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R-735

TRAVERSE GRAVIMETER - CEI 2025000
FS-2 QUALIFICATION UNIT
TEST REPORT

October 1972

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Richard Martorana wrote Section 3.1, Robert Reid wrote Section 3.2, John Eterno summarized the data in Sections 3.3 and 3.4, and William Beaton wrote Sections 4.0, 5.0, and 12.0

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SECTION 1

INTRODUCTION

1.1 GENERAL

This report summarizes the results of the testing of the Traverse Gravimeter Qualification Unit FS-2 at M.I.T./C. S. Draper Laboratory from June 30, 1972 to September 19, 1972.

1.2 SCOPE

This report summarizes test results, failures, discrepancies and schedule progress of the Traverse Gravimeter Qualification Unit FS-2. More detailed information may be obtained from the actual Traverse Gravimeter data package.

1.3 TEST PROCEDURES

The following is a very brief summary of the Traverse Gravimeter test procedures and their purpose.

1.3.1 TP 25015 - TG CURRENT MONITOR. - This test measures the current useage in each of the TG modes; STANDBY, ON, GRAV, BIAS and READ.

1.3.2 TP 25020 - TG LEVEL TEST. - This test verifies the TG level accuracy and the ability of the TG to remode to operate when tilted greater than 15^{o} from vertical.

1.3.3 TP 25025 - TG TEMPERATURE TEST. - This test verifies proper operation of the TG temperature display (8th digit) and verifies the ability of the TG to undergo a thermal cycle. In addition, the temperature of the TG thermostat opening and closing points is ascertained.

1.3.4 TP 25030 - TG ACCEPTANCE VIBRATION. - This test subjects the TG to a workmanship vibration test.

1.3.5 TP 25035 - THERMAL VACUUM TEST. - This test verifies the ability of the TG to undergo a simulated mission under vacuum and varying temperature conditions.

1.3.6 TP 25036 - OPERATIONAL TEST DURING T-V. - This test verifies the ability of the TG to take measurements during a simulated lunar traverse.

1.3.7 TP 25045 - TG PERFORMANCE TEST. - This test verifies the repeatability and slope stability of the TG during earth gravity measurements.

1.3.8 TP 25055 - TG VISUAL INSPECTION. - This test verifies and defines the steps necessary to ensure proper appearance and dimensions of the TG. In addition, the weight and center of gravity of the Traverse Gravimeter are measured.

1.3.9 TP 25075 - BASELINE VERIFICATION TEST. - This is a basic functional test designed to verify TG level capability, measurement operation, toggle and pushbutton operation, display operation and to obtain VSA bias and scale factor data.

1.3.10 TP 25080 TG QUALIFICATION VIBRATION. - This test verifies the ability of the TG to undergo launch sine, dwell, and random vibration in the X, Y, and Z axes, and Lunar Rover Vehicle vertical vibration.

1.3.11 TP 25081 - TG MECHANICAL UNIT / ISOFRAME VIBRATION. - This test verifies the ability of the TG Isoframe Assembly to undergo a launch dwell vibration and a 5G acceleration simultaneously.

1.3.12 TP 25085 LAUNCH DEPRESSURIZATION. - This test verifies the ability of the TG to undergo a Launch Depressurization.

1.3.13 TEN DAY COOLDOWN. - TP 25045 was performed, then the TG was cooled down for ten days and TP 25045 performed again to verify the ability of the TG to perform properly after the simulated launch cooldown.

SECTION 2

TEST RESULTS

The test results of the Traverse Gravimeter Qualification Unit will be summarized in chronological order.

2.1 TESTS PERFORMED AT DL-11

2.1.1 TG TEMPERATURE TEST - TP 25025. - This test was successfully completed with the exception of steps D7a, D7c, and D21 which were out of specification. These items were closed by ECR 20518, which clarified instructions and added instrumentation error to the tolerances.

2.1.2 BASELINE VERIFICATION TEST - TP 25075. - This test was successfully completed with the exception of an incorrect formula in the calculations. ECR 20520 corrected the typographical error.

2.2 TESTS PERFORMED AT BEDFORD FLIGHT FACILITY

2.2.1 BASELINE VERIFICATION TEST - TP 25075. - This test was successfully completed with the correction noted in ECR 20520 (see Paragraph 2.1.2).

2.2.2 TG ACCEPTANCE VIBRATION - TP 25030. - This test was successfully completed.

2.2.3 BASELINE VERIFICATION TEST - TP 25075. - This test was successfully completed with the same comment as Paragraph 2.1.2.

2.2.4 TG CURRENT MONITOR - TP 25015. - This test was successfully completed with the exception of some out of specification conditions of a typographical nature which were cleared by ECR 20519.

2.2.5 TG PERFORMANCE TEST - TP 25045. - This test was successfully completed with the exception of an out of specification condition at step F.5. This was cleared by waiver number 0005 and later by ECR 20535 which changed the test configuration. It was determined the P.L.L. repeatability improved considerably by performing this test on the TG Battery rather than the GSE Breakout Box.

2.2.6 BASELINE VERIFICATION TEST - TP 25075. - This test was successfully completed with the same comment as Paragraph 2.1.2.

2.2.7 TG LEVEL TEST - TP 25020. - This test was successfully completed with the exception of an out of specification condition at step R. 3. This was a typographical error and misinterpretation of test procedure that was cleared by ECR 20517.

2.3 TESTS PERFORMED AT DL-11

2.3.1 LAUNCH DEPRESSURIZATION - TP 25085. - This test was successfully completed.

2.3.2 TG VISUAL INSPECTION - TP 25055. - This test was successfully completed.

2.4 TESTS PERFROMED AT BEDFORD FLIGHT FACILITY

2.4.1 TG THERMAL VACUUM TEST - TP 25035. - This test was successfully completed.

2.4.2 OPERATIONAL TEST DURING T-V-TP 25036. - This test was successfully completed during the first traverse.

2.4.3 OPERATIONAL TEST DURING T-V-TP 25036. - This test was successfully completed during the second traverse.

2.4.4 BASELINE VERIFICATION TEST - TP 25075. - This test was successfully completed.

2.4.5 ISOFRAME/MECHANICAL UNIT VIBRATION - TP 25081. - This test was successfully completed.

2.4.6 TG QUALIFICATION VIBRATION - TP 25080. - This test was successfully completed.

2.5 VERIFICATION TESTS PERFORMED DURING TP 25080

2.5.1 VIBRATION VERIFICATION TEST - TP 25076. - This test was successfully completed six times during TP 25080.

2.5.2 BASELINE VERIFICATION TEST-- TP 25075. —This test was successfully completed three times during TP 25080 with the exception of the last time at steps I. 6 and I. 12 which were cleared by waiver 0006.

2.5.3 TG CURRENT MONITOR - TP 25015. - This test was successfully completed.

2.5.4 TG LEVEL TEST - TP 25020. - This test was successfully completed.

2.5.5 TG PERFORMANCE TEST - TP 25045. - This test was successfully completed with the exception of an out of specification condition at step F. 5 - see waiver 0005.

2.5.6 BASELINE VERIFICATION TEST - TP 25075. - This test was successfully completed.

2.6 TESTS PERFORMED AT DL-11

2.6.1 TG TEMPERATURE TEST - TP. - This test was successfully completed except for out of specification condition at step D.7 which was cleared by Internal Failure Report No. 29.

2.6.2 TEARDOWN AND INSPECTION. - The inspection was successfully completed. During the inspection Internal Failure Report No. 31 was generated when it was noted that the anti-backlash gear was not centered. ECR 20548 clarified TP 25020 so that this would not happen again.

SECTION 3

DETAILED TEST RESULTS

3.1 THERMAL VACUUM TEST TP 25035

3.1.1 GENERAL. - During the period of July 24 to July 28, 1972, the TGE qualification model (FS2) underwent thermal vacuum testing at Bedford. A hot mission was simulated with stowage, soakback, two traverse and two rest periods. Throughout the test the TG maintained temperature control. All simulation and remote actuation apparatus operated continuously so that the test ran uninterrupted for eighty-two hours.

3.1.2 APPARATUS. - In the period between thermal vacuum testing of the engineering and qualification models, several revisions were made in the simulation apparatus in order to make it more reliable. The major changes are as follows.

1. Thermocouples on the pallet and lunar surface simulator (LSS) were moved from the back to gravimeter side of each in order to get more accurate estimates of radiative flux between the TG and simulation apparatus. Temperature control sensors for these surfaces were similarly moved.

2. The couplers were revised to increase the gap between the back of the TG blanket and the pallet simulator in order to eliminate physical contact between the two surfaces.

3. The bottom pin removal was made independent of the side pin removal by coupling it to a single high-force uni-directional solenoid.

4. The remote button actuator was revised so that one could see the button click into its contact position. In addition the tips of the actuators or "fingers" were changed to larger teflon coated hemispherical surfaces to protect the blanket.

5. Activation switches for operation of all remote manipulators were panel mounted beside the viewing port. This enabled one technician to view the remote control apparatus as he was using it.

3.1.3 TG CONFIGURATION. - The TGE deviated from flight configuration since three thermocouples were brought out of the instrument through the aft foot. These (Cu-Cn) thermocouples were attached to the I-oven, battery and housing. They

represent a conductance leak through the blanket of 0.0043 watts/^{o}F. The leak was not monitored as in previous tests by heat stationing the thermocouples due to other configuration constraints of qualification testing.

3.1.4 PROCEDURE. - The TGE was brought to Bedford on July 21 when installation was begun in the simulation apparatus. Preparation and final adjustment of the apparatus was carried out for three days as outlined in part C of TP 25035. The test began at 10PM on July 24. This hour was chosen as t = 0 so that the traverse phases of the mission would occur at reasonable hours. Hot stowage phase took twenty-four hours wherein the LSS, pallet and shroud were held to 73^{o}F ± 10^{o}F (Figure 1). The TG was in standby. After twenty-four hours soakback began that simulated a seventeen hour linear ramp function of temperature between 73^{o}F and 123^{o}F (Figure 2). At the end of soakback the TG was put into operate mode, pins removed, couplers placed in "p" position, crygenics applied to the shroud and simulator temperatures reset for hot traverse. Temperatures on the LSS and pallet were set at 208^{o}F which exposes the TG to an infrared radiative flux equivalent to the total energy (infrared plus ultraviolet) that the TG would experience for a sun angle of 30^{o}. The time variation of the sun's elevation angle was simulated with a temperature ramp. Simulator temperatures for the first traverse are shown in Figure 3. Data was taken according to TP 25036 and is listed in Table I and plotted in Figure 4. One sigma is 0.514 ppm.

Six hours after Traverse I began, Rest I was initiated by setting the TG in standby mode, opening the radiator, lowering the couplers and controlling the pallet and LSS at -100^{o}F (Figure 5). These temperature changes (as well as all other transients between mission phases) were accomplished within the first hour of succeeding phases. Throughout the remainder of the test the shroud was held at -320^{o}F. Rest I lasted fourteen hours after which the radiator was shut and couplers raised for the next traverse.

Traverse II began at t = 61 and lasted for seven hours (Figure 6). It was conducted the same as Traverse I except that the roughing pump was not operating which may be a partial explanation for the lower value of one sigma of 0.4423 ppm. The sun angle at the end of Traverse II was 40^{o}. Gravity data is shown in Table II and Figure 7.

Rest II was an exact repeat of Rest I. It began at t = 68 and ended at t = 82, completing the test (Figure 5). Heat was then applied to all simulation apparatus for about two hours prior to backfilling the chamber with dry gaseous nitrogen. The blanket was inspected after the TG was removed from the chamber. No damage could be detected.

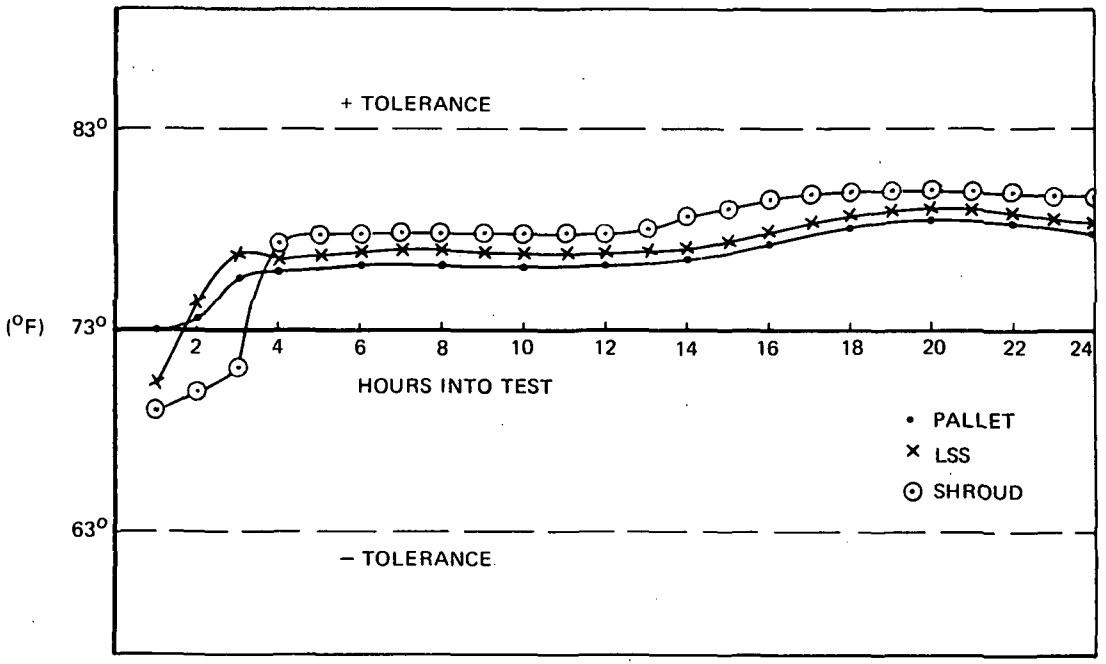


Fig. 1 Simulator Temperature During Stowage

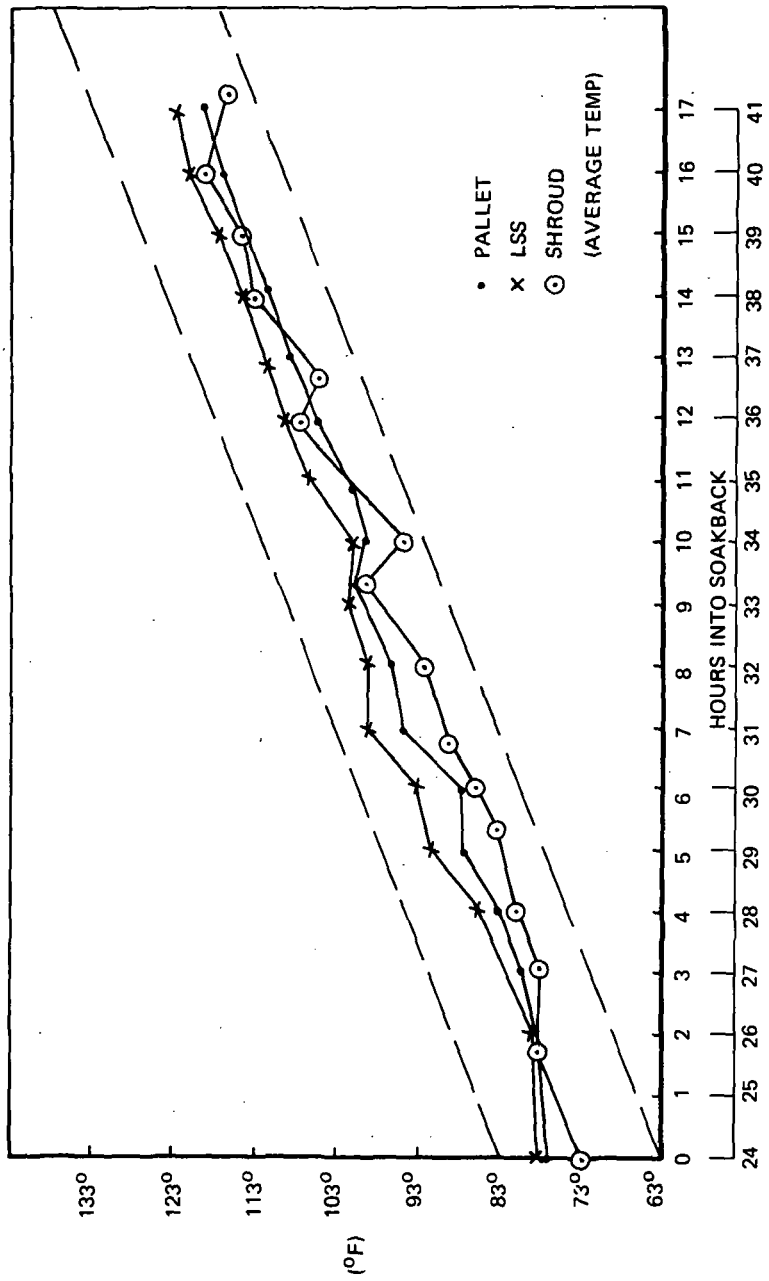


Fig. 2 Simulator Temperatures During Soakback

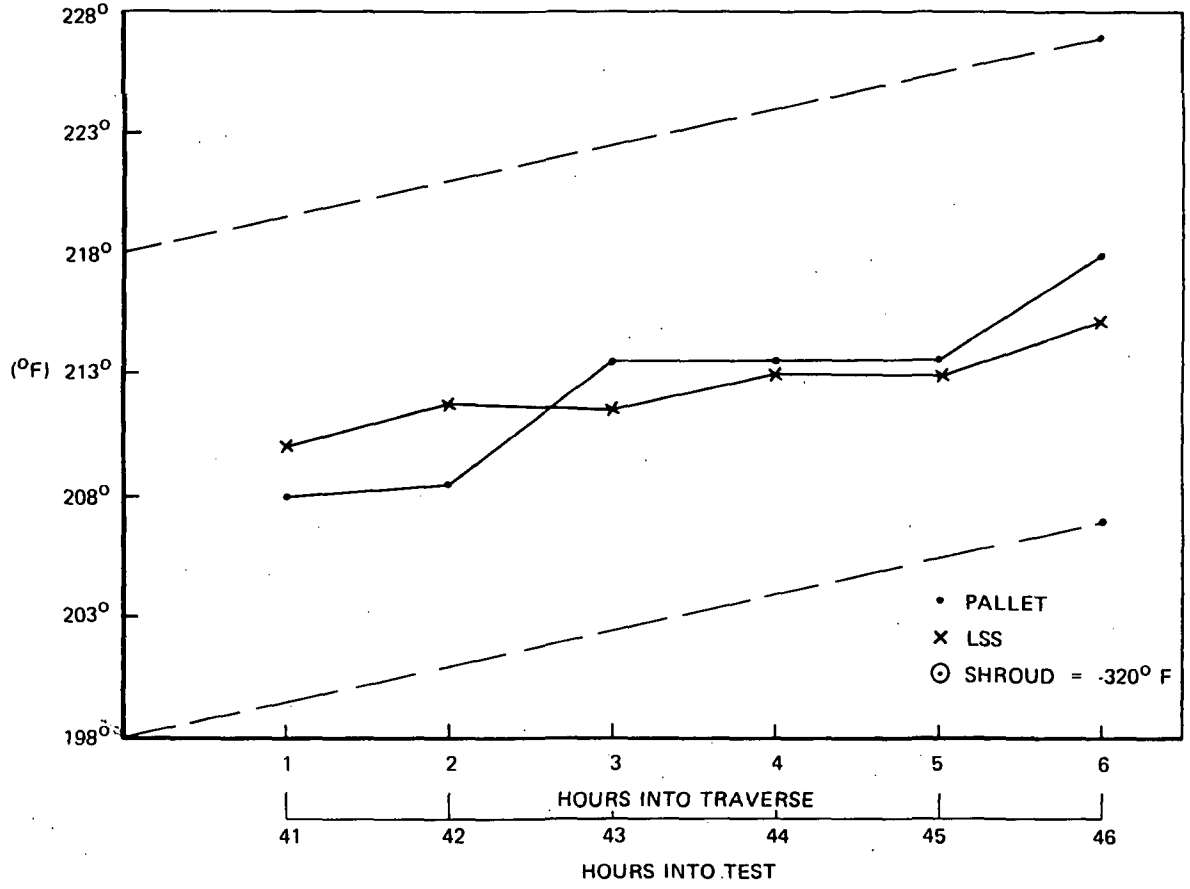
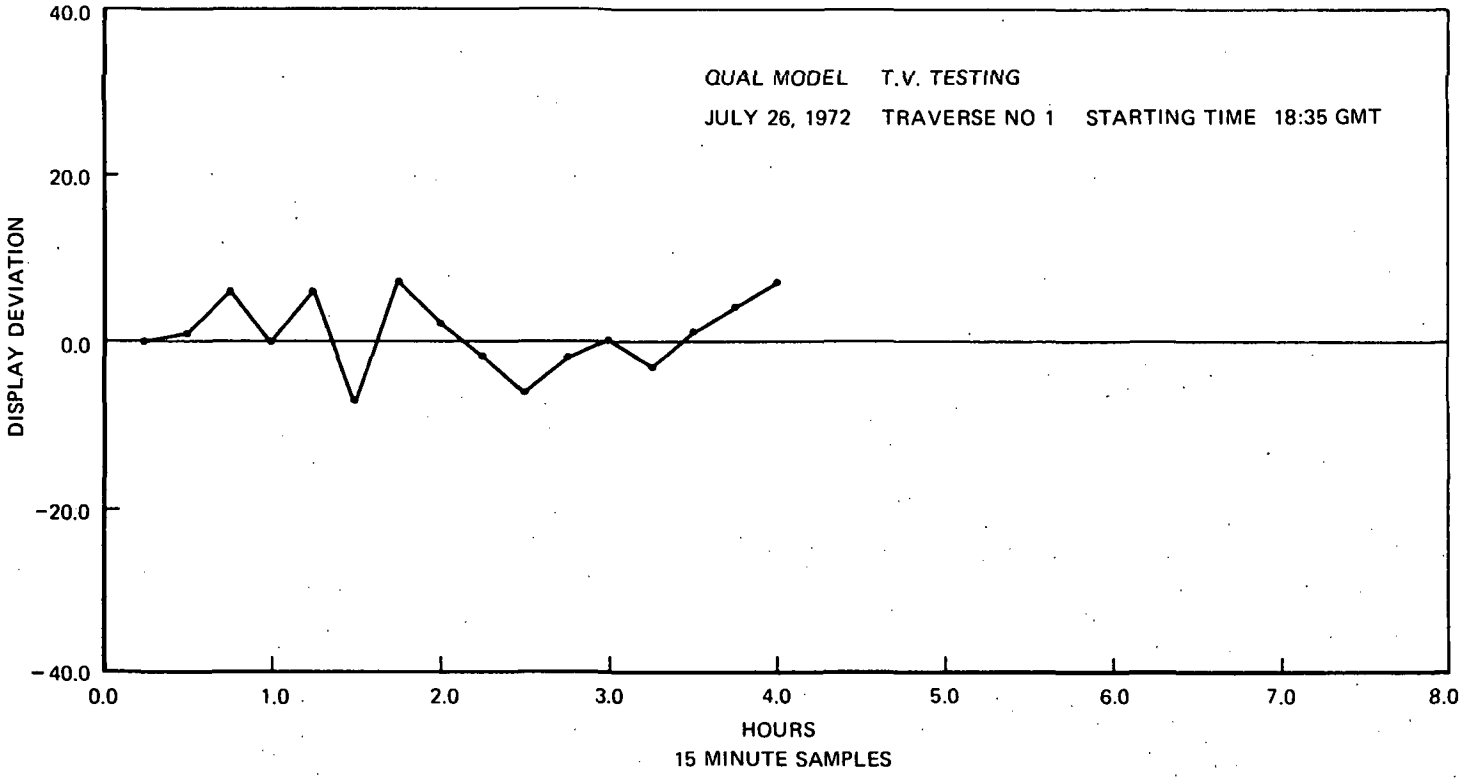


Fig. 3 Simulator Temperatures During Traverse I

TABLE I

TRAVERSE I GRAVITY DATA

Time (hrs after t = 0)		Data
41.43		843079441
41.53		82541
.62		84041
.68		83841
.75		83941
.82		83941
.88		84841
.95		84341
42.02		84141
.10		83641
.33		83641
.66	(bias)	952207441
.73		843083841
43.08		83941
.33		84441
.58		83841
.83		84441
44.08		83141
.33		84542
.58		84042
.83		83642
45.08		83242
.33		83642
.58		83842
.83		83542
46.08		83942
.33		84242
.58		84562
.75	(bias)	952206062
.83		843082962



REFERENCE VALUE	8.430839×10^6	SIGMA	0.5140 PPM
REJECTED DATA	0 OF 16	TREND	0.0334 PPM/DAY
		SIGMA/TREND	0.5140 PPM
		MEAN	8430840.0

Fig. 4 Deviation of TG Display (Counts) From Average (Traverse I)

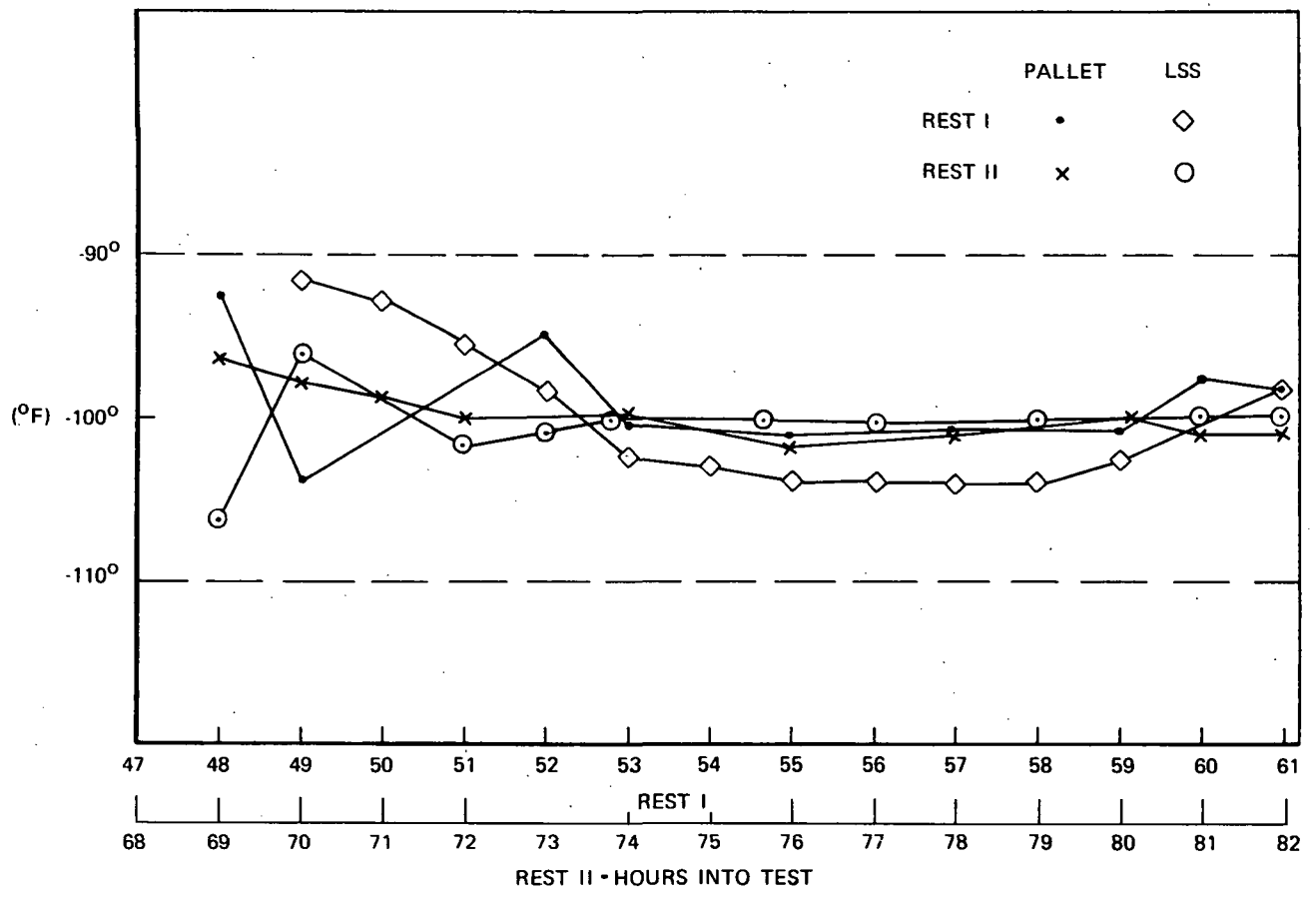


Fig. 5 Simulator Temperatures During Rest Periods

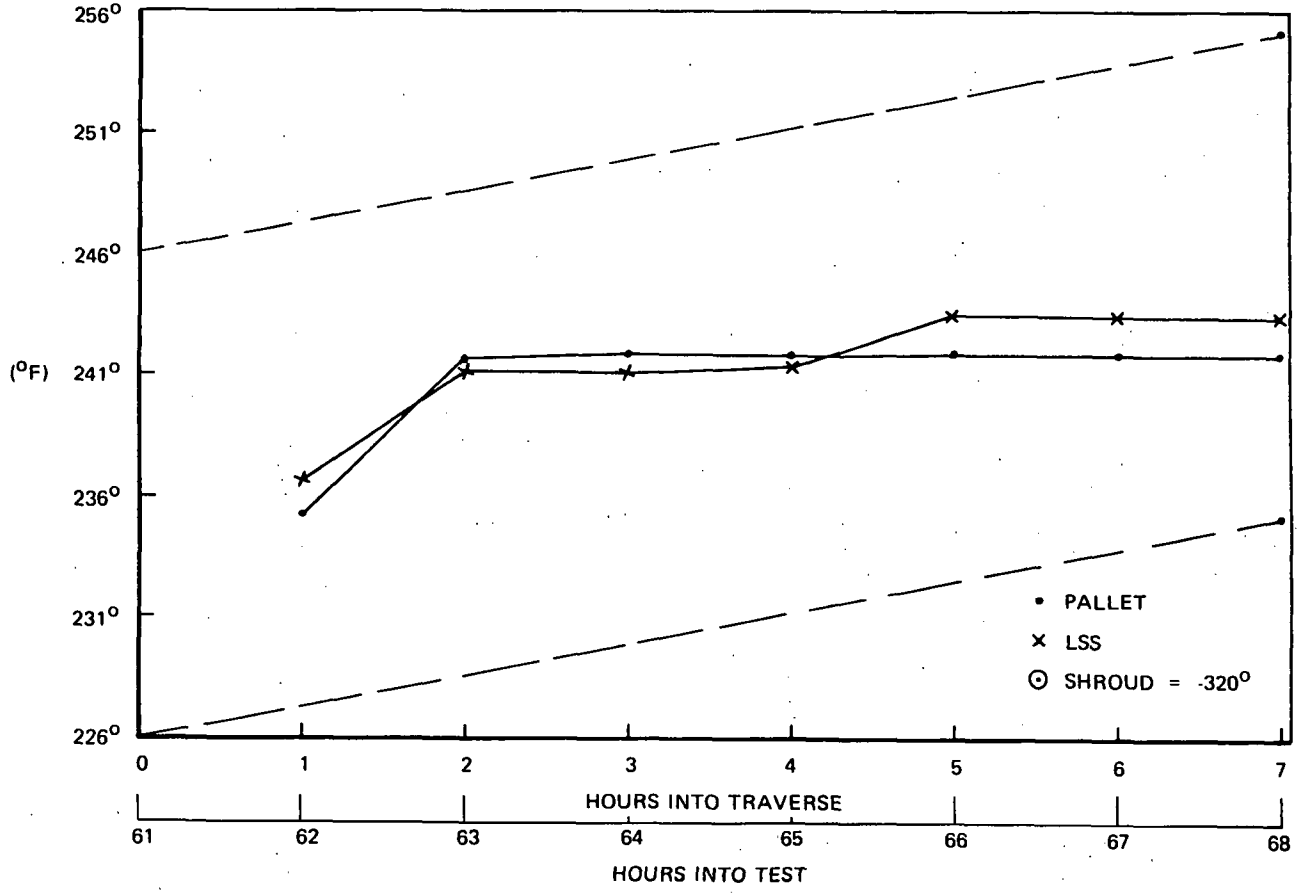
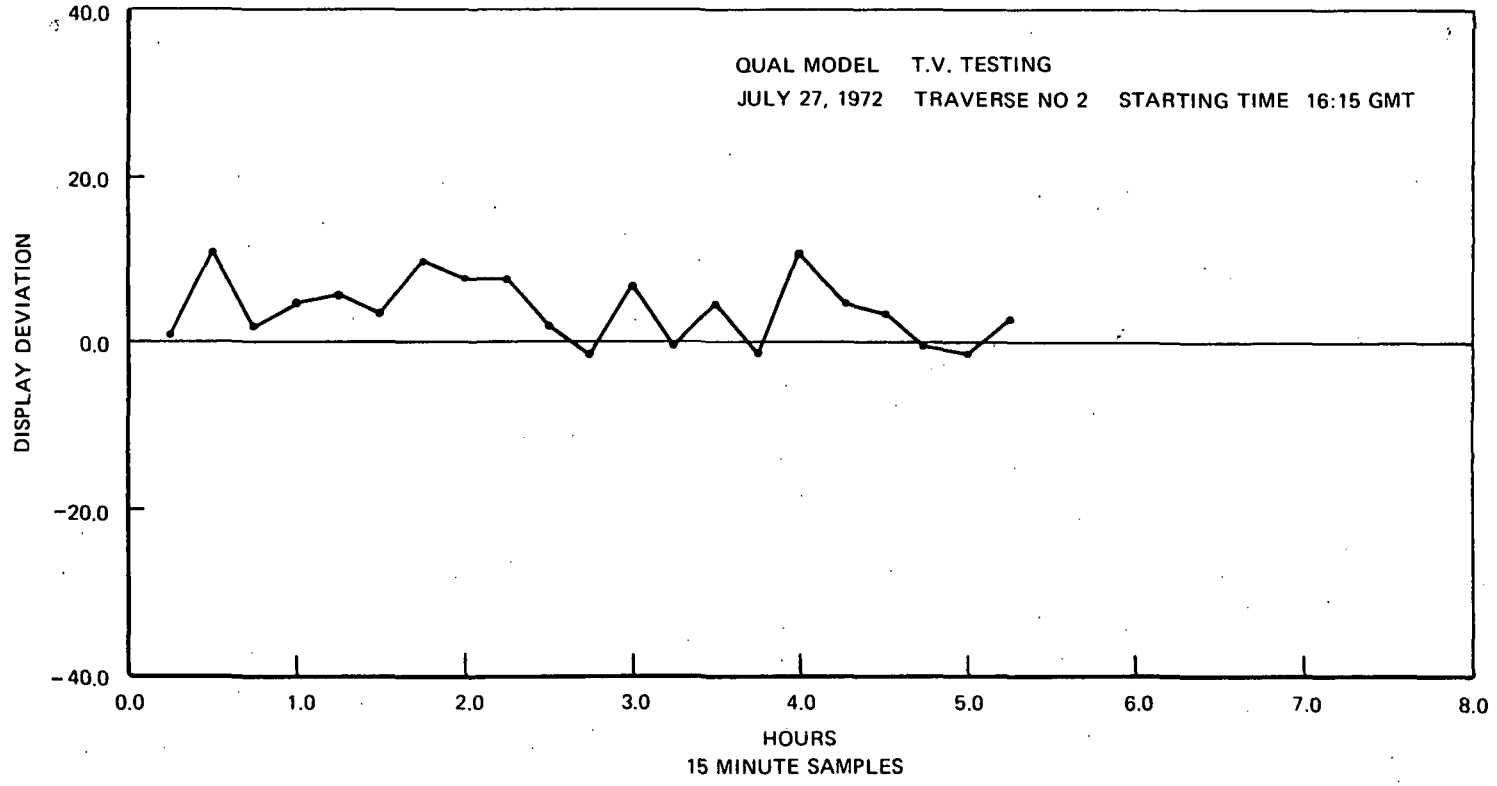


Fig. 6 Simulator Temperatures During Traverse II

TABLE II

TRAVERSE II GRAVITY DATA

Time (hrs after t = 0)		Data
61.08		843077341
.15		81941
.22		82141
.32		82341
.41		82841
.50		82941
.57		82941
.63		81741
.70		82641
.78		82541
62.00		82541
.25	(bias)	952205941
.50		843082741
.75		83741
63.00		82841
.25		83141
.50		83241
.75		83041
64.00		83641
.25		83441
.50		83441
.75		82841
65.00		82541
.25		83341
.50		82641
.75		83141
66.00		82541
.25		83741
.50		83141
.75		83041
67.00		82641
.25		82541
.50		82941
.75	(bias)	952205941
68.00		843082041



REFERENCE VALUE	8.430828×10^6	SIGMA	0.4638 PPM
REJECTED DATA	0 OF 21	TREND	-2.1588 PPM/DAY
		SIGMA/TREND	0.4423 PPM
		MEAN	8430832.0

Fig. 7 Deviation of TG Display (Counts) From Average (Traverse II)

Temperature data was recorded continuously on one set of strip chart recorders and hourly on a digital thermocouple recorder. Although the simulators were well instrumented with many thermocouples the average temperature of three strategically located thermocouples on each simulator was taken as the simulator temperature.

3.1.5 RESULTS. - The temperature response at the three monitored TG components (I-oven, battery, and housing) is shown in Figure 8. The maximum temperature of the I-oven was about $110^{\circ}F$ occurring at about $t = 48.5$ hours, just into the first rest period. Rest I cooled the I-oven enough to limit its maximum temperature after Traverse II to about $98.5^{\circ}F$ at $t = 72$ hours.

During Traverse I a total of thirty measurements were taken (grav + bias). The last two display digits were "41" for the first eighteen measurements, "42" for the next nine, and "62" for the last three points. Thus, the P-oven went $0.018^{\circ}F$ above its control set point. For the second traverse a total of thirty-five measurements were made but the last two digits never changed from "41" ($0.009^{\circ}F$ above set point).

The total battery power consumption for the mission was 11.3 amp-hours.

3.2 TG QUALIFICATION VIBRATION TP 25080/TP 25081

3.2.1 GENERAL. - The qualification vibration tests of the Traverse Gravimeter were performed on 11 and 14 August, 1972, at the Special Test Facility of the CSDL.

3.2.2 PREPARATION. - Early in the program, a mechanical mock-up of the TG was built (called Mechanical Unit) which simulated as closely as possible the weights and compliances of the major components. Critical parts were instrumented with vibration accelerometers, in particular a dummy VSA. Before the qualification test was performed, this mechanical model was subjected to the test levels in an attempt to predict the effects on real components, and several qualification dry-runs were performed to familiarize personnel with the procedures.

Prior to the test the control accelerometer was calibrated by comparing it with one belonging to R&QA which had previously been calibrated with NBS Traceability.

3.2.3 APPARATUS. - The following instruments and apparatus were used:

Ling PP60/140/c70 Shaker and Slip Table.
Isolation Vibration Fixture.
TG Z axis Fixture.
Endevco Accelerometer.
Hewlett Packard 136A X-Y-Y recorder.
Kepco #52-256-96 Power supply and Associated cables.

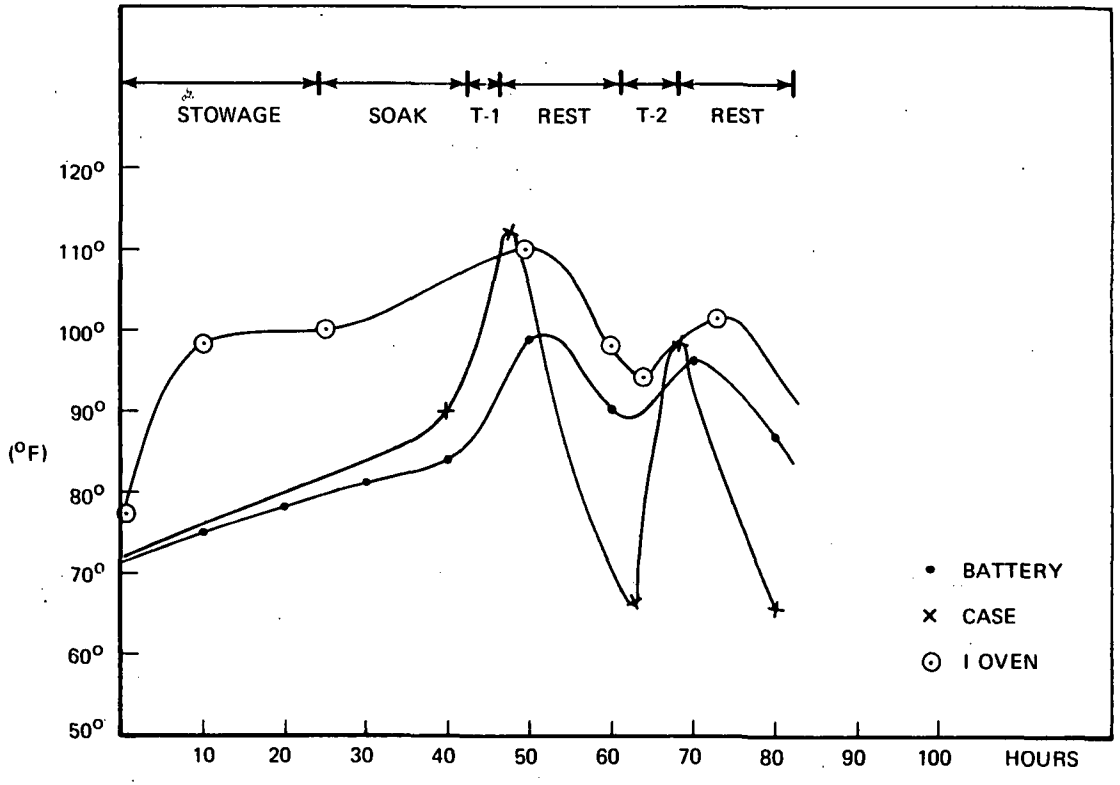


Fig. 8 TG Component Temperatures During Thermal-Vacuum Test

Isoframe assembly.

150 pound Spring assembly.

TG Mechanical model.

TG Flight System #2 (Qualification Model).

3.2.4 VIBRATION PROFILE. - The sinusoidal and random profiles were those specified for the TG location in the LM. Two level reductions at specific frequencies were requested because of possible damage to the VSA. These were reviewed by NASA and approved as being consistent with actual flight levels. The TG axes are related to LM axes as follows:

TG	LM
X	α
Y	X
Z	β

3.2.5 PROCEDURE. - The first test was the combined environment test of the isoframe mechanical unit, TP 25081. The isoframe was mounted on the slip table of the shaker with the input along the TG Y (Launch axis). The mechanical unit was mounted on the isoframe and the spring loading assembly attached to it by means of a web sling. The spring was stretched to provide a static load on the TG of 150 pounds to simulate the maximum launch accelerating of 5 g's on a 30 pound package. The assembly was then subjected to 0.9 g's @ 6 Hz for 10 seconds. This test indicated that the worst expected combined environment would not cause the isolators to bottom. This was considered an important design goal.

The remainder of the isoframe qualification was combined with the TG tests.

Since the shaker was already set up for the Y axis, it was decided to deviate from the sequence indicated in TP 25080 and do the Y, Z, and then X axes. R&QA and ONR concurred with the deviation. The procedure for the Y axis was repeated for the Z and X axes using the appropriate vibration profiles, and only the Y axis is described in detail.

The mechanical unit was mounted on the isoframe and secured with flight pins. The sinusoidal dwell level, 0.9 g's @ 6 Hz, was applied for a time sufficient to obtain a record of level on the X-Y-Y recorder. The level was verified and the mechanical unit removed and FS2 mounted. The dwell level was applied to the TG for the required 10 seconds. No visible failures were observed and the TG was removed and a 3 measurement test as described in TP 25076 performed.

The mechanical unit was replaced and the sine sweep for the Y axis was run at 3 oct/min and recorded. FS2 was then mounted and this shake performed.

Actual time for the sweep from 20 to 100 Hz was 1 minute 26 seconds. The 3 measurement test was repeated on the TG.

The X axis qualification random profile was then set up on the random signal generator. When it was in satisfactory agreement with the specification, the vibration was applied to an empty fixture and the profile recorded on the X-Y-Y recorder. The mechanical unit was then mounted and the procedure repeated, using a 1 oct/min sweep rate for the recording filter. The shaker table motion agreed with the specification and so the mechanical unit was removed and FS2 mounted. The shaker was run at 1/2 Qualification power level for a time long enough to record the profile on the X-Y-Y recorder at 3 octaves/minute. Again the record was satisfactory and the actual test performed at full power as determined by integrating the spectral power density of the profile. In this case it was 6.1 g's rms. The duration of this test was 1 minute.

This completed the Y axis vibration and a 10X test of TG performance was done as described in TP 25075.

The fixture was then rotated 90^{o} on the slip table for a Z axis input and the sequence repeated. For this axis, the random level was 7.8 g's rms.

Following completion of Z axis shake, the shaker was rotated 90^{o} to the upright position for X axis. Testing was then adjourned for the weekend, and the TG returned to the test lab.

The X axis shake including a random level of 8.2 g's rms was performed on Monday morning thus completing the flight portion.

The final portion of the test was Rover simulation and was performed on Monday afternoon. The Z axis fixture was mounted on the shaker and the isoframe was mounted on it. The vibration profile was verified with the mechanical model. For this test the TG was mounted without the flight pins and the Velcro fasteners on the display and radiator covers were removed. Because of some difficulties in obtaining the very low frequencies, the test was performed in two stages sweeping from 5 to 10 Hz for 15 minutes and then from 10 to 20 Hz for 15 minutes. No performance checks were made between the stages.

3.2.6 RESULTS. - No external failures were noted in any of the components. The instrument showed a bias shifting of 17.5μg and a scale factor shift of 2.59 ppm.

3.2.7 CONCLUSION. - The TG-isoframe assembly is capable of surviving the flight vibration environment. The bias and scale factor shifts are considerably less than those sustained in acceptance vibration (91μg's and 5.87 ppm respectively). The isolators perform as predicted and do a satisfactory job of protecting the TG; also the isolators will not bottom out during the most severe combined loading.

3.3 TG PERFORMANCE TEST TP 25045

Table III summarizes the results of TP 25045.

3.4 BASELINE VERIFICATION TEST TP 25075

Table IV summarizes the results of TP 25075.

TABLE III TP 25045

NOTES	DATE	MEAN	σ	SHORT TERM DRIFT**	LONG TERM DRIFT
BFF PAD 5	7/10/72	8430752	0.164	0.471	0.504
ON VACUUM	7/10/72*	8430749	1.230	2.199	0.229
THERMAL-VAC					
- TRAN 1	7/26/72*	8430840	0.514	0.033	
- TRAN 2	7/27/72*	8430832	0.442	-2.159	
BFF PAD 5	8/22/72	8430995	0.209	2.130	0.573
POST VIB	8/22/72*	8430986	1.490	3.612	-1.399
BFF POST	9/6/72	8431041	0.121	0.923	-0.142
COOLDOWN	9/6/72*	8431034	1.160	-0.280	-1.755
SPECIAL TEST	9/8/72	8431035	0.156	0.402	
ON BATTERY	9/8/72*	8431033	0.332	0.929	

* PLL Data

** No Specification applies.

TABLE IV TP 25075

NOTES	DATE	TILT	BIAS (Hz) (Average)	σ (μg)	S/F (Hz/g) (Average)	σ (PPM)
CAMBRIDGE	7/6/72	YES	7.820176	0.537	128.808242	0.216
BFF PRE-VIB	7/7/72	YES	7.820838	0.365	128.808042	0.262
BFF POST-VIB	7/7/72	YES	7.832572	0.459	128.808798	0.238
BFF TP 25045	7/11/72	NO	7.831188	0.316	128.808818	0.134
CAMBRIDGE	7/13/72	NO	7.831136	0.167	128.809808	0.151
BFF POST T-V	8/3/72	NO	7.829680	0.383	128.809202	0.202
BFF POST VIB	8/11/72					
- Y AXIS	8/11/72	YES	7.828798	0.370	128.809588	0.527
- Z AXIS	8/11/72	YES	7.828559	0.264	128.809559	0.259
- X AXIS	8/14/72	YES	7.827489	0.257	128.809669	0.257
- ROVER	8/14/72*	YES	7.827494	1.031	128.809610	1.191
BFF TP 25045	8/24/72	NO	7.826542	0.254	128.809500	0.210
BFF POST COOL	9/7/72	NO	7.825849	0.273	128.809493	0.072
*W/O 2 BAD TEMP DATA PTS	8/14/72	YES	7.827430	0.307	128.809535	0.281

SECTION 4

FAILURES AND DISCREPANCIES

4.1 FAILURE REPORTS

There were two FIARs, 03 and 04, written against TG 002.

4.1.4 FIAR 03 (Exhibit A) documented an out of specification condition that was discovered after reduction of the data obtained from the first performance test, TP 25045, during pre-qualification acceptance. The performance specification with the phase lock loop in requires that the standard deviation of a least square line fit of the data be 1.0 ppm or less. Reduction of the data showed it to be 1.2299 ppm. This condition resulted from two factors, 1) the phase lock loop module specification was too loose; the stability requirement at the module level was less than 3.0 ppm, and 2) the test was run with external power and the breakout box inserted instead of the battery. Because the breakout box does not have the thermal mass of the battery the phase lock loop was subjected to thermal changes that it would not see when mounted on the battery.

The obvious incompatability between the system specification and the module specification was corrected by tightening the module specification to 0.75 ppm. Additionally, the performance test, TP 25045, was revised to have the test run on internal battery power.

A waiver, 0005 (Exhibit B), was prepared at QTRR and approved by MSC to allow continuation of the qualification test with the out of specification condition. The condition was present on all subsequent performance tests run with the breakout box in.

FIAR 03 has been closed out by MSC.

4.1.2 FIAR 04 (Exhibit C) documented an out of specification condition that was noted after performing the baseline verification test, TP 25075, that was run after the simulated rover vibration of TP 25080. This condition occurred because the thermal design has marginal control capability during earth testing without vacuum. The precision oven temperature decreased about 0.03^{o}C from nominal, as evidenced by the last digit of the display going from a 3 to a 6. Apparently the rover vibration

NASA - MANNED SPACECRAFT CENTER
FAILURE INVESTIGATION ACTION REPORT

NO. TG03

1. PROJECT	2. WHERE DETECTED			3. ORG. REPORT NO.	4. PROB. CLASSIF.	5. DATE REPORTED
TRAVERSE GRAVIMETER	FACILITY	Organization MIT/DL	LOCATION Cambridge		☐ FAILURE ☐ UNSAT. COND.	7-14-72

6. CONTRACTOR	7. END ITEM NAME	8. ITEM UNDER TEST	9. NEXT ASSY. NAME	10. REPORTED ITEM
MIT/DL	TRAVERSE GRAV.	TG		
11. TPS NUMBER	7a. EI MODEL NO.	8a. CONTR. PART NO.	9a. CONTR. PART NO.	10a. CONTR. PART NO.
25045	2025000	2025000		
12. ROUTING VIA	7b. EI SERIAL NO.	8b. SUPPLIER PART NO.	9b. SUPPLIER PART NO.	10b. SUPPLIER PART NO.
	002			
13. SPEC/PROCESS NO. DATE: PARA:		8c. SERIAL NO.	9c. SERIAL NO.	10c. SERIAL NO.

14. COND.	15. CAUSE	16. SYMPT	17. Fail TYP	18. Detected During	19.	20. SYSTEM NAME	10d. Time/Cycles (ACUM)

21. DESCRIPTION OF FAILURE/CONDITION

Out of spec. condition at step F.5 of performance specification.

spec. requirement is ≤ 1.0 ppm
recorded, 1.2299 ppm
Acceptance Test prior to Qual. Test

22. CRITICALITY

23. INITIATOR/CONTACT	ORG.	DATE	24. RIE	ORG.	DATE

25. HARDWARE ANALYSIS REQUESTED/INSTRUCTIONS

26. ASSIGNED TO	ORG.	DATE	27. REQUESTER	ORG.	DATE

28. CAUSE OF FAILURE/ANALYSIS RESULTS

Problem caused by PLL #4 being at the limit of the module specification (1.0 ppm).

Module spec. to high to be compatible with system performance requirements.

29. SYSTEM ENGINEER	ORG.	DATE	30. RIE	ORG.	DATE

31. CORRECTIVE ACTION REQUESTED

32. ACTION ASSIGNED TO	ORG.	DATE	33. REQUESTED	ORG.	DATE

34. CORRECTIVE ACTION TAKEN

1. Waiver No. 0005 prepared applies to Qual. Test only, not flight units.
2. PLL module test specification changed from 5 ppm to 0.75 ppm per attached ECR 20534.
3. Performance test procedure, TP 25045, changed to require measurements to be made on internal battery power per ECR 20835.
4. New PLL to be tested at 0.75 ppm and used on all flight system.

35. ACTION BY	ORG.	DATE	36. RIE	ORG.	DATE	37. CLOSE-OUT	DATE

MSC FORM 2174 (JUL 66)

PAGE 1 OF 1

Exhibit A Failure Investigation Action Report No. 03

No. 0005

CHARLES STARK DRAPER LABORATORY

DEVIATION/WAIVER REQUEST

CATEGORY A☐ B☐ C☐ D☐

DATE 7-24-72

SHEET 1 OF 1

PART NUMBER 2025000 NOMENCLATURE Traverse Gravimeter

NEXT ASSEMBLY _____ FINAL ASSEMBLY 2025000

SERIAL NUMBER FS - 2 QUANTITY INVOLVED 1

VENDOR MIT/Draper Lab CONTRACT NUMBER NAS 9-11555

PURCHASE ORDER NUMBER _____ TYPE FP CPFF CPIF

DETAILS OF NON-CONFORMITY: Failed Step F-5 of Performance Test Procedure TP 25045

REASONS FOR NON-CONFORMITY:

Standard deviation of performance data taken with Phase Lock Loop "in", exceeded the 1.0 ppm spec by 20%. Cause of the problem is due to the module spec being the same as the system spec. In this case, the module performance was at the limit of the spec and there was no margin for system error.

ACTION THAT MIGHT BE TAKEN TO CORRECT DEFECT IN EXISTING ITEM, IF ANY:

Replace PLL #4 with one having tighter performance characteristics. However, it is recommended that PLL #4 be left in system 002 until after qualification test because of the unavailability of other PLL modules.

ACTION TAKEN TO PREVENT RECURRENCE OF NON-CONFORMITY:

1. Module test specification was tightened to 0.75 ppm per ECR 20534.
2. Test procedure changed to reflect that measurements be made with TG on internal battery power per ECR 20535. (Ref. T.P. 25045)

EFFECT ON PRODUCTION SCHEDULE/COST IF REQUEST NOT APPROVED:

Delay of several weeks for resumption of qualification testing due to unavailability of PLL modules.

LIMITATIONS OF USAGE: YES ☐ NO ☒

APPROVALS

W. J. Beaton
RELIABILITY

Sheldon W. Buck
ORIGINATOR

Sheldon W. Buck
DESIGN ENGINEERING/DRB

John B. Humphrey
CMO

CUSTOMER REPRESENTATIVE

TP 22925-1

NASA - MANNED SPACECRAFT CENTER
FAILURE INVESTIGATION ACTION REPORT

NO. IG 04

1. PROJECT	2. WHERE DETECTED			3. ORG. REPORT NO.	4. PROB. CLASSIF.	5. DATE REPORTED
TRAVERSE GRAV.	FACILITY: BEDFORD	Organization: MIT/CSDL	LOCATION: Camb., Mass.	—	☐ FAILURE ☒ UNSAT. COND.	8/24/72

6. CONTRACTOR	7. END ITEM NAME	8. ITEM UNDER TEST	9. NEXT ASSY. NAME	10. REPORTED ITEM
MIT/CSDL	TRAVERSE GRAV.	TRAVERSE GRAV.	—	—
11. TPS NUMBER: 25075	7a. EI MODEL NO.: —	8a. CONTR. PART NO.: 2025000	9a. CONTR. PART NO.: N/A	10a. CONTR. PART NO.: N/A
12. ROUTING VIA: N/A	7b. EI SERIAL NO.: 002	8b. SUPPLIER PART NO.: N/A	9b. SUPPLIER PART NO.: N/A	10b. SUPPLIER PART NO.: N/A
13. SPEC/PROCESS NO.: N/A DATE: PARA:		8c. SERIAL NO.: N/A	9c. SERIAL NO.: N/A	10c. SERIAL NO.: N/A

14. COND.	15. CAUSE	16. SYMPT	17. Fail TYP	18. Detected During	19.	20. SYSTEM NAME	10d. Time/Cycles (ACUM)
R64	437	ZY8	002	120: 2TE	941	N/A	N/A

21. DESCRIPTION OF FAILURE/CONDITION

Out of spec. reading at steps I.6 & I.12
I.6 reads 1.031 mg - spec is ≤ 1.0 mg
I.12 reads 1.191 ppm - spec is ≤ 1.0 ppm

22. CRITICALITY: 003

23. INITIATOR/CONTACT	ORG.	DATE	24. RIE	ORG.	DATE

25. HARDWARE ANALYSIS REQUESTED/INSTRUCTIONS

N/A

26. ASSIGNED TO	ORG.	DATE	27. REQUESTER	ORG.	DATE

28. CAUSE OF FAILURE/ANALYSIS RESULTS

Condition caused by marginal operation of Temperature Control system, at earth pressure. The "P" oven temperature drifted out to about .03°C because of the Dewar Vibration Test fixture acting as a heat sink. When TG was removed from test fixture, normal temperature was achieved. If the one data point taken when the 'P' oven temperature cooled is omitted, the data is easily within spec.

29. SYSTEM ENGINEER	ORG.	DATE	30. RIE	ORG.	DATE

31. CORRECTIVE ACTION REQUESTED

N/A

32. ACTION ASSIGNED TO	ORG.	DATE	33. REQUESTED	ORG.	DATE

34. CORRECTIVE ACTION TAKEN

This condition is due to the test fixture being used acting as a heat sink. It is not expected to cause any problems during Lunar operations. A waiver #0006 has been prepared. Waiver not required for failure close out.

35. ACTION BY	ORG.	DATE	36. RIE	ORG.	DATE	37. CLOSE-OUT	DATE

MSC FORM 2174 (JUL 68)

PAGE 1 OF 1

Exhibit C Failure Investigation Action Report No. 04

test fixture acted as a heatsink and caused cooldown to the oven. After removal from the test fixture, the first measurement indicated a temperature shift had occurred. All subsequent measurements were normal. However, by factoring the first measurements into the calculations for standard deviation of bias and scale factor, it was sufficient to cause the system requirement of TP 25075 to be out of specification. The standard deviation of the five bias measurements should have been less than 1.0 mg - it was 1.031 mg. The standard deviation of the five scale factor measurements should have been less than 1.0 ppm - it was 1.191 ppm.

A waiver, 0006, was prepared to allow continuation of qualification testing, but MSC has indicated that the waiver is not necessary.

FIAR 04 has been closed out by MSC.

4.2 DISCREPANCIES

Discrepancies were documented on the MIT/DL internal form. Any anomaly that did not warrant recording on a FIAR was recorded on the internal form. Two discrepancies were noted during test:

4.2.1 MIT/DL failure report #29 (Exhibit D) documented an out of specification condition at step D.7 of TP 25025. Step D.7 requires the battery heater thermostat to turn on at $47 \pm 6^{\circ}F$ when the chamber temperature is lowered to $20^{\circ}F$. The battery heater thermostat came on $39^{\circ}F$, two degrees below tolerance. Because of previous problems that were experienced with the Daystrom recorder, a calibration check using an ice bath and thermometer was performed; the particular channel in question was found to be reading two degrees below actual temperature. Allowing for the recorder error, the reading obtained is considered within the allowable specification.

4.2.2 During teardown of the TG 002 after qualification test it was noted that the anti-backlash gear segment was not centered on the pinion. This condition was documented on internal failure report #31 (Exhibit E). Condition was caused by tilting the TG off vertical more than fifteen degrees during bias measurement of TP 25020 on August 22. The TP 25020 has been clarified by ECR 20548 to prevent recurrence of this condition by test personnel.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
INSTRUMENTATION LABORATORY

FAILURE REPORTING FORM

SHEET 1 OF 1

Project: TG	End Item Name:	Serial No.	No. 29
Assembly Name: TG	Dwg. No.: TP 25025	Serial No. 002	
Part Name:	Dwg. No.	Date: 9-14-72	

Description of Failure:

During TG Temperature Test on S/N2, F9-2, Qual. Model, out of spec condition was observed at step 7.00. page 6. Battery Temp. recorded as 39°F, spec. 47° ± 6°F.

E. J. Connor
Originator

Failure Analysis:

After previous testing using this recorder, calibration revealed recorder to be 1 to 2°F low.

Calibration of particular channel used to monitor battery temp. showed recorder to be 2°F low for the above test.

R. T. Mortorano 9/14/72
Engineer Date

Corrective Action:

2° F increase in data point raises temp. to 41° F, within spec. of 47° F ± 6° F.

E. J. Connor 9-14-72
R & QA Engineer Date

TP17123

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
INSTRUMENTATION LABORATORY

FAILURE REPORTING FORM

SHEET 1 OF 1

Project: TG	End Item Name: TRAVERSE GRAVIMETER	Serial No. 002	No. TG 031
Assembly Name: "Y" AXIS GEAR BOX	Dwg. No.: 2023071	Serial No. 002	
Part Name: GEAR SECTOR, ASSY	Dwg. No. 2025183	Date:	

Description of Failure:

Visual inspection after Qual Test revealed floating spur gear (2025192) and spur gear (2025058) not properly aligned per drawing and assy procedures, to obtain desired antibacklash control.

E. Connor / R. Moselek
Originator

Failure Analysis:

During performance of TP 23020, TG Level Test, (8-22-72), the TG was tilted off vertical by more than 15° during a BIAS measurement (STEPS R.1 to R.3). Tilt during BIAS of >15° caused limit switches to be inoperative allowing gear to be driven off pinion. (EJC)

R. Moselek 10-1-72
Engineer Date

Corrective Action:

1) Test personnel cautioned not to tilt TG off vertical by >15° during a BIAS measurement.
2) ECR 20548 clarified TP configuration.
3) Gears were realigned per drawing 2025183. Work and inspection documented on work req. 230.

E. J. Connor 10-4-72
R & QA Engineer Date

TP13123

SECTION 5

SUMMARY OF WAIVERS AND DEVIATIONS

Waiver #0005 (Exhibit B) was the only waiver written against the TG 002. This waiver was requested because of an out of specification condition that was observed during the pre-qualification acceptance test. The condition was documented on FIAR 03. Waiver #0005 has been approved by NASA/MSC, and FIAR 03 closed out.

SECTION 6

SUMMARY OF ECR'S

6.1 ECR 20518:

Clarified test procedure and added instrumentation tolerance to TP 25025.

6.2 ECR 20520

Corrected incorrect formula needed for calculation in TP 25075.

6.3 ECR 20519:

Corrected typographical error in TP 25015.

6.4 ECR 20535:

Changed TG configuration for performance of TP 25045.

6.5 ECR 20517:

Clarified operational procedure in TP 25020.

SECTION 7

DEVIATIONS FROM QUALIFICATION TEST SPECIFICATION

7.1 PROCEDURE NO. ND 2025808, PAGE 22, PARAGRAPH 3.2, 6.1.1 B AND C

TP 25036 is slightly different than outlined in this paragraph. Instead of the alternating between Normal and Bias measurements, Normal measurements were made. A Bias measurement was made at the start and at the end of the test and approximately thirty-two Normal measurements were made. This sequence simulates more exactly the actual traverse sequence planned for Apollo 17, and it was felt more engineering information could be gained with respect to the TG operation on the traverse.

7.2 PROCEDURE NO. ND 2025808, PAGES 38, 39, 41, 42, AND 43

The actual test flow differed from that planned in the Qualification Test Specification. The actual test flow is listed in this report paragraph 8.2. The reasons for the changes were to affect a more expeditious test flow and to reduce configuration changes. These test flow changes were coordinated with NASA/MSC.

SECTION 8

DEVIATIONS FROM QUALIFICATION TEST PROCEDURE

8.1 PROCEDURE NO. 2025810, PAGE 3, PARAGRAPH 3.3.4

In addition to the Daystrom recorders indicated, a Kaye Model 8000 digital thermocouple recorder was used.

8.2 PROCEDURE NO. 2025810, PAGE 7 AND 8

The order of the test program was changed in order to affect a more expeditious performance of the tests because of availability of test facilities, personnel and configuration of the TG. The test order follows:

	2025810		As Performed	
1	25085	DL-11	25025	DL-11
2	25055		25075	
3	25025		25075	BFF
4	25075		25030	
5	25075	BFF	25075	
6	25030		25015	
7	25075		25045	
8	25015		25075	
9	25020		25020	
10	25045		25075	DL-11
11	25035/36		25085	
12	25075		25055	
13	25080		25035/46	BFF
14	25081		25075	
15	25015		25081	
16	25020		25080	
	25045		25015	
	cool down		25020	
	25045		25045	
	25025	DL-11	25075	
			10 day cool down	

25045	
25075	
25045*	
25075*	
25025	DL-11

NOTES:

*Tests added to verify better TG performance tests by running TG on Battery rather than Power Supply.

In addition, TP 25075 was performed after transportation of the TG more times than anticipated in 2025810.

SECTION 9

SCHEDULE CONSIDERATION

9.1 The "As Performed" Qualification test schedule is indicated in Figure 9.

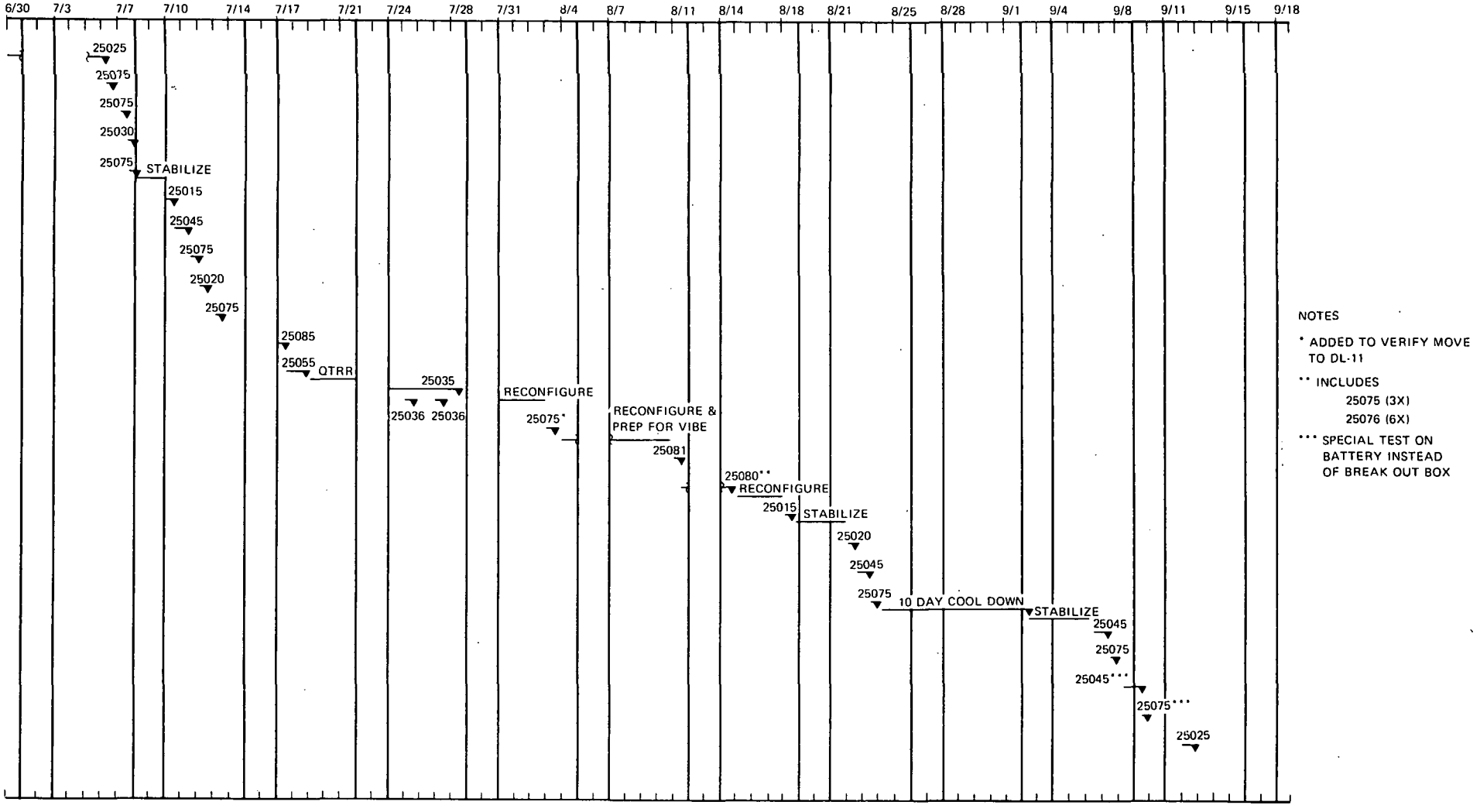


Fig. 9 TG "As Run" Schedule

SECTION 10

PHOTOGRAPHS

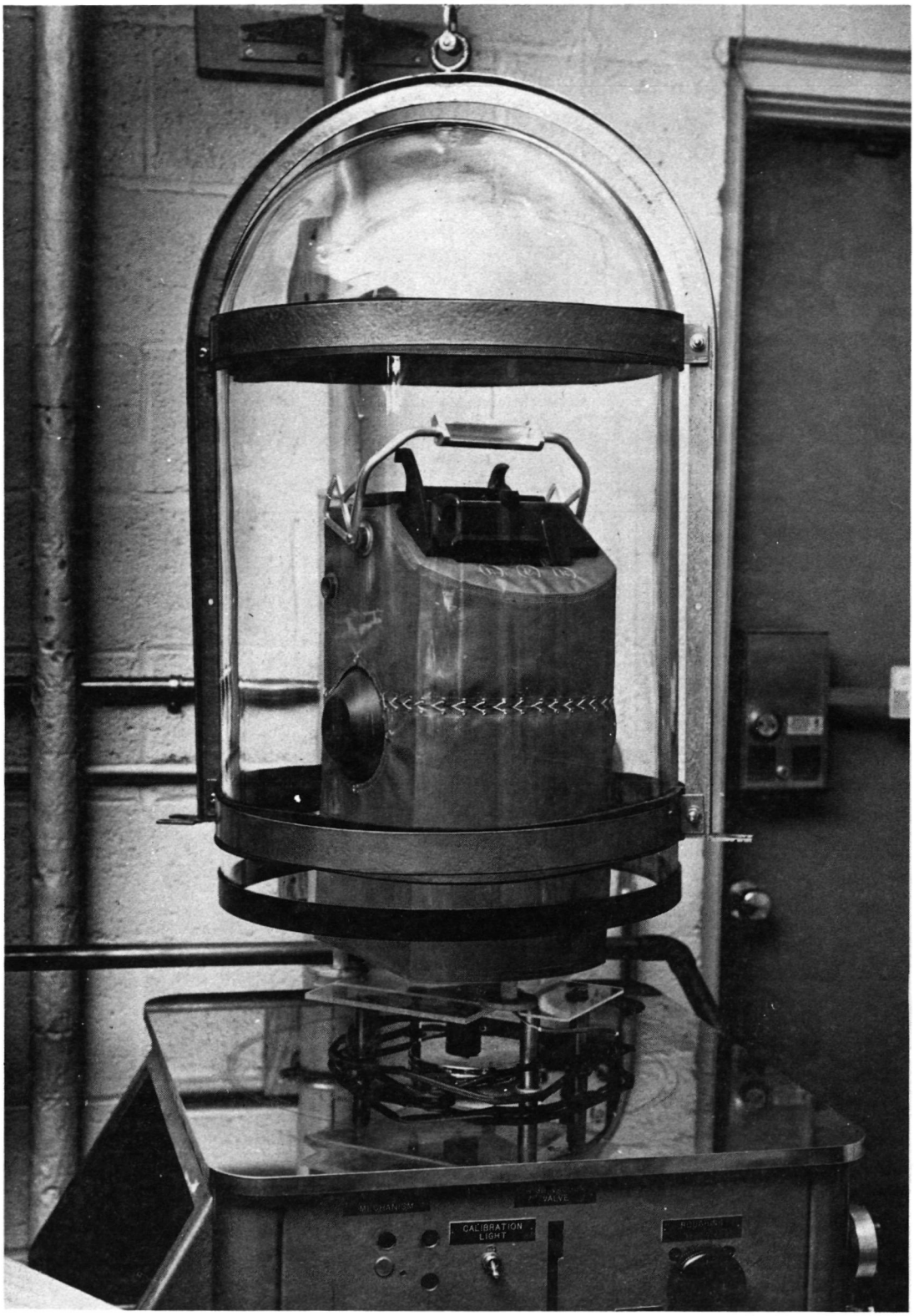


Fig. 10 Typical Launch Depressurization Set-Up

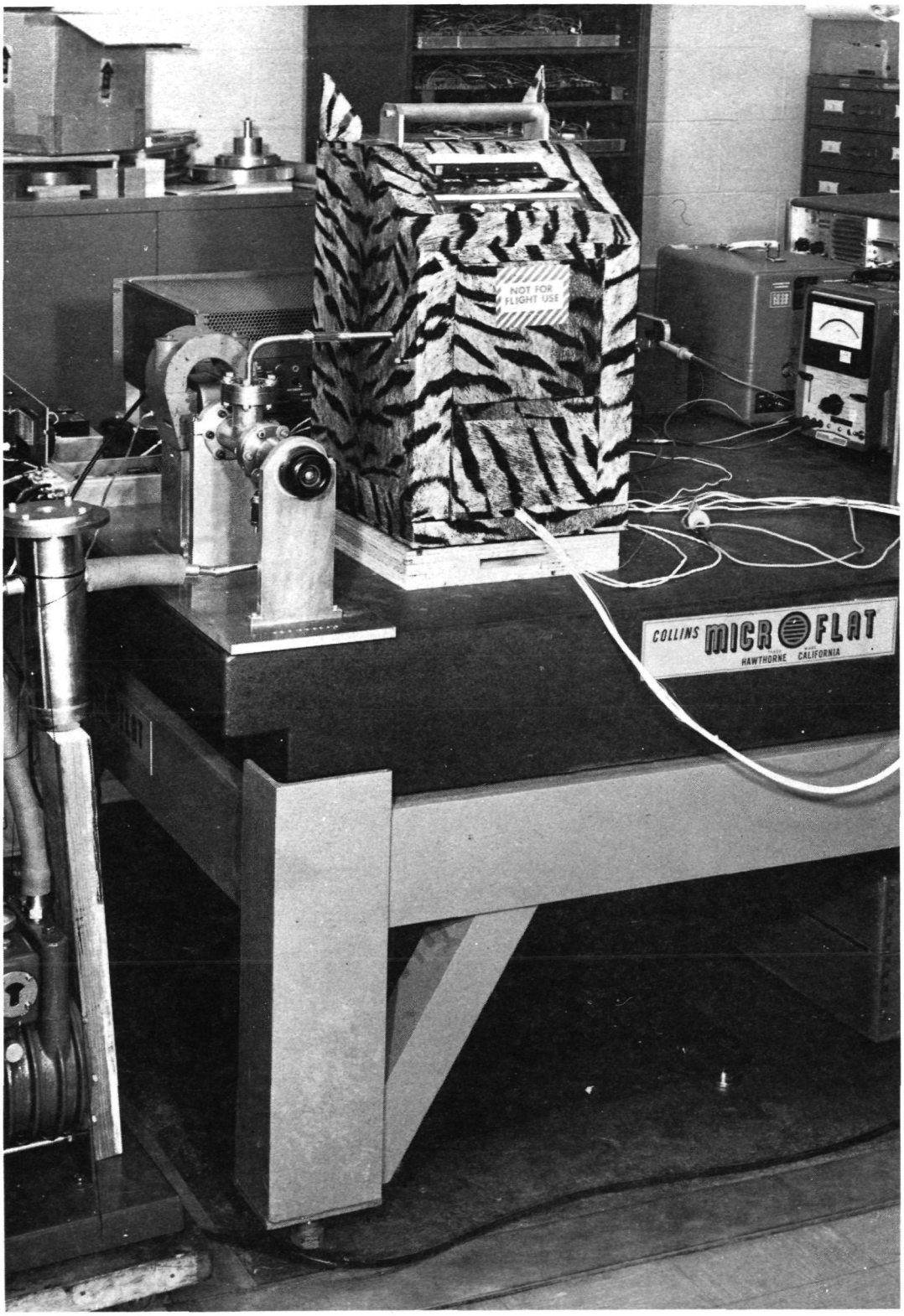


Fig. 11 Typical Performance Test Set-Up

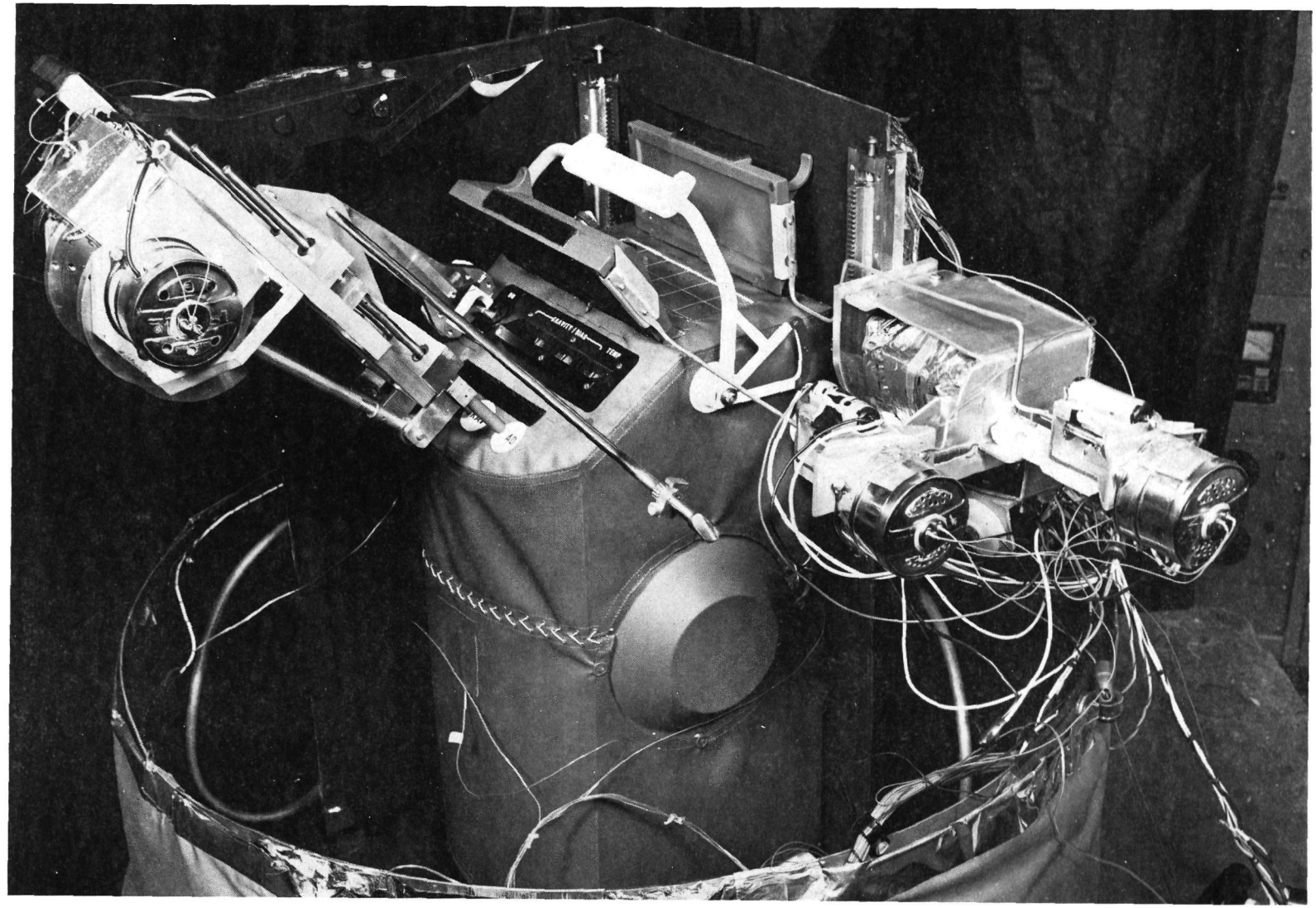


Fig. 12 Thermal Vacuum Simulator Apparatus

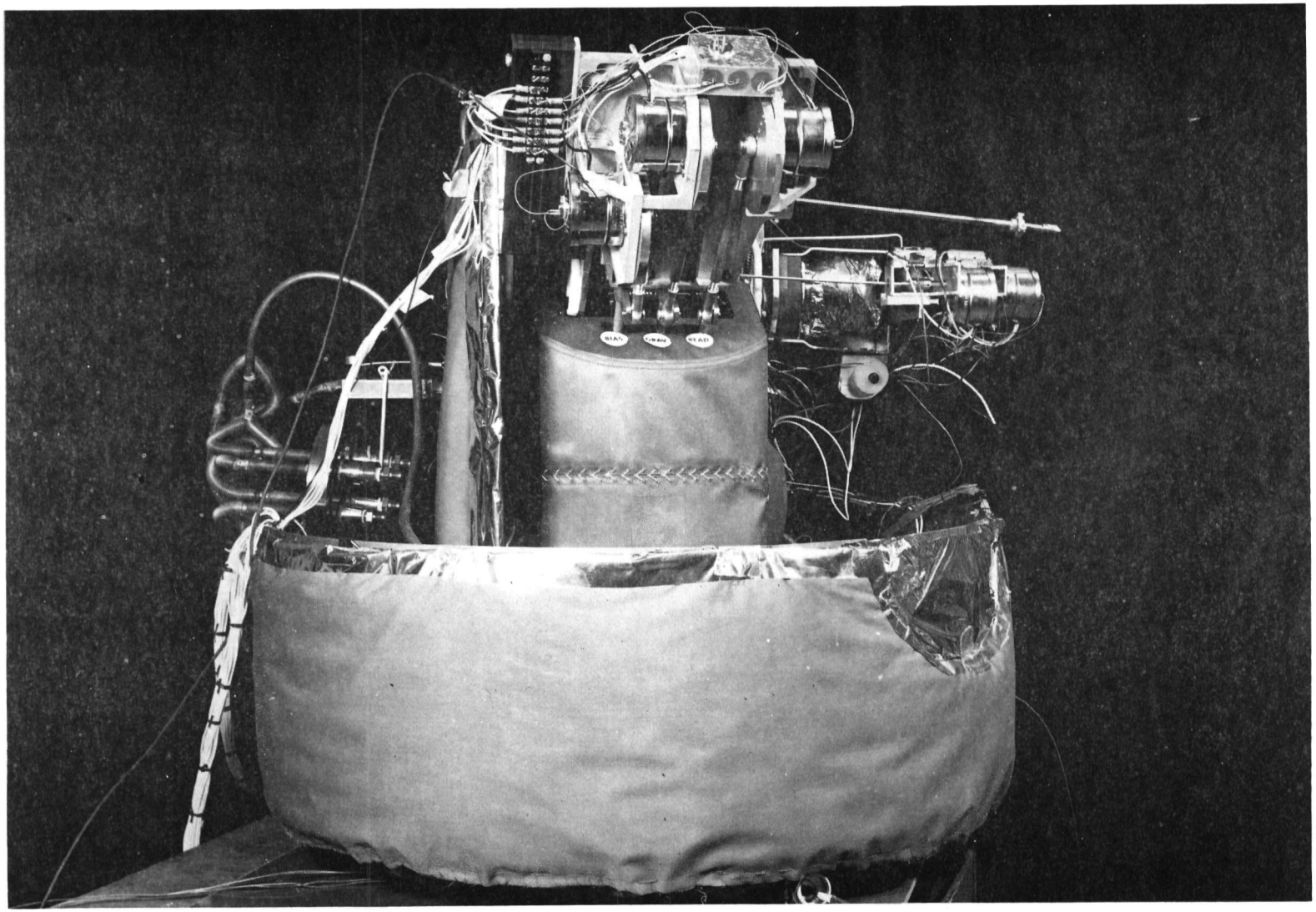


Fig. 13 Thermal Vacuum Simulator Apparatus

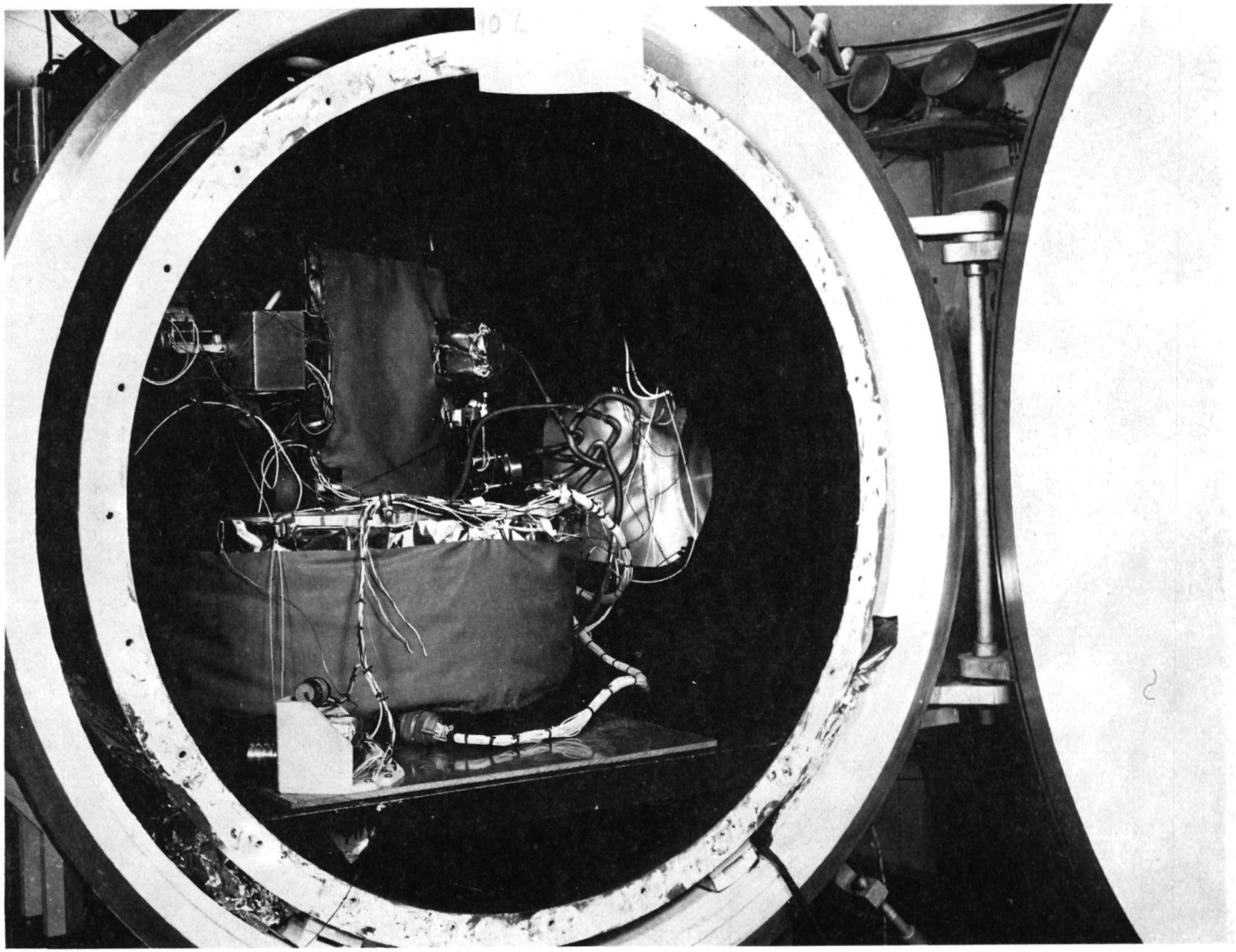


Fig. 14 Thermal Vacuum Simulator Apparatus in Vacuum Chamber

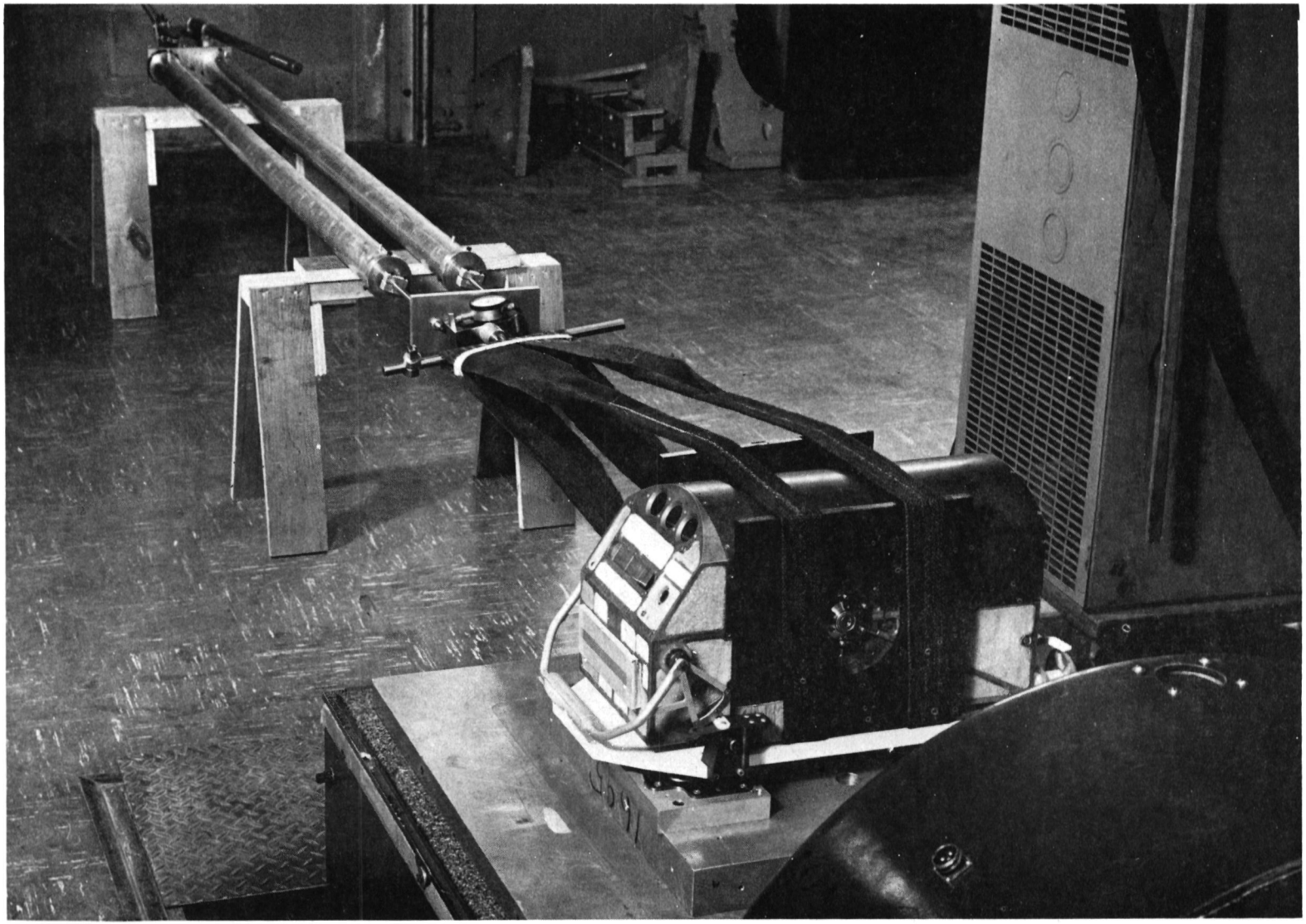


Fig. 15 Traverse Gravimeter Mechanical Unit/Isoframe Test

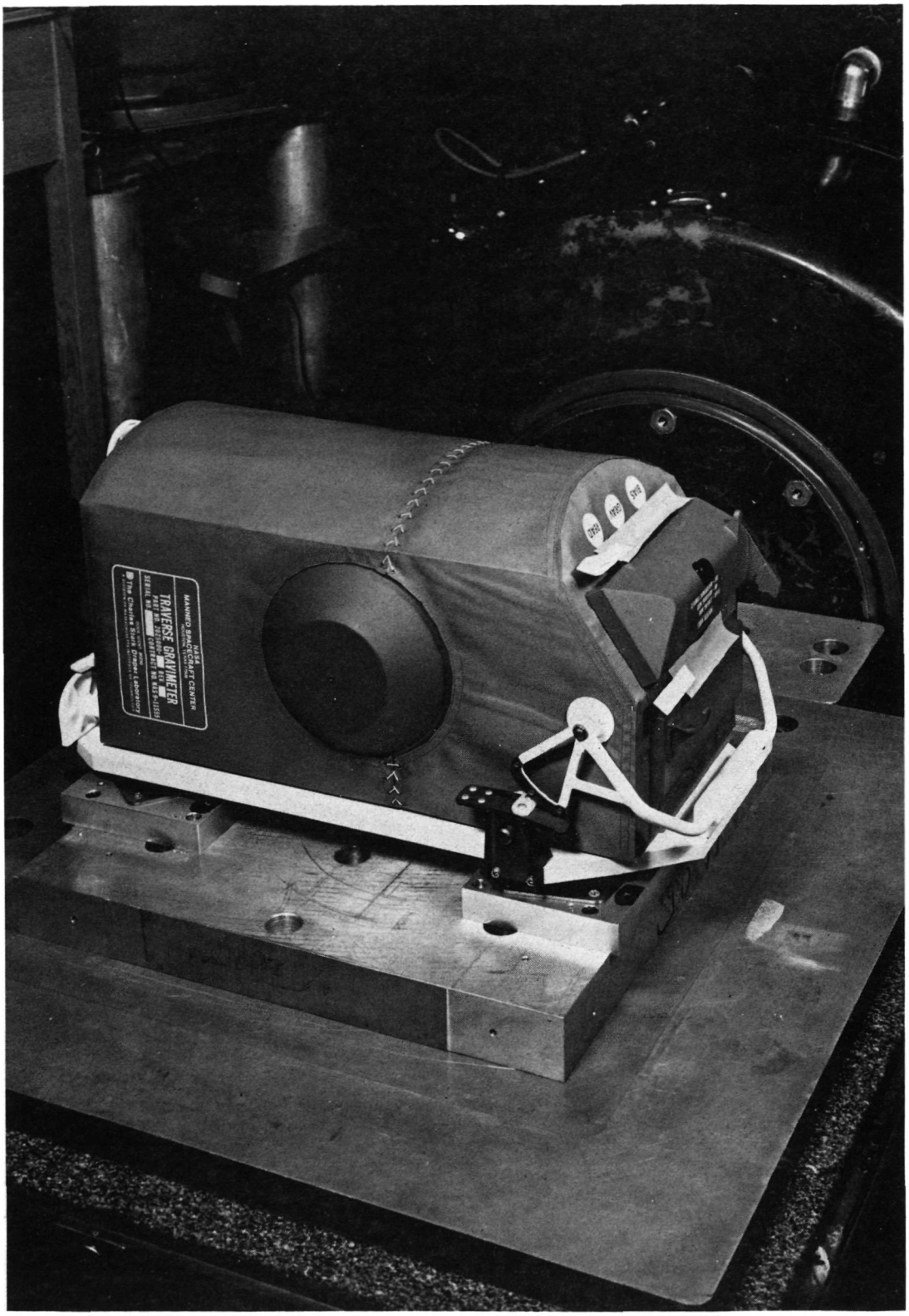


Fig. 16 TG Qualification Vibration - Y Axis

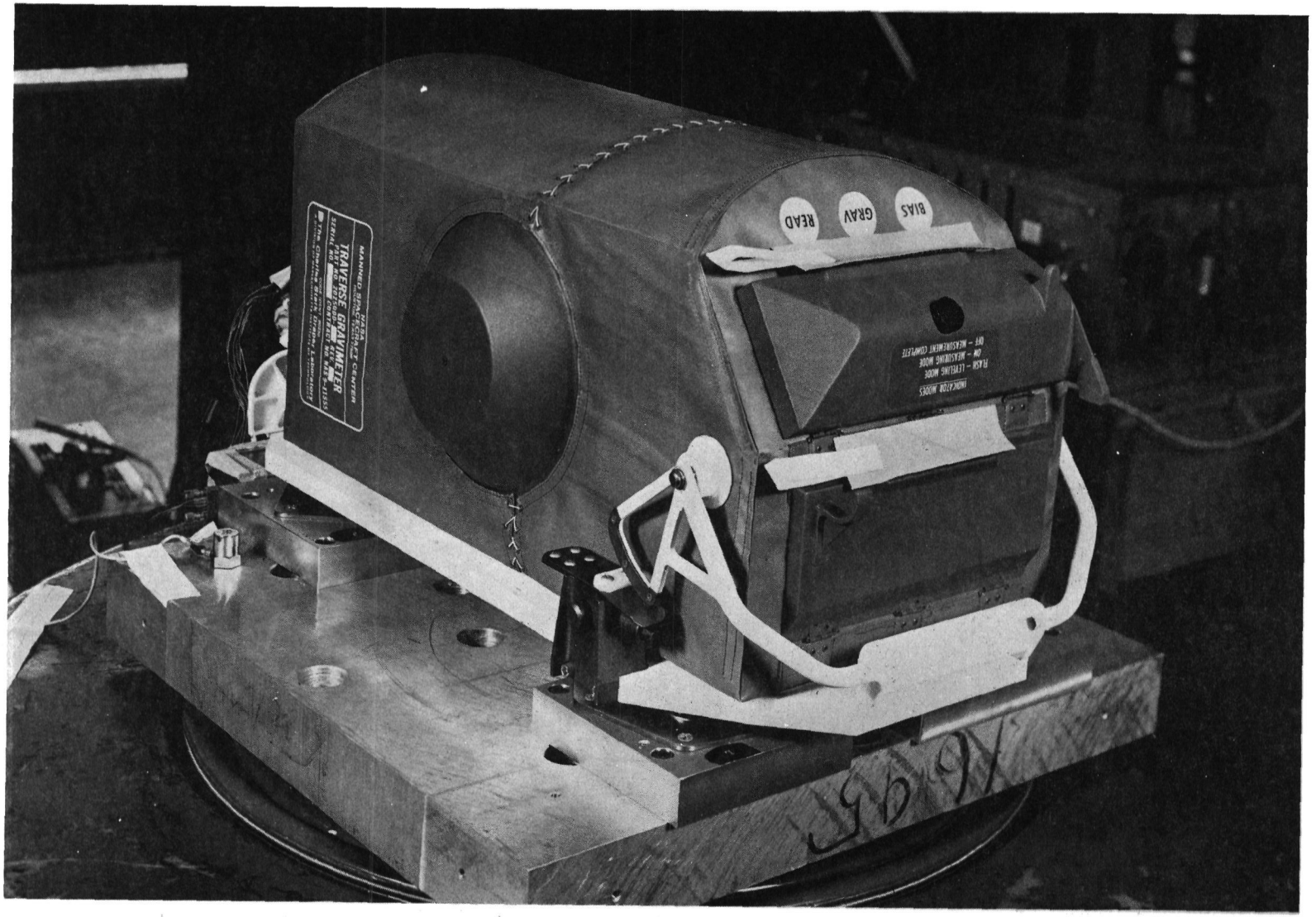


Fig. 17 TG Qualification Vibration - X Axis

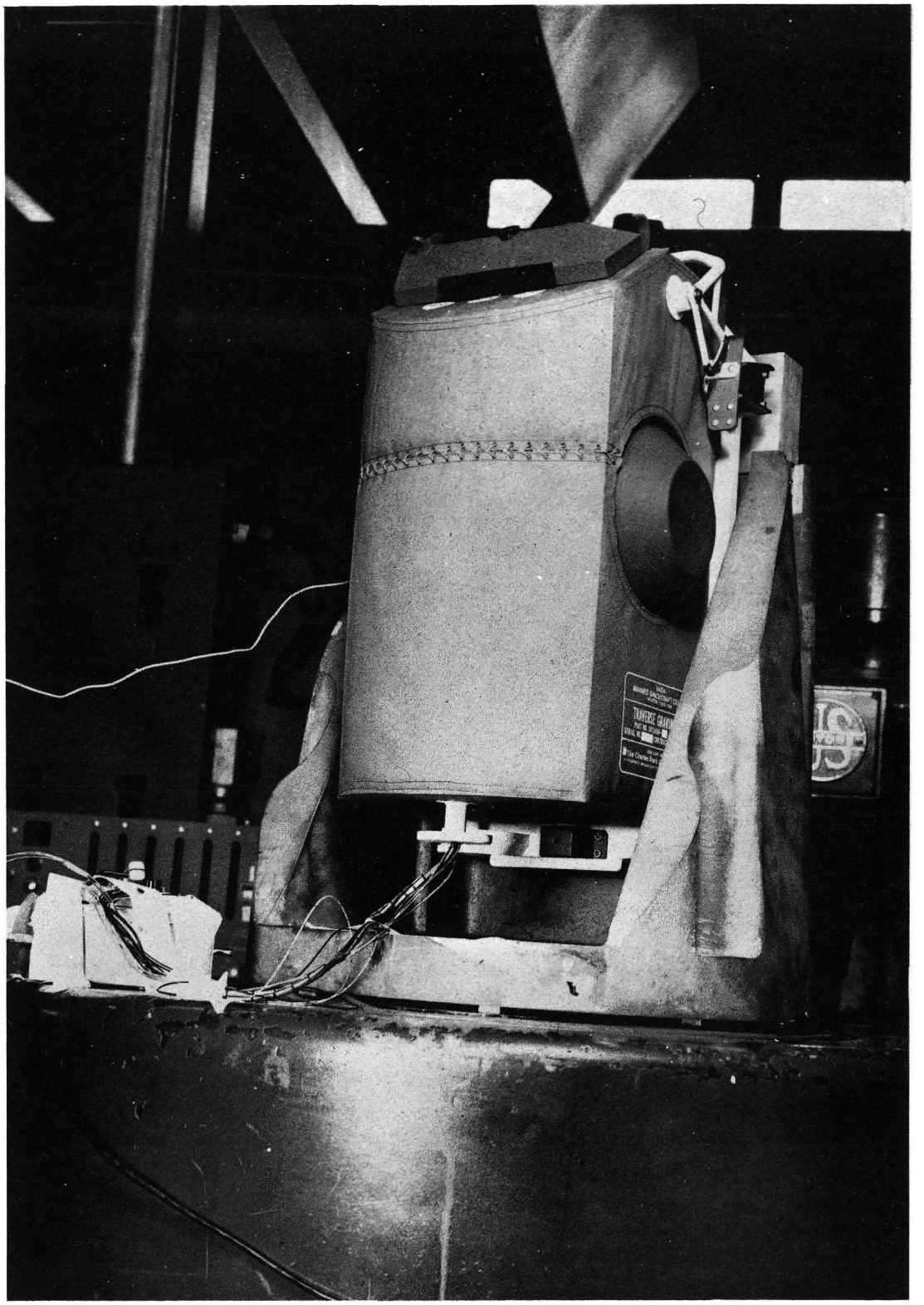


Fig. 18 Rover Vertical Vibration

SECTION 11

TEARDOWN AND INSPECTION

After completing all prescribed tests in accordance with the Qualification Test Procedure, 2025810, the system was partially disassembled to allow for inspection of damage and replacement of the phase lock loop module, S/N 004, in accordance with MSC direction per MSC memo EG9-72-140 (Exhibits F and G).

The TG main cover was removed and the battery pack assembly extracted. This allowed inspection of the base harness, gimbals, and gear boxes; by rotating the gimbals it was possible to inspect the "E" frame harness.

The "E" frame harness was examined for conformity to revision A of PFP #29 (Process Flow Plan). Rework of the tie points to the harness was required to obtain conformity to revision A of the PFP.

It was noted the anti-backlash gear segment was not centered on the pinion. This condition was documented on internal failure report #31. During performance of TP 25020, while doing a bias measurement the TG was tilted greater than fifteen degrees; apparently this caused the gear segment to come off the pinion. It came back on the pinion when returning to normal position, but was off center. The off center condition had no effect on the TG. The anti-backlash gear was recentered during reassembly of the TG in preparation of reacceptance test. The phase lock loop module S/N 004 was replaced by S/N 006 in accordance with MSC direction. No other anomalies were noted and the TG was reassembled in preparation of reacceptance tests.

FS-2

WORK REQUISITION

NO. 230

PROJECT: TG	CHARGE:	DATE: 9-19-72
UNIT NAME: TG - SUB ASSEMBLY	NO. REQ. 1	REQ. BY CONNOR
DWG. NO. 2025204 REV	ORIGINATOR: E. Connor	

SPECIAL INSTRUCTIONS

Teardown / Inspection per NASA (EG9-72-140).
Document operations required to complete teardown / inspection / rebuild.

ASSEMBLY S/N 002

RAW MATERIAL DATA

TYPE: _____ LOT NO. OR PO NO. _____

OPERATION INSTRUCTIONS/RECORD

OPR. NO.	DESCRIPTION	COMPLETION DATE	OPERATOR OR INSPECTOR INITIALS OR STAMP
1	Remove main cover and one side cover.		J. Coccia 9/19/72
2	Disconnect T-Connector, Battery Cables and		J. Coccia 9/19/72
3	Remove Battery S/N 2 with PLL S/N 4.		J. Coccia 9/19/72
4	Rotate "E" Frame & Gimbal to provide		E. Connor - W. Boston
	visibility of "E" Frame Harness		
5	Inspect harness for damage & check		
	to see if tie down configuration		WJB 9-19-72
	meets Rev A of PFP # 29		
6	Removed tie downs on "E" Frame		
	Harness to make it conform to		
	Rev A of PFP #29		
7	Reenter anti backlash sector gear		EJC 9/19/72
	SEE SHEET 2		

COMPLETION APPROVALS:

FOREMAN/SUPERVISOR _____ AREA OR SHOP _____ E. J. Connor QC REPRESENTATIVE

TP 1036

ADDENDUM SHEET

TG (PROJECT)

ASSEMBLY WORK ORDER

W.O. NO. 230

PAGE _____ OF _____

ASSEMBLY NAME	DWG. NO. 2025204	REV.	ASSEMBLY SER. NO. FS-2

BUILD HISTORY/CHANGE INCORPORATED:

STEP NO.	TYPE	DESCRIPTION (9/19/72)	PERFORMED BY	DATE
1.	Remove transparent cover at Y axis gear box			
2.	Remove 4 screws from gear box cover Y axis			
3.	Remove 2 flat head screws from J8 connector cover			
4.	Remove cover at "Y" axis.			
5.	Remove motor pinion gear.			
6.	Remove sector pinion gear.			
7.	Clean and oil both gears and reinstall.			
8.	Remove locking screw from sector gears.			
9.	Replace bracket at J8 connector.			
10.	Replace transparent cover.			
		J. Cossio 9/19/72		

SECTION 12

MSC FORM 772

Exhibits H - L are copies of MSC Form 772 historically recording the significant events of the Qualification Test program on Traverse Gravimeter Flight System No. 2.

SYSTEM AND COMPONENT HISTORICAL RECORD

1. ITEM NAME	2. ITEM NUMBER	3. DRAWING NUMBER	4. MANUFACTURER	5. SERIAL NUMBER
TRAVERSE GRAVIMETER	2025000	2025000	MIT/DL	002

6. SYSTEM/SUBSYSTEM	7. PROJECT	8. LIFE LIMITS: TIME/CYCLES		9. EFFECTIVITY
	LUNAR SURFACE EXPERIMENT	OPERATING	STORAGE	

10. SPECIAL HANDLING AND/OR SHIPPING INSTRUCTIONS

11. DATE	12. LOCATION	13. HISTORICAL EVENTS	14. TIME/CYCLES	15. QC STAMP
6/30/72	MIT/DL-11	Started Temp Cycle, TP 25025 Section C - Test Completed	1 hr. 52 min	WJB
6/30/72	MIT/DL-11	Reran step C of TP 25025 because first test not run		
		on internal power as called for on TP.	1.3 hrs.	WJB
7/5/72	MIT/DL-11	Over weekend water pipe in ceiling broke flooding		
		area. No apparent damage to TG 002.		WJB
7/5/72	MIT/DL-11	Ran step D of Temp. Test, TP 25025 - out of spec.		
		conditions at steps D.7a, D.7c, & 21 cleared by		
		ECR # 20518.	13.5 hrs	WJB
7/6/72	MIT/DL-11	Ran test TP 25075, Baseline Verification	1.4 hrs	WJB
7/6/72	-	Moved TG to Bedford test facility	0.75 hrs	WJB
7/7/72	BFF	Ran Baseline Verification, TP 25075		WJB
7/7/72	BFF	Ran Workmanship Vibration, TP 25030		WJB
7/7/72	BFF	Nut not torqued down on terminals to GSE Level		
		Measure Light. Light became intermittent. Ran TP 25075		WJB
7/7/72	BFF	Purged down system in preparation for TP 25015		
		& secured for weekend.		WJB

MSC FORM 772 (REV JUL 67) (Previous editions are obsolete)

Exhibit H System and Component Historical Record

11. DATE	12. LOCATION	13. HISTORICAL EVENTS	14. TIME/CYCLES	15. QC STAMP
7/10/72	BFF	Ran Current Monitor Test, TP 25015, steps 7 & 11		
		out of spec. Cleared by revision to TP on ECR # 20519		WJB
7/10/72	BFF	Ran Performance Test, TP 25045, complete through		
		step D.13 and secured for day.		WJB
7/11/72	BFF	Completed TP 25045, data reduction showed		
		out of spec. condition at step F.3. FIAR TG 03		WJB
7/11/72	BFF	Ran Baseline Verification, TP 25075		WJB
7/12/72	BFF	Ran Level Test, TP 25020. Step R.3 was out of		
		spec. due to misinterpretation of TP. Reran and		
		it was okay. TP used was not formally released		
		and contains many typos. All discrepancies		
		cleared by ECR # 20317.		WJB
7/13/72	DL-11	Ran unscheduled TP 25075, LEVEL ONLY, to verify		
		TG after transportation to Cardridge.		WJB
7/14/72	DL-11	Start reconfiguring for launch Degrees, TP 25085		WJB
7/15/72	DL-11	Continued reconfiguration for TP 25085. Flight		
		handles not available. Used Interface Mock-up		
		S/N 2 handle. Decals missing from Display Cover.		WJB
7/19/72	DL-11	Battery Pack assembly S/N 1 removed and Battery		
		Pack assembly S/N 2 installed to provide a		
		fully charged battery for thermal vacuum testing		WJB

Exhibit I System and Component Historical Record (Cont)

SYSTEM AND COMPONENT HISTORICAL RECORD

1. ITEM NAME	2. ITEM NUMBER	3. DRAWING NUMBER	4. MANUFACTURER	5. SERIAL NUMBER
TRAVERSE GRAVIMETER		2025000	MIT/DL	002

6. SYSTEM/SUBSYSTEM	7. PROJECT	8. LIFE LIMITS: TIME/CYCLES		9. EFFECTIVITY
	LUNAR SURFACE EXPERIMENT	OPERATING	STORAGE	

10. SPECIAL HANDLING AND/OR SHIPPING INSTRUCTIONS

11. DATE	12. LOCATION	13. HISTORICAL EVENTS	14. TIME/CYCLES	15. QC STAMP
7/13/72	DL-11	Reconfigure for TP 25085, Launch Depressurization.		
		Handle from Interface Mock-up S/N 002 used due to		
		non-availability of flight handles		WJB
7/17/72	DL-11	Run Launch Depressurization Test, TP 25085		WJB
7/17/72	DL-6	Perform weight & C.G. portion of TP 25055.		WJB
7/18/72	DL-11	Perform dimensional inspection per TP 25055		WJB
7/21/72	-	Moved to Bedford Test Facility for Thermal Vacuum		
		Test, TP 25035 and secured for weekend.		WJB
7/24/72	BFF	Start Thermal Vacuum Test		WJB
7/28/72	BFF	Completed Thermal Vacuum Test - no problems		WJB
8/1/72	BFF	Reconfigured for Verification Test, TP 25075		WJB
8/3/72	BFF	Ran Verification Test, TP 25075 - no problems.		
		Test run in level position only per ECR		WJB
8/9/72	BFF	Fit check with Isoframe - Fit checks OK		WJB
8/10/72	BFF	Install "T" connector in preparation for vibration test		WJB
8/11/72	BFF	Started qualification vibration, TP 25080		WJB

MSC FORM 772 (REV JUL 67) (Previous editions are obsolete)

Exhibit J System and Component Historical Record (Cont)

11. DATE	12. LOCATION	13. HISTORICAL EVENTS	14. TIME/CYCLES	15. QC STAMP
8/11/72	BFF	Completed Y & Z axis sine sweep, sine dwell, and random		
		per TP 25080 - no problems. Secured for weekend.		WJB
8/14/72	BFF	Completed X axis sine, dwell, and random per TP 25080		
		- no problems. Reconfigure for Current Monitor Test,		
		TP 25015		WJB
8/18/72	BFF	Ran Current Monitor, TP 25015 - no problems, secured		
		for weekend.		WJB
8/21/72	—	Data reduction of TP 25075, Post Qual Vib shows out of spec		
		condition at steps I.6 & I.12. See Waiver 0006 & FIAR 04		WJB
8/22/72	BFF	Ran level test. TP - 25020 - no problems		WJB
8/23/72	BFF	Completed 6 hour run of Performance Test, TP 25045		WJB
8/23/72	BFF	Completed Performance Test, TP 25045. Begin 10 day		
		cool down cycle per MSC authorization.		WJB
8/28/72	—	Out of spec conditions at steps F.5 & G.2 covered by Waiver #0008		WJB
9/2/72	BFF	Completed 10 day cool down. Place TB in standby		WJB
9/6/72	BFF	Start 6 hour Performance run, TP 25045 - completed		WJB
9/7/72	BFF	Completed TP 25045		WJB
9/7/72	BFF	Ran Verification Test 25079 in Level Position only		EJC
9/7/72	BFF	Installed battery, S/N 02, removed BOB		EJC
9/8/72	BFF	Run TP 25045 on battery power		EJC
9/9/72	BFF	Completed TP 25045, performed TP 25079 on level surface only.		EJC

Exhibit K System and Component Historical Record (Cont)

SYSTEM AND COMPONENT HISTORICAL RECORD

1. ITEM NAME	2. ITEM NUMBER	3. DRAWING NUMBER	4. MANUFACTURER	5. SERIAL NUMBER
TRAVERSE GRAVIMETER		2025000	MIT/DL	002

6. SYSTEM/SUBSYSTEM	7. PROJECT	8. LIFE LIMITS: TIME/CYCLES		9. EFFECTIVITY
	LUNAR SURFACE EXPERIMENT	OPERATING	STORAGE	

10. SPECIAL HANDLING AND/OR SHIPPING INSTRUCTIONS

11. DATE	12. LOCATION	13. HISTORICAL EVENTS	14. TIME/CYCLES	15. QC STAMP
9/11/72	BFF	TG put on internal power and shipped to Cambridge		
		DL-11 for completion of Qual Tests		EJC
9/12/72	DL-11	Start Temp. Test TP 25025 - Complete Test -		
		See Interval Report #29		EJC
9/19/72	DL-11	Post-qualification teardown and inspection. One		
		anomaly noted. See Interval Report #31.		
		Replaced S/N004 PLL with S/N006 per MSC		
		direction.		WJB

MSC FORM 772 (REV JUL 67) (Previous editions are obsolete)

Exhibit L System and Component Historical Record (Cont)

SECTION 13

CONCLUSION

Very few serious problems were encountered during the Traverse Gravimeter Qualification test program. Of the problems that did occur most were procedural errors or typographical errors in the Test Procedures, or improper tolerances. One reason for this is the initial failure of the Engineering Unit which therefore did not allow pre-running the Test Procedures before the actual Acceptance and Qualification testing. This led to the performance of some of the Test Procedures for the first time on the Qualification Unit. In order to avoid problems because of this, efforts were made to ensure that test personnel either designed or wrote the test procedure, and were therefore most familiar with the purpose of the test.

One other difficulty encountered during the test program was difficulty in re-configuring the TG for test. The main reason for this is again the lack of the Engineering unit to gain experience on and originate procedures from this experience. Therefore most of the work done in this area was generated without actual hardware to work on.

One important configuration change was made for TP 25045. It was discovered that the TG performance data improved appreciably when the TG was powered by a Battery rather than a Power Supply. TP 25045 was modified to include this change.

The TG successfully passed the Qualification Tests with no serious mechanical or performance degradation and all of the minor problems were cleared through the appropriate paper work. In conclusion, it is felt the Qualification test program was successful and that the Traverse Gravimeter has demonstrated the ability to successfully undergo the Apollo 17 mission.