ALSEP

MAGNETIC DEFLECTION MASS SPECTROMETER

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CONTENTS

ILLUSTRATIONS

I. INTRODUCTION

A. SCOPE

The scope of this document is to present a report on the development, schedule, tests, and status of the Lunar ALSEP Mass Spectrometer designed to measure the composition of the lunar atmosphere from a position on the lunar surface as part of an ALSEP array of scientific experiments. Included also is a discussion of the rationale for choosing a magnetic mass spectrometer for this program. Expenditure of funds to date is given. Projected development and delivery schedules, along with manpower requirements, and cost projections are presented to show the feasibility of building flight mass spectrometers commensurate with the Apollo 17 flight schedules. Refer to Figures 1-1 and 1-2 for photos of the Spectrometer. Sufficient information is included to illustrate the fact that The University of Texas at Dallas (UTD) has the experience, knowledge, personnel, hardware, and software (documentation) to provide the support that the Lunar ALSEP Mass Spectrometer Program will require.

B. RATIONALE FOR TYPE OF MASS SPECTROMETER PROPOSED

A magnetic deflection sector field, type of mass spectrometer was selected for development into a package suitable for measuring the composition of the lunar atmosphere as part of an ALSEP array of scientific instruments under a contract NAS9-7591, received from MSC in November, 1967. This development phase of the program is now completed. This instrument has also been proposed in "Gas Analyzer for the Lunar Atmosphere-GALA", proposal No. 6969, dated October 25, 1969 (from UTD, John H. Hoffman, PI) for future ALSEP missions. The main reason for selecting a magnetic deflection instrument is its inherent simplicity and stability and its long-proven record in laboratory usage throughout the world for isotopic abundance studies, nuclidic mass determinations, geochronology studies, hydrocarbon analyses and many others. Upwards of 30 magnetic instruments have been flown successfully in rockets to study the composition of the earth's upper atmosphere and ionosphere and five satellites have carried such instruments (the PI of the above referenced proposal has prepared and flown 14 rocket instrument and one satellite Mass Spectrometer with two additional satellite instruments under construction).

The magnetic deflection spectrometer is inherently simple in its design and operation. A sweep voltage is applied to the ion source region which accelerates ions into a collimated beam that enters normally into a magnetic field which separates the ions into different trajectories as a function of their mass. The magnetic field is derived from a small high-flux permanent magnet with low leakage. Being a permanent magnet, no electrical power is consumed in its function. The magnetic field is stable, as are the power supplies which drive the Mass Spectrometer sweep voltage and detector systems making the entire system stability high. Because the magnet design produces little stray field, the flux around the instrument, ie, 12 inches from the magnetic shield encompassing the instrument, is of the order of 1000 gamma. No. R. F. fields are used, the electronics, therefore, being straightforward require a minimum of shielding.

The mass resolution of the magnetic deflection mass spectrometer is adequate to meet the requirements for lunar atmospheric studies. The resolution is such that at mass 135 less than 1 percent contribution occurs from either adjacent mass number peak. At mass 39 there is less than 1 part in 300 contribution from the mass 40 peak (Ar^{40}). The sensitivity of the mass spectrometer is of the order of 5 x 10^{-5} amps/torr of ion current collected at the electron multiplier detector. This sensitivity is equivalent to detection of an ion peak, at 1 count/sec. of 10^{-15} torr. At 10 counts/sec. the signal to noise ratio is 2 or 3. Therefore, the practical sensitivity of the instrument is 10^{-14} torr.

The dispersion of the ion beams at the collector part of the instrument is sufficient to allow the simultaneous detection of three ion beams of mass ratio 1:12:40. This arrangement permits a scan of the mass spectrum from 1 to 160 amu (less the 5 to 11 amu range) by varying the ion sweep voltage by only a factor of 4 (nominally 300 to 1200 volts) thereby simplifying the electronics power supply and reducing the time required to scan the mass spectrum. At a 1 second per voltage step scan rate of the ion sweep voltage, the mass spectrum is scanned in 2000 seconds.

An optional mode of operation allows the complete spectrum to be scanned in 200 seconds at 0.1 sec./step with a corresponding reduction in sensitivity.

The weight of the mass spectrometer package including structural and thermal configuration is 22 pounds. [The power required to operate the instrument is 14 watts including the thermal control circuit, with an additional 6 watts required for a heater that operates below 0°C. Size of the complete package is 11¼" x 7¼" x 12".

The PI for the proposed ALSEP Mass Spectrometer experiment received his PhD in physics at the University of Minnesota under Prof. A. O. Nier. His dissertation involved the construction and use of a double-focussing magnetic Mass Spectrometer to study the distribition of cosmogenic helium in iron meteorites. He has had 12 years experience in the design, construction and operation of magnetic mass spectrometers, as well as data analysis for rocket and satellite experiments.

Complementing capabilities in mass spectrometry, the current research of the University of Texas at Dallas faculty includes an active program of study of planetary atmospheres and exospheres. The Lunar Atmosphere is of great interest to this group both as a planetary atmosphere and as the only accessible example of a classical exosphere.

Two of the co-investigators, F. S. Johnson and D. Evans, are engaged in the Lunar Atmosphere Detector experiment of the present ALSEP program. In addition, R. R. Hodges and F. S. Johnson have published the only (apparently) serious theoretical analysis of global transport of gases in the lunar atmosphere (in Journal of Geophysical Research, 73, 7307, 1968). Ongoing theoretical studies of planetary atmosphere, as well as participation in the ALSEP Lunar Atmosphere Detector experiment and the Mass Spectrometer (SMOG) of the Lunar Orbit Science Program, ensure the degree of competence and continuity essential to realizing the scientific potential of the proposed Mass Spectrometer on the lunar surface.

II. STATUS REPORT

A. CHRONOLOGY OF DEVELOPMENT OF LUNAR MASS SPECTROMETER

The developmental contract NAS9-7591 received from MSC on November 15, 1967 to design, develop, and test a mass spectrometer capable of measuring the composition of the lunar atmosphere. Work was begun immediately on the design of the magnet and analyzer geometry as well as the electronic circuitry. The initial contract called for the instrument to scan the mass range from 12 to 160 amu. Eleven different electronic subassemblies were developed and tested, the details of which are described in Section III.

An electron bombardment ion source was developed with its associated emission control circuitry. In March 1968, all of the electronic circuits were designed, bread-boarded and testing was underway. Attention was then directed to the packaging of the circuits for the prototype model. Thermal and structural analyses were begun at MSC. Mechanical assembly of a breadboard analyser and ion source was completed in May 1968 and testing was begun in the Ultra-High Vacuum chamber at UTD. An electrostatic focusing ion source constructed for the project exhibited some space change limiting of the electron beam. The problem was later rectified by the addition of an axial magnetic field to focus the electron beam on the trap (anode).

The Ground Support Equipment (GSE) was designed and constructed at MSC in conjunction with engineers from UTD. (The system is described in Section III.) The GSE and Data Detection and Compression circuits of the Mass Spectrometer underwent a life test beginning in June 1968 and continuing until November 1968 without exhibiting a failure.

The breadboard designs and tests of the Mass Spectrometer experiment were essentially completed by October 1968. At that time an extension of the contract to July 1969 was approved which added the following requirements:

1) Design, develop, and fabricate magnetic sector tubes and associated electronics to determine mass ranges from 1 a.m.u. to 150 a.m.u. The previous requirement was from 12 to 150 a.m.u.
2) Design and develop necessary internal electronic circuits on suitable thermal boards to provide an internal operating temperature between -20°C to +80°C for proper operation on the lunar surface.
3) Design and develop the necessary additional ionization potential gun and associated electronic sweep circuits.
4) Design and develop method to provide internal calibration of the spectrometer when in a sealed configuration.

A meeting was held on October 18, 1968 at MSC between representatives of SCAS and MSC for the purpose of determining the scope of the project, its definite goals, and the division of effort between the two organizations.

Basically, the project now included constructing two models of the mass spectrometer experiment. The first was a Test Unit which was used for thermal and structural tests to be conducted mainly at MSC. MSC had the main responsibility for building and testing this unit. The second model was a Prototype Unit. This unit was similar to a flight model suitable for the ALSEP program. The main responsibility for developing the analyzer tube, magnet, ion source and electronics lay with UTD. MSC developed the housing and thermal control hardware.

In December 1968, the structural and thermal designs of the prototype were completed and a structural model constructed at MSC. Testing of this model to ALSEP Qualification level vibration specifications was successfully completed on May 22, 1969. The same model was fitted with printed circuit boards having heat loads equal to the design heat dissipation of the prototype PC boards. A thermal vacuum test of lunar day and night conditions conducted in June 1969 showed no heat dissipation problems. In general, the temperatures ran cool. See Section V for results.

The Prototype instrument was constructed simultaneously with the Structural and Thermal models. The instrument was completed in August 1969 and tested at UTD. (See Section IV for test results.) However, a major catastrophe occurred in that a high-voltage arc destroyed a large number of integrated circuits in the digital sweep control circuit and the output detector circuitry. The problem was finally traced to a large capacitor which had no discharge path and had accidentally, through handling, discharged through the components that were destroyed. The problem was rectified, new components obtained and the Prototype environmental tests were conducted at MSC in January 1970. The results may be found in Section V. The contract was extended to March 31, 1970 to cover these tests.

A contract to develop the Lunar Orbiter Mass Spectrometer was received by UTD on January 29, 1970. Subsequently, the majority of the electronics circuits of the ALSEP instrument were redesigned and re-packaged. A complete set of drawings exists. The new generation of circuit designs represents a "second generation" design for the Mass Spectrometer. Approximately 70 to 80 percent of the designs of the Orbital Mass Spectrometer electronics are identical to those for the proposed ALSEP instrument, the differencies lying in the interface with the ALSEP Central Station and it is proposed to use the new designs whenever possible for the ALSEP instrument.

B CURRENT STATUS OF HARDWARE

A prototype model of the Mass Spectrometer proposed for the Lunar ALSEP mission has been constructed and tested. The instrument has undergone ALSEP qualification level environmental tests at MSC, the results of which are discussed in Section V. These included both a vibration and thermal vacuum test. The instrument passed both with no problems having been uncovered. The prototype Mass Spectrometer is shown in Figures 2-1 and 2-2. Thermal control is accomplished by an active heater control circuit in the electronics housing (the top half of the package in the picture). Heaters are operated below 0°C and turned off above 6°C. The electronics package is surrounded on five sides by a thermal blanket, and covered with surface mirrors on the top side. The mirrors are attached to a radiator plate to which the electronics printed circuit boards are tightly coupled thermally. Heat loss is by radiation from the mirrored surface.

On January 29, 1970 a contract was received at UTD to build a Mass Spectrometer for the Lunar Orbital Science Mission. This instrument is similar to the ALSEP Prototype except for the mass range scanned (12-66 amu for the orbital instrument). The complete electronics circuitry has been redesigned for the orbital instrument using the ALSEP designs as a basis. Significant improvements have been made in these "second generation" circuits. The similarity between the orbital Mass Spectrometer and the proposed ALSEP plight instrument is so great that approximately 70 to 80 percent of the circuits would be identical and be used unchanged (same artworks and PC cards) for the ALSEP mission. The differences lie mainly in the command interface and the high voltage sweep stepping control circuits (a wider mass range is scanned by the ALSEP instrument).

The magnetic analyzer for the proposed instrument is similar to that developed for the ALSEP Prototype and very little design work would be required in this area. The structural and thermal designs done previously would be applicable.

The Ground Support Equipment (GSE) to support testing of the Mass Spectrometer has been developed and is operational. Its functions are described in Section III.

III. TECHNICAL SPECIFICATIONS

A. MASS SPECTROMETER

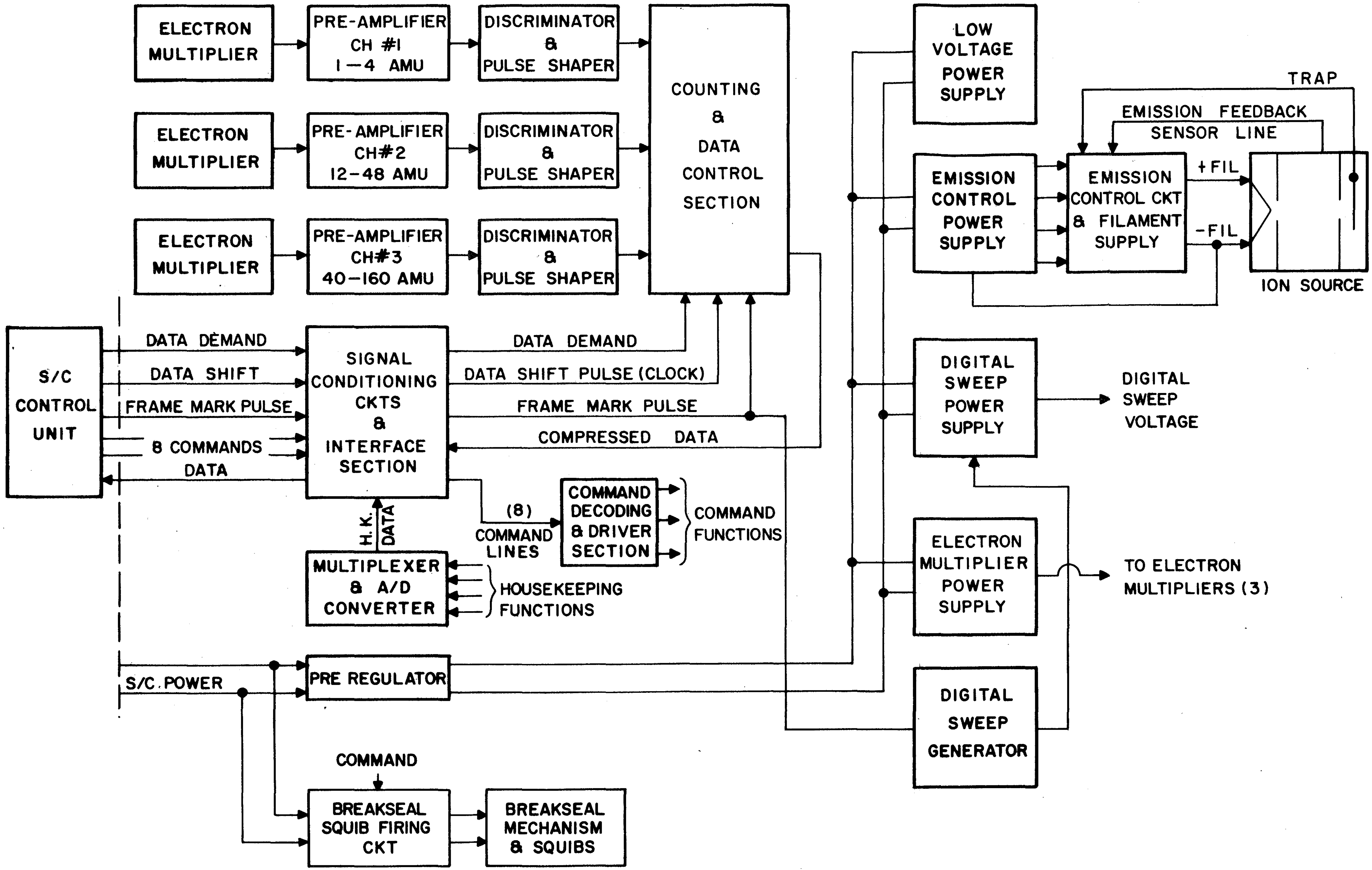
The primary objective of the ALSEP Mass Spectrometer is to measure the composition of the lunar atmosphere. This shall be accomplished utilizing a magnetic sector-field mass spectrometer as part of an ALSEP array of experiments to be placed on the Lunar surface by an Astronaut. The instrument will scan the mass range from 1 to 150 amu in three sections, and will have a sensitivity of 10^{-14} torr.

1. System Performance Characteristics

For the following discussion, refer to the block diagram of the Spectrometer (Figure 3-1).

The mass spectrum is scanned by varying the ion-accelerating voltage in a step-wise manner and counting the number of ions collected by each of three electron multiplier detector systems during each voltage step. The mass range scanned is divided into 3 ranges, 1-4, 12-48, and 40-160 amu, each range being detected by one of the electron multipliers. This is accomplished in the following manner (refer to Figure 3-2):

Atmospheric gas molecules collected by the inlet aperture of the mass spectrometer are ionized by electron impact in the ion source and collumated into a beam which traverses a magnetic field that acts as a momentum analyzer. Ions following three preselected trajectories are focussed on three separate collector



LUNAR MASS SPECTROMETER
FUNCTIONAL BLOCK DIAGRAM

slits and allowed to impinge on the cathodes of separate electron multipliers. The resultant electronic gain of the multiplier yields a charge pulse at its anode which is counted by pulse amplifier and counter circuitry. The ion-accelerating voltage is varied in a step-wise manner from approximately 280 volts to 1220 volts in 2000 steps.

Dwell time on each step (the counting period) is not critical, but can be selected by command to be either 100 milliseconds or 1 second. Counts are accumulated for this period and stored in a 21-bit accumulator, (one for each channel). An enable pulse from the ALSEP Data System triggers the counting period, and steps the ion accelerating voltage. Immediately following the enable pulse, the data are compressed and stored in 10-bit buffer registers to be sampled by the telemeter system within the next counting period following the data accumulation. Meanwhile count accumulation for the next voltage step occurs. Two enable pulses (10-per-second rate) are received each 100 millisecond period. The trailing edge of the later one initiates the start of a counting period. The voltage step number initiated by a sweep start flag determines the mass number of the ion being detected.

The ion accelerating voltage sweep is generated by varying the voltage in a series of 1980 steps from 280 volts to 1220 volts according to the following plan: 900 steps at 0.225 volts per step, 520 steps at 0.45 volts per step, 560 steps at 0.90 volts per step, 10 steps at zero volts for background counting, and 10 steps at zero volts for a 32 kHz calibration frequency. A flag will indicate data or background and serve as a marker for the start of each sweep. The maximum range of the 1220 volt end of the sweep is $\pm$30 volts; maximum range of the 280 volt end of the sweep is $\pm$10 volts, depending on the magnetic field value. The minimum number of steps between adjacent mass peaks below mass 135 is 12 and the mass resolution is such that at mass 130 amu there is less than 1 percent contribution from adjacent peaks. At a dwell time of one second per step the sensitivity of the instrument is on the order of 10^{-14} torr. The response time of the high voltage step change shall be less than 10 milliseconds.

Internal calibration occurs after each sweep of the mass spectrum during the 20 zero-volt background and calibration steps by applying an internal 32 kHz clock output to the counter inputs for the last 10 steps of this period.

a. Telemeter Format

The ALSEP Data System format contains 8000 8-bit words repeated each second. Ten sets of two 8-bit words each per 100 millisecond period contain the mass spectrometer data; a single discrete bit is the data-background flag. In addition, a single zero to five analog housekeeping channel, which is sampled once per second, is provided. Sixteen (16) instrument parameters are monitored, commutated internally to the instrument and outputed sequentially on this channel. The housekeeping monitors are shown in the following list.

1. +12 volts
2. +5 volts
3. -12 volts
4. -15 volts
5. Emission current
6. Filament current
7. Instrument current
8. Electron multiplier voltage (low mass)
9. Electron multiplier voltage (high mass)
10. Sweep high voltage monitor
11. Temperature 1 (Electronics)
12. Temperature 2 (Ion Source)
13. Status flags (Multiplier HI-LO)
14. Status flag (Discriminator HI-LO)
15. Status flag (Filament 1-2)
16. Marker (0 volts).

Summary of telemeter requirements:

30 10-bit words/second

10 discrete flag bits/second

1 sample/second housekeeping channel (analog input).

b. Commands - Seven up-leg command words, 6 of which are encoded by pairs give 15 discrete command functions. These are tabulated below.

Command No.	Command Generated	Command No.	Command Generated
1 & 2	High Data Rate	3 & 4	Multiplier Lo
1 & 3	Low Data Rate	3 & 5	Break Seal
1 & 4	Discriminator Hi	3 & 6	Dust Cover
1 & 5	Discriminator Lo	4 & 5	Power On
1 & 6	Filament No. 1	4 & 6	Power Off
2 & 3	Filament No. 2	5 & 6	Not assigned
2 & 4	Multiplier Hi	7	Command Clear
2 & 5	Emission Off		
2 & 6	Emission On		

2. Subsystem Performance Characteristics

For purposes of discussion relating to functional subsystem levels, the Mass Spectrometer is divided into the Data Subsystem, Ion Source and Control Subsystem, Sweep High Voltage Subsystem, Power Converter Subsystem, and the Thermal Control, Housekeeping Monitor and Signal Conditioning Subsystem, Refer to Figures 3-3 through 3-7 for subsystem block diagrams.

a. Data Subsystem

The Data Subsystem (Figure 3-3) consists of the high voltage power supply, electron multiplier, preamplifier, discriminator and pulse shaper, prescaler, and counter and data compressor.

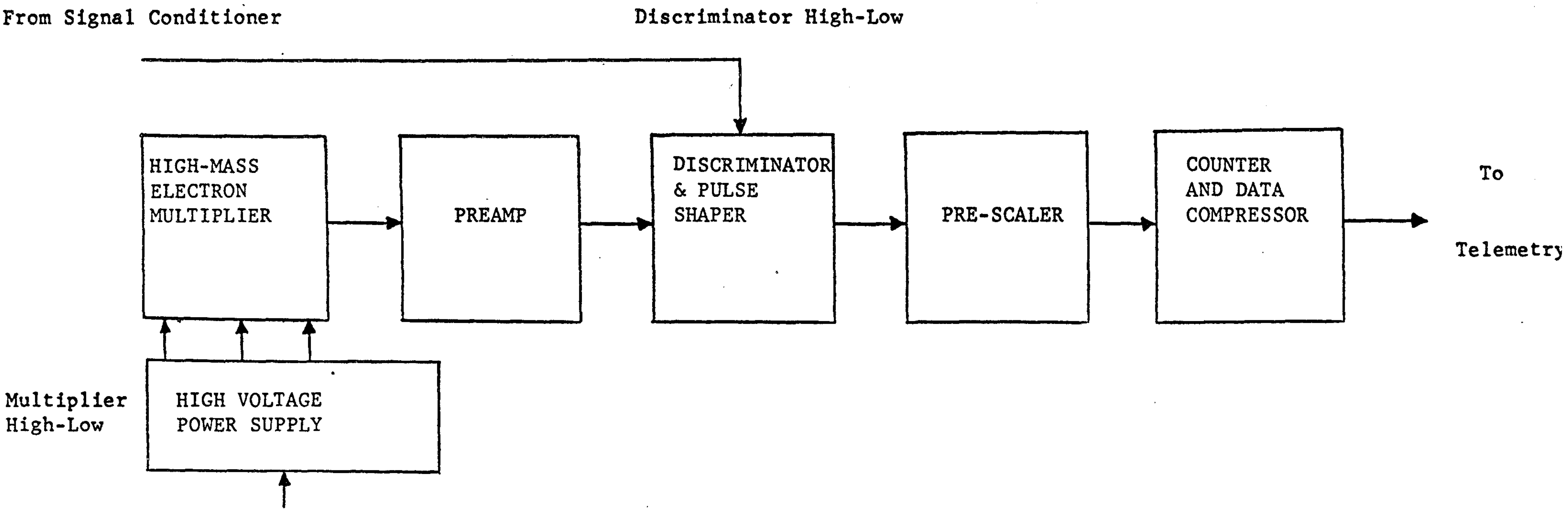


FIGURE 3-3. DATA SUBSYSTEM BLOCK DIAGRAM
THREE CHANNELS REQUIRED

The electron multiplier high voltage power supply requires voltage inputs of -12 volts, +12 volts, and +20 volts in addition to the multiplier gain control voltage. It supplies a nominal output voltage of 3500 volts which is adjustable by command.

The electron multiplier (ion collector) has a gain of 10^6 and functions as collector for the ions which pass through the magnetic analyzer. Three electron multipliers are required in the Spectrometer, one for each mass range channel. (Refer to Section III A-1). Each ion striking the multiplier cathode produces an output pulse which is counted.

Basically an AC amplifier with approximately 60 db gain, the preamplifier amplifies the pulse output of the electron multiplier to a usable level for the discriminator and pulse shaper.

The input reference level of the discriminator is controlled by command. This command can set the discriminator's sensitivity level at one of two values such that a noise pulse will not trigger the discriminator. A pulse amlitude exceeding the preset cutoff level of the discriminator will cause the discriminator to conduct and will produce a pulse output to the pre-scaler.

The pre-scaler is a divide-by-two counter which selects every other pulse for output to the counter and data compressor.

The counter and data compressor converts a 21-bit number into 10 bits for readout. Steps in which the data are compressed are as follows (refer to the following figure for a typical data compressor output):

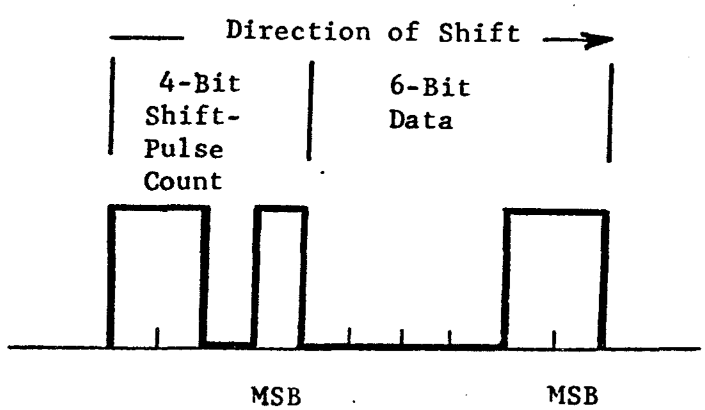
1. The data number is transferred from a 21-bit counter to a 21-bit shift register.
2. Shifting of the data number begins. A shift counter is used to count each shift pulse.
3. The shifting process stops when the most significant one bit (MSB) of the data number is detected in the last stage of the shift register.
4. The six bits following this MSB are saved for readout. This number is called "D".
5. The number of shifts is transferred to the four stages in the shift register immediately behind the number "D". This shift count is called "S".
6. A maximum of 21-7 = 14 shifts is allowed. These 14 shifts will position the six lowest significant bits so they will be equal to "D".
7. Shift count 14 stops the shifting process whether MSB is equal to 1 or 0. The counter will increment to 15 if MSB = 0. If MSB = 1, the shift counter will remain at 14. The 6-bit number "D" will be read out first starting with the most significant bit.

"S" follows with its most significant bit first. The equation for reconstructing the value of the 10-bit register bit is:

$$(D264)\ 2^{14-S}, \text{ if } S\text{-}14$$

$$D \qquad\qquad , \text{ if } S=15$$

When the shift count S-14, the MSB is always equal to 1. Therefore, the value 64 must be added to obtain the correct data value. When S=15 the MSB=0, and no correction to "D" is required.



Typical Data Compressor Output

b. <u>Ion Source and Control Subsystem</u>.

The Ion Source and Control Subsystem (Figure 3-4) consists of the emission control circuit, and the ion source. Two filaments are available for redundancy. The following paragraphs provide a discussion of subsystem performance characteristics.

The emission control circuit is used to control and switch the filament voltages in case of failure of the operating filament. The operating filament, requiring approximately 1.6 amps, is at a potential of -80 volts with respect to the ionization chamber, and the standby filament, which serves as an electron trap, is maintained at a +45 volts referenced to sweep voltage. Additional functions include application and control of voltages on the focus grid, ion chamber, and J plates number 1 and 2. The potential on the focus grid is -3 volts referenced to sweep voltage, and the ion chamber has the ion-accelerating sweep voltage applied to it. This sweep voltage, which is a series of voltage steps, provides the Mass Spectrometer's ability to scan the ion spectrum.

The ion source performs the function of ionization by electron bombardment of the atmospheric gas molecules, accelerating these ions and forming a collumated beam directed into the magnetic analyzer.

c. <u>Sweep High Voltage Subsystem</u>.

The Sweep High Voltage Subsystem (Figure 3-5) consists of the sweep high voltage power supply and the digital sweep control circuit. A discussion of their performance characteristics is presented in the following paragraphs.

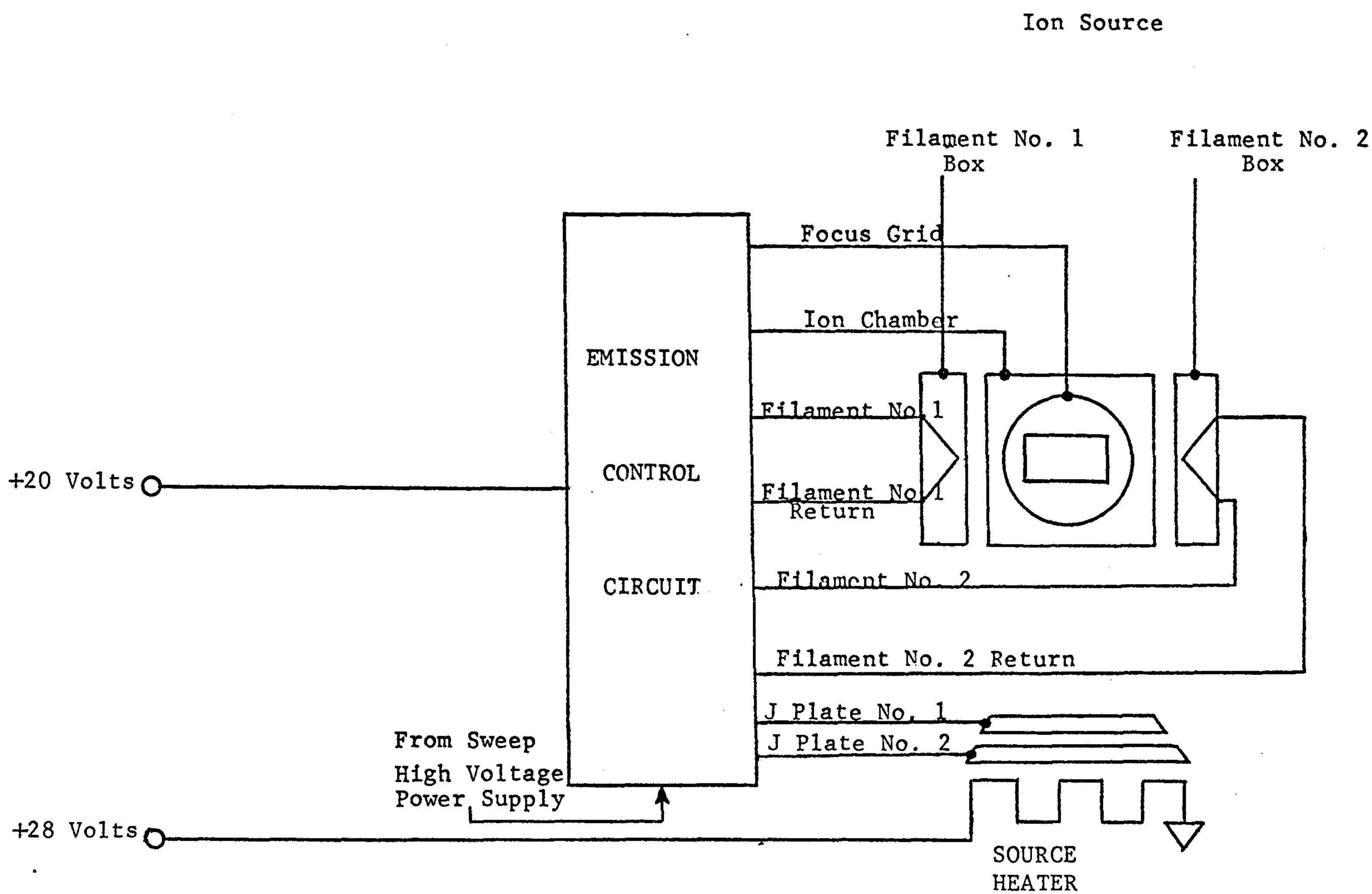


FIGURE 3-4. ION SOURCE AND CONTROL SUBSYSTEM BLOCK DIAGRAM

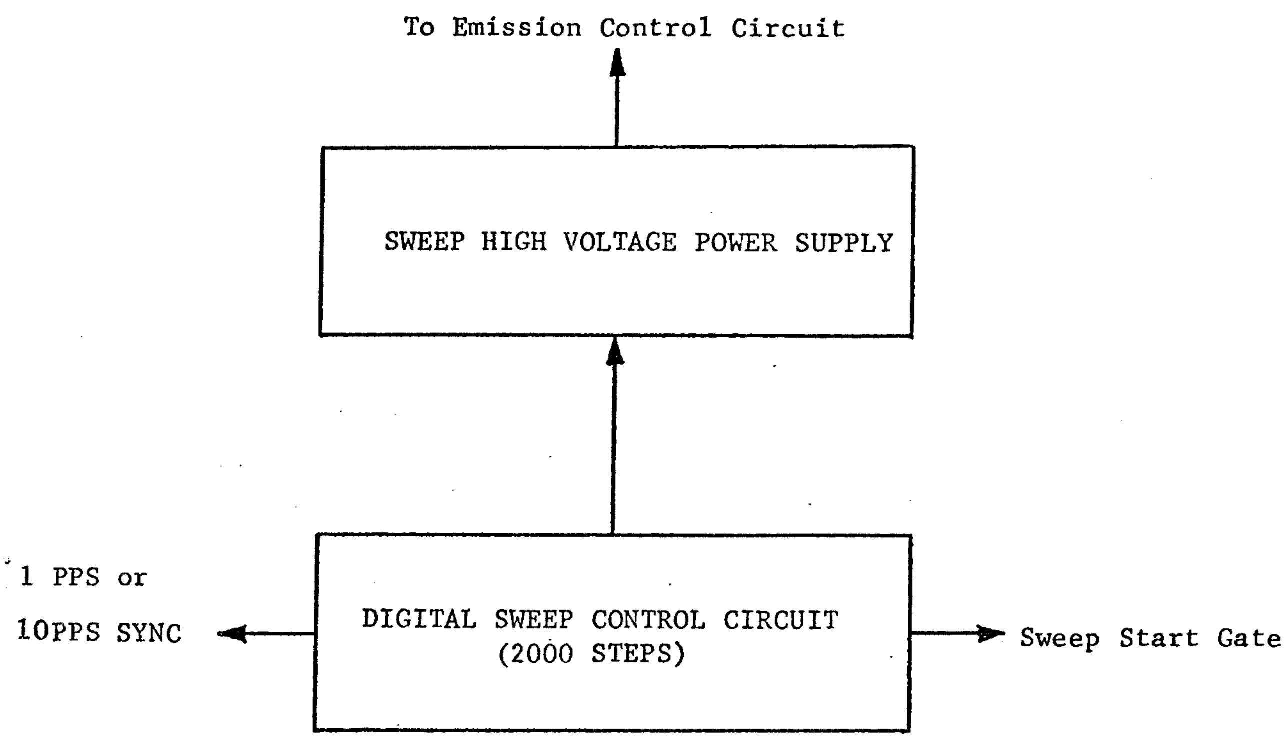
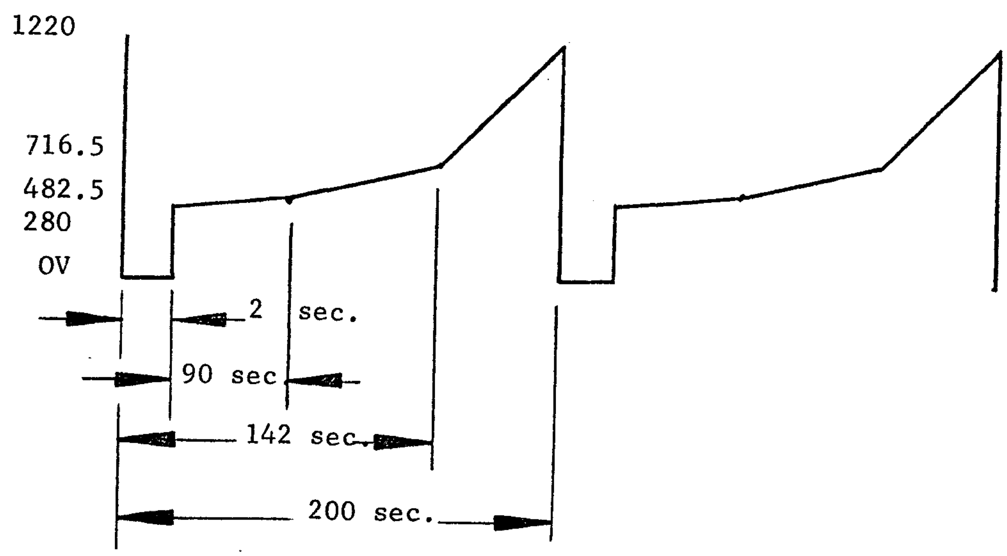


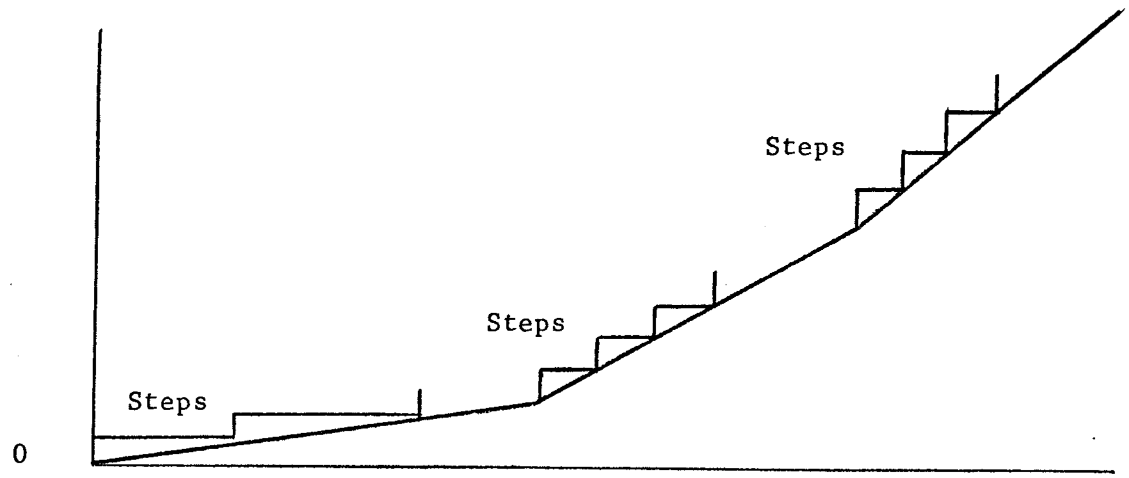
FIGURE 3-5. SWEEP HIGH VOLTAGE SUBSYSTEM BLOCK DIAGRAM

The sweep high voltage power supply develops the high voltage level on which the ion source rides. The circuit obtains +20V from the switching pre-regulator, and the two control signals (sweep and pedestal) from the digital sweep control circuit. This combination provides an output voltage which sweeps from 0 volts to 1220 volts in the following manner:

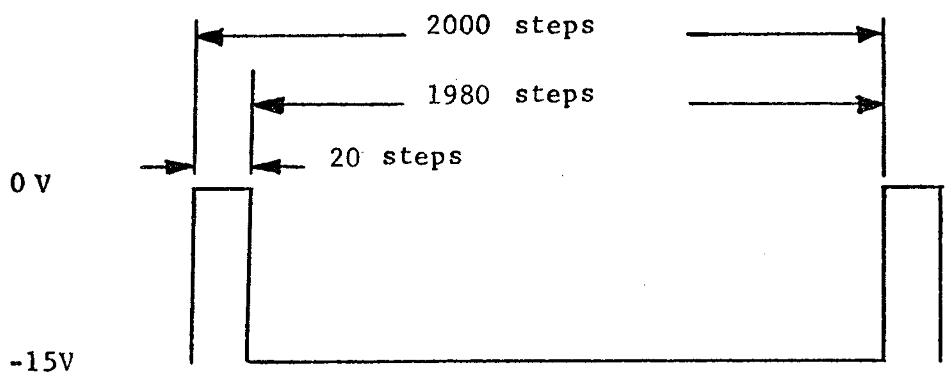


After setting in the background count mode (0 volts) for twenty counting periods (equivalent to 20 zero volt steps) the output begins to increase in a stepwise manner from 280V by 0.225 volt steps (900) until it reaches 482.5. The step size then doubles to 0.45 volt/step for 520 additional steps to 716.5 volts. The step size again doubles to 0.90 volts/step for 560 steps to 1220 volts. The total number of steps, including the background mode is 2000, at 0.1 sec/step the sweep time is 200 sec. The output now returns to zero volts and the sweep cycle starts over.

The digital sweep control circuit develops a sweep output and a pedestal output. Together these two outputs control the sweep high voltage power supply. These outputs are referenced to the 10 PPS or 1 PPS input (10 steps/sec. or 1 sec/step). The sweep output consists of three straight lines which approach an exponential as shown.



The pedestal voltage is at zero volts for 20 steps and -15 volts for 2000 steps as shown.



d. Power Converter Subsystem.

The Power Converter Subsystem (Figure 3-6) consists of the switching pre-regulator and the low voltage power supply.

The switching pre-regulator obtains 28 volts from the Central Station and provides a regulated +20V to $\pm$.25V output, at more than 85 percent efficiency. This output is used for the low voltage power supply, the

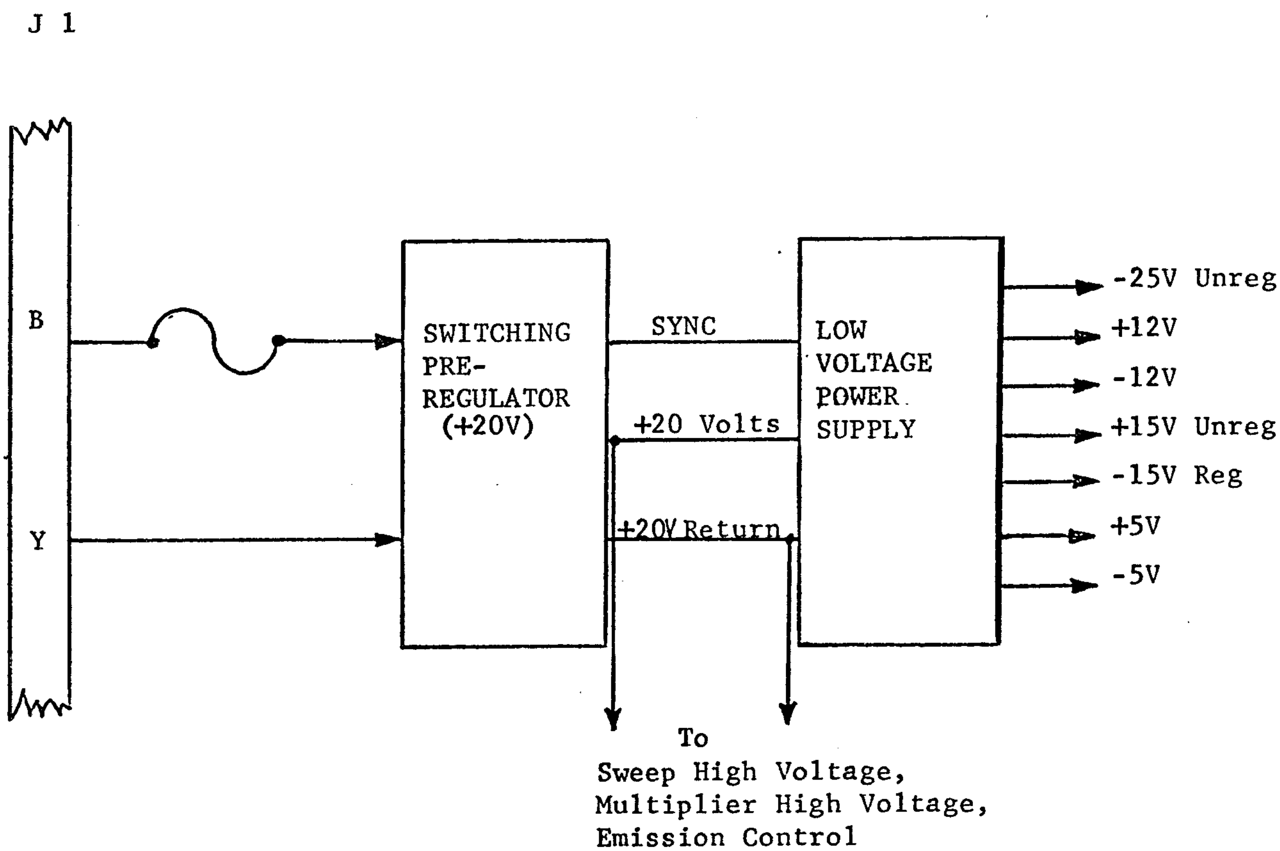


FIGURE 3-6. POWER CONVERTER SUBSYSTEM BLOCK DIAGRAM

sweep high voltage power supply, the multiplier high voltage power supply, and the emission control circuit. The circuit is operated as a driven regulator. The drive oscillator develops a 50KHz signal which is scaled to 25KHz and used to externally drive the regulator, which supplies 0.6 amps of current in normal operation. In the event the drive oscillator should fail, built in redundancy provides for the circuit to self-oscillate and continue to provide the output at a slightly reduced efficiency. In the event the output is shorted or overloaded, the circuit will operate in the current limit mode and will drain less current from the CM than in the normal mode. The input is also designed to accept rather large voltage spikes (50V) on the CM input line.

The low voltage power supply accepts the +20 volts from the switching pre-regulator and develops -25 volts, +12 volts, -12 volts, -15 volts, -15 volts reference, +5 volts and -5 volts. These voltages are used throughout the instrument. The circuit is driven at 12.5KHz from the same drive oscillator as the switching pre-regulator. The circuit is driven at one-half the frequency of the switching pre-regulator to obtain a well balanced power system. In the event of a drive oscillator failure, the circuit will self-oscillate and continue to provide all outputs at a slightly reduced efficiency.

e. Thermal Control, Housekeeping Monitor, and Signal Conditioning Subsystem

This Subsystem (Figure 3-7) consists of thermal control, housekeeping monitor, and signal conditioning circuits installed on printed circuit boards.

The thermal control circuitry consists of the -12 volt monitor, -15 volt reference monitor, instrument current monitor, mass spectrometer temperature monitor, electronic temperature monitor, and thermal control. It performs its function of regulating Spectrometer temperature by utilizing these reference, monitor, and control circuits to switch on and off a pair of patch heaters. Housekeeping and monitor circuits consist of the multiplexer, output buffers, two 32 KHz oscillators, and a divide-by-ten counter. The multiplexer samples 16 analog monitors at the rate of one per second, and the information is sent by separate voltage followers to the spacecraft and to the diagnostic connector. Buffers are provided to ensure that signals reach the Spectrometer with minimum deterioration due to cable loss. One of the 32 KHz oscillators is used to provide, through a monostable multivibrator, 50-nanosecond internal calibration pulses to the preamp-discriminator. It also provides a 32 KHz pulse stream to the high-mass data compressor.

The other 32 KHz oscillator provides a 32 KHz pulse stream to the low-mass and intermediate mass data compressors, and to the instrument current monitor circuit. The divide-by-ten counter receives the buffered 10 PPS from the spacecraft and generates a 1 Hz pulse stream which is used in the multiplexer, and a sync pulse for the diagnostic BTE.

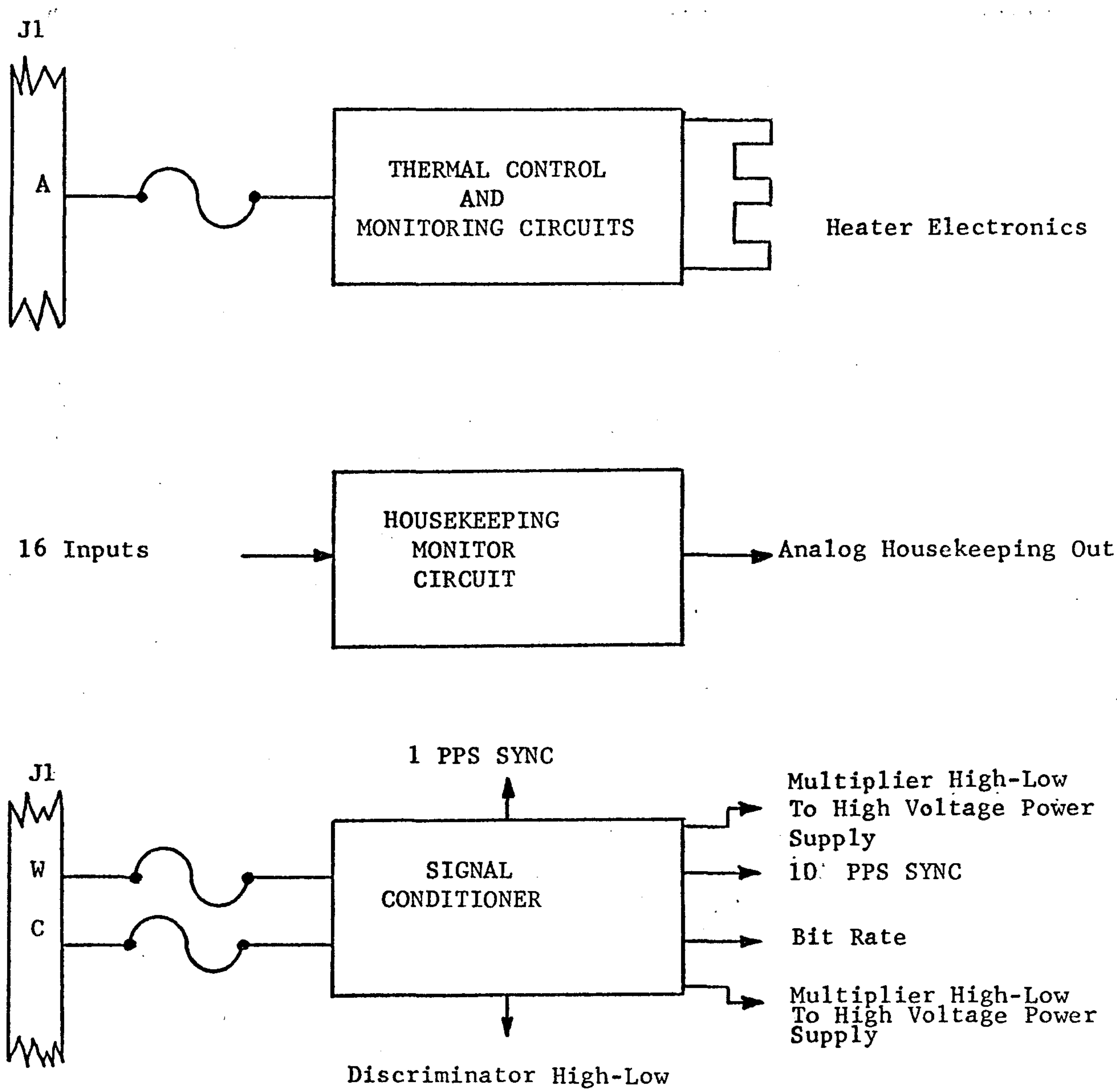


FIGURE 3-7. THERMAL CONTROL, HOUSEKEEPING MONITOR, AND SIGNAL CONDITIONER SUBSYSTEM BLOCK

3. Component Performance Characteristics

The component level treatment of the Mass Spectrometer consists of dividing the PC boards and other components into separate and discrete functional entities. Schematic diagrams of the PC boards are provided for a better understanding of the individual component. (Refer to Figures 3-8 through 3-19). For a more detailed discussion of performance characteristics, refer to subsystem discussion in Section III A-2.

a. Multiplier High Voltage Power Supply.

The power supply outputs identical voltage outputs to Channels A, B and C. Discrete circuits of the multiplier high voltage power supply (Figure 3-8) consist of the following:

Circuit	Characteristics
1. DC to DC converter	Converts CM output for Spectrometer use
2. Control loop op amps	Referenced at -15 volts
3. Output filter	
4. Diode voltage divider networks	Constant level outputs
5. Voltage monitor	

b. Electron Multiplier

The electron multiplier (Figure 3-2) is reduced to separate components as follows:

Component	Characteristics
1. Cathode	Ion-electron conversion
2. Dynodes	Electron multiplication
3. Anode	

c. Preamplifier

The preamplifier (Figure 3-9) is basically a straight-forward ac amplifier. There is one each preamplifier in Channels A, B and C.

d. Discriminator and Pulse Shaper.

These two circuits (Figure 3-9) are divided down to their lowest functional level and their titles describe their function. There is one each discriminator and pulse shaper in Channels A, B and C.

e. Pre-scaler

The pre-scaler (Figure 3-9) is a divide-by-two counter which selects every other pulse for output to the counter and data compressor. There is one each per-scaler in Channels A, B and C.

f. Counter and Data Compressor.

There is one each counter and data compressor in Channels A, B and C. Circuit delineation of the counter and data compressor (Figure 3-10) is as follows:

Circuit	Characteristics
1. Timing and control	Reference
2. 21-bit counter	Counts each shift pulse
3. 21-bit shift register	Data compression
4. Shift pulse counter	Stops shifting process

g. Emission Control.

The emission control (Figure 3-11) selects and controls the filament which is the source of electrons in the ion source.

Discrete circuits are as follows:

Circuit	Characteristics
a. DC to DC converter	T1 designed with 1600 volts isolation
b. Emission 1 detector (Module EM-1)	Filament fails, 5 second delay, 30 msec. one-shot pulse output
c. Bistable (Flip-flop multi-vibrator (Module EM-2)	Triggered by 30 msec. pulse
d. Emission current regulator	Emission current at constant level
e. Filament monitor	T4 and T7 sense current in filaments
f. Sweep voltage dropping network	Provides voltage for drawout and plates J1 and J2

h. Sweep High Voltage Power Supply

The following list shows the circuits contained within the sweep high voltage power supply (Figure 3-12).

Circuit	Characteristics
a. Input filter	
b. DC to DC inverter	Converts CM output for use in Spectrometer
c. Cockroft-Walton quadrupler	Voltage multiplier
d. Op amp	Provides control
e. Photo-sensitive transistor	Control

i. Digital Sweep Control

The digital sweep control (Figure 3-13) consists of the following circuits:

Circuit	Characteristics
a. Binary counters	These circuits are used to develop a sweep and pedestal output for control of the sweep high voltage.
b. Logic circuits	
c. Digital/analog converter	

j. Switching Pre-Regulator

The switching pre-regulator (Figure 3-14) consists of the following:

Circuit	Characteristics
a. Input filter	Input designed to accept voltage spikes of 50 volts.
b. Pre-regulator	0.6 amps current (normal)
c. Blocking oscillator	Provide operation in case of failure in normal mode
d. Scales (Flip-flop)	Scales 50 KHz to 25 KHz
e. Fold-back current limiter	
f. Output filter	

k. Low Voltage Power Supply

Discrete circuits contained in the low voltage power supply (Figure 3-15) are as follows:

Circuit	Characteristics
a. Input filter	Filter and isolation
b. Inverter drive	
c. DC to DC converter	Converts DC output for use in Spectrometer
d. Low voltage regulator	Regulates output
e. Failure mode	Self-oscillation provides power at reduced efficiency

l. Thermal Control

Thermal control circuits (Figure 3-16) are contained in the following list:

Circuit	Characteristics
a. -12 volt monitor	Utilizes the reference, monitor, and control circuits to switch on and off a pair of patch heaters.
b. -15 volt monitor	
c. Instrument current monitor	

d. Mass Spectrometer temperature monitor

e. Electronic temperature monitor

f. Thermal control

m. Housekeeping Monitor

Housekeeping monitor circuits (Figure 3-17) are listed as follows:

Circuit	Characteristics
a. Multiplexer	Samples 16 analog monitors
b. Output buffers	Ensure minimum deterioration of signal
c. 32 KHz oscillators (2)	One provides 50-nanosecond internal calibration pulses to preamp-discriminator and a high-mass data compressor. The other provides 32 KHz pulse stream to the low-mass and intermediate mass data compressors, and to the instrument current monitor.
d. Divide-by-ten counter	Receives buffered 10 PPS input and generates 1 Hz pulse stream for multiplexer and sync pulse for diagnostic BTD.

n. Signal Conditioning

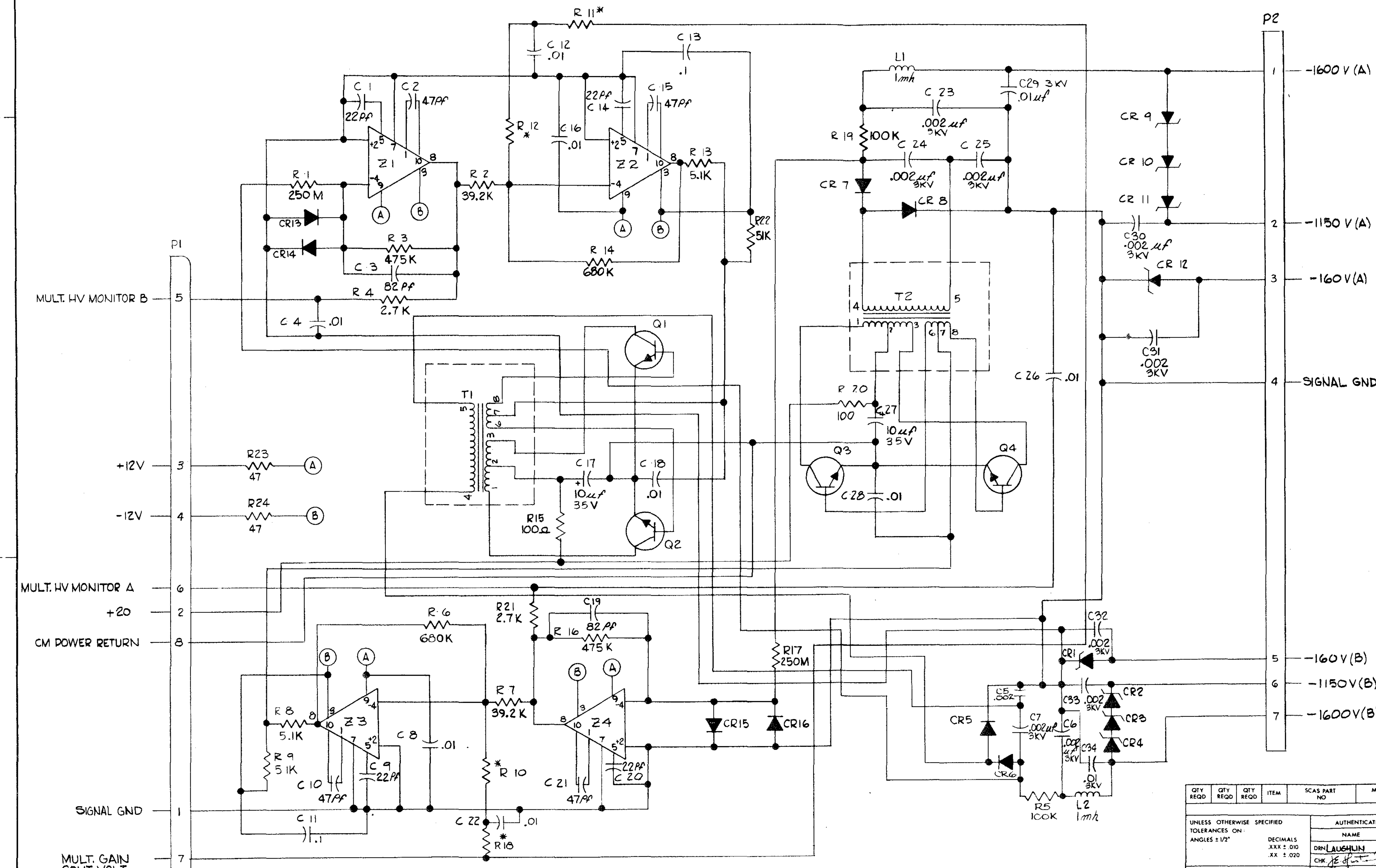
Signal conditioning (Figure 3-18) consists of the following:

Circuit	Characteristics
a. Babcock BR16 non-latching relays (5)	Switch gains for high and low mass

o. Heater and Sensor Circuit

Refer to Figure 3-19.

LTR	DESCRIPTION	DATE	APPROVAL
REVISIONS			
A	CHANGES MADE PER DCN #20	4/2/70	H.B.
B	REV PER DCN 27 4-10-70 MLH	4/10/70	JEH E.M.



3. RESISTORS INDICATED THUS * ARE TO BE SELECTED DURING FUNCTIONAL TEST
2. CAPACITOR VALUES ARE IN MICRO-FARADS
1. RESISTOR VALUES ARE IN OHMS;

NOTES: UNLESS OTHERWISE SPECIFIED:

LAST NO. USED	NOT USED
Z4	
Q4	
CR16	
R24	
C34	
L2	
T2	
P2	

REF DES	PART TYPE	RATING
Z1-4	NH0001/883	
Q1-4	S2N2102	
CR1,12	1N990B	
CR2-4,9-11	1N989B	
CR5-8	SO30G	
CR13-16	JANTX1N914	
R1,17	MOX-750	±1%
R2,3,7,10-12,16-18	RNC55	±1%, ⅛W
R4,5,6,8,9,13,14,19,21-24	RCR07	±5%, ¼W
R15,20	RCR20	±5%, ½W
C1-3,9,10,14,15,19-21	CKR05	±10%, 200V
C4,8,12,16,18,22,11,13,26,28	CKR06	±10%, 200V
C5-7,23-25,30-33	DD30-202	±20%, 3000V
C17,27	CSR13	±20%, 50V
C29,34	41C121A2	±20%, 3000V
L1,2	1537-745	±10%, .2W
T1,T2	150-	

NEXT ASSY	USED ON
R150-500	
APPLICATION	

QTY REQD	QTY REQD	QTY REQD	ITEM	SCAS PART NO	MFG'R PART NO	NOMENCLATURE OR DESCRIPTION
LIST OF MATERIAL						

UNLESS OTHERWISE SPECIFIED TOLERANCES ON: ANGLES ± 1/2° DECIMALS .XXX ± .010 .XX ± .020

MATERIAL

APPLIED FINISH

AUTHENTICATION: DRN LAUGHLIN 2-26-1970; CHK 3/23/70; DSGN 3/24/70; APP 3/30/70; APP 3-30-70; R/QA 3-31-70

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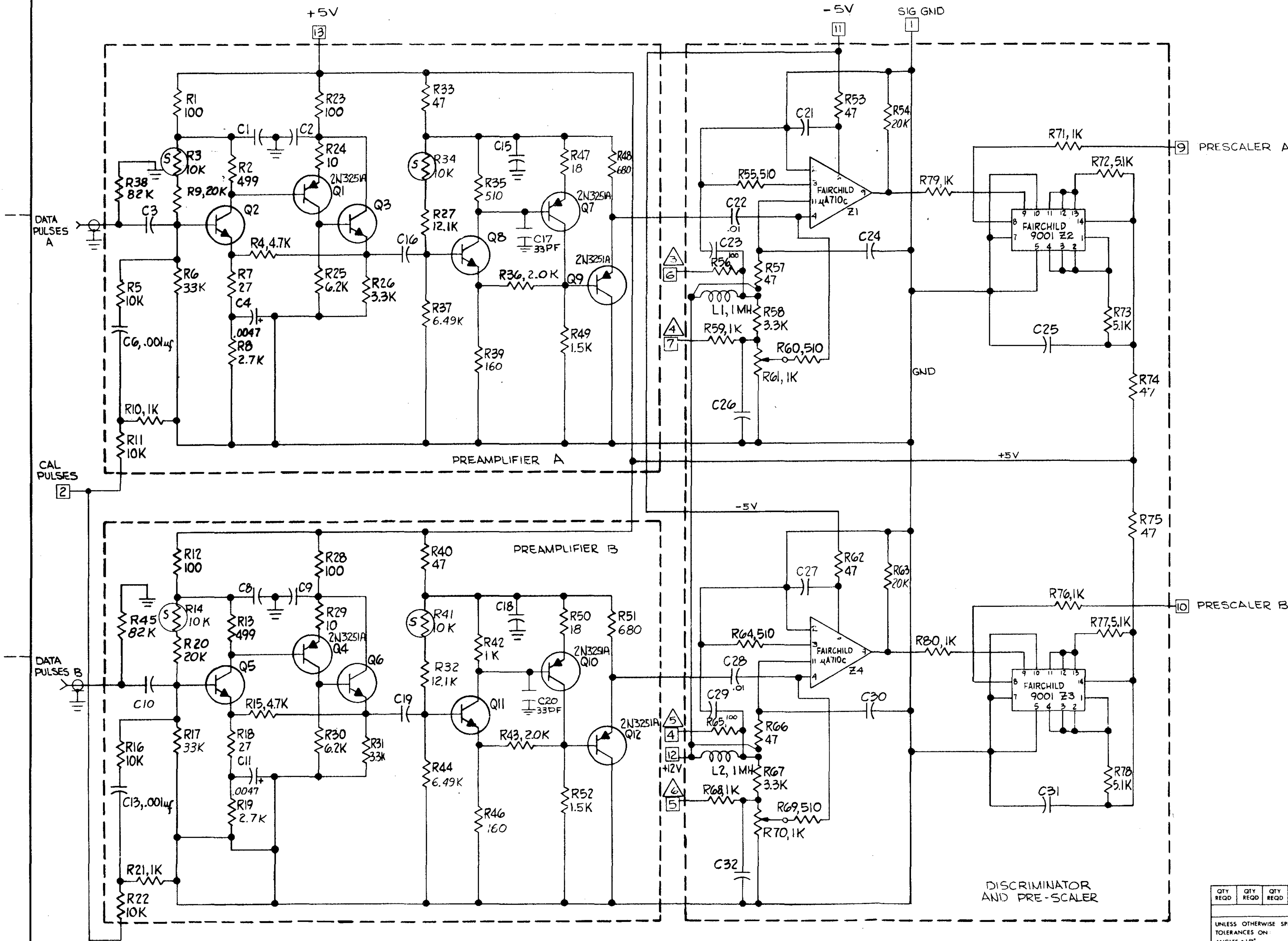
SCHEMATIC DIAGRAM — MULT HIGH VOLTAGE POWER SUPPLY A11

D 150-602 REV B

SCALE: NONE WT SHEET 1 OF 1

Figure 3-8. Multiplier High Voltage Power Supply PC Board Schematic Diagram

LTR	REVISIONS DESCRIPTION	DATE	APPROVAL
A	REVISED PER DCN NO. 33 4-15-70	4/16/70	JEH F.M.



LAST NO. USED	NOT USED
Z4	
Q12	
R80	
C32	C5, 7, 12, 14
L2	

REF DES	PART TYPE	RATING
Z1, Z4	U3F7710312	
Z2, Z3	9001	
Q1, 4, 7, 9, 10, 12	JAN TX 2N3251A	
Q2, 3, 5, 6, 8, 11	JANTX2N2222A	
R1-2, 4-8, 10-13, 15-19, 21-26, 28-31, 33, 35, 36, 38-40, 42-43, 45-60, 62-69, 71-80	RCR07G	±5%, 1/4W
9, 20, 27, 32, 37, 44	RNC55H	±1%, 1/10W
R61, 70	3260 W	±5%, .2W
C1-4, 8-11, 15, 16, 18, 19, 21-32	CKR06	±10%, 200V
C6, 13, 17, 20	CKR05	±10%, 200V
L1, 2	1537	±10%, .2W
R3, 14, 34, 41	TM-1/8	±10%, 1/8W

NOTES: UNLESS OTHERWISE SPECIFIED

1. RESISTOR VALUES ARE IN OHMS; 1/4 WATT, ±5%
2. CAPACITOR VALUES ARE .1 MICRO-FARAD, ±10%, 100V

△3 DISCRIMINATOR A GAIN #1

△4 DISCRIMINATOR A GAIN #2

△5 DISCRIMINATOR B GAIN #1

△6 DISCRIMINATOR B GAIN #2

7. ☐ INDICATES CONNECTOR PIN

QTY REQD	QTY REQD	QTY REQD	ITEM	SCAS PART NO	MFGR PART NO	NOMENCLATURE OR DESCRIPTION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED TOLERANCES ON: ANGLES ±1/2° DECIMALS XXX ± .010 XX ± .020

MATERIAL

APPLIED FINISH

NEXT ASSY	USED ON
	R150-500

APPLICATION

AUTHENTICATION	NAME	DATE
DRN	M. Boroughs	2/19/70
CHK		3/23/70
DSGN		3/23/70
APP	R	3/23/70
APP		3/23/70
R/QA		3/31/70

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SCHEMATIC DIAGRAM – PREAMP, DISCRIMINATOR AND PRE-SCALER A7

D 150-572 A REV

SCALE NONE WT SHEET 1 OF 1

Figure 3-9. Preamplifier, Discriminator, and Pre-scaler PC Board Schematic Diagram

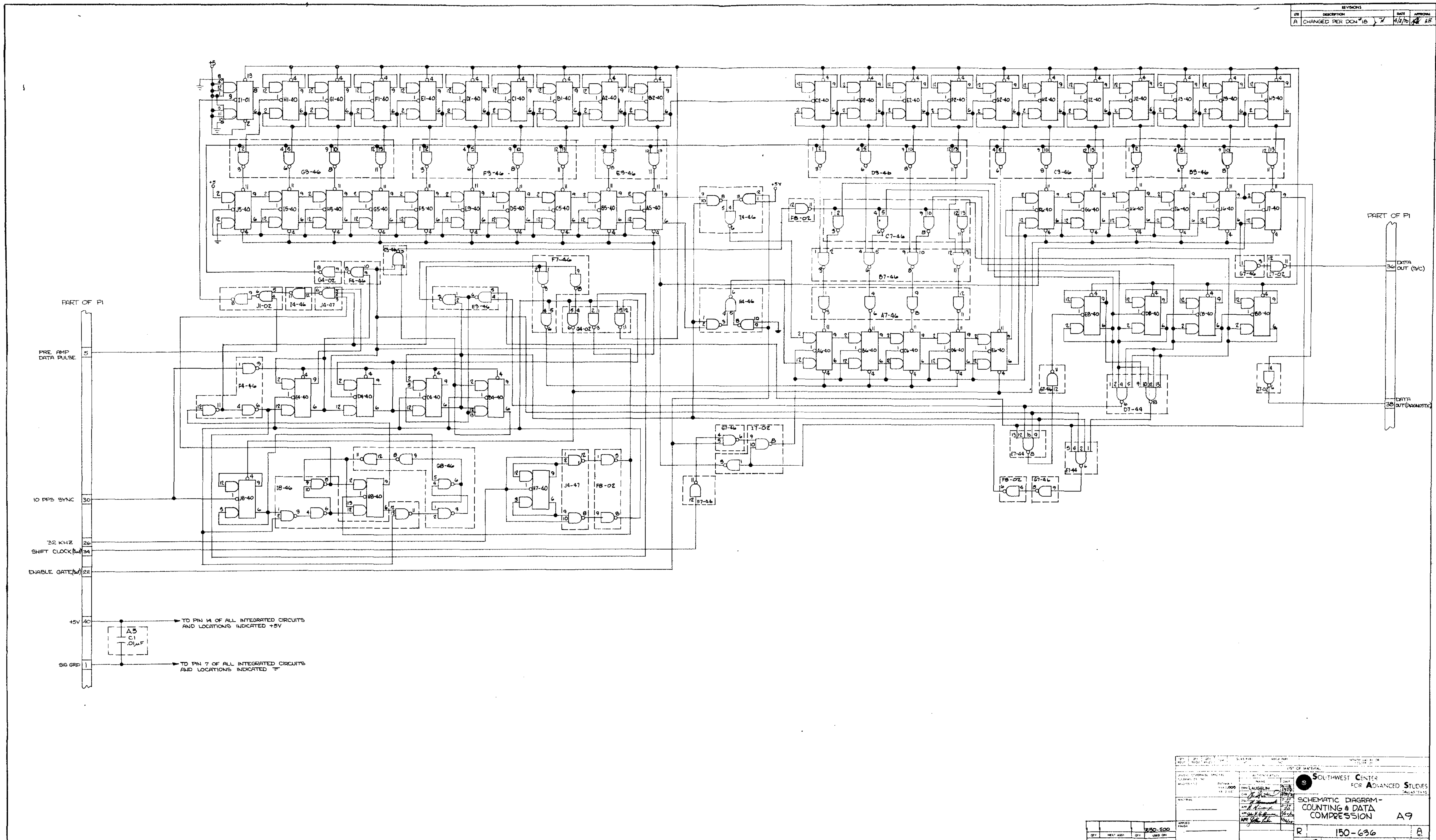
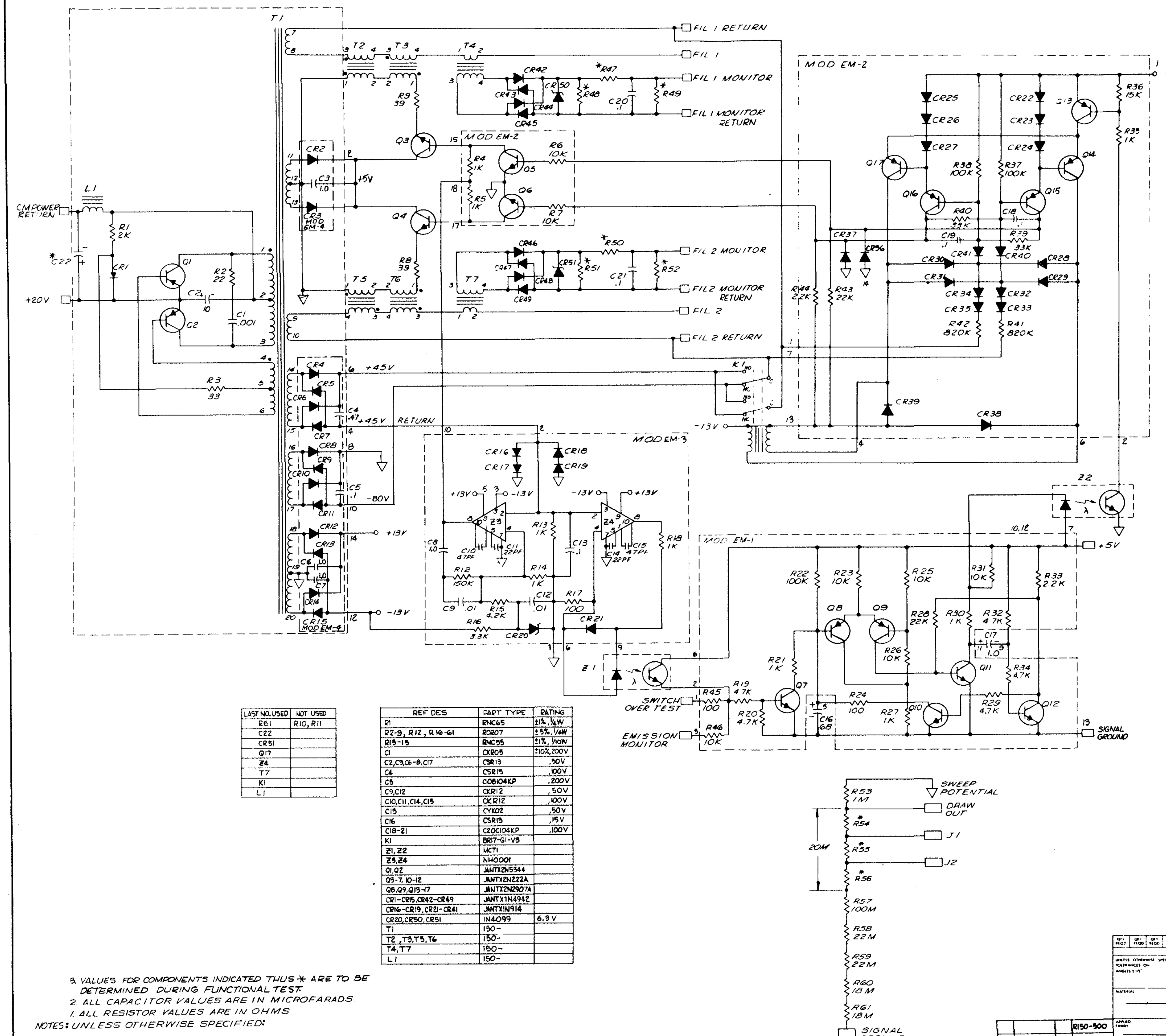


Figure 3-10. Counter and Data Compressor PC Board Schematic Diagram

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	REV PER DCN 26 4/10/70 M.H.		



LAST NO. USED	NOT USED
R61	R10, R11
C22	
CR51	
Q17	
Z4	
T7	
K1	
L1	

REF DES	PART TYPE	RATING
R1	RNC65	±1%, ¼W
R2-9, R12, R16-61	RCR07	±5%, 1/4W
R13-15	RNC55	±1%, 1/10W
C1	CKR05	±10%, 200V
C2, C3, C6-8, C17	CSR13	,50V
C4	CSR15	,100V
C5	C08104KP	,200V
C9, C12	CKR12	,50V
C10, C11, C14, C15	CKR12	,100V
C13	CYK02	,50V
C16	CSR13	,15V
C18-21	C20C104KP	,100V
K1	BR17-G1-V3	
Z1, Z2	MCT1	
Z3, Z4	NH0001	
Q1, Q2	JANTX2N5344	
Q3-7, 10-12	JANTX2N222A	
Q8, Q9, Q13-17	JANTX2N2907A	
CR1-CR15, CR42-CR49	JANTX1N4942	
CR16-CR19, CR21-CR41	JANTX1N914	
CR20, CR50, CR51	1N4099	6.3V
T1	150-	
T2, T3, T5, T6	150-	
T4, T7	150-	
L1	150-	

NOTES: UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTOR VALUES ARE IN OHMS
2. ALL CAPACITOR VALUES ARE IN MICROFARADS
3. VALUES FOR COMPONENTS INDICATED THUS * ARE TO BE DETERMINED DURING FUNCTIONAL TEST.

QTY	NEXT ASSY	QTY	USED ON
			R150-500

APPLICATION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED TOLERANCES ON ANGLES ±1/2° DECIMALS .XXX ±.010 .XX ±.030

MATERIAL

APPLIED FINISH

AUTHENTICATION — DRN M.L. MARRIS 4-2-70

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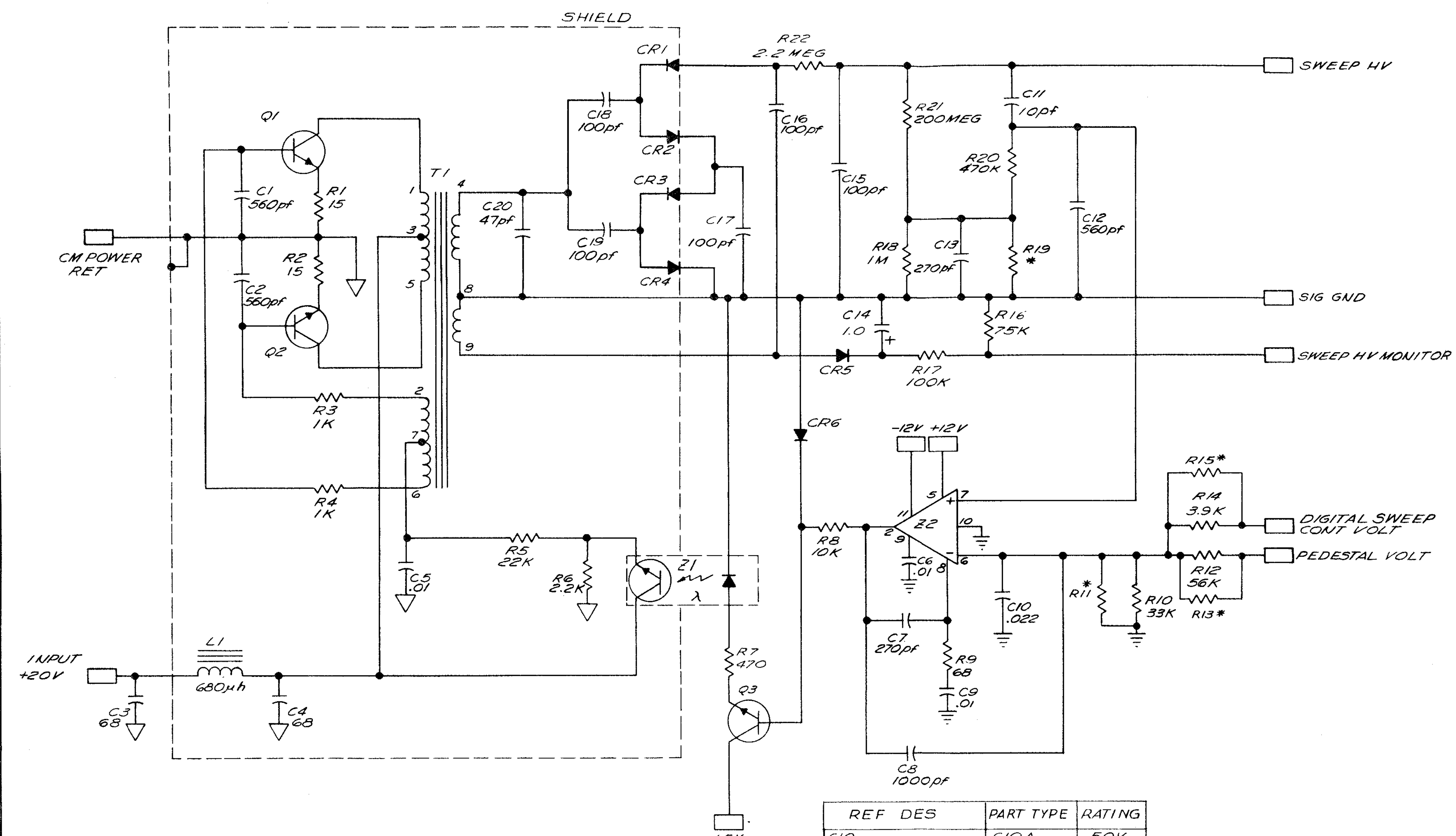
DALLAS TEXAS

SCHEMATIC DIAGRAM-EMISSION CONTROL A12

E 150-683 A

SCALE NONE SHEET 1 OF 1

Figure 3-11. Emission Control PC Board Schematic Diagram



LAST NO. USED	NOT USED
R22	
C20	
Q3	
CR6	
Z2	
T1	
L1	

REF DES	PART TYPE	RATING
C10	C10A	50V
C7, C13	C10A	100V
R1-R20, R22	RCR07	±5% ¼W
R21,	MOX-750	±1%
C1,C2,C5,C6,C8,C9,C12	CKR12	,100V
C3,C4	CLR65	,60V
C11,C15-C20	DD30	,3KV
C14	CSR13	,50V
Q1,Q2	S2N2102	120V
CR1-CR4	S030G	
CR5,CR6	JANTX1N914	
Z1	MCT1	
Z2	2404BG	
T1	B65571	
L1	1537-742	
Q3	JANTX2N2222A	

NOTES: UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTOR VALUES ARE IN OHMS
2. ALL CAPACITOR VALUES ARE IN MICROFARADS
3. VALUES INDICATED THUS *, ARE TO BE DETERMINED DURING FUNCTIONAL TEST

QTY REQD	QTY REQD	QTY REQD	ITEM	SCAS PART NO	MFG'R PART NO	NOMENCLATURE OR DESCRIPTION

LIST OF MATERIAL

R150-500 — NEXT ASSY — USED ON — APPLICATION

UNLESS OTHERWISE SPECIFIED TOLERANCES ON: ANGLES ± 1/2° DECIMALS .XXX ± .010 .XX ± .020

MATERIAL

APPLIED FINISH

AUTHENTICATION	NAME	DATE
DRN.	M.L.HARRIS	4-3-70
CHK.	[signature]	4/14/70
DSGN.	[signature]	4/14/70
APP.	[signature]	4/14/70
APP.	[signature]	4/14/70
R/QA	[signature]	4/14/70

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SCHEMATIC DIAGRAM — SWEEP HIGH VOLTAGE POWER SUPPLY A5

D 150-623 REV

SCALE — WT — SHEET 1 OF 1

REVISIONS: LTR | DESCRIPTION | DATE | APPROVAL

Figure 3-12. Sweep High Voltage Power Supply PC Board Schematic Diagram

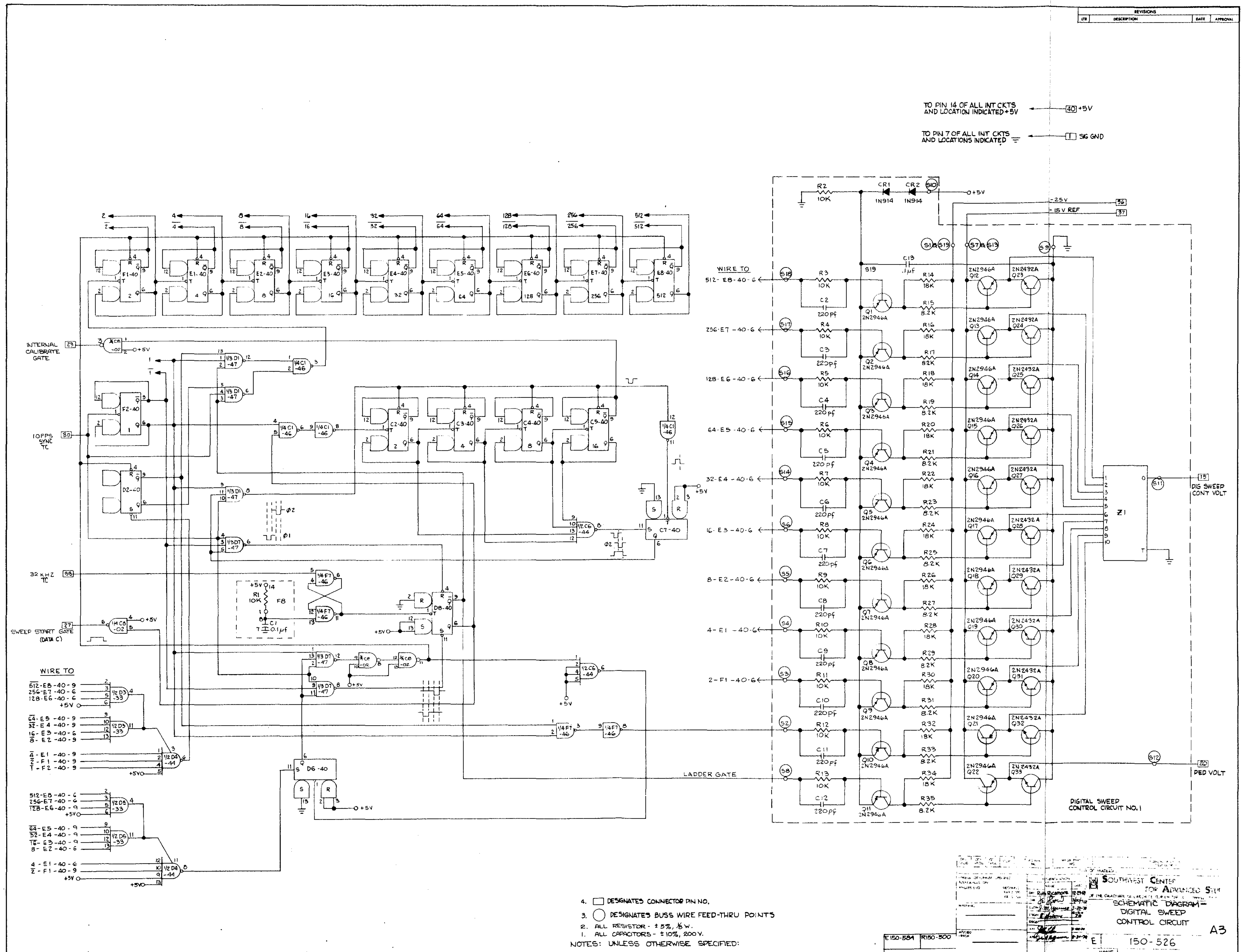
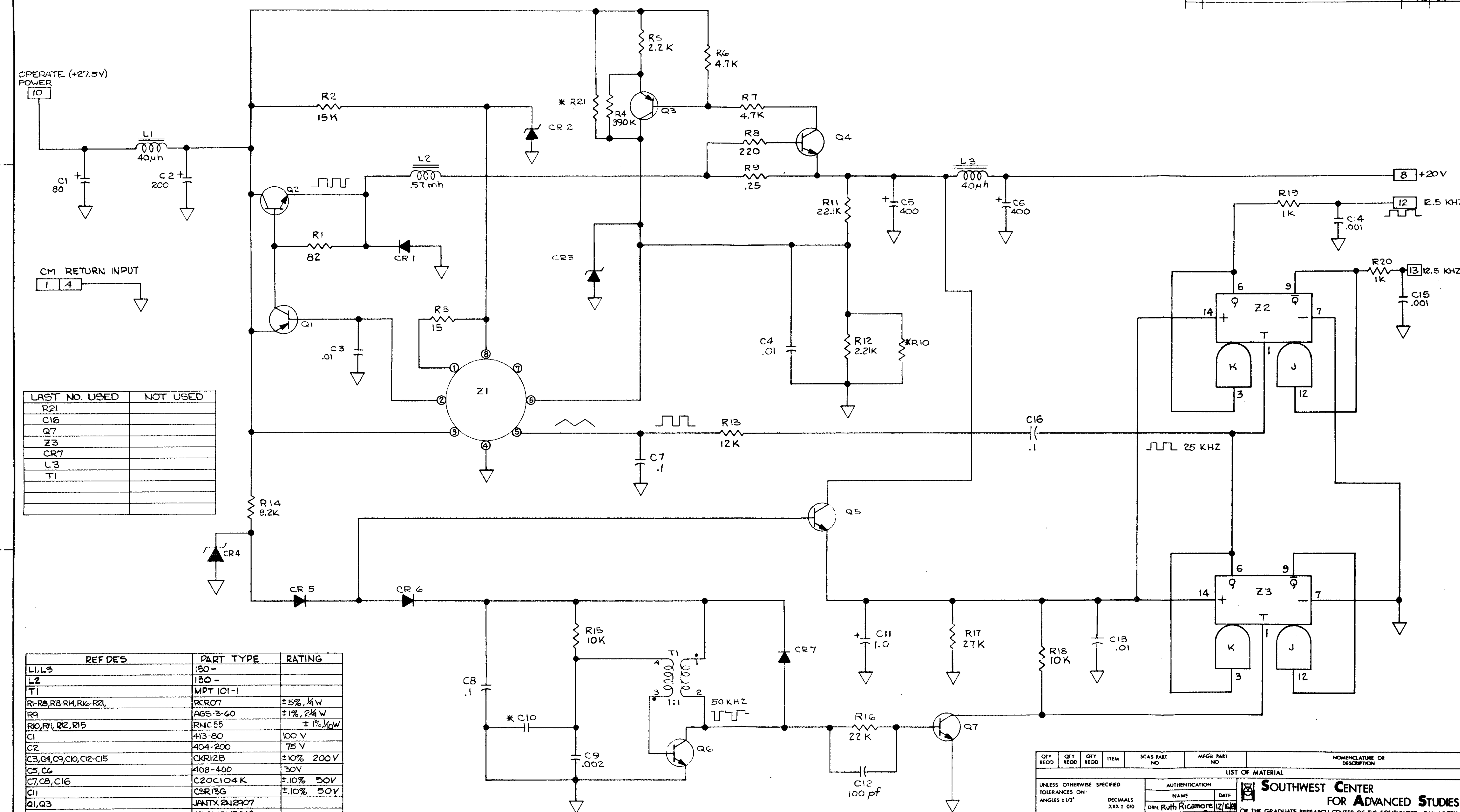


Figure 3-13. Digital Sweep Control PC Board Schematic Diagram



REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	REV PER DCN 30 4-14-70 M.H.	4/14/70	

LAST NO. USED	NOT USED
R21	
C16	
Q7	
Z3	
CR7	
L3	
T1	

REF DES	PART TYPE	RATING
L1, L3	150 -	
L2	150 -	
T1	MPT 101-1	
R1-R8, R13-R14, R16-R21,	RCR07	±5%, ¼W
R9	AGS-3-60	±1%, 2¼W
R10, R11, R12, R15	RNC55	±1%, 1/10W
C1	413-80	100 V
C2	404-200	75 V
C3, C4, C9, C10, C12-C15	CKR12B	±10% 200V
C5, C6	408-400	30V
C7, C8, C16	C20C104K	±.10% 50V
C11	CSR13G	±.10% 50V
Q1, Q3	JANTX 2N2907	
Q2	JANTX 2N3448	
Q4, Q5, Q7	JANTX 2N2222A	
Q6	JANTX 2N2369A	
Z1	LM105/883	
Z2, Z3	HL10455	
CR1	1N3880R	
CR2, CR3, CR4	1N4099	6.8V
CR5-CR7	JANTX 1N914	

NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTOR VALUES ARE IN OHMS
2. CAPACITOR VALUES ARE IN MICRO-FARADS.
3. * VALUES TO BE SELECTED DURING FUNCTIONAL TEST

QTY REQD	QTY REQD	QTY REQD	ITEM	SCAS PART NO	MFGR PART NO	NOMENCLATURE OR DESCRIPTION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED TOLERANCES ON: ANGLES ± 1/2° DECIMALS .XXX ± .010 .XX ± .020

MATERIAL

APPLIED FINISH

AUTHENTICATION	NAME	DATE
DRN.	Ruth Ricamore	12/16/69
CHK.	[signature]	3/31/70
DSGN.	[signature]	4-2-70
APP.	[signature]	4-2-70
APP.	[signature]	3-31-70
R/QA	[signature]	4-3-70

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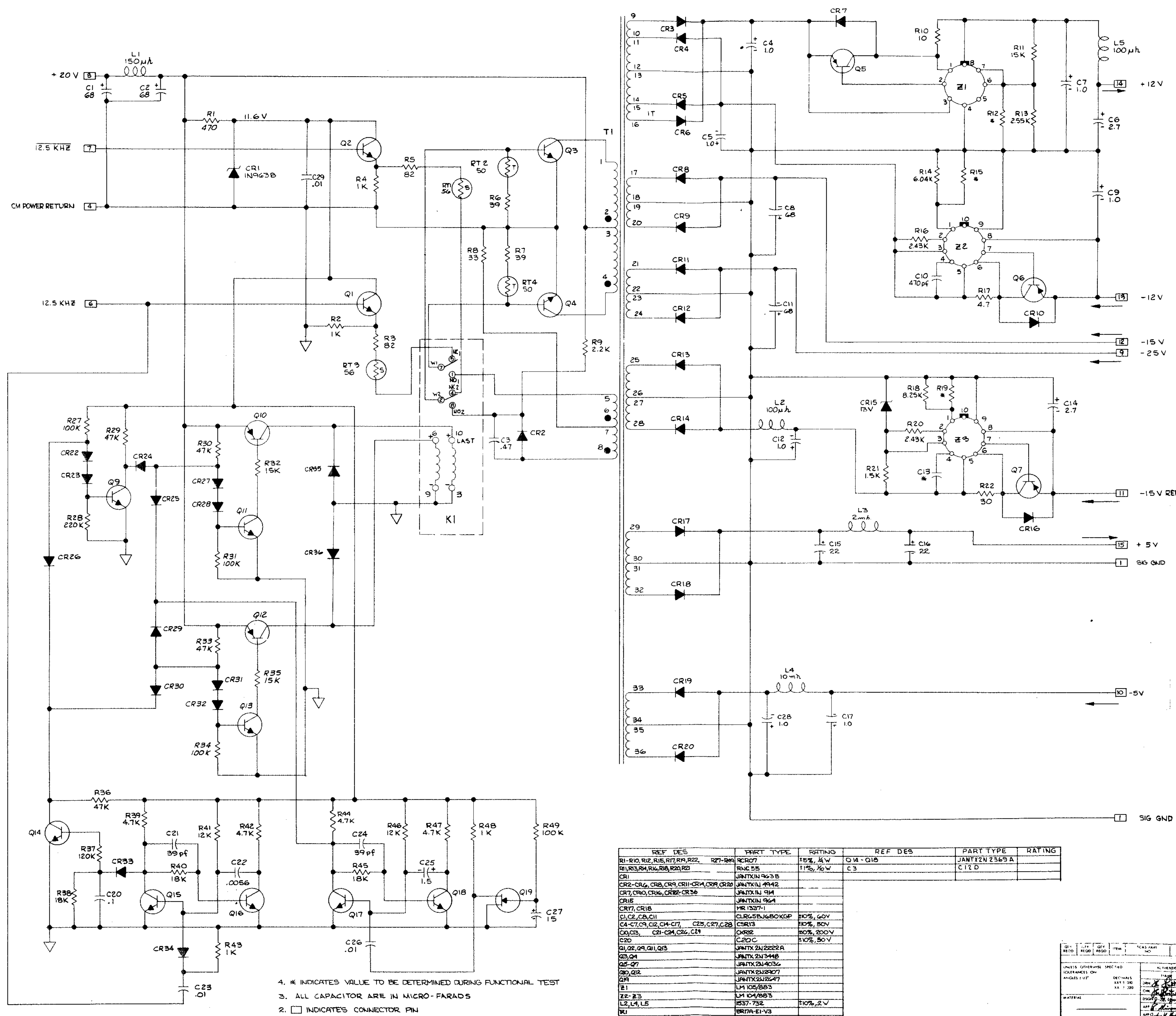
SCHEMATIC DIAGRAM - SWITCHING PRE-REGULATOR A1

D 150-519 A REV

SCALE NONE WT SHEET 1 OF 1

	R150-500
NEXT ASSY	USED ON
APPLICATION	

Figure 3-14. Switching Pre-regulator PC Board Schematic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE IN OHMS
2. ☐ INDICATES CONNECTOR PIN
3. ALL CAPACITOR ARE IN MICRO-FARADS
4. * INDICATES VALUE TO BE DETERMINED DURING FUNCTIONAL TEST

LAST NO. USED	NOT USED
R49	R23-R26
CR36	CR21
C29	C18, C19
Q19	Q8
Z3	
L5	
K1	
T1	
RT4	

REF DES	PART TYPE	RATING	REF DES	PART TYPE	RATING
R1-R10, R12, R15, R17, R19, R22, R27-R49	RCR07	±5%, 1/4 W	Q14 - Q18	JANTX2N2369A	
R11, R13, R14, R16, R18, R20, R21	RNC55	±1%, 1/10 W	C3	C12D	
CR1	JANTX1N963B				
CR2-CR6, CR8, CR9, CR11-CR14, CR19, CR20	JANTX1N4942				
CR7, CR10, CR16, CR22-CR36	JANTX1N914				
CR15	JANTX1N964				
CR17, CR18	MR1337-1				
C1, C2, C8, C11	CLR65BJ680KGP	±10%, 60V			
C4-C7, C9, C12, C14-C17, C25, C27, C28	CSR13	±10%, 50V			
C10, C13, C21-C24, C26, C29	CKR12	±10%, 200V			
C20	C20C	±10%, 50V			
Q1, Q2, Q9, Q11, Q13	JANTX2N2222A				
Q3, Q4	JANTX2N3448				
Q5-Q7	JANTX2N4036				
Q10, Q12	JANTX2N2907				
Q19	JANTX2N2647				
Z1	LM105/883				
Z2-Z3	LM104/883				
L2, L4, L5	1537-732	±10%, .2W			
K1	BR17A-E1-V3				
RT1, RT3	TG 1/8-56				
T1	150-				
L1	150-				
L3	150-				
RT2, RT4	LB15J1				

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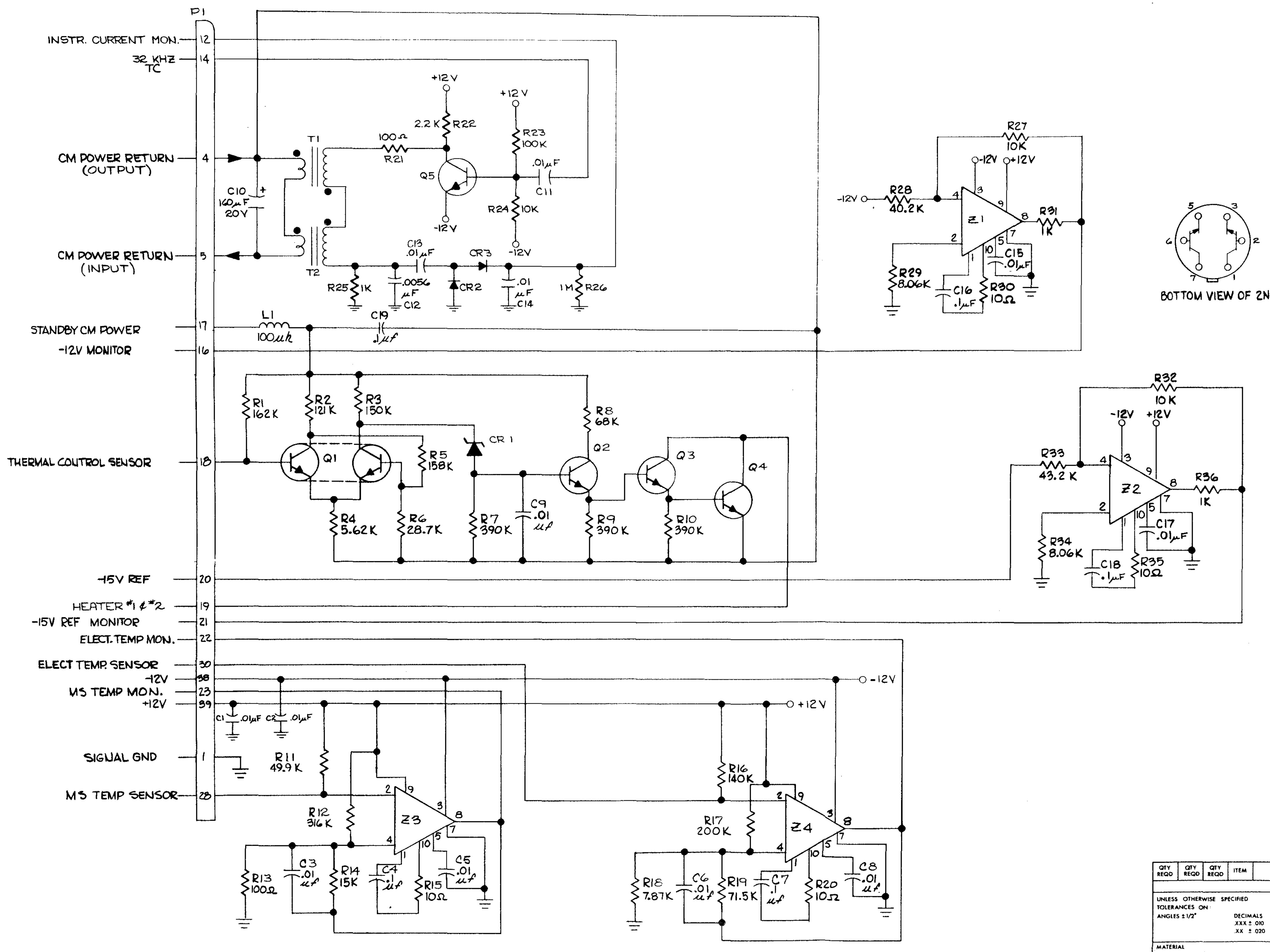
SCHEMATIC DIAGRAM – LOW VOLTAGE POWER SUPPLY

E 150-615 A

R150-500

Figure 3-15. Low Voltage Power Supply PC Board Schematic Diagram



LAST NO. USED	NOT USED
R36	
Q5	
Z4	
C19	
CR3	
T2	
P1	
L1	

REF DES	PART TYPE	RATING
Z1 - Z4	NH0001/883	—
Q1	JANTX2N2920	—
Q2-Q4	JANTX2N2102	—
Q5	JANTX2N2222A	—
CR1	JANTX1N4104	—
CR2, CR3	JANTX1N914	—
C1-C9, C11-C19	CKR06	± 10%, 200V
C10		± 20%, 20V
R1-R6, R11-R14, R16-R19, R27-R29, R32-R34	RNC 55H	± 1%, 1/10 W
R7-R10, R15, R20-R26, R30, R31, R35, R36	RCR07	± 5%, 1/4 W
L1	1537-732	± 10%, .2W
T1, T2	150-	—

REVISIONS

LTR	DESCRIPTION	DATE	APPROVAL

QTY REQD	QTY REQD	QTY REQD	ITEM	SCAS PART NO	MFG'R PART NO	NOMENCLATURE OR DESCRIPTION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED TOLERANCES ON: ANGLES ± 1/2° DECIMALS .XXX ± .010 .XX ± .020

MATERIAL

APPLIED FINISH

AUTHENTICATION		
	NAME	DATE
DRN	LAUGHLIN	3-4 1970
CHK	[signature]	3/6/70
DSGN	[signature]	3-20 1970
APP	[signature]	3-20 70
APP	[signature]	3-26-70
APP	[signature]	3-31-70

R150-500	
NEXT ASSY	USED ON
APPLICATION	

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SCHEMATIC DIAGRAM-THERMAL CONTROL A2

D 150-616 REV

SCALE NONE WT SHEET 1 OF 1

Figure 3-16. Thermal Control PC Board Schematic Diagram

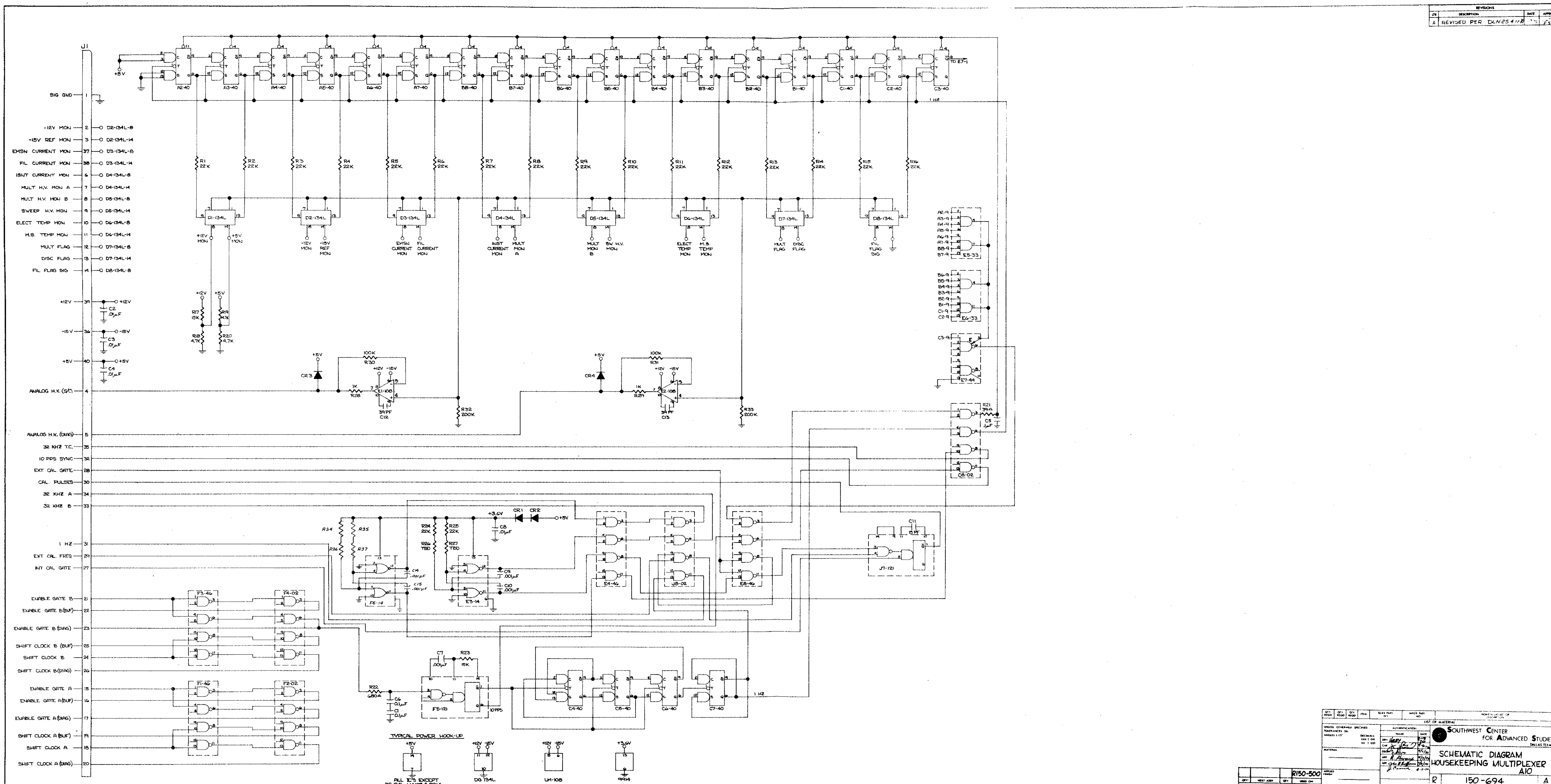


Figure 3-17. Housekeeping Multiplexer PC Board Schematic Diagram

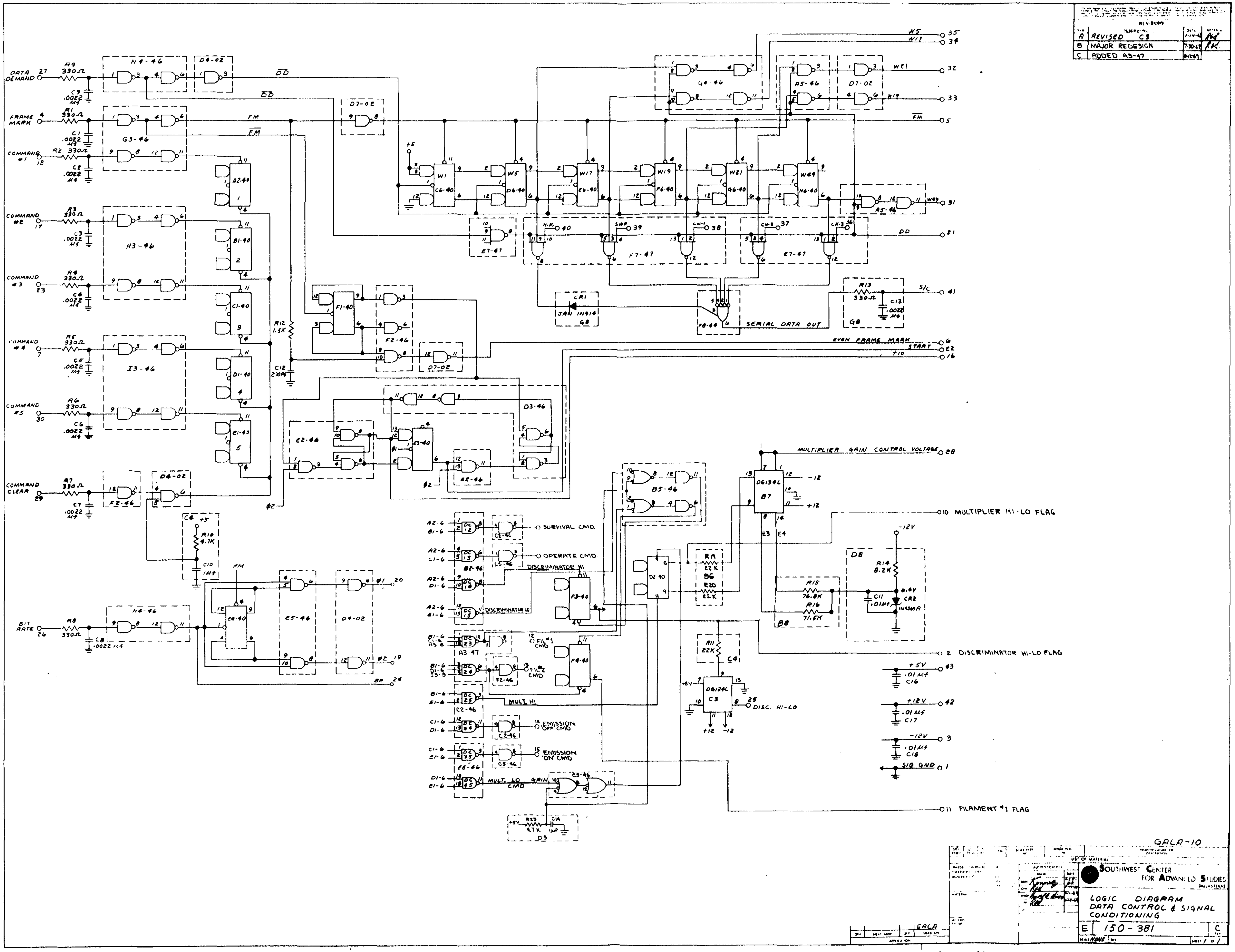
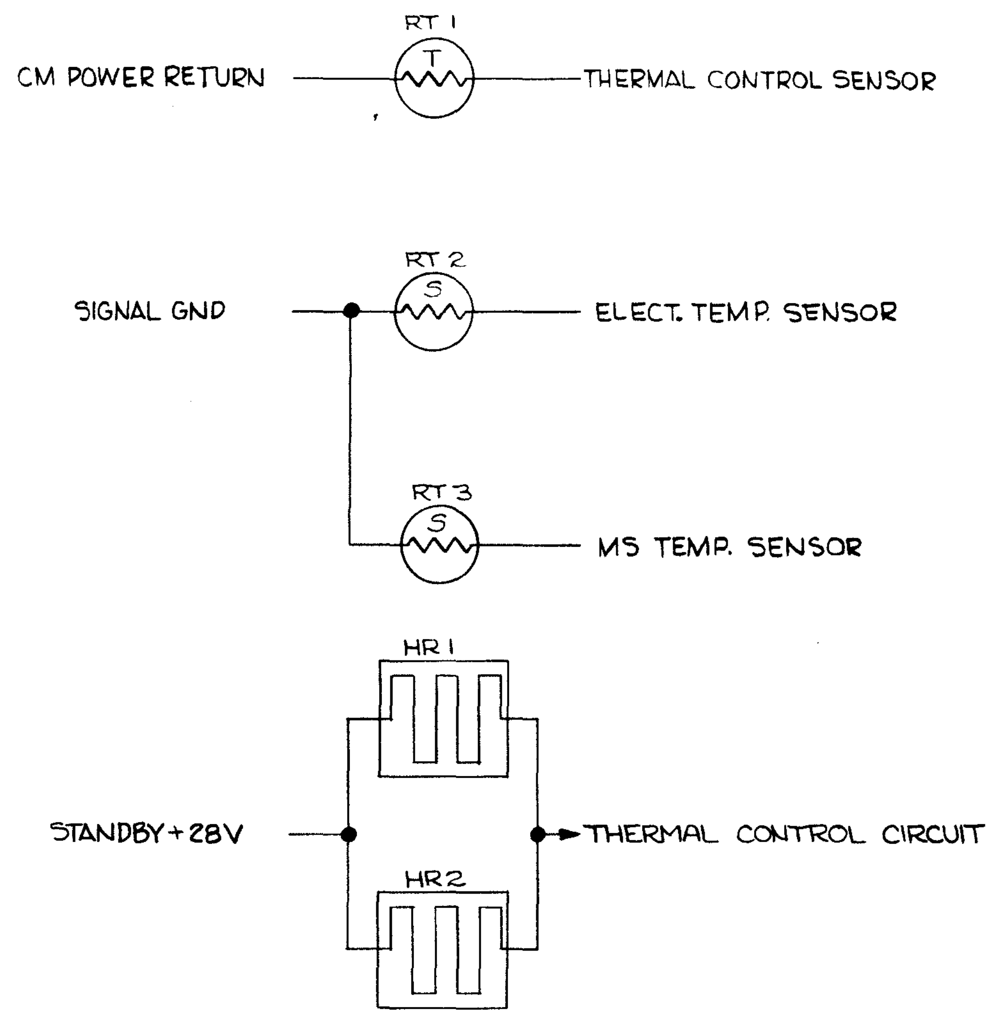


Figure 3-18. Signal Conditioning PC Board Schematic Diagram

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL



LAST NO. USED	NOT USED
RT 3	
HR 2	

REF DES	PART TYPE	RATING
RT1	GB34P2	
RT2,	118YM	
HR1, HR2	E/F 111689	
RT3	104MB6AAAC	

QTY REQD	QTY REQD	QTY REQD	ITEM	SCAS PART NO	MFG'R PART NO	NOMENCLATURE OR DESCRIPTION

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED TOLERANCES ON: ANGLES ± 1/2° DECIMALS .XXX ± .005 .XX ± .020

MATERIAL

APPLIED FINISH

AUTHENTICATION	
NAME	DATE
DRN. LAUGHLIN	3-20 1970
CHK. [signature]	4/
DSGN [signature]	4/17/70
APP. [signature]	4/17/70
APP. [signature]	4-17-70
R/QA [signature]	4-17-70

SOUTHWEST CENTER FOR ADVANCED STUDIES
DALLAS, TEXAS

SCHEMATIC DIAGRAM —
HEATER & SENSOR CIRCUIT

C | 150-644 | REV

SCALE NONE | WT | SHEET 1 OF 1

1	R150-500	1	R150-500
QTY	NEXT ASSY	QTY	USED ON

APPLICATION

Figure 3-19. Heater and Sensor Circuit Schematic Diagram

4. System Physical Characteristics

a. Configuration

Size -11-1/2" x 7-1/2" x 12"

Weight - 22 pounds maximum

A base plate bisects the 12" dimension. The electronics are mounted on one side, the analyzer on the other. A magnetic (conetic) shield encloses the analyzer section.

b. Magnetic Analyzer

A magnetic analyzer consists of an ion source, drift tube, three collector slits, three electron multipliers and a permanent magnet. Three ion beams emerge from the magnet after traversing paths of radii 0.39, 1.37 and 2.50 inches in the magnet gap and impinge upon separate collector slits. The mass ranges scanned across each collector are from 1 to 4 amu (low mass) 12 to 48 amu (intermediate mass) and 40 to 160 amu (high mass).

c. Ion Source

1. Electron bombardment type.
2. Two filaments for redundancy.
    a) Selection automatic by sensing emission current. If none after 5 seconds, switch to other filament.
    b) Filament current - 2 amps maximum - (monitored as a housekeeping function).
    c) Filament voltage - Approximately 1 volt.
    d) Emission current - Approximately 150 V. (monitored as a housekeeping function).
    e) Electron energy - 80 eV.

3. Trap - +45 volts (fixed) with respect to shield (sweep voltage). Tolerance ±5 volts.

The following electrodes derive their potentials from a voltage divider between the sweep high voltage and ground.

4. J. Plates (2) - Approximately 10 percent below sweep voltage (independently adjustable).

5. Focus Plate - Approximately 0.5 percent below sweep voltage.

d. Magnet

1. Alnico 9 magnets.
2. 1/8" thick pole faces.
3. Gap - 0.220" ± 0.001".
4. Field strength - 4700 ± 150 gauss.

e. Detector

An electron multiplier and counting system follows each collector slit. Each counting system is capable of counting uniform pulses at a 8 mHz rate and storing the data in a 21-bit accumulator. The data stored in the accumulator is compressed in a pseudo-logarithmic fashion to a 10-bit word with 7-bit accuracy and stored in a buffer register. Transfer of the data to the ALSEP Data System is accomplished by a serial pulse train activated by an enable pulse from the Data System.

f. Electron Multiplier

Type	Voltage Range	Load
Ampex P152	-3500	100 Megohms

Dark Current - Less than 1 Picoamp at a gain of 10^7.

Gain - Minimum output pulse shall be 2 x 10^{-14} coulomb.

Voltage Stability - ±100 volts.

The two voltages are selectable by command.

g. Counting System

1. Pulse pair resolution -0.12 sec.
2. Maximum counts per step -10^6.
3. Maximum counting rate - 8 mHz.
4. Background counting rate - Less than 4 counts/second at discriminator setting of 60 db below 1 volt.
5. Counting period - 100 m sec or 1 second.

   One or ten periods per second synced to TM system.

   Two discriminator levels are selectable by command.

B. GROUND SUPPORT EQUIPMENT (GSE)

The purpose of this technical specification is to establish the requirement for the Bench Test Equipment (BTE) Console Unit and the BTE Suitcase Unit as a part of the UTD Mass Spectrometer.

The BTE Console Unit has the capability to provide power and stimuli to the Mass Spectrometer. It also provides a monitoring and data recording capability.

The BTE Suitcase Unit provides a limited stimuli and data monitoring capability which, when used with other GFE, permit the user to analyze a high percentage of possible Mass Spectrometer faults.

1. Design Specifications

a. Electrical

The UTD-BTE units will interface electrically with the ALSEP Mass Spectrometer.

A. C. Power and Grounding System - The UTD-BTE Units are equipped as follows:

(a) BTE Console Unit

AC Power Requirements

Voltage: 120 volts + 3%, -10%, single phase, 3 wire.

Frequency: 60 ± 1H2

Harmonic Content: 3% RMS maximum

Peak Power: 20 Amps

A. C. Connector: Pyle National P/N P205003

Static Ground Stud: Burton Electrical Eng. Co. P/N 7350-0
P/N 2640-0003-0000

Instrument Ground Stud: Burton Electrical Eng. Co.
P/N 2640-0003-0000

(b) BTE Suitcase Unit

AC Power Requirements

Voltage: 120 volts + 3%, -10%, single phase, 3 wire.

Frequency: 60 ± 1H2

Harmonic Content: 3% RMS maximum

Peak Power: 10 Amps

A. C. Connector: Pyle National P/N P205202

Static Ground Stud: Burton Electrical Eng. Co.
P/N 7350-0369-0000

Instrument Ground Stud: Burton Electrical Eng. Co.
P/N 2640-003-0000

Signal Interface with ALSEP Mass Spectrometer - The Console BTE will interface with the SC connector and the diagnostic connector of the Mass Spectrometer. The Suitcase BTE will interface with the diagnostic connector only.

(a) UTD-BTE Spacecraft Connector.

The connector mounted on the UTD-BTE is type PV0G22B55 SNC.

(b) UTD-BTE Diagnostic Connector.

The diagnostic connector on both the UTD-BTE console and suitcase are type PV0G18B32 SNC.

b. Mechanical

The mechanical characteristic of the UTD-BTE Units are as described in the following paragraphs.

Physical Properties - The Console BTE is housed in an EMCOR II enclosure having the following outline dimensions:

HEIGHT:	62 inches maximum
WIDTH:	24 inches maximum
DEPTH:	26 inches maximum
WEIGHT:	400 pounds maximum

The console is equipped with six inch diameter wheels and two inch diameter lifting hooks.

The UTD-MSGSE Suitcase is housed in a portable case have the following maximum characteristics:

HEIGHT:	10 inches maximum
WIDTH:	24 inches maximum
DEPTH:	24 inches maximum
WEIGHT:	75 pounds maximum

The suitcase unit will have a removeable top cover.

2. Requirements

a. Console BTE

The Console BTE will provide all electrical power, stimuli and communication signals required to operate the Mass Spectrometer in each of.its modes.

Power - The console BTE will provide electrical power to the ALSEP Mass Spectrometer via the SC connector (J1).

The BTE provides the following basic powering capability at the BTE-SC connector:

Voltage	36 VDC maximum, 27.5 VDC nominal
Current:	1.5 amperes maximum, 0.75 amperes nominal
Voltage Control:	OV to 36 VDC, 10 turns
Meters:	Voltage and current
Line Regulation:	0.005%
Load Regulation:	0.01%
Protection:	Current limiting and overvoltage
Model:	KEPCO CK36-1-5M power supply KEPCO VP-KCA overvoltage protector

Command and Control - The console BTE provides all of the ALSEP Central Station.

In addition the console BTE provides other functions which are desireable for checkout and test operations. The console BTE provides diagnostic capability similar to those provided by the suitcase BTE. The suitcase BTE provides only those functions which are required by the diagnostic connector.

Switches - The following switches will be provided:

(a) Console GSE

Switch 1 - Experiment Power ON/OFF/STANDBY (with lamp indication of status)

Switch 2 - Discriminator HIGH/LOW (with lamp indication of status)

Switch 3 - Electron Multiplier HV HIGH/LOW (with lamp indication of status)

Switch 4 - Ion Source EMISSION ON/OFF/STANDBY (with lamp lamp indication of status)

Switch 5 - DVM function selector - Housekeeping, Volts, Amps, Manual, Calibrate (with lamp indication)

Switch 6 - Calibrate External Control/Frequency Select - 10 MHz, 4 MHz, 1 MHz, 128 KHz (with lamp indication)

Switch 7 - Filament Switchover Test (with lamp indication)

Switch 8 - Console Power ON/OFF (with lamp indication of status)

(b) Suitcase GSE

Switch 1 - Test Unit Power ON/OFF

Switch 2 - Calibrate External Control

Switch 3 - Calibrate Frequency Select

Switch 4 - Filament Test ON/OFF

Data Display - The Console GSE will provide decimal and binary display of the data work from the ALSEP Mass Spectrometer Switch. Status displays are by lamp indicator. Analog data is displayed in decimal form on the DVM. Lamps are provided to verify the instrument interface with commands.

Logic Unit - The Console BTE will provide all of the digital logic to the ALSEP Mass Spectrometer in such fashion as to essentially duplicate the function to be provided by the central station. The Logic Unit will be constructed from commercial logic cards manufactured by Computor Controls Company. The Logic Unit will provide the following functions:

(a) Data Word Enable Gate.

The Logic Unit will generate and provide three synchronized word gates of 10 bit duration to the experiment. The word gates will occur at a 10 cps rate. The three word enable gates may be consecutive or separated by a multiple of 8 bits. The format will be fixed to duplicate the assignment of the Central Station. The word enable gates will appear on separate lines.

(b) Data Shift Clock.

A data shift clock will be provided synchronous with each enable word gate. Each series of shift clock pulses will contain 10 shift pulses. The shift pulse coincidence with the first bit will be omitted. The first shift will occur at the start of the second bit period.

(c) Data Decompression.

The data processor will provide logic to decode the compressed 10 bit data word from each ion counter channel into 4 code bits and 6 data bits.

(d) Binary to Decimal Conversion.

Each 10 bit binary data word will be converted to binary coded decimal and made available to the Data output register. The data output register will provide the circuits to interface with the printer and the lamp display.

Data Printing Equipment - The Console BTE prints on paper tape the results of the data processor operations. Printing originates from a Franklin Printer Model 1630D-16-6A16. The printer prints on command from the data processor at a rate of 20 lines per second. The print format is as follows:

The anolog printout, from the housekeeping updates at a 1 cps rate.

Print Format:

(a) Columns 1-5	(2.56B) Three digits with decimal and blank column. This number will be outputted to the printer from the DVM via the data processor. The number will represent the Analog H. K. signal.
(b) Columns 6-9	(128B) A three digit number followed by a blank space. This number will represent the sweep step.
(c) Columns 10-16	(999999L) of (999999H), A six digit number followed by either an "L" or an "H". The number represents the decimal output from the data word corresponding to the experiment ion counters. The "L" indicates low mass while the "H" indicates high mass.

Printer Characteristics:

Maximum Printing Speed	30 lines/sec
Print Drum Type	6A16 standard
Print Columns	16 columns

Marking System	Inked ribbons
	Fan fold paper
Finish	Standard commercial
Power Requirement	110 VAC, 60 cps
Print Logic	8-4-2-1 "1" state position
Logic Levels	
"1"	4.0 VDC ± 1.5 VDC
"0"	0, 0, +.5, -0.0VDC
Print Command	Same as above
Output Gate	Same as above

Digital Voltmeter - A DVM whose principal function is to monitor the analog housekeeping signal is provided as a part of the Console GSE unit.

DVM Characteristics - The DVM has built-in systems capability. The DVM has the following characteristics:

Ranges	10V, 100V, and 1000V
Accuracy	±(0.05% of reading + 0.001% of range) 24 hours; 23°C ± 1°C ± (0.01% of reading + 0.003% of range) 90 days.
Imput Impedance	10^{10} ohms, 10V range 10^{7} ohms, 100V and 1000V ranges
Speed	25 ms max unfiltered 500 ms max filtered
Maximum Data Range	80 ms unfiltered
Data Output	DTL and TTL compatable, fully isolated.

Analog Housekeeping Functions - The analog housekeeping data will be in the following format:

H. K. Sub-Com Position No.	Function	Nominal Reading	Tolerance Min	Max.
1.	+ 12 volts	+ 2.00 V.	1.97 V.	2.03 V.
2.	+ 5 volts	+ 2.50 V.	1.37 V.	2.63 V.
3.	- 12 volts	+ 3.00 V.	2.96 V.	3.04 V.
4.	- 15 volts	+ 4.00 V.	3.99 V.	4.01 V.
5.	Emission Current Mon.	+ 3.00 V.	TBD	TBD
6.	Filament Current Mon.	+ 2.50 V.	TBD	TBD
7.	Instrument Current a) Normal Operation b) Normal & Heaters			
8.	Elec. Multiplier H. V. Lo-Mass Monitor a) Mult. HI b) Mult. LO			
9.	Elec. Multiplier H. V. Hi-Mass Monitor a) Mult. HI b) Mult. LO			
10.	Sweep H. V. Monitor	0 to 5 V.		time dependent
11.	Temperature No. 1	0 to 5 V.		temp. dependen
12.	Temperature No. 2	0 to 5 V.		temp. dependen
13.	Multiplier Flag a) Mult. HI b) Mult. LO	 4.00 V. 0.00 V.	 3.70 V. 0.00 V.	 4.30 V. 0.050 V.
14.	Discriminator Flag a) Mult. HI b) Mult. LO	 3.00 V. 0.00 V.	 2.75 V. 0.00 V.	 3.25 V 0.050 V.

H. K. Sub-Com Position No.	Function	Nominal Reading	Tolerance Min	Max.
15.	Filament Flag			
	a) Filament No. 1	0.00 V.	0.00 V.	0.05 V.
	b) Filament No. 2	4.00 V.	3.50 V.	4.50 V.
16.	Sync Marker	0.00 V.	0.00 V.	0.05 V.

IV. PERFORMANCE TEST RESULTS

A Prototype Acceptance Test Procedure has been written and is attached to this section. This procedure is used for testing the functional operation of the instrument in the Ultra-High Vacuum Chamber at UTD and during the environmental tests at MSC. The latter are discussed in Section V.

The tests conducted at UTD consisted of an operational checkout test to ensure proper operation of the instrument. The analyzer section was initially tested in the vacuum chamber utilizing electronics mounted external to the chamber to facilitate adjustment of the variable parameters. Mass spectra were taken which are shown in Figure 4-1 for the three mass ranges of the instrument. The high mass range extends to mass 160 amu but only the portion to mass 86 is shown in the figure. The mass resolution is such as to clearly separate mass 3 from 4 in the low mass channel, 40 from 41 in the intermediate mass channel, and 112 from 113 in the high mass channel. This resolution is sufficient to prevent more than a 1 percent interference between the Xenon isotopes in the 130 amu mass range, also, there is less than 1 part in 300 of the mass 40 peak at mass 39. The figures are tracings from an analog output from the instrument, the ordinate being a log scale. The amplitude scale is shown at the left. In lunar operation, the data collection will be in digital form, that being the number of counts obtained per voltage step of the high voltage sweep ciruit (see Section III). A sample printout is shown in Figure 4-2. The number of ions counted on each voltage step is listed as a function of time,

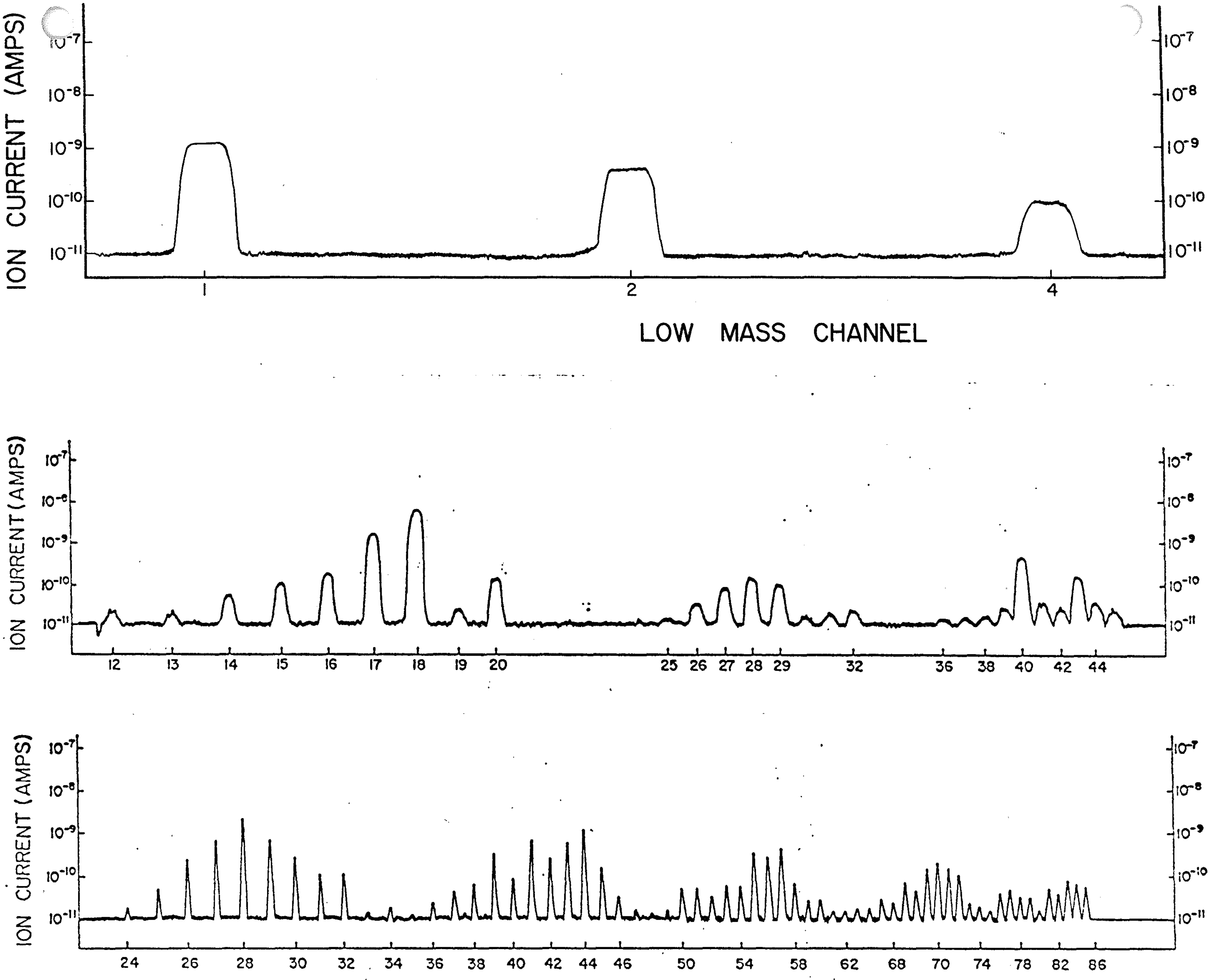


FIGURE 4-1 MASS SPECTRUM

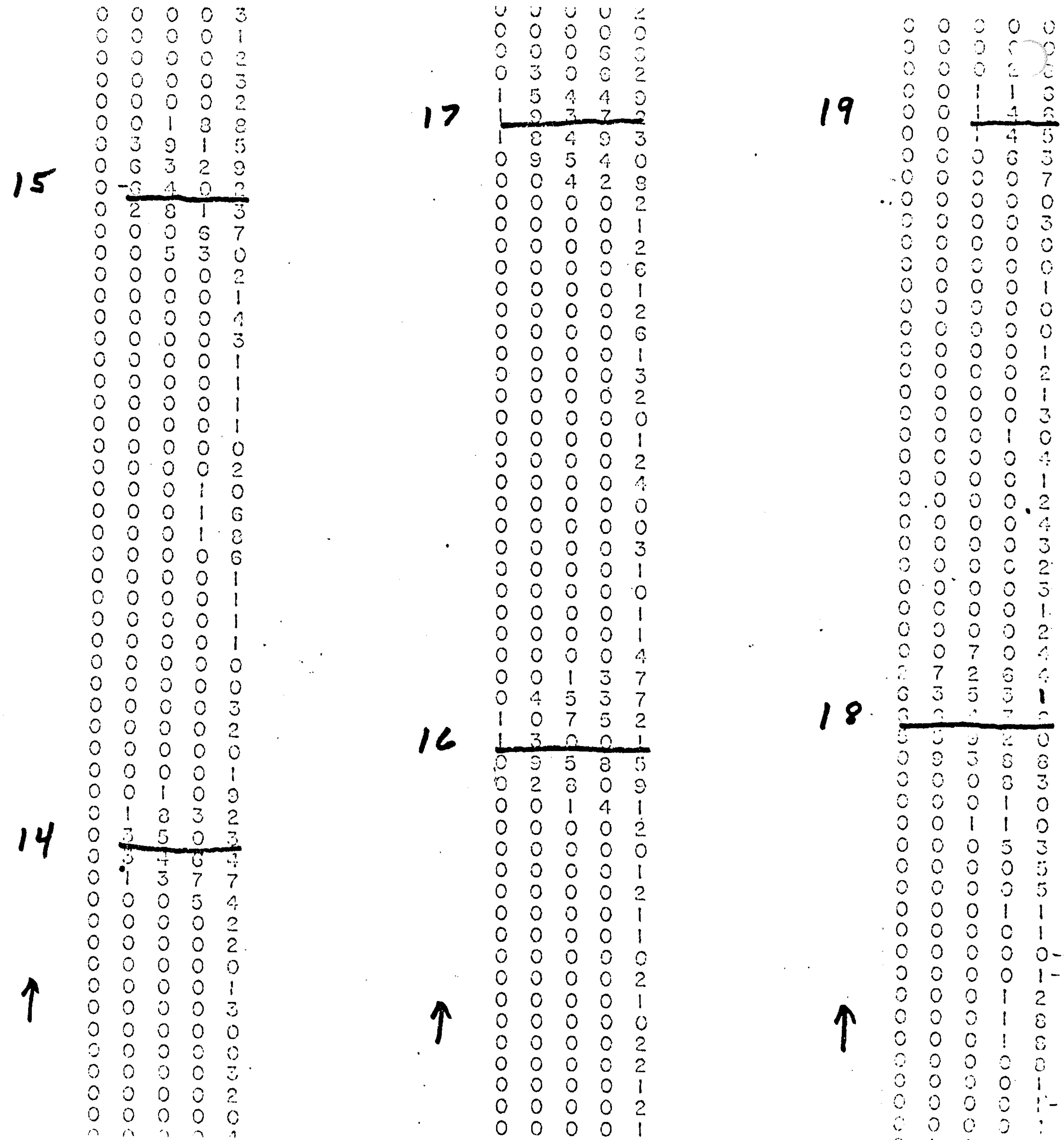


Figure 4-2.
DIGITAL MASS
SPECTRUM AMU
PRINTOUT

time after sweep start, indicated by a flag, being related to mass number. One count per step (nominally taken to be 1 second) represents a sensitivity of 1×10^{-15} torr. Ten counts per step, signal to noise ratio of 2 or 3, represents a usable sensitivity of 10^{-14} torr. The background counted rate is usually from 0 to 3 counts per step.

The entire prototype instrument was operated in the vacuum chamber 24 hours after pumping was initiated. With an ambient pressure of 10^{-7} torr the instrument electronics exhibited no tendency toward high voltage arcing or corona problems. This test proved that adequate outgassing parts were designed into the electronics package to prevent such problems.

Future tests of the Mass Spectrometer include participation in the planned comparison tests between three proposed Lunar Mass Spectrometers to be conducted at the JPL Molsink in the fall of 1970. The purpose of these tests is to compare the operation of these instruments at very low pressures and to study their sensitivity to various gases.

V. ENVIRONMENTAL TEST RESULTS

A. STRUCTURAL TESTS

A structural model of the Mass Spectrometer was constructed containing weighted PC boards to simulate actual weights, a dummy analyzer tube and an actual magnet. The specifications (ERD-SM-1001) to which the instrument was subjected are included in this section.

The structural model successfully underwent a 3-axis vibration test to ALSEP qualification levels on May 23, 1969. A report on the test (Document No. 644D.41.12) is included in this section. In a previous vibration test a failure occurred in the horizontal shake test in the electronics package. The two sets of four printed circuit cards mounted on stand-offs from the radiator plate broke loose due to a shearing of the studs on which they were mounted. This problem was corrected and the subsequent test proved the system acceptable. The prototype Mass Spectrometer was subjected to the same test as the structural model on January 9, 1970 with the result that no structural problems occurred and the instrument was operational before and after the test. As a result of these tests, the structural design of both the mechanical hardware and the electronics packaging is considered to be proven adequate for flight on Apollo missions.

B. THERMAL VACUUM TESTS

A thermal model of the Mass Spectrometer was constructed using the structural model fitted with PC boards. These PC boards were to dissipate the design power of each electronics subassembly and were adequately fitted with thermocouples. A thermal vacuum test simulating both lunar night and lunar day was conducted in a vacuum chamber at MSC on the Thermal Model in June, 1969, according to the test specifications, ERD-SM-1001. During the cold test it was found that in a survival mode -- heater power only -- 6 watts were required to maintain the coldest point in the electronics section at -75°F. This is barely within specifications of survival of electronic components.

With no heater power and 10.8 watts of experiment power, the coldest point was -17°F which is barely tolerable. The addition of 6 watts of heater power raised the temperature to 35°F which is quite acceptable. During the hot test with experiment power on, 10.8 watts, the hottest point in the electronics area was 81°F, well within specifications of electronics components. No major problems resulted from these tests and the thermal design of the package is considered adequate. However, if all of the temperatures were increased 20 to 25°F, they would lie more within the design ranges. This may be accomplished by masking off a portion of the mirrors on the radiator plate. A plot of the test results is shown in Figure 5-1.

A thermal vacuum test of the prototype Mass Spectrometer was conducted in January 1970 to the same test specifications as the thermal model. A number of thermocouples were attached to key parts of the electronics modules and the analyzer section. A plot of equilibrium temperatures for various power input conditions is shown in Figure 5-2. From the figure it is seen that the coldest temperature experienced by the baseplate with heater power only on is -30°F while with the electronics power on it is +15°F. The warmest temperature seen is +80°F. The worst case electronics temperatures are -20°F, +40°F and +100°F. respectively. Again, the electronics appears to be well protected by the thermal control system. The baseplate temperature excursions are considerably larger, -180°F to +190°F, but there are no components in this region that are temperature sensitive.

These tests indicate that the thermal design of the Mass Spectrometer is sufficient to protect the instrument on the lunar surface and ensure its workability through many lunar days.

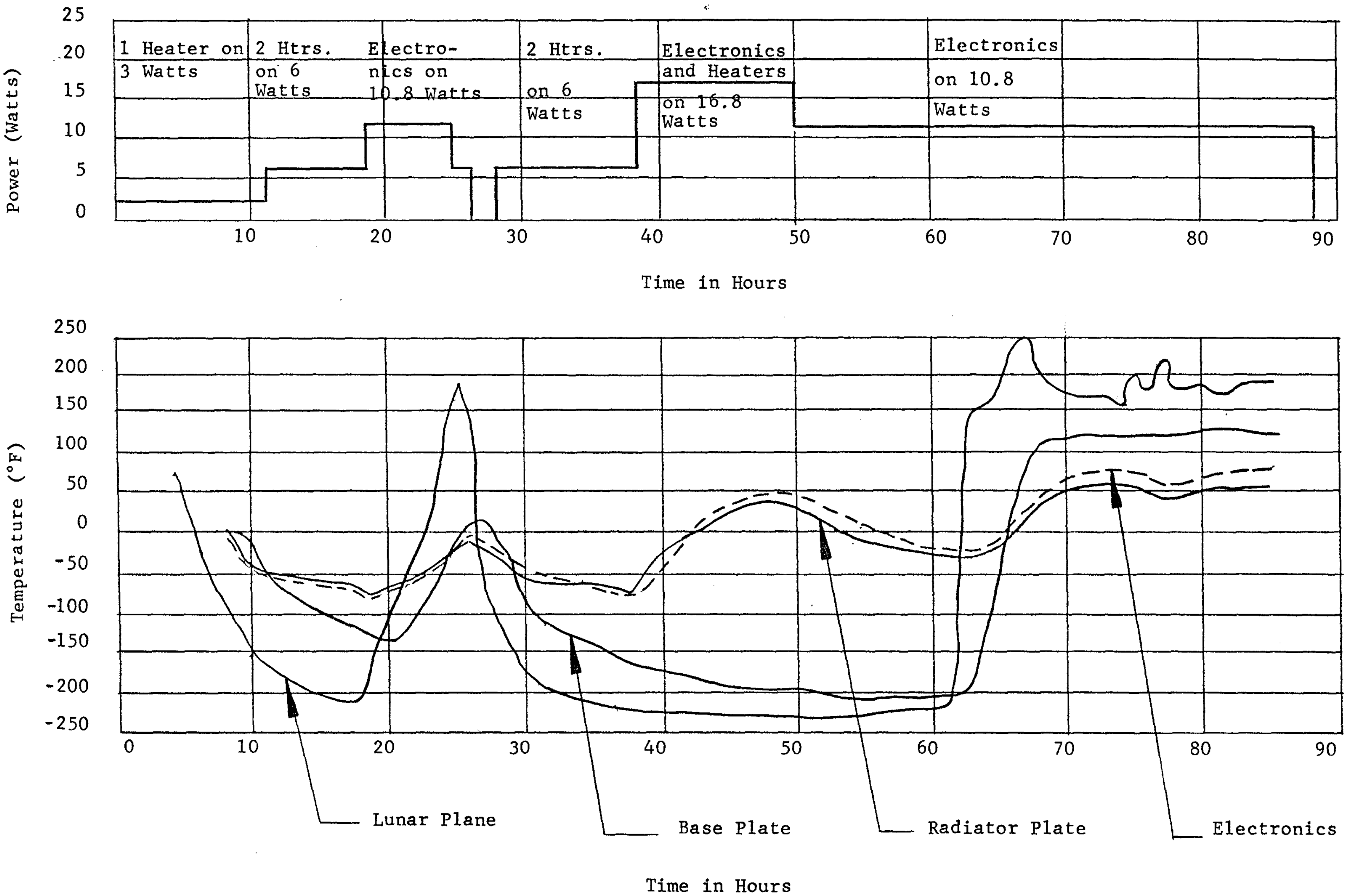
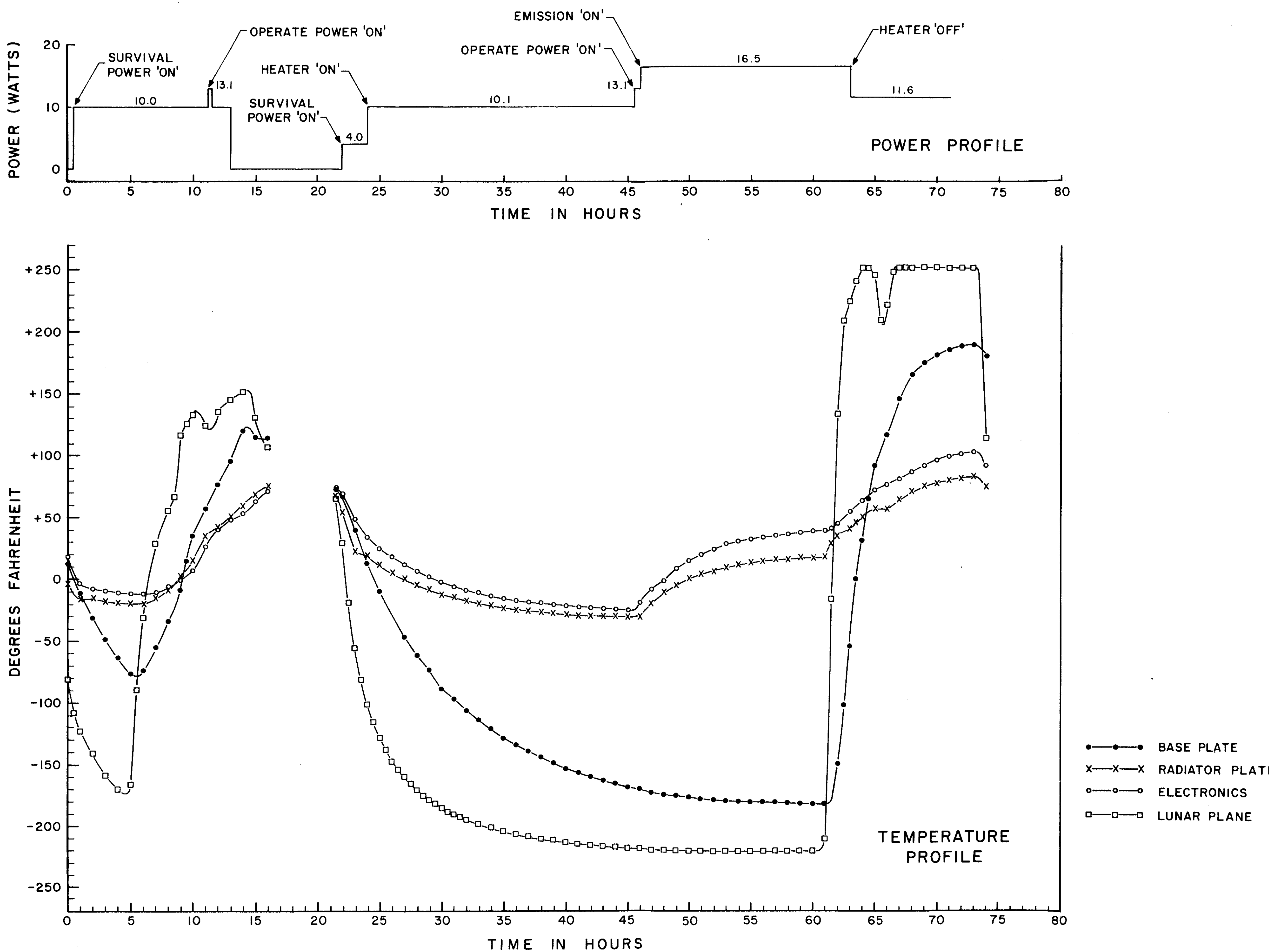


FIGURE 5-1. THERMAL VACUUM TESTS (THERMAL MODEL)



GALA THERMAL VACUUM

VI. QUALITY ASSURANCE PLAN

SM09-OC-023

APR 13 1970

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

REPLY TO
ATTN OF: BG931/L235-70/T94

APR 9 1970

University of Texas at Dallas
P. O. Box 30365
Dallas, Texas 75230

Attention: Mr. D. R. York
Program Manager

Gentlemen:

Subject: NAS 9-10410 - Quality Assurance Plan - QAP-100-1.

The Quality Assurance Plan QAP -100-1 which you submitted on March 17, 1970 has been reviewed by the appropriate NASA-MSC personnel.

Subject plan is approved as submitted.

Sincerely,

R. Paul Clyatt
Contracting Officer

Copies: D. Canham
J. Carroll
J. Hoffman
J. Vanderford
J. Van Lehn

UNIVERSITY OF TEXAS
AT DALLAS

QUALITY ASSURANCE PLAN

QAP-100-1

for

MASS SPECTROMETER EXPERIMENT

for

Contract NAS 9-10410

March 13, 1970

NASA/MSC Approvals

____

____

John H. Hoffman

Dr. John H. Hoffman
Project Scientist/P.I.

J. M. Carroll

Mr. J. M. Carroll
Quality Assurance Reliability
Project Engineer

D. R. York

Dennis York
Program Manager

INDEX

REVISION LOG

Date	Section/Paragraph Revised	QAR Signature	NASA Signature

1.0 Introduction

1.1 General

1.1.1 This plan presents the Quality Assurance operating policies and procedures which govern and direct the conduct of those activities which directly or indirectly influence the quality of the University of Texas at Dallas Space Experiments.

1.2 Distribution, Control and Revisions to Manual

1.2.1 Distribution and Control - The distribution of this manual shall be controlled by the Reliability/Quality Assurance Project Office. All controlled manuals will be serialized and issued by serial number. The master manual files and distribution log will be maintained and controlled by the Reliability/Quality Assurance Project Office. The distribution log shall contain the following:

(a) Manual Serial Numbers

(b) Person or Organization to whom each serial number is assigned

(c) Issue date of each serial number

(d) Dates of up-dating and reason for up-dating of each serial number

(e) Reliability/Quality Assurance Project signature beside each entry

Subsequent to the original issue of each manual, it will be the responsibility of the person or organization to whom each manual is assigned to maintain the manual current. As revisions are initiated and released, copies of the revisions will be forwarded to the respective personnel and/or organizations and the appropriate entries completed in the distribution log.

1.2.2 Revisions - In the event of procedure revisions, the issue data will appear on each page, (e.g., Revised: 2-10-67) and each revised paragraph will be indicated by an asterik in the left hand margin (i.e. *1st revision, **2nd revision, etc.). The revision index shall be changed to indicate the latest revisions. Each revision shall require the approval of the Reliability/Quality Assurance Project Manager , the Project Scientist, the Program Manager and NASA.

2.0 Basic Requirements

2.1 UTD Quality Assurance Project Organization

2.1.1 The Project Scientist will direct the overall activities of the experiment. The Quality Assurance activities are directed by a Reliability and Quality Assurance Project Manager who reports to the Program Manager. Approximately 50% of his time will be related to quality assurance. Figure 1 graphically presents the organizational structure.

2.1.2 The required quality assurance tasks may be accomplished by personnel outside the quality organization. Whenever this implementation method is necessary the Reliability and Quality Assurance Project Manager will maintain overall control and approval responsibility.

2.2 Subcontractor and Vendor Control

2.2.1 The applicable quality assurance requirements of the contract will be imposed upon all UTD sub-contractors and upon vendors of subassemblies or assemblies.

2.3 Drawing Control

2.3.1 Drawing approval and Release

2.3.1.1 Drawing approval -- All drawings and changes initiated shall require the approval of Engineering, Quality Assurance and the Project Scientist. Approval shall be indicated by approval signatures of representatives from each of the above sections in the appropriate spaces provided in the document title block.

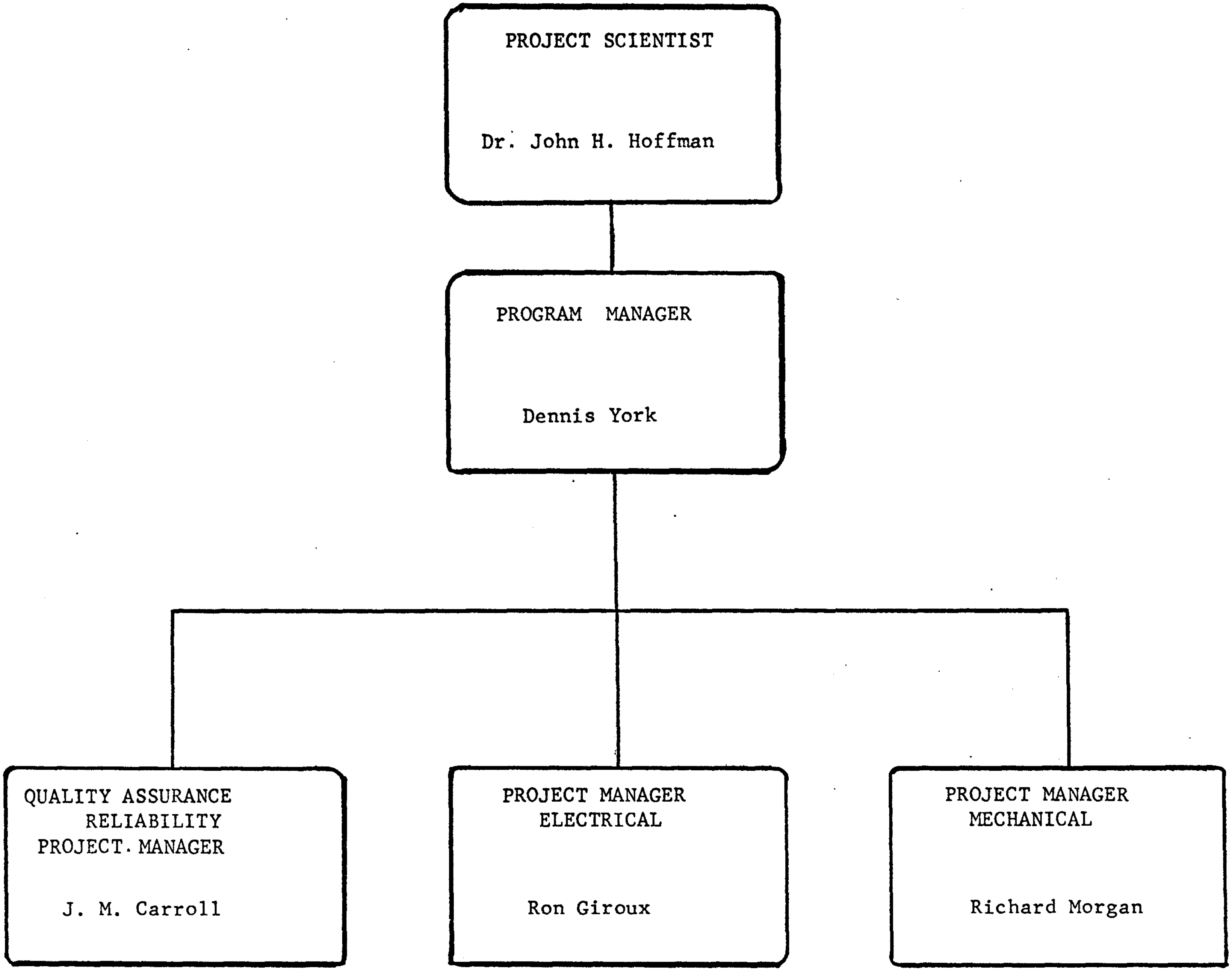

PROJECT SCIENTIST
Dr. John H. Hoffman
PROGRAM MANAGER
Dennis York
QUALITY ASSURANCE
RELIABILITY
PROJECT MANAGER
J. M. Carroll
PROJECT MANAGER
ELECTRICAL
Ron Giroux
PROJECT MANAGER
MECHANICAL
Richard Morgan

FIG. 1

2.3.1.2 Drawing release -- All drawings approved as specified by 2.3.1.1 above shall be recorded in the Master Indentured Drawing List by the Document File Clerk prior to release. Following release, each document master shall be maintained in a Master Document File for the Experiment.

2.3.1.3 Drawing change Notices (DCN'S) -- Each DCN shall be recorded in the Master Indentured Drawing List according to the effected drawing, revision, DCN number and release date. The Document File Clerk shall sign and date each entry in the blocks provided.

2.3.1.4 Responsibilities -- The Document File Clerk will be responsible for drawing release and maintenance of the Master Indenture Drawing Lists and Master Document Files.

2.3.2 Drawing Issue

2.3.2.1 General -- Released drawing prints will be issued only by one of the following methods:

2.3.2.1.1 Procurement -- Drawings required for procurement shall be listed by number, revision, and DCN's as applicable, on the purchase order. Drawings may be checked out by QA to attach to purchase orders and these prints will be stamped "not maintained."

2.3.2.1.2 Receiving Inspection -- The Receiving Inspection Planning shall specify the required maintained drawings to be checked out of Master Document Files. Following completion of the required inspection and test, the drawings shall be routed to Inspection Records with the respective inspection documentation.

The Inspection Records Clerk shall be responsible to return the drawings to the Master Document Files. Drawings shall not be allowed in the Receiving Inspection and Test area unless they are accompanied by appropriate receiving and/or inspection planning sheets.

2.3.2.1.3 Fabrication and Test -- The Fabrication and Assembly Planning shall specify the required maintained drawings for each part. These documents shall be included in a drawing package which shall be released to manufacturing with the respective fabrication and assembly planning. Following completion of all the required fabrication, assembly, inspection and test operations required by the planning, the respective drawings and inspection documentation shall be routed to Inspection Records. The Inspection Records Clerk shall be responsible to return the drawings to the Master Document Files Clerk. Drawings shall not be allowed in the Production and Test Areas unless they are accompanied by the appropriate fabrication and assembly planning.

2.3.2.1.4 Handwritten changes on any drawings are not official changes and shall not be used for fabrication, inspection or test of flight equipment and shall not be allowed in the Production and Test Area.

3.0 Inspection Requirements

3.1 Procured Material Control

3.1.1 Purchase Order Review and Approval

3.1.1.1 Purpose -- Quality Assurance Review and approval of purchase orders is an important element of the procured material control activities. This procedure defines the requirements for prompt and effective review and approval of all purchase orders.

3.1.1.2 Purchase Requests -- All purchase requisitions initiated shall be routed through Quality Assurance for review and approval prior to release to Purchasing for procurement. The purchase requisition shall specify all the necessary information to be included on the purchase order for procurement. This information shall include the pertinent technical, and configuration data; and the approved procurement source. Following approval, Quality Assurance shall retain a copy of the purchase requisition for Inspection Records. If drawings or specifications are required, Quality Assurance shall obtain the documents from the Master Document Files and attach to the purchase request.

3.1.1.3 Purchase Orders - - Quality Assurance shall review and approve all purchase orders prior to release. This review is to ensure that all the pertinent information specified by the purchase requisition has been included on the purchase order and that the proposed drawings and specifications are attached. Quality Assurance approval shall be indicated by an approval signature and stamp of Quality Assurance.

3.1.2 Procured Material Inspection

3.1.2.1 Purpose -- This procedure provides the instructions to implement those activities necessary for timely and effective inspection and processing of material procured through Receiving Inspection to material storage.

3.1.2.2 Receiving Inspection and Test -- Upon receipt of each batch of procured articles, Receiving Inspection shall perform the following operations:

3.1.2.2.1 The purchase order shall be reviewed for proper Quality Assurance approved.

3.1.2.2.2 The Receiving Inspection Planning Sheet shall be reviewed to determine the required inspections, tests, drawings and specifications.

3.1.2.2.3 The required drawings and specifications shall be checked out of the Master Document Files according to the latest changes specified by the Master Indentured Drawing List.

3.1.2.2.4 The procurement source shall be checked with that specified by the applicable List of Materials Drawing.

3.1.2.2.5 The configuration requirements specified by the purchase order, drawings and specifications shall be checked for compatibility. The configuration of the procured article(s) shall be checked to assure compliance with the applicable drawing and specification requirements.

3.1.2.2.6 The inspection and test documentation accompanying the procured articles shall be checked for completeness and accuracy in accordance with the requirements of the planning and procurement specification.

3.1.2.2.7 Certificates of Compliance shall be checked for completeness.

3.1.2.2.8 The required inspections, tests, and documentation shall be completed in accordance with the Receiving Inspection Planning requirements.

3.1.2.2.9 The Inspection Log shall be completed as defined by Quality Procedure 3.1.5.1.7.

3.1.2.2.10 A Batch number shall be assigned to the accepted material and entered on the Log.

3.1.3 Accepted Procured Materials

3.1.3.1 Following completion of the required inspections, tests and acceptance, each part or package shall be acceptance stamped identified by part name, number, purchase order number and batch number and placed in controlled storage.

3.1.4 Nonconforming Procured Material -- All procured material which fails to comply with the required inspection and test requirements shall be rejected by a Defective Material Tag (DMT), as defined in Section 3.8, identified with a "Withhold" Stamp and placed in the Receiving Inspection Hold Area for review and disposition by the Material Review Board. The DMT number shall be recorded on the purchase order and any inspection and test documentation.

3.1.4.1 Nonconforming Procured Material to be Returned to the Supplier -- Nonconforming procured material which is dispositioned by the Material Review Board to be returned to the Supplier, shall be retained in the Receiving Inspection Hold Area to await shipping instructions. Purchasing will be notified of the MRB disposition and shall be provided with a copy of the completed Defective Material Tag.

3.1.5 Receiving Inspection Planning

3.1.5.1 Requirements and Responsibilities -- Receiving Inspection Plans shall be initiated by Quality Assurance Engineering for all procured articles. These plans shall define the required inspections and tests for each type procured parts and materials. The plans shall be completed according to the following instructions:

3.1.5.1.1 The inspection plans (Attachment I) shall be numbered in numerical sequence and placed in a manual type binder. The manual shall be identified as, "UTD Space Experiment, Receiving Inspection Planning".

3.1.5.1.2 The type material shall be adequately defined as to part name and part number in the spaces provided on the planning.

3.1.5.1.3 The applicable List of Materials Drawing, drawing number, and specification numbers including procurement, material, process and test specification shall be listed in the spaces provided. Only the basic document numbers shall be listed.

3.1.5.1.4 All special instructions such as test facilities to be utilized, shelf life expiration periods, periodic inspection requirements, data recording requirements, etc. shall be defined in the space provided on the plan.

Receiving Inspection Planning Plan No:

Part Name	Part Number

List of Materials Drawing	Drawing No.(s)	Specification No.(s)

Special Instructions:

Test No.	AQL	Test Description

Prepared by:	Date:	Approved by:	Date:

3.1.5.1.5 The required inspections and tests shall be defined in the applicable numerical sequence, including a detail description of each operation, test equipment required, required results, etc.. Sampling techniques per Mil-STD-105D, single sampling, level II, may be employed for minor, and noncritical parameters.

3.1.5.1.6 The Engineer responsible for the plan initiation shall sign the date and spaces provided.

3.1.5.1.7 Receiving Inspection Log -- An Inspection Log (Attachment II) shall be completed and maintained for all source and receiving inspection activities by the responsible Quality Assurance personnel. The information required by the Inspection Log will be recorded for all material procured. One entry shall be completed for each batch of material inspected.

3.1.6 Receiving Inspection Records

3.1.6.1 Purpose -- This procedure provides the necessary instructions for collection, filing and recall of Receiving Inspection Records.

3.1.6.2 Requirements and Responsibilities -- The Inspection Records Clerk shall be responsible for maintaining the Inspection Records Files. Any files shall be established and maintained in such a manner that any record can be recalled in a minimum of time.

3.1.6.2.1 Purchase Orders -- The inspection copy of all completed purchase orders shall be filed in numerical order. The clerk shall ensure that all purchase orders are properly completed prior to filing.

UTD

ATTACHMENT II

RECEIVING INSPECTION LOG

DATES From__________ To__________

Date	Part Name	Part Number	Manufacturer	Purchase Order	Number Inspected	Number Rejected	Number Accepted	DMT Number	Receiving Insp. No. Planning	Batch Number

3.1.6.2.2 Supplier Certificates of Compliance -- All certificates of compliance shall be filed with the respective purchase orders.

3.1.6.2.3 Test Data and Documentation -- Test data and documentation shall be reviewed by the clerk for completeness. These records shall then be filed with the respective purchase orders.

3.1.6.2.4 Defective Material Tags (DMT) -- The clerk shall review all DMT's to assure that all required signatures are complete and when required, rework acceptance is properly acceptance stamped. The DMT's shall be filed in numerical sequence.

3.1.6.2.5 All documents which are not properly completed shall be returned to Receiving Inspection for completion.

3.2 Government Source Inspection Requirements

The purchase order shall clearly specify one of the following as required:

(1) "All work on this order is subject to inspection and test by the Government at all times (including the period of performance) and places; and, in any event, prior to shipment. The Government representative who normally services your plant should be notified forty-eight (48) hours in advance of the time articles are ready for inspection or test."

(2) "Supplier Certificate of Conformance Required"

(3) "All work on this order is subject to inspection and test by UTD at all times and places; and, in any event, prior to shipment. UTD shall be notified 48 hours in advance of the time that articles are ready for inspection and test."

(4) The following statement shall be included on all purchase orders which do not specify Government source inspection: "The Government reserves the right to inspect any or all of the materials included in this order at the supplier's plant."

3.3 Control of Government Furnished Property

3.3.1 Purpose -- This procedure provides the instructions necessary for control of Government property furnished to UTD.

3.3.2 Receiving of GFP -- Receiving Inspection shall perform the following activities upon receipt of GFP:

(a) Perform a complete inspection of the property to determine any evidence of carrier damage, shortages and general physical condition.

(b) Record all discrepancies and/or shortages on a Defective Material Tag and notify the Government Representative for inspection and verification.

(c) All discrepancies and/or shortages shall be resolved with NASA by Quality Assurance and the Project Scientist.

(d) Following resolution of any problem areas and completion of the required documentation the equipment shall be placed in controlled storage.

3.4 Storage Control

3.4.1 General -- The UTD does not maintain a stock or storage area for Center-wide use. The material used on the project will be in a controlled storage area which is separate from all other projects.

3.4.2 Responsibilities -- Quality Assurance will be responsible for maintaining the controlled stock areas. Controls will be used to assure that all parts remain identified and that unauthorized parts are not placed in the Storage Area. Parts and materials will be removed from the storage area only with properly approved planning sheet authorization.

3.4.3. Parts Identification -- Parts in controlled stores will be identified by tags or labels by part name, part number, purchase order number, date received and a batch number which is assigned by the receiving inspector.

3.4.4 Traceability of Issued Parts -- When parts are issued to production the Batch number of parts issued will be recorded on the production planning sheet. The planning sheet shall be stamped by the person issuing the parts to verify that the parts issued are from controlled stock and that traceability records have been maintained.

3.4.5 Inventory Records -- A log will be maintained by the records clerk of all parts in controlled storage.

3.4.6 Inspection Surveillance of Storage Areas and Material Handling -- This procedure provides instructions for periodic reviews of the Storage Areas and surveillance of parts and materials handling. A minimum of once each month, an inspection of the Storage Areas, including line storage and installation areas, shall be conducted. This inspection shall include the following:

3.4.6.1 All parts and materials are properly acceptance marked with stamps, tags, etc..

3.4.6.2 All parts, materials and assemblies in the line storage and installation areas are adequately protected.

3.4.6.3 Parts and Material Handling -- This inspection activity shall include checks to ensure that all parts and materials are adequately protected during movement and transportation from one location to another.

3.4.6.4 Reporting -- A monthly progress report shall be issued by Quality Assurnace which outlines the results of the inspections. All deficiencies noted and corrective action implemented shall be reported.

3.5 Control of Raw Materials

3.5.1 General -- Supplier Certificates of Compliance as to physical and chemical characteristics will be required for all raw material. Following acceptance, the raw material packaging shall be acceptance stamped or in case of sheet and bar stock, an inspection tag shall be securely attached to the stock which contains the acceptance stamp, date, purchase order and batch number. This tag shall remain on the stock during storage until the entire piece of stock has been used for fabrication. All articles shall be adequately packaged or protected to prevent damage, deterioration or loss and placed in controlled storage.

3.6 Control of Fabrication and In-Process Inspection

3.6.1 Fabrication and Test Cleanliness and Control

3.6.1.1 General Requirements

Flight hardware shall be designed, manufactured, assembled, and handled in a manner to insure the highest practical level of cleanliness. The greatest practicable precaution shall be taken to insure freedom from debris within the hardware. Inaccessible areas where debris and foreign material can become lodged, trapped, or hidden shall be avoided. Protective covers shall be provided to prevent entrance of debris into inaccessible areas. Where appropriate, these protective covers may be designed for ground operations only, and removed for flight.

3.6.1.2 Exterior Surface Cleanliness Requirements

The hardware exterior surfaces shall be visibly clean and free of hydrocarbons. Visibly clean shall be construed to mean the freedom of the surface from particulate matter 50 microns and larger in size and from all films other than known innocuous films.

Selection of the cleaning solution and/or method shall be consistent with the contaminates to be removed, the materials of construction of the hardware to be cleaned, and the level of cleanliness desired.

Cleaning methods must be non-detrimental to the materials of construction. Application of each cleaning solution must be restricted to usuages where problems subsequent to cleaning will not occur as a result of the application, e.g., corrosion from entrapped fluids, etc..

3.6.1.3 Cleanliness Inspection

Freedom of hydrocarbons shall be verified by inspection with an ultraviolet light (black light) or other suitable method. Freedom of particulate matter shall be verified by visual observation made with the unaided eye and light of sufficient intensity to illuminate the area being inspected.

Cleaning and bagging of hardware shall be accomplished in a Clean Room or clean work station of class 340,000 or better.

3.6.1.4 Packaging Requirements for End Item Shipments

Hardware shall be double-bagged with an inter-bag of nylon-6, two mils thick, and an outer-bag of anti-static polyethylene film six mils thick Heavy items, or items having sharp points, edges, etc., which may puncture or otherwise damage the barrier bags, shall be overwrapped with a sufficient amount of two mils thick nylon-6 film to form a cushion. The interior of each bag shall be purged with a dry inert gas immediately prior to heat sealing. Each bag shall be heat sealed using a sealing technique that will assure that the volume of gas sealed in the bag is a minimum possible, thus, permitting room for expansion of entrapped gas during air shipment.

3.6.1.5 Certification of Cleanliness

A decal shall be placed on the outside of the inter-bag indicating that the hardware has been cleaned to meet the requirements of MSC-Spec-C-8. The decal shall show evidence of company and government inspection, verification of cleaning and packaging and date of inspection.

3.6.2 Personnel Training and Certification -- All personnel whose duties include soldering or welding operations or inspection of such operations shall be properly certified in accordance with NHB 5300.4 (3A) or RQA/E2 welding for Electronic Packaging. This requirement applies both to UTD and subcontractor personnel.

3.6.3 Fabrication and Assembly Planning -- Each fabrication or assembly drawing which is released shall be translated into instructions which establish the parts required from stock, the routing, the sequence of fabrication or assembly, the points of inspection, and the testing instructions. The Fabrication and Assembly Planning shall be utilized in conjunction with the engineering drawings and test procedures. This Planning shall include the initials of the operator performing each operation, the inspection stamps, discrepancy references, and rework verifications. Planning sheets shall be formally issued and controlled to assure that engineering changes are incorporated and that configuration is at all times subject to verification. Completed planning shall become a part of the historical inspection record.

3.6.4 Fabrication Inspection -- During fabrication and assembly, inspection shall be responsible to monitor all manufacturing operations, perform the inspection operations required by the planning and verify the configurations specified.

3.6.4.1 Detailed Inspection Planning -- In those instances where special inspection instructions are required which cannot be included as a part of the Fabrication and Assembly Planning, special inspection instructions shall be prepared and referenced on the Fabrication and Assembly Planning.

3.6.5 Fabrication Testing -- Tests shall be performed during the fabrication process as specified by the Fabrication and Assembly Planning. Inspection shall be responsible to verify that the testing is performed per the test procedure plans and to verify that the test data recorded is legible and within limits.

3.6.5.1 In Process Test Specifications and Procedures -- In Process and sub-assembly test procedures shall be referenced on the Fabrication and Assembly Planning. Test data sheets shall be used with the test procedures.

3.6.5.2 Formal Test Specifications, Procedures, Certifications and Reports -- Detailed Test Specifications, Procedures and Data Sheets will be prepared for the pre-acceptance test program. The Test Specifications, Procedures and Data Sheets will be prepared by engineering and will be approved by the Quality Assurance Project Manager . For acceptance and qualification tests, the specifications, procedures and data sheets shall be approved by Quality Assurance and by NASA before the tests are conducted. Quality Assurance will witness all subsystem and Flight Acceptance tests and certify test results. Reports will be prepared for all acceptance level tests by the Project Scientist. These reports will be approved by Quality Assurance and submitted to NASA.

3.6.6 Fabrication and Test Inspection Records

3.6.6.1 Purpose -- This procedure provides the necessary instructions for collection, filing and recall of Fabrication and Test Inspection Records.

3.6.6.2 Procedures and Responsibilities - The Inspection Records Clerk shall be responsible for maintaining the Inspection Records File. All Files shall be established and maintained in such a manner that any record can be recalled in a minimum of time.

3.6.6.2.1 Fabrication and Assembly Planning -- The Records Clerk shall review the planning to assure that all inspection and test operations have been properly acceptance stamped. The drawings, specifications and changes contained in the document package shall be returned to the Master Document Files. The Inspection Copy of the planning sheets shall be filed by part number and serial number.

3.6.6.2.2 Discrepancy Sheets -- The records clerk shall review the discrepancy sheets to assure that all discrepancies are properly acceptance stamped.

3.6.6.2.3 Defective Material Tag (DMT) -- The Records Clerk shall review all DMT's to assure that all required signatures are complete and when required, rework acceptance is properly acceptance stamped. The DMT's shall be filed in numerical order.

3.6.6.2.4 Inspection and Test Data -- The Records Clerk shall review all Inspection and Test Data to assure that all entries are complete and properly acceptance stamped. This data shall be filed by part number and serial number.

3.6.6.2.5 All documents which are not properly completed shall be returned to Inspection for completion.

3.6.6.2.6 Final Acceptance -- Following satisfactory completion of all inspections and tests, a test log shall be assembled in duplicate. Inspection shall be responsible to assemble the log record and verify each entry. Final UTD acceptance shall be indicated by the signature of the Project Manager, Project Scientist, Quality Assurance and an inspection acceptance stamp and date on the log cover.

3.7 Process Control -- All processing, such as chemical surface treatment, plating, soldering, cleaning, embedding or conformal coating, etc., shall be accomplished in accordance with the proper process procedures and/or specifications approved by QA.

Sub-contracted processing shall require QA approval of supplier process specifications and certifications. The specifications, certifications and records will be available for Government inspection. Inspection shall be responsible to monitor the process operations and perform the necessary inspection to assure specification compliance.

3.8 Nonconforming Material

The purpose of this procedure is to set forth the controls necessary to assure proper handling and dispositioning of non-conforming materials. These provisions are intended to protect against the unauthorized use of materials which would adversely affect the reliability and quality of the Instrument.

3.8.1 Nonconforming Material Reporting

3.8.1.1 Inspection Discrepancy Sheet -- The Inspection personnel detecting conditions of nonconformance shall report these conditions on the Inspection Discrepancy Record which is a permanent part of the planning sheet. If the material is obviously unfit for further use or is found to be uneconomically repairable, it may be scrapped in accordance with UTD Government approved procedure for identifying and disposing of scrap. Items which cannot be reworked to print and which are not obvious scrap or uneconomically repairable scrap shall be referred to the MRB by completion of a DMT.

3.8.1.2 Defective Material Tag (DMT) -- When MRB action is required, the responsible Quality Assurance personnel shall complete the DMT (Attachment III). The defective material and DMT shall be immediately placed in the nonconforming material hold area awaiting MRB action.

Defective Material Tag (DMT) No. 101 Date:

Nomenclature	Part Number	S/N	Ref. Design
N/A Part Number	N/A S/N	Manufacturer	
Oper. Code	Failure Code	Reported by	Purchase Order

Failure Description

Cause	Corrective Action

Disposition	Acceptable	Rework	Scrap	RTV
Quality Assurance	Engineering	Government	Customer	

Instructions:

Vendor Fa/Car No. Carr No. Far No.

3.8.2 Control of Nonconforming Material

3.8.2.1 Purpose -- This procedure defines the use and control of a Nonconforming Material Hold Area to facilitate segregation of nonconforming material from productive material

3.8.2.2 General -- The Nonconforming Material Hold Area shall be under the direct control of Quality Assurance. It shall consist of a suitable storage cabinet which can be locked. Quality Assurance shall control all keys to the cabinet. This hold area is part of the overall nonconforming material control system. Its use shall be reserved for the retention of discrepant material pending disposition by the Material Review Board and temporary storage of scrapped material awaiting disposal.

3.8.2.3 Access -- Access to the hold area shall be limited to the following:

(a) Quality Assurance Personnel

(b) Material Review Board Members

All other personnel requiring access shall be admitted access if escorted by authorized personnel.

3.8.2.4 Material Control -- No material shall be removed from the hold area unless the removal is authorized by a member of the Material Review Board. Inspection shall daily review all rejected material in the hold area to ensure that the responsible personnel are aware of its existence in order to facilitate timely flow of the discrepant material. A log will be maintained on MRB items showing current status and final disposition. When the final disposition is to scrap, the material will be positively identified and segregated.

3.8.3 Material Review Board

3.8.3.1 Purpose -- The purpose of this procedure is to set forth the organization and function of the UTD Material Review Board whose primary duty shall be decision-making on disposition of nonconforming material on the Program and to make decisions for disposition of discrepancy reports on completed systems.

3.8.3.2 Material Review Board Members -- The Material Review Board shall be composed of the following members:

(1) One UTD representative whose primary responsibility is R&QA.

(2) One UTD representative whose primary responsibility is design.

(3) One government representative acting on behalf of the cognizant NASA installation.

3.8.3.3 Appointment of Material Review Board Members -- The MRB members shall be appointed by the UTD Project Scientist.

3.8.3.4 Conditions Requiring Material Review Board Action -- Each nonconformance which cannot be corrected by normal procedures requires an MRB action.

3.8.3.5 Material Review Board Action -- The MRB must make one of the following dispositions:

3.8.3.5.1 "Scrap" -- The article cannot be used under any circumstances.

3.8.3.5.2 "Acceptable As Is" -- The article, although not conforming to the letter of the requirement, can be utilized without jeopardizing reliability or performance.

3.8.3.5.3 "Repair to Special Instructions"-- The article can be returned to an acceptable state of conformance using approved standard repair procedures.

3.8.3.5.4 Request for waiver/deviation -- A waiver may be requested from the contracting officer.

3.8.3.6 Disposition by MRB -- Dispositions to "accept as is" or to "repair to special instructions" must be by unanimous agreement of the MRB.

Any member may require the disposition to be "scrap" unless a waiver is obtained to use the material. A waiver/deviation request may be prepared by the contractor and submitted to the contracting officer for action if he feels that the material should not be scrapped.

3.8.3.7 Subcontractor MRB -- Quality Assurance may delegate MRB responsibility to major subcontractors. In this case the MRB actions will be limited to nonconformances of a minor or incidental nature which do not affect safety, function or interchangeability.

3.9 Control of Inspection, Measuring and Test Equipment

3.9.1 Calibration and Certification of Electrical/Electronic Test Equipment

3.9.1.1 General -- All measuring and test equipment utilized for acceptance of Scientific Instruments shall be maintained in a calibrated condition with standards traceable to the National Bureau of Standards.

3.9.1.2 Calibration Facility -- An outside calibration facility shall be selected and utilized for this activity. Quality Assurance shall approve the calibration facility selected.

3.9.1.3 Indication of Calibration Status -- Calibration status shall be indicated by an appropriate decal on the face or visible surface of each piece of equipment. The decal shall contain the name of the calibration facility, calibration acceptance stamp, date of calibration and date of calibration expiration. Equipment not to be used for acceptance shall be so marked with high visibility labels. Equipment not properly calibrated or for which the calibration period has expired, which is being utilized for final acceptance testing, shall be tagged with a red tag stating "Calibration Required" and removed from the test area for routing to the calibration facility.

3.9.2 Calibration and Certification of Mechanical Inspection Tools

3.9.2.1 General -- All new tools shall be submitted to Quality Assurance for inspection upon receipt. Qualification of new tools shall consist of:

3.9.2.1.1 Visual inspection of conformance to vendor specification, physical damage, missing parts, etc..

3.9.2.1.2 All linear measurement tools shall be qualified and calibrated to standards traceable to the National Bureau of Standards.

3.9.2.2 Existing UTD inspection tools shall be submitted to Quality Assurance for recalibration and qualification per paragraph 3.9.2.1.2, above.

3.9.2.3 Acceptable Tools -- Upon successful completion of the qualification and calibration of a tool, a serial number shall be applied to a decal which shall be applied to the body of the tool.

3.9.2.4 Discrepant Tools -- Tools failing to pass qualification and/or calibration tests shall be rejected and not used until it can pass qualification and/or calibration.

3.9.2.5 Tool Issuance -- No tool shall be issued for inspection use prior to a current certification of calibration as defined by paragraph 3.9.2.3, above. This requirement applies to UTD and employee owned tools.

3.9.3 Calibration Records -- Quality Assurance shall maintain a record of all inspection, test and measuring equipment by type,serial number, calibration record, if any, and date of calibration. The Inspection Record Clerk shall notify Inspection and Manufacturing Supervision one week prior to calibration expiration date.

3.9.4 Calibration Periods --

All Linear measurement tools - 6 months
All test equipment - - - - - - 6 months
All traceable standards - - - 1 year

3.10 Indication of Inspection Status

3.10.1 Quality Assurance Stamp Configuration -- This procedure defines the configuration of the UTD Quality Assurance Stamps for Space Experiments.

3.10.1.1 Stamp Configuration and Description

3.10.1.1.1 

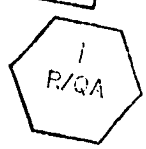
Acceptance

3.10.1.1.2 

Withhold

3.10.1.1.3 

Material Review Board

3.10.1.1.4 

Reliability/Quality Assurance

3.10.1.2 Each stamp shall bear a non-repetitive number which can be traceable to the person to whom the stamp was issued.

3.10.2 Issue and Control of Quality Assurance Stamps -- Quality Assurance shall be responsible to issue and maintain records by stamp number and individual to whom each stamp is issued. In the event that a stamp is lost or misplaced, Quality Assurance shall be notified and a replacement stamp will be issued. When it has been determined that a stamp has been permanently lost, a cancellation notice shall be issued prohibiting the lost stamp number use for a minimum period (6) months from the date of the cancellation notice. When a person with an assigned stamp leaves the employ of UTD, Quality Assurance shall recall the individual's stamp.

3.10.3 Use of Stamps -- Stamps shall be affixed to tags or documents in such a manner so as to be completely legible and visible. When a stamp impression applied to a document must be voided, the individual who applied the stamp will write the word "Void" over the impression in ink. The date, reason for voiding, and the individual's signature shall be noted opposite the stamp impression. Only the individual affixing the stamp impression originally or his supervisor may void a stamp impression.

3.10.3.1 Acceptance Stamps -- Acceptance Stamps shall be used by the responsible inspector to stamp planning operations, data and documentation to signify acceptance of the applicable inspection operation, and/or article. The stamps shall also be utilized to identify the individual entering discrepancies on discrepancy sheets, and initiating DMT's.

3.10.3.2 Withhold -- Withhold Stamps shall be used by the responsible inspector to stamp articles indicating the need for Material Review Action.

3.10.3.3 Material Review Board Stamps -- Material Review Board Stamps shall be used by Material Review Board personnel in conjunction with "Withhold" Stamp to signify salvage of items. The MRB Stamp shall be applied to the article interlocking the edge of the Withhold Stamp.

3.11 Packing, Packaging, and Shipping

3.11.1 General Instruction for Shipping Inspection -- Quality Assurance will initiate shipping check list, including documents required, for each instrument to be shipped. The completed check list with inspection stamps affixed shall become part of the historical record and be filed in Inspection Records by part and serial number.

3.11.2 The scientific instrument handling and shipping containers shall be designed to protect the instrument from the rigors of handling, shipping and storage under all the expected environmental conditions specified in the contract.

3.11.3 A removable instruction tag shall be attached to each scientific instrument which defines the special handling, storage, etc. during receiving inspection, installation and operation at the destination.

3.11.4 The container marking transportation and shipping instructions shall be in accordance with the contract and NASA instructions.

3.11.5 The equipment will be cleaned and packaged in accordance with the requirements in Section 3.6 before transporting to shipping.

3.12 Sampling Inspection

Sampling Inspection will be used only for standard nut, bolts, etc. and will be based on the sampling tables of MIL-STD-105D. All other parts will be subject to one-hundred percent inspection.

3.13 Records of Inspections and Tests

3.13.1 Inspection and Test Records -- All records of inspections and tests as specified in this plan will be maintained and filed by the records file clerk in the Quality Assurance office. These records will be available to NASA representatives at all times.

3.13.2 Historical Record Card -- Engineering will initiate and maintain MSC Form 772 for all deliverable hardware items beginning with end item tests and continuing until the unit is shipped. Reliability/Quality Assurance shall be responsible for including the completed Form 772 in the ADP.

3.14 Corrective Actions

All discrepancy reports will be analyzed by Quality Assurance to determine if corrective actions are necessary to prevent further discrepancies. In cases where corrective action appears necessary a corrective action request will be issued to the appliciable department manager.

VII. RELIABILITY PLAN

SMW3-UC-034
APR 14 1970

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

REPLY TO ATTN OF: BG931/L238-70/T94

APR 10 1970

University of Texas at Dallas
P. O. Box 30365
Dallas, Texas 75230

Attention: Mr. D. R. York
Program Manager

Gentlemen:

Subject: NAS 9-10410 - Reliability Program Plan

The University of Texas at Dallas Reliability Plan RP-100-1 submitted for review and approval by your letter of March 17, 1970 is approved.

Sincerely,

R. Paul Clyatt
Contracting Officer

Copies to: D. Carlson
J. Carroll
J. Hoffman
J. Vanderford
J. Van Helm
D. York

UNIVERSITY OF TEXAS
AT DALLAS

RELIABILITY PLAN
RP-100-1

for

MASS SPECTROMETER EXPERIMENT

for

Contract NAS 9-10410

March 13, 1970

NASA/MSC Approvals

____

____

Dr. John H. Hoffman
Project Scientist/P.I.

Mr. J. M. Carroll
Quality Assurance Reliability
Project Manager

Dennis York
Program Manager

REVISION LOG

Date	Section/Paragraph Revised	QAR Signature	NASA Signature

INDEX

1.0 Introduction

1.1 General

1.1.1 This Plan presents the Reliability operating policies and procedures which govern and direct the conduct of those activities which directly or indirectly influence the reliability of the University of Texas at Dallas Space Experiments.

1.2 Distribution, Control and Revisions to Manual

1.2.1 Distribution and Control - The distribution of this manual shall be controlled by the Reliability/Quality Assurance Project Office. All controlled manuals will be serialized and issued by serial number. The master manual files and distribution log will be maintained and controlled by the Reliability/Quality Assurance Project Office. The distribution log shall contain the following:

(a) Manual Serial Numbers

(b) Person or Organization to whom each serial number is assigned

(c) Issue date of each serial number

(d) Dates of up-dating and reason for up-dating of each serial number

(e) Reliability/Quality Assurance Project signature beside each entry

Subsequent to the original issue of each manual, it will be the responsibility of the person or organization to whom each manual is assigned to maintain the manual current. As revisions are initiated and released, copies of the revisions will be forwarded to the respective personnel and/or organizations and the appropriate entries completed in the distribution log.

1.2.2 Revisions - In the event of procedure revisions, the issue data will appear on each page, (e.g., Revised: 2-10-67) and each revised paragraph will be indicated by an asterik in the left hand margin (i.e. *1st revision, **2nd revision, etc.). The revision index shall be changed to indicate the latest revisions. Each revision shall require the approval of the Reliability/Quality Assurance Project Manager, the Project Scientist, the Program Manager and NASA.

2.0 Management

2.1 UTD Reliability Project Organization

2.1.1 The Project Scientist will direct the overall activities of the experiment. The reliability activities are directed by a Reliability and Quality Assurance Project Manager who reports to the Program Manager. Approximately 50% of his time will be related to reliability engineering. Figure 1 graphically presents the organizational structure.

2.1.2 The required reliability tasks may be accomplished by personnel outside the reliability organization. Whenever this implementation method is necessary the Reliability and Quality Assurance Project Manager will maintain overall control and approval responsibility.

2.2 Subcontractor and Vendor Control

2.2.1 The applicable reliability requirements of the contract will be imposed upon all UTD sub-contractors and upon vendors of subassemblies or assemblies.

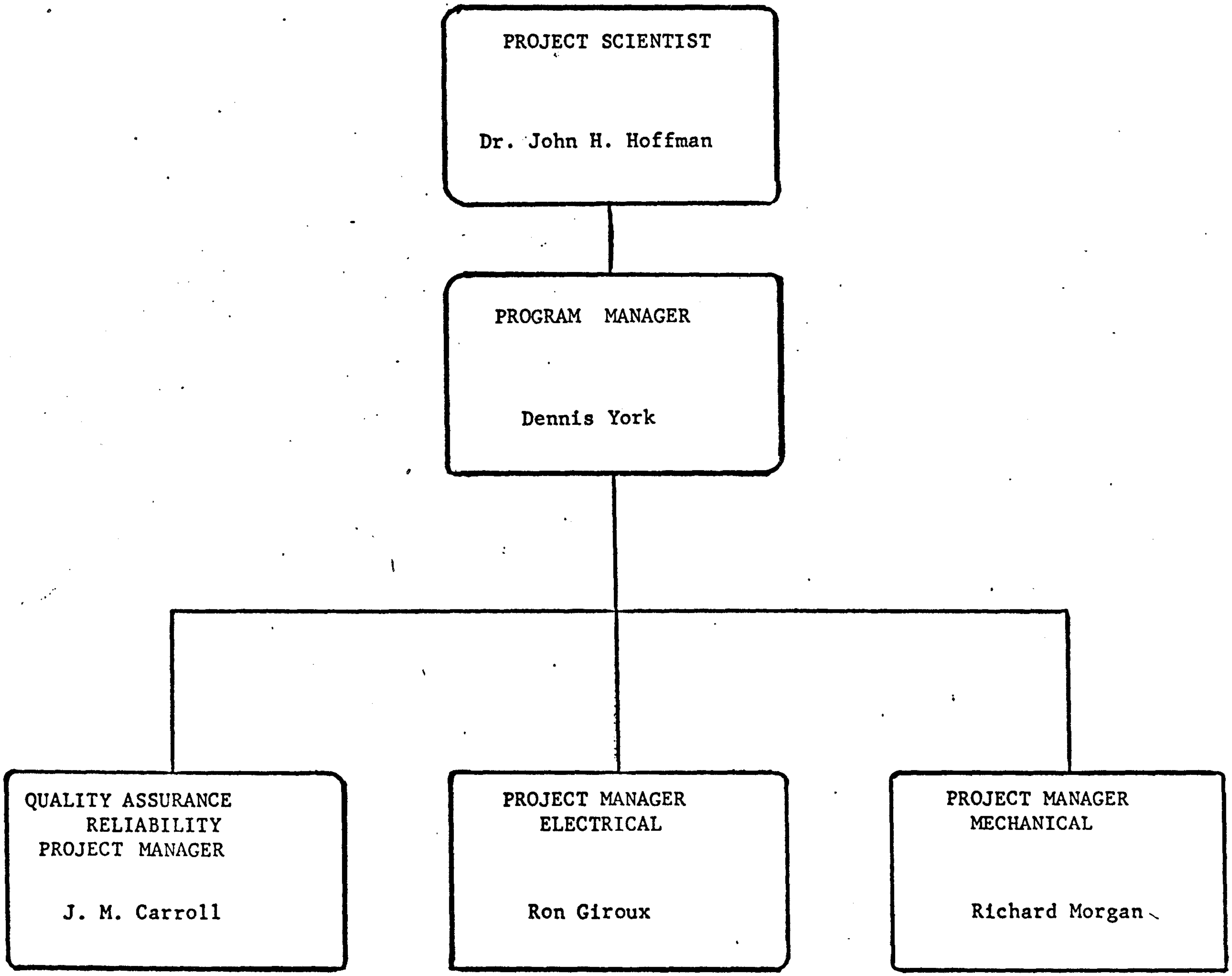

PROJECT SCIENTIST
Dr. John H. Hoffman
PROGRAM MANAGER
Dennis York
QUALITY ASSURANCE RELIABILITY PROJECT MANAGER
J. M. Carroll
PROJECT MANAGER ELECTRICAL
Ron Giroux
PROJECT MANAGER MECHANICAL
Richard Morgan

FIG. 1

3.0 Reliability Engineering

3.1 Design Specifications

3.1.1 The Engineering Design Group shall be responsible for generating design specifications for all items of hardware at the system and subsystem level. These specifications shall cover as a minimum the following requirements:

(a) Performance

(b) Environmental Conditions

(c) Test conditions (including overstress)

(d) Derating factors

3.1.2 The Reliability/Quality Assurance Project Manager shall be responsible for the review and concurance with all design specifications and for requiring design engineering to update specifications when necessary.

4.0 Failure Mode, Effect Analysis (FMEA)/Single Failure Point Summary(SFPS)

4.1 The Reliability/Quality Assurance Project Manager will be responsible for the preparation of the failure mode, effect analysis and Single Failure Point Summary of the interface circuits and major subassemblies. The analysis will be a major item for early design review activities and will be used to assist in the preparation of test plans and procedures.

4.2 The formats for the FMEA and SFPS are shown as Figures 2 and 3 respectively.

Figure 2

SYSTEM ______________________

SUB SYSTEM ______________________

DATE ______________________

FAILURE MODE EFFECT ANALYSIS

ITEM NAME PART NUMBER	FUNCTION	FAILURE MODE	FAILURE EFFECT ON ASSEMBLY	FAILURE EFFECT ON SYSTEM	ALTERNATE IN-FLT. CAPABILITY	CRITICALITY CATEGORY

STEM ____________________ PROGRAM ____________________

SYSTEM ____________________ PREPARED BY ____________________

E ____________________

SINGLE FAILURE POINT

SUMMARY

ITEM NAME PART NUMBER	FUNCTION	FAILURE MODE	FAILURE EFFECT ON SYSTEM	JUSTIFICATION FOR RETENTION OR DESIGN ACTION

5.0 Design Review Program

5.1 The Project Scientist will establish a schedule of design reviews. These reviews will cover all levels of design and will put strong emphasis on reliability aspects of the design.

5.2 Design Reviews will be attended by representatives of all applicable UTD departments including Reliability and Quality Assurance. NASA Representatives will be invited to attend all reviews.

5.3 A detailed agenda of each major design review will be prepared jointly by the Project Scientist and the Reliability/ Quality Assurance Project Manager . The agenda will be provided to NASA 15 days in advance of reviews. Review minutes and formal review reports will be the responsibility of the Program Manager

5.4 The Reliability/Quality Assurance Project Manager will be responsible for follow-up of reliability and quality assurance action items resulting from the reviews.

5.5 Engineering design changes will not be allowed after the Critical Design Review of any particular element of the experiment without the consent of the Configuration Control Board which will include the Reliability/Quality Assurance Project Manager , NASA and other engineering and management personnel.

6.0 Non conformance Reporting and Corrective Action

6.1 General -- Nonconforming material shall be contolled by the implementation and enforcement of the UTD Standard Procedures. These procedures provide the means for the internal reporting, reviewing, and dispositioning of nonconforming or defective materials and parts. Methods of obtaining corrective action, positive identification, and segregation of nonconforming materials are also provided for in the UTD Standard Procedures.

6.2 Nonconformance Reporting, Analysis, and Corrective Action

6.2.1 Reporting Nonconformance Events to NASA

Nonconformance reporting to NASA MSC shall be initiated by Quality Assurance Commencing with qualification tests, end item tests such as pre-delivery acceptance, and continued until the article has completed its operational requirements. All nonconformance events regardless of the circumstances under which they occur will be reported first by telephone within 24 hours and then by the methods outlined below. The reportable events include major defects and all failures.

6.2.1.1 A report will be made on all major defects and all failures as defined below to NASA MSC on MSC Form 2174 (FIAR form). The initial reports shall be completed and forwarded to MSC by U. S. Airmail within 5 days after the nonconformance source is isolated to a replaceable assembly or comparable level. A copy of the FIAR form shall be transmitted to the following address:

Problem Assessment Engineering, Unit 763
P. O. Box 58408
Houston, Texas 77058

A copy of the FIAR form shall be provided to the delegated resident government agency. The FIAR hard copy shall remain with the failed hardware.

6.2.1.2 Failure analysis and recommended corrective actions shall be submitted to MSC within 20 working days after the initial notification of nonconformance occurrence. In the event this requirement cannot be complied with within the above-specified time limit, a plan of action for failure report closure and a summary of all actions to date relative to the nonconformance will be reported.

6.2.1.3 In the case of hardware which is returned to UTD for failure analysis, corrective action, and/or repair, the failure analysis results and recommended corrective actions shall be indicated on the form accompanying the hardware.

6.2.1.4 If UTD is in possession of the hardware at the time of approval of the corrective action by NSC, UTD shall place the FIAR form hard copy in the data package accompanying the hardware.

6.2.1.5 Significant nonconformances shall be reported by telephone to NASA MSC within 24 hours of occurrence. Subcontractors shall report significant nonconformances to the next higher level contractor in the contractor tier. Such events shall be reported to the following contact point:

NASA Problem Assessment Engineering Unit
Telephone: Area Code 713-932-4511
Extension 3433 or 3440

In addition, UTD shall submit written follow-up reports for all significant nonconformances reported by telephone utilizing the FIAR Form.

6.2.2 Definitions

A. Nonconformance - The term nonconformance is a general term encompassing all failures and defects.

1. Defect - Any deviation from the requirements established by applicable drawings, specifications, instructions, and/or assembly, test, handling, and storage procedure that does not have any effect on the required functions of the part or higher level of assembly. This definition excludes failures.

a. Major Defect - A defect for which engineering disposition is required. It is a condition which cannot be corrected to the specified configuration using standard planned operations. It is an event which could lead to a failed condition but does not affect the function of the article, i.e., contamination, corrosion, workmanship requiring engineering disposition, etc. A major defect is the same as an unsatisfactory condition.

b. Minor Defect - A defect which does not require engineering disposition. A minor defect is one which can be returned to the specified configuration by using standard operations or is accepted by the cognizant Quality Engineer as insignificant. Examples: Burrs, scratches, etc..

2. Failure - The inability of a system, subsystem, component, or part to perform its required function within specified limits, under specified conditions for a specified duration. All occurrences fitting this definition are failures even though the cause may be something other than an inherent part fault such as: (1) the failure of another part, (2) human error in handling or procedure, and (3) failure to test facilities or instrumentation.

Failures are categorized into five types:

Type 1 - Primary Failure: Any failure which is inherent in the failure article and which is self-induced within that article.

Type 2 - Secondary Failure: Any failure which is induced by a source outside the failed article.

Type 3 - Suspected Failure: An interim classification assigned until the failure may be classified as: Primary, secondary, overstress, or no failure.

Type 4 - No Failure: A classification assigned when, after all tests and analyses are conducted, the suspected article is found to meet all applicable specifications.

Type 5 - Overstress: A classification assigned <u>only</u> in the event of a failure occurring as a result of a planned overstress condition.

B. Significant Nonconformances - A significant nonconformance is any <u>major</u> <u>defect</u> or <u>failure</u> which meets the following specifications.

1. A major defect becomes classified as a significant nonconformance when it could affect personnel safety, contribute to schedule impact or launch delay, or add significant cost.

2. A failure becomes classified as a significant nonconformance when it occurs during testing upon which certification (qualification) may be based, formal certification (qualification) testing, spacecraft testing operational testing, or when the failure could affect personnel safety, contribute to a schedule or launch delay, or add significant cost.

7.0 Parts and Materials Program

7.1 Parts for the MS shall be selected from the types listed below with the highest listed category having preference.

A. Established Rel (ER) MIL SPEC

Example: (RNR,CKR,etc.)

B. JAN-TX (Testing Extra) MIL STD 701

Example: (Jan Only)
(MIL-S-19500)

C. Other Military Spec + Screen & Burn-In

Example: (MIL-R11) + Screen & Burn-In

D. Industry Spec + Screen & Burn-In

Example: (Programs)
(UNIQUE,SHURE) + Screen & Burn-In

E. Supplier Specs + Screen & Burn-In

Example: (mfg-or labs) + Screen & Burn-In

F. User Specification (Unique Parts) + Screen & Burn-In

Example: (UT at Dal Designed) + Screen & Burn-In

7.2 Parts specifications, screen and burn-in specifications, and derating guides shall be prepared by engineering approved by Reliability Engineering and made available as Type III documents. Industry Hi-reliability specifications shall be reviewed for adequacy and additional screen and burn-in specifications shall be prepared if required. Screen and burn-in specifications will be prepared for items in category C , D, E and F above. The screen and burn-in operation may be performed by an independent testing laboratory.

7.3 A parts list shall be prepared by Engineering early in the contract, will be approved by UTD Reliability Engineering and submitted to NASA for review as a type II document two (2) weeks prior to CDR.

7.4 Lot traceability shall be maintained on all purchased parts. Upon receipt by UTD individual part traceability will be maintained on all parts, subassemblies and assemblies in the following manner.

Each batch of parts received by UTD will be inspected by the receiving inspector. The parts which are accepted will be tagged with the part name, part number, purchase order number and a batch number assigned by receiving inspection. This information will also be included on the inspection log. The parts will then be placed in controlled storage. When parts are issued by the use of production planning sheets, the batch numbers of parts issued will be recorded on the planning sheets and become a part of the permanent record for the part.

7.5 Non-Metallic Materials

7.5.1 Non-metallic materials shall be selected primarily by their outgassing characteristics. A non-metallic material list will be submitted to MSC two (2) weeks prior to the CDR.

7.5.2 Non-metallic materials which are not approved by MSC shall be removed from the system wherever possible. When it is required that non-metallic materials not approved by MSC be used, a request for waiver letter will be transmitted to MSC.

7.6 Parts Failure Analysis

7.6.1 Parts which fail during receiving inspection will be returned to the vendor. A failure analysis will not be made at UTD.

7.6.2 Parts which fail during sub-assembly testing at UTD will be removed from the system and tagged with a defective material tag as described in the UTD Quality Assurance Plan. The UTD Material Review Board will investigate the failure and make recommendations as to corrective actions to be taken.

7.6.3 Part failure which occurs during acceptance testing, qual testing and field testing will be reported as outlined in Section 6 of this plan.

7.7 The storage and handling procedures for parts and materials is described in detail in the UTD Quality Assurance Plan. In general, all parts and materials for the Mass Spectrometer Experiment will be maintained in a limited access stock room which will contain only parts for the experiment. The parts will be identified as described in Section 7.5.

7.8 Parts Qualification

A. Parts which have been qualified on similar Apollo or ALSEP missions will be considered as qualified for the Mass Spectrometer Experiment.

B. Parts which cannot be traced to previous qualifications will be considered to be qualified if they have been subjected to MIL-STD-202D test methods which meet or exceed the levels required by the Mass Spectrometer Experiment.

C. If a part cannot be qualified by the above methods, it will be qualified in higher level testing.(Section 8). A qualification Status list will be prepared showing the method for qualifying each part.

7.9 Parts Application and Derating

The reliability engineer shall assist the design engineers in preparing a parts application analysis for his design. The results of the analysis will be used to determine if sufficient parts deratings have been used. Appendix B of MSCM 5320 shall be used as a guide in parts derating.

8.0 Qualification Testing

8.1 General -- Qualification test plans and procedures and the environmental requirements document will be prepared by engineering. The test procedures will be in sufficient detail to assure that qualification requirement as specified in the test plan will be assured. Complete reports will be written for each test by engineering. The test plans and procedures and reports will be reviewed and approved by Reliability/Quality Assurance and submitted to NASA for approval as required by Contract. All qualification testing will be monitored by a representative of the Reliability/Quality Assurance Project Manager . Failure reporting during qualification testing will be as described in paragraph 6.2.

9.0 Reliability Documentation

9.1 Documentation, General Instructions

9.1.1 A Reliability/Quality Assurance Documentation file will be maintained by the Reliability/Quality Assurance Project Manager. This file will contain copies of all procedures, reports, specifications, data sheets, etc. which pertain to reliability or quality assurance.

9.2 Reliability Program Plan

9.2.1 This document comprises the final Reliability Program Plan.

9.3 Reliability Progress Reporting

9.3.1 Reliability Progress reporting will be accomplished by providing a specific section in each monthly management report. The reliability progress reporting may include areas such as:

A. Procurement Status

B. Documentation Status

C. Current Problem Areas

D. Status of Previous Problem Areas

9.4 Submission of Documentation

9.4.1 The Reliability/Quality Assurance Project Manager will be responsible for submission of all deliverable reliability documentation to NASA.

VIII. SYSTEM SAFETY PLAN

SM09-OC-067
APR 30 1970

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

REPLY TO ATTN OF: BG931/I274-70/T94

APR 29 1970

University of Texas at Dallas
P. O. Box 30365
Dallas, Texas 75230

Attention: Mr. D. R. York
Program Manager

Gentlemen:

Subject: NAS 9-10410, System Safety Plan

The System Safety Plan which you submitted under subject contract has been reviewed by the Program Management Safety Office.

Subject plan is approved as submitted.

Sincerely,

R. Paul Clyatt
R. Paul Clyatt
Contracting Officer

Copies to: R. Bickel
J. Carroll
R. Giroux
J. Hoffman
R. Morgan
C. Petak

UTD Document #150-430

THE UNIVERSITY OF TEXAS AT DALLAS
Dallas, Texas

SYSTEM SAFETY PLAN

for the

MASS SPECTROMETER EXPERIMENT

CONTRACT NAS9-10410

31 March 1970

Prepared by: J. M. Carroll
J. Carroll
R&QA Project Manager

Approved by: John H. Hoffman
J. H. Hoffman
Project Scientist/PI

Reviewed by: R. L. Bickel
R. L. Bickel
Project Safety Officer

Approved by: D. R. York
D. R. York
SMOG Program Manager

Reviewed by: Charles E. Petak
C. E. Petak
Physical Plant Director

INDEX

1.0 SCOPE

1.1 Purpose - The purpose of this plan is to identify safety program requirements and assign responsibilities for the implementation of safety tasks in support of design, testing and flight usage of the Mass Spectrometer Experiment of the Lunar Orbital Science Mission.

1.2 Objective - The objective of the plan is to eliminate or prevent critical or catastrophic hazards which may affect the safety of personnel or equipment.

2.0 REFERENCE DOCUMENTS

2.1 References:

a. System Safety Plan for ALEM Lunar Orbital Experiments dated 9 December 1969, NASA-MSC

b.	KMI 1710.1 Attachment A	General Safety Plan Kennedy Space Center	10-4-66

2.2 Applicable Documents

a. Contract NAS9-10410

Exhibit A System Safety Requirements

3.0 DEFINITIONS

3.1 Safety Terms - The safety terms used here are those defined in the System Safety Plan for ALEM Lunar Orbital Experiments, prepared by the Safety Office of the NASA-MSC, Houston, Texas, December 9, 1969.

a.) Safety - Freedom of chance of injury or loss to personnel, equipment or property.

b.) System Safety - The organized application of scientific and engineering techniques and analyses for the identification of potential hazards throughout all phases of the program life cycle.

c.) Public Safety - The extension of system and industrial safety for the protection of the general public.

d.) Hazard - Conditions which can cause injury or death to personnel, significant loss of equipment of property, and which may produce harmful change in the natural earth environment.

e.) Inherent Hazard - The presence of a risk resulting from equipment design, equipment intrinsic nature, environment, procedural deficiency, or combinations of these conditions.

3.2 Hazard Categories - These categories are taken from the document referenced in 3.1, above.

a.) Safety Catastrophic - Conditions such that environment, personnel error, design characteristics, procedural deficiencies, or subsystem or component malfunction will cause death or injury to personnel.

b.) Safety Critical - Conditions such that environment, personnel error, design characteristics, procedural deficiencies, or subsystem or component malfunction will cause a hazard which requires immediate corrective action to avoid loss of, or injury, to personnel.

c.) Safety Marginal - Conditions such that environment, personnel error, design characteristics, procedural deficiencies, or subsystem failure or component malfunction will degrade system performance but which can be counteracted or controlled without major damage or any injury to personnel.

d.) Safety Negligible - Conditions such that personnel error, design characteristics, procedural deficiencies, subsystem failure, or component malfunction will not result in major system degradation, and will not produce system functional damage or personnel injury.

4.0 MANAGEMENT

4.1 Policy - The University of Texas at Dallas has established policies that require Safety to be an integral part of its management. The Physical Plant Director has the overall safety responsibility for the University of Texas at Dallas.

In addition to the Physical Plant Director, a Project Safety Officer has been assigned to the Mass Spectrometer Program.

The Project Safety Officer coordinates the management and technical disciplines in order to identify safety problem areas and to provide the necessary corrective actions. He also is responsible for the review of potentially hazardous conditions, and implementation of the tasks to be carried out under this plan.

5.0 SAFETY TASKS

5.1 Formal Reviews and Problem Resolution - The Project Safety Officer will participate in formal reviews to evaluate and resolve safety problems which have been uncovered by UTD. He will also respond to MSC reports of potentially hazardous situations, take the necessary corrective action, and document the task and the results.

5.2 Safety Criteria - The following safety criteria will be utilized by UTD in the order of precedence as shown, in order to accurately assess potential hazards and to take the necessary corrective action.

a.) Design for minimum hazard

b.) Safety devices

c.) Warning devices

d.) Special procedures

e.) Residual hazards research

5.3 Safety Waivers and Deviations - Safety waivers and deviations may be requested by UTD. Such requests will be directed to NASA-MSC for engineering review and concurrence.

5.4 Accident or Incident Investigations - Accidents or incidents shall be investigated by the Project Safety Officer to assure that the necessary corrective action is taken. He will establish methods for conducting such investigations, documenting the problem, and reporting it.

5.5 Reporting - The Project Safety Officer shall make a monthly report which will include:

a.) The status of the safety review concerning operational checkout procedures and test preparation sheets.

b.) A list of MSC and contractor identified hazards, their status, disposition, and corrective action.

c.) A list of design changes affecting safety and their status.

d.) A list of safety dicrepancies, their status, and disposition.

5.6 Hazard Reduction - The Project Safety Officer will conduct a hazard analysis to validate the criticality category assigned to the hardware by an FMEA, and to identify potential hazards. For this analysis he will utilize existing safety activities and reports, the Single Failure Point Summary, the products of design reviews and engineering analyses, and make an evaluation of the spacecraft interfaces.

MASS SPECTROMETER EXPERIMENT

for

EXTENDED ALSEP

ENVIRONMENTAL TEST SPECIFICATION

for the

MASS SPECTROMETER

ERD-SM-1001

NASA-Manned Spacecraft Center

Earth Resources Division

TF4 5-5-69

1.0 SCOPE

1.1 General

This specification establishes environmental test requirements for the Mass Spectrometer Experiment.

1.2 Applicability

Decisions regarding the applicability of the requirements set forth in this specification shall be made by the Earth Resources Division (TF4). The environmental extremes shown in this specification are for qualification units only.

1.3 Objectives

The objectives of the tests outlined in this specification are to gain assurance that the Mass Spectrometer will survive all of the environmental loads to which it will be exposed during transportation, launch, boost, and lunar descent, and that it will function properly throughout its intended life.

2.0 APPLICABLE DOCUMENTS

2.1 ICS 314103 Bendix ICS for ALSEP/LSM

2.2 LED-520-ID Grumman Aircraft Engineering Corporation

2.3 MIL-STD 810-A

3.0 TEST LOCATION

All tests in this specification shall be conducted at NASA Manned Spacecraft Center, Houston, Texas or at a testing laboratory specified by the Earth Resources Division.

3.1 Test Facilities

3.1.1 General

The equipment used in conducting the tests specified herein shall be capable of producing and maintaining the required conditions with the Mass Spectrometer installed in a non-operating state.

3.1.2 Conditions for the Test Area

Laboratory conditions for conducting operational checkout prior to and/or following each environmental test shall be maintained as follows:

(1) Temperature: 25°C ± 5°C,

(2) Relative Humidity: 70% or less.

3.1.3 Measuring, Control, and Recording Equipment

(1) All measurements of the environmental conditions shall be made with instruments which are appropriate for the test being conducted. The accuracy of the measurements shall be listed and made available to the Earth Resources Division One (1) week prior to start of the tests. The list shall include the following: manufacturer and model number, accuracy of the instrument, and data of calibration. The calibrations shall be traceable to National Bureau of Standards.

(2) Control of the extremes shall be accomplished within the tolerance specified below exclusive of the measuring instrument tolerances.

(a) Temperature: Plus or minus 2°F after stabilization

(b) Sinusoidal Vibration: Plus or minus 10% for the applied 20-60 and 60-100 Hz frequency ranges.

(c) Random Vibration: The specified power spectral density shall be equalized to within ± 3 db over the entire frequency range.

(d) Thermal Vacuum: Temperature - ± 2°C after stabilization.

(3) Recording instruments shall be used so that a permanent record of all applied loads can be made available to the project engineer for review and approval prior to acceptance of the specimen tested. Recordings should be made on paper with strip chart recorders and/or X-Y plotters if possible.

4.0 EVALUATION OF TEST SPECIMEN

The test specimen shall be subjected to an operational test prior to each phase of environmental testing in order to determine at which point failure occurs, should a failure occur. In the event of a failure the test specimen shall be investigated and the cause of the failure determined by cognizant personnel. A report shall then be submitted to the Earth Resources Division for evaluation and they shall make a decision to either repair and proceed with the test or to review the failure with design personnel and submit a new specimen with corrective changes incorporated. Individual measurements to be made on the specimen at each test level shall be determined by the Earth Resources Division. In addition to the operational test a visual examination shall be made prior to each phase of environmental testing. Operational tests to be performed are as specified in Appendix 1 of this specification.

4.1 Waiver of Test Requirements

Although complete evaluation of flight experiments is desirable, due to a limited time element in the overall program some or all environmental tests may be waived by the Earth Resources Division on any units, if it is feasible to do so after reasonable assurance of reliable design has been established on qualification models.

5.0 ENVIRONMENTAL CONDITIONS

5.1 Sinusoidal Vibration

The Mass Spectrometer Experiment test specimen shall be rigidly attached to a test fixture, and the fixture attached to the vibration exciter. The specimen shall then be subjected to vibration as specified in Table I in each of three mutually perpendicular axis. For definition of X_L, Y_L, Z_L axis system see Figure 1. The specimen shall be visually examined and functionally tested prior to vibration along each axis to insure proper operation.

TABLE I

Frequency	"g" level	Duration
5-20 Hz	00.370 D.A.	One sweep at 1 octave/min.
20-60 Hz	7.15 ± 1.0 0-peak	
60-100 Hz	8.50 ± 1.0 0-peak	Decrease Frequency Only

5.2 Random Vibration

The Mass Spectrometer Experiment test specimen shall be rigidly attached to a test fixture, and the fixture attached to the vibration exciter. The specimen shall be subjected to the vibration as specified in Table II for a period of 5.0 minutes in each of three mutually perpendicular axis. The specimen shall be visually examined and functionally tested prior to vibration on each axis to insure proper performance.

TABLE II

Frequency (Hz)	Power Spectral Density
23-60	12 db/octave ± 1 db increase
60-150	0.387 g^2/Hz
150-530	12 db/octave ± 1 db decrease
530-2000	0.00185 g^2/Hz

5.3 Lunar Surface Temperature Simulations

The Mass Spectrometer Experiment test specimen shall be placed in a lunar surface simulation chamber in a deployed state with the survival power turned on.

The chamber shall then be pumped down to a pressure of at least 10^{-6} torr. The lunar surface temperature shall be approximately -300°F or with the temperature of the electronics package stabilized. The electronics package stabilization shall be determined by a one degree change per hour in the temperature.

The Mass Spectrometer test specimen shall continue to operate while the lunar surface plate temperature is increased to +250°F until stabilization of the electronics package (one degree change per hour).

The Mass Spectrometer Experiment test specimen shall be de-energized and the chamber pressure and temperature brought back to room ambient conditions.

6.0 TEST CONCLUSION

Upon completion of the above environmental task, the Mass Spectrometer shall be visually inspected for component damage. Following the visual inspection an extensive functional test shall be performed to insure performance within specified limits.

6.1 Test Report

A formal report shall be submitted within thirty days after completion of the test. The report shall contain the final analysis of all test data gathered during the test program.

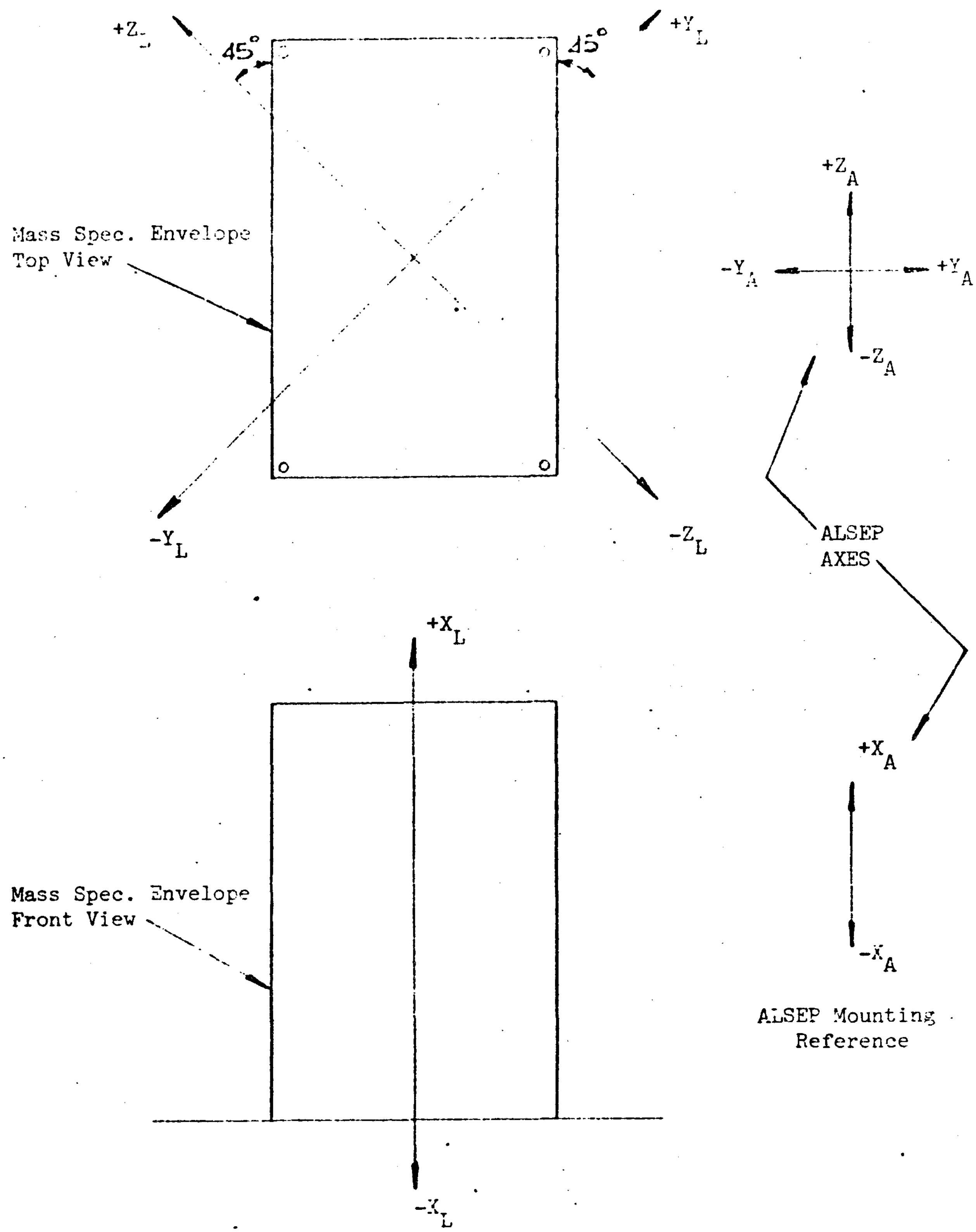


Figure 1
DEFINITION OF LM - ALSEP AXES

OUTLINE OF THERMAL/VACUUM TEST FOR MASS SPECTROMETER

This test outline will apply to the thermal/vacuum test unit of the Mass Spectrometer (MS) for advanced Apollo Lunar Surface Experiments Package. The environmental test specification ERD-SM-1001 section 5.3 will be performed in its entirety in the following sequence:

1) Install the MS in the vacuum chamber with all interconnecting cables and thermal couples. (There will be approximately 6 cables for heater strips, heater resistors and platinum resistors, and approximately 50 T.C. cables.)
2) Perform electrical check for all cables. Provide read out on all T.C.
3) Close and pump chamber down.
4) Add liquid nitrogen to walls until reading equilibrium temperatures. (Time approximately 24 to 36 hours to equilibrium temperatures.)
5) Perform electrical tests simulating both survival mode and "full-up" operation of MS at lunar night conditions.
6) Turn on solar simulators with solar radiation normal to top (on solar mirrors) of Mass Spectrometer.
7) Reach equilibrium temperatures which record all T.C. read outs.
8) Perform electrical tests simulating "full-up" operation of MS at lunar noon conditions.

9) Record all chamber pressures.

10) Turn solar plane to 45° from normal and reach equilibrium temperatures.

11) Turn off solar simulators and bring chamber up to atmospheric pressures.

VIBRATION TEST RESULTS
FOR THE
MASS SPECTROMETER (GALA)
STRUCTURAL MODEL

LEC Document No. 644D.41.12

PREPARED BY: D. L. Vincent
D. L. Vincent

APPROVED BY: L. B. York
L. B. York

NASA-MANNED SPACECRAFT CENTER

July 29, 1969

VIBRATION TEST RESULTS FOR THE MASS SPECTROMETER (GALA) EXPERIMENT STRUCTURAL MODEL

INTRODUCTION

On Monday, 19th May, 1969, the structural model of the Mass Spectrometer (GALA) Experiment was tested at the Space Electronics Systems Division, Environmental Test and Evaluation Section in Building 15.

The purpose of the vibration test was to show that the structure and packaging of the experiment were capable of satisfactorily surviving the specified vibration environment and that all structural items (such as the dust covers) were capable of fulfilling their function after exposure to that environment. Further, it was proposed to obtain some estimate of the dynamic envelope of the experiment when subjected to the specified vibration levels.

The structural model consisted of all structural components for the GALA, together with dust covers and release mechanism, P/C boards with component mass simulation, simulated sensor (supplied by Southwest Center for Advanced Studies, Dallas, Texas) and simulation of the ALSEP Central Station cable and reel. Figure 1 shows the mounting of the model to the vibration fixture and the correlation of LM and ALSEP axes; vibration of the test model was in the direction of the ALSEP axes to the levels defined in Appendix 1. All screws on the model were assembled with "LOCTITE NUTLOCK" and tightened to the following torque leadings: -

SCREW SIZE	TIGHTENING TORQUE
4-40	7 Lb.-Ins.
6-32	9 Lb.-Ins.

TEST

The test started with vibration in the vertical axis (X_A), first in the sinusoidal mode followed by the random mode. No excessive vibration of components was noted during either mode and, as far as could be noted by eye, the dynamic envelope was small - in the order of 1/16 inch all round. On completion of this axis, the model was removed from the fixture and examined for any evidence of failure. None was noted, all parts appearing to have satisfactorily withstood vibration in this axis.

NOTE 1. - It is recommended that the vibration fixture be re-designed as a "box-type" fixture for testing of the prototype and future models.

Testing was then continued in the horizontal axes. At this point it was noted that the fixture (or rather, the individual mounting pillars) resonated at around 1000 Hz. This improved once the test model was secured to the pillars, but there were indications that resonance still occurred below 2000 Hz[1]. The first horizontal axis to be run was across the width of the unit (Y_A). Once again, the sinusoidal mode was run, followed by random. In this axis also, the dynamic envelope looked good and was estimated to be similar to the vertical axis in magnitude. On completion of the random mode the model was removed from the fixture and examined for any evidence of failure. Externally, all was well, but upon shaking the model along its length there were audible indications that some part or parts were loose internally. At this point, the test was stopped and the model returned to Building 31 for disassembly and examinations.

POST-TEST EXAMINATION

Upon removal of the radiator plate and simulated electronics from the structure, it was found that the two "stacked" P/C board assemblies had become detached from the radiator plate. Dismantling the simulated electronics assembly revealed that the eight mounting pillars had failed where attached to the radiator plate (see Figure 2). Further examination showed that two of the eight mounting screws for the "stacked" P/C boards had broken close to the mounting pillars. Dismantling of the "stacked" P/C boards showed that seven of the 32 retaining washers securing the spacers (see Figure 3) had become loose (but not detached).

All other parts of the structure and electronics were sound and secure, and the dust-covers operated satisfactorily when released. It was also noted during disassembly that none of the screws (inserted as previously described) had "backed-off" or loosened.

During the next two days (20th and 21st May) the failures were investigated and corrected (see Appendix B) and on Thursday, 23rd, May, the unit was resubmitted to vibration test. Testing was only undertaken in the horizontal axes.

RE-TEST

The unit was re-tested first in the Y_A axis (in which it had previously failed) both in sinusoidal and random model. On completion, the unit was removed from the fixture and showed no evidence of failure. The test unit was replaced on the fixture and subjected to sinusoidal and random vibration in the Z_A axis. Once again, upon completion, the unit was examined for evidence of failure. None was to be seen (or heard). The test was then considered to be completed and the structural model returned to Building 31 to be disassembled and examined.

CONCLUSION

Upon disassembly, thorough examination of the model showed no evidence of failure of any of the parts. Hence, the structural model of the GALA is regarded as having satisfactorily completed its testing.

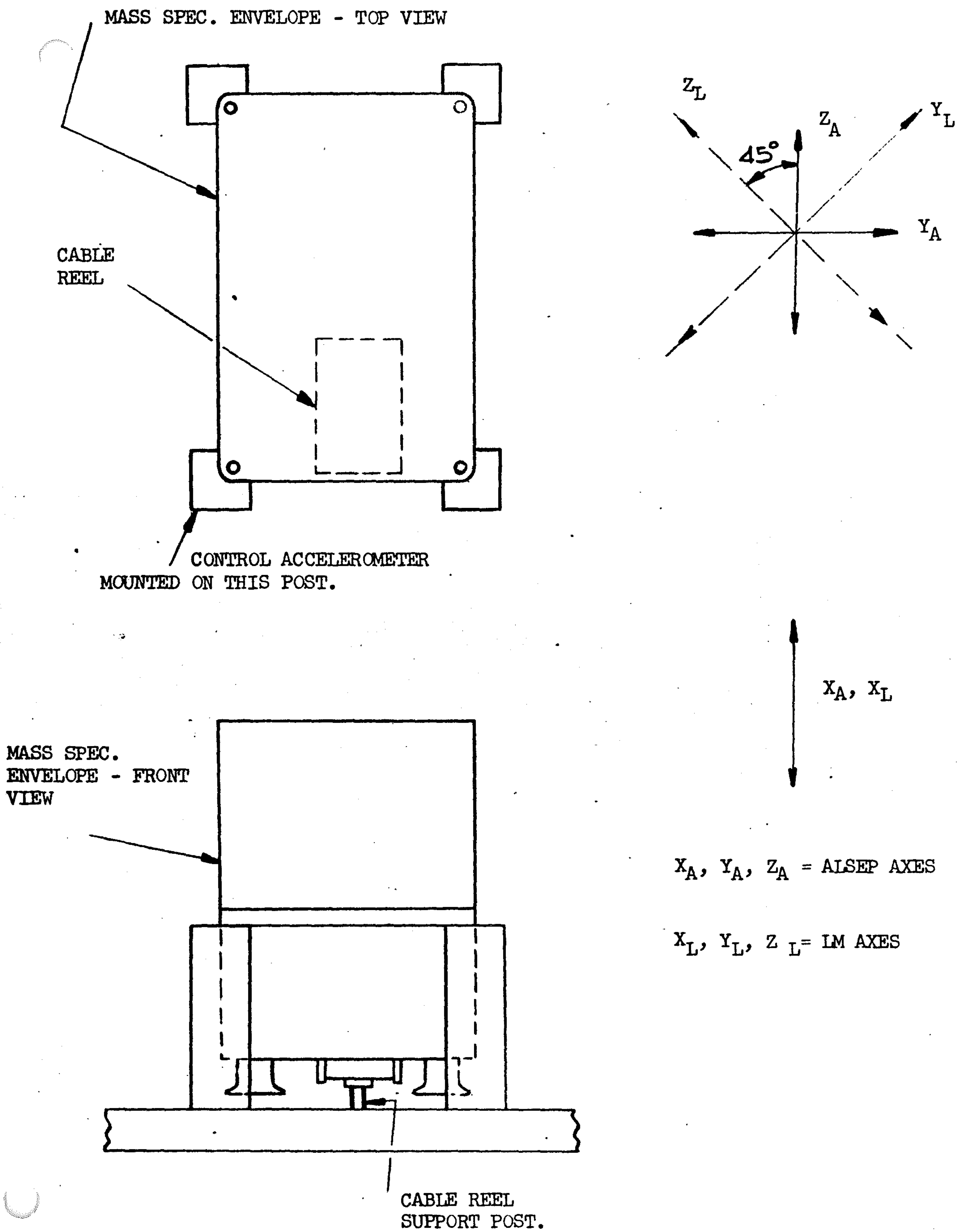
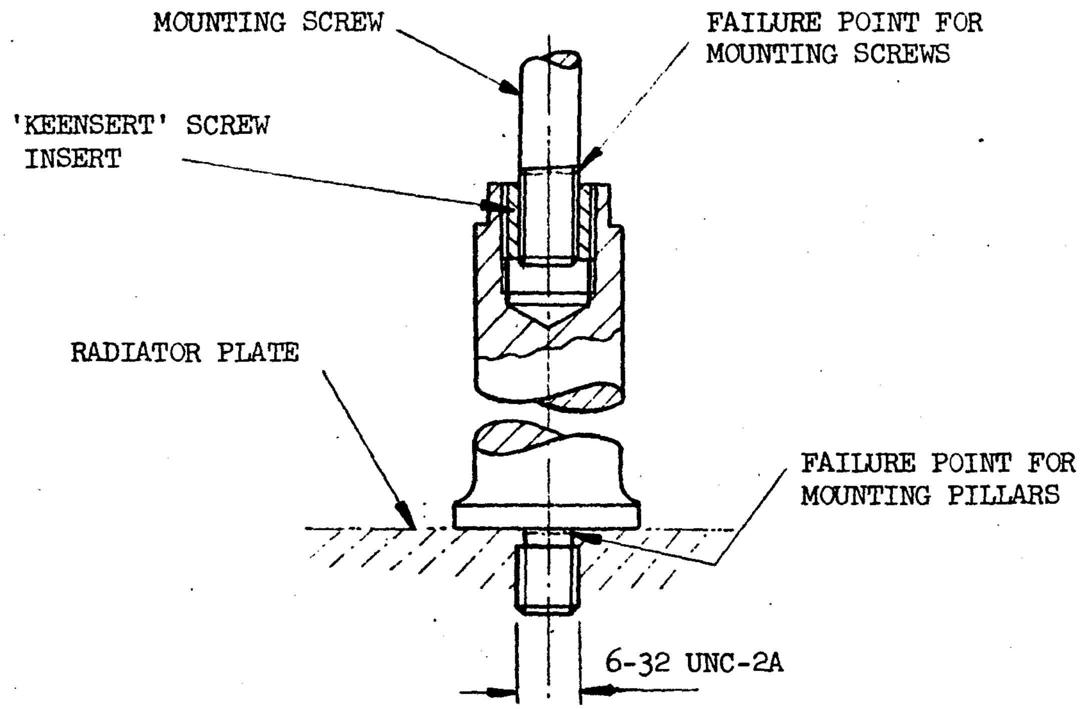
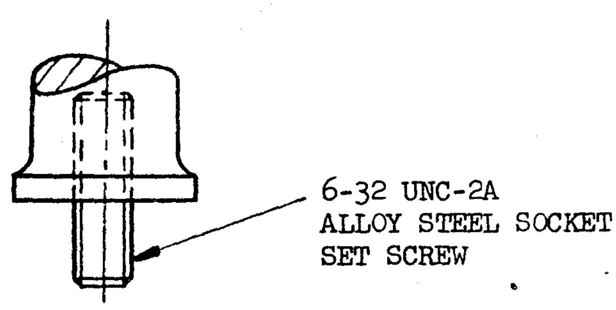


FIG. 1 - TEST MODEL MOUNTING AND DEFINITION OF AXES



(a) FAILURE POINTS ON
MOUNTING PILLARS



(b) MODIFICATION TO
MOUNTING PILLAR

FIG. 2 - MOUNTING PILLAR FAILURE

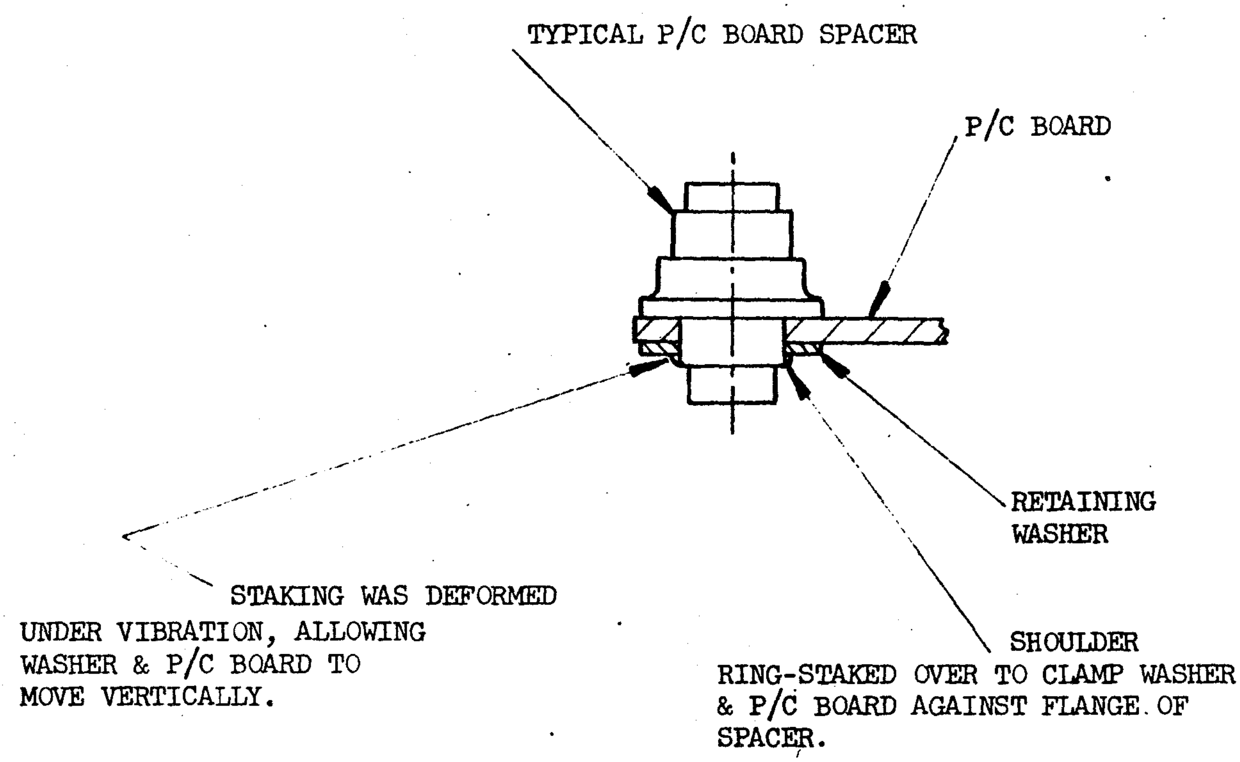


FIG. 3 - P/C BOARD SPACER

APPENDIX A

VIBRATION TEST LEVELS

SINUSOIDAL

FREQUENCY	"g" LEVEL	DURATION
5 - 20 Hz	0.370" D.A.	One sweep at 1 octave/min.
20 - 60 Hz	7.15 ± 1.0 (0 to peak)	
60 - 100 Hz	8.50 ± 1.0 (0 to peak)	Decrease frequency only.

RANDOM

FREQUENCY	POWER SPECTRAL DENSITY (g^2/Hz)
23 - 60	12 dB/octave ± 1 dB increase
60 - 150	0.387
150 - 530	12 dB/octave ± 1 dB decrease
530 - 2000	0.00185

NOTE: - For details of test requirements see ERD-SM-1001, "Environmental Test Specification for the Mass Spectrometer".

APPENDIX B

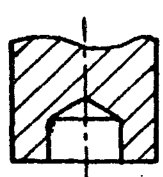
FAILURE INVESTIGATION AND CORRECTION

The failure of the mounting pillars at the point of attachment to the radiator plate was closely examined, and gave every indication of having failed due to stress concentration at the corner of the undercut closest to the shoulder of the pillar. Examination of unassembled pillars showed that the undercut at this shoulder had been made with a conventional "parting-off" tool and therefore had a very sharp internal corner. (The part drawing did not indicate that this was unacceptable.) Assuming that stress concentration was the primary cause of failure, a simple modification to eliminate the point of concentration was decided upon. As can be seen in Figure 2(b), the pillar was tapped to accept a set-screw, which was "epoxied" into the pillar to provide a permanent modification. This fix enabled the re-testing to be completed within 3 days of the original test, and was satisfactory on all counts.

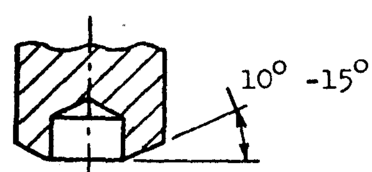
It is suggested that the pillar design be modified to incorporate the set-screw, as it meets all the restraints placed on this particular attachment to the radiator plate. The additional strength of the set-screw provides a higher factor of safety in this area, to cover any contingency or modification to the electronics P/C boards.

Upon examination of the mounting screw failures (see Figure 2(a)) the opinion was formed that this occurred after the pillars had failed, and was due to the hammering of the stacked P/C boards and pillars against the side of the inner housing of the thermal bag. Therefore, no corrective action was taken and the subsequent re-testing was completed with no failure.

The loosening of the retaining washers (see Figure 3) was examined. None of the washers were actually free on the spacer, but two were capable of moving 3/64 inch vertically and five others rotated upon the spacer, indicating that the ring-staking had backed off. The failure was attributed to inadequate staking. The tool used was a simple "home-made" punch (see (a) below) and the shoulder to be staked only allowed a limited amount (.012 inch) of material to be deformed. The loose washers were re-staked, using the same tool as before and successfully completed test. However, it is recommended that the staking tool be modified (see (b) below) to deform more material over the washer and clinch it tighter; also the detail design of the spacers should be investigated to determine whether a wider shoulder for staking could be provided.



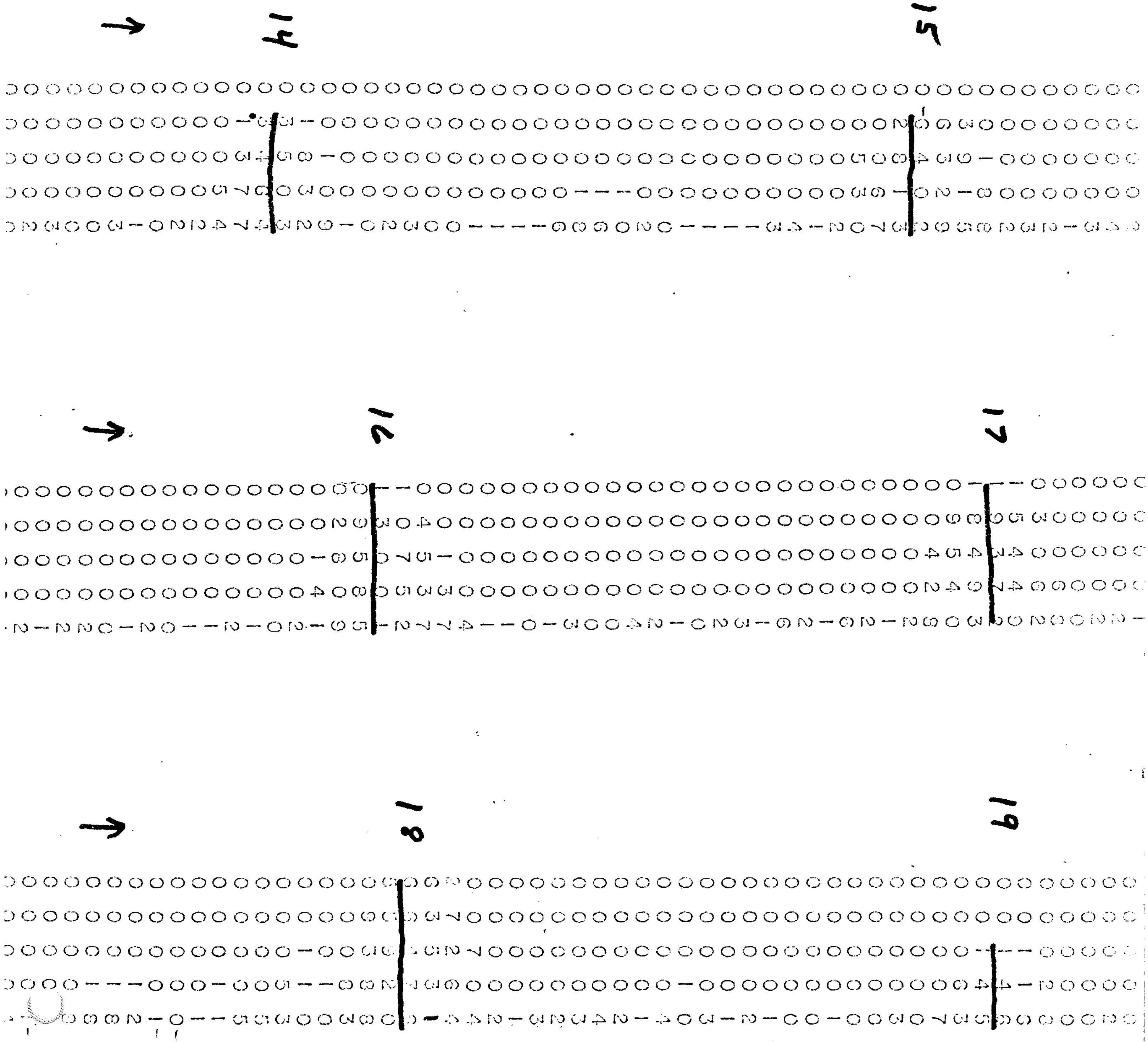
a



b

FIG. -3

DIGITAL MASS SPECTRUM
AMU



GAS ANALYZER FOR LUNAR ATMOSPHERE (GALA)

PROTOTYPE ACCEPTANCE TEST PROCEDURE

GAS ANALYZER FOR LUNAR ATMOSPHERE (GALA)

PROTOTYPE ACCEPTANCE TEST PROCEDURE

1.0 Objective:

The objective of this test procedure is to verify the functional and mechanical acceptance of the GALA package for a future APOLLO flight.

2.0 Scope:

The test procedure is to provide assurance of the overall system compatability with the APOLLO scientific instrument requirements.

3.0 Gas Analyzer for Lunar Atmosphere Operation:

3.1 Inputs from Data Processor:

The GALA package requires three (3) timing and control signals, plus eight (8) up-link commands from the Data Processor to perform the experimental measurements. These signals are discussed below.

3.1.1 The three (3) timing and control signals are used to process and output to the Data Processor five (5) 10-bit digital data words.

The three (3) input signals are:

A. Frame Mark
B. Data Demand
C. Shift Clock (Bit rate)

For a description of the above mentioned signals see attached memorandum data January 16, 1968.

3.1.2 The eight (8) up-link commands are used to establish operational modes of the experiments to provide flexibility in performing the intended measurement.

3.1.2.1 Eight (8) commands are utilized to perform thirteen (13) separate operations; a command decoder is used to achieve this.

Command No.	Command Generated
1, 2 & 6	Survival
1, 3 & 6	Operate
1, 4 & 6	Discriminator HI
1, 5 & 6	Discriminator LO
2, 3 & 6	Filament #1
2, 4 & 6	Filament #2

(Gas Analyzer for Lunar Atmosphere (GALA) Prototype Acceptance Test Procedure)

Command No.	Command Generated
2, 5 & 6	Multiplier HI
3, 4 & 6	Emission OFF
3, 5 & 6	Emission ON
4, 5 & 6	Multiplier LO
6	Command Clear
7 & 6	Dust Cover
8 & 6	Breakseal

Command 6 follows every command generated, example: To go to the operate mode send commands 1, 3 & 6.

3.1.2.2 Survival Mode:

This is a low power mode of operation. The following circuits have full power applied to them:

1. Switching Pre-regulator
2. Low Voltage Power Supply
3. Data Control and Signal Conditioning Card
4. Thermal Control and Squib Firing Ckts. Card

All other circuitry are without power.

3.1.2.3 Operate Mode:

This is the normal mode of operation, however, the system is not fully operative unless the Emission is ON.

3.1.2.4 Discriminator HI-LO:

The HI-LO operation is needed to control the discriminator setting. The discriminator follows the charge sensitive pre-amplifier.

3.1.2.5 Filament #1, #2:

This system has two (2) separate filaments for redundancy in the ion source, selectable by command.

3.1.2.6 Multiplier HI-LO:

The gain of the three (3) multipliers can be changed by varying the high voltage applied to them. Two (2) separate gain settings are possible through the command system.

3.1.2.7 Emission ON-OFF:

Through the use of commands the Emission Control Card can be turned ON or OFF.

(Gas Analyzer for Lunar Atmosphere (GALA) Prototype Acceptance Test Procedure)

3.1.2.8 Breakseal:

This command, when sent, will blow the squibs in the can cutter and the entrance will be exposed to the outside environment.

3.1.2.9 Dust Cover:

This command, when sent, will blow the squib and the dust cover will be released. This exposes the mirrors to the sunlight.

3.1.2.10 Command Clear:

This command is sent with every command in the command generated list (3.2.2). This clears the J-K flip flops in the command decoder.

3.2 GALA Outputs:

The GALA package has five (5) outputs all of which are ten (10) bit words. Three (3) are used to carry data from the three (3) channels of the mass spectrometer. One ten (10) bit word is the status of the digital sweep generator. The last word is used for housekeeping and flags.

3.2.1 Each of the three (3) data words has the format as shown in Figure 1, which consists of the 6-bits of the 21-bit counter and the four (4) bits of the shift counter.

3.2.2 Housekeeping Functions:

All housekeeping functions are sub-commutated. A fifteen (15) position commutator is stepped through by the frame mark pulse that is generated within the experiment.

Housekeeping Data Assignments:

Position No.	H. K. Data
1	-12V
2	+ 5V
3	+12V
4	Spare
5	A/D Calibrate
6	Filament Current
7	Instrument Current

(Gas Analyzer for Lunar Atmosphere (GALA) Prototype Acceptance Test Procedure)

Position No.	H. K. Data
8	H. V. Mult. Monitor
9	H. V. Sweep Monitor
10	Temp. #1 (Electronics)
11	Temp. #2 (M.S.)
12	Spare
13	Flags
14	Spare
15	-16V Ref.

The thirteenth (13th) position is the flag word.

Figure 2 shows the digital format. of the Housekeeping FCNS.

3.2.2.1 Below is a tabulation of the flag assignments going from right to left (see Figure 3) as these bits would appear on the data line.

Bit Position	Function	"1"Represents
10 (MSB)	H. K. Multiplexer Pos #1	Pos #1
9	Digital Sweep Start	Start
8	Spare	----
7	Discriminator HI-LO	HI
6	Filament #1 - #2	#1
5	Spare	----
4	Emission ON-OFF	ON
3	Spare	----
2	Spare	----
1 (LSB)	Multiplier HI-LO	HI

A zero ("0") will represent a spare.

Figure 3 shows the bit assignment.

4.0 Experiment Test Set Operation

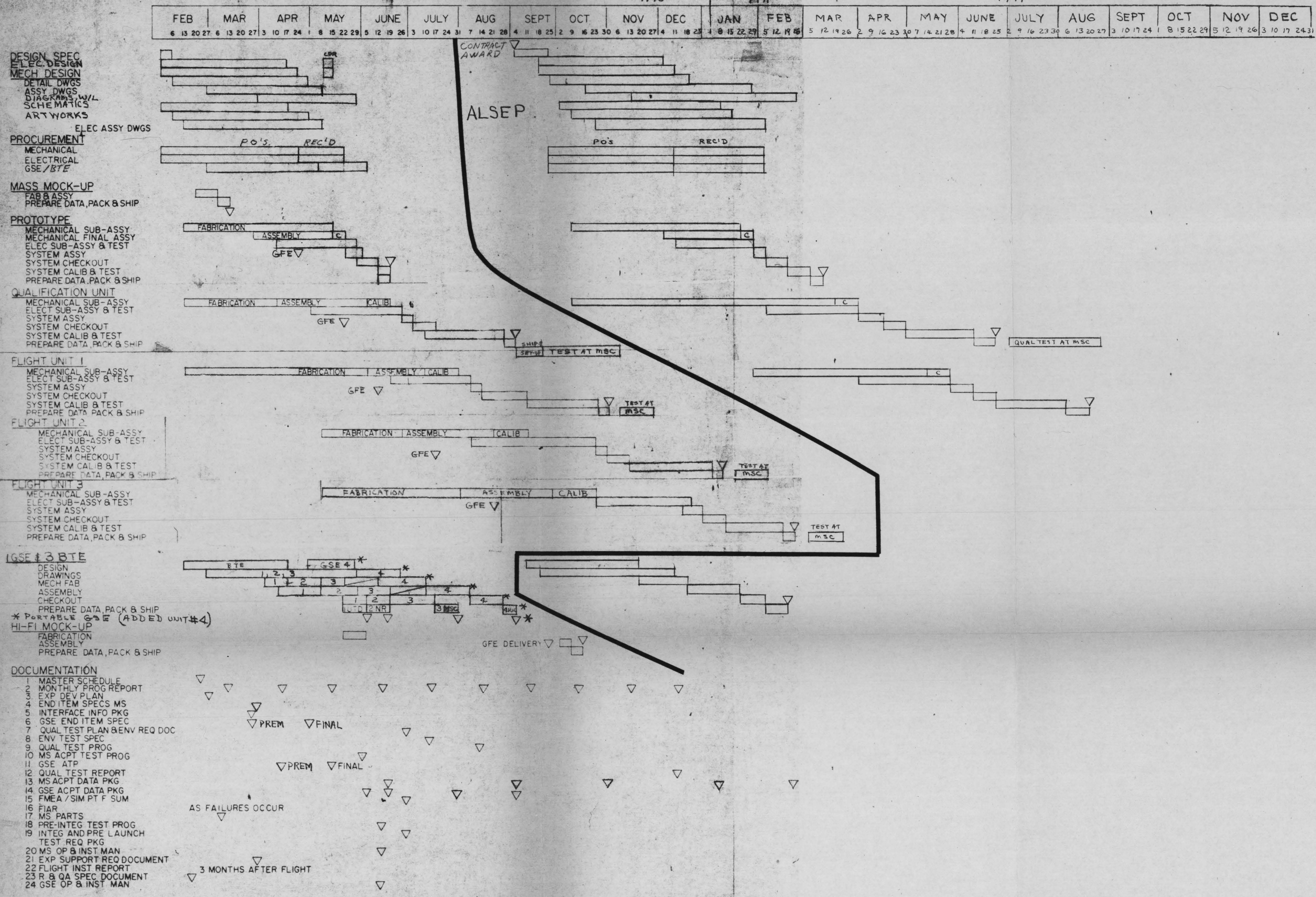
4.1 The GALA Experiment Test Set (ETS) provides the input signals, power, visual readout, and data processing capabilities during bench testing.

4.2 ETS

The ETS consists of the following Equipment;

1) Digital Voltmeter (DVM)
2) Digital logic System
3) 12 column Printer
4) Power Supply
5) Control Panel with data display.

PROPOSED MASTER SCHEDULE FOR
MASS SPECTROMETER EXPERIMENT



29 Apr. 1970

4.3 ETS Digital Data Display

The digital data consists of five ten bit words which are printed out by the twelve (12) column printer. Column 1 which is numbered from 1 to 5 indicates the word number.

Word numbers 3, 4, 5, are the three Mass spectrometer channel data words; which are located in columns 6 thru 12 inclusive. These are read out in decimal.

Word 2 represents the status of the digital sweep counter in the high voltage sweep control circuit. It is read out as a decimal number and is located in columns 9 thru 12 inclusive.

Multiplexer Position	HK. Function	Normal Reading.	Tolerance
1	-12V	125	± 5
2	+5V	127	± 20
3	+12V	140	± 5
4	GND	000	---
5	A/O CAL	155	± 3
6	Fil I	000	---
7	Inst. I	000	---
8	Mult H. V.	Hi 181 Lo 169	± 3
9	Sweep H. V.	000 →204	---
10	T_1	000	
11	T_2	000	---
12	Spare	000	---
13	Flags	---	---
14	Spare	000	---
15	-16V	149	± 3

IX. MANAGEMENT

A. MANAGEMENT PLAN

A management plan which was written and is being implemented for the Lunar Orbital Mass Spectrometer program is attached. Basically, the same plan would be applicable to the management of the ALSEP program.

B. SCHEDULE

A copy of the master schedule for the Orbital program extended to include the development and delivery of the ALSEP mass spectrometer is attached. It is assumed that the program would begin with contract award on September 1, 1970. A prototype, qual model, one flight model, and a GSE development and delivery schedules are shown. Additional flight models could be delivered on approximately 3 month centers after the first. This schedule assumes the design fabrication and testing to be done at UTD utilizing some sub-contract work, and the radiation plate, fiberglass housings, thermal bag and qual testing operation to be GFE from MSC.

The schedule shows that the ALSEP program phases into the Orbital program smoothly with essentially no impact and efficiently utilizes the manpower and facilities of the Orbital program as they become available. The current status of the Orbital development program shows all categories to be on schedule or within one week of schedule, so the attainment of the proposed schedule for ALSEP appears to be quite feasible.

C. MANPOWER

A direct labor man hours spread chart, Figure 9-1, shows a total labor requirement of 77,600 hours. Breakdown according to 6 labor categories is given in Section III of the form DD633-4.

D. FINANCIAL PLAN

1. Funds Expended to Date

The total funding of Contract NAS9-7591, the development contract, was $255,225.

A copy of a UTD Budget Status Report, Figure 9-2, is attached to show a breakdown of the expenditure of these funds. The overhead rate is 85 percent of salaries and wages from contract inception to September 1, 1969 and 70 percent after that date. (The Southwest Center for Advanced Studies became the University of Texas at Dallas on September 1, 1969. The overhead rate change was a result of this transition.)

Figure 9-3 shows the total expenditure to-date of the Orbital program (Contract NAS9-10410) and the projected costs to completion.

2. Proposed Cost for ALSEP

The proposed total cost spread for the ALSEP program is shown in Figure 9-4. A total of $1, 527, 000 is projected. This budget assumes a start date of September 1, 1970 and runs for 3 years. It includes funds for a prototype, qual model, 2 flight models and a flight spare model and 3 GSE models as well as 2 mock-ups. It also includes funds for 1 year of data analysis. A further breakdown of the budget is given in the Form DD-633-4, attached.

The University of Texas at Dallas
Dallas, Texas

MANAGEMENT PLAN

Mass Spectrometer Experiment

for

Apollo "J" Series Missions

Contract No. NAS9-10410

February 27, 1970

John H. Hoffman
John H. Hoffman
Project Scientist/PI

CONTENTS

I. General Management

A. Program Definition

The University of Texas at Dallas has a contract from NASA/MSC to design, produce, test and deliver a Mass Spectrometer experiment to be flown on the Apollo "J" series mission flights. The scientific purpose of the experiment is to determine the composition of the lunar atmosphere and thereby study its origin, production, loss and transport mechanisms.

The contract calls for the delivery of three flight Mass Spectrometers, one for each of two missions and a spare, one each of a qualification unit, a prototype, a mass mock-up and a hi-fidelity model. In addition, 3 units of ground support equipment are required.

Due to the nature of the hardware, being a scientific experiment, the engineering personnel both electrical and mechanical, guide the development, fabrication testing and preparation for delivery of each deliverable end item. The program is carried out in a research laboratory type environment that affords the opportunity for the close supervision the engineering staff must give to produce a workable, tested and calibrated instrument. The engineering guidance assures an intimacy between all personnel assigned to the program which is typical of a research laboratory.

The Mass Spectrometer experiment being developed for the Apollo "J" Series Missions is based upon the design and development concepts accomplished under a previous NASA Contract for a mass spectrometer for the ALSEP program. An engineering model of the instrument was developed which successfully passed ALSEP qualification level vibration and thermal vacuum tests. The design of the present instrument is similar to the ALSEP unit in structural and packaging design and electronic functions. However, the interfaces with the SIM, being different from the ALSEP, necessitated redesign in a number of areas of the experiment.

B. Organization Structure

The PI/Project Scientist is a member of the UTD faculty in the Division of Atmospheric and Space Sciences, headed by Dr. Wm. B. Hanson, who reports directly to the Acting President of UTD, Dr. F. S. Johnson. UTD is under the Vice Chancellor for Academic Affairs of the University of Texas System, headquartered in Austin, Texas. The program is organized into four functional groups, i.e. Program Management, Electrical Engineering and Production, Mechanical Engineering and Production and Quality Assurance and Reliability.

Organizational Charts showing the structure of the management of the program from the PI down through the Program Manager to the three Project Managers, heading the divisions of Mechanical, Electrical and QA&R, and separate charts delineating each of the three divisions are attached.

The nucleus of the supervisors and workers are UTD personnel with experience in rocket and satellite instrumentation development and fabrication. However, additional manpower necessary to meet the required delivery schedules will be comprised of contract (temporary) personnel of critical skills available in the local labor market.

C. Functional Responsibilities

The management of the program shall cover all phases of the hardware design, development, production, test and preparation for delivery of end item units. The program is organized as follows:

The principal investigator serves in a dual capacity of PI and Project Scientist. In the latter position, he has the responsibility of maintaining scientific control of the hardware phase of the program. He will make the necessary scientific and technical decisions to insure the proper design and operation of the experiment. He chairs the Configuration Control Board which is convened to approve changes to designs and drawings after the design freeze. Calibration of the mass spectrometer will be accomplished under the Project Scientist's direction.

The Program Manager has the complete management responsibility for the program. He coordinates efforts in the three areas headed by Project Managers: Electrical, Mechanical and Quality Assurance and Reliability. Budget direction, schedule maintenance, documentation, facility utilization and manpower control necessary to accomplish delivery of contract items fall under his supervision. He reports directly to the Project Scientist. While the Program Manager has complete authority to control the program management, the Project Scientist maintains technical control of the design, production and testing of the hardware. A matrix management concept is used which permits the freedom necessary to allow for innovative ideas in the development of the instrument, yet maintains the necessary control to insure the timely production, testing and delivery.

Program control is maintained through weekly management meetings held each Monday morning at which time the progress of the previous week in all functional areas is discussed. The master schedule is updated by shading the areas of the bar-time-charts showing percent of task accomplished. A vertical line at the current date shows the status of tasks versus schedule. Also, real and potential problems are reviewed with planned progress for the coming week established.

Electrical Engineering and Production, under the direction of the Project Manager (Electrical) has the responsibility for the electrical design production and test of the Mass Spectrometer. The individual electrical engineers are responsible for design, supervision of fabrication, test and documentation associated with the respective sub-systems (ref. UTD Document #150-400). Each engineer prepares a PERT-type-chart which establishes the time schedule and milestones for his effort. The construction of the hardware requires the preparation of a planning sheet and a manufacturing authorization. The Project Manager (Electrical) must approve the steps outlined in the planning sheet and he is responsible for the official release of the Manufacturing

Authorization. Both of these documents are submitted to QA for approval, (ref. UTD Document #150-401).

At the end of each week (Friday p.m.) a meeting is held between the PM (Electrical) and his engineers. The agenda consists of the following:

1) Progress by each engineer as related to his PERT chart and status on each sub-system is discussed.
2) Progress on necessary documentation.
3) Interface between sub-systems are reviewed by all. Any revision or updates are discussed and recorded.
4) Manufacturing and test schedules are examined for possible conflicts.
5) General discussion between engineers as to any existing problems and their possible solutions. Action items are taken and a time schedule is imposed as to when these items are to be closed out.
6) New data or revisions from MSC and NR are related to all personnel.

During the week the PM inspects each engineering area and holds a short informal session with the engineer.

The Monday following the Friday another meeting is held between the PI and PM's and QA&R. A summary progress report is given as to the status of the program and any action items that need immediate attention.

The Project Manager (Electrical) has the responsibility of getting official approval on electronic components and materials not on the approval parts list. He also reviews and approves all manufacturing and test procedures which are prepared by the engineers.

Mechanical Engineering and Production under the direction of the Project Manager (Mechanical) has the responsibility for the mechanical design and electrical packaging of the Mass Spectrometer, the detailed and assembly drawings, electrical layouts and pictorial drawings, and the fabrication and assembly of mechanical parts. Designs are converted to release drawings by the drafting department under the direction of the project draftsman. All released drawings are controlled as specified in UTD #150-401 Drafting Department Procedure.

The production machine shop is authorized by the Project Manager (Mechanical), per UTD #150-423, to produce hardware using prints issued only by the Records Clerk (responsibilities per UTD #150-423). The Production Machine Shop Supervisor prepares planning sheets per UTD #150-421 and coordinates adequate inspection coverage with the QA&R Project Manager. All parts are controlled in accordance with UTD #150-421.

Due to the intricate nature of many of the parts and the critical alignment of the Mass Spectrometer analyzer slits, the mechanical design engineers follow the parts through fabrication and assist in the assembly of all units. The Mechanical Design Group initiates purchase requisitions for all hardware necessary to assemble units. The Production Machine Shop initiates purchase requisitions for all raw material that is specified on the drawing. All planning sheets and purchase requisitions are approved by QA. Revisions to released drawings are accomplished per UTD #150-425.

The functional responsibilities of the Quality Assurance and Reliability group are delineated in Section II.

D. Facilities

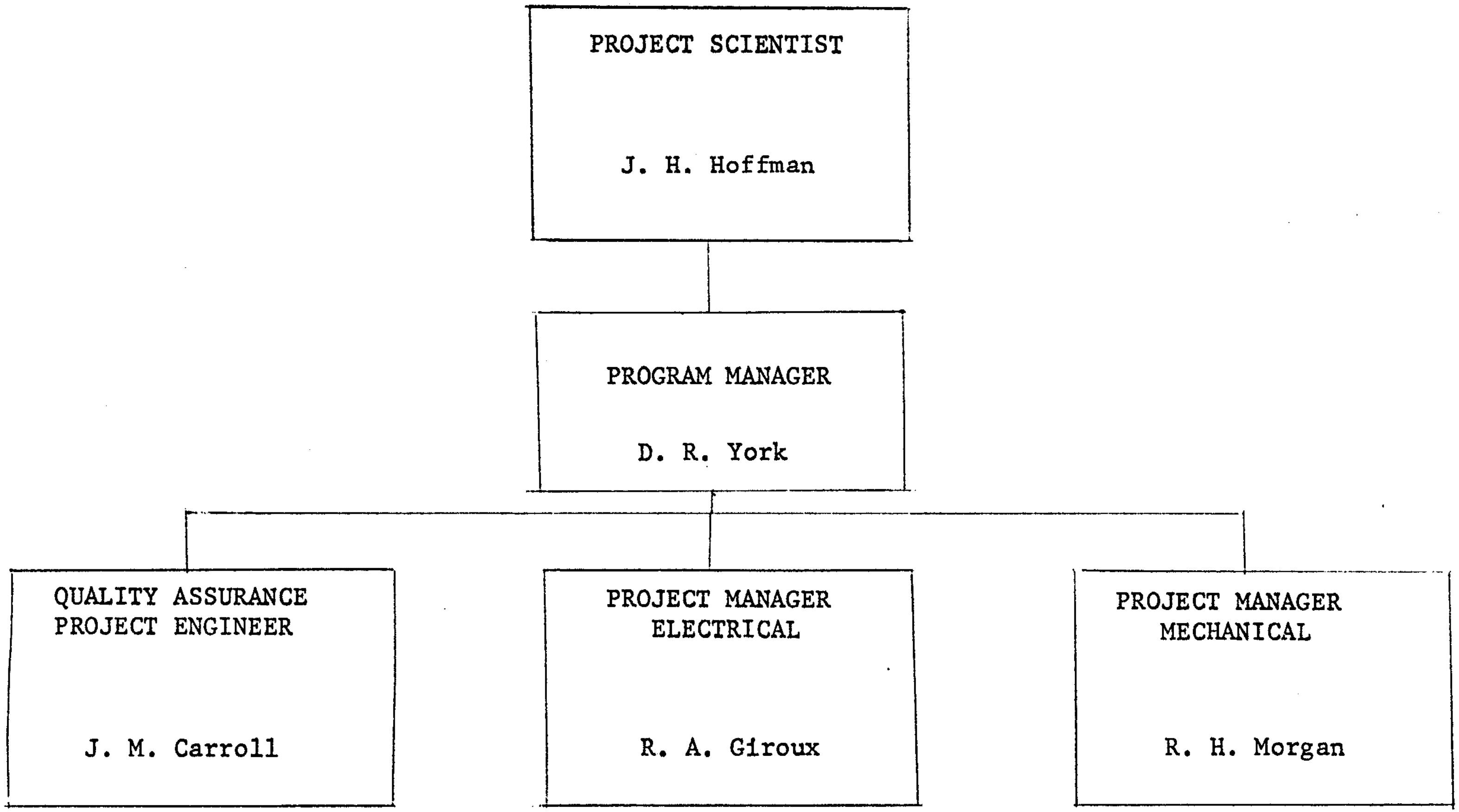
Fifty-six hundred square feet of floor space, all in the same building, are devoted to this project. The area includes office space, laboratories, stock rooms, drafting rooms, electrical assembly area, and a machine shop. A building floor plan is attached in Section 6. The Mass Spectrometer is produced in a clean room environment utilizing laminar flow type clean benches located in a controlled area. All controlled operations, soldering welding, and assembly will be accomplished by trained employees and certified to NASA standards as required. In this regard, there are two NASA certified instructors in-house.

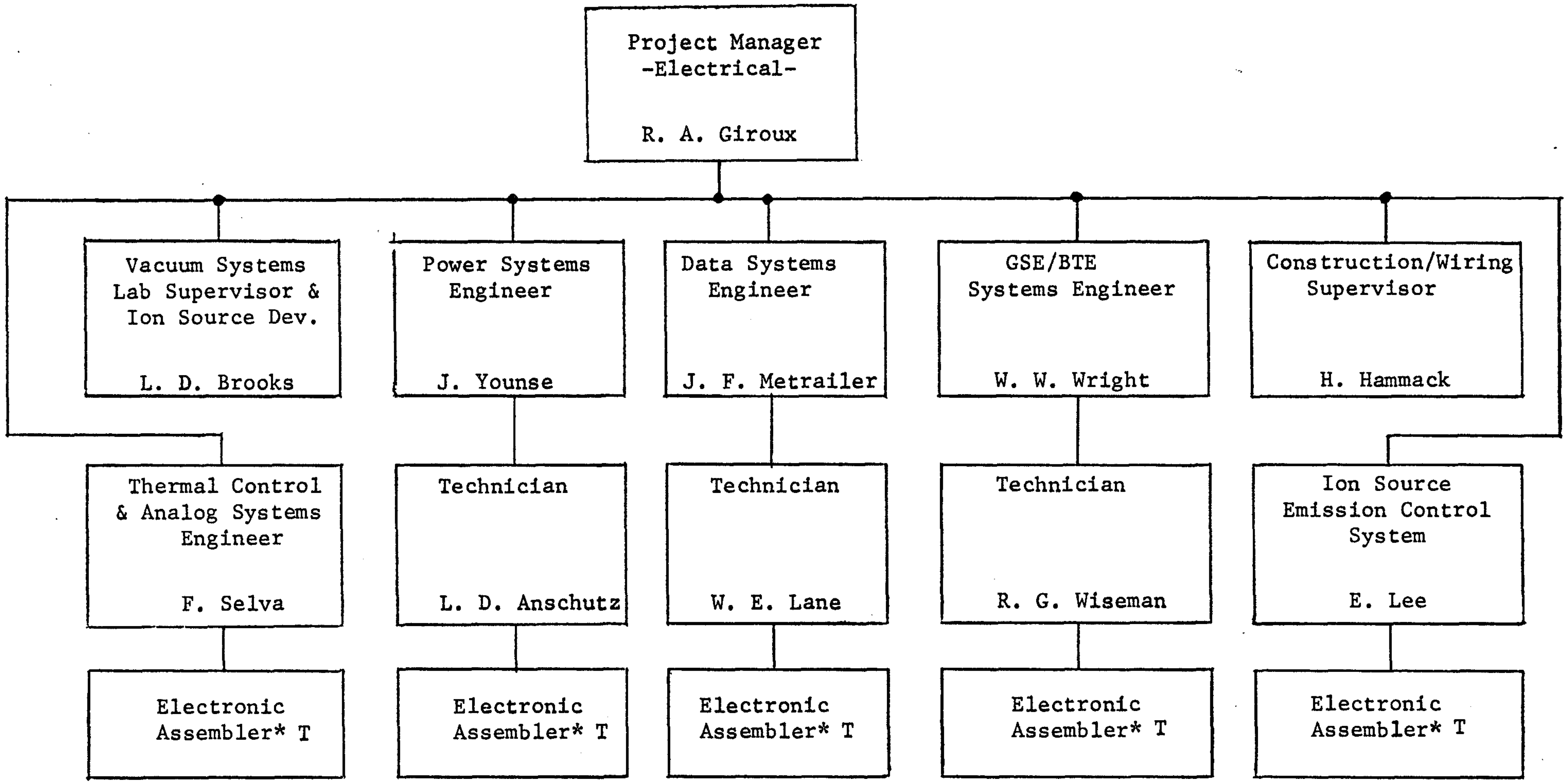
E. Budget Control

Upon award of NASA Contract NAS9-10410 to UTD, major task elements were defined and appropriate budgets allocated. The key personnel who were involed in the planning and proposal preparation of the Mass Spectrometer Program and who will be responsible for the production, testing, and delivery of the scientific instruments actively participated in the budget allocation process.

The MS Program Task Budgets were utilized by accounting to establish a separate account for each task. A monthly computer output expense summary for each of the accounts is distributed to the MS Program Manager, who has direct responsibility for each defined task. By this method of accounting which shows monthly charges broken down into all categories and lists the monthly commitments, the precise status of the individual task in relation to its projected progress can be determined.

Information needed for Government and The University of Texas at Dallas reports such as NASA Form 533, "Contractor Financial Management Report," is taken from these computer run expense summaries. These reports are prepared by the Program Manager and Budget Analyst, who have the responsibility to effectively forecast funding requirements and control expenditures within the contractual funding limitations.

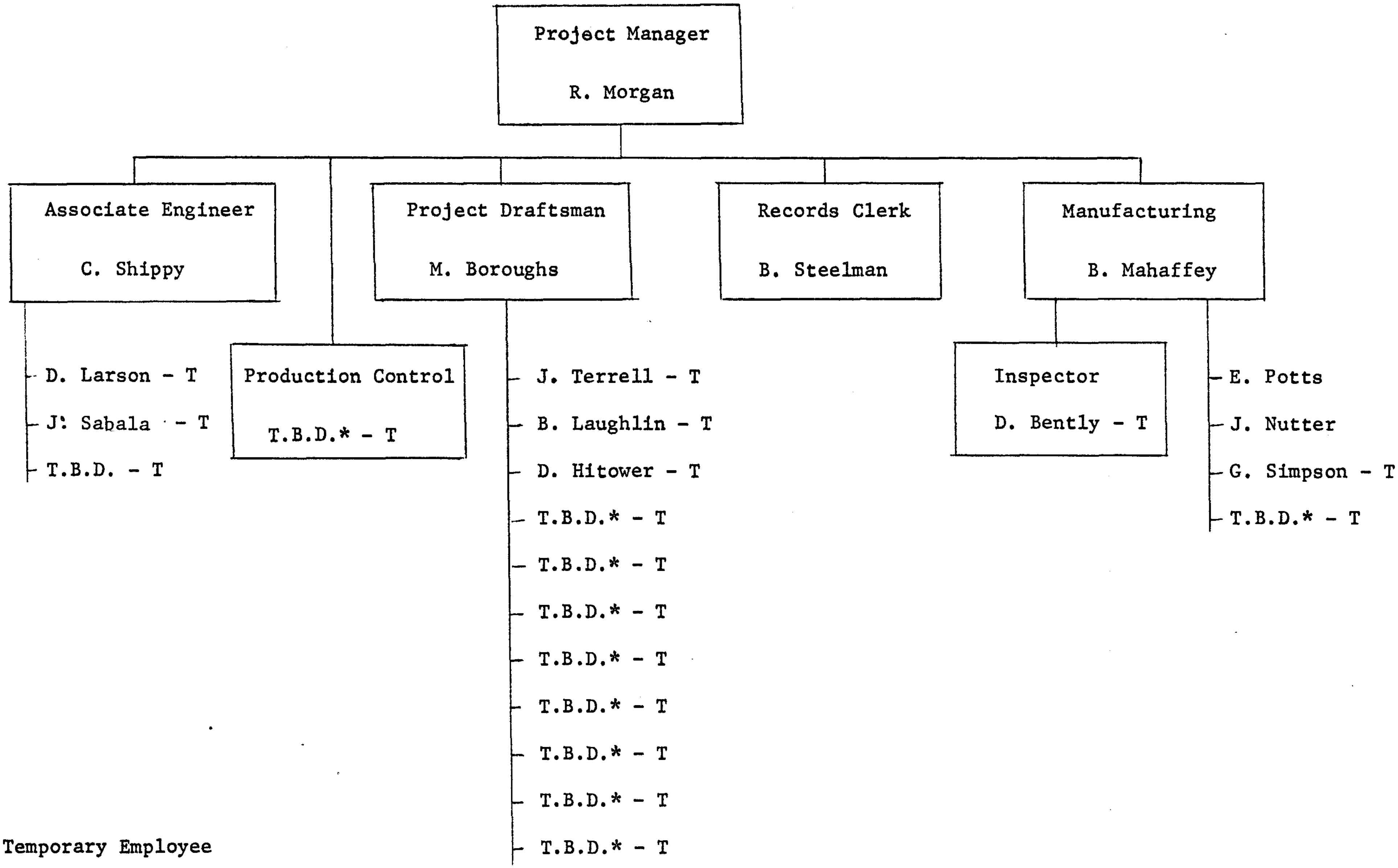

PROJECT SCIENTIST
J. H. Hoffman
PROGRAM MANAGER
D. R. York
QUALITY ASSURANCE PROJECT ENGINEER
J. M. Carroll
PROJECT MANAGER ELECTRICAL
R. A. Giroux
PROJECT MANAGER MECHANICAL
R. H. Morgan



T = Temporary Employee

*Available as depicted on man-loading charts

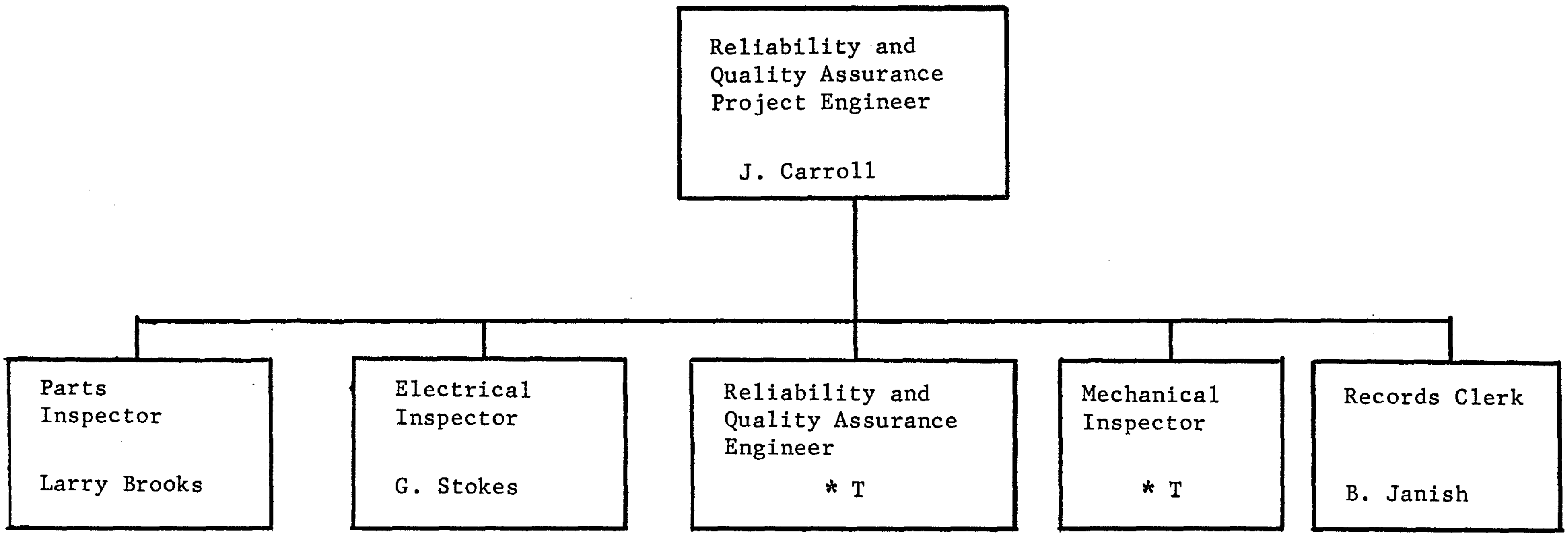
ORGANIZATIONAL CHART - MECHANICAL



T = Temporary Employee

*Available as depicted on man-loading charts

RELIABILITY AND QUALITY ASSURANCE ORGANIZATIONAL CHART



T = Temporary Employee
*Available as depicted on man-loading charts

II. Quality Assurance and Reliability

The Quality Assurance and Reliability responsibilities for the Mass Spectrometer have been combined under the Quality Assurance and Reliability Project Engineer as shown in the Organizational Chart in Section 1.

The Quality Assurance and Reliability group will assure that the necessary controls, inspections and tests are performed to insure that a reliable Mass Spectrometer is supplied which meets or exceeds all specified requirements of the contract.

Separate Quality Assurance and Reliability Plans have been prepared which detail the methods used to implement Quality Assurance and Reliability on the Mass Spectrometer Project. The following items describe the major tasks of Quality Assurance and Reliability:

1) Assist design engineers in parts selection.
2) Approve all design specifications.
3) Approve all purchase orders.
4) Perform incoming inspections.
5) Control all stock and finished parts.
6) Issue parts and material only with approved planning sheets.
7) Establish with manufacturing all inspection points during fabrication.
8) Perform all inspections.

9) Maintain log on test and inspection equipment.
10) Maintain control of hand tools.
11) Monitor all acceptance and qualification testing.
12) Prepare and submit all reliability documentation as specified in contract.
13) Control all non-conforming material.
14) Maintain records on all inspections and tests.
15) Operate personnel training and certification program.
16) Establish a schedule for and monitor calibration cycles of equipment and tools.
17) Inspect packing, packaging and shipping.

The UTD is not a manufacturing orientated organization and for that reason some of the manufacturing functions have been placed under the Quality Assurance and Reliability group. A description of these functions and the method of implementing them are discussed below.

1) Incoming Inspection — Incoming inspection of all program materials is performed by Quality Assurance personnel.
2) Stock Control — In order to control the parts and material to the degree necessary Quality Assurance and Reliability will operate the stock control for the project. All parts and material will be identified, controlled, and maintained in locked cabinets in a limited access area by the Quality Assurance and Reliability group. Parts will be

issued from the stock area only upon presentation of properly approved manufacturing planning sheets. Nonconforming material will also be controlled by Quality Assurance and Reliability, but will be segregated in a separate section of the stock control area.

III. Configuration Management

Drawing and Specification change control for flight units is a vital and necessary element in the Quality Assurance System to ensure that flight articles are fabricated, inspected and tested to the latest applicable drawings and specifications.

Design drawings will present an accurate representation of the hardware to be produced. Sufficient detail will be included in order to minimize the need for verbal instructions to fabrication personnel. Drawing changes will be accomplished by drawing revision except in the event that expedite action is required. In such cases Drawing Change Notices (DCN's) may be utilized. Drawing revision blocks are maintained in the upper right-hand part of each revised drawing to identify the drawing revision (i.e. A, B, C, etc.) was-is information and hardware effectivity. Space is provided beside each revision block for approval signatures. Also, a block is provided following the drawing number to indicate the latest applicable revision (i.e. A, B, C, etc.). The DCN's identify the drawing to be changed by number, revision, was-is information and hardware effectivity. Appropriate blocks are provided for approval signatures. Released DCN's will be attached to the effected drawings. DCN's are incorporated as drawing revisions no later than at the end of the program or when the number of DCN's to an individual drawing exceeds three (3).

Specifications initiated for the space experiments are classified in three (3) categories; procurement, test and end item. Specifications changes are accomplished by revision. Each specification contains revision blocks on the cover sheet to indicate the applicable revision (i.e. A, B, C, etc.), description of change, date of revision and spaces for approval sngiatures.

All drawings, specifications and respective changes initiated are reviewed and approved by Quality Assurance and Reliability prior to release. The review is to ensure that:

a) Adequate quality requirements are defined.

b) The presentation is clear and understandable.

c) Tolerances are realistic and there is no interference at worst case.

d) Adequate rejection and acceptance criteria is defined.

e) Part/component reliability is not degraded by the fabrication process.

f) Fabrication and assembly operations can be accomplished in accordance with the applicable process specifications.

g) Proper effectivity for changes is clearly specified.

All drawings, specifications and respective changes initiated require the approval of Engineering, Quality Assurance and Reliability and the Project Scientist. Approval is indicated by approval signatures of representatives from each of the above sections in the appropriate spaces provided in the document title block. After approval copies of these documents are furnished to NASA.

All drawings and specifications approved as specified above are recorded in the applicable Master Indentured Drawing or Specification List by the Document File Clerk prior to release. Following release, each document master is maintained in a Master Document File for the Experiment. Each document is recorded and released according to the following:

Drawings are recorded in the Master Indentured Drawing List by title, number, revision (i.e. Original release, Revision A, Revision B, etc.) and release date. The file clerk signs and dates each entry in the blocks provided.

Each DCN is recorded in the Master Indentured Drawing List according to the effected drawing, revision, DCN number and release date. The Document File Clerk signs and dates each entry in the blocks provided.

Specifications are recorded in the Master Indentured Specification List by title, number, revision (i.e. Original release, Revision A, Revision B, etc.) and release date. The Document File Clerk signs and dates each entry in the blocks provided, and also is responsible for drawing and specification release and maintenance of the Master Indenture Drawing/Specification Lists and Master Document Files.

Released drawing prints are issued only by the Document File Clerk.

Drawings and specifications required for procurement are listed by number, revision, and DCN's as applicable, on the purchase order. These drawings and specifications may be checked out by QA to attach to purchase orders and these prints will be stamped "NOT MAINTAINED".

The Critical Design Review will be held at the 90% completion of design and drawings. The CDR will effect a design freeze and any drawings completed after the Review will be frozen by the approval and release process. Any design or drawing changes resulting after the CDR will be acted upon by the Configuration Control Board.

The Configuration Control Board will be composed of the Principal Investigator (Chairman) Program Manager, Project Manager (Electrical), Project Manager (Mechanical), and QA. The Board will function in the event of any changes required in the instrument after the CDR. The CCB will decide if the change is warranted and necessary and whether an ECP is required.

Changes are classified as two types, Class I and Class II. Class I changes affect form, fit, function, weight or interface of the experiment and must be approved by NASA before implementation. Class II changes affect internal design only, but are recorded for transmittal to NASA monthly.

IV. Test Management

In general, all testing through development, fabrication and acceptance will be described in the individual Test Plans. These plans shall include, but not be limited to, the following: test logic, test objectives and constraints, summary description, test sequence, schedule, equipment and facilities required.

Throughout the preliminary and final design tasks development tests will be conducted on critical circuits or breadboards to assure that the instrument, as designed, will meet the requirements of the Experiment Performance Specifications.

As sub-systems and systems are fabricated, bench tests will be conducted to determine that these items meet the performance specifications established.

Acceptance tests will be conducted on all deliverable hardware prior to delivery. The acceptance criteria for each deliverable unit will be described in the respective Acceptance Data Packages.

The testing is divided into three (3) phases.

PHASE I

This deals with the testing of individual sub-systems during the breadboarding and engineering model stages. A test plan will be generated by the design engineer to insure that the sub-system performance specifications will be met under all prescribed conditions. This test plan will be submitted to the Project Manager (Electrical) for his approval prior to the actual test.

PHASE II

This phase is related to the fabrication, test procedures and final acceptance testing of the prototype and flight sub-systems. A test plan will be used similar to the one in Phase I, which will also include a detailed test sequence, test objectives, parameter tolerances, and a description of the test equipment needed. The plan will be submitted to the Project Manager (Electrical) for his approval prior to the actual test. All test equipment must have a valid calibration certificate. All sub-system test results will be documented and submitted to the Project Manger (Electrical).

PHASE III

This phase deals with the tests that are to be performed on the completely assembled prototype and flight Mass Spectrometers and associated GSE.

The Project Manager (Electrical) will prepare a detailed Systems Accpetance Test Plan that will verify the overall system specifications requirements. This Plan will include test procedures, system parameter tolerances, test equipment (valid calibration certificates) and test facilities to be used. The Project Scientist will approve this test plan prior to the actual test. Acceptance tests will be conducted on all deliverable hardware prior to delivery. Quality Assurance will monitor and approve all acceptance test data before inclusion in the Acceptance Data Package.

V. Logistics Support

UTD has been contracted to build one spare Mass Spectrometer instrument, but does not contemplate the necessity of producing spare sub-module or module components. A normal rate of manufacturing mortality was utilized in the procurement of production piece parts.

Hardware maintenance and technical support will be provided during pre-installation, integrated systems and pre-launch tests, and any other off-site tests, including real time mission duration. This activity is a function of the Flight Support phase of the program, which is budgeted and controlled as a separate major task element of the contract.

Technical and scientific support during the mission and post-mission operations will be provided as a function of the Principal Investigator's Effort, which is budgeted and controlled as a separate major task element of the contract.

VI. Development Schedule

A master schedule attached to this section was developed indicating start and completion dates for Engineering Design, Procurement and Fabrication, Assembly, Calibration, Test and Shipment of all deliverable Mass Spectrometer instruments and associated Ground Support Equipment. All significant milestones were utilized in constructing Pert Charts depicting span times for each of the production steps of a deliverable End Item. Subsequent manloading was accomplished to maintain an orderly production flow and assure deliveries required by the Contract. Particular emphasis was placed on optimum utilization of full time UTD personnel, augmented only as required by contract services personnel in the functions of Mechanical Design, Drafting, Machinist, assembler and inspector. The use of overtime and multiple shift operations, while available, were not considered in the Master Schedule.

The manloading of each production operation in concert with the amount of dedicated facilities and equipment indicated that an uninterrupted production flow would accomplish delivery of the second and third Mass Spectrometer Flight Units ahead of contract delivery dates. Should a later decision be made to require delivery of MS Flight Units to KSC, instead of NR, on a relaxed schedule the first Flight Unit production could be shifted to allow completion and testing of the Qualification Unit before a significant amount of Fabrication is accomplished on any of the Flight Units. Certain operations depicted in the Master Schedule are sequenced in such a manner to recognize limitations on facilities, efficient utilization of Key Personnel, and the variation in time spans of critical operations.

The Master Schedule will be updated daily for Status Visibility as an integral part of schedule management by the Program Manager and functional department heads. Regularly scheduled Production Status meetings will be held to discuss Program Progress, problem areas, and any negative slack which may have developed on any controlled milestones. The Program Manager will conduct staff meetings weekly, as a minimum, to assure adequate Program Progress to meet contractual delivery dates of deliverable End Items.

PRODUCTION & ENGINEERING SPACE COMMITMENTS

Room #	Function	Floor Area	Percent of Occupancy	Actual Area Used
141	Production & Engineering	340 sq.ft.	50%	170 sq. ft.
143	Production & Engineering	670 sq.ft.	50%	335 sq. ft.
143A	Office	170 " "	100%	170 " "
143B	Office	170 " "	100%	170 " "
145	Production & Engineering	340 " "	50%	170 " "
145A	Production & Engineering	340 " "	50%	170 " "
147	Production & Engineering	100 " "	70%	70 " "
144	Receiving Insp. & Stock	340 " "	100%	340 " "
110	Office	100 " "	100%	100 " "
110A	Office	190 " "	100%	190 " "
157	Production & Engineering	670 " "	100%	670 " "
159	Production & Engineering	220 " "	100%	220 " "
159A	Production & Engineering	100 " "	100%	100 " "
159B	Office	170 " "	100%	170 " "
167	Office	145 " "	100%	145 " "
167A	Office	215 " "	100%	215 " "
B23	Production & Engineering	360 " "	100%	360 " "
B23B	Office	50 " "	100%	50 " "
B23C	Office	90 " "	100%	90 " "
B27	Production & Engineering	280 " "	75%	210 " "
B27A	Office	90 " "	65%	60 " "
B29	Production & Engineering	330 " "	100%	330 " "
B59	Production & Engineering	1000 " "	70%	700 " "
B59A	Office	175 " "	50%	90 " "
B61	Production & Engineering	500 " "	70%	350 " "
	Total Production & Engineering			4,195 sq. ft.
	Total Office Space			1,450 sq. ft.
				5,645 sq. ft.

February 24, 1970

MS PROGRAM PRODUCTION SHOP EQUIPMENT

Mechanical -

4 Milling Machines -	75% of Capacity Used
2 Lathes -	50% of Capacity Used
1 Surface Grinder -	As Needed (50%)
1 Shear	As Needed (25%)
Drill Presses	As Needed (50%)
Saws	As Needed
Hand Tools	As Needed
Inspection Equipment	As Needed

Drafting -

Adequate floor space available

Contract draftsmen supply tables and equipment for themselves.

Outside Machine Shops -

All area shops are low on work now.

Electron Discharge Milling - Texon Tool & Die Co.

Jig Boring - Astro Tool Co.

Arrangements have been made with both companies to perform this work.

Electronics -

Welders	67% of Capacity Used
Test Equipment	75% of Capacity Used

One scope is available for every engineer and technician.

Vacuum Systems (2) - Normally only one is used

Xenox, Ozalid, Itek printing, Photographic reproduction processes available.

ENGINEERING SUPPORT GROUP

MECHANICAL DESIGN GROUP
PROCEDURE

January 22, 1970

General

I. General
   1. a. Receive job from group supervisor.
      b. Complete job.
      c. Have Drafting Department make drawings if required.
      d. Obtain signatures required on drawings.
      e. Have UTD drawing nos. assigned to all drawing by Drafting Department.
      f. Obtain prints for shop, etc.
      g. Leave drawings in Drafting Department for filing.

II. Final Drawings - Designers may produce drawings if necessary. However, when a UTD drawing number is assigned, the drawing must not leave the drafting room.

III. Release - A released drawing is one that: (a) contains all information necessary to fabricate a part or assembly, or describe a circuit, (b) is clean, legible and free from tears or holes, (c) has a title block containing all required information including signatures of the draftsman, designer or engineer, project engineer or scientist, and the mechanical design supervisor, (d) a complete revision block, (e) used on block.

IV. Revisions - When a designer or engineer wishes to make a change to a released UTD drawing, he should mark the changes on a file copy print in red pencil and give the print to the drafting supervisor, to make the changes. Be sure to fill out a job record sheet. The revision block must be filled in. Signatures of the draftsman, designer and/or engineer must be entered on the revision block.

V. Responsibilities - The designer or engineer is responsible for the content of all drawings produced or revised under his cognizance. The Drafting Department will be responsible for the format, appearance, availability, and the maintenance of all completed drawings. Designers or engineers must adhere to drafting department standards of format.

VI. (1) Assignments of Drawing Numbers - Prior to assigning UTD drawing numbers the designer may keep all drawings produced in the design department. The design department flat file will be used. Any numbering system the designers desires may be used except the UTD numbering system. When UTD numbers are on the drawings it will be the responsibility of the designer to maintain and file them.

(2) UTD drawing numbers to be assigned as specified in the Drafting Department procedures.

VII. Assemblies - If assembly drawings are not required, a drawing list bearing the name of the assembly will be made, e.g., detector housing assembly drawing list. Drawing numbers of all details and/or subassemblies used in the assembly will be listed in numerical order.

VIII. Records - The designer or engineer should stamp his working prints "File Copy", "Shop Copy", etc., to facilitate handling and record keeping. Markings stamped on prints by the designer or engineer take precedence over markings stamped by drafting, however, drafting will accept for revision to the original any UTD numbered print with the stamp "File Copy" on it.

ENGINEERING SUPPORT GROUP

DRAFTING DEPARTMENT PROCEDURE

January 22, 1970

GENERAL

1. The drafting department will be responsible for the format, appearance, availability, and maintenance of all released drawings. A released drawing is one that, (a) contains all information necessary to fabricate a part or assembly, or describe a circuit, (b) is clean, legible, and free from tears or holes, (c) has a title block containing all required information including signatures of project engineer or scientist, and the mechanical design supervisor, (d) a completed revision block (if it is a revised drawing) with signatures of the draftsman and designer or engineer, (e) used on block with next assembly and quantity information.

2. All drawings produced by the drafting department will be kept there and have UTD drawing numbers assigned. Drawings produced in other areas will become the property of the drafting department when UTD drawing number is assigned. The drafting department will be responsible for all drawings which bear UTD drawing numbers.

3. The UTD drawing number index will be maintained by the drafting supervisor. He will assign drawing numbers sequentially within existing blocks unless there is reason to do otherwise. All drawings and illustrations bearing UTD drawing numbers will be listed in the index.

4. Revisions to UTD drawings will be made by the drafting department. A revision record will be entered in the revision block when the title block contains signatures as specified in paragraph #1. Revision records on unreleased drawings will be kept only if requested on the Job Record Sheet.

5. A used on block should be on all UTD drawings. The information for the used on block will be provided by engineering, after signatures are on the title block the revision procedure of paragraph #4 must be followed, otherwise it is not necessary.

6. When a new drawing is made, or a revision to an existing drawing is made, the draftsman shall run one blue line print, stamp the date and the words "File Copy" just above the title block and list of material. If the drawing is not released as specified in paragraph #1, stamp the words "Preliminary for information only" in the same area. If the drawing is released omit the "Preliminary" stamp. Return the file copy and the originator information per paragraph #13, and file the tracing.

7. Drawings will be revised by drafting only when a blueline print marked file copy per paragraph #6 is supplied.

8. Normally drawings should contain only one detail part or assembly. However, certain situations such as complexity or fabrication considerations make it practical to have multiple details or assemblies on one drawing. To permit this a suffix is added to the UTD drawing number. This suffix is known as a dash number. This permits calling for one particular detail or assembly of a drawing to be fabricated or subsequently assembled. The subscript to the UTD drawing number should appear immediately beneath the detail views or assembly views on the drawing. The call out for a dash numbered part or assembly in another drawing list of material should appear in the UTD part no. colum, eg., C140-251-01.

9. When a file copy is marked void, obsoleted or superceded by..., drafting must mark the original as void and date it. The entry for that drawing in the drawing no. index must have a line drawn through it and the word "void" entered in the right hand margin. If the drawing is superceded by another drawing bearing a different UTD drawing no., this fact must be noted on the original including the date and the superceding UTD drawing number. The UTD drawing number index entry for that drawing should have a line drawn through it and the word "superceded" entered in the right hand margin.

10. Printed circuit board schematics will be drawn on 17" x 22" (c) size so they can be photographically reduced to 8 ½" x 11" sheet (no fold outs).

11. All illustrations produced or maintained by the drafting department are to bear 105 series UTD drawing numbers if the originator desires a UTD drawing number. The number does not have to be prominent, but should be permanent. In the event that it is objectionable or impossible for the number to appear on the front it will be placed on the opposite side.

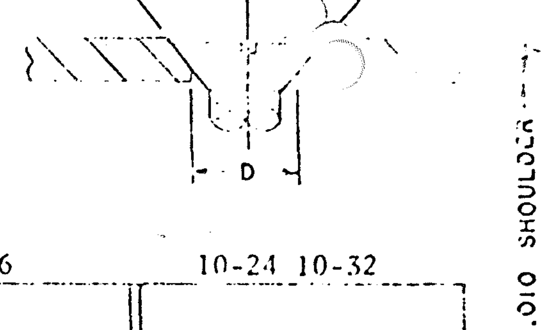
12. The original of an illustration bearing a UTD drawing number may be removed from the drafting department if necessary; however, a notation should be made in a UTD log indicating who has it and the date it was removed. The illustrations are to be stored numerically in the letter file.

13. When a job is completed notification of the originator will be attempted. The orginator should contact the drawing department the day his work is due and make arrangements to pick the work up.

APPROVED BY:

RICHARD H. MORGAN

$$D = C'S\ldots\left[1-\frac{2(t-\text{SHOULDER})\tan\frac{\alpha}{2}}{\text{CSK DIA}}\right]$$



COUNTERSINKS IN THIN PLATES FOR FLATHEAD MACHINE SCREWS
TO INSURE A SHOULDER OF APPROXIMATELY .010

METAL THICKNESS	2-56 2-64	4-40 4-48	6-32 6-40	8-32 8-36	10-24 10-32
.025	.147 DIA* C'SINK 82° +2° TO .177 DIA				
.032	.136 DIA* C'SINK 82° ±2° TO .177 DIA	.187 DIA* C'SINK 82° ±2° TO .230 DIA			
.040	.120 DIA* C-SINK 82° ±2° TO .177 DIA	.173 DIA* C'SINK 82° ±2° TO .230 DIA	.221 DIA * C'SINK 82° ±2° TO .284 DIA	.281 DIA* C'SINK 82° ±2° TO .337 DIA	
.050	.104 DIA* C'SINK 82° ±2° TO .177 DIA	.157 DIA* C'SINK 82° ±2° TO .230 DIA	.209 DIA* C'SINK 82° ±2° TO .284 DIA	.261 DIA* C'SINK 82° ±2° TO .337 DIA	.323 DIA* C'SINK 82° ±2° TO .390 DIA
.063	.093 DIA C'SINK 82° ±2° TO .177 DIA	.136 DIA* C'SINK 82° ±2° TO .230 DIA	.185 DIA* C'SINK 82° ±2° TO .284 DIA	.238 DIA* C'SINK 82°±2° TO .337 DIA	.296 DIA* C'SINK 82° ±2° TO .390 DIA
.080	SAME AS ABOVE	.120 DIA C'SINK 82° ±2° TO .230 DIA	.157 DIA* C'SINK 82° ±2° TO .284 DIA	.213 DIA* C'SINK 82°±2° TO .337 DIA	.272 DIA* C'SINK 82°±2° TO .390 DIA
.090	SAME AS ABOVE	SAME AS ABOVE	.147 DIA C'SINK 82°±2° TO .284 DIA	.191 DIA* C'SINK 82°±2° TO .337 DIA	.250 DIA* C'SINK 82°±2° TO .390 DIA
1/8	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	.173 DIA C'SINK 82°±2° TO .337 DIA	.199 DIA C'SINK 82°±2° TO .390 DIA
3/16	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE

* Countersink mating part to this diameter.

STANDARD SCREWS, NUTS AND WASHERS

Size of Screw			#2	#4	#6	#8	#10	#12	1/4	5/16	3/8	1/2
Diameter of Screw			.086	.112	.138	.164	.190	.216	.250	[illegible]	[illegible]	[illegible]
Single Hole Clearance			.095	.120	.147	.173	.199	.220	.261	[illegible]	[illegible]	[illegible]
Multiple Hole Clearance(±.005 Tol. On Centers)			[illegible]	.128	.159	.185	.205	.234	.272	[illegible]	[illegible]	[illegible]
Multiple Hole Clearance(±.1/64 Tol. On Centers)			[illegible]	.147	.173	.199	.228	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diameter of Head Machine Screw	Round Head	Max.	[illegible]	.211	.260	.309	.359	[illegible]	.472	[illegible]	[illegible]	–
		Min.	[illegible]	[illegible]	.240	.287	.334	[illegible]	.443	[illegible]	[illegible]	–
	Flat Head	Max.	.172	.225	.279	.332	.385	[illegible]	.507	–	–	–
		Min.	.156	.207	.257	.308	.359	.410	.477	–	–	–
	Oval Head	Max.	.172	.225	.279	.332	.385	–	–	–	–	–
		Min.	.156	.207	.257	.308	.359	–	–	–	–	–
	Fillister Head	Max.	.140	.183	.226	.270	.313	–	.414	–	–	–
		Min.	[illegible]	.166	.203	.250	.292	–	.389	–	–	–
Height of Head Machine Screw	Round Head	Max.	.070	.086	.103	.119	.136	.152	.174	.214	.254	–
		Min.	.059	.075	.091	.107	.124	.140	.151	[illegible]	.239	–
	Flat Head	Max.	.051	.067	.083	.100	.116	.132	.153	–	–	–
		Min.	.040	.055	.069	.084	.098	.112	.151	–	–	–
	Oval Head	Max.	.090	.104	.128	.152	.176	–	–	–	–	–
		Min.	.063	.084	.105	.126	.148	–	–	–	–	–
	Fillister Head	Max.	.083	.107	.132	.156	.180	–	.237	–	–	–
		Min.	.063	.094	.103	.126	.148	–	.207	–	–	–
Hex. Head Cap Screw	Across Flats		–	–	–	–	–	–	7/16	1/2	9/16	
	Across Corners		–	–	–	–	–	–	.505	.577	[illegible]	
	Height of Head		–	–	–	–	–	–	[illegible]	15/64	[illegible]	[illegible]
Diameter Plain Washer(±.010)	Steel		–	–	3/8	7/16	1/2	9/16	5/8	11/16	13/16	[illegible]
	Brass		7/32	9/32	5/16	3/8	7/16	1/2	9/16	[illegible]	7/8	–
Diameter Spring Lockwasher	Steel	Max.	.161	.213	.245	.303	.331	.367	.457	[illegible]	.650	
		Min.	[illegible]	.208	.234	.291	.317	.351	.442	[illegible]	[illegible]	[illegible]
	Bronze	Max.	[illegible]	.249	.245	.272	.331	.367	.457	.534	.650	[illegible]
		Min.	[illegible]	.239	.234	.260	.317	.351	.442	[illegible]	.630	[illegible]
Dia. Shakeproof Int. Teeth Lockwasher		Max.	.165	[illegible]	.295	.336	.381	.405	.476	[illegible]	.692	[illegible]
		Min.	.175	.255	.275	.328	.370	.394	[illegible]	.594	[illegible]	[illegible]
Dia. Shakeproof Ext. Teeth Lockwasher		Max.	–	.255	.317	.381	.406	–	.506	[illegible]	[illegible]	[illegible]
		Min.	–	.275	.307	.370	.393	–	.494	[illegible]	.670	[illegible]
Thickness (Max.) Plain Washer	Steel		–	–	.054	.054	.079	[illegible]	.079	[illegible]	.079	[illegible]
	Brass		.022	.032	.039	.039	[illegible]	[illegible]	.048	[illegible]	[illegible]	–
Thickness Spring Lockwasher	Steel		1/32	1/32	1/32	1/32	1/32	1/16	1/16	[illegible]	[illegible]	[illegible]
	Bronze		1/32	1/32	1/32	3/64	[illegible]	1/16	1/16	[illegible]	[illegible]	
Thickness (Max.) Shakeproof Lockwasher			.011	.019	.019	.019	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thickness Hex. Nut			[illegible]	.093	.109	.125	[illegible]	[illegible]	[illegible]	[illegible]	.250	[illegible]
Across Flats, Hex. Nut			.187	[illegible]	.312	.343	.375	[illegible]	.437	[illegible]	.625	[illegible]
Across Corners, Hex. Nut			.216	.289	.361	.397	.433	.505	.505	[illegible]	[illegible]	

THE UNIVERSITY OF TEXAS AT DALLAS

SMOG PURCHASING PROCEDURES

<u>All Purchase Requisitions written against account #E1660 must follow this procedure:</u>

I. A. Purchase Request must be properly filled out -

1.) Include sufficient description of part.

2.) Manufacturer.

3.) Manufacturer's part number.

4.) Quantity.

5.) Price/each.

6.) Delivery date.

B. List local distributors (3 if possible) -

1.) Phone number.

2.) Person to be contacted, if possible.

C. Submit Request to Project Manager.

D. All Requests will then be forwarded to Quality Assurance Project Engineer for his initials.

E. Control of all flight quality parts will be the responsibility of the Quality Assurance Project Engineering Office.

F. Control of all the remaining parts will be the responsibility of the Requestor.

G. Surplus parts will be the responsibility of the Project Manager.

H. All flight quality parts to be delivered to Room 110A.

II. The person writing the Requisition will be known as the Requestor. He will supply all information necessary to complete the Requisition including the account number, sub-account, and other identification, if required. He will initial the Requisition in the "requested by" space. The Requestor may keep the bottom copy (PINK) for his records.

III. The remaining portions of the Requisition will be forwarded to the appropriate Project Manager (Ron Giroux for Electrical, Richard Morgan for Mechanical) for approval. The Project Manager will remove and retain the salmon colored copy.

IV. The remaining portions of the Purchase Requisition will be forwarded to the Executive Officer for approval and from there to Quality Assurance (Jim Carroll). QA will approve and add any necessary information. QA will retain the yellow copy of the Purchase Requisition.

V. QA will forward the Purchase Requisitions to Purchasing where orders will be placed. Purchasing will return to QA three (3) copies of the Purchase Order. QA will keep one copy and forward two copies to the appropriate Project Manager. The Project Manager will forward one copy of the Purchase Order to the Requestor. If any errors or changes are involved the Requestor should notify the Project Manager and determine the best method of implementation.

VI. QA will retain all material purchased for deliverable units until manufacturing authorization is given. The material will then be issued according to requirements. QA will not retain material purchased for non-deliverable units and will issue it to the Requestor. Disposition of surplus materials will be at the discretion of the Project Manager.

Document #150-420
December 30, 1969

PRINTED CIRCUIT BOARD ARTWORK DRAWING

I. GENERAL

A printed circuit board artwork drawing is the first phase of a process which transforms a schematic diagram into a finished printed circuit board. This is usually a multi-sheet drawing (front) and (back). Since the completed artwork drawing issued as a pattern in the fabrication of printed circuit boards, it is essential that accuracy of layout and correct taping techniques be used in forming the circuit configuration.

II. FORMAT - FINAL ARTWORK

There are two (2) methods for selecting the proper format when starting a printed circuit board artwork drawing. All artwork drawings will be made on a stable base, transparent sheet with the correct format on it.

(1) For non-standard boards, the board outline or corner register marks and other markings may be drawn in with ink or formed by an opaque tape. The board outline and corner register marks should be 1/64 inch minimum, at 1/1 scale, outside the maximum perimeter dimensions of the fabricated board.

(2) For standard boards, the board outline is taped. The circuit board outline shall be positioned on the format sheet in such a manner that it will not interfere with revisions or title block.

III. TAPING TECHNIQUES

Printed circuit artworks shall be laid out directly on the correct format as described previously in the section covering FORMATS. The circuit configuration is formed by utilizing adhesive backed pads, fillets, symbols, and strips of red tape which are available in a variety of shapes and sizes. This methods lends itself to speed of layout and extreme flexibility in correcting errors of effecting changes of design.

In order to prevent the possibility of the tape creeping and pulling away from the pads or pulling the pads off position, the tape shall be severed with an X-Acto knife as near as possible to the center hole in the pad.

Every effort should be made to keep the taped-up artwork flat while in engineering, in process, or in transit. One exception to this is the approval to use the mailing tubes furnished by the drafting section.

All tape should be cut rather than torn. A torn edge exposes the adhesive which catches and holds dirt and lint, thus presenting a fairly distinct and heavy line to the camera.

IV. SCALE

Printed circuit board artwork drawings are made at not less than 4/1 scale; however, all dimensions are shown as actual size. A general tolerance of $\pm$ .003 inch ($\pm$ .012 artwork size) shall be observed for all measurements, such as board outline, mounting hole locations, and within the pattern of all terminal areas.

V. GRID ALIGNMENT AND CENTERING MARKS (For non standard boards)

Positioning marks, are required on printed circuit artworks in order that the circuit may be precisely positioned on the boards for manufucaturing purposes. The positioning marks must be placed on the standard grid and as near the center of the board as the grid will permit. Extreme care must be used in placing the marks on the artwork to keep them in the same plane and 90 degrees apart.

When artwork for a double-sided board is being prepared, the positioning marks must be placed on both artworks so that the relationship to the base hole or pads is identical for both sides of the artwork.

VI. INDEXING

Each printed circuit board artwork shall have at least two indexing holes or close tolerance datum marks, one of which may be a mounting hole or other hole, from which primary dimensions originate. The second hole, shall be dimensioned with respect to the first hole and, if possible, located on the same center line. Should there be no established holes that will satisfy the above condition, then manufacturing hole shall be used. The holes selected shall be part of the artwork and shall be located on the grid. They shall be spared as far apart as practical to which effect they may be in a horizontal or vertical plane. These holes are extremely important and must be accurately positioned, as they are used for locating, aligning, and positioning operations necessary to the fabrication of the board. They shall be identified on the drawing with a leader and call-out.

VII. TERMINAL AREA (PAD)

A pad shall be provided for each point of attachment of a component part lead or other electrical connection to the printed circuit board. These pads shall consist of a circular, tear drop or other smooth shaped conductor, in that order of preference, completely circumscribing the component lead mounting hole.

The practice of removing part of a recommended minimum pad to provide proper spacing between pads or other elements of the circuit is .230 from the center of the pad to the flattened side. The circuit should be relocated if it appears that the clearances will not be sufficient. All pads shall be located on a grid intersection. Pads for component parts whose spacing is such that all terminal holes do not fall on grid intersections shall have at least one terminal hole located on a grid intersection.

In the instance of double-sided circuit boards, pads are not required on both sides of the board. When making the artwork for such boards, however, in order that all holes may be drilled from the same side, the circuit side should be chosen as the drilling side.

When a component is mounted on a printed circuit board with mechanical hardware, a pad is used as a drilling guide on the circuit side of the board and shall be small enough so that the corresponding copper pad on the printed circuit board will be completely removed.

VIII. PRINTED BOARD CONDUCTIVE PATTERNS AND SPACING

Conductor line width, hole diameters, ring wall thickness, and spacing between lines should be as large as possible. In the etching process, it is practical to maintain pad center diameters of .015 minimum and ring wall width of 0.32 minimum. The preferred conductor width is 0.62, but as a preferred minimum, the conductor width shall not be less than .031. Ground conductors should be larger than other.

The minimum spacing between conductors for circuit power up to and including 50 volts shall be as indicated in the table. For spplications where secondary short circuit protection is provided in the form of fuses, circuit breaker, etc., and where the normal operating power is 50 watt but does not exceed 2,000 watts, the minimum spacing between conductors shall be twice that indicated in the table.

The minimum spacing between conductors shall be in accordance with grade A or grade B of the table, as specified by the contract or order. Spacings less than .026 inch shall only be used on those boards where there is no potential (voltage) greater than 50 volts DC or AC peak. Grade B spacings are for use where the board will be directly exposed to severe contaimnation.

REF. MIL-STD-275A

VOLTAGE BETWEEN CONDUCTORS (DC OR AC PEAK VOLTS)	SEA LEVEL - 10,000 FT.					OVER 10,000 FT.			
	UNCOATED			COATED		UNCOATED		COATED	
	GRADE "A" MIN	PRE	GRADE "B"	MIN	PRE				
0-50	.015	.031	.080	.015	.031	.026	.031	.022	.031
51-150	.026	.031	.080	.022	.031				
151-300	.062	.062	.125	.030	.031				
301-500	.125		.300	.060	.062				
	.0003 PER VOLT		.0006 PER VOLT						
51-100						.062	.062	.030	.031
101-170						.125		.060	.062
171-250						.250		.125	
251-500						.500		.250	

From MIL-STD-275A

IX. REFERENCE DESIGNATIONS

(1) Reference designators per MIL-STD-16C will be used where practical to identify parts on P.C. board assemblies and should be parallel or perpendicular to one edge of board.

(2) Assemblies or sub-assemblies may be identified per MIL-STD-16C or they may be identified with a short noun phrase, e.g. power supply or low voltage power amplifier, on the artwork within the outline of the fabricated board. Abbreviations per MIL-STD-12B will be used for the latter.

(3) Transformers will have each lead numbered numerically and sequentially starting with 1.

(4) Integrated circuits will have pin 1 identified.

(5) Connectors will have pin 1 and the last pin identified.

(6) P.C. board assemblies shall be identified by inclusion of the board assembled drawing number on the artwork followed by the revision status.

Example:

D-150-539-01 C
Dwg. No. — Rev. Status

This identification must be inside the trimline.

(7) Conductors which carry principal circuit functions, e.g. B+, GRD, etc. should be identified along the conductor where convenient.

X. SHIELDED BOARDS

Some printed circuit boards have the (FRONT) or component side shielded. This is done by using a reverse exposure process which leaves a common ground, copper area, over the entire side of the board.

XI. DRAWING NUMBER

The basic drawing number assigned to the artwork drawing shall be the same for the (FRONT) and (BACK) of the printed circuit board.

The assembled circuit board drawing number shall be put on the artwork, inside the board outline.

XII. REPRODUCTION

(1) P.C. board artworks should not be reproduced in the ozalid machine. If it is necessary to have a blueprint copy of the artwork, the artwork must be checked carefully after printing for loss of pads and pulled or dislocated tape.

(2) Artworks are reproduced satisfactorily from a photographed film master or auto positive. Blueprint copies can be made from these.

(3) If a permanent master is desired for the file the film master or autopositive is excellent.

(4) All released artworks will be processed for photographing and reduction for board printed fabrication purposes by the document file clerk.

XIII. REVISIONS

The revisions for an artwork drawing shall be handled the same as any other drawing change notice. It shall be permissible to revise the artwork and its associated drawings on one revision, all drawing numbers being called out on one DCN.

When working with a printed circuit board artwork it is very important that the revision data is kept up to date. It is also important, when looking at a printed circuit board, to know what revision artwork was used to make the board. In order to make this possible a revision block shall be put on the front and back of all printed circuit board artworks. This revision block shall be one-half inch minimum inside dimension and be made with one-eighth inch opaque tape.

During the development of an printed circuit board artwork it may become necessary to send filmwork of this artwork to the etch lab to have boards made. If a revision is made to the printed circuit board artwork after this time the letter "A" should be placed in the revision block.

Filmwork should then be re-issued to the etch lab and each time from then on when a revision is made to the printed circuit board artwork the next letter revision shall be added and the filmwork re-issued.

After the printed circuit board artwork has been released and the first drawing change notice is initiated the revision description block in the upper right hand corner of the printed circuit board artwork drawing will be filed out for the first time. If there have been several development changes, the revision description block should read, e.g."Revisions A through C development changes." Revision D would then be entered under this with the appropriate "DCN" number and description of the drawing change notice. In addition to this, the revision block and the artwork printed circuit board would then be changed from Revision "C" to Revision "D" and both sides of the artwork.

XIV. STORAGE

(1) Taped up artworks will be stored in the tracing file by the file clerk after they have been released and photographed.

XV. MASTER GRID

All printed circuit artwork is to be prepared at a 4:1 scale. A stable polyester (or equivalent) master grid (4:1 scale) shall be utilized to assure accuracy. The master grids shall be accurate with respect to tru-position within .003 of an inch and periodic checks shall be made to verify their accuracy. The basic grid units of length shall be 0.100, 0.050, or 0.025 inch in that order of preference.

The master grid is utilized by placing the format on which the front side of the artwork is to be prepared on top of the master grid. The grid should be oriented so that the grid designation (A,B,J, etc.) is located next to the title block of the front artwork format.

The designation of the grid used should be placed in the border of the artwork format below the title block. Following this method, it is possible to make all revisions using the same grid.

XVI. REFERENCE DOCUMENTS

(1)	MIL-STD-275A	Printed Wiring for Electronic Equipment
(2)	MIL-P-13949	Plastic Sheet, Laminated, Copper Clad
(3)	MIL-STD-429	Printed Circuit Terms and Definitions
(4)	MIL-STD-12B	Abbreviations for use in Drawings---------

Manufacturing Procedure for S.M.O.G.

I. General

1. General machine shop procedure of 1/21/70 apply unless contrary to this procedure.

2. Manufacturing will only accept for fabrication prints of released drawings stamped "SHOP COPY" dated and accompanied by a manufacturing authorization originated by the project manager. These prints and authorizations will be issued only by the document file clerk who will be authorized to release prints for fabrication by the project manager.

3. Manufacturing will generate planning paper for each print.

   A. Planning Paper Content

   1. Mfg. By (Name and address)
   2. Order of operations (see note)
   3. Individuals initial performing operation (see note)
   4. Inspections
   5. Drawing No. and Rev. symbol
   6. Special Instructions
   7. P. O. #
   8. Material and Ident.
   9. Quantity each part
   10. Unit #
   11. Batch #

   NOTE: If sub contracted in full omit steps 2 & 3.

II. Inspection

1. Inspector will inspect each part for dimensional accuracy at the point of fabrication specified in the planning.

2. Inspector will initial the planning if the work is acceptable, if it is not acceptable he will fill out a discrepancy report and route it to the project manager for action. If the discrepancy is minor the part(s) may be reworked and inspected. If the discrepancy is major, i.e., requires rebuild or material addition, the defective material tag must be filled out and the D.M.T. No. placed on the discrepancy report.

3. Discrepancy No. (serialize all discrepancies)

4. Machinist performing rejected operation (omit for subcontract)

5. Signature of inspector

6. D.M.T. No.

III. Documentation

1. Each print must be accompanied by the planning paper, discrepancy report(s) and any DCN's that are issued. This

packet of paperwork must accompany the parts as they proceed thru production. Final Q.C. inspection will be responsible for the paperwork.

IV. Finishing

1. Plating, painting or conversion coatings may be done by subcontractors. Finishing will be inspected for appearance and conformance with specifications and requirements per drawing by the fabrication inspector.

V. Cleaning

1. All metallic fab parts are to be vapor degreased and deburred prior to inspection. Non-metallic parts should be scrubbed in hot water.

VI. Packaging

1. All fab parts will be packaged in plastic bags, after fabrication and cleaning is complete.

VII. Handling

1. All parts for each print will be kept together in so far as practical. As parts are moved from one operation to another the documentation as specified in paragraph III must accompany them. If parts are from different raw material batches, they must be kept separated by batch.

VIII. Raw Material

1. Purchasing

A. Manufacturing will write purchase requisitions for all raw materials. Raw material purchased will be kept in separate stock and identified as S.M.O.G. material. Purchase requisitions will be approved by the project manager, quality control and the executive officer.

2. Certification

A. All Raw material P. R.'s must require certification that the material shipped is the material specified and from what batch nos, run nos., etc. it came from. This certification should accompany the material. Receiving inspection will verify and retain this certification.

3. Receiving

A. Raw material will be received by U.T.D. receiving and routed to quality control receiving for control and documentation purposes. Q.C. will store the material.

4. Distribution

A. Q.C. stores will issue material as required by manufacturing.

S.M.O.G. Manufacturing Authorization

I. General
   I. To be issued by project manager to manufacturing thru the Document File to authorize construction of detail parts or sub-assemblies. Drawings for the detail parts of sub-assemblies must be released prior to this authorization.

II. Format
   I. See attached sheet.

III. Routing
   I. One copy to accompany prints marked "SHOP COPY" to manufacturing.

S.M.O.G. MANUFACTURING AUTHORIZATION

APP. ______________________________ DATE ______________

DRAWING NO.	REV.	QTY.	DESTIN-ATION	PREVIOUS AUTHORITY				TOTAL QTY.	
					QTY.		QTY.		

Document #150-423
January 27, 1970

S.M.O.G. Document File Clerk Responsibilities

1. All approved drawings and specifications shall be recorded in the applicable Master Indentured Drawing or Specification List prior to release.

2. All released document masters shall be maintained in the Master Document File.

3. Drawings shall be recorded in the Master Indentured Drawing List, by title, number, revision (i.e. Original release, revision A, revision B, etc.) and release date. Sign and date each entry in the blocks provided.

4. Each DCN shall be recorded in the Master Indentured Drawing List according to the effected drawing revision, DCN number and release date. Sign and date each entry in the blocks provided.

5. Have absolute control of released drawing, specification, and DCN file.

6. Fun all ozalid prints and stamp them with the correct stamp. Maintain record of print distribution and maintain latest revision of prints in distribution files.

7. Process P.C. board artworks for photographing.

8. Process manufacturing authorizations.

C. L. Shippy

R. H. Morgan

MECHANICAL SPECS. FOR S.M.O.G. SPECTROMETER

NEED:

I. Magnet Assembly (Need by 12/3/68)

1. Yoke mat. thk. and outline
2. P. piece thk. and outline
3. Magnet thk. and outline
4. Mtg. facility
5. Shielding R'QMT
6. Finish - nickel plate
7. Assy. technique - glue or solder?
8. Slot width

II. Analyser Assy. (Need by 12/3/69)

1. Geometry Details
   a. Slit locations
   b. Path parameters
   c. Shield housing I.D. and material
   d. Plating

2. Slit Details
   a. Maximum deviation of slit measured to base plate
   b. Material & plating
   c. Thickness
   d. Length & width
   e. Included angle

3. Multiplier Description
   a. Mfg. type and part no.
   b. Shielding requirements
   c. Preferred orientation
   d. Terminals (if any)

III. Source Assy. (Need by 12/8/69)

1. Slit details (same as II/2)
2. Changes to filament
3. Other changes
4. Terminals (preferred type)

IV. Base Plate

1. Interface with electronics details
   a. Mounting
   b. Wiring
2. Connector Types (if any)

V. Collector Assy. & Shield

1. Collector Assy. information
2. Shield Material & Thickness

VI. General

1. Wiring Information
   a. Wire size & type for each lead & phys. dim.
   b. Preferred hook-up arrangement
   c. Connector types
   d. Sleeving
   e. Junction devices

VII. Environment

1. Vibration
   a. Sinusoidal
   b. Random
2. Shock
3. Thermal and/or thermal vac
4. Salt spray

Document #150-425
Date: January 20, 1970

SMOG, DRAWING CHANGE NOTICE PROCEDURE

I. PURPOSE

This procedure establishes the requirements for making revisions to all engineering drawings, and describes the method of processing such revisions.

II. RESPONSIBILITIES

The Individual requesting a drawing change is responsible for initiating a Drawing Change Notice and forwarding to the cognizant Engineer.

The cognizant Engineer is responsible for evaluation of proposed changes, and securing the Project Manager's and Quality Control's approval.

All persons assembling, testing or fabricating equipment which contains items to be changed by DCN are responsible for taking corrective action in accordance with the DCN. Upon receipt of a revision which would be unsatisfactory for use, he should immediately notify the Project Manager.

III. GENERAL INFORMATION/DEFINITION

A. The following general provisions are included as a part of this procedure:

1. Where a design change involves several different drawings and parts, these related changes will be delineated on the same Drawing Change Notice.

   Examples: Fab part and associated engraving. Bill of Material Change associated with circuit board wiring change. A design change involving fab parts, Bill of Material, and schematic.

2. This procedure provides that copies of the Drawing Change Notice will be distributed as quickly as possible after the change information has been finalized by the Engineer. This DCN provides the information and authorization for Manufacturing to proceed with the change.

3. Copies of the DCN are also supplied to all persons on the effected drawing distribution of equipment using the

revised item. In the event the change will have a detrimental effect on the equipment under his cognizance he will promptly confer with the Engineer, who made the change, and the Project Manager, and work out a mutually acceptable solution to the problem.

B. Interchangeability of Revised Items:

The following shall be used as a guide in determining whether or not the revised item is interchangeable with the previous version of the item. Where the revised item is not interchangeable, it must be identified by a new part number.

1. A revised fab item or subassembly is interchangeable when it can be used as a direct replacement for the old part without a need for mechanically modifying the item to which it is assembled.

2. An electrical component or electrical assembly is interchangeable when it can be used as a direct replacement for the old item without modification or degradation of the assembly or unit in which it is used.

C. Requirements for Making Drawing Changes:

Request for DCN shall be directed to the cognizant Engineer. The individual requesting the change may use the DCN for submitting his request.

1. It will be the responsibility of the Engineer to evaluate all proposed changes for feasibility, relative value versus cost, etc. The Engineer will consult with manufacturing to establish an effectivity that produces the least disruption to manufacturing schedules without unduly delaying the introduction of the change. Where the merits of a proposed change are not justified, the request for change will be denied by the cognizant Engineer.

2. Where the need for making change information available to Manufacturing is extremely urgent, the Engineer will write up the DCN (supplying all information, sketches, and securing project manager's approval) and hand carry one copy stamped "PRELIMINARY COPY" to Manfacturing. A marked print showing the applicable DCN number and the Engineer's approval signature may be used when needed. The Engineer will be responsible for putting the DCN into the change system promptly.

IV. PROCEDURE

Preparation of DCN Form

A. Engineering Responsibility:

1. Fill in the following blocks on DCN form:

   Engineer (name) Phone ( )
   Date submitted( )
   Drawing Numbers affected (list all drawing numbers affected)
   Symbol No. (enter next rev. symbol)
   Distribution (enter any special distribution required)

   a. Effectivity - The types of effectivity are shown on the DCN, one for fab items, one for assembly items. It will be the joint responsibility of the Engineer and Manufacturing to establish an effectivity that will implement the change on a basis that assures the maximum benefits from making the change.

      (1) The Engineer will show the applicable effectivity.

      (2) Where a change to a fab item has no effect on assembly manufacturing operations, only fab effectivity will be shown.

      (3) Where a change to a fab item affects assembly operations, write ups, etc., show both fab and assembly effectivity.

   b. Disposition - Check applicable block

   c. MRB Action - to be indicated by Project Manager in the event of scrap or rework disposition.

   d. Reason for change (check applicable block and give other reasons where required).

2. Mark up (latest version) FILE COPY to show specific changes required. All new part numbers added by revision must be covered by assigned drawings or by drawings released with the DCN. All change information must be marked in RED PENCIL. Drafting instructions or information to be shown only on the DCN shall be shown in GREEN PENCIL.

   Where applicable, the Engineer will show on the marked print or DCN, the approved method for reworking existing items to incorporate the change, the configuration of the reworked item may have extra holes, etc., and will not conform 100% to the revised drawing detail.

3. Where it is determined that a DCN in process must be altered or modified, this will be permissable providing prints of the DCN have not been distributed. Where prints of the DCN have already been distributed, alteration must be handled as follows:

   a. Where minor errors (not affecting the L/M) are detected in the DCN after copies have been distributed, the errors may be corrected in the following manner.

Pull the original DCN, and add a dash 1 (-1) after the DCN number. Make corrections by obvious marking on the DCN. Add notation to the effect that "THIS DCN ISSUED TO CORRECT ERROR IN DCN ______________."

b. Where major deficiencies are found to exist in a DCN which was distributed, the DCN may be cancelled by a new DCN.

Notation shall be made on the new DCN that:

"THIS DCN CANCELS AND SUPERSEDES DCN ______________."

Where necessary, a DCN may be written to supplement a previously issued DCN. In this instance, the following notation shall be shown on the supplemental DCN:

"THIS DCN SUPPLEMENTS DCN ______________."

B. Drafting Responsibility:

1. Document File Clerk will enter the number of each part affected by the change in the DCN log and will assign a serial number to the DCN form. Where there is a change still in process on parts affected by the DCN being logged in, the Document File Clerk will notify the Engineer of the pending change and request disposition of the new DCN.

2. Drafting will check change information for compliance with requirements.

3. Drafting will make the change on basis of information shown on the marked print. A sketch may be included on the DCN (or continuation sheet) to help clarify certain details. The information will be specific and sufficiently detailed to allow manufacturing to incorporate the change on the basis of information shown on the DCN except in the following cases:

    a. Where more than a write-up and sketch are required to delinerate certain details.

    b. Where the complexity of writing up extensive wiring diagram changes, etc., are such that it is not feasible to make a completely detailed write-up.

    c. Where artwork is involved.

    d. Where addition of subassembly or assemblies are involved.

4. List of Material Changes:

   a. Changes to drawing L/M's will be delineated in the following manner:

      (1) Enter deleted items - show part number, quantity, and electrical symbol.

      (2) Enter added items - show part number, quantity, and electrical symbol.

      (3) Enter quantity changes - show part number, quantity was (   ) quantity is (   ). Show electrical symbol changes.

5. Revision of Tracing:

   a. Drafting will check the tracing and revise to incorporate required changes, revision block will be filled in according to standard practice, and the revised tracing will be checked for errors. DCN Serial No. and Unit Effectivity will be entered in the Revision Block.

   b. The draftsman making the change will initial the appropriate block on the DCN to indicate the tracing has been revised, the drafting checker will enter his initials and the Engineer's initial and DCN date in the drawing revision block.

   c. The revised tracing, DCN original, and marked print be forwarded to the Document File Clerk for processing.

   d. The Document File Clerk will issue revised prints.

SMOG DRAWING CHANGE NOTICE

_____Tracing Revised

DCN__________________

Sheet_______of________

Engineer: Phone: Date:

Project Manager Approval:________________ Q.C. Approval________________

Affected Drawings: Rev. Sym. No. Special Distribution:

FAB EFFECTIVITY

_____All parts
_____Parts in assys.-fin goods
_____Parts in assys.-in process
_____Parts in assy. stock
_____Parts in process-in fab
_____Future fab parts
_____Unit Serial No. Effectivity

_____MRB Action

ASSEMBLY EFFECTIVITY

_____All assys.
_____Assys. in fin. goods
_____Assys. in process
_____Future prod. assys.

DISPOSITION OF ITEMS MADE

_____Rework _____Scrap

_____Use as is

REASON FOR CHANGE:

_____Correct Error _____Improve Design _____Records

SMOG DRAWING CHANGE NOTICE

CONTINUATION

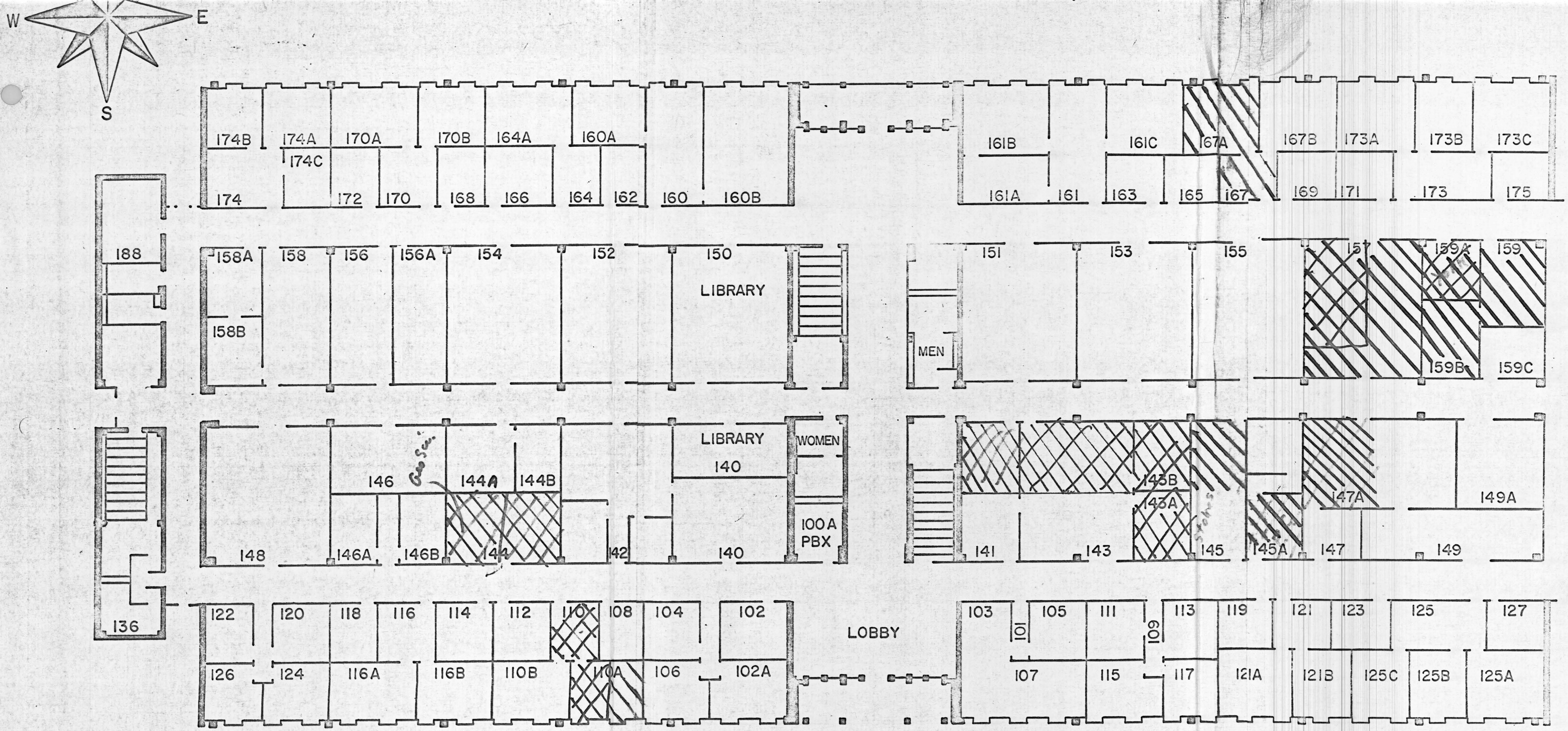
Engineer:

DCN ____________/________

Sheet ______ of ________

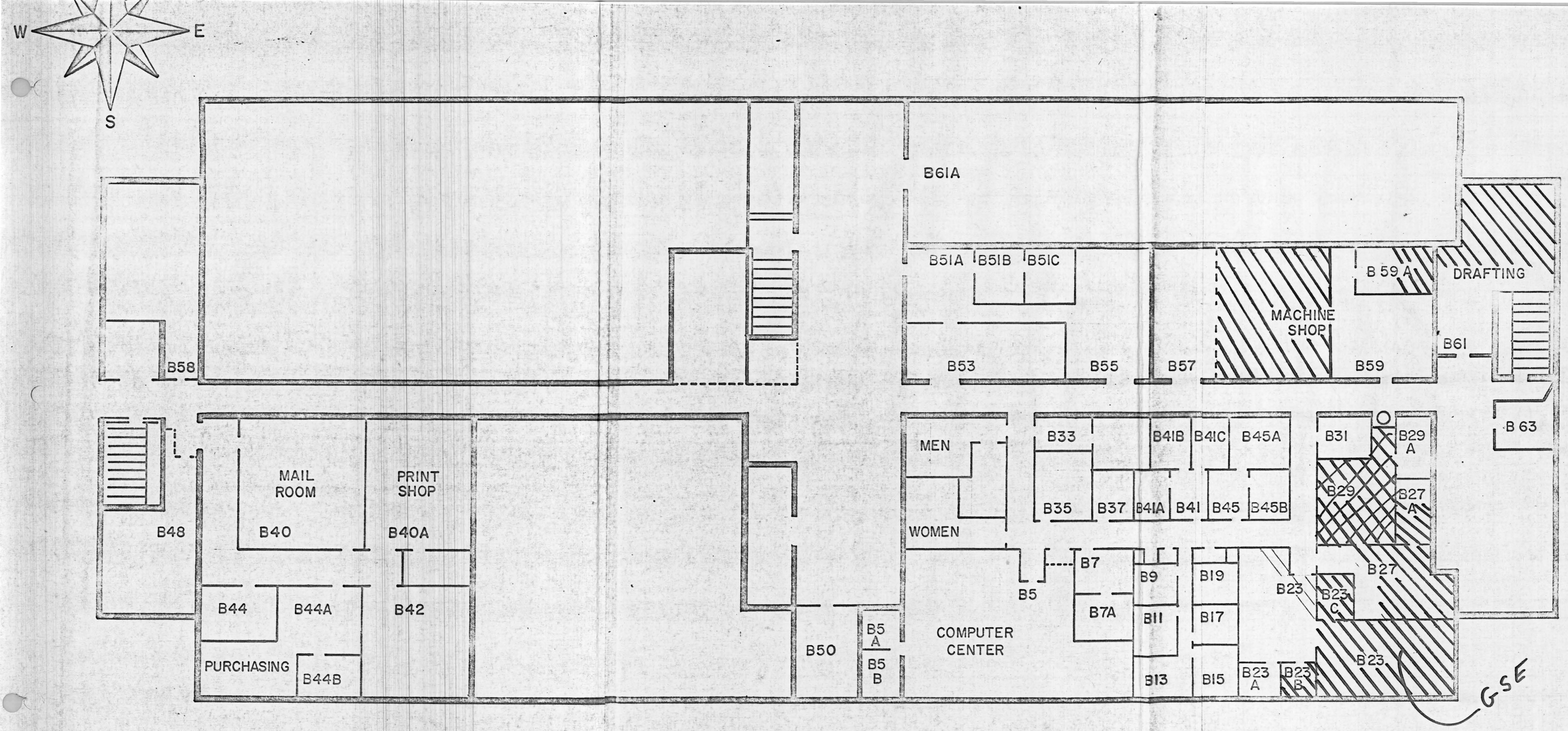
Affected Drawings:

Rev. Sym. No.:



FIRST FLOOR

Scale: 1 inch = 16 feet



BASEMENT

Scale: 1 inch = 16 feet

DIRECT LABOR

PROGRAM__________ STATUS AS OF __________

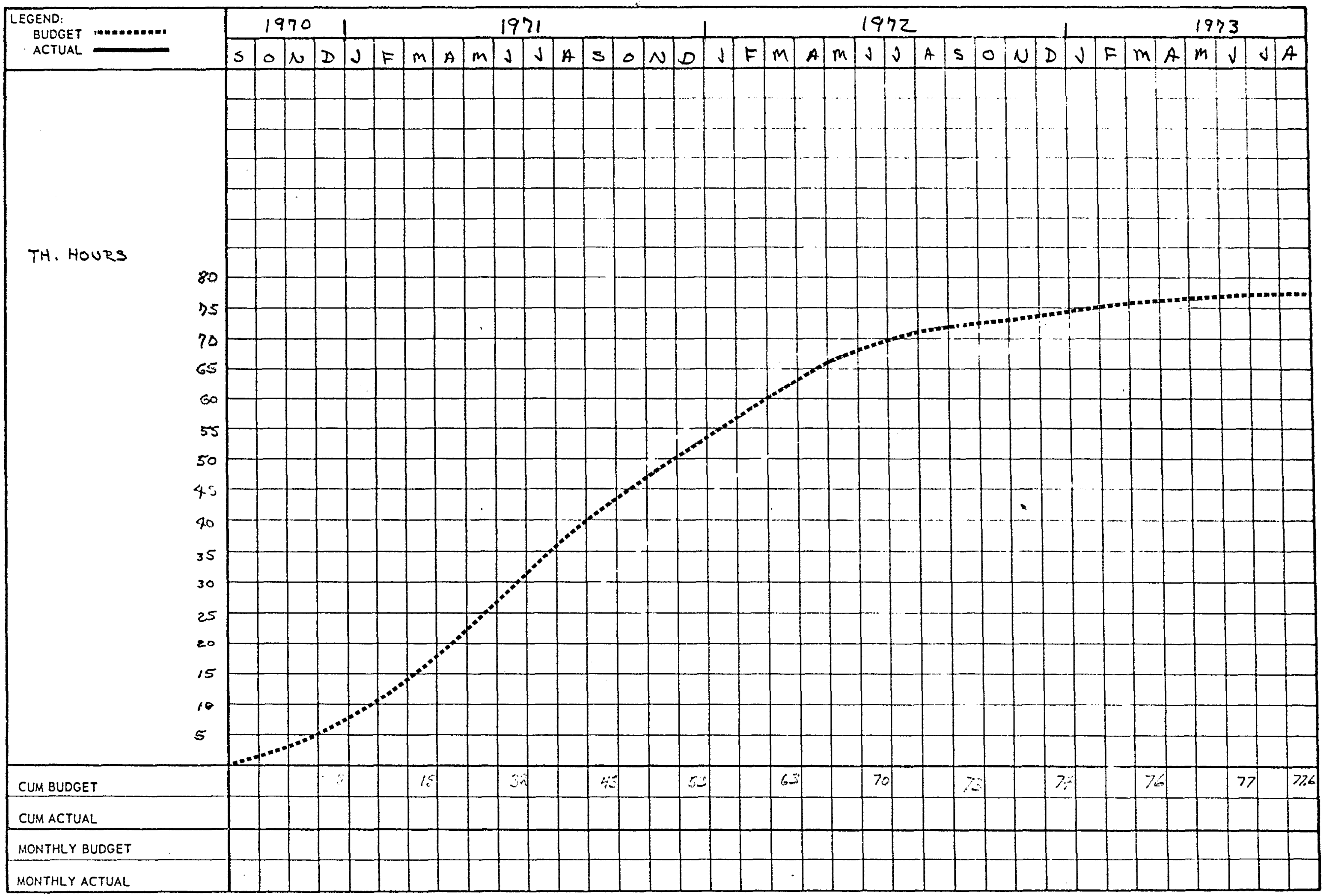


FIGURE 9-1

BUDGET STATUS REPORT
CONTRACT NO. NAS 9-7591

SOU

HIGH SENSI 111

REPORT DATE: 02/28/70 | PAGE: 1

DIVISION		SPONSOR	PRINCIPAL INVESTIGATOR OR DEPT. HEAD	COST CENTER/PROJECT NO
OASS	DC	NASA	FS JOHNSON	E1618-00

DESCRIPTION OF CHARGES	EXPENSE CODE	CUMULATIVE PROJECT COST — COST FROM INCEPTION TO DATE
SALARY AND WAGES	0100	
FACULTY-SCIENTIFIC-ENGINEERING	0110	9,300.61
NON-FACULTY-SCIENTIFIC-ENGINEERING	0120	35,663.62
TECHNICAL	0140	40,784.20
SECRETARIAL	0150	1,375.50
TOTAL SALARIES & WAGES	0100	87,123.93
ACCRUAL FOR VACATIONS,SICK LEAVE,HOL	0210	10,150.45
ACCRUAL FOR STAFF BENEFITS	0220	9,325.44
TOTAL ACCRUALS	0200	19,475.89
SUPPLIES AND EXPENDABLE EQUIPMENT	0310	59,726.46
PURCHASED SERVICES	0330	4,636.94
PROJECT EQUIPMENT	0340	9,886.58
POSTAGE,FREIGHT AND CUSTOMS	0360	361.41
COMMUNICATIONS	0370	788.21
PRINTING,BINDING,REPRODUCTION	0380	575.13
BOOKS,PERIODICALS AND REPRINTS	0390	7.50
EMPLOYEE TRAVEL	0410	2,514.59
COMPUTER COST	0430	294.25
COST CHARGED TO OTHERS	0820	140.00CR
REPAIR AND SERVICE CHARGES	0903	156.40
RENTAL OF EQUIPMENT	0912	271.70
TOTAL OTHER CHARGES		79,079.17
TOTAL OTHER CHGS & ACCRUALS		98,555.06
SUB-TOTAL		185,678.99
COSTS CHARGED TO OTHERS	0820	140.00
COST CENTER TOTAL	*	185,818.99
TOTAL COMMITMENTS		513.80
GRAND TOTAL		186,332.79
Overhead		68,861.00
TOTAL		255,193.79

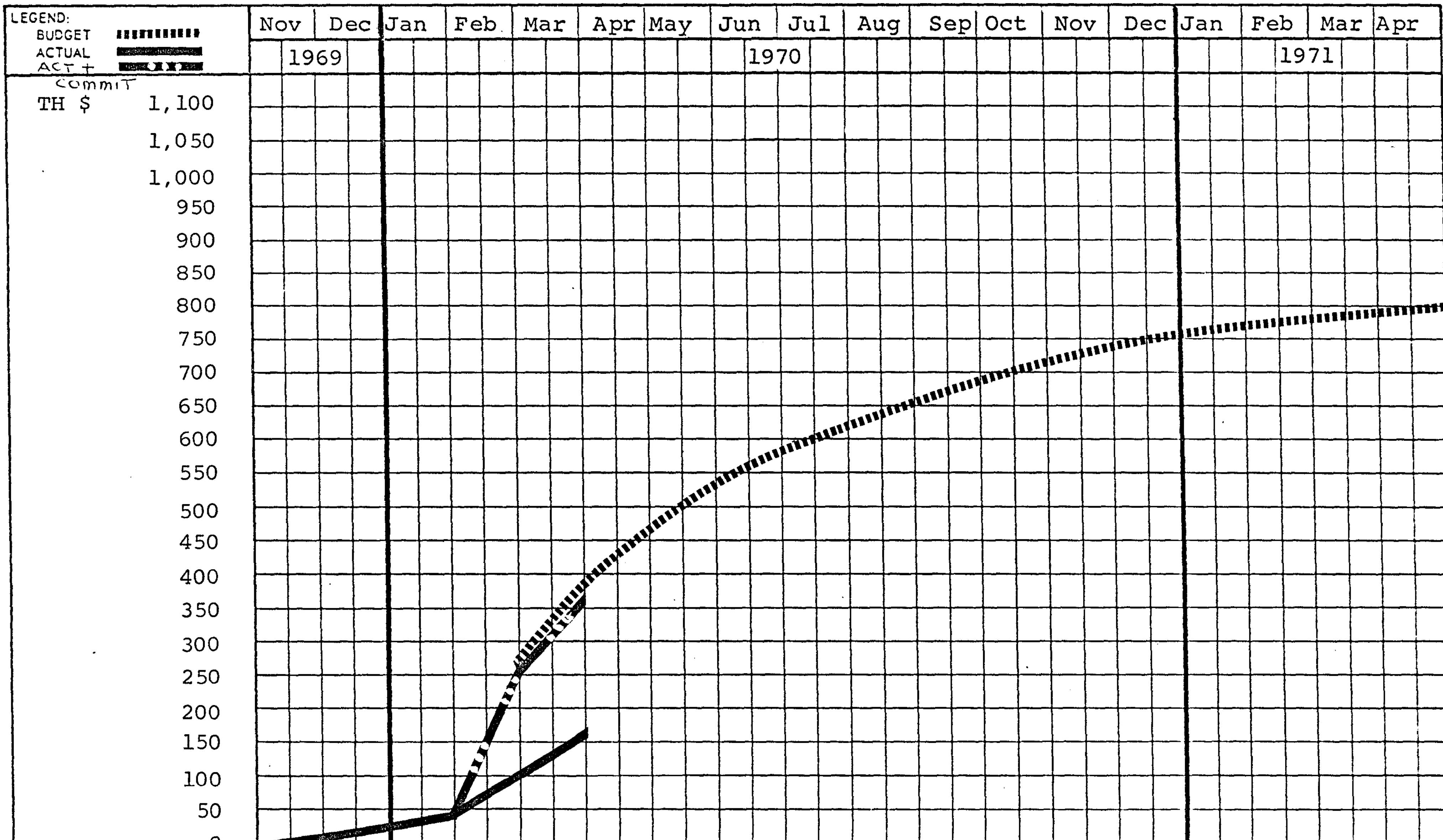
FIGURE 9-2

NASA Contract NAS 9-10410

PROGRAM UTD Mass Spectrometer

TOTAL PROGRAM COST

STATUS AS OF ____________



	Nov 1969	Dec 1969	Jan 1970	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 1971	Feb	Mar	Apr
CUM BUDGET TH $			38.7	109.6	162.9	346.8	492.9	580.6			698.4			762.2			788.0	
CUM ACTUAL TH $	6.9	21.6	38.7	109.6	162.9													
MONTHLY BUDGET TH $			38.7	71.9	53.3	183.9	146.1	87.7										
MONTHLY ACTUAL TH $	6.9	14.7	17.1	71.9	53.3													

FIGURE 9-3

PROGRAM COST

FIGURE 9-4 (Sheet 1)

DEPARTMENT OF DEFENSE

CONTRACT PRICING PROPOSAL

(RESEARCH AND DEVELOPMENT)

Form Approved Budget Bureau No. 22-R100

This form is for use when *(i)* submission of cost or pricing data *(see NASA PR 3.807-3)* is required and *(ii)* substitution for the DD Form 633 is authorized by the contracting officer.

PAGE NO. | NO. OF PAGES

NAME OF OFFEROR: The University of Texas at Dallas

HOME OFFICE ADDRESS (Include ZIP Code): The University of Texas at Dallas, P. O. Box 30365, Dallas, Texas 75230

SUPPLIES AND/OR SERVICES TO BE FURNISHED: Mass Spectrometer - Gas Analyzer for the Lunar Atmosphere (GALA) for Apollo Lunar Surface Experiments Program

DIVISION(S) AND LOCATION(S) WHERE WORK IS TO BE PERFORMED: Division of Atmospheric and Space Sciences

TOTAL AMOUNT OF PROPOSAL: $1,527,000

GOVT SOLICITATION NO.:

DETAIL DESCRIPTION OF COST ELEMENTS

1. DIRECT MATERIAL *(Itemize on Exhibit A)*			EST COST ($)	TOTAL EST COST[1]	REFERENCE[2]
a. PURCHASED PARTS			206,000		
b. SUBCONTRACTED ITEMS			133,000		
c. OTHER - (1) RAW MATERIAL					
(2) YOUR STANDARD COMMERCIAL ITEMS					
(3) INTERDIVISIONAL TRANSFERS *(At other than cost)*					
TOTAL DIRECT MATERIAL				339,000	
2. MATERIAL OVERHEAD 3 *(Rate % X $ base =)*					
3. DIRECT LABOR *(Specify)*	ESTIMATED HOURS	RATE/HOUR	EST COST ($)		
Scientific (P/I)	15,200	7.75	117,800		
Engineering (EE & ME)	13,500	7.63	103,000		
Manufacturing/Fabrication	15,400	4.98	76,700		
Quality Assurance & Reliability	14,500	4.46	64,700		
Documentation/Drafting	8,000	5.75	46,000		
Program Management & Administration	11,000	8.27	91,000		
TOTAL DIRECT LABOR				499,000	
4. LABOR OVERHEAD *(Specify department or cost center)* 3	O.H. RATE	X BASE =	EST COST ($)		
70% of Direct Labor	70%	499,000	349,000		
TOTAL LABOR OVERHEAD				349,000	
5. SPECIAL TESTING *(Including field work at Government installations)*			EST COST ($)		
Test support program (1-1/2 years) to follow hardware construction program for 2 years					
TOTAL SPECIAL TESTING				79,000	
6. SPECIAL EQUIPMENT *(If direct charge) (Itemize on Exhibit A)*					
7. TRAVEL *(If direct charge) (Give details on attached Schedule)*			EST COST ($)		
a. TRANSPORTATION			35,000		
b. PER DIEM OR SUBSISTENCE			15,000		
TOTAL TRAVEL				50,000	
8. CONSULTANTS *(Identify - purpose - rate)*			EST COST ($)		
TOTAL CONSULTANTS					
9. OTHER DIRECT COSTS *(Itemize on Exhibit A)*				201,000	
10. *TOTAL DIRECT COST AND OVERHEAD*				1,527,000	
11. GENERAL AND ADMINISTRATIVE EXPENSE *(Rate % of cost element Nos.)* 3				.	
12. ROYALTIES 4					
13. *TOTAL ESTIMATED COST*				1,527,000	
14. FEE OR PROFIT					
15. *TOTAL ESTIMATED COST AND FEE OR PROFIT*				1,527,000	

This proposal is submitted for use in connection with and in response to *(Describe RFP, etc.)*

and reflects our best estimates as of this date, in accordance with the instructions to offerors and the footnotes which follow.

TYPED NAME AND TITLE: S. C. Fallis, Vice President for Business Affairs

SIGNATURE:

NAME OF FIRM: The University of Texas at Dallas

DATE OF SUBMISSION: 5/6/70

DD FORM APR 68 633-4 (NASA EDITION)

FIGURE 9-4 (Sheet 2)

EXHIBIT A - SUPPORTING SCHEDULE *(Specify. If more space is needed, use blank sheets)*

COST EL NO.	ITEM DESCRIPTION *(See footnote 5)*	EST COST *($)*
7	b. Reasonable actual subsistence costs incurred up to	
	$30 per day or $25 per diem, plus misc. travel expenses.	
	Theoretical Supporting Study	$ 42,000
	Computer 750 hours at $175/hr	132,000
	Reproduction/communication	15,000
	Operational support supplies	12,000
	TOTAL OTHER DIRECT COSTS	$201,000

I. HAVE THE DEPARTMENT OF DEFENSE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, OR THE ATOMIC ENERGY COMMISSION PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER GOVERNMENT PRIME CONTRACT OR SUBCONTRACT WITHIN THE PAST TWELVE MONTHS?

[X] YES [ ] NO *If yes, identify below.*

NAME AND ADDRESS OF REVIEWING OFFICE *(Include ZIP Code)*	TELEPHONE NUMBER/EXTENSION
Defense Contract Audit Agency, 500 S. Ervay, Dallas, Tx 75201	214-749-3425

II. WILL YOU REQUIRE THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS PROPOSED CONTRACT?

[ ] YES [X] NO *If yes, identify on a separate page.*

III. DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT?

[X] YES [ ] NO *If yes, identify:* [ ] ADVANCE PAYMENTS [X] PROGRESS PAYMENTS *OR* [ ] GUARANTEED LOANS

IV. DO YOU NOW HOLD ANY CONTRACT *(or, do you have any independently financed (IR & D) projects)* FOR THE SAME OR SIMILAR WORK CALLED FOR BY THIS PROPOSED CONTRACT?

[X] YES [ ] NO *If yes, identify* NASA Contract NAS9-7591

V. DOES THIS COST SUMMARY CONFORM WITH THE COST PRINCIPLES SET FORTH IN NASA PR, PART 15 *(see 3.807-2(c)(2))*?

[X] YES [ ] NO *If no, explain on a separate page.*

INSTRUCTIONS TO OFFERORS

1. The purpose of this form is to provide a standard format by which the offeror submits to the Government a summary of incurred and estimated cost *(and attached supporting information)* suitable for detailed review and analysis. Prior to the award of a contract resulting from this proposal the offeror shall, under the conditions stated in NASA PR 3.807-3, be required to submit a Certificate of Current Cost or Pricing Data (see NASA PR 3.807-3(e) and 3.807-4).

2. As part of the specific information required by this form, the offeror must submit with this form, and clearly identify as such, cost or pricing data (that is, data which is verifiable and factual and otherwise as defined in NASA PR 3.807-3(e)). In addition, he must submit with this form any information reasonably required to explain the offeror's estimating process, including:
   a. the judgmental factors applied and the mathematical or other methods used in the estimate including those used in projecting from known data, and
   b. the contingencies used by offeror in his proposed price.

3. When attachment of supporting cost or pricing data to this form is impracticable, the data will be specifically identified and described *(with schedules as appropriate)*, and made available to the contracting officer or his representative upon request.

4. The format for the "Cost Elements" is not intended as rigid requirements. These may be presented in different format with the prior approval of the contracting officer if required for more effective and efficient presentation. In all other respects this form will be completed and submitted without change.

5. By submission of this proposal, offeror, if selected for negotiation, grants to the contracting officer, or his authorized representative, the right to examine, for the purpose of verifying the cost or pricing data submitted, those books, records, documents and other supporting data which will permit adequate evaluation of such cost or pricing data, along with the computations and projections used therein. This right may be exercised in connection with any negotiations prior to contract award.

FOOTNOTES

1 Enter in this column those necessary and reasonable costs which in the judgment of the offeror will properly be incurred in the efficient performance of the contract. When any of the costs in this column have already been incurred (e.g., on a letter contract or change order), describe them on an attached supporting schedule. Identify all sales and transfers between your plants, divisions, or organizations under a common control, which are included at other than the lower of cost to the original transferor or current market price.

2 When space in addition to that available in Exhibit A is required, attach separate pages as necessary and identify in this "Reference" column the attachment in which information supporting the specific cost element may be found. No standard format is prescribed; however, the cost or pricing data must be accurate, complete and current, and the judgment factors used in projecting from the data to the estimates must be stated in sufficient detail to enable the contracting officer to evaluate the proposal. For example, provide the basis used for pricing materials such as by vendor quotations, shop estimates, or invoice prices; the reason for use of overhead rates which depart significantly from experienced rates (reduced volume, a planned major rearrangement, etc.); or justification for an increase in labor rates (anticipated wage and salary increases, etc.). Identify and explain any contingencies which are included in the proposed price, such as anticipated costs of rejects and defective work, or anticipated technical difficulties.

3 Indicate the rates used and provide an appropriate explanation. Where agreement has been reached with Government representatives on the use of forward pricing rates, describe the nature of the agreement. Provide the method of computation and application of your overhead expense, including cost breakdown and showing trends and budgetary data as necessary to provide a basis for evaluation of the reasonableness of proposed rates

4 If the total royalty cost entered here is in excess of $250 provide on a separate page (or on DD Form 783, Royalty Report) the following information on each separate item of royalty or license fee: name and address of licensor; date of license agreement; patent numbers, patent application serial numbers, or other basis on which the royalty is payable; brief description, including any part or model numbers of each contract item or component on which the royalty is payable; percentage or dollar rate of royalty per unit; unit price of contract item; number of units; and total dollar amount of royalties. In addition, if specifically requested by the contracting officer, a copy of the current license agreement and identification of applicable claims of specific patents shall be provided.

5 Provide a list of principal items within each category indicating known or anticipated source, quantity, unit price, competition obtained, and basis of establishing source and reasonableness of cost.

GPO 864-074

FIGURE 9-4 (Sheet 3)