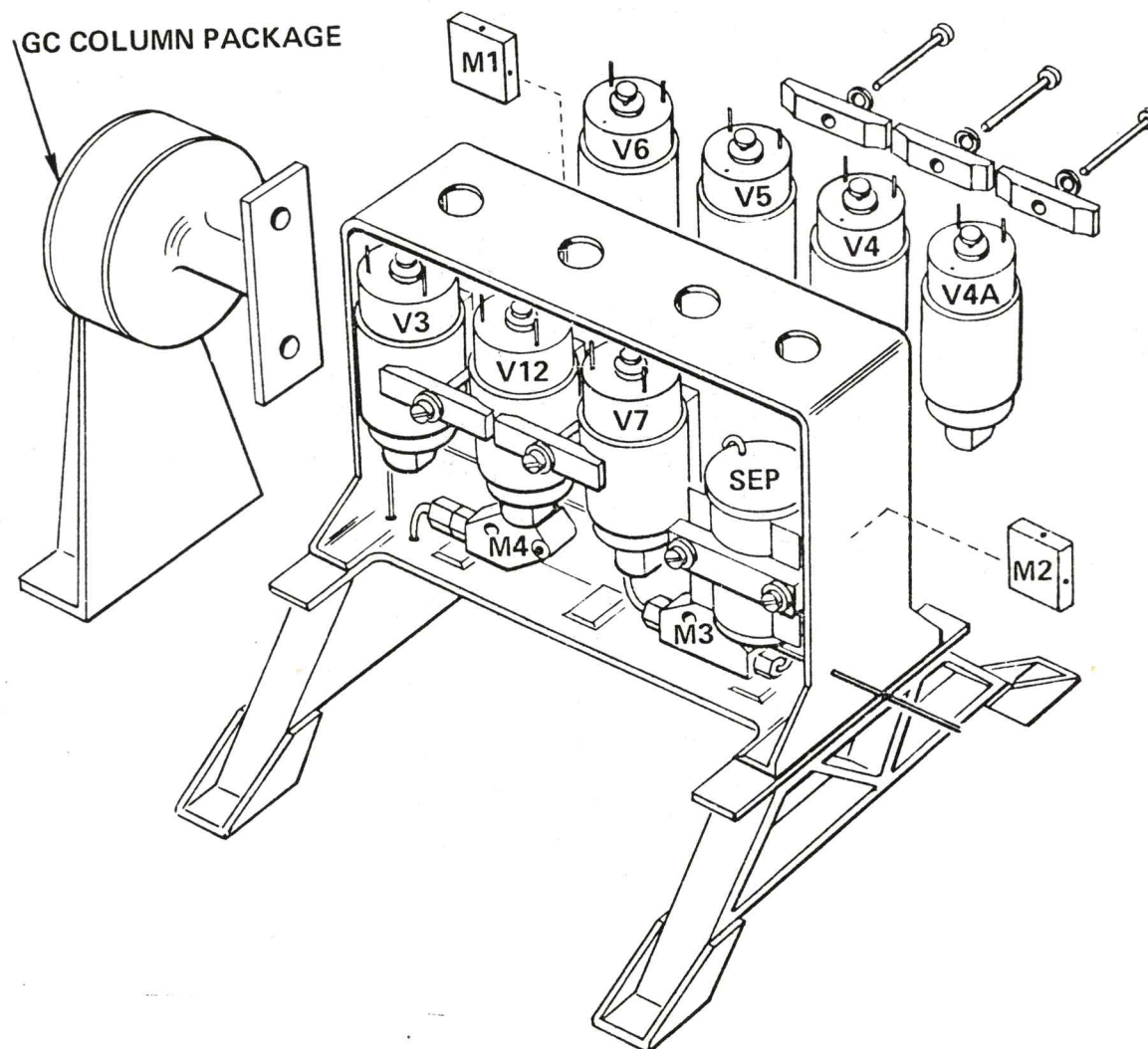


Figure 4.8.2.2-9 - THERMAL ZONE - GC ASSEMBLY

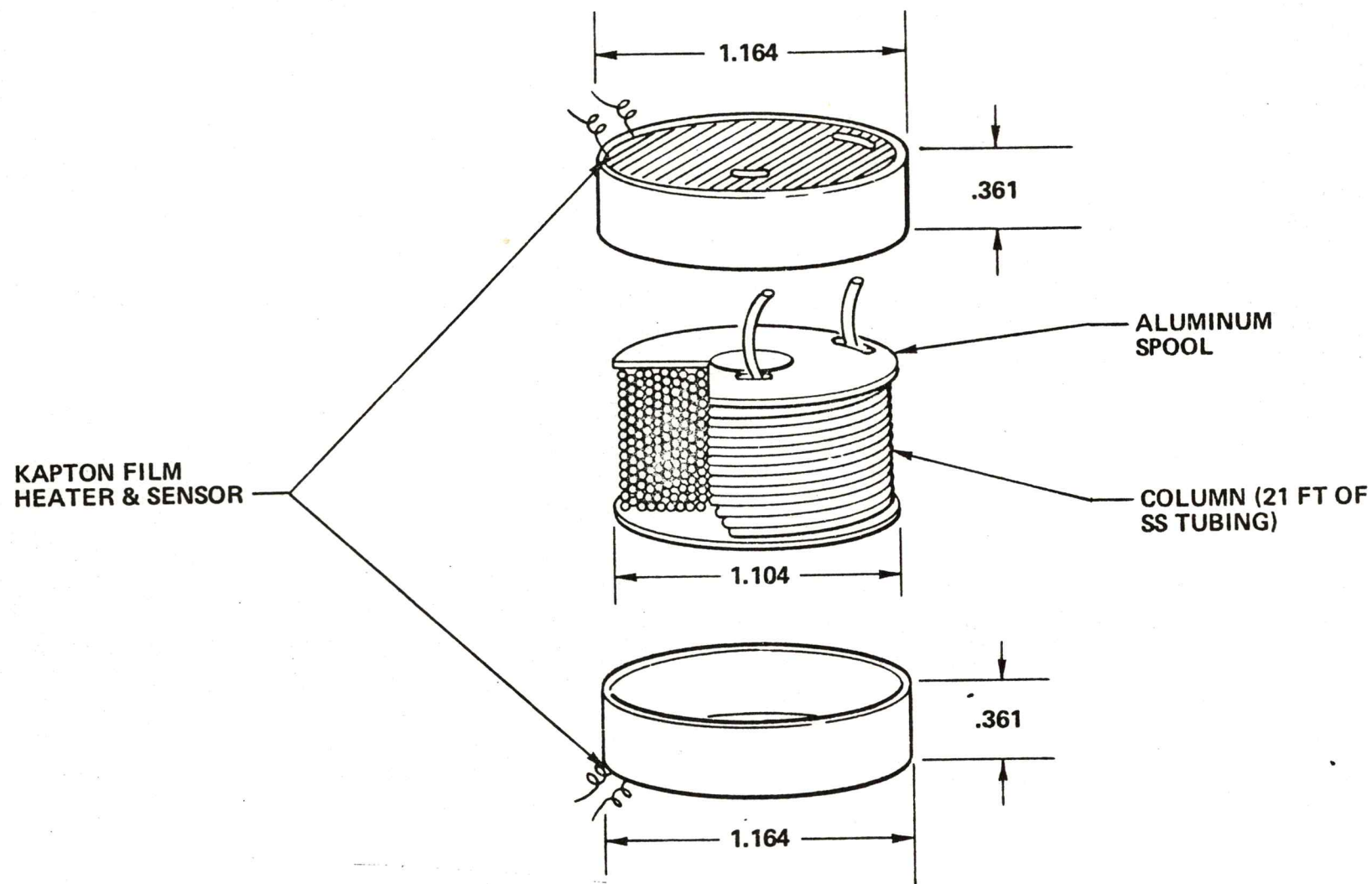
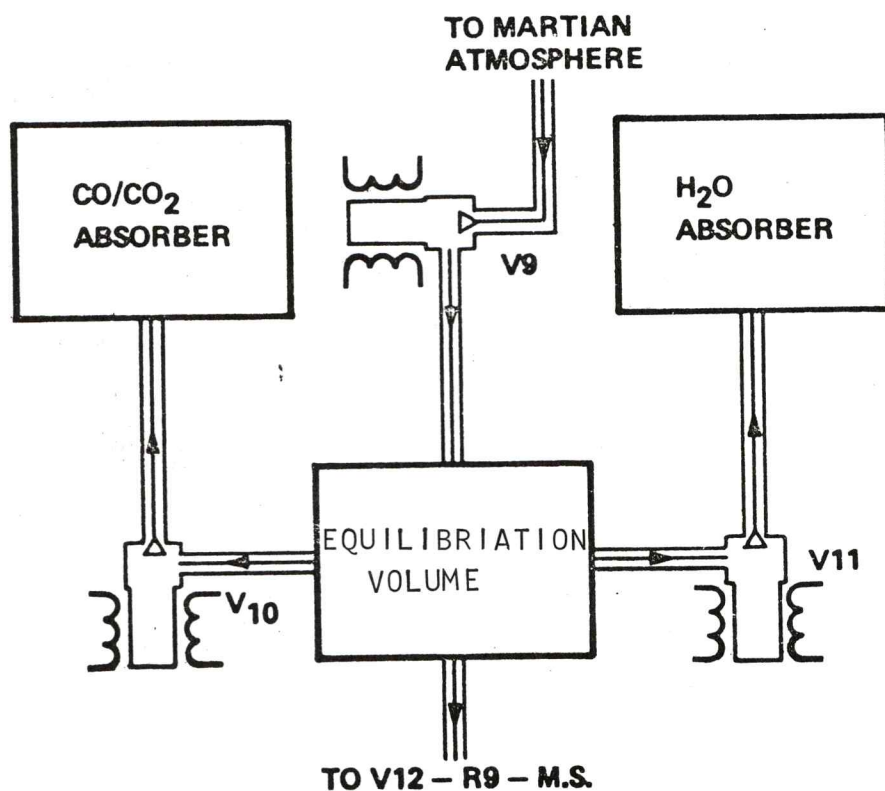


Figure 4.8.2.2-10 - GC COLUMN

GAS FLOW BLOCK DIAGRAM



VALVES ARE OPERATED INDEPENDENTLY	
V9 OPEN	ATMOSPHERE SAMPLE TO EQUILIBRIATION VOLUME
V12 OPEN	SAMPLE OF ATMOSPHERE DIRECTLY TO M.S.
V10 OPEN	ABSORBS CO ₂ AND CO FROM SAMPLE
V11 OPEN	ABSORBS H ₂ O FROM CO ₂ - CO REACTION
V12 OPEN	SAMPLE OF FILTERED ATMOSPHERE TO M.S.

Figure 4.8.2.2-11- ATMOSPHERIC FILTER ASSEMBLY (AFA)

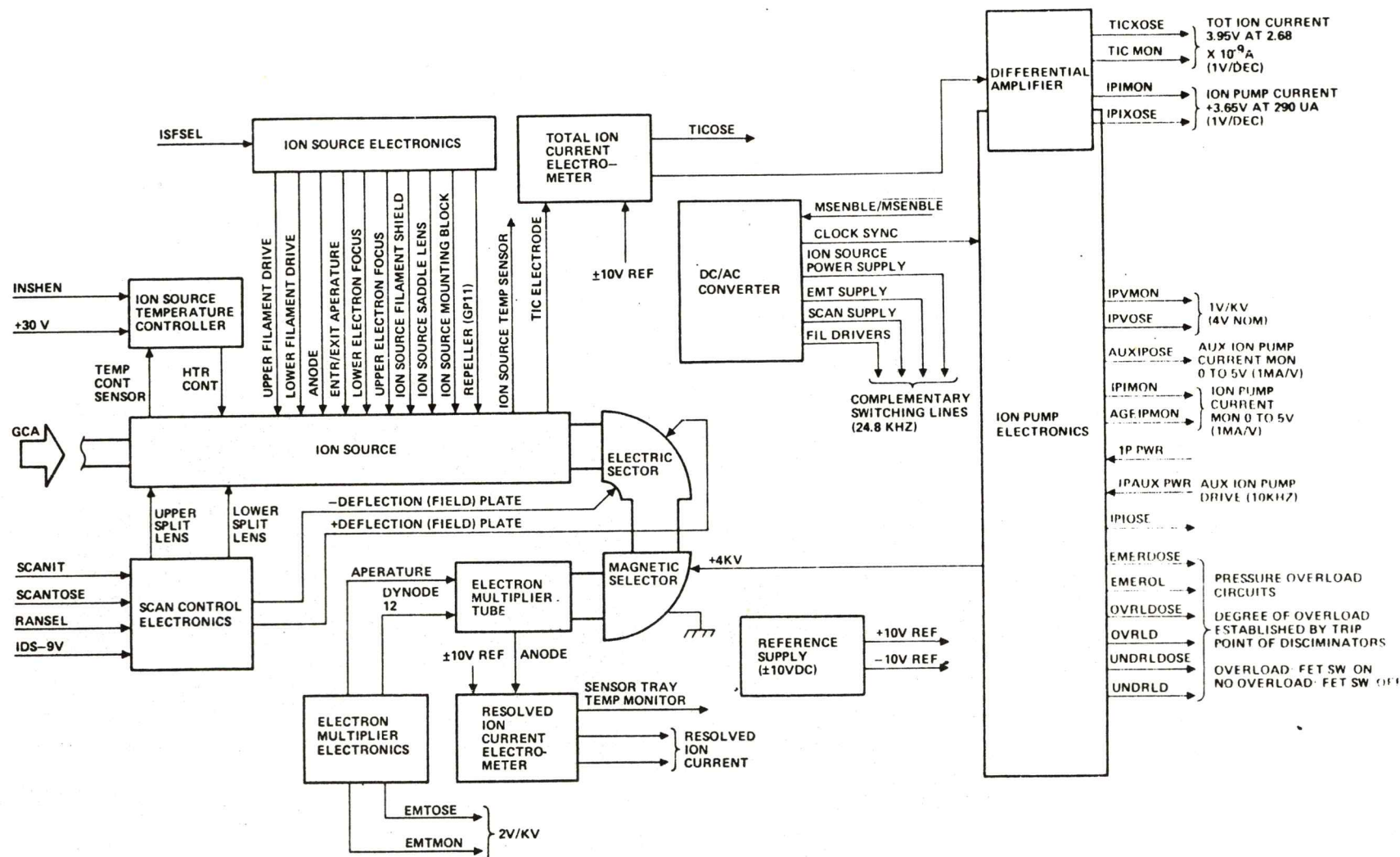


Figure 4.8.2.2-12 - MASS SPECTROMETER ASSEMBLY BLOCK DIAGRAM

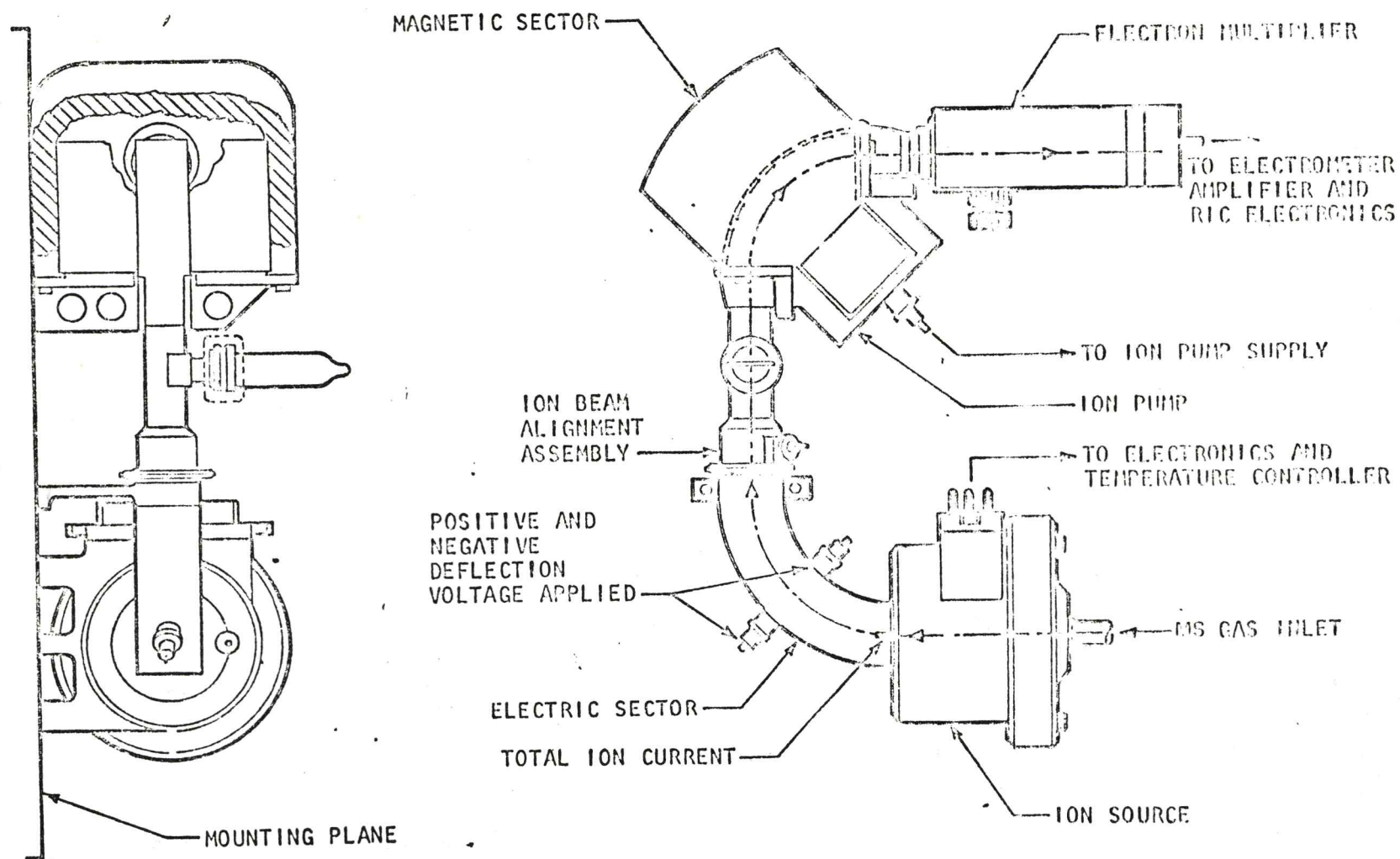


Figure 4.8.2.2-13 - Mass Spectrometer Analyzer

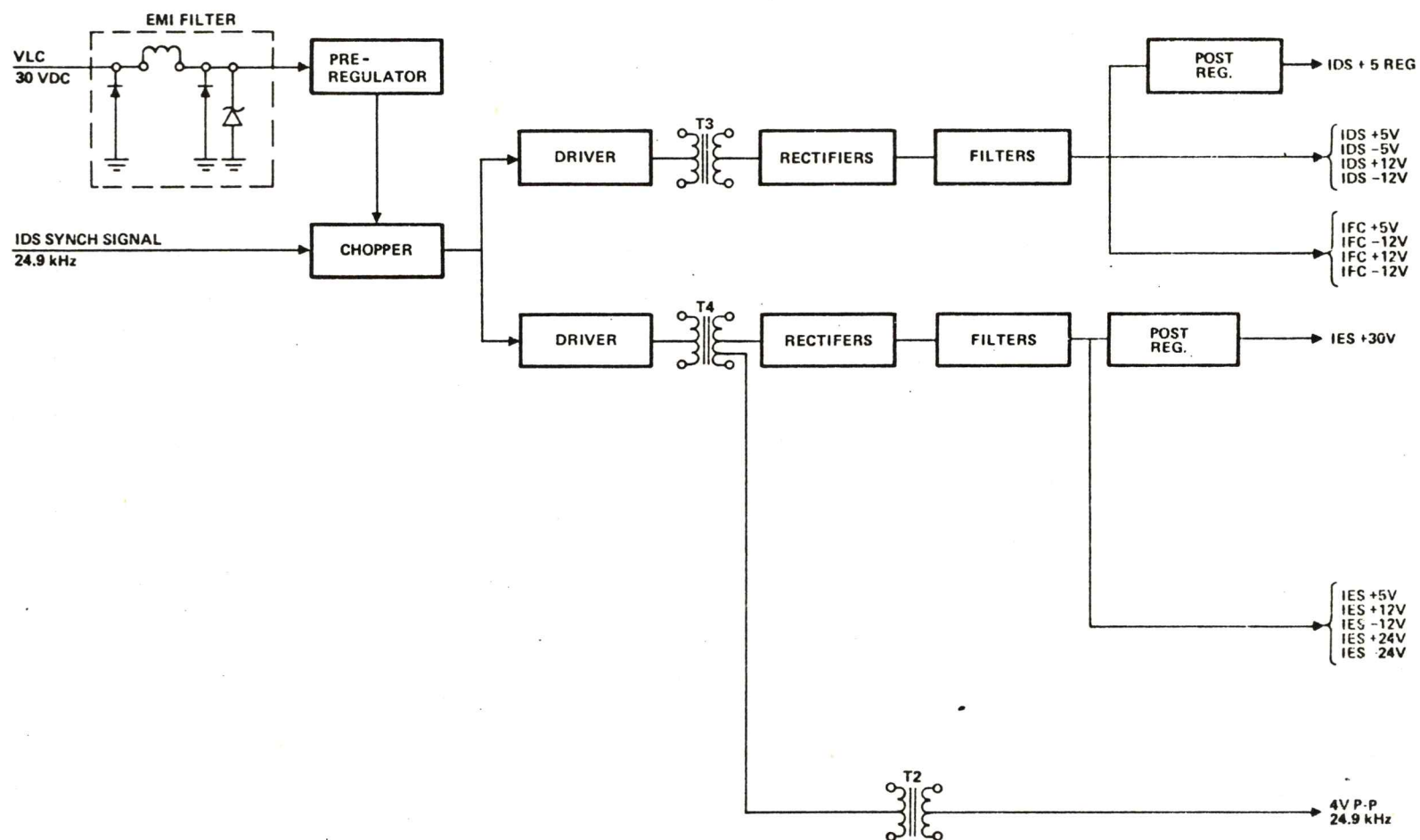


Figure 4.8.2.2-14 BLOCK DIAGRAM POWER CONDITIONING SUBSET

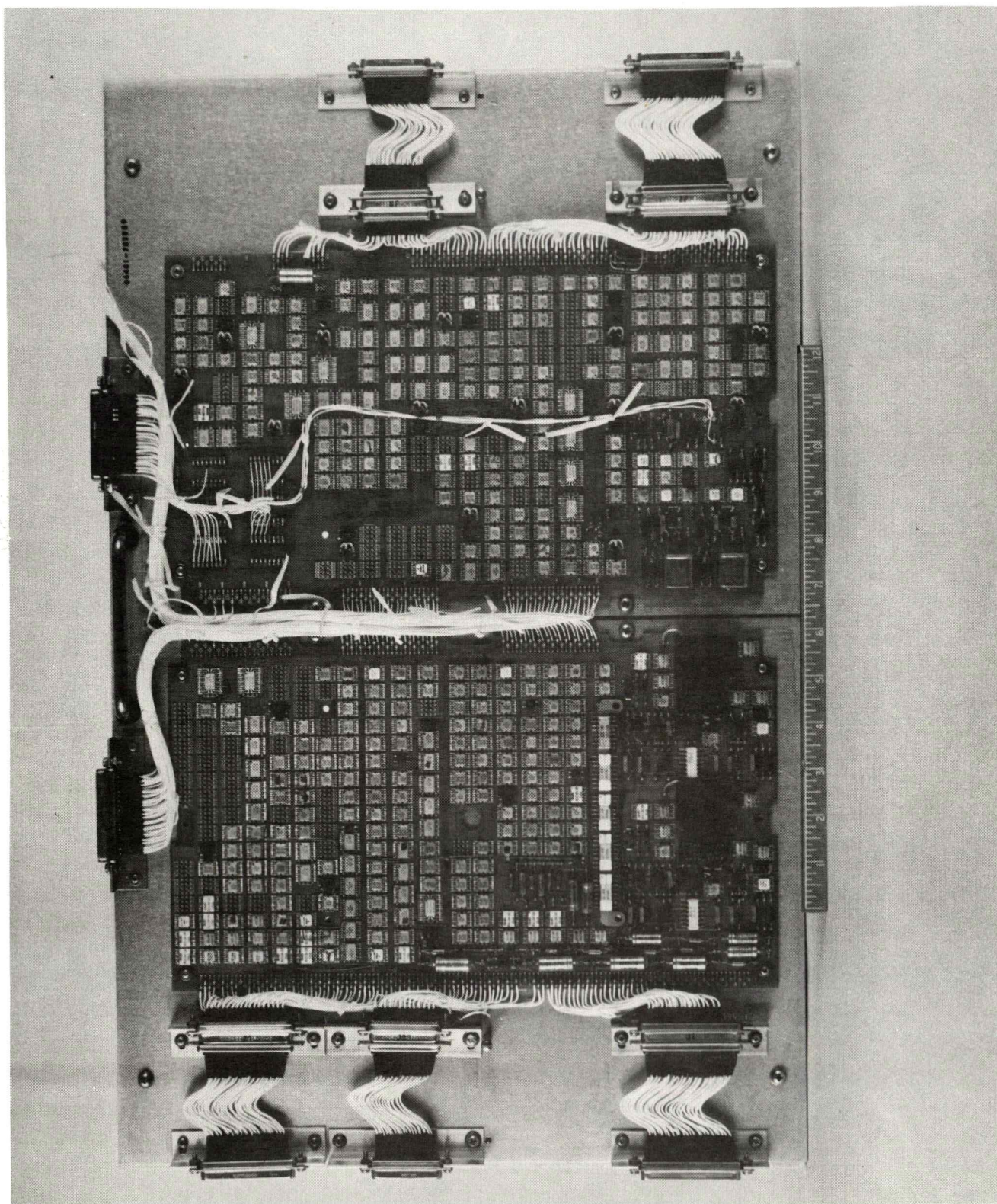


FIGURE 4.8.2.2-15 INSTRUMENT DATA SUBSYSTEM (IDS)

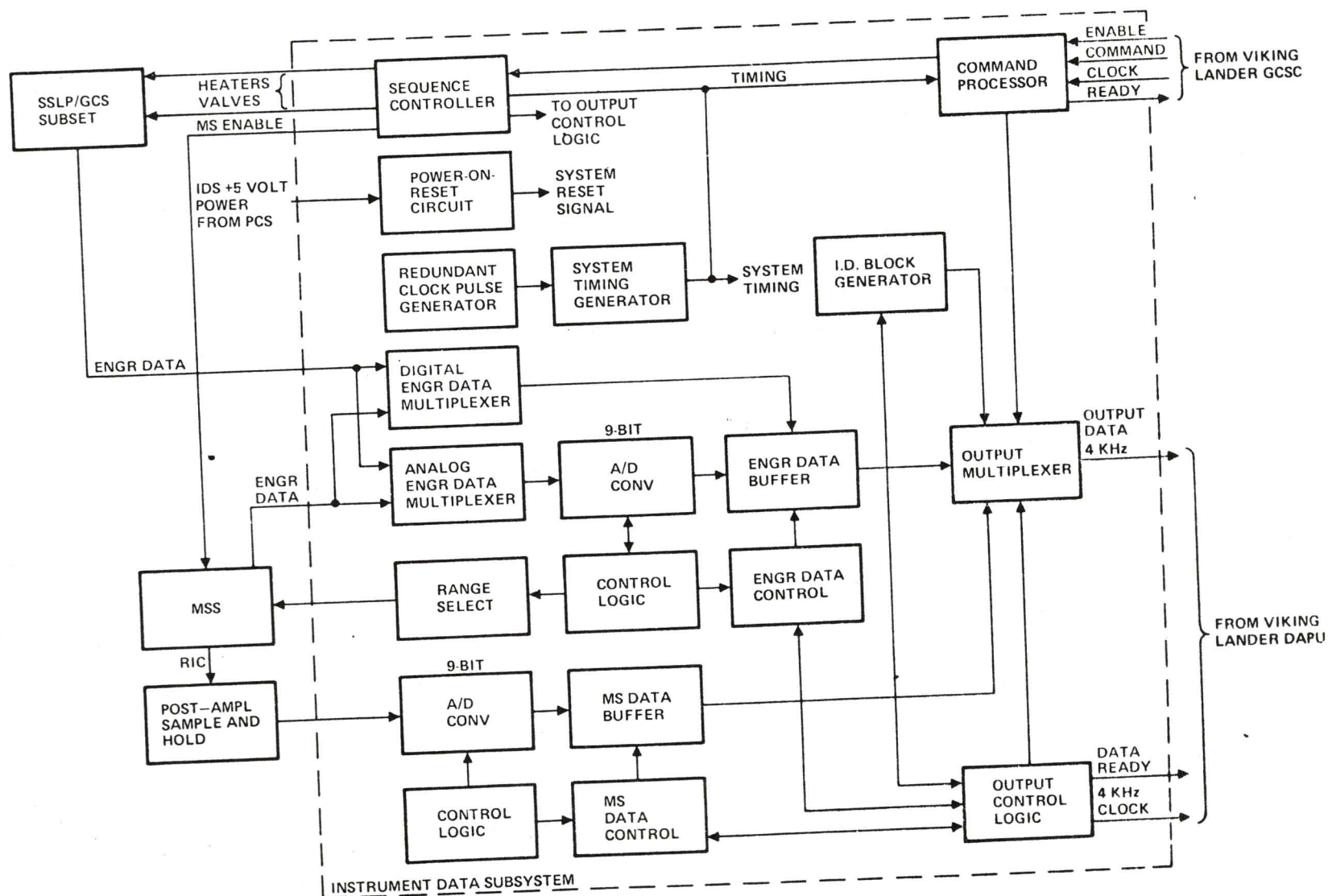


Figure 4.8.2.2-16 - IDS BLOCK DIAGRAM

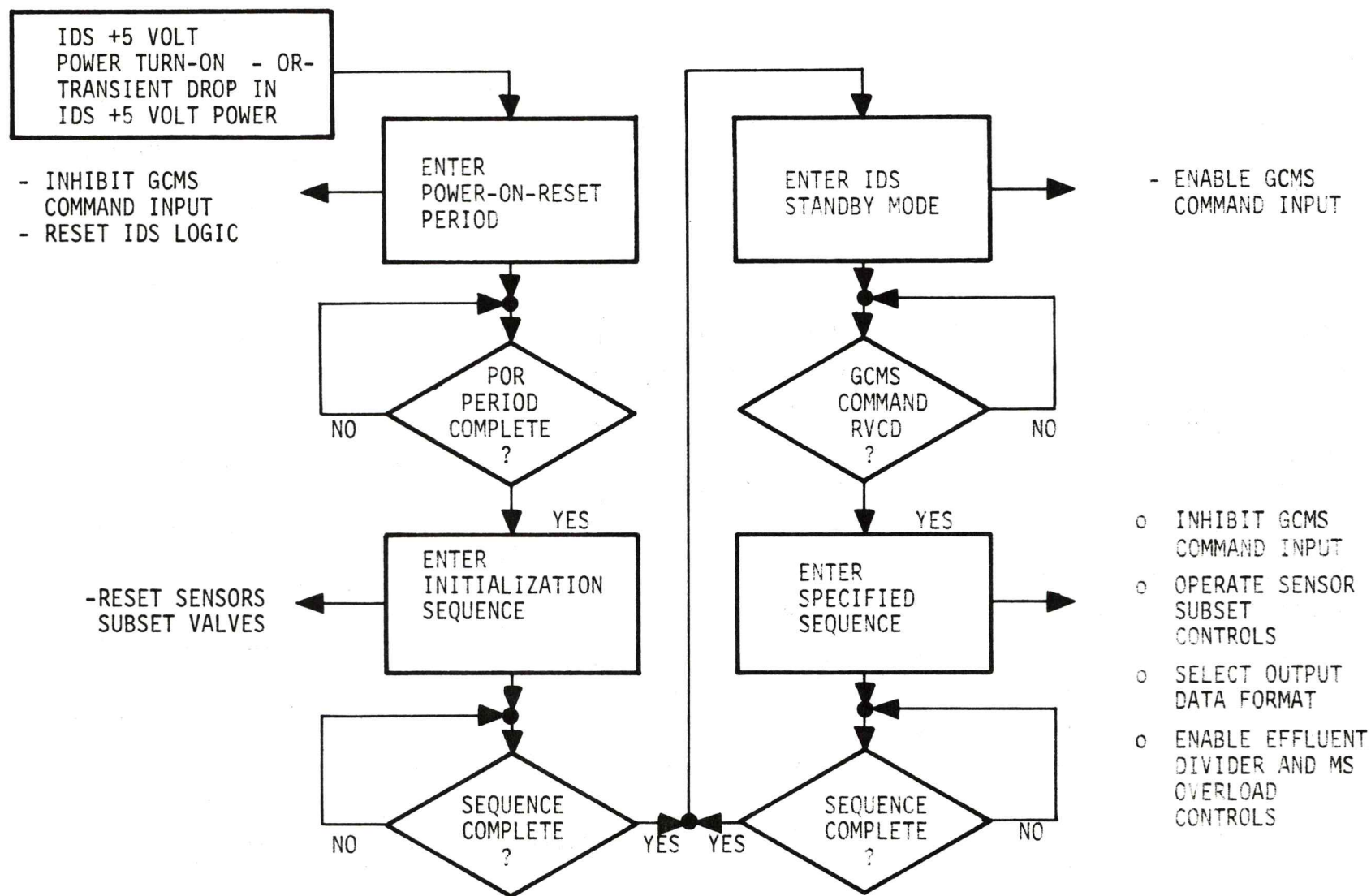
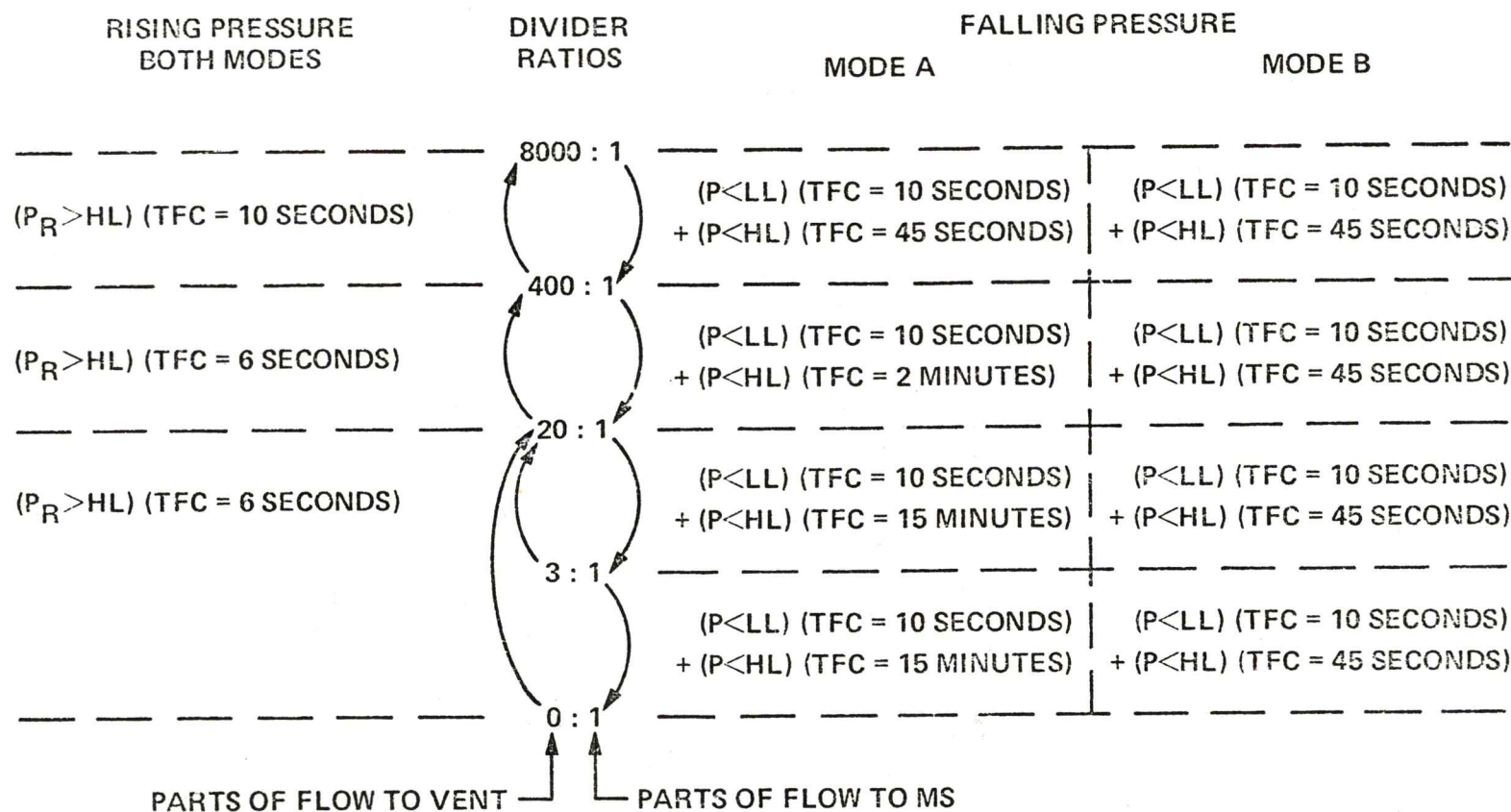


Figure 4.8.2.2-17 - CONTROL SYSTEM FLOW DIAGRAM - MASTER CONTROL ROUTINE



NOTES: P = PRESSURE IN MS ANALYZER
 P_R = PRESSURE + RATE OF INCREASE IN MS ANALYZER
 HL = OVERLOAD DISCRIMINATOR LEVEL
 LL = UNDERLOAD DISCRIMINATOR LEVEL
 TFC = TIME FILTER COUNT

NOTATION:
 X + Y = X OR Y
 (X) (Y) = X AND Y

Figure 4.8.2.2-18 - EFFLUENT DIVIDER CONTROL - LOGICAL RELATIONSHIPS

4.8.2.2.5 GCMS/VL INTERFACE

This section presents information on the GCMS/VL electrical and telemetry interfaces. See Figure 4.8.2.2-19 for the GCMS/VL interface block diagram. For more detail on the total GCMS/VL interface refer to ID-3703161, Viking Lander System to Gas Chromatograph Mass Spectrometer Interface Requirements Document.

a. Electrical Interface

The GCMS operates from VL unregulated 24 to 37 Vdc power during all instrument operations. This power is furnished by the VL via two separate lines, one for the various heaters (high current) including the pyrolysis ovens, the other for the remainder of the GCMS electronics (low current). The GCMS ion pump current and the GCMS emergency power are supplied on separate lines.

b. Command Interface

The GCMS operational modes and parameters are controlled by means of coded commands which are sent to the GCMS by the VL Guidance Control and Sequencing Computer (GCSC). The interface between the GCMS and the GCSC consist of two digital signals and two discrete signals. The digital signals consist of the data signal and the Shift Pulse signal.

1) Digital Signals

a) Data Signal

The coded command words consist of a 48 bit, PCH NRZ waveform, serial bit data stream transmitted as a differential output at 16 KBPS. The command format is as follows:

LAST BIT SENT
FROM GCSC

FIRST BIT SENT
FROM GCSC

48-----25 24 23 22 21 20 19 18 17-----1

FORMAT AS
DEFINED IN TABLE 4.8.2.2-1
"GCMS Command Structure"

0's

NOTE: Bit No. 25 as defined in Table 4.8.2.2-1 corresponds to Bit No. 01, and Bit 26 to 02 through 48 to 24, in Litton Document 7861-0112, Paragraph 3.3.2.1.1.

b) Shift Pulse Signal

The RZ waveform shift pulse signal is present only when data is being transferred from the GCSC to the GCNS. The pulse rate is at 16 KBPS. The phase relationship between the Shift Pulse and the Data Signal is as shown in Figure 4.8.2.2-20.

2) Discrete Signals

The discrete signals are the enable signal and the data ready signal.

a) Enable Signal

The Enable Signal is transmitted during transmission of the data word (command). The leading edge of the signal leads the first shift pulse indicating that a message is forthcoming. The trailing edge of the signal lags the final shift pulse and indicates that the message is complete and the command may be executed. The phase relationship with respect to shift pulses and data pulses are shown in Figure 4.8.2.2-20.

c. Data Interface

The VL Data Acquisition and Processor Unit (DAPU) accepts scientific and engineering data from the GCNS IDS during GCNS operational sequences preparatory to transmission to Earth. The GCNS provides the scientific and engineering data as a formatted digital bit train except in the case of the ion pump current measurement which is provided as both formatted digital bit train and a high level analog signal. The formatted data output is active whenever the GCNS is powered On.

1) High Level Analog Signal

The high level analog signal is available at all times that the ion pump power is applied and is sampled on a periodic basis. The ion pump current signal is sampled, formatted and interfaced with other VL data by the DAPU.

2) Formatted Digital Data

The transfer of formatted data from the GCNS to the DAPU is accomplished by the following signals:

- a) Data Ready (from GCNS to DAPU);
- b) Data Ready (from GCNS to GCSC);

- c) Data Shift Clock (from DAPU to GCMS);
- d) GCMS Data (from GCMS to DAPU).

(1) Data Ready Signal

The GCMS provides the data ready signal to indicate that the formatted digital message is available for transfer to the DAPU.

(2) Data Shift Clock Signal

A RZ, 4 KBPS, square wave data shift clock signal is provided by the DAPU to the GCMS IDS for shifting data out of the IDS buffer storage register. The data shift clock is present only when the Data Ready discrete signal from the GCMS is in the On state. The phase relationship between the data shift clock pulses and the GCMS data pulse is shown in Figure 4.8.2.2-21.

(3) GCMS Data Signal

One bit of NRZ digital data is shifted out of the GCMS buffer on each cycle of the shift clock signal as long as the data ready signal is On and recognized by the DAPU as shown in Figure 4.8.2.2-21. The first bit is present at the time the data ready signal is sent. The GCMS removes the data ready signal when the last bit to be transferred has been shifted out of the IDS buffer storage register.

(4) GCMS Data Format

Each data message from the GCMS starts with the 31 bit pseudorandom noise SYNC word followed by a 21 bit identifier. The first five bits identify the experiment. Bit six identifies the data format; bit seven the data mode; the next 10 bits give the scan frame count and the last four bits give the Mass Spectrometer data block count. IDS data formats are as shown in Figures 4.8.2.2-22 and 4.8.2.2-23.

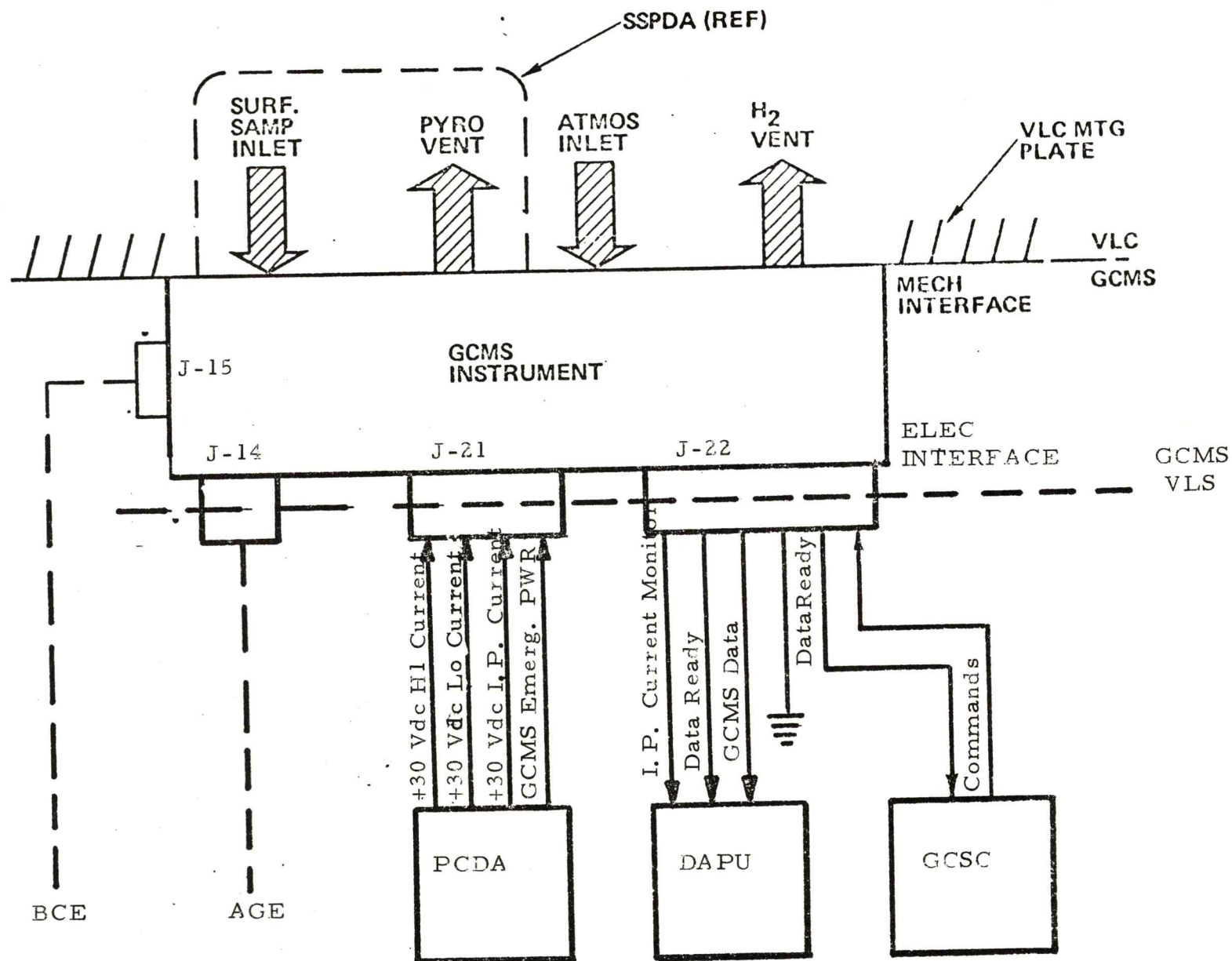


Figure 4.8.2.2-19 GCMS INTERFACE BLOCK DIAGRAM

TABLE 4.8.2.2-1 - GCMS COMMAND STRUCTURE-OPERATION SELECT CODES

COMMAND BIT NUMBER
SEE COMMAND FORMAT 4.8.2.2.5b

FUNCTION

25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

NO CONTROL OPERATIONSYSTEM VENT

VENT-IN-FLIGHT/GCA-AFA	0	0	0	0	0	0
OPEN PYROLYZER VENT VALVE V-13	0	0	0	0	1	0
CLOSE PYROLYZER VENT VALVE V-13	0	0	0	0	1	1
VENT-IN-FLIGHT/HSA	0	0	0	1	0	0

BIT 48 MUST BE SET TO 1

SYSTEM CONDITIONING

OPEN HYDROGEN GAS SUPPLY VALVE V-0	1	1	0	1	1	0
CONDITION GC COLUMN (SEE BAKEOUT SEQ)	0	0	0	1	0	1
CHECK SYSTEM GAS STATE	0	0	0	1	1	1
RESET SYSTEM VALVES -VL THRU V12	0	0	1	0	0	0

SEE PAGES 31 AND 32 FOR
PARAMETER SELECT CODES FOR BITS
31 THRU 48

ATMOSPHERIC SAMPLE PROCESSING

OPEN ATMOSPHERIC INLET VALVE V-9	0	0	1	0	0	1
CLOSE ATMOSPHERIC INLET VALVE V-9	0	0	1	0	1	0
OPEN CO/CO2 ABSORBER VALVE V-10	0	0	1	0	1	1
CLOSE CO/CO2 ABSORBER VALVE V-10	0	0	1	1	0	0
OPEN H2O ABSORBER VALVE V-11	0	0	1	1	0	1
CLOSE H2O ABSORBER VALVE V-11	0	0	1	1	1	0
ANALYZE ATMOSPHERIC SAMPLE S-8	0	0	1	1	1	1

SOIL SAMPLE PROCESSING

DUMP/UNSEAL SAMPLE OVEN	0	1	0	0	0	0
PREHEAT/UNSEAL/INDEX SAMPLE OVEN	0	1	0	0	0	1
LOAD/UNSEAL/INDEX/SEAL SAMPLE OVEN	0	1	0	0	1	0

ANALYZE ORGANIC SAMPLE-SHORT*	0	1	0	0	1	1
ANALYZE ORGANIC SAMPLE-MEDIUM*	0	1	0	1	0	0
ANALYZE ORGANIC SAMPLE-LONG*	0	1	0	1	0	1
ANALYZE ORGANIC SAMPLE-SHORT**	1	0	0	1	0	1
ANALYZE ORGANIC SAMPLE-MEDIUM**	1	0	0	1	1	0
ANALYZE ORGANIC SAMPLE-LONG**	1	0	0	1	1	1

*HYDROUS ** ANHYDROUS

(1) OVEN CARRIAGE TRANSFER POSITION FUNCTION WILL BE USED WITH SAMPLE OVEN FUNCTIONS ONLY

(2) MS OUTPUT GAIN AND ION SOURCE FILAMENT SELECT FUNCTIONS WILL BE USED WITH ANALYZE ORGANIC SAMPLE ONLY

TABLE 4.8.2.2-1 GCMS COMMAND STRUCTURE-OPERATION SELECT CODES - (Cont)

FUNCTION	COMMAND BIT NUMBER																							
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
<u>BACKUP PYROLYZER ASSEMBLY CONTROL</u>																								
OPEN OVEN SEAL CLAMP	0	1	0	1	1	0																		
CLOSE OVEN SEAL CLAMP (SEAL OVEN)	0	1	0	1	1	1																		
FORWARD INDEX OVEN CARRIAGE	0	1	1	0	0	0																		
TO TRANSFER POSITION																								
REVERSE INDEX OVEN CARRIAGE	0	1	1	0	0	1																		
TO TRANSFER POSITION																								
LOAD SAMPLE OVEN	0	1	1	0	1	0																		
DUMP EXCESS SAMPLE	0	1	1	0	1	1																		
PREHEAT SAMPLE OVEN	0	1	1	1	0	0																		
NO ACTION	0	1	1	1	0	1																		
GCMS VERIFICATION S-12	0	1	1	1	1	0																		
NO ACTION	0	1	1	1	1	1																		
ATMOSPHERIC SAMPLE/ENRICHMENT	1	0	0	1	0	0																		
NO ACTION	1	0	1	0	0	0																		
INDEX OVEN CARRIAGE TO POSITION 1	1	0	1	0	0	1																		
INDEX OVEN CARRIAGE TO POSITION 2	1	0	1	0	1	0																		
INDEX OVEN CARRIAGE TO POSITION 3	1	0	1	0	1	1																		
INDEX OVEN CARRIAGE TO POSITION 4	1	0	1	1	0	0																		
INDEX OVEN CARRIAGE TO POSITION 5	1	0	1	1	0	1																		
INDEX OVEN CARRIAGE TO POSITION 6	1	0	1	1	1	0																		
INDEX OVEN CARRIAGE TO POSITION 7	1	0	1	1	1	1																		
NO ACTION	1	1	0	0	0	0																		
NO ACTION	1	1	0	0	0	1																		
NO ACTION	1	1	0	0	1	0																		
NO ACTION	1	1	0	0	1	1																		
NO ACTION	1	1	0	1	0	0																		
NO ACTION	1	1	0	1	1	1																		
NO ACTION	1	1	0	1	1	1																		
VENT-IN-FLIGHT/MSA	1	1	1	0	0	0																		

SEE PAGES 31 AND 32 FOR
PARAMETER SELECT CODES FOR
BITS 31 THRU 48

TABLE 4.8.2.2-1 - GCMS COMMAND STRUCTURE - PARAMETER SELECT CODES (Cont)

<u>FUNCTION</u>	COMMAND BIT NUMBER															
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
NO ACTION	1	1	1	0	0	1										
NO ACTION	1	1	1	0	1	0										
NO ACTION	1	1	1	1	1	1										
NO ACTION	1	1	1	1	0	0										
NO ACTION	1	1	1	1	0	1										
NO ACTION	1	1	1	1	1	0										
NO ACTION	1	1	1	1	1	1										
BAKE-OUT-IN-FLIGHT CLASS 2	1	0	0	0	0	0										
BAKE-OUT-IN-FLIGHT CLASS 3	1	0	0	0	0	1										
BAKE-OUT-IN-FLIGHT CLASS 4	1	0	0	0	1	0										
SAMPLE UNIT ATMOSPHERIC	1	0	0	0	1	1										
BAKE-OUT-IN-FLIGHT CLASS 1	0	0	0	1	1	0										

SEE PAGES 31 AND 32 FOR
PARAMETER SELECT CODES FOR
BITS 31 THRU 48

TABLE 4.8.2.2-1 - GCMS COMMAND STRUCTURE - PARAMETER SELECT CODES (Cont)

FUNCTION	COMMAND BIT NUMBER																							
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
<u>OVEN SEAL CLAMP POSITION CHECK</u>																								
DEFEAT CHECK								0	0															
DEFEAT CHECK								0	1															
CHECK FOR CLOSED POSITION								1	0															
CHECK FOR OPEN POSITION								1	1															
<u>OVEN CARRIAGE POSITION CHECK</u>																								
DEFEAT CHECK								0	0	0														
CHECK FOR POSITION - 1								0	0	1														
CHECK FOR POSITION - 2								0	1	0														
CHECK FOR POSITION - 3								0	1	1														
CHECK FOR POSITION - 4								1	0	0														
CHECK FOR POSITION - 5								1	0	1														
CHECK FOR POSITION - 6								1	1	0														
CHECK FOR POSITION - 7								1	1	1														
<u>OVEN CARRIAGE TRANSFER POSITION</u>																								
UNDEFINED																0	0	0						
TRANSFER TO POSITION - 1																0	0	1						
TRANSFER TO POSITION - 2																0	1	0						
TRANSFER TO POSITION - 3																0	1	1						
1)**TRANSFER TO POSITION - 4																1	0	0						
TRANSFER TO POSITION - 5																1	0	1						
TRANSFER TO POSITION - 6																1	1	0						
TRANSFER TO POSITION -7																1	1	1						
<u>MS OUTPUT GAIN SELECT</u>																								
MAXIMUM																0	0							
2)** NOMINAL																0	1							
INTERMEDIATE																1	0							
UNDEFINED																1	1							
<u>ION SOURCE FILAMENT SELECT</u>																								
FILAMENT NO. 2																		0						
FILAMENT NO. 1																		1						

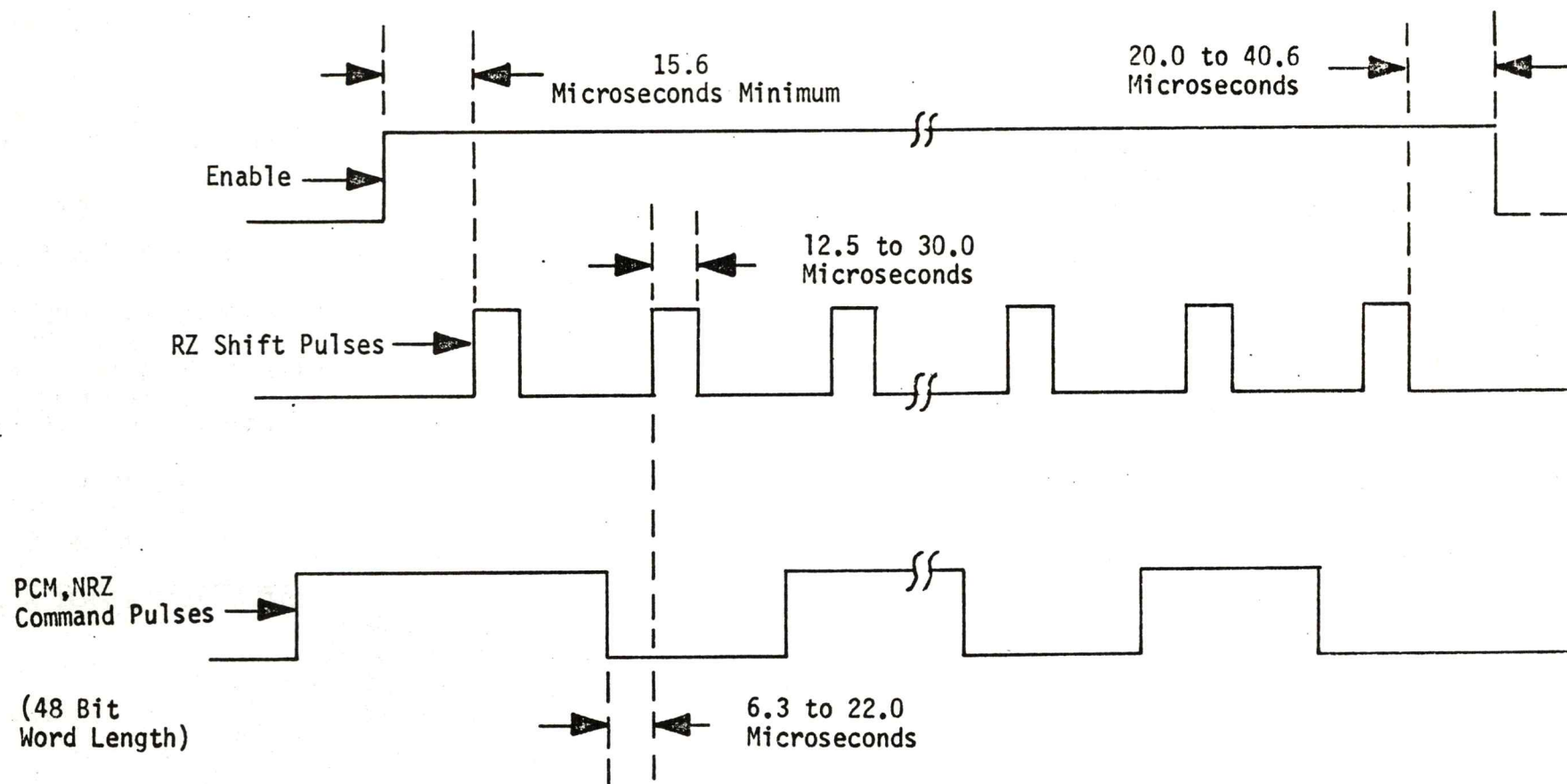
(1) OVEN CARRIAGE TRANSFER POSITION FUNCTION WILL BE USED WITH SAMPLE OVEN FUNCTIONS ONLY (**SEE SOIL SAMPLE PROCESSING).

(2) MS OUTPUT GAIN & ION SOURCE FILAMENT SELECT FUNCTIONS WILL BE USED WITH ANALYZE ORGANIC SAMPLE ONLY.

TABLE 4.8.2.2-1 - GCMS COMMAND STRUCTURE - PARAMETER SELECT CODES (Cont)

		COMMAND BIT NUMBER																								
FUNCTION		25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	
SEE COMMAND FORMAT 4.8.2.2.5b																										
<u>ION BEAM VOLTAGE SELECT</u>																										
70	ELECTRON VOLTS																								0	
45	ELECTRON VOLTS																								1	
<u>OVEN SELECT</u>																										
	NONE																								0	0
	OVEN - 1																								0	1
	OVEN - 2																								1	0
																									1	1
	SEE PAGES 28, 29																									
	AND 30 FOR																									
	OPERATION SELECT CODES																									
	FOR BITS 25 THRU 30																									
<u>OVEN TEMPERATURE SELECT</u>																										
50	DEGREES C.																								0	0
200	DEGREES C.																								1	1
350	DEGREES C.																								1	0
500	DEGREES C.																								1	1
<u>OUTPUT DATA RATE SELECT</u>																										
SEND EVERY	SCAN																								0	0
SEND EVERY	SECOND SCAN																								0	0
SEND EVERY	FOURTH SCAN																								1	1
SEND EVERY	EIGHTH SCAN																								1	1
<u>INSTRUMENT DATA MODE SELECT</u>																										
	NORMAL																									0
	BACKUP																									1
<u>INSTRUMENT CONTROL MODE SELECT</u>																										
	NO ACTION																									0
	NO ACTION																									1
<u>SPARE BIT</u>																										
	NO ACTION																									0
	VENT-IN-FLIGHT/HSA (INHIBIT VI)																									1

WHERE NO PARAMETER SELECT CODE
BITS ARE SHOWN OR SELECTED,
0s ARE TO BE USED



- 1) Power can be Turned on Receiving Circuit with Leading Edge of Enable
- 2) Signals are Current Mode Differential
- 3) Bit No. 1 Command Pulse will be present Prior to Enable "High" Level

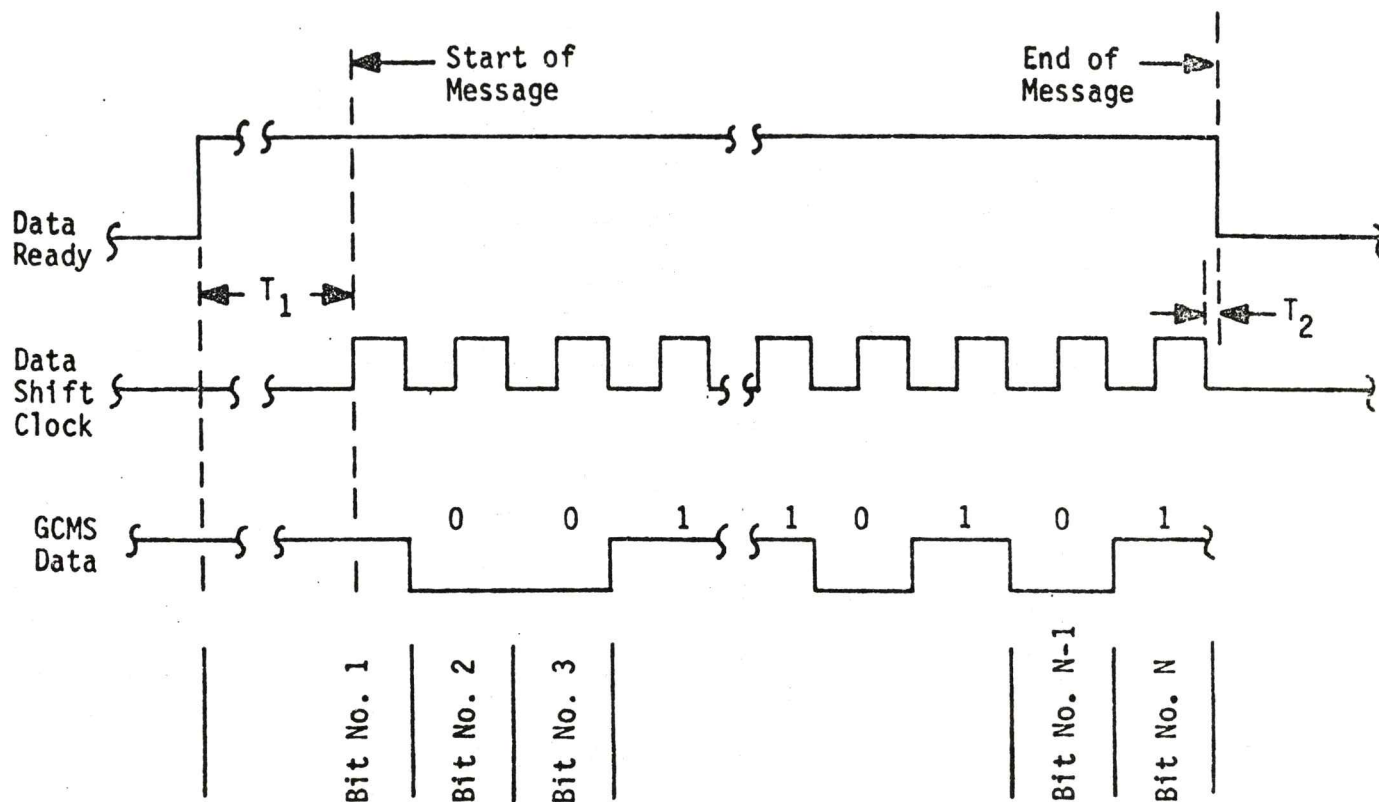
Figure 4.8.2.2-20 - Phase Relation Requirement of Command Pulses

T_1 (Minimum) = Zero Time

T_1 (Maximum) = 310 Milliseconds (This Max. Time may be exceeded one time during an analysis to a max. of 1 second in addition to constraints in para. 3.2.9.4)

T_2 (Maximum) = 0 to 30 Microseconds

Data Shift Clock Duty Cycle = 50% \pm 1%



- Notes:
- 1) Bit No. 1 Data Level shall be Present when the Ready Line "High" Level is Initiated by the GCMS
 - 2) Data Level shall Change with the Falling Edge of the Data Shift Clock Signal
 - 3) The propagation delay between the data shift clock signal into the GCMS and the GCMS data output shall not exceed 40 microseconds. This is the delay from the time when shift pulse signal changes from "ON" to "OFF" state to the time when the data signal changes state, either direction.
 - 4) Signals are Current Mode Differential.
 - 5) N = Total Number of Bits in Message.

Figure 4.8.2.2-21 - Data Interface Characteristics

ENGR. DATA WORD GROUP	DIGITAL SUBCOM WORD				ANALOG SUBCOM WORD
01.	0103 VALVE V0 STATUS	0103 VALVE V1 STATUS	0103 VALVE 2 STATUS	0103 VALVE V3 STATUS	0104 H ₂ PRESSURE
02.	0203 VALVE V7 STATUS	0203 SPARE	0203 VALVE V9 STATUS	0203 VALVE V10 STATUS	0204 SAMPLE INLET TEMPERATURE
03.	0303 VALVE V11 STATUS	0303 VALVE V12 STATUS	0303 VALVE V13 STATUS	0303 IDS OSCILL. STATUS	0304 THERMAL ZONE TEMPERATURE
04.	0403 EMERGENCY OVER- LOAD DISCRIMIN- ATOR STATUS	0403 OVERLOAD DIS- CRIMINATOR STATUS	0403 UNDERLOAD DISCRIMINATOR STATUS	0403 SPARE	0404 OVEN OUTLET LINE TEMP- ERATURE
05.	0503 OVEN SEAL CLAMP OPEN STATUS	0503 OVEN SEAL CLAMP CLOSED STATUS	0503 OVEN TEMP SENSOR STATUS	0503 SPARE	0504 G.C. COLUMN TEMPERATURE
06.	0603 OVEN CARRIAGE POSITION BIT-1	0603 OVEN CARRIAGE POSITION BIT-2	0603 OVEN CARRIAGE POSITION BIT-3	0603 CARRIAGE POSITION STATUS PROBE	0604 SEPARATOR BIAS CURRENT
07.	0703 OVEN TIME-TO- TEMP BIT-1	0703 OVEN TIME-TO- TEMP BIT-2	0703 OVEN TIME-TO- TEMP BIT-3	0703 OVEN TIME-TO- TEMP BIT-4	0704 ION SOURCE TEMPERATURE
08.	0803 SPARE	0803 SPARE	0803 SPARE	0803 SPARE	0804 SENSOR TRAY TEMPERATURE
09.	0903 SPARE	0903 SPARE	0903 SPARE	0903 SPARE	0904 ION PUMP HIGH VOLTAGE
10.	1003 SPARE	1003 SPARE	1003 SPARE	1003 SPARE	1004- EMT HIGH VOLTAGE
11.	1103 CODED COMMAND WORD BIT 1	1103 CODED COMMAND WORD BIT 2	1103 CODED COMMAND WORD BIT 3	1103 CODED COMMAND WORD BIT 4	1104 ENGR. A/D CONVERTER CALI- BRATE

Figure 4.8.2.2-23 - Engineering Data Subcommutated Words

ENGR. DATA WORD GROUP		DIGITAL SUBCOM, WORD				ANALOG SUBCOM WORD	
12.	1203 CODED COMMAND WORD BIT-5	1203 CODED COMMAND WORD BIT-6	1203 CODED COMMAND WORD BIT-7	1203 CODED COMMAND WORD BIT-8	1204 SPARE		
13.	1303 CODED COMMAND WORD BIT-9	1303 CODED COMMAND WORD BIT-10	1303 CODED COMMAND WORD BIT-11	1303 CODED COMMAND WORD BIT-12	1304 SPARE		
14.	1403 CODED COMMAND WORD BIT-13	1403 CODED COMMAND WORD BIT-14	1403 CODED COMMAND WORD BIT-15	1403 CODED COMMAND WORD BIT-16	1404 SPARE		
15.	1503 CODED COMMAND WORD BIT-17	1503 CODED COMMAND WORD BIT-18	1503 CODED COMMAND WORD BIT-19	1503 CODED COMMAND WORD BIT-20	1504 SPARE		
16.	1603 CODED COMMAND WORD BIT-21	1603 CODED COMMAND WORD BIT-22	1603 CODED COMMAND WORD BIT-23	1603 CODED COMMAND WORD BIT-24	1604 SPARE		
	1 BIT	1 BIT	1 BIT	1 BIT	9 BITS		

FIGURE 4.8.2.2-23 ENGINEERING DATA SUBCOMMUTATED WORDS

4.8.2.2.6 POWER REQUIREMENTS

a. Power Consumption

Profiles for the power consumed during the GCNS operating sequences planned during Cruise are shown in Figures 4.8.2.2-24 through 4.8.2.2-31.

b. GCNS Ion Pump

The GCNS ion pump power consumption during analysis periods will not exceed two watts average and 10 watt peak.

c. GCNS Emergency Power

Any time the voltage on the experiment bus drops below 21 volts for a period of one millisecond or longer, the GCSC removes power from the GCNS within six minutes. At the time the power is removed the VL provides, on the emergency interface circuit, an emergency power pulse. The pulse is used as both the command and power for the instrument to reset to the safe status.

4.8.2.2.7 MISSION SOFTWARE

This section contains a brief description of how the TLMP, DECSET, HFILE and ATHORG programs are used for handling and reduction of GCNS data.

a. TLMP

All ground received data are sent to Viking Mission Control and Computing Center (VMCCC) where the first step in data processing is performed by TLMP. For GCNS data, TLMP has no decalibration functions, but simply identifies GCNS frames and places these into a System Data Record (SDR) for DECSET.

b. DECSET

For GCNS data, DECSET performs two operations. First, it inputs the SDR from TLMP and separates the GCNS data from all other types of data; secondly, it time tags the data and formats the data into a GCNS data file.

c. HFILE

Both TLMP and DECSET operate on the IBM 360/75, whereas ATHORG is programmed to run on the UNIVAC 1108. Thus, there is a need to transfer the GCNS data files output by DECSET from the 360 to the 1108 so that ATHORG may input and process them. This function is provided by a program called HFILE.

d. ATHORG

ATHORG receives the GCHS data files and begins the final step in processing. ATHORG is divided into three major portions: main processor, engineering executive, and science executive with functions of initialization and program control, processing of engineering data, and processing of mass scan data respectively.

The main processor first determines if the data to be processed are atmospheric or organic. This obviously important function is accomplished by comparing the GCSC times associated with the analysis against a list of those items known to correspond to atmospheric and organic experiments. Then, after inputting the data base parameters pertaining to the type of analysis, the main processor outputs various descriptive information concerning the data and passes control to the engineering executive.

The engineering executive, as its name implies, decalibrates the data into engineering units, prints and plots the data, and checks for measurements exceeding alarm limits. For an organic analysis, the engineering executive additionally creates a gas chromatogram and effluent divider status. These functions complete, control is returned to the main processor, where, if designated by user input, an LTENP data file (ATTENP or ORTENP) is generated and output. Control then passes to the science executive.

The science executive begins processing the mass scan data by calculating the mass spectra in the form of mass number versus intensity. The type of analysis then dictates which of the following two courses of action is taken. For an atmospheric analysis, the science executive processes the mass spectra by:

- 1) Averaging the intensities at equal mass numbers for background and gas sample scans.
- 2) Producing standard deviations for the average spectra.
- 3) Correcting the averaged gas sample scan by subtracting the averaged background scan intensities at equal mass numbers.
- 4) Calculating the relative abundances of Carbon Dioxide, Carbon Monoxide, Argon, Nitrogen, Oxygen, water vapor, Neon, Krypton, Xenon and others.

For an organic analysis, the science executive processes the mass spectra by:

- 1) Calculating the sum of intensities for each scan number.
- 2) Generating mass chromatograms.

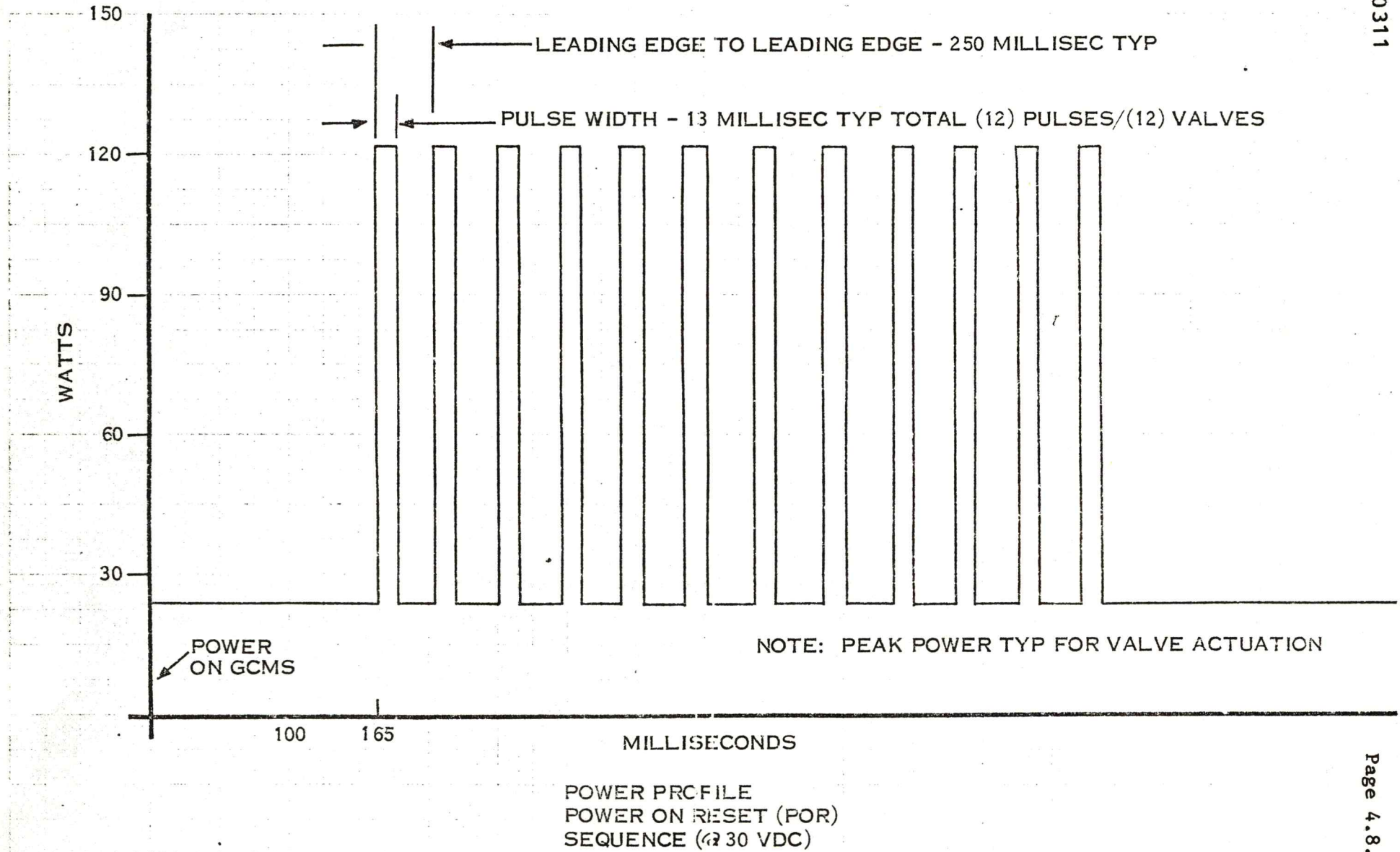


Figure 4.8.2.2-24

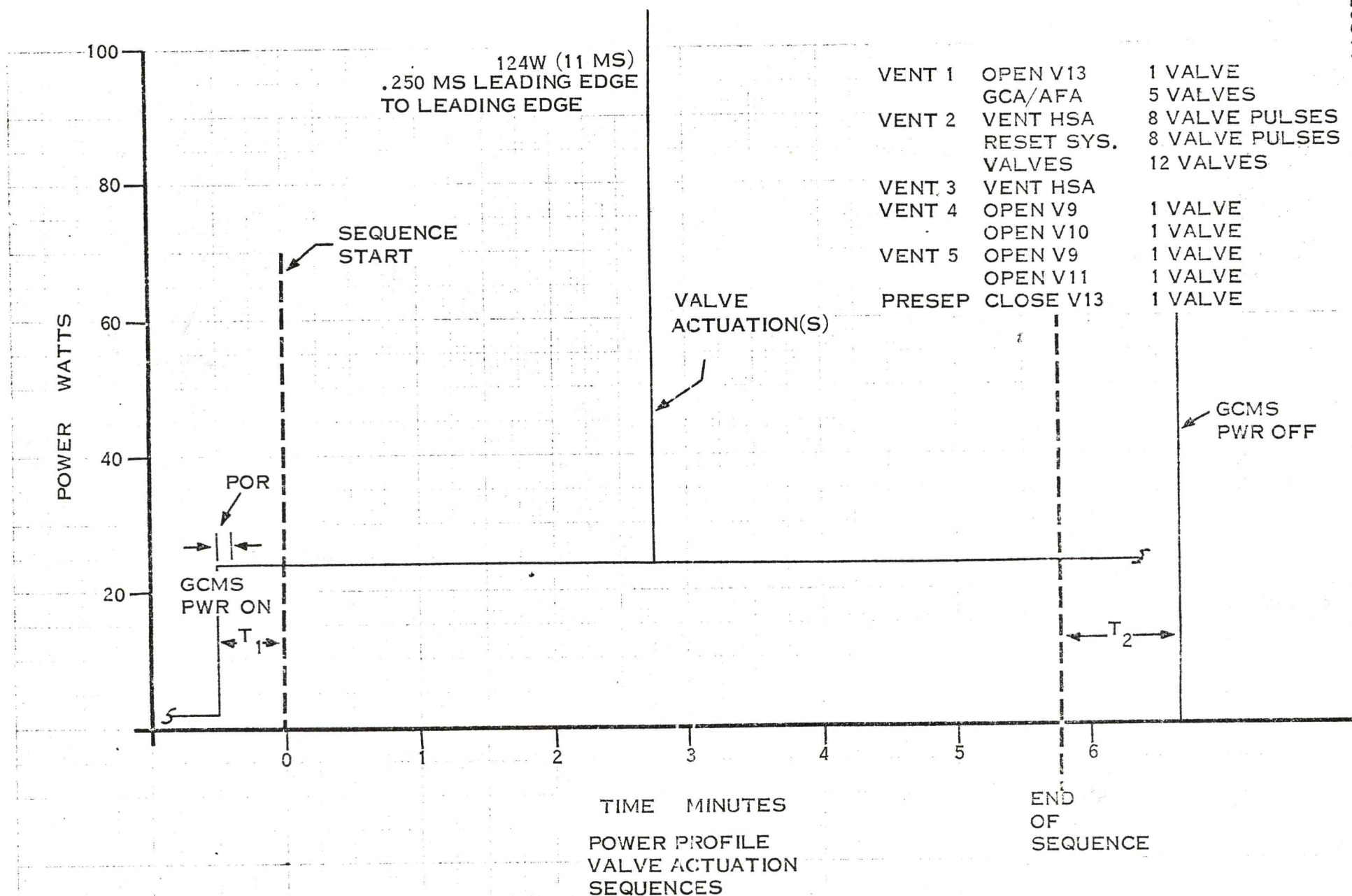


Figure 4.8.2.2-25

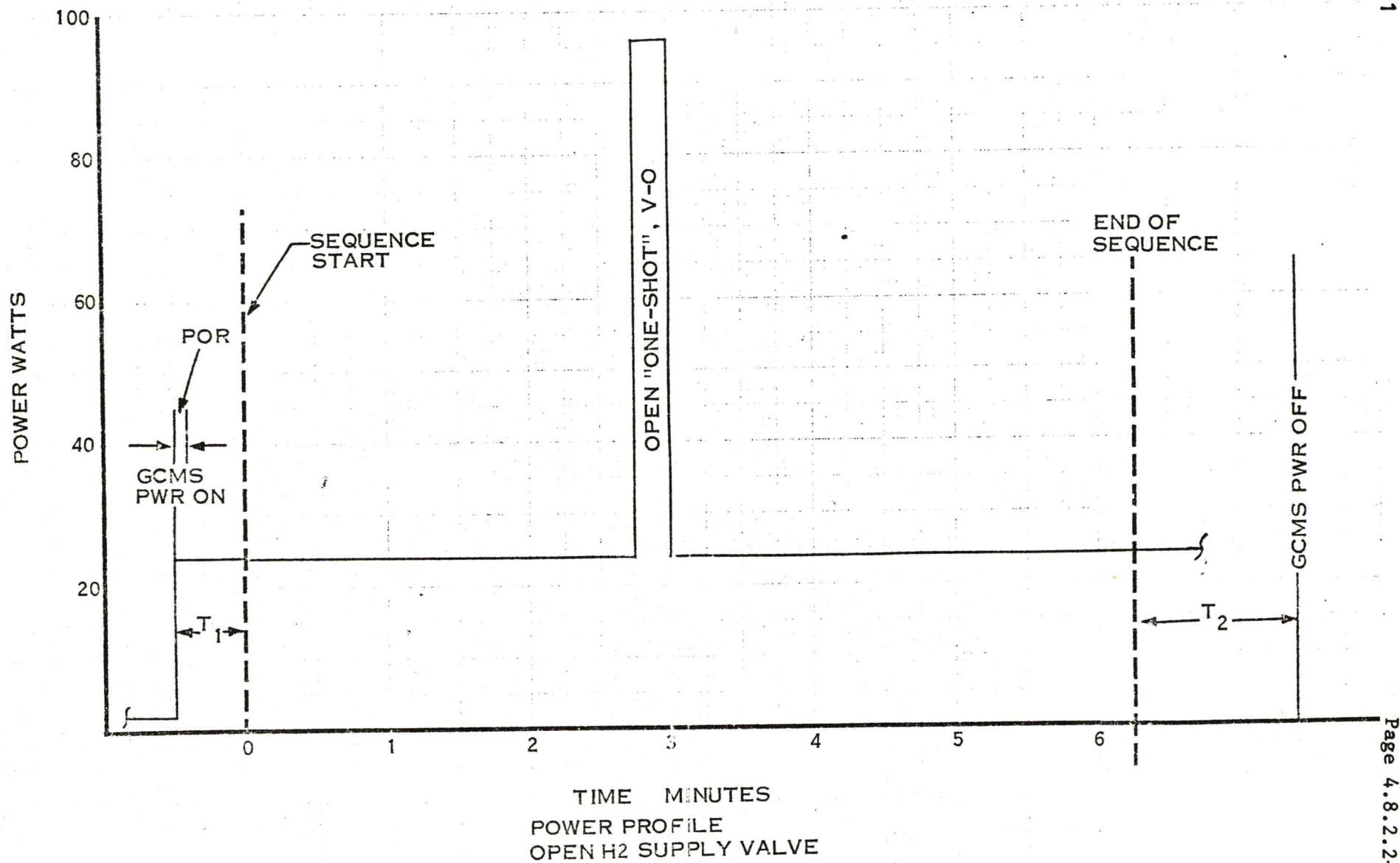


Figure 4.8.2.2-26

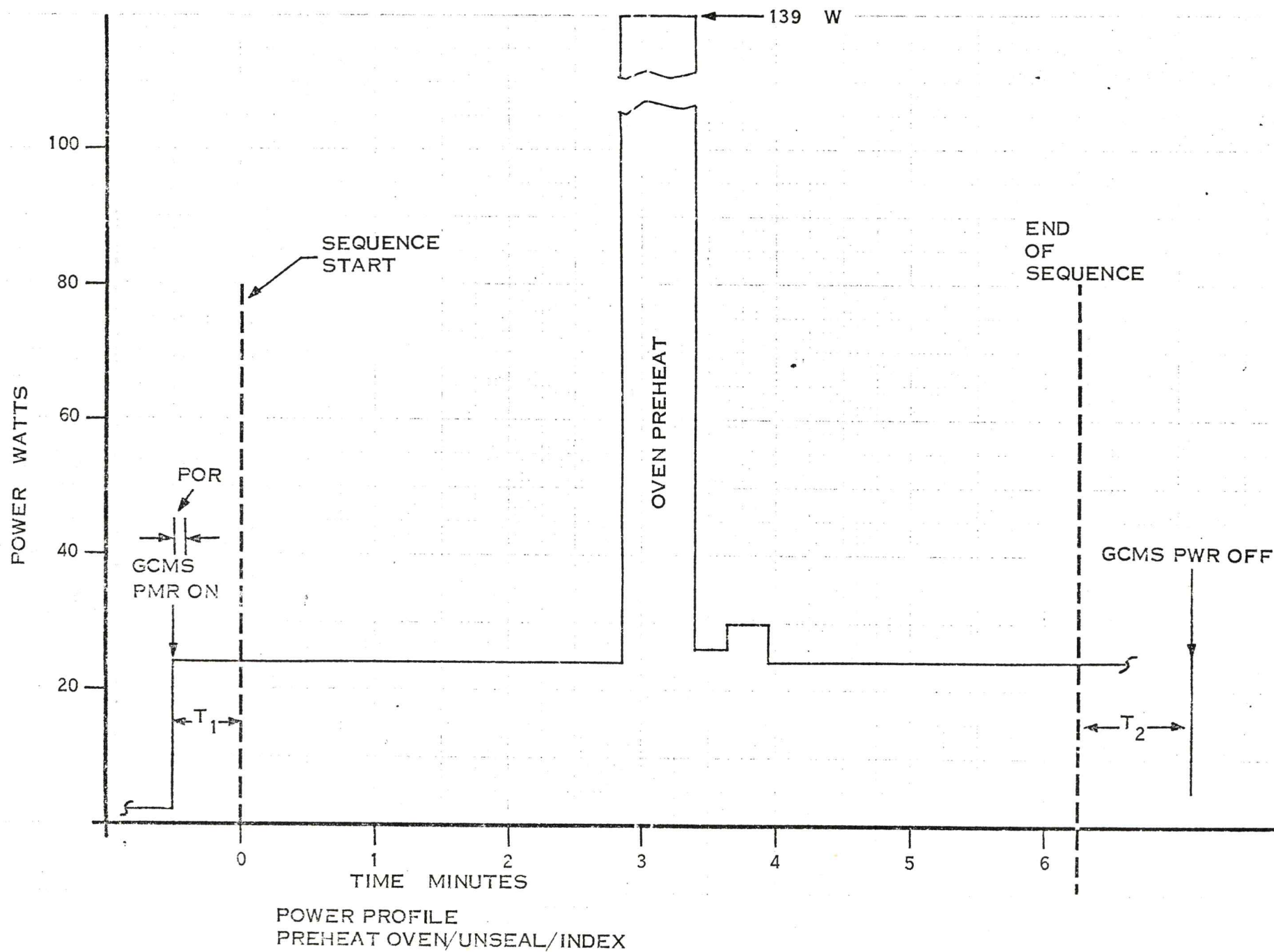


Figure 4.8.2.2-27

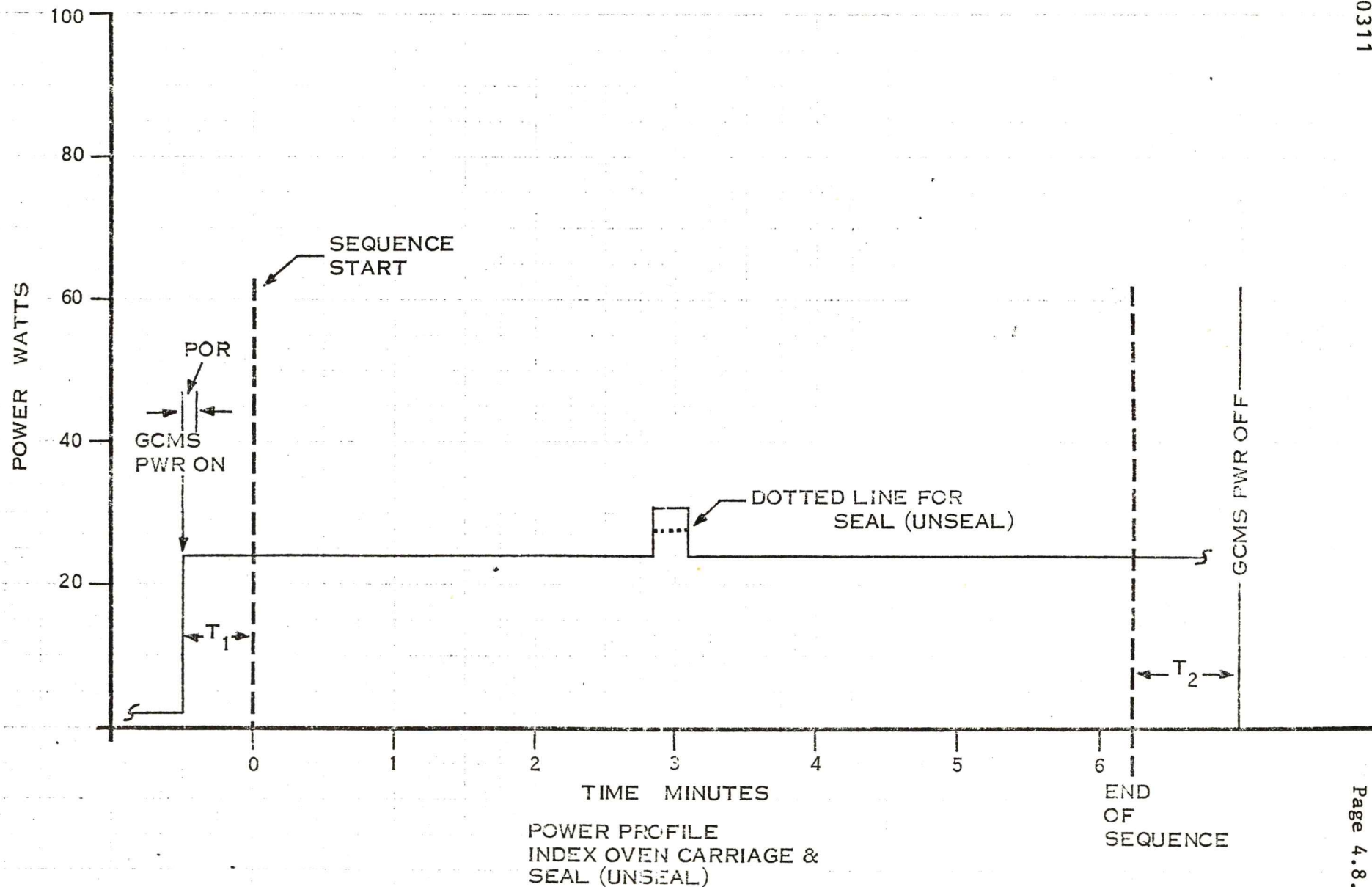
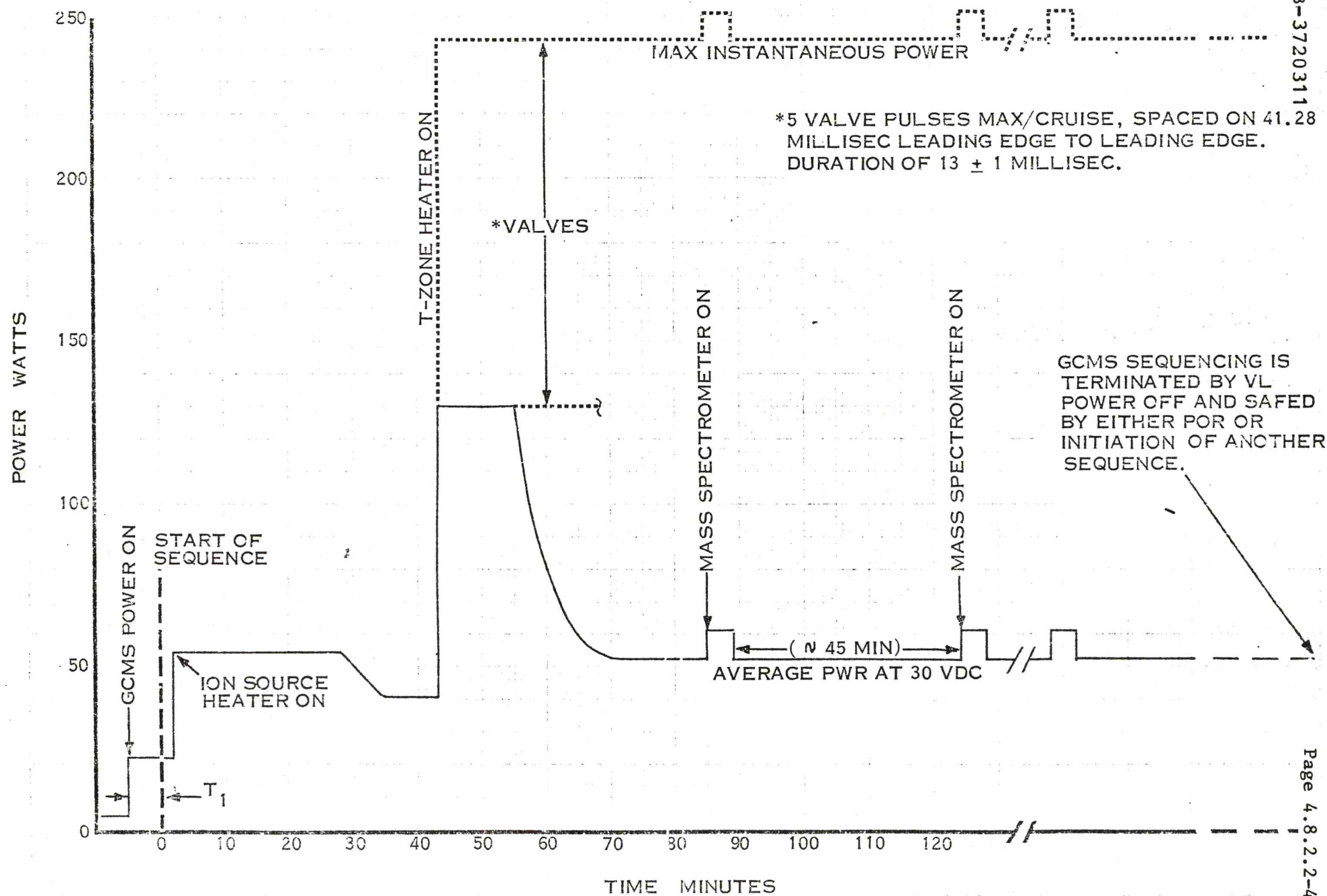
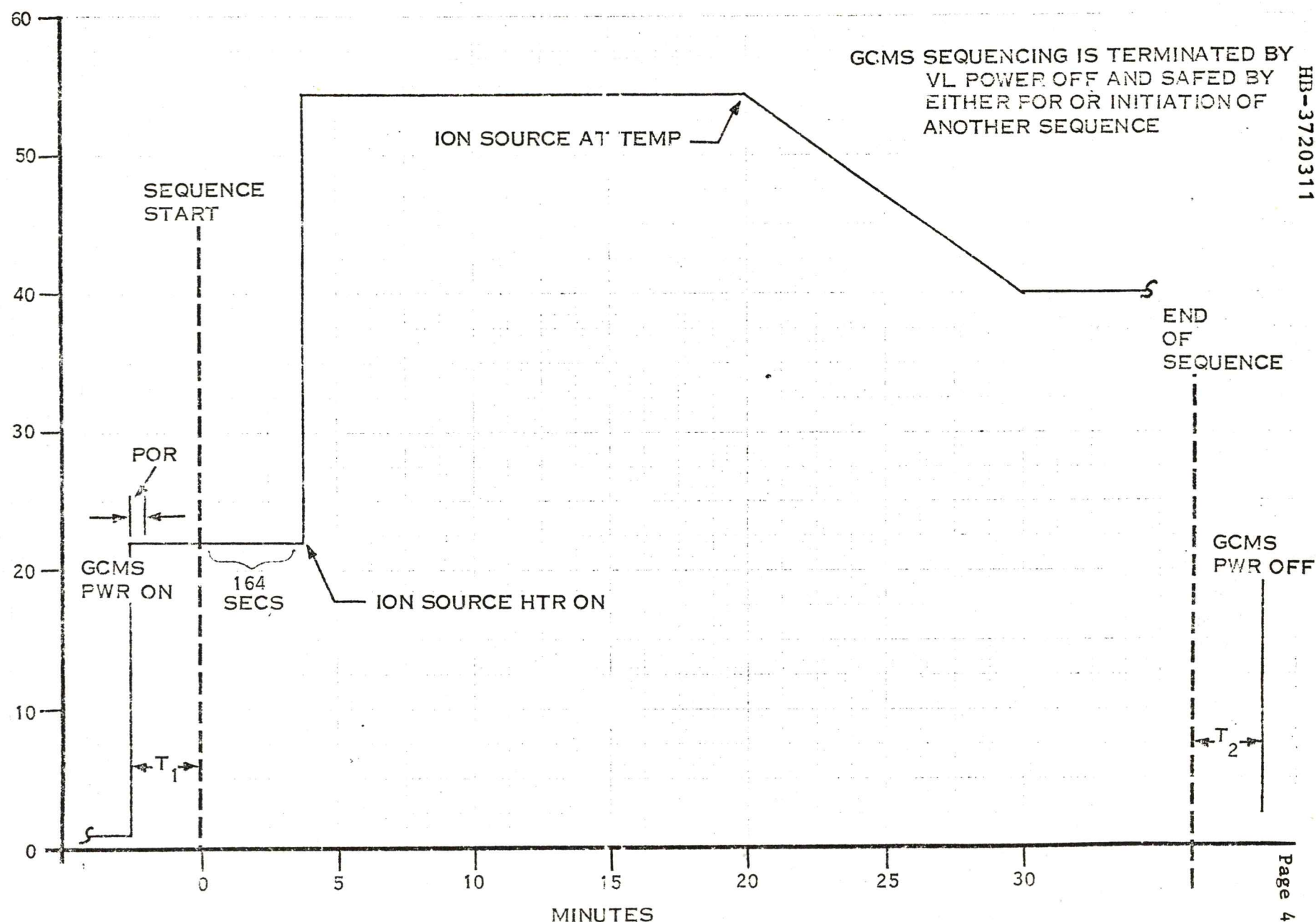


Figure 4.8.2.2-28



POWER PROFILE. BAKEOUT-IN-FLIGHT
CLASS III

Figure 4.8.2.2-29



POWER PROFILE, BAKEOUT IN FLIGHT
CLASS I

Figure 4.8.2-30

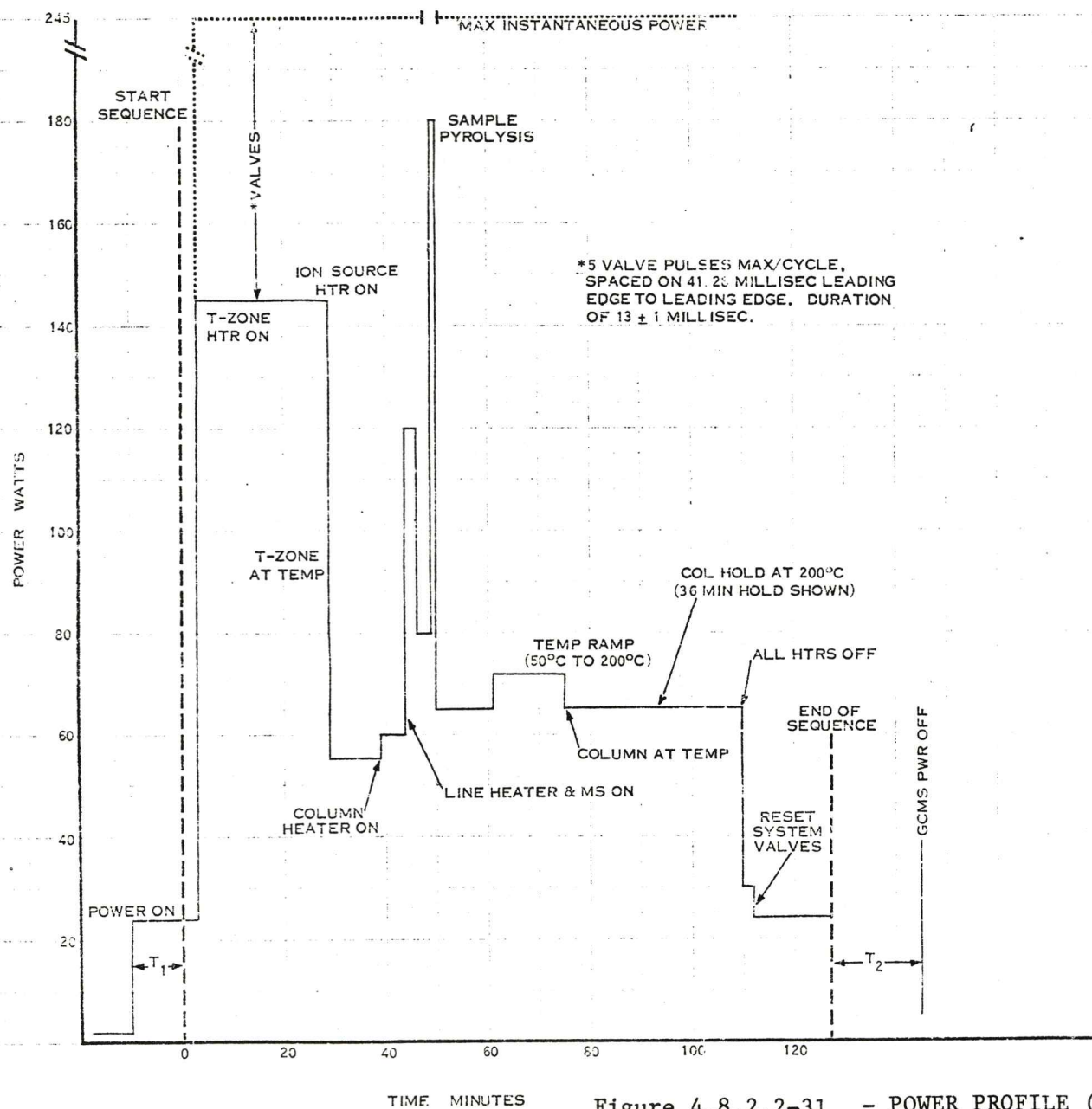


Figure 4.8.2.2-31 - POWER PROFILE (AT 30 VDC) ORGANIC ANALYSIS

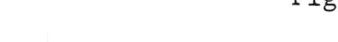


Figure 4.8.2.2-32 - GCMS FUNCTIONAL SCHEMATIC SHEET 1 of 4

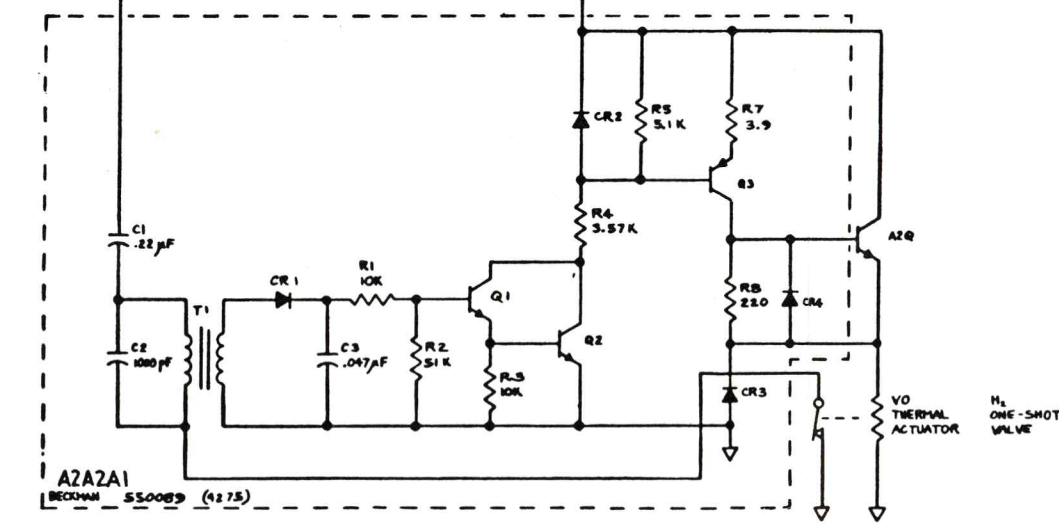


Figure 4.8.4.2-32 - GCMS FUNCTIONAL SCHEMATIC SHEET 2 of 4

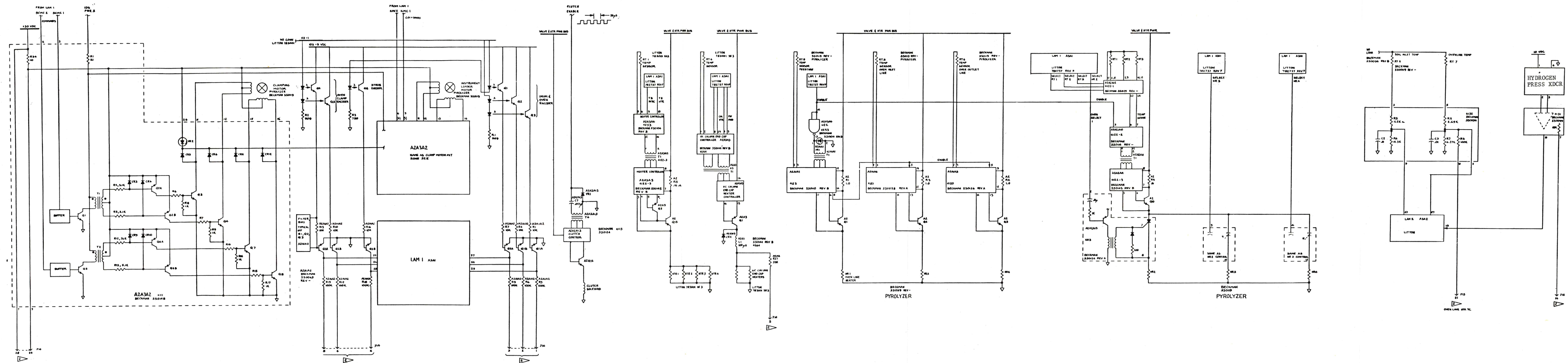


Figure 4.8.2-32 - GCMS FUNCTIONAL SCHEMATIC SHEET 3 of 4

4.8.2.3 Lander Camera System

4.8.2.3 LANDER CAMERA SYSTEM

4.8.2.3.1 PURPOSE

Two identical Lander Camera Systems (LCSs) are used for the following purposes:

- a. Geologically characterize the Martian landscape;
- b. Look for macroscopic evidence of life;
- c. Support surface sample acquisition;
- d. Support the Magnetic Properties and Physical Properties Investigations.

4.8.2.3.2 FUNCTIONAL DESCRIPTION

Figure 4.8.2.3-1 presents a view of the VL. Its two cameras are separated by 0.8 m and view the surrounding terrain from a height of 1.3 m. Figure 4.8.2.3-2 shows an outline drawing of the field of view available to the cameras. A large segment of the camera field of view is obscured by the VL structure. Important to calibrating the camera performance are the three reference test charts mounted on the VL, two of which can be viewed by each camera. The shaded surface area defines the area accessible to the Surface Sampler that collects surface materials for three other science instruments: a Biology Laboratory, a Gas Chromatograph Mass Spectrometer (GCMS), and an X-Ray Fluorescence Spectrometer (XRFS).

A roll maneuver (i.e., rotation about an axis parallel to the camera axis) is planned during the final VL descent phase. An important constraint on VL orientation is to avoid shadowing the Surface Sampler area at favorable sun elevations. A general goal is to obtain morning and afternoon lighting of the sampler area, first from one direction and then from the other, to insure that all features in this area can be viewed at one time or another out of shadow. However, the spacecraft may land in an orientation that results in a different, less favorable lighting geometry.

4.8.2.3.2.1 CONSTRUCTION

Figure 4.8.2.3-3 presents a simplified cutaway view of the camera and Figure 4.8.2.3-4 is a functional schematic. The upper elevation assembly rotates in azimuth during operation, and the lower azimuth assembly is bolted to the VL. General design and operating characteristics are listed in Table 4.8.2.3-1 and performance characteristics in Table 4.8.2.3-2.

The thin camera housing and the major support structure are made of beryllium to provide lightness, stiffness, and low thermal expansion and contraction. The inner surfaces of the

housing are treated with a matte black finish to reduce internal light reflections, and the outer mating surfaces are gold plated to suppress electromagnetic interference. A 3- to 5-cm thick blanket of fiberglass and aluminum foil insulates the entire camera to reduce radiative and convective transfer to the cold Martian atmosphere. In addition, thermostatically controlled heaters are located in the vicinity of critical components to maintain their temperature above -40°C .

The elevation assembly is hermetically sealed and filled with argon gas at a pressure of nearly 1 bar (10^5 N/m^2). The azimuth assembly is exposed to the Martian atmosphere. Dust is prevented from entering by a labyrinth seal between the rotating and stationary parts of the camera.

The camera has two windows. The outer window, referred to as the contamination cover and not shown in Figure 4.8.2.3-4, is hinged on one side and spring-loaded. By rotating the camera nearly 360° in a rapid slew mode, a lever can be forced against the side of the dust post with sufficient impact to release a catch on the contamination cover which then permits a spring to move it out of the optical path. This cover protects the inner window from gaseous condensation during the VL heat sterilization process prior to flight, and from dust contamination during the first few days or weeks of operation on Mars.

The narrow window entrance is usually stored behind a post to avoid unnecessary exposure to dust. The post contains two small tungsten filament light sources that permit the camera performance to be checked when the VL is stored inside the Aeroshell during the flight to Mars. CO sub 2 carried under pressure in a container inside the VL can be released on command through a tube (which is attached to the post) to blow dust off the window.

Light which passes through the window is reflected by a mirror that nods up and down to provide the elevation scanning. Imaging data are acquired only during the relatively slow upward motion. Motion is controlled by a commutator type dc torque motor. A tachometer provides servo damping, and a resolver provides position information. The resolver consists of a dual unit: a coarse unit which provides low-resolution absolute position information over the complete rotation of the shaft for selecting the elevation field of view, and a fine unit with a 36-times higher angular sensitivity which provides high-resolution relative position information for photogrammetric accuracy within the field of view.

The light that is reflected by the nodding mirror is imaged by an achromatic triplet lens onto a photosensor array. The lens aperture diameter is 0.95 cm and the focal length is 5.37 cm. Light falling on the photosensor array is transduced into an electrical signal as will be explained later.

Immediately below the lens is a dark reference shutter which consists of a rotary solenoid that controls a paddle-shaped black metal shutter. When energized, the solenoid shaft moves the shutter over the exit pupil of the lens to block external light from reaching the photosensor array. The design includes a spring that forces the shutter to the open position in case of a failure of the solenoid or associated electronics. The dark reference shutter is closed for sampling the photosensor-preamplifier dark current which is stored for later subtraction from the signal current, and for calibrating the photosensor array with a small tungsten filament lamp which is located below the shutter. The inner surface of the optical tunnel between lens and photosensor array contains a multiaperture baffle that is designed not only to reduce veiling glare but also to attenuate radio frequency interference from the VL antennas.

The elevation assembly, which contains the camera elements described so far, tapers down to a narrow shaft below the photosensor array. All the cables that provide connections between the electrical elements in the elevation assembly and the control and signal processing electronics in the azimuth assembly spiral down through the inside of this shaft. The azimuth servo assembly is mounted on the outside of the shaft. The servo consists of a torque motor, tachometer, and resolver similar to the elevation servo components mounted on the mirror shaft, but exposed to the ambient atmosphere. Other differences are that the motor has a higher torque capacity to handle the higher inertia of the elevation assembly, and that the tachometer permits nearly 360° rotation.

4.8.2.3.2.2 CONTROL ELECTRONICS

Figure 4.8.2.3-5 presents a block diagram of the camera electronics. The four major sections are: (1) digital control electronics which consist of a command register, sequencing logic, and data buffer, (2) photosensor array, (3) video processing electronics, and (4) azimuth and elevation servos.

a. Digital Control Electronics

The command register employs a 48-bit shift register to store the 48-bit command word from the VL Guidance, Control, and Sequencing Computer (GCSC). When the sequencing logic senses that the VL computer has turned on power for the camera, it clears all memory elements to a preset state and commands the azimuth and elevation servos to a safe position (170° azimuth and -40° elevation). Immediately after a command sequence, the azimuth start and elevation pointing angles are loaded into their respective counters, forcing the servos to slew to the commanded positions. Upon receipt of clock pulses from the VL Data Acquisition and Processing Unit (DAPU), the sequencing logic selects first engineering data from various sources and

then video data from the memory. This process is repeated for each line scan in an image.

While the engineering data are passed onto the VL DAPU, synchronous with the data clock pulses, the elevation mirror is given a command to initiate its upward scan from its rest position slightly below the first pixel in the selected field of view. The upward scan is maintained by incrementing the elevation counter by one pixel after every five clock pulses. The sequencing logic initiates an Analog-to-Digital (A/D) conversion command for the photosensor array signal as soon as the mirror enters the field of view. Upon completion of this conversion, the resultant 6-bit pixel word is ready to be entered into the memory. The sequencing logic writes this word into the memory immediately after the last engineering data bit is read out to the DAPU. The mirror continues to move upward at the selected scan velocity, and five data clock pulses after the first A/D conversion command the sequencing logic initiates the next conversion command. This operation continues until 3072 bits (512 pixels by 6 bits) of video data have been written into and read out from the memory. The sequencing logic then loads the elevation counter with a position that returns the mirror to its initial location slightly below the desired field of view, and advance the azimuth counter by one bit which, in turn, rotates the elevation assembly by one step in azimuth.

This basic operation is repeated exactly until the azimuth counter has advanced to a count which is equal to the azimuth stop command stored in a comparator. Normally, the GCSC will stop the flow of data clock pulses near this time, ending the Imaging sequence. However, camera operation will still continue as long as data clock pulses are received, except that the azimuth advance will then be inhibited. This latter capability, referred to as repeated line-scan mode, is used for special experiments.

It may have been noticed that a 6-bit video data word is written into the memory over the same interval in which 5 bits of video data are continuously read out of the memory. The amount of data accumulated in the memory reaches up to 524 bits which are stored in a 512 bit random access memory and a 12-bit register. This scheme converts the 75% mirror scanning efficiency to a 90% video data format efficiency.

So far the discussion has tacitly assumed a particular Imaging mode: namely, high-resolution Imaging with any one of four broadband photodiodes. To distinguish among these photodiodes, the photodiode focused to the

nearest distance is referred to as BB1, to the next nearest distance BB2, and so forth. Several other Imaging modes can be commanded, as follows:

A low-resolution (survey) Imaging mode is effected by tripling the number of incrementing pulses sent to the elevation servo between video samples and to the azimuth servo between active line scans.

A multispectral (color or infrared) Imaging mode is effected by alternately selecting three diodes (either blue-green-red-blue-etc. or IR3-IR2-IR1-IR3, etc.) for successive elevation scans and inhibiting the azimuth servo until three elevation scans have been completed. Actually, this logic permits not only the nominal color and infrared line-sequential diode sequence but also other sequences. Two sequences are of particular interest: BB1-IR3-IR2-IR1-BB1-etc. and BB2-blue-green-red-BB2-etc. They can aid in comparing albedo measurements made in the visual and near-infrared region.

A calibration mode is initiated by closing the dark reference shutter, and then energizing the internal lamp. The magnitude of the lamp current is selected by a 2-bit command word, and an Imaging sequence is simulated. The calibration sequence requires four line-scan periods: the initial line-scan period is not used, the second provides a dark current sample, the third provides time for the lamp to warm up to a stable temperature, and the fourth provides the calibration signal. This calibration sequence can be commanded to occur at the beginning and/or end of an Imaging sequence.

The sequencing logic also energizes the two lamps in the camera dust cover on receipt of a command that calls for the low-resolution (survey) Imaging mode with a high-resolution (BB1) photodiode. Additional logic control functions are the selection of gains and offsets and the removal of the contamination cover.

b. Photosensor Array

The light sensitive part of the photosensor array is a miniature array of 12 silicon photodiodes with responsivities shown in Figure 4.8.2.3-6. The four outer diodes are spaced at different distances from the lens for electrical focus selection for high-resolution (black and white) imaging. Six of the other diodes are covered with optical filters for multispectral (color or infrared) Imaging. Another diode is unfiltered and used for rapid surveys of the terrain, and one is

covered with a red filter and used for directly viewing the Sun.

The nominal aperture diameter of the high-resolution diodes is 0.041 mm, and of the low-resolution diodes is 0.119 mm. Eleven of the diodes have their own preamplifier to convert their small output current into a usable signal, while the Sun diode signal current is sufficiently high to be directly handled by the video processing electronics. The Photosensor Array (PSA), which also contains the logic for selecting any of these diodes and amplifiers, is sealed into a gold-plated covar capsule with a fused silica window.

Figure 4.8.2.3-7 shows a simplified circuit diagram of the PSA and video processing electronics. The photodiode preamplifiers are conventional current-to-voltage converters. The input stage of each preamplifier is built-up from a matched pair of junction Field-Effect Transistors (FET) which were chosen so that their low gate leakage current (typically about 2 pA at 25° C) would not cause dc drift in the photosensor array output with changing temperature.

The outputs from the preamplifiers are summed into a buffer amplifier. The gain of this stage is the ratio of the amplifier feedback resistance to the input resistance of each channel. The input resistance were selected to compensate for different photodiode aperture sizes and filter transmittance characteristics.

The cameras are exposed to a steady low flux of neutrons and gamma rays from the VL Radioisotope-Thermoelectric Generators (RTG) during the nearly 1 year cruise from Earth to Mars. Radiation damage by the neutrons degrades the photodiode performance, particularly in the infrared region from 0.8 to 1.1 μ m where the absolute responsivity is reduced by an estimated 15 to 40% and the temperature dependence of the relative spectral responsivity is increased.

c. Video Processing Electronics

The output from the PSA summing amplifier is passed either directly (for the rapid scan mode) or through a low-pass filter (for the slow scan mode) to circuits which provide commandable gains and offsets, automatic dark current subtraction, and A/D conversion. The primary electrical filtering which the signal undergoes is the integration in the A/D converter.

Six gains can be commanded in steps of powers of 2, and 32 offsets can be commanded in small steps from a slightly negative offset up to nearly the full dynamic range of the camera, as shown in Figure 4.8.2.3-7. These commandable gains and offsets provide a means of decreasing quantization intervals (at the expense of dynamic range) without increasing data bits per pixel.

The sequencing logic commands the dark reference shutter to be closed at specific intervals. It is closed between successive line scans in the slow scan mode, between the 63rd and 64th line scan and then after every 64th line scan in the monospectral rapid-scan mode, and between the last four lines of each group of 64 lines (61-62-63-64 ...125-126-127-128...) in the multispectral rapid-scan mode. A sample-and-hold circuit in the video processing electronics is also commanded at this time to store the dark current level output from the PSA. Three different capacitors are used in the multispectral Imaging modes.

A failure of the solenoid or associated electronics might keep the shutter open during dark current sampling. The stored dark current sample corresponds then to the signal value that occurs at the time of sampling, and this signal value will be subtracted from the video signal generated during the following line scans. Once detected in the Imaging data returned to Earth, this problem can be avoided by substituting on command a grounded line for the PSA output during the dark current sampling period. A commandable offset is then used to approximately subtract the dark current value. The slightly negative offset shown in Figure 4.8.2.3-8 was introduced to permit this feature.

d. Servos

The elevation and azimuth servo design are similar; however, the performance of the elevation servo is more demanding. The elevation counters (Figure 4.8.2.3-5) derive the commanded position angle from digital inputs that represent the desired pointing angle, the photodiode location offset, and the increment pulses. The scan rate is 4.7 scans/s in the rapid scan mode and 0.073 scan/s in the slow scan mode.

The elevation scan profile is shown in Figure 4.8.2.3-9. A line-scan efficiency of 75% was selected as the best compromise between power requirement, torque motor size, memory size, video signal bandwidth requirement, and achievable servo performance. The servo is operated as a Type 1 (steady-state velocity error) servo during run-up and Imaging, and as a Type 0 (steady-state position error) servo during flyback.

The absolute angles error given in Table 4.8.2.3-2 include all errors of the servo-mechanism and the positioning of the PSA. This error is less than two pixels in the low-resolution Imaging modes and about three pixels in the high-resolution Imaging mode along the azimuth direction; and twice this value along elevation because of the mirror reflection. The relative pixel registration error is the error of the angular location of any pixel with respect to any other pixel in an image. This error is on the average less than 30% of a pixel diameter.

Spatial registration of multispectral Imaging data is a function of the accuracy of the photodiode spacing in addition to the servo performance. The total effective error in the center spacing of the color and near-infrared data is less than 30% of the pixel diameter.

The frame width in elevation is determined by the number of pixels per line scan (512) and the instantaneous field of view, or angular extent of each pixel. It is 20.49° and 61.44° for the high- and low-resolution Imaging modes, respectively. The elevation of the field of view can be selected upon command at about 10° intervals so that the total camera field of view ranges from about 40° above a plane normal to the optical axis to about 60° below this plane. The frame width in azimuth can be varied in 2.5° intervals up to a maximum of 342.5° .

4.8.2.3.3 DATA TRANSMISSION

Figure 4.8.2.3-9 illustrates the VL data storage and transmission facilities. The following options exist for handling Imaging data. Data acquired at 16 Kbps can either be directly transmitted to one of the VOs or stored on tape. Data acquired at 250 bps can either be directly transmitted to Earth or stored on tape via the 2×10^6 bit memory. Data stored on tape can be transmitted to the VOs at 16 Kbps or 4 Kbps, or transmitted to Earth at 1 K, 500, or 250 bps. The data transmitted to one of the VOs are stored on one of two tape recorders, and later transmitted to Earth at 16 Kbps, 8 Kbps, 4 Kbps, 2 Kbps or 1 Kbps; the primary rate is 4 Kbps. Data are received on Earth by the Deep Space Network (DSN).

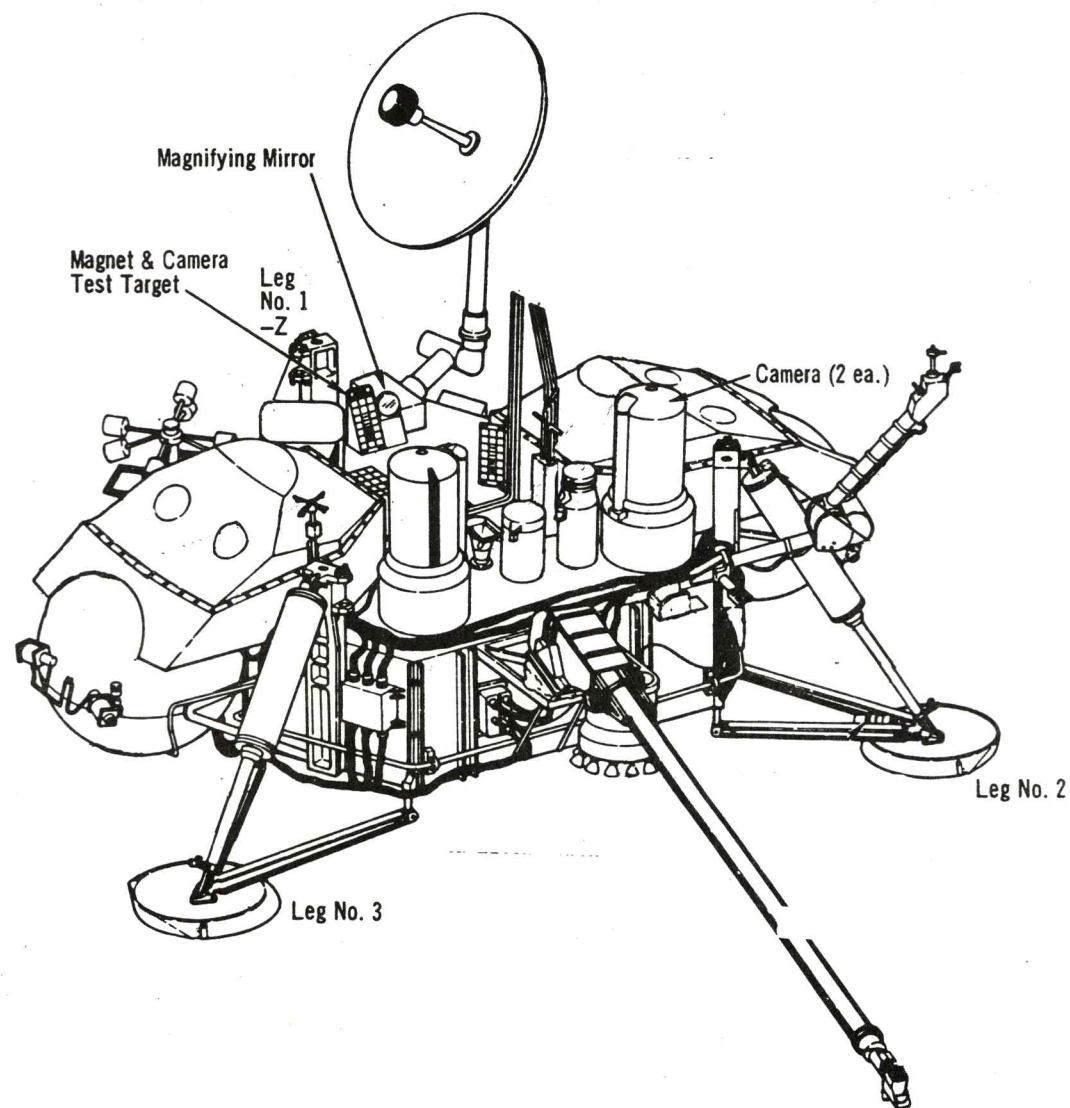


Figure 4.8.2.3-1 - LANDER CAMERA LOCATIONS

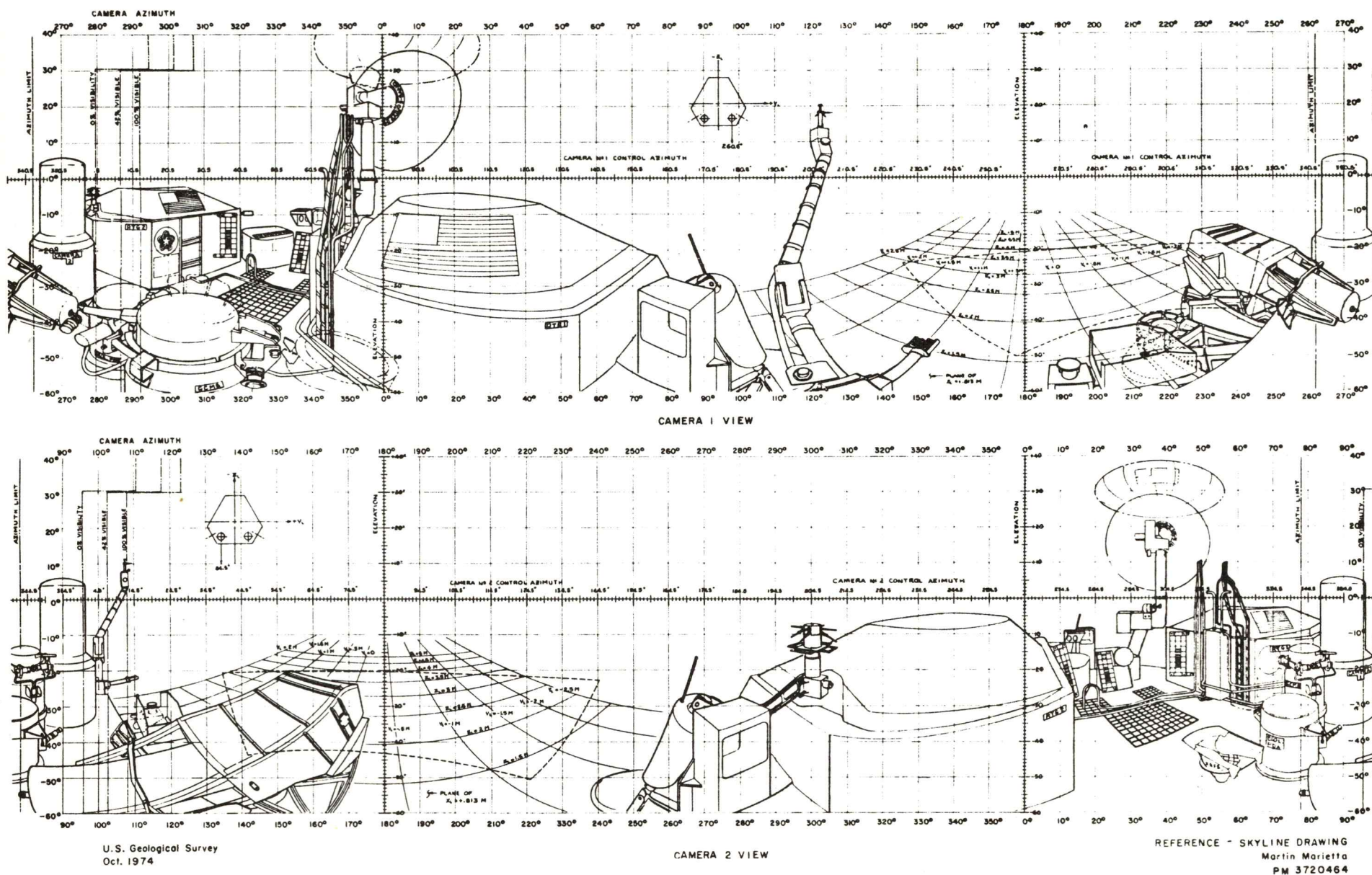


Figure 4.8.2.3-2 - FIELD OF VIEW OF THE VIKING LANDER CAMERAS

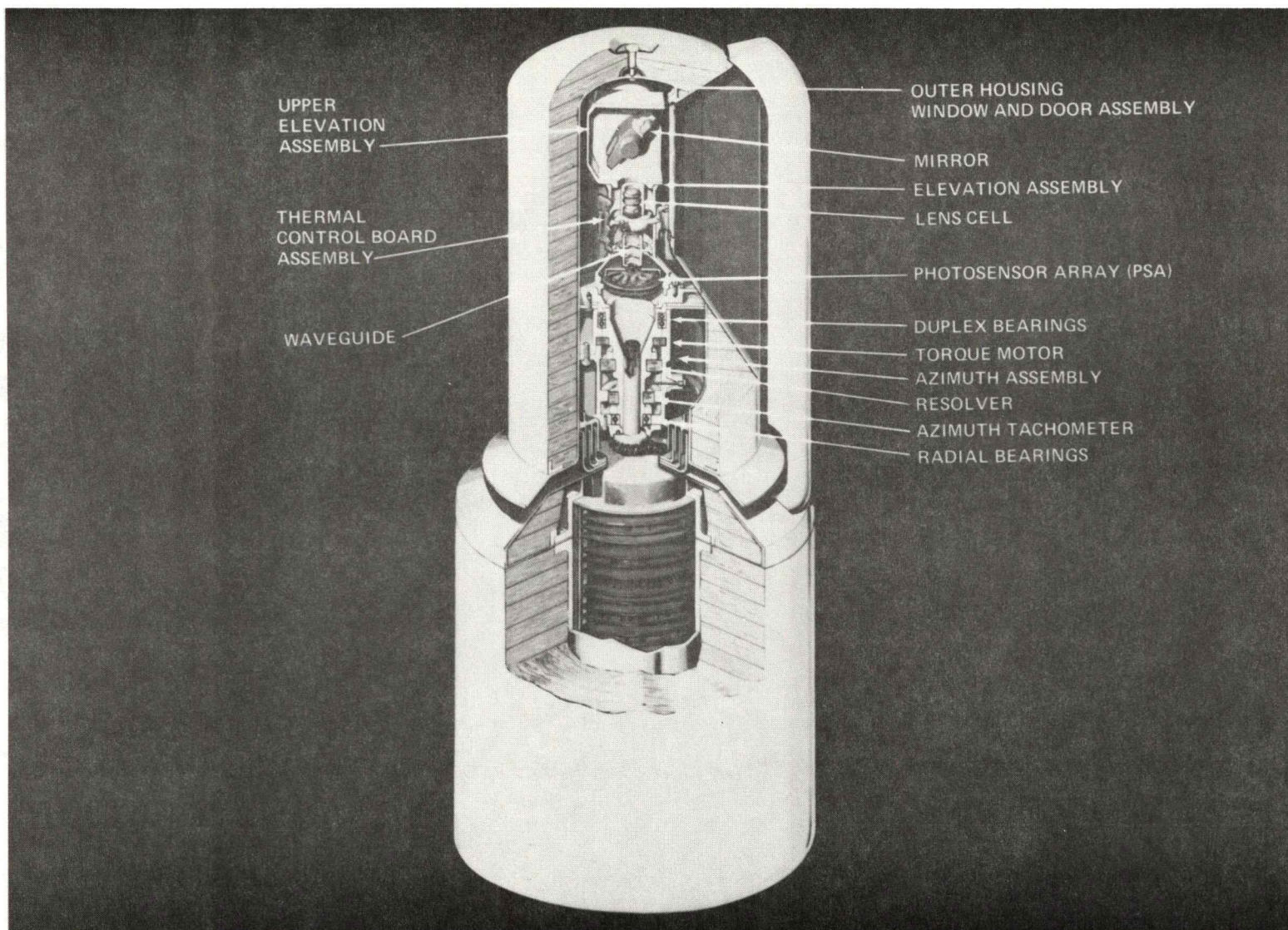
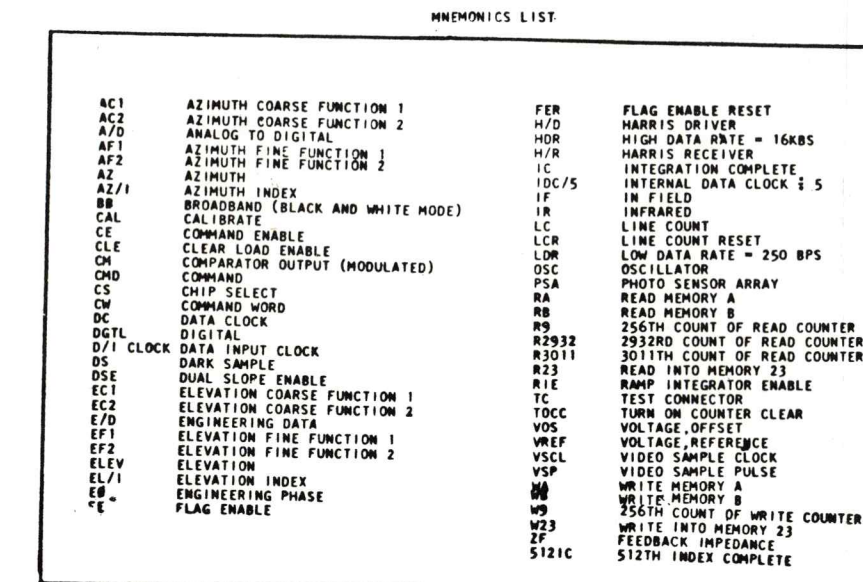


Figure 4.8.2.3- 3 - SIMPLIFIED CUTAWAY VIEW OF VIKING LANDER CAMERAS



- NOTES:
1. CAMERA 1 AND CAMERA 2 REFERENCE DESIGNATORS ARE PREFIXED BY D31A1 AND D31A2 RESPECTIVELY.
 2. REMOVABLE TEST HARNESS.
 3. CAMERA 2 ELECTRONICS ARE IDENTICAL TO CAMERA 1 ELECTRONICS.
 4. TRIM RESISTOR VALUE TO BE SELECTED DURING TEST.
 5. FET SWITCHES ARE SHOWN AS FUNCTIONAL SWITCHES FOR CLARITY.
 6. BENCH TEST ONLY.
 7. THE FOLLOWING DRAWINGS WERE USED FOR REFERENCE:

	ASSY	DRAWING NO	TITLE	REV
	A1A1	213425	ELEVATION SERVO #1	B
	A1A2	213426	ELEVATION SERVO #2	C
	A2A1	213427	AZIMUTH SERVO #1	B
	A2A2	213428	AZIMUTH SERVO #2	C
	A2A3	213422	THERMAL CONTROL	B
	A3A1	213382	F1/F2 GENERATOR OSCILLATOR (C) ELECTRONICS	M/C
	A3A2	213583	F1/F2 GENERATOR OSCILLATOR (P) ELECTRONICS	B/C
	A4A1	213421	CONTROL ELECTRONICS #1	E
	A4A2	213434	CONTROL ELECTRONICS #2	C
	A5A1	213384	F1/F2 GENERATOR MULTIPLEXER (C) AZIMUTH	E
	A5A2	213385	F1/F2 GENERATOR MULTIPLEXER (P) AZIMUTH	B/C
	A6A1	213721	VIDEO PROCESSING ELECTRONICS #1	M/C
	A6A3	213580	VIDEO PROCESSING ELECTRONICS #3	E
	A7A1	213461	VIDEO MEMORY	B
	A7A2	213779	BUFFER MEMORY	M/C
	A8A1	213465	SERVO POWER AMPLIFIER #1	E
	A8A2	213502	SERVO POWER AMPLIFIER #2	C
	A8A3	213463	SERVO POWER AMPLIFIER #3	E
	A9A1	213013	VIDEO PROCESSING ELECTRONICS #2	C
	A9A2	213422	CONTROL ELECTRONICS #3	E
	A11A1	213498	ONLINE CONTROL ASSEMBLY	B
	A1	B37FS5200200	POWER SUPPLY	A
	A2	B37FS5200100	LOGIC AND SOLENOID VALVE DRIVERS	B
	A3	B37FS5200100	DATA CONTROL ASSEMBLY	A

Figure 4.8.2.3-4 - LCS FUNCTIONAL SCHEMATIC



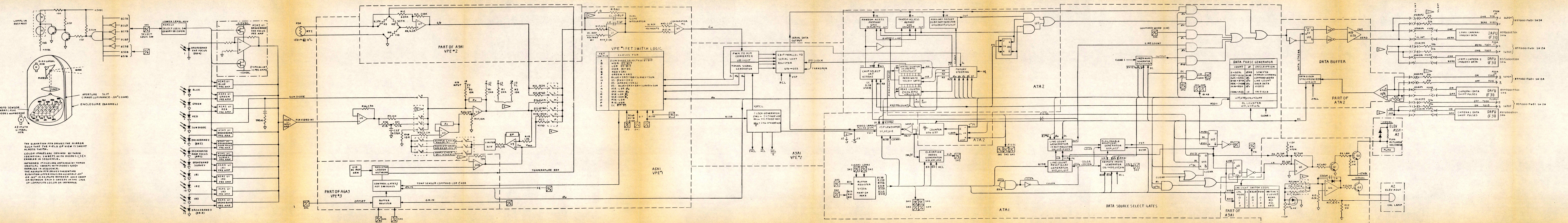
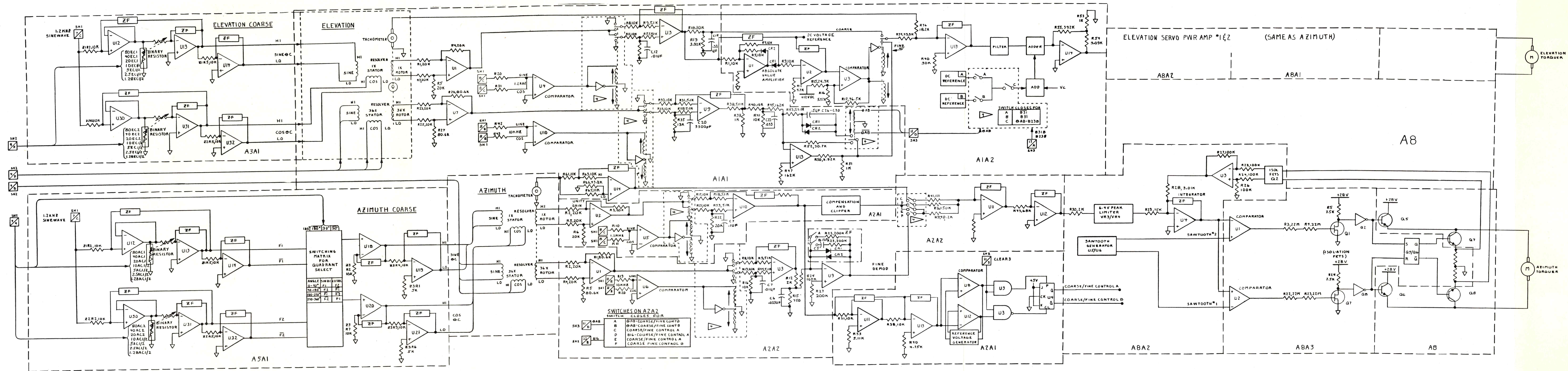


Figure 4.8.2.3-4 - LCS FUNCTIONAL SCHEMAT



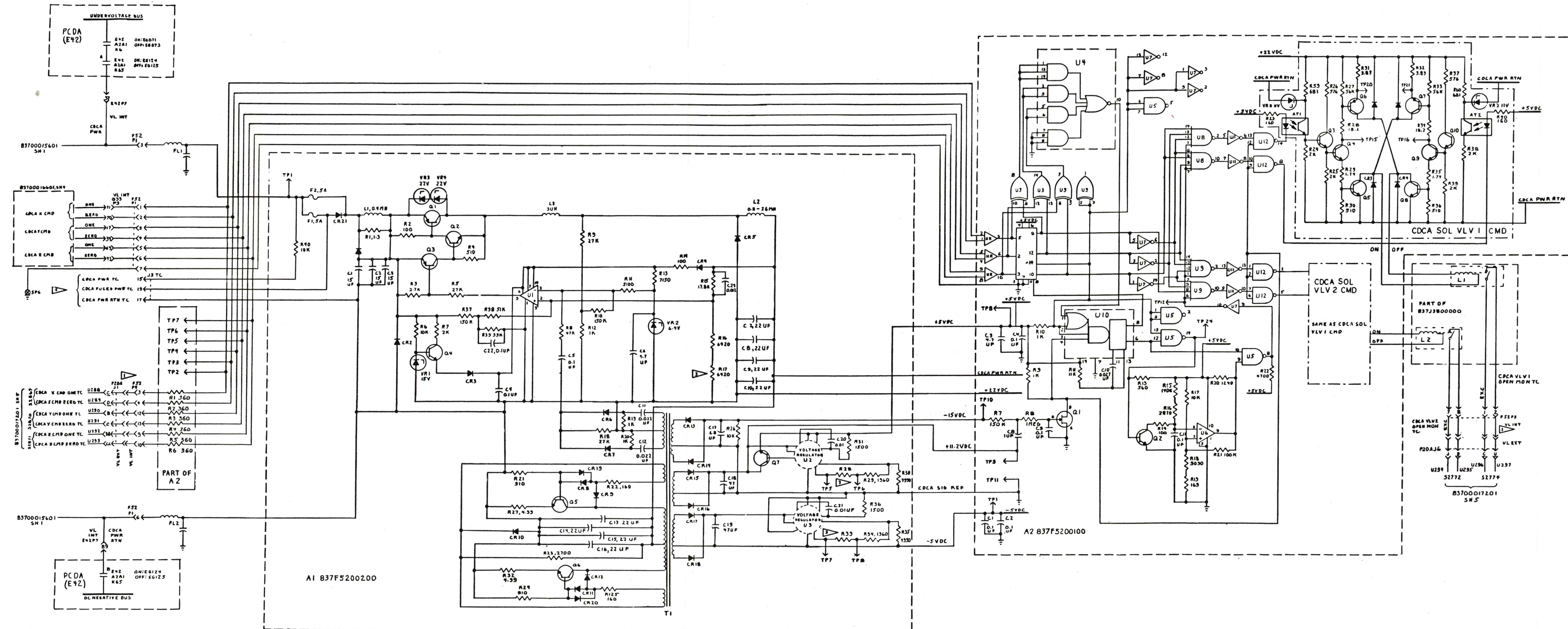


Figure 4.8.2.3-4 - LCS FUNCTIONAL SCHEMATIC

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Height, cm	55.6
Diameter, cm	
Upper, elevation assembly	14.4
Lower, azimuth assembly	25.6
Weight, kg	7.26
Power, W	
Internal calibration	22
Low-resolution imaging	34
High-resolution imaging	27
Standby	22
Thermal control (aver. for cold day)	3
Slew to new command (less than 30 s)	111
Environment	
Atmosphere	Earth or CO sub 2
Atmospheric pressure, mbar	
Earth	1000
Cruise	Vacuum
Mars	2.8 to 20
Ambient temperature, °C	
Sterilization	+113
Mars	-126 to +52
Hazards	up to 70 m/s dust storm

TABLE 4.8.2.3-1 DESIGN AND OPERATING CHARACTERISTICS

CHARACTERISTICS	SURVEY	COLOR & IR	HIGH RESOLUTION
Instantaneous field of view, deg	0.12	0.12	0.04
Picture element registration error, deg	± 0.036	± 0.013	± 0.006
Absolute angle error, deg			
Elevation	± 0.3	± 0.2	± 0.2
Azimuth	± 0.15	± 0.1	± 0.1
Frame width, deg			
Elevation	61.44	61.44	20.48
Azimuth: min; max	2.5; 342.5	2.5; 342.5	2.5; 342.5
Field of view, deg			
Elevation	100; from 40° above to 60° below horizon in 10° steps		
Azimuth	342.5; in multiples of 2.5° steps		
Geometric depth of field, m	1.7 to ∞	1.7 to ∞	1.7 to ∞
In-focus distance, m	3.7	3.7	1.9, 2.7, 4.5, and 13.3
Picture elements per line	512	512	512
Bits per picture element	6	6	6
Bits per degree azimuth	2.84×10^4	8.53×10^4	8.53×10^4
Time per degree azimuth			
Rapid scan, s	1.84	5.52	5.52
Slow scan, min	2.0	6.0	6.0

Table 4.8.2.3-2 - PERFORMANCE CHARACTERISTICS

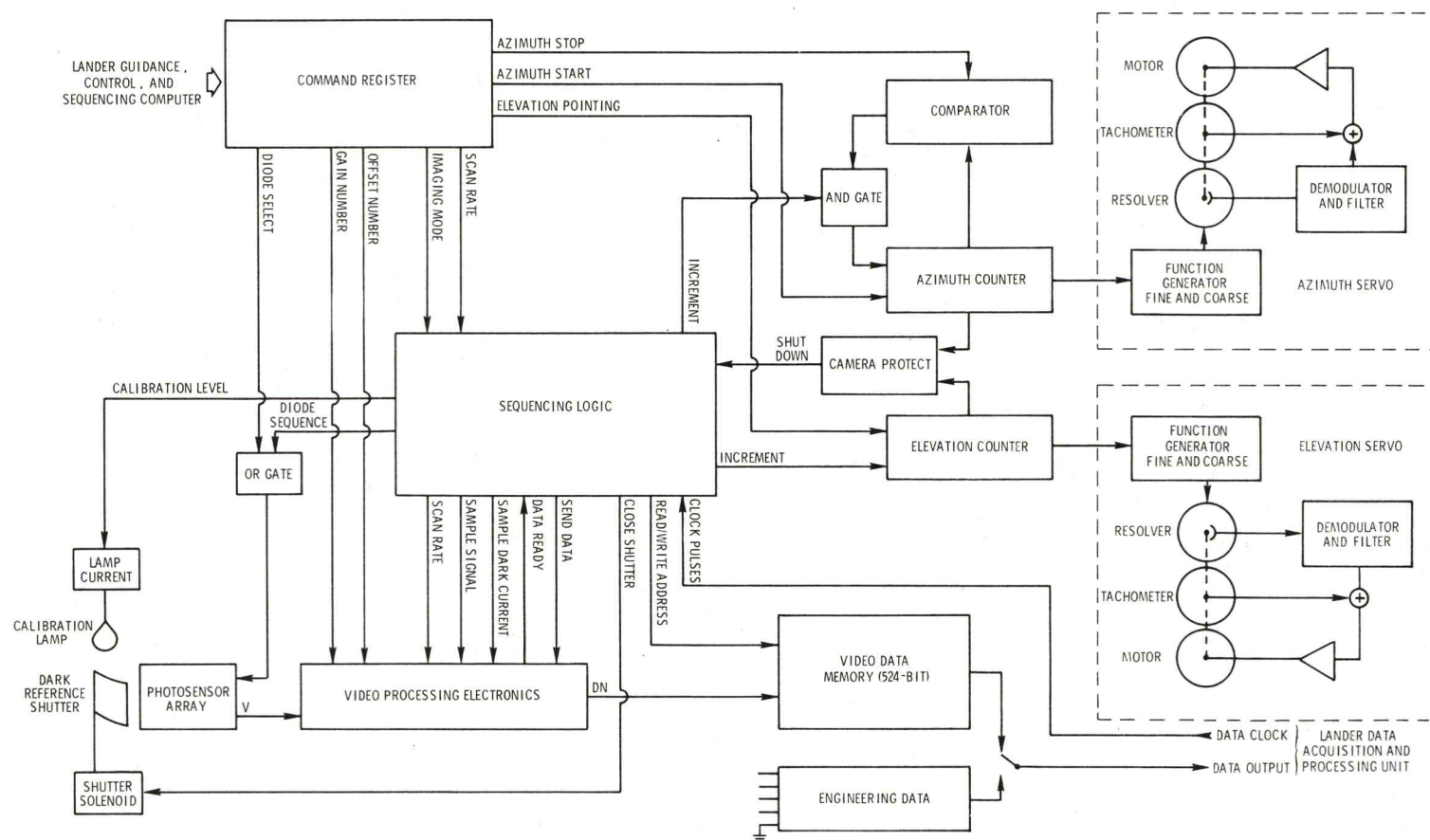


Figure 4.8.2.3-5 - BLOCK DIAGRAM OF CAMERA ELECTRONICS

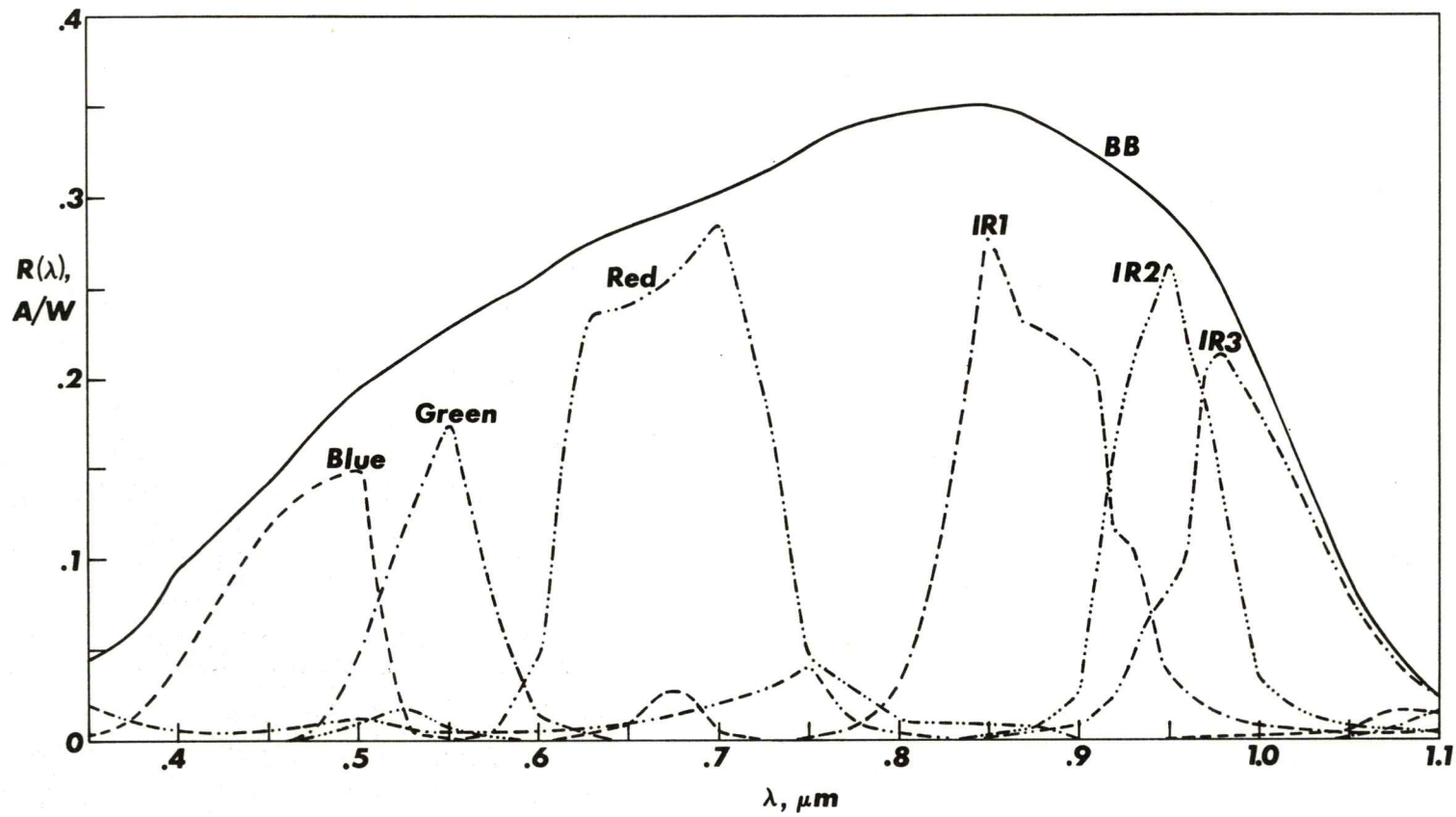


Figure 4.8.2.3-6
FILTER RESPONSIVITIES

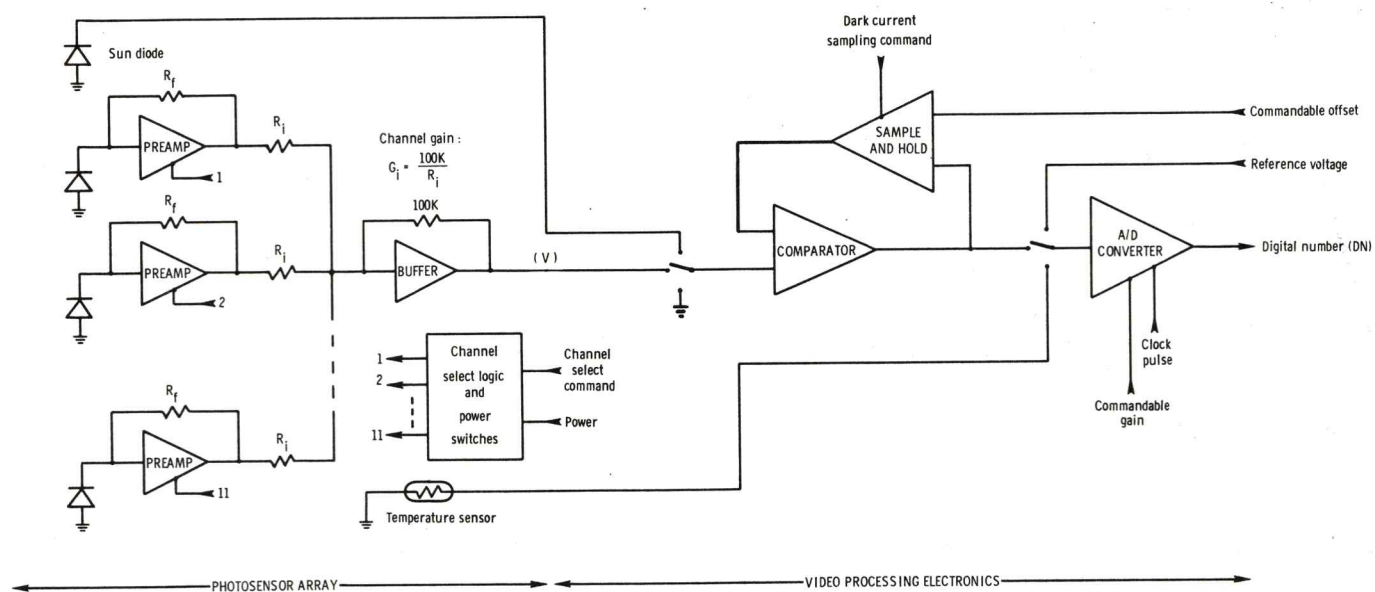


Figure 4.8.2.3-7 - SIMPLIFIED CIRCUIT DIAGRAM OF PHOTSENSOR ARRAY AND VIDEO ELECTRONICS

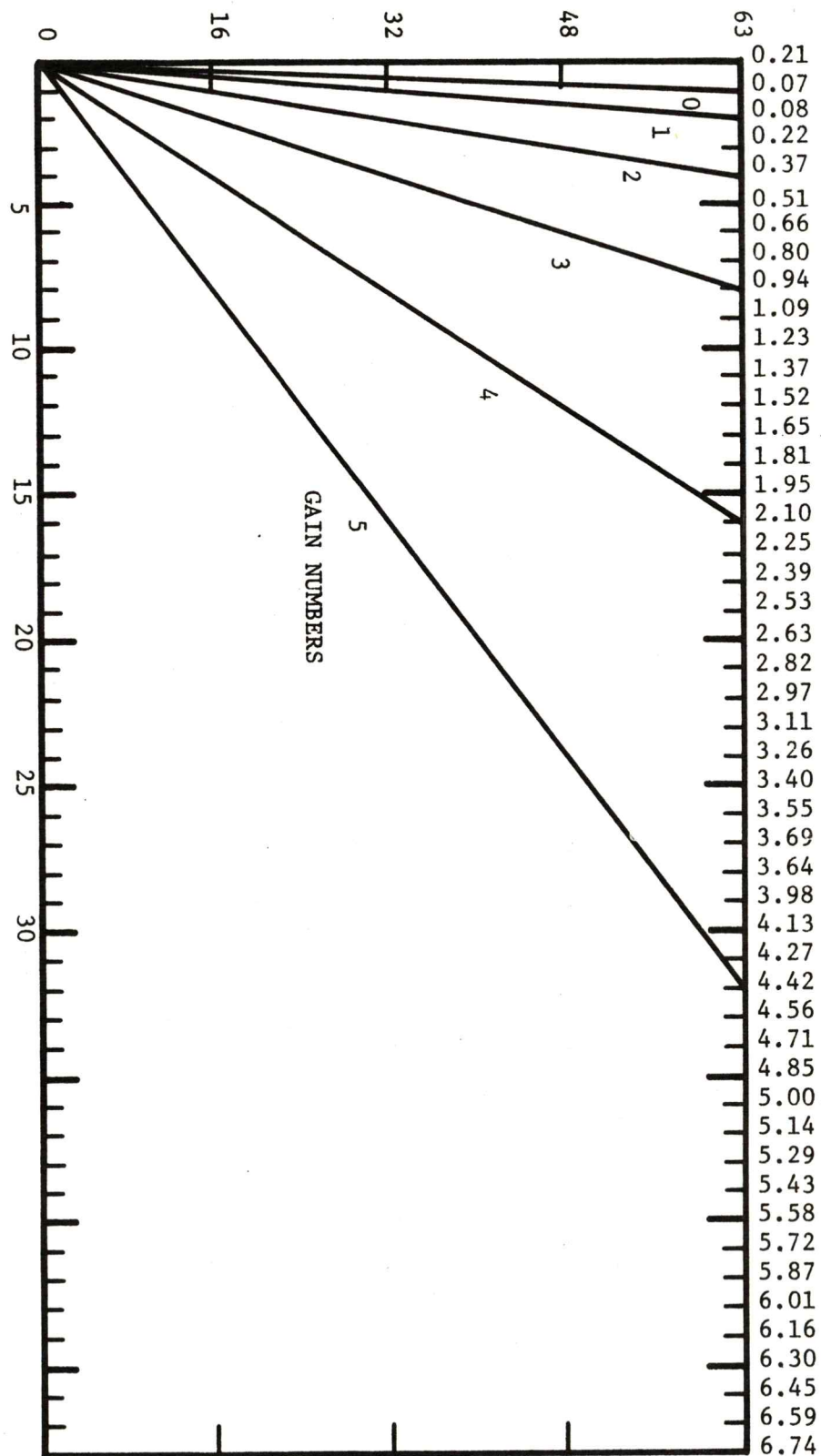
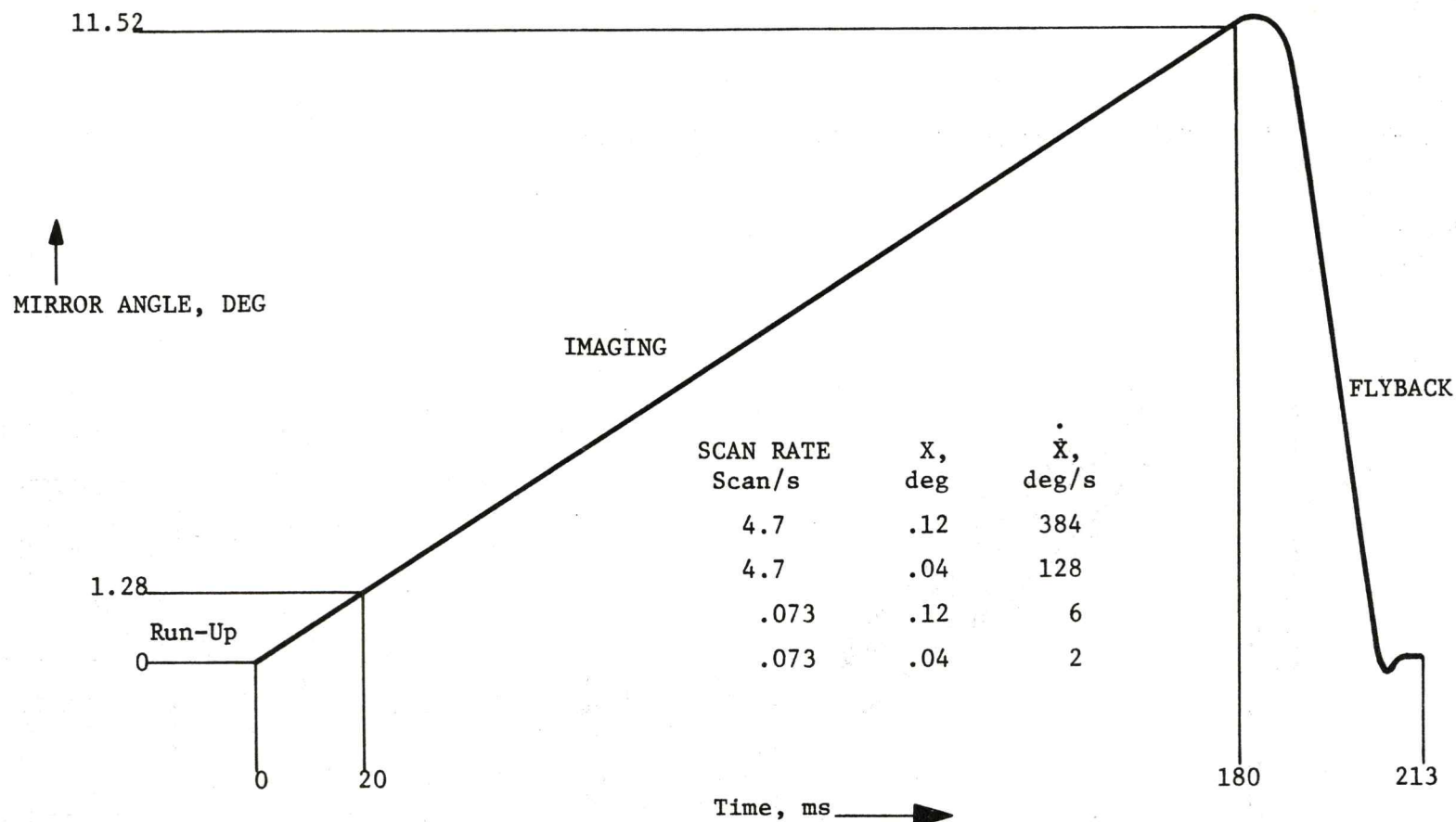


Figure 4.8.2.3- 8 - COMMANDABLE GAINS AND OFFSETS



ANGULAR AND TIME VALUES ARE GIVEN FOR THE HIGH-RESOLUTION ($X = 0.04^\circ$) AND RAPID SCAN (4.7 SCANS/s) MODE; ANGULAR VALUES ARE MULTIPLIED BY 3 FOR LOW-RESOLUTION ($X = 0.12^\circ$) IMAGING, AND TIME VALUES ARE MULTIPLIED BY 64 FOR THE SLOW SCAN RATE (0.073 SCANS/s).

Figure 4.8.2.3- 9 - ELEVATION SCAN PROFILE

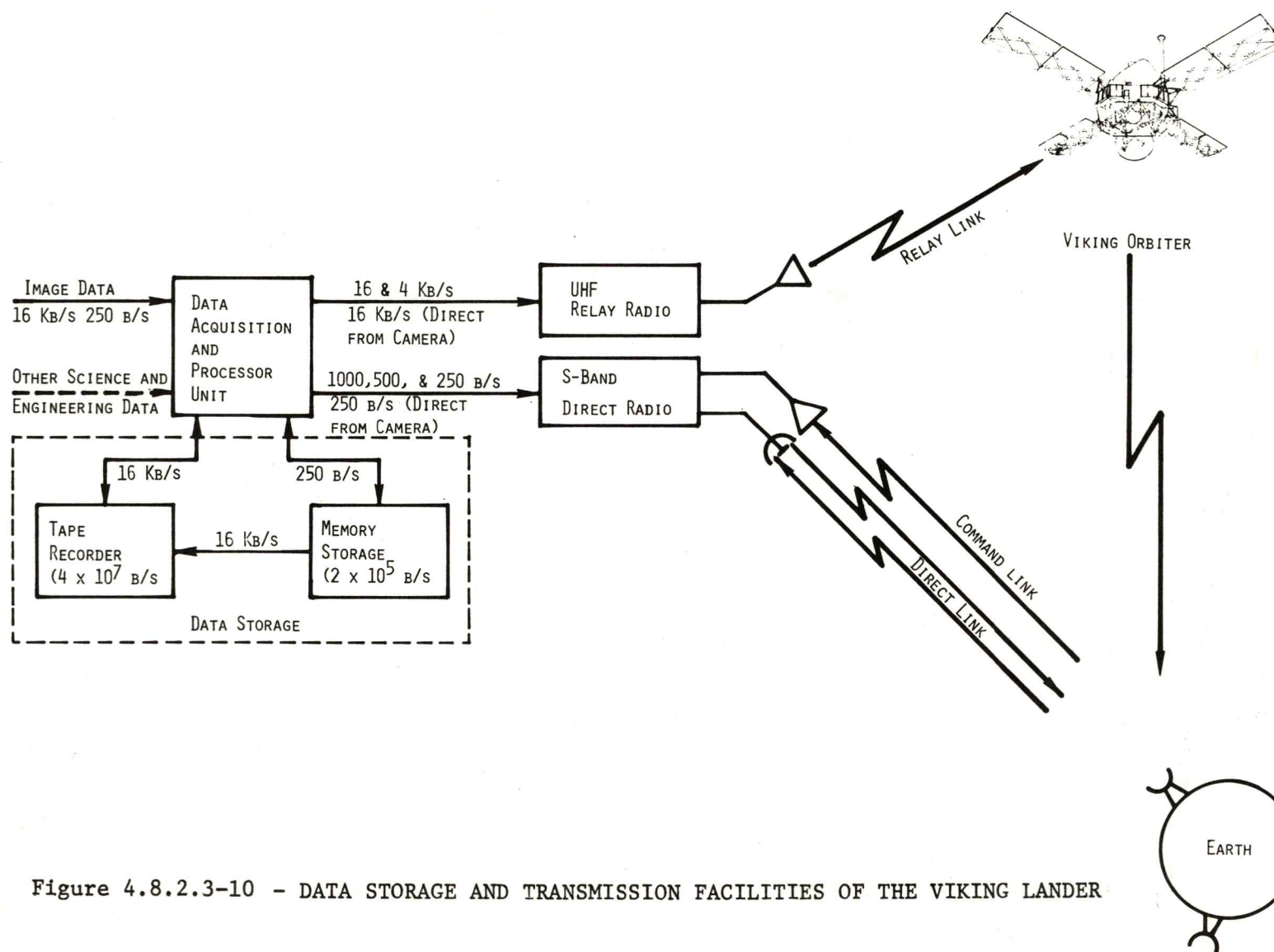


Figure 4.8.2.3-10 - DATA STORAGE AND TRANSMISSION FACILITIES OF THE VIKING LANDER

4.8.2.4 Magnetic Properties Investigation

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4.8.2.4 MAGNETIC PROPERTIES INVESTIGATION

TBS

4.8.2.5 Meteorology Instrument System

4.8.2.5 METEOROLOGY INSTRUMENT SYSTEM

4.8.2.5.1 PURPOSE

The purpose of the Meteorology Investigation is to measure the meteorological environment near the surface of Mars and to obtain data on motion systems which may be occurring in the Martian atmosphere. The time scales associated with these motion systems range from a fraction of a second to many months. The turbulent motion in the atmospheric boundary layer (first few meters of atmosphere) represent the smallest scales while diurnal variations, passage of weather systems, and seasonal variations are characteristic of the longer time scales. The Meteorology Investigation will determine these variations where possible in the nominal mission and may possibly determine the seasonal variations in the event of an extended mission.

The specific parameters to be measured for characterizing the meteorological environment are pressure, temperature, wind speed, and wind direction. These parameters are measured as a function of time as weather systems pass over the Viking Lander (VL).

4.8.2.5.2 FUNCTION

The Meteorology Instrument will operate during the Post-Landed portion of the nominal mission and during any extended mission. It will measure the atmospheric parameters of pressure, temperature, and wind velocity (wind speed and wind direction) in the Martian boundary layer. Due to the composition and low surface pressures of the Martian atmosphere, the Meteorology Instrument has the capability to operate and make measurements over large variations in temperature and wind velocity. The instrument operating requirements are as follows:

a. Ambient Temperature

The instrument will measure Martian atmosphere ambient gas temperature over a range of 130°K to 350°K with accuracy of $\pm 3^\circ\text{K}$.

b. Wind Velocity

The wind sensors will operate over a wind speed range of 2 to 150 meters per second at ambient pressures between 2 and 20 millibars (mb) and ambient temperatures between 130°K and 350°K. The sensors have a wind speed accuracy of ± 4 meters per second or ± 20 percent (whichever is greater) over most of the ambient conditions anticipated for the proposed landing sites (see PD-7400090 for the high accuracy ranges). They have a wind direction accuracy of ± 20 degrees at wind speeds of 5 to 25 meters per second and ± 10 degrees

over the high accuracy ranges above a wind speed of 25 meters per second (as specified in PD-7400090).

c. Pressure

The ambient pressure sensor used in conjunction with the Meteorology Investigation is the same sensor used during the parachute entry phase of the mission. This sensor will measure the Martian surface pressure to an accuracy of ± 0.5 mb over a pressure range of 1 mb to 30 mb.

4.8.2.5.2.1 METEOROLOGY INSTRUMENT ASSEMBLIES

The Meteorology Instrument consists of the following three interconnected assemblies:

- a. Meteorology Sensor Assembly (MSA)
- b. Meteorology Electronics Assembly (MEA)
- c. Meteorology Boom Assembly (MBA)

1) MSA

The MSA is shown in Figure 4.8.2.5-1. The MSA supports the wind and temperature sensors and provides a housing for the low level electronics.

The wind speed and wind direction measurement utilizes the technique of constant temperature hot film anemometer consisting of a very thin conducting film (platinum) deposited on a substrate (pyrex glass rod). In operation this film is maintained at a constant temperature (approximately 100°C) above ambient temperature by controlling, with a feed-back amplifier (servo), the amount of power supplied to the platinum film. The amount of power supplied to the sensor is then a measure of the heat transfer from the sensor. The heat transfer from the cylinder (sensor) is primarily by convection if the sensor diameter is small and the wind speed is above some minimum value. If the power supplied to the sensor is measured the convective heat transfer or wind velocity, normal to the sensor, can be determined. If two sensors are used, which are mounted at 90° with respect to each other, the power supplied to each sensor is then a function of the wind direction.

The basic wind sensor cannot distinguish wind from the plus or minus directions which results in an ambiguity in wind direction. For this reason a

quadrant sensor is included in the system. This sensor consists of a heated post and four thermocouple junctions mounted around the assembly (Figure 4.8.2.5-2). The post temperature is controlled at a nominal 100°C above ambient temperature similar to the wind sensors. The thermocouples measure a differential temperature due to the post thermal wake and therefore by locating the position of the wake, a wind direction quadrant can be determined and wind sensor ambiguity can be removed.

The temperature sensor is a three thermocouple array (Figure 4.8.2.5-3); the thermocouples are chromel-constantan with all three junctions connected in parallel. The parallel connection is used to provide redundancy against breakage of a single thermocouple wire. These junctions are connected in series with a reference junction located within the temperature module in the low level electronics housing at the base of the wind sensor pedestal. The temperature module assembly provides a temperature controlled environment for the reference junction and the parasitic junctions resulting from conversion of the thermocouple wire, to copper wire, for signal transmission to the NEA.

2) NEA

The NEA (Figure 4.8.2.5-4) provides the required electronics to support the sensors except for low level electronics contained within the MSA. The NEA provides the power train for the two active wind sensors and the quadrant sensors and controls their overheat temperatures at nominally 100°C. The sensor signals (wind, quadrant and temperature sensors) are gathered, pre-conditioned and converted into digital outputs. The NEA also formats, stores, and delivers the data to the Data Acquisition and Processor Unit (DAPU).

The NEA includes the following components and capabilities:

- a) Power supplies to provide all regulated and isolated power required by the Meteorology Investigation for the raw input power.
- b) A command processor to receive the commands from the Guidance Control and Sequencing Computer (GCSC) and to convert these commands to signals for control of the Meteorology Investigation.

- c) A sequence control unit to operate in conjunction with the command processor, the GCSC sampling pulse, and the master clock pulse train to generate the synchronization of the system.
 - d) Selected sensor electronics required to drive the temperature and wind sensors.
 - e) Electronics to condition the various sensor outputs into levels compatible with the analog to digital converter unit.
 - f) A digitizing unit to convert the analog sensor signals to digital words. The MSA provides all electronics necessary to convert all data to acceptable data words compatible with storage and subsequent transmission to the DAPU.
 - g) Capability for accepting serially transmitted time information from the GCSC for storage in the MSA memory.
 - h) Electronics to format the digital data prior to storage and to support the memory unit for both read and write activity.
 - i) A memory unit to store measured data during system operation. The memory has the capability of storing nominally 5000 bits of information.
- 3) MSA (Figure 4.8.2.5-1)

The MSA consists of a deployable boom which supports the MSA in a stowed position during the Launch, Cruise, and Entry phases of the mission. A short time after landing a pyrotechnic activated pin puller is actuated releasing the boom. The boom deploys under the action of a torsion spring contained at the hinge point, and latches provide a detent type locking of the boom in the deployed position. In order to prevent entrainment of sand or dust in critical hinge areas, the hinge and latch mechanisms are housed and sealed in a cover arrangement prior to deployment. The MSA also supports the MSA electrical harness and connectors. A connector interface is provided at the base of the MSA for electrical attachment to the MSA. An overall functional schematic of the instrument is shown in Figure 4.8.2.5-6.

DEPLOYED CONFIGURATION

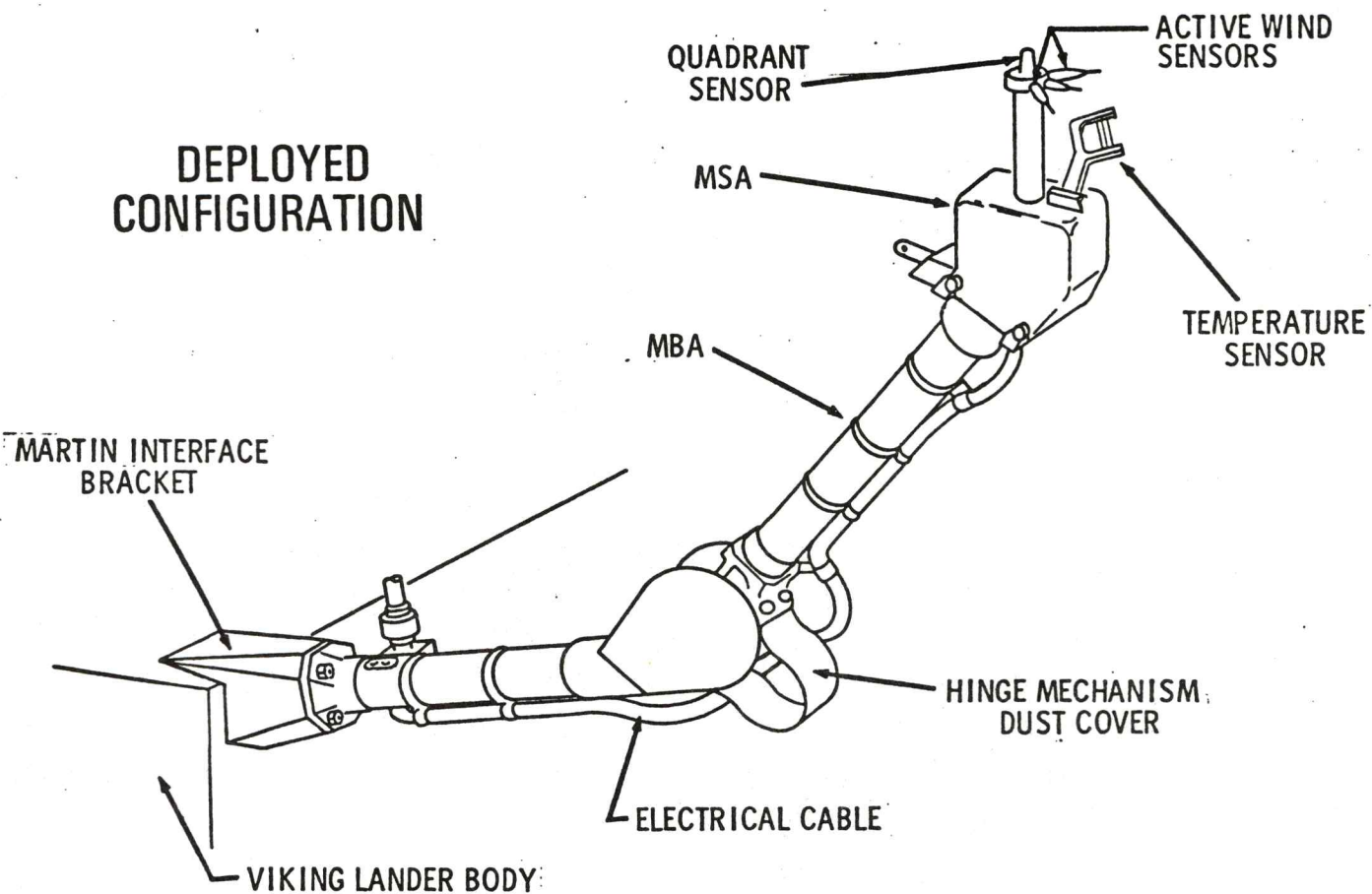


FIGURE 4.8.2.5-1

METEOROLOGY INSTRUMENT
BOOM ASSEMBLY-DEPLOYED
CONFIGURATION

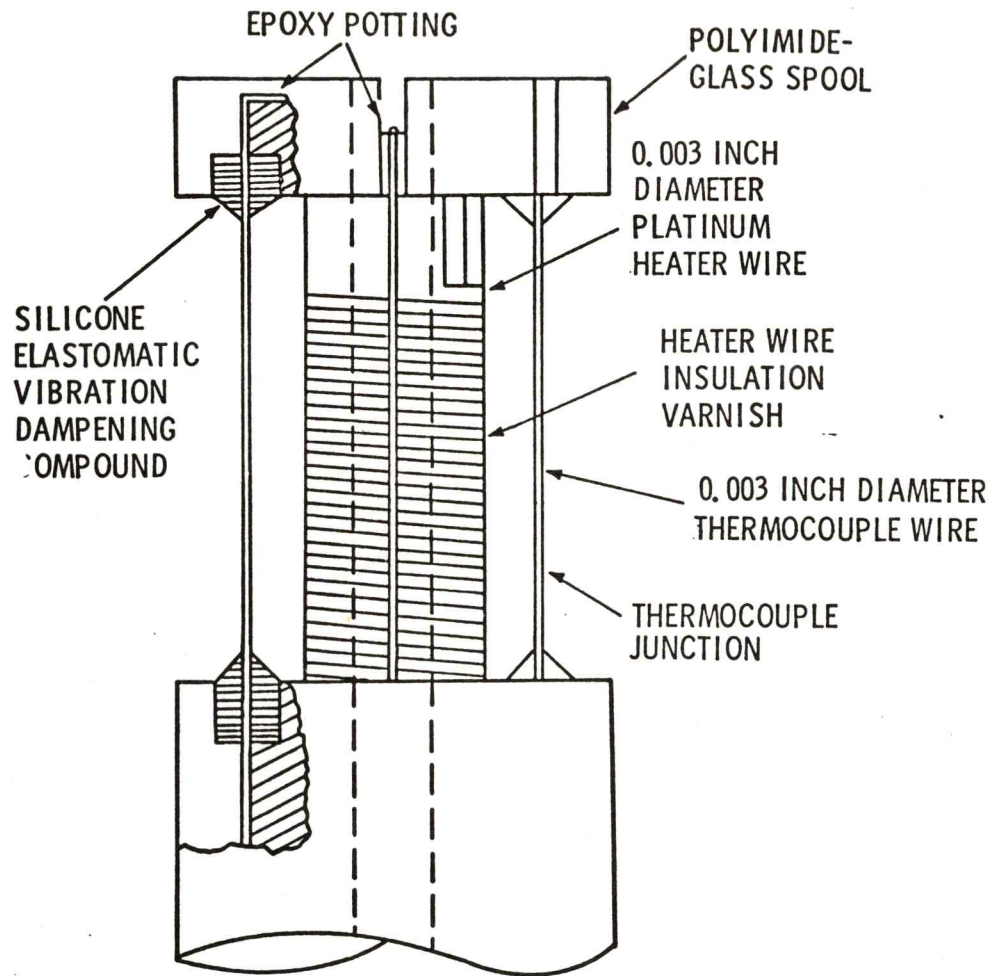


FIGURE 4.8.2.5-2
QUADRANT SENSOR DESIGN

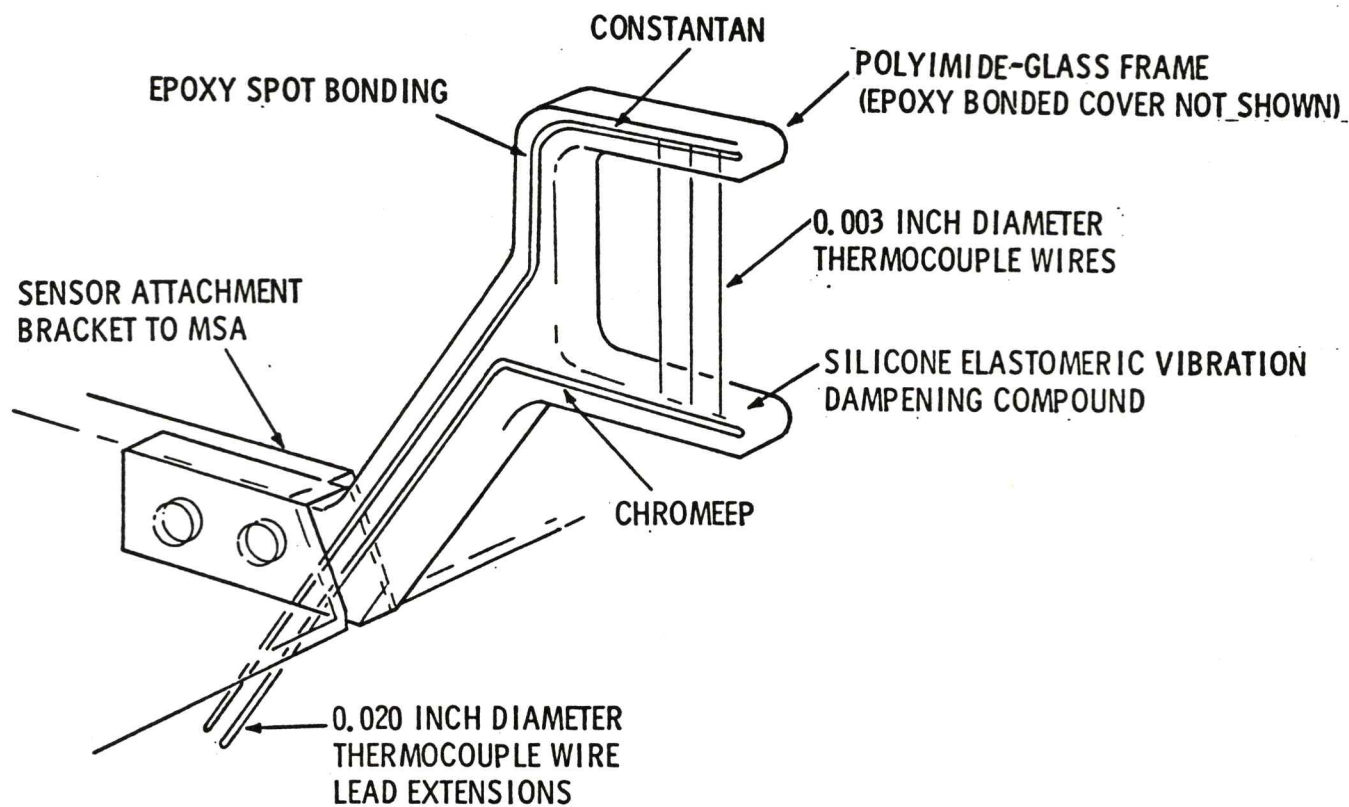


FIGURE 4.8.2.5-3
TEMPERATURE SENSOR

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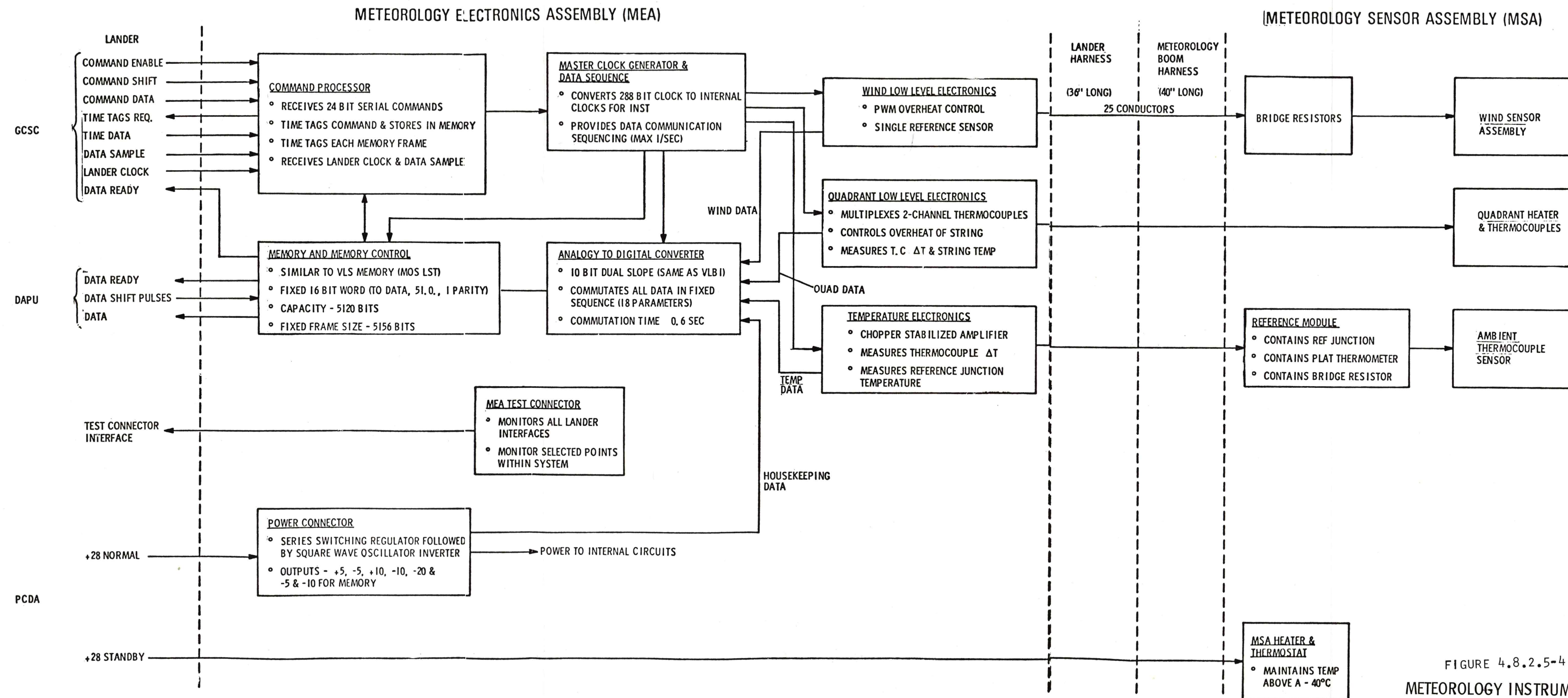


FIGURE 4.8.2.5-4
METEOROLOGY INSTRUMENT ASSEMBLIES

4.8.2.5.3 OPERATING MODES

The Meteorology Instrument operates and collects data from a ground updatable sequence stored in the GCSC. This sequence consists of four tables of eight Meteorology modules per table for a total capability of 32 modules per day. Each table has an entry pointer that allows the table to be entered at any predetermined module in the table. Each of the four tables can contain only one type of module that is defined by the following parameters:

- a. Module duration
- b. Number of samples per module
- c. Interval between samples

In addition to the above inputs that need to be defined for each table, the intervals between modules must also be defined (i.e. 8 delta times per table). The sequence is then generated by stepping down through each of the four tables and then recycling back to the beginning. This allows for a flexible sequence with four different types of modules (i.e. duration and sample interval) spaced at various intervals throughout each sequence (i.e. delta Sol normally).

A Meteorology module consists of one or more buffer memory dumps of 5156 data bits. Each buffer dump contains 16 samples of Meteorology data. For a sample interval of 4 seconds the buffer would fill up and dump every 64 seconds. If the module duration in that table were defined at 384 seconds (96 sample pulses) 6 buffer dumps would occur for each module in the table.

4.8.2.5.4 OPERATIONAL SEQUENCE

For both VL-A and VL-B the initial Meteorology sequence is stored in the GCSC and can be updated after landing. The sequence is initiated by the GCSC sending a command to the Power Control and Distribution Assembly (PCDA) to turn on Meteorology operate power. The master clock (288 KHz) and operate power are then supplied to the Meteorology Instrument. After power and the clock have been received the MEA issues a time tag request to the GCSC. The GCSC then responds with the proper time tag to Meteorology and waits a predetermined warm up time (e.g. 16 sec) before issuing sample commands. The warmup time is necessary for stabilization of the hot film wind sensors.

The preprogrammed Meteorology sequences for VL-A and VL-B are shown in Tables 4.8.2.5-1 and 4.8.2.5-2, respectively. As can be seen in the tables the Meteorology Investigation is currently scheduled for 20 modules per Sol. Each sequence contains 2 long data taking periods each day spaced approximately 12 hours apart and precessing or moving by one period (e.g. 1 hour 27 minutes, 2 seconds, per day) each day. For VL-A the

first period (4 back to back modules) starts at 18:00:00 hours and lasts for approximately 40 minutes. The second period starts at 12:11:50 and lasts for approximately 19 minutes. These two long modules, taken near noon and sunset for the first full day of operation, will help the Meteorology Team determine some of the meteorologically significant characteristics of the atmosphere early in the mission.

4.8.2.5.5 INTERFACES

Meteorology interfaces with the GCSC, DAPU, PCDA, and the VL.

a. Electrical Interfaces

The Meteorology electrical interfaces are shown in Figure 4.8.2.5-5 and listed in Table 4.8.2.5-3

4.8.2.5.6 POWER REQUIREMENTS

The Meteorology Instrument input power requirements are shown in Table 4.8.2.5-4.

TABLE 4.8.2.5-1
VL-A METEOROLOGY SUMMARY

	Local Lander Time	Table No.	Module Duration	Module No.	Sample Interval	No. Samples	Δ Times	No. of Bits Generated (3)
(1)	18:00:00	1	576 sec	1	4 sec	144	$\Delta t_1 = 4 \text{ sec}$	46404
	18:09:56	1	576	2	4	144	$t_2 = 4 \text{ sec}$	46404
	18:19:52	1	576	3	4	144	$t_3 = 4 \text{ sec}$	46404
	18:29:48	1	576	4	4	144	$t_4 = 2842$	46404
	19:27:02	1	576	5	4	144	$t_5 = 4630$	46404
	20:54:04	1	576	6	4	144	$t_6 = 4630$	46404
	22:21:06	1	576	7	4	144	$t_7 = 4630$	46404
	23:48:08	1	576	8	4	144	$t_8 = 4630$	46404
(2)	00:35:36	2	672	1	8	84	$t_1 = 4534$	25780
	02:02:38	2	672	2	8	84	$t_2 = 4534$	25780
	03:20:40	2	672	3	8	84	$t_3 = 4534$	25780
	04:56:42	2	672	4	8	84	$t_4 = 4534$	25780
	06:23:44	2	672	5	8	84	$t_5 = 4534$	25780
	07:50:46	2	672	6	8	84	$t_6 = 4534$	25780
	09:17:48	2	672	7	8	84	$t_7 = 4534$	25780
	10:44:50	2	672	8	8	84	$t_8 = 4534$	25780
	12:11:52	3	1176	8	2	588	$t_8 = 4030$	185616
	13:38:54	4	336	5	4	84	$t_5 = 4870$	25780
	15:05:56	4	336	6	4	84	$t_6 = 4870$	25780
	16:32:58	4	336	7	4	84	$t_7 = 4870$	25780
	18:00:00	4	336	8	4	84	$t_8 = 4871$	25780

(1) SOL 0 Meteorology

(2) SOL 1 Meteorology

(3) Each module also generates 3072 bits of Format 4 data

Table 4.8.2.5-2
VL-B METEOROLOGY SUMMARY

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	Local Lander Time	Table No.	Module Duration	Module No.	Sample Interval	No. Samples	Δ Times	No. of Bits Generated (4)
(1)	11:24:00	1	4348 sec	8	2 sec	2174	$\Delta t_8 = 43256$ sec	696,060
	24:37:40	2	672	1	8	84	$t_1 = 4534$	25,780
	01:25:07	2	672	2	8	84	$t_2 = 4534$	25,780
	02:52:09	2	672	3	8	84	$t_3 = 4534$	25,890
	04:19:11	2	672	4	8	84	$t_4 = 1534$	25,780
	05:46:13	2	672	5	8	84	$t_5 = 4534$	25,780
	07:13:15	2	672	6	8	84	$t_6 = 4534$	25,780
	08:40:17	2	672	7	8	84	$t_7 = 4534$	25,780
	10:07:19	2	672	8	8	84	$t_8 = 4534$	25,780
	11:34:21	3	1176	8	2	588	$t_8 = 4030$	185,616
	13:01:23	4	336	5	4	84	$t_5 = 4870$	25,780
(2)	14:28:25	4	336	6	4	84	$t_6 = 4870$	25,780
	15:55:27	4	336	7	4	84	$t_7 = 4870$	25,780
	17:22:29	4	336	8	4	84	$t_8 = 4871$	25,780
	18:49:32	1	576	1	4	144	$t_1 = 4$	46,404
	18:59:28	1	576	2	4	144	$t_2 = 4$	46,404
	19:09:24	1	576	3	4	144	$t_3 = 4$	46,404
	19:19:20	1	576	4	4	144	$t_4 = 2842$	46,404
	20:16:34	1	576	5	4	144	$t_5 = 4630$	46,404
	21:43:36	1	576	6	4	144	$t_6 = 4630$	46,404
	23:10:38	1	576	7	4	144	$t_7 = 4630$	46,404
	24:37:40	1		8	4	144	$t_8 = 4630$	46,404

TABLE 4.8.2.5-2 (Cont)
VL-B METEOROLOGY SUMMARY

Local Lander Time	Table No.	Module Duration	Module No.	Sample Interval	No. Samples	Δ Times	No. of Bits Generated (4)
(3) { 01:25:07	2	672	1	8	84	$\Delta t_1 = 4534$	25,780
02:52:09	2	672	2	8	84	$t_2 = 4534$	25,780
04:19:11	2	672	3	8	84	$t_3 = 4534$	25,780
05:46:13	2	672	4	8	84	$t_4 = 4534$	25,780
07:13:15	2	672	5	8	84	$t_5 = 4534$	25,780
08:40:17	2	672	6	8	84	$t_6 = 4534$	25,780
10:07:19	2	672	7	8	84	$t_7 = 4534$	25,780
11:34:21	2	672	8	8	84	$t_8 = 4534$	25,780
13:01:23	3	1176	8	2	588	$t_8 = 4030$	185,616
14:28:25	4	336	5	4	84	$t_5 = 4870$	25,780
15:55:27	4	336	6	4	84	$t_6 = 4876$	25,780
17:22:29	4	336	7	4	84	$t_7 = 4876$	25,780
18:49:31	4	336	8	4	84	$t_8 = 4871$	25,780

(1) Initialization

(2) Sol 2 Meteorology

(3) Sol 2 Meteorology

(4) Each module also generates 3072 bits of Format 4 data

Table 4.8.2.5-3
Meteorology Interface Signals

<u>Function</u>	<u>From</u>	<u>To</u>
Time Request	HEA	GCSC
Digital Time Tag	GCSC	HEA
Command Enable	GCSC	HEA
Command Shift Pulses	GCSC	HEA
Digital Command	GCSC	HEA
Data Sample Pulse	GCSC	HEA
Data Ready	HEA	GCSC
Clock (288 KHZ)	GCSC	HEA
Data Ready	HEA	DAPU
Data Shift Pulses	DAPU	HEA
Digital Data	HEA	DAPU
HEA Operate Power (+28Vdc)	PCDA	HEA
Power Return	PCDA	HEA
HEA Standby Power (+28Vdc)	PCDA	HEA
Signal Return	PCDA	HEA

TABLE 4.8.2.5-4

METEOROLOGY POWER REQUIREMENTS

<u>Input Power</u>	<u>Voltage</u>	<u>Peak Power</u>	<u>Average Power</u>
MEA Operate	+28Vdc Nominal	13 Watts	6.6 Watts System Power 0.35-4.3 Watts for wind and quadrant sensor power
MEA Standby	+28Vdc Nominal	3.0 Watts	1.0 Watt

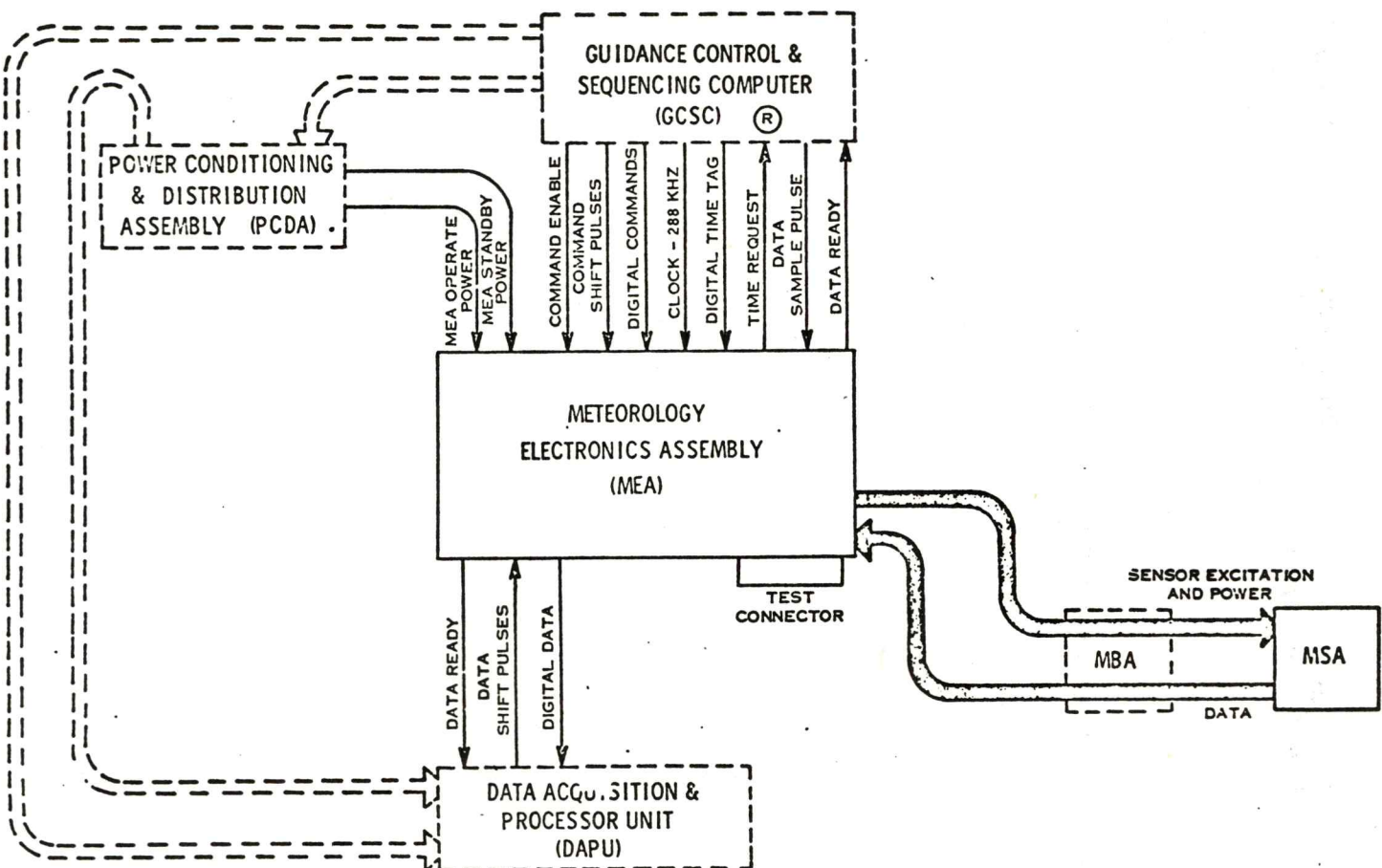
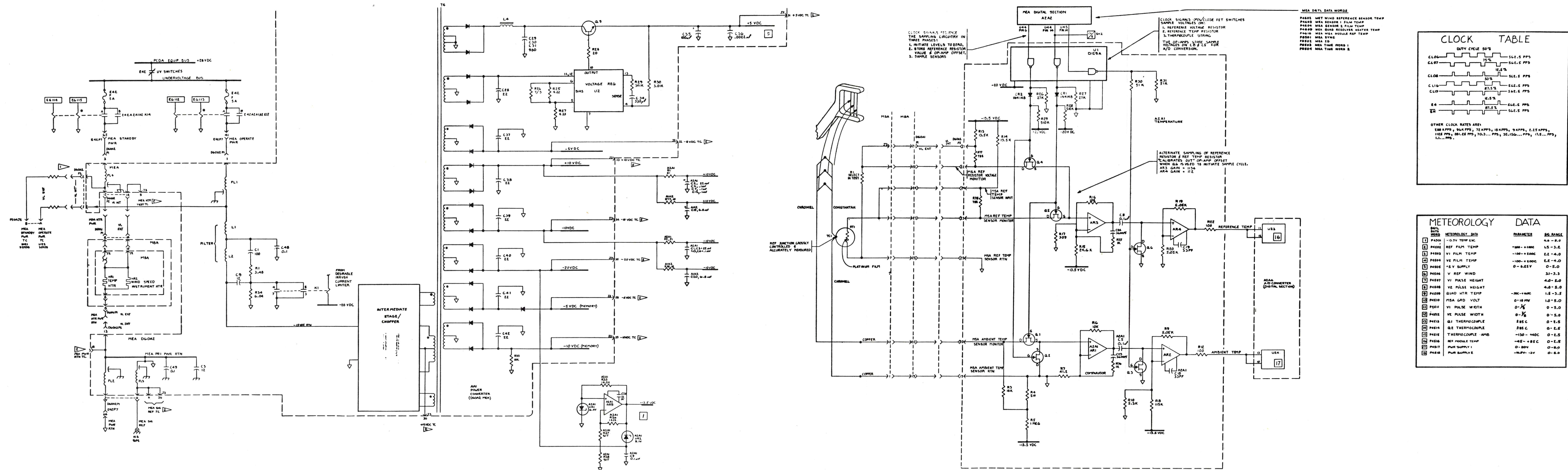


FIGURE 4.8.2.5-5
METEOROLOGY SYSTEM FUNCTIONAL
SCHEMATIC



NOTES:

- REPAIRABLE TEST HARNESS
BENCH TEST ONLY

REF. DRAWINGS:
MEAS - METEOROLOGY - MEAS INSTR. SYS - A
MEAS - METEOROLOGY - MEAS INSTR. SYS - B
MEAS - METEOROLOGY - MEAS INSTR. SYS - C
MEAS - METEOROLOGY - MEAS INSTR. SYS - D
MEAS - METEOROLOGY - MEAS INSTR. SYS - E
MEAS - METEOROLOGY - MEAS INSTR. SYS - F
MEAS - METEOROLOGY - MEAS INSTR. SYS - G
MEAS - METEOROLOGY - MEAS INSTR. SYS - H
MEAS - METEOROLOGY - MEAS INSTR. SYS - I
MEAS - METEOROLOGY - MEAS INSTR. SYS - J
MEAS - METEOROLOGY - MEAS INSTR. SYS - K
MEAS - METEOROLOGY - MEAS INSTR. SYS - L
MEAS - METEOROLOGY - MEAS INSTR. SYS - M
MEAS - METEOROLOGY - MEAS INSTR. SYS - N
MEAS - METEOROLOGY - MEAS INSTR. SYS - O
MEAS - METEOROLOGY - MEAS INSTR. SYS - P
MEAS - METEOROLOGY - MEAS INSTR. SYS - Q
MEAS - METEOROLOGY - MEAS INSTR. SYS - R
MEAS - METEOROLOGY - MEAS INSTR. SYS - S
MEAS - METEOROLOGY - MEAS INSTR. SYS - T
MEAS - METEOROLOGY - MEAS INSTR. SYS - U
MEAS - METEOROLOGY - MEAS INSTR. SYS - V
MEAS - METEOROLOGY - MEAS INSTR. SYS - W
MEAS - METEOROLOGY - MEAS INSTR. SYS - X
MEAS - METEOROLOGY - MEAS INSTR. SYS - Y
MEAS - METEOROLOGY - MEAS INSTR. SYS - Z

YBS - COMPONENT SELECTED
DURING TEST.

SEE DWG 8370020001 FOR ORIGIN
OF SIGNALS.

FIGURE 4.8.2.5-6 METEOROLOGY FUNCTIONAL
SCHEMATIC (SHEET 1)

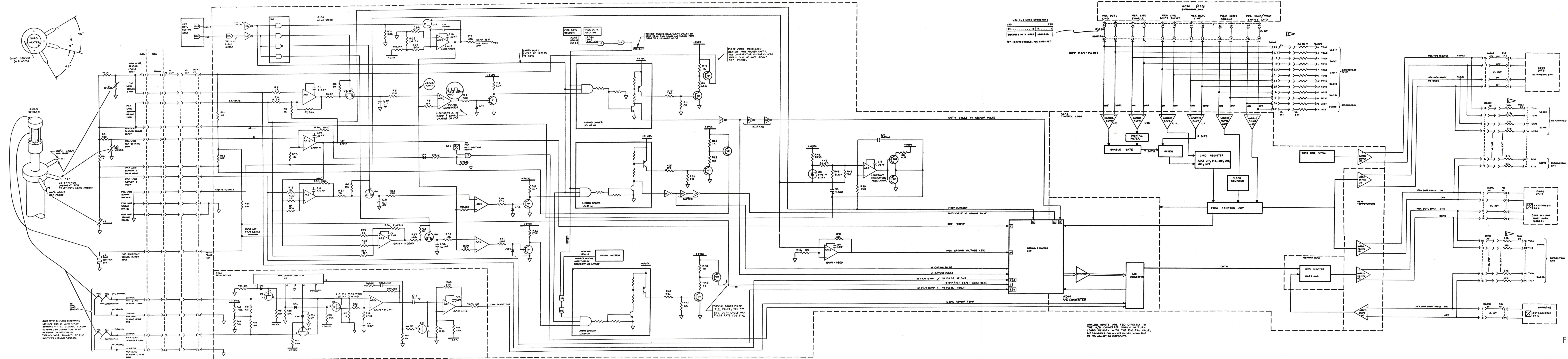


FIGURE 4.8.2.5-6 METEOROLOGY FUNCTIONAL SCHEMATIC (SHEET 2)

4.8.2.6 Seismometer

4.8.2.6 SEISMOMETER

4.8.2.6.1 PURPOSE

The purpose of the Seismology Investigation is to provide information relevant to the structure, composition, and dynamics of the interior of Mars. In particular, the objectives of this investigation are as follows:

- a. To determine the amplitude, spectrum, polarization, and source of continuous background microseism activity;
- b. To determine whether Mars is a tectonically active planet and to determine the level, nature, and location of tectonic activity;
- c. To determine the internal structure and composition of Mars; specifically, to determine if Mars has a crust and a core, and to determine if the mantle of Mars is similar in composition to the mantle of the Earth;
- d. To determine the influx rate of meteorites;
- e. To determine the mechanical properties of the material near the Viking Lander (VL).

To accomplish the foregoing, the Seismometer will measure three orthogonal (one vertical, two horizontal) components of VL motion and present suitable signals representing ground displacement, amplitude, and frequency to the VL data system. The Seismometer includes sensors, amplifiers, filters, and data compression circuits. Selectable gain and filter characteristics are provided.

The Seismometer will provide the first indication of the level of tectonic activity of Mars, the level of microseismic activity, and the structure of the interior of Mars. It will also register disturbances caused by wind and other meteorological events, meteorite impacts, and will monitor disturbances created by VL activity.

4.8.2.6.2 FUNCTION

The Seismometer will operate during the Post Landed mission to measure three perpendicular components of ground motion. The Seismometer is capable of detecting ground displacement in all three axes of 50×10^{-6} millimeters, or less, at a frequency of 1.0 ± 0.2 Hz, and 1×10^{-6} millimeters or less, at 4.0 ± 1 Hz, with the unit operating at the level attitude (vertical axis of sensitivity parallel to the local gravity vector).

The Seismometer consists of the following two functional subassemblies contained in a single housing:

- a. Sensor Subassembly
- b. Electronics Subassembly

The instrument assemblies are depicted in Figures 4.8.2.6-1 through 4.8.2.6-3.

- 1) Sensor Subassembly (Figures 4.8.2.6-2 and 4.8.2.6-4)

The Sensor Assembly contains the following functional devices:

- a) Three mutually perpendicular seismic sensors, one vertical (Y-axis), and two horizontal (Y&Z axes). These sensors are mass-coil assemblies suspended in such a way that the coil is positioned between the poles of two facing channel magnets. Motion of the coil normal to the field of the magnets generates an analog signal proportional to the amplitude and frequency of the respective components of ground motion. These outputs are hard-wired into the electronics assembly to be filtered, amplified, and then placed into a digital format;
 - b) Calibration actuators for each sensor that operate in response to an external command and cause a mechanical displacement of the sensors;
 - c) Three caging devices that release the moving elements of all three seismic sensors in response to external commands;
 - d) A means of electrically testing the sensor and electronics while caged.
- 2) Electronics Subassembly (Figures 4.8.2.6-3 and 4.8.2.6-4)

The Electronics Assembly receives analog inputs from the Seismic Sensors and serial digital command signals from the Guidance Command and Sequencing Computer (GCSC). Formatted data from the Seismometer to the Data Acquisition and Processor Unit (DAPU) are serial digital signals that include experiment identification, synchronization, time information, and experiment data.

The Electronics Assembly contains the following functional devices:

- a) Variable gain amplifiers, (X, Y, Z) with gain selectable by Earth command. The amplifiers have a nominal gain of 100 dB with attenuators to provide 0dB, 6dB, 12dB, 18dB, 24dB, 30dB, and 36dB attenuations;
- b) A programmable low-pass filter with selectable cutoff frequencies of 0.5, 1.0, 2.0, and 4.0 Hz;
- c) A data processor that contains an event detector with selectable sensitivity, a circuit for detecting the absolute average of the seismic signal, an axis crossing counter which produces a running count of the positive going axis crossings of the seismic signal, and circuitry for automatically stepping the programmable filter through the frequency cutoffs provided;
- d) A calibration function generator;
- e) A data multiplexer with sampling rates determined by operating mode;
- f) A data register that contains dual 2048 bit buffers;
- g) An 8-bit analog-to-digital converter;
- h) Digital circuitry and switches necessary to accomplish the following:
 - (1) Decode and implement 24-bit serial commands from the GCSC;
 - (2) Provide data sampling, formatting, storage, and transfer in the operational modes.
- i) Circuitry for the actuation of non-explosive uncaging initiators by the application of electrical power from the Power Conditioning and Distribution Assembly (PCDA);
- j) Power conditioner which accepts electrical power from the VL PCDA unregulated bus and provides the necessary power conversion, filtering, and regulation to power the Seismometer.

4.8.2.6.3 OPERATING MODES

The Seismometer collects data in three different modes: Normal, Event, and High. The data sampling in these modes is as follows:

- Normal - One eight bit sample every 14.85 seconds in each of the three axes.
- Event - One sample, consisting of one eight bit word and one five bit word, every 0.99 seconds in each of the three axes.
- High - One eight bit sample every 0.0495 second in each of the three axes.

The data rates are as follows:

- Normal - 1.6162 bps
- Event - 39.394 bps
- High - 484.85 bps

All three modes are commandable by ground update. If the Seismometer is in the Normal mode with event triggers enabled and a seismic event occurs such that its amplitude exceeds a predetermined multiple of the average background level, the Seismometer will trigger into the Event mode automatically. The Seismometer reverts to the Normal mode after the average level of the seismic event becomes smaller than the predetermined multiple of the average background level for a sufficient period of time. The Event data rate mode can be triggered only while the Seismometer is in the Normal mode and at least one of the triggers is enabled.

Normally, the Seismometer will be in the Normal mode with one or more of the triggers enabled; however, periods of operation in both the Event and High modes are scheduled each Sol. In general, all triggers will be inhibited during Relay Communications Equipment (RCE), Direct Communications System (DCS), Surface Sampler Control Assembly (SSCA), Imaging, and Gas Chromatograph Mass Spectrometer (GCMS) sequences.

The amount of data that can be generated by the Seismometer for a given Sol is a function of the number of data buffer transfers allowed. A buffer is full when it contains 2048 bits. The nominal Seismometer data allocation is 500 data buffer dumps per day. As soon as the allocated number of data buffer transfers has been reached, the Seismometer is powered off.

NOTE: When transferring data to the DAPU the Seismometer inserts a 46 bit initial sequence ahead of the stored data, making a transfer of 2094 bits of data per buffer dump.

A simplified data flow schematic is shown in Figure 4.8.2.6-5 and nominal frequency response curves in Figures 4.8.2.6-6 through 4.8.2.6-10. All of the functions associated with the event triggering, axis crossing counters and Event mode amplitude operate on the digitized output from the analog amplifiers and consequently these channels have the frequency response derived from Figure 4.8.2.6-6. The Event mode amplitude data is obtained by rectifying this output and smoothing it using the 0.5 Hz digital filter.

a. Normal Mode

The Normal mode is used to determine the seismic background noise level (i.e., microseismic activity), its nature, variation with time, and correlation with meteorological phenomena. It also acts as an event counter for small events which fall below the trigger threshold level. The output of each Seismometer channel is filtered, rectified, and averaged in a 12.87 second running average circuit and sampled every 14.85 seconds.

To determine the frequency content of the background noise, a variable low-pass filter with four cutoff frequencies is incorporated in the Seismometer. The Seismometer can be commanded to remain in any one of the frequency ranges or alternatively commanded to automatically step continuously through the filters taking 8 samples in each channel before incrementing to the next frequency.

b. Event Mode

Seismic activity due to "Marsquakes" or meteorite impacts will be transient phenomena. When such transient events occur it is necessary to record data at some faster rate so that various phases can be identified and analyzed. The allowable data rate still means that some data compression is necessary even when a trigger occurs.

The data compression scheme consists of a seismic event envelope detector and an axis crossing counter for each seismic axis. Two data words per sample are required: amplitude (8 bits) and axis crossing counter (5 bits).

The seismic event detector is designed to detect an event when its amplitude exceeds a predetermined multiple of the average background level. The multiple is selected by ground command (x4, x8, x12, x16, x20 being the selectable values of multiple).

After the occurrence of an event of sufficient magnitude to cause triggering of the detector, the following occurs:

- 1) The Seismometer automatically switches itself into the Event mode;
- 2) The programmable filter is switched to the 0.5 Hz break point to provide proper smoothing of the seismic envelope.

The trigger stretches the on-time by an amount which varies from approximately 2 seconds for a false trigger to nominally one minute for the longest event. When the signal level from the seismic event falls below the threshold (i.e., background level times the threshold multiple) the "count-down" is initiated and the Seismometer will finally revert to the Normal mode. It is also possible to operate in the Event mode by command.

c. High Data Rate Mode

The High data rate mode allows relatively wide-band transmission of seismic data. This mode will be used primarily for Seismometer calibration and for periodic short looks at the seismic background activity. This mode can only be entered as a result of a command.

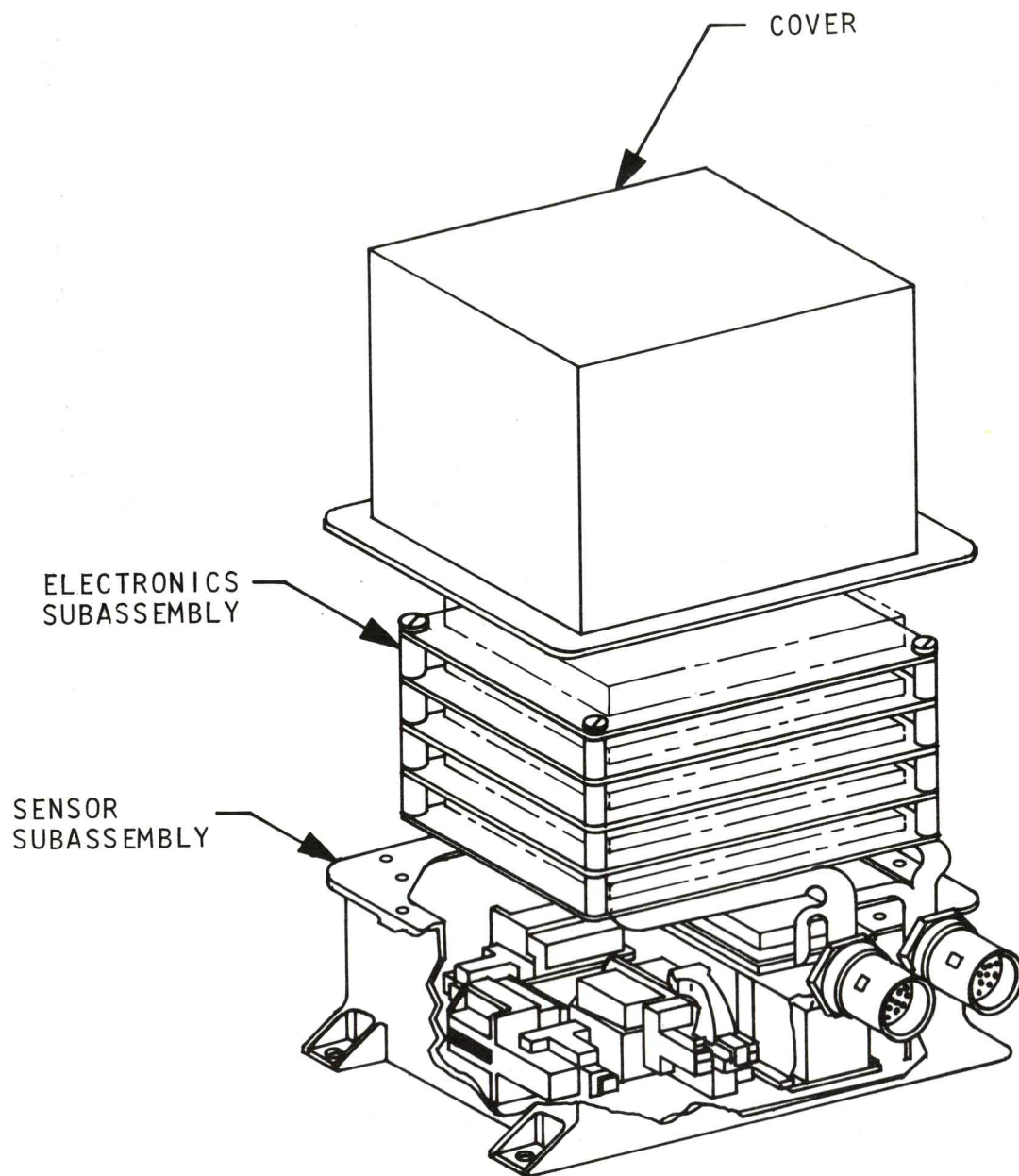


FIGURE 4.8.2.6-1 SEISMOMETER ASSEMBLY

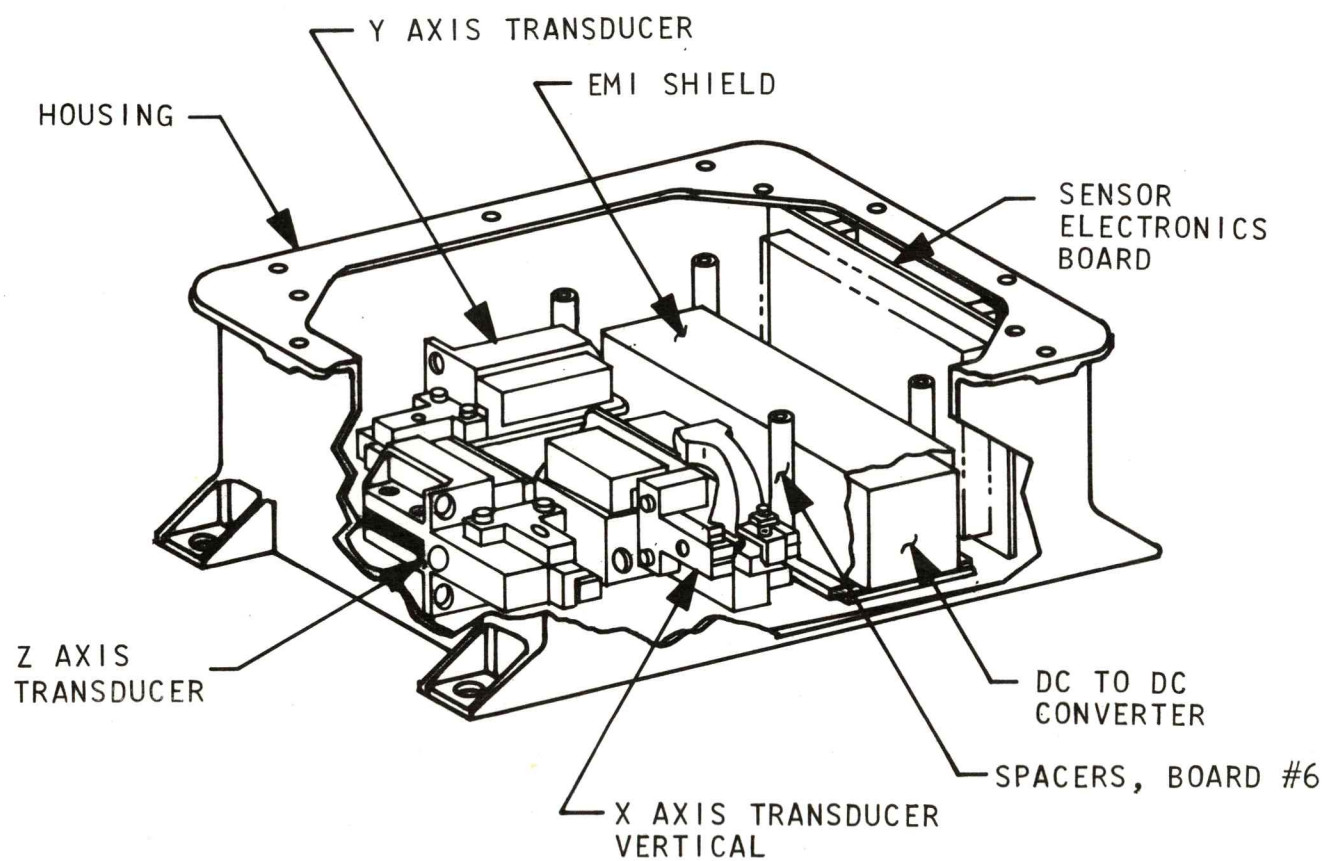


FIGURE 4.8.2.6-2 SENSOR SUBASSEMBLY

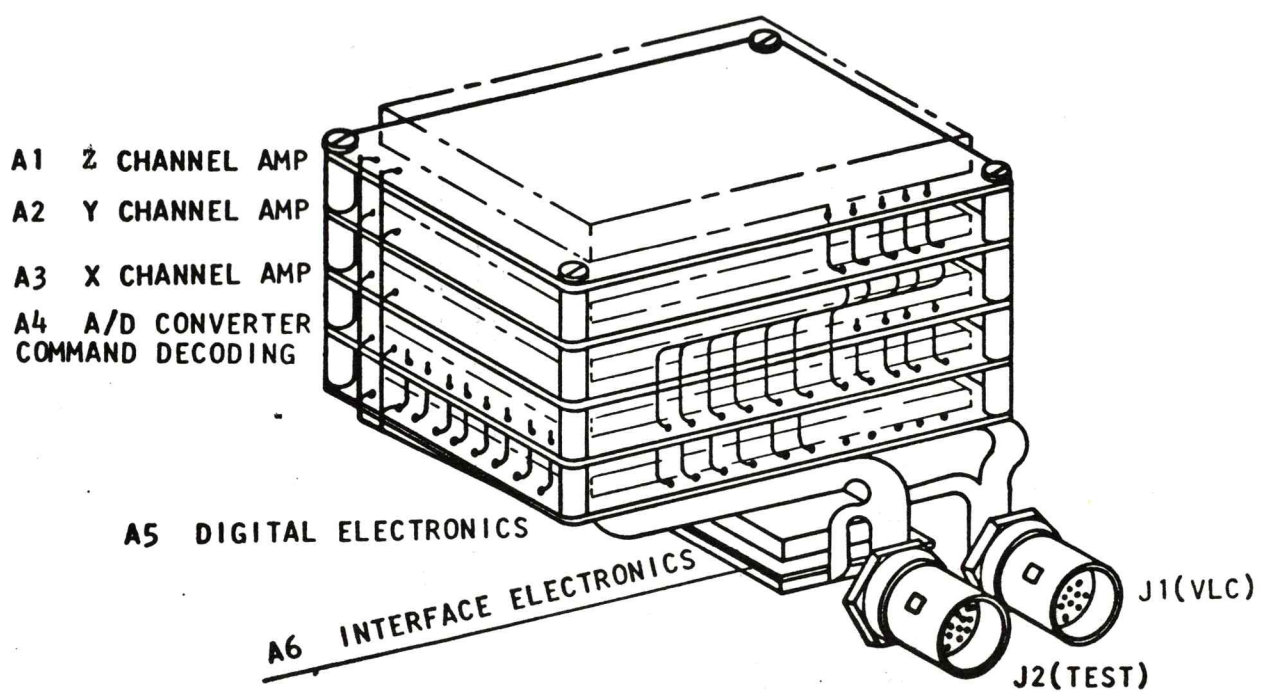
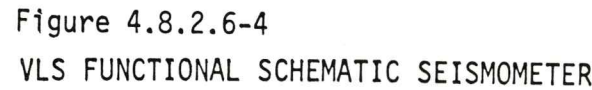
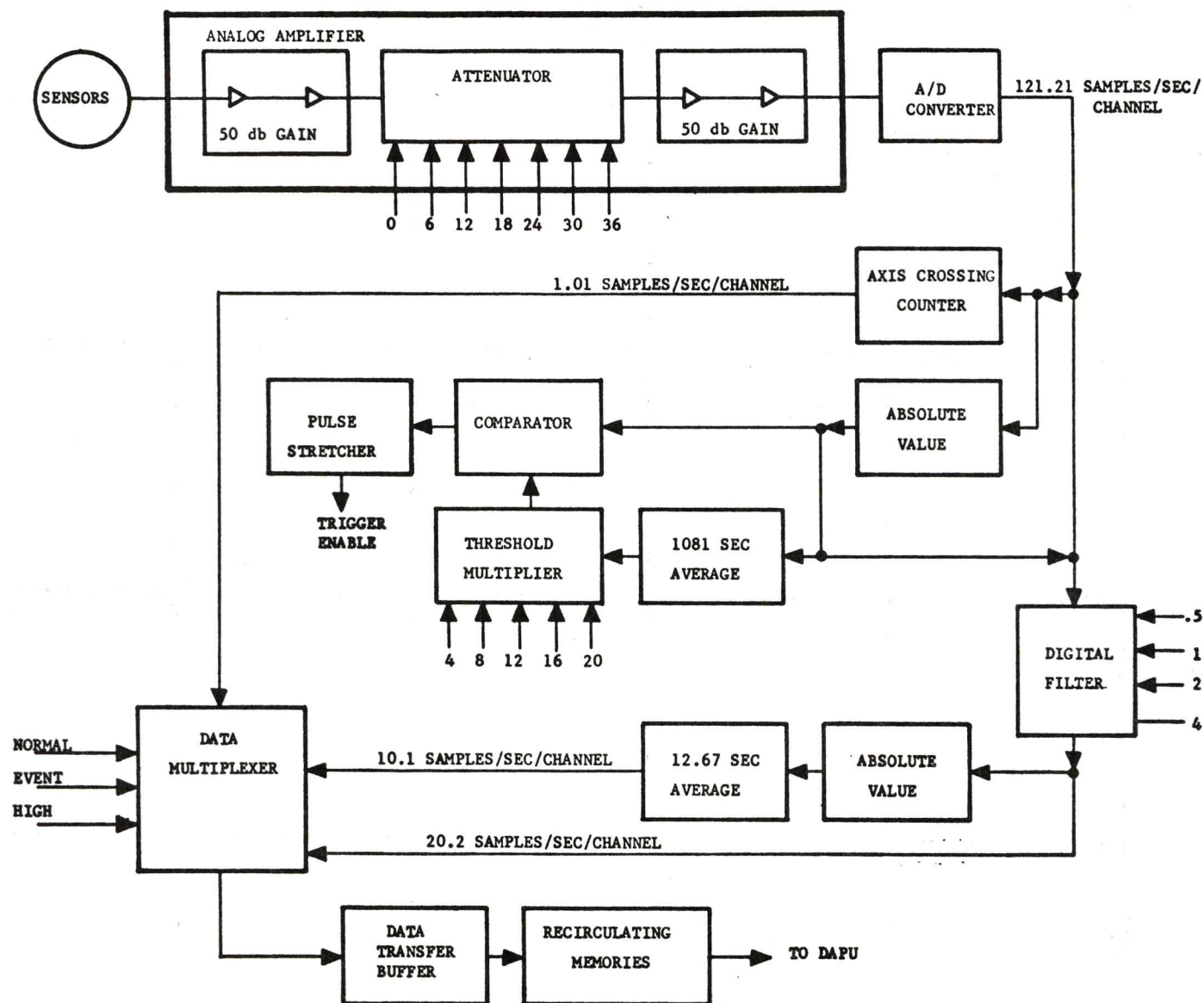


FIGURE 4.8.2.6-3
ELECTRONICS SUBASSEMBLY

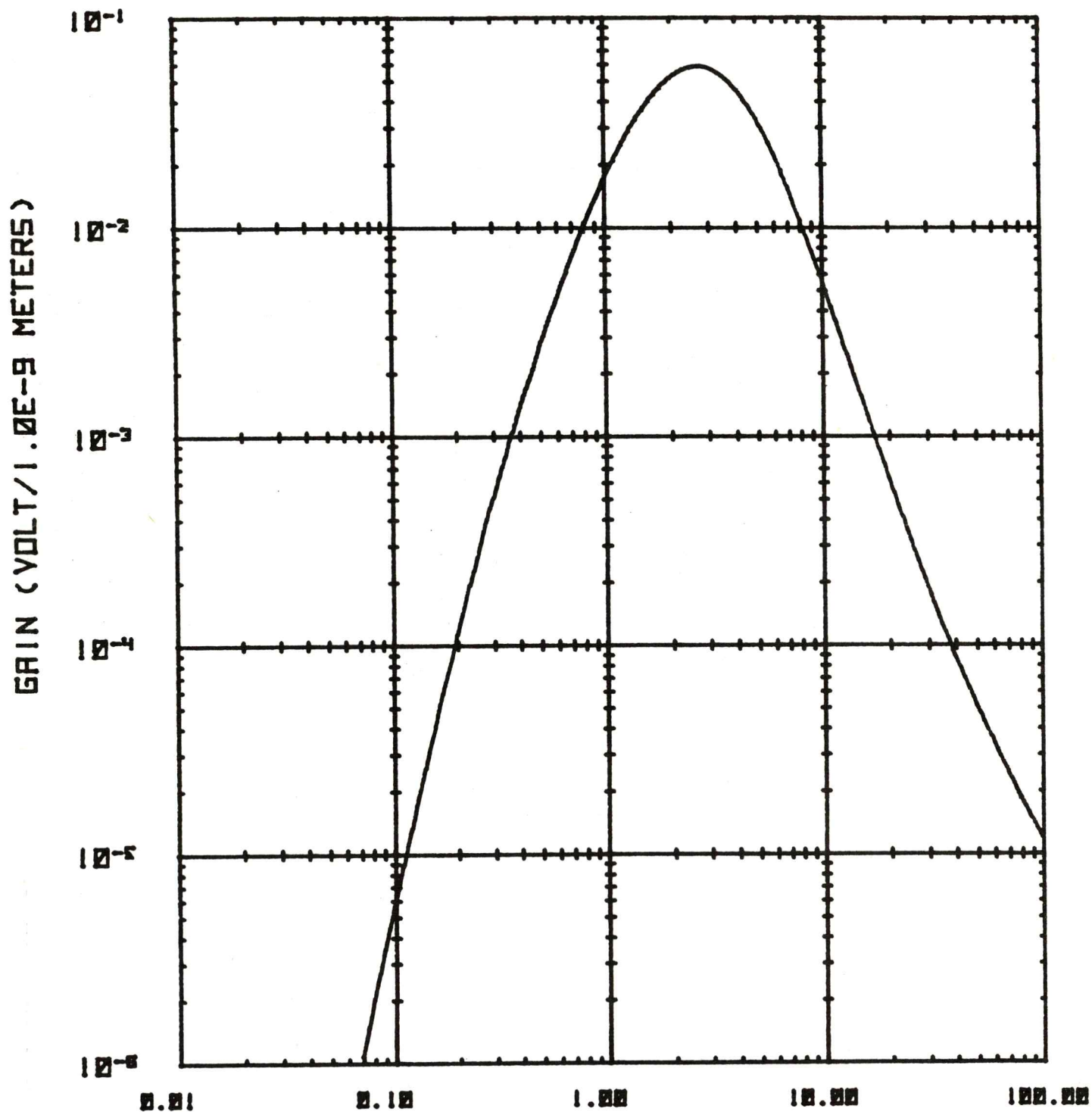




SEISMOMETER DATA FLOW

FIGURE 4.8.2.6-5

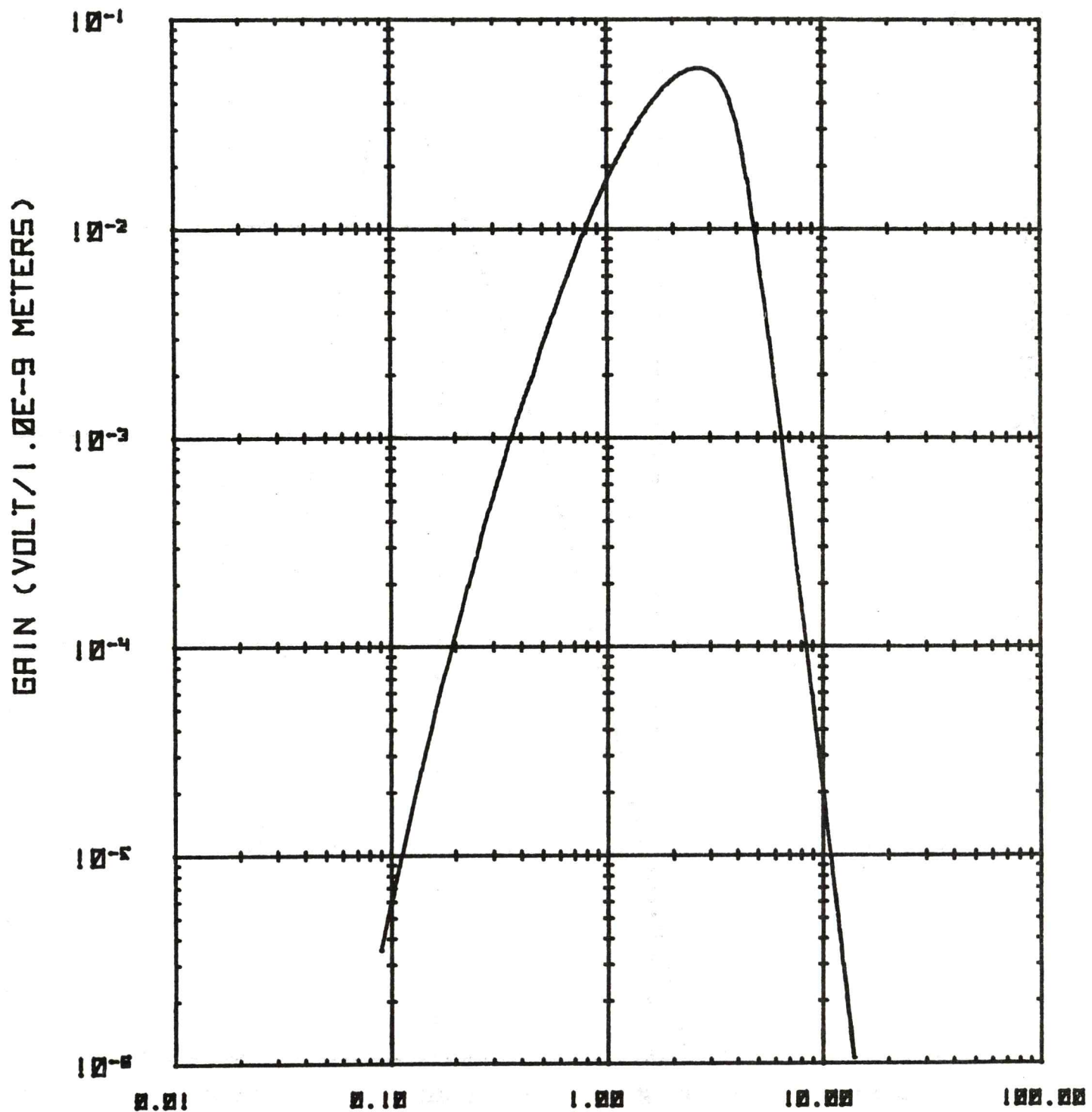
SEISMOMETER SENSOR-AMPLIFIER RESPONSE



FREQUENCY (HZ)

FIGURE 4.8.2.6-6

SEISMOMETER RESPONSE WITH 4 HZ FILTER



FREQUENCY (HZ)

FIGURE 4.8.2.6-7

SEISMOMETER RESPONSE WITH 2 HZ FILTER

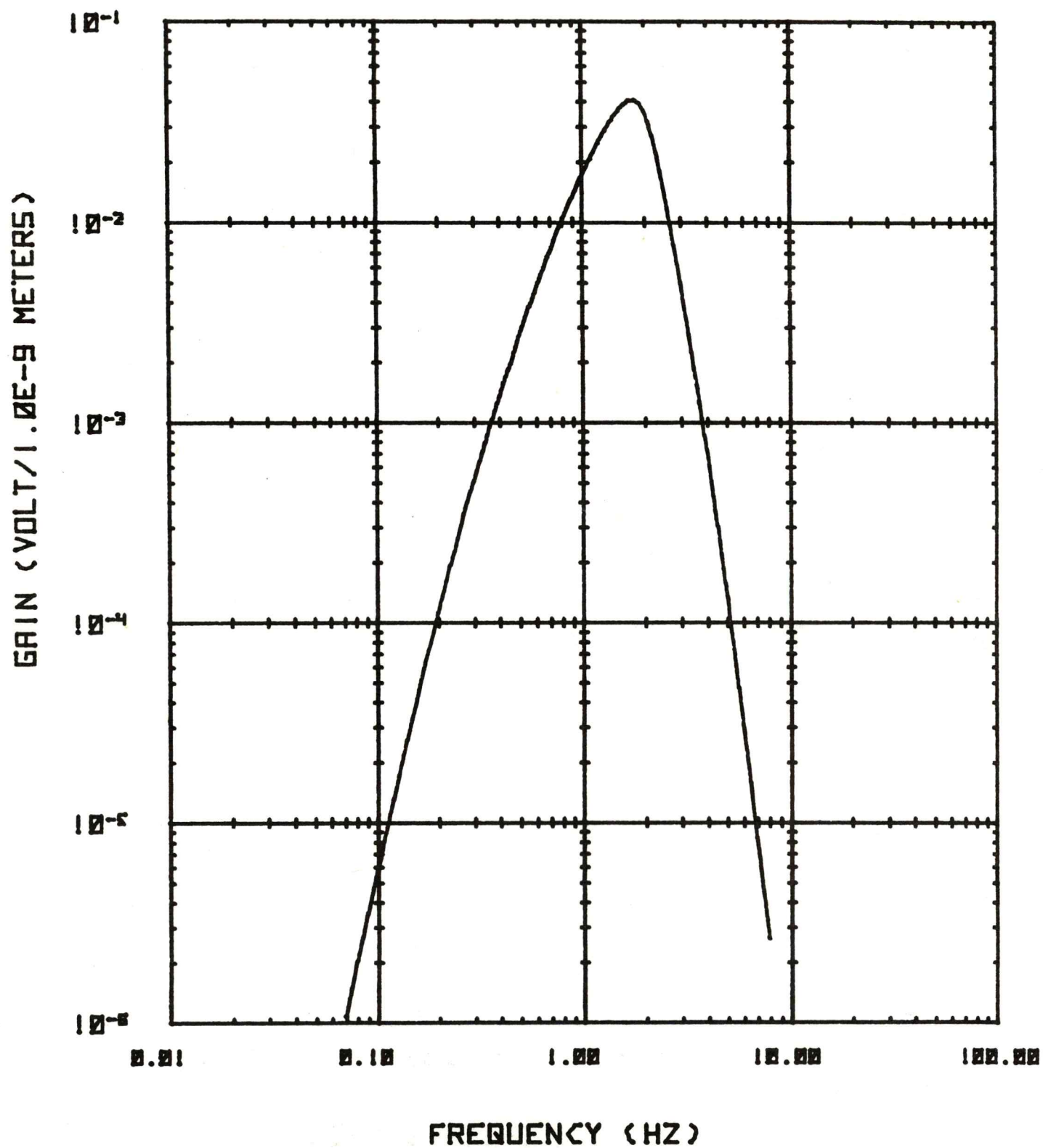
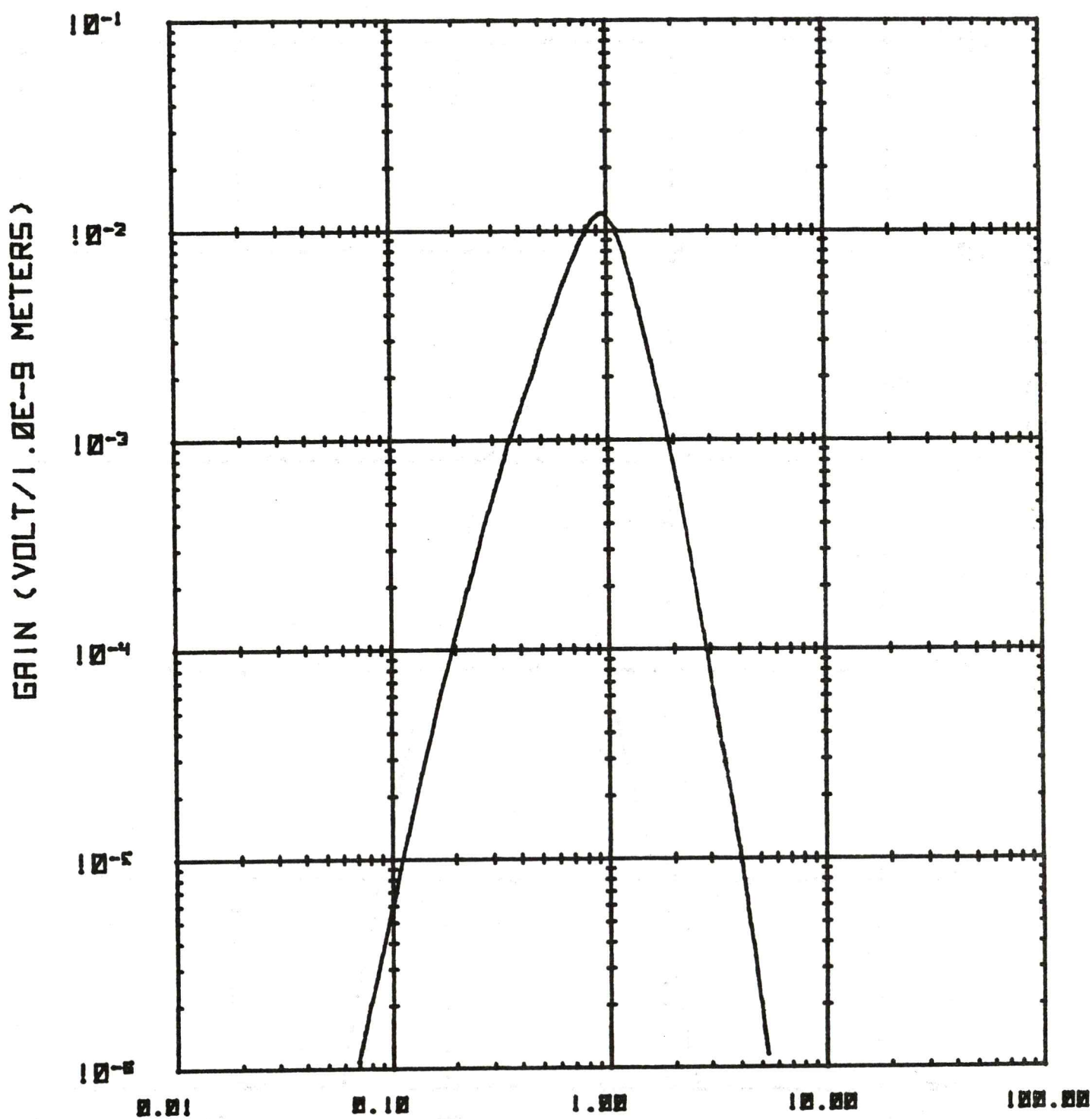


FIGURE 4.8.2.6-8

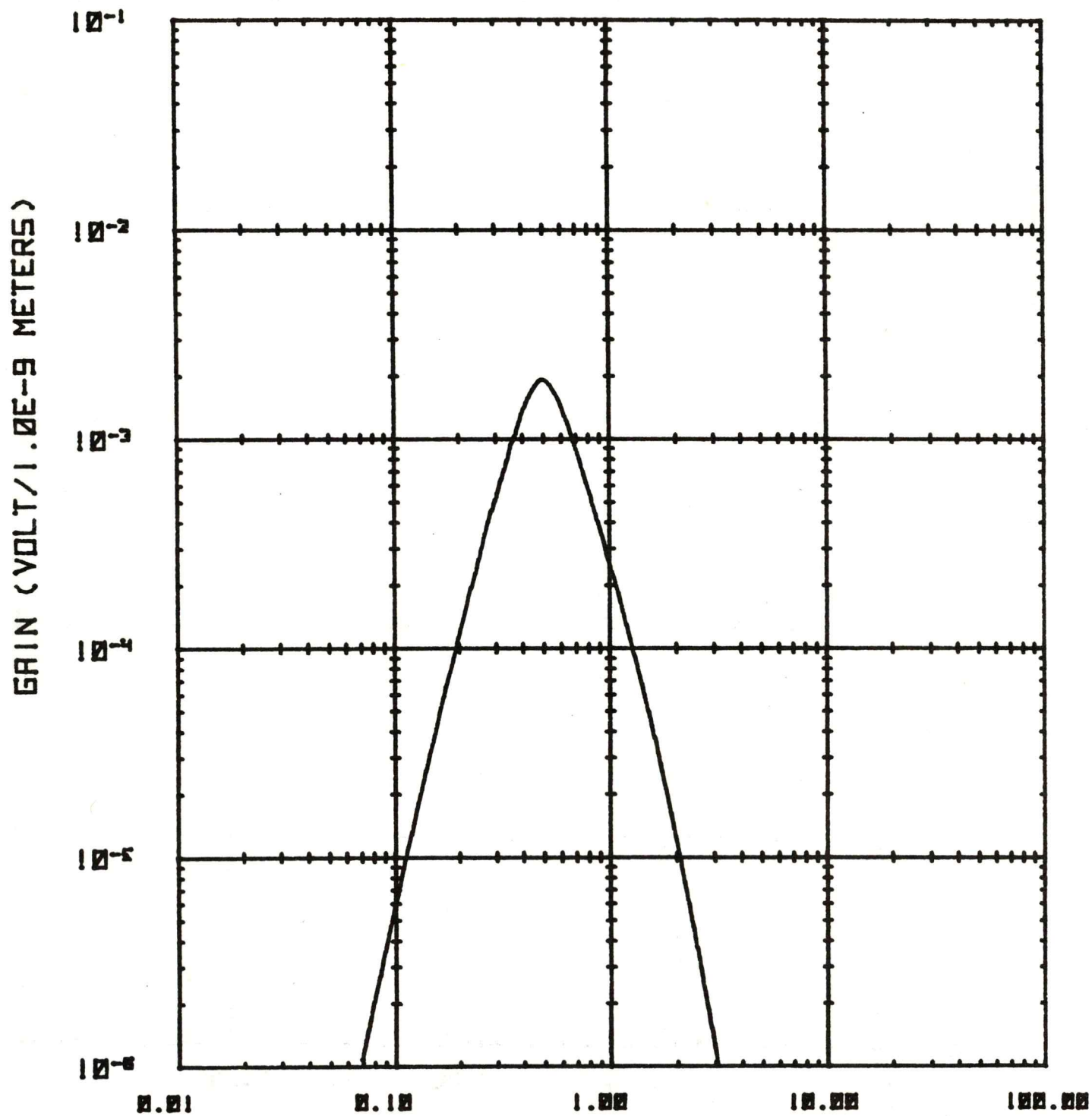
SEISMOMETER RESPONSE WITH 1 HZ FILTER



FREQUENCY (HZ)

FIGURE 4.8.2.6-9

SEISMOMETER RESPONSE WITH 0.5 HZ FILTER



FREQUENCY (HZ)

FIGURE 4.8.2.6-10

4.8.2.6.4 OPERATIONAL SEQUENCE

Seismometer operation is controlled by the GCSC. Soon after landing a seismometer initialization sequence is started in which caged operation in all modes is exercised to determine instrument electronic noise levels. The Seismometer is then uncaged and after a preprogrammed delay the flight software enters a normal operating sequence.

This sequence consists of a series of commands which will be used for instrument calibration. On completion of the calibration the Seismometer is controlled by entering one of two command tables in the GCSC. Each table contains 12 GCSC-to-Seismometer commands with unique delta times. When one table is completed, software re-enters the calibration sequence and then alternates to the other table.

A GCSC-to-Seismometer command is issued as a function of entering the DCS, RCE, GCMS, Imaging, and SSCA sequences; issuing commands from the Seismometer tables is also inhibited. Five unique commands exist one for each of the above sequences. These commands can be changed by uplink and are not a part of the Seismometer command tables. The purpose of these commands is to provide Seismometer settings compatible with the sequence to be performed, typically to inhibit triggering. Upon completion the DCS, RCE, GCMS, Imaging, and SSCA sequences, the GCSC reissues the last command issued (or which would have been issued) in the Seismometer command table. This allows the Seismometer to return to its normal operating sequence. The Seismometer flight software sequences are shown in Figure 4.8.2.6-11.

Upon filling a data buffer, the Seismometer will provide a data ready signal to the GCSC and DAPU. If the DAPU is busy when the Seismometer provides a data ready signal, the GCSC will allow completion of the data transfer in process before commanding the DAPU to collect the Seismometer data. However, if a Data Storage Memory (DSM) to Tape Recorder transfer signal occurs before the Seismometer data is transferred, then the DSM transfer will occur before the Seismometer is serviced.

The GCSC counts the number of Seismometer data readies that are serviced and, if it reaches the allowable number for the day, the GCSC commands power removal from the Seismometer. The number of buffer dumps is re-initialized every day as a part of the RCE sequence. The RCE sequence also has a programmed Seismometer Power Off-Power On sequence incorporated into it.

The Seismometer requests a time from the GCSC each time it starts writing data into a new buffer and each time there is a Seismometer operating mode change. The GCSC responds by shifting a 24 bit mission time to the Seismometer. Transfer of the mission time word has to be completed within 16 μ sec of the time request going high in order to be correctly written into the Seismometer data stream.

4.8.2.6.5 INTERFACES

The Seismometer interfaces with the GCSC, DAPU, and PCDA.

a. Electrical Interfaces

The electrical/signal interfaces are shown in Figure 4.8.2.6-12. The types of signals corresponding to these interfaces are listed in Table 4.8.2.6-1.

1) Discretes

These signals are used to perform enable, status and request functions, and are generated by the Seismometer;

2) Serial Digital Signals

These signals are used to transmit coded commands and mission time to the Seismometer from the GCSC and to transfer seismic data from the Seismometer to the DAPU. The format is Pulse Code Modulation (PCM), Non-Return to Zero (NRZ)-L, and the bit rate is 16 Kbps \pm 0.1 percent.

3) Clock Signal

This signal is used to transmit the basic time reference from the GCSC. It is an Return to Zero (RZ) format, at a bit rate of 576 Kbps \pm 0.01 percent, and a duty cycle of 46% to 60%.

4) Shift Pulses

These signals are used to clock commands and mission time to the Seismometer and to clock formatted data from the Seismometer to the DAPU. The format is RZ at a bit rate of 16 Kbps \pm 0.1 percent.

b. Mechanical Interfaces

The Seismometer mechanical interface, i.e. mounting and location on the VL, is shown in Figure 4.8.2.6-13.

4.8.2.6.6 POWER REQUIREMENTS

The application of power is controlled by commands from the GCSC to the PCDA.

a. Input Voltage

The PCDA undervoltage bus supplies the Seismometer with nominal steady state input voltage of 30 Vdc (24 min.

to 37 max.) at a maximum current of 5.0 amps. This voltage is then converted to the voltages required by the Seismometer electronics as shown in Figure 4.8.2.6-4 (Functional Schematic). The power consumption levels are as follows:

	<u>Average</u>	<u>Peak (1.0 sec)</u>
Normal Mode	3.0 watts	6.0 watts
Event Mode	3.3 watts	6.0 watts
High Data Rate Mode	3.6 watts	6.0 watts
Calibration	4.0 watts	10.0 watts

b. **Uncaging Power Input**

The power to uncage the Seismic sensors is supplied through two redundant circuits from the PCDA, as shown in Figure 4.8.2.6-4. These circuits apply voltages (25.4 to 33.5 Vdc) sequentially at a maximum current of 5.0 amps for 270 msec - 375 msec.

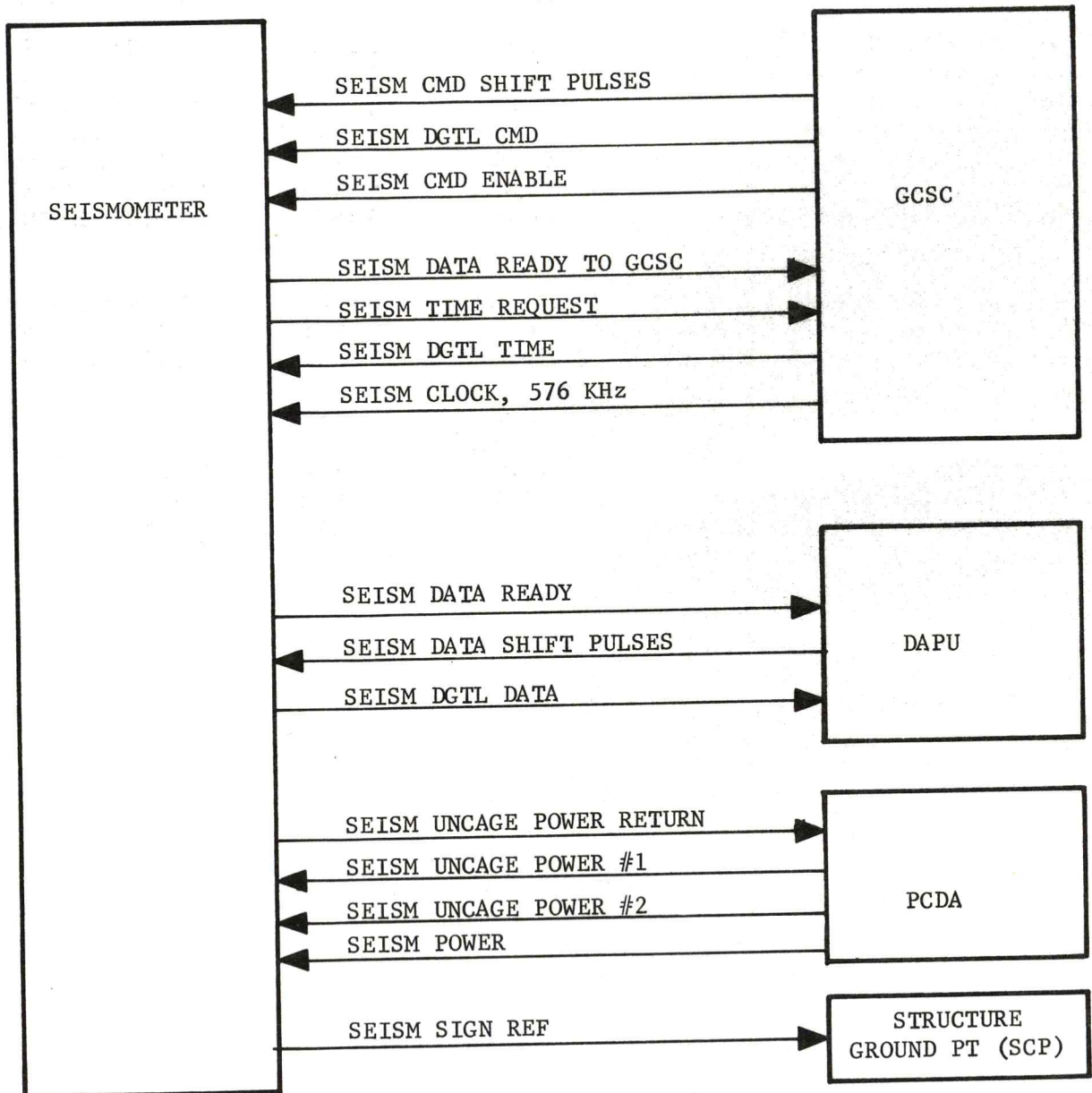
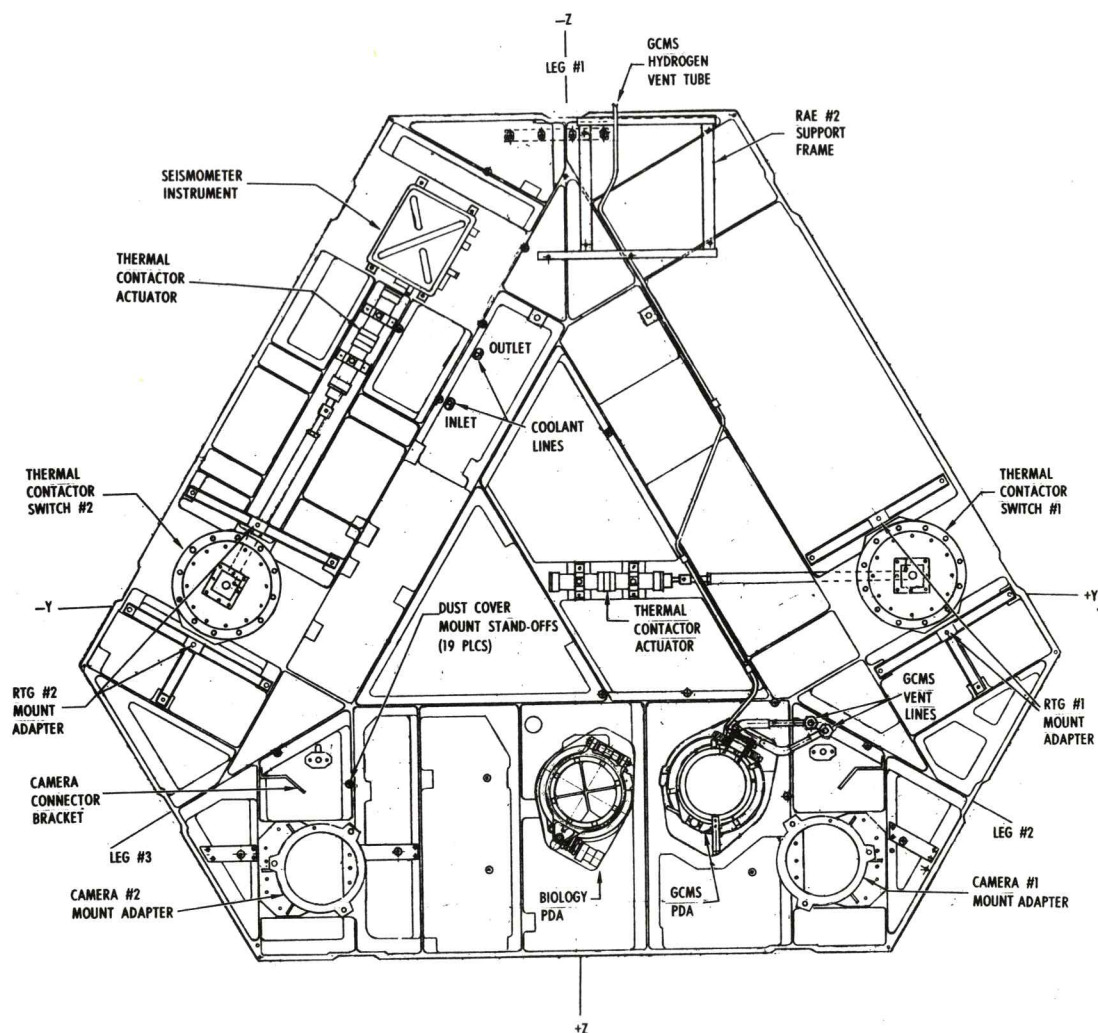


FIGURE 4.8.2.6-12
SEISMOMETER ELECTRICAL INTERFACE

TABLE 4.8.2.6-1

SEISMOMETER INTERPACE SIGNALS

<u>FUNCTION</u>	<u>FROM</u>	<u>TO</u>	<u>TYPE OF SIGNAL</u>
Seism DGTL Cmd	GCSC	Seism	DIGITAL CONTROL
Seism Cmd Enable	GCSC	Seism	DISCRETE CONTROL
Seism Cmd Shift Pulses	GCSC	Seism	DIGITAL CONTROL
Seism Time Request	Seism	GCSC	DISCRETE MONITOR
Seism DGTL Time	GCSC	Seism	DIGITAL DATA
Seism Clock, 576 KHz	GCSC	Seism	DIGITAL CONTROL
Seism Data Ready to GCSC	Seism	GCSC	DISCRETE MONITOR
Seism Data Ready	Seism	DAPU	DISCRETE CONTROL
Seism Data Shift Pulses	DAPU	Seism	DIGITAL CONTROL
Seism Dgtl Data	Seism	DAPU	DIGITAL MONITOR
Seism Pwr	PCDA	Seism	POWER
Seism Sig Ref	Seism	SGP	RETURN
Seism Uncage Power #1	PCDA	Seism	POWER
Seism Uncage Power #2	PCDA	Seism	POWER
Seism Uncage Power Return	Seism	PCDA	RETURN



(VIEWED FROM TOP OF LANDER)

FIGURE 4.8.2.6-13 LANDER EQUIPMENT PLATE COMPONENT ARRANGEMENT

4.8.2.7 Surface Sampler Assembly (SSA)

4.8.2.7 SURFACE SAMPLER ASSEMBLY (SSA)

4.8.2.7.1 PURPOSE

The primary purpose of the SSA is to acquire, process, and distribute samples from the Mars surface to the Gas Chromatograph Mass Spectrometer (GCMS), Biology, and X-Ray Fluorescence Spectrometer (XRFS) experiments. Secondary functions for the SSA include support of Physical Properties, Magnetic Properties, and Meteorology Investigations.

The SSA components (Figure 4.8.2.7-1) include the Surface Sampler Acquisition Assembly (SSAA), GCMS Processing and Distribution Assembly (PDA), Biology PDA and the Surface Sampler Control Assembly (SSCA). Figures 4.8.2.7-1A through -1E are photographs of the Science Test Lander illustrating various Surface Sampler operations. Related SSA/Physical/Magnetic Properties support components (Figure 4.8.2.7-2) include boom mounted mirrors, collector head backhoe magnets, magnet cleaning brush, 4X magnifying mirror, and the crosshatched squares printed on top of the VL. The specific purposes of the foregoing components are as follows:

a. SSAA

The SSAA consists of a controlled 3-axis 10-foot furlable tube boom and collector head capable of acquiring surface samples at any location within an approximate 130 ft² area in front of the VL, and delivering 2000-micron sieved samples to the required experiments.

b. GCMS PDA

The GCMS PDA receives 2000 (and below)-micron particle size samples from the SSAA, sieves and comminutes (grinds) the samples to 300 (and below)-micron particle size, and delivers 1 cc metered samples to the GCMS Instrument.

c. Biology PDA

The Biology PDA receives 2000 (and below)-micron particle size samples from the SSAA, sieves the samples to 1500 (and below)-micron particle size, and delivers 7 cc metered samples to the Biology Instrument.

d. SSCA

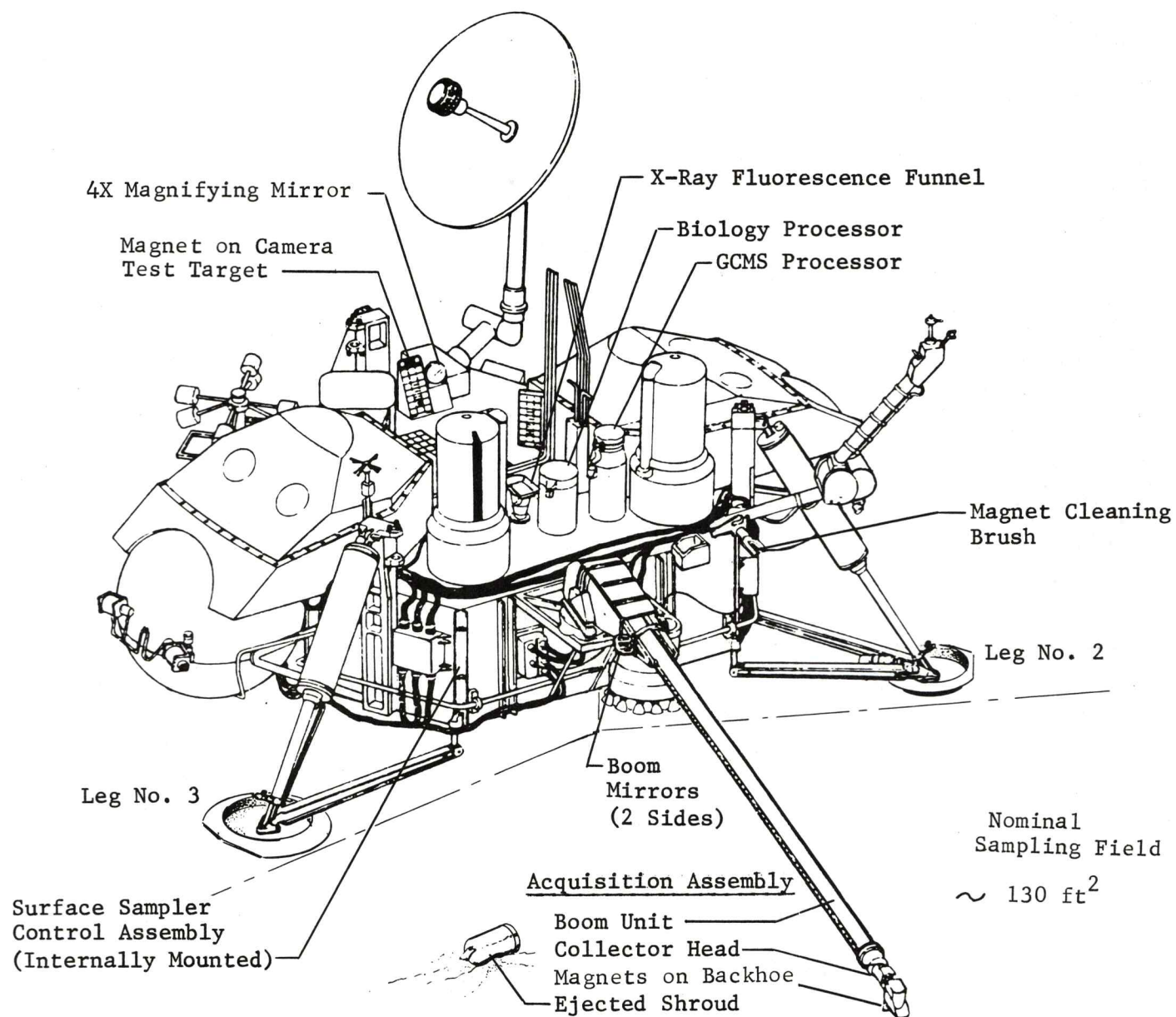
The SSCA consists of the electronics necessary to provide control functions and data acquisition for the SSAA, Biology PDA, and GCMS PDA. A redundant "Side 2" operational capability is provided for the control functions only (no data).

e. **Physical/Magnetic Properties Support Components**

Physical/Magnetic Properties Support Components consist of the following:

- 1) **Boom mounted mirrors for viewing footpads and Terminal Descent engine cratering effects;**
- 2) **Collector head backhoe magnet array for collecting magnetic material during normal sampling operations;**
- 3) **Magnet cleaning brush for removing magnetic material from the backhoe magnets;**
- 4) **Magnifying mirror (4X) for improved camera viewing of the collector head and backhoe magnets;**
- 5) **Crosshatched squares on VL top surface for collector head deposition of surface material and**
- 6) **Temperature sensor on the collector head lower jaw for surface temperature data;**
- 7) **Boom and GCHS PDA comminutor motor current sensors for inferring surface properties.**

FIGURE 4.8.2.7-1 SURFACE SAMPLER ASSEMBLY COMPONENTS



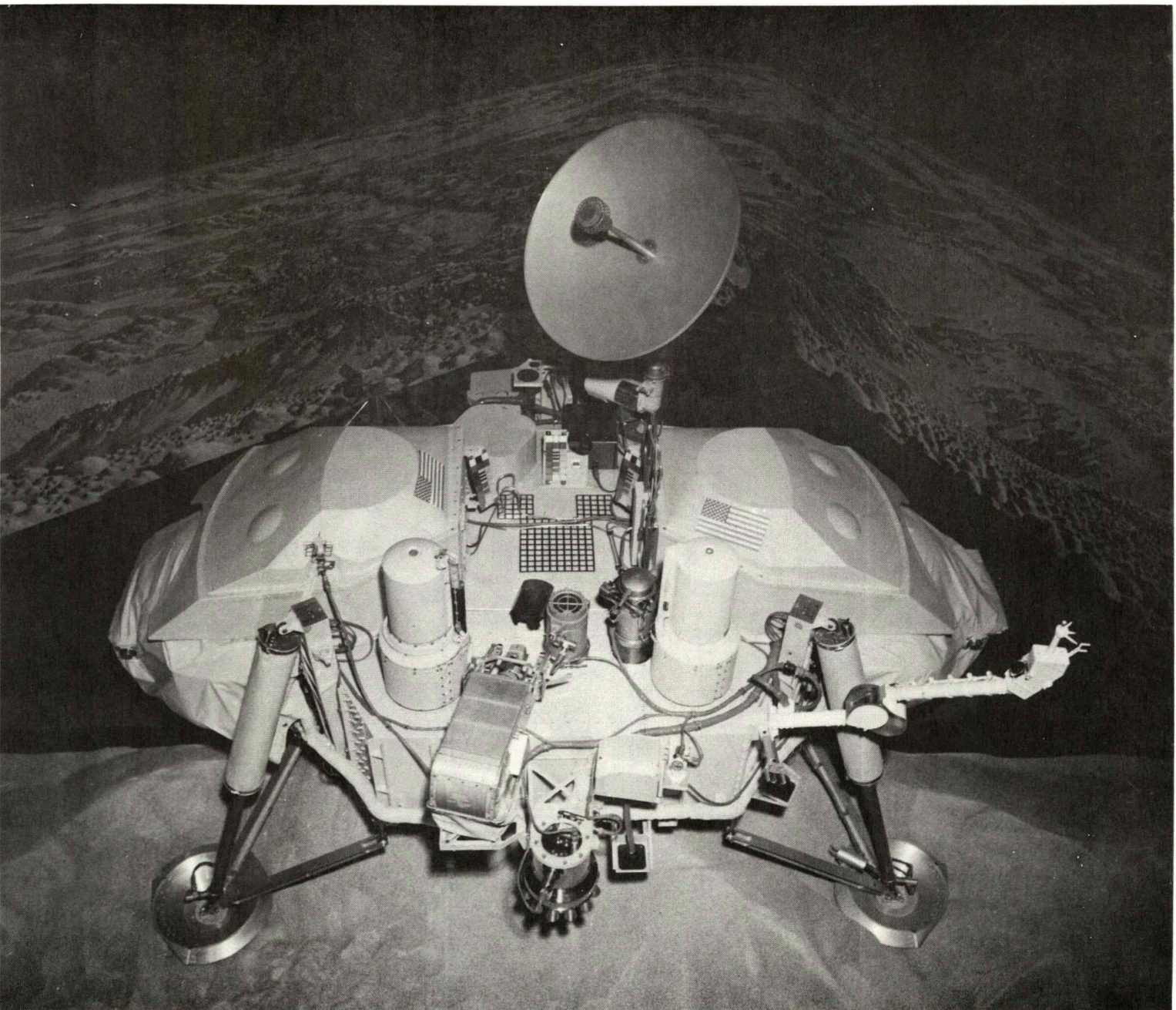


FIGURE 4.8.2.7-1A
SCIENCE TEST LANDER OVERVIEW

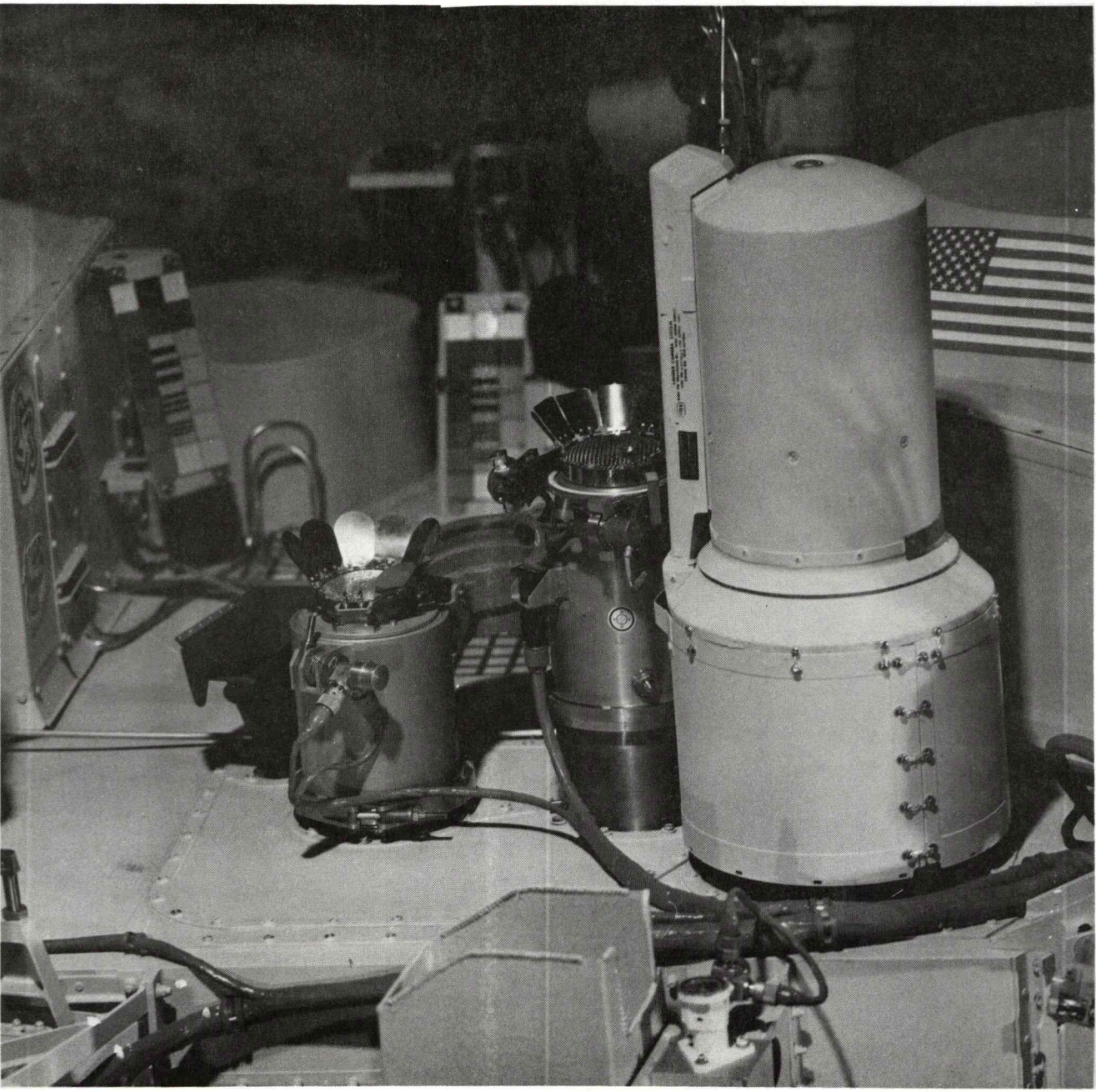


FIGURE 4.8.2.7-1B
STL-DEPLOYED PROCESSOR LIDS

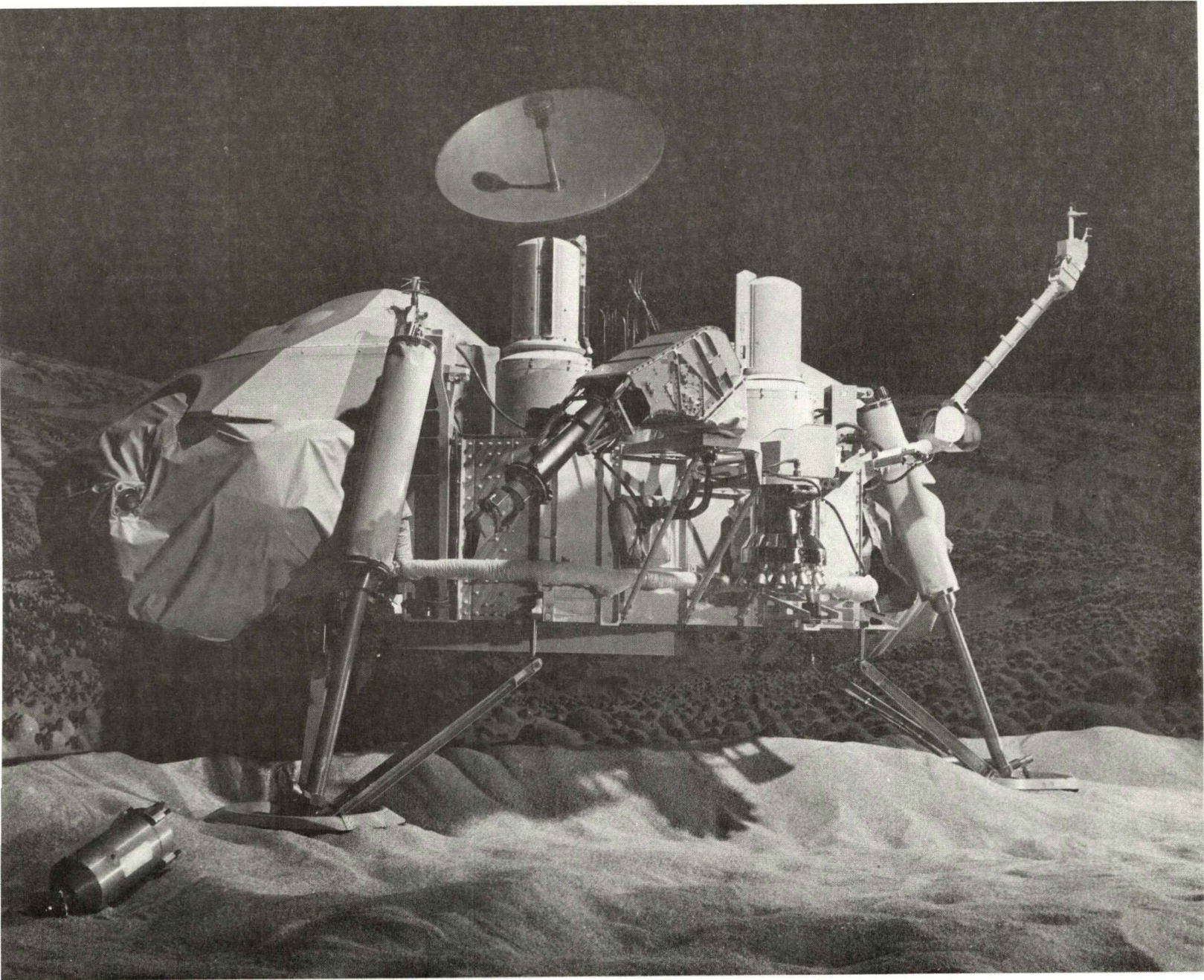


FIGURE 4.8.2.7-1C STL- COLLECTOR HEAD SHROUD EJECT

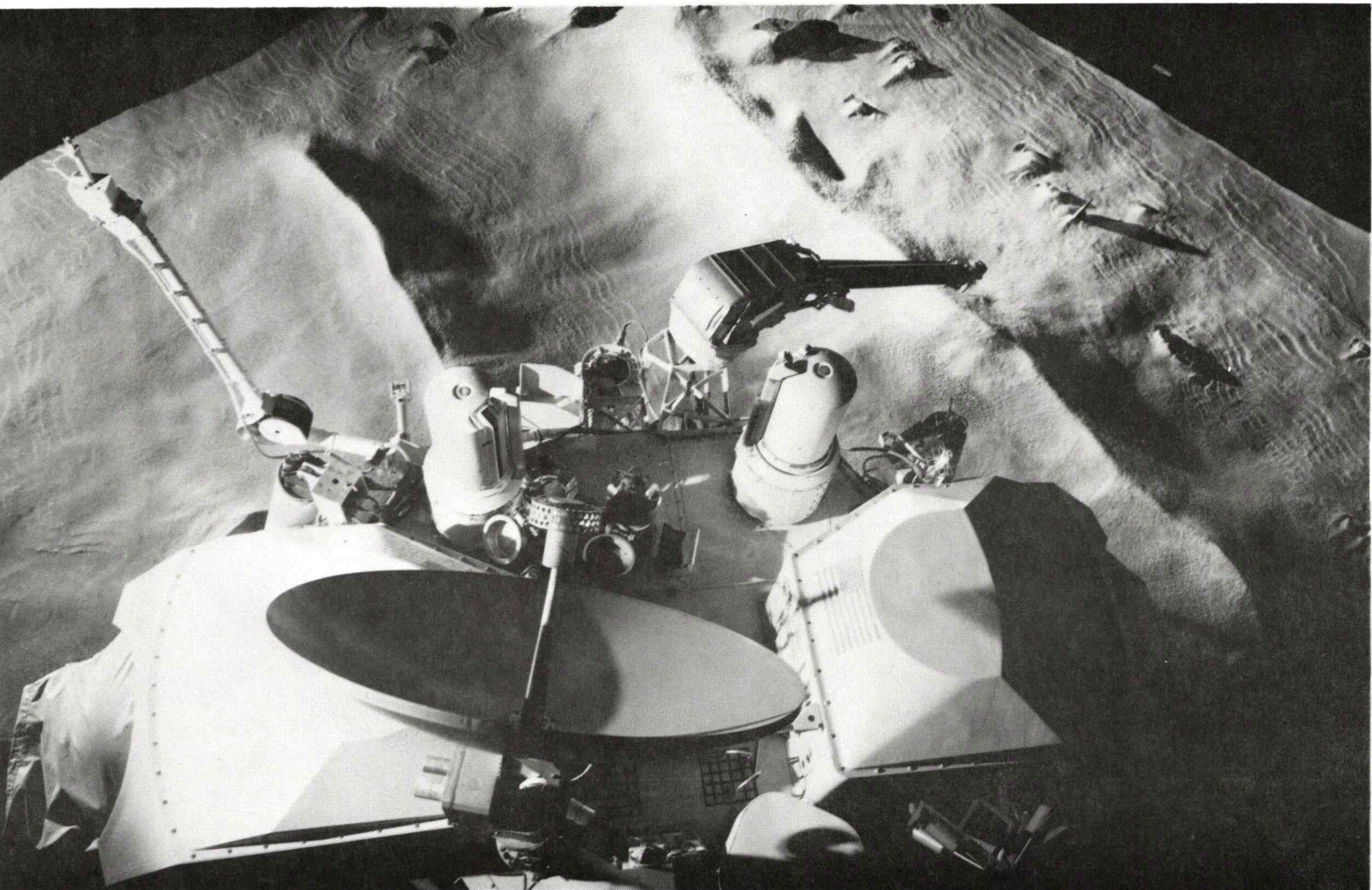


FIGURE 4.8.2.7-1D STL-BOOM DEPLOYMENT.
TO SAMPLING SITE



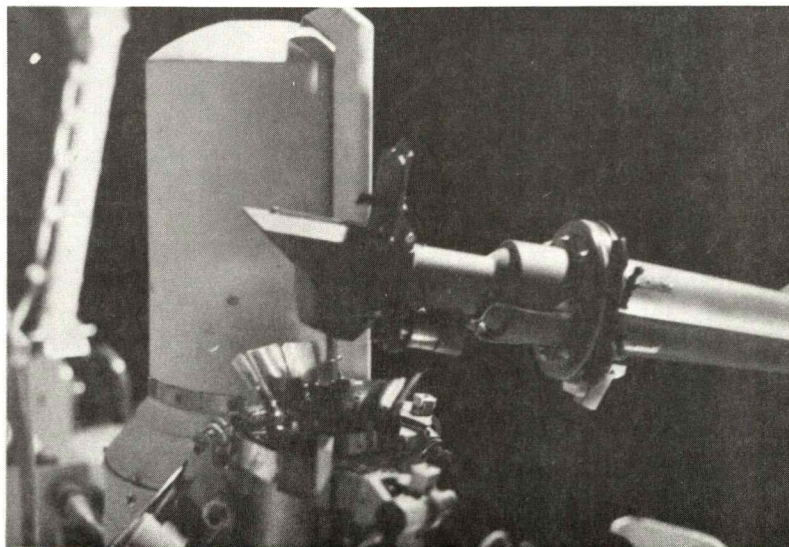
a) SURFACE CONTACT



b) CH OPEN



c) SAMPLE ACQUISITION



d) SAMPLE DELIVERY TO GCMS PDA

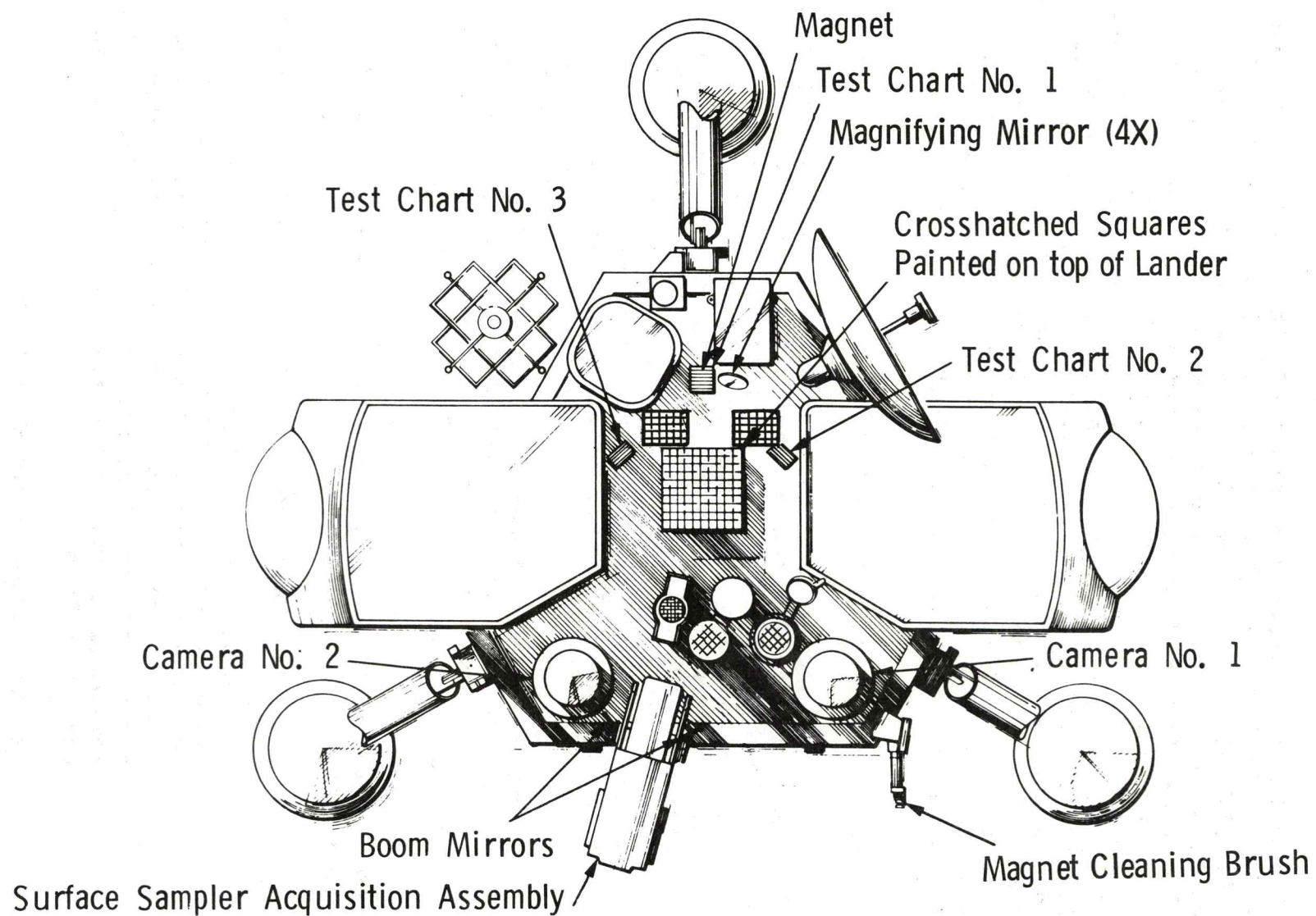


Figure 4.8.2.7-2 SSA/Physical-Magnetic Properties Support Components

4.8.2.7.2 ACQUISITION ASSEMBLY FUNCTIONAL DESCRIPTION

The Acquisition Assembly consists of the Boom Unit (Figure 4.8.2.7-3), Collector Head (Figure 4.8.2.7-4) and Shroud Unit (Figure 4.8.2.7-3). The extendable/retractable boom element, combined with the integrated azimuth/elevation gimbal system, allows the Collector Head to be commanded to any location within the articulation limits of the Boom Unit. The Collector Head, with its solenoid operated lid, backhoe, and 180-degree rotation capability, is designed to acquire samples from a variety of potential surface materials, and deliver "raw samples" or 2000-micron-sieved samples to the various VL experiments. The backhoe permits surface trenching operations, collection of magnetic surface materials, and the "brushing" of loose surface materials which may overlay a bedrock substrate. Specific design characteristics of the Acquisition Assembly components are described below.

a. Boom Unit (Figure 4.8.2.7-3)

The major element of the Boom Unit is the furlable tube boom which is fabricated from 0.012 inch thick Carpenter Custom 455 stainless steel. The boom material is chemically milled into tapered channel beams. Each boom element consists of two beams seam-welded together as shown in Figure 4.8.2.7-3. The channel configuration is used to provide space for the integral Collector Head control flat cable. A 0.004 inch tip-to-0.0075-inch base longitudinal taper is milled in each of the two channel beams to minimize weight while maintaining an approximately constant elevation lifting moment capability at all extended distances. Sprocket drive holes are provided in each flange of the boom. The 133-inch boom element is heat treated to form its spring-loaded "free-state" bisinusoidal shape.

Other elements of the Boom Unit and functions include the following:

1) Collector Head Control and Instrumentation Cable

This cable is a flat-type polyvinyl insulated cable containing 26 circuits of 22 and 26 AWG equivalent conductors installed within the boom element. This flexible, furlable cable routes all electrical functions from the Boom stationary base connector to the Boom element tip plate-mounted Collector Head.

2) Extend-Retract Drive Mechanism

This mechanism contains a Motor Drive Assembly (MDA), single-stage spur gear reduction train, and

redundant potentiometer which operates within a SSCA-controlled analog/digital feedback circuit for commanding precise extend-retract movements. The retracted boom element (and integral Collector Head control cable) is stored in a flattened configuration on a 6-inch diameter drum located within the Boom housing. During extension operations, rotary power is applied by the MDA through a 4:3 spur gear reduction to the sprocket drive, which engages the boom element sprocket holes and causes the boom element (and Collector Head) to move outward. The boom element can be extended to a nominal 115 inches. During retract operations, the MDA direction of rotation is reversed, which causes the "flip-flop" extend/retract mechanism to remove power from the sprocket drive, and apply MDA rotary power to the storage drum through a 4:1 spur gear reduction. Mechanical guidance of the furlable tube boom element from the "free state" to the "flattened state" (and vice versa) is accomplished by a combination of support rollers, support guide rails, and the spring-loaded "shoe assembly" which applies a frictional load to the boom element during storage on the drum.

3) Azimuth Drive Unit

This unit contains a MDA, 1:2 spur gear and 30:1 worm drive, and redundant potentiometer which operate within a SSCA-controlled analog/digital feedback circuit for commanding azimuth movements of the Boom Unit. The total azimuth travel is a nominal 288°.

4) Elevation Drive Assembly

This assembly contains a MDA, two 10:1 worm gear stages, and redundant potentiometer which operate within a SSCA-controlled analog/digital feedback circuit for commanding elevation movements of the Boom Unit. The total elevation travel is a nominal 43° below horizontal and 31° above the horizontal.

5) Motor Drive Assemblies (MDAs)

The MDAs used for operating the extent/retract, azimuth, and elevation axes of the boom are similar in design. The basic electric motors are powered from 24-35 Vdc SSCA-provided sources, and are permanent magnet, redundant brush commutator type devices operating in the 2000-6000 rpm speed range. A combination of planetary and spur gears

provide the appropriate speed reductions. The basic motors are hermetically sealed within a 1 ATM nitrogen pressurized housing, using torque-limiting samarium cobalt magnetic rotary feed-through devices for transferring the rotary power through the hermetic barrier. A portion of the gear reduction train is located outside the hermetically-sealed housing on each MDA, and is protected by the gear housing and rotary shaft seal. Capacitive-inductive brush noise filters are used with each MDA. All bearings and gears are lubricated with solid film lubricants.

6) Potentiometers

Dual cup, analog position feedback potentiometers are mechanically coupled to each axis of the Boom Unit. These 10K ohm pots contain thin film deposited cermet elements with a solid film lubricant. A 4 Vdc excitation source for the pots is located within the SSCA. Redundant use of the pots is associated with redundant power supplies and control circuits located within the SSCA.

7) Overtravel Control Switches

Switches are coupled to all axes of the Boom Unit which will actuate at the operating extremes of each axis. These switches, combined with the SSCA control logic, preclude unsafe operations of the Boom Unit against the respective mechanical limit stops. Additionally, mechanical overloading of the Boom Unit during normal sampling operations (or obstruction contact) is precluded via operation of the MDA magnetic feed-through torque limiters. Non-permanent buckling of the boom element can occur at the greater extensions before operation of the torque limiters, but the spring-loaded element buckling will recover through normal operation.

8) Locking Pin

A locking pin passes through a portion of the forward, lower boom structure and a VL-mounted support post. The pin maintains the Boom Unit in a rigid position for sustaining launch and landing loads. The pin is removed from its Boom-to-VL post locking position by a pin extractor guide mounted to the Collector Head adapter plate which moves forward during the initial boom extend operation. When completely clear of the Boom structure and VL support post, the pin is free to drop to the surface from its extractor guide.

9) Dust Protection

The Boom Unit outer skins provide the major internal protection from wind-blown dust. A flexible, RTV-coated nomex cloth "skirt" provides dust protection between the stationary pedestal and the gimballed yoke. A boom dust wiper assembly consisting of a spring-loaded nomex cloth seal, precludes the entrance of dust in the area where the boom element extends/retracts into the Boom Unit housing.

A summary of Boom Unit operating parameters is provided in Table 4.8.2.7-1.

b. Collector Head and Magnet Cleaning Brush (Figure 4.8.2.7-4)

The Collector Head consists primarily of a sample scoop, solenoid actuated lid with integral 2000 micron sieve, and a 180-degree rotation motor which is similar in design to the Boom Unit NDAs. During normal sampling operations, the Collector Head lid is opened, the lower scoop is driven into the surface, the lid is closed, and the Boom Collector Head is elevated to acquire the sample. Combination Boom Unit extend/retract, azimuth, and elevation commands are subsequently issued to properly position the Collector Head over the appropriate VL experiment. If a bulk sample (unsieved) is to be delivered (XRFS only), the SSCA issues a 45° rotation of the Collector Head and a 4.4 Hz signal to the solenoid-actuated lid which causes the material to be deposited into the instrument. If a 2000-micron-sieved sample is desired, the Collector Head is rotated 180 degrees such that the lid sieve is on the underside. The SSCA issues an 8.8 Hz signal to the solenoid which vibrates the acquired sample through the sieve and into the experiment inlet. Maximum collector head lid opening is 1 1/4 inch.

Other elements of the Collector Head and their functions include the following:

1) Lid-Open Indicator Switch

This switch provides a position signal to the SSCA, and is used in a feedback circuit for limiting the maximum lid opening during 8.8 Hz vibration operations. This switch is actuated if the lid is open 1/16 inch;

2) Surface Contact Switch

This switch provides a "command complete" signal to the SSCA when the boom is lowered to the surface and the Collector Head is "gimballed" upward approximately 5-10 degrees as a result of surface contact pressure;

3) Rotation Position Switch

This switch provides a "command complete" signal to the SSCA when the Collector Head is rotated to the desired upright, 45-degree, or inverted positions;

4) Temperature Sensor

This sensor is a platinum temperature sensor bridge which provides an indication of ambient and surface temperatures in support of the Physical/Magnetic Properties and Meteorology investigations;

5) Backhoe

The backhoe provides a means for "backhoeing" surface trenches by employing appropriate boom commands. This capability is used for acquisition of sub-surface samples and in support of the Physical/Magnetic Properties investigations;

6) Magnet Array

The Magnet Array contains two samarium cobalt magnets with varying flux densities at the forward and rear backhoe surfaces. The circular patterns formed when magnetically attracted surface materials are contacted can be viewed directly by the cameras, or indirectly through the VL-mounted 4X magnification mirror by properly positioning the Boom Unit;

7) Magnet Cleaning Brush

This VL-mounted device is used to remove magnetically attracted material from the Collector Head backhoe magnet array. Cleaning is accomplished by positioning the Collector Head near the VL brush and commanding one or more rotations of the Collector Head such that the magnet array is passed through the stainless steel bristles of the stationary brush;

8) Backhoe Brush

This brush is used for "sweeping" up small piles of samples if the surface should consist of rock substrate overlaid with granular material.

A summary of Collector Head operating parameters is provided in Table 4.8.2.7-2.

C. Shroud Unit (Figure 4.8.2.7-3)

The Shroud Unit consists primarily of a pressurized aluminum cannister which provides positive contamination control protection to the Collector Head from the time that it is nanograde-level cleaned during final assembly, until its use during the first Mars surface operation.

The shroud is attached to the Collector Head adapter plate by two spring-loaded over-center locking latches which are restrained in the lock position by two small rails located within the Boom Unit forward truss. A series of eight compression springs are located around the rear circumference of the Shroud such that they contact the Collector Head adapter plate. As the boom is initially extended, the locking latches slide along their mating restraint rails for approximately 3 inches. The rails terminate at this point, the over-center latches release, and the compression springs apply approximately 125 pounds of separation force to eject the Shroud.

If the Shroud should fail to eject via incomplete release of the latches, a boom retraction command which follows the extension will result in the flat rear side of the latches contacting the latch restraint rails in an interference manner. This results in the full retract force of the boom (approximately 40-60 pounds) assisting the 125-pound compression spring force for Shroud eject. Additionally, if the Shroud latches release but the shroud catches on the Collector Head, a hook mounted on the forward end of the Shroud is available for "hooking" a VL protrusion to assist Shroud removal.

Pressurization of the Shroud Unit is accomplished through a pressurization port located on the front of the cannister. Pure nitrogen is used as the pressurizing gas, and a pressurization level of 20 psia is maintained at all times by ground support equipment until final VL encapsulation and sterilization. The nitrogen gas will decay to a relatively low level during the cruise to Mars.

A leaf-spring type Collector Head restraint tab is welded to the inside top of the Shroud Unit. This

spring pre-loads the Collector Head in-flight retaining tab (Figure 4.8.2.7-4) to preclude vibration about the gimbal axes during launch and landing operations. The Collector Head must be rotated to the 45° position to clear the Shroud Unit restraining spring prior to Shroud eject.

The Shroud is scheduled to be ejected on Sol 2 or Sol 3 during Planetary Operations. A constraint has been levied such that the Shroud ejection must be planned between 1000 and 1600 hours local VL time. This restraint is mandatory because tests have shown that the "O-Ring" seal between the Shroud and the Collector Head adapter plate exhibits excessive friction at temperatures below -100°F.

4.8.2.7.2.1 OPERATIONAL SEQUENCE

A simplified description of a typical operating sequence is as follows:

a. Initial Prelaunch Conditions;

- 1) Shroud Unit installed and latched;
- 2) Boom element retracted to "retract" limit switch;
- 3) Boom Unit Azimuth/Elevation positioned to launch stowed configuration;
- 4) Lock pin installed, restraining Boom to VL support post.

b. Shroud Eject Sequence (Sol 2 only):

- 1) Extend Boom approximately 2 inches to release locking pin;
- 2) Elevate to clear VL support post, Azimuth CW, and de-elevate to shroud eject site near VL footpad No. 3;
- 3) Rotate Collector Head 45° to release from Shroud restraint spring; extend 11 inches to eject Shroud; rotate Collector Head to upright position.

c. Boom Park Sequence (Sol 2 only) - Retract Boom, elevate to clear PDAs, azimuth CCW; extend 2 inches to set dust seal and de-elevate to park position.

NOTE: Park position coordinates are similar to the launch stowage coordinates (i.e. boom de-elevated and pointing toward the rear side of

the VL) in order to minimize exposure to wind-blown dust.

d. Surface Sampling and Delivery Sequence (Sol 8 and Subsequent):

- 1) Elevate from park position to clear PDAs, azimuth CW and extend to desired sampling site;
- 2) De-elevate to surface contact (surface contact gimbals the Collector Head which actuates the surface contact switch and terminates the de-elevate command);
- 3) Open Collector Head lid, extend 6 inches; close lid and elevate to acquire sample;
- 4) Retract Boom, azimuth CCW to appropriate instrument coordinates (i.e. GCMS, Biology, XRPS); rotate Collector Head to inverted position; de-elevate into instrument wind deflector, and vibrate Collector Head to deposit 2000 micron sieved sample;
- 5) Elevate Boom, retract, and rotate Collector Head to upright position.

e. Collector Head Purge of Excess Sample (Sol 8 and Subsequent):

- 1) Azimuth Boom CW, de-elevate, and extend to desired purge site coordinates;
- 2) Rotate Collector Head to 45° position and vibrate in 4.4 Hz mode to purge material; rotate Collector Head to upright position.

f. Repeat c. to park Boom (Sol 8 and subsequent).

NOTE: The foregoing is a simplified summary of a typical sampling sequence. Sequences d., e. and f. are repeated for subsequent sampling operations. Many other options are available such as multiple sample acquisition if insufficient sample is acquired during the first attempt; delivery of bulk samples which do not pass through the Collector Head 2000-micron sieve, trenching operations using the Collector Head backhoe, camera viewing of magnet array-attracted sample both directly and through the magnification mirror, depositing sample on the VL grid for

camera viewing,
surface/subsurface/ambient temperature
measurements, etc.

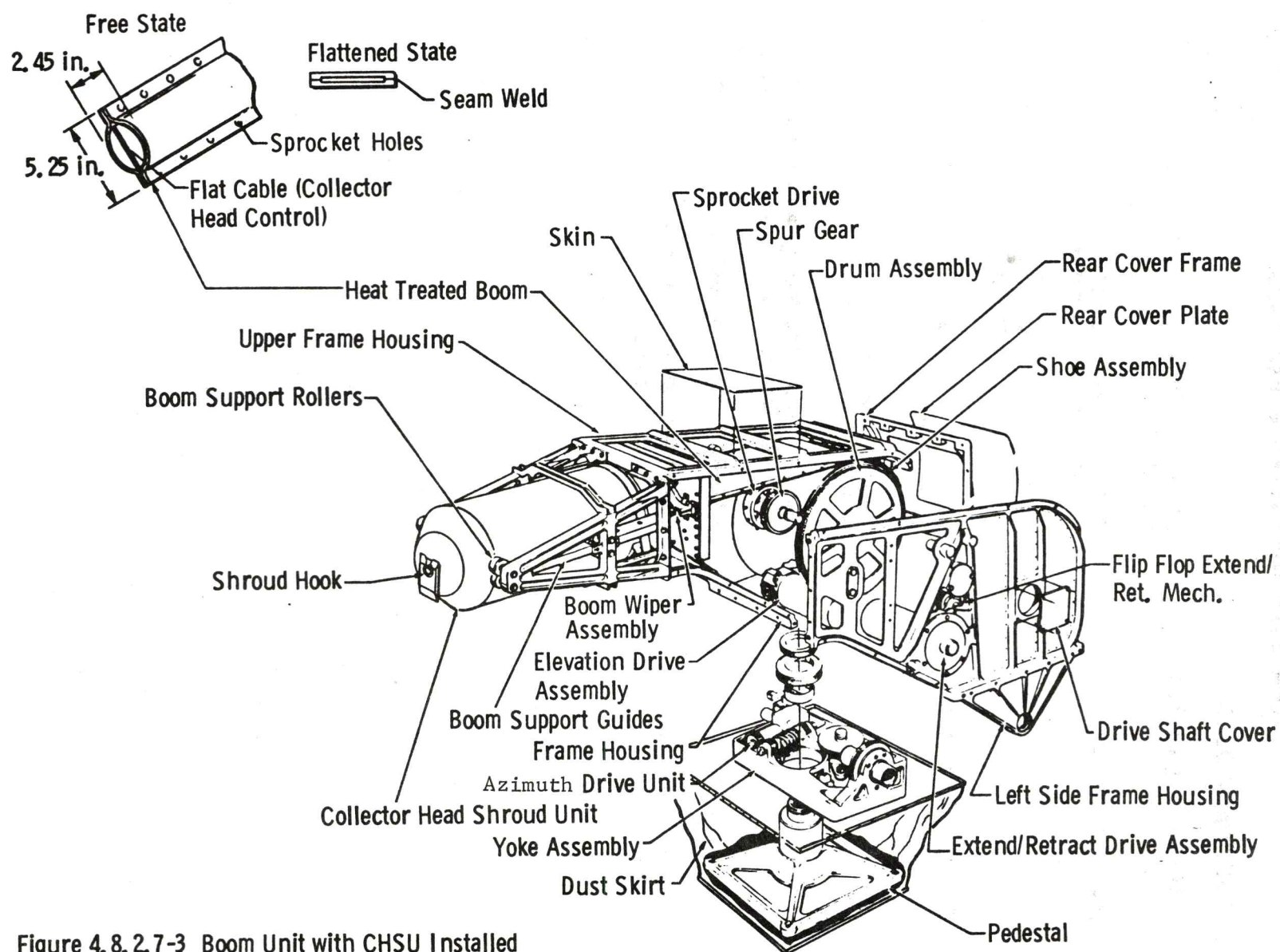


Figure 4.8.2.7-3 Boom Unit with CHSU Installed

Table 4.8.2.7-1
BOOM UNIT OPERATING PARAMETERS

EXTEND/RETRACT AXIS

Extend Capability	-	20.2 to 136.1 inches (AZ C.L. TO CH-Tip)
Extension Rate	-	0.413 in/sec minimum (21.5 VDC @ +120°F to -170°F) 1.038 in/sec maximum (35.0 VDC @ +120° to -170°F)
Retraction Rate	-	0.592 in/sec minimum (21.5 VDC @ +120°F to -170°F) 1.098 in/sec maximum (35.0 VDC @ +120°F to -170°F))
Sampling Capability	-	30 lbs tension/compression, 4.5 lbs shear force at full extension
Motor Current	-	170-600 ma (depending on load)
Potentiometer Sensitivity	-	0.0288-0.0307 VDC/In. (4.0 VDC Excitation)

Table 4.8.2.7-1
BOOM UNIT OPERATING PARAMETERS (Continued)

AZIMUTH AXIS

Azimuth Capability	-	288 Degrees
Azimuth Rate (CW or CCW)	-	1.02°/Sec Minimum (21.5 VDC @ +120°F to -170°F) 1.90°/Sec Maximum (35.0 VDC @ +120°F to -170°F)
Motor Current	-	13-50 ma (depending on load)
Potentiometer Sensitivity	-	0.0122 - 0.0127 VDC/Deg (4.0 VDC Excitation)

Table 4.8.2.7-1
BOOM UNIT OPERATING PARAMETERS (Continued)

ELEVATION AXIS

Elevation Capability	-	74 Degrees
Elevate Up Rate	-	0.57°/Sec Minimum (21.5 VDC @ +120°F to -170°F) 1.68°/Sec Maximum (35.0 VDC @ +120°F to -170°F)
Elevate Down Rate	-	0.75°/Sec Minimum (21.5 VDC @ +120°F to -170°F) 1.68°/Sec Maximum (35.0 VDC @ +120°F to -170°F)
Motor Current	-	100-500 ma (depending on load)
Potentiometer Sensitivity	-	0.0122-0.0127 VDC/Deg (4.0 VDC Excitation)

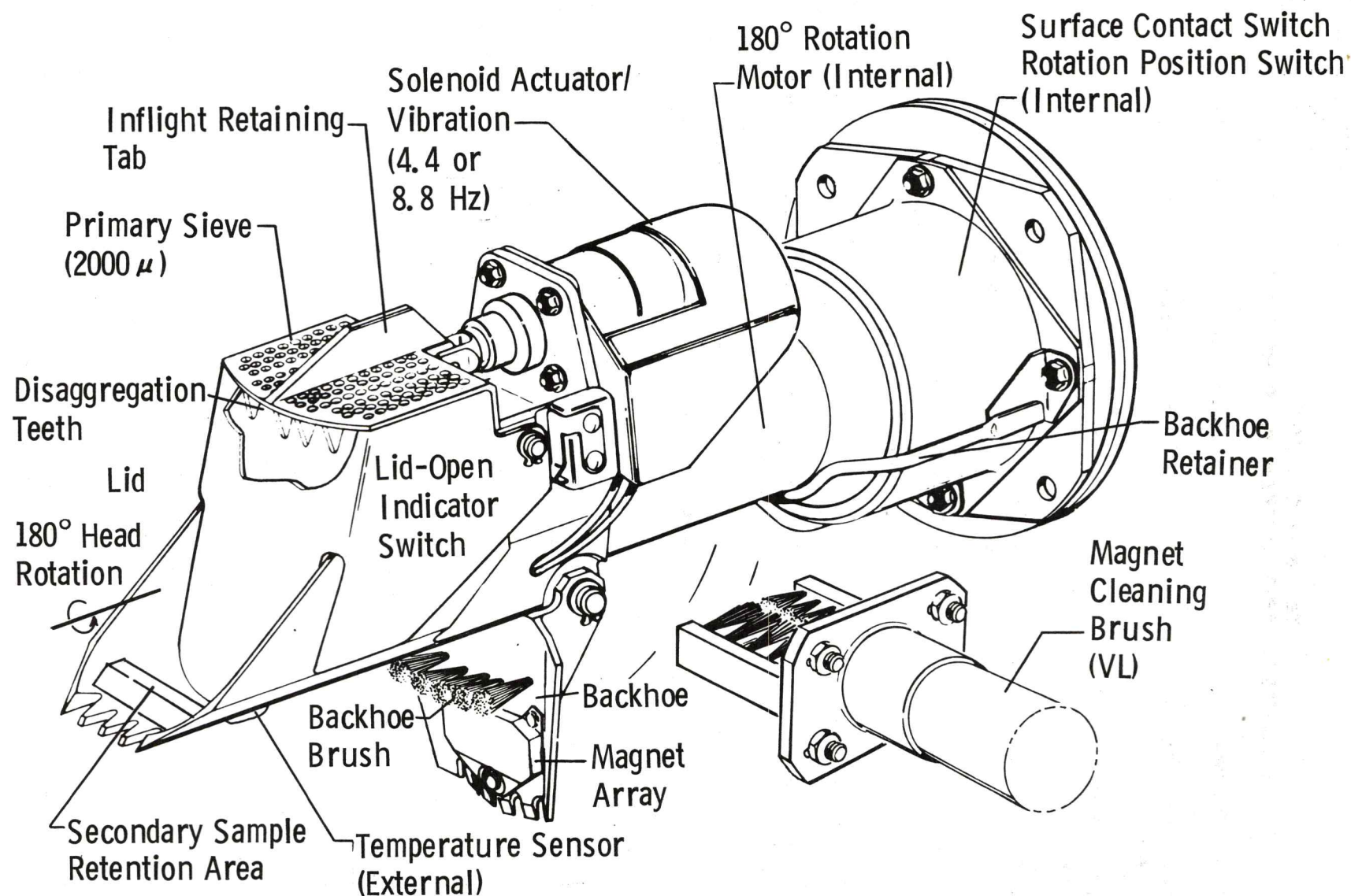


Figure 4.8.2.7-4 Collector Head and Magnet Cleaning Brush

Table 4.8.2.7-2
COLLECTOR HEAD OPERATING PARAMETERS

Sample Volume	-	60 to 100cc (average acquired)
Secondary Sample Volume	-	10 to 15cc (average acquired)
Sample Delivery Sieve	-	2000-microns
Lid/Sieve Operating Modes	-	Full Open/Close, 4.4 Hz, 8.8 HZ Vibratory Modes
Switch Operation	-	Surface Contact, Upright/45°/inverted rotational positions, and lid Open/Close.
Rotation Motor	-	
Speed	-	2.5 - 5.0 RPM (depending on load and voltage)
Current	-	12 - 35 ma (depending primarily on load)

4.8.2.7.3 GCMS PDA FUNCTIONAL DESCRIPTION (Figure 4.8.2.7-5)

The GCMS PDA contains all of the necessary elements for receiving a 2000-micron sieved sample from the Collector Head, sieving the sample through a 2000-micron sieve, comminuting (grinding) a 600 (and below)-micron sample, sieving this sample through a 300-micron sieve, and metering and delivering a 1 cc sample to the GCMS instrument. Excess material is routed to a closed dump box. The PDA, dump box, and interfacing sample delivery tube are mounted directly to the GCMS instrument.

The elements of the PDA are contained within a pressurized lid-covered housing. In a manner similar to the Collector Head Shroud, ground support equipment is used to maintain 20 psia of pure nitrogen in the nanograde-level clean PDA until final VL encapsulation and sterilization. The PDA pressure is vented through the GCMS during the cruise portion of flight. Early in the Post-Landed mission a tension release device is activated by the VL Power Conditioning and Distribution Assembly (PCDA), and the band clamp which seals the PDA is released, allowing the double torsion spring-powered lid to open. The spring-loaded wind deflectors deploy upward, and the PDA is available for normal operations.

Primary elements of the PDA and functions include the following:

a. Tension Link Release Device

This device is a redundant mechanical lock which maintains an approximate 700-pounds tension force on the V-type band clamp, which in turn, seals the PDA. It is released by applying electrical power to a "meltable" wire wrap which redundantly "frees" both ends of the tension link locking bolt.

b. Wind Deflector

The wind deflector consists of deployable leaves which minimizes sample loss during Collector Head delivery under windy conditions.

c. 2000-Micron Sieve

This sieve provides additional sieving of the delivered sample to a particle size acceptable to the Comminuter.

d. Comminuter

The Comminuter consists of a motor-driven grinder which receives 2000-micron sieved sample from the funnel and comminutes it to a 600-micron (and below) sample size when operating in the "grind mode", as illustrated in

Figure 4.8.2.7-6. The grinding is accomplished by the rotating auger crushing the sample against the non-rotating housing, and sieving occurs as a result of the "stirring spring" rotating against the distributor 300-micron sieve. "Purge mode" operation occurs when the motor direction is reversed, and the cam-operated auger translates downward approximately 1/4-inch thus increasing the auger-to-wall diametric clearance from 600 to 4000-microns. This operational mode is used primarily for purging the 2000-micron sieve, funnel, and comminuter of excess sample material with the distributor positioned in the dump position. An agitator (Figure 4.8.2.7-5) is vibrated from a single lobe on the auger which agitates (by contact) the 2000-micron sieve and funnel to maintain gravity flow of the sample material into the comminuter. Design of the motor is similar to that described for the Boom.

e. Distributor

The Distributor consists of a motor-driven shuttle block with sample cavities for loading and metering the sample, delivering the metered sample to the GCHS instrument, and directing excess material to the dump box through a line as illustrated. The 1 cc metering cavity contains a redundant sample level detector which signals the SSCA when the cavity has been filled. The distributor also contains the 300-micron sieve located over the metering cavity, and a solenoid vibrator which assists in the gravity flow of sample material. Design of the motor is similar to that described for the Boom.

f. Sample Level Detector

The Sample Level Detector consists of a balanced bridge circuit with two sensing elements located in the metering cavity and a reference element located in a dummy chamber on the distributor. When the rising sample level in the metering cavity contacts the lower sensing element, the resultant thermal unbalance creates a corresponding circuit electrical unbalance which is monitored by the SSCA. The circuit is used both for "level full" and "level empty" indications. The upper sensing element is used with SSCA Power Side 2.

g. Sample Bypass Tube and Cover

This Tube and Cover provides a redundant path for delivering a sample directly to the GCHS Instrument. This emergency operational mode involves removal of the bypass tube cover using appropriate commands to the Acquisition Assembly and depositing the sample into the bypass tube which bypasses all PDA mechanisms. A

summary of GCHS PDA operating parameters is provided in Table 4.8.2.7-3.

4.8.2.7.3.1 OPERATIONAL SEQUENCE

A simplified description of a typical operating sequence is as follows:

a. Initial Prelaunch Conditions:

- 1) PDA lid closed and sealed with the band clamp and tension link release device;
- 2) Distributor located in the "deliver" position, and comminuter in the "comminute" position.

b. Energize tension link release device to open lid and deploy wind deflectors (Sol 3).

c. Drive distributor to "meter" position (Sol 8 for first operation).

d. Turn on comminuter to "grind" mode.

e. Position collector head over PDA, rotate 180°, de-elevate Boom, and vibrate/sieve 2000 micron material into PDA.

f. Turn off comminuter after a "level full" indication is generated by the 1 cc sample level detector.

g. Drive distributor to "deliver" position, turn on distributor vibrator, comminuter, and deliver sample to GCHS instrument while sensing for a level detector "empty" indication.

h. Turn off comminuter, distributor vibrator, and drive distributor to "dump" position.

i. Turn on comminuter to "sieve (purge)" mode, turn on distributor vibrator and purge all excess sample into dump box.

j. Turn off comminuter, vibrator, and return distributor to original "deliver" position.

Note: Several optional sequences are available such as dumping possible windblown dust from the PDA prior to receiving a surface sample, multiple acquisitions if an insufficient sample is initially acquired, by-passing level detector checks, etc. These options are described in greater detail in a later section.

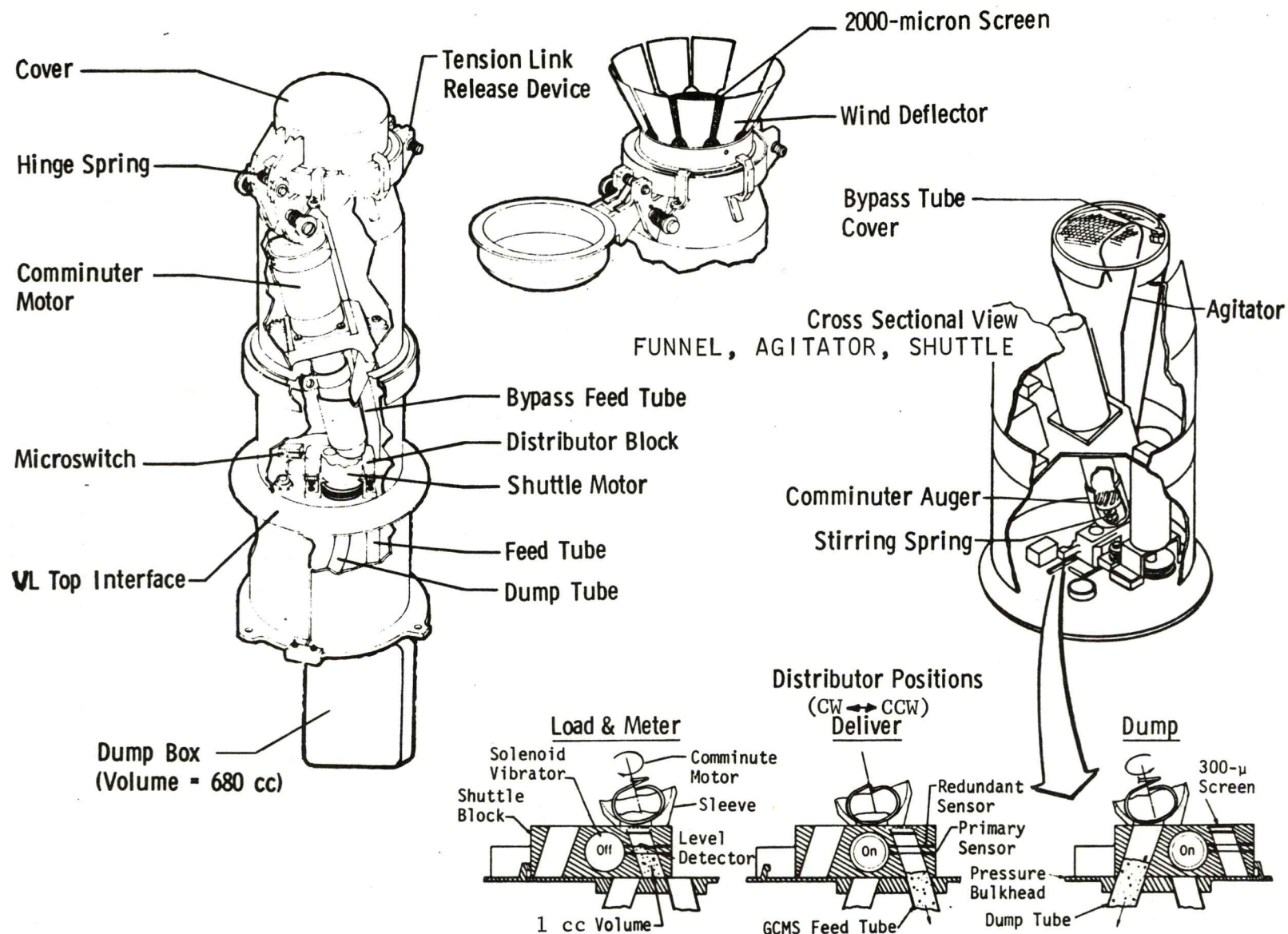


Figure 4.8.2.7-5 GCMS Processing and Distribution Assembly

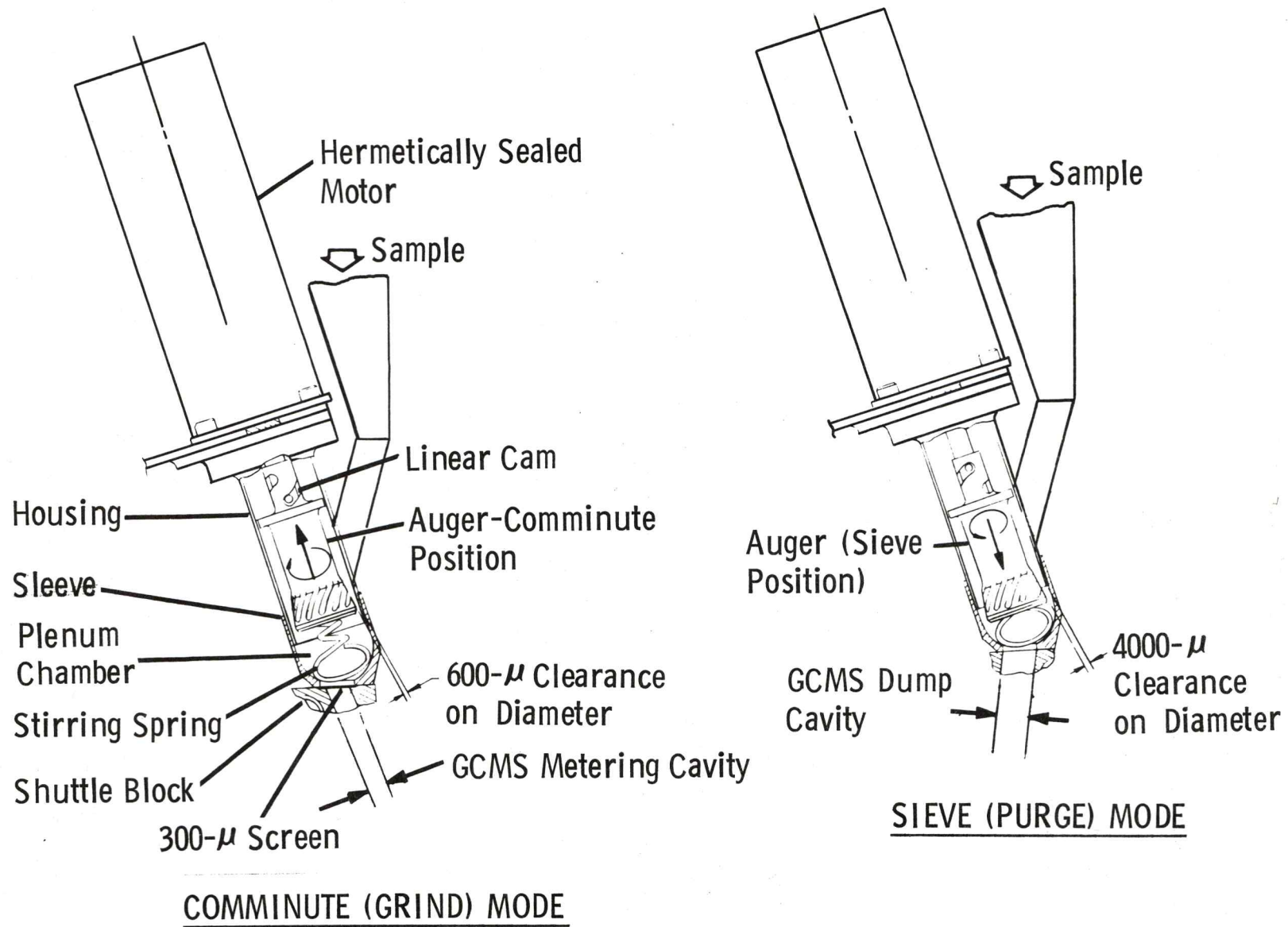


Figure 4.8.2.7-6 GCMS-PDA Comminuter Operation

Table 4.8.2.7-3
GCHS PDA OPERATING PARAMETERS

Input Sample	-	<2000 micron particle size
Output Sample	-	0.7 to 1.5 cc, <300 micron particle size
Comminuter	-	
Operating Modes	-	Sample grind or purge (depending on direction of rotation)
Speed	-	50 - 450 RPM (depending on load and voltage)
Current	-	0.4 to 6.0 Amps (depending primarily on load)
Distributor	-	
Drive Motor	-	0.1 in/sec at 14-30 ma (depending on load and voltage)
Level Sensor	-	Thermal bridge type
Vibrator	-	8.8 Hz

4.8.2.7.4 BIOLOGY PDA FUNCTIONAL DESCRIPTION (FIGURE 4.8.2.7-7)

The Biology PDA contains all of the necessary elements for receiving a 2000-micron sieved sample from the Collector Head, sieving the sample through a 1500-micron sieve, metering a 7 cc sample and delivering it to the Biology Instrument. Excess material is routed to a closed dump box. The PDA, dump box, and interfacing sample delivery tube are mounted directly to the Biology Instrument.

The elements of the PDA are contained within a lid-covered housing. Early in the Post-Landed mission a pyrotechnic pin puller is actuated by the VL Lander Pyrotechnic Control Assembly (LPCA), and a double torsion spring rotates the lid to the open position. The spring-loaded wind deflectors deploy upward, and the PDA is available for normal operations.

Primary elements of the PDA and functions include the following:

a. Wind Deflector

The Wind Deflector consists of deployable leaves which minimizes sample loss during Collector Head delivery under windy conditions.

b. 1500-Micron Sieve

This sieve provides additional sieving of the delivered samples to a particle size accommodatable by the Biology Instrument.

c. Solenoid Actuated Agitator

This Agitator agitates (by contact) the 1500-micron sieve and funnel to maintain gravity-flow of the sample material into the distributor.

d. Distributor

The Distributor consists of a motor-driven shuttle block with sample cavities for loading and metering the sample, delivering the metered sample to the Biology Instrument, and directing excess material to the dump tube as illustrated. The 7 cc metering cavity contains a redundant sample level detector which signals the SSCA when the cavity has been filled. A bridge-type platinum temperature sensor is located near the metering cavity to provide a sample temperature measurement. The distributor also contains a solenoid vibrator which assists in the gravity flow of the sample material. Design of the motor is similar to that described for the Boom.

e. Sample Level Detector

Operation of the Sample Level Detector is similar to that described for the GCMS-PDA (Paragraph 4.8.2.7.3).

f. Sample Bypass Tube and Cover

This Tube and Cover provide a redundant path for delivering a sample directly to the Biology Instrument. This emergency operational mode involves removal of the bypass tube cover using appropriate commands to the Acquisition Assembly, and depositing the sample into the bypass tube which bypasses all PDA mechanisms.

A summary of Biology PDA operating parameters is provided in Table 4.8.2.7-4.

4.8.2.7.4.1 OPERATIONAL SEQUENCE

A simplified description of a typical operating sequence is as follows:

a. Initial Prelaunch Conditions:

- 1) PDA lid closed and locked with the pyrotechnic pin puller;
- 2) Distributor located in the "deliver" position.

b. Energize pin puller to open lid and deploy wind deflectors (Sol 0).

c. Drive distributor to "dump" position, turn on processor vibrator, and purge possible wind blown dust into dump box (Sol 8 for first operation).

d. Turn off processor vibrator, and drive distributor to "meter" position.

e. Position collector head over PDA, rotate 180°, de-elevate Boon, turn on processor vibrator, and vibrate/sieve a 2000-micron size sample into PDA.

f. Turn off processor vibrator and conduct a "level full" check by the 7 cc level detector.

g. Drive distributor to "deliver" position, turn on the distributor and processor vibrators, and deliver the sample to the Biology Instrument.

h. Turn off vibrators, energize level detector and sense for an "Empty" indication; drive distributor to the "dump" position, turn on vibrators, and purge all excess sample into dump box.

- i. Turn off vibrators and return distributor to original "deliver" position.

Note: Several optional sequences are available similar to those described for the GCMS PDA.

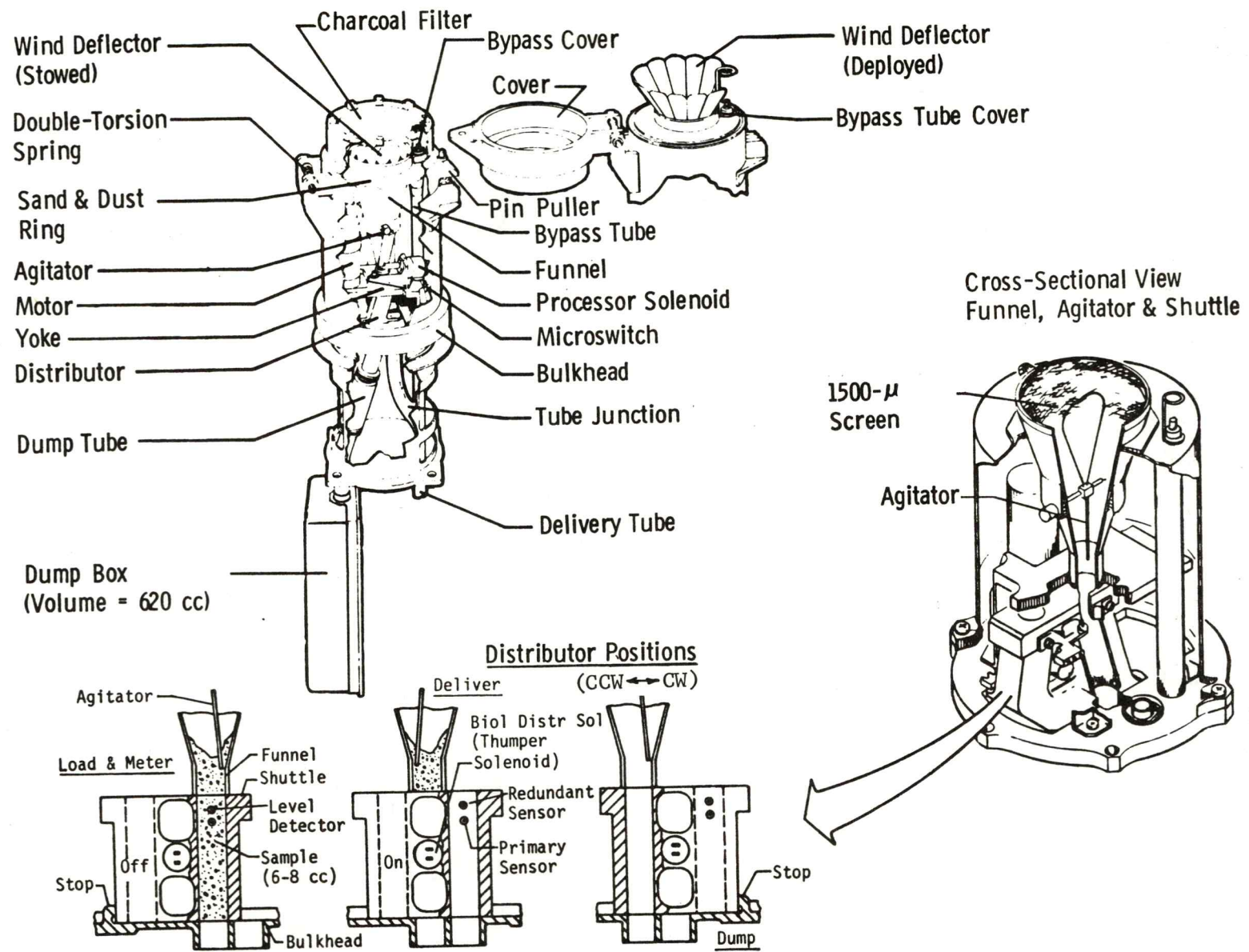


Figure 4.8.2.7-7 Biology Processing and Distribution Assembly

Table 4.8.2.7-4
BIOLOGY PDA OPERATING PARAMETERS

Input Sample	-	<2000-micron particle size
Output Sample	-	6-8 cc, <1500-micron particle size
Processor Vibrator	-	8.8 Hz
Distributor	-	
Drive Motor	-	0.1 in./sec. @ 14-30 ma (depending on load and voltage)
Level Sensor	-	Thermal bridge type
Temperature Sensor	-	Platinum bridge type
Vibrator	-	8.8 Hz

4.8.2.7.5 SURFACE SAMPLER CONTROL ASSEMBLY FUNCTIONAL DESCRIPTION (FIGURE 4.8.2.7-8)

The SSCA contains all of the necessary electronics to provide the control functions and data formatting for the three major electro/mechanical components of the SSA: The Acquisition Assembly, GCSC PDA, and Biology PDA. Digital coded commands are received from the GCSC which are processed and transformed into stimuli for operating the various motors, solenoids, potentiometers, switches, temperature transducers and sample level detectors located within the three electro/mechanical components. Data is collected by the SSCA from the three components and digitally formatted for transmission to the Data Acquisition and Processor Unit (DAPU). These data consist of Boom position in all three axes, temperature of the Collector Head and Biology PDA distributor, six switches, sample level detectors, and motor/solenoid operating currents. The electronic circuits for providing these functions are classified by function and incorporated on corresponding circuit boards as illustrated in Figure 4.8.2.7-8.

Most of the SSA commands are executed with "feedback control" to assure completion of the commanded functions. As an example, the 3-axes of operating freedom (azimuth, elevation, extend/retract) of the Boom incorporates potentiometers which transmit analog position data to the SSCA which, through an analog/digital converter is "matched" with the digital command word in a comparator to provide the necessary command achieved function. Similar command achieved functions are accomplished by switch reactions for other motor-driven devices within the SSA.

Operation of the SSCA requires integrated interfaces with other VL components including the GCSC, DAPU, and PCDA. These interfaces and functions are illustrated in Figure 4.8.2.7-9. All SSA software operating logic and command table data bases are stored within the GCSC. At the appropriate times during the mission, the GCSC commands the PCDA to "Power ON" the SSCA, and appropriate 24-bit digital commands are serially issued to the SSCA to commence SSA operations. The command-by-command operation with appropriate "delta times" between commands continue until completion of the particular sequence unless a "No-Go" is issued by the SSCA. This indicates an improper response to a command, and the GCSC will remove power from the SSCA and all further SSA operations will cease until new commands are "uplinked" from Mission Control. Redundant command interfaces are provided with the GCSC, and redundant control circuits are provided for critical SSA functions within the SSCA. A single non-redundant interface is provided with the DAPU which includes the provision for "clocking-out" 120-bit data frames which are formatted in conjunction with each GCSC-issued command. A redundant power control interface is provided with the PCDA as illustrated.

Simplified schematics of the SSCA functional operation are shown in Figures 4.8.2.7-10 and 4.8.2.7-11. Specific functions of the major sections include the following:

a. Command Decoder (Redundant Sides 1 and 2):

- 1) Stores last 16 bits (9-24) from the GCSC issued 24-bit command word (1st 8 bits are not used) in a command data register.
- 2) Decodes the last 7-bits (18-24) of the command word as the desired command, i.e. Azimuth motor, Collector Head solenoid, etc.
- 3) Provides a digital comparator which compares boom commanded position bits (9-17) with the analog/digital Boom potentiometer feedback signal to de-energize the respective Boom motor when a "match" is attained.
- 4) Provides a means of de-energizing any commanded motor when its associated position switch is actuated, indicating a "position achieved".
- 5) Generates a "No-Go" signal and stops all operations at any time a Boom over travel switch is actuated, or a command has not been achieved within the GCSC allotted "delta time" (GCSC subsequently "powers down" the SSCA via the PCDA).

b. Motor Drivers (Partially Redundant)

Provides polarity reversible power drive to respective motors as addressed by the command decode section. Provides redundant (Side 1 or Side 2) drive capability for all motors except comminuter. Incorporates 6 amp feedback current limit for comminuter motor.

c. Solenoid Drivers (Non-Redundant)

Incorporates current limiting of 1.7, 0.85, and 0.44 amps for Collector Head, Biology PDA, and GCHS PDA solenoids respectively. Provides fused protection from solenoid shorts. Provides special 8.8 Hz, 4.4 Hz, and steady state power on operation modes for the Collector Head solenoid.

d. Analog/Digital Converter (Redundant Sides 1 and 2)

- 1) Provides 4-volt reference for potentiometer and temperature bridges.
- 2) Accepts 0-4 volt input for motor currents, solenoid currents, Biology PDA distributor

temperature, Collector Head temperature and Boom potentiometers. Provides a 9-bit binary number output proportional to the analog input.

e. Power Supply (Redundant Sides 1 and 2)

Provides ± 15 Vdc for Analog Circuits, ± 15 VDC for isolated analog circuits, ± 5 Vdc for digital logic and ± 5 Vdc for sample level detectors.

f. Data Management (Non-Redundant)

- 1) Controls signal conditioning and multiplexing so that correct transducer (i.e. potentiometer, current, or temperature) is sampled and its equivalent analog voltage is provided to the Analog to Digital (A/D) converter and appropriate data register.
- 2) Controls discrete events data register for receiving sample level detector and switch actuation functions. Provides a Physical Properties timer which will time current measurements at 2 and 4 seconds after Boom R/R and elevation motor start, and 4 and 15 seconds after comminutor motor start. Provides a Physical Properties timed temperature measurement of the Collector Head at 2 and 10 seconds after solenoid command.
- 3) Provides a data-ready signal to DAPU and GCSC after all data is compiled and removes when data is transmitted. Receives DAPU shift pulses, and serially "transmits" data lead by a 31-bit pseudorandom sync code and 5-bit identification code.

4.8.2.7.5.1 OPERATIONAL SEQUENCE

a. Power Up Operations

The SSCA receives its primary power from the PCDA. Initiation of the PCDA is controlled by the GCSC utilizing its internal logic and stored Mission Event Words which control the exact mission time (Sol, hour, minute, second) at which various sequences are to be initiated. The SSCA is normally operated from the PCDA "Power 1" side. However, in the event of a PCDA "Power 1" failure, or if any of several critical SSCA control circuits should experience a failure, redundant circuits within the SSCA are available and are initialized by application of PCDA "Power 2". Since "Power 2" operation of the SSCA is considered to be an

emergency backup, no redundant data handling circuitry has been provided.

b. Command Operations

Following completion of the "Power Up" operation, the GCSC transmits 24 bit command words serially to the SSCA, with a sufficient "delta-time" provided between commands to permit execution under worst case conditions of VL temperature and bus voltage. Associated with the GCSC transmitted digital commands are command shift pulses which clock the command data into the storage register, and a command enable which controls the execution of the command. The GCSC/SSCA timing functions and command word identification is illustrated in Figure 4.8.2.7-12. The qualitative address portion of the command (bits 18-24) is decoded and acted upon by the falling edge of the enable discrete. The decoded command selects the appropriate solid state switch to apply power to the desired motor or solenoid, and concurrently the corresponding boom potentiometer or position switch is monitored for proper response. Either of the following events will terminate a non-latching (feedback command such as a boom motor) operation:

- 1) The position feedback A/D converter output matches the input position command in the digital comparator;
- 2) Activation of the appropriate position switch;
- 3) A new command is received from the GCSC which occurs after expiration of the "delta time" allowed for the previous command.

If either Case 1) or 2) occurs (normal command and response), a "data ready" signal is sent to the DAPU and GCSC, and the DAPU transmits shift pulses to "clock out" the SSCA data. The occurrence of Case 3 implies two distinct actions:

- 1) For non-latching (feedback) commands: The command was not executed as determined by the absence of a proper feedback signal within the "delta time" allowed by the command. In this case a "no-go" is automatically generated upon receipt of the new command, all SSCA operations are terminated, and no data is transmitted. A "No-Go" will also be generated if a boom overtravel switch is actuated.
- 2) For latching (non-feedback) commands: The command was executed, and terminated after the allowed "delta time" expires and a new command is issued.

The total list of commands available for the SSA, and the digital coding for each is tabulated in Table 4.8.2.7-5. A summary of these commands and associated functions is as follows:

- 1) **Boom Operation-** Commands the boom to move up or down, CW or CCW, or extend/retract depending upon the address (Bits 18-24). Bit 18 determines the direction of operation, and Bits 9-17 are set depending upon the geometric position to which the boom is to be commanded. The commanded motor drives the boom in the correct direction until the A/D potentiometer position feedback matches the digital command in the comparator. Algorithms for boom movements are as follows:

<u>Axis</u>	<u>Units</u>	<u>Algorithm</u>	<u>Bit Position Limits</u>	<u>Engineering Unit Limits</u>
Az	Deg.	272.45-.6312xq	21-426	259°-3°
E/R	In.	-4.274+.2630xq	21-455	1"-115"
Elev.	Deg.	-162.579+.6312xq	191-307	-42°-+31°

Where "q" is the quantitative value in decimal bits.

It should be noted that the "Bit Position" and "Engineering Unit" limits shown refer to approximate mission limits with the boom mounted on the VL. Consideration must be given to VL obstacles (cameras, PDA's, etc) when commanding the boom. Also, individual boom limit switch and hardstop locations vary somewhat between VL-1 and VL-2, and these differences are depicted in a later paragraph of this section.

- 2) **Collector Head Rotate-Clockwise**

The Collector Head rotates at a 3.0 RPM rate to the subsequent position in sequence; from inverted (backhoe up) to the 45 degree position or from the 45 Degree position to the upright position. The upright position is used to collect the surface sample.

- 3) **Collector Head Rotate-Counterclockwise**

The Collector Head rotates to the subsequent position in sequence; from upright (backhoe down) to the 45 degree position, or from the 45 degree position to the inverted position. The inverted

position is used for depositing the sample in the processors and for sieving Physical Properties samples on the VL grid and the 45 degree position is used for purging of excess sample.

4) GCMS Distributor Rotate-Clockwise

The GCMS Distributor motor moves the shuttle block to the subsequent position in sequence; from dump to delivery position, or from delivery to meter position.

5) GCMS Distributor Rotate-Counter-Clockwise

The GCMS Distributor motor moves the shuttle block to the subsequent position in sequence; from meter to delivery position; or from delivery to the dump position.

6) Biology Distributor Rotate-Clockwise

The Biology distributor motor moves the shuttle block to the subsequent position in sequence; from meter to delivery position, or from delivery to dump position.

7) Biology Distributor Rotate-Counter-clockwise

The Biology distributor motor moves the shuttle block to the subsequent position in sequence; from dump to delivery position, or from delivery to meter position.

8) GCMS Processor Commminute Mode On

The Processor motor drives the auger within the comminuter housing which provides grinding of soil such that 600-micron or less sized particles are allowed to pass to the shuttle block 300-micron sieve. The shuttle block will normally be in the metering position during this operation. This command also activates the level sensor.

9) GCMS Processor Sieve Mode On

The GCMS Processor motor drives the auger within the comminuter housing down which provides bypassing of soil such that 4000-micron or less sized particles are allowed to pass to the shuttle block 300-micron sieve or dump. The shuttle block will normally be in the dump position during this operation. This command also activates the level sensor.

- 10) **GCMS Processor Commminute/Sieve Mode Off**
Terminates GCMS Processor motor operation. This command will always be issued between commanding a commminute mode and sieve mode or vice versa. This command also deactivates the level sensor.
- 11) **GCMS Processor Commminute/Sieve Mode Off**
Same as above.
- 12) **Biology Distributor Vibrate On**
This command activates a thumper solenoid within the Biology Distributor Shuttle to aid in delivery of the soil sample from the metering tube to the Biology Instrument and to aid in the dumping process.
- 13) **Biology Distributor Vibrate Off**
This command terminates the Biology distributor thumper solenoid activation.
- 14) **GCMS Distributor Vibrate On**
This command activates the GCMS distributor solenoid which vibrates the GCMS Shuttle block to aid in delivery of the soil sample from the metering tube to the GCMS Instrument and to aid in the dumping process. When in the dumping process, the GCMS auger should be in the sieve position.
- 15) **GCMS Distributor Vibrate Off**
This command terminates GCMS distributor shuttle block vibration.
- 16) **Biology Processor Vibrate On**
Activates an agitator rod which aids in filling the Biology Processor metering tube. The mode is also utilized during the dump process.
- 17) **Biology Processor Vibrate Off**
Terminates activation of the Biology Processor agitator rod. This command also activates the level sensor.
- 18) **Collector Head Lid Close**

Removes voltage from collector head open/close solenoid. It also terminates collector head vibration mode if on.

19) Collector Head Lid Open

This command applies voltage to the Collector Head open/close solenoid opening the lid and thus enabling soil collection.

20) Collector Head Vibrate - High Frequency Mode

This command activates collector head vibration at 8.8 hertz and with the collector head lid opening to 1/8 inch and closing at 8.8 hertz or 4.4 hertz contingent on the jaw switch being closed or open at command actuation respectively. This mode is nominally used for sieving.

21) Collector Head Vibrate - Low Frequency Mode

This command activates collector head vibration at 4.4 hertz and with the collector head lid opening to 1-1/4 inches and closing at 4.4 hertz. This mode is nominally used for purging.

22) Solenoid Current Limit Disable

This command inhibits the current limit function to the solenoids.

23) Solenoid Current Limit Enable

This command restores the current limit function.

24) No-Go Inhibit Enable

Inhibits the SSCA NO-GO discrete being issued to GCSC. Extreme care should be utilized in the use of this command since it bypasses the built in logic to protect the surface sampler.

25) No-GO Inhibit Disable

This command enables the SSCA NO-GO discrete function to the GCSC.

c. Sample Level Detector Operation

Operation of the sample level detectors is accomplished indirectly in conjunction with other previously described PDA commands, as described below.

1) GCMS Level Detector

The sample level "sense" operation is initiated concurrently with the comminuter "On" command. Approximately 7 seconds after issue of the "On" command, power is supplied to the distributor level detector bridge. The power remains on for 7 seconds, is off for 29 seconds, on for 7 seconds, etc. the Sequence terminates only when the level detector indicates a full condition, or the comminuter motor is commanded to stop. Conditions which can exist are as follows:

- a) If the level detector is filled, the event complete register to GCSC and TH data register are set to indicate a full condition.
- b) If the comminuter motor is commanded to stop after the level detector is filled, the event complete register and TH data register are reset to indicate an empty condition.
- c) If the comminuter motor is commanded to stop and the level detector is not filled, the sensing operation terminates and the event complete register and TH data register remain set to the empty condition.

The operating logic which utilizes the "level full" and "level empty" data is contained within the GCSC and is described in a later paragraph of this section.

2) Biology Level Detector

The sample level "sense" operation is initiated concurrently with a biology processor solenoid vibrate "On" command followed by an "Off" command. Approximately 7 seconds after issue of the "Off" command, power is supplied to the distributor level detector bridge. The power remains on for 7 seconds for the sense operation, and is then terminated (no repetitive cycling as with GCSCS). The conditions which can exist are as follows:

- a) If the level detector indicates a full condition, the event complete register and the TH data register are set to indicate a full condition.
- b) The registers will reset to an empty condition upon receipt of a Biology Processor Solenoid vibrate command.

- c) If the level detector indicates an empty condition, the event complete register and the TM shall remain set to their empty condition. Additional sensing cycles require a repeat of the "Sense" operation.

d. Data Operation

A 120-bit data frame is acquired during the "delta time" provided for the execution of each 24-bit command word with some exceptions as indicated below. The data is accumulated in a storage register, and when all data has been compiled, a "data ready" is transmitted to the DAPU and GCSC. Subsequently the DAPU transmits shift pulses to the SSCA to "clock-out" the data at a 16 KBPS rate. The SSCA/DAPU timing functions and data word identification are illustrated in Figure 4.8.2.7-13.

A Data Ready signal is generated for every command, providing the following conditions are met:

- 1) A command complete is obtained;
- 2) One current measurement is made;
- 3) Two temperature measurements are made.

An interruption by a new command before the above three steps are complete will cause loss of data, and an interruption during any of the three steps will cause loss of data. An interruption before step 1 is complete will also cause a No-Go to be generated. Additionally, there are two special function commands (Solenoid current limit disable/enable and No-Go Inhibit enable/disable) which do not initiate a data taking sequence. Biology and GCMS level detector indications do not influence the data accumulation functions.

A summary of data accumulation strategy includes the following:

- 1) Boom Azimuth Commands

A single sample current measurement (No. 1) within 5 seconds after initiation of the command, Biology PDA temperature (No. 1), Collector Head temperature (No. 2), and the remaining data in accordance with Figure 4.8.2.7-13.

- 2) Boom Extend/Retract and Elevation Commands

Similar to 1), except two current measurements are made at 2 (No. 1) and 4 (No. 2) seconds after command initiation.

3) Solenoid Commands (Exclusive of Collector Head)

Same as 1).

4) Commminute/Sieve Commands

Similar to 1), except two current measurements are made at 4 and 15 seconds after command initiation.

5) Collector Head, Biology and GCMS Distributor Motor Commands

Same as 1).

6) Collector Head Solenoid

Same as 1), except both temperatures (temp 1 and temp 2) are measured at the Collector Head at 2 and 10 seconds after command initiation.

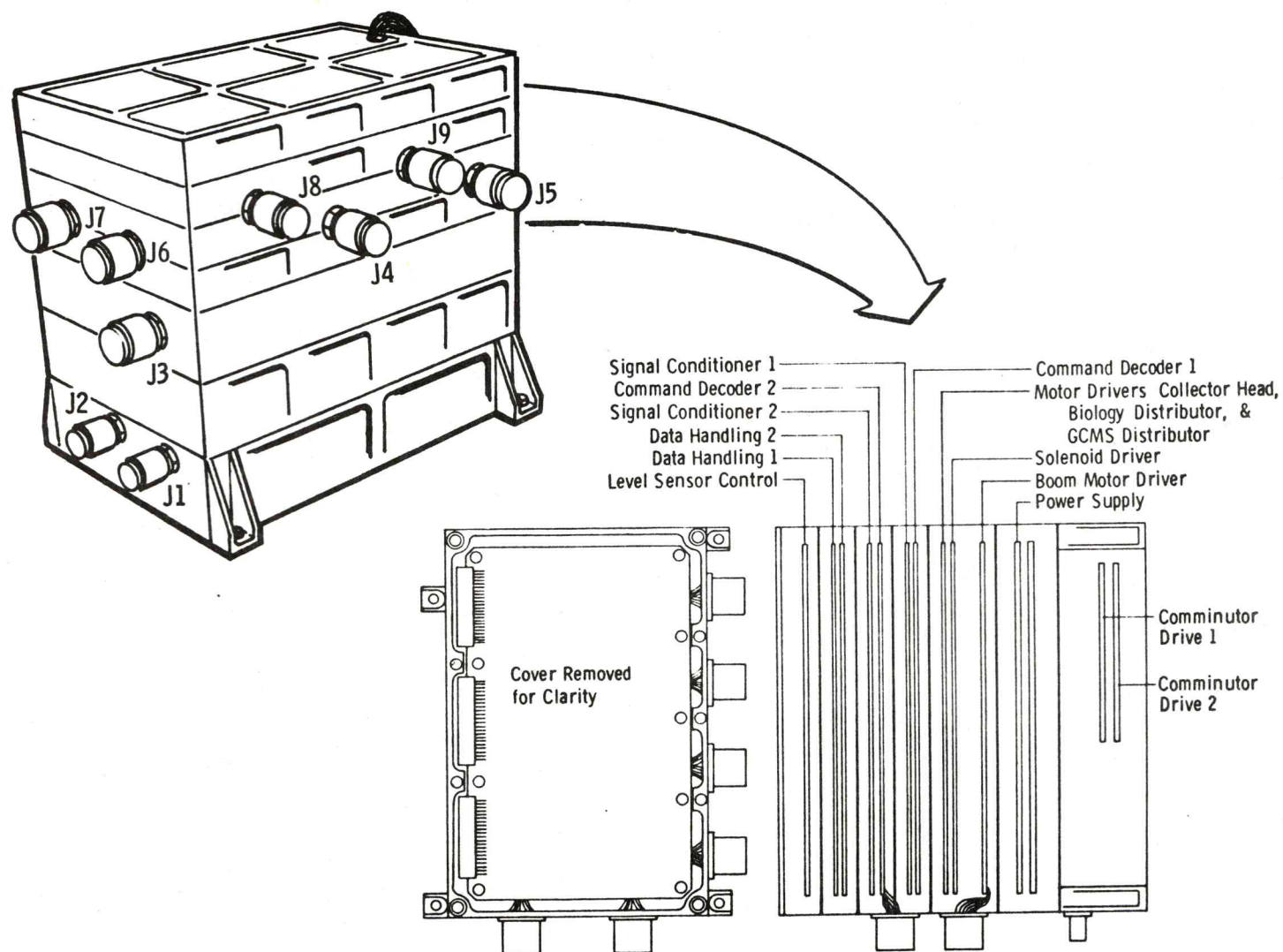


Figure 4.8.2.7-8 Surface Sampler Control Assembly

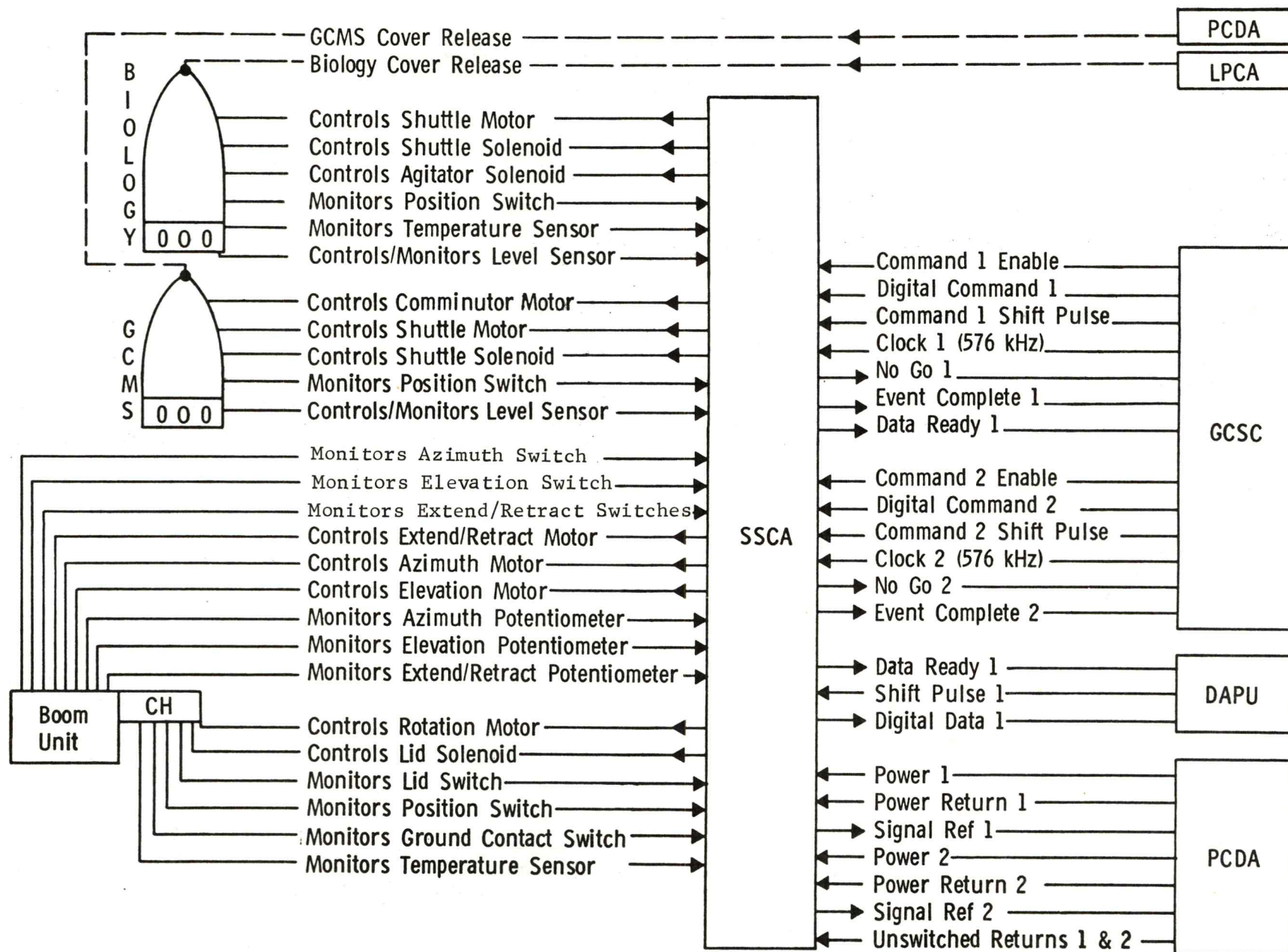


Figure 4.8.2.7-9 - SSCA INTERFACES

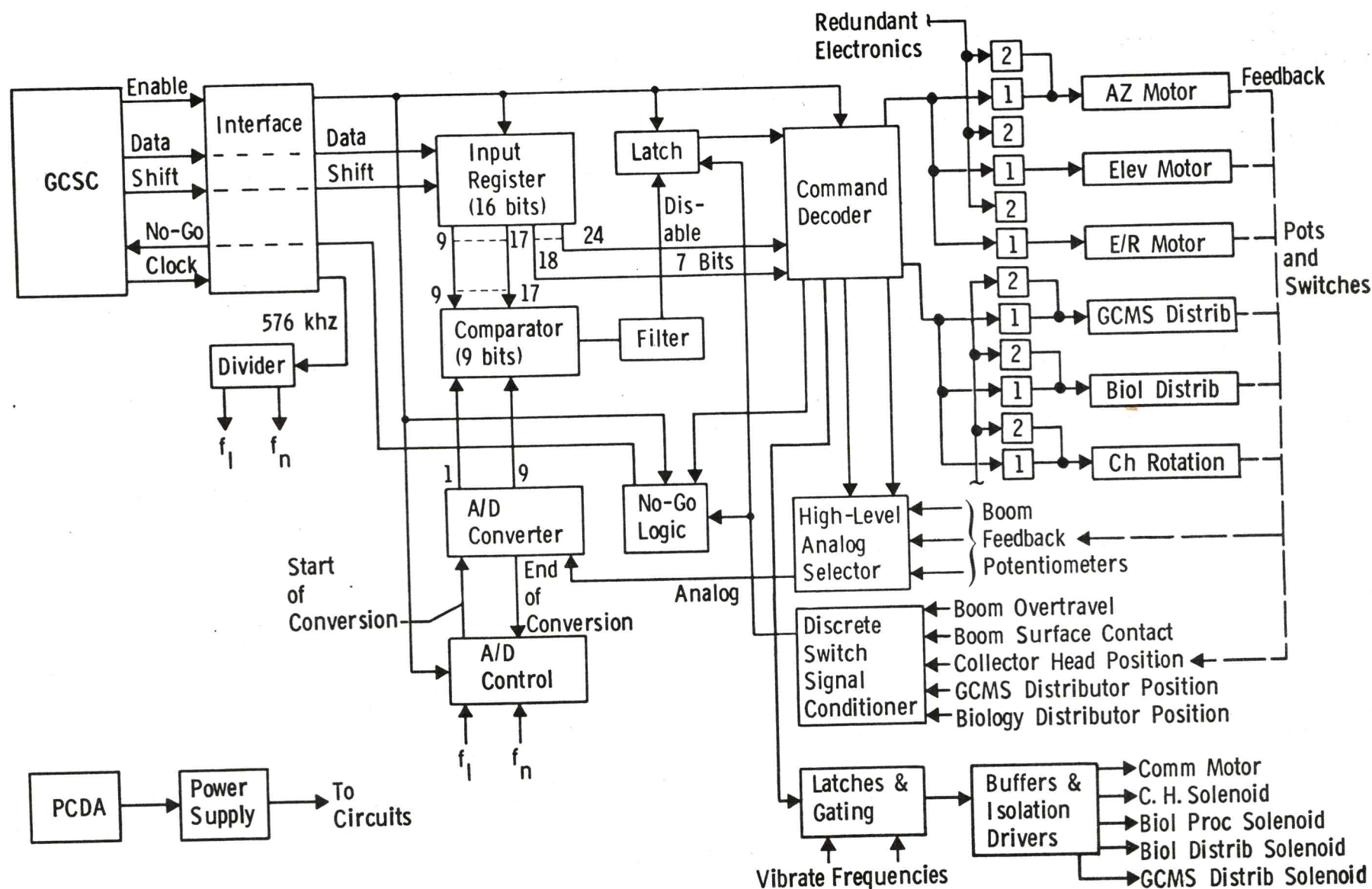


Figure 4.8.2.7-10 - SIMPLIFIED SSCA COMMAND OPERATIONS

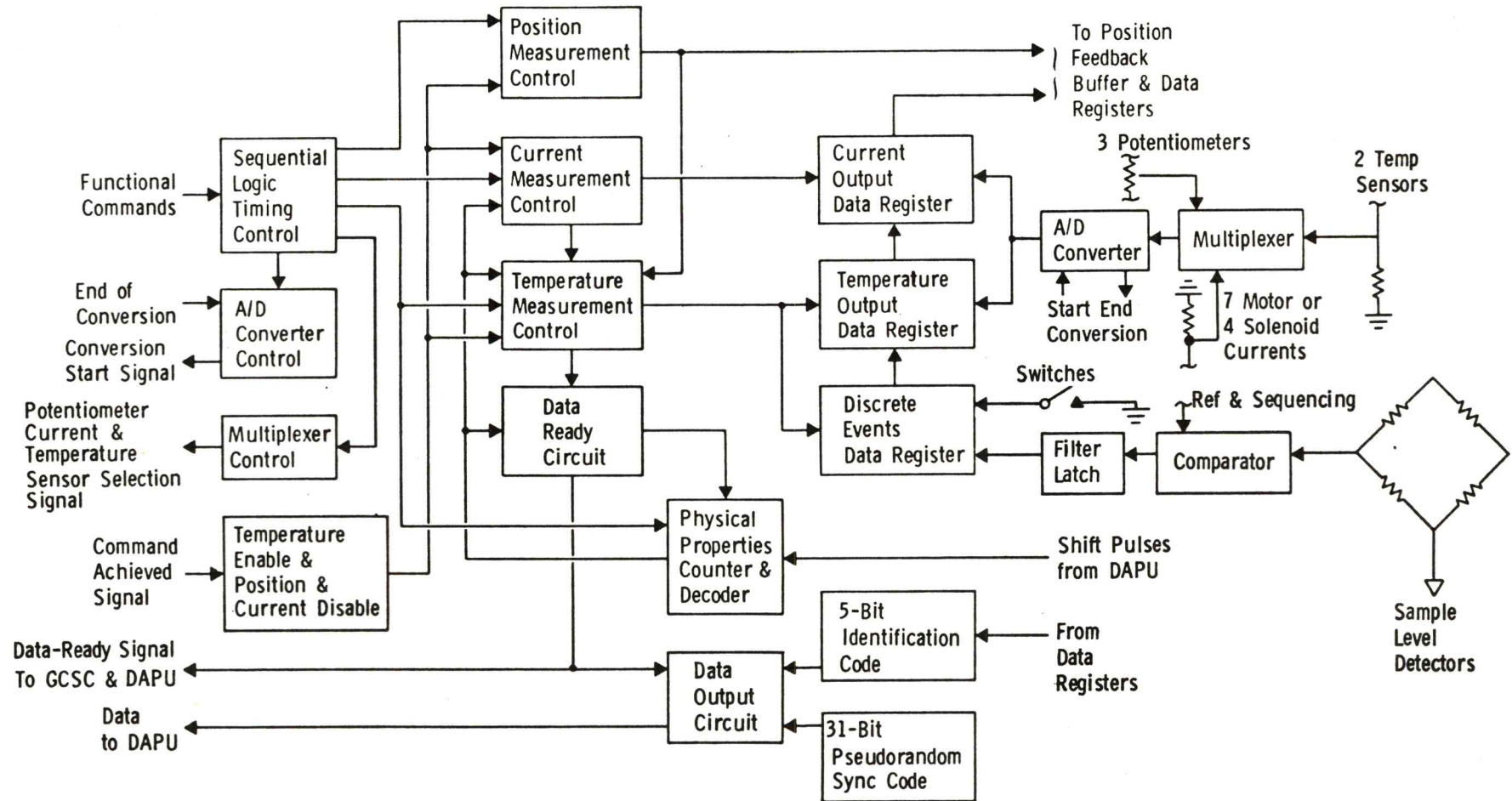
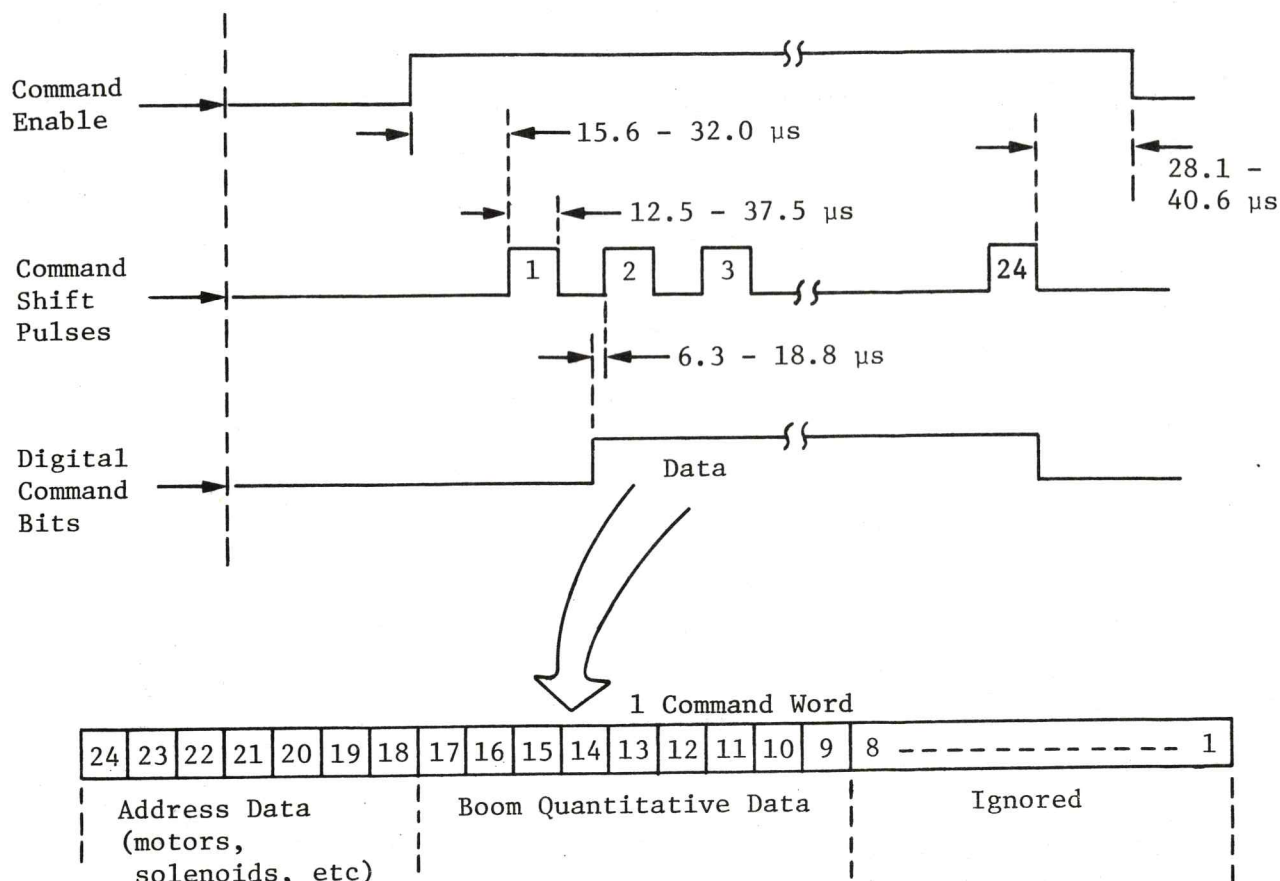


Figure 4.8.2.7-11 - SIMPLIFIED SSCA DATA MANAGEMENT OPERATIONS

GCSCSSCA

Command Transfer Rate = 16 kbps

Figure 4.8.2.7-12 GCSC/SSCA COMMAND TRANSFER

Table 4.8.2.7-5
SSCA COMMAND CODE

BIT								FUNCTION
24	23	22	21	20	19	18	17-9	
1	0	0	0	1	0	1	X	BOOM ELEVATE-UP
1	0	0	0	1	0	0	X	BOOM ELEVATE-DOWN
1	1	0	0	1	0	1	X	BOOM AZIMUTH - CW
1	1	0	0	1	0	0	X	BOOM AZIMUTH - CCW
1	1	1	0	1	0	1	X	BOOM EXTEND
1	1	1	0	1	0	0	X	BOOM RETRACT
0	1	1	0	1	0	1	X	COLLECTOR HEAD ROTATE - CW
0	1	1	0	1	0	0	X	COLLECTOR HEAD ROTATE - CCW
1	1	0	1	1	0	1	X	GCMS DISTRIBUTOR ROTATE - CW
1	1	0	1	1	0	0	X	GCMS DISTRIBUTOR ROTATE - CCW
0	0	1	0	1	0	1	X	BIOLOGY DISTRIBUTOR ROTATE-CW
0	0	1	0	1	0	0	X	BIOLOGY DISTRIBUTOR ROTATE-CCW
1	0	1	0	1	1	0	X	GCMS PROCESSOR COMMINUTE MODE ON
1	0	1	0	1	0	1	X	GCMS PROCESSOR SIEVE MODE ON
1	0	1	0	1	0	0	X	GCMS PROCESSOR COMMINUTE/SIEVE MODE OFF
1	0	1	0	1	1	1	X	GCMS PROCESSOR COMMINUTE/SIEVE MODE OFF
1	0	0	1	1	0	1	X	BIOLOGY DISTRIBUTOR VIBRATE ON
1	0	0	1	1	0	0	X	BIOLOGY DISTRIBUTOR VIBRATE OFF
0	0	0	1	1	0	1	X	GCMS DISTRIBUTOR VIBRATE ON
0	0	0	1	1	0	0	X	GCMS DISTRIBUTOR VIBRATE OFF
0	1	0	1	1	0	1	X	BIOLOGY PROCESSOR VIBRATE ON
0	1	0	1	1	0	0	X	BIOLOGY PROCESSOR VIBRATE OFF
1	0	1	1	1	0	0	X	COLLECTOR HEAD LID CLOSE
1	0	1	1	1	1	1	X	COLLECTOR HEAD LID OPEN
1	0	1	1	1	0	1	X	COLLECTOR HEAD VIBRATE-HF MODE
1	0	1	1	1	1	0	X	COLLECTOR HEAD VIBRATE-LP MODE
1	0	0	1	0	0	1	X	SOLENOID CURRENT LIMIT DISABLE
1	0	0	1	0	0	0	X	SOLENOID CURRENT LIMIT ENABLE
0	1	0	1	0	0	1	X	NO-GO INHIBIT ENABLE
0	1	0	1	0	0	0	X	NO-GO INHIBIT DISABLE

Quantitative Data (X) - The quantitative data field will position the boom to the specified position when the address field contains the bit structure for the BOOM functions. The quantitative data field will have no effect for all other address field functions although one of the bits must contain a "1".

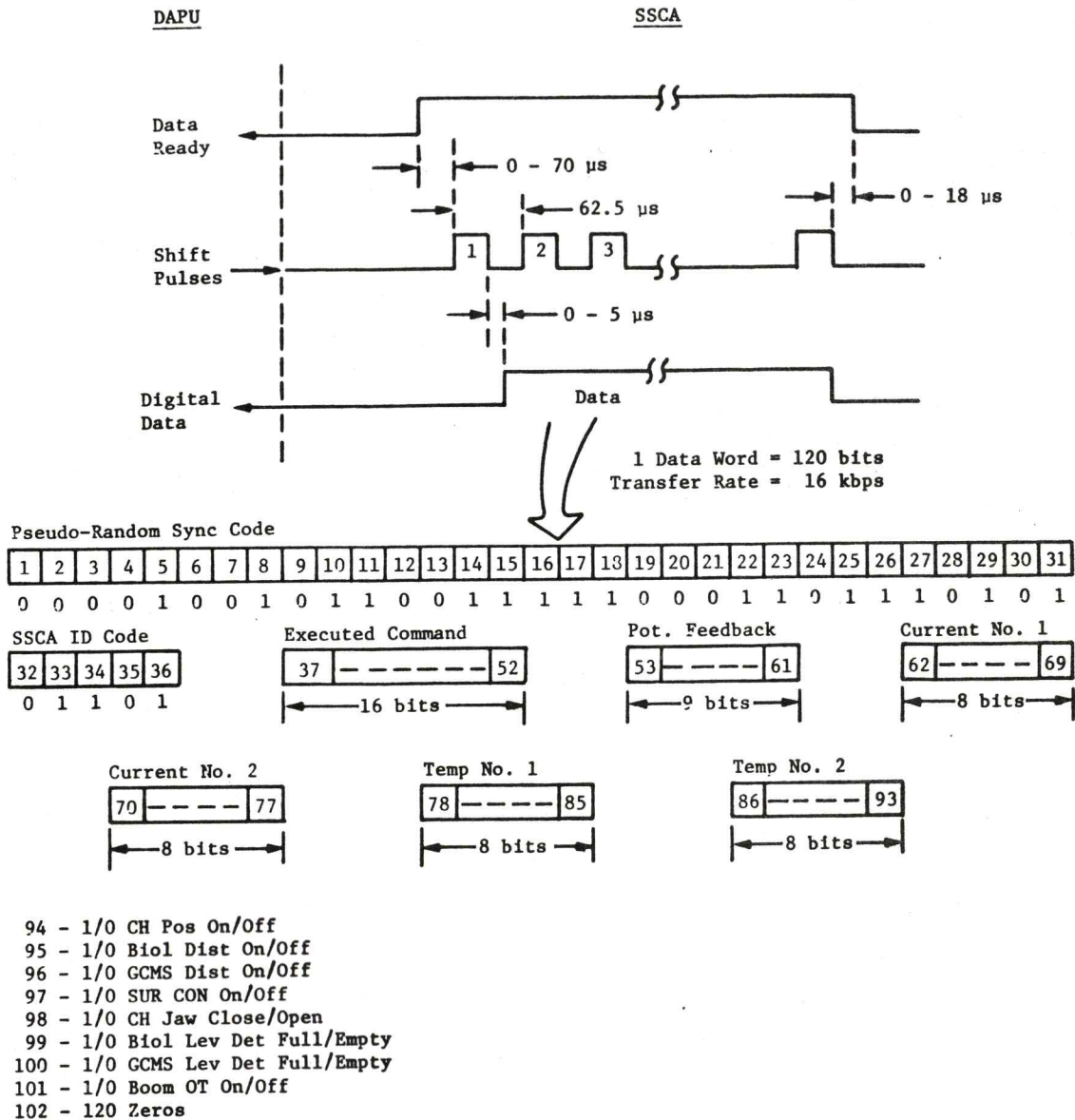


Figure 4.8.2.7-13 - SSCA/DAPU DATA TRANSFER

4.8.2.7.6 OPERATING MODES

The Surface Sampler Assembly is primarily a service instrument, rather than a science instrument, and therefore the related data acquired is of an engineering nature used for verifying proper operation. Two modes of operation are available for the SSA, Power 1 and Power 2 sides. The availability of two operating modes was incorporated into the design primarily for redundancy. Certain critical circuits within the SSCA are redundant as previously described, and either side can be "powered on" through update commands to the PCDA. However, the data output is available only with the power 1 side of operation as described below. For both operating modes the SSCA command sequences are stored in the GCSC for the preprogrammed mission, or can be changed via command uplink for the primary mission.

a. Power 1 Side Operations

This operating mode contains all of the SSA functional elements, i.e., the commands, control, and data acquisition capabilities. A 120-bit data frame (Figure 4.8.2.7-13) consisting of the pseudo random sync code, SSCA identification code, and 15 engineering measurements, is compiled for 26 of the 30 possible Surface Sampler Commands (1). The 4 command exceptions to the normal data acquisition routine are the no-go inhibit disable/enable, and solenoid current limit disable/enable commands. During normal SSA operations, the 120-bit data words compiled in conjunction with each 24-bit command word are stored in the DAPU until such time that they can be serially downlinked through the Deep Space Network (DSN) to the JPL Mission Control. The data are then compiled and processed by the program DECSET which outputs the data on a line printer in engineering units. Table 4.8.2.7-6 illustrates the format of the SSCA DECSET program and Table 4.8.2.7-6A illustrates a similar Science Test Lander ground program using a HP-9830 computer. All data are in engineering units except the current measurements which are tabulated in octal bits. Off-line conversion for current is required because of the differences in current scaling factors for the various motors and solenoids, and the effects of VL bus voltage which must be included. The executed command word is tabulated both in octal and engineering units.

Note (1) There are actually a grand total of 3,090 theoretically possible commands considering all boom positions in both directions of azimuth, elevation, and extend/retract.

b. Power 2 Side Operations

This operating mode available by uplink command to the PCDA is an emergency type redundant operation, and no data formatting capability has been provided. The normal command and control capability exists and normal sequences can be executed but the type of available data described for Power 1 Side operation does not exist for side 2. Some "inferred" type of information can be acquired by monitoring the VL bus current as the various SSCA sequences are executed. Additional data can also be acquired through the VL imaging subsystem.

4.8.2.7.7 OPERATIONAL SEQUENCE

a. Control Logic

Command and control of the SSA is accomplished by a combination of the SSCA electronics and the control logic which is stored in the GCSC. The control logic is contained within the Surface Sampler Control Module (SSCACH) which provides command sequencing of the SSCA to deliver surface samples to the Biology, GCNS, and XRPS instruments. The SSCACH also provides command sequencing for shroud eject, and to perform boom movement activities used for Physical and Magnetic Properties Investigations.

Entry is made to the GCSC command module SSCACH through HSET. The Mission Event Word (HEW) format is fixed for the particular sequence to be executed in the control module, and the time of sequence execution is pre-programmed into the GCSC. The SSCA HSET word and its options are illustrated in Figure 4.8.2.7-14. Bits 0-6 are blank, bits 7, 8, 9 and 11 control which sequences are to be executed, bits 10 and 12 control the use/non-use of sample level detector full/empty information, bits 13-20 control the number of retry sample acquisitions for GCNS and Biology, and bits 21-23 control the number of collector head vibrate sequences to be performed over the GCNS PDA.

The total logic flow diagram for the SSCA is illustrated in Figure 4.8.2.7-14. Associated with the logic flow are tables of commands which are stored within the GCSC and which are "called up" by the Control Module as the logic flow process demands. There exists 14 tables of commands for the SSCA, with a maximum total of 226 commands available. In each table, the contents of word "0" is an index which indicates which command in the table is to be output first, the contents of word "1" is the total number of commands to output from the table, and the contents of word "2" through word "n" contain ordered pairs of GCSC to SSCA commands and the associated delay times which follow the command output to allow for command

completion. The titles of these tables, current number of preprogrammed commands and the number of spares is tabulated in Figure 4.8.2.7-14.

Upon entry to the SSCA Control Module, the Mission Event Word (MEW) is contained in the GCSC A-Register with the bits set as previously described. The SSCA control module may be scheduled at any time on any landed day during the mission. As a function of being scheduled, the decision elements (which correspond to the options provided by Flight-Ops through the HSET Tables) are set, Seismometer commanding is inhibited, a special SSCA Seismometer command issued, DAPU powered on continuously for the duration of SSCA activity, DRU power Group II and V are powered on continuously, power on the SSCA, the SSCA EX1 enabled, GCSC register R6 is cleared of any inadvertent discretes caused during the SSCA power up, and the series of SSCA commands issued (which are dependent upon the decision elements set after entry to the SSCACH). Upon completion of the SSCA commanding, the SSCA EX1 is disabled, the SSCA is powered off, the last Seismometer command scheduled by the Seismometer routine prior to entering or during the SSCACH execution is issued, Seismometer commanding enabled, the DAPU is returned to normal operation, power off to DRU power group V enabled, and the SSCACH exited.

B. Preprogrammed Mission Sequences

The preprogrammed mission sequences are those which are stored within the GCSC at the time of VL landing, and which will be automatically executed if not changed by subsequent uplink. The sequences which are stored for the SSCA include Shroud Eject, Biology-GCHS-XRPS sample acquisition, and a combined Physical/Magnetic Properties Experiment. Detail commands and delta times for all tables are listed in Table 4.8.2.7-7 thru 4.8.2.7-21. Referring to Figure 4.8.2.7-14, the SSCA sequences are summarized as follows:

- 1) Shroud Eject (SOL 2-10:20:50)
 - a) HSET Entry at appropriate local lander time
 - b) SSCA No-GO Bypass Flag Set - No (normal setting)
 - c) SSCA No-GO Flag Set - No (will be yes if there has been a previous no-go)
 - d) Biol Bypass 2 Bit Set- No
 - e) Biol Scheduled Bit Set- No

- f) SSCA Shroud Eject - Yes
 - g) Process Table 11 commands (only Cnds 1-9)
 - h) X-Ray Bit Set - Yes
 - i) Set Table 11 Header (bypass shroud eject commands 1-9 next time)
 - j) Set Table 9 Header - (bypasses Collector Head purge, cnds 1-7)
 - k) Process Table 9
 - l) Set Table 9 Header to original value (do all commands next time)
 - m) Exit
- 2) Biology Acquisition (SOL 8-6:54:28)
- a) HSET Entry at Appropriate Local Lander Time
 - b) SSCA No-Go Bypass Flag Set - No (normal setting)
 - c) SSCA No-GO Flag Set - No (will be YES if there has been a previous No-Go)
 - d) Biol Bypass 2 Bit Set- No
 - e) Biol Sched Bit Set- Yes
 - f) ENQUE SSCA Biol Delivery
 - g) Start ENQUE Time- Initiates a 1 hr-33 min-33 sec timer to start Biology Instrument at 8:25:00 on Sol 8 regardless of the time required for the parallel acquisition/delivery loop
 - h) SSCA Shroud Eject Bit Set- No
 - i) X-Ray Bit Set- No
 - j) Process Table 1 Commands
 - k) GCNS bit Set- No
 - l) Biology Scheduled Bit Set- Yes
 - m) Process Table 6 commands
 - n) Bypass 2 Bit Set- No

- o) Biology PDA Full- Yes
- p) Exit - Wait for Biology Engue to run out
- q) Start Biology Control Module
- r) Process Table 7 commands
- s) Bypass Bit 2 Set- No
- t) Biology PDA Level Empty- Yes (Non operation for PPH 2.1) but TR data available
- u) Set Biology Delivery Flag
- v) Process Table 12 commands
- w) Process Table 8 commands
- x) Set Table 6 Header to Original Value (do all commands next time)
- y) Process Table 9 commands
- z) Set Table 9 Header to original value (do all commands next time)
- aa) Exit

NOTE: If o) Biology PDA FULL = No, then:

- (1) Sample Acquisition Re-try $\neq 0$ (= 2 for PPH)
- (2) Set Table 6 Header to alternate value (Retains distributor in meter position by bypassing commands 1-5)
- (3) Process Table 12 commands
- (4) Process Table 1 commands (Do-Loop)
- (5) Repeat Items 1) through aa)

NOTE: Items (1) through (5) will be repeated an additional (3rd) time if item o) still indicates NO. If a NO is attained on the 3rd try, Tables 14) and 12) will be processed followed by items x) through aa) and the sequence will terminate. Sufficient Biology start Engue time has been allowed to accomodate the maximum of 3 sampling attempts.

- 3) GCMS Acquisition (Sol 8 - 8:52:50)
- a) HSET Entry at appropriate local lander time
 - b) SSCA NO-GO Bypass Flag Set - No (normal setting)
 - c) SSCA NO-GO Flag Set - No (will be YES if there has been a previous NO-GO)
 - d) Biol Bypass 2 Bit Set- No
 - e) Biol Sched Bit Set- No
 - f) SSCA Shroud Eject Bit Set- No
 - g) X-Ray Bit Set- No
 - h) Process Table 1 commands
 - i) GCMS Scheduled Bit Set- Yes
 - j) Process Table 2 commands
 - k) Process Table 3 commands
 - l) Bypass 1 Bit Set- YES (bypass level full logic for preprogrammed mission only)
 - m) GCMS PDA Level Full- (will indicate YES or NO for TH only)
 - n) Process Table 4 commands
 - o) Bypass 1 Bit Set- YES (bypass level empty logic)
 - p) GCMS PDA Level Empty- (will indicate YES or NO for TH only)
 - q) Set GCMS Delivery Flag
 - r) Process Table 12 commands
 - s) Process Table 5 commands
 - t) Set Table 2 Header to Original Value (do all commands next time)
 - u) Biology Scheduled Bit Set- No
 - v) Process Table 9 commands

- w) Set Table 9 Header to original value (do all commands next time)
- x) Exit
- 4) XRFS Acquisition (Sol 8 - 10:35:50 & 11:22:50)
(Sol 18 - 7:29:50 & 8:11:50)
 - a) HSET Entry at appropriate local lander time
 - b) SSCA No-Go Bypass Flag Set- No (normal setting)
 - c) SSCA No-Go Flag Set- No (will be YES if there has been a previous No-Go)
 - d) Biol Bypass 2 Bit Set- No
 - e) Biol Sched Bit Set- No
 - f) SSCA Shroud Eject Bit Set- No
 - g) X-Ray Bit Set- Yes
 - h) Process Table 10 commands
 - i) Process Table 9 commands
 - j) Set Table 9 Header to original value (do all commands next time)
 - k) Exit

NOTE: XRFS Sol 8 and 18 sequences will automatically recycle at 20 day intervals if not altered by uplink commands.

- 5) Physical/Magnetic Properties (Sol 39 - 7:29:50)
 - a) HSET Entry at appropriate local lander time
 - b) SSCA No-Go Bypass Flag Set- No (normal setting)
 - c) SSCA No-Go Flag Set- NO (will be YES if there has been a previous No-Go)
 - d) Biol Bypass 2 Bit Set- No
 - e) Biol Sched Bit Set- No
 - f) SSCA Shroud Eject Bit Set- Yes

- g) Process Table 11 commands (less commands 1-9)
- h) X-Ray Bit Set- No
- i) Process Table 9 commands
- j) Set Table 9 Header to original value (do all commands next time)
- k) Exit

It should be noted that if a NO-GO is obtained during any of the previously described automatic preprogrammed sequences, all SSCA activities will terminate until the cause of the problem is determined from downlink data, and corrective action commands can be uplinked to the VL.

c. Primary Mission Design

The Preprogrammed mission employs a sequence philosophy which assumes no uplink capability. Therefore, items such as ignoring the Biology sample level detector empty logic, using any wind blown dust sample for GCNS, and bypassing all GCNS sample level detector logic have been incorporated. The Primary Mission Design will be similar to the PPH, but will have the following changes:

- 1) Re-instatement of all Biology sample level detector full/empty logic;
- 2) Dump GCNS PDA windblown dust samples prior to acquisition of Surface Samples;
- 3) Re-instatement of all GCNS sample level detector full/empty logic and associated "do-loop" Surface Sampling repeat acquisitions.
- 4) Changes of sample sites dependent upon imagery investigations;
- 5) Perform additional Biology and GCNS sample acquisitions.

Additionally, many other adaptive sequence changes are possible, and likely, due to the numerous unanticipated situations which may occur. The SSA possesses considerable operational flexibility within the bounds of the control logic and command tables data base.

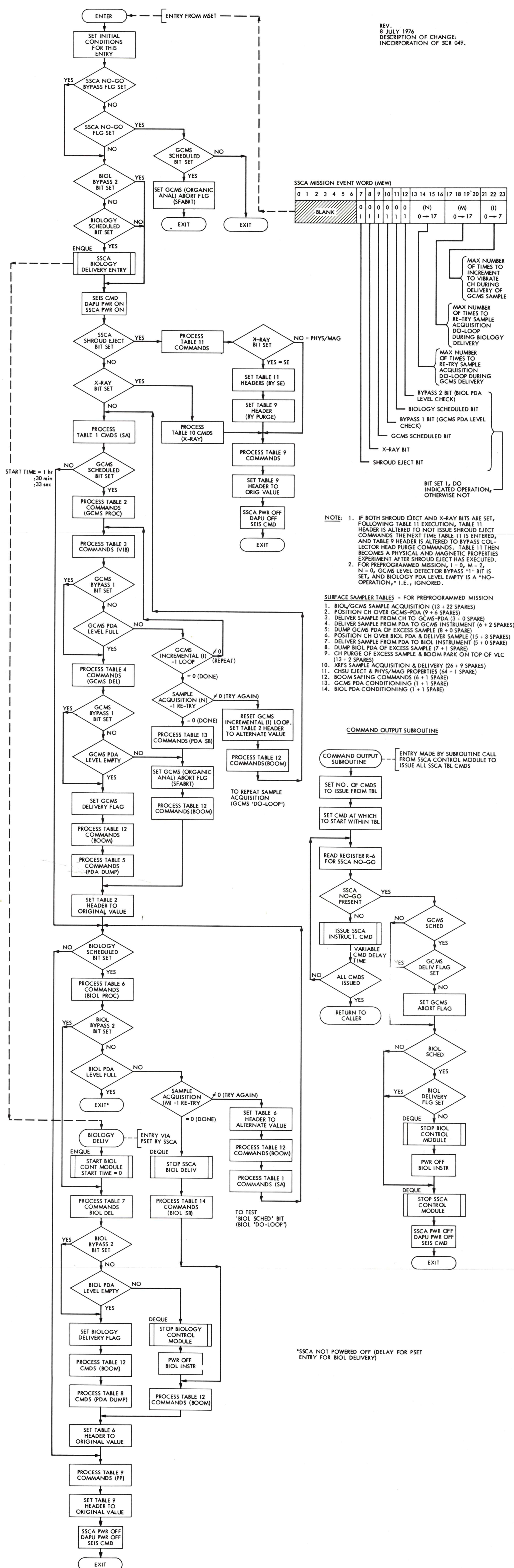


Figure 4.8.2.7-14 SSCA Logic Flow

SURFACE SAMPLER SUBSYSTEM

DATE THIS TABULATION MADE - DAY 230 1975 TIME 00:45:15

VIKING LANDER: 1

T1=LATEST AVAILABLE TIME WORD - LLT
T2=EARTH RECEIVED TIME - GMT
T3=GCSC TIME DERIVED FROM LPBK FILE - LLT

TIME (SOL) DAY HR MN SEC	COMMAND DESCRIPTION	COMMAND (OCTAL)	CMD POS. (DEG) (IN)	ACHVD POS. (DEG) (IN)	I1 (AMPS)/OCT	I2 (AMPS)/OCT	T1 DF	T2 DF	C/H PSN	BIO PSN	GMS PSN	SRF PSN	C/H JAW	BIO LD	GMS LD	BM OT
T1=-32:***:***:*** T2=229:20:35: 5.250 T3=***:***:***:***	BIO DIST ROT CW	12577400	*****	*****	17	0	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.313 T3=***:***:***:***	BIO DIST ROT CCW	12177400	*****	*****	15	0	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.375 T3=***:***:***:***	BIO PROC VIB ON	26577400	*****	*****	141	0	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.438 T3=***:***:***:***	BIO PROC VIB OFF	26177400	*****	*****	1	0	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.500 T3=***:***:***:***	HEAD ROTATE - CCW	32177400	*****	*****	15	0	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.563 T3=***:***:***:***	HEAD LID OPEN	57577400	*****	*****	242	0	75	75	1	1	1	0	0	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.625 T3=***:***:***:***	HEAD LID CLOSE	56177400	*****	*****	1	0	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.688 T3=***:***:***:***	HEAD ROTATE - CW	32577400	*****	*****	17	0	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.750 T3=***:***:***:***	BOOM ELEV - DOWN	42156000	-23.7	-21.2	34	33	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.813 T3=***:***:***:***	BOOM AZM - CW	62720400	9.2	6.7	23	0	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.875 T3=***:***:***:***	BOOM EXTEND	72413000	1.5	1.5	60	0	75	75	1	1	1	0	1	0	0	0
T1=-32:***:***:*** T2=229:20:35: 5.938 T3=***:***:***:***	BOOM RETRACT	72010000	-0.1	0.7	71	0	75	75	1	1	1	0	1	0	0	1

Table 4.8.2.7-6 - TYPICAL SSCA DECSET DATA

***** VIKING SCIENCE TEST LANDER *****

DATE:

TIME:

OPERATOR:

TEST DESCRIPTION

SURFACE SAMPLER SUBSYSTEM.

INPUT COMMAND				SSCA DATA OUTPUT				SWITCH POSITION	
N	FLT CMD, OCTAL	TIME, SEC	COMMAND DESCRIPTION	POS, ENG	11, OCT	12, OCT	T1, F	T2, F	W O T E L N T
1	145203	183	AZ CW	189.8	17	0	89	89	1 1 1 0 1 0 0 0
2	104306	76	ELEV DN	-37.6	30	31	89	88	1 1 1 0 1 0 0 0
3	165235	89	EXTEND	37.0	45	40	89	86	1 1 1 0 1 0 0 0
4	64063	11	CH ROT CCW	0.0	12	0	89	86	1 1 1 0 1 0 0 0
5	136064	30	CH L/F VIB	0.0	147	0	86	86	1 1 1 0 0 0 0 0
6	134065	17	CH CLOSE	0.0	0	0	85	85	1 1 1 0 1 0 0 0
7	65066	11	CH ROT CW	0.0	14	0	89	85	1 1 1 0 1 0 0 0
8	164038	59	RETRACT	2.0	54	51	89	85	1 1 1 0 1 0 0 0
9	105412	85	ELEV UP	5.3	44	42	89	85	1 1 1 0 1 0 0 0
10	144651	250	AZ CCW	4.2	16	0	89	86	1 1 1 0 1 0 0 0
11	165040	15	EXTEND	4.1	51	0	89	86	1 1 1 0 1 0 0 0
12	104352	37	ELEV DN	-14.9	30	31	89	86	1 1 1 0 1 0 0 0
13	134067	17	CH CLOSE	0.0	0	0	86	86	1 1 1 0 1 0 0 0

Table 4.8.2.7-6A - TYPICAL SSCA STL HP-9830 COMPUTER PRINTOUT

TBL	ENT	CMD	ΔT , SEC	DEC. POS.	CMD DESCRIPTION	POSITION		COMMENT	16-BIT OCTAL	24-BIT OCTAL
						START	STOP			
1	1	1	65	289	+ EL	-14.863°	19.857°	From Park EL	105441	42620400
	2	3	191	136	Az CW	3.529°	186.598°	From Park Az	145210	62504000
	3	5	248	405	Ext.	4.143"	102.253"	From Park Ext.	165625	72712400
	4	2	80	194	-E1	19.857°	-40.114°	Surface Contact	104302	42141000
	5	24	17	001	CH Open				137001	57400400
	6	29	5	511	NO-GO Inhibit				051777	24777400
	7	5	25	428	Ext	102.253"	108.303"	Acquire Sample	165654	72726000
	8	23	17	511	CH Close				134777	56377400
	9	30	5	511	NO-GO Enable				050777	24377400
	10	26	3	002	CH Vib L/F			No Data	136002	57001000
	11	23	17	003	CH Vib Off				134003	56001400
	12	1	102	286	+E1	Surface	17.964°		105436	42617000
	13	6	186	32	Ret	108.303"	4.143°		164040	72020000
	14-35	--	---	---	---					
		TOTAL	961							

TABLE 4.8.2.7-7

BIOLOGY/GCMS SAMPLE ACQUISITION (VL-1 PPM 2.1)

[illegible]

TABLE 4.8.2.7-8 POSITION COLLECTOR HEAD OVER GCMS-PDA (VL-1 PPM2.1)

[illegible]

TABLE 4.8.2.7- 10 DELIVER SAMPLE FROM PDA TO GCMS INSTRUMENT (VL -1 PPM 2.1)

[illegible]

TABLE 4.8.2.7-11 DUMP GCMS PDA OF EXCESS SAMPLE (VL -1 PPM 2.1)

TBL	ENT	CMD	ΔT , SEC.	DEC. POS.	CMD DESCRIPTION	POSITION		COMMENT	16-BIT OCTAL	24-BIT OCTAL
						START	STOP			
6	1	11	15	027	BIO DIST CW	DELIVER	DUMP	DUMP WIND BLOWN SAMPLE	025033	12415400
	2	21	67	028	PROC VIB ON				055034	26416000
	3	22	20	029	PROC VIB OFF				054035	26016400
	4	12	15	030	BIOL DIST CCW	DUMP	DELIVER		024036	12017000
	5	12	22	031	BIOL DIST CCW	DELIVER	METER		024037	12017400
	6	4	180	407	AZ CCW	186.598°	15.523°	BIOL PDA AZ	144627	62313400
	7	5	25	56	EXT.	4.143"	10.456"	BIOL PDA EXT	165070	72434000
	8	8	11	033	CH CCW	B/H DOWN	45°		064041	32020400
	9	8	16	034	CH CCW	45°	B/H UP		064042	32021000
	10	2	28	264	- EL	17.964°	4.076°	BIOL PDA ELEV	104410	42204000
	11	21	7	035	PROC VIB ON				055043	26421400
	12	25	45	036	CH VIB H/F			DELIVER SAMPLE TO BIOL PDA	135044	56422000
	13	23	30	037	CH VIB OFF				134045	56022400
	14	22	20	038	PROC VIB OFF			LEVEL FULL CK	054046	26023000
	15	23	138	039	CH CLOSE			FALSE CMD FOR LEVEL SENSOR DATA	134047	56023400
	16-18	---	---	---				& 28° CAM SURVEY		
		TOTAL	639							

TABLE 4.8.2.7- 12 POSITION C H OVER BIOLOGY PDA & DELIVER SAMPLE (VL - 1 PPM 2.1)

[illegible]

TABLE 4.8.2.7- 14 DUMP BIOLOGY PDA OF EXCESS SAMPLE (VL - 1 PPM 2.1)

TBL	ENT	CMD	Δ T, SEC	DEC. POS.	CMD DESCRIPTION	POSITION		COMMENT	16-BIT OCTAL	24-BIT OCTAL
						START	STOP			
9	1	3	183	131	AZ CW	VARIES	189.755°	FROM GCMS, BIOL AND XRFS	145203	62501400
	2	2	76	198	- EL	VARIES	- 37.589°	FROM GCMS, BIOL AND XRFS	104306	42143000
	3	5	89	157	EXT	VARIES	37.022°	FROM GCMS, BIOL AND XRFS	165235	72516400
	4	8	11	051	CH CCW	B/H DWN	45°		064063	32031400
	5	26	30	052	CH VIB L/F			PURGE CH OF EXCESS SAMPLE	136064	57032000
	6	23	17	053	CH VIB OFF				134065	56032400
	7	7	11	054	CH CW	45°	B/H DWN		065066	32433000
	SUB-TOTAL		417							
	8	6	59	24	RET	VARIES	2.039"		164030	72014000
	9	1	85	266	+ EL	VARIES	5.338°		105412	42605000
	10	4	250	425	AZ CCW	VARIES	4.160°	MAG MIRROR AZ	144651	62324400
	11	5	15	32	EXT	2.039	4.143"	TO SET BOOM DUST SEAL	165040	72420000
	12	2	37	234	- EL	5.338"	-14.863°		104352	42165000
	13	23	17	055	CH CLOSE			FALSE COMMAND FOR SAFETY	134067	56033400
	14-15	--	--	--						
	SUB-TOTAL		463							
	TOTAL		880							

TABLE 4.8.2.7- 15 CH PURGE OF EXCESS SAMPLE & BOOM PARK (VL -1 PPM 2.1)

TBL	ENT	CMD	ΔT , SEC	DEC. POS.	CMD DESCRIPTION	POSITION		COMMENT	16-BIT OCTAL	24-BIT OCTAL
						START	STOP			
10	1	1	45	266	+ EL	-14.863°	5.338°	FROM PARK	105412	42605000
	2	3	190	138	AZ CW	3.529°	185.336°	FROM PARK	145212	62505000
	3	5	246	405	EXT.	4.143"	102.253"	FROM PARK	165625	72712400
	4	2	70	194	-EL	5.338°	- 40.114°	SURFACE CONTACT	104302	42141000
	5	24	17	056	CH OPEN				137070	57434000
	6	29	5	511	NO-GO INHIBIT				051777	24777400
	7	5	25	428	EXT	102.253"	108.303"	ACQUIRE SAMPLE	165654	72726000
	8	23	17	511	CH CLOSE				134777	56377400
	9	30	5	511	NO-GO ENABLE				050777	24377400
	10	26	3	057	CH VIB L/F				136071	57034400
	11	23	17	058	CH VIB OFF				134072	56035000
	12	1	78	266	+ EL	SURFACE	5.338°		105412	42605000
	13	23	100	059	CH CLOSE			FALSE COMMAND 7.5° HR OF MAGNETS	134073	56035400
	14	6	189	24	RET	108.303"	2.039"		164030	72014000
	15	4	178	424	AZ CCW	185.336°	4.792°	XRFS AZ	144650	62324000
	16	5	33	60	EXT	2.039"	11.508"	XRFS EXT	165074	72436000
	17	8	11	060	CH CCW	B/H DWN	45°		064074	32036000
	18	8	16	061	CH CCW	45°	B/H UP		064075	32036400
	19	2	27	244	- EL	5.338°	-8.550°	XRFS ELEV	104364	42172000
	20	25	60	062	CH VIB H/F			DELIVER XRFS SAMPLE	135076	56437000

TABLE 4.8.2.7-16 XRFS SAMPLE ACQUISITION & DELIVERY (VL -1 PPM2.1)

[illegible]

TBL	ENT	CMD	ΔT , SEC	DEC. POS.	CMD DESCRIPTION	POSITION		COMMENT	16-BIT OCTAL	24-BIT OCTAL
						START	STOP			
11	1	5	14	25	EXT	0.724"	2.302"	FROM POST	165031	72414400
	2	1	72	289	+ EL	-19.282°	19.857°		105441	42620400
	3	3	248	27	AZ CW	4.792°	255.407°		145033	62415400
	4	2	82	194	- EL	19.857°	-40.114°		104302	42141000
	5	8	15	067	CH CCW	B/H DWN	45°		064103	32041400
	6	5	39	68	EXT	2.302"	13.612"	CHSU EJECT	165104	72442000
	7	6	27	32	RET	13.612"	4.143"		164040	72020000
	8	23	265	068	CH CLOSE			FALSE CMD 35° HR OF BOOM	134104	56042000
	9	7	11	069	CH CW	45°	B/H DWN		065105	32442400
	SUB TOTAL		173							
	10	1	32	251	+EL	-14.863°	-4.131°	FROM PARK ELEV	105373	42575400
	11	8	11	070	CH CCW	B/H DWN	45°		064106	32043000
	12	8	16	071	CH CCW	45°	B/H UP		064107	32043400
	13	5	146	098	EXT	4.143"	21.503"	7.5° HR OF B/H IN MAG MIRROR	165142	72461000
	14	6	44	24	RET	21.503"	2.039"		164030	72014000
	15*	3	76	307	AZ CW	4.160°	78.651°	BRUSH AZ	145463	62631400
	16*	5	39	83	EXT	2.039"	17.557"	BRUSH EXT	165123	72451400
	17*	7	16	072	CH CW	B/H UP	45°		065110	32444000
	18*	7	11	073	CH CW	45°	B/H DWN		065111	32444400
	19*	2	25	233	-EL	-4.131°	-15.494°	BRUSH EL	104351	42164400

TABLE 4.8.2.7-17 CHSU SHROUD EJECT & PHYSICAL/MAGNETIC PROPERTIES (VL- 1 PPM 2.1)

TBL	ENT	CMD	Δ T, SEC	DEC. POS.	CMD DESCRIPTION	POSITION		COMMENT	16-BIT OCTAL	24-BIT OCTAL
						START	STOP			
11	20 *	8	16	074	CH CCW	B/H DWN	45°	MAG CLEANING	064112	32045000
	21 *	8	28	075	CH CCW	45°	B/H UP	MAG CLEANING	064113	32045400
	22 *	3	12	300	AZ CW	78.019°	83.070°	AZ SAFING CMD	145454	62626000
	23 *	6	36	24	RET	17.557"	2.039"		164030	72014000
	24 *	1	30	251	+EL	-15.494°	-4.131°	MIRROR ELEV	105373	42575400
	25 *	4	82	425	AZ CCW	83.070°	4.160°	MIRROR AZ	144651	62324400
	26 *	5	155	98	EXT	2.039"	21.503"	7.5° HR AFTER MAG CLEANING	165142	72461000
	27 *	6	44	24	RET	21.503"	2.039"		164030	72014000
	28	3	251	27	AZ CW	4.160°	255.407°		145033	62415400
	29	2	276	194	-EL	-4.131°	-40.114°	35° HR OF BOOM MIRROR	104302	42141000
	30	4	66	134	AZ CCW	255.407°	187.861°		144206	62103000
	31	1	81	266	+ EL	-40.114°	5.338°		105412	42605000
	32	5	352	405	EXT	2.039"	102.253"	7.5° HR DIRECT VIEW OF B/H	165625	72712400
	33	7	16	076	CH CW	B/H UP	45°		065114	32446000
	34	7	11	077	CH CW	45°	B/H DOWN		065115	32446400
	35	2	62	194	-EL	5.338°	-40.114°	SURFACE CONTACT	104302	42141000
	36	29	5	511	NO-GO INHIBIT				051777	24777400
	37	6	20	382	RET	102.253"	96.203	TRENCH	164576	72277000
	38	23	17	511	CH CLOSE			FALSE CMD	134777	56377400
	39	30	5	511	NO-GO ENABLE				050777	24377400

TABLE 4.8.2.7-17

CHSU SHROUD EJECT & PHYSICAL/MAGNETIC PROPERTIES (VL -1- PPM2.1)

(CONTINUED)

TBL	ENT	CMD	ΔT , SEC	DEC. POS.	CMD DESCRIPTION	POSITION		COMMENT	16-BIT OCTAL	24-BIT OCTAL
						START	STOP			
11	40	1	81	266	+EL	SURFACE	5.338 [°]		105412	42605000
	41	5	39	428	EXT	96.203"	108.303"		165654	72726000
	42	2	62	194	-EL	5.338 [°]	-40.114 [°]	SURFACE CONTACT	104302	42141000
	43	24	17	078	CH LID OPEN				137116	57447000
	44	29	5	511	NO GO INHIBIT				051777	24777400
	45	5	29	451	EXT	108.303"	114.353"	ACQUIRE SAMPLE	165703	72741400
	46	23	612	511	CH LID CLOSE			TEMP DATA	134777	56377400
	47	30	5	511	NO-GO ENABLE				050777	24377400
	48	23	17	079	CH LID CLOSE			TEMP DATA	134117	56047400
	49	1	81	266	+EL	SURFACE	5.338 [°]		105412	42605000
	50	6	130	405	RET	114.353"	102.253"	7.5 [°] HR OF B/H	164625	72312400
	51	6	179	24	RET	102.253"	2.039"		164030	72014000
	52	4	184	425	AZ CCW	187.861 [°]	4.160 [°]	MIRROR AZ	144651	62324400
	53	5	51	87	EXT	2.039"	18.609"		165127	72453400
	54	2	108	258	-EL	5.338 [°]	0.288 [°]	7.5 [°] HR OF FRONT PORCH OF CH	104402	42201000
	55	2	16	251	-EL	0.288 [°]	-4.131 [°]		104373	42175400
	56	5	17	098	EXT	18.609"	21.503"		165142	72461000
	57	8	11	080	CH CCW	B/H DWN	45 [°]		064120	32050000
	58	8	170	081	CH CCW	45 [°]	B/H UP	7.5 [°] HR & COLOR OF B/H	064121	32050400
	59	25	45	082	CH VIB H/F			SIEVE PILE ON TOP OF VL	135122	56451000

TABLE 4.8.2.7-17 CHSU SHROUD EJECT & PHYSICAL/MAGNETIC PROPERTIES (VL-1 PPM 2.1)

(CONTINUED)

TBL	ENT	CMD	ΔT , SEC	DEC. POS.	CMD DESCRIPTION	POSITION		COMMENT	16-BIT OCTAL	24-BIT OCTAL
						START	STOP			
11	60	23	170	083	CH VIB OFF			7.5° HR & COLOR OF B/H	134123	56051400
	61	1	25	266	+EL	-4.131°	5.338°		105412	42605000
	62	7	16	084	CH CW	B/H UP	45°		065124	32452000
	63	7	11	085	CH CW	45°	B/H DWN		065125	32452400
	64	6	42	24	RET	21.503"	2.039"		164030	72014000
	65	--	--	--						
	SUB	TOTAL	4104							
		TOTAL	4857							
	* Cmds.	15-27	to be replaced with CH Close Dummy Command							

TABLE 4.8.2.7- 17 CHSU SHROUD EJECT & PHYSICAL/MAGNETIC PROPERTIES (VI -1 PPM 2.1)
(CONTINUED)

[illegible]

TABLE 4.8.2.7-18 BOOM SAFING COMMANDS (VL-1 PPM 2.1)

TABLE 4.8.2.7-19 GCMS PDA CONDITIONING (VL -1 PPM 2.1)

[illegible]

TABLE 4.8.2.7-20 BIOLOGY PDA CONDITIONING (VL - 1 PPM 2.1)

TABLE 4.8.2.7-21 COMMAND DIFFERENCES FOR VLC_2 (VL-1 PPM 2.1 BASE)

4.8.2.7.8 INTERFACES

The functional interfaces between the SSCA, and Biology PDA, GCMS PDA, Boom Unit, PCDA, LPCA, GCSC, and DAPU have been previously described. Command, data, and timing functions are summarized in Figure 4.8.2.7-9. Hardline interfaces are employed between the SSCA, and the Biology PDA, GCMS PDA, Boom Unit and PCDA. Redundant hardline interfaces also exist between the PCDA and GCMS PDA Tension link release band initiator, and the LPCA and Biology PDA pyroactuated pin puller. Standard Harris driver/receiver isolation interfaces are employed between the SSCA, and GCSC and DAPU as illustrated in Figures 4.8.2.7-15 and 16. The signal and current levels of these interfaces are as follows:

INPUT		
<u>DRIVER INPUT</u>	<u>DRIVER OUTPUT/RECEIVER</u>	<u>RECEIVER OUTPUT</u>
Disabled or	I sub A approx. ZERO	$\leq 0.45V$
Driver Power Off	I sub B approx. ZERO	(logic low)
$\phi 1$ Open	I sub A approx. ZERO	$\leq 0.45V$
$\phi 2$ 0.4V	1.9 ma \leq I sub B	(logic low)
	≤ 6.0 ma	
$\phi 1$ 0.4V	1.9 ma \leq I sub A	$\geq 2.5V$
	≤ 6.0 ma	
$\phi 2$ Open	I sub B approx. ZERO	(logic high)

As previously described, a redundant power interface exists between the PCDA and SSCA, and various critical circuits are redundant within the SSCA. The PCDA to SSCA interface is illustrated in Figure 4.8.2.7-17.

Details of all electrical interfaces are illustrated in the SSA functional schematics.

4.8.2.7.9 POWER REQUIREMENTS

The SSCA power requirements vary considerably and are directly dependent upon the sequence being run. The SSCA electronics requires a quiescent operating current of approximately 350-400 ma with no motors or solenoids operating. As the various motors or solenoids are commanded to operate, a corresponding increase in current will occur for the duration that the device is being operated. Studies are currently in progress to characterize the current requirements over a wide range of temperatures and VL bus voltages. Typical values of current requirement at a 32.0 Vdc bus at room temperature are as follows:

SSCA (Quiescent)	350-400ma
PDA Shuttles and Collector Head Motors (Including SSCA)	450-500ma
GCMS Commnuter Motor (Including SSCA and Level Detector)	1,650-7,200ma
Biology Processor Vibrator	

(Including SSCA)	750-1,110ma
Collector Head Jaw Open	
(Including SSCA)	2150-2,200ma
Collector Head Jaw Vibrator 4.4 Hz	
(Including SSCA)	1100-1,400ma
Collector Head Jaw Vibrator 8.8 Hz	
(Including SSCA)	450-600ma
Biology Level Detector	
(Including SSCA)	500-600ma
Boom Azimuth (Including SSCA)	500-600ma
Boom Elevation (Including SSCA)	550-1000ma
Boom Extend/Retract (Including SSCA)	550-1100ma

An average power operating level of 35.4 watts is anticipated for the Preprogrammed Mission Surface Sampler Sequences.

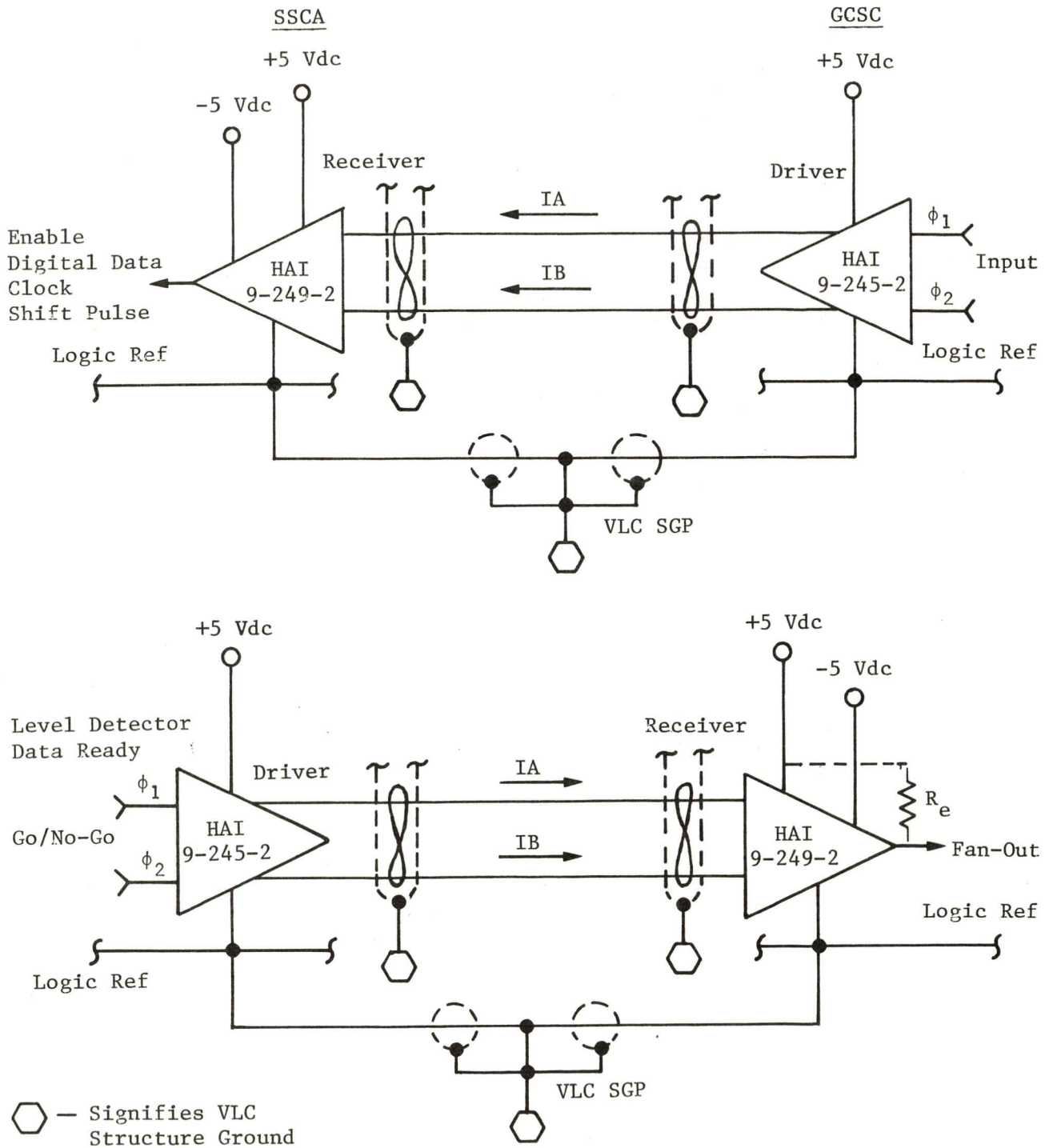


Figure 4.8.2.7-15 GCSC-to-SSCA Electrical Interface

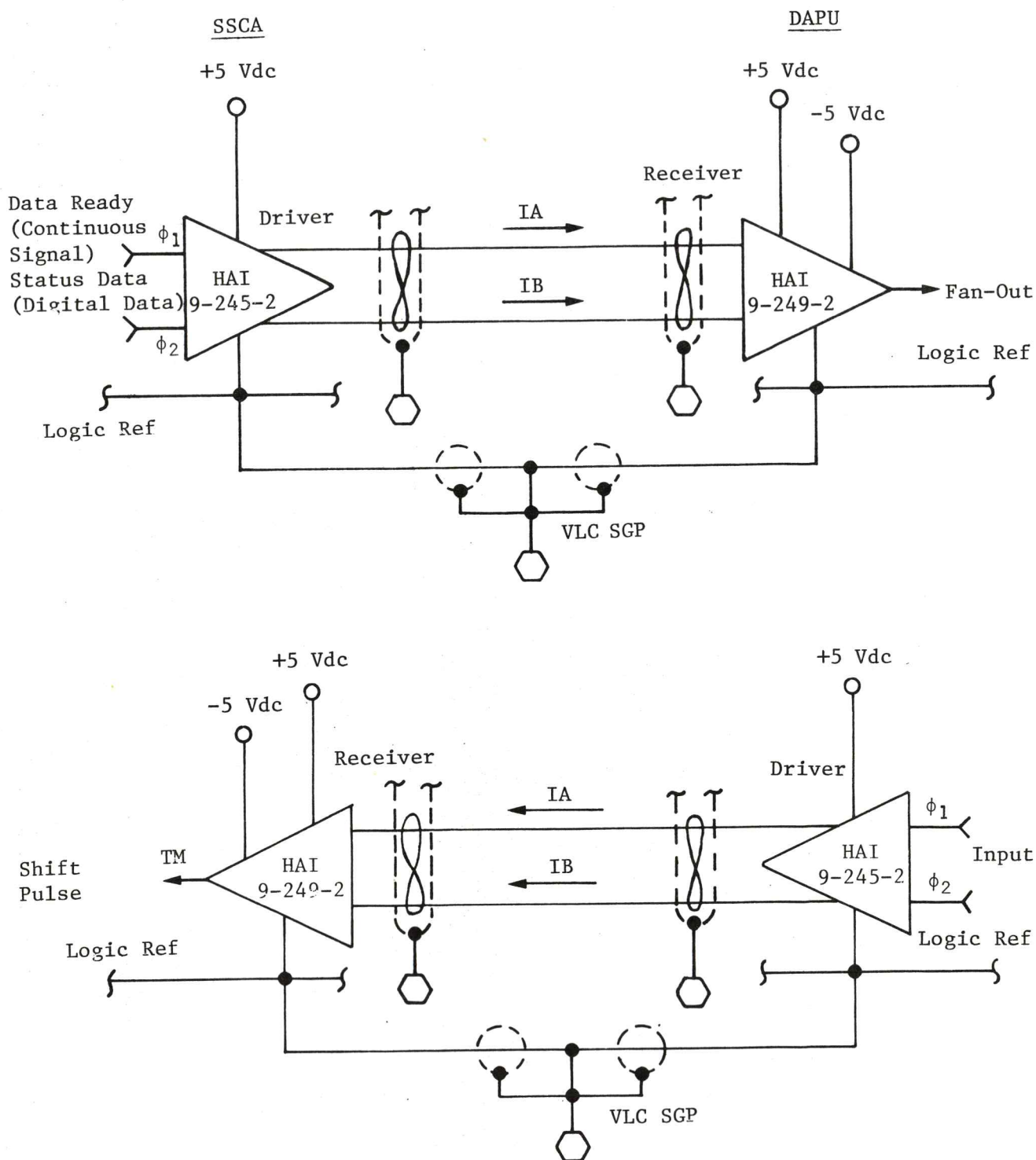


Figure 4.8.2.7-16 DAPU-to-SSCA Electrical Interface

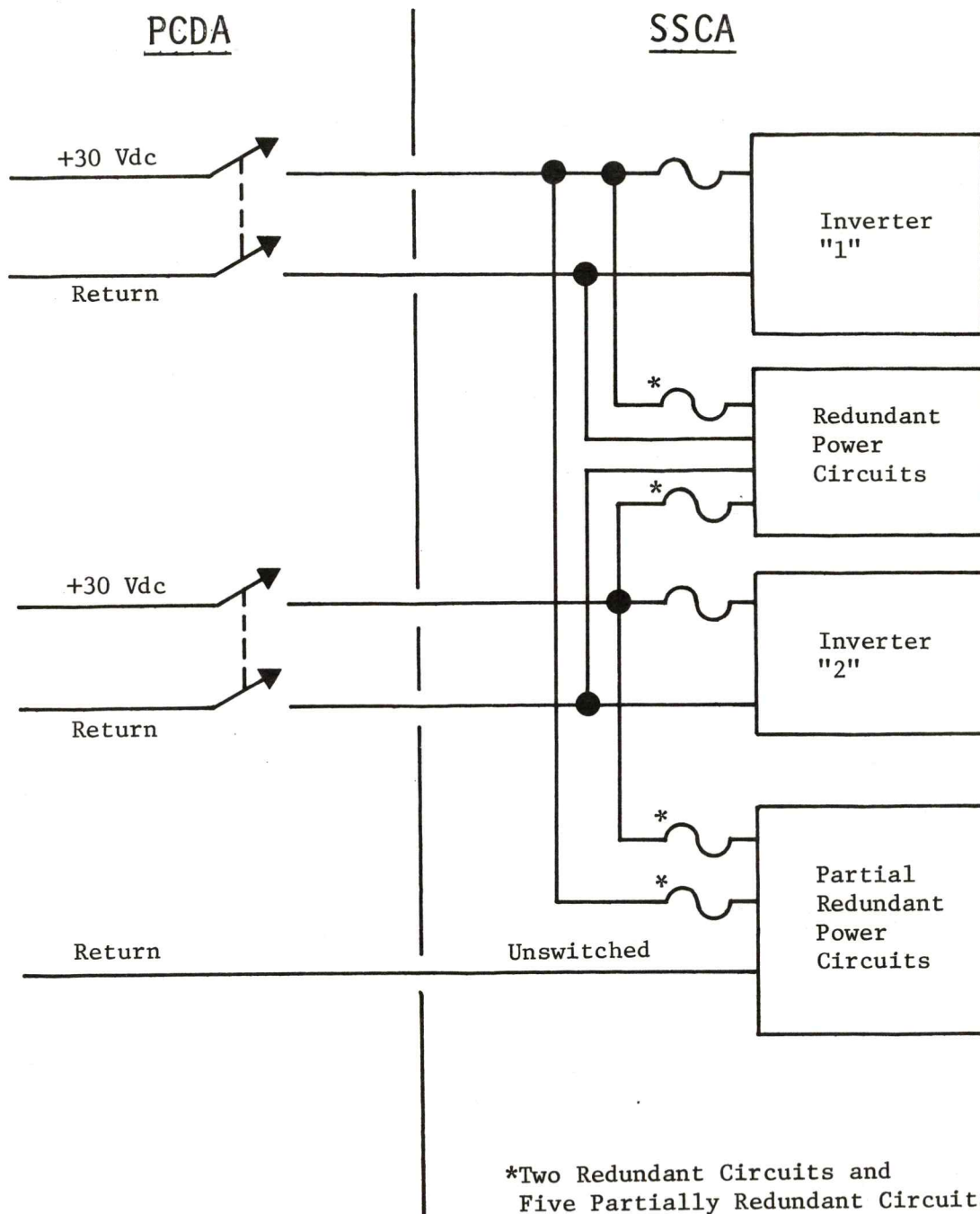


Figure 4.2.8.7-17 PCDA/SSCA Electrical Interface

4.8.2.7.10 GENERAL OPERATIONAL DATA AND CONSTRAINTS**a. Command Generation**

The SSA Preprogrammed Mission logic flow and data base command tables were described in the previous section. Update sequences for the SSA can be accomplished by developing appropriate changes to the data base tables, utilizing the spare command space as available, and revising the Mission Event Word Parameters such that the appropriate logic flow is executed. Changes such as variation of sampling sites, updating of the physical/magnetic properties sequences utilizing the spare commands which become available after shroud eject, and changes to correct emergency situations can be developed. Current mission rules require that the following sequence of events be followed prior to execution of SSA mission commands:

- 1) Develop the desired sequences by proper study;
- 2) Program the sequence and verify proper hardware operation using the Science Test Lander and HP-9830 Desk Computer for command and data control;
- 3) Uplink the desired sequence to the VL GCSC;
- 4) Downlink the desired sequence to verify proper storage in the VL GCSC;
- 5) Execute the mission sequence.

The Surface Sampler sequences are generally tabulated on Science Instrument Parameters (SIPs) forms. The special command table form used for Surface Sampler is illustrated in Table 4.8.2.7-22. The commands are coded in both 16-bit and 24-bit octal (rather than binary) which are standard inputs for the VL ground software programs. Other information provided includes command entry number, command number, delay times, decimal position, and other descriptive engineering units information. Auxiliary tabulations have been developed for use in octal coding of Boom positioning commands from engineering units requirements. Program XFORM has been developed for interchangeably converting the Viking Camera Coordinate system into Surface Sampler coordinates in order to provide accurate sampling commands based upon imagery study. The form illustrated in table 4.8.2.7-23 contains Mission Schedule Event Table (MSET) initiation commands and logic gate settings as indicated.

Additional specific information required for generation of Surface Sampler commands is provided in the following paragraphs.

b. Surface Sampler Rates and Command Delay

When generating SSCA commands, sufficient delay time must be specified before issuing the next command, for the following reasons:

- 1) Sufficient time must be allowed to ensure completion of the command operation to avoid generating a system No-Go on non-latching (position analog or switch feedback) commands;
- 2) Sufficient time must be allowed to ensure that all data attendant to the command is received, compiled in the data registers, and a "Data Ready" flag generated.

Surface Sampler Boom rates test data have been reviewed at varying voltages over the temperature range of -170°F to +120°F. The rates vary significantly with voltage and slightly with temperature. The minimum rates, extrapolated to a VL bus voltage of 21.5 Vdc, should be used for all Preprogrammed and Primary Mission Design calculations, as follows:

<u>Axis</u>	<u>Rate</u>
Azimuth CW	1.02°/sec
Azimuth CCW	1.03°/sec
Elevate Up	0.57°/sec
Elevate Down	0.75°/sec
Extend	0.413 In/sec
Retract	0.592 In/sec

In a similar manner, the minimum translation rates for the switch-to-switch positioning of the PDA distributors and Collector Head rotation have been determined.

The time required to compile data is also somewhat dependent upon the nature of the command. Worst case data compilation time, added to worst-case command execution time, must be allowed as the command delay before executing the following command. This information, along with a tabulation of anticipated 120-bit transmitted data from each command, is compiled in Table 4.8.2.7-24.

c. Boom Operating Limits

There exists numerous commands, and combinations of commands, which, if executed, could cause damage to the boom, or other VL components. The SSCA and GCSC command logic does not possess the capability for rejecting commands which could result in damage. Figure 4.8.2.7-18 illustrates the general safe operating range of the Surface Sampler Boom, limit switch and hardstop settings, and other related information. This illustration should be used only as a guide, however, and final verification of command safety should be accomplished on the Science Test Lander.

d. NO-GO Inhibit Sequences

The No-Go Inhibit Sequence is utilized in conjunction with those non-latching (feedback required) commands which may not be capable of execution such as attempting to acquire a surface sample in hard material which would prevent the boom from attaining the commanded position. The series of commands which must be utilized for surface sampling after the Boom has been commanded to de-elevate to the Surface Contact switch actuation is as follows:

- 1) Command Collector Head Open- Prepares for sample acquisition;
- 2) Command No-Go Inhibit Set (Inhibit Enable)- Inhibits no-go circuit and prevents data ready signal to GCSC and DAPU;
- 3) Command Boom to Extend (or Retract) Position- Accomplishes the following:
 - a) Precludes generation of "command complete" signal even if boom attains desired position;
 - b) Temp data register will not be loaded without a);
 - c) Data ready will not be generated without b);
 - d) Command data register will be loaded with boom command;
 - e) Boom position data register will be loaded with actual achieved position;
 - f) Current data registers will load with E/R data.
- 4) Command Collector Head Close- Accomplishes the following:

- a) Latches up command, boom position, and current data registers;
 - b) Loads both temperature data registers with collector head sensor data.
- 5) Command No-Go Inhibit Reset (Inhibit Disable) - Accomplishes the following:
- a) Allows release of a Data Ready to GCSC and DAPU;
 - b) Re-instates No-Go capability.

Appropriate times between the commands must be allowed in accordance with Table 4.8.2.7-24. The No-Go Inhibit sequence may be used for other non-latching (feedback) commands to preclude generation of No-Go's. A similar sequence must be utilized:

- 1) Command No-Go Inhibit Set;
- 2) Position Command;
- 3) Collector Head Lid Close (or Similar Command);
- 4) Command No-Go Inhibit Reset.

Extreme caution must be exercised when generating command lists which use no-go inhibit sequences because of potential hardware damage.

e. Miscellaneous Operational Constraints

The following provides a generalized tabulation of miscellaneous sequence generation constraints:

- 1) The SSCA NO-GO BYPASS FLAG must be set non-zero to make the SSCA NO-GO test. A decision to bypass the no-go check should be approved by the Mission Director.
- 2) If a SSCA no-go occurs during any SSA sequence with item 1) set in the non-zero position, Flight Operations must reset the SSCA No-Go flag to a negative number prior to the next entry or the new program will immediately Exit.
- 3) Word "0" (command at which to begin output) in any command table must be ≥ 1 .
- 4) Word "1" (number of commands to issue) in any command table must be ≥ 1 .

- 5) The delay time following any SSCA command must be great enough to allow completion of the command (if another SSCA command is to be issued) or a SSCA No-Go will occur.
- 6) Values of Mission Event Word bits W, H, and I (GCMS Do-Loop, Biology Do-Loop, Collector Head Vibration repeats) must be ≥ 0 .
- 7) If the shroud eject bit (MEW-7) is set non-zero, only Tables 11 and 9 will be executed.
- 8) If the shroud eject bit (MEW-7) is set non-zero, and the XRFS bit (MEW-8) is set non-zero, only Tables 10 and 9 will be executed.
- 9) If the shroud eject and XRFS bits (MEW-7,8) are zero, GCMS and/or Biology delivery sequences may be executed.

The following provides a generalized tabulation of miscellaneous SSCA circuit responses:

- 1) No data will be transmitted on No-Go Inhibit Enable/Disable commands.
- 2) Boom Unit motors will not be automatically shut down if an overtravel switch is actuated during a No-Go Inhibit Enable command sequence while operating on SSCA Side 1. Shutdown will occur when operating on Side 2.
- 3) No-Go Inhibit Enable sequences disable position switch feedback motor shutdown when operating on SSCA Side 1, and shutdown can be controlled only by the delta time between commands. Motor torque limiters will "clutch" at hardstop positions. Position switch feedback motor shutdown will occur normally when operating on Side 2.
- 4) All position motor feedback operations (Pots or switches) will be terminated by the leading edge of the next GCSC issued command enable signal, and a No-Go generated if not operating in a No-Go Inhibit mode.
- 5) A No-Go generated by the SSCA will preclude execution of all subsequent motor commands, but not solenoid commands.
- 6) Solenoid Current Limit Enable commands will not provide data.

- 7) The GCMS sample level detector "sense" cycle is initiated by execution of the Communter ON command (Comminute or Sieve modes) and can be terminated only by a Comminute OFF command. Additional commands to "comminute" or "Sieve" do not affect the level detect sequence but can initiate the data acquisition sequence.
- 8) The Biology level detector "sense" cycle is initiated by the processor Vib On/Off commands for one (1) cycle only. Additional cycles can be attained by repeating processor Vib On/Off commands.
- 9) After the GCMS sample level detector latch is set "full" to the GCSC and DAPU, only a Communter OFF command or a power down/power up sequence will reset the latches.
- 10) After the Biology sample level detector latch is set "full" to the GCSC and DAPU, only a Biology processor Vib On command or a power down/power up sequence will reset the latches.
- 11) The communter motor is a latching command, and any other motor or solenoid can technically be operated simultaneously.
- 12) The Collector Head Surface Contact switch will shut down only the elevation drive motor and the No-Go circuit will not be activated.
- 13) Actuation of Collector Head rotation and PDA Distributor switches will cause shutdown of all motors except the communter.

4.8.2.7.11 SSA FUNCTIONAL FLOW DIAGRAMS

Figures 4.8.2.7-19 through 4.8.2.7-25 provides a "top-level" view of Surface Sampler Control circuitry and interfaces with other VL components. Detail design information is available in the Surface Sampler Team Analysis Data Files.

DEVELOPED BY: _____ DATE: _____

VERIFIED BY: _____ DATE: _____

APPROVED BY: _____ DATE: _____

[illegible]

PAGE _____ OF _____

TABLE 4.8.2.7-22 SCIENCE INSTRUMENT PARAMETERS (SIPS) FORM

TABLE 4.8.2.7-23 MISSION SCHEDULE EVENT TABLE (MSET) FORM



APPROVED BY: _____ DATE: _____

[illegible]

TBL	NCMD	PTR
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

[illegible]

* RESET ONLY IN EVENT OF NO-GO

- COMMAND GENERATION -			- RETURN DATA -												
COMMAND NUMBER	COMMAND DESCRIPTION	MINIMUM ALLOWABLE DELAY (SEC)	POSITION ACHIEVED FDBK	POSITION SWITCH FDBK	AMPS-1 (2 SEC MAX)	AMPS-2 (+4 SEC)	AMPS-2 (+15 SEC)	BIO PDA T-1 @ 2 SEC	CH T-2 @ 2 SEC	CH T-1 @ 12 SEC	COMMAND DESCRIP.	LEVEL SENSOR	NON-POS. SWITCH	OVERTRAVEL SWITCH	NO-GO
1	BOOM ELEVATE-UP	10 + TRAVEL	X		X	X		X	X		X			NOTE 4	X
2	BOOM ELEVATE-DWN	10 + TRAVEL	X		X	X		X	X		X		X	NOTE 4	X
3	BOOM AZIMUTH-CW	7 + TRAVEL	X		X			X	X		X		(SURCON)	NOTE 4	X
4	BOOM AZIMUTH-CCW	7 + TRAVEL	X		X			X	X		X			NOTE 4	X
5	BOOM EXTEND	10 + TRAVEL	X		X	X		X	X		X			NOTE 4	X
6	BOOM RETRACT	10 + TRAVEL	X		X	X		X	X		X			NOTE 4	X
7	CH ROTATE-CW (INVERTED TO 45°)	7 + 9 TRAVEL = 16		X	X			X	X		X				X
7A	CH ROTATE-CW (45° TO UPRIGHT)	7 + 4 TRAVEL = 11		X	X			X	X		X				X
8	CH ROTATE-CCW (UPRIGHT TO 45°)	7 + 4 TRAVEL = 11		X	X			X	X		X				X
8A	CH ROTATE-CCW (45° TO UPRIGHT)	7 + 9 TRAVEL = 16		X	X			X	X		X				X
9	GCMS DISTRIB-CW	7 + 9 TRAVEL = 16		X	X			X	X		X				X
10	GCMS DISTRIB-CCW	7 + 9 TRAVEL = 16		X	X			X	X		X				X
11	BIO DISTRIB-CW (METER TO DELIV)	7 + 15 TRAVEL =22		X	X			X	X		X				X
11A	BIO DISTRIB-CW (DELIV TO DUMP)	7 + 8 TRAVEL = 15		X	X			X	X		X				X
12	BIO DISTRIB-CCW (DUMP-TO-DELIV)	7 + 8 TRAVEL = 15		X	X			X	X		X				X
12A	BIO DISTRIB-CCW (DELIV-TO-METER)	7 + 15 TRAVEL =22		X	X			X	X		X				X
13	GCMS COMM MODE ON	20			X		X	X	X		X	X			
14	GCMS SIEVE MODE ON	20			X		X	X	X		X	X			
15	GCMS COMM MODE OFF	20			0		0	X	X		X				
16	GCMS SIEVE MODE OFF	20			0		0	X	X		X				
17	BIO DISTRI VIB ON	7			X	0		X	X		X				
18	BIO DISTRI VIB OFF	7			0			X	X		X				
19	GCMS DISTRI VIB ON	7			X			X	X		X				
20	GCMS DISTRI VIB OFF	7			0			X	X		X				
21	BIO PROCESSOR VIB ON	7			X			X	X		X				
22	BIO PROCESSOR VIB OFF	7			C			X	X		X	X			
23	CH LID CLOSE	17			0				X	X	X		X		
24	CH LID OPEN	17			X				X	X	X		X		
25	CH LID VIB-HF (8.8 HZ)	17			X				X	X	X		X		
26	CH LID VIB-LV (4.4 HZ)	17			X				X	X	X		X		
27	SOL CURRENT LIM DISABLE	10	NO DATA												
28	SOL CURRENT LIM ENABLE	10													
29	NO-GO INHIBIT ENABLE	5													
30	NO-GO INHIBIT DISABLE	5													

- NOTES:
- 1) MINIMUM DELAY TIME INCLUDES 2 SECOND DAPU WARMUP FOR ALL COMMANDS
 - 2) "TRAVEL" IS THE TIME TO COMPLETE THE OPERATION
 - 3) "X" IN COLUMN INDICATES REAL DATA EXPECTED; "BLANK" INDICATES ALL ZEROES EXPECTED; "0" INDICATES 0-VALUE
 - 4) SWITCH ACTUATION AND "NO-GO" IF BOOM OVERTRAVEL SWITCH IS ACTUATED (DATA WILL BE ACQUIRED)
 - 5) IF POSITION IS NOT ACHIEVED (COMMAND COMPLETE) BEFORE NEXT COMMAND IS RECEIVED, A NO-GO WILL BE GENERATED. IF DATA NOT IN SSCA OUTPUT, CHECK GCSC DATA.
 - 6) THE 31 BIT PSEUDO RANDOM SYNC CODE AND 5-BIT I.D. MUST BE CORRECT FOR DATA TO BE VALID
 - 7) NO DATA WILL BE RECEIVED ON "SIDE 2"; VLC BUS CURRENT WILL PROVIDE VERIFICATION OF OPERATIONS

TABLE 4.8.2.7-24 - COMMANDS, TIMES, DATA GENERATION

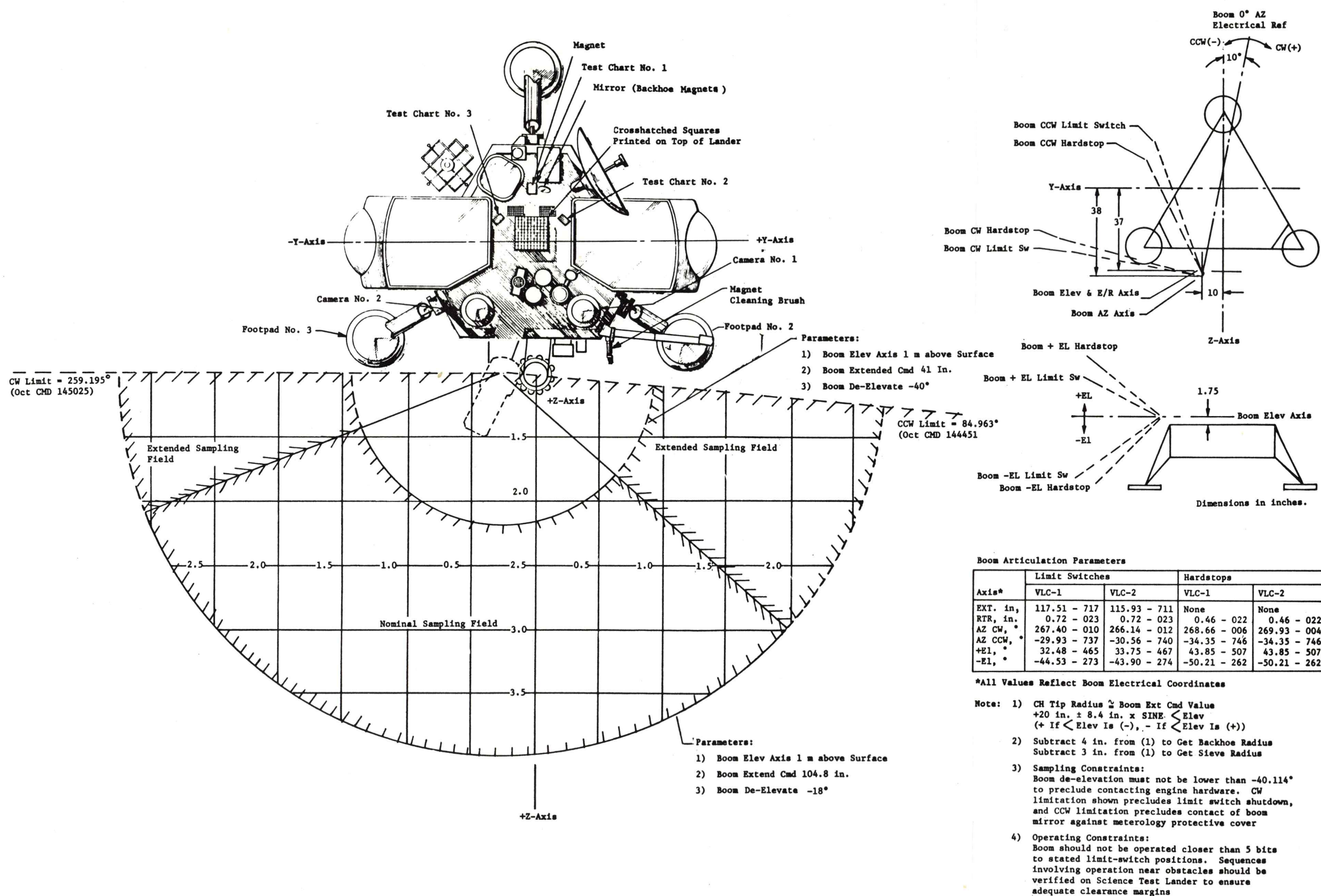
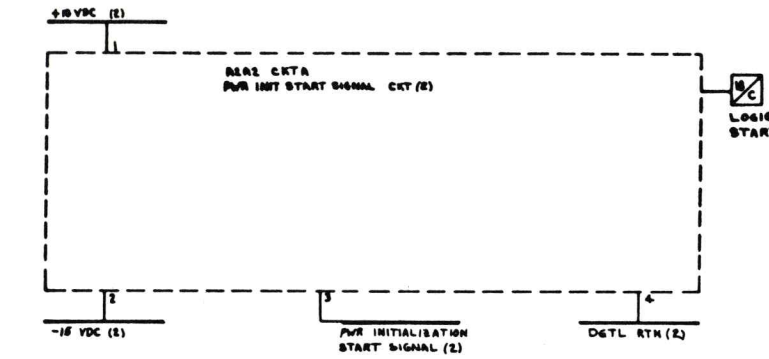


FIGURE 4.8.2.7-18 - BOOM OPERATING CONSTRAINTS



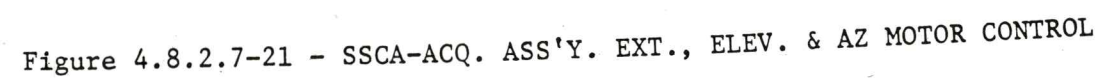


SURFACE SAMPLER CONTROL ASSY
PWR SUPPLY & DISTR

Fig.

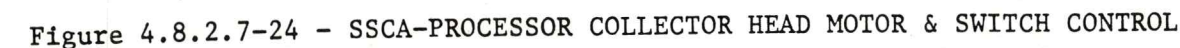
INDEX

Figure 4.8.2.7-20 - SSCA-POWER SUPPLIES AND DISTRIBUTION









4.8.2.8 X-Ray Fluorescence Spectrometer (XRFS)

4.8.2.8 X-RAY FLUORESCENCE SPECTROMETER (XRFS)

4.8.2.8.1 PURPOSE

The purpose of the XRFS in the Viking Lander is to chemically analyze the surface material of Mars. The data from the XRFS will be used by the Inorganic Chemical Team to determine the elements present on the Mars surface. From this determination, comparisons with compositions of geologic samples from the Earth, Moon, and meteorites will be made. The XRFS is capable of measuring the weight concentrations of elements from magnesium up through the heavier elements. In particular it is capable of determining the concentration of twelve elements at detection limits as low as 50 ppm and with accuracies ranging from 70 ppm for Zirconium to 3.0% for aluminum. The elements are Al, Ca, Fe, K, Mg "0", S, Si, Ti, Rb, Sr, Zr; the element "0" is defined as the sum of the elements of atomic number less than twelve.

4.8.2.8.2 FUNCTION DESCRIPTION

The XRFS functions by bombarding the surface material with two radioisotope sources, Fe-55 and Cd-109, and then measuring the energy of the resultant X-rays emitted from the sample material. The Fe-55 source excites the material with 5.9 keV X-rays and a set of proportional counters detects the X-rays, emitted from the lighter elements of Mg through Ti. A second set of proportional counters detects the energy of the X-rays emitted from the sample bombarded by the 22.2 keV X-rays of the Cd-109 source. This set detects the heavier elements of K through U.

The XRFS functions by receiving a sample from the Viking Surface Sampler Acquisition Assembly (SSAA) (Section 4.8.2.7). The SSAA delivers at least 30cc of material by sieving the collected material through its 2000 micron sieve. The delivery is made by setting the SSAA into the wind spoiler of the XRFS Soil Delivery system and vibrating the jaw of the SSAA. The sample material then gravity-flows into the XRFS funnel, through the XRFS one inch diameter delivery tube, to the soil cavity within the electronics box.

4.8.2.8.2.1 INSTRUMENT DESCRIPTION

a. General

The XRFS instrument is made up of two parts. Figure 4.8.2.8-1 identifies these as the Soil Delivery System and the Electronics Box. The Soil Delivery System and the Electronics Box are bolted to either side of the VL equipment plate and the one inch diameter delivery tube is dust sealed to the electronics box measurement cavity by an "O" ring press type fitting.

The XRFS Soil Delivery System's wind spoiler is located on the VL as shown pictorially in Figure 4.8.2.8-2 and schematically in Figures 4.8.2.8-3 and 4.8.2.8-4. Figure 4.8.2.8-5 is a picture of the Proof Test Capsule (PTC) looking from Leg 1 forward with the Surface Sampler in the parked position.

b. Soil Delivery System

A schematic drawing of the Soil Delivery System (as it is mounted in the VL) is shown in Figure 4.8.2.8-6. The top edge of the spoiler is nominally 5.5 inches above the VL dust cover. The baffles are made of .002 inch CRES and have a black passivation (class 4) finish. They depress with the insertion of the SSAA and return to position when the SSAA is removed. The tube is nominally one inch inside diameter made of CRES-321 with its inside surface cleaned of high points (32 finish). The tube is at an angle of 15° from the normal to the equipment plate plane. The bonds between the parts of the Soil Delivery System are verified to provide a conductive electrical joint of less than 50 million (MHC STP 72601 type 2). The screen is made of .032 diameter CRES wire and the distance between centers of the wire is nominally 0.5 inches. The peak of the screen is nominally 0.36 inches above the funnel and the approximate slope to the peak is 15° to the plane of the top of the funnel. Figure 4.8.2.8-6 is a picture of the XRFS Soil Delivery System.

c. Electronic Assembly

The XRFS Electronic Assembly can be divided into three functional sections. Figure 4.8.2.8-7 indicates the location of these sections.

1) Measuring Section

The Measuring Section is schematically shown in a top view in Figure 4.8.2.8-8. The measuring cavity, located in this section, is made of bar Al (6061-T651) and the inside dimension is nominally 1.0 inch square. A top view of the measuring cavity can be seen in Figure 4.8.2.8-13. The height of the measuring cavity is 2.8 inches. (Total volume inside the measuring cavity is approximately 46 cc). The outer surface of the measuring cavity, facing the Fe-55 source, is coated with between .0001 to .0002 inches of nickel. Elevation cross-sections of Figures 4.8.2.8-9 and 4.8.2.8-10 show the source-window-plaque orientation and the detail parts for the Fe-55 and Cd-109 areas of the measuring section.

2) Electronics Section

The Electronics Section (Areas 2a, b & c on Figure 4.8.2.8-7)

The electronics section will be functionally described by following the XRFS functional flow diagram, Figure 4.8.2.8-11.

a) Signal Flow

The signal starts from the emission of an X-Ray (Figure 4.8.2.8-11 center) from either material or gas in the measuring cavity or the elements in the calibration plaques. The X-ray passes through the window of the proportional counter (top-center of Figure 4.8.2.8-11). The gain of the proportional counter is set by the high voltage selected (see calibration section). The signal is amplified and the output of each proportional counter goes into individual charge amplifiers; U-1, U-2, U-3, U-4, respectively, for PC-1, 2, 3 and 4. The FET switch (U-5) selects the charge amplifier output commanded and sends the signal to the amplifier/filter section. The signal is amplified, shaped and filtered and sent into the discriminator circuit. The charge amplifier, FET switch, filtering and shaping circuits are in the pre amplifier board A-7 and the A-8 board provides the output interface to the discriminator. A-7 is located in area 2b and the A-8 board is located in the dump cavity, area 3 of Figure 4.8.2.8-7.

b) Power Supplies

The power supplies are schematically shown in the left hand part of Figure 4.8.2.8-11. The 24 to 37 volts dc from the VL Power Conditioning and Distribution Assembly (PCDA) (thru a fuse and redundant relay contacts), goes through filter FL-3, located in the dump cavity section 3, and into board A-7. A-7 is the low voltage power supply which provides inrush current protection and provides regulated ± 5 and ± 15 volts to all the other electronic boards in the unit. The power drain in the unit is 2.6 watts. The low voltage power supply is identified in the picture of Figure 4.8.2.8-12.

The High Voltage Power Supply, A-3, is powered by +15V and $\pm 5V$ from the low voltage power supply. It supplies up to 1300V dc to the High Voltage Filter Board A-1. The high voltage at A-1 is fed back through a 100 Megohm resistor to the High Voltage Power Supply where a matched (temperature coefficient) 218K ohm resistor divides the voltage to compare to the command voltage setting input from the A-5 board. The A-3 and A-1 boards are covered with high voltage potting to prevent corona and arcing of the high voltage circuits in the 5 torr Mars atmosphere. Figure 4.8.2.8-12 shows the location of the High Voltage Supply and Figure 4.8.2.8-13 views the High Voltage Filter Board, A-1, showing the high voltage potting with the gold vapor-deposited coating over the potting.

c) Logic Processor

The Processor Circuit Board, A-6 is diagramed in the middle of Figure 4.8.2.8-11. It receives the commands from the Guidance Control and Sequencing Computer (GCSC) and then executes these commands by:

- (1) Sending a discrete signal to the pre-amplifier board A-2 selecting the Proportion Counter section to be used.
- (2) Sending a 7 bit word to the DAC Board, A-5, to select the high voltage setting to be used.
- (3) Sending a 7 bit word to the DAC Board, A-5, to select the window discriminator channel at which to start the counting.
- (4) Setting the count period.

The Processor Circuit sequences the IRFS to step, in-turn, from the selected discriminator channel through 128 channels. After counting for the commanded count period in channel 127 the unit will continue to cycle through channel 0 and sequence through the channels until a new command is received or power is removed from the unit.

The discriminator circuit is on the processor board A-6 (top right hand corner of Figure 4.8.2.8-11 and shown in Figure 4.8.2.8-13.

The discriminator accepts pulses of the commanded signal level during the commanded count period. The signal levels are sequential commanded by the processor. Each signal passed for the channel is counted by entering a digital "1" into a pseudo-random event counter (the pseudo-random event counter is described in Figure 4.8.2.8-19). At the end of the counting period the 16 bit pseudo random word is shifted into the proper memory position in the 16 bit by 16 bit memory. The event counter is then shifted again into the next position in the memory. After eight channels are put into memory the "data" ready flag (a "one") is sent to the GCSC.

The VL Data Acquisition and Processor Unit (DAPU) then sends shift pulses, at 16 K bits per second, into the XRPS shifting into the VL Data Storage Memory (DSM) 312 bits of data. The data consists of 256 bits from memory and 56 bits of overhead data. The contents of the 312 bit frame is explained in Figure 4.8.2.8-20.

3) Dump Section

The dump cavity, dump valve and dump solenoid can be seen in Figures 4.8.2.8-7 and 4.8.2.8-12. The dump valve operates by command and operates for 61 seconds. The dump action during this "On" time is a 4 cycle per second vibration. The dump cavity has a volume of greater than 600 cc total and a practical useful volume of at least 500 cc when the gravity vector is 25 degrees from the vertical.

4.8.2.8.3 OPERATING MODES

4.8.2.8.3.1 CALIBRATION

When the XRPS is commanded to perform an analysis, and there is no sample material in the cavity, the instrument is in the calibration mode. Calibration plaques are located on the measuring cavity walls opposite the Fe-55 window and the Cd-109 window. If no material obstructs the path of the X-ray, from these sources, from hitting the calibration plaque, then the proportional counter will receive the X-ray emitted from the plaque elements. "Insitu" calibration can be made on Mars by performing an analysis before surface material is dumped into the measuring cavity. A calibration sequence can be performed by either operating the dump valve or not operating the dump valve.

A second calibration mode exists which allows calibration of PC-1 and 2 with material in the cavity. The calibration flag (see Figure 4.8.2.8-8) can be commanded to cover the window of the Fe-55. PC 1 & 2 will then receive the X-rays from the aluminum, calcium and Fe-55 backscatter.

Adjustments to the instrument gain can be made by updating the high voltage for each PC tube. The high voltage is commandable in 5V steps from 715 to 1350 volts.

4.8.2.8.3.2 ANALYSIS

The analysis mode of operation can be run using parameter variations of system gain, count period in each channel, start channel and proportional counter to be used.

The system gain is set by using the choice of 127 steps of high voltage to the PC tubes. Count period can be 7.68, 30.72, 61.40, 122.9, 245.8, or 491.5 seconds. Proportion counter to be used is selectable and the channel to start the analysis is selectable for channel 0, 8, 16, etc to channel 120.

4.8.2.8.3.3 OPERATIONAL SEQUENCES

Figure 4.8.2.8-14 diagrams the experiment sequence and the following paragraphs explain the diagram.

- a. The GCSC commands the PCDA to supply power to the XRFS and the GCSC supplies 100 Hz to the XRFS. The XRFS goes to the reset state when the power is applied to the instrument.

- 1) Reset State

In the reset state the instrument is ready to receive a command and the unit safes itself by inhibiting the dump valve from operating and applying less than 1035 volts to the proportional counter.

- b. The GCSC then sends a command enable ("On" is a logic 1 signal) to the XRFS.

- 1) The XRFS is still in the reset state but the command receiver for the command shift pulse and digital command is powered up (U-62 in Figure 4.8.2.8-11). Within fifteen seconds after it sends the command enable signal the GCSC then sends the 16 Kbps shift pulses followed (0-5 microseconds) by the first digital command bit.

- c. The GCSC sets the command enable to "OFF" within 30 microseconds after the 24th command bit is sent. The

XRFS reacts to the command enable "OFF" by starting to sequence:

1) Dump State

If the command sent to the instrument was a "dump" command. The XRFS first operates the dump valve for 61 seconds and then sequences to the count state; if the command is not a "dump" command the XRFS goes immediately in the count state.

2) Count State

In the count state the instrument starts at the channel commanded and accumulates counts for the commanded count period.

3) Data Store State

At the end of the count period the unit goes into its data storage mode. In this mode it shifts the contents of the event counter into the memory, increments to the next higher discriminator window, and shifts the event counter a second time into the next memory position. It then sets itself ready to store data on the next memory position.

4) Eight Channel Count

If eight channels have not been counted since the last command was received/or since the last data ready was raised; then the instrument goes back to the count state. When eight channels have been counted the unit sequences to:

5) Data Ready

With eight channels of data in the XRFS memory the unit then sends a data ready signal to the GCSC and the DAPU. In the Data Ready State the unit sits and waits and does not accumulate any data and the data receivers and drivers are powered-up. The unit will sit this way until the DAPU responds to the data ready.

- d. The DAPU then sends 16 Kbps shift pulses to the XRFS and shifts to the DSH 312 bits of data. This consists of 256 bits from memory, 20 of updated command image, 31 bits of synchronism word and 5 bits of instrument ID.

1) Data Ready Off

With the last bit counted out of the XRFS memory, the unit cycles back to the count state.

2) Count State

The unit counts pulses in the next highest channel for the commanded count period.

e. GCSC delta t is timed out:

1) If the XRFS delta t has not timed out the GCSC does nothing and continues in the counting state.

2) If the delta t has timed out the GCSC then decides which command is to be executed next.

f. If the last command was command Number 11, then the GCSC powers off the XRFS.

If the last command was not command Number 11, then the sequence to send the next command in the table and goes to sequence B in Figure 4.8.2.8-14.

4.8.2.8.3.4 INTERFACES

a. Electrical interfaces between the XRFS and the VL are shown in Figures 4.8.2.8-15, -16 and -17.

b. Software Interface

The GCSC software control of the XRFS is shown in Figure 4.8.2.8-18.

c. Data Output

The XRFS 312 bits of data are identified in Figure 4.8.2.8-21. The data frame identifier, bits 41-44, which is the updated command word bits 9-12, is identified by Figure 4.8.2.8-22.

d. Command Words

Identification of the 24 bit command word transmitted from the GCSC to the XRFS is given in Section L of the Command List, 83703021228, which is reproduced in Figure 4.8.2.8-23. Contained in this figure is the identification of the inputs for the Science Instrument Parameter (SIP), (IDUNP, KTR, ICPER, IVOLT, MWG), to LSEQ/LCON software programs.

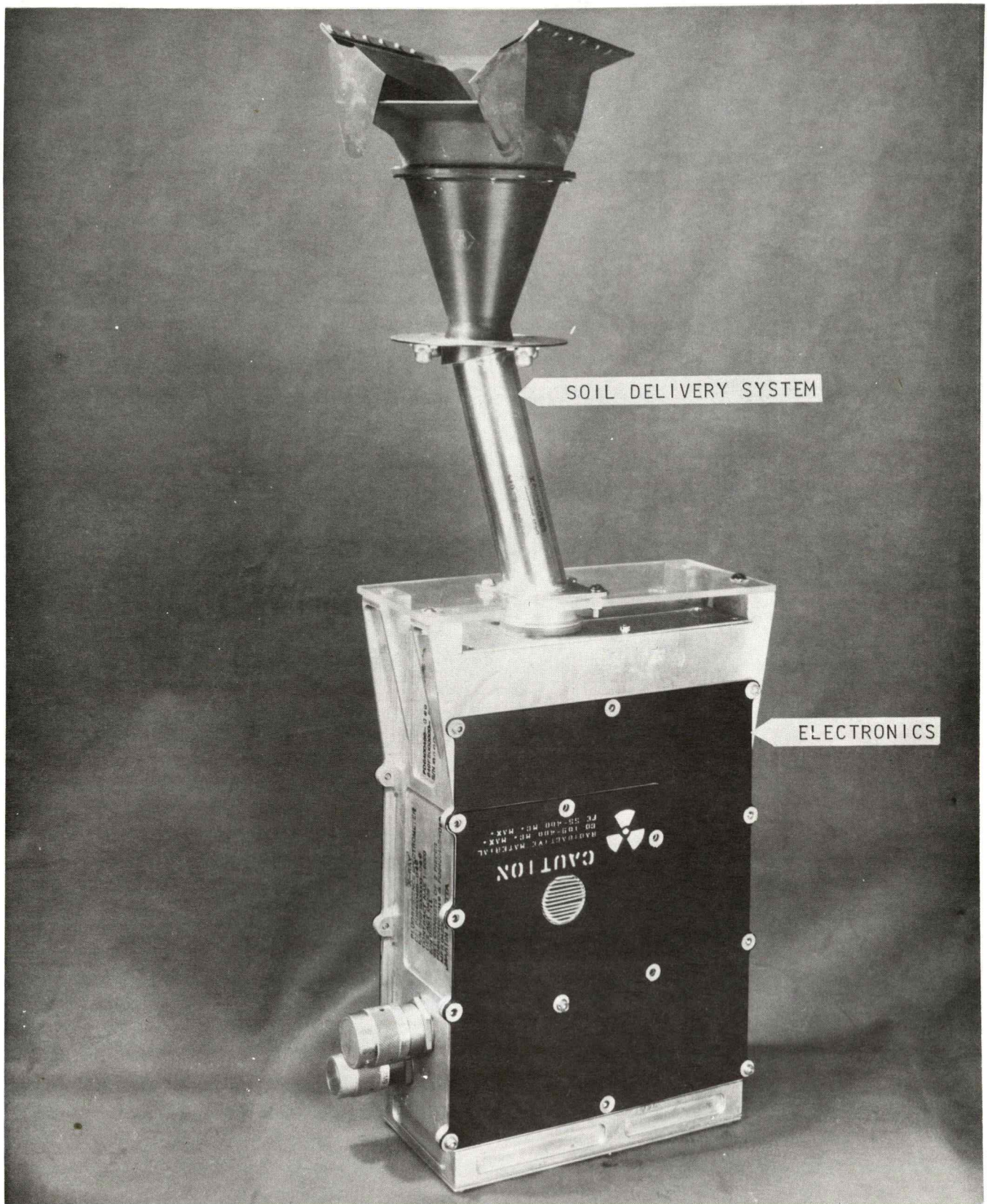


FIGURE 4.8.2.8-1 X-RAY FLUORESCENCE SPECTROMETER

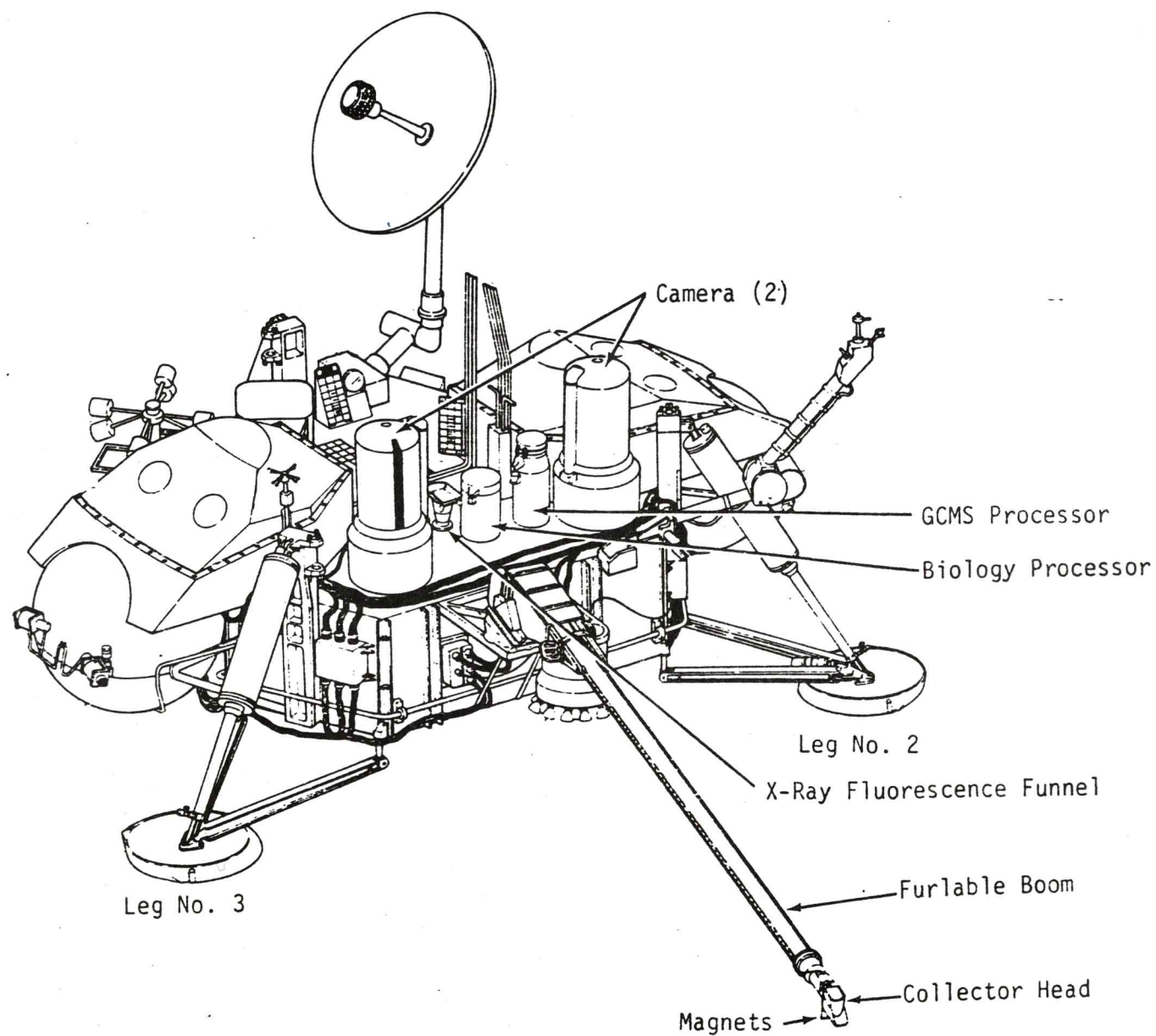


FIGURE 4.8.2.8-2 XRFS SOIL DELIVERY SYSTEM WIND SPOILER LOCATION
VIKING LANDED CONFIGURATION

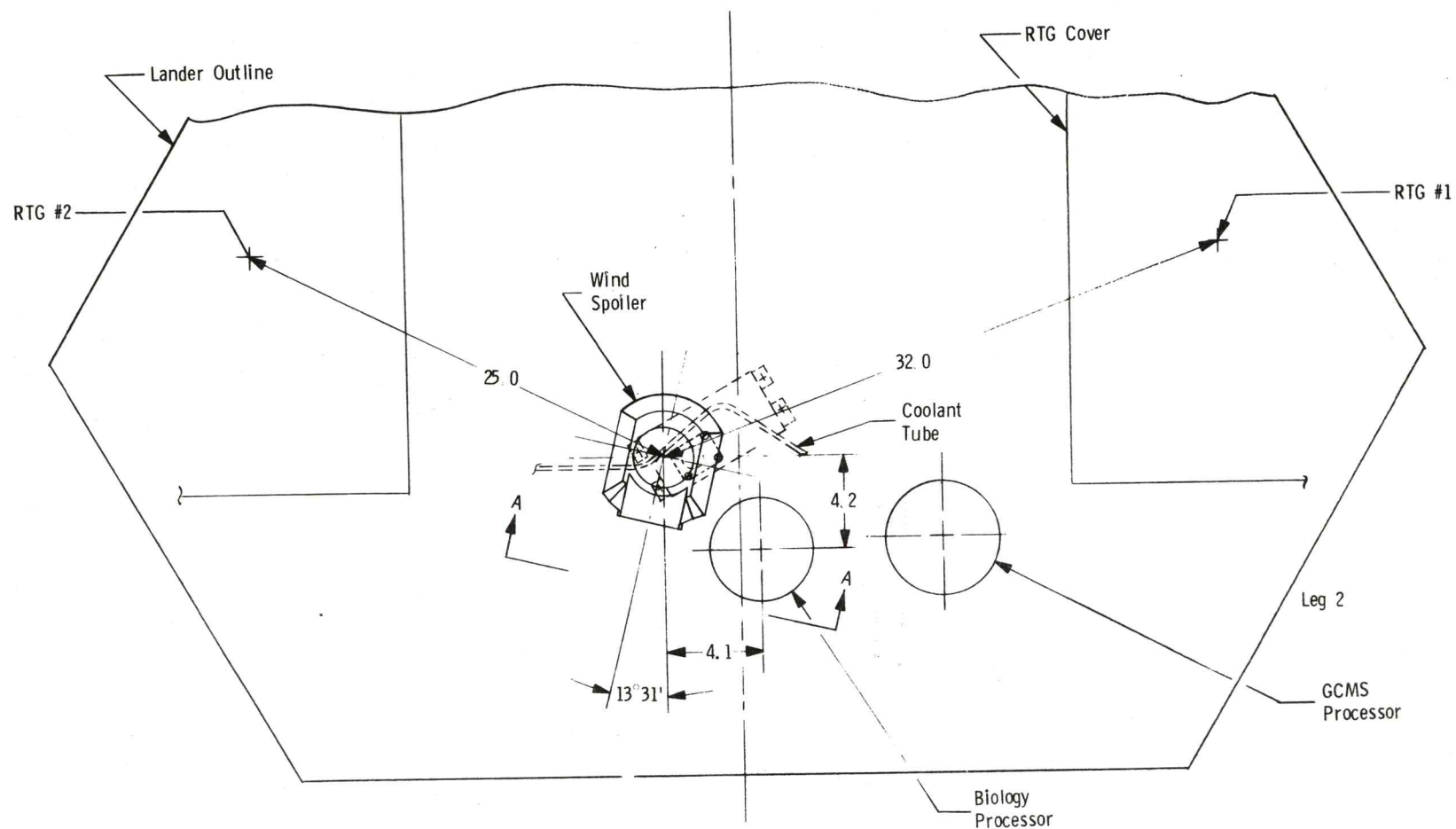


FIGURE 4.8.2.8-3
XRFS - FUNNEL LOCATION

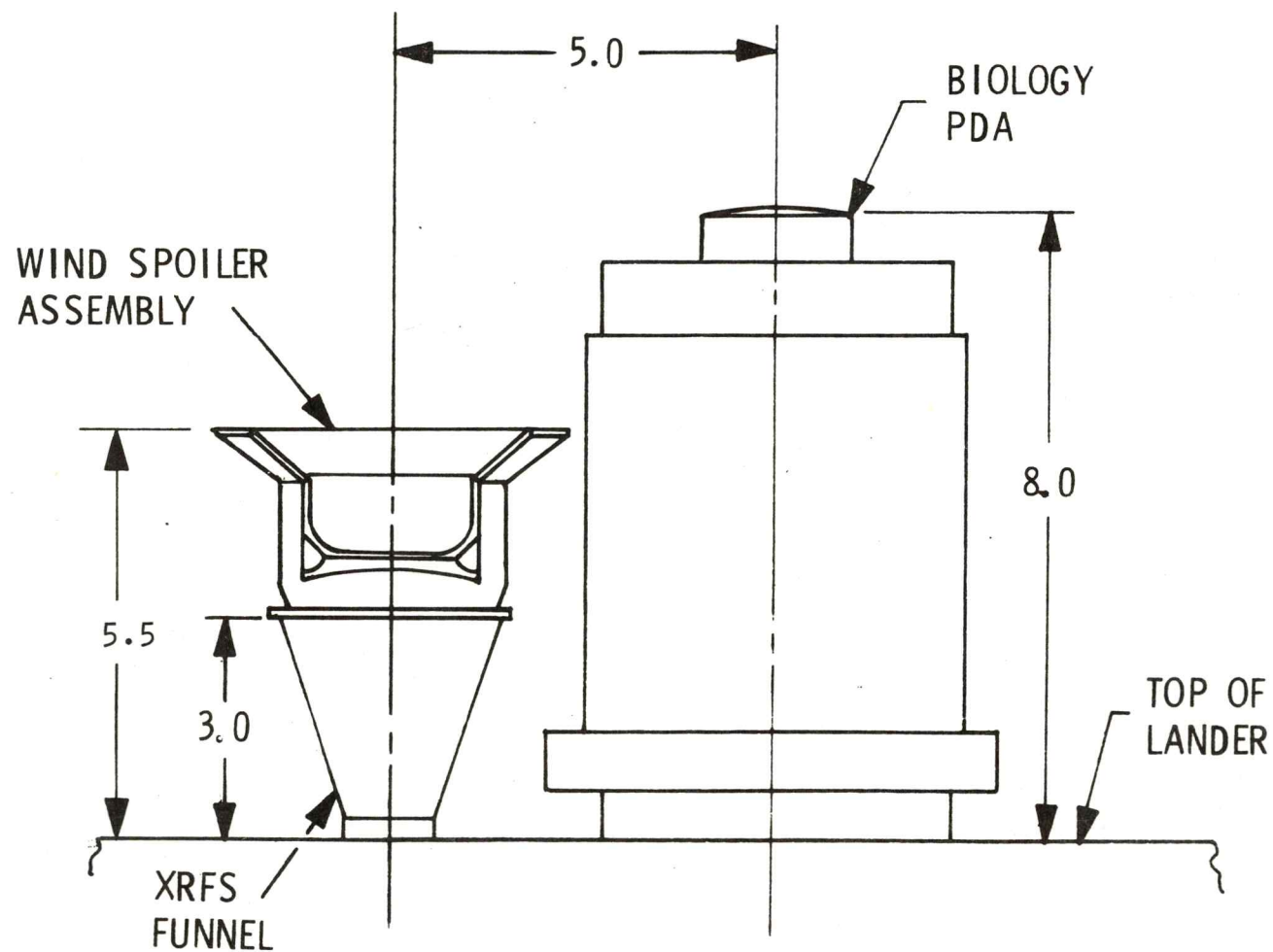


FIGURE 4.8.2.8-4

FUNNEL ELEVATION

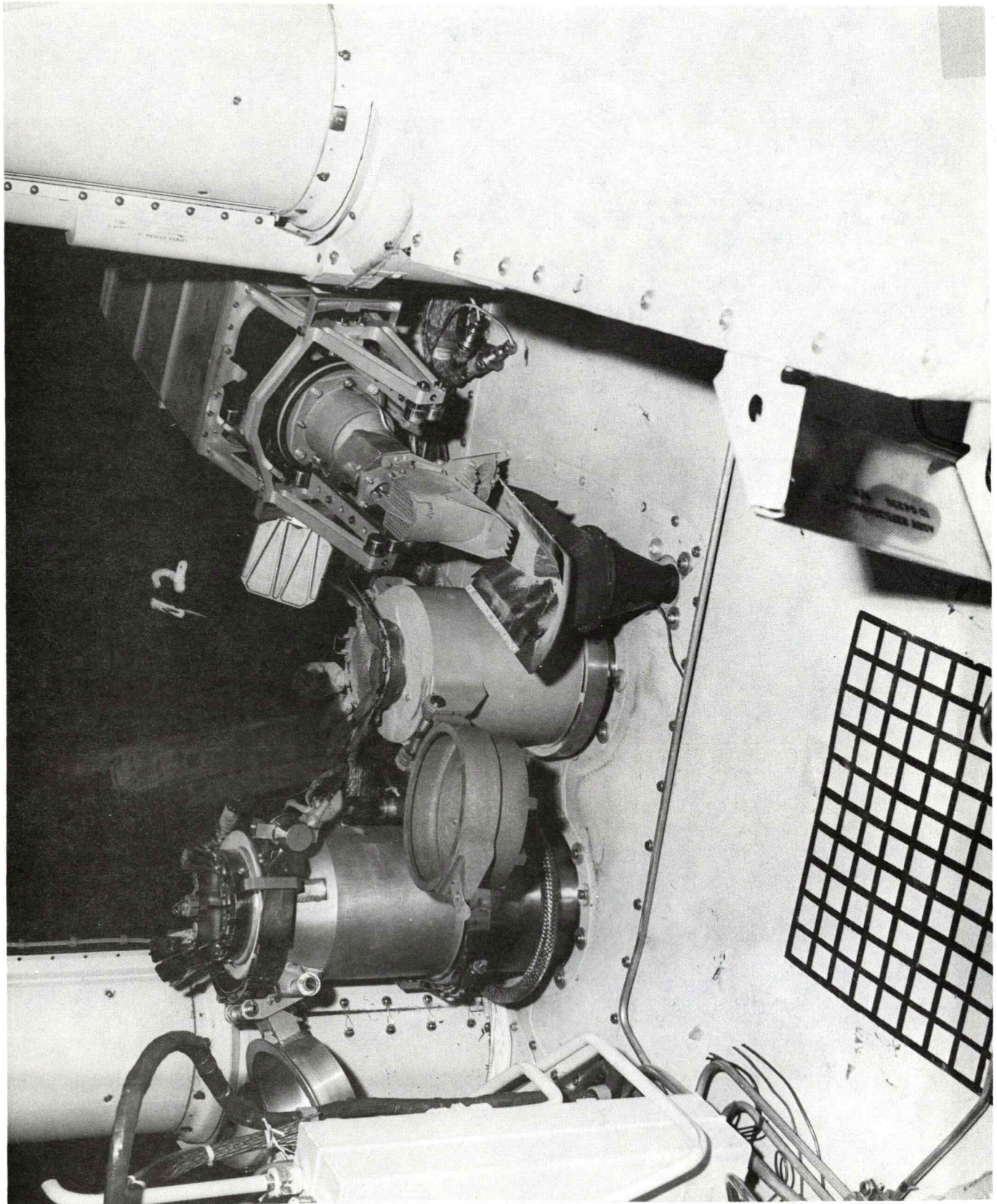


FIGURE 4.8.2.8-5 PTC VIEWED FROM LEG #1

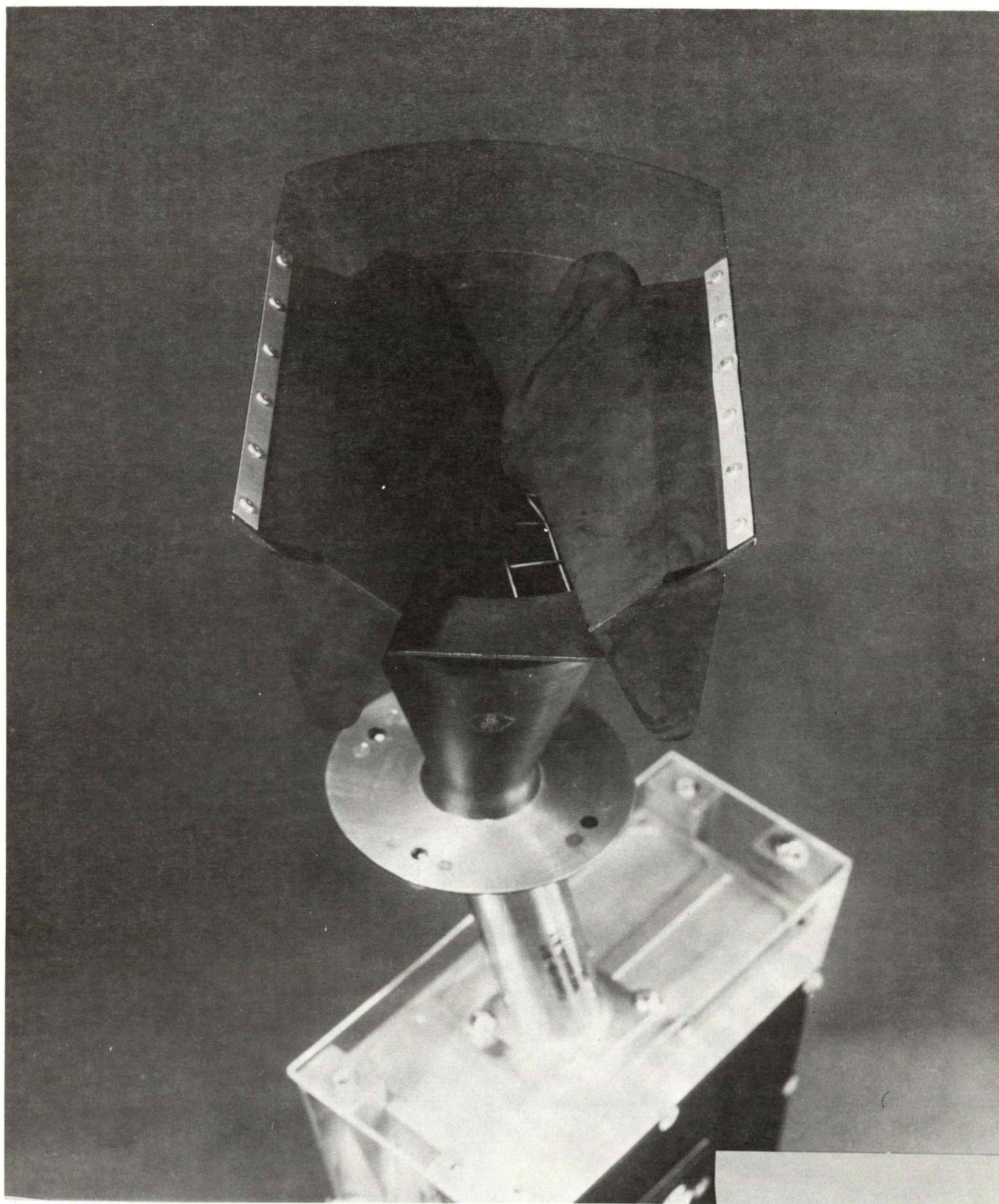


FIGURE 4.8.2.8-6 XRFS SOIL DELIVER SYSTEM

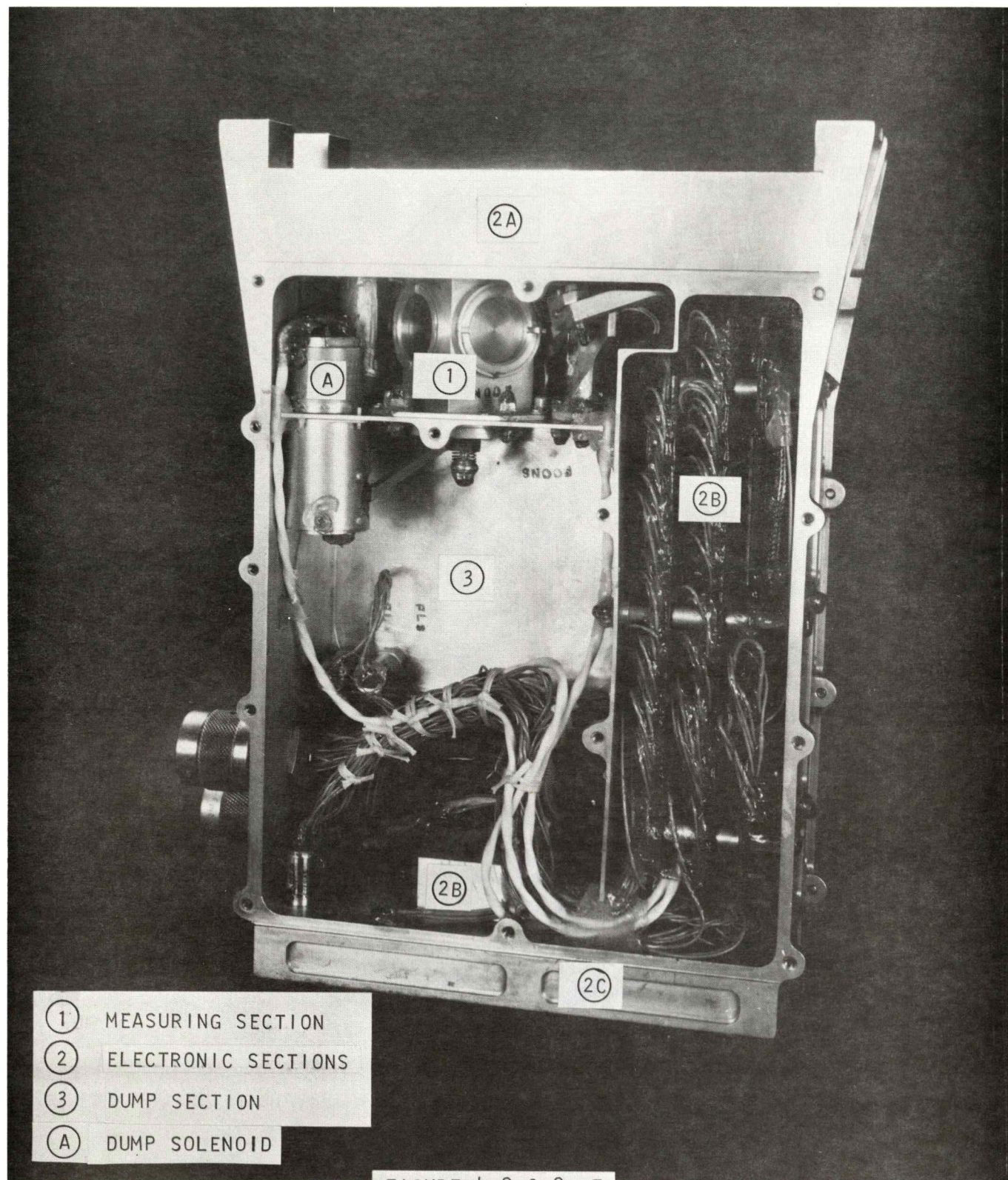


FIGURE 4.8.2.8 -7

XRFS ELECTRONICS ASSEMBLY

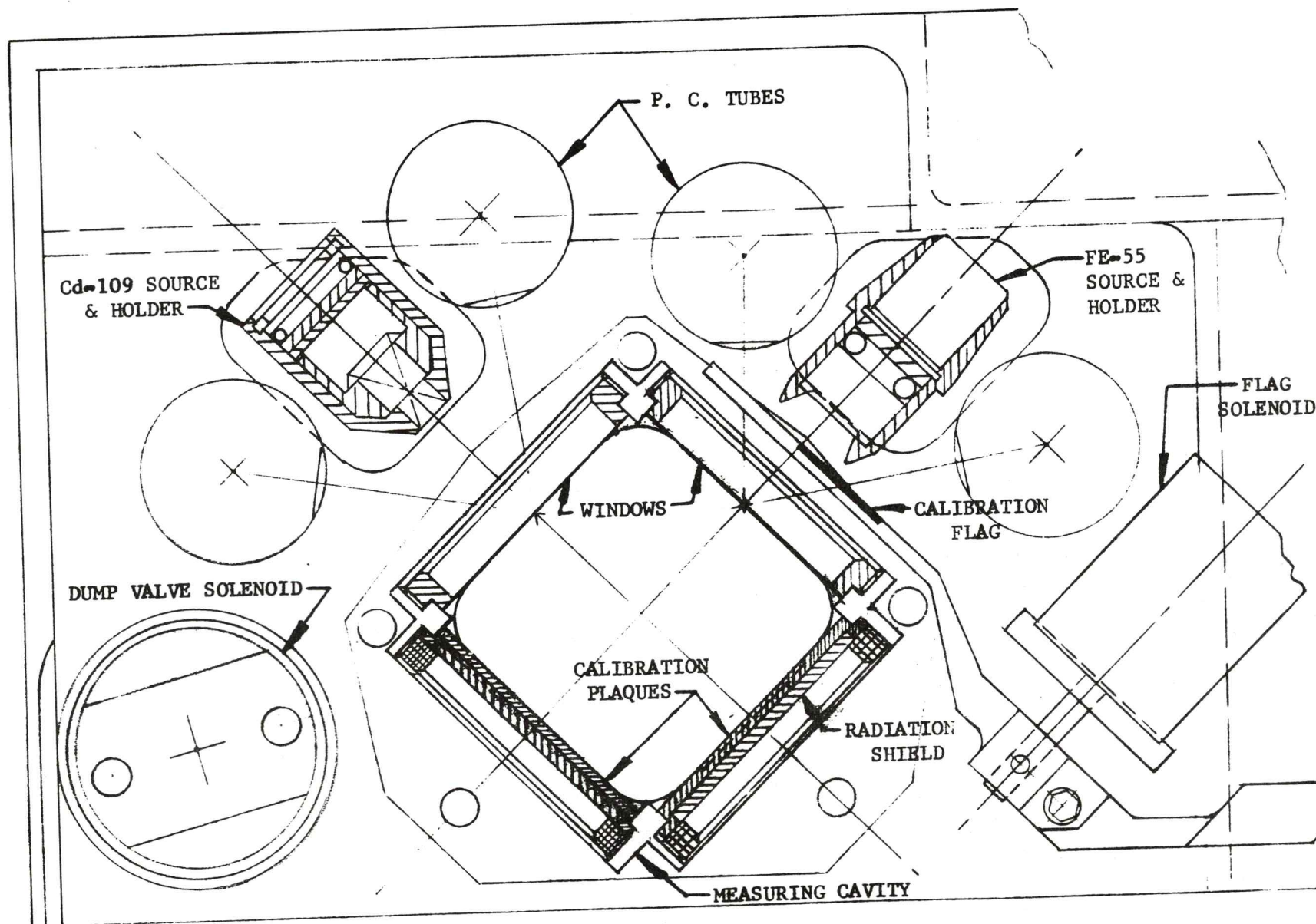


FIGURE 4.8.2.8-8
HORIZONTAL SECTION - MEASURING CAVITY AND SOURCEHOLDERS

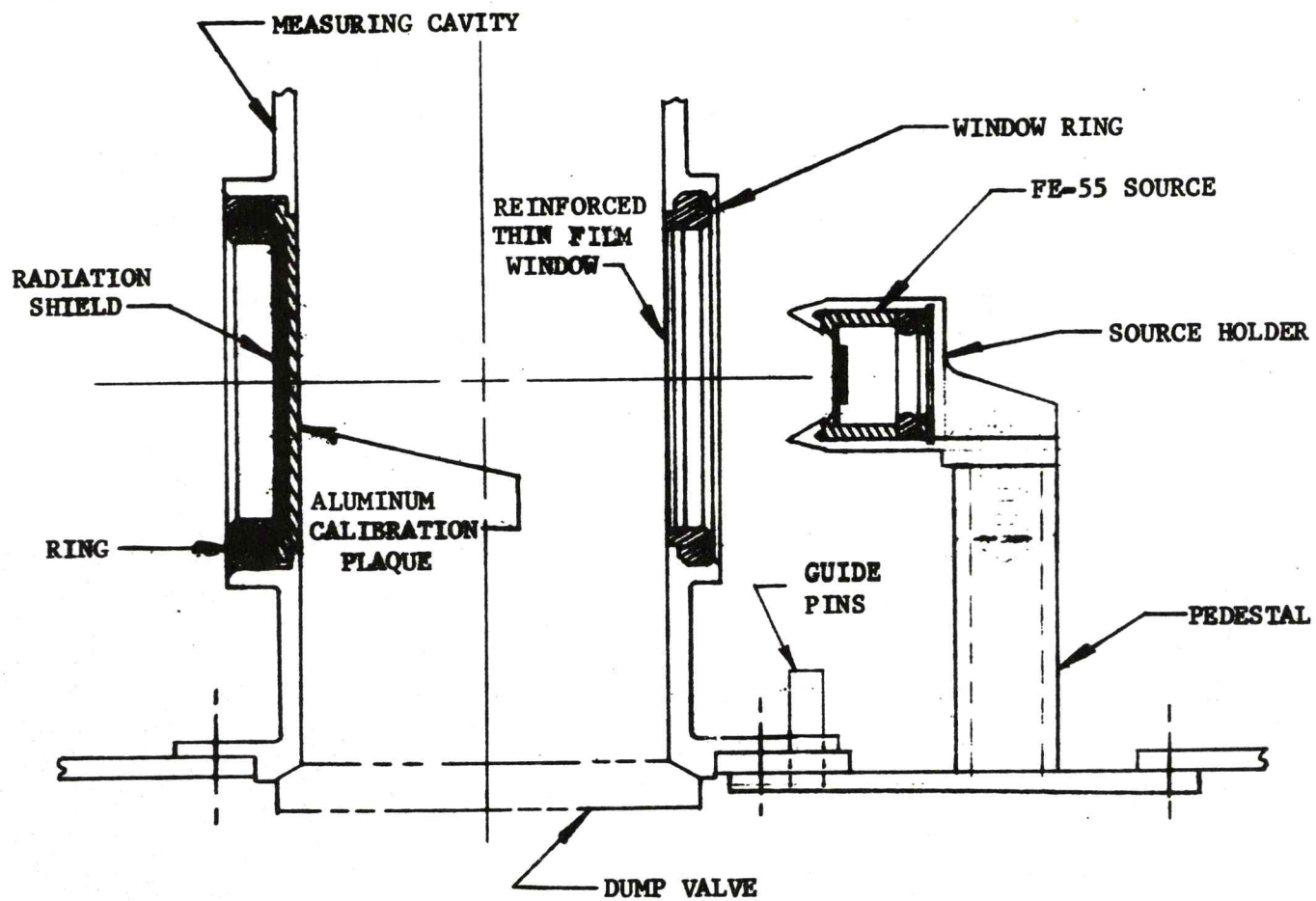


FIGURE 4.8.2.8-9 SECTION - FE-55 SOURCE/WINDOW/PLAQUE

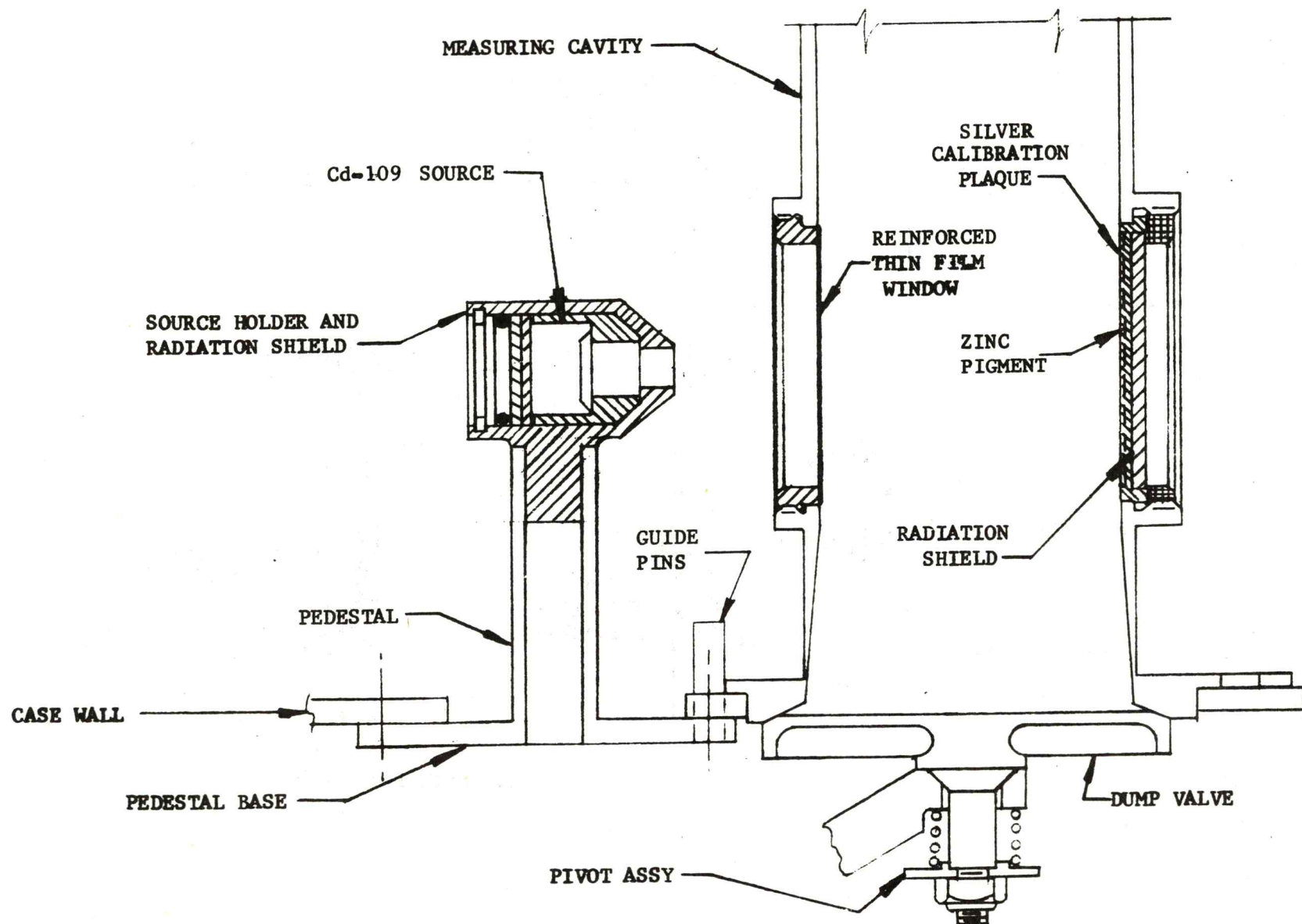
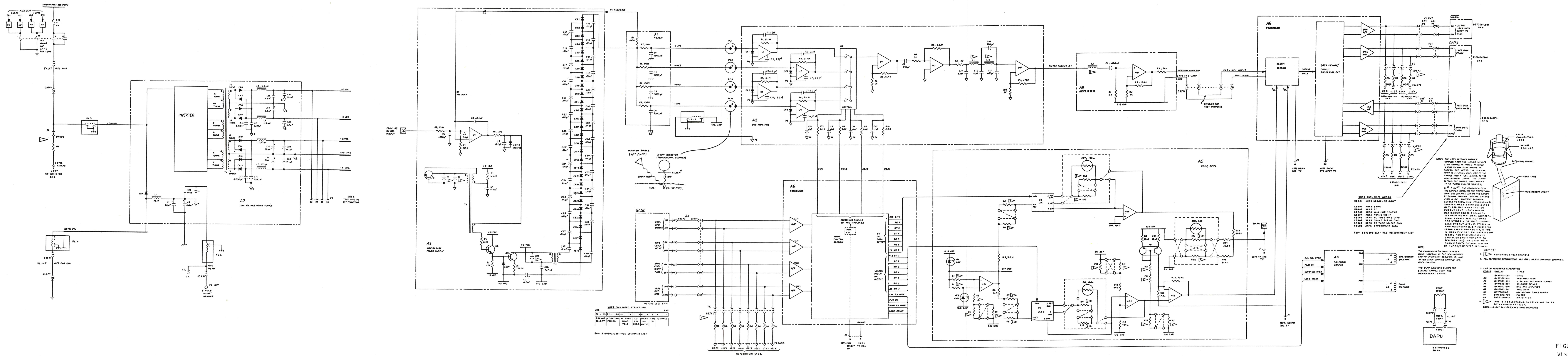
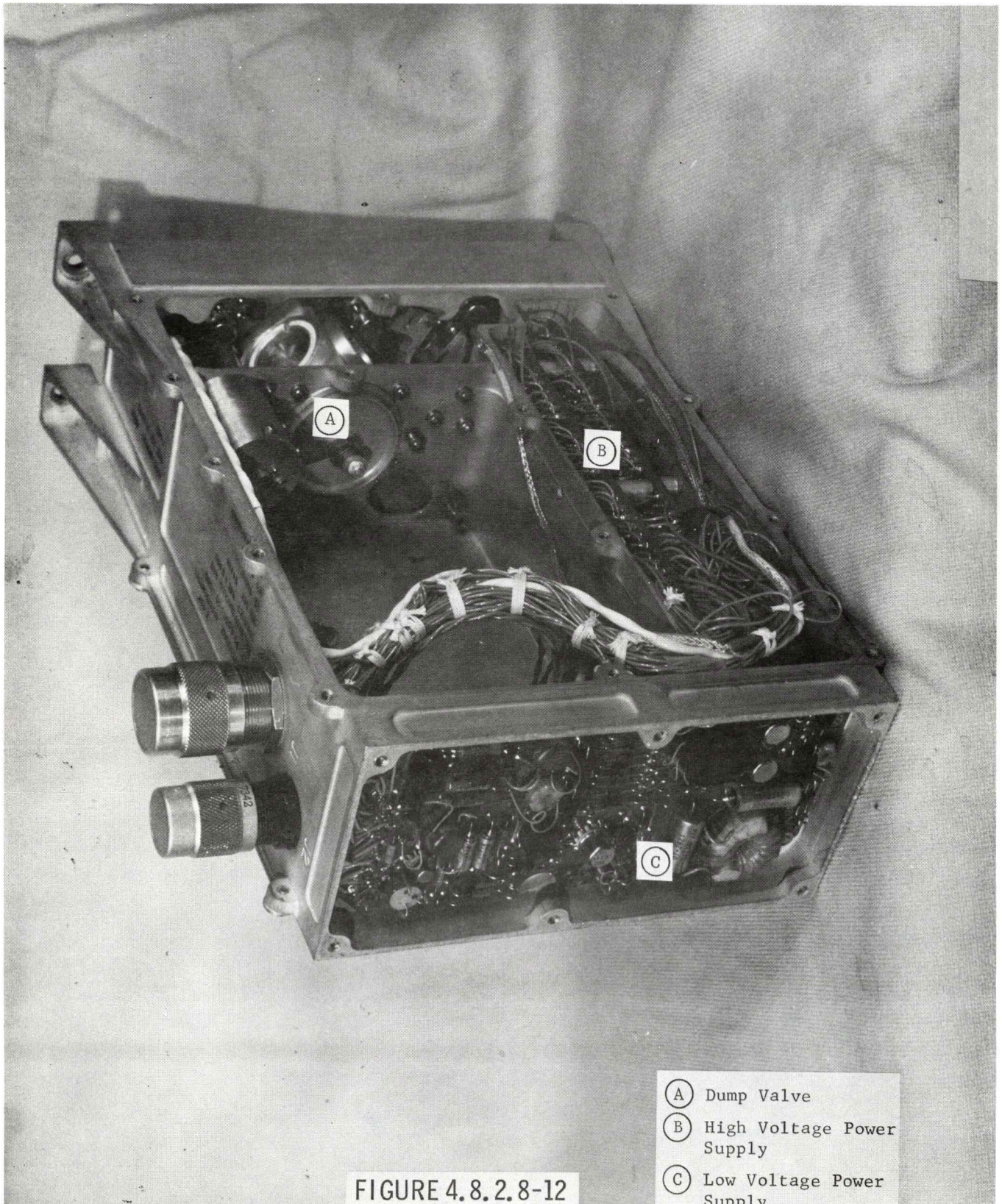
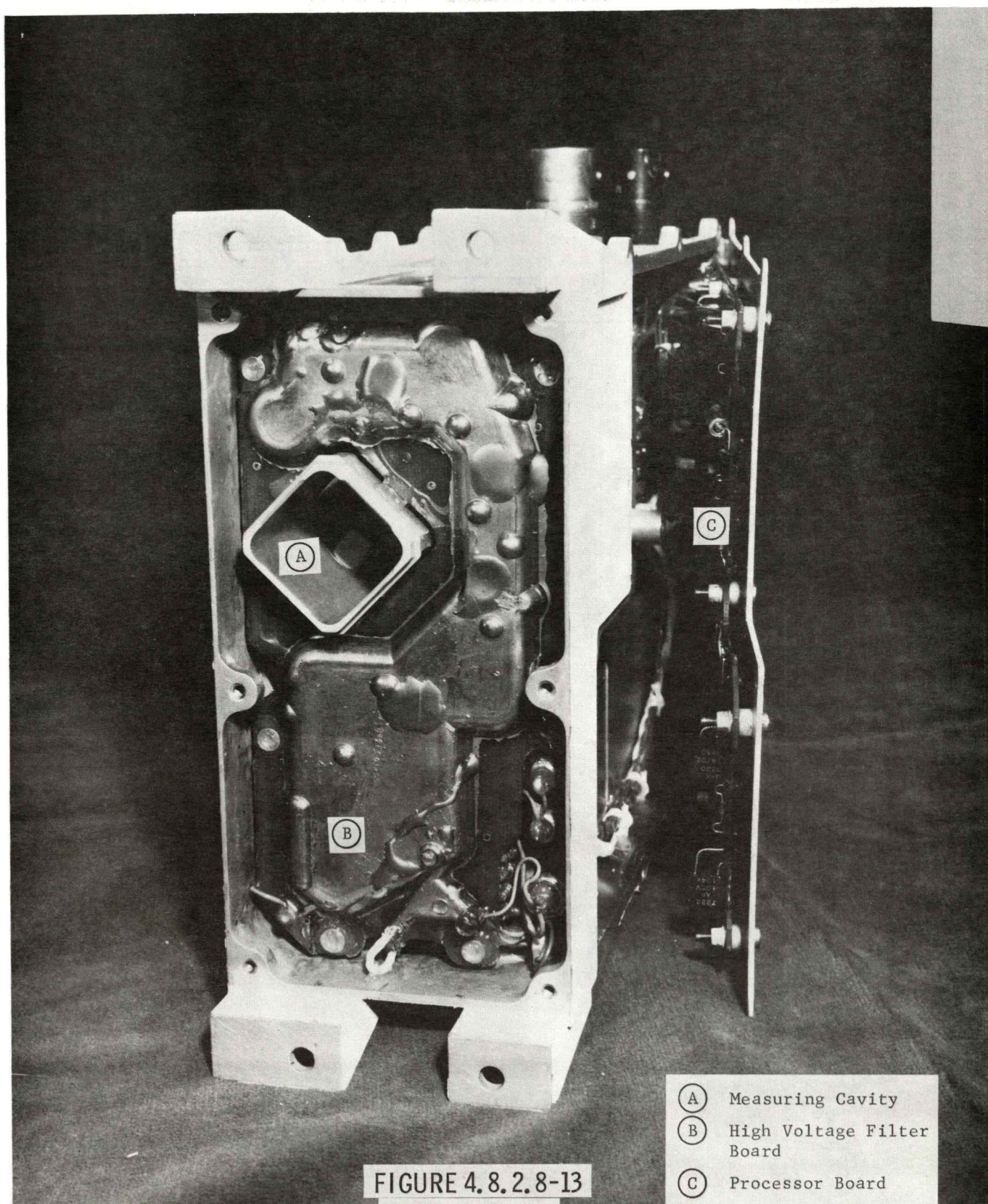


FIGURE 4.8.2.8-10

SECTION - CD-109 SOURCE/WINDOW/PLAQUE







XRFS TOP VIEW-BACK COVER OPEN

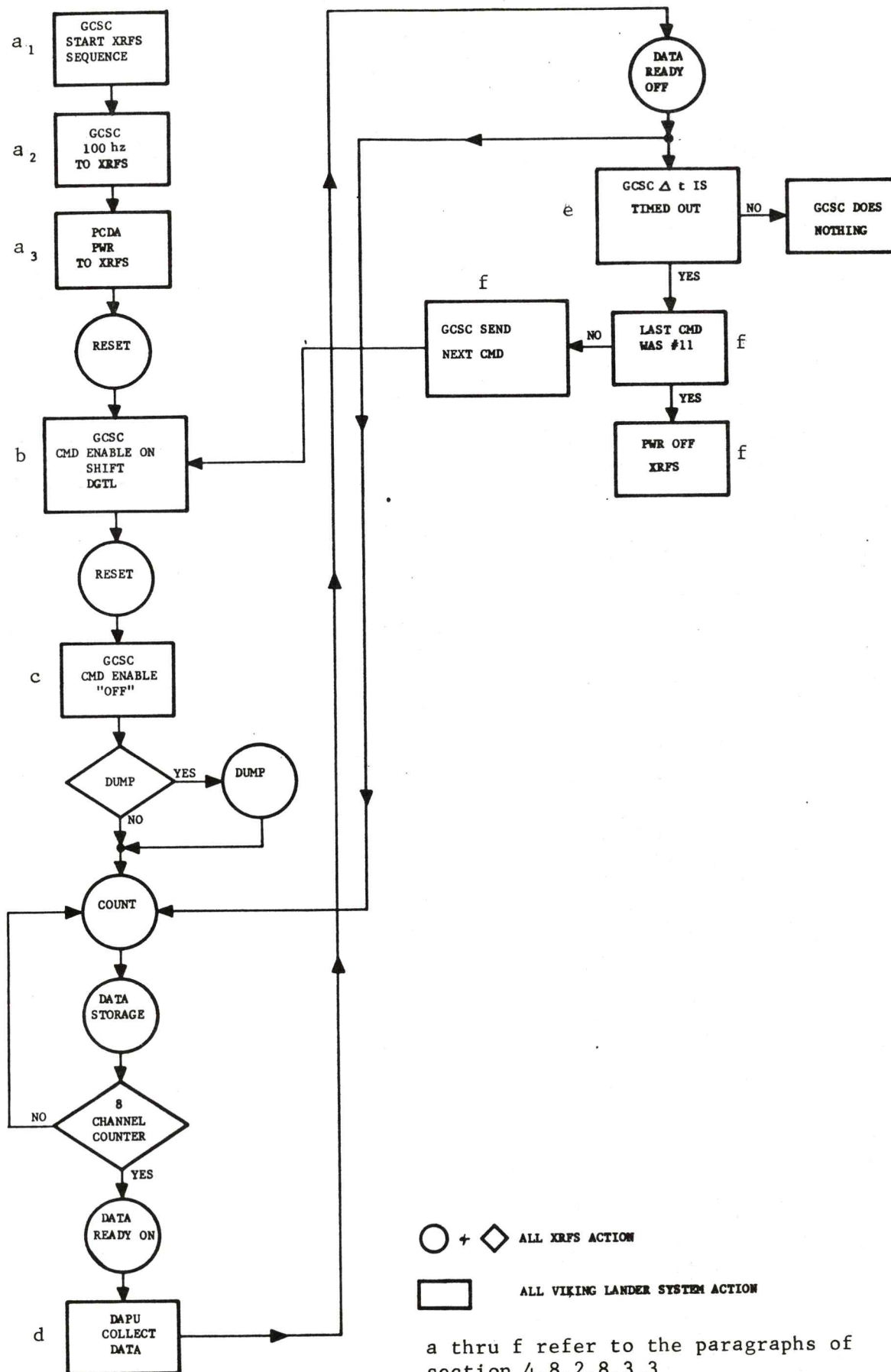


Figure 4.8.2.8-14 - XRFS/VIKING SYSTEM SEQUENCING

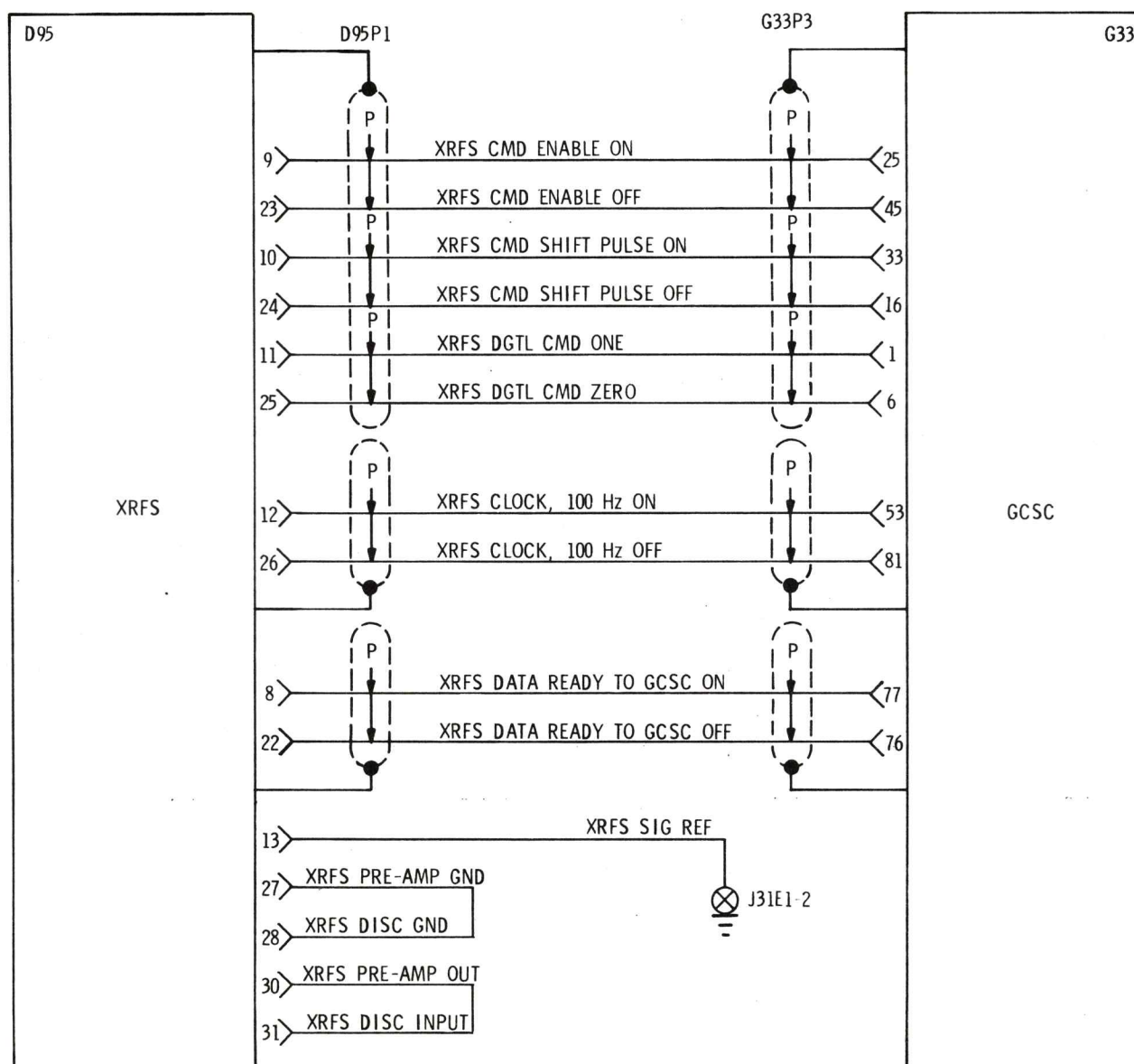


FIGURE 4.8.2.8-15
XRFS - G&C INTERFACE

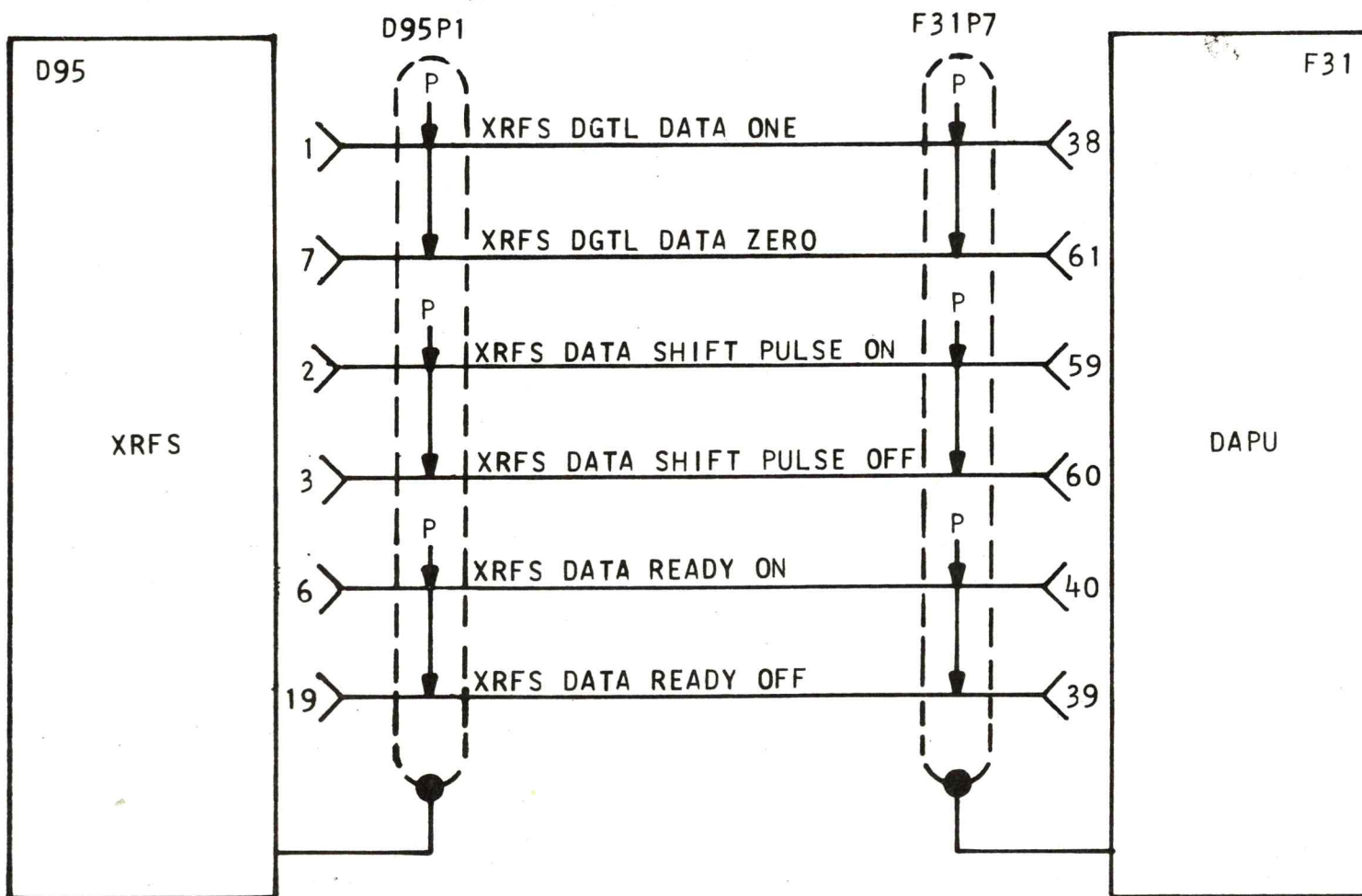


FIGURE 4.8.2.8-16

XRFS T/M INTERFACE

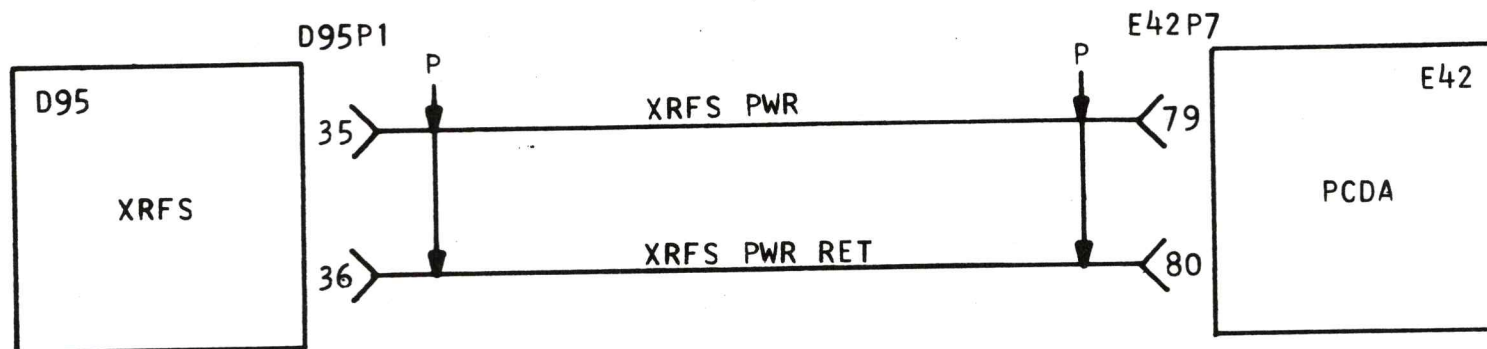


FIGURE 4.8.2.8-17
XRFS POWER INTERFACE

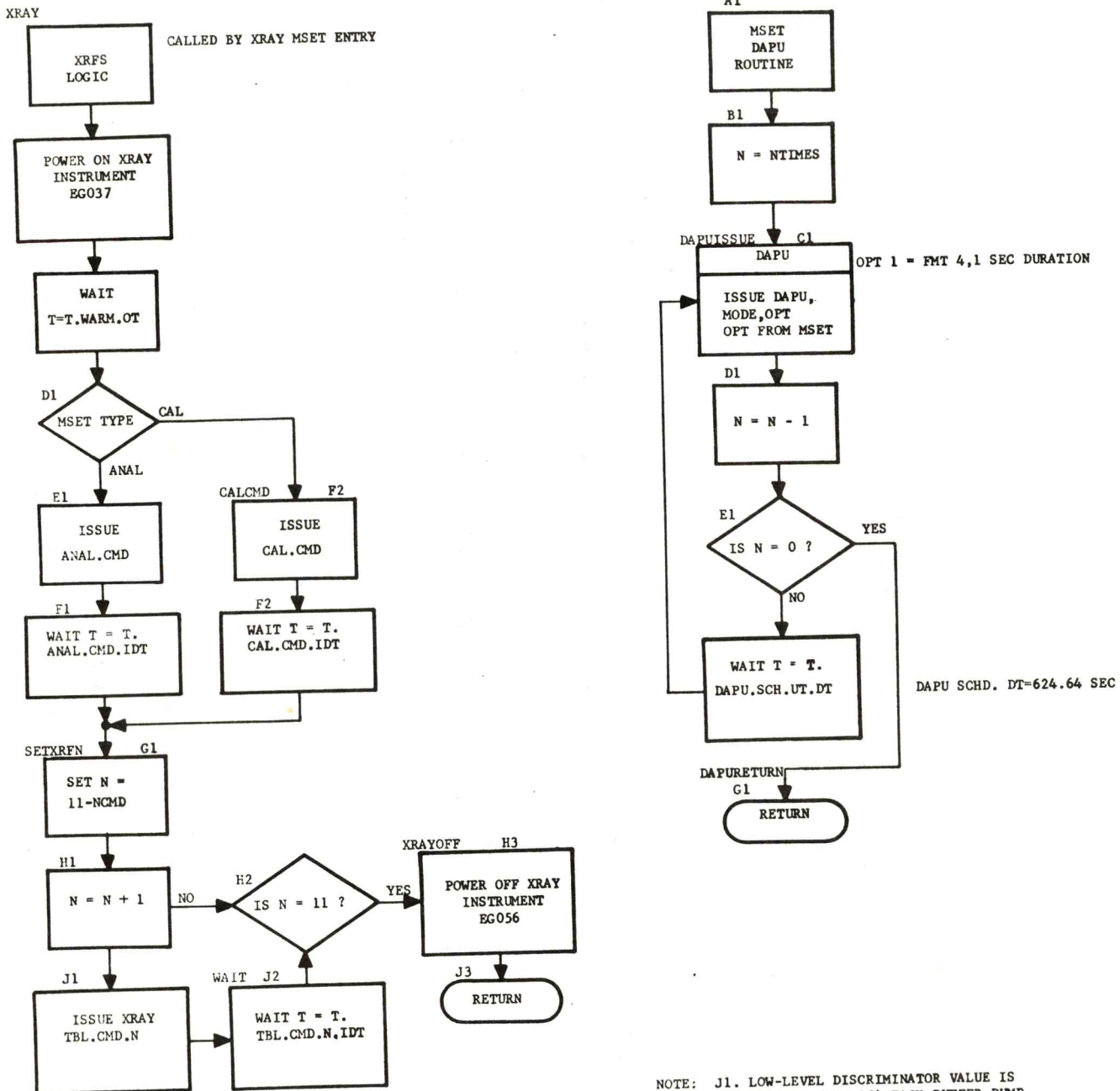


FIGURE 4.8.2.8-18 GCSC X-RAY FLUORESCENCE SOFTWARE

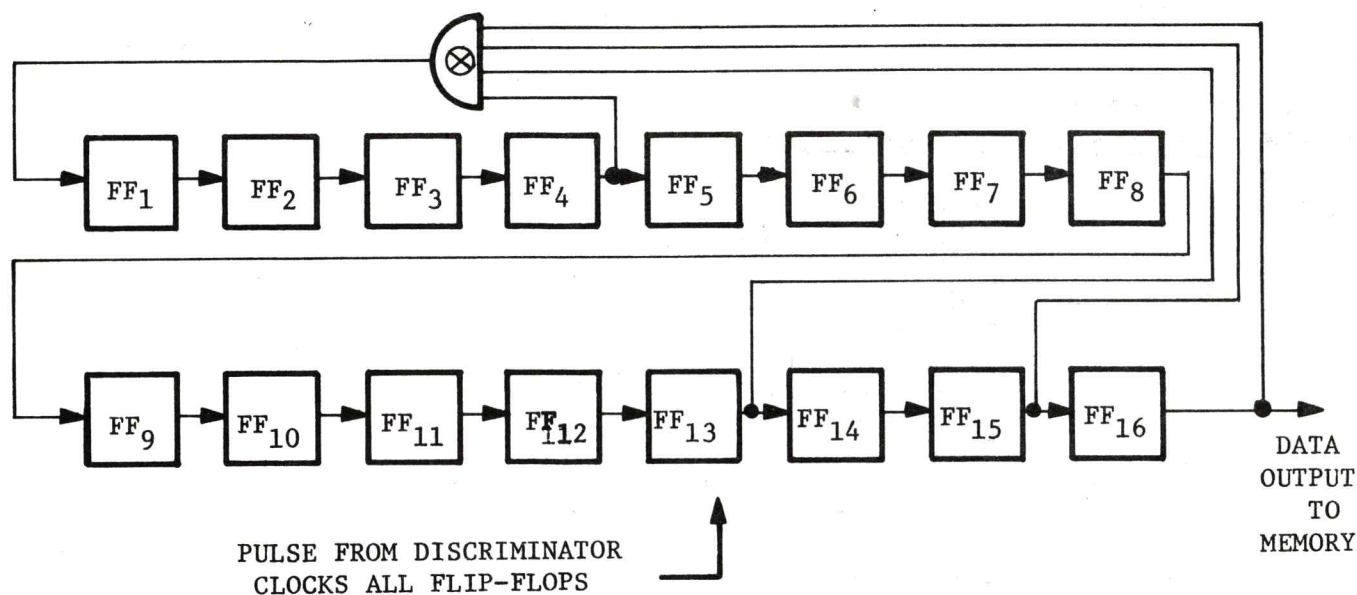


FIGURE 4.8.2.8-19 - XRFs PSEUDO-RANDOM EVENT COUNTER

NOTES: 1. The event counter is a 16 bit maximal length pseudo-random shift register. The count period is 65,535. The initial state, corresponding to a count of zero, is all ones. The counter, shown above, consists of a 16 bit shift register with feedback consisting of the exclusive "OR" sum of the outputs of the 4th, 13th, 15th, and 16th flip-flops. The feedback is returned to the input of the 1st flip-flop. These feedback connections correspond to the primitive polynomial 2100135 of degree sixteen from the "Table of Irreducible Polynomials, Appendix C" in Error Correcting Codes by W. W. Ptereson, M.I.T. Press; Copyright 1961.

2. The 32 bit pseudo random word in each experiment data field shall be coded as follows:

- a) The first sixteen bit locations contains the identical bit structure present in the event counter at the end of the counting period for the channel being measured.
- b) The second sixteen bit locations contains the bit structure in the first sixteen bit locations plus 16 counts.
- c) The event counter is initialized only upon the receipt of a Command word. The event counter may accumulate counts up to the maximum of 65,535 counts during any command sequence. Therefore, the data reduction system must be capable of recognizing a data field in which the count recycles to its initial state. Figure 4.8.2.8-20 details the contents of the Data Field pseudo random word.

<u>Data Field</u>	<u>Bit Location From-Thru</u>		<u>Data Counts Stored</u>
LCS	57	72	(EC) + Co
	73	88	(EC) + Co + 16
LCS+1	89	104	(EC) + Co + C1 + 32
	105	120	(EC) + Co + C1 + 48
LCS+2	121	136	(EC) + Co + C1 + C2 + 64
	137	152	(EC) + Co + C1 + C2 + 80
LCS+3	153	168	(EC) + Co + C1 + C2 + C3 + 96
	169	184	(EC) + Co + C1 + C2 + C3 + 112
LCS+4	185	200	(EC) + Co + C1 + C2 + C3 + C4 + 128
	201	216	(EC) + Co + C1 + C2 + C3 + C4 + 144
LCS+5	217	232	(EC) + Co + C1 + C2 + C3 + C4 + C5 + 160
	233	248	(EC) + Co + C1 + C2 + C3 + C4 + C5 + 176
LCS+6	249	264	(EC) + Co + C1 + C2 + C3 + C4 + C5 + C6 + 192
	265	280	(EC) + Co + C1 + C2 + C3 + C4 + C5 + C6 + 208
LCS+7	281	296	(EC) + Co + C1 + C2 + C3 + C4 + C5 + C6 + C7 + 224
	297	312	(EC) + Co + C1 + C2 + C3 + C4 + C5 + C6 + C7 + 240

Where (EC) is the event counter bit structure prior to accumulating the counts for the LCS. If this data format is the first data format after a command word, then (EC) = 0.

Cn is the number of counts for each LCS + n for n = 0 through 7.

LCS = The lowest number Channel sampled in the format. The channel numbers for the format are given by data bits 41-44 and identified by the listing of Figure 4.8.2.8-22.

FIGURE 4.8.2.8-20
DATA FIELD COUNT CONTENT

Data Name: Synchronism word

Bits Nos: 31 1

Code: 1010111011000111110011010010000

Data Name: Identification word

Bit Nos: 36 35 34 33 32

Code: 0 1 0 0 0

Data Name: Command

Bits Nos: 40 37

Code: 8-Command word bits nos. -5

Data Name: Data Frame Identifier

Bits Nos: 44 41

Code: Refer to Figure 4.8.2.8-22

Data Name: Command

Bits Nos: 56 45

Code: 24-Command word bits nos. -13

Data Name: Experiment Data from Lowest Channel selected (LCS)

Bit Nos: 88 57

Code: Last Bit-Pseudo Random Word*-First Bit

FIGURE 4.8.2.8-21
DATA OUTPUT BITS 1 THROUGH 312
(SHEET 1 OF 3)

Data Name: Experiment Data from Channel No. (LCS + 1)

Bits Nos: 120 89

Code: Last Bit - Pseudo Random Word* - First Bit

Data Name: Experiment Data from Channel No. (LCS + 2)

Bits Nos: 152 121

Code: Last Bit - Pseudo Random Word* - First Bit

Data Name: Experiment Data from Channel No. (LCS + 3)

Bit Nos: 184 153

Code: Last Bit - Pseudo Random Word* - First Bit

Data Name: Experiment Data from Channel No. (LCS + 4)

Bit Nos: 216 185

Code: Last Bit - Pseudo Random Word* - First Bit

Data Name: Experiment Data From Channel No. (LCS + 5)

Bit Nos: 248 217

Code: Last Bit - Pseudo Random Word* - First Bit

Data Name: Experiment Data from Channel No. (LCS + 6)

Bits Nos: 280 249

Code: Last Bit - Pseudo Random Word* - First Bit

FIGURE 4.8.2.8-21
DATA OUTPUT BITS 1 THROUGH 312
(SHEET 2 OF 3)

Data Name: Experiment Data from Channel No. (LCS + 7)

Bit Nos: 312 281

Code: Last Bit - Pseudo Random Word* - First Bit

* Definition of the Pseudo Random Word is given in
Figure 4.8.2.8-19

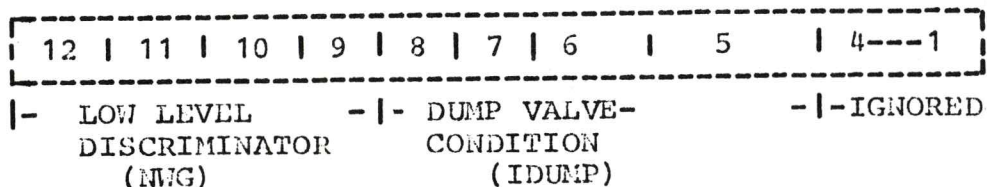
FIGURE 4.8.2.8-21
DATA OUTPUT BITS 1 THROUGH 312
(SHEET 3 OF 3)

Data Bit Nos.				Channels Sampled in the Data Format Frame
<u>44</u>	<u>43</u>	<u>42</u>	<u>41</u>	
0	0	0	0	120 through 127
0	0	0	1	0 through 7
0	0	1	0	8 through 15
0	0	1	1	16 through 23
0	1	0	0	24 through 31
0	1	0	1	32 through 39
0	1	1	0	40 through 47
0	1	1	1	48 through 55
1	0	0	0	56 through 63
1	0	0	1	64 through 71
1	0	1	0	72 through 79
1	0	1	1	80 through 87
1	1	0	0	88 through 95
1	1	0	1	96 through 103
1	1	1	0	104 through 111
1	1	1	1	112 through 119

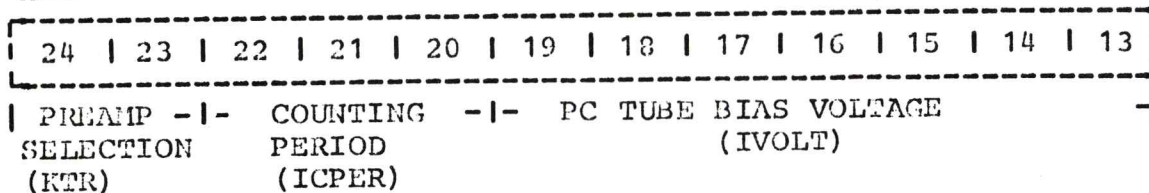
NOTE: Bits number 41 through 44, of the "Command" field in the Data Format, shall consist of up-dated command word bits 9 through 12; the Data frame bits 41-44 will identify the eight channels of experiment data that is contained in that formatted frame. The frame identification code is as above.

FIGURE 4.8.2.8-22
DATA FRAME IDENTIFIER

*FBR



*LBR



- a. DUMP VALVE CONDITION- Conditions the XRFs as follows:

BITS				CONDITION	IDUMP
8	7	6	5		
1	0	1	1	Dump Valve Open	1
1	0	1	0	Dump Valve Open	2
1	1	0	0	Calibration Flag	3
0	0	0	1	Analysis	4
0	0	0	0	Analysis	5
1	0	0	1	Analysis	6
1	0	0	0	Analysis	7
0	0	1	1	Analysis	8
0	0	1	0	Analysis	9
1	1	1	1	Analysis	10
1	1	1	0	Analysis	11
0	1	0	1	Analysis	12
0	1	0	0	Analysis	13
0	1	1	1	Analysis	14
0	1	1	0	Analysis	15
1	1	0	1	Alternate Calibration Flag	16

FIGURE 4.8.2.8-23
XRFs COMMAND WORD STRUCTURE

- b. LOW LEVEL DISCRIMINATOR- Sets up the XRFS to start counting at the selected channel for the counting period specified by bits 20-22. The XRFS will sequentially step to the next higher energy channel and will continue to step through sequential channels, for the commanded counting period, until a new command is received or power is removed from XRFS.

BITS				NWG	
12	11	10	9		

0	0	0	0	Start counting at Channel	0
0	0	0	1	Start counting at Channel	8
0	0	1	0	Start counting at Channel	16
0	0	1	1	Start counting at Channel	24
0	1	0	0	Start counting at Channel	32
0	1	0	1	Start counting at Channel	40
0	1	1	0	Start counting at Channel	48
0	1	1	1	Start counting at Channel	56
1	0	0	0	Start counting at Channel	64
1	0	0	1	Start counting at Channel	72
1	0	1	0	Start counting at Channel	80
1	0	1	1	Start counting at Channel	88
1	1	0	0	Start counting at Channel	96
1	1	0	1	Start counting at Channel	104
1	1	1	0	Start counting at Channel	112
1	1	1	1	Start counting at Channel	120

- c. PC TUBE BIAS VOLTAGE- Selects the high voltage that is applied to the four Proportional Counters. (defined by bits 23-24).

FIGURE 4.8.2.8-23
XRFS COMMAND WORD STRUCTURE
(CONTINUED)

BITS							IVOLT
19	18	17	16	15	14	13	(Voltage)
1	0	0	0	0	0	0	1350
1	0	0	0	0	0	1	1345
1	0	0	0	0	1	0	1340
1	0	0	0	0	1	1	1335
1	0	0	0	1	0	0	1330
1	0	0	0	1	0	1	1325
1	0	0	0	1	1	0	1320
1	0	0	0	1	1	1	1315
1	0	0	1	0	0	0	1310
1	0	0	1	0	0	1	1305
1	0	0	1	0	1	0	1300
1	0	0	1	0	1	1	1295
1	0	0	1	1	0	0	1290
1	0	0	1	1	0	1	1285
1	0	0	1	1	1	0	1280
1	0	0	1	1	1	1	1275
1	0	1	0	0	0	0	1270
1	0	1	0	0	0	1	1265
1	0	1	0	0	1	0	1260
1	0	1	0	0	1	1	1255
1	0	1	0	1	0	0	1250
1	0	1	0	1	0	1	1245
1	0	1	0	1	1	0	1240
1	0	1	0	1	1	1	1235
1	0	1	1	0	0	0	1230
1	0	1	1	0	0	1	1225
1	0	1	1	0	1	0	1220
1	0	1	1	0	1	1	1215
1	0	1	1	1	0	0	1210
1	0	1	1	1	0	1	1205
1	0	1	1	1	1	0	1200
1	0	1	1	1	1	1	1195
1	1	0	0	0	0	0	1190
1	1	0	0	0	0	1	1185
1	1	0	0	0	1	0	1180
1	1	0	0	0	1	1	1175
1	1	0	0	1	0	0	1170
1	1	0	0	1	0	1	1165

FIGURE 4.8.2.8-23
XRF5 COMMAND WORD STRUCTURE
(CONTINUED)

BITS							IVOLT
19	18	17	16	15	14	13	(VOLTAGE)
1	1	0	0	1	1	0	1160
1	1	0	0	1	1	1	1155
1	1	0	1	0	0	0	1150
1	1	0	1	0	0	1	1145
1	1	0	1	0	1	0	1140
1	1	0	1	1	0	0	1135
1	1	0	1	1	0	0	1130
1	1	0	1	1	0	1	1125
1	1	0	1	1	1	0	1120
1	1	0	1	1	1	1	1115
1	1	1	0	0	0	0	1110
1	1	1	0	0	0	1	1105
1	1	1	0	0	1	0	1100
1	1	1	0	0	1	1	1095
1	1	1	0	1	0	0	1090
1	1	1	0	1	0	1	1085
1	1	1	0	1	1	0	1080
1	1	1	0	1	1	1	1075
1	1	1	1	0	0	0	1070
1	1	1	1	0	0	1	1065
1	1	1	1	0	1	0	1060
1	1	1	1	0	1	1	1055
1	1	1	1	1	0	0	1050
1	1	1	1	1	0	1	1045
1	1	1	1	1	1	0	1040
1	1	1	1	1	1	1	1035
0	0	0	0	0	0	0	1030
0	0	0	0	0	0	1	1025
0	0	0	0	0	1	0	1020
0	0	0	0	0	1	1	1015
0	0	0	0	1	0	0	1010
0	0	0	0	1	0	1	1005
0	0	0	0	1	1	0	1000
0	0	0	0	1	1	1	995
0	0	0	1	0	0	0	990
0	0	0	1	0	0	1	985
0	0	0	1	0	1	0	980
0	0	0	1	0	1	1	975
0	0	0	1	1	0	0	970
0	0	0	1	1	0	1	965

FIGURE 4.8.2.8-23
XRFS COMMAND WORD STRUCTURE
(CONTINUED)

BITS							IVOLT
19	18	17	16	15	14	13	(Voltage)
0	0	0	1	1	1	0	960
0	0	0	1	1	1	1	955
0	0	1	0	0	0	0	950
0	0	1	0	0	0	1	945
0	0	1	0	0	1	0	940
0	0	1	0	0	1	1	935
0	0	1	0	1	0	0	930
0	0	1	0	1	0	1	925
0	0	1	0	1	1	0	920
0	0	1	0	1	1	1	915
0	0	1	1	0	0	0	910
0	0	1	1	0	0	1	905
0	0	1	1	0	1	0	900
0	0	1	1	1	0	0	890
0	0	1	1	0	1	1	890
0	0	1	1	1	0	1	885
0	0	1	1	1	1	0	880
0	0	1	1	1	1	1	875
0	1	0	0	0	0	0	870
0	1	0	0	0	0	1	865
0	1	0	0	0	1	0	860
0	1	0	0	0	1	1	855
0	1	0	0	1	0	0	850
0	1	0	0	1	0	1	845
0	1	0	0	1	1	0	840
0	1	0	0	1	1	1	835
0	1	0	1	0	0	0	830
0	1	0	1	0	0	1	825
0	1	0	1	0	1	0	820
0	1	0	1	0	1	1	815
0	1	0	1	1	0	0	810
0	1	0	1	1	0	1	805
0	1	0	1	1	1	0	800
0	1	0	1	1	1	1	795
0	1	1	0	0	0	0	790
0	1	1	0	0	0	1	785
0	1	1	0	0	1	0	780
0	1	1	0	0	1	1	775
0	1	1	0	1	0	0	770
0	1	1	0	1	0	1	765

FIGURE 4.8.2.8-23
XRES COMMAND WORD STRUCTURE
(CONTINUED)

BITS							IVOLT
19	18	17	16	15	14	13	(Voltage)
0	1	1	0	1	1	0	760
0	1	1	0	1	1	1	755
0	1	1	1	0	0	0	750
0	1	1	1	0	0	1	745
0	1	1	1	0	1	0	740
0	1	1	1	0	1	1	735
0	1	1	1	1	0	0	730
0	1	1	1	1	0	1	725
0	1	1	1	1	1	0	720
0	1	1	1	1	1	1	715

FIGURE 4.8.2.8-23
XRFS COMMAND WORD STRUCTURE
(CONTINUED)

- d. COUNTING PERIOD- Selects the delta time each low level discriminator channel is monitored.

BITS			ICPER	COUNTING PERIOD
22	21	20		+/- 0.1% ACCURACY

0	0	1	8	7.68 sec
0	0	0	30	30.72 -A sec
0	1	0	31	30.72 -B sec
1	0	0	61	61.4 sec
0	1	1	122	122.9 -A sec
1	1	1	123	122.9 -B sec
1	0	1	246	245.8 sec
1	1	0	492	491.5 sec

- e. PREAMPLIFIER SELECTION- Selects one of four preamplifiers and Proportional Counter combinations for the analysis to be conducted.

BITS		KTR	ACTION
24	23		

0	0	1	PC-1 Section data
0	1	2	PC-2 Section data
1	0	3	PC-3 Section data
1	1	4	PC-4 Section data

* FBR: First bit received
LBR: Last bit received

4.8.2.9 Lander Science Camera Duster

4.8.2.9 LANDER SCIENCE CAMERA DUSTER

4.8.2.9.1 PURPOSE

The purpose of the Lander Science Camera Duster is to remove both incident and wind blown dust from the VL Camera windows.

Since the degree of dust accumulation on the cameras is unknown, the duster has the flexibility to dust each or both cameras on command from Earth. The criteria of operation will be based on the quality of the image received from the VL camera. Depending on the Imaging Investigations planned for each Sol and upon cumulative usage which the duster has seen, the duster will be operated as needed after the initial isolation valve is opened.

4.8.2.9.2 FUNCTION

The Lander Science Camera Duster consists of two major subassemblies, the Pneumatic System and the Electronic Control System (see Figures 4.8.2.9-1 and 4.8.2.9-2). The black box of the Electronic Control Assembly forms the mounting platform for the Pneumatic System. A block diagram of the Camera Duster System logic is shown in Figure 4.8.2.9-3. The storage vessel contains high purity CO sub 2 which is the cleaning medium. A one percent helium tracer is added for leak detection prior to installation. A pyrotechnically operated normally closed isolation valve contains the CO sub 2 with zero leakage through storage, Launch, Cruise and landing operations. After landing the isolation valve is opened which results in the solenoid valves containing the CO sub 2. The solenoid valves may then be operated on command to either or both of the VL cameras. The line to each VL camera is a 0.10 inch diameter teflon tube routed up through the VL cover plate and subsequently to each camera. Each tube is directed up the camera post to a nozzle that directs the gas onto the window of each camera. The nozzle is directed to impinge on the window at a downward angle of 40° from the vertical and aimed at a point 1 inch below the top edge of the window. The nozzle is a shrouded supersonic nozzle that provides a high velocity inner core of gas flow for maximum cleaning capability and a subsonic outer core of gas to minimize entrainment of "air"-borne dust particles.

4.8.2.9.3 OPERATING MODES

The design of the system provides for a zero leakage Cruise mode by virtue of a pyrotechnically operated normally closed isolation valve. This valve remains closed during storage, Launch, and Cruise and landing phases of the mission to maximize the reliability of the storage system. At Landing plus 0:05:55, the isolation valve will be actuated which is the same time the Biology cover is released and the Meteorology Boom is deployed. This enables the camera to be used immediately after the dust settles from the landing operation. Presumably, the camera will

operate with it's dust shield protecting the camera lens in place. This is a desirable mode and since the camera duster does erode the glass it could clean the lens cover until the image degrades and then move the lens cover out of the way.

The Lander Camera Duster should not be operated when the outside atmospheric temperature is below -80°F since the storage medium is CO sub 2. If the temperatures is any lower than this, the CO sub 2 could condense on the inside walls of the teflon tubing which, if allowed to go to complete plugging of the tube could result in full storage pressure being impressed on the tubing and its subsequent rupture.

A study was made in 1975 for Landing Sites A & B which indicated operation could take place between 9:00 AM and 5:30 PM but in no case should the -80°F condition be violated.

4.8.2.9.4 OPERATION SEQUENCE

The normal sequence of operations is shown in Figure 4.8.2.9-4. Basically, when either Camera 1 or Camera 2 is to be dusted, the duster is actuated for 40 msec to purge the nozzle and tubing of any dust while the camera is in the stowed position. The camera is then rotated to $22\ 1/2^{\circ}$ during a 6 second interval. When this is achieved the camera duster is actuated for 200 msec to clean the window. The camera is retained in the cleaning position until a full 10 seconds has passed, at which time the Surface Sampler Control Assembly (SSCA) #2 bus is turned off and the camera is free to operate on its normal sequence. It should be pointed out that the Camera Duster System is not limited to cleaning only one camera. Both may be cleaned simultaneously if stereo images are to be obtained.

Generally speaking, the camera will not be dusted until the image degrades to the point where the picture is unacceptable. The criteria employed during development of the system was that a 5% degradation in transmissibility of the window would be the point at which it would be commanded to clean. The use of the system is on a command basis so that a trade-off can be made as to quality of the image and conservation of the cleaning commodity. If conditions permit the window will be cleaned at the start of each Sol on which images are to be taken.

The sequence of events is controlled by issuance of two Power Conditioning and Distribution Assembly (PCDA) commands to power on the camera duster electronics. After 1 second, discretes in R8 are set up based on ground decisions in accordance with the following table:

	LCS 1			LCS 2		
	25	26	27	25	26	27
Solenoid On	0	0	1	0	1	0
Solenoid Off	0	1	1	1	0	0
Reset	0	0	0	0	0	0

4.8.2.9.5 INTERFACES

Figures 4.8.2.9-3, -4 and -5 present the system block diagram, sequence wave form and the location of duster mounting on the VL.

4.8.2.9.6 POWER REQUIREMENTS

The power requirements of the camera duster are as follows:

Stand by	5.0 watts
Ave Power	5.0 watts
Peak Power	120 watts

The power for the camera duster electronics obtained through Connector J1 from the PCDA (E42) under-voltage bus is routed through the SSCA P51P1 connector and back to the PCDA DC negative bus. The camera duster command signals are from the Guidance Control and Sequencing Computer (GCSC) and originate through driver designations 48A, 49A & 49B through Connector J03 of the GCSC to the connector P52P1 (J2) of the Camera Duster Control Assembly. The pyrotechnic valve signal originates at the GCSC command designator DG033 and is fed through the LPCA to connectors with reference designators H31A101J1 and H31A102J2 on the camera duster mounted pyro valve.

4.8.2.9.7 GENERAL OPERATIONAL DATA AND CONSTRAINTS

The Camera Duster will accommodate at least 100 total dusting cycles which can be used in a single or dual mode to either camera. It is preferred that the cameras be operated from 10:00 AM to 2:00 PM but for landing sites A and B analysis indicates they may be operated from 9:00 AM to 5:30 PM; however, the camera duster must not be operated below -80°F atmospheric temperature.

The actual command to use the camera duster is to be at the discretion of the science team depending upon the amount of image degradation. Development tests indicate erosion damage is less for a clean window than for a dirty window; therefore, it may be desired to actuate the camera duster every 5 days or so depending upon camera usage and system capacity. The system may be commanded to operate until it no longer cleans or works without damage to the system.

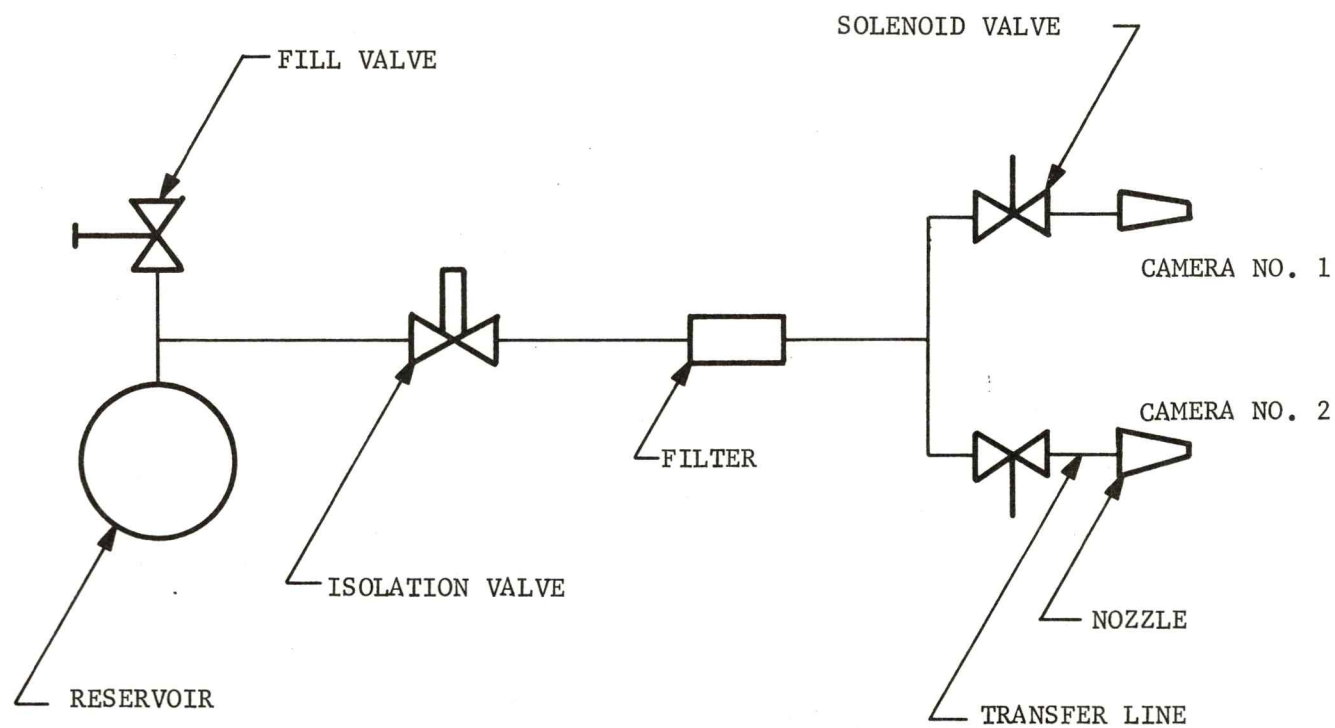


FIGURE 4.8.2.9-1 PNEUMATIC SYSTEM SCHEMATIC



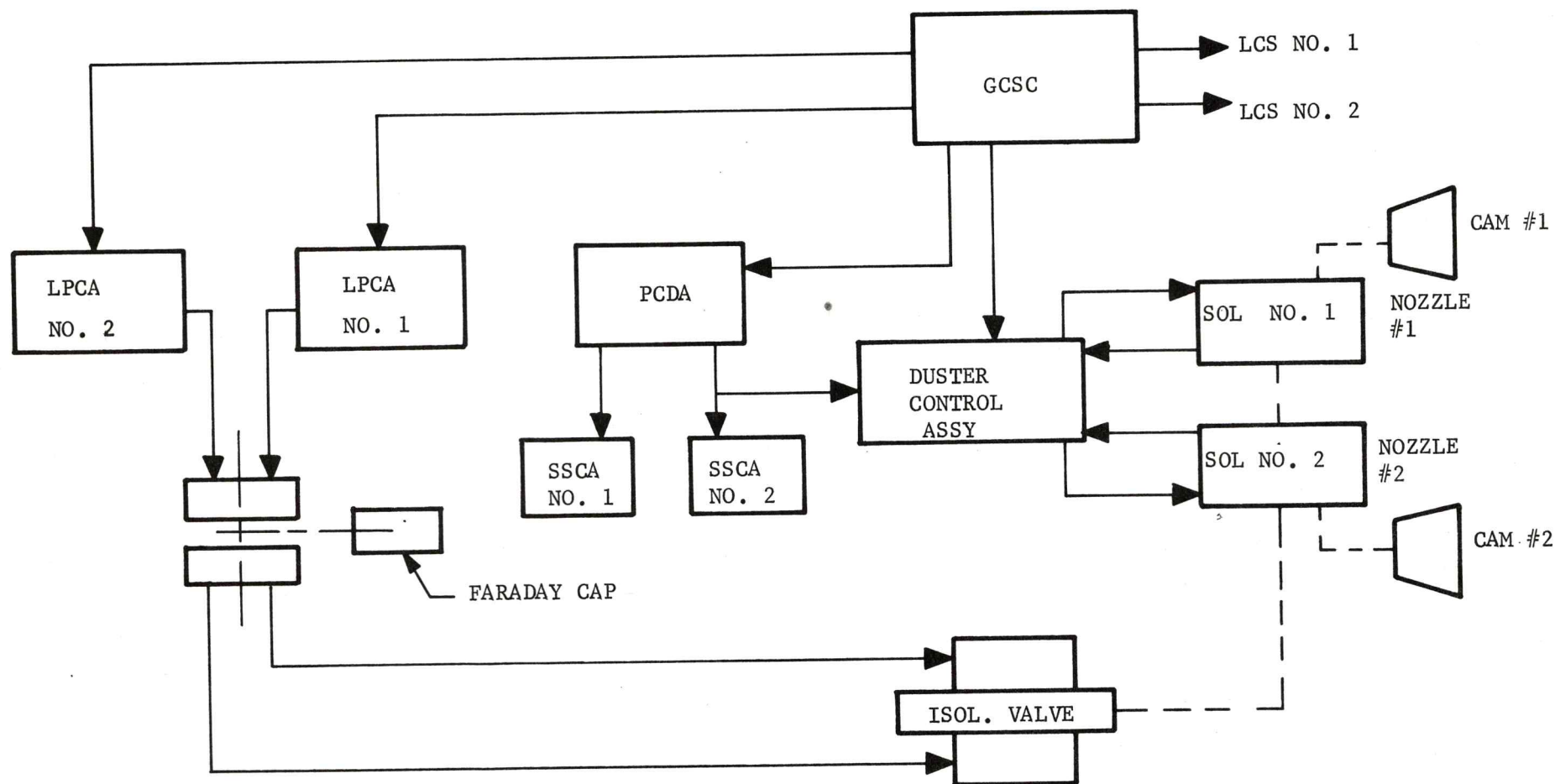


FIGURE 4.8.2.9-3 BLOCK DIAGRAM - CAMERA DUSTER

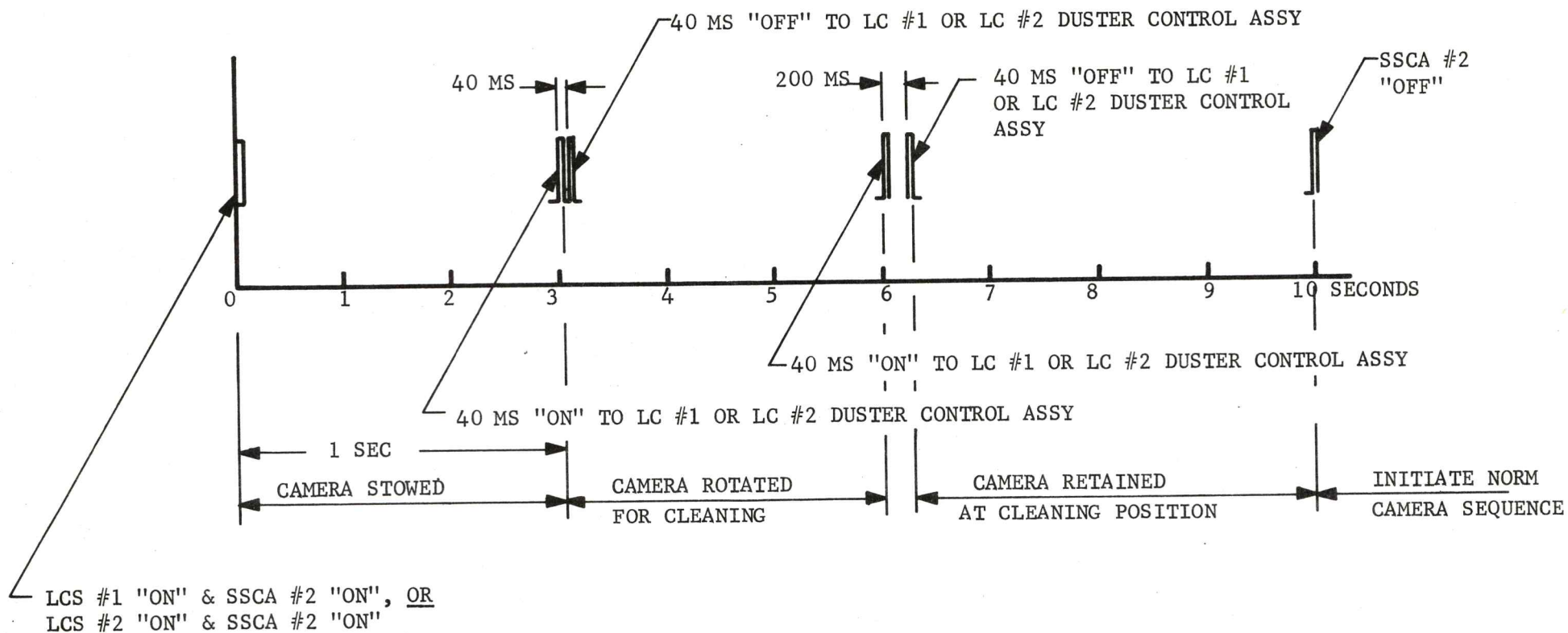


FIGURE 4.8.2.9-4 SEQUENCE WAVE FORM - CAMERA DUSTER

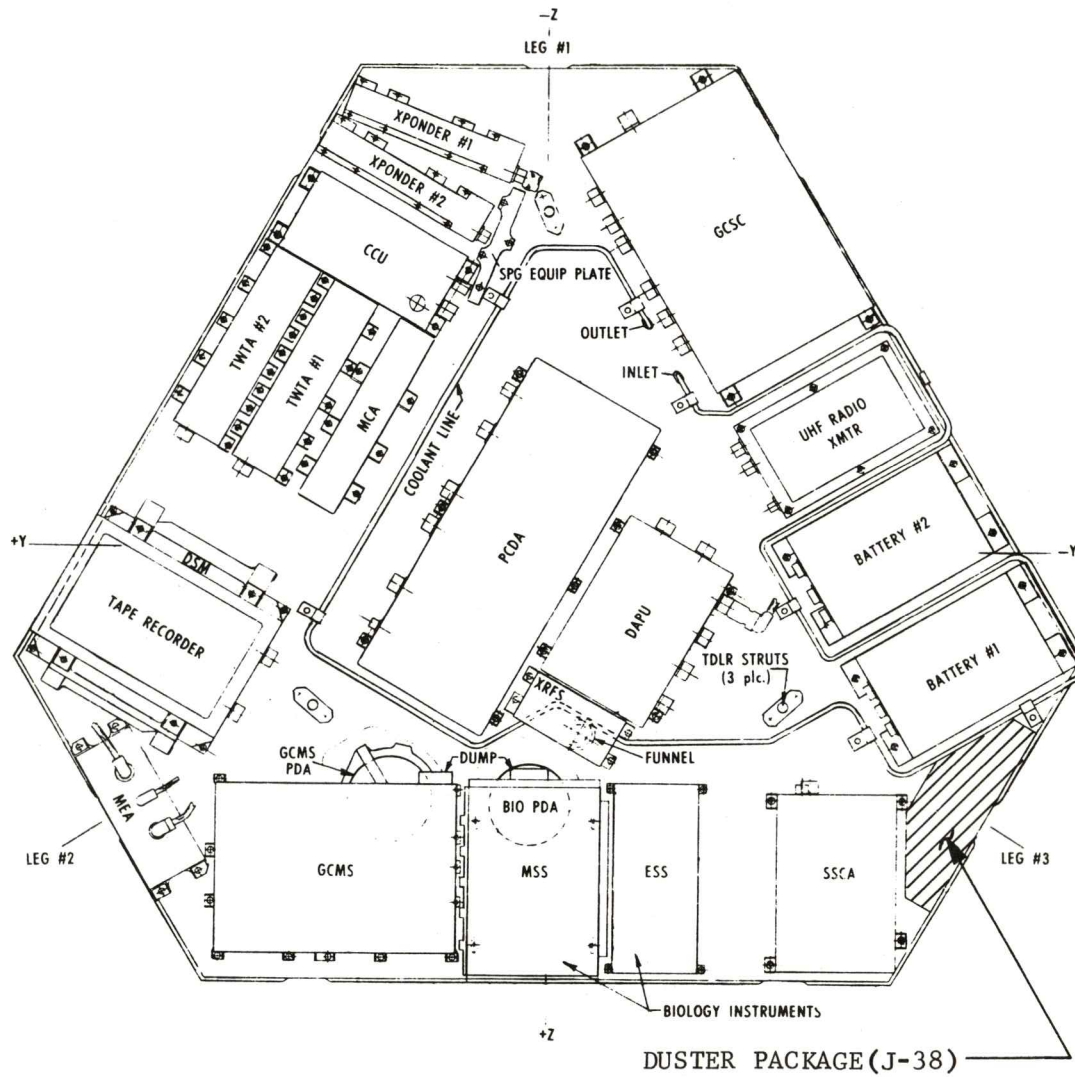


FIGURE 4.8.2.9-5 CAMERA DUSTER MODULE LOCATION

4.8.2.10 Physical Properties Investigation

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4.8.2.10 PHYSICAL PROPERTIES INVESTIGATION

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