Bendix

Aerospace Systems Division

LMS Reliability
FMECA and SPFS
Contract No. NAS 9-5829

NO.	REV. NO.
ATM 970	B

PAGE 1 OF 183

DATE 21 March 1972

Presented herein are the Failure Mode Effects and Criticality Analysis and the Single Point Failure Summary for the Lunar Mass Spectrometer.

The "A" Revision was required to include the Lock Out Switching Circuit (see page 174 for description).

The "B" Revision is required due to the design change on the Emission Control from a fixed mode ionization voltage (Assy. #151-700) to a multi-mode ionization voltage (Assy. #151-550). The multi-mode E.C. assembly will be used in the flight model only. The Qual model will use the fixed mode ionization voltage.

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TABLE OF CONTENTS

DISCUSSION

PARA NO.	DESCRIPTION	PAGE NO.
1.0	INTRODUCTION	7
2.0	APPLICABLE DOCUMENTS	7
3.0	OBJECTIVES	7
4.0	FMECA METHODOLOGY	7
5.0	CONCLUSIONS	19
6.0	REVISIONS	20

TABLES

NO.	DESCRIPTION	PAGE NO.
I	SUMMARY OF SINGLE POINT FAILURES FOR BxA CIRCUITS	21
II	SINGLE POINT FAILURE SUMMARY FOR COUNTING AND DATA COMPRESSION	22
III	SINGLE POINT FAILURE SUMMARY FOR SIGNAL CONDITIONER AND COMMAND DECODER	24
IV	SINGLE POINT FAILURE SUMMARY FOR HOUSE-KEEPING MULTIPLEXER	28
V	LOW VOLTAGE POWER SUPPLY	33
VI	ION PUMP HIGH VOLTAGE POWER SUPPLY	37

TABLES (CONT)

NO.	DESCRIPTION	PAGE NO.
VII	MULTIPLIER HIGH VOLTAGE SUPPLY	40
VIII	CONTROL AND MONITOR	42
IX	SUMMARY OF SINGLE POINT FAILURES FOR UTD CIRCUITS	44
X	SINGLE POINT FAILURE SUMMARY FOR ANALYZER	45
XI	SINGLE POINT FAILURE SUMMARY FOR EMISSION CONTROL (MOTHER BOARD)	46
XII	SINGLE POINT FAILURE SUMMARY FOR EMISSION CONTROL (EC-1)	49
XIII	SINGLE POINT FAILURE SUMMARY FOR EMISSION CONTROL (EC-2)	50
XIV	SINGLE POINT FAILURE SUMMARY FOR EMISSION CONTROL (EC-3)	51
XV	SINGLE POINT FAILURE SUMMARY FOR CALIBRATION OSCILLATOR	52
XVI	SINGLE POINT FAILURE SUMMARY FOR PRE-AMP/DISCRIMINATOR	53
XVII	SINGLE POINT FAILURE SUMMARY FOR SWEEP HIGH VOLTAGE POWER SUPPLY (MOTHER BOARD)	55
XVIII	SINGLE POINT FAILURE SUMMARY FOR SWEEP HIGH VOLTAGE POWER SUPPLY (MODULE 1)	57

TABLE (CONT)

NO.	DESCRIPTION	PAGE NO.
XIX	SINGLE POINT FAILURE SUMMARY FOR SWEEP HIGH VOLTAGE POWER SUPPLY (MODULE 2)	58
XX	SINGLE POINT FAILURE SUMMARY FOR SWEEP HIGH VOLTAGE POWER SUPPLY (MODULE 3)	59
XXI	SINGLE POINT FAILURE SUMMARY FOR SWEEP HIGH VOLTAGE POWER SUPPLY (MODULE 4)	60
XXII	SINGLE POINT FAILURE SUMMARY FOR SWEEP HIGH VOLTAGE POWER SUPPLY (MODULE 5)	61
XXIII	COMMAND FUNCTION CRITICALITY	62
XXIV	SPF CRITICALITY COMBINATIONS FOR SIGNAL CONDITIONER	63

APPENDICES

PARA. NO.	TITLE	PAGE NO.
1.0	APPENDIX A - BxA FMECA WORKSHEETS	64
1.1	COUNTING AND DATA COMPRESSION	65
1.2	COMMAND DECODER AND SIGNAL CONDITIONER	71
1.3	HOUSEKEEPING MULTIPLEXER	78
1.4	LOW VOLTAGE POWER SUPPLY	83
1.5	ELECTRON MULTIPLIER HIGH VOLTAGE POWER SUPPLY	88

TABLE (CONT)

PARA. NO.	TITLE	PAGE NO.
1.6	ION PUMP HIGH VOLTAGE POWER SUPPLY	90
1.7	CONTROL AND MONITOR	93
2.0	APPENDIX B - UTD FMECA WORKSHEETS	96
2.1	ANALYZER	97
2.2	EMISSION CONTROL	99
2.2.1	MOTHER BOARD	99
2.2.2	EC-1	111
2.2.3	EC-2	114
2.2.4	EC-3	118
2.3	PRE-AMP/DISCRIMINATOR	120
2.3.1	CALIBRATION OSCILLATOR	120
2.3.2	PRE-AMP/DISC #1	122
2.3.3	PRE-AMP/DISC #2	128
2.3.4	PRE-AMP/DISC #3	135
2.4	SWEEP HIGH VOLTAGE POWER SUPPLY (S.H.V.P.S.)	142
2.4.1	MOTHER BOARD	142
2.4.2	MOD 1	151

TABLE (CONT)

PARA. NO.	TITLE	PAGE NO.
2.4.3	MOD 2	153
2.4.4	MOD 3	156
2.4.5	MOD 4	159
2.4.6	MOD 5	161

DIAGRAMS

FIGURE	TITLE	PAGE NO.
1	LMS ELECTRONICS	162
2	POWER SUPPLY MODULE	163
3	EMISSION CONTROL	164
4	PROGRAM SWEEP HI VOLTAGE P/S	165
5	ANALYZER	166

PHOTOGRAPHS

6	PRE-AMP/DISCRIMINATOR SUBASSEMBLY	167
7	PRE-AMP/DISCRIMINATOR ASSEMBLY	168
8	EMISSION CONTROL	169
9	SWEEP HI VOLTAGE POWER SUPPLY BOTTOM VIEW	170
10	SWEEP HI VOLTAGE POWER SUPPLY TOP VIEW	171
11	EMISSION CONTROL AND SWEEP HV/PS ASSEMBLY TOP VIEW	172
12	EMISSION CONTROL AND SWEEP HV/PS ASSEMBLY BOTTOM VIEW	173

REVISIONS

6.1	LOCK OUT SWITCH	174

1.0 Introduction

Presented herein are the Failure Mode, Effects and Criticality Analyses as performed on the Bendix supplied assemblies and components of the Lunar Mass Spectrometer Experiment. Work Sheets in Appendix A are for BxA and work sheets in Appendix B are for UTD.

2.0 Applicable Documents

2.1 ATM 966, PARTS APPLICATION ANALYSIS, dated: 5/15/71

2.2 ATM 605A, FAILURE RATE DATA FOR ALSEP, dated 10/26/70.

3.0 Objectives

3.1 Establish the effects of the individual part failure modes on the operation of the Mass Spectrometer.

3.2 Establish the probability of occurrence of each recorded part failure mode for the mission duration of two years.

3.3 Establish the most predominat part failure modes in terms of probability of occurrence.

3.4 Establish the Mass Spectrometer reliability from the point of view of Failure Mode, Effects and Criticality Analysis.

4.0 FMECA Methodology

The FMECA was made by starting at the system level and expanding downward to the component level. The FMECA has been performed in the manner shown in the attached worksheets. This effort follows the steps described below:

1. Identify: Name of System, end-item and subassembly; also identify subassembly drawing number and operating time of subassembly for the duration of the ALSEP mission.

2. Enter in Column 1 the reference designator of the part whose failure modes and effects are considered.

3. Enter in Column 2 the part failure mode considered, and its incidence ratio "(α)" in relation to all of the part's failure modes. This ratio is obtained from ATM 605A.

4. Enter in Column 3 the effects of the failure mode on the subassembly. This "effect" is described concisely in a most descriptive and most recognizable statement. Ordinarily, it is best to enter here the "subassembly" failure mode; at times though, it is clearer to indicate what happens to a certain stage (i.e., Q1 cut off or saturated, whereupon the output signal could be zero).

5. Enter in Column 4 the effects of the subject failure mode on the end-item output functions. Wherever possible, quantitative data is entered here; where quantitative data is extremely difficult to arrive at, a concise qualitative statement is entered instead.

6. Enter in Column 5 the failure mode probability of occurrence. This figure ($\alpha Q = \alpha \lambda t$) is the product of the subassembly operating time throughout the mission, the part generic failure rate obtained from the Parts Application Analysis (PAA) worksheets given in ATM 966, and the failure mode incidence ratio obtained from ATM 605 in Column 2. The part failure rate obtained from the PAA worksheets already reflects the part's duty cycle.

7. Enter the criticality ranking in Column 6. (See Paragraph 4.2)

4.1 Assumption

The failure rates are taken from ATM 966 as stated in item 6 above with the exception of operations for relays and dust cover control circuits.

4.1.1 Relay "Q"

The value of relay failure probability is based on the number of expected operations during the two year period. The number of

operations is 30 for all but the dust cover release relay which is 50. The value of Q is given by:

$$Q = \frac{.01 \times \text{No. of Operations}}{10^4 \text{ Operations}}$$

4.1.2 Dust Cover Release Circuits

The time "t" for calculating the failure probability for all components in the dust cover release circuits except the relays is given as 5 hours since this circuit will not be used after the dust cover is released.

4.2 Criticality Rankings

The guide for the criticality rankings is given below:

CR1 - End-Item failure modes that totally disable the Mass Spectrometer.

CR2 - End-Item failure modes that partially disable the Mass Spectrometer such as loss of some, but not all, data.

CR3 - End-Item failure modes that have no adverse effect on the Mass Spectrometer but made data analysis difficult.

CR4 - End-Item failure modes that have no effect on the Mass Spectrometer. These failures are all of the monitor type such as various currents and temperatures as well as some heaters.

In addition, there are some failures which if they occurred would be difficult, if not impossible to determine. There would be no loss of data or functions. These failures are noted as "0".

4.3 Single Point Failure Summary

Presented herein is the Single Point Failure Analysis Summary as performed in the Lunar Mass Spectrometer. A summary sheet

summarizes the total criticality for each assembly at each criticality level: criticality level 1 (CR1), criticality level 2 (CR2), criticality level 3 (CR3), and criticality level 4 (CR4). Component parts for each assembly have also been criticality ranked. Criticality levels are further distinguished at high or low logic output levels. For each circuit the reliability for CR1 is"

$$R_{CR1} = e^{-\lambda_1 t}$$

where $\lambda_1 t$ is equal to the sum of the "λt" in the criticality CR1. This is the highest reliability value and is the reliability for the single point failures. Likewise the reliability number for CR2 is the sum of the "λt" for CR1 and CR2; the reliability for CR3 is the sum of the "λt" for CR1, CR2, and CR3 and for CR4 is the sum of the "λt" for CR1 through CR4. Criticality 4 is the lower reliability since the total circuit must operate. The value of the reliability is given for each criticality and each circuit for both BxA and UTD built circuits as detailed below:

TABLE I is the single point failure summary for BxA circuits.

TABLE IX is the single point failure summary for UTD circuits and the total for the experiment.

TABLES II through VIII are the Single Point Failure Summary for each of BxA built circuits. TABLES X through XXII are UTD's SPFS.

TABLE XIII is the criticality summary for the command functions.

4.4 Circuit Operation

4.4.1 The LMS consists of a three channel mass count, each of the three channels covering a different mass range. While meaningful data may be obtained from any one channel, the channels are not redundant except for a small overlap between each adjacent channel. In addition housekeeping data such as instrument temperatures may be obtained. Unit failures are defined at outputs, not inputs.

Only single failures are discussed. Multiple failures necessary to cause a failure are a low probability.

The values of "Q" discussed in the summary are based on the FMECA for UTD and BxA. These values may not agree with the information given in ATM-965 and ATM-966 since those Q values were based on a parts count only and do not include the effect of α. Each circuit is discussed below.

4.4.2 Counting and Data Compression (FIGURE 1)

There are three separate channels. Failure of any one channel will not cause failure of either remaining channel. There is no redundancy within a given channel; therefore, each component will have a failure mode which will cause a loss of the total channel as reflected in the FMECA. The value of "Q" x 10^{-5} is given in the summary. Each channel is rated as criticality two. There are 5 single point failures.

4.4.3 Command Decoder and Signal Conditioner (FIGURE 1)

This circuit contains two functions, one is the command decoder. This circuit combines the "6" command signals, in groups of two, to form the 15 function commands. Command "7" is an execute command for each of the 15 commands. Any unit in the command "7" circuit has a criticality of "1". Loss of this command will inhibit clearing the command register and executing the commands. Likewise, any element in the command register circuits, is given a criticality of "1" since each command signal is used at least once in a critical function.

There is one capacitor on each board which is critical to all circuits. On the Command Decode and Signal Conditioner the reference designator is "C_1". This capacitor is across the +5 volt of D.C. line and is a decoupling capacitor. An open circuit may cause oscillation of the digital circuit and a short circuit will cause a loss of the low voltage power supply output until the short is removed. Change in capacitance value (± 25%) will not cause any degradation. The fifteen command functions are listed in Table IV. This table indicates the criticality of each command in the "on" and "off" condition.

The Signal Conditioner is a serializer for the three input channels as well as for the housekeeping data. In these circuits, as in other circuits, an output of a unit may have one criticality in the one, "1", state and another criticality in the "0" state. As an example, the housekeeping output if locked in a "1" will cause the loss of all housekeeping data, a criticality of 4; if locked in a "0" it will inhibit data from all three channels and is a criticality of 1. To determine the effect of each output on the eight possible failure modes, a table was made up listing the outputs (down) and the failure modes (across). For each output the "1" state and "0" state was noted under the appropriate failure mode. These modes are given below with their criticality rating.

Number	Mode	Logic	Criticality
1	Loss of all Channels	A'B'C'	I
2	Loss of two Channels	A'B'C	II
3	Loss of two Channels	A'B C	II
4	Loss of two Channels	A B'C'	II
5	Loss of one Channel	A'B C	II
6	Loss of one Channel	A B'C	II
7	Loss of one Channel	A B C'	II
8	Loss of Housekeeping	(HK)'	IV

A table describing each output by reference designator is given in Table XXIV. There is no redundancy in this circuit since the failure probability is low and would not be improved by redundancy due to the added circuits. The effect of each component is reflected in the FMECA and the value of $Q \times 10^{-5}$ is given in the single point failure summary.

4.4.4 Low Voltage Power Supply (FIGURE 2)

This circuit consists of a multivibrator controlled inverter, rectifier and filter outputs of -20, ±15, +13, and +5 volt D. C., and three regulators with outputs of +12, -12, and -15 volts. Loss of any of these outputs will cause a loss of the total experiment.

There is a short circuit protection circuit which consists of a one-shot. Excessive current in the primary circuit will cause this one

shot to trigger which in turn will remove the power from the multivibrator for about one second period. The short circuit protection has a criticality of 1 for a failure that removes power from the oscillator and 4 for failure to remove power in an overload condition. None of the circuitry is redundant. Failure of any component as indicated in the FMECA will cause total loss of the experiment. The value of $Q \times 10^{-5}$ is summarized in the single point failure summary. There is a time delay turn on for the L. V. P. S. This circuit eliminates a current spike when the power is initially applied to the L. V. P. S. The transformer in the power supply has a 2. 5 volt winding which, when power has reached a steady state condition, will saturate the turn on transistor.

The solid state circuitry used to latch the relays for turn on and turn off of the H. V. P. S. s is located on this circuit.

4.4.5 Electron Multiplier High Voltage Power Supply (FIGURE 2)

This circuit consists of:

1. An on/off D. P. D. T latching relay
2. A voltage feedback for regulating the output voltage
3. A redundant tuned circuit oscillator inverter
4. A voltage multiplier filter
5. A circuit to control the multiplier H. V. for high and low gain setting
6. A short circuit protection
7. An output amplifier to housekeeping for voltage out monitor.

If the elements in question fail such as to inhibit the inverter, the failure mode is a criticality of "1". If the failure mode causes a loss of regulation, the mode is assigned a criticality of "2". Failures which cause the loss of housekeeping data are given a criticality of "4". The rectifiers in the voltage multiplier are redundant to short circuits since each rectifier is capable of withstanding 1 KV-PIV. Of course, and open in one of these diodes causes a total failure of the high voltage and loss of experiment.

4.4.6 Ion pump Hi-Voltage Power Supply (FIGURE 2)

This circuit consists of:

1. An on/off D. P. D. T. latching relay
2. A short circuit protection circuit
3. A voltage regulator input
4. A non-redundant oscillator/invertor
5. A high voltage oscillator
6. A log amp for monitor of the ion pump current (and pressure)
7. A voltage monitor circuit.

4.4.7 Control and Monitor (Figure 1)

This circuit consists of three controls:

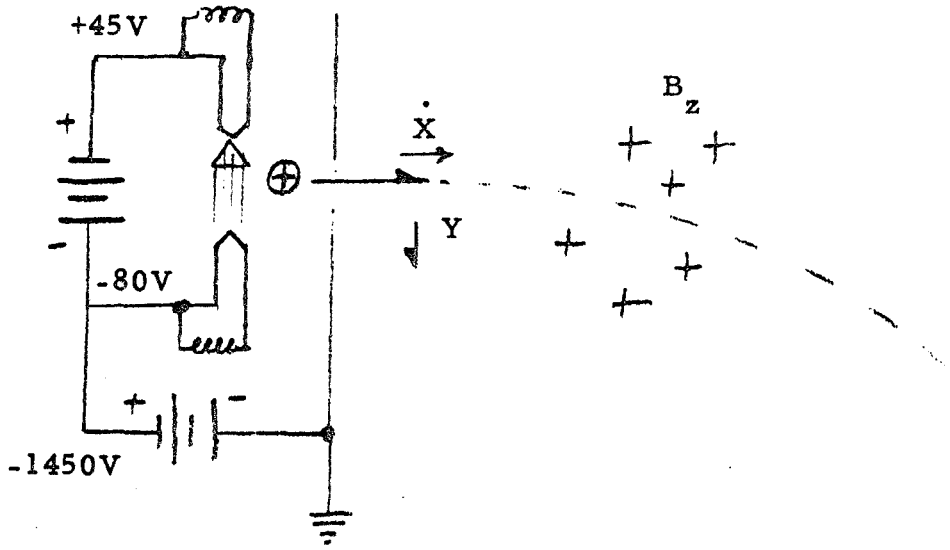
1. Control of the bake out/survival heaters: this circuit operates in the stand-by mode only and either bake out or the survival heaters will be on in stand-by. The criticality of this circuit is 4.

2. Dust cover release control: this circuit consists of a one shot pulse generator which applies power to a heater. This circuit will be used once after deployment within 28 hours after turn on. The circuit has a criticality of 3 since failure of the circuit will cause data failure during lunar day.

3. Backup Heater Control: this circuit is used to turn on a heater during lunar night operation should added power be needed. The criticality of this circuit is 4.

4.4.8 Analyzer Assembly (Figure 5)

The Analyzer Assembly consists of an Ion Source, and Ion Pump, a Getter, a Magnet, three multiplier tubes, and a chamber assembly. The rare gas enters the Ion Source and is ionized by a cross-stream bombardment of electrons. These ions are accelerated by an electric field created by the sweep hi-voltage. For any given point in the time-sweep curve, the energy of the ion is a constant for a single ionized atom irregardless of the mass. Assume an ion of mass "m" has a charge "Q" is accelerated through a voltage "V" in the "X" direction. A magnetic field "B_z" is applied perpendicular to the plane of motion (xy). This field is represented by "+" symbols.



The particles will leave the slit in the Ion Source and enter the chamber with an energy "E" which is:

$$E = VQ$$

but the energy is also given by:

$$E = \frac{m\dot{X}^2}{2}$$

where $\dot{X}$ is the velocity of the particle. Since the energy is constant, one can say:

$$\dot{X}^2 \propto 1/m \text{ or } \dot{X} \propto 1/\sqrt{m}$$

The magnetic force due to a moving charge in a magnetic field acts on the ion at a right angle to its linear velocity causing the ion to move in a circular motion of radius "R". The radius is defined when the centrifugal force of the particle equals the magnetic force, or:

$$m\dot{X}^2/R = K, \dot{X}QB_z$$

Using the fact that the velocity is proportional to the square root of the mass of the ion, one can derive the radius "R" as being proportional to the square root of the mass or:

$$R \propto \sqrt{m}$$

Therefore, one can conclude that the radius is a function of the voltage and mass.

4.4.8.1 Ion Source

The Ion Source consists of two filaments, one of which acts as an anode and the other (heated) acts as the cathode for the electron bombardment. The energy and number of these electrons are controlled by the emission control circuits. This total circuit acts as a positive pole for the ion accelerator. The Ions are accelerated to the slit in the chamber opening. Two plates, called "J" plates, are used to focus this beam on the slit. In the event that one filament should burn out, the other filament can be activated, by remote command, as the cathode and the burned out filament used as the anode.

4.4.8.2 Analyzer Chamber (Figure 5)

The Chamber consists of the main chamber area which has permanent magnet mounted such that the magnetic field is perpendicular to the plane of motion for the ions. There are three slits, in back of which the multiplier tubes are mounted, which must be aligned accurately in order to have the correct data output.

4.4.8.3 Ion Pump

This device is a cold cathode type of ionizing pump in which the gas atoms are ionized and trapped in an area of high magnetic field. The current generated by the ion flow in the pump will serve as a vacuum measurement; one of the most important functions of this device.

4.4.8.4 Getter

This device is used to absorb gas atoms and thereby serves as a second unpowered vacuum pump.

4.4.8.5 Multiplier Tubes

This device consists of a tube with a number of grid elements mounted and evenly spaced along the tube. These elements, when machanically shocked, will emit electrons. Equal value resistors interconnect each element making an equal-potential distribution along the tube for acceleration purposes. The positive potential is applied to the anode, last grid, and the negative ground is connected to the first grid. When the ion impinges on the first element of these tubes, a small number of electrons are emitted from this element. These electrons are accelerated by a divided potential between the first and second element of the tube. Upon impinging with the second element, a secondary emission of electrons is given off which, in number, is greater than the first quantum of electrons. This process is repeated through repeated elements until the electrons are collected on the anode of the tube, hence the name "Electron Multiplier". This process allows a single charged ion to be multiplied, charge wise, to a measurable pulse. The number of electrons collected on the anode, and the size of the pulse, is proportional to the energy of the ions; therefore, an ion accelerated by the low voltage end of the sweep will have lower output pulse amplitude and higher signal to noise ratios.

4.4.9 Emission Control (Figure 8)

The emission control circuits control the number of bombardment electrons used to single ionize the gas atom to be analysed. This is done by circuits which will:

1. Supply a variable A.C. voltage for exciting the filament which is used as the cathode.

2. Supply a fixed - 80 D.C. voltage to the cathode (heated filament) and a fixed +45 D.C. voltage to the anode (unheated filament).

3. Operate a variable D.C. ladder network to supply four different J-plate voltage ratios which when set, will be a fixed percentage of the sweep high voltage output.

The variable A.C. voltage is controled by a fixed A.C. voltage in series with a variable inductance (magnetic amplifier) which in turn is controlled by a emission current sensing amplifier. There is also an op-amp output for Housekeeping monitoring of the emission current. It should be noted that this circuitry as well as the filaments are floating at the high negative sweep voltage potential.

There are three modules and a motherboard which physically make up the emission control board. (See figure 3.)

4.4.10 Program Sweep Hi-Voltage Power Supply (Figure 10)

This circuit produces the sweep high voltage which is used to accelerate the ions. The circuit physically consists of a motherboard and five modules. The motherboard interconnects the circuits for the five modules and has the circuitry for the digital to analog programmed sweep. The digital circuitry is such that the output will sweep out a voltage which is exponetial with respect to time automatically, or can the manually stepped (exponetial) or can be locked at a given voltage. The exponetial voltage waveform in accomplished by counting first every fourth frame count, then every other count, and finally every count. This digital count is fed into a D/A converter, the output of which will have an approximate exponetial waveform. This output is fed to the comparator in module 2. Module #3 receives a fraction of the high voltage out and conditions it for the housekeeping monitor and for the comparator in Module #2. When the sampled negative hi-voltage exceeds the D/A output, the switch in Module #5 will turn off the inverter oscillator in Module #1. When the oscillator is turned off the hi-voltage will drift down slowly (due to leakage) until the D/A output exceeds the hi-voltage sample from Module #3. At this point the switch in Module #5 will turn on the oscillator. In this way the hi-voltage will track the D/A output function-wise.

Module #4 contains the multiplier and filter for the 1450 volt output.

4.4.11 Pre-Amp/Discrimator (Figure 6)

This circuit consists of three separate amplification circuits, one for each channel of Data. Also included is a calibration oscillator and pulse shaper. The oscillator is used once during each cycle to produce a known count in the counter. This count can be used to check the operation of the counting and data compression. A switching circuit is used to set the discriminator level high or low. This level determines the height of the pulse necessary to pass the discriminator and allows the counts to go through but inhibits the noise level.

The preamp has a high impedance FET input stage. The circuit has about 40 db of gain and has a pulse pair resolution of 500 nsec. The discriminator has two levels of discrimination each 6 db apart. The output of the discriminator is fed into a one shot pulse shaper with an output of 150 ns and a 2.5 volt minimum pulse height.

5.0 Conclusion

As a result of the FMECA work sheet analysis and the SPFS, the following statements can be made:

5.1 The probability of the LMS working for 2 years with at least one channel of mass count data as minimum is .978. (CR1)

5.2 The probability of the LMS working for 2 years with at least all three channels of mass count data as a minimum is .938. (CR2)

5.3 The probability of the LMS working for 2 years with at least all three channels of mass count and all functional variation of accumulating this count during both lunar day and lunar night is .915. (CR3)

5.4 The probability of the LMS working for 2 years without a single noticeable failure both in lunar day and lunar night is .876. (This includes all housekeeping monitors and environmental controls.) (CR4)

5.5 In the addition of the multimode emission control circuitry (per Revision "B" of this document), the increase in parts have affected the Reliability by less than 0.01%.

The probability of success goal for the LMS for 2 years (.90) has been met for CR 3 and is 96% of the goal for (CR4).

6.0 Revisions

6.1 See page 174 for revision "A" change description.

6.2 The "B" revision includes the design change by UTD to include the multimode emission control circuit. This change effects the Emission Control assembly only and both circuits are electrically interchangeable. The change involves a redesign of the "J" Plate voltage control circuitry; the addition of a Quad mode ion source ionization voltage; and a new power transformer with different output voltage levels. The multimode assembly (151-550) has one additional cordwood module.

To update ATM-970A to the "B" Revision, pages 44 and 46 through 51 have been revised to reflect the new SPFS. Pages 99 through 119 (work sheets) have been replaced with pages 99 through 108. Pages 109 through 119 are now deleted.

TABLE I

SUMMARY OF SINGLE POINT FAILURES FOR BXA CIRCUITS

CIRCUIT	PROBALITITY OF SUCCESS FOR: CRI	CRII	CRIII	CRIV	TABLE NO.
Counting and Data Compression (A, B, and C)	.9999467	.9745231	.9742673	.9742673	II
Signal Condition and Command Decoder	.9958849	.9947557	.9917915	.9897481	III
Housekeeping Multiplexer	.9995367	.9995367	.9919044	.9814738	IV
Low Voltage Power Supply	.9942753	.9942753	.9939349	.9923856	V
Multiplier H.V. P.S.	.9974734	.9965394	.9965394	.9961556	VI
ION Pump HVPS	.9999946	.9999946	.9999946	.9968490	VII
Monitor & Control	.9999697	.9998798	.9998798	.9984371	VIII
TOTAL	.987137	.959962	.949219	.931192	

TABLE II
SINGLE POINT FAILURE SUMMARY
COUNTING AND DATA COMPRESSION

Ref. Designator A	B	C	$CRx10^{-5}$	$CR2x10^{-5}$	$CR3x10^{-5}$	$CR4x10^{-5}$
U1-2	U5	U9		5.84		
U1-6	U5	U9		5.84		
U1-8	U5	U9		5.84		
U1-10	U5	U9		5.84		
U1-12	U5	U9		5.84		
U1-14	U5	U9		5.84		
U2	U6	U10		36.75		
U3	U7	U11		36.75		
U4	U8	U12		36.75		
U14-8	U15	U16		17.50		
U14-13	U15	U16		8.75	8.75	
U17-2	U21	U25		17.05		
U17-10	U21	U25		17.05		
U18-9	U22	U26		36.75		
U19-9	U23	U27		36.75		
U20-13	U24	U28		36.75		
U29-10	U30	U31		35.00		
U33-13	U37	U41		36.75		
U34-9	U38	U42		36.75		
U35-9	U39	U43		36.75		
U36-13	U40	U44		36.75		
U45-2	U46	U47		17.05		
U45-10	U46	U47		17.05		
U48-2	U52	U56		5.84		
U48-6				5.84		
U48-8				5.84		
U48-10			NOT	USED		
U48-12				5.84		
U48-14	U52	U56		5.84		
U49-9	U53	U57		17.50		
U49-12	U53	U57		17.50		
U50-9	U54	U58		36.75		
U51-13	U55	U59		36.75		
U60-3	U32	U13		8.74		

TABLE II (CONT.)
SINGLE POINT FAILURE SUMMARY
COUNTING AND DATA COMPRESSION

Ref. Designator A	B	C	CRx10^{-5}	CR2x10^{-5}	CR3x10^{-5}	CR4x10^{-5}
U60-5	U32	U13		8.74		
U60-8				8.74		
U60-14	U32	U13		8.74		
U61-3	U62	U63	NOT	USED		
U61-5				8.74		
U61-8				8.74		
U61-14	U62	U63	NOT	USED		
U64-3	U68	U72		8.74		
U64-5			NOT	USED		
U64-8			NOT	USED		
U64-14	U68	U72		8.74		
U65-3	U69	U73		17.05		
U65-6	U69	U73		17.05		
U65-13	U69	U73		17.05		
U66-9	U70	U74		36.75		
U67-13	U71	U75		36.75		
C1	C3	C5		.08		
C2	C4	C6		.08		
J1-2	J1-9	J1-11		1.75		
J1-27	J1-26	J1-25		1.75		
J1-30	J1-29	J1-28		1.75		
TOTAL PER CHANNEL				869.67	8.75	
SUBTOTAL ALL CHANNEL				2,609.01	26.25	
C7			.08			
J1-1&31; 10&40; 24; 22			5.25			
TOTAL ALL CHANNELS			5.33	2,609.01	26.25	

TABLE III

SINGLE POINT FAILURE SUMMARY
SIGNAL CONDITIONER & COMMAND DECODER

Ref. Designator	CR1 Q x 10^{-5}	CR2 Q x 10^{-5}	CR3 Q x 10^{-5}	CR4 Q x 10^{-5}
U1-2	4.69			
U1-6	4.69			
U1-8	4.69			
U1-10	4.69			
U1-12	4.69			
U1-14	4.69			
U2-2	4.69			
U2-6	4.69			
U2-8	4.69			
U2-10	4.69			
U2-12	4.69			
U2-14	4.69			
U3-9/8	13.85			
U3-12/13	13.85			
U4-9/8	13.85			
U4-12/13	13.85			
U5-9/8	13.85			
U5-12/13	13.85			
U6-2	9.70		4.15	
U6-10			9.70	4.15
U7-12			27.90	
U8-12			27.90	
U9-2			13.85	
U9-10	4.15		9.70	
U10-2	9.70		4.15	
U10-10			13.85	
U11-2			13.85	
U11-10			13.85	
U12-2			4.15	9.70
U12-10			4.15	0
U13-2		13.85		
U13-10		13.85		
U14-12			27.90	

TABLE III (CONT.)

SINGLE POINT FAILURE SUMMARY
SIGNAL CONDITIONER & COMMAND DECODER

Ref. Designator	CR1 Q x 10^{-5}	CR2 Q x 10^{-5}	CR3 Q x 10^{-5}	CR4 Q x 10^{-5}
U15-9/8	6.93		6.93	
U15-12/13				13.85
U16-9/8			13.85	
U16-12/13	NOT USED			
U17-2	4.69			
U17-6			4.69	
U17-8			4.69	
U17-10			4.69	
U17-12	3.28		1.41	
U17-14	4.69			
U18-8/9				13.85
U18-12/13	NOT USED			
U19-8/9			6.93	6.93
U19-12/13	NOT USED			
U20-8/9		13.85		
U20-12/13	NOT USED			
U21-8/9			13.85	
U21-12/13	6.98		6.93	
U22-8/9			6.93	0
U22-12/13	NOT USED			
U23-2	3.28		1.41	
U23-6	1.41		3.28	
U23-8		3.28	1.41	
U23-10			4.69	
U23-12	3.28		1.41	
U23-14			4.69	
U24-2	13.85			
U24-10	4.15		9.70	
U25-2	3.80			
U25-6	3.80			0
U25-8	5.44			
U25-10	1.64			3.80
U25-12			5.44	

TABLE III (CONT.)

SINGLE POINT FAILURE SUMMARY
SIGNAL CONDITIONER & COMMAND DECODER

Ref. Designator	CR1 Q x 10^{-5}	CR2 Q x 10^{-5}	CR3 Q x 10^{-5}	CR4 Q x 10^{-5}
U25-14	5.60			
U26-3			6.86	
U26-5			6.86	
U26-8	2.06		4.80	
U26-14			6.86	
U27-8/9			6.86	
U27-12/13	NOT USED			
U28-2			3.80	0
U28-6			1.64	3.80
U28-8			3.80	0
U28-10			3.80	1.64
U28-12	5.44			
U28-14			5.44	
U29-3			7.70	
U29-5			7.70	
U29-8			2.31	5.39
U29-14			5.39	2.31
U30-3	6.86			
U30-5	4.80			0
U30-8	6.86			
U30-14	6.86			
U31-3	4.80	2.06		
U31-5	4.80	2.06		
U31-8	4.80	2.06		
U31-14	4.80			2.06
U32-2	1.64	3.80		
U32-6	1.64	3.80		
U32-8	5.44			
U32-10	5.44			
U32-1	1.64	3.80		
U32-14	5.44			

TABLE III (CONT.)

SINGLE POINT FAILURE SUMMARY
SIGNAL CONDITIONER & COMMAND DECODER

Ref. Designator	CR1 Q x 10^{-5}	CR2 Q x 10^{-5}	CR3 Q x 10^{-5}	CR4 Q x 10^{-5}
U33-?		4.69		
U33-6	3.28		1.41	
U33-8	4.69			
U33-10	4.69			
U33-12		4.69		
U33-14		3.28		1.41
U34-9	7.00			
U34-10	3.50	3.50		
U34-12		3.50		3.50
U35-2	9.70	4.15		
U35-10	9.70	4.15		
U36-2	9.70	4.15		
U36-10	9.70			4.15
C1	.08			
C2	.08			
C3	.08			
C4	.08			
C5	.08			
C6	.08			
C7	.08			
C8	.08			
C9	.13			
C10	.08			
C11	.08			
C12	.08			
R1	.02			
R2	.02			
Connector	39.48	18.40	43.16	33.12
Total	411.51	112.92	396.42	109.63

TABLE IV
SINGLE POINT FAILURE SUMMARY
HOUSEKEEPING MULTIPLEXER

Ref. Design	CR1 ($Qx10^{-5}$)	CR2 ($Qx10^{-5}$)	CR3 ($Qx10^{-5}$)	CR4 ($Qx10^{-5}$)
U1-10	Not Used			—
U1-12				12.70
U2-10				12.70
U2-12				12.70
U3-10	Not Used			—
U3-12				12.70
U4-10	Not Used			—
U4-12				12.70
U5-10				12.70
U5-12				12.70
U6-10				12.70
U6-12				12.70
U7-1	7.00			
U7-5	7.00			
U7-8				7.00
U7-14				7.00
U8-1			7.00	
U8-5				7.00
U8-8				7.00
U8-14				7.00
U9-1			6.35	
U9-5	6.35			
U9-8	6.35			
U9-14	6.35			
U10				29.88
U11-12 & 13	Not Used			
U11-9 & 8			12.70	
U12-12 & 13				12.70
U12-9 & 8				12.70
U13-12 & 13				12.70
U13-9 & 8				12.70
U14-12 & 13				12.70
U14-9 & 8				12.70

TABLE IV (CONT.)
SINGLE POINT FAILURE SUMMARY
HOUSEKEEPING MULTIPLEXER

Ref. Design	CR1 ($Qx10^{-5}$)	CR2 ($Qx10^{-5}$)	CR3 ($Qx10^{-5}$)	CR4 ($Qx10^{-5}$)
U15-12 & 13				12.70
U15-9 & 8				12.70
U16-12 & 13				12.70
U16-9 & 8				12.70
U17-12 & 13				12.70
U17-9 & 8				12.70
U18-12 & 13			12.70	
U18-9 & 8			12.70	
U19-12 & 13			12.70	
U19-9 & 8			12.70	
U20-3				8.45
U20-5				8.45
U20-13				8.45
U21-9 & 8			12.70	
U21-12 & 13			12.70	
U22-9 & 8			12.70	
U22-12 & 13			12.70	
U23-9 & 8			12.70	
U23-12 & 13			12.70	
U24-9 & 8			12.70	
U24-12 & 13			12.70	
U25-9 & 8			12.70	
U25-12 & 13			12.70	
U26-9 & 8			12.70	
U26-12 & 13			12.70	
Q1-2			27.75	27.75
Q1-7			27.75	27.75
Q2-2			27.75	27.75
Q2-7			27.75	27.75
Q3-2			27.75	27.75
Q3-7			27.75	27.75
Q4-2			27.75	27.75
Q4-7			27.75	27.75
Q5-2			27.75	27.75

TABLE IV (Cont.)
SINGLE POINT FAILURE SUMMARY
HOUSEKEEPING MULTIPLEXER

Ref. Design	CR1 ($Qx10^{-5}$)	CR2 ($Qx10^{-5}$)	CR3 ($Qx10^{-5}$)	CR4 ($Qx10^{-5}$)
Q5-7			27.75	27.75
Q6-2			27.75	27.75
Q6-7			27.75	27.75
Q7-2			27.75	27.75
Q7-7	(Open Loss of Spare)		27.75	
Q8-2			27.75	27.75
Q8-7			27.75	27.75
AR-1				25.35
AR-2				25.35
AR-3			25.35	
AR-4			25.35	
AR-5				25.35
AR-6				25.35
R-1	(No Effect)			
R-2			.04	
R-3				.04
R-4				3.00
R-5				3.00
R-6				3.00
R-7				3.00
R-8				3.00
R-9				3.00
R-10				3.00
R-11				3.00
R-12				3.00
R-13			3.00	
R-14			3.00	
R-15			.08	
R-16			.08	
R-17			3.00	
R-18				3.00
R-19				3.00
R-20				3.00
R-21			3.00	

TABLE IV (Cont.)
SINGLE POINT FAILURE SUMMARY
HOUSEKEEPING MULTIPLEXER

Ref. Design	CR1 ($Qx10^{-5}$)	CR2 ($Qx10^{-5}$)	CR3 ($Qx10^{-5}$)	CR4 ($Qx10^{-5}$)
-22			3.00	
R-23				3.00
R-24				3.00
R-25				3.00
R-26				3.00
R-27				3.00
R-28				3.00
R-29				3.00
R-30				3.00
R-31				3.00
R-32				3.00
R-33				3.00
R-34				3.00
R-35				3.00
-36				3.00
37			3.00	
-38				3.00
R-39				3.00
R-40				3.00
R-41				3.00
R-42	Used in Spare Circuit			
C1	.08			
C2	.08			
C3	.08			
C4	.08			
C5	.08			
C6				.08
C7	.08			
C8			.02	
				.09
				.09
C11				.09
C12				.09
C13			.09	

TABLE IV (Cont.)
SINGLE POINT FAILURE SUMMARY
HOUSEKEEPING MULTIPLEXER

Ref. Design	CR1 ($Qx10^{-5}$)	CR2 ($Qx10^{-5}$)	CR3 ($Qx10^{-5}$)	CR4 ($Qc10^{-5}$)
C14			.08	
C15			.09	
C16				.09
C17				.09
CR1			5.60	
CR2			5.60	
J(connector)	12.80		9.60	96
TOTAL	46.33	NONE	763.23	1061.24

TABLE V
SINGLE POINT FAILURE SUMMARY
LOW VOLTAGE POWER SUPPLY

C.B.	Ref. Dsg.	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
A-3	VR1	22.60			
	VR2	22.60			
A-2	VR1	22.60			
	VR2	22.60			
A-1	VR1	22.60			
	AR1				14.80
M.B.	R1	.42			1.70
	R2				2.79
	R3				2.79
	RT1				52.50
A1	R1				2.79
	R2				2.79
	R3				2.79
	R4				2.79
	R5				2.79
	R6				2.79
	R7				2.79
A2	R1	2.79			
	R2	2.79			
	R3	.04			
	R4	2.79			
	R5	2.79			
	R6	.05			
A3	R1	.02			
	R2	0			
	R3	.28			
	R4	.02			
	R5	2.79			
	R6	2.79			
	RT1	10.50			
A4	R1	2.79			
	R2	2.79			
	R3	2.79			
A4	R4	2.79			

TABLE V (Cont.)
SINGLE POINT FAILURE SUMMARY
LOW VOLTAGE POWER SUPPLY

C.B.	Ref. Dsg.	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
A4	R5	No Effect			
	R6	.28			
	R7	2.70			
	R8	.02			
	R9	.02			
	R10	0			
	R11	.02			
	R12	0			
	R13	No Effect			
	R14	0			
	R15	.28			
	R16	0			
	R17	.22			
	R18	0			
	R19	.28			
	R20	.02			
	R21	No Effect			
A5	R1	.02			
A6	R1				.28
	R2	.28			
	R3	.28			
	R4				.28
	R5			.28	
	R6			.28	
	R7			.28	
	R8			.28	
	R9			.28	
	R10			.28	
	R11			.28	
	R12			.28	
	T1	17.50			
M.B.	L1	2.80			
A5	L1	2.80			
	L2	2.80			
	L3	2.80			
	L4	2.80			

TABLE V (Cont.)
SINGLE POINT FAILURE SUMMARY
LOW VOLTAGE POWER SUPPLY

C.B.	Ref. Dsg.	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
M.B.	C1	.29			
	C2	.30			
	C3	.30			
	C4	.29			
T1	C1	.08			
A1	C1				.08
	C2				.08
A2	C1	.08			
	C2	.05			
	C3	.08			
	C4	.05			
A3	C1	.08			
	C2	.05			
	C3	.08			
	C4	.02			
A4	C1	.08			
	C2	.05			
	C3	.09			
	C4	.08			
	C5	.08			
A5	C1	.29			
	C2	.29			
A5	C3	.29			
	C4	.29			
	C5	.04			
	C6	.04			
	C7	.05			
	C8	.05			
	C9	.04			
	C10	.04			
	C11	.04			
	C12	.04			
A2	Q1	17.80			

TABLE V (Cont.)
SINGLE POINT FAILURE SUMMARY
LOW VOLTAGE POWER SUPPLY

C.B.	Ref. Dsg.	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
A3	Q1	15.90			
A4	Q1	15.90			
	Q2	2.84			
	Q3	7.95			
A4	Q4	15.90			
	Q5	15.90			
	Q6	15.90			
	Q7	15.90			
A5	Q1	18.50			
	Q2	18.50			
A6	Q1	7.95			7.95
	Q2	7.95			7.95
	Q3			15.90	
	Q4			15.90	
	Q5				15.90
	Q6				15.90
A4	CR1	NO	EFFECT		
	CR2	NO	EFFECT		
	CR3	NO	EFFECT		
	CR4	4.62			
	CR5	11.55			
	CR6	11.55			
	CR7	NOT	USED		
	CR8	NOT	USED		
	CR9	4.62			
A5	CR1	11.55			
	CR2	11.55			
	CR3	11.55			
	CR4	11.55			
	CR5	11.55			
	CR6	13.81			
	CR7	13.81			
	CR8	13.81			
	CR9	13.81			
	CR10	11.55			
	CR11	11.55			
	CR12	11.55			
Connector		23.8			12.4
	TOTAL	572.47	00.00	34.04	154.93

TABLE VI
SINGLE POINT FAILURE SUMMARY
ION PUMP HIGH VOLTAGE SUPPLY

Design.	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
Q_1				2.89
Q_2				17.80
Q_3				27.70
Q_4				8.10
Q_5				16.80
Q_6 (2,3,4)				8.09
Q_6 (5,6,7)				8.09
VR1				3.46
(A1)CR1-16				111.04
CR1				4.61
CR2				4.61
CR3				6.94
CR4				.0
CR5				1.59
CR6				1.54
R_1				.02
R_2				.02
R_3				.39
R_4				.39
R_5				.35
R_6				.02
R_7				.02
R_8				.02
R_9				.02
R_{10}				.02
R_{11}				.39
R_{12}				.39
R_{13}				.39
R_{14}				.39
R_{15}				.39
R_{16}				.39
R_{17}				.39
R_{18}				.39
R_{19}				.39

TABLE VI (CONT.)
SINGLE POINT FAILURE SUMMARY
ION PUMP HIGH VOLTAGE SUPPLY

Ref Design.	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R_{20}				.39
R_{21}				.39
R_{22}				.39
R_{23}				.39
R_{24}				.39
R_{25}				.39
R_{26}				.39
R_{27}				.39
R_{28}				.39
R_{29}				.39
R_{30}				.39
R_{31}				.39
R_{32}				.35
R_{33}		NOT USED		
R_{34}				.39
R_{35}				.39
R_{36}				.39
R_{37}				.39
R_{38}				.39
R_{39}				.39
R_{40}				.39
R_{41}				.39
R_{42}				.39
R_{43}				.39
(A-1)R1				.02
R2				0
C_1				.10
C_2				.10
C_3				.08
C_4				.08
C_5				.08
C_6	.09			
C_7	.09			
C_8				.09
C_9				.09
C_{10}				.09
C_{11}				.09

TABLE VI (CONT.)
SINGLE POINT FAILURE SUMMARY
ION PUMP HIGH VOLTAGE SUPPLY

f Design		CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
	C_{12}	.09			
	C_{13}	.09			
	C_{14}				.09
	C_{15}	.09			
	C_{16}	.09			
	C_{17}				.09
	C_{18}				.09
A-1	C1-9				.72
	T1				35.00
	K1				5.00
	AR1				11.65
	AR2				11.65
	AR3				11.65
	Total	.54	00	00	314.56

TABLE VII

SINGLE POINT FAILURE SUMMARY

MULTIPLIER HIGH VOLTAGE SUPPLY

Ref Design	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
Q1	44.60	24.80		
Q2	3.52			
Q3	3.52			
Q4	6.35	3.52		
Q5	3.52			
Q6	3.52	6.35		
AR1				74.5
K1	5.00			
K2		5.00		
VR1	10.60	24.80		
CR1	4.52			
CR2	4.52			
CR3				6.80
CR4				6.80
CR5	6.80			
CR6	2.26	4.52		
CR7		6.80		
CR8		6.80		
CR9		4.52		
CR10		4.52		
C1				.08
C2	.08			
C3	.08			
C4	.08			
C5	.08			
C6	0.23			
C7	1.35			
C8		.08		
C9		.08		
C10		.08		

TABLE VII

SINGLE POINT FAILURE SUMMARY

MULTIPLIER HIGH VOLTAGE SUPPLY

Ref Design	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R1				.39
R2				.39
R3				.39
R4				.39
R5	.02	0		
R6	0			
R7	0			
R8	.02			
R9	.02			
R10		.02		
R11	.02	0		
R12	No effect			
R13	.03			
R14	.02			
R15		.02		
R16		.02		
R17		.39		
R18		.39		
R19		.39		
R20		.39		
T1	35.00			
A1 CR1 thru CR12	116.00			
C1 thru C6	.48			.48
A2 R1 thru R5	.10			
C1 thru C4	0.32			
R6				.39
Total	252.66	93.41		90.13

TABLE VIII

SINGLE POINT FAILURE SUMMARY

CONTROL AND MONITOR

Ref. Design	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R_1				.15
R_2				0
R_3				0
R_4				.13
R_5				2.78
R_6		<< .01		
R_7		<< .01		
R_8		<< .01		
R_9		<< .01		
R_{10}				.15
R_{11}				.15
R_{12}				.14
R_{13}				.14
R_{14}				0
R_{15}				0
R_{16}		<< .01		
R_{21}				2.61
C_1		<< .01		
C_2		<< .01		
C_3		<< .01		
C_4	.03			
Q_1A				5.88
Q_1B				10.60
Q_2A				6.35
Q_2B				11.40
Q_3A		10.60		
Q_3B		11.25		
Q_4A				16.45
Q_4B				16.45
Q_5A				17.70
Q_5B				17.70

TABLE VIII (CONT.)

SINGLE POINT FAILURE SUMMARY

CONTROL AND MONITOR

Ref. Design	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
CR_1				
CR_2				4.62
CR_3		4.62		
CR_4				4.62
CR_5				4.62
CR_6				4.62
K_1			0	1.50
K_2		2.50		
K_3				3.00
K_4	1.50			1.50
K_5	1.50			1.50
V_1		.02		
σ_1		<< .01		9.65
TOTAL	3.03	8.99	0.00	144.27

TABLE IX-A

SUMMARY OF SINGLE POINT FAILURES FOR UTD CIRCUITS

CIRCUIT	PROBABILITY OF SUCCESS FOR: CRI	CRII	CRIII	CRIV	TABLE
Analyzer	.99996	.99784	.99503	.98500	X
*Emission Control	.49719	.44571	.98378	.98367	
Mother Board	.99883	.99735	.98823	.98823	XI
EC-1	.99986	.99986	.99931	.99920	XII
EC-2	.99958	.99958	.99827	.99827	XIII
EC-3	.99923	.99923	.99923	.99923	XIV
EC-4	.99969	.99969	.99869	.99869	XXIV
Cal. Oscillator	.9999920	.99999	.9912500	.9975908	XV
*Pre Amp/Disc.	.99995	.99627	.99627	.991450	XVI
#1	.9999842	.9987570	.9987570	.9971414	
#2	.9999842	.9987570	.9987570	.9971414	
#3	.9999842	.9987570	.9987570	.9971414	
*Sweep H.V.	.99289	.98672	.9837206	.98198	
Mother Board	.9945338	.9883613	.9869637	.9864810	XVII
Mod #1	.9996981	.9996981	.9991548	.9989358	XVIII
#2	.9994495	.9994495	.9992912	.9990319	XIX
#3	.9999784	.9999784	.9991130	.9988047	XX
#4	.9995280	.9995280	.9995280	.9993190	XXI
#5	.9996888	.9996888	.9996228	.9993351	XXII
TOTAL UTD	.9900	.97668	.95100	.94103	

*Figures are subproducts of items below.

TOTAL BXA	.98714	.95996	.94922	.93119
TOTAL LMS	.97728	.93759	.90271	.87628

TABLE X

SINGLE POINT FAILURE SUMMARY FOR ANALYZER

Part	CR1 $\times 10^{-5}$	CR2 $\times 10^{-5}$	CR3 $\times 10^{-5}$	CR4 $\times 10^{-5}$
Breakseal	1.752			
Multiplier #1		70.070		
#2		70.070		
#3		70.070		
Resistor String #1		.78		7.00
#2		.78		7.00
#3		.78		7.00
Filament #1			71.82	
#2			71.82	
Temperature Sensor			79.72	
Source Heater			52.56	122.64
Ion Pump				876.00
TOTAL	1.752	212.55	275.92	1019.64

TABLE XI A

SINGLE POINT FAILURE SUMMARY FOR EMISSION CONTROL (MOTHER BOARD)

Part	CR1x10^{-5}	CR2x10^{-5}	CR3x10^{-5}	CR4x10^{-5}
R1	.020			
R2	.00			
R3	.020			
R4			.020	
R5			.020	
R6			.020	
R7			.020	
R8			.020	
R9			.020	
R10			.020	
R11			.010	
R12			.010	
R13			.020	
R14			.38	
R15			.38	
R16			.02	
R17			.02	
R18		.02		
R19			.02	
R20			.02	
R21			2.94	
R22	.02			
R23			.38	
R24			.38	
R25			.02	
R26	.02			
R27	2.94	26.49		
R28	2.94	26.49		
R29	2.94	26.49		
R30	2.94	26.49		
R31	2.94	26.49		
R32	2.94	26.49		
R33	2.94	26.49		
R34	2.94	26.49		

TABLE XI A

SINGLE POINT FAILURE SUMMARY FOR EMISSION CONTROL (MOTHER BOARD)

Part	CR1x10^{-5}	CR2x10^{-5}	CR3x10^{-5}	CR4x10^{-5}
R35	2.94	26.49		
R36	.00			
R37			.02	
R38			.02	
R39			.02	
R40			.02	
R41			.02	
R42			.02	
R43			.02	
R44			.02	
R45			.02	
C2	.25			
C3	.09			
C4			.09	
C5			.090	
C6			.71	
C7	.71			
Q1	13.77			
Q2	13.77			
Q3			4.94	
Q4			4.94	
Q5			6.94	
Q6			6.94	
Q7		6.94		
Q8			6.94	
Q9			6.94	
Q10			6.94	
CR1	3.50			
CR2			6.30	
CR3			6.30	
CR4			6.30	

TABLE XI A

SINGLE POINT FAILURE SUMMARY FOR EMISSION CONTROL (MOTHER BOARD)(Cont.)

Part	CR1x10^{-5}	CR2x10^{-5}	CR3x10^{-5}	CR4x10^{-5}
CR5			6.30	
CR6			6.30	
CR7			6.30	
CR8			6.30	
CR9			6.30	
CR10			71.80	
CR11			71.80	
CR12			71.80	
CR13			71.80	
CR14			5.26	
CR15			71.80	
CR16			5.26	
CR17			5.26	
CR18			5.26	
CR19			5.26	
CR20			5.26	
CR21			3.50	
CR22			3.50	
CR23			3.50	
CR24			3.50	
CR25	3.50			
CR26	3.50			
CR27	3.50			
CR28	3.50			
CR29	21.54	50.26		
CR30			1.75	
CR31			1.75	
CR32		1.75		
CR33			5.26	
Z1			31.50	
Z2			31.50	
Z3			31.50	

TABLE XI

SINGLE POINT FAILURE SUMMARY FOR EMISSION CONTROL CONTROL (MOTHER BOARD) (CONT.)

Part	CR1x10^{-5}	CR2x10^{-5}	CR3x10^{-5}	CR4x10^{-5}
Z4			31.50	
Z5		31.50		
Z6		31.50		
Z7			31.50	
Z8-2		4.38		
Z8-6		4.38		
Z8-8	Not	Used		
Z8-10		4.38		
Z8-12		4.38		
Z8-14			4.38	
Z9-3		8.76		
Z9-5			8.76	
Z9-13			8.76	
K1			3.5	
K2			3.50	
K3			3.50	
K4			3.50	
K5			3.50	
K6			3.50	
T1	14.60		2.92	
T2			17.52	
T3			17.52	
T4			17.52	
T5			17.52	
T6			17.52	
T7			17.52	
L1	8.65			
S1			25.00	
Total	117.53	148.23	914.11	0.00

TABLE XII

SINGLE POINT FAILURE SUMMARY FOR
EMISSION CONTROL
(EC-1)

Part	CR1x10^{-5}	CR2x10^{-5}	CR3x10^{-5}	CR4x10^{-5}
R1			.032	
R2			.032	
R3			.019	
R4			.019	
R6			.019	
R7			.019	
R8			.019	
R9			.019	
R9			.019	.019
R10				.019
R11				.019
C1			2.71	
C2			2.71	
Q1			2.12	4.24
Q2			2.14	4.24
Q3			10.5	
Q4	7.0		3.5	
Q5	7.0		3.5	
CR1			6.61	
CR2			6.61	
CR3			4.41	2.20
CR4			5.25	
CR5			5.25	
Total	14.0		55.48	11.25

TABLE XIII A

SINGLE POINT FAILURE SUMMARY FOR
EMISSION CONTROL
(EC-2)

Part	CR1x10^{-5}	CR2x10^{-5}	CR3x10^{-5}	CR4x10^{-5}
C1			.78	
C2	.79		.09	
C3	.79		.09	
C4	.79		.09	
C5	.79			
C6	.79		.788	
C7			.87	
C8			.87	
C9	.79			
R1	.02			
R2	.02			
R3	.02			
R4	.02			
R5	.02			
R6			.02	
R7			.02	
R8	.02			
R9			.02	
CR1	No effect			
CR2				
CR3				
CR4				
CR5			42.06	
CR6			3.50	
CR7			42.06	
CR8			3.50	
Z1	37.58			
Z2		NA	37.58	
Total	42.44	00.00	131.55	00.00

TABLE XIV A

SINGLE POINT FAILURE SUMMARY FOR
EMISSION CONTROL
(EC-3)

Part	CR1x10^{-5}	CR2x10^{-5}	CR3x10^{-5}	CR4x10^{-5}
C1	.25			
C2	1.16			
C3	.52			
C4	.61			
C5	.61			
CR1	5.26			
CR2	5.26			
CR3	5.26			
CR4	5.26			
CR5	5.26			
CR6	5.26			
CR7	5.26			
CR8	5.26			
CR9	5.26			
CR10	5.26			
CR11	5.26			
CR12	5.26			
CR13	5.26			
CR14	5.26			
Total	76.79			00.00

TABLE XXIV A

SINGLE POINT FAILURE SUMMARY FOR
EMISSION CONTROL
(EC-4)

Part	CR1x10^{-5}	CR2x10^{-5}	CR3x10^{-5}	CR4x10^{-5}
R1			.02	
R2			.02	
R3			.02	
R4			.02	
R5	.38			
R6	.38			
R7			.38	
R8			.38	
R9			.02	
R10			.02	
R11	.02			
R12			.02	
C1			.71	
C2			.71	
C3	.88			
C4	.88			
C5			.88	
C6			.88	
CR1			21.54	
CR2			21.54	
CR3	21.54			
CR4			21.54	
CR5			5.26	
CR6			5.26	
Q1			6.94	
Q2			6.94	
Q3	6.94			
Q4			6.94	
Total	31.02	00.00	100.04	00.00

TABLE XV

SINGLE POINT FAILURE SUMMARY FOR CALIBRATION OSCILLATOR

Part	CR1 x10^{-5}	CR2x10^{-5}	CR3 x10^{-5}	CR4 x10^{-5}
Q1			23.12	
Q2			21.20	
CR1			6.62	4.416
CR2			6.62	4.416
CR3			6.62	4.416
R1			.019	.366
R2			.019	.366
R3			.019	.366
R4			.019	.366
R5			.385	
R6			.019	.366
C1			.788	.088
C2			.788	.088
C3	.788			.088
C4			.788	.088
Z1			26.28	
Z2			26.28	
XTL 1			105.12	
Total	.788		224.704	15.43

TABLE XVI

SINGLE POINT FAILURE SUMMARY FOR PRE-AMP/DISCRIMINATOR

Part	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R1			.019	.366
R2			.294	2.649
R3		.019		.366
R4		.019		.366
R5		.294	2.649	
R6		.294	2.649	
R7		.019		.366
R8		.294	2.649	
R9		.019		.366
R10		.019		.366
R11		.019		.366
R12		.019		.366
R13		.019		.366
R14		.019		.366
R15		.019		.366
R16		.019		.366
R17		.019		.366
R18		.019		.366
R19		.019		.366
R20		.019		.366
R21		.019		.366
R22		.019		.366
R23		.019		.366
R24			.019	.366
R25			.019	.366
R26			.019	.366
R26		.019		.366
R27		.019		.366
R28		.019	.366	
R29		.019		.366
R30		.019		.366
R31		.019	.366	
R32		.019		.366
R33		.019		.366
R34		.019		.366

TABLE XVI

SINGLE POINT FAILURE SUMMARY FOR
PRE-AMP/DISCRIMINATOR* (Cont.)

Part	CR1 x10^{-5}	CR2 x10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
C1		.063		.007
C2		.788		.088
C3		.063		.007
C4		.788		.088
C5		.788		.088
C6		.788		.088
C7		.788		.088
C8		.788		.088
C9		.788		.088
C10		.788		.088
C11		.788		.088
C12		.788		.088
C13		.788		.088
C14		.788		.088
C15		.788		.088
C16		.788		.088
C17		.788		.088
C18	.788			.088
C19		.788		.088
C20	.788			.088
Q1		8.23	19.19	
Q2		6.36	14.84	
Q3		12.93	30.17	
Q4		6.36	14.84	
Q5		12.93	30.17	
Q6		14.93	30.17	
CR 1		6.63		4.42
CR2		4.42	2.21	4.42
CR3		7.88	2.63	15.77
Z1		13.66	7.36	
Z2		26.28		
Total	1.576	122.720	161.559	39.105

* Applies to PRE-AMP/DISC's No. 1 or No. 2 or No. 3.

TABLE XVII

SINGLE POINT FAILURE SUMMARY FOR SWEEP HIGH VOLTAGE POWER SUPPLY (MOTHER BOARD)

Part	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R1	.294		2.649	
R2	.294		2.649	
R3				.385
R4				.385
R5				.385
R6	.019			.366
R7	.019			.366
R8	.019			.366
R9	.019			.366
R10				.385
C1	.788			.088
C2				.876
C3				.876
C4	.788			.088
C5	.788			.088
C6	.788			.088
C7				.876
C8	.788			.088
T1	17.52		17.52	
CR1	8.32			5.68
CR2	8.32			5.68
CR3	8.32			5.68
CR4		1.96	3.92	3.92
Z1	6.57		13.14	
Z2		26.28		
Z3		26.28		
Z4	13.14		13.14	
Z5	7.88		18.40	
Z6	18.40		7.88	
Z7	13.14		8.76	4.38
Z8	26.28			

TABLE XVII

SINGLE POINT FAILURE SUMMARY FOR
SWEEP HIGH VOLTAGE POWER SUPPLY
(MOTHER BOARD)

Part	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
Z9		26.28		
Z10	13.14	13.14		
Z11	13.14			
Z12	26.28			
Z13	26.28			
Z14	26.28			
Z15	26.28			
Z16	26.28			
Z17	26.28			
Z18	26.28			
Z19	17.74	8.54		
Z20		57.81		
Z21		57.81		
Z22		57.81		
Z23	26.28			
Z24	13.14		13.14	
Z25	21.90			
Z26	26.28			
Z27		57.81		
Z28		57.81		
Z29		57.81		
Z30	17.08		9.2	
Z31	6.57		6.57	13.14
Z32	13.14		13.14	
Z33	20.59	1.31		4.38
Z34		57.81		
Z35		57.81		
Z36		57.81		
Z37	14.89		11.39	
Z38	26.28			
Total	546.620	624.080	141.498	48.932

TABLE XVIII

SINGLE POINT FAILURE SUMMARY
FOR SWEEP HIGH VOLTAGE POWER SUPPLY
(MODULE 1)

Part	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R1	.294		2.649	
R2	.019			.366
R3	.019			.366
R4	.294			2.649
R5	.019			.366
R6	.019			.366
C1	.788			.088
C2	.788			.088
C3	.788			.088
Q1	9.2		21.46	
Q2	9.2		21.46	
L1	8.76		8.76	17.52
Total	30.188		54.329	21.897

TABLE XIX

SINGLE POINT FAILURE SUMMARY
FOR SWEEP HIGH VOLTAGE POWER SUPPLY
(MODULE 2)

Part	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R1	.019			.366
R2	.019			.366
R3	.019			.366
R4	.019			.366
R5	.019			.366
R6			.019	.366
R7			2.943	
R8	.294		2.649	
C1	.788			.088
C2	.788			.088
C3	.788			.088
C4	.788			.088
C5	.788			.088
C6	.788			.088
C7	.788			.088
Q1	6.93			12.19
CR1	4.62			6.93
Z1	37.58		20.23	
Total	55.035		25.841	25.932

TABLE XX
SINGLE POINT FAILURE SUMMARY FOR SWEEP HIGH VOLTAGE POWER SUPPLY (MODULE 3)

Part	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R1	.294		2.649	
R2			.019	.366
R3			.294	2.649
R4			.294	2.649
R5			.294	2.649
R6			.294	2.649
R7			.294	2.649
R8			.294	2.649
R9	.294		2.649	
C1	.788			.088
C2	.788			.088
C3			.788	.088
C4			.788	.088
C5			.246	.984
CR1			6.61	4.41
CR3			6.61	4.41
Z1			57.81	
Total	2.164		86.543	30.826

TABLE XXI

SINGLE POINT FAILURE SUMMARY
FOR SWEEP HIGH VOLTAGE POWER SUPPLY
(MODULE 4)

Part	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R1	.019			.366
C1	2.523			.380
C2	.788			.088
C3	.788			.088
C4	1.07			.119
C5	4.73			.526
C6	4.73			.526
C7	4.73			.526
CR1	6.93			4.62
CR2	6.93			4.62
CR3	6.93			4.62
CR4	6.93			4.62
Total	47.098			20.999

TABLE XXII

SINGLE POINT FAILURE SUMMARY FOR SWEEP HIGH VOLTAGE POWER SUPPLY (MODULE 5)

Part	CR1 x 10^{-5}	CR2 x 10^{-5}	CR3 x 10^{-5}	CR4 x 10^{-5}
R1	.019			.366
C1	.83		3.3	
C2	.83		3.3	
Z1	18.92			12.62
CR1	10.52			15.78
Total	31.119		6.6	28.766

TABLE XXIII

COMMAND FUNCTION CRITICALITY

Symbol	Function	Locked On	Locked Off
CA-1	Step, Mult, and Sweep H. V. On	II	I
CA-2	Lock (Sweep Hold)	II	II
CA-3	One-Step	III	III
CA-4	Emission/Fil. Off	I	II
CA-5	Filament #1 On	II	II
CA-6	Filament #2 On	II	II
CA-7	Mult High	III	III
CA-8	Mult Low	III	III
CA-9	Disc High	III	III
CA-10	Disc Low	III	III
CA-11	Bake Out Enable	IV	IV
CA-12	Bake Out Disable	IV	IV
CA-13	Dust Cover Removal	III	III
CA-14	Ion Pump On	I	IV
CA-15	Ion Pump, Mult, and Sweep H. V. Off	I	II

TABLE XXIV

SPF CRITICALITY COMBINATIONS FOR SIGNAL CONDITIONER

This table gives the criticality rating and effect on each channel with respect to the failure mode of each circuit output in the Signal Conditioner. The primed letters indicated the respective failed channel. HK' is the lose of housekeeping digital date only.

Criticality Ret. Design	I $A'B'C'$	II $AB'C'$	II $A'BC'$	II $A'B'C$	II $A'BC$	II $AB'C$	II ABC'	IV HK'	Channel
U 24-2	1/0								
U 25-10	1							0	
U 31-3	0				1				
U 31-5	0					1			
U 31-8	0						1		
U 31-14	0							1	
U 32-2			1			0			
U 32-6		1			0				
U 32-12				1			0		
U 33-2						1	0		
U 33-8	1/0								
U 33-10	1/0								
U 33-12			0	1					
U 33-14				0				1	
U 34-9	1/0								
U 34-10	0		1						
U 34-12				1			0		
U 35-2		0			1				
U 35-10				0			1		
U 36-2			0						
U 36-10	0							1	

APPENDIX A

BxA FMECA WORKSHEETS

Channel A
Counting and Data Compression

SYSTEM	PREPARED BY	NO.	REV.
ALSEP-Array E	R. W. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE 65 of 183	
LMS	2347400		
ASSY	SUB NO.	DATE	
Count. & D/C	2347552	5/24/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
U1	Pin 2 or 6 = 1/0	1	Loss of clear to counters and loss of parallel dump of input data to shift registers	Loss of Channel A data	2(5.84)	II
U1	Pins 10 or 12 = 1/0	1			2(5.84)	
U1	Pins 8 or 14 = 0	.7			2(4.09)	
U14	Pin 8/9 = 1/0	1			17.50	
U49	Pins 12/13 = 1/0	1			17.50	
U49	Pin 9/8 = 1/0	1			17.50	
U48	Pin 2 = 1/0	1			5.84	
U2, 3, 4, 19, 20, 35, 36, 50, 51, 66, 67, 18, 34, 65	All Pins = 1/0	1	Loss of all data in Channel A		14(36.75)	
	Pin 3 = 1/0	1			17.05	
U60	Pins 3 = 1/0	1	Loss of 200 kc (free run) clock		8.74	
	Pins 5 = 1/0	1			8.74	
	Pins 8 = 1/0	1			8.74	
	Pins 14 = 1/0	1			8.74	
U48	Pins 12 or 14 = 1/0	1	Loss of 200 kc clock as shift pulse		2(5.84)	
U45	Pin 10 = 1/0	1			5.84	
U64	Pin 3 = 1/0	1			8.74	
U17	Pins 2 or 10 = 0	.7			2(11.80)	
U1	Pins 8 or 14 = 1	.3			2(1.75)	

Channel A
Counting and Data Compression

SYSTEM	PREPARED BY	NO.	REV.
ALSEP	R. W. Hiebert	ATM 970	B
END ITEM	DWG. NO.	PAGE 66 of 183	
LMS	2347400		
ASS'Y	DWG NO.	DATE	
Count. & D/C	2347552	3/29/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
U14	Pin 12/13 = 0	.5	200 kc clock is inhibited		8.75	
U29	Pin 10 = 1/0	1			35.00	
U61	Pins 5 or 8 = 1/0	1	Loss of dump of compress data		2(8.74)	
U65	Pins 5 or 13 = 1/0	1	Loss of digital multiplexer	Loss of Channel A data	2(17.05)	II
U48	Pin 8 = 1/10	1			5.84	
U17	Pin 2 or 10 = 1	.3			2(5.25)	
U48	Pin 6 = 1/0	1			5.84	
U45	Pin 2 = 1/0	1			17.05	
U64	Pin 14 = 1/0	1			8.74	
U33	All outputs = 1/0	1			36.75	
U61	Pin 5 = 1/0	1	Loss of shift pulse		8.74	
U61	Pin 8 = 1/0	1	Loss of MODE and CLEAR pulse for compressed data circuits		8.74	
U14	Pin 12/13 = 1	.5	Counter will not stop at full count	Loss of information only on full resister; data may be difficult to interpret	8.75	III
C1, 2	Open or Short	.9	Loss of Channel A oscillator	Loss of Channel A	2(.08)	II
J1 Pins 30, 27		1	Loss of Channel A data		3(1.75)	
C7	Short	.9	Loss of power (+5 VDC)	Loss of all data	.08	I
J1 Pins 1 & 31; 10 & 40 24, 82		1			2(.88) 2(1.75)	

Channel B
Counting and Data Compression

SYSTEM	PREPARED BY	NO.	REV.
ALSEP-Array E	R. W. Hiebert	ATM 970	
END ITEM	DWG NO.	PAGE 67 OF 183	
ASSY	DWG NO.	DATE	
Count. & D/C	2347552	3/29/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
U5	Pin 2 or 6 = 1/0	1	Loss of clear to counters and loss of parallel dump of input data to shift registers	Loss of Channel B data	2(5.84)	II
U5	Pins 10 or 12 = 1/0	1			2(5.84)	
U5	Pins 8 or 14 = 0	.7			2(4.09)	
U15	Pin 8/9 = 1/0	1			17.50	
U53	Pins 12/13 = 1/0	1			17.50	
U53	Pin 9/8 = 1/0	1			17.50	
U52	Pin 2 = 1/0	1			5.84	
U6, 7, 8, 23, 24, 39, 46, 54, 55, 70, 71, 22, 38,	All pins = 1/0	1	Loss of all data in channel B		14(36.75)	
69	Pin 3 = 1/0	1			17.05	
U32	Pins 3 = 1/0	1	Loss of 200 kc (free run) clock		8.74	
	Pins 5 = 1/0	1			8.74	
	Pins 8 = 1/0	1			8.74	
	Pins 14 = 1/0	1			8.74	
U52	Pins 12 or 14 = 1/0	.1	Loss of 200 kc clock as shift pulse		2(5.84)	
U46	Pin 10 = 1/0	1			5.84	
U68	Pin 3 = 1/0	1			8.74	
U21	Pins 2 or 10 = 1/0	.7			2(11.80)	
U5	Pins 8 or 14 = 1	.3			2(1.75)	
U15	Pin 12/13 = 0	.5	200 kc clock is inhibited		8.75	
U30	Pin 10 = 1/0	1			35.00	

Channel B
Counting and Data Compression

SYSTEM	PREPARED BY	NO.	REV.
ALSEP-Array E	R. W. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE 68 of 183	
LMS	2347400		
ASSY	DWG NO.	DATE	
Count & D/C	2347552	3/29/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^5	CRITICALITY
U62	Pins 3 or 14 = 1/0	1	Loss of dump of compress data		2(8.75)	
U69	Pins 5 or 13 = 1/0	1	Loss of digital multiplexer	Loss of Channel B data	17.05	II
U52	Pin 8 = 1/0	1			5.84	
U21	Pin 2 or 10 = 1	.3			2(5.25)	
U52	Pin 6 = 1/0	1			5.84	
U46	Pin 2 = 1/0	1			17.05	
U68	Pin 14 = 1/0	1			8.74	
U37	All outputs = 1/0	1			36.75	
U62	Pin 5 = 1/0	1	Loss of shift pulse		8.74	
U62	Pin 8 = 1/0	1	Loss of MODE and CLEAR pulse for compressed data circuits		8.74	
U15	Pin 12/13 = 1	.5	Counter will not stop at full count	Loss of information only on full resister; data may be difficult to interpret	18.75	III
J1 Pins 9, 29, 26	Open		Loss of Channel B	Loss of Channel B	3(1.75)	II
C3, 4	Open or Short		Loss of Channel B oscillator		2(.08)	

Channel C
Counting and Data Compression

SYSTEM	PREPARED BY	NO.	REV.
ALSEP-Array E	R. W. Hiebert	ATM 970	
END ITEM	DWG NO.	PAGE 69 of 183	
LMS	2347400		
ASSY	DWG NO.	DATE	
Count. & D/C	2347552	3/20/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
U9	Pin 2 or 6 = 1/0	1	Loss of clear to counters and loss of parallel dump of input data to shift registers	Loss of Channel C data	2(5.84)	II
U9	Pins 10 or 12 = 1/10	1			2(5.84)	
U9	Pins 8 or 14 = 0	.7			2(4.09)	
U16	Pin 8/9 = 1/0	1			17.50	
U59	Pins 12/13 = 1/0	1			17.50	
U57	Pin 9/8 = 1/0	1			17.50	
U56	Pin 2 = 1/0				5.84	
U10, 11, 12, 29, 28, 43, 44, 58, 59, 74, 75, 26,	All pins = 1/0		Loss of all data in Channel C		14(36.75)	
42, 73	Pin 3 = 1/0	1			17.05	
U13	Pins 3 = 1/0	1	Loss of 200 kc (free run) clock		8.74	
	Pins 5 = 1/0	1			8.74	
	Pins 8 = 1/0	1			8.74	
	Pins 14 = 1/0	1			8.74	
U56	Pins 12 or 14 = 1/0	1	Loss of 200 kc clock as shift pulse		2(5.84)	
U47	Pin 10 = 1/0	1			5.84	
U72	Pin 3 = 1/0	1			8.74	
U25	Pins 2 or 10 = 0	.7			2(11.80)	
U9	Pins 8 or 14 = 1	.3			2(1.75)	
U16	Pin 12/13 = 0	.5	200 kc clock is inhibited		8.75	
U31	Pin 10 = 1/0	1			35.00	

Channel C
Counting and Data Compression

SYSTEM	PREPARED BY	NO.	REV.
ALSEP-Array E	R. W. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS	2347400	70 of 183	
ASSY	DWG NO.	DATE	
Count. & D/C	2347552	3/29/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10⁻⁹	CRITICALITY
U63	Pins 3 or 14 = 1/0	1	Loss of dump of compress data		2(8.74)	
U73	Pins 5 or 3 = 1/0		Loss of Channel C data	Loss of Channel C data	17.05	II
U56	Pin 8 1/0	1			5.84	
U25	Pin 2 or 10 = 1	.3			2(5.25)	
U56	Pin 6 = 1/0	1			5.84	
U47	Pin 2 = 1/0	1			17.05	
U72	Pin 14 = 1/0	1			8.74	
U41	All outputs = 1/0	1			36.75	
U63	Pin 5 = 1/0	1	Loss of shift pulse		8.74	
U63	Pin 8 = 1/0	1	Loss of MODE and CLEAR pulse for compressed data circuits		8.74	
U16	Pin 12/13 = 1	.5	Counter will not stop at full count	Loss of information only on full resistor; data may be difficult to interpret.	18.75	III
J1 Pins 28, 25, 11	Open		Loss of Channel C data only	Loss of Channel C	3(1.75)	II
C5, 6	Short or Open		Loss of Channel C oscillator		2(.08)	

SIGNAL CONDITIONER & COMMAND DECODER

SYSTEM	PREPARED BY	NO.	REV.
ALSEP - Array E	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE 71 of 183	
LMS			
ASSY	DWG NO.	DATE	
See Above	2347542		

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R2	Open	.05	Loss of all three channels	Loss of all three channels (ABC) to central station	.02	
R1	Open	.05			.07	
C12	Short	.9			.08	I
C11	Short	.9			.08	
C9	Short	.9			.13	
C10	Short	.9			.08	
J Pins 18, 31, 10 & 40		1			2(3.68)	
U34	Pin 10 = 0	.5			3.50	
U34	Pin 9 = (1/0)	1.0			7.00	I
U33	Pin 10 = (1/0)	1.0			4.89	
U33	Pin 8 = 1/0	1.0			4.89	
U35	Pin 8 = (1/0)	1.0			5.44	I
U36	Pin 10 = 0	.7			9.70	
U25	Pin 10 = 1	.3			1.63	I
U32	Pin 6 = 1	.3		Loss of channels B and C but not A	1.63	
U32	Pin 2 = 1	.3		Loss of channels A and C but not B	1.63	II
U32	Pin 12 = 1	.3		Loss of channels A and B but not C	1.63	
U31	Pin 3 = 0	.7			4.80	
U31	Pin 5 = 0	.7			4.80	
U31	Pin 8 = 0	.7			4.80	I
U24	Pin 2 = 1/0	1.0			6.86	
U31	Pin 14 = 0	.7			4.80	
U34	Pin 12 = 1	.50	Partial Loss of Data	Loss of Channel A and B and not C	3.50	
U33	Pin 14 = 0	.70			3.28	II
U33	Pin 12 = 1	.30			1.41	
U35	Pin 10 = 0	.70			9.70	

SIGNAL CONDITIONER & COMMAND DECODER

SYSTEM	PREPARED BY	NO.	REV.
ALSEP - Array E	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		72 of 183	
ASSY	DWG NO.	DATE	
See Above	134754		

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10⁻⁶	CRITICALITY
U34	Pin 10 = 1	.50		Loss of Channel Aand C but not B	3.50	
U33	Pin 12 = 0	.70			3.50	II
U36	Pin 2 = 0	.70			9.70	
U35	Pin 2 = 0	.70		Loss of Channel B and C but not A	9.70	II
U35	Pin2 =1	.30		Loss of Channel A only	4.15	
U32	Pin 6 = 0	.70			3.90	II
U31	Pin 3 = 1	.30			2.06	
J Pin 26		1			3.68	
U36	Pin2 = 1	.30		Loss of Channel B only	4.15	
U33	Pin 2 = 1	.30			3.26	
U31	Pin 5 = 1	.30			2.06	II
U32	Pin 2 = 0	.70			3.80	
J Pin 25		1			3.68	
U35	Pin 10 = 1	.30		Loss of Channel C only	4.15	
U34	Pin 12 = 0	.50			3.50	
U33	Pin 2 = 0	.70			1.40	II
U31	Pin 8 = 1	.30			2.06	
U32	Pin 12 = 0	.70			3.80	
J Pin 29		1			3.68	
U33	Pin 14 = 1	.30		Loss of Housekeeping Data	3.26	
U25	Pin 10 = 0	.70			3.90	
U36	Pin 10 = 1	.30			4.15	IV
U31	Pin 14 = 1	.30			2.06	
U2, 6, 8, 10, 12, 14	Output Pins = (1/0)	1.0	Loss of Commands #1 through 6	Loss of all data	6(4.69)	I
U2, 6, 8, 10, 12, 14	Output Pins = (1/0)	1.0			6(4.69)	I
U17	Pin 14 = (1/0)	1.0	Loss of Command including 7		4.69	
U25	Pin 14 = (1/0)	1.0			5.60	I
U30	Pin 14 = (1/0)	1.0			6.86	
U30	Pin 8 = (1/0)	1.0			6.86	
U32	Pin 9 = (1/0)	1.0			5.44	
U32	Pin 14 = (1/0)	1.0			5.44	
U3	Output Pins = (1/0)	1.0	Loss of Commands #1 through 6		6(13.85)	I
U4		1.0				
U5		1.0				

SIGNAL CONDITIONER & COMMAND DECODER

SYSTEM	PREPARED BY	NO.	REV.
ALSEP - Array E	R. Hiebert	ATM 970	B
END ITEM	CWS NO.	PAGE 73 of 183	
LMS			
ASSY	DWG NO.	DATE	
See Above	2147512		

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
U25	Pin 6 = 0	0.7	Loss of #1 through 6 commands	Loss of all data	3.70	
U25	Pin 2 = 10	1.0	Loss of Command 7 to command gates		3.80	
U32	Pin 10 = 0/1	1.0	Loss of +5 turn on pulse		5.44	I
C1	Short/Open	.9	Loss of Power or oscillation		.08	
C2, 3, 4, 5, 6, 7, 8	Short	.9	Loss of a command signal 1 through 6		7(.13)	
J Pins 33, 34, 35 36, 37, 48		1.0			6(3.68)	I
U20	Pin 9 = 1 (8 = 0)	.5	Disc gain locked low, J-plate step inhibited	Loss of some data but not all	6.93	
U13	Pin 10 = 1	.3			4.15	
U13	Pin 2 = 0	.7			9.70	II
J Pins 46, 11	Pin 46, 11	1.0			2(3.68)	
U20	Pin 9 = 0 (8 = 1)	.5	Disc gain locked high, J-plate step unable to inhibit.		6.93	
U13	Pin 10 = 0	.7			9.70	II
U13	Pin 2 = 1	.3			4.15	
J Pin 19	Pin 19	(1)	Unable to turn on bakeout heater	Loss of bakeout function no loss of data	3.68	
U28	Pin 10 = 0	.7			3.80	
U29	Pin 8 = 1	.3			2.31	
U29	Pin 14 = 0	.7			5.39	III
U19	Pin 8 = 0 (9 = 1)	.5			6.93	
U6	Pin 10 = 0	.7			9.70	
U12	Pin 2 = 1	.3			4.15	
U28	Pin 6 = 1	.3			1.64	
U28	Pin 10 = 1	.3	Unable to turn OFF bakeout heater	Bakeout heater automatically comes on in standby. No loss of data	1.64	
U28	Pin 6 = 0	.7			3.80	
U29	Pin 8 = 0	.7			5.39	
U29	Pin 14 = 1	.3			2.31	IV
U19	Pin 8 = 1 (9 = 0)	.5			6.93	
U6	Pin 10 = 1	.3			4.15	
U12	Pin 2 = 0	.7			9.70	
J Pin 18	Pin 18	1			3.68	

SIGNAL CONDITIONER & COMMAND DECODER

SYSTEM	PREPARED BY	NO.	REV.
ALSEP - Array E	R. Hiebert	ATM 970	
END ITEM	DWG NO.	PAGE	
LMS		74 of 183	
ASSY	DWG NO.	DATE	
See Above	2347542		

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
J Pin 50	Pin 50	1.0	Unable to turn backup heater off	Loss of function	3.68	IV
U23	Pin 10 = 0	.7			3.28	
U23	Pin 14 = 1	.3			1.41	
J Pin 52	Pin 52	1.0	Unable to turn backup heater on		3.68	IV
U23	Pin 10 = 1	.7			3.28	
U23	Pin 14 = 0	.3			1.41	
U15	Pin 8 = ϕ (Pin 9 = 1)	.5	Sweep high voltage unable to turn on	Loss of all data	6.93	I
U9	Pin 10 = ϕ	.7	Unable to turn off sweep high voltage	Loss of function	9.70	III
J	Pin 42	1			3.68	
U23	Pin 6 = 0	.7	Unable to turn multiplier high voltage off	Loss of function	3.28	III
U23	Pin 12 = 1	.3			1.41	
U23	Pin 2 = 1	.3			1.41	
U24	Pin 10 = 0	.7			9.70	
U16	Pin 8 = 1	.5	Lock high	Unable to manual step once set	6.93	III
U17	Pin 6 = 1	.3			3.28	
U26	Pin 5 = 0	.7			4.80	
J	Pin 15	1			3.68	
U16	Pin 8 = 0	.5	Lock low	Step only, unable to sweep	6.93	III
U17	Pin 6 = ϕ	.7			3.28	
U26	Pin 5 = 1	.3			2.06	
U9	Pin 2 = 1/0	1	Unable to operate J-plate or step function	Partial loss of data	13.85	III
J	Pin 21	1			3.68	
U17	Pin 10 = 0	.7	Unable to set mult gain high		3.28	III
U11	Pin 10 = 1	.3			4.15	
U26	Pin 14 = 1	.3			4.80	
U11	Pin 2 = 0	.3			9.70	
J	Pin 14	1			3.68	

SIGNAL CONDITIONER & COMMAND DECODER

SYSTEM	PREPARED BY	NO.	REV.
ALSEP - Array E	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE 75 of 183	
LMS			
ASSY	DWG NO.	DATE	
See Above	2347542		

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
U17	Pin 10 = 1	.3	Unable to set multiplier low	Partial loss of data	1.41	III
U11	Pin 10 = 0	.7			9.70	
U11	Pin 2 = 1	.3			4.15	
U26	Pin 14 = 0	.7			4.80	
J	Pin 54	1			3.68	
U29	Pin 5 = 0	.7	FIL #1 Locked on "0" (Unable to turn off FIL #1)	FIL #2 Locked off, unable to turn on FIL #2	5.39	III
U21	Pin 9 = 1 (8 = 0)	.5			6.93	
U29	Pin 3 = 0	.7	FIL #2 Locked On (0), Unable to turn off FIL #2	FIL #1 Locked off, unable to turn on #1	5.39	III
U21	Pin 9 = 0 (8 = 1)	.5			6.93	
U7	Pin 12 = 0	.7			19.50	
U28	Pin 14 = 1	.3			1.64	
J	Pin 3	1	Unable to turn on FIL #1	Unable to turn on FIL #1	3.68	III
U14	Pin 12 1/0	1			27.90	
U29	Pin 5 = 1	.3			2.30	
J	Pin 2	1	Unable to turn on FIL #2	Unable to turn on FIL #2	3.68	III
U29	Pin 3 = 1	.3			2.31	
U7	Pin 12 = 1	.3			8.36	
U28	Pin 14 = 0	.7			3.80	
U21	Pin 12 = 1 (13 = 0)	.5	Unable to turn off filaments	Unable to switch from FIL #1 (2) to #2 (1) or turn off Filaments	6.93	III
U17	Pin 12 = 1	.3			1.41	
U26	Pin 8 = 0	.7			4.80	
U10	Pin 2 = 1	.3			4.15	
U21	Pin 12 = 0 (13 = 1)	.5	Unable to turn on either fill. Both fill will lock off	Loss of all data	6.93	I
U17	Pin 12 = 0	.7			3.28	
U26	Pin 8 = 1	.3			2.06	
U10	Pin 2 = 0	.7			9.80	
U33	Pin 6 = 0	.7			3.28	
U28	Pin 12 = 1/0	1	Unable to turn on either Fill. Both Fill will lock off	Loss of all data	5.44	I
U30	Pin 3 = 1/0	1			6.86	

SIGNAL CONDITIONER & COMMAND DECODER

SYSTEM	PREPARED BY	NO.	REV.
ALSEP - Array E	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		76 of 183	
ASSY	DWG NO.	DATE	
See Above	2347542		

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
U28	Pin 8 = 0	.7	Failure to remove dust cover	Imped data taking operate only during lunar nite	3.80	III
U22	Pin 8 = 1	.5			6.93	
U12	Pin 10 = 1	.3			4.15	
U28	Pin 2 = 0	.7			3.80	
J	Pin 20	1			3.68	
U28	Pin 8 = 1	.3	When cover is removed this is a "don't care" condition	No Failure	0	IV
U22	Pin 8 = 0	.5			0	
U12	Pin 10 = 0	.7			0	
U28	Pin 2 = 1	.3			0	
U17	Pin 8 = 0	.7	Ion pump locked off or unable to turn on	Unable to use Ion pump	4.69	III
U8	Pin 12 = 1	.3			8.37	
U15	Pin 9 = 1 (8 = 0)	.5			6.93	
U23	Pin 8 = 1	.3			1.41	
J Pin 16	Pin 16	1.0			3.68	
U15	Pin 13 1/0	1.0	Ion pump flag incorrect	Loss of housekeeping data on Ion pump	13.85	IV
U6	Pin 2 = 1	.3	Unable to turn OFF high voltages	Loss of function	4.15	III
J	Pin 49	1			3.68	
U6	Pin 2 = 0	.7	Unable to turn on ony high voltages	Loss of all data	9.70	I
					19	
J	Pin 51	1	Unable to turn Ion pump off	Loss of function	3.68	III
U23	Pin 8 = 0	.7			3.28	
U8	Pin 12 = ϕ	.7			19.50	
U17	8 = 1	.3			1.41	
U23	Pin 12 = 0	.7	Unable to turn on mult H. V.	Loss of all data	3.28	I
U23	Pin 6 = 1	.3			1.41	
U9	Pin 10 = 1	.3			4.15	
U23	Pin 2 = 0	.7			3.28	
U24	Pin 10 = 1	.3			4.15	
J	Pin 53	1			3.68	

SIGNAL CONDITIONER & COMMAND DECODER

SYSTEM	PREPARED BY	NO.	REV.
ALSEP - Array E	R. Hiebert	ATM 970	8
END ITEM	DWG NO.		PAGE 77 of 183
LMS			
ASSY	DWG NO.		DATE
See Above	2347542		

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
U25	Pin 12 = 1/0	1	Manual one Step Lock High or Low	Loss of Manual Step Ability	5.44	III
U26	Pin 3 = 1/0	1			6.86	
U27	Pin 8 = 1/0	1			6.86	
U10	Pin 10 = 1/0	1			13.85	
U18	Pin 8 = 1/0		Mult gain flag inoperative	Loss of housekeeping data on mult gain level	13.85	IV
U34	Pin 12 = 1	.5	Loss of all housekeeping data	Loss of all housekeeping digital data	3.50	
U33	Pin 14 = 1	.3			1.41	
U31	Pin 14 = 1	.3			2.06	
J	Pin 30	1			3.68	
U33	Pin 6 = 1	.3	Loss of turn on pulse	May have to reset two command	1.41	III
U30	Pin 5 = 0	.7	Loss of all commands	Loss of all data	4.80	I
J	Pin 45	1	Loss of discgain flag	Loss of housekeeping data		IV
	Pin 44	1	Loss of ion pump flag			
	Pin 12	1	Loss of bakeout flag			
	Pin 17	1	Loss of FIL flag			
	Pin 13	1	Loss of multgain flag			
J	Pin 43	1	Loss of data demand	Loss of all data		I
	Pin 47	1	Loss of frame mark			

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP-Array E	R. Hiebert	ATM 970	A
END ITEM	DWG NO.	PAGE 78 of 183	
LMS	2347400		
ASSY	DWG NO.	DATE	
Housekeeping	2347557	4/29/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
C_8	Short	0.2	1. Loss of Emission current monitor 2. Loss of other data also.	1. Loss of Emission Current Monitor. 2. Loss of Analog Housekeeping.	0.02	III
$U_{9/1}$, $U_{8/1}$, $U_{11/9}$, U_{19}, U_{18}, U_{22}, U_{21}, $U_{24-1413}$, U_{23}, U_{26}, U_{25}	High/Low	(1)			178.45	
AR_4, AR_3	High/Low/Drift	(1)			50.70	
Q_1, Q_2, Q_3, Q_4 $Q_{5/7}$, Q_6, Q_7, Q_8	Short	(.5)			416.25	
R_2	Open	.1			.04	
R_{21}, R_{22}, R_{13}, R_{14} R_{17}, R_{37}	Open/Short/Drift	1			18.00	
$Q_{5/2}$	Open	(.5)			27.75	
U_{24-918}	9 High/Low	1			12.70	
R_{15}, R_{16}	Open/Short	.1			0.08	
C_{15}, C_{13}	Open/Short	1			0.18	
CR, CR_2	Short	0.4			11.20	
C_{14}	Short	0.9			0.08	
J	Pin 26	1			3.20	
	Pin 3/33	1			3.20	
	Pin 2/32	1			3.20	
$U_{9/5}$, $U_{7/1\&5}$	High/Low	1	Loss of 90th Frame Mark	Loss of System Data	6.35	I
C_7	Short	0.9			14.00	
J	Pin 44	1			0.08	
	Pin 1 & 31	1			3.2	
	Pin 10 & 40	1			3.2	
	Pin 12	1			3.2	
					3.2	

SYSTEM	PREPARED BY	NO.	REV.
ALSEP-Array E	R. Hiebert	ATM-970	B
END ITEM	DWG NO.	PAGE 79 of 183	
LMS	2347400		
ASSY	DWG NO.	DATE	
Housekeeping	2347557		

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
Q_1-2	Open	.5	Item (1): Ion Pump Current Mon.	Loss of all Analog Housekeeping Data Except Emission Current Monitor	27.75	VI
R_{18}	Short/Open/Drift	1			3.00	
Q_1-7	Open	.5	Loss of Item (2)		27.75	
R_{19}	Short/Open/Drift	1	Ion Pump Voltage Mon.		3.00	
Q_2-2	Open	.5	Loss of Item (3)		27.75	
R_{12}	Short/Open/Drift	1	+12V monitor		3.00	
Q_2-7	Open	.5	Loss of Item (4)		27.75	
R_{20}	Short/Open/Drift	1	Experiment Current Mon.		3.00	
Q_3-2	Open	.5	Loss of Item (5)		27.75	
R_{26}, R_{27}, R_{28}	Short/Open/Drift	1	+12V monitor		9.00	
Q_3-7	Open	.5	Loss of Item (6)		27.75	
R_{29}, R_{30}, R_{31}	Short/Open/Drift	1	+5V monitor		9.00	
Q_4-2	Open	.5	Loss of Item (7)		27.75	
R_6, R_5, R_4, R_3	Short/Open/Drift	1	Ion Source Temp Monitor		12.00	
AR-1	High or Low	1			25.35	
C_9 - C_{10}	Short/Open	(1)			0.18	
Q_4-7	Open	.5	Loss of Item (8)		27.75	
R_9, R_{11}, R_{10}, R_7 R_8	Short/Open/Drift	1	Emission Control Temp Monitor		15.00	
C_{11}, C_{12}	Short/Open	(1)			0.18	
AR6	High/Low	1			25.35	
Q_5-7	Open	.5	Loss of Item (9)		27.75	
R_{38}	Short/Open/Drift	1	FIL #1 Monitor		3.00	

SYSTEM	PREPARED BY	NO.	REV.
ALSEP "E"	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE 80 of 183	
LMS	2347400		
SUBSY	DWG NO.	DATE	
Housekeeping	2347557	4/29/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
Q_5-2	Short	(.5)	Loss of all Items but Emission Current Mont	Loss of all Analog Item except Emission Current	27.75	IV
Q_6-2	Open	(.5)	Loss of Item 10 -12V Monitor	Loss of Analog, Housekeeping functions	27.75	
R_{36}, R_{35}, R_{23}, R_{24}	Short/Open/Drift	(1)			12.00	
C_{16}	Short/Open	(1)			0.09	
AR5	High/Low	(1)			25.35	
Q_6-7	Open	(.5)	Loss of Item 11 -15 Volt Monitor		27.75	
R_{35}, R_{33}, R_{32}, R_{34}	Short/Open/Drift	(1)			12.00	
C_{17}	Short/Open	(1)			0.09	
AR2	High/Low	(1)			25.35	
Q_7-2	Open	(.5)	Loss of Item 12 LVPS TEMP MON		27.75	
R_{41}	Short/Open/Drift	(1)			3.00	
Q_7-7	Open	(.5)	Loss of Spare	No Loss of any Data	27.75	0
R_{42}	Short/Open/Drift	(1)			3.00	
Q_8-2	Open	(.5)	Loss of Item 13 Fil #2 Mon	Loss of Analog Housekeeping function	27.75	IV
R_{39}	Short/Open/Drift	(1)			3.00	
Q_8-7	Open	(.5)	Loss of Item 14 MHV MON		27.75	
R-40	Short/Open/Drift	(1)			3.00	
$U_{6/10}$, U_{10}	High/Low	1	Loss of Word 1 & 90th Frame Pulse Shupe	Loss of All Digital H.K. Data	12.70 29.88	IV
$U_{7/14}$					7.00	
$U_{7/8}$	High/Low	1	Loss of Word 1 Shaped		7.00	
$U_{8/5}$	High/Low	1	Loss of 90th Shaped		7.00	IV

SYSTEM	PREPARED BY	NO.	REV.
ALSEP "E"	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE 81 of 183	
LMS	2347400		
ASSY	DWG NO.	DATE	
Housekeeping	2347557	4/29/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
$U_{9/8 \& 14}$	High/Low	1	Loss of Shift Pulse	Loss of All data	12.70	I
C_1	Short	0.9			.08	
C_2, C_3, C_4, C_5	Short	0.9	Loss of +12, -12, -15, or +5 Vol to Experiment	Loss of all data	.32	
U_{12}, U_{13}, U_{14}, U_{15}, U_{16}	High/Low	(1)	Loss of shift Registor	Loss of All Digital H.K. Data	27.00	IV
U_{17}-12/13	High/Low	(1)	Loss of 1/2 Digital H.K. Data	Loss of 1/2 Digital H.K. Data	12.70	IV
U_{17}-9/8	High/Low	(1)	Loss of 1/2 Data	Loss of 1/2 Digital H.K. Data	12.70	IV
U_2-12	High	.3	Loss of Command 6 Status & EIL Flag	Loss of 2/15 H.K. Digital Data	3.81	IV
U_{1-12}	High	.3	Comb #5 status & Mult SW H.V. FLG.		3.81	
U_{4-12}	High	.3	Comb #4 Status & source Heater FLG		3.81	
U_{3-12}	High	.3	Comb #3 Status & Dust Cover FLG.		3.81	
U_{6-12}	High	.3	Comb #2 Status & Ion Prmp FLG.		3.81	
U_{5-12}	High	.3	Comb #1 Status & Lock Sup Hold Flag		3.81	
U_{5-10}	Low/High	.1	Unable to Clk out H.K. Digital Data	Loss of all Digital H.K. Data	12.70	IV
U_{20-3}	High	.3	Loss of Sweep Start FLG.	Loss of 1/15 of Digital H.K. Data	2.54	
U_{20-5}	High	.3	Loss of Disc Hi/Lo Flg.		2.54	
U_{20-13}	High	.3	Loss of Mult. Hi/Lo Flg.		2.54	
C_6	Short/Open	.9	Loss of Shaped Pulse	Loss of Digital H.K. Data	.08	
$U_{2/10}$	High/Low	1	Loss of word 1 Shaped	Loss of Digital H.K. Data	12.70	
$U_{8/14}$	High/Low	1	Loss of Clk (word #1)		7.00	
$U_{5/8}$	High/Low	1	Loss of reset		7.00	

SYSTEM	PREPARED BY	NO.	REV.
ALSEP "E"	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS	2347400	82 of 183	
ASSY	DWG NO.	DATE	
Housekeeping	2347557	4/29/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
U_1-12	Pin 12 - Low	.7	Loss of all H.K. digital data	Loss of all H.K. digital data	6(8.9)	IV
U_2-12						
U_4-12						
U_3-12						
U_6-12						
U_5-12	Pin 12 - Low					
U_{20}-3	Pin 3 - Low	.7			8.9	
U_{20}-5	Pin 5 - Low				8.9	
U_{20}-13	Pin 13 - Low	.7			8.9	
R_1-	Open Short or drift	1		No effect	0	IV
2J	Pins 18, 45, 21, 8, 13, 7, 34, 6, 15, 9, 14, 4, 17, 5, 16, 51, 43, 50, 52, 23, 22, 20, 24, 25, 28, 27, 57, 42, 11, 41		Loss of all H.K. digital data	Loss of all H.K. digital data	106.0	

SYSTEM	PREPARED BY	NO.	REV.
ALSEP Array E	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE 83 OF 183	
LMS	2347400		
ASSY	DWG NO.	DATE	
LVPS	2347482	4/6/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

(C.B.)	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
(A-4)	Q_1 (A & B)	Collector-emitter; Collector-base; or Emitter-base Short, Collector, Base or Emitter open,	.35	1. Loss of oscillator drive 2. Wave form will become unsemetrical causing saturation of power transformer	Loss of all Data	15.90	I
(A-4)	C_2	Short	.2			.29	
(M.B.)	C_1	Short	.2			.05	
	R_1, R_2, R_3, R_4	Short, open, or drift in value	1			4 (2.79)	
(M.B.)	C_2, C_3	Short, open, or drift in value	1			2 (.30)	
(A-4)	CR_5, CR_6	Short or open	1			2 (11.55)	
(A-4)	C_1, C_4	Short	.90			2 (.08)	
(A-3)	VR 1	Output inoperative	.65			22.60	
	C_1	Short	.90			.08	
	C_2	Short	.20			.05	
	R_1	Open	.05			.02	
	R_3	Open	.10			.28	
	R_2	Short	0			0	
	RT1	Short	.2			10.50	
(A-4)	Q_2, Q_3B	Collector-base short Collector-Emitter short	.125	Loss of 12 V to oscillator due to false turn on of power supply protection circuit.		2.84	
	Q_3 (A)	Emitter-base short, collector base, emitter open	.225			7.95	
	R_9, R_{11}	Open	.05			2 (.02)	
	R_{15}	Open	.10			.28	
	R_7, R_{10}, R_{12}, R_{14}	Short	0			0	

SYSTEM	PREPARED BY	NO.	REV.
ALSEP Array E	R. Hiebert	ATM 970	
END ITEM	DWG NO.	PAGE 84 of 183	
LMS	2347400		
ASSY	PART NO.	DATE	
LVPS	2347482	4/6/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10⁵	CRITICALITY
CR_4, CR_9	Short	.40		Loss of all Data	2 (4.62)	1
R_1	Open	.20	Loss of grd return		.42	
T_1	Open/Short	.50	Loss of part to one or move output supplies		17.50	
C_1	Short	.90			.08	
R_6, R_{19}	Open	-.10	Loss of inverter driving circuit.		2 (.28)	
R_9, R_{20}	Open	-.05			2 (.02)	
R_{17}	Open or drift up	.55			.22	
C_5	Short	.90			.08	
R_{16}, R_{18}	Short	0			0	
Q_4, Q_5, Q_6, and Q_7	all modes except B drift< 25%	.350			4 (15.90)	
C_1, C_2	Short	.20			2 (.29)	
Q_1, Q_2	All failure modes except B drift>25%	.350			2 (18.50)	
R_1	Open or Short	.05			.02	
CR_1 and CR_2	Open or Short	1			2 (11.55)	
CR_3 or CR_{12}	Open or Short	1	Loss of -15 and/or -20 volt supply		2 (11.55)	
C_3, C_4	Short or Open	.2			2 (.29)	
L_1	Open	.8			2.80	
R_1, R_2	Open, Short, or drift	1			2 (2.79)	
R_3	Open	.10			.04	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP Array E	R. Hiebert	ATM 970	
END ITEM	DWG NO.	PAGE 85 of 183	
LMS	2347400		
ASSY	DWG NO.	DATE	
LVPS	2347482	1/6/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10⁵	CRITICALITY
C_1	Short	.9	Loss of -12 and/or -15 volt supply	Loss of all Data	.08	1
C_2	Short	.2			.05	
VR_1	All failure modes	1			22.6	
C_4	Short	.2			.29	
CR_4, CR_{11}	Short or Open	1	Loss of -12 Volt Regulator		2 (11.55)	
C_{12}, C_{11}	Short/Open	.2			2 (.04)	
L_4	Open	.8			2.80	
C_3	Short	.9			.08	
C_4	Short	.2			.05	
R_6	Open	.05			.05	
R_5, R_4	Short/Open/Drift	1			2 (2.79)	
Q_1	All failure modes except B drift< 25%	.35			17.80	
VR-2	All failure modes	1			22.60	
Q_1	All failure modes except B drift< 25%	.35	Loss of +12 Volt Regulated supply		15.90	
VR_2	All failure modes	1			22.60	
R_5, R_6	Short/Open/Drift	1			2 (2.79)	
ART1	Short	.20			10.5	
C_3	Short	.90			.08	
C_4	Short	.20			.02	
R_4	Open	.05			.02	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP Array E	R. Hiebert	ATM 970	
END ITEM	DWG NO.	PAGE 86 of 183	
LMS	2347400		
ASSY	DWG NO.	DATE	
LVPS	2347462	5/6/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
C_5, C_6, C_9, C_{10}	Open/Short	.20	Loss of + 12 volt supply	Loss of all Data	4 (.04)	I
CR_6, CR_{10}	Open/Short	1			2 (13.81)	
L_2, L_3	Open	.8			2 (2.80)	
CR_5, C_9	Open/Short	1			2 (11.55)	
CR_7, CR_8	Open/Short	1	Loss of +5 volt source.		2 (13.81)	
C_7, C_8	Open/Short	.20			2 (.05)	
L_1	Open	.8			2.80	
R_3, R_4, R_5, R_6, R_7	Open, Short, or drift	1	Loss/incorrect readings of current from current monitor	Loss of Power Supply Current Monitor	7 (2.79)	IV
R_1, R_2						
AR_1	Output inoperative	.65			14.8	
C_1, C_2	Short	.90			2 (.08)	
R_1	Short/Drift	.8			1.70	
R_1, R_4	Open, Short	.1	Unable to turn multiplier H.V. off- Locked on	No Loss of Data	2 (.28)	IV
Q_{1A}, Q_{2A}		.35			2 (7.95)	
R_2, R_3		.1	Unable to turn multiplier H.V. on Locked off	Loss of all Data	2 (.28)	I
Q_{1B}, Q_{2B}		.35			2 (7.95)	
R_5, R_8	Short/Open	.1	Unable to turn multiplier gain low, locked high	Loss of some Data	2 (.28)	III
Q_3A, Q_4R	All modes except B drift>25%	.35			2 (7.95)	

SYSTEM	PREPARED BY	NO.	REV.
ALSEP Array E	R. Hiebert	ATM 970	
END ITEM	DWG NO.	PAGE 87 of 183	
LMS	2347400		
ASSY	DWG NO.	DATE	
LVPS	2347482	4/6/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
R_6, R_7	Short/Open	.1	Unable to turn multiplier gain high, locked low	Loss of Some Data	2 (.28)	III
Q_3B, Q_4B	All modes except B drift >25%	.35			2 (7.95)	
R_9, R_{12}	Short/Open	.1	Ion pump H. V. power supply locked on unable to turn off inoperate mode	No loss of Data	2 (.28)	IV
Q_5A, Q_6A	All modes except "B" drift>25%	.35			2 (7.95)	
R_{10}, R_4	Short/open	.1	Ion pump H. V. power supply locked off, unable to turn on inoperate mode	Loss of data on vacuum	2 (.28)	IV
Q_5B, Q_6B	All modes except B drift>25%	.35			2 (7.95)	
R_2	Open Short or Drift	1	Loss of temperature monitor on L. V. P. S.	Loss of temperature monitor on L. V. P. S.	2.79	IV
RT1		1			52.50	
R_3		1			2.79	
Connector Pins 4 & 24; 5&25; 14 & 34; 13 & 33; 15, 35, 17, 37, 29, 9 40, 11 & 31; 2 & 22; 10 & 30; 1 & 21; 3 & 23	Open Connection on connector	1	Loss of Power	Loss of Data	23.8	I
Connector Pins 39, 36, 38, 19, 20	Open Connection	1	Loss of house keeping data or 10n pump power	No Loss of Data	12.4	IV

SYSTEM	PREPARED BY	NO.	REV.
ALSEP "E"	R. HIEBERT	ATM 970	
END ITEM	DWG NO.	PAGE 88 of 183	
LMS			
ASSY	DWG NO.	DATE	
MULT HV/PS	2347571	5/15/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
AR1	All Failure Modes	1	Loss of Multiplier H.V. Monitor	Loss of Multiplier Hi-Voltage Power Supply housekeeping data	74.5	
C_1	Open/Short	19			.08	
R_1, R_2, R_3, R_4	Short, Open, or Drift	1			4.(.39)	IV
A2 - R6	Short, Open, or Drift	1			.39	
CR3, CR4	Open, Short	.6			2(6.80)	
A-1:			Loss of Multiplier H.V.	Loss of all Data		
C_1, C_2, C_3,	Short or Open	.9			3(.08)	
C_4, C_5, C_6	Short or Open	.9			3(.08)	
CR_1 Thru CR_{12}	Short or Open	.60			116.00	
T_1	All Failure Modes	1			35.00	
A-2:						I
C_1, C_2, C_3, C_4	Short	.90			4(.08)	
R_1, R_2, R_3, R_4, R_5	Open	.05			5(.02)	
Q_2, Q_3	Collector Base Short	.125	Oscillator will not		2(3.52)	
R_8, R_9	Open	.05	Operate		2(.02)	
R_6, R_7	Short	0			2(.08)	
C_2, C_3						
Q_1	Emitter, base, or collector	.225	Loss of Power to Oscillator	Loss of Multiplier High	44.60	I
Q_4	Open; Emitter-Base Short			Voltage and All Data	6.35	
Q_5, Q_6	Collector-Base Short	.125			2(3.52)	
C_6	Short	.200			.23	
C_7	Short	.200			1.35	
CR_6	Open	.20			2.76	
R_5, R_{11}, R_{14}	Open	.05			3(.02)	
R_{13}	Short or Open	.05			.03	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP "E"	F. HEBERT	ATM 970	
END ITEM	DWG NO.	PAGE 89 of 183	
LMS			
ASSY.	PART NO.	DATE	
MULT. HV/PS	2347571	5/15/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
VR_1	Short	.30	Loss of oscillator	Loss of all data	10.60	I
C_5, C_9	Short or Open	.90			2(.08)	
CR_5	Short/Open	.60			6.80	
CR_1, CR_2	Short	.40			2(4.52)	
K_1	All Failure on dates	1			5.00	
K_2	All Failure Modes	1	Loss of Regulation and/or ability to change gain	Partial Loss of data	5.00	II
CR_9, CR_{10}, CR_6	Short	.40			3(4.52)	
Q_1	Collector-Base Short	.125			24.80	
Q_4	Collector-Base Short	.125			3.52	
Q_6	Emitter, Base, or Collector Open	.225			6.35	
VR_1	Open	.10			1.13	
CR_7, CR_8	Short or Open	.60			2(6.80)	
C_8, C_9	Short or Open	.90			2(.02)	
R_{15}, R_{16}	Short or Open	.05			2(.02)	
R_{17}, R_{18}, R_{19}, R_{20}	Short, Open, or Drift	1.0			4(.39)	
R_5, R_{11}	Short	0			0	
R_{10}	Open	.05			.02	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE (11) OF 183	
LMS			
ASS'Y	DWG NO.	DATE	
Ion Pump H. V. P. S.	2347570	5/15/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^3	CRITICALITY
Q1	C-B Short	.125	Regulator inhibited from turning on	Ion pump cannot be turned on	2.89	IV
Q2	E-B Short; Collector, Base, or Emitter Open	.225			11.45	
Q3					17.80	
Q4					5.20	
VR1	Short	.30			3.46	
R1	Open	.05			.02	
C1	Short	.20			.10	
R3, R4	Short, Open, or Drift	1			2(.39)	
R5	Open, Short, or Drift	1			(.35)	
R2	Open	.05			.02	
CR1, CR2	Short	.40			2(4.61)	
K1	All failure modes	1			5.00	
C2	Shorted	.2	Oscillator inoperative		.10	IV
Q5	Emitter-base; collector-base short or emitter, base, or collector open	.350			16.80	
C3	Short	.90			.08	
R7	Short or Open	.05			.02	
C4	Open or Short	.90			.08	
R6	Short or Open	.05			.02	
T1	Open or Short	1	Failure of H. V. Output		35.00	
C1 thru C9	Short or Short	.90			9(.08)	
CR1 thru CR16	Open or Short	.60			16(6.94)	
R1	Open	.05			.02	
R2	Short	0			0	
CR3	Open or Short	.60	Loss of high voltage out monitor	No effect on Ion pump. Loss of housekeeping data	6.94	IV
R8, 9, 10	Open or Short	.05			3(.02)	
C5	Short or Open	.90			.08	
CR4	Open or Short	.60	Loss of temp compensation to voltage out monitor	No loss of data; no effect on circuit	0	0
Q2	Collector-base Short	.125	Loss of Regulation on high voltage output	Ion pump voltage will be high or low		IV
Q3						
Q4						
VR-1	Open	.10			2.90	
R2	Short	.05			.02	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP E	PREPARED BY: R. Hiebert	NO.: ATM 970	REV.
END ITEM: LMS	DWG NO.	PAGE 91 of 183	
ASSY: Ion Pump H.V.A.S	DWG NO.: 2347570	DATE: 5/15/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R_{28}, R_{29}, R_{34}, R_{21}, R_{22}, R_{26}, R_{13}, R_{37}, R_{15}, R_{40}, R_{41}, R_{42}	Drift Up or Open	.5	AR1 reads high; AR3 reads high AR2 reads low	Monitor will indicate high current	13(.20)	IV
R_{43}, R_{32}	" "	.5			1 (.17)	
Q_6 (5, 6, 7)	Collector-Emitter or Collectorbase. Short	.125			2.89	
Q_6 (1, 2, 3)	Emitter-base Short	.225			5.20	
	Emitter, Collector, base Open	.			18 (.19)	
R_{12}, R_{14}, R_{11}, R_{16}, R_{17}, R_{18}, R_{19}, R_{20}, R_{23}, R_{24}, R_{25}, R_{27}, R_{31}, R_{30}, R_{39}, R_{38}, R_{35}, R_{36}	Drift Down or Short	.5				
AR1, AR3,	Output Locks High	.5			2(11.65)	
AR2,	Output Low	.5			11.65	
CR5, CR6	Short	.4	Output of AR3 incurrent	Loss of Current Monitor	2(1.59)	IV
C_8, C_9, C_{10}, C_{11}, C_{14}, C_{17}, C_{18}	Short	.9			6(.09)	
C_8, C_9, C_{11}, C_{14}, C_{17}, C_{18}	Open	0	Amplifiers may oscillate		0	
C_6, C_7, C_{12}, C_{13}, C_{15}, C_{16}	Short	.9	Loss of + or - 12Volt DC Power	Loss of all data	6(.09)	I

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E		ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		92 of 183	
ASSY	DWG NO.	DATE	
Ion Pump H. V. P. S	2347570	5/15/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R_{11}, R_{12}, R_{14}, R_{16}, R_{17}, R_{18}, R_{19}, R_{20}, R_{23}, R_{24}, R_{25}, R_{27}, R_{30}, R_{31}, R_{35}, R_{36}, R_{38}, R_{39}	Drift Up or Open	.5	AR1, AR3, reads low AR2 reads high	Monitor will indicate a low current	18(.20)	IV
Q_6 (1, 2, 3)	Collector-Emitter or Collector base short	.125			2.89 5.20	
Q_6 (5, 6, 7)	Emitter-base short Emitter, base, or Collector Open	.225				
R_{13}, R_{15}, R_{21}, R_{22}, R_{26}, R_{27}, R_{29}, R_{34}, R_{37}, R_{40}, R_{41}, R_{42}	Drift Down or Short	.5			14(.19)	
R_{43} R_{32}	" " "	.5			(.18)	
AR1, AR3	Output locks ion	.5			2(11.65)	
AR2	Output High	.5			11.65	

SYSTEM	PREPARED BY	NO.	REV.
AILSEP "E"	R. Hiebert	ATM 970	
END ITEM LMS	DWG NO.	PAGE 93 OF 183	
ASSY Control & Monitor	DWG NO. 2347532	DATE 4/27/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R_6	Shorted/Open	.05	Unable to release dust cover	Partial loss of data	<< .01	
C_1, C_2, C_3	Open/Shorted	.20			<< .01	
U_1 Pin 6	Locked Low	.50			.02	II
R_7 R_8	Open/Short	.05			<< .01	
K_2	Locked Open	.50			2.50	
CR_3	Shorted	.40				
Q_3A	Emitter base Short	.225			4.62	
Q_3B	Emitter, base, or collector open	.225			10.60	
J_1		1.00			11.25	
J_1	Pin 12, 19, 16, 17 open	1.00			<< .01	
R_9, R_{20}	Open	.20			<< .01	
C_4	Short	.20	Loss of +5 volts	Loss of all data	.03	I
R_{12}, R_{13}	Short/Open	.05	Loss of backup heater control	No loss of data	2(.14)	IV
R_{10}, R_{11}	Short/Open	.05			2(.15)	
Q_{4A}, Q_{4B}	All Failure modes except β drift < 25%	.35			2(16.45)	
Q_{5A}, Q_{5B}	Same as above	.35			2(17.70)	
CR_4, CR_5	Short	.40			2(4.62)	
K_3	Locked in position A or B	1.00			3.00	
J_1	Pin 8, 20 open	1.00			2(1.93)	
R_{21}	Open/Short	.30			2.61	
R5	Open Short drift	1	Loss of Analoge Channel	Loss of analoge channel to ground	2.78	IV

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP "E"	R. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		94 of 183	
ASSY	DWG NO.	DATE	
Control & Monitor	2347532	4/27/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
J_1	Pin 29, 15, 11, open	1.00	Loss of control for bake out heater in standby	LMS cannot be outgassed	3(1.93)	IV
K_4, K_5	Locked open	.50			2(1.50)	
K_1	Locked "A"	.50			1.50	
CR_2	Shorted	.40			4.62	
Q_2B	Emitter - base short;	.225			11.40	
Q_1B	Emitter, base, collector open	.225			10.60	
R_1	Open	.05			.15	
R_4	Open	.05			.13	
Q_2A	Collector Base Short	.125			6.35	
Q_1A	Collector Base Short	.125			5.88	
R_2	Shorted	.0			0	
CR_6	Shorted	.40			4.62	
K4, 5	Locked Shut	.5	Unable to disconnect bake out heaters	Arcing of high voltage Loss of all data	2(1.50)	I
K_1	Locked B	0	Unable to turn off bake out heater in standby	No effect on data	0	0
CR_1	Shorted					
Q_2A	Emitter base Short					
Q_1A	Emitter, base, collector open					
R_2	Open					
R_3	Open					
Q_2B	Collector-base Short					
Q_1B	Collector-base Short					

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP "E"	PREPARED BY: R. Hiebert	NO.: ATM 970	REV.: B
END ITEM: LMS	DWG NO.:	PAGE 25 OF 193	
ASS'Y: Control & Monitor	DWG NO.: 2347532	DATE: 4/27/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^3	CRITICALITY
R_1	Shorted	0	Unable to turn off bake out heater in standby	No effect on data	0	0
$R_{14/15}$	Open		Loss of survival heaters		0	0

APPENDIX B

UTD FMECA WORKSHEETS

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	
END ITEM	DWG NO.	PAGE	
LMS		97 of 183	
ASSY	DWG NO.	DATE	
ANALYZER		2-10-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
Multiplier #1	Low Gain	.5	Loss of data for one mass range	No counts on one mass range	35.03	2
	Open Connection	.5	Loss of data for one mass range	No counts on one mass range	35.03	2
R1 - R16	Open	.1	Loss of data for one mass range	No counts on one mass range	77.789	2
	Drift	.9	Minor effect	Slight change in multiplier gain	700.11	4
Multiplier #2	Low Gain	.5	Loss of data for one mass range	No counts on one mass range	35.03	2
	Open Connection	.5	Loss of data for one mass range	No counts on one mass range	35.03	2
R17 - R32	Open	.1	Loss of data for one mass range	No counts on one mass range	77.789	2
	Drift	.9	Minor effect	Slight change in multiplier gain	700.11	4
Multiplier #3	Low Gain	.5	Loss of data for one mass range	No counts on one mass range	35.03	2
	Open Connection	.5	Loss of data for one mass range	No counts on one mass range	35.03	2
R33 - R48	Open	.1	Loss of data for one mass range	No counts on one mass range	77.789	2
	Drift	.9	Minor effect	Slight change in multiplier gain	700.11	4
Filament #1	Open	1.0	None unless Filament #2 fails	No Filament #1 emission	71.82	3
Filament #2	Open	1.0	None unless Filament #1 fails	No Filament #2 emission	71.82	3
Temperature Sensor	Open	.1	No temperature indication for flanges	No temperature sensor	7.97	3
	Drift	.9	Error in temperature indication	Error in sensor	71.75	3
Bakeout Heater	Open	.2	Data during first month of mission may be inaccurate	Cannot bake out ion source	35.04	3
	Short	.1	Data during first month of mission may be inaccurate	Cannot bake out ion source	17.52	3
	Drift	.7	No effect	No effect	122.64	4
Analyzer Alignment	Loss of mechanical alignment	1.0	Loss of data	Loss of output	1.752	1

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM ALSEP E	PREPARED BY J. Carrol	NO. ATM 970	REV. B
END ITEM LMS	DWG NO.	PAGE 38 of 183	
ASSY ANALYZER	DWG NO.	DATE 2-10-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^3	CRITICALITY
Breakscal	Will not open	1.0	No useful data	Cannot expose analyzer to atmosphere	1.752	1
on Pump	Open or short	1.0	Possible loss of some data in early part of mission	Vacuum may not be maintained in	876	4

E MISSION CONTI

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	R. W. Hiebert	ATM 970	
END ITEM	DWG NO.	PAGE	
LMS		99 of 183	
ASS'Y	DWG NO.	DATE	
Mother Brd	151-552	3-13-72	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
R_{27} thru R_{35}	Open or Short	.1	Loss of J Plate Voltage	Loss of all data	2.94	I
R_{26}	Open/Short	.05			.02	
CR 29 (Z)	Short	.3			21.54	
CR25 thru 28	Short	.4			3.50	
K5 & 6	All Failure Modes	1.0	J Plate Voltage Cannot be changed	Data difficult to interpret	3.50	II
CR29	Drift or Open	.7			50.26	
R_{27} thru R_{35}	Drift	.9			26.49	
Z6	All Failure	1			31.50	
$R_{18, 39, 42}$	Open/Short	.05			.02	
Q7	All but B drift < 25%	.3			6.94	
CR32	Open	.2			1.75	
Z8 - 10	Locked in 1/0	1			4.38	
Z9 - 3	Locked in 1/0	1			8.76	
Z8 - 2	Locked in 1/0	1			4.38	
Z8 - 6	Locked in 1/0	1			4.38	
CR11, 12, 13 15, 16, 10	Open/Short/drift	1.0	Incorrect/loss of Emission Control Voltage in multi Mode. Unable to step through E. C. Voltage	Loss of function	71.8	III
CR14	Open/Short	.6			5.26	
CR21 thru 24	Short	.4			3.50	
CR17 thru 20	Short/Open	.6			5.26	
K_3/K_4	Any Failure	1			3.50	
K_2	B_1 to B_2 open A_1 to A_2 open Y coil inoperative	.6			2.10	
CR-10	Open/Short/drift	1			71.80	
R25	Open/Short	.05			.02	
$R_{16, 40, 37}$	Open/Short	.05			.02	
Q_5	All but B drift < 25%	.3			6.94	
CR30	Open	1			1.75	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
Z8 -14	Locked in 1/0	1	Incorrect/loss of Emission Control Voltage in multi Mode. Unable to step through E. C. Voltage	Loss of function	4.38	
Z9 - 5	Locked in 1/0	1			8.76	
Z4 & 7	All failure	1			31.50	
R20	Open/Short	.05			.02	
$R_{43, 44, 45}$	Short or Open	.02			.02	
R_{19}		.02			.02	
R_{22}	Short	0.0			0.00	
Q8, 9, 10	All but β drift < 25%	0.3			6.94	
R_{21}	Open	.10			2.94	
R_{22}	Open	.05	Loss of sweep Hi Voltage	Loss of all data	0.04	I
R_{21}	Short	0.0			0.00	
C7	Short	.9			0.71	
$R_{23, 24, 14, 15}$	Short open drift	(1)	Loss of Emission Current monitor/ Incorrect readings	Loss of Housekeeping data	.38	III
S1		(1)			25.00	
CR33	Open/Short	.6			5.26	
Z3	All failure Modes	1.0			31.50	
C6	Short	.9			0.71	
Z9 - 13	Locked in 1/0	1.0	Unable to switch E. C. to the fixed mode of operation	Loss of function, no loss of data	8.76	III
Z8 - 12		1.0			4.38	
CR31	Open	.2			1.75	
$R_{14, 41, 38}$	Open/Short	.05			.02	
Z5	Any failure	1.0			31.50	
K2	X Coil open A1/A2 or B2/B3 open	.4			1.40	
Q_6	All but β drift < 25%	.3			6.94	

EMISSION CONTR

SYSTEM	PREPARED BY	NO.	REV
ALSEP E	R. W. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		101 of 183	
ASS'Y	DWG NO.	DATE	
Mother Brd	151-552	3-13-72	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^5$	CRITICALITY
CR1	Shorts	.4	E. C. Power oscillator stops loss. E. C. Voltage	Loss of all data	3.5	I
R_1	Shorts/Opens	.05			.02	
L1	Opens	.25			8.76	
R_8	Opens	.05			.02	
C2	Shorts/Opens	.2			.25	
T1	Coil 1, 2, 3 open/short	.5			2.92	
	Coil 4, 5, 6 open/short	.5			2.92	
	Coil 7, 8 short	.25			.73	
	Coil 9, 10 short	.25			.73	
	Coil 11, 12, 13 short	.25			1.46	
	Coil 14, 15 short or open 16, 17 18, 19 19, 20	.50			1.46	
C3	Short	.1			.09	
Q1	All But B drift < 25%	.3			13.77	
Q2	All But B drift < 25%	.3			13.77	
T1	Coil 7 - 8 open	.24	No Filament #1 current	None unless Filament #2 Fails	.73	III
T2	Coil 3 - 4 open	.25			4.38	
T3	Coil 3 - 4 open	.25			4.38	
T4	Coil 1 - 2 open	.25			4.38	
D1	Coil #2 open or bud cont.	.5			1.75	
Q3	Open	.2			4.94	
R_{11}, R_{10}	Open	.05	Filament #1 can not be commanded on		.02	
Z1	All But Sensor Short	.8			25.2	
Z2	Sensor short	.2			6.3	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
R_6	Open	.05	No Control on Filament #1 current		.02	III
T1	Coil 9 - 10 open	.25	No Filament #2 current	None unless Filament #1 fails	.73	III
T5	Coil 3 - 4 open	.25			4.38	
T6	Coil 3 - 4 open	.25			4.38	
T7	Coil 1 - 2 open	.25			4.38	
K1	Coil #1 open or short bad contacts	.5			1.75	
Q4	Open	.2	No		4.94	
Z1	Sensor Short	.4	Filament #2 can not be commanded on		6.30	
Z2	All but sensor short	.6			25.20	
R_{12}, R_{13}	Open	.05			.02	
R_7	Open	.05	No Control on Filament #2 current		.02	
R_4, R_5	Open	.05	No Filament #1 monitor or incurrent values noted	Loss of monitor on Housekeeping	.02	III
CR2, 3, 4, 5	Open/Short	.6			6.63	
C4	Short	.1			.09	
T4	Coil 1 - 2 short	.25			4.38	
	Coil 3-4 open or short	.5			8.76	
T7	Coil 1 - 2 short	.25	No Filament #2 monitor or incorrect valves noted		4.38	
	Coil 3 - 4 open or short	.5			8.76	
C5	Short	.1			.09	
R_8, R_9	Open	.05			.02	
CR6, 7, 8, 9	Open or short	.6			6.63	
T5	Coil 1-2 open/short	.5	Filament #2 operates at all times at maximum current	Minor degradation of data	8.76	III
	Coil 3-4 short	.25			4.38	
T6	Coil 1-2 open/short	.5			8.76	
	Coil 3-4 short	.25			4.38	
T2	Coil 1-2 open/short	.5	Filament #1 operates at all times at maximum current		8.76	

EMISSION CONTRO.

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	R. W. Hiebert	ATM 970	B
END ITEM	DWG NO.	PAGE 103 of 183	
LMS			
ASSY	DWG NO.	DATE	
Mother Brd	151-552	3-13-72	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
T3	Coil 3-4 short	.25	Filament #1 operates at all times at maximum current	Minor degradation of data	4.38	III
	Coil 1-2 open/short	.5			8.76	
	Coil 3-4 short	.25			4.38	
T1	Coil 11-12 open	.25	Filament current operates about 1/2 power		.73	
	Coil 12-13 open	.25			.73	

EMISSION CONTROL

SYSTEM	PREPARED BY	NO.	REV.
ALSEP "E"	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		108 of 183	
ASSY	DWG NO.	DATE	
EC-1	151-55L	3-13-72	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE		FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
			ASSEMBLY	END ITEM		
C1	Short	.9	No effect unless system overheats	No effect except 1.74 watt extra power dissipated lm K1.	2.71	3
C2	Short	.9	No effect unless system overheats	No effect except 1.74 watt extra power dissipated lm K1.	2.71	3
R1	Open	.05	No effect unless Filament #2 fails	Filament #1 will not operate	.032	3
R2	Open	.05	No effect unless Filament #1 fails	Filament #2 will not operate	.032	3
R3	Open	.05	No system effect unless Filament #2 is on	Filament #1 cannot be turned off	.019	3
R4	Open	.05	No system effect unless Filament #1 is on	Filament #2 cannot be turned off	.019	3
R5	Open	.05	Filament #2 command might not operate - Filament #1 - OK	C2 of K1 would be energized for Filament #1 or Filament #2 command	.019	3
R6	Open	.05	None unless Filament #2 fails	Filament #1 cannot be turned on	.019	3
R7	Open	.05	None unless filament in operation fails	Filament commands will not function	.019	3
R8	Open	.05	None unless Filament #1 fails	Filament #2 connot be turned on	.019	3
R9	Open	.05	Filament #1 command might not operate Filament #2 - OK	C2 of K1 would be energized for Filament #2 or Filament #1 command	.019	3
R10	Open	.05	No effect	Filament #1 will not turn off	.019	4
R11	Open	.05	No effect	Filament #2 will not turn off	.019	4
Q1	Open	.2	No effect	Filament #1 cannot be turned off	4.24	4
	Short	.1	No effect unless Filament #2 faile	Filament #1 cannot be turned on	2.12	3
Q2	Open	.2	No effect	Filament #2 cannot be turned off	4.24	4
	Short	.1	No effect unless Filament #1 fails	Filament #2 cannot be turned on	2.12	3

EMISSION CONTROL

SYSTEM	PREPARED BY	NO.	REV.
ALSEP "E"	J. Carrol	ATM970	B
END ITEM	DWG NO.	PAGE	
LMS		105 of 183	
ASSY	DWG NO.	DATE	
EC-1	151-55L	3-13-72	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
Q3	Open	.2	No effect unless Filament #2 fails	Filament #1 cannot be turned on	7.0	3
	Short	.1	Filament #2 command will not function Filament #1 command OK	Filament #2 command would try to turn on both filaments - Filament #1 command OK	3.5	3
Q4	Open	.2	No output data	Neither Filament could be energized	.70	1
	Short	.1	Power consumption in K1 up 1.84w	Relay K1 would be energized at all times	3.5	3
Q5	Open	.2	No effect unless Filament #1 fails	Filament #2 cannot be turned on	7.0	1
	Short	.1	Filament #1 command will not function Filament #2 command OK	Filament #1 command would try to turn on both filaments - Filament #2 command OK	3.5	3
CR1	Open	.2	No effect unless Filament #2 fails	Filament #1 cannot be turned on	2.20	3
	Short	.4	No effect unless one filament fails	Filament #2 command would energize both coils of K1	4.41	3
CR2	Open	.2	No effect unless Filament #1 fails	Filament #2 cannot be turned on	2.2	3
	Short	.4	No effect unless one filament fails	Filament #1 command would energize both coils of K1	4.41	3
CR3	Open	.2	No probable effect	No effect unless high meg. transcient occurs	2.20	4
	Short	.4	High power dissipated in relay (1.84w)	Q4 on at all times	4.41	3
CR4	Open	.2	No effect unless Filament #2 fails	Transcient could damage Q3 and Filament #1 could not be turned on	1.75	3
	Short	.4	No effect unless Filament #2 fails	Filament #1 could not be turned on	3.5	3
CR5	Open	.2	No effect unless Filament #1 fails	Transcient could damage Q3 and Filament #2 could not be turned on	1.75	3
	Short	.4	No effect unless Filament #1 fails	Filament #2 could not be turned on	3.5	3

EMISSION CONTROL

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	R. W. Hiebert	ATM 970	B
END ITEM LMS	DWG NO.	PAGE 106 of 183	
ASS'Y E.C.-2	DWG NO. 151-552	DATE 3-14-72	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^3	CRITICALITY
C_2, C_3, C_4, C_7, C_8	Drift	.1	Filament current unstable		.09	III
R6, R7, R9	Open	.05	Loss of current monitor	Loss of current monitor in housekeeping	.02	III
C_7, 8	Short	.9			.79	
CR6, CR8	Short	.4			3.50	
Z2	Output open or shut	.65			37.58	
Z1	Output open or short	.65	Loss of filament 1 and 2 current	Loss of all data	37.58	I
C_2, C_3, C_4	Short	.9			.79	
C_5, C_9, C_6	Short	.9			.79	
R2, R8, R3, R5	Open	.05			.02	
R4, R1	Open	.05			.02	
C_1, C_4	Short	.9	Emission current not correct	Data difficult to interpret	.78	III
CR5, CR7	Drift	.60			42.06	

EMISSION CONTROL

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		107 of 183	
ASS'Y	DWG NO.	DATE	
EC-3	151-551	3-13-72	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE		FAILURE PROBABILITY Q x 10^5	CRITICALITY
			ASSEMBLY	END ITEM		
C1	Short	.2	No output data	No 6V filament control voltage - overloads transformer	.246	1
C2	Short	.2	No output data	No 45 volt supply - overloads transformer	1.16	1
C3	Short	.1	No output data	No -80 volt supply - overloads transformer	.517	1
C4	Short	.2	No output data	No +13 volt supply output - overloads transformer	.61	1
C5	Short	.2	No output data	No -13 volt supply output - overloads transformer	.61	1
CR1	Open or Short	.6	No output data	No 6V supply output	5.26	1
CR2	Open or Short	.6	No output data	No 6V supply output	5.26	1
CR3	Open or Short	.6	No output data	No +45V supply output	5.26	1
CR4	Open or Short	.6	No output data	No +45V supply output	5.26	1
CR5	Open or Short	.6	No output data	No +45V supply output	5.26	1
CR6	Open or Short	.6	No output data	No +45V supply output	5.26	1
CR7	Open or Short	.6	No output data	No -80V supply output	5.26	1
CR8	Open or Short	.6	No output data	No -80V supply output	5.26	1
CR9	Open or Short	.6	No output data	No -80V supply output	5.26	1
CR10	Open or Short	.6	No output data	No -80V supply output	5.26	1
CR11	Open or Short	.6	No output data	No +13V supply output	5.26	1
CR12	Open or Short	.6	No output data	No +13V supply output	5.26	1
CR13	Open or Short	.6	No output data	No -13V supply output	5.26	1
CR14	Open or Short	.6	No output data	No -13V supply output	5.26	1

EMISSION CONTROL

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	R. W. Hiebert	ATM 970	B
END ITEM LMS	DWG NO.	PAGE 108 of 183	
ASSY E.C.-4	DWG NO. 191-352	DATE 3-14-72	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
Q_1	All but drift in β < 25%	.3	Loss of ability to command E.C. into multi-mode function	Loss of function	6.94	III
CR5	Open 1 short	.6			5.26	
C_1	Open/short	.9			.71	
R1, R2, R9	Open/short	.05			.02	
CR1	Short	.3			21.54	
Q_2	All but drift in β < 25%	.3	Loss of ability to command E.C. into straight mode function		6.94	
CR6	Open/short	.6			5.26	
R3, R4, R10	Open/short	.05			.02	
CR2	Short	.3			21.54	
C_2	Open/short	.9			.71	
Q_3	All but β drift < 25%	.3	Loss of J plate voltage control	Possible loss of data	6.94	I
R5, R6	All failure modes	1			.3	
C_3, C_4	All failure modes	1.0			.88	
R11	Open/short	.05			.02	
CR3	Short	.3			21.54	
Q_4	All but β drift < 25%	.3	Loss of ability to advance step in multi mode. Locked in on step.	Loss of function	6.94	II
R7, R8,	All failure modes	1			.38	
C_3, C_4	All failure modes	1.0			.88	
R12	Open/shut	.05			.02	
CR4	Short	.3			21.54	

Pages 109 through 119 have been deleted due to the "B" revision.

PRE-AMP/DISCRIMINATOR

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E		ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		120 of 183	
ASSY	DWG NO.	DATE	
CAL. OSC	151-660	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
R1	Open	.05	All discriminators stay in High Gain state	Output stays in low position	.019	3
	Drift	.95	No effect	No appreciable effect	.366	4
R2	Open	.05	All discriminators stay in High Gain state	Output stays in low position	.019	3
	Drift	.95	No effect	No appreciable effect	.366	4
R3	Open	.05	No internal calibrate signal	Loss of signal	.019	3
	Drift	.95	No effect	No effect	.366	4
R4	Open	.05	Loss of internal calibrate signal	Loss of signal	.019	3
	Drift	.95	No effect	No effect	.366	4
R5	Open	.05	Loss if internal calibrate signal	Loss of signal	.019	3
	Drift	.95	Minor	Output signal pulse shape change	.366	3
R6	Open	.05	Minor	Output signal pulse shape change	.019	3
	Drift	.95	No effect	No effect	.366	4
C1	Short	.9	Loss of internal calibrate signal	Loss of signal	.788	3
	Drift	.1	No effect	No effect	.088	4
C2	Short	.9	Loss of internal calibrate signal	Loss of signal	.788	3
	Drift	.1	No effect	No effect	.088	4
C3	Short	.9	Loss of +5V power supply - no output	Loss of signal	.788	1
	Drift	.1	No effect	No effect	.088	4
C4	Short	.9	Loss of internal calibrate signal	Loss of signal	.788	3
	Drift	.1	No effect	No effect	.088	4

PRE-AMP/DISCRIMINATOR

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E		ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		121 of 183	
ASSY	DWG NO.	DATE	
CAL. OSC	151-660	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^5	CRITICALITY
Q1	Open	.2	All discriminators stay in low gain state	Output stays in high state	4.62	3
	Short	.1	All discriminators stay in high gain state	Output stays in low state	2.31	3
	Drift	.70	Discriminators position may stay in high gain state	Output may not stay in high state	16.19	3
Q2	Open or Short	.30	Loss of internal calibrate signal	Loss of signal	6.36	3
	Drift	.70	Minor	Output wave shape change	14.84	3
CR1	Short	.4	All discriminators may stay in high gain state	Output may stay in low position	4.416	3
	Open	.2	All discriminators stay in low gain state	Output stays in high position	2.208	3
	Drift	.4	No effect	No effect	4.416	4
CR2	Short	.4	All discriminators stay in low gain state	Output stays in high position	4.416	3
	Open	.2	All discriminators stay in high gain	Output stays in low position	2.208	3
	Drift	.4	No effect	No effect	4.416	4
CR3	Short	.4	All discriminators may stay in high gain state	Output may stay in low position	4.416	3
	Open	.2	All discriminators stay in low gain state	Output stays in high position	2.208	3
	Drift	.4	No effect	No effect	4.416	4
Z1	1 of 4 gates low	.7	Loss of internal calibrate signal	Loss of signal	18.4	3
	1 of 4 gates high	.3	Loss of internal calibrate signal	Loss of signal	7.88	3
Z2	One shot open or short	1.0	Loss of internal calibrate signal	Loss of signal	26.28	3
XTL 1	Open or short	1.0	Loss of internal calibrate signal	Loss of signal	105.12	3

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		122 of 183	
ASSY	WMS NO.	DATE	
Pre-Amp/Discriminator	151-660	2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R1 Module #1	Open	.05	Loss of internal calibrate signal	No internal calibrate signal	.019	3
	Drift	.95	No effect	No effect	.366	4
R2	Open	.1	No calibrate signal	Calibrate signal saturates pre-amp	.294	3
	Drift	.9	No effect	No effect	2.649	4
R3	Open	.05	No data output on one mass range	Loss of pre-amp output	.019	2
	Drift	.95	No effect	No effect	.366	4
R4	Open	.05	Loss of one mass range data	No output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R5	Open	.1	Loss of one mass range data	No output signal	.294	2
	Drift	.9	Slight loss of data	Change in gain	2.649	3
R6	Open	.1	Loss at one mass range	No output signal	.294	2
	Drift	.9	Slight loss of data	Change in gain	2.649	3
R7	Open	.05	Loss of one mass range data	Loss of signal	.019	2
	Drift	.95	No effect	No effect	.306	4
R8	Open	.1	Loss of one mass range data	Loss of output signal	.294	2
	Drift	.9	Slight loss of data	Change in gain	2.649	3
R9	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R10	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R11	Open	.05	Loss of one mass range data	Loss of output signal	.019	2

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J+ Carrol	ATM 970	
END ITEM	DWG NO.	PAGE	
LMS		123 of 183	
ASSY	DWG NO.	DATE	
Pre-Amp/Discriminator	151-660	2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
	Drift	.95	No effect	No effect	.366	4
R12	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R13	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	Slight effect in pulses counted	No effect	.366	4
R14	Open	.05	Loss of one mass range data	Lofs of output signal	.019	2
	Drift	.95	Slight effect in pulses counted	No effect	.366	4
R15	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	Slight effect in pulses counted	No effect	.366	4
R16	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R17	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R18	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R19	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R20	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R21	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		124 of 183	
ASS'Y	DWG NO.	DATE	
Pre-Amp/Discrimin[illegible]or 151 660		2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
	Drift	.95	No effect	No effect	.366	4
R22	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R23	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R24	Open	.05	Minor effect	Cannot change discriminator gain	.019	3
	Drift	.95	No effect	No effect	.366	4
R25	Open	.05	Minor	Circuit in slightly higher than high gain position	.019	3
	Drift	.95	No effect	No effect	.366	4
R26	Open	.05	Minor	Circuit in slightly higher then high gain position	.019	3
R27	Open	.05	May count noise pulses	Circuit in very high gain position	.019	2
	Drift	.95	No effect	No effect	.366	4
R28	Open	.05	No pulses counted Loss of one mass range	Discriminator gain extremely low	.019	2
	Drift	.95	Slight effect	Slight change in gain	.366	3
R29	Open	.05	Loss of some data	Discriminator output erratic	.019	2
	Drift	.95	No effect	No effect	.366	4
R30	Open	.05	Loss of one mass range	Loss of output signal	.019	2
	Drift	.95	No effect	No appreciable effect	.366	4
R31	Open	.05	Loss of some data	Discriminator output erratic	.019	2
	Drift	.95	Slight effect	Slight offset	.366	3
R32	Open	.05	Loss of one mass range	No output	.019	2

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP B	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE 125 of 183	
LMS			
ASSY	DWG NO.	DATE	
Pre-Amp/Discriminator	151-660	2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
	Drift	.95	No effect	No effect	.366	4
R33	Open	.05	Loss of some data	Discriminator output erratic	.019	2
	Drift	.95	No effect	No effect	.366	4
R34	Open	.05	Loss of one mass range data	No output	.019	2
	Drift	.95	No effect	No effect	.366	4
C1	Drift	.1	No effect	No effect	.007	4
	Short	.9	Loss of one mass range data	Signal line loaded	.063	2
C2	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	Signal line loaded	.788	2
C3	Drift	.1	No effect	No effect	.007	4
	Short	.9	Loss of one mass range data	Loss of signal	.063	2
C4	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C5	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C6	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C7	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C8	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C9	Drift	.1	No effect	No effect	.088	4

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	
END ITEM	DWG NO.	PAGE 126 of 183	
LMS			
ASSY	DWG NO.	DATE	
pre-Amp/Discriminator	151-660	2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^3	CRITICALITY
C10	Short	.9	Loss of one mass range data	No output signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C11	Short	.9	Loss of one mass range data	No output signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C12	Short	.9	Loss of one mass range data	No output signal	.788	2
	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C13	Short	.9	Loss of some data	Loss of discriminator gain	.788	2
	Drift	.1	No effect	No effect	.088	4
C14	Short	.9	Loss of data on one mass range	R19 will fail open No discriminator output	.788	2
	Drift	.1	No effect	No effect	.088	4
C15	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C16	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C20	Short	.9	Loss of data	Loss of Sweep High Voltage isolation	.788	1
	Drift	.1	No effect	No effect	.088	4
C17	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No appreciable change	Output pulse width becomes smaller (30 n)	.088	4
C19	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	
END ITEM	DWG NO.	PAGE 127 of 183	
LMS			
ASSY	DWG NO.	DATE	
Pre-Amp/Discriminator	151-660	2-10-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10⁻⁹	CRITICALITY
C18	Short	.9	Loss of data	No +5 power	.788	1
	Drift	.1	No effect	No effect	.088	4
Q1	Short or Open	.3	Loss of one mass range data	Loss of output signal	8.23	2
	Drift	.7	May lose some data	Change in gain	19.19	3
Q2	Short or Open	.3	Loss of one mass range data	Loss of output signal	6.36	2
	Drift	.7	May lose some data	Change in gain	14.84	3
Q3	Short or Open	.3	Loss of one mass range data	Loss of output signal	12.93	2
	Drift	.7	May lose some data	Change in gain	30.17	3
Q4	Short or Open	.3	Loss of one mass range data	Loss of output signal	6.36	2
	Drift	.7	May lose some data	Change in gain	14.84	3
Q5	Short or Open	.3	Loss of one mass range data	Loss of output signal	12.93	2
	Drift	.7	May lose some data	Change in gain	30.17	3
Q6	Short or Open	.3	Loss of one mass range data	Loss of output signal	12.93	2
	Drift	.7	May lose some data	Change in gain	30.17	3
CR1	Open	.2	Possible loss of one mass range data	No effect unless spike occurs on signal line - then no output signal	2.21	2
	Short	.4	Loss of one mass range data	Loss of output signal	4.42	2
	Drift	.4	No effect	No effect	4.42	4
CR2	Open	.2	Possible loss of one mass range data	Change in gain	2.21	3
	Short	.4	Loss of one mass range data	Loss of output signal	4.42	2
	Drift	.4	No effect	No effect	4.42	4
CR3	Short	.3	Loss of one mass range data	No output signal	7.88	2

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		128 of 183	
ASS'Y	DWG NO.	DATE	
Pre-Amp/Discriminator	151-660	2-10-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
	Drift	.6	No effect	No effect	15.77	4
	Open	.10	Loss of some data	Change in discriminator level	2.63	3
Z1	Output Open or Short	.65	Loss of one mass range data	No output signal	13.66	2
	Drift	.35	Small loss of data	Slight loss of sensitivity	7.36	3
Z2	Output High or Low	1.0	Loss of one mass range data	No output pulse	26.28	2
R1 Module #2	Open	.05	Loss of internal calibrate signal	No internal calibrate signal	.019	3
	Drift	.95	No effect	No effect	.366	4
R2	Open	.1	No calibrate signal	Calibrate signal saturates pre-amp	.294	3
	Drift	.9	No effect	No effect	2.649	4
R3	Open	.05	No data output on one mass range	Loss of pre-amp output	.019	2
	Drift	.95	No effect	No effect	.366	4
R4	Open	.05	Loss of one mass range data	No output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R5	Open	.1	Loss of one mass range data	No output signal	.294	2
	Drift	.9	Slight loss of data	Change in gain	2.649	3
R6	Open	.1	Loss at one mass range	No output signal	.294	2
	Drift	.9	Slight loss of data	Change in gain	2.649	3
R7	Open	.05	Loss of one mass range data	Loss of signal	.019	2
	Drift	.95	No effect	No effect	.306	4
R8	Open	.1	Loss of one mass range data	Loss of output signal	.294	2
	Drift	.9	Slight loss of data	Change in gain	2.649	3
R9	Open	.05	Loss of one mass range data	Loss of output signal	.019	2

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM ALSEP E	PREPARED BY J. Carrol	NO. ATM 970	REV.
END ITEM LMS	DWG NO.	PAGE 130 of 183	
ASSY Pre-Amp/Discriminator	DWG NO. 151-660	DATE 2-10-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
	Drift	.95	No effect	No effect	.366	4
R10	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R11	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R12	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R13	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	Slight effect in pulses counted	No effect	.366	4
R14	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	Slight effect in pulses counted	No effect	.366	4
R15	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	Slight effect in pulses counted	No effect	.366	4
R16	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R17	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R18	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R19	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP E	PREPARED BY: J. Carrol	NO.: ATM 970	REV.
END ITEM: LMS	DWG NO.	PAGE 131 of 183	
ASS'Y: Pre-Amp/Discriminator	DWG NO. 151 660	DATE 2-10-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R20	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R21	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R22	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R23	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R24	Open	.05	Minor effect	Cannor change discriminator gain	.019	3
	Drift	.95	No effect	No effect	.366	4
R25	Open	.05	Minor	Circuit in slightly higher then high gain position	.019	3
	Drift	.95	No effect	No effect	.366	4
R26	Open	.05	Minor	Circuit in slight higher then high gain position	.019	3
	Drift	.95	No effect	No effect	.366	4
R27	Open	.05	May count noise pulses	Circuit in very high gain position	.019	2
	Drift	.95	No effect	No effect	.366	4
R28	Open	.05	No pulses counted - Loss of one mass range	Discriminator gain extremely low	.019	2
	Drift	.95	Slight effect	Slight change in gain	.366	3
R29	Open	.05	Loss of some data	Discriminator output erratic	.019	2
	Drift	.95	No effect	No effect	.366	4
R30	Open	.05	Loss of one mass range	Loss of output signal	.019	2

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP E	PREPARED BY: J. Carrol	NO.: ATM 970	REV.
END ITEM: LMS	DWG NO.	PAGE 132 of 193	
ASSY: Pre-Amp/Discriminator	DWG NO.: 151-660	DATE: 2-10-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
	Drift	.95	No effect	No appreciable effect	.366	4
R31	Open	.05	Loss of some data	Discriminator output erratic	.019	2
	Drift	.95	Slight effect	Slight offset	.366	3
R32	Open	.05	Loss of one mass range	No output	.019	2
	Drift	.95	No effect	No effect	.366	4
R33	Open	.05	Loss of some data	Discriminator output erratic	.019	2
	Drift	.95	No effect	No effect	.366	4
R34	Open	.05	Loss of one mass range data	No output	.019	2
	Drift	.95	No effect	No effect	.366	4
C1	Drift	.1	No effect	No effect	.007	4
	Short	.9	Loss of one mass range data	Signal line loaded	.063	2
C2	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	Signal line loaded	.788	2
C3	Drift	.1	No effect	No effect	.007	4
	Short	.9	Loss of one mass range data	Loss of signal	.063	2
C4	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C5	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C6	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	I. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		133 of 183	
ASSY	DWG NO.	DATE	
Pre-Amp/Discriminator	151-660	2-10-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
C7	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C8	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C9	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C10	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C11	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C12	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C13	Short	.9	Loss of some data	Loss of discriminator gain	.788	2
	Drift	.1	No effect	No effect	.088	4
C14	Short	.9	Loss of data on one mass range	R19 will fail open No discriminator output	.788	2
	Drift	.1	No effect	No effect	.088	4
C15	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C16	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C20	Short	.9	Loss of data	Loss of Sweep High Voltage isolation	.788	1
	Drift	.1	No effect	No effect	.088	4

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		134 of 183	
ASSY	DWG NO.	DATE	
Pre-Amp/Discriminator	151-660	2-10-71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
C17	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No appreciable change	Output pulse width becomes smaller (30 n)	.088	4
C19	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C18	Short	.9	Loss of data	No +5 power	.788	1
	Drift	.1	No effect	No effect	.088	4
Q1	Short or Open	.3	Loss of one mass range data	Loss of output signal	8.23	2
	Drift	.7	May lose some data	Change in gain	19.19	3
Q2	Short or Open	.3	Loss of one mass range data	Loss of output signal	6.36	2
	Drift	.7	May lose some data	Change in gain	14.84	3
Q3	Short or Open	.3	Loss of one mass range data	Loss of output signal	12.93	2
	Drift	.7	May lose some data	Change in gain	30.17	3
Q4	Short or Open	.3	Loss of one mass range data	Loss of output signal	6.36	2
	Drift	.7	May lose some data	Change in gain	14.84	3
Q5	Short or Open	.3	Loss of one mass range data	Loss of output signal	12.93	2
	Drift	.7	May lose some data	Change in gain	30.17	3
Q6	Short or Open	.3	Loss of one mass range data	Loss of output signal	12.93	2
	Drift	.7	May lose some data	Change in gain	30.17	3
CR1	Open	.2	Possiblit loss of one mass range data	No effect unless spike occurs on signal line - then no output signal	2.21	2
	Short	.4	Loss of one mass range data	Loss of output signal	4.42	2
	Drift	.4	No effect	No effect	4.42	4

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 920	B
END ITEM	DWG NO.	PAGE	
LMS		135 of 183	
ASSY	DWG NO.	DATE	
Pre-Amp/Discriminator	151-660	2-10-71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE		FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
			ASSEMBLY	END ITEM		
CR2	Open	.β	Possible loss of one mass range data	Change in gain	2.21	3
	Short	.4	Loss of one mass range data	Loss of output signal	4.42	2
	Drift	.4	No effect	No effect	4.42	4
CR3	Short	.3	Loss of one mass range data	No output signal	7.88	2
	Drift	.6	No effect	No effect	12.77	4
	Open	.10	Loss of some data	Change in discriminator level	2.63	3
Z1	Output Open or Short	.65	Loss of one mass range data	No output signal	13.66	2
	Drift	.35	Small loss of data	Slight loss of sensitivity	7.36	3
Z2	Output High or Low	1.0	Loss of one mass range data	No output pulse	26.28	2
R1 Module #3	Open	.05	Loss of internal calibrate signal	No internal calibrate signal	.019	3
	Drift	.95	No effect	No effect	.366	4
R2	Open	.1	No calibrate signal	Calibrate signal saturates pre-amp	.294	3
	Drift	.9	No effect	No effect	2.649	4
R3	Open	.05	No data output on one mass range	Loss of pre-amp output	.019	2
	Drift	.95	No effect	No effect	.366	4
R4	Open	.05	Loss of one mass range data	No output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R5	Open	.1	Loss of one mass range data	No output signal	.294	2
	Drift	.9	Slight loss of data	Change in gain	2.649	3
R6	Open	.1	Loss at one mass range	No output signal	.294	2
	Drift	.9	Slight loss of data	Change in gain	2.649	3

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	
END ITEM	DWG NO.	PAGE	
LMS		36 of 183	
ASSY	DWG NO.	DATE	
Pre-Amp/Discriminator	151-660	2-10-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
R7	Open	.05	Loss of one mass range data	Loss of signal	.019	2
	Drift	.95	No effect	No effect	.306	4
R8	Open	.1	Loss of one mass range data	Loss of output signal	.294	2
	Drift	.9	Slight loss of data	Change in gain	2.649	3
R9	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R10	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R11	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R12	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R13	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	Slight effect in pulses counted	No effect	.366	4
R14	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	Slight effect in pulses counted	No effect	.366	4
R15	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	Slight effect in pulses counted	No effect	.366	4
R16	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R17	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	
END ITEM	DWG NO.	PAGE	
LMS		137 of 183	
ASSY	DWG NO.	DATE	
Pre Amp/Discriminator	151-660	2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^5	CRITICALITY
R16	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R19	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R20	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R21	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R22	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R23	Open	.05	Loss of one mass range data	Loss of output signal	.019	2
	Drift	.95	No effect	No effect	.366	4
R24	Open	.05	Minor effect	Cannot change discriminator gain	.019	3
	Drift	.95	No effect	No effect	.366	4
R25	Open	.05	Minor	Circuit in slightly higher then high gain position	.019	3
	Drift	.95	No effect	No effect	.366	4
R26	Open	.05	Minor	Circuit in slightly higher then high gain position	.019	3
	Drift	.95	No effect	No effect	.366	4
R27	Open	.05	May count noise pulses	Circuit in very high gain position	.019	2
	Drift	.95	No effect	No effect	.366	4

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP E	PREPARED BY: J. Carrol	NO.: ATM-070	REV.
END ITEM: LMS	DWG NO.:	PAGE 138 of 183	
ASSY: Pre Amp/Discriminator	DWG NO.: 151-660	DATE: 2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R28	Open	.05	No pulses counted Loss of one mass range	Discriminator gain extremely low	.019	2
	Drift	.95	Slight effect	Slight change in gain	.366	3
R29	Open	.05	Loss of some data	Discriminator output erratic	.019	2
	Drift	.95	No effect	No effect	.366	4
R30	Open	.05	Loss of one mass range	Loss of output signal	.019	2
	Drift	.95	No effect	No appreciable effect	.366	4
R31	Open	.05	Loss of some data	Discriminator output erratic	.019	2
	Drift	.95	Slight effect	Slight offset	.366	3
R32	Open	.05	Loss of one mass range	No output	.019	2
	Drift	.95	No effect	No effect	.366	4
R33	Open	.05	Loss of some data	Discriminator output erratic	.019	2
	Drift	.95	No effect	No effect	.366	4
R34	Open	.05	Loss of one mass range data	No output	.019	2
	Drift	.95	No effect	No effect	.366	4
C1	Drift	.1	No effect	No effect	.007	4
	Short	.9	Loss of one mass range data	Signal line loaded	.063	2
C2	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	Signal line loaded	.788	2
C3	Drift	.1	No effect	No effect	.007	4
	Short	.9	Loss of one mass range data	Loss of signal	.063	2

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM ALSEP E	PREPARED BY J. Carrol	NO. ATM 970	REV. B
END ITEM LMS	DWG NO.	PAGE 139 of 183	
ASSY Pre Amp/Discriminator	DWG NO. 151-660	DATE 2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
C4	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C5	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C6	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C7	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C8	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C9	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C10	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C11	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of one mass range data	No output signal	.788	2
C12	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C13	Short	.9	Loss of some data	Loss of discriminator gain	.788	2
	Drift	.1	No effect	No effect	.088	4
C14	Short	.9	Loss of data on one mass range	R19 will fail open No discriminator output	.788	2
	Drift	.1	No effect	No effect	.088	4

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		140 of 183	
ASSY	DWG NO.	DATE	
Pre Amp/Discriminator	151-660	2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^3	CRITICALITY
C15	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C16	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C20	Short	.9	Loss of data	Loss of Sweep High Voltage isolation	.788	1
	Drift	.1	No effect	No effect	.088	4
C17	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No appreciable change	Output pulse width becomes smaller (30 n)	.088	4
C19	Short	.9	Loss of one mass range data	Loss of signal	.788	2
	Drift	.1	No effect	No effect	.088	4
C18	Short	.9	Loss of data	No +5 power	.788	1
	Drift	.1	No effect	No effect	.088	4
Q1	Short or Open	.3	Loss of one mass range data	Loss of output signal	8.23	2
	Drift	.7	May lose some data	Change in gain	19.19	3
Q2	Short or Open	.3	Loss of one mass range data	Loss of output signal	6.36	2
	Drift	.7	May lose some data	Change in gain	14.84	3
Q3	Short or Open	.3	Loss of one mass range data	Loss of output signal	12.93	2
	Drift	.7	May lose some data	Change in gain	30.17	3
Q4	Short or Open	.3	Loss of one mass range data	Loss of output signal	6.36	2
	Drift	.7	May lose some data	Change in gain	14.84	3

SYSTEM	PREPARED BY	NO.	REV.
ALSEP E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE 141 of 183	
LMS			
ASSY	DWG NO.	DATE	
Pre Amp/Discriminator	151-660	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
Q5	Short or Open	.3	Loss of one mass range data	Loss of output signal	12.93	2
	Drift	.7	May lose some data	Change in gain	30.17	3
Q6	Short or Open	.3	Loss of one mass range data	Loss of output signal	12.93	2
	Drift	.7	May lose some data	Change in gain	30.17	3
CR1	Open	.2	Possible loss of one mass range data	No effect unless spike occurrs on signal line - then no output signal	2.21	2
	Short	.4	Loss of one mass range data	Loss of output signal	4.42	2
	Drift	.4	No effect	No effect	4.42	4
CR2	Open	.2	Possible loss of one mass range data	Change in gain	2.21	3
	Short	.4	Loss of one mass range data	Loss of output signal	4.42	2
	Drift	.4	No effect	No effect	4.42	4
CR3	Short	.3	Loss of one mass range data	No output signal	7.88	2
	Drift	.6	No effect	No effect	15.77	4
	Open	.10	Loss of some data	Change in discriminator level	2.63	3
Z1	Output Open or Short	.65	Loss of one mass range data	No output signal	13.66	2
	Drift	.35	Small loss of data	Slight loss of sensitivity	7.36	3
Z2	Output High or Low	1.0	Loss of one mass range data	No output pulse	26.28	2

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	B
END ITEM LMS	DWG NO.	PAGE 142 of 183	
ASSY Mother Bd.	DWG NO. 151-698	DATE 3/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-9}	CRITICALITY
R1	Open	.1	Loss of regulation - output voltage fails high	Loss of most data - one data point may be available	.294	1
	Drift	.9	Output voltage will not agree with pre-	Data difficult to interpret	2.649	3
R2	Open	.1	Loss of regulation - output voltage fails high	Loss of most data - one data point may be available	.294	1
	Drift	.9	Output voltage will not agree with pre-assigned steps	Data diffiuclt to interpret	2.649	3
R3	Open	.05	Possible noise on sweep control voltage	Minor	.019	4
	Drift	.95	No effect	No effect	.366	4
R4	Open	.05	Sweep counter will not reset as turn on	Minor synch. problem	.019	4
	Drift	.95	No effect	No effect	.366	4
R5	Open	.05	Step-lock command will not reset counter	Minor synch. problem	.019	4
	Drift	.95	No effect	No effect	.366	4
R6	Open	.05	Sweep counter will not advance	No output data	.019	1
	Drift	.95	No effect	No effect	.366	4
R7	Open	.05	Sweep counter will not advance	Minor synch. problem	.019	1
	Drift	.95	No effect	No effect	.366	4
R8	Open	.05	Sweep counter will not advance	Minor synch. problem	.019	1
	Drift	.95	No effect	No effect	.366	4
R9	Open	.05	Sweep counter will not advance	Minor synch. problem	.019	1
	Drift	.95	No effect	No effect	.366	4
R10	Open	.05	Circuit does not reset at power turn on	Minor synch. problem	.019	4
	Drift	.95	No effect	No effect	.366	4

A2 A2
Programmed Sweep Hi-Voltage Power Supply

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: Array E	PREPARED BY: J. Carrol	NO.: ATM 970	REV.	
END ITEM: LMS	DWG NO.	PAGE 143 of 183		
ASS'Y: Mother Brd.	DWG NO.: 151-698	DATE: 2/10/71		

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
C1	Short	.9	No sweep control output voltage	No output data	.788	1
	Drift	.1	No effect	No effect	.088	4
C2	Short	.9	Circuit does not reset at power turn on	Minor synch. problem	.788	4
	Drift	.1	No effect	No effect	.088	4
C3	Short	.3	Step lock command does not clear counter	Minor synch. problem	.788	4
	Drift	.1	No effect	No effect	.088	4
C4	Short	.9	No sweep counter output	No output data	.788	1
	Drift	.1	No effect	No effect	.088	4
C5	Short	.9	No sweep counter output	No output data	.788	1
	Drift	.1	No effect	No effect	.088	4
C6	Short	.9	No sweep counter output	No output data	.788	1
	Drift	.1	No effect	No effect	.088	4
C7	Short	.9	Counter does not reset at turn on	Minor synch. problem	.788	4
	Drift	.1	No effect	No effect	.088	4
C8	Short	.9	No sweep control output voltage	No output data	.788	1
	Drift	.1	No effect	No effect	.088	4

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	B
END ITEM LMS	DWG NO.	PAGE 144 of 183	
ASSY Mother Brd	DWG NO. 151-698	DATE 3/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
CR1	Short	.4	No sweep control output voltage	No output data	5.68	1
	Open	.2	No sweep control output voltage	No output data	2.64	1
CR2	Drift	.4	No effect	No effect	5.68	4
CR2	Short	.4	No sweep control output voltage	No output data	5.68	1
	Open	.2	No sweep control output voltage	No output data	2.64	1
	Drift	.4	No effect	No effect	5.68	4
CR3	Short	.4	No sweep control output voltage	No output data	5.68	1
	Open	.2	No sweep control output voltage	No output data	2.64	1
	Drift	.4	No effect	No effect	5.68	4
CR4	Short	.4	Stop-lock reset command inoperative	Minor synch. problem	3.92	3
	Open	.2	Stop mode of operation inoperative	No manual operation	1.96	2
	Drift	.4	No effect	No effect	3.92	4
Z1 (12-14)	Output Low	.7	Decimal input of 2 imposed on ladder at all times	Error in sweep high voltage	4.6	3
	Output High	.3	No decimal 2 input to ladder	Error in sweep high voltage	1.97	3
(1-3)	Output Low	.7	Decimal input of 1 imposed on ladder at all times	Error in sweep high voltage	4.6	3
	Output High	.3	No decimal 1 input to ladder	No output data	6.57	1
(9-8)	Output High or Low	1.0	Sweep counter will not advance	No output data	6.57	1
Z2	Ouptut High	.5	Counter advancers at double rate slope for 0-690 steps incorrect	Loss of part of datt	13.14	2
	Output Low	.5	Counter does not advance at double rate	Loss of part of data	13.14	2

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE 145 of 183	
LMS			
ASSY	DWG NO.	DATE	
Mother Brd	151-698	2/10 71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^3	CRITICALITY
Z3	Output High	.5	Counter advances at 4 times rate for all steps (0-1330)	Loss of part of data	13.14	2
	Output Low	.5	Counter will not advance at 4 times rate for steps 940 to 1330	Loss of part of data	13.14	2
Z4	Output High	.5	Step counter will not advance	No output data	13.14	1
	Output Low	.5	Background and calibrate cycle will be by-passed	Data difficult to interpret	13.14	3
Z5	Output High	.3	Sweep counter will not advance	No output data	7.88	1
	Output Low	.7	Background and calibrate cycle does not operate	No background or cal. counts obtained	18.396	3
Z6	Output High	.30	Internal calibrate signal cannot be generated	No internal calibration signal	7.88	3
	Output Low	.07	Internal cal. signal present at all times	No output data	18.396	1
Z7 (13-12)	Output High or Low	1.0	Sweep counter will not operate except manually	No output data	4.38	1
(9-10)	Output High or Low	1.0	Sweep counter will not advance	No output data	4.38	1
(1-14)	Output High or Low	1.0	Sweep counter will not operate except manually	No output data	4.38	1
(3-2)	Output High	.3	Sweep counters not cleared when stop command given	Temporary loss of signal	1.31	4
	Output Low	.7	Sweep counters not cleared when stop command given	Temporary loss of signal	3.07	4
(5-6)	Output High	.3	Decimal input of 1 imposed on ladder network at all times	Error in Sweep High Voltage	1.31	3
	Output Low	.7	No decimal 1 input to ladder network	Error in Sweep High Voltage	3.07	3
(7-8)	Output High	.3	Decimal input of 2 imposee on ladder network at all times	Error in Sweep High Voltage	1.31	3
	Output Low	.7	No decimal 2 input to ladder network	Error in Sweep High Voltage	3.07	3

A2 A2
Programmed Sweep Hi-Voltage Power Supply

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	
END ITEM	DWG NO.	PAGE 146 of 183	
LMS			
ASS'Y	DWG NO.	DATE	
Mother Brd.	151-698	2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
Z8 (1, 2-12)	Output High	.3	Sweep counter will not advance	No output data	3.94	1
	Output Low	.7	Counter will not stop at step 1330	Manual operation only	9.2	1
(6, 8-10)	Output High	.3	Sweep counter will not advance	No output data	3.94	1
	Output Low	.7	Count will not stop at step 1330	Manual operation only	9.2	1
Z9	Output High	.3	Two times count rate is not enabled	Loss of some data	7.88	2
	Output Low	.7	Two times count rate starts at step 2	Loss of some data	18.39	2
Z10 (1-2)	Output High	.3	Count rate does not stop at 1330 steps	Loss of some data	3.94	1
	Output Low	.7	Counter will not advance	No data	9.2	1
(6-10)	Output High	.3	4 times count rate is not enabled	Loss of some data	3.94	2
	Output Low	.7	4 times count rate starts at step 2	No data	9.2	2
Z11	Output Low	.5	Step counter will not advance	No output data	6.57	1
	Output High	.5	Step counter will not advance	No output data	6.57	1
Z12	Output Low	.5	Step counter will not advance	No output data	13.14	1
	Output High	.5	Step counter will not advance	No output data	13.14	1
Z13	Output Low	.5	Step counter will not advance	No output data	13.14	1
	Output High	.5	Step counter will not advance	No output data	13.14	1
Z14	Output Low	.5	Step counter will not advance	No output data	13.14	1
	Output High	.5	Step counter will not advance	No output data	13.14	1
Z15	Output Low	.5	Step counter will not advance	No output data	13.14	1
	Output High	.5	Step counter will not advance	No output data	13.14	1
Z16	Output Low	.5	Step counter will not advance	No output data	13.14	1
	Output High	.5	Step counter will not advance	No output data	13.14	1

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		17 of 183	
ASSY	DWG NO.	DATE	
Mother Brd	151-698	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^3	CRITICALITY
Z17	Output Low	.5	Step counter will not advance	No output data	13.14	1
	Output High	.5	Step counter will not advance	No output data	13.14	1
Z18	Output Low	.5	Step counter will not advance	No output data	13.14	1
	Output High	.5	Step counter will not advance	No output data	13.14	1
Z19 (1-3)	Output Low	.7	Sweep counter cannot be stopped and manually stopped	Output data cannot be obtained by stopping	1.97	2
	Output High	.3	Sweep counter operates manually only	Manual operation only	4.6	1
(6-5)	Output High	.3	Sweep counter will not operate manually	No manual operation	1.97	2
	Output Low	.7	Sweep counter will not operate manually	No manual operation	4.6	2
(9-8)	Output High	.3	Sweep counter will not advance	No output data	1.97	1
	Output Low	.7	Sweep counter will not advance	No output data	4.6	1
(12-14)	Output High	.3	Sweep counter will not advance	No output data	1.97	1
	Output Low	.7	Sweep counter will not advance	No output data	4.6	1
Z20	Any output Open or Short	.65	Sweep control voltage incorrect	Sweep output voltage incorrect	37.58	2
	Drift	.35	Sweep control valtage incorrect	Sweep output voltage incorrect	20.23	2
Z21	Any output Open or Short	.65	Sweep control voltage incorrect	Sweep output voltage incorrect	37.58	2
	Drift	.35	Sweep control voltage incorrect	Sweep output voltage incorrect	20.23	2
Z22	Any output Open or Short	.65	Sweep control voltage incorrect	Sweep output voltage incorrect	37.58	2
	Drift	.35	Sweep control voltage incorrect	Sweep output voltage incorrect	20.23	2
Z23	Output Low	.5	Step counter will not advance	No output data	13.14	1
	Output High	.5	Step counter will not advance	No output data	13.14	1

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM Array E	PREPARED BY J. Carrol	NO. ATM 970	REV. B
END ITEM LMS	DWG NO.	PAGE 148 of 182	
ASSY Mother Brd.	DWG NO. 151-698	DATE 2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
Z24	Output Low	.5	Internal calibration will not function	No internal calibration	13.14	3
	Output High	.5	Internal Cal. Signal present at all times	Continuous cal. signal - no output data	13.14	1
Z25 (1-14)	Output High or Low	1.0	Sweep counter will not advance	No output data	4.38	1
(3-2)	Output High or Low	1.0	Sweep counter will not advance	No output data	4.38	1
(5-6)	Output High or Low	1.0	Sweep counter will not advance	No output data	4.38	1
(13-12)	Output High or Low	1.0	Sweep counter will not advance	No output data	4.38	1
(9-p0)	Output High	.3	Sweep counter will not advance	No output data	2.19	1
	Output Low	.7	Counter does not stop at 1330 steps	Loss of some data	2.19	1
Z26 (6, 8-10)	Output High	.3	Sweep Counter will not advance	No ouputt data	3.94	1
	Output Low	.7	Sweep counter will not advance	No output data	9.2	1
(1, 2-12)	Output High	.3	Sweep counter will not advance	No output data	3.94	1
	Output Low	.7	Sweep counter will not advance	No output data	9.2	1
Z27	Any output Open or Short	.65	Sweep control voltage incorrect	Sweep output voltage incorrect	37.58	2
	Drift	.35	Sweep control voltage incorrect	Sweep output voltage incorrect	20.23	2
Z28	Any output Open or Short	.65	Sweep control voltage incorrect	Sweep output voltage incorrect	37.58	2
	Drift	.35	Sweep control voltage incorrect	Sweep output voltage incorrect	20.23	2
Z29	Any output Open or Short	.65	Sweep control voltage incorrect	Sweep output voltage incorrect	37.58	2
	Drift	.35	Sweep control voltage incorrect	Sweep output voltage incorrect	20.23	2
Z30 (9-10)	Output High	.3	Sweep counter will not advance	No output data	3.94	1
	Output Low	.7	Background cal. counter will not reset	No background or cal. cycle	9.2	3
(12-2)	Output High or Low	1.0	Sweep counter will not operate except manually	No output data	13.14	1

A2 A2
Programmed Sweep Hi-Voltage Power Supply

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: Array E	PREPARED BY: J. Carrol	NO.: ATM 970	REV.: B
END ITEM: LMS	DWG NO.:	PAGE 149 of 183	
ASSY: Mother Brd	DWG NO.: 151-698	DATE: 2/10/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
Z31 (9-8)	Output High	.3	Continuous cal. gate	No output data	1.97	1
	Output Low	.7	No internal cal. gate	No internal cal. signal	4.6	3
(12-14)	Output High	.3	No internal cal. gate	No internal cal signal	1.97	3
	Output Low	.7	Continuous cal. gate	No output data	4.6	1
(7-5)	Output High orLow	1.0	Counters not reset at turn on	Output data out of sync	6.57	4
(2-3)	Output High or Low	1.0	Counters not reset at turn on	Output data out of sync	6.57	4
Z32	Output High	.5	Sweep voltage stops not syncronized with frame makrs. No manual stop function	Data difficult to interpret	13 14	3
	Output Low	.5	Step counter will not advance	No output data	13.14	1
Z33 (1-14)	Output High	.3	Sweep counter will not advance	No output data	1.31	1
	Output Low	.7	Sweep counter will not advance	No output data	3.07	1
(5-6)	Output High or Low	1.0	Counter cannot be advanced manually	Data packs cannot be analyzed	4.38	1
(7-8)	Output High or Low	1.0	Counter cannot be advanced manually	Data packs cannot be analyzed	4.38	1
(3-2)	Output Low	.7	Sweep counter will not advance except manually	Manual sweep advance only	3.07	1
	Output High	.3	Step-lock command will not operate	Counter cannot be stopped by command	1.31	2
(9-10)	Output High	.3	Sweep counter will not operate	No output data	1.31	1
	Output Low	.7	Sweep counter cannot be turned off	Minor effect	3.07	4
(13-12)	Output High	.3	Sweep counter cannot be turned off	Minor effect	1.31	4
	Output Low	.7	Sweep counter will not operate	No output data	3.07	1

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE 150 of 183	
LMS			
ASSY	DWG NO.	DATE	
Mother Brd.	151-698	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
Z 34	Any output Open or Short	.65	Sweep control voltage incorrect	Sweep output voltage incorrect	37.58	2
	Drift	.35	Sweep control voltage incorrect	Sweep output voltage incorrect	20.23	2
Z 35	Any output Open or Short	.65	Sweep control voltage incorrect	Sweep output voltage incorrect	37.58	2
	Drift	.35	Sweep control voltage incorrect	Sweep output voltage incorrect	20.23	2
Z 36	Any output Open or Short	.65	Sweep control voltage incorrect	Sweep output voltage incorrect	37.58	2
	Drift	.35	Sweep control voltage incorrect	Sweep output voltage incorrect	20.23	2
Z 37 (14-3)	Output High	.3	Sweep counter will not advance	No output data	2.63	1
	Output Low	.5	Sweep counter will not advance	No output data	6.13	1
(10-13)	Output High	.3	Sweep start flag does not function	No flag indication of cal. cycle	2.63	3
	Output Low	.7	Sweep start flag gives continuous indication	False flag indication that unit is in continuous cal.	6.13	3
(7-5)	Output High	.3	Cal. signal switch will not operate	No internal calibration signal	2.63	3
	Output Low	.7	Cal. signal switch always present	Continuous cal. signal - no data	6.13	1
Z 38	Output High	.5	Step counters will not reset or will be held in reset	No output data	13.14	1
	Output Low	.5	Step counters will not reset or will be held in reset	No output data	13.14	1
T1	Open or Short (Any winding)	.5	No output voltage	No output data	17.52	1
	Drift	.5	Change in efficiency	No effect unless circuit breaker opens	17.52	3

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	
END ITEM	DWG NO.	PAGE 151 of 183	
LMS			
ASSY	DWG NO.	DATE	
A2-A2-A1	151-631	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R1	Open	.05	Loss of output voltage	Loss of all data	.294	1
	Drift	.95	No effect	No effect	2.2649	4
R2	Open	.05	Loss of output voltage	Loss of all data	.019	1
	Drift	.95	Ne effect	No effect	.366	4
R3	Open	.05	Loss of output voltage	Loss of all data	.019	1
	Drift	.95	No effect	No effect	.366	4
R4	Open	.05	Loss of output voltage	Loss of all data	.294	1
	Drift	.95	No effect	No effect	2.649	4
R5	Open	.05	Loss of output voltage	Loss of all data	.019	1
	Drift	.95	No effect	No effect	.366	4
R6	Open	.05	Loss of regulation	Loss of output data	.019	1
	Drift	.95	No effect	No effect	.366	4
C1	Short	.9	No output voltage	Loss of output data	.788	1
	Drift	.1	No effect	No effect	.088	4
C2	Short	.9	No output voltage	Loss of output data	.788	1
	Drift	.1	No effect	No effect	.088	4
C3	Drift	.1	No effect	No effect	.088	4
	Short	.9	No output voltage	No output data	.788	1
Q1	Open or Short	.30	No output voltage	No output data	9.2	1
	Drift	.70	Decrease in efficience	No effect unless power exceeds specs.	21.46	3

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		42 of 183	
ASSY	DWG NO.	DATE	
A2-A2-A1	151-631	4/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^5	CRITICALITY
Q2	Open or Short	.30	No output voltage	No output data	9.2	1
	Drift	.70	Decrease in efficiency	No effect unless power exceeds specs.	21.46	3
L1	Open	.25	Loss of output voltage	Loss of output data	8.76	1
	Short	.25	Loss of input filter - possible noise on output voltage	Background data increase. Data difficult to interpret	8.76	3
	Drift	.5	No effect	No effect	17.52	4

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		153 of 183	
ASSY	DWG NO.	DATE	
A2-A2-A2	151-636	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R1	Open	.05	Loss of output voltage	Loss of all data	.019	1
	Drift	.95	No effect	No effect	.366	4
R2	Open	.05	Loss of output voltage	Loss of all data	.019	1
	Drift	.95	No effect	No effect	.366	4
R3	Open	.05	Loss of output voltage	Loss of all data	.019	1
	Drift	.95	No effect	No effect	.366	4
R4	Open	.05	Loss of regulation	No output data	.019	1
	Drift	.95	No effect	No effect	.366	4
R5	Open	.05	Output voltage will increase to maximum value	Loss of most data	.019	1
	Drift	.95	No effect	No effect	.366	4
R6	Open	.05	Pedestal voltage will not be present - all output voltage will be less than normal	Loss of part of data	.019	3
	Drift	.95	No effect	No effect	.366	4
R7	Open	.1	Pedestal voltage will not be present - all output voltage will be less than normal	Loss of part of data	.294	3

A2 A2
Programmed Swsep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	
END ITEM	DWG NO.	PAGE 154 of 183	
LMS			
ASSY	DWG NO.	DATE	
A2-A2-A2	151-636	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE		FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
			ASSEMBLY	END ITEM		
	Drift	.9	Output voltage will not be desired voltage	Data difficult to interpret	2.649	3
R8	Open	.1	Output voltage will increase to maximum value	Loss of most data	.284	1
	Drift	.9	Output will not be the desired value	Data difficult to interpret	2.649	3
C1	Drift	.1	No effect	No effect	.088	4
	Short	.9	No output voltage	No output data	.788	1
C2	Drift	.1	No effect	No effect	.088	4
	Short	.9	No output voltage	No output data	.788	1
C3	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of regulation	No output data	.788	1
C4	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of regulation	No output data	.788	1
C5	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of regulation	Loss of output data	.788	1
C6	Drift	.1	No effect	No effect	.088	4
	Short	.9	No output voltage	No output data	.788	1
C7	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of regulation	Loss of output data	.788	1
Q1	Open	.2	No output voltage	Loss of output data	4.62	1
	Short	.1	Maximum output voltage - no regulation	Loss of most data	2.31	1
	Drift	.7	No effect	No effect	16.19	4

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	Array E	PREPARED BY	J. Carrol	NO.	ATM 970	REV.	B
END ITEM	LMS	DWG NO.		PAGE	155 of 183		
ASSY	A2-A2-A2	DWG NO.	157-636	DATE	2/10/7.		

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
C4	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of regulation	No output data	.788	1
C5	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of regulation	Loss of output data	.788	1
C6	Drift	.1	No effect	No effect	.088	4
	Short	.9	No output voltage	No output data	.788	1
C7	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of regulation	Loss of output data	.788	1
Q1	Open	.2	No output voltage	Loss of output data	4.62	1
	Short	.1	Maximum output voltage - no regulation	Loss of most data	2.31	1
	Drift	.7	No effect	No effect	16.19	4
CR1	Short	.4	No output voltage	No output data	4.62	1
	Open	.2	Output of Z2 not clamped for negative pulses	Minor effect	2.31	4
	Drift	.4	No effect	No effect	4.62	4
Z1	Output Open or Short	.65	No output voltage	No output data	37.58	1
	Drift	.35	Output voltage in error	Data difficult to interpret	20.23	3

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM: Array E	PREPARED BY: J. Carrol	NO.: ATM 970	REV. B
END ITEM: LMS	DWG NO.	PAGE 156 of 183	
ASSY: A2-A2-A3	DWG NO.: 151-641	DATE: 2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R1	Open	.1	Loss of regulation - output voltage fails high	Loss of most data - one data point may be available	.294	1
	Drift	.9	Output voltage will not agree with pre-assigned steps	Data difficult to interpret	2.649	3
R2	Open	.05	Loss of output voltage	Loss of all data	.019	3
	Drift	.95	No effect	No effect	.366	4
R3	Open	.1	No housekeeping HV monitor output	Data difficult to interpret	.294	3
	Drift	.9	No effect	No effect	2.649	4
R4	Open	.1	No housekeeping HV monitor output	Data difficult to interpret	.294	3
	Drift	.9	No effect	No effect	2.649	4
R5	Open	.1	Incorrect HV monitor output	Data difficult to interpret	.294	3
	Drift	.9	No effect	No effect	2.649	4
R6	Open	.1	No housekeeping HV monitor output	Data difficult to interpret	.294	3
	Drift	.9	No effect	No effect	2.649	4
R7	Open	.1	In correct HV monitor output	Data difficult to interpret	.294	3
	Drift	.9	No effect	No effect	2.649	4
R8	Open	.1	No housekeeping HV monitor output	Data difficult to interpret	.294	3
	Drift	.9	No effect	No effect	2.649	4
R9	Open	.1	Loss of output voltage	Loss of all data	.294	1
	Drift	.9	Data difficult to interpret	Output voltage will not agree with pre-assigned steps	2.649	3
C1	Drift	.1	No effect	No effect	.088	4
	Short	.9	Output voltage will go to highest value possible	Loss of most data	.788	1

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM Array E	PREPARED BY J. Carrol	NO. ATM 970	REV. B
END ITEM LMS	DWG NO.	PAGE 157 of 183	
ASSY A2-A2-A3	DWG. NO. 151-041	DATE 2/12/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{3}	CRITICALITY
C2	Drift	.1	No effect	No effect	.088	4
	Short	.9	Output voltage will go to highest value possible	Loss of most data	.788	1

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	B
END ITEM	DWG NO.	PAGE	
LMS		158 of 183	
ASS'Y	DWG NO.	DATE	
A2-A2-A3	151-641	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
C3	Drift	.1	No effect	No effect	.088	4
	Short	.9	No sweep HV monitor output	Data difficult to interpret	.788	3
C4	Drift	.1	No effect	No effect	.088	4
	Short	.9	No HV monitor output	Data difficult to interpret	.788	3
C5	Drift	.80	No effect	No effect	.984	4
	Short	.20	No HV monitor output	Data difficult to interpret	.246	3
CR1	Short	.4	No sweep HV monitor output	Output data difficult to interpret	4.41	3
	Open	.2	Sweep HV monitor output not clamped for maximum output	Output data difficult to interpret	2.2	3
	Drift	.4	No effect	No effect	4.41	4
CR2	Short	.4	No sweep HV monitor output	Output data difficult to interpret	4.41	3
	Open	.2	Sweep HV monitor output not clamped for maximum output	Output data difficult to interpret	2.2	3
	Drift	.4	No effect	No effect	4.41	4
CR3	Short or Open	.6	No sweep HV monitor output	Output data difficult to interpret	6.61	3
	Drift	.4	No effect	No effect	4.41	4
Z1	Input or output Open or Short Power inputs open	.65	No sweep HV monitor output	Data difficult to interpret - no indication of Sweep HV	37.58	3
	Drift	.35	Sweep HV monitor output incorrect	Data difficult to interpret - no indication of Sweep HV	20.23	3

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM: Array E	PREPARED BY: J. Carrol	NO.: ATM 970	REV.
END ITEM: LMS	DWG NO.	PAGE 159 of 183	
ASSY: A2 A2 A1	DWG NO.: 151-709	DATE: 2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
R1	Open	.05	Loss of output voltage	Loss of all data	.019	1
	Drift	.95	No appreciable effect	No effect	.366	4
C1	Short	.9	No output voltage	No output data	2.523	1
	Drift	.1	No effect	No effect	.280	4
C2	Short	.9	No output voltage	No output data	.788	1
	Drift	.1	No effect	No effect	.088	4
C3	Drift	.1	No effect	No effect	.088	4
	Short	.9	Loss of output voltage	Loss of all output data	.788	1
C4	Short	.9	No output voltage	No output data	1.07	1
	Drift	.1	No effect	No effect	.119	4
C5	Drift	.1	No effect	No effect	.526	4
	Short	.9	No output voltage	No output data	4.73	1
C6	Drift	.1	No effect	No effect	.526	4
	Short	.9	No output voltage	No output data	4.73	1
C7	Drift	.1	No effect	No effect	.526	4
	Short	.9	No output voltage	Loss of output data	4.73	1
CR1	Short	.4	No output voltage	No output data	4.62	1
	Open	.2	No output voltage	No output data	2.31	1
	Drift	.4	No effect	No effect	4.62	4
CR2	Short	.4	No output voltage	No output data	4.62	1
	Open	.2	No output voltage	No output data	2.31	1
	Drift	.4	No effect	No effect	4.62	4

A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	
END ITEM	DWG NO.	PAGE 168 of 183	
LMS			
ASSY	DWG NO.	DATE	
A2-A2-A4	151-709	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^3	CRITICALITY
CR3	Short	.4	No output voltage	No output data	4.62	1
	Open	.2	No output voltage	No output data	2.31	1
	Drift	.4	No effect	No effect	4.62	4
CR4	Short	.4	No output voltage	No output data	4.62	1
	Open	.2	No output voltage	No output data	2.31	1
	Drift	.4	No effect	No effect	4.62	4

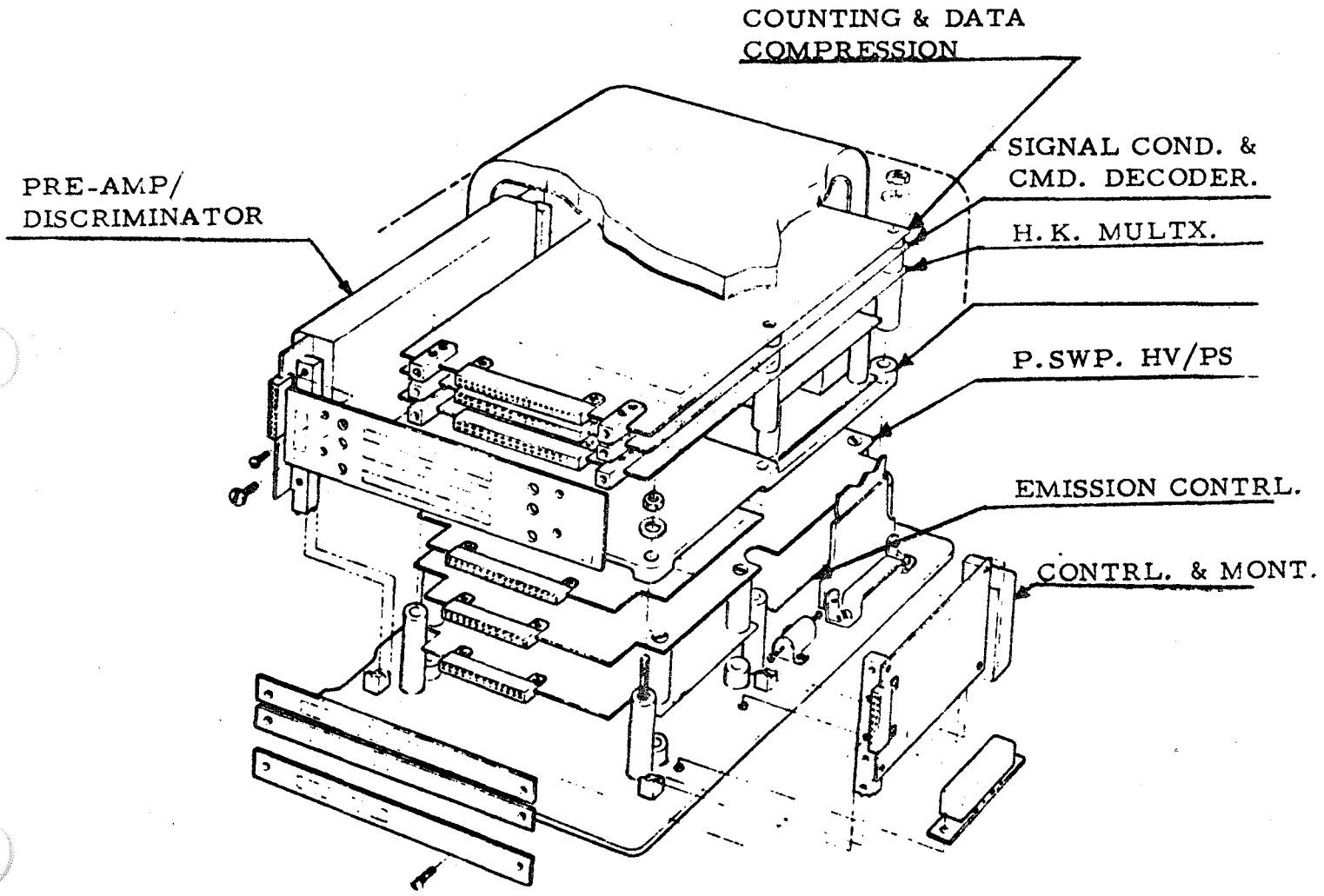
A2 A2
Programmed Sweep Hi-Voltage Power Supply

SYSTEM	PREPARED BY	NO.	REV.
Array E	J. Carrol	ATM 970	A
END ITEM	DWG NO.	PAGE	
LMS		161 of 193	
ASSY	DWG NO.	DATE	
A2-A2-A5	151-692	2/10/71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
R1	Open	.05	No output voltage	Loss of input data	.019	1
	Drift	.95	No effect	No effect	.366	4
C1	Drift	.8	No appreciable effect	Noise may be fed back to central station	3.3	3
	Short	.2	No output voltage	No output data	.83	1
C2	Drift	.8	No appreciable effect	Noise may be fed back to central station	3.3	3
	Short	.2	No output voltage	No output data	.83	1
CR1	Short	.3	No output voltage	No output data	7.89	1
	Open	.1	Excessive voltage across Q4 - may fail	No output data	2.63	1
	Drift	.6	No effect	No effect	15.78	4
Z1	Diode - Open or Short	.6	Loss of output voltage	Loss of output data	9.46	1
	Diode - Drift	.4	No effect	No effect	6.31	4
	Sensor - Open	.2	No output	Loss of output	3.15	1
	Sensor- Short	.4	Maximum output voltage - no regulation	Loss of most data	6.31	1
	Sensor - Drift	.4	No effect	No effect	6.31	4

FIGURE 1
LMS ELECTRONICS



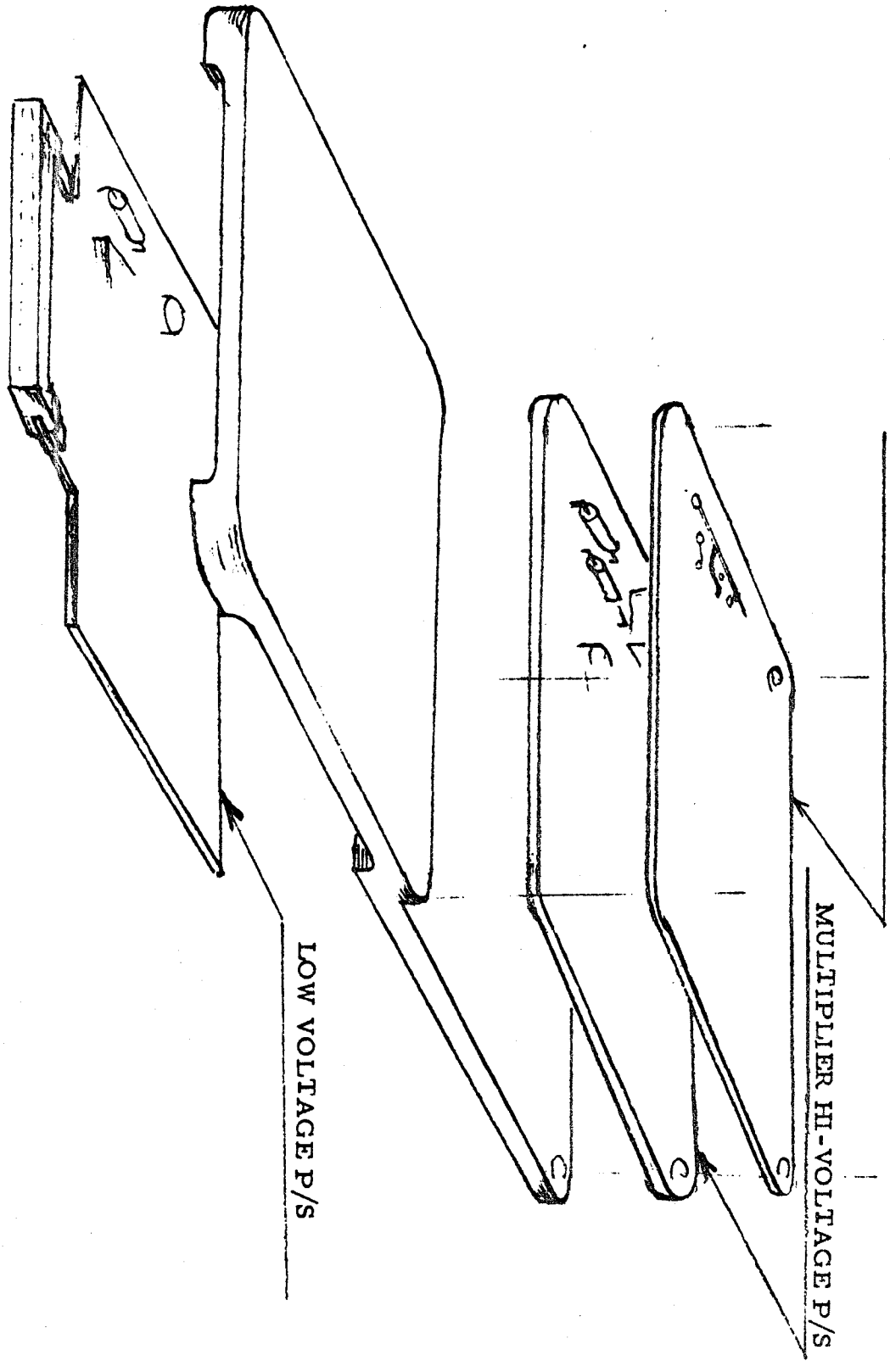


FIGURE 2
POWER SUPPLY MODULE

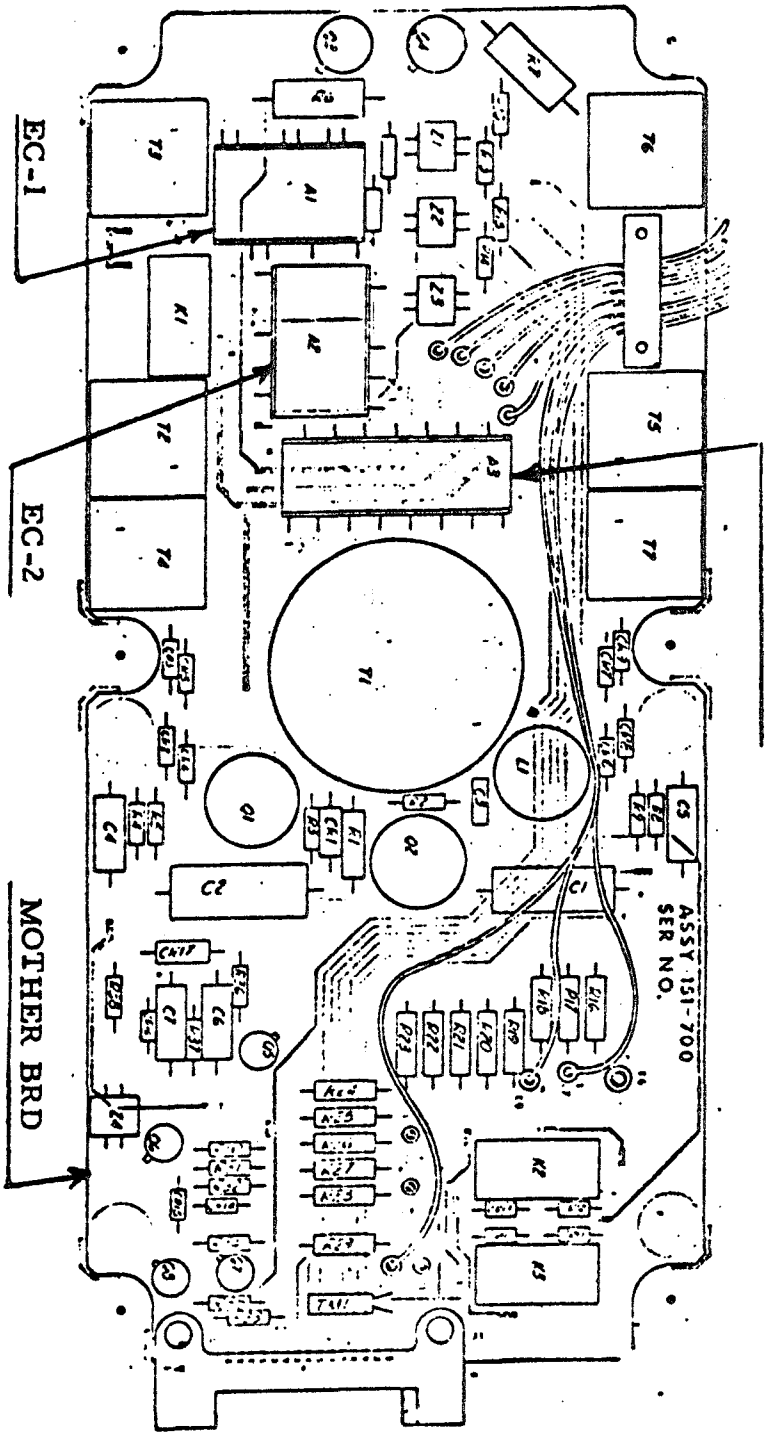


FIGURE #3
EMISSION CONTROL

FIGURE 4
PROGRAMMED SWEEP HI-VOLTAGE POWER SUPPLY

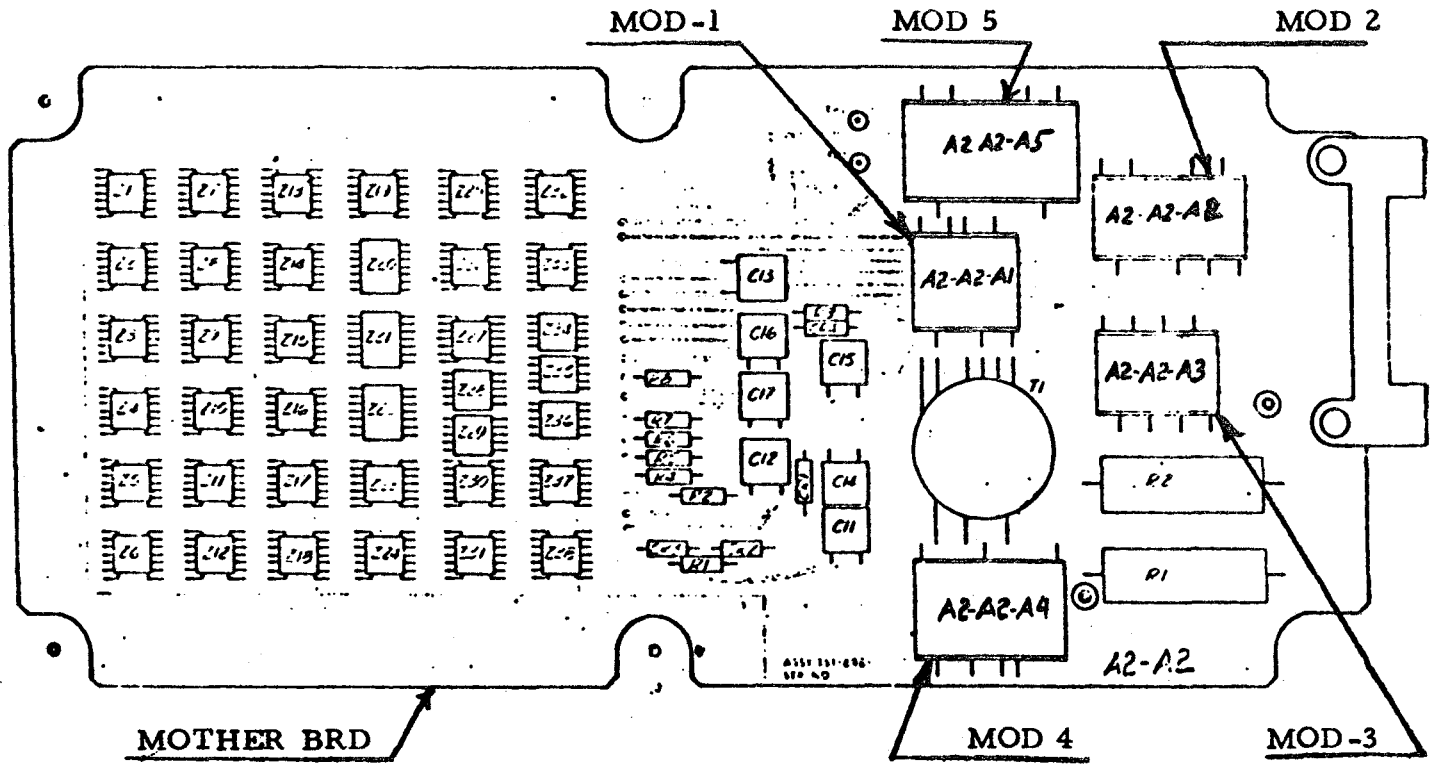


FIGURE 5
ANALYZER

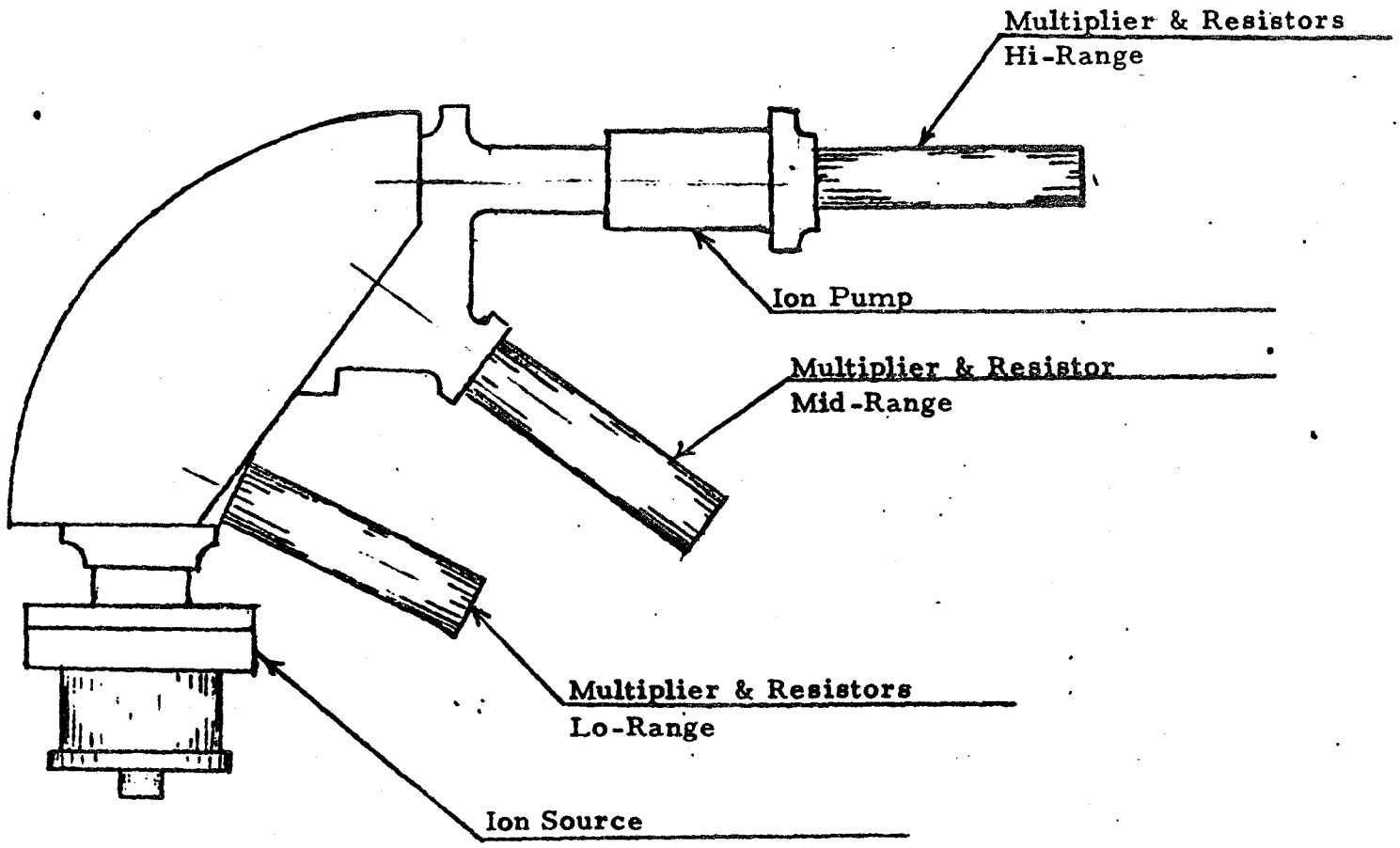


FIGURE 6

PRE-AMP/DISCRIMINATOR SUB ASSY.

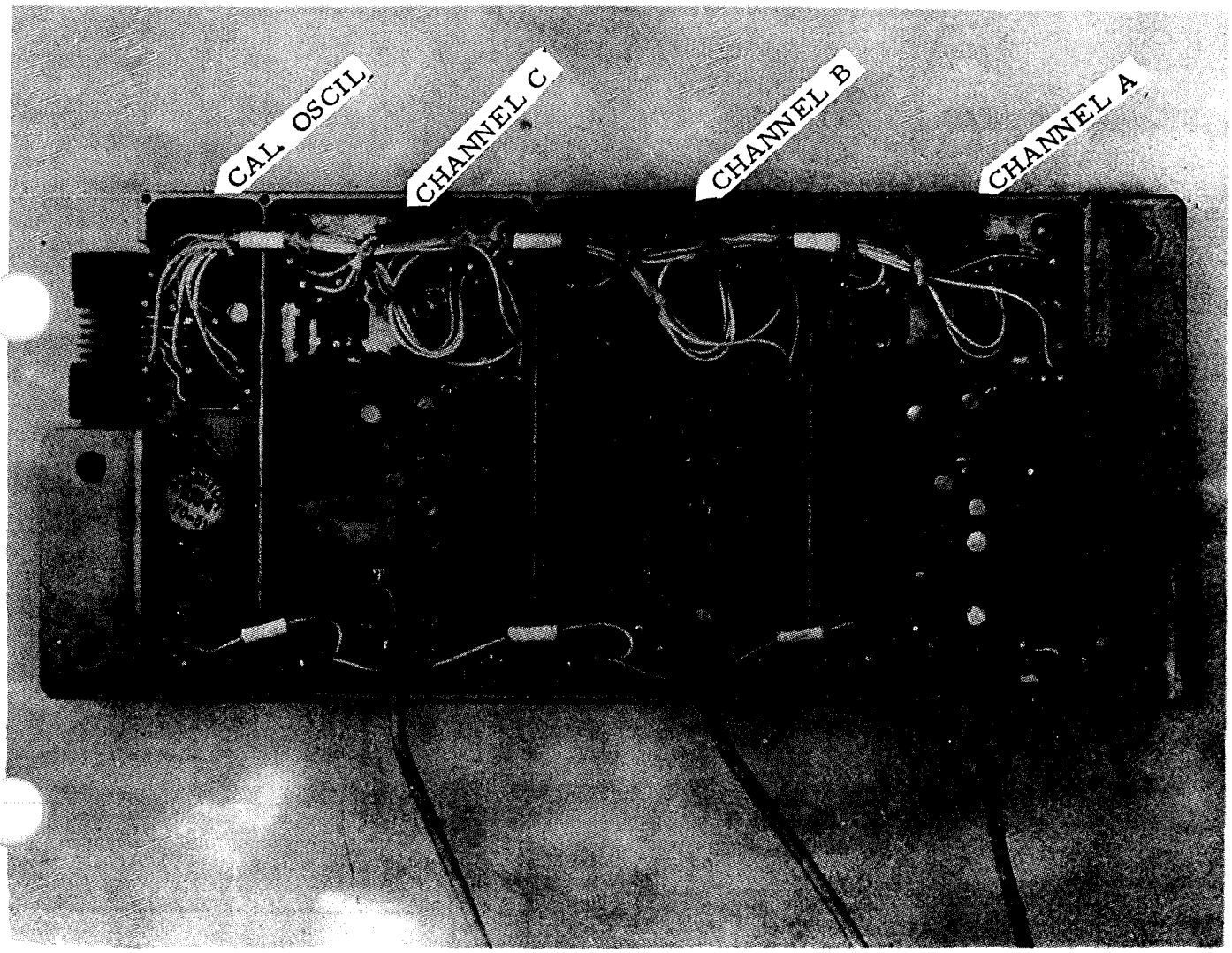


FIGURE 7

PRE-AMP/DISCRIMINATOR ASSY.

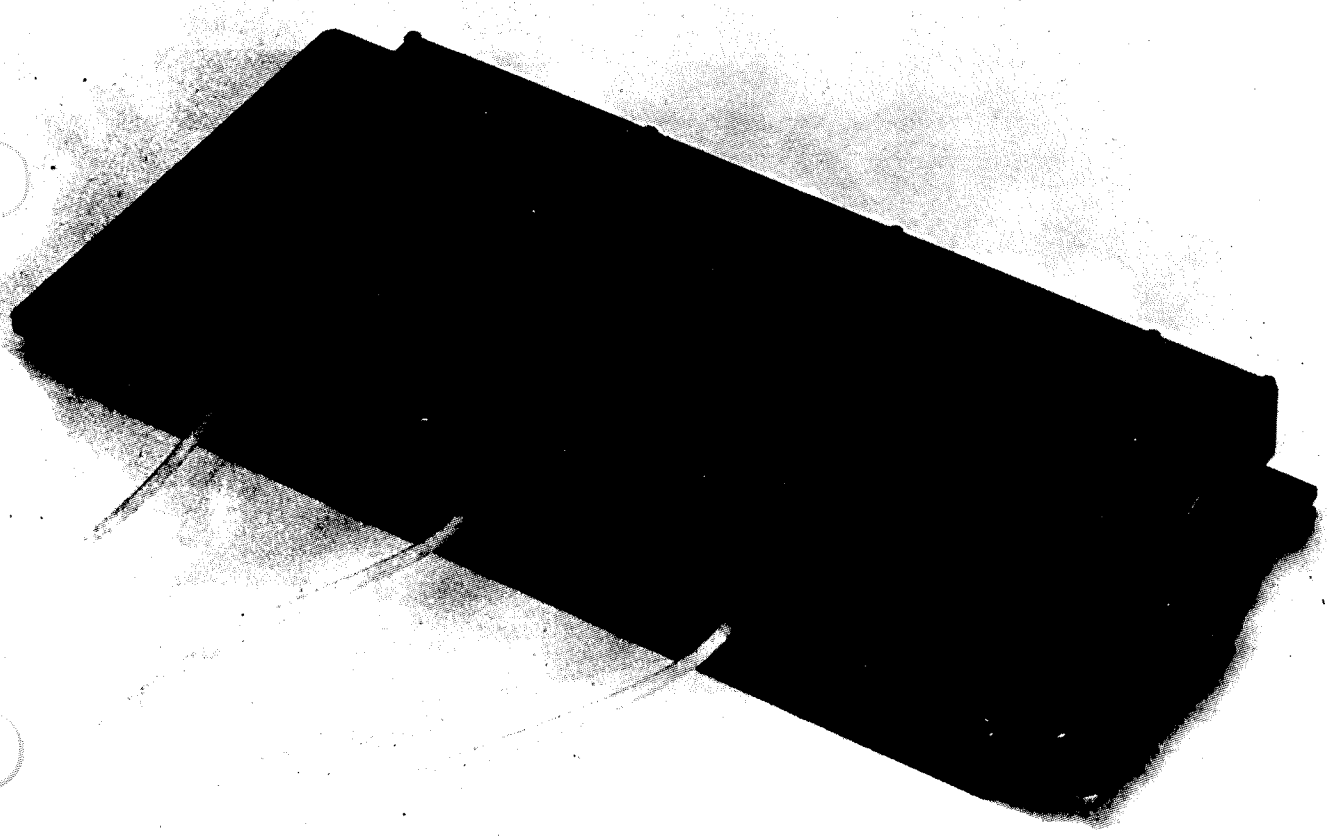


FIGURE 8

EMISSION CONTROL

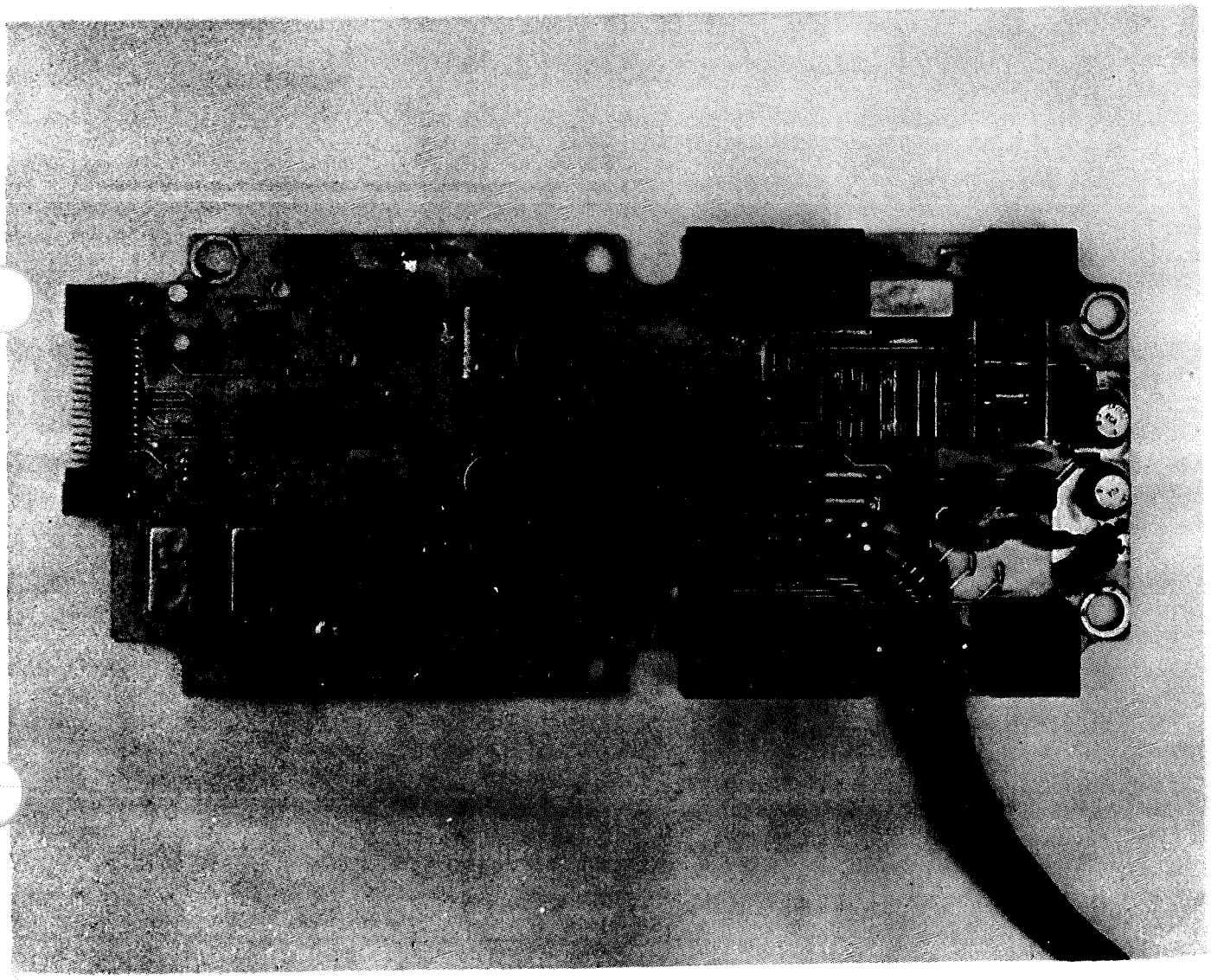


FIGURE 9

SWEEP HI VOLTAGE POWER SUPPLY
(BOTTOM VIEW)

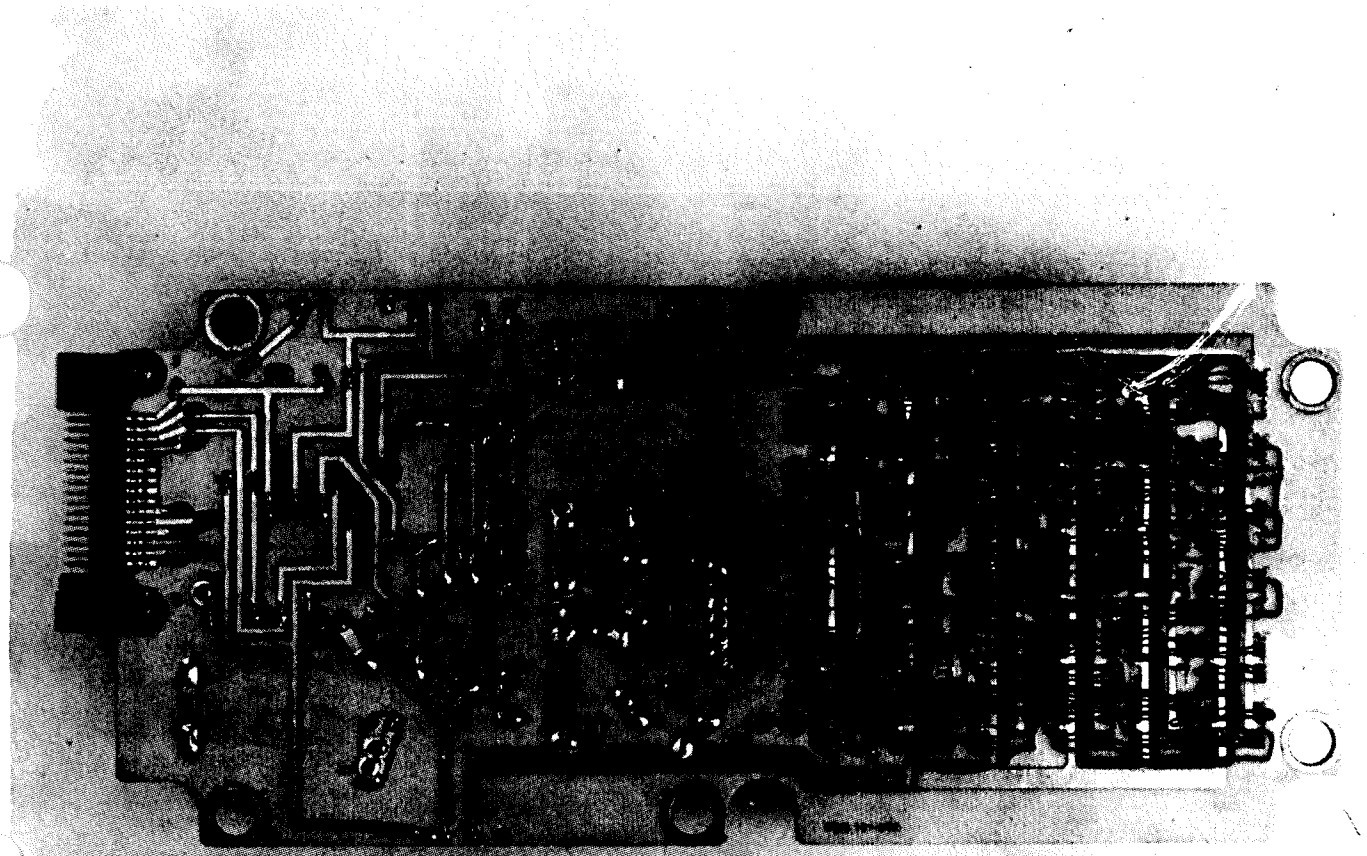


FIGURE 10

SWEEP HI VOLTAGE POWER SUPPLY
(TOP VIEW)

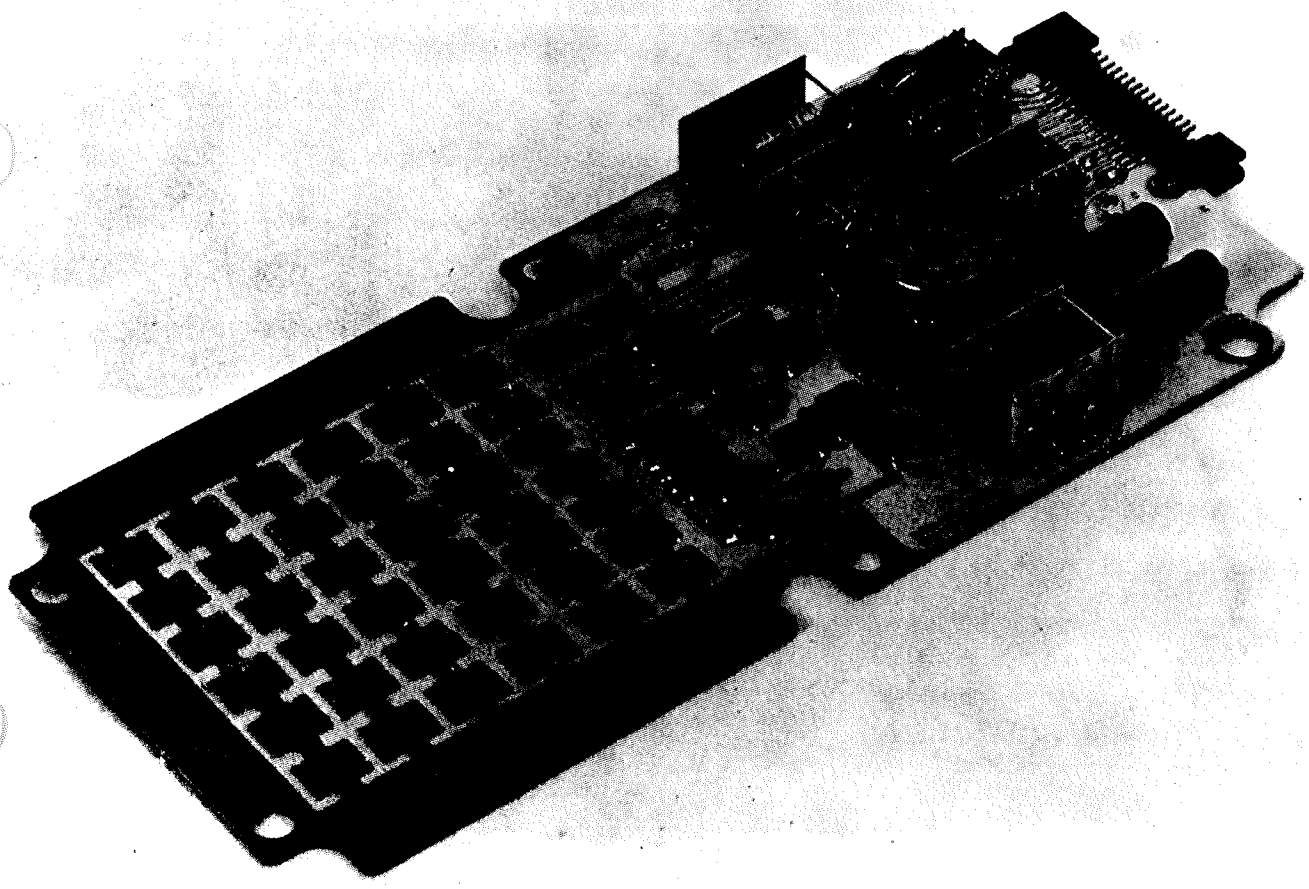


FIGURE 11

EMISSION CONTROL & SWP HV/PS ASSEMBLY
(TOP VIEW)

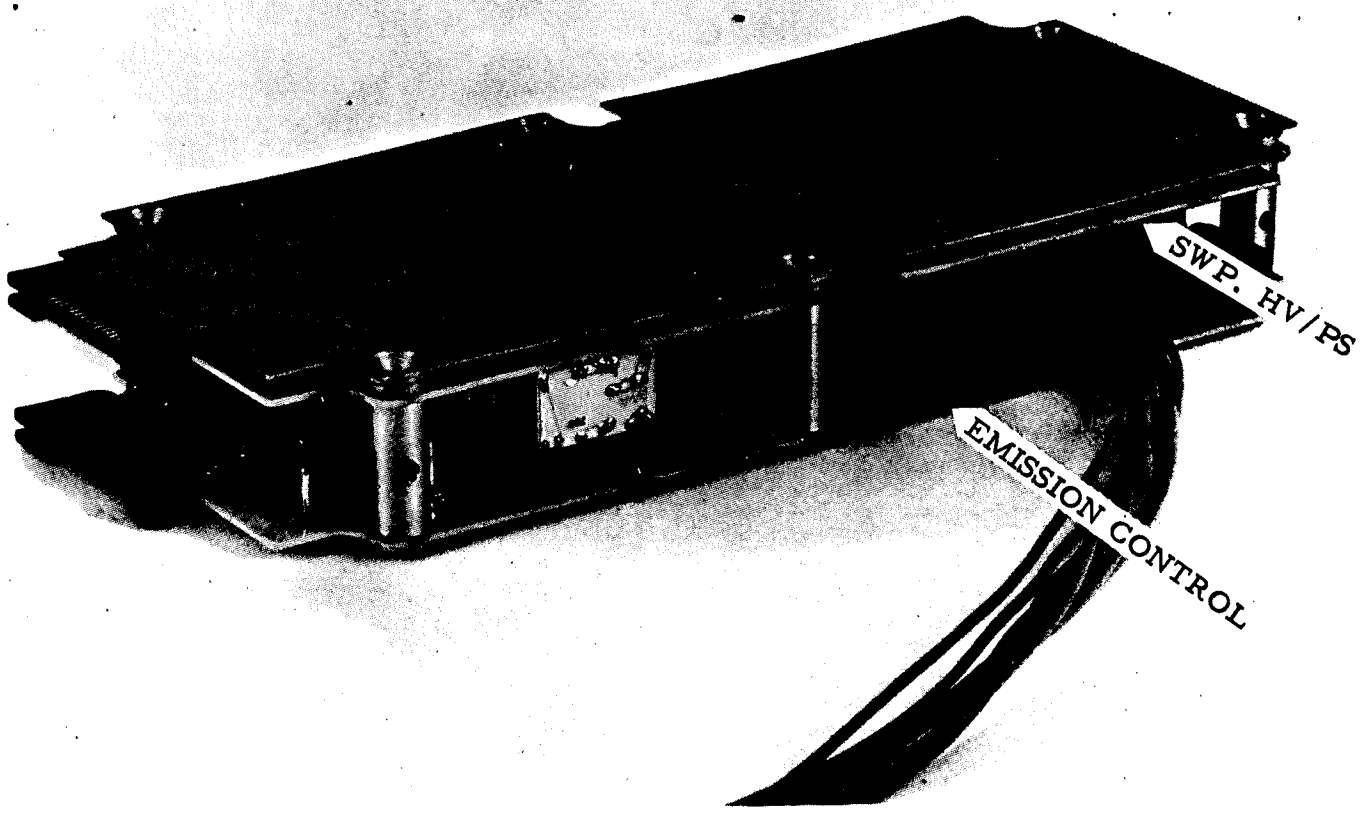
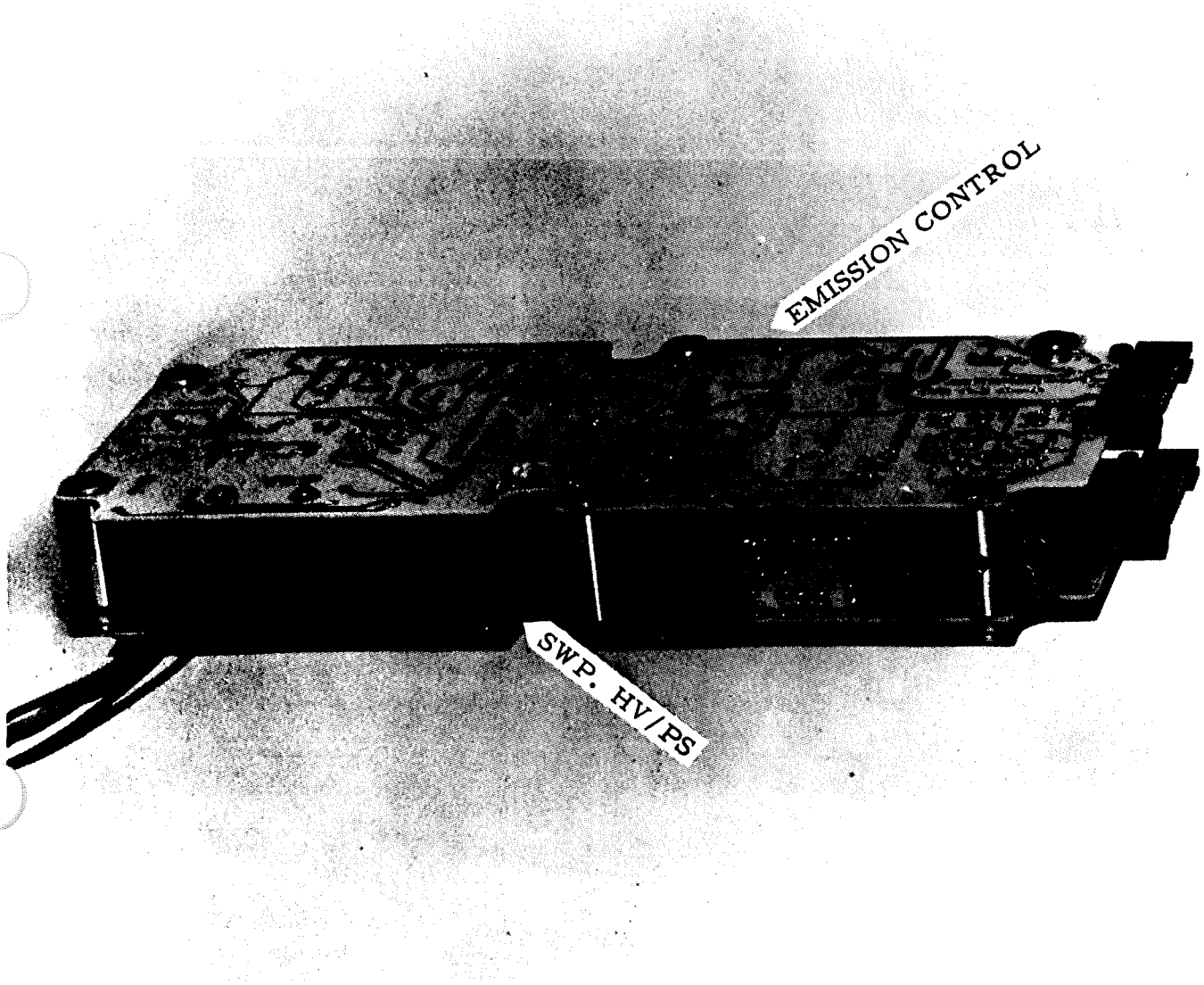


FIGURE 12

EMISSION CONTROL & SWP HV/PS ASSEMBLY
(BOTTOM VIEW)

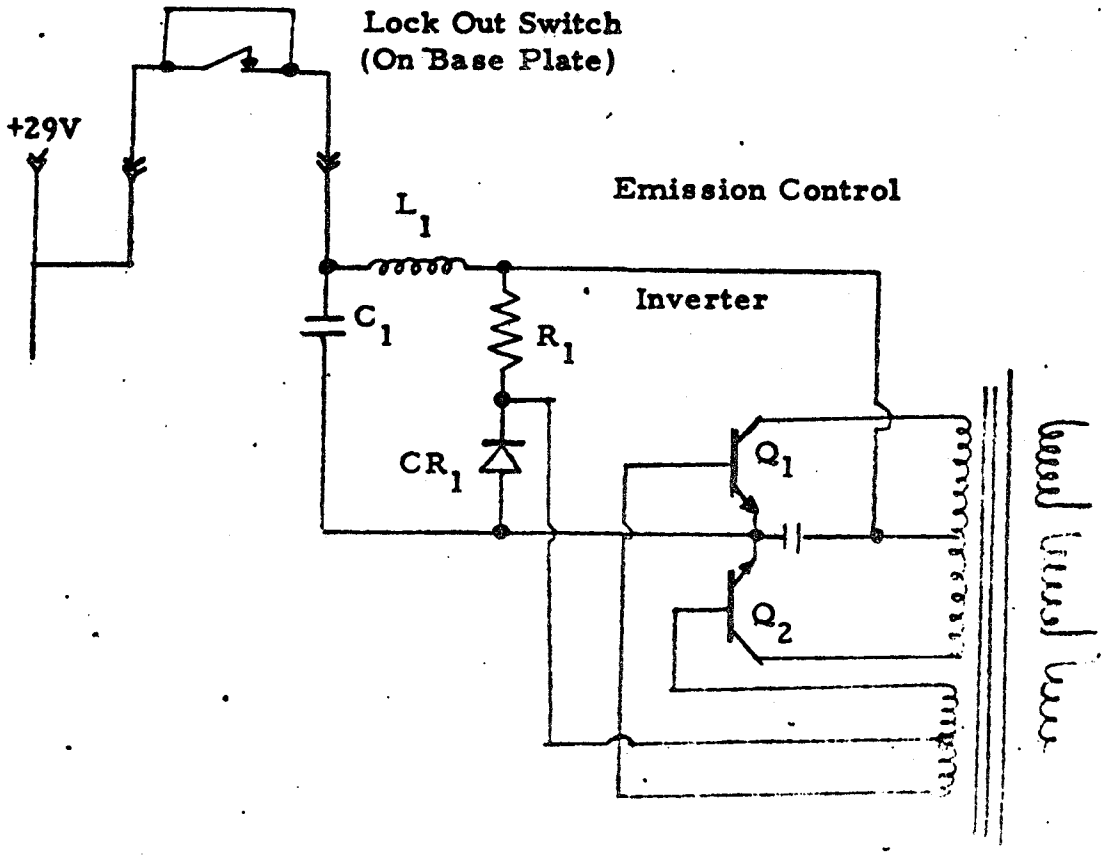


6.1 Lock Out Switch

This switch was added to prevent accidental turn on of the ion source filaments (numbers 1 or 2) during ground test when the chamber is back filled with argon. The switch is mounted on the base plate and is a normally closed switch. The switch, when activated, will open the +29 volt supply to the emission control inverter circuit. The switch is activated by a pin inserted through the base plate from outside the LMS. The pin is "flaged" DO NOT FLY and will be removed after final test. The switch will also be hard wired for a short circuit prior to flight.

For the reason that the switch is to be hard wired and shorted out before flight, the reliability of this switch will not effect the reliability of the LMS.

The switch is controlled by BxA SCD number 2346242-1. The Emission Control Schematic number is 151-702. The circuit is shown below.



Pages 175 through 183 are reserved for future revisions.