APRIL 1967

ENGINEERING MODEL TEST PROGRESS REPORT

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1.0 PROGRESS SUMMARY

This is the sixth monthly progress report on the ALSEP Engineering Model Systems Tests which covers the efforts during the time period 1 April through 30 April.

The EM Systems Tests at the end of April were running about two weeks behind the schedule established in ATM-605, Category #4 tests of Array B were just being commenced at the end of April. The slip can be attributed, in roughly equal parts, to three causes:

1. The non-availability of the Heat Flow Experiment for integration with the Central Station during March

2. The late delivery of the SIDE EM which was on line April 5 through April 7, 1967

3. The added task of performing Category #2 tests and integrating with the Central Station the new Cold Cathode Gauge Experiment (CCGE), designed and build by MSC.

Currently, Array B testing is continuing although the CPLEE EM is not on line, and with the SIDE Breadboard (BB) substituted for the SIDE EM.

Category #2 tests have been completed on the ASE, the SIDE EM, the CCGE (MSC) EM, and the HFE EM. Category #3 tests of the available experiments in the Array B configuration are about 30% completed. Improvements have been incorporated in the ASE to reduce the sensitivity of the real-time event detector to external EMI noise excitation, and the improved circuits have yet to be integrated with Central Station.

The spurious interaction checks in the Category #3 tests of Array B have proved to be largely impractical without the use of the STS to decommutate and format the HFE data. The HFE STS program is running and is now satisfactory, apart from some problem in processing the science data arithmetically after the data has been correctly acquired. It is intended to employ this program during the remainder of the Category #3 tests.

A simple STS program which decommutates and formats for print out the CCGE data has been checked and operated correctly.

The operation of the PSE and SIDE BB has continued to be good. The HFE has been operating satisfactorily so far as can be established without the use of the STS to acquire and analyze its data. Operation of the CPLEE has been restricted, but was apparently satisfactory. For the greater part of the period covered by this report, operation of the Central Station was good, apart from the previously reported PCU #1 failure. However, a new EMI problem, associated with the analog multiplexer, was detected towards the end of April and this is being investigated.

A check of the noise level of the Prototype Model PCU operating in the EM System has been made and is discussed in this report.

2.0 MONTH'S ACCOMPLISHMENTS

The significant accomplishments of the EM testing during this month are:

1. Completion of Category #2 tests on the ASE EM
2. Completion of Category #2 tests on the SIDE EM
3. Completion of Category #2 tests on the CCGE (MSC) EM
4. Completion of Category #2 tests on the HFE EM
5. Initial Category #3 testing of a full-up Array B experiment configuration
6. Confirmation of the STS software program for testing the CCGE (MSC)
7. Checking of the HFE STS program, which only requires correction of the data analysis subroutine.

3.0 TEST RESULTS

3.1 ENGINEERING MODEL TEST CONFIGURATION

The Central Station and Experiments have been arranged in the Array B configuration during the entire reporting period. The PSE, SIDE and CPLEE ETS's are used during the tests to display the experiment data, and the DOME is used to read the ASE data. It was decided at an early stage in the HFE tests not to utilize the HFE ETS as the low experiment data rate, one HFE subframe per 90 ALSEP frames, with up to 16 subframes in a HFE main frame, making the use of hard copy data print out highly desirable. This decision has been completely justified by practical experience; and effort has been concentrated on checking and debugging the STS software, which provides effective error detection and error flag indication.

Table 3.1-1 shows the status of all equipment on line during the month.

The preparations made in March to permit either the STS #1, which is at a remote location, to be used for EM tests; or alternatively the STS #2 Programmer Processor to be used via a special demodulator, effectively resolved the conflicts in GSE utilization between the various ALSEP models.

TABLE 3.1-1

STATUS OF ENGINEERING MODEL HARDWARE ON LINE

Month Ending: 30 April 1697

Prime Equipments

Subsystem/Component	Modified Brassboard	Engineering Model	Remarks & Status
Data Subsystem			
Data Processor	X		
Multiplexer - A/D Converter		X	EMI problem
Diplexer		X	
Diplexer Switch		X	
Transmitter "A"			Hardwire link
Transmitter "B"			
Receiver			Hardwire link
Command Decoder	X		
PDU		X	
Wire Harness		X	Array B
Terminal Strip		X	
Power Subsystem			
RTG Simulator (BxA)		X	
RTG Generator (GE)			
PCU		X	
PDM		X	
Structural/Thermal			
Base Plate		X	
Dust Detector			
		X	Part time
Experiments			
Passive Seismic		X	
Solar Wind			
Magnetometer			
SIDE/CCIG	X	X	EM 4/5/67 - 4/7/67
CPLEE		X	Limited operation
ASE		X	
Heat Flow		X	
CCGE (MSC)		X	

TABLE 3. 1-1 (CONT.)

STATUS OF ENGINEERING MODEL HARDWARE ON LINE

Month Ending 30 April 1967

GSE

Subsystem/Component	On Line	Operation Satisfactory	Operation Unsatisfactory	Remarks
Signal Breakout Boxes				
Passive Seismic #1	X	X		
#2				
Solar Wind				
Magnetometer				
SIDE/CCIG	X	X	Also used with	CCGE (MSC)
CPLEE	X	X		
ASE	X	X		
Heat Flow				
Data SS Test Set				
DDS 1000	X			Intermittent
Uplink				Sync. problem.
Downlink				Returned to DSS
Experiment Simulators				Group for Qual.
RF Test Set				Model tests.
Experiment Test Sets				
Passive Seismic	X	X		
Solar Wind				
Magnetometer				
SIDE/CCIG	X	X		
CPLEE	X	X		
ASE	X	X		
Heat Flow				
CCGE (MSC)	X	X		
System Test Set				
Data Unit #1	X	X		
#1 Programmer Processor	X	X		
#2 Programmer Processor			X	Power supply
#3 Programmer Processor	X	X		failed.

However, a power supply failure in the STS #2 Programmer Processor rendered it inoperable for the last two weeks of April, so further cables were run to permit the STS #3 Programmer Processor to be used with the ALSEP EM, so that it is now possible to use any of the three machines to process the ALSEP EM data.

3.2 CENTRAL STATION STATUS

The Central Station status is similar to that discussed in previous reports. Again, no operating problems or faults have been encountered in the data subsystem, either in the uplink or the downlink portions during this reporting period. Hardwire links between the data subsystem and the GSE have been used as the RF GSE test equipment has not been available for EM tests.

An EMI problem was detected during inspection of the analog signal interface between the HFE and the Central Station during Category #2 tests. Figure 3.2-1 shows the noise level on the HFE analog line #1 during a full sequence of 90 ALSEP frames, with the experiment on; experiment power off; and with the experiment disconnected from the Central Station. Figure 3.2-2 shows the same noise during the 16 ALSEP frames in which the experiment is active. Figures 3.2-3 and 3.2-4 are similar to Figures 3.2-1 and 3.2-2 respectively but show the HFE analog line #5. Figure 3.2-5 shows the detail of the maximum amplitude of noise recorded on the HFE analog line #5.

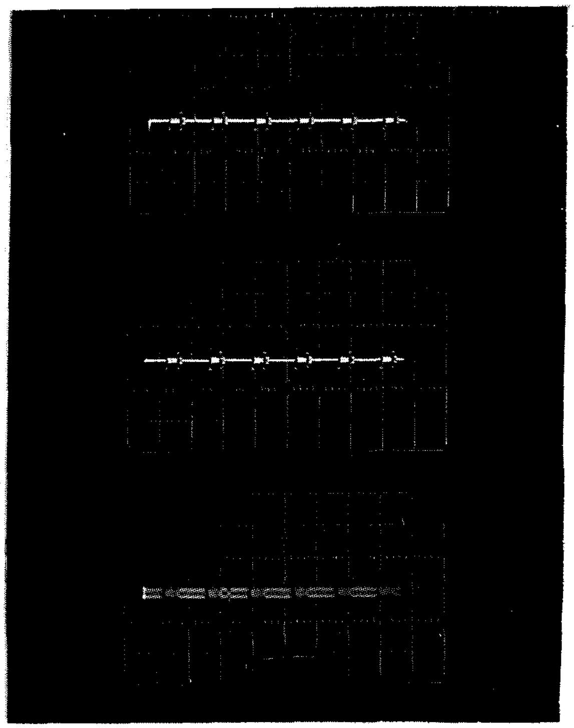
No similar noise has been observed earlier on other experiment interfaces during Category #2 tests but there are two reasons for attributing the source of the noise to the analog multiplexer in the Central Station and therefore to some change within the multiplexer:

1. The noise is not changed by turning the experiment power on and off, and is little changed by disconnecting the experiment from the Central Station.

2. The multiplexer employs a 15 x 6 gate format, and the 15 ALSEP frame repetition period of the noise level is obvious in Figures 3.2-1 and 3.2-3. Appreciable noise can only be detected on frames 8 through 13 of the 15 frame sequence, as shown in Figures 3.2-2 and 3.2-4.

Investigations to determine the cause of the change in analog multiplexer behavior, and any effect of this on the downlink data are being pursued. No housekeeping data errors which might be attributable to the noise have been detected up to the time of writing.

Figure 3.2-1 HFE Analog
Line #1 Noise



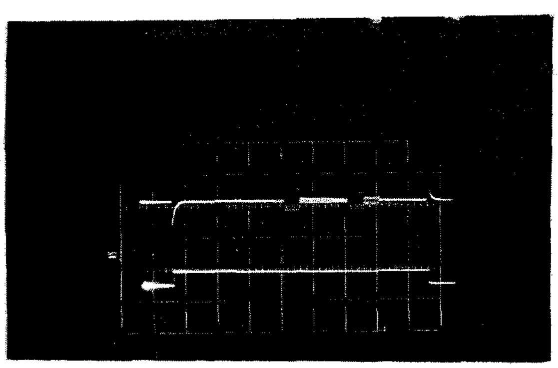
Analog Line 200 m v/cm
Records show one full sequence of 90 ALSEP Frames,i.e. #1 to #90, 6 sec/cm Approx.

1) Expt. On

2) Expt. Off

3) Expt. Disconnected

Figure 3.2-2 HFE Analog
Line #1 Noise

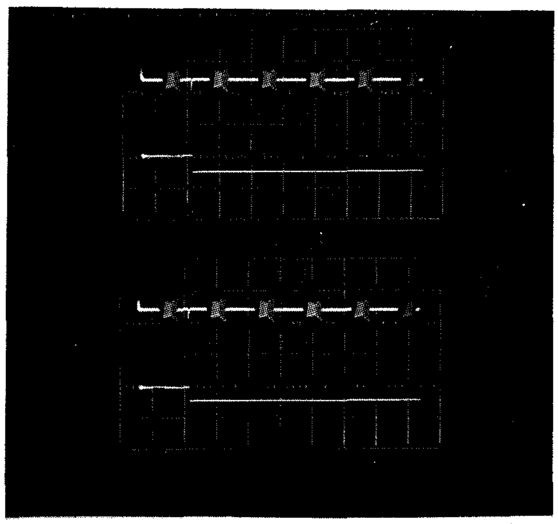


Top Trace: Analog Line
200 m v/cm
Bottom Trace: Input Current 100 m A/cm
#1 Through #16
ALSEP Frames, Approx. 1.2 sec/cm

Expt. On

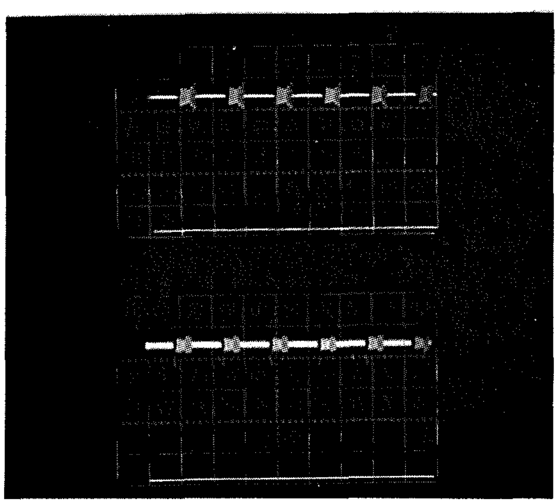
Figure 3.2-3 HFE Analog Line #5 Noise

All Records:
Top Trace Analog Line 200 mV/cm
Bottom Trace: Experiment Input Current (Timing Signal) 100 mA/cm
Records Show One Full Sequence of 90 ALSEP Frames, i.e., #1 to #90, 6 sec/cm Approx.



1) Experiment On

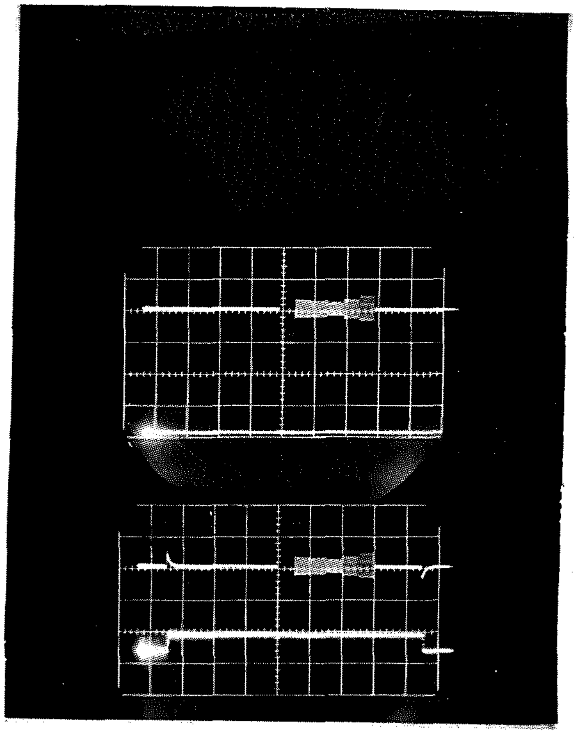
2) Experiment On



3) Experiment Off

4) Experiment Disconnected

Figure 3.2-4 HFE Analog Line #5 Noise



Both Records:
Top Trace: Analog Line 200 mV/cm

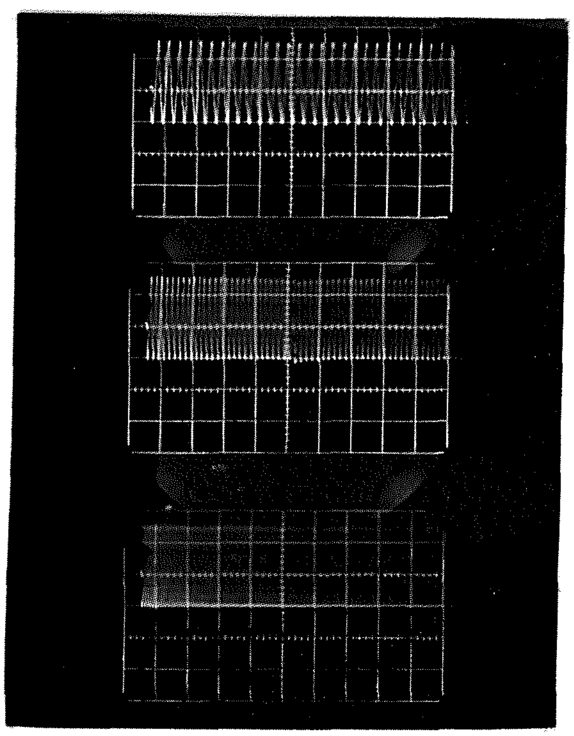
Bottom Trace: Input Current 100 mA/cm

#1 Through #16 ALSEP frames, Approx. 1.2 sec/cm

1) Expt Off

2) Expt On

Figure 3.2-5 HFE Analog Line #5 Noise



Detail - Max. Noise Amplitude

All 200 m V/cm
Expt. Off

1) 5μ s/cm

2) 10 μs/cm

3) 20 μ s/cm

The power system status is the same as reported last month in ATM-643, with almost all testing being performed with PCU #2 in operation, because of the failures within the PCU #1 which have been previously reported. The PCU #2 is functioning well and no new problems have occurred.

3.3 SOLAR WIND, LUNAR SURFACE MAGNETOMETER AND PASSIVE SEISMIC EXPERIMENTS

The SWE, an Array A experiment, has not been the subject of any further testing during this reporting period. Category #2 tests of the SWE were reported in ATM-618 and ATM-626, and Category #3 tests were reported in ATM-626 and ATM-643.

The LSM is another Array A experiment and no further tests have been performed on it during April. A report of both the Category #2 and Category #3 tests on the LSM EM will be found in ATM-626.

The PSE has only been tested during the Array B Category #3 tests which have been conducted in the last month. The test results are discussed later in this report. Category #2 tests of the PSE are documented in ATM-618 and ATM-626, and the Category #3 tests are documented in ATM-626 and ATM-643 for the Array A and Array A3 experiment configurations respectively.

3.4 CATEGORY #2 TESTS

3.4.1 Suprathermal Ion Detector Experiment/Cold Cathode Gauge Experiment Engineering Model

The SIDE EM was received for systems testing and integration with the Central Station early in April. Two views of the experiment are shown in Figure 3.4.1-1.

Testing did not proceed smoothly, fifteen unanticipated discrepancies with either malfunctions or incomplete functional operation of the SIDE EM were recorded. The EM had been accepted at BxA with the high voltage supplies locked out and with no power line input current limiter fitted. It was discovered that the dust cover solenoid was also omitted, and it was not apparent from the test results which of the functional problems were due to malfunctions and which were due to omissions. Table 3.4.1-1 lists the discrepancies which were noted during Category #2 tests of the SIDE EM. These are discussed in greater detail in the subsequent paragraphs.

TABLE 3.4.1-1

SIDE EM DISCREPANCIES NOTED IN EM TESTS

	Discrepancy	ICS Paragraph	ICS Value	Acceptable Value to Bendix	Remarks
1.	Velocity filter voltage indication is noisy when filter is off.	3.2.2.1	Not Detailed	Operational value	1. Breadboard was steady when off.
2.	HE CPA and LECPA voltage indications were noisy when off.	3.2.2.1	Not Detailed	Operational Value	2. Breadboard was steady when off.
3.	HE CPA voltage apparently did not step and indication stayed at digital indication of 255.	3.2.2.1	As Table III	As Table III	3. Breadboard stepped through sequence.
4.	LE CPA voltage apparently did not step properly.	3.2.2.1	As Table III	As Table III	4. EM stepped through 10 steps rather than 20. Master reset did not reset SIDE to 20 step sequence.
5.	CCGE and Channeltron HV supplies were locked out.	3.2.2.1	As Table III	As Table III	5. Known on delivery.
6.	Dust cover solenoid was not included.	3.1.1.6	NA	NA	6. BxA not informed beforehand of this omission.
7.	Command to rest SIDE counter at 10 gave no response.	Not Specified	———	Proper Command Response	7. BxA not informed beforehand of this fault.

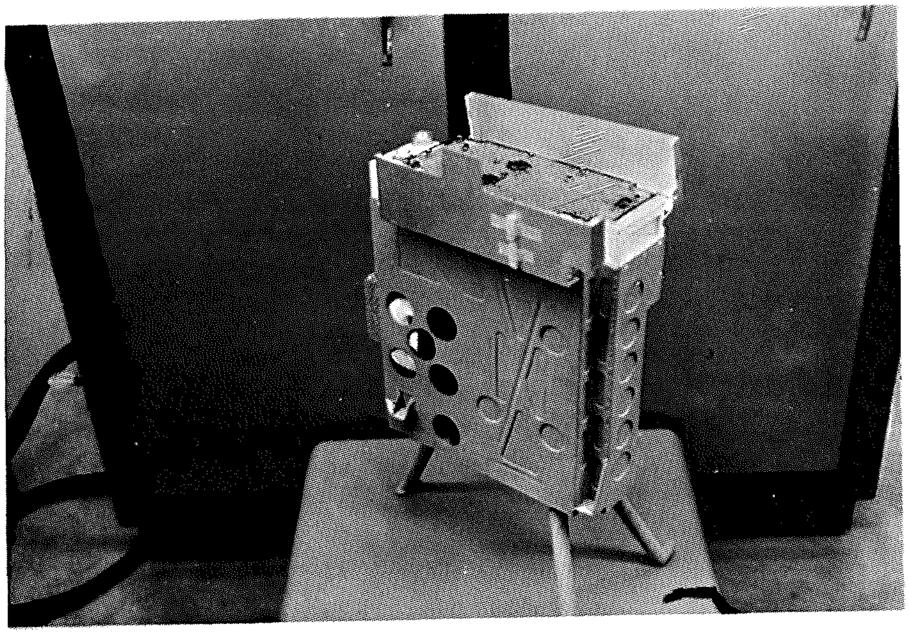
TABLE 3.4.1-1 (CONT.)

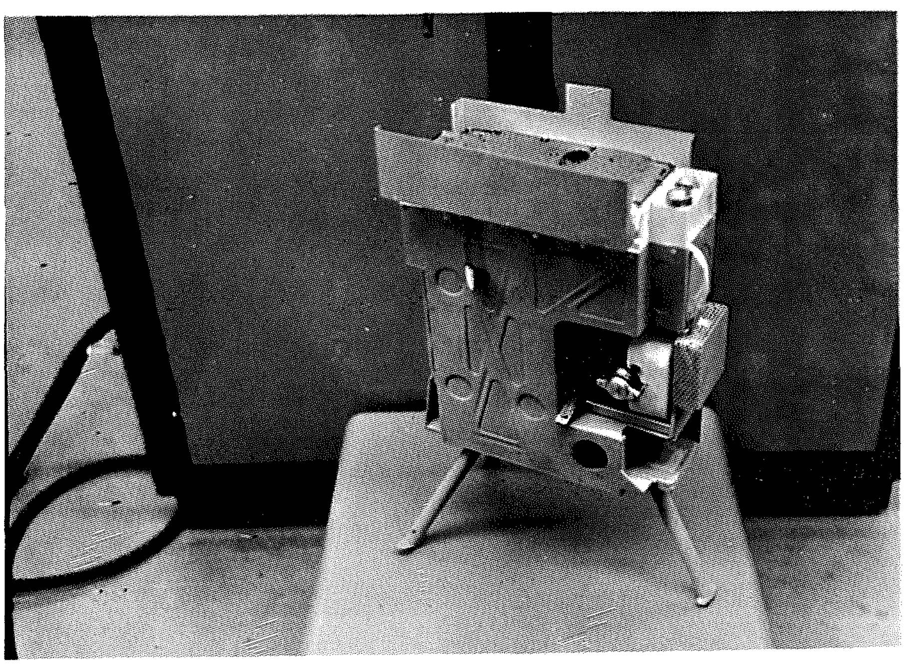
	Discrepancy	ICS Paragraph	ICS Value	Acceptable Value to Bendix		Remarks
8.	Command to reset SIDE counter at 79 gave no response.	Not Specified	———	Proper Command Response	8.	BxA not informed beforehand of this fault.
9.	Command to reset SIDE counter at 79 and velocity filter at 9 gave only proper velocity filter response.	Not Specified	———	Proper Command Response	9.	Same as No. 8.
10.	Output data remained at zero in calibration mode.	3.1.1.5	Not Detailed	Operational Values	10.	Same as No. 8.
11.	Output data remained at zero in all modes of operation.	Not Specified	———	Operational Values	11.	Same as No. 8.
12.	Excessive turn-on power transient.	3.2.3.1	13W (448 mA)	13W	12.	No surge limiter included and BxA surge limiter required for operation.
13.	Excessive noise on +29 volt line.	3.2.3.6	150 mV p-p	150 mV p-p	13.	300 mV p-p observed.

TABLE 3.4.1-1 (CONT.)

	Discrepancy	ICS Paragraph	ICS Value	Acceptable Value to Bendix	Remarks
14.	GPS not stepping properly.	3.2.2.1	As Table IV	As Table IV	14. GPS would jump repeatedly between 4 and 0 and then not change on the following cycle.
15.	GPV sequence not correct.	3.2.2.1	As Table IV	As Table IV	15. Did not follow the GPS. GPV changed erratically.
16.	Temperature sensor outputs remained at zero as telemetered	3.2.2.1	Not Detailed	Operational Values	16. BxA not informed beforehand of this fault.
17.	A/D converter calibration data errors.	3.2.2.1	As Table III	As Table III	17. Considerable errors on the calibrations as telemetered.
18.	The pre-regulator duty factor channel off scale.	3.2.2.1	Not Detailed	Operational Values	18. The telemetry channel was apparently saturated.

Figure 3.4.1-1 (a) and (b) Two General Views of the SIDE Engineering Model





Power

In view of the absence of the power line input current limiter which resulted in a non-representative power system interface, the normal power interface test procedure was abbreviated for the SIDE EM.

As might be anticipated, the experiment turn-on current transient exceeded the ICS limit.

The power line noise feedback was considerably lower than for the SIDE BB, although it was still in excess of the ICS limit. The recorded value was 250 mV p-p as is shown in Figure 3. 4. 1-2.

The operating power profile, and also the turnoff transient were normal and in accordance with the ICS.

Commands

The commands were observed to enter the experiment registers correctly, but several problems were encountered following execution during the command response tests.

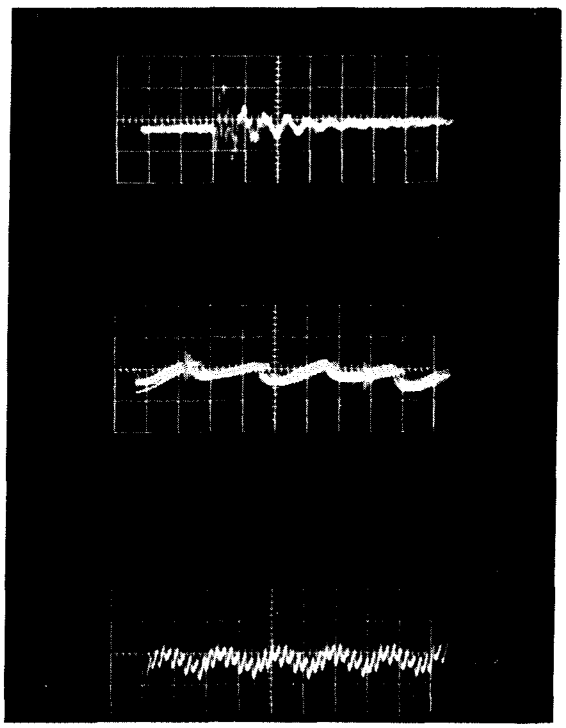
Of the various short cycle commands, i. e. , reset sequence at 10, reset at 39, reset at 79, reset sequence at 79 and velocity counter at 9, only the velocity counter reset correctly and the main sequence responded to the reset at 39 command, otherwise, the main sequence would not reset following these commands.

The sequence would correctly enter the calibration mode on command, but the output data was zero with no indication of calibration circuit operation.

The various on-off voltage commands were all executed correctly. However, when three of these voltages, i. e. , the velocity filter voltage, the high-energy curved plate analyzer and the low-energy curved plate analyzer supplies were turned off, the telemetry outputs monitoring these supplies were noisy, rather than being zero as had been observed with the SIDE BB.

Although the ground plane stepper was correctly controlled by the hold/sequence command, the step as indicated via telemetry would jump repeatedly between 4 and 0 and then not change on the following cycle. The telemetered ground plane voltage on the other hand was erratic and apparently did not follow the indicated step, on occasions the telemetered voltage was zero and some of the voltage steps were never observed.

Figure 3.4.1-2 SIDE Power Line Noise



All records +29V 100 mV/cm

2 μs/cm

20 μs/cm

200 μs/cm

The experiment responded correctly to times ten accumulation interval on/off command.

The opening of the experiment dust cover could not be checked during the command response test as the operating solenoid was not fitted to the EM.

Timing and Data Signal Waveforms

The timing and data signal waveforms were visually observed during the interface checks. All of these appeared to be within the ICS limits, but time did not permit detailed records to be made during the SIDE EM Category #2 tests.

Downlink Performance

The downlink data was decommutated and displayed using the ETS in its system test mode. The data was satisfactorily displayed and six discrepancies were observed.

1. The science data channels remained at zero in all modes of operation.

2. The high-energy curved plate analyzer voltage apparently did not step and the indication on the digital read-out tubes stayed at 255 throughout the sequence when the supply was on.

3. The low-energy curved plate analyzer voltage was not sequencing correctly, it did not reliably either step at the correct SIDE frame, i.e., every twentieth frame, or step to the next successive level in the sequence.

4. The monitored outputs of the experiment temperature sensors in the housekeeping data remained at zero.

5. The A/D converter calibration data showed considerable errors.

6. The pre-regulator duty factor channel in the housekeeping data was off scale.

No attempt was made to operate the experiment with the STS in view of the discrepancies which had been recorded using the ETS, so that no test was made of the parity checking circuits which are incorporated in the experiment.

Also, additional tests were not performed because of the urgency expressed by PI for return of SIDE to the experiment subcontractor.

3.4.2 Cold Cathode Gauge Experiment (MSC)

Following the completion of subsystem tests on this experiment, it was integrated with the Central Station and Category #2 tests were performed between 4/11/67 and 4/14/67. A general view of the CCGE (MSC) is shown in Figure 3.4.2-1. Integration and testing proceeded very smoothly, no problems were encountered during the tests and the experiments functioned very well throughout the tests.

This experiment is designed so that it is able to physically replace the SIDE, so that apart from the interpretation of the CCGE (MSC) output data and command response, in Category #2 tests it may be checked for conformity to the SIDE ICS requirements. Only one minor discrepancy was observed, the crosstalk from the shift onto the data line was larger than has been observed for other experiments, and it marginally exceeded the ICS limit of 100 mV.

A summary of the results of the Category #2 testing performed on the CCGE (MSC) is given below:

Power

The experiment power interface conformed to all the requirements of the ICS, and this is the first of the experiment EM's for which full conformity has been achieved. The power-line noise feedback was exceptionally low, indeed it could not be measured. Limitations of the test setup and measuring techniques produce an upper bound of 20 mV p-p for the experiment noise feedback. The experiment-power consumption is modest, 1-1/2W nominal, and there can be little doubt that this generally eases the problems of meeting the ICS requirements, e.g., the turn-on transient current limit. A summary of the experiment power consumption follows:

Experiment Status	Input Current
1. Normal	50 mA
2. Turn-On Peak	90 to 100 mA
3. Variation During Operation	10 mA increment
4. Standby Heater	Not measured, thermostatically controlled.

The experiment turn-on power line transients are shown in Figure 3.4.2-2.

Figure 3.4.2-1 The CCGE (MSC)

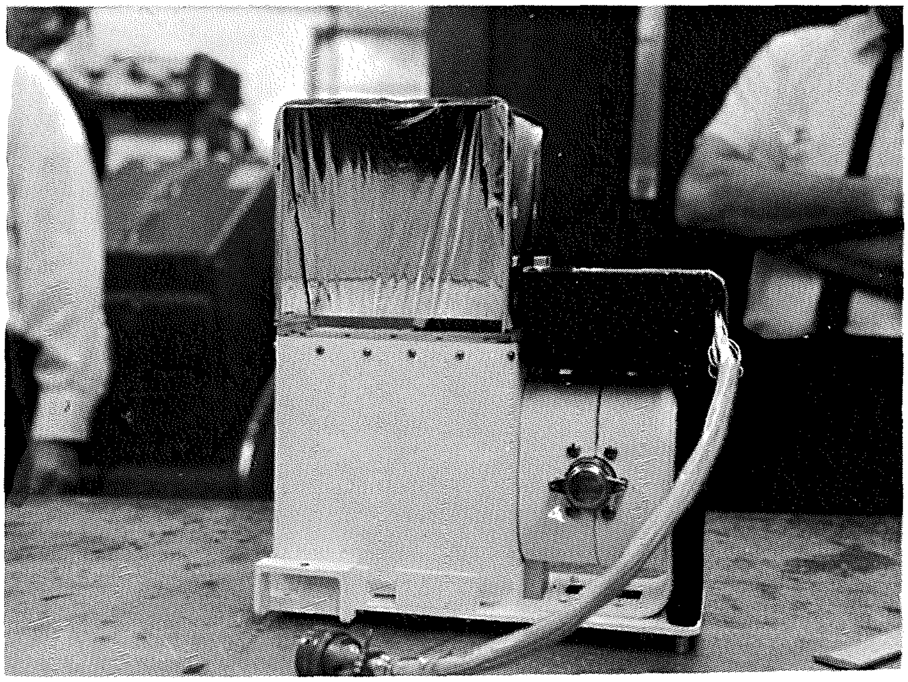
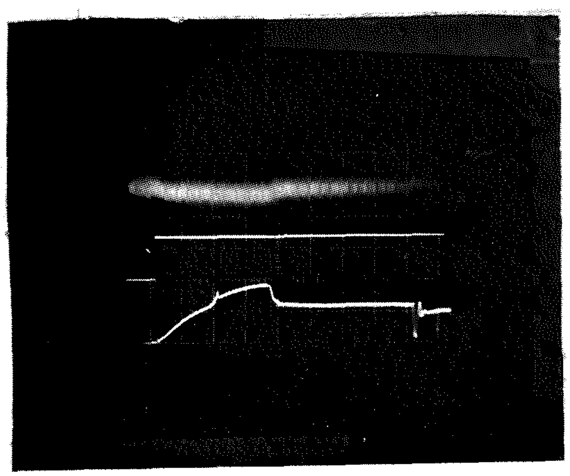


Figure 3.4.2-2 ~~HFE~~ 2. Turn-On Transients

Top Trace: 29V at PCU 100 mV/cm
Middle Trace: 29V at CCGE 20 V/cm
Bottom Trace: Input Current In Power Return 50 mA/cm



20 mS/cm
PCU #2, 15 W Reserve

The experiment input terminal voltage decayed smoothly at turnoff, and no overshoot or oscillatory transients could be detected. The turnoff power line transients are shown in Figure 3.4.2-3. The oscillation of the input current shown on this record after the Central Station relay contact has opened is the standby power on transient, and is observed because the current is monitored in the experiment power return line.

The only current variation during normal operation which was observed was a small fluctuation, lasting typically for 2 mS, following the transmission of a data word. A typical record is shown in Figure 3.4.2-4.

Commands

The experiment responded correctly to all the commands. These commands control the experiment sensitivity and select operate or calibrate modes of operation.

The command line waveforms at the Central Station interface were correct, and there was no evidence of undue loading or noise due to cross-talk.

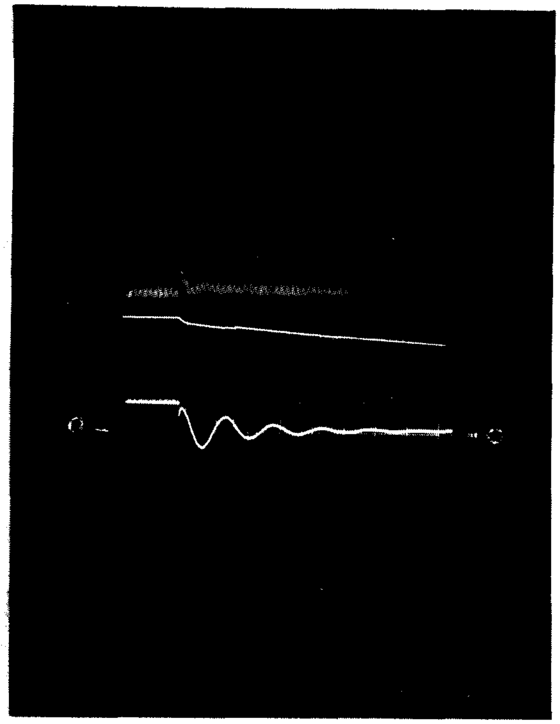
Timing and Data Signal Waveforms

All the timing and data signal waveforms were normal and with one exception were in accordance with the ICS specification values. Typical data for all five CCGE (MSC) words are shown together with the corresponding shift and demand signals are shown in Figure 3.4.2-5.

Detail oscillograph records were taken of all the waveforms, and these are available at BxA. The one discrepancy noted was the crosstalk from the shift onto the data line, the amplitude at the fall of the shift was 250 mV p-p. Also a small amount of ripple was present on the data line following the termination of a CCGE word, but this ripple is within the ICS noise limit of 100 mV p-p. The ripple is illustrated in Figure 3.4.2-6, and the shift crosstalk in Figure 3.4.2-7.

There is evidence that the shift to data line crosstalk largely arose within the experiment, the SIDE BB was later connected to the Central Station in place of the CCGE using the same connector and SBOB to provide essentially the same interface as for the CCGE, and the crosstalk was recorded with the SIDE on, SIDE off and also with the SIDE disconnected, as shown in Figure 3.4.2-8. It will be observed that the inherent crosstalk in the system is less than the ICS level of 100 mV p-p, and that it is very little affected by the operation of the SIDE BB.

Figure 3.4.2-3 CCGE Turnoff Transients



Top Trace: +29v at PCU 100 m v/cm

Middle Trace: +29v at CCGE 20 v/cm

Bottom Trace: Input Current In Power Return 50 mA/cm

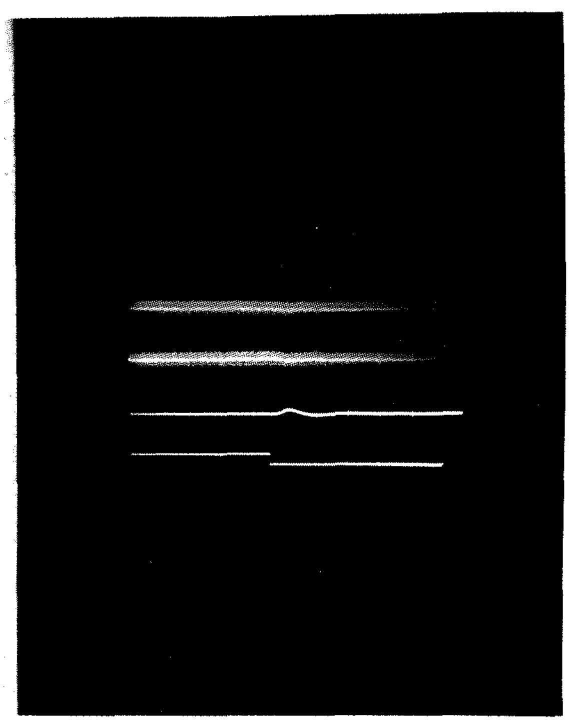
Zero on 1st Major Division

500 µs/cm

PCU #2 15 w Reserve.

Note that the current trace is the sum of the operating power "Off" and the standby Power "On" transients. The oscillation is the stand-by on current.

Figure 3.4.2-4 Detail of CCGE Power Profile



+29 v @ Central Station	100 mv/cm.
+29 v @ Expt.	100 mv/cm.
Input current	50 ma/cm.
Data Demand	10 v/cm.

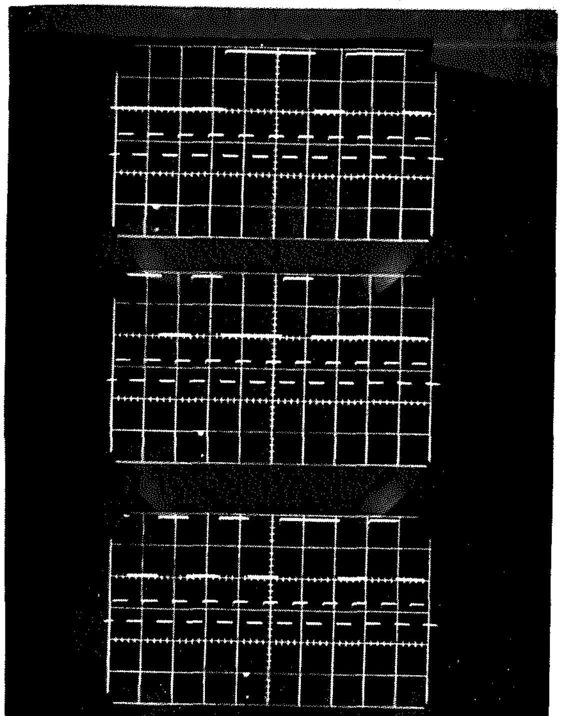
2 m s/cm

Figure 3.4.2-5 CCGE Data Shift and Demand for the Five Experiment Words

All records:

Top trace	Data	2 V/cm
Middle trace	Shift	5 V/cm
Bottom trace	Demand	5 V/cm

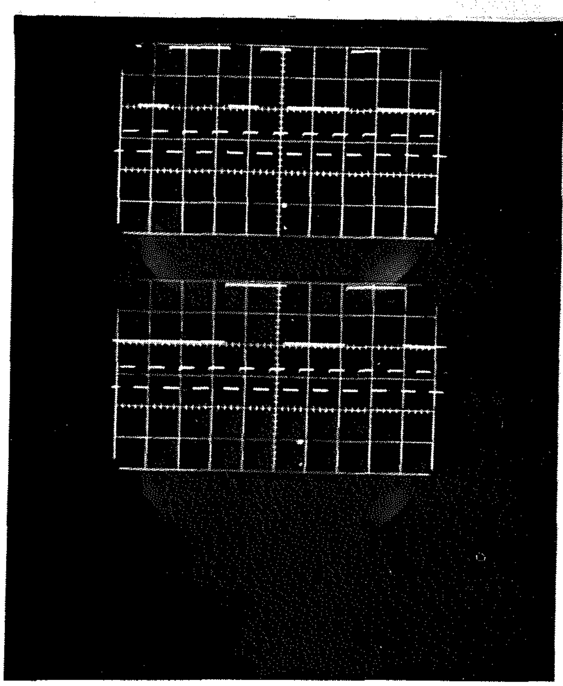
Data and shift	1 ms/cm
Demand	100 ms/cm intensified at sweep of upper traces



CCGE Word #1

CCGE Word #2

CCGE Word #3

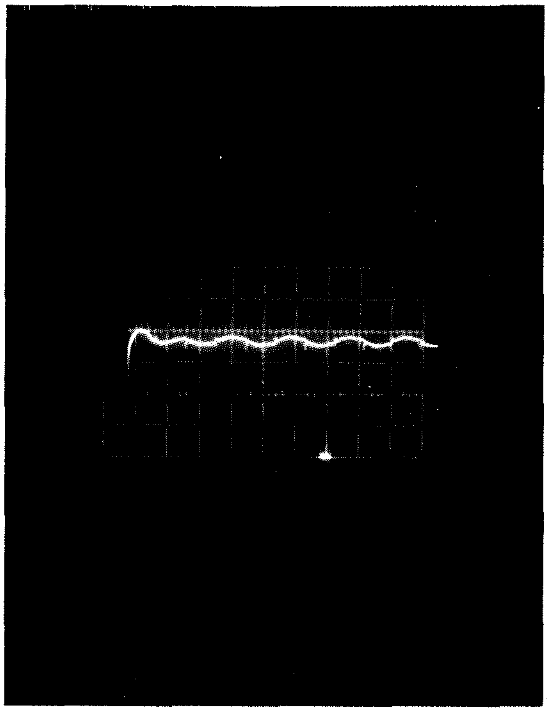


CCGE Word #4

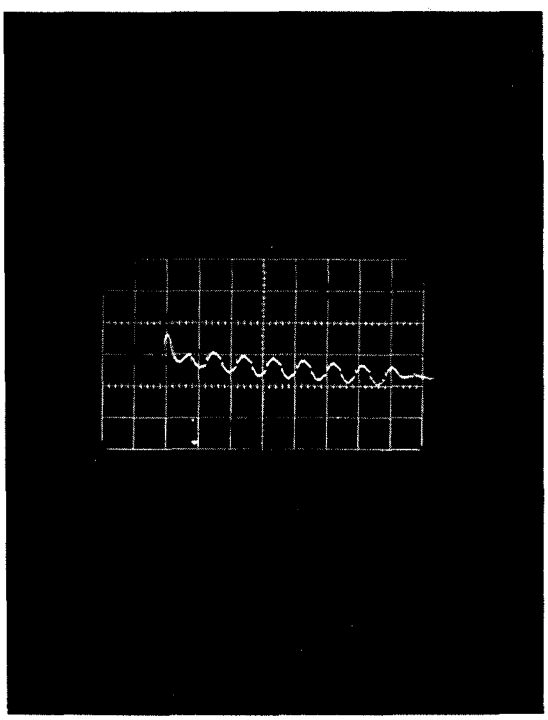
CCGE Word #5

Figure 3.4.2-6 CCGE Data Line Noise

Note: Spikes coincides with rise and fall of shift pulse.



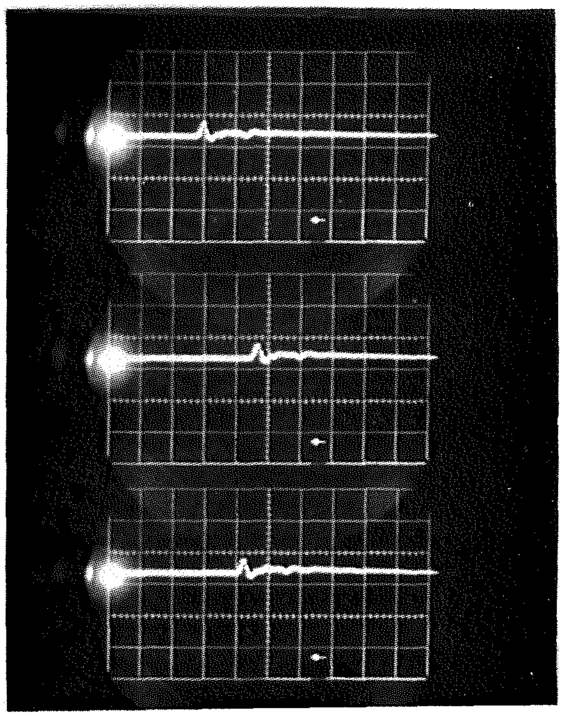
200 mv/cm
500 µ sec 1 cm



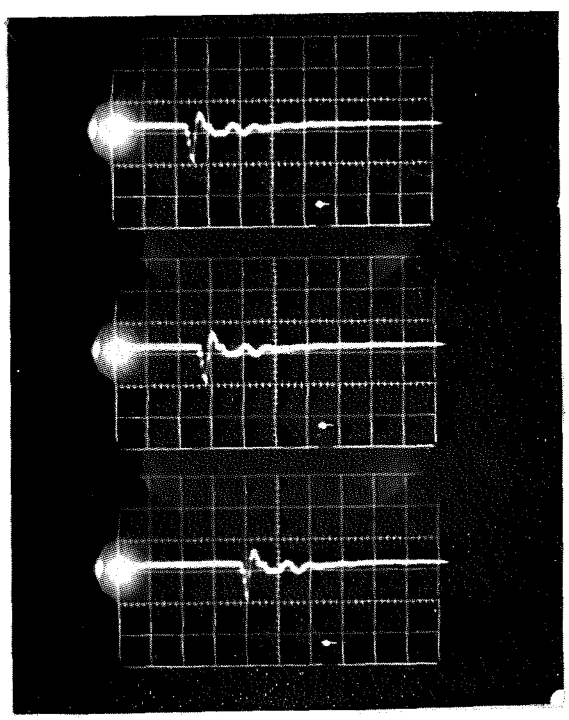
100 mv/cm
1 m sec/cm

Figure 3.4.2-7 CCGE Line Noise/Crosstalk (Data Line Low)

All Records: Top Trace Data Line 200 mv/cm, 2 μ sec/cm. Bottom Trace Demand Line 5 v/cm 20 m sec/cm.



1) At the time of the rise of the shift.

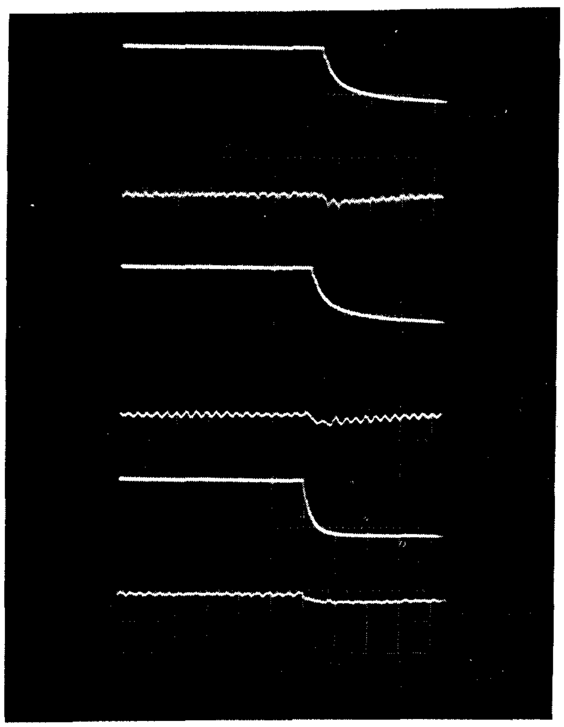


2) At the time of the fall of the shift.

Figure 3.4.2-8 SIDE Data Line Noise/Crosstalk (Data Line Low)

At Fall of Shift

All records:
Top Trace: Shift 2 V/cm
Bottom Trace: Data line 200 mV/cm
2 μs/cm



SIDE On

SIDE Off

SIDE Disconnected

Downlink Performance

A simple program which decommutates and formats for print out the CCGE (MSC) data was prepared for the STS. This was checked during the CCGE Category #2 tests and it was confirmed that the program operated correctly. A limited cross-check was made between data print outs simultaneously obtained from the STS and the ETS. No differences between the two test set outputs were observed during a limited check of about 1000 bits, but time did not permit a more extensive comparison to be made between the outputs of the two test sets.

3.4.3 Heat Flow Experiment

The HFE was integrated with the Central Station and Category #2 tests performed between the 4/17/67 and 4/21/67. These tests proceeded rather more slowly than for other experiments. This is a reflection of the low experiment data rate rather than of any fault within the experiment, and for the same reason the Array B experiment configuration Category #3 tests will also be somewhat protracted. The HFE is shown in Figure 3.4.3-1.

As with the first models of other experiments, the HFE power converter was unshielded and this lead to excessive power line noise feedback, and corresponding crosstalk onto other interface lines. The converter noise was the most significant problem observed in the tests, a full list of discrepancies is given in Table 3.4.3-1 and these are discussed in the summary of the Category #2 tests below:

Power

The power-line input current transient at turn on exceeded the Central Station breaker setting, the peak current recorded was approximately 600 mA, and the current exceeded 400 mA for more than 2 mS. Typical records for the experiment voltage and current at turn on are shown in Figure 3.4.3-2. The large oscillatory voltage transient, shortly after turn on, is caused by relay contact bounce and is effectively one form of experiment turnoff transient and will be discussed later. It was already known from the experiment subsystem test results that some means of limiting the turn-on current transient will have to be incorporated in the experiment.

The HFE has a characteristic power profile, during the period when it is actively generating data, i.e. in ALSEP frames 90 through 15 of the 90 frame sequence, the current is at one level and then reduces to a lower level for frames 16 through 89 as some of the experiment circuits are turned off in the quiescent mode of the experiment. The model of the HFE employed

TABLE 3.4.3-1

HFE DISCREPANCIES NOTED IN EM TESTS

Discrepancy	ICS Paragraph	ICS Value	Acceptable Value to Bendix	Remarks
1. Excessive power converter noise on all interfacing lines.	3.2.3.6	150 mV p-p	150 mv p-p on +29 VDC, 100 mV p-p other lines	1. 1.4 volts peak-to-peak on +29 VDC line, 300 mv p-p on data, 500 mv p-p on analog.
2. No meaningful science outputs can be obtained without a GSE cold chamber.	Under negotiation in CCP #26			2. A chamber to keep probe at temperatures about -50°C and to maintain a gradient along probe to less than 2°C is needed.
3. Excessive turn-on transient.	3.2.3.3	450 mA	450 mA	3. Approximately 600 ma.
4. Excessive turn-off voltage transient.	Not specified		Between -60V to +120V	4. Ranges from -360 volts to +210 volt, contact arcing clearly observed.
5. Erratic termination of data word by HFE data programmer	NA	NA	NA	5. Word sometimes ends on fall of demand and on ocassions a spurious half-data bit is seen after fall of demand. Under investigation to determine significance and cause.

TABLE 3.4.3-1 (CONT.)

	Discrepancy	ICS Paragraph	ICS Value	Acceptable Value to Bendix		Remarks
6.	Logic error in control circuit—EM requires special command sequence.	NA	NA	NA	6.	Known discrepancy corrected by additional gating for command.
7.	Only one heat flow probe was provided.	NA	NA	NA	7.	Two probes to be provided on all succeeding models.
8.	Power profile indicates that high heater comes on transiently on commanding low heater off	AL 280000 3.1.1.4.2	Regulate to 20 μw	—	8.	Actual heater excitation sequence cannot be observed during EM tests. Under investigation by experiment group.

Figure 3.4.3-1 The HFE-Electronics and Probe

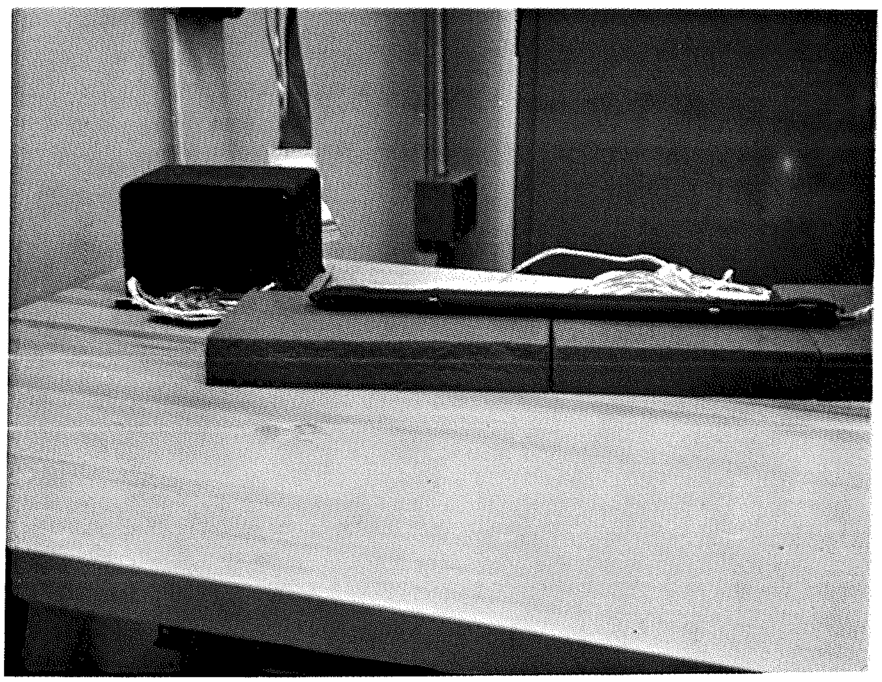
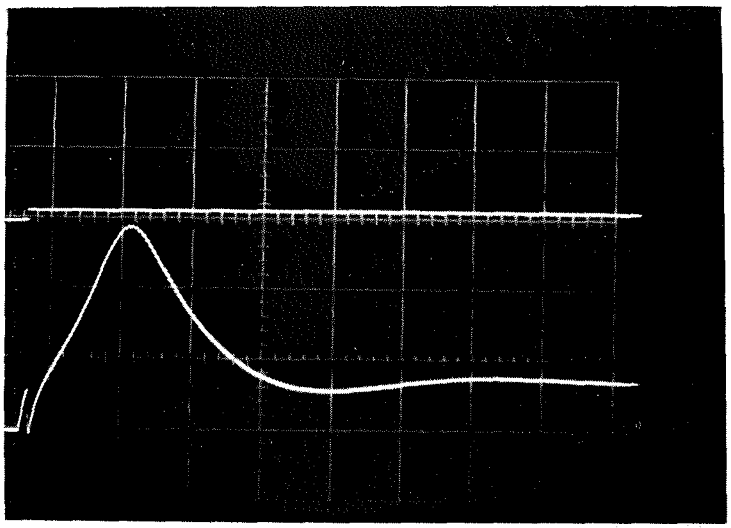


Figure 3.4.3-2 HFE Turn-On Transients

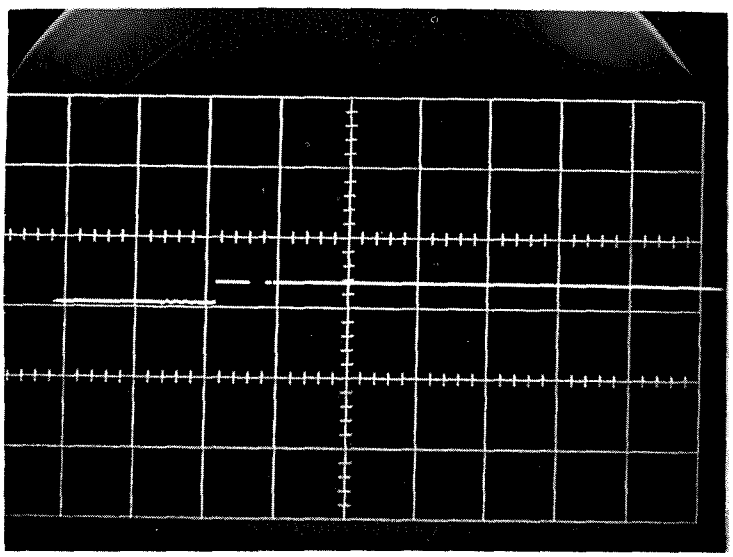


a) Voltage and Current

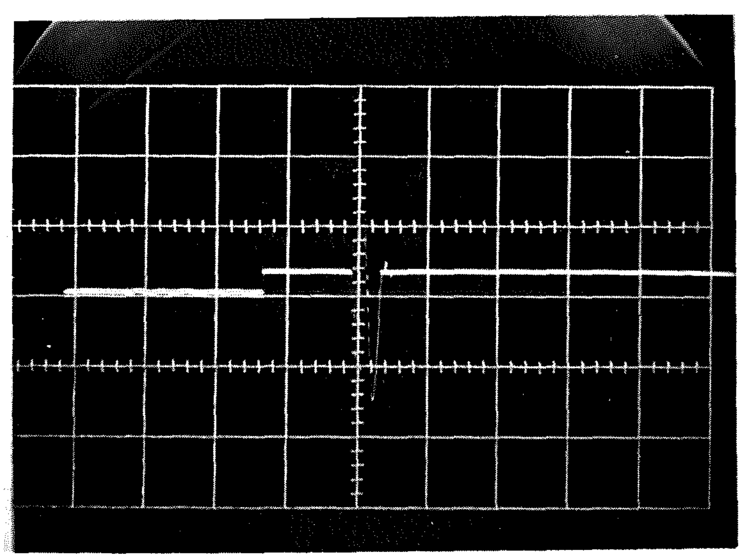
/ 29 v to Expt.
200 v/cm

Input Current
200 mA/cm

2 m s/cm



b) Voltage
+29V to Expt.
100 V/cm
500 μs/cm



c) Voltage

/ 29 v to Expt.
100 v/cm
200 μ s/cm

in the EM systems tests only contained the circuits for one sensor channel and so the current consumption was not representative of the operational models. The recorded power consumption was:

Experiment Status	Input Current Active	Input Current Quiescent
Normal, heaters off	183 mA	138 mA
Low heater on	205 mA	147 mA
High heater on	238 mA	198 mA
Incremental changes (all heater modes)	about 10mA	negligible
Standby	———	100 mA

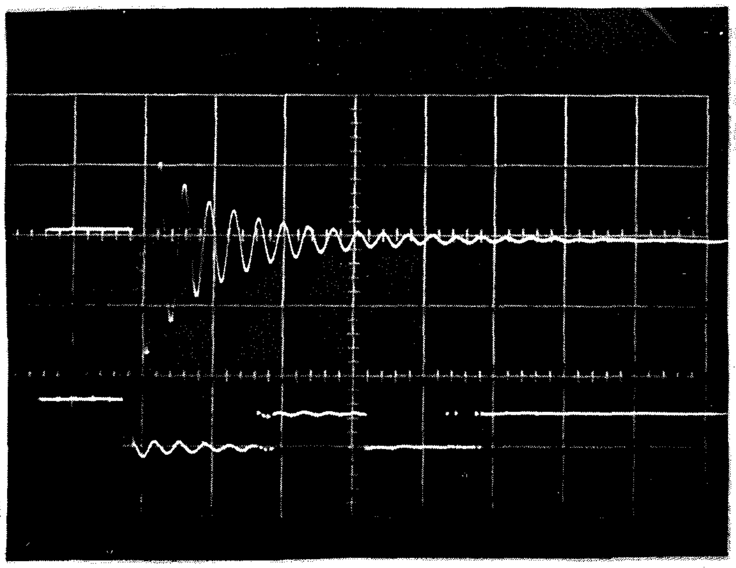
The experiment input power line voltage and current transients at turnoff are shown in Figure 3.4.3-3. It will be observed that a large oscillatory voltage transient follows the opening of the Central Station relay contact arising from the energy stored in the experiment input circuits.

The first negative-going swing has a somewhat indeterminate amplitude, and there can be little doubt that an arc is drawn between the relay contacts when these first break and before the contacts obtain their full separation; and the amount of energy lost in the arc is variable. On all the turnoff transients observed, the arcing could be detected. The amplitude of the transient after the arc was extinguished ranged up to peak values of -360V, +210V. The oscillatory voltage transient at turn on, associated with relay bounce, is essentially similar to and due to the same mechanism, as the turnoff transient. The current transient at turnoff was measured in the experiment power return line, and the standby power on current transient can also be seen in Figure 3.4.3-3 (b).

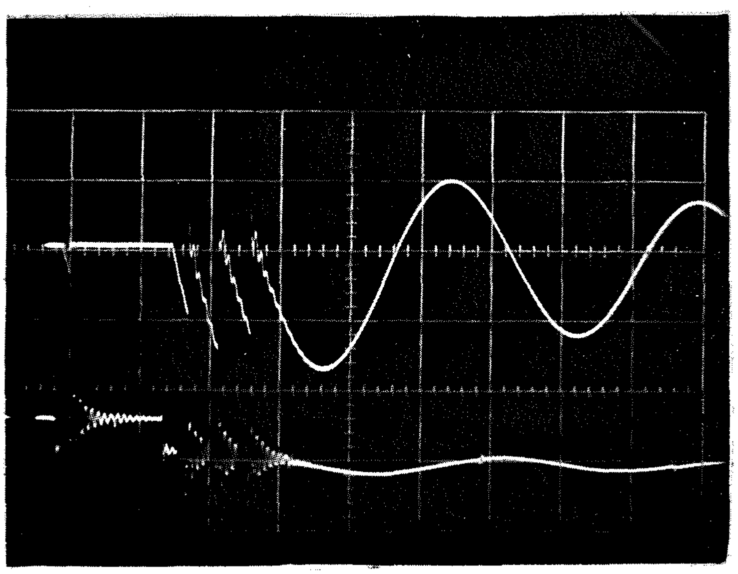
The power converter noise level varies somewhat between the active and quiescent operating modes of the experiment, and is presumably dependent on the input power. Typical noise transients on the input power line voltage and current are shown in Figure 3.4.3-4. The noise shows the characteristic unbalance of power converter transients between the noise induced on alternate half cycles of the converter, and both the larger and smaller peaks are shown for the quiescent and active modes of the experiment. The larger voltage transient amplitude is about 1.4V peak-to-peak, with a corresponding current transient of about 70 mA peak-to-peak. Later models of the HFE will incorporate a shielded power converter and improved filters on the input power lines which should substantially reduce the noise feedback.

Both Records: Top Trace ≠ 29v at expt. 200 v/cm.
Bottom Trace: Experiment Input current in power return line 200 m A/cm.

Figure 3.4.3-3 HFE Turnoff Transients



a) 200 μ s/cm

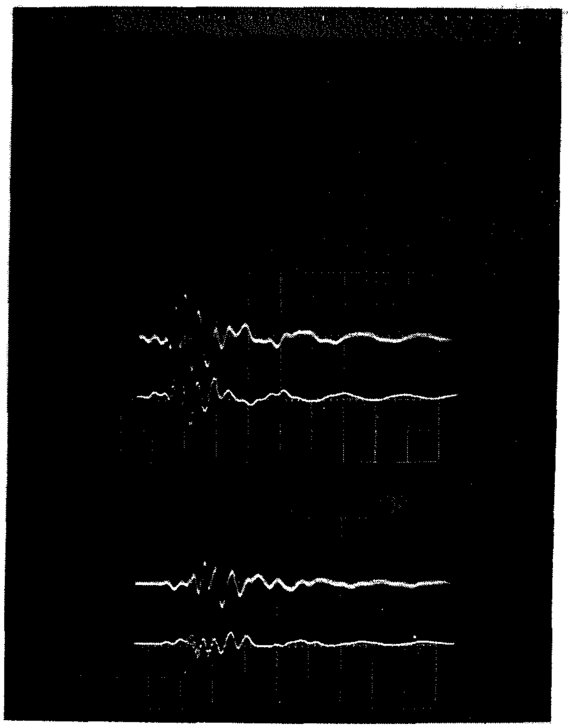


b) 20 μ s/cm

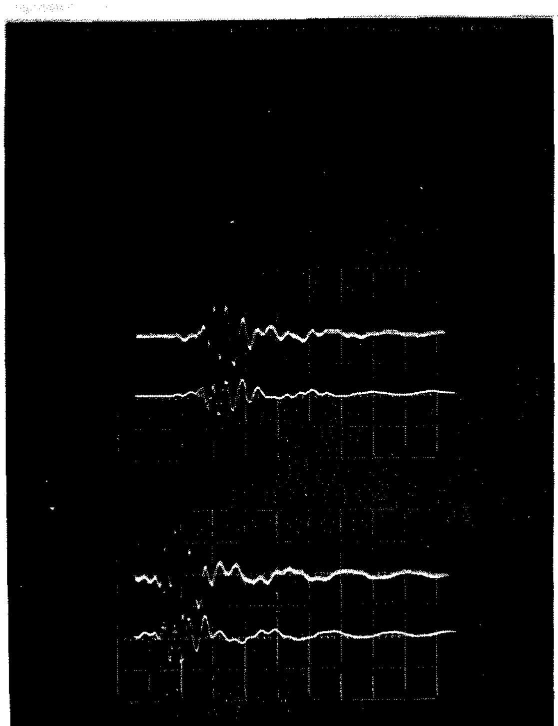
All Records: Top Trace ∤29° 500 m v/cm
Bottom Trace Expt Input
Current 50 m A/cm

Figure 3.4.3-4 HFE Power Line Noise, Voltage and Current

1 μ s/cm



1) Expt. Quiescent



2) Expt. Active

Commands

Command response was correct for this model of the HFE which requires a slightly different command sequence to obtain certain experiment short cycle sequences than later models. The command sequence employed in the response test initiated the various experiment operating modes and short cycle sequences, substantially independently, starting from the basic reset operating mode of the experiment and correct operation in each experiment mode was confirmed. More complex command sequences will be run later during Category #3 tests using the STS to monitor and process the experiment data.

The only unexpected phenomenon observed was that the power line input current recorded on commanding the low-power heater off was consistent with a sequence in which the high-power heater would first be turned on for one or two seconds then both heaters would be turned off. The actual heater excitation sequence could not be observed during the test, and this point has been referred to the experiments group for investigation.

The command line interface waveforms indicated that the loading of the experiment circuits on the Central Station circuits was minimal. Power converter noise crosstalk could be observed on the interface lines, as shown in Figure 3.4.3-5, and the amplitude was sufficient to carry the logic "low" level beyond the ICS limits of 0 to +0.4V.

Timing and Data Signal Waveforms

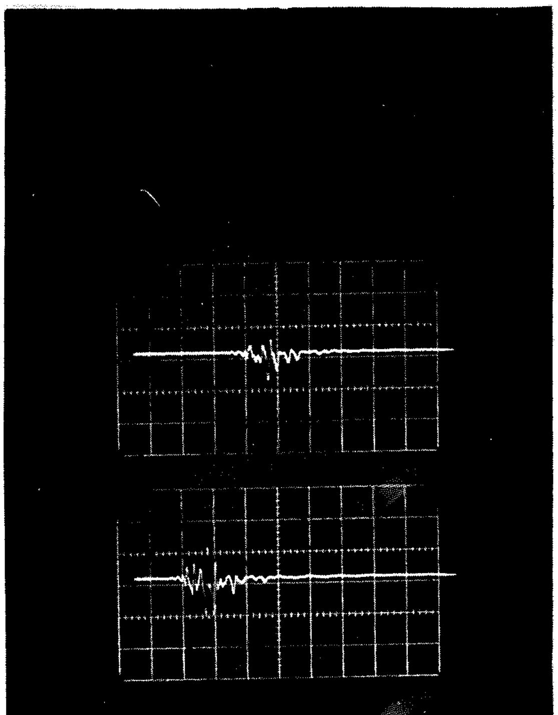
The timing signal waveforms at the experiment interface were examined and detail records are available at BxA. All the waveforms were in accordance with the ICS limits except that the 90th Frame Mark pulse as shown in Figure 3.4.3-6 has an unusually slow rise time.

The experiment output data waveform was normal and Figure 3.4.3-7 shows typical data waveforms for the HFE word #1, together with the corresponding shift and data demand signals. An anomaly was observed on clearing the last bit of a data word, normally the data line would fall to the low level at the fall of the shift, but on occasions the data line did not fall until the end of the data demand pulse. The four possible states are shown in Figure 3.4.3-8; last data bit "one", fall of data line with shift; last data bit "one", fall of data line with data demand; last data bit "zero", data line remains low through termination of data demand pulse; last data bit "zero" followed by a rise of the data line to a high level at the fall of the shift, the high level being terminated at the fall of the demand pulse. The significance and cause of the observed experiment data processor behavior are not clear and these are being further investigated.

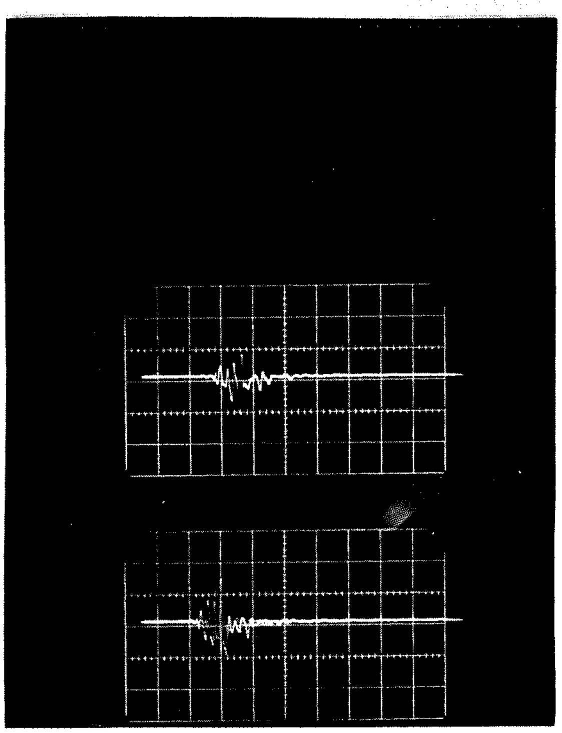
Figure 3.4.3-5 HFE - Command Line Noise, Channel 1. Detail of Large and Small Peaks

All Records: 500 m v/cm Zero on Centre Line

2 μ s/cm Command Line Low

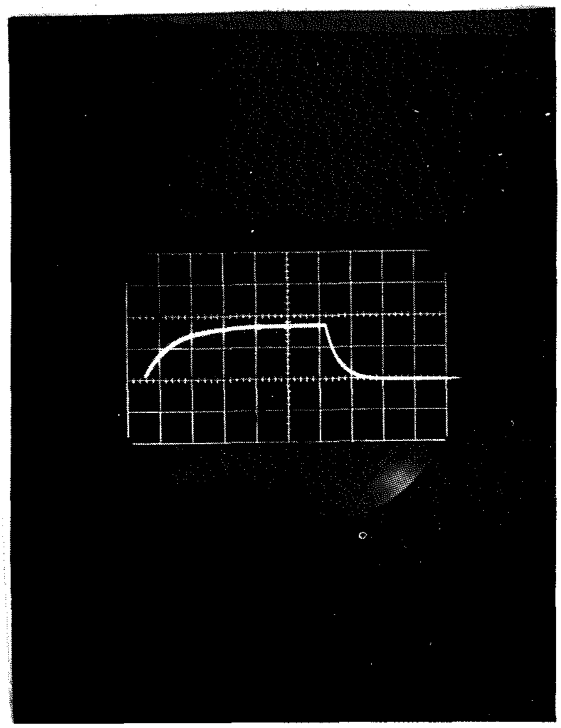


1) Expt. Quiescent



2) Expt. Active

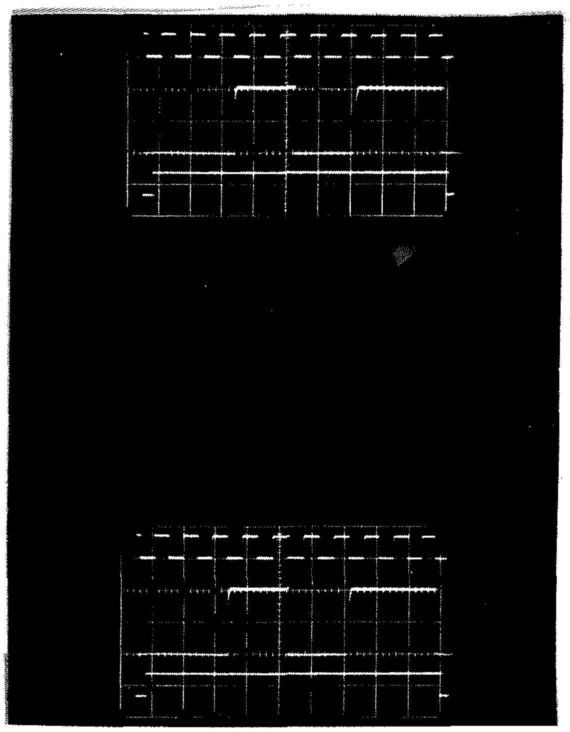
Figure 3.4.3-6 HFE - 90th
Frame Mark Data
Processor X



2 v/cm

20 μ s/cm

Figure 3.4.3-7 HFE Data, Shift and Demand, HFE Word #1, Data Processor X



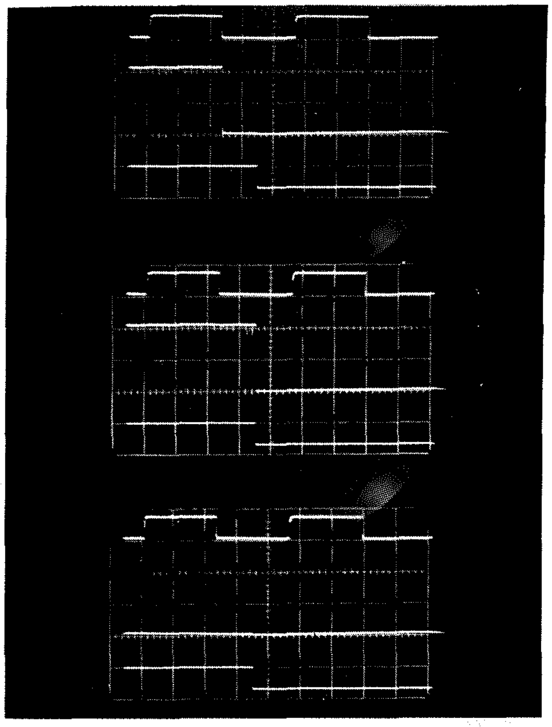
BOTH RECORDS: Top Trace Shift 5 v/cm
Middle Trace Data 2v/cm
Bottom Trace Data Demand 5 v/cm

1 m s/cm

ALL RECORDS: - Top Trace Shift 5 v/cm
Middle Trace Data 2 v/cm
Bottom Trace Data Demand 5 v/cm

200 μ s/cm

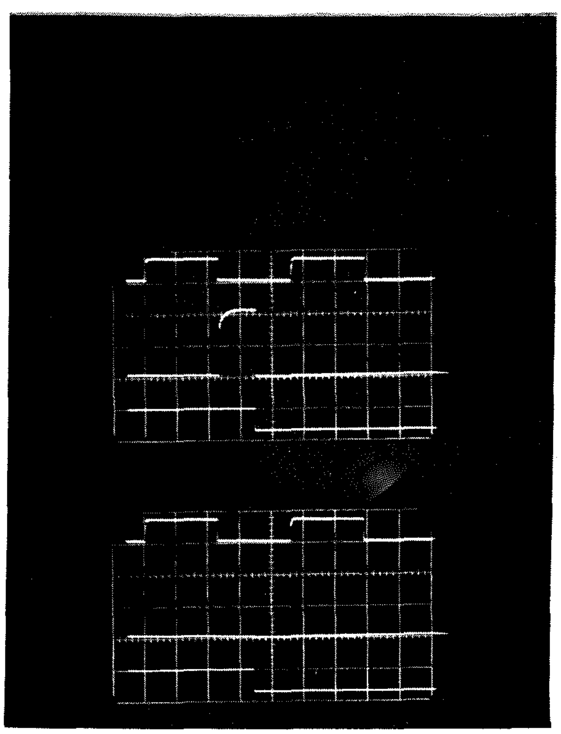
Figure 3.4.3-8 HFE Data-End of Data Word



1) Last Data Bit "one" Fall with Shift

2) Last Data Bit "one" Fall with Data Demand

3) Last Data Bit "zero"



4) Last Data Bit "Zero" Followed by High on Line between Fall of Shift and Fall of Data Demand

Power converter noise crosstalk was evident on the data line. The magnitude of the crosstalk was found to be dependent on the shift signal level as shown in Figure 3.4.3-9, the noise amplitude being substantially higher when the shift signal was high than when the shift signal was low. The crosstalk from the larger and smaller converter noise peaks are shown in detail in Figure 3.4.3.-10, the larger transient when the shift is high, has an amplitude of 300 mV peak-to-peak, the smaller being 200 mV peak-to-peak. The crosstalk on the data line at the fall of the shift is also shown in the same figure, and is about 100 mV peak-to-peak.

Analog Signals

The analog outputs from the HFE were correctly monitored by the Central Station.

Two forms of spurious noise signals were found to be present on these lines; one has already been discussed in Section 3.2, noise apparently being generated by the Central Station analog multiplexer; the other is experiment power converter noise crosstalk which has an amplitude of 400 to 500 mV peak-to-peak on the analog lines. This converter noise crosstalk is shown in Figure 3.4.3-11.

Downlink Performance

During the Category #2 tests of the HFE the data subsystem test set display unit, the DDS 1000, was used to display and print out the experiment data. No problems were encountered in using this test set to read the data, as confirmed by observing the recorded values of the two experiment sequence counters outputs.

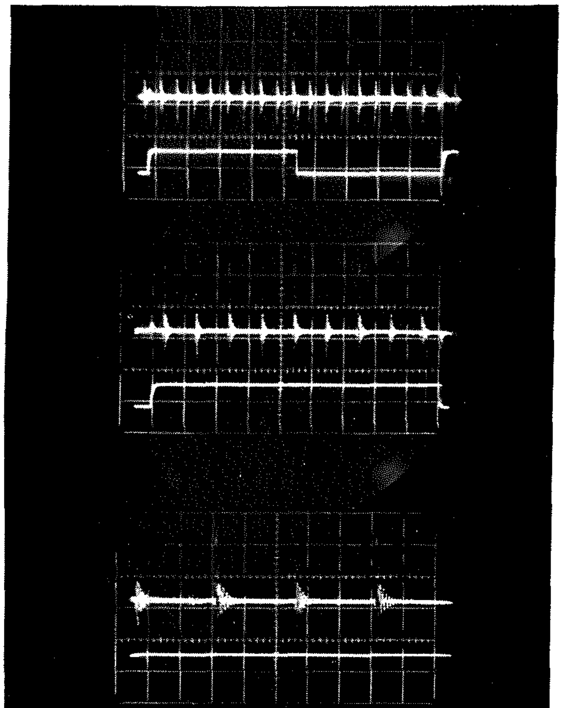
It was not possible to operate with the sensor in a controlled environment. Therefore meaningful science output data could not be obtained.

3.4.4 Active Seismic Experiment

The remaining experiment interface checks which were outstanding at the time of writing the March Progress Report, ATM-643, were completed early in April. No discrepancies were observed, there is no apparent change in the power line quality on energizing the ASE, and the command line waveforms are in accordance with the ICS requirements. The shift and data signal waveforms were discussed in ATM-643 and are shown in Figure 3.3.4-1 of that report.

All records: - Top trace data line 100 mV/cm
Bottom trace shift 5 V/cm
Note dependence of noise amplitude on shift signal level.

Figure 3.4.3-9 HFE - Data Line Noise

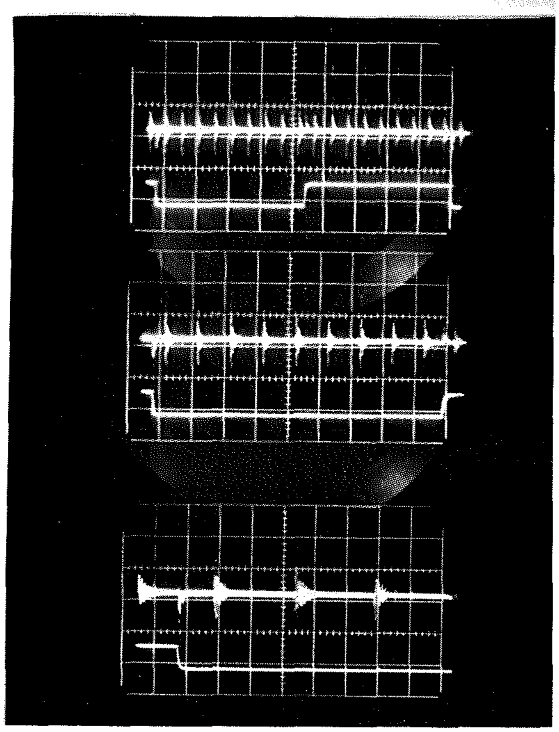


1) Data Processor X

100 μ s/cm

50 μ s/cm

20 μ s/cm



2) Data Processor Y

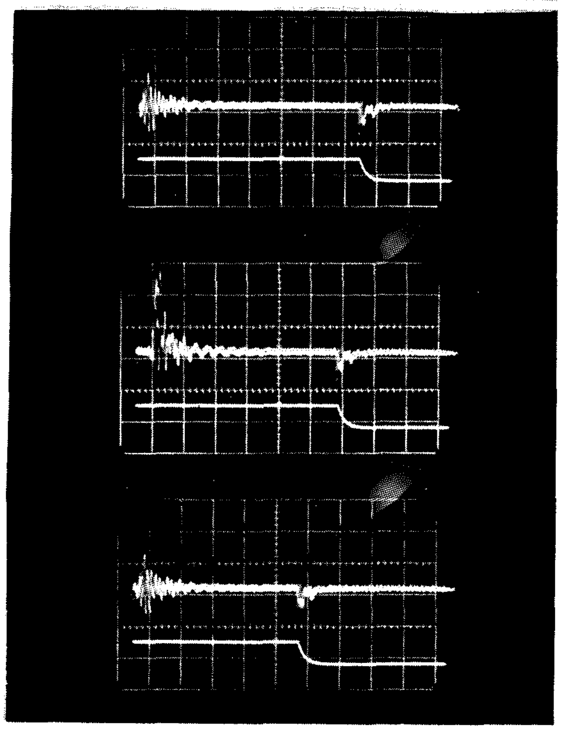
100 μ s/cm

50 μ s/cm

20 μ s/cm

All Records: Top Trace Data Line 100 m v/cm
Bottom Trace Shift 5 v/cm
5 μ s/cm

Figure 3.4.3-10 HFE Data Line Noise



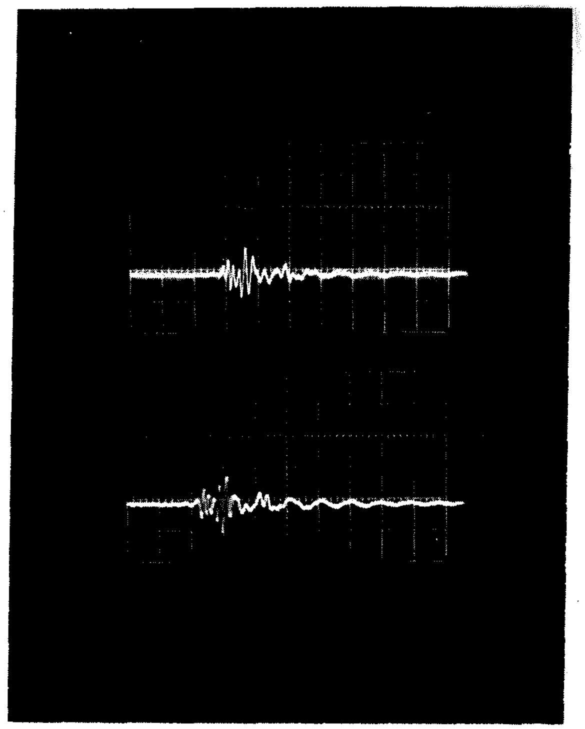
Detail of

1) Large & small convertor induced noise peaks, shift high

2) Crosstalk at fall of shift.

DATA PROCESSOR Y

Figure 3.4.3-11 HFE Analog Line #1 Noise
Detail of Converter Crosstalk



Experiment Active

Small peak
200 mV/cm
2 μs/cm

Large peak
200 mV/cm
2 μs/cm

3.5 CATEGORY #3 TESTS

3.5.1 Array A Tests

Category #3 testing of the original Array A experiment configuration was reported in ATM-626, and the tests of the Array A3 experiment configuration were reported in the March Progress Report, ATM-643. As was also reported in March, the ALSEP System Engineering Model was rebuilt to the Array B configuration during March, and no further Category #3 tests of the Array A configuration were planned, nor have been made, following the rebuild.

3.5.2 Array B Tests

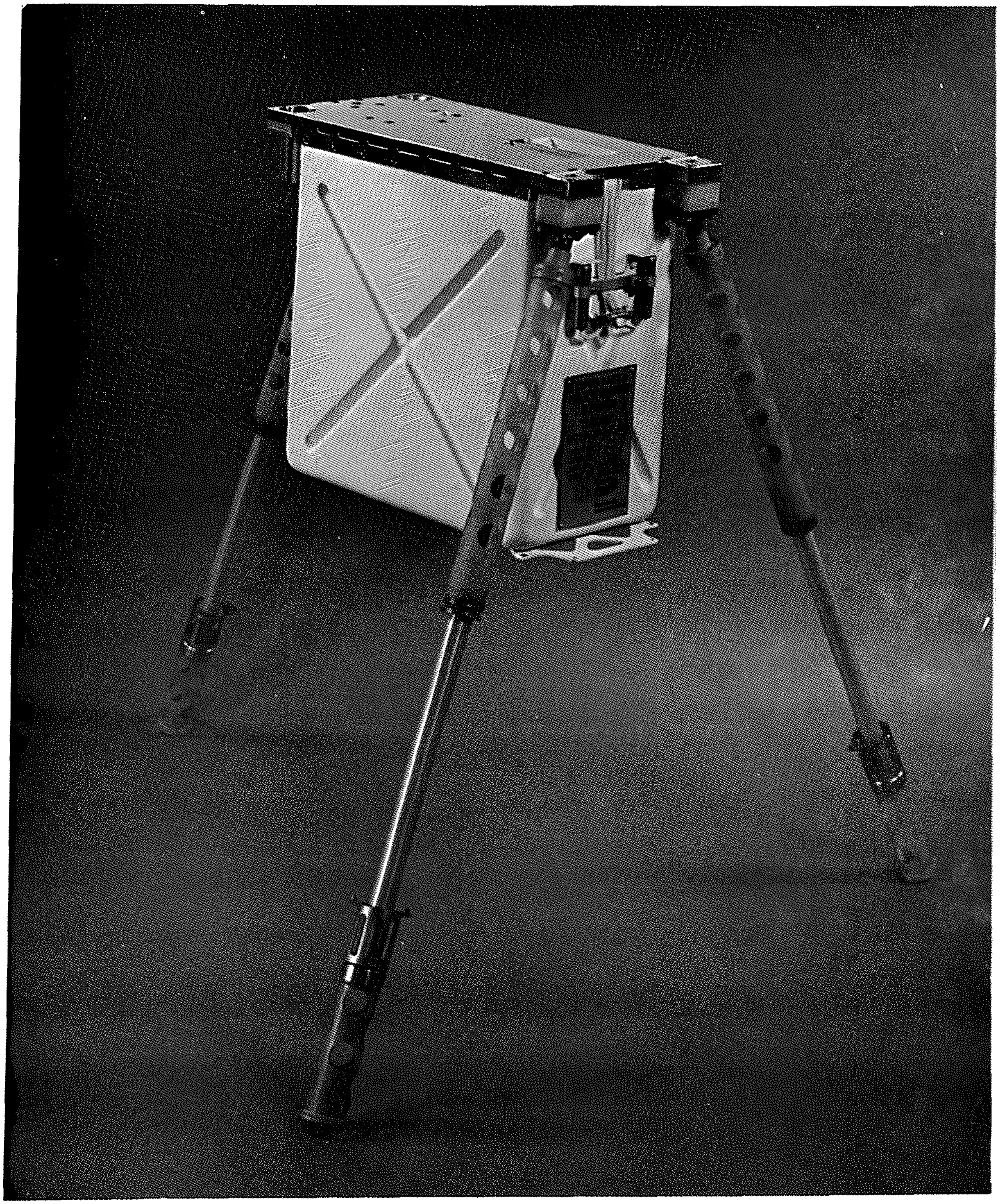
The Array B experiment configuration comprising the PSE EM, the HFE EM, the CPLEE EM, the SIDE BB and the ASE EM was assembled with the Central Station and the five experiments were operated for the first time 4/26/67. Later, it was necessary to remove the CPLEE from the array for further subsystem testing in vacuum, and it could not be placed on line again for further ALSEP system tests before the end of the reporting period. Figure 3.5.2-1 shows the CPLEE Engineering Model.

Our experience with operating the HFE during Category #2 tests indicated that it would be very difficult and tedious to continue with the Category #3 tests without using the STS to read and analyze the HFE data, and that it would be impractical to perform meaningful interaction tests with manual HFE data logging and analysis. As the HFE is the only Array B experiment which has not previously been subjected to Category #3 testing in at least one experiment array, priority was given to confirming the HFE STS program.

The HFE program was loaded and run 4/27/67. This program in addition to decommutating the experiment data and formating it for print out, tracks the various experiment operating modes and data sequences in accordance with the commands which have previously been sent to the experiment. The program also analyses the data arithmetically, and calculates the experiment offset and gain settings and the ratio of the various bridge outputs and excitation levels. Error tests are provided for the observed experiment status bits compared to the commanded status for both the operating mode and data sequences, and the experiment analog housekeeping data is also formatted for print out and error checked against pre-set tolerances.

The program had been written for the HFE Prototype Model, and the changes required to accommodate the somewhat different EM command sequence were patched into the program. Checking and debugging of the program proceeded smoothly, and all functions are now being performed

Figure 3.5.2-1 The CPLEE Engineering Model



correctly apart from erroneous calculation of the ratio of the bridge outputs and excitation levels. The subroutine for this calculation involves a sign test and division in double precision arithmetic and the programmer is working on this problem. However, this has little impact on the EM Category #3 tests as the ratio calculation has little meaning with the experiment's probe in an uncontrolled environment.

Just prior to starting the Category #3 tests, the PSE EM was operated with the STS and the problems of operating in this test mode reported in ATM-643 were resolved. Faults were located in the STS D/A converter, these were rectified and it was confirmed that the STS will now read and display the PSE data correctly.

3.6 STS SOFTWARE STATUS

The STS software package for testing the ALSEP Central Station and all experiments is now complete, with the exception of ASE program which is now being checked by the programmers on the PDP-8 ALSEP simulator. The only program which requires correction is the HFE program in which the subroutine used to calculate the ratio of the bridge outputs to bridge excitations is not operating properly. Otherwise, all the programs are running correctly and have been verified during the ALSEP EM System Tests.

As reported above in Section 3.5.2 faults in the STS analog to digital converter have been rectified and the STS will now process and display the PSE output data correctly.

3.7 EM TESTS ON THE PROTOTYPE PCU

The prototype PCU ran with the EM to evaluate the magnitude of the PCU low- and high-frequency ripple and noise. These prototype equipment tests were performed on the EM because of the existence of test monitoring points at PCU output lines which are not available in the prototype arrangement.

There are two noise and ripple sources within the PCU. One component is a continuous low frequency ripple at the converter frequency and the second is a short duration impulsive noise burst on the leading and trailing edges of the DC - DC converter chopper.

Table 3.7-1 summarizes the results of these tests. As shown the low frequency ripple is within specification of 100 mv noise for all voltages at the PCU output and on the +29V line at the experiments (SIDE signal breakout box). Two values are listed for the high-frequency noise corresponding to characteristic alternate small and large spikes observed. The amplitude of the high-frequency noise on the +29VDC lines at the experiment is greatly diminished by the filtering effects of the experiment circuit protection devices. No apparent difference between PCU #1 and #2 was noted. The test results are shown in Figures 3.7-1 through 3.7-7.

TABLE 3.7-1

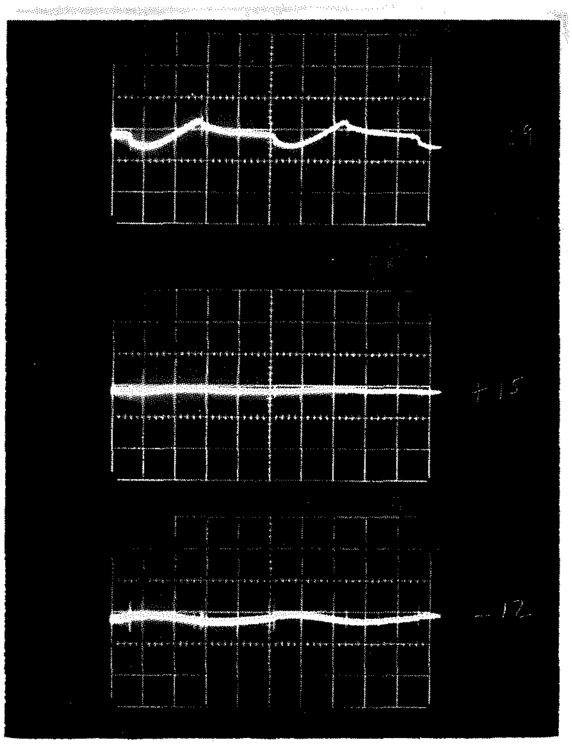
PROTOTYPE PCU NOISE

	Low Frequency Noise Peak-to-Peak		High Frequency Noise Voltage Peak-to-Peak		
Voltage	At PCU	At Experiment	At PCU Output	At Experiment	Remarks
+29 VDC	100 mv	90 mv (SIDE SBOB)	80 to 160 mv	50 to 70 mv	Alternate small and large high frequency spikes noted.
+15	30	30	40 to 60	______	
+12	45	______	80 to 150	______	
+5	40	______	40 to 130	70 (ASE Connector)	
-6	40	______	30 to 110	______	
-12	50	______	80 to 220	150 (ASE Connector)	
+16 VDC	Not measured		150 to 260	______	

NOISE CHARACTERISTICS

		High Frequency	Low Frequency
Frequency Components	-	3 to 5 MHz	11.3 KHz
Duration	-	Few μ sec	Continuous
Repetition Rate	-	22.5 KHz	Continuous

Figure 3.7-1 Prototype PCU #1 Noise

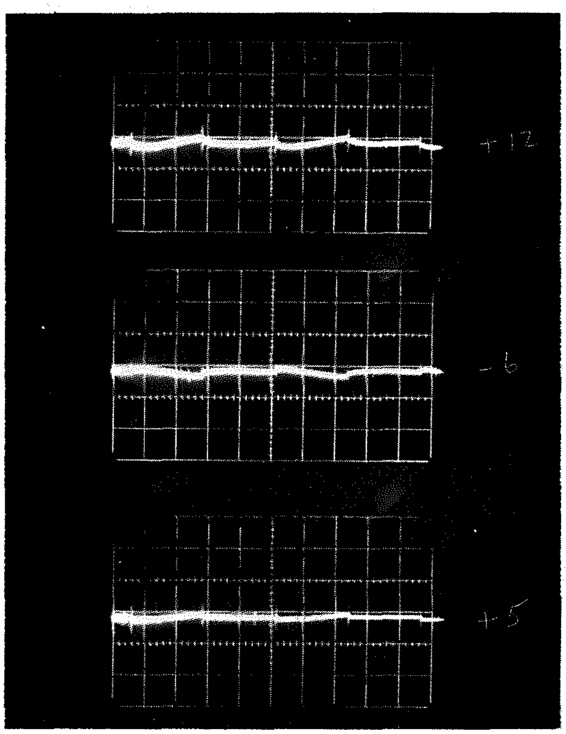


PCU #1 at PCU

+29 VDC

+15 VDC

-12 VDC



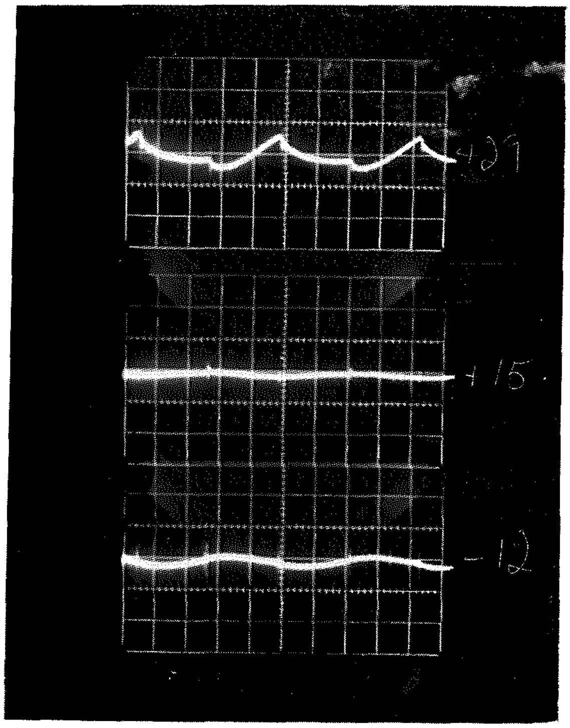
All records
100 mv/cm
20 μ sec/cm

+12 VDC

-6 VDC

+5 VDC

Figure 3.7-2 Prototype PCU #2 Noise



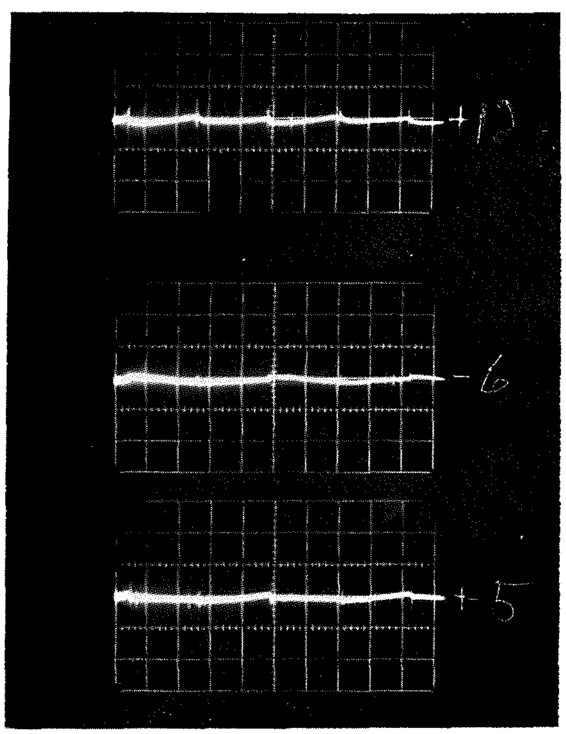
PCU #2 at PCU

+29 VDC

+15 VDC

+12 VDC

All records
100 mv/cm
20 μ sec/cm

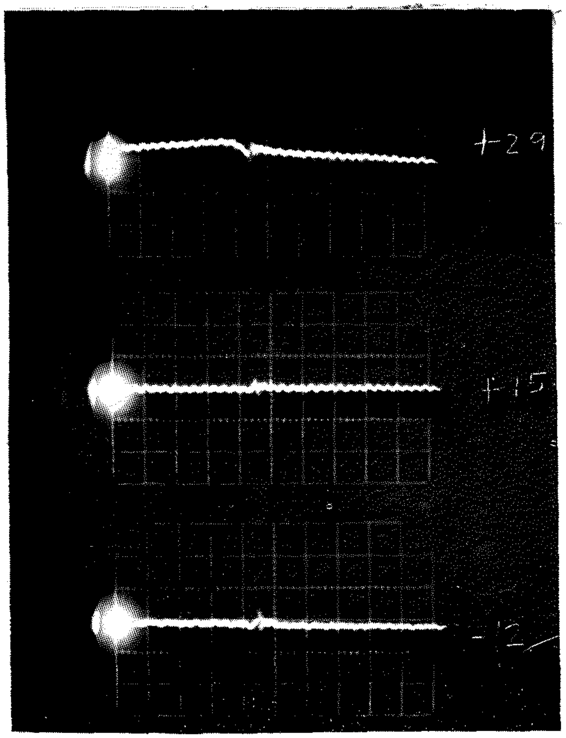


+12 VDC

-6 VDC

+5 VDC

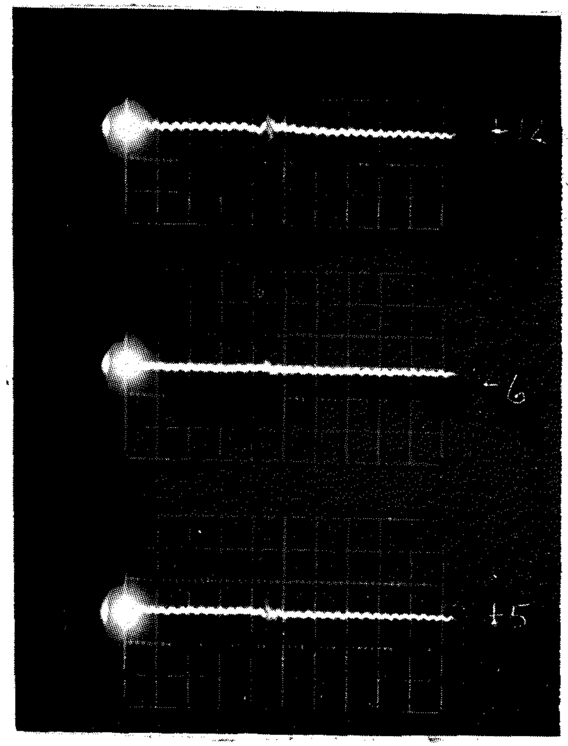
Figure 3.7-3 Prototype PCU #2 Noise Detail



+29 VDC

+15 VDC

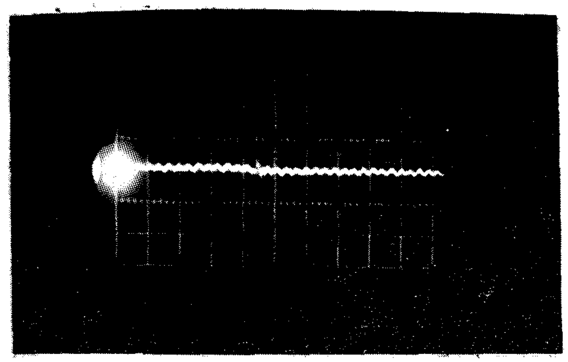
-12 VDC



+12 VDC

-6 VDC

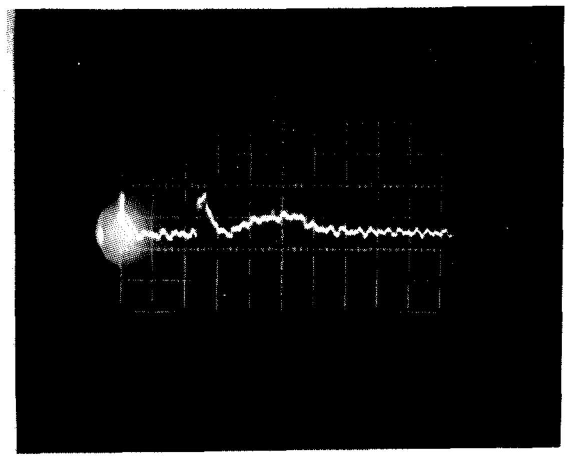
+5 VDC



+5 VDC

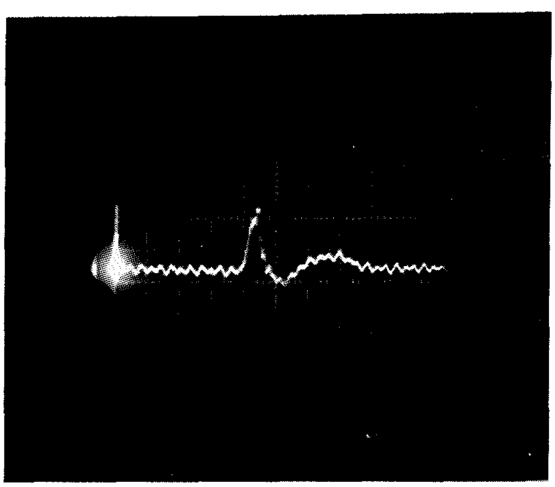
All records
100 mV/cm
2 μ sec/cm

Figure 3.7-4 Prototype PCU 16V Input Line Noise



+16 VDC RTG Input
56 watts input - 3 watts reserve

PCU #1
100 mv/cm
2 µsec/cm

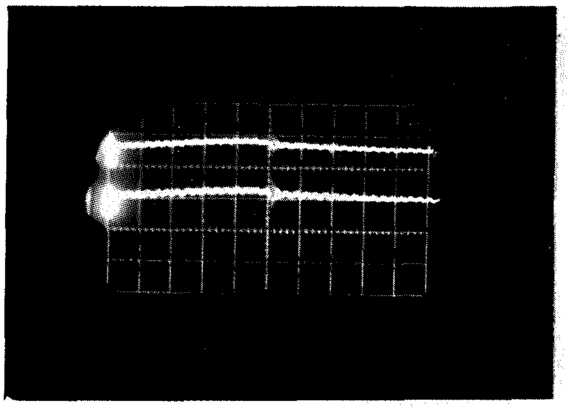


PCU #2
100 mv/cm
2 µsec/cm

Figure 3.7-5 Prototype PCU Noise

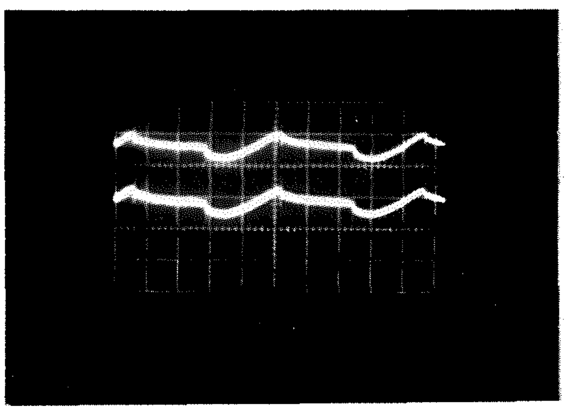
Comparison of Noise at PCU and SIDE SBOB

Top Trace	SIDE - SBOB
Bottom Trace	PCU Output

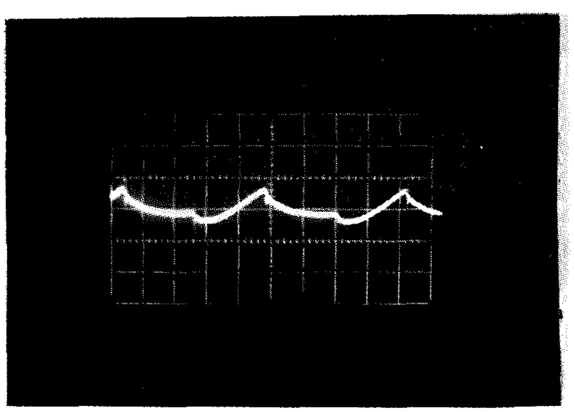


PCU #2
+29 VDC

100 mv/cm
2 μsec/cm
Alternate single sweeps



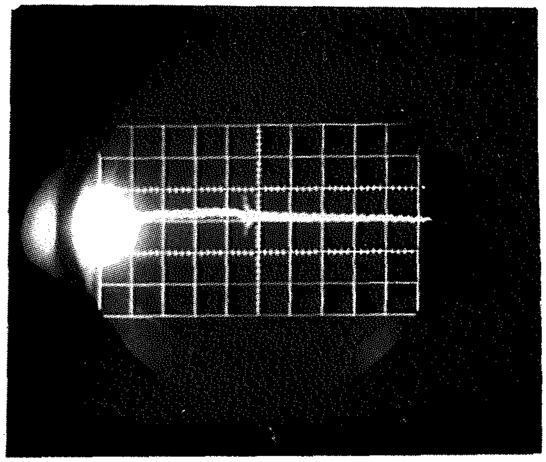
100 mv/cm
20 μsec/cm



At SIDE SBOB
100 mv/cm
20 μsec/cm

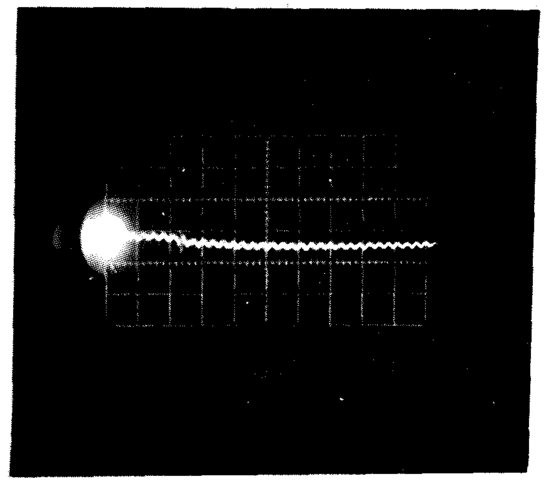
Figure 3.7-6 Prototype PCU Noise

Comparison of Noise at PCU and SIDE SBOB



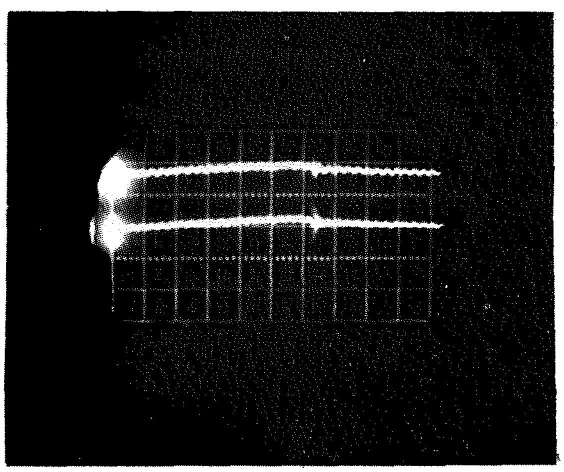
Large Spike at PCU

100 mv/cm
2 μ sec/cm
+29 VDC

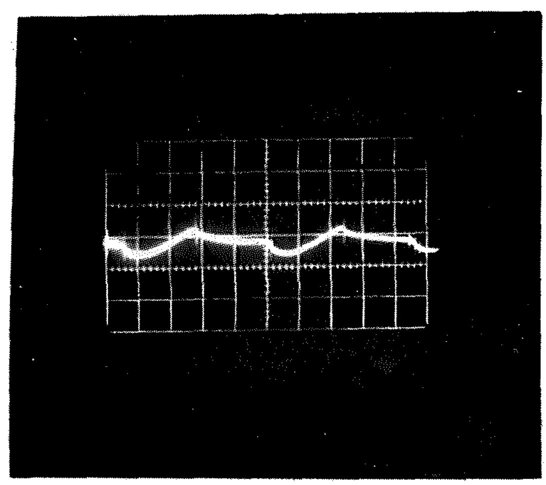


Small Spike at PCU

100 mv/cm
2 μ sec/cm



Top - SIDE SBOB
Bottom - PCU
100 mv/cm
2 μ sec/cm

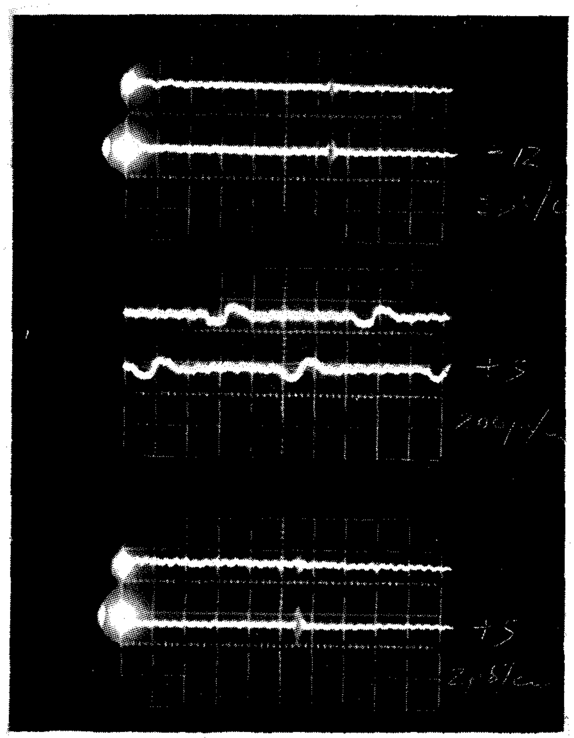


100 mv/cm
20 μ sec/cm

Figure 3.7-7 PCU Noise. Comparison Noise at PCU and ASE SBOB

All Cases
Top Trace - ASE SBOB
Bottom Trace - PCU Output in Central Station

100 mv/cm



PCU #1

-12V
2 μ sec/cm

+5V
200 μsec/cm

+5V
2 μsec/cm

Ripple on Middle Trace is Caused by EM GSE

The values of both high- and low-frequency noise on experiments +29 VDC lines is within specification and should have no effect on experiment operation. The 150 mv noise on the ASE -12 VDC line is under continued evaluation in EM model Array "B" tests. Initial evaluation of the effects of the PCU output noise on the data subsystem indicate no problems should exist. The data subsystem components most suspect to interference from the high-frequency noise are transmitter, receiver, and analog multiplexer. The transmitter uses +29 VDC for power stages and +12 VDC which is internally regulated to +10 VDC. No PM or FM effects due to ripple are expected. Small AM effects are to be expected (less than 3%). The command receiver has no internal regulation and uses +12 and -6 VDC line, ripple and noise will cause AM effect only which should be negligible. The +12 VDC ripple may produce sufficient local oscillator FM to cause uplink bit errors. Receiver noise tests run at Philco showed no effects by inserting 100 mv noise at frequencies up to 50 KHz. This is to be evaluated on the prototype system by observing prototype receiver output for any 11 KHz modulation and by bit error checks.

High-frequency filtering is provided on the +12 and -12 VDC lines within the analog multiplexer. The small values of noise on the +15 and +5 volt lines should not present any problems.

4.0 STATUS AND SCHEDULE

The EM Systems Tests at the end of April were running about two weeks behind the schedule established in ATM-605, Category #4 tests of Array B were just being commenced at the end of April. The slip can be attributed, in roughly equal parts to, to these causes:

1. The non-availability of the HFE for integration with the Central Station during March
2. The late delivery of the SIDE EM which was on line April 5 through April 7, 1967
3. The added task of performing Category #2 tests and integrating with the Central Station the new CCGE (MSC).

Currently, Array B testing is continuing although the CPLEE EM is not on line, and with the SIDE BB substituted for the SIDE EM.

For the reasons given in Section 3.5 it was considered that the spurious interaction checks in the Category #3 tests of Array B would be impractical without the use of the STS to decommutate and format the HFE data. The STS program is running and is now satisfactory apart from some problem in processing the science data arithmetically after the data has been correctly acquired. This has little impact on the EM Systems Tests, and so effectively the Category #3 and Category #4 tests of the Array B experiment configuration have been combined and are proceeding as one test sequence.

The tests which have to be performed on the Array B are:

1. The spurious interaction checks in the Category #3 and #4 of the main experiment array

2. An end-to-end test of the ASE and Central Station.

APPENDIX A

ENGINEERING MODEL SYSTEMS INTEGRATION TESTS BRIEF LOG

Date	Comment
4/3	DOME checked out, reading ASE data in the downlink mode.
4/4	Power and command interface between ASE and Central Station checked. SIDE EM received for subsystem tests.
4/5	SIDE EM integrated with Central Station. Power system compatibility checked.
4/6	Command response test of SIDE. Numerous discrepancies detected.
4/7	SIDE command response test completed. Signal interface checked.
4/10	Test results written up. Monthly progress report edited.
4/11	CCGE (MSC) and ETS received. Subsystem test performed. Test set up prepared for Category #2 tests. Meeting at Marshall Labs to discuss SIDE EM test results.
4/12	CCGE integrated with Central Station. Good power interface. Command response correct.
4/13	CCGE STS program checked, confirmed correct, used to verify experiment command response. Interface recording started, shift crosstalk onto data line noted.
4/14	CCGE interface signal recording completed.
4/17	HFE integrated with Central Station. Excessive power converter noise observed. Brief command response test performed. Interface signal recording started.
4/18	HFE timing and data signal waveforms recorded. Anomalous operation on last data bit noted.

APPENDIX A (CONT.)

Date	Comment
4/19	Full HFE command response test confirmed, with data display on the DDS 1000.
4/20	HFE power interface recording.
4/21	HFE analog lines examined. Central Station multiplexer noise observed and recorded.
4/24	PSE EM run with STS, faults in A/D converter located and rectified, STS fully operational with PSE.
4/25	System set up in preparation for Array B Category #3 tests.
4/26	Full up Array B on line, no obvious power incompatibilities.
4/27	HFE program loaded into DPS 2000, run. Modified to suit HFE EM command sequence.
4/28	HFE program debugged. All errors corrected apart from ratio subroutine.

APPENDIX B

STATUS OF INCORPORATION OF DESIGN CHANGES RECOMMENDED AS A RESULT OF EM TESTS

The following tables list for each experiment, subsystem, and/or component the problem encountered in EM tests which suggest design changes. These tables reflect the status of incorporation of the suggested changes in the subsequent ALSEP models. In the case of SIDE breadboard and EM, two sets of tables are given since the performance of the two units differed so widely.

These comments are passed on to experiment PI's or subsystem designers within a few days of detection or isolation of the problems.

CENTRAL STATION SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
A. PCU					
1. Radiated and Conducted EMI	*	Yes	Yes	Yes	Redesigned filters and case incorporated in prototype.
2. Ripple Off During Normal Operation From Signal From Off PCU	*	Yes	Yes	Yes	Eliminated by connecting emitters of transistors directly to ground instead of through a switch.
3. Reserve Power Output Unbalance to Ripple Off Circuit	*	Yes	Yes	Yes	Eliminated problem by connecting reserve power sensing resistor network to hard ground. Signal conditioning of reserve voltage in PDU will be incorporated in qual model.
4. Ripple Off of Experiments During PCU Changeover	*	Yes	Yes	Yes	Voltage transients eliminated by connecting 1100 μF input capacitor on +16 volt line directly to ground.
5. Auto Turn On with RTG		Yes	Yes	Yes	Circuit added to prototype.
6. PCU Auto Switch Over From 1 to 2		Yes	Yes	Yes	Modified sensing circuit for increased temperature stabilization, also addition of automatic switch back capability.

*Engineering Model modified during Engineering Model Tests.

CENTRAL STATION SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Model	Remarks
7. RTG Current Sensing Circuit		Yes	Yes	Yes	Redesigned circuit to employ saturable reactor sensing.
8. Failure of PCU to Switch Over on Several Occasions		Yes	Yes	Yes	Verification of command receipt via word 46. Modification of relay drive circuit incorporated in prototype.
9. Apparent Intermittent Regulator on PCU #1		?			PCU #1 eventually failed. Problem believed due to loose connection in PCU. Tests continued using PCU #2.
10. Inability to Utilize Full PCU Reserve		Yes	Yes	Yes	Low frequency noise on PCU reserve voltage (~30 HZ), accompanied by noise and voltage reduction on output of PCU. Regulator modified to eliminate oscillation in prototype.
B. PDU					
1. Addition of telemetry	No	No	No	No	Not incorporated because of schedule and cost.
2. Larger Telemetry Change for Experiment Three Standby Indication	*	Yes	Yes	Yes	Resistor network redesigned to furnish larger output.

*Modified in EM

CENTRAL STATION SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
3. Failure to Switch Transmitters During Catastrophic Increases of Transmitter A Input Current		Yes	Yes	Yes	+29V supply dropped to +10V by the fault current. Switching occurred after about 5 sec. Protection circuit was made more tolerant of heavy overloads.
C. RF Subassembly					
1. Receiver					
a. Local Oscillator Automatic Switch-Over Search		No	Yes	Yes	Inability to switch back from local oscillator B to A will be eliminated by adding an automatic search circuit in the qual model.
b. Temperature Sensitivity of Local Oscillator		Yes	Yes	Yes	Redesigned local oscillator X16 multiplier to achieve better dimensional stability with temperature.
c. Inability to reset Receiver Circuit Breaker Other Than With Delayed Sequence Command	*	Yes	Yes	Yes	12-hour timer will be used to reset the breaker.

*Engineering Model modified.

CENTRAL STATION SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
2. Transmitter					
a. Transmitter Serial #1 Modulated .7 Radians Instead of 1.25	**	Yes	Yes	Yes	Redesigned modulator to give better temperature stabilization and added an additional buffer.
b. 1 KHz Modulation of Power Source on Serial #1		Yes	Yes	Yes	Drift in modulator caused AM modulation at 1 KHz. Change listed in 2(a) will eliminate problem.
c. Transmitter Serial #2 Input Power Fluctuates		Yes	Yes	Yes	8 to 10W power increment. Originally for period of seconds only. Progressively deteriorated. Culminated in complate failure of transmitter. Cause unknown. Returned to subcontractor for repair. Improved component selection and Q.A. on succeeding models should prevent reoccurrence.
D. Command Decoder					
1. Flip-Cal Command Triggered During PCU Changeover	Yes	Yes	Yes	Yes	Apparent over sensitive IC was result of +5V line rising to 9V during changeover. Maximum Vcc for IC is 8V, maximum operating is 5.5V. Problem eliminated by grounding capacitor in +16V line of PCU, transient now only 5.6V.

**Engineering Model Serial #2 modified.

CENTRAL STATION SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
E. Analog Multiplexer					
1. Failure to Switch With Data Processor Change Over	Yes	Yes	Yes	Yes	Analog A/D converter failed to switch over with data processor. Data processor changeover command trigger by noise on power lines during PCU changeover. Switch over failure due to difference in response time of data processor and A/D converter relays during abnormal +5V power glitch. PDU modified to prevent reoccurrence.
2. Addition of Telemetry to Enable Identification of Data Processor		No	No	No	Addition of Telemetry for identification of data processor investigated and recommended. Request to modify PC boards refused by change board on basis of cost and schedule.
3. RF Noise on Analog Multiplexer Input Lines		?	?	?	Multiplexer appears to be feeding 600-KHz noise, up to 500 mv amplitude back on to its input lines. Amplitude is correlated to position of multiplexer 15-step commutator and is constant throughout a given step. No noise present on remaining 9 steps. Problem under investigation.

CENTRAL STATION SUGGESTED MODIFICATIONS
RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
4. Failure of FET Input Gates		?	?	?	Cause unknown. Changes have been incorporated in prototype and beyond to prevent failures due to negative voltages. However, prototype experienced similar fault.

F. Data Processor

No faults observed in EM tests.

SOLAR WIND SUGGESTED MODIFICATIONS RESULTING FROM EM TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
1. Noise in Negative High Voltage Power Supply		Yes	Yes	Yes	Aware of problem prior to EM tests. Modified in prototype.
2. 5.9V on Command Line		Yes	Yes	Yes	Incorrect bias circuit. Modified in prototype.
3. Operational Current Transient at Beginning of Each Voltage Step		No	No	No	Energy storage device disabled in EM. Problem corrected in EM #2. Prototype has similar transient indicating inoperative circuit. Circuit was removed on all models.
4. Power Line Noise	No Change Required				About 200 mv peak-to-peak.
5. Initial Turn-Off Voltage Transient	No Change Required				ICS value redefined such that the 35V p-p turnoff transient is within specification.
6. Reference Dwg. of Patch Panel Incorrect and Incomplete		Yes	Yes	Yes	Drawing has been revised.
7. Recent Turn-Off Voltage Transient	See Item 5	Yes	Yes	Yes	Apparent change in EM between Nov. 1966 and Jan. 1967. Latest measurement, transient peaks at +130V, -70V, ringing at 133 KHz. Prototype measured 50V peak-to-peak.

PASSIVE SEISMIC SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
1. ETS Single Point Ground		Yes			Single point ground violated in ETS via sensor input to electronics. Corrected in subsequent models of ETS.
2. Power Line Noise		No	No	No	1.5 to 2.0 volts. Modification not included in prototype.
3. ETS loading of ETS Buffered Control Signals i.e., Shift Pulse and Data Gate	*	Yes	Yes	Yes	Additional ETS's to be modified.
4. No Provision for External Frame Mark on ETS	*	Yes	Yes	Yes	To be included in subsequent ETS's.
5. No Connection to Survival Power in PSE Connector		Yes	Yes	Yes	To be included in prototype PSE.
6. Absence of Isolation Diodes on Survival Line		Yes	Yes	Yes	To be included in prototype PSE.
7. Provide Current Limiting in Heater and Leveling Motor Lines		Yes	Yes	Yes	These lines connected after present PSE current limiter, in prototype and subsequent models.

*ETS at Bendix modified.

PASSIVE SEISMIC SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
8. Correct 1 ms Rise Time on Positive Going Edge of Uncage Command Pulse		?	?	?	Under investigation. Not measured on initial prototype tests.
9. Power Converter Noise Inducing Noise on Science Data Lines		Yes	Yes	Yes	Appears that power converter noise radiated within Central Station Electronics package induces noise on science line inputs to A-D converter. Elimination of power converter EMI should eliminate problem. Noise eliminated on Prototype although converter noise is still present.
10. Turnoff-Voltage Transient		Yes	Yes	Yes	Problem referred to Teledyne. Corrected on prototype.
11. 29V Noise Due to Level Power Switch On		Yes	Yes	Yes	Placing load behind current limiter will eliminate problem. See Item 7.
12. Power Converter Noise On, Timing, Control Command Lines and Analog Lines		No	?	?	350-800 mv noise on timing and control, analog, and data line.
13. Failure of Short Period ETS Sensor Simulator Channel		?			Problem referred to Teledyne.

LSM SUGGESTED MODIFICATIONS RESULTING FROM
ENGINEERING MODEL TEST

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
1. Turn On Power Transient		Yes	Yes	Yes	Not accurately measured. A 50 ohm power limiting resistor in +29V line was used to reduce surge to below 14W in both the bread-board and EM. Prototype turn-on transient within spec.
2. Flip-Cal Power Transient		No	Yes	Yes	Total current during flip-cal with motors on, greater than 500 ma for both breadboard and EM. Prototype was 520 ma.
3. Operation Power		No	Yes	Yes	No significant change in power level noted between breadboard and EM. Normal current ripple from 165-210 ma. Power reduction to be incorporated in qual.
4. Test Set Display Jitter					Schmitt trigger levels required adjustment in order to accept timing and control pulses from ALSEP for both breadboard and EM. Jitter reappeared before completion of LSM EM tests. Cause unknown but appears due to EMI within the ETS.
5. Improper Flip Calibrate		Yes	Yes	Yes	Flip-cal gave variable results. Power profile was unexplainable from information furnished to Bendix. Sequencing of power to motor phases was variable, Y motor power intermittent, Z motor power disabled. Design modifications incorporated in prototype which corrected performance.

LSM SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
6. Intermittent Z Offset Display		Yes	Yes	Yes	Improper response of Z offset noted in breadboard. The EM model indicated Z offset was intermittent between 0 and +50%. Modification to prototype rectified fault.
7. Transients in X, Y and Z Axis Data		No	?	?	Occurred with and without digital filter in. Analog raster X axis from ETS indicates less noise with filter out. Cause unknown. Fault still noted in prototype.
8. Z Offset Cycle Incorrect		No	Yes	Yes	Z offset cycle in response to sequence of commands responds with +75, +25, 0, +75, +50, +25, and 0. X and Y axis respond +25, +50, +75, -75, -50, -25, and 0. Status bits for offsets are opposite value given in ICS Table IV. Cycle was not correct in prototype.
9. Data Level at 1.8V Between Demand Intervals		No change.			Problem corrected temporarily on EM by addition of 3.9K resistor between demand and signal ground on SBOB. BxA DSS indicates this 1.8V level will not effect DP operation.
10. LSM Not in Proper Preset Condition on Turn-On		No	Yes	Yes	On turn-on flip-cal was not inhibited, to be corrected on qual and subsequent.

LSM SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TEST

Problem Requiring Modification	Change Incorporated Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
11. Calibrate Raster From Analog Output of ETS Garbled		No	Yes	Yes	X-axis calibrate raster from ETS analog output was garbled with digital filter in. With filter out raster appeared better but was displaced due to permanent offset in the sensor or sensor electronics. Fault due to improper feedback resistor in feed back channel. Not corrected on prototype.
12. Permanent Offset Believed to be in Sensor Electronics Would Not Allow Flux Tanks to Zero Data Channel		No	Yes	Yes	Cause probably same as 11 and should be corrected in qual.
13. Power Ripple Inconsistent		Yes	Yes	Yes	Power ripple unexplainably changes from its characteristic signal intermittently during normal operation of LSM. Cause unknown. Not noted on prototype.
14. No Z Axis Flip Electronics		No	Yes	Yes	Z axis flip electronics missing as reported to Bendix by Philco. X and Z axis science channels were connected together with opposite sign. Prototype to be completely functional.
15. Engineering Data for Words 4 and 12 Unstable		No	Yes	Yes	Data in word 4 and 12 of LSM sequence shifted between 002 and 127 decimal. Believed due to saturated sensor. No change to prototype.

LSM SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TEST

Problem Requiring Modifications	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
16. Y Sensor Position is not 0^o, 90^o or 180^o during flip cal		Yes	Yes	Yes	Y Sensor Motor supposedly disabled although Y motor power appeared intermittent. Unknown which position sensor should be in although normal position is 0^o. Cause of fault unknown. Corrected in prototype.
17. X and Z Data Read Same Sign During Flip-Cycle		Yes	Yes	Yes	Z channel supposedly connected to X channel because of disabled Z motor. This resulted in normal reversal of sign, i.e., -X and +Z with the same absolute magnitude. Both signs were positive during part of flip-cal sequence. Could be A-D converter fault. Exact cause unknown. Prototype corrected.
18. Science Mode Status Indicated During Flip Motor On		No change required.			Status bits changed from cal to science mode during flip motor power on. Found to be normal mode of operation.
19. X, Y, and Z Data Channels Saturated Inconsistently During Flip-Cal		No	Yes	Yes	Operation due to improper feedback resistors. Not corrected on prototype.
20. Data Levels Before and After Flip-Cal are Inconsistent		No	Yes	Yes	Same as 19.

LSM SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TEST

	Change Incorporated				
Problem Requiring Modification	Engineering Model	Prototype Model	Qual. Model	Flight Models	Remarks
21. Engineering Data 16 Frame Sub-Commutator Stops Intermittently, Skips and Jumps Forward		No	?	?	Cause unknown. Similar operation noted in prototype.
22. Logic and Power Switching Logic Apparently Unduly Sensitive to EMI		No	?	?	Power glitches occurred intermittently and during switching Sanborn recorder. Science data glitches accompanied the power glitches.
23. Channels 6 & 7 Engineering Data Change During Flip/Cal		No change required.			Channel 6 is normally @42 changes to 38. Channel 7 is normally @10 changes to 11. These level sensor outputs may not be valid with LSM on its side.
24. Z Offset Changes During Flip/Cal		No	Yes	Yes	Z changes to - 50% at beginning of flip cal. returns to 0 during flip. Cause unknown.

SIDE SUGGESTED MODIFICATIONS RESULTING FROM EM TESTS OF SIDE BREADBOARD

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
1. Turn-on Power Transient	No	No	Yes	Yes	Power transient was reduced by addition of current limiter in breadboard returned for Category #3 tests. Change will not be in EM/prototype due to packaging problems.
2. Inability to Complete One-Time Commands or Test CCGE	Yes	Yes	Yes	Yes	CCGE electronics added to breadboard for Category #3 tests. Only the sensors, which draw negligible power, are not operational.
3. GPS Counter Produced Value Differing From ICS	Yes	Yes	Yes	Yes	ICS value will be changed to reflect count of 0 thru 11 with a sign bit (MSB).
4. Power Line Noise	Yes	Yes	Yes	Yes	Shielding of power converter being added to eliminate EMI. It is anticipated other noise will be eliminated by this technique. No additional filtering is being added. EM about 300 mv p-p.
5. False Experiment Standby Indication	Yes	Yes	Yes	Yes	An additional diode in series with the heater power line was added to isolate the power line from the standby sensing circuit.

SIDE SUGGESTED MODIFICATIONS RESULTING FROM EM TESTS OF SIDE BREADBOARD

	Change Incorporated				
Problem Requiring Modification	Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
6. ETS Printer Extraneous Output		Yes			Problem appears to be due to EMI and is still under investigation. Corrected on subsequent ETS's.
7. Random Analog Data Generated by Noise Crosstalk	Yes	Yes	Yes	Yes	See remarks item 4. Noise on analog line is 3 to 5 volts.
8. Radiated EMI	Yes	Yes	Yes	Yes	See item 4.

SIDE SUGGESTED MODIFICATION RESULTING FROM ENGINEERING MODEL TESTS

	Problem Require Modification	Change Incorporated: Prototype Model	Qual. Model	Flight Model	Remarks
1.	Velocity filter voltage indication is noisy when filter is off.	Yes	Yes	Yes	1. Breadboard was steady when off.
2.	HECPA and LECPA voltage indications were noisy when off.	Yes	Yes	Yes	2. Breadboard was steady when off.
3.	HECPA voltage apparently did not step and indication stayed at digital indication of 255.	Yes	Yes	Yes	3. Breadboard stepped through sequence.
4.	LECPA voltage apparently did not step properly.	Yes	Yes	Yes	4. EM stepped through 10 steps rather than 20. Master reset did not reset SIDE to 20 step sequence.
5.	CCGE and Channeltron high voltage supplies were locked out.				5. Known on delivery. Cannot be operated without vacuum system.
6.	Dust cover solenoid was not included.	Yes	Yes	Yes	6. BxA not informed beforehand of this omission.
7.	Command to reset SIDE counter at 10 gave no response.	Yes	Yes	Yes	7. BxA not informed beforehand of this fault.

	Problem Requiring Modification	Change Incorporated: Prototype Model	Qual. Model	Flight Model		Remarks
8.	Command to reset SIDE counter at 79 gave no response.	Yes	Yes	Yes	8.	BxA not informed beforehand fault.
9.	Command to reset SIDE counter at 79 and velocity filter at 9 gave only proper velocity filter response.	Yes	Yes	Yes	9.	Same as No. 8.
10.	Output data remained at zero in calibration mode.	Partial	Yes	Yes	10.	Same as No. 8. on Proto Calibration will exist on all but one channel.
11.	Output data remained at zero in all modes of operation.	Yes	Yes	Yes	11.	Same as No. 8.
12.	Excessive turn-on power transient.	Yes	Yes	Yes	12.	No surge limiter included and BxA surge limiter required for operation.
13.	Excessive noise on +29 volt line.	Yes	Yes	Yes	13.	300 mv p-p observed.

Problem Requiring Modification	Change Incorporated: Prototype Model	Qual Model	Flight Models	Remarks
14. GPS not stepping properly	Yes	Yes	Yes	14. GPS would jump repeatedly between 4 and 0 and then not change on the following cycle.
15. GPV sequence not correct	Yes	Yes	Yes	15. Did not follow the GPS. GPV changed erratically.
16. Temperature sensor outputs remained at zero as telemetered	Yes	Yes	Yes	16. BxA not informed beforehand of this fault.
17. A/D converter calibration data errors	Yes	Yes	Yes	17. Considerable errors on the calibration as telemetered.
18. The pre-regulator duty factor channel off scale	Yes	Yes	Yes	18. The telemetry channel was apparently saturated.

CPLEE SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
1. Failure of Current Limiter in Subsystem Test	Repaired	Yes	Yes	Yes	Current limiter was replaced. Redundant circuit has been incorporated in prototype model.
2. Command Line Number 7 Circuitry Failed		Yes	Yes	Yes	Circuit has been redesigned and has been incorporated in prototype and verified in EM.
3. Programmer Gates Which Provide Commands to Switchable Power Supply Failed	Yes	Yes	Yes	Yes	Circuit has been redesigned and has been incorporated in prototype logic module and verified in EM.
4. Intermittent Digital Data Operation With EM Central Station	?				Investigation indicates that experiment logic may have low noise margin. Category #2 tests completed with revised grounding and filtering of timing lines to reduce noise input to experiment. Improved shielding incorporated in prototype.
5. Power Line Noise		Yes	Yes	Yes	1.0V p-p noise on +29V line. Additional shielding incorporated in prototype. Corrected on prototype (<100 mv).

HEAT FLOW EXPERIMENT SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

		Change Incorporated				
	Problem Requiring Modification	Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
1.	Excessive power convertor noise on all interfacing lines.	No	Yes	Yes	Yes	1. 1.4 volts peak-to-peak on ≠29 VDC line, 300 mv p-p on data, 500 mv p-p on analog.
2.	No meaningful science outputs can be obtained without a GSE cold chamber.	Under negotiation in CCP #26				2. A chamber to keep probe at temperatures about -50°C and to maintain a gradient along probe to less than 2°C is needed.
3.	Excessive turn-on transient.		Yes	Yes	Yes	3. Approximately 600 ma.
4.	Excessive turn-off voltage transient.		Yes	Yes	Yes	4. Ranges from -360V to +210V contact arcing clearly observed. Input filter circuit redesigned.
5.	Erratic termination of data word by HF data programmer.		?	?	?	5. Word sometimes ends on fall of demand and on ocassions a spurious half-data bit is seen after fall of shift. Under investigation to determine cause.

HEAT FLOW EXPERIMENT SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

	Change Incorporated				
Problem Requiring Modification	Engineering Model	Prototype Model	Qual Model	Flight Models	Remarks
6. Logic error in control circuit.		Yes	Yes	Yes	6. Known discrepany corrected by additional gating for command.
7. Only one heat flow probe was provided.	No	Yes	Yes	Yes	7. Two probes to be provided on all succeeding models.
8. Power profile indicates that high heater comes on transiently on commanding low heater off		?	?	?	8. Actual heater excitation sequence cannot be observed during EM tests. Under investigation by expt. group.

ACTIVE SEISMIC SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated Engineering Engineering	Prototype Model	Qualify Model	Flight Model	Remarks
1. Failure to Turn On	Modified	Yes	Yes	Yes	Experiment current surge caused experiment to turn itself off.
2. Single-Point Failure Prohibits Experiment Power Turnoff	Modified	Yes	Yes	Yes	Experiment turn off depended on presence of standby power. Standby power blown fuse prohibits experiment turnoff. Circuit protection circuits have been redesigned and rely only on presence or absence of +29VDC to turn experiment on or off.
3. False Event Indications		?	?	?	Modified unit awaiting additional tests.

CCGE(MSC) SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

Problem Requiring Modification	Change Incorporated: Engineering Model	Prototype Model	Qual Model	Flight Model	Remarks
1. Crosstalk from shift on to data line	No	Yes	Yes	Yes	1. 250 mv peak-to-peak signals noted on falling edge of shift line. Only 100 mv mv peak-to-peak cross talk seen when SIDE connected to same interface. Implies that some of observed CCGE cross talk is internal to experiment. Corrected prior to proto delivery.

SIGNAL BREAK-OUT BOX SUGGESTED MODIFICATIONS RESULTING FROM ENGINEERING MODEL TESTS

	Change Incorporated		
Problem Requiring Modification	Engineering Model	Prototype & Subsequent Models	Remarks
1. Oscillations in Output of Buffered Timing and Control Signals.	Yes	Yes	Oscillations due to capacitance of coax line feeding ETS. 96 OHM resistor added in series with output to provide phase shift.
2. Ground Loops in Current Monitoring due to Mechanical Grounding of Current Jacks.	Yes	Yes	Shield Connection Eliminated on one end of tests leads.
3. Addition of Analog Buffer Amplifiers to Passive Seismic SBOB to Drive Test Set.	No	No	Additional amplifier box fabricated for EM testing. Do not anticipate requirement for proto thru Flight Model Tests when using ETS.
4. Oscillation of SWS Demand Buffer Amplifier when Driving ETS.	No	No	Additional isolating amplifier used for EM testing.
5. Incorporate Fuses in Power Lines on SBOB	Yes (Partially)	Yes	Provide Central Station additional protection from "Pilot Error".