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Prototype "A"
Thermal Vacuum Test Summary

NO. ATM-729

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RETURN TO WILEY

SEE PAGE 22

JAMES

MAAC

GALUTHIER

SHARPE

This ATM presents the results of the ALSEP Prototype System Thermal Vacuum Test. A final report, including analysis of these results, will be published at a later date.

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I. TEST SCOPE

ALSEP was subjected to a simulated lunar environment in the Bendix 20" x 27' Space Simulation Chamber. Each subsystem was functionally evaluated to assure an acceptable performance in the lunar environment. The following phases were evaluated:

Th

- a) System start-up under a simulated lunar morning environment.
- b) System performance under a simulated lunar noon environment and
- c) System performance under a simulated lunar night environment.

II. TEST OBJECTIVES

The Proto A Thermal Vacuum Test was performed to ensure that the Central Station and each experiment subsystem operates correctly in conjunction with each other in simulated lunar night and lunar day environments. In addition, the test provided thermal data which will be used to refine the analytical predictions of the Thermal Subsystems' Lunar performance.

III. SUMMARY OF RESULTS

A. Introduction:

An "ALSEP System Thermal Vacuum Test" was performed in the Bendix 20' x 27' Space Simulation Chamber. During the test, a lunar start-up sequence under a simulated lunar morning environment using the GE Model 14 generator was performed. After the generator output had stabilized, a simulated lunar noon environment was established and all systems after having reached thermal equilibrium, were exercised through an Integrated Systems Test. Following this test, a simulated lunar night environment was established and again all systems allowed to reach thermal equilibrium. A second Integrated Systems Test was performed and upon completion, ALSEP was shut down and the chamber returned to room ambient conditions.



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III SUMMARY OF RESULTS (CON'T.)

The lunar environment simulated in Bendix 20' x 27' Space Simulation Chamber is keyed to four environmental parameters:

- a) Pressure
- b) Cold Sink of Space
- c) Lunar Surface Temperatures
- d) Radiant Solar Energy

When power was applied to ALSEP, pressure of 5×10^{-6} Torr or less was maintained by the chamber's pumping system, which has an ultimate capability of evacuating the system to 5×10^{-8} Torr. The cold sink of space was simulated with a liquid nitrogen cooled shroud, maintained at -300°F and having an absorbance to thermal radiation in excess of 0.90. A lunar surface capable of simulating the temperature excursions on the moon (-300°F to $+250^{\circ}\text{F}$) was fabricated from aluminum. The lower temperature extremes are realized by flowing LN_2 through the surface, and the higher temperatures are achieved using an array of infrared lamps. A separate surface simulator was constructed for the Passive Seismic Experiment. The damped surface temperature, as seen by the seismometer under the PSE thermal shroud, are simulated with a temperature controlled flow of trichloroethylene through the surface. The radiant solar energy is simulated with an array of infrared lamps. Each ALSEP subsystem has its own lamp array, separately controlled from all others. The level of energy being absorbed by each irradiated surface is being monitored and controlled by a radiometer, calibrated to read the absorbed energy.

B. Test Description

The Proto "A" Thermal Vacuum Test Set-Up started on 9 December, 1967 (Test Set-Up) and the removal of ALSEP from the chamber was completed December 27, 1967. The total span of test time including environmental excursions and IST's was as scheduled (Figure 1) about seven - 24 hour days. A detailed description of events during this seven day period and test set-up is presented in this section under the heading - Chronological Sequence of Events. A detailed test description of each ALSEP subsystem is contained in Section IV.



SCHEDULE

Title

PROTO A
THERMAL VAC

Issued On:

12/10/77

Updated On:

Line	Item	DECEMBER												
		14	15	16	17	18	19	20	21	22	23	24		
1	T.P 2333040												1	
2	TP 6.5 PRE-TEST ENVIRON.												2	
3	SYSTEMS VERIFICATION												3	
4													4	
5	TP 6.6 AMBIENT TEMP-												5	
6	VACUUM TEST												6	
7	PUMP DOWN												7	
8													8	
9	IST (2333032)												9	
10	6.2 STS TURN-ON												10	
11	6.4 TURN ON												11	
12	6.5 C.S VERIFY												12	
13	6.6 SWE												13	
14	6.7 SIDE												14	
15	6.8 PSE												15	
16	6.9 LSM												16	
17													17	
18	TP 6.7 ENVIR REF TEST												18	
19	COLD WALL												19	
20	REF												20	
21													21	
22	TP 6.8 ASEP TURN ON												22	
23	AMBIENT STAB.												23	
24	TURN ON												24	
25													25	
26	TP 6.9 LUNAR NOON												26	
27	+250° ENVIR.												27	
28	IST (2333032)												28	
29													29	
30	TP 6.10 LUNAR NITE												30	
31	-300° F ENVIR.												31	
32	IST (2333032)												32	
33	TP 6.11 RETURN TO AMBIENT												33	
34	6.12 IST (2333032)												34	

Remarks

*

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In addition, a more detailed analysis of the data will follow through the coming weeks as data is reduced and analyzed by ALSEP Test, Systems Engineering, the Project Engineers, the Principal Investigators, and Thermal Engineering.

During the conduct of the test, approximately 50 key subsystem parameters were recorded every 30 minutes and plotted. This data included all the parameters of Table I.

TABLE I

PROTO "A" THERMAL VACUUM CRITICAL PARAMETERS

<u>PARAMETER</u>	<u>MONITORING DEVICE or H/K WORD</u>
1. Thermal Plate #1	4
2. Converter Input Current	5
3. Shunt Reg. Current #1	8
4. Exp. #1 & 2 Status	12
5. Shunt Reg. Current #2	13
6. Exp. #3, 4 & 5 Status	14
7. Structure Temp. #3	15
8. T/X A Temp.	19
9. T/X B - D. C. Current	22
10. Thermal Plate #2	28
11. T/X B Temp	31
12. Structure Temp. #1	59
13. Thermal Bag (Inner)	60
14. Thermal Bag (Outer)	72
15. PCU Reg. #1 Temp.	77
16. PCU Reg. #2 Temp.	78
17. T/X A D. C. Current	81
18. Structure Temp. #4	88
19. #2 SWE Temp. Sens. Mod.	STS
20. #4 SWE Temp. Sens. Cp As'y	TEMP
21. #1 LSM X-Sensor	Monitor
22. #5 LSM Electronics	Monitor
23. #3 SIDE	Monitor
24. PSE Sensor Temp.	Monitor
25. Thermal Plate - PCU	1
26. Thermal Plate - T/X A	2
27. Thermal Plate - T/X B	3
28. SIDE	5
29. SWE	7
30. PSE (Sensor)	9
31. LSM (Electronics)	11
32. LSM (Sensor)	12
33. RTG Pressure Oper.	VTVM
34. RTG Hot Frame Aver. Temp.	2
35. RTG C/F Avg. or Individ.	1

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TABLE I Cont'd

<u>PARAMETER</u>	<u>MONITORING DEVICE or H/K WORD</u>
36. PSE Lunar Surface	Circular Recorder
37. LSM Lunar Surface	Pre Korder
38. 14 x 14 L/S - Outer	Pre Korder
39. 14 x 14 L/S - Inner	Pre Korder
40. 14 x 14 L/S - Center	Mini-Box
41. Cold Shroud	Circular Recorder
42. RTG Sim. - 16 Volts	RTG Simulator
43. RTG Sim. - Amps	RTG Simulator
44. IPU - Volts	IPU Test Console
45. PSE Temp.	Sanborn
46. PCU #1 Cur. (Res. Power)	Sanborn
47. PCU #2 Cur. (Res. Power)	Sanborn
48. Chamber Pressure	Meter
49. Exp. #1 Binary Display	STS
50. Exp. #2 Lock	STS
51. Exp. #3 Lock	STS
52. Exp. #4 Lock	STS
53. PSE Sensor Exciter	Excitor
54. Data Atten. 1000 cps.	STS
55. Attenuator 1000 cps.	STS
56. Regulator Resistor	DAS
57. Bell Time Check	



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III SUMMARY OF RESULTS (CON'T.)

C. CHRONOLOGICAL SEQUENCE OF EVENTS

9 December 1967 &
10 December 1967

During the weekend of 9 December 1967, paragraphs 6.1 thru 6.3 of T.P. 2333040 (ALSEP System Thermal Vacuum Test Procedure) were verified. No significant problems were encountered. A test setup verification only was performed since an actual environmental simulation verification test was previously performed. This active test included a pump to "ultimate". Environmental control equipment, such as the Tenney heat exchanger, IR controllers, etc., were not turned on during this verification since connections had not been disturbed from the previous test. The connections of LN₂ lines, thermocouples, and cabling were completed during this period and the environmental simulation (IR arrays, lunar surface heaters, etc.) setup was verified via the Data Acquisition System readouts.

Deployment of ALSEP went very smoothly and no significant problems were encountered. Both sub-pallets and the four experiments were manually deployed without use of handling fixtures. Elevating pads were placed under the Central Station. The Central Station power cable 50W202 between the Central Station and RTG switching circuit was too short. A substitute cable was used to allow test setup to continue and the thermal vacuum cable lengthened and replaced before pump-down.

11 December 1967

System Test setup, paragraphs 6.1 thru 6.2 of TP 2333032 (ALSEP Program Thermal Vacuum Integrated System Test Procedure) was performed, which included STS checkout. The P.S.E. flat cables which mate with C.S. J30 and J35 were not properly labeled; reference to P.I.A. procedure for part designation solved the problem. Two pins on J80, Central Station - SIDE interface, were pushed in. A Manufacturing technician succeeded in pulling out these pins and the connector was inspected. The STS was then turned off to allow final alignment of IR arrays and other touch-up of TP 2333040 items to be completed.

12 December 1967

System turn-on and Central Station verification were performed (including PCU input current sensor calibration) on Tuesday morning, 12 December. (O.T.'s are discussed in detail in Section IV.)



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12 December 1967 (cont.)

The ambient IST on SWE was completed without any problems. The SIDE experiment failed to turn on. The subframe LOCK lamp failed to illuminate, indicating an error in the data bit stream. Inspection of the MC-4000 (Monroe) printout indicated the experiment ON command was received correctly. Experiment status via HK-14 indicated the experiment was no longer in STANDBY. However, the PCU regulator current (HK-13) indicated no current was being drawn by the experiment. The experiment was switched to STANDBY and visual inspection of the Central Station connection indicated the connector was installed improperly. The ambient IST (PSE) was continued with the SIDE experiment disconnected. Meanwhile, the SIDE was operated with its experiment test set. A partial SIDE PIA indicated the experiment operated normally with no evidence of damage.

During the SIDE PIA, the PSE ambient IST was performed. PDM #1 dump load was switched on to maintain the Central Station power within regulation. All other experiments were switched to STANDBY OFF since the PSE had not operated since it had been mechanically "re-caged". The following problems were noted during the PSE Ambient IST.

- a. The PSE exciter changed status without command. The problem appeared to be noise from the Sanborn recorder marker circuit. The marker circuit was turned off during the remainder of the test.
- b. The PCU #1 switch-over command was transmitted as an initial condition at the start of PSE IST; however, a look at H/K data reveals the PCU apparently switched from PCU 2 to 1 and then back again. The loss of lock was used as the original indication that the command was received properly. The apparent switch-back to PCU 2 was discovered at paragraph 6.8.3.18.1 of the PSE Ambient IST and at that time PCU Set #1 was executed correctly.
- c. The short period amplitude at 0 db indicated low amplitude.
- d. The LP CAL transient, paragraph 6.8.8.4, was low. A value of 3.6VDC was obtained. The specified value was 4.2 to 7.0 VDC.

DR 5301

Upon completion of the PSE IST, the Central Station interfaces for the SIDE experiment were checked for damage using the experiment simulator cable. The power circuits and the timing and control signals appeared normal. The SIDE was then reconnected and ambient IST was initiated. Turn-on of the experiment was satisfactory and a normal lock was achieved by the data processor.

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13 December 1967

At Section 6.7.9 (Reset SIDE frame counter at 79), it was found that the command input register had not responded to commands 104 and 106 (was 001, should have been 005). Command 106 was transmitted again with no effect. All experiments were commanded to STANDBY and the Central Station was turned off. The chamber was entered and the SIDE disconnected and the connectors inspected; no discrepancies noted. Cable 50W103 (STS - Central Station, SIDE simulation) was connected and power applied to the Central Station. The Standby and Operating voltage and current on STS read correctly, so commands 104, 105, 106, 107, and 110 were transmitted and verified discrete pulses were received from the Central Station. The discrete pulses read correctly on the STS command monitor; approximately 4.0 volts and 20 msec. The Central Station was turned off and the SIDE removed from the chamber. During operation of SIDE on the ETS, it was revealed that the SIDE flat cable connector P80 had intermittent connections; the connector was cleaned and the SIDE was connected back in the chamber. The SIDE was turned on again and commands 104, 105, 106 and 107 were transmitted and it was verified that the C.I.R. changed state correctly after each transmission.

The SIDE IST was started again and the test proceeded smoothly except for the normal SIDE problems as previously noted in DR 6303.

The LSM IST was started and proceeded smoothly, except for the normal LSM problems, noted previously in DR 5301. During 6.9.7, Flip Calibrate, the Z motor status was incorrect (DR 6249). The IST was completed, and then the P.I. representative entered the chamber and repaired the Z motor cable. The Flip Calibrate (Z motor) section of the procedure was re-verified and the operation was proper.

Upon completion of the Ambient IST, Section 6.5 of TP 233040 (Environmental Systems Verification) was started. All IR arrays and IR sensors were realigned and a few open thermocouples on the lunar surface were repaired and checked out. The PSE was dusted and the SIDE dust cover opened, the mirrors cleaned and the SIDE leveled. Also, other miscellaneous final environmental systems touch-up and loose ends were cleaned up. The large chamber door was closed, and the ALSEP susceptibility to the EMI generated by the IR arrays was checked. ALSEP was turned on (all experiments POWER ON) and approximately 30 minutes of H/K and experiment data obtained; power was then applied to the IR lamps to give a baseline of any potential EMI problems between ALSEP and the IR arrays. Another



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13 December 1967 (con't.)

30 minutes of H/K and experiment data were then obtained. The only obvious EMI effect appeared to be in the SWS experiment. Several SWS words, both calibration and science data, indicated an out-of-tolerance condition intermittently while the IR array power was adjusted to the final values.

After the EMI test, final verification of all test items internal to the chamber was completed and all lock-out connectors were installed. A final reverification of all ALSEP hook-ups, wiring connections, and general inside chamber readiness was performed with the NASA/MSC resident Test Manager and the Bendix Thermal Project Engineer.

14 December 1967

Final completion of paragraph 6.5 (Environmental Systems Verification) of Test Procedure 2333040 occurred on Thursday Dec. 14, 1967.

During the Environmental Systems Verification, involving final power-applied checks of all IR arrays, lunar surfaces and monitoring systems, the following problems were encountered:

1. The circuit breaker for the outer zone of the 14' x 14' lunar surface kicked out at 90°F. The problem was traced to dirt clogging the water cooling line to the RI controller, which caused overheating; the problem was corrected.
2. During continuity checks, a resistance of 0.26 M Ohms was measured between pins E, C, F, and J of cable 60W300 (spec: greater than 1 M Ohm). The problem was isolated to cable 50W300 (RTG to chamber coldwall). Cable 50W300 and coldwall feed-thru were removed. It was revealed that connector P4, which mates with IPU Generator J4, was contaminated with Hi-Temp solder resin. This resin was chemically removed and resistance readings revealed measurement now in spec. Cable 50W300 and coldwall feed-thru were reconnected.
3. During checkout of the DAS-RTG interface, 6.5 Ohm resistance was measured between pins Y, V, A and T of Cable 60W302 (should be less than 2 Ohm; reference DR 6323). This was caused by grounding loop problems on the IPU Console which were rectified.



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14 December 1967 (con't.)

The roughing pumps were turned on upon completion of Section 6.5 of T.P. 2333040. Also, the RTG-EFCS was turned on to 100 watts prior to pumpdown so that a final test of the DAS-RTG interface could be performed and the RTG-Central Station interface was checked by a readout on the RTG Simulator +16 Voltmeter.

Pump-down was started at 7:30 P.M. A pressure of 10^{-5} torr was achieved at 10:50 P.M.



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15 December 1967

The seventeen hour vacuum soak was reached and the Vacuum IST started at 4:00 P.M. Central Station verification was completed with no significant problems. During the SWS IST, the experiment failed to turn on. The experiment #3 POWER ON (SWE) command was first executed at 20/12/51. At 20/13/22 a loss of main frame sync. occurred and the subframe status indicator on the STS processor switched from check to search. Analysis of the STS printer tape indicated a normal station with no significant O.T's. Solar Wind turn-on was again tried at 20/17/23, 20/18/06 and 20/20/13. The current profile of the PCU shunt regulator, displayed on the Sanborn strip chart recorder, indicated that the experiment started its stepping sequence but failed to continue after several steps. It was decided to attempt turn on again during a future section of the test after an additional attempt to turn on was unsuccessful at 20/32/25.

Operation of the SIDE during vacuum IST was satisfactory. During SIDE turn on, at a chamber pressure of 3×10^{-6} torr, the -3.5 KV and +4.5 KV read-outs indicated a slight shift into the O.T. region. Noise in the science words was also noted but did not appear erratic. Analysis of data indicated the operation of the experiment was satisfactory and the SIDE IST completed.

16 December 1967

Upon completion of the SIDE IST, the SIDE high voltages were turned off (chamber pressure 3.0×10^{-6} torr).

During the IST for the Passive Seismic, the response to Gain Change SPZ command was O.T., as noted in DR 6253, and, similarly, the response to Cal. LP command on traces 2, 5 (DR 6265). At paragraph 6.8.11.4, HK-69 printout indicated that the PSE experiment had not responded to the Uncage Command (DR 6266). The command was re-transmitted; correct response occurred and the IST was completed.

During the IST for the LSM, TM Word 5 indicated O.T., a previously noted condition (DR 6306, 6332); the experiment was commanded to Standby then ON twice more before the condition cleared. The IST was completed satisfactorily except for normal discrepancies for this unit (DR 5301).

The LN_2 turn-on for the Lunar Night reference test was started at 10:40 A.M. A chamber pressure increase to a maximum of 1.5×10^{-5} torr was noted after LN_2 flow to the Lunar surface was initiated. The LN_2 pumps to the surface were switched



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16 December 1967 (cont.)

off and the surface was gravity fed to maintain the pressure below 5×10^{-6} torr. The environmental reference test was completed and the warm-up for the Lunar Morning turn-on started at 10:00 P.M.

At 23.40 hours on 12/16 Main Frame Sync was momentarily lost for 13 seconds and a diffusion pump faltered. This was believed to be caused by Edison lines switchover.

17 December 1967

Central Station and experiment temperatures were monitored for evidence of Lunar Morning stabilization. SIDE and LSM were stabilized at 0400; however, thermal plate temperatures 1 and 2 were not stabilized according to the definition in TP 2333032. Both were reading approximately 0°F and were rising at approximately 1°F per hour, at which rate, to reach the stabilization per 2333032 would have taken approximately 50 hours. Thermal Engineering was called in, and confirmed that if power were removed from Central Station at that time, the temperature would not drop by more than 10°F per hour. At 0600 hours the thermal plate temperatures were approximately 30°F above the danger limits and, based on a total power-off estimate of less than 1 hour during switchover to the RTG, it was decided to go ahead with the Lunar Morning turn-on (Ref. DR 6329).

Prior to the switchover, and in order to minimize any delay during power off conditions, Section 6.4.3.11 (Lunar Morning Program Loading) was performed before 6.4.3.1. At this point, it was found that the SIDE velocity filter had turned off. Commands 104, 107, and 110 were transmitted to turn SIDE velocity filter back on (DR 6330). Turn on started at 351-06-22-54, with personnel continuously monitoring Daystrom temperature printouts and standing by to switch back to the RTG simulator in case of any emergency conditions. ALSEP was turned off at 06.40.02 and the switching circuit switched over at 06.44.53. At 06.50.10 the EFCS turn on was initiated (par. 6.8.28 of 2333040), and at 07.01.20 the PCU input voltage (measured on RTG Simulator Panel) was +3.5 volts. By 07.42.02 the input voltage was 20.0 volts, and at 351-07-42-52, with an input voltage of 20.18 volts, turn on was accomplished with a 12.0 volts DC reading on the Central Station +12 Sense Voltmeter (RTG Simulator Panel). During the turn-on, the thermal plate temperatures (external thermocouples) fell from $+5^{\circ}\text{F}$, $+2^{\circ}\text{F}$, $+2^{\circ}\text{F}$ to 0°F , -2°F , -2°F (LSM was $+17^{\circ}\text{F}$ at turn on, SIDE was $+20^{\circ}\text{F}$). ALSEP's transmitter was commanded on and downlink was established, and a check of the Central Station parameters revealed that HK-64 and HK-76 (PCU 1 and 2 power oscillator temperatures) were out of software tolerance. These temperatures were back in tolerance within 20 minutes. HK-66 (Transmitter B AGC voltage) again went O.T. (previously noted), so continued by switching to Transmitter A.



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At the request of the P.I., the LSM experiment was turned on first, per 6.3.4.2.7, at 08.15.03. SIDE was turned on at 08.32.58 (Chamber pressure 9.2×10^{-7} torr). An attempt was made to shut off SIDE high voltages (errors were noted in Word 2), but the experiment would blow its circuit breaker and revert to STANDBY. SIDE remained in STANDBY (DR 6330) and the PSE turn-on was performed. At this time, the SIDE P.E. was consulted on the problem of SIDE blowing its circuit breaker and reverting to STANDBY. Since the experiment was still relatively cold, the internal heater was automatically on and transmission of the high voltage off command which also includes the one-time command to blow the dust cover caused the experiment to switch back to STANDBY, as there was not enough power to blow the cover with the internal heater on.

The problem was solved by turning SIDE ON and applying up to 150 volts to the IR array over SIDE for a period of approximately 30 minutes, while continuously monitoring the reserve power display. At 11.40.00 it was observed that the reserve power jumped up by approximately 4-1/2 watts as SIDE's heater turned off. The SIDE high voltages were immediately turned off and the printout indicated SIDE performing properly. The Solar Wind Experiment was left in STANDBY mode.

Warm-up for Lunar Noon conditions was started at approximately "Earth" Noon (12/17).

At 10:50 P.M., the SIDE experiment IR array was switched off after it was visually determined that the SIDE experiment had tipped over - apparently due to one leg collapsing. The RTG IR array was not energized during Lunar Noon excursion because the background radiation appeared to create sufficient radiation. No other problems were noted during this period.



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18 December 1967

Stabilization for the Lunar noon IST was reached at approximately noon on 18 December 1967. During the Lunar noon IST the Central Station verification was performed with no major problems. The turn on of the Solar Wind experiment was attempted again without success. Turn on was attempted once with the X processor to eliminate the possibility of an open clock connection between the Y processor and experiment shift pulse line.

During the SIDE IST, it was noted that the -3.5 kV high voltage had switched off, apparently by itself. The +4.5 kV was switched off as a precaution while the data printout was investigated. It was decided to leave the -3.5 kV off temporarily until the high voltage On/Off command sequence. The +4.5 kV was turned ON to continue the IST. No further problems were noted until the CCIG high voltage On/Off command sequence. The turn on of the +4.5 kV resulted in the experiment switching, without command, to Standby. The experiment was returned to the operating mode and the +4.5 kV was turned off. The Channeltron high voltage On/Off sequence was not attempted because of the initial problem with -3.5 kV turning off by itself.

Upon completion of the SIDE IST, the experiment was switched to Standby to reduce SIDE internal temperatures. The experiment was lying on its side because of the collapse of one leg and, consequently, the thermal control system could not function properly.

The PSE Lunar noon IST was not performed in its normal sequence since the data readout indicated the PSE sensor temperature was still too low and off scale and had not stabilized.

The LSM Lunar Noon IST was performed without problems until the Y site survey. Data indicated, from the printer and reserve current profile, that the sequence was not completed correctly. As a result, the Z axis site survey was not performed. A Flip/Calibrate was performed in place of the Z survey to aid in determining the cause of the problem. The Z axis failed to flip properly during the Y survey.

The PSE Lunar noon IST was completed thru paragraph 6.8.5. No problems were noted with exception of the sensor temperature readout. The data indicated the sensor temperature at the start of the PSE IST was still low and off scale (DR 6358).

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19 December 1967

The PSE Lunar noon IST was completed, paragraph 6.8.5.2 and on, without any additional problems, at 353-02-13-07.

A deviation was undertaken at this time to gather engineering data (DR 6359), consisting of power switching, measurement of dump load temperature rise, and SIDE heater drain (determined from later readings of reserve power).

In addition, some checks were made on the incident radiation on LSM, using the radiometers, at the request of the P.I. The transition to Lunar night was started at 05.45 on 19 December. During the cool-down, Solar Wind was commanded from STANDBY to ON ten times, but did not respond. Also, during this time, another engineering evaluation test was performed (DR 6371), involving checks of backup heater drain, PDM 1 and 2 drain, and changes in reserve power when PSE, LSM and SWE were momentarily commanded from ON to STANDBY to OFF to ON. For the Lunar night cool-down PSE, LSM, SIDE were ON (SIDE high voltages off), with SWE in STANDBY.

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The excursion to, and stabilization at, Lunar night took approximately 24 hours. During the excursion, the Central Station backup heaters came on when the thermostat thermocouple (DAS channel #62) was reading -10°F .

The Lunar night IST started at 0443 of 20 December.

Central Station verification proceeded with a large number of HK words O. T. (DR 6370), though it was found that many HK thermistor temperatures were generally reading $5 - 10^{\circ}\text{F}$ lower than the corresponding DAS temperatures. Both Transmitter A and B had O. T. readings of AGC voltage, causing deviations in switching sequence (DR 6365).

The SWE experiment turn-on was tried again but without success (DR 6365).

The SIDE IST was started with the chamber pressure at 1.2×10^{-6} torr. A portion of the SIDE IST was performed but commands 107 and 110 could not be sent due to the SIDE heater being on which would cause the SIDE to trip its circuit breaker (DR 6374). It was not possible to proceed with the SIDE IST with its heater on.

PSE was not run per engineering direction due to it operating at a temperature below $+107^{\circ}\text{C}$ (about 97°F).

LSM was tested in accordance with the IST procedure, except due to the large thermal gradient across both the sensors and the electronics, the P.I. representative decided not to perform a Flip/Calibrate initiate.

After completion of the Lunar night IST, a series of engineering evaluation tests were performed prior to warm-up to ambient conditions. A test of the ripple off circuit was made with the RTG Simulator as a power source. The PCU reserve power was decreased by switching PDM #1 load on; the RTG power was then reduced slowly until the SIDE rippled off (noted via subcom. sync. lamp). In addition, the ripple off was confirmed by HK-14. The RTG power was then reduced further until the PSE rippled off (noted by the binary display on the programmer processor panel). This event was confirmed by HK-12 and SIDE and PSE experiments returned to their normal operating mode. Ripple off due to power transients was checked by switching PDM #2 ON with normal station operating conditions (except SWS which was in Standby). Ripple off of both SIDE and PSE was confirmed



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by the housekeeping after turn on of the dump load. Prior to warm up to ambient, the power to the RTG EFCS was increased to evaluate the RTG temperature so a final radiometer check could be made and also check RTG output power at the EFCS 1500 watts. Power was increased to 1500 watts and temperatures allowed to stabilize.

The only other deviation during this period was the reload of the SIDE Basic program to operate SIDE in the "On" mode; to allow STS temperature monitor readouts, since SIDE was approaching its critical cold temperature.

The warm-up to ambient was initiated at 9:15 P.M., 20 December 1967. At approximately 23:36 hours on 20 December, the chamber pressure rose to 8×10^{-6} torr due to a leak in the liquid N_2 vent. SIDE was immediately commanded to Standby, as the high voltages were on, and until chamber pressure was restored to less than 5×10^{-6} .

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At 03.30 hours, 21 December, the chamber pressure was 1.5×10^{-6} torr and the SIDE experiment was turned on with the experiment at $+45^{\circ}\text{F}$. At this time, the portion of the SIDE Lunar night IST which was aborted (6.7.11.4 thru 6.7.19.6) was successfully completed, as the SIDE heater had now turned off. Having returned the environment to ambient temperature, ALSEP was turned OFF at 04.58 and the excursion to ambient pressure started.

The chamber was returned to ambient at approximately 0800 21 December 1967. ALSEP inspection of test setup was conducted by the Bendix Test Conductor, Quality Control, DCAS, and the NASA Test Manager. The inspection revealed the nylon bolt on the SIDE leg had fractured causing SIDE to tip over; no other unusual conditions were observed. The ambient IST was started at 11:00 A.M. 21 December 1967.

The Central Station verification was conducted with no major problems.

The SWE experiment turn-on was tried again but with no success.

The SIDE and PSE Post-Ambient IST's were accomplished with no additional problems noted. During the Post-Ambient LSM IST, the X axis failed to flip from 180° to 0° ; status indicated the X axis had flipped to the 90° position (DR 6349).



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One additional Flip/Calibrate was performed and all axes flipped to 180 degrees, including the X axis. No further problems were noted and the final post-ambient IST was completed at 8:45 P.M.

Turn off of all equipment was completed at 9:00 P.M. on 21 December. Photos were taken of the chamber and individual experiments. Upon completion of the photo coverage the LSM, SWS, and SIDE experiments were removed from the chamber. Both the SIDE and LSM were prepared for shipment to their respective P.I. representatives for analysis. The SWS was run through a PIA turn on to determine if it would operate properly on the ETS. The same problem appeared to exist as occurred in Thermal Vacuum since all data read "all ones" for approximately 40 steps and then the data dropped to all zeros, i.e. no data output.

The SWS was then prepared for shipment; all gear was secured to complete the Prototype Thermal Vacuum Test.

On Tuesday, 26 December 1967, the Central Station and PSE were removed from the chamber and placed in the Components Lab. awaiting further disposition.

On Wednesday, 27 December 1967, all experiment connectors on the Central Station were inspected by Quality Assurance, Test, and the Project Engineer, and DR's were written concerning marking of connectors; appropriate action is being taken.

Throughout the past weeks de-briefing sessions on the Thermal Vacuum test have taken place and analyses and test reports concerning test data are being written.



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III SUMMARY OF RESULTS

D. ALSEP Performance

The ALSEP Prototype Thermal Vacuum test proved to be, extremely informative and successful. Certainly, the three phases to be evaluated (Lunar, Morning, Noon, and Night Performance) as stated in TEST SCOPE of this ATM were completely and thoroughly investigated and evaluated. The OBJECTIVES (to ensure correct subsystem operation) as stated in this ATM, were complied with, however, in some case, due to malfunctions and/or other problems, correct subsystem operation was not obtained; but these discrepancies are the very type of things that need to be uncovered in a full-up prototype test rather than in a flight configuration.

The Central Station, both functionally and thermal-control wise, performed extremely well. With the exception of a few minor OT's due to software interface problems; no new problems were uncovered during thermal vacuum testing. In addition, the thermal data obtained will allow a more accurate prediction of future Thermal Subsystem operations.

The performance of the SWE experiment could not be adequately evaluated since after the ambient IST, the SWE never did turn-on again.

The SIDE experiment performance was hampered by one of the experiment legs falling off and the experiment falling on it's side, just before the start of the Lunar Noon test. However, data obtained during the thermal vacuum IST's corresponded to similiar ambient IST's. The major problem was the command sequence for SIDE (due to the SIDE heater power drain) during the cold environments.

The PSE experiment operation was normal (same as previous ambient IST's) however considerable difficulty was encountered with control of the PSE operating temperature.

All the IST's on the LSM conformed to previous ambient IST, including problems with the flip-calibrate and site survey sequences. Also, the temperature gradients between the LSM sensors and the sensors and electronics was greater than anticipated.

Both the RTG subsystem and the System Test Set operated extremely well throughout the test. No major problems were encountered with either subsystem.

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III SUMMARY OF RESULTS (CON'T.)

A detailed test description and analysis of each major ALSEP subsystem is included in the next Section IV of this ATM (DETAILED TEST DESCRIPTION). Also, included in this Section is a test description of the Lunar Environmental Simulation.



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IV. DETAILED TEST DESCRIPTION

The following Section contains a detailed test analysis of each subsystems operation during the Prototype Thermal Vacuum test.



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A. TEST ITEM: CENTRAL STATION SUBSYSTEM

TEST METHOD:

The functional operation of the Central Station was similar for all environmental conditions, Lunar morning, Lunar night, and Lunar day.

PERFORMANCE:

The Central Station operated extremely well, except for some H/K O.T's. Data Processor X inoperative (Pre-T/V problem), and Transmitter A and B O.T's. The Central Station heater came on (thermostat closed) at -10°F as expected; on the warmup, the heater went off at approximately 0°F.

DISCREPANCIES:

1. H/K words 10, 11, 25, 29, 40, 44, 45, 55, 57, 73, 74, 75, 86, 89, and 90 are unassigned channels. Of these unassigned channels, H/K 25, 29, 55, 73, 74, 75, and 86 at various times were O.T. Limits on the software program were 0 to 2 (octal); these limits are being opened to 0 to 377.
2. Transmitter B, AGC Voltage H/K 66 and H/K 51 - Transmitter A AGC voltage was O.T. during portions of the test. The limits on the software for H/K 66 will be opened to reflect these readings. The O.T. on H/K 51 during the Lunar night condition revealed an abnormal condition; however, frequency, power output and deviation for TxA were unchanged in comparison with in tolerance reading of H/K 51.
3. H/K 5 (PCU Input Current), 36 (Local Oscillator Level Receiver) were O.T. at various times throughout the test. Software limits on these channels will be opened to reflect the required changes.
4. RTG Hot and Cold Junction temperatures H/K 6, 7, 37, 52, 67, 82, were O.T. at various times throughout the test. There are no temperature sensors on the Model 14 generator but they are simulated by precision resistors in the RTG Simulator. Due to the long lead lines used in T/V, stray noise could have caused these intermittent O.T's.



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5. H/K 88 - Primary Structure, Bot. No. 2 Temperature was O.T. and acted as an "open" thermistor. On tear-down of Central Station, a confirmation of this condition will be obtained.

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B. TEST ITEM: SOLAR WIND EXPERIMENT

TEST METHOD: Thermal Vacuum Test

PERFORMANCE:

The Solar Wind experiment was deployed in the Thermal Vacuum chamber on the 14' x 14' simulated Lunar Surface on 11 December. Paragraph 6.6 of the Thermal Vacuum IST (TP 233032) was completed without a discrepancy on 12 December. On 15 December, Paragraph 6.6 of the Vacuum IST was initiated. The SWS failed to respond to the turn On command at 20.12.51. At 20.13.22 the STS processor sub-commutator lock lamps indicated a loss of main frame sync. and at that time the SWS sub-commutator lock lamps switched from check to search.

Analysis of the STS printer data indicated a normal station. The problem was believed to be similar to a previous fault, Reference DR 5295, in which the experiment failed to sequence properly on turn-on, but, with additional turn-on's would eventually start and perform satisfactorily. Therefore, several additional turn-ons were attempted without success. Analysis of the current profile from the power receiver indicated the experiment was not sequencing and DR 6300 was generated and the Vacuum IST for SWS aborted. Additional attempts to turn on the experiment documented in the referenced DR, were performed throughout the remainder of the Thermal Vacuum test without success. Upon completion of the test, the initial paragraphs of the experiment PIA, TP 2333017, were performed in an attempt to determine if the experiment would operate satisfactorily with its ETS in an ambient condition; however, this test was also unsuccessful. Data output indicated "all ones" for approximately 40 steps, at which time the data shifted to all zeros. The maximum and minimum temperature extremes monitored during the Thermal Vacuum test, in which the experiment was operated in the STANDBY mode, were -36°F and 106°F.



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C. TEST ITEM: SIDE EXPERIMENT

TEST METHOD: PRE-TEST AMBIENT IST

PERFORMANCE:

The IST was started at 04.21 hours on 13 December 1967. During the test the following occurred:

1. At Section 6.7.3.2 of TP 2333032, no lock was observed on SIDE. HK-13 indicated no experiment current drain. Experiment was commanded to STANDBY OFF. Inspection disclosed the flat cable connection to Central Station (P80 to J80) was reversed. (It was later discovered that the SIDE connector J80 was installed upside down on Central Station per print; this has been rectified.) The SIDE was connected to the ETS and a PIA test conducted. The experiment performed normally. The SIDE simulator cable from STS to Central Station J80 was connected to measure interface parameters. These were:

PWR. STANDBY: 28.95V, 101.6 mA

PWR. ON: 28.15V, 214.8 mA

FR. MARK = 4.0V, 118 u sec, 400 mV (zero)

EV. FR. MK = 4.0V, 118 u sec., 400 mV (zero)

SHIFT = 4.0V, 940 u sec., 400 mV (zero)

DEMAND = 5 DEM. /FRAME

9.4 msec

4.0 V, 400 mV (zero)

Since all parameters were normal, the experiment was reconnected to Central Station and test resumed at Section 6.7.3.1. Normal discrepancies of the unit and software were noted.

2. At Section 6.7.8, it was observed that after transmission of commands 106 and 110 the CIR cleared but the Mode Register (MR) indicated experiment was in reset at 10 mode instead of reset at 9 (DR 6268).



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The commands were transmitted twice more, but the MR still did not indicate any change from reset at 10 mode. The experiment was commanded to STANDBY, then to ON and transmission of 106 and 110 repeated. MR still was in Reset at 10 mode so Section 6.7.8 was aborted as this mode could not be reached.

3. At Section 6.7.9, following transmission of commands 104 and 106 to reset frame counter at 79, the CIR did not indicate correctly (was 001, should be 005). Command 106 was retransmitted with no effect so the Central Station was shut down and the SIDE removed. Central Station Connector J80 was inspected for damage and found to be normal. The SIDE simulator cable 50W103 to Central Station J80 was installed and the Central Station turned on. The SIDE parameters measured at the STS were:

PWR. STANDBY: 28.96V, 101.6 mA

PWR. ON: 28.51V, 214.5 mA

Commands 104, 105, 106, 107, and 110 were transmitted and the measured parameters of the discrete pulses on the command monitor at STS were proper as follows:

Command 104 = 20 u sec., 4.0V
Command 105 = 20 u sec., 4.0V
Command 106 = 20 u sec., 4.0V
Command 107 = 20 u sec., 4.0V
Command 110 = 20 u sec., 4.0V

Since the Central Station interface was correct, the SIDE was connected to the E. T. S. via the open rear door and a PIA performed. It was found that when the flat cable connector P80 was connected to the ETS and stressed, SIDE data was lost (intermittent connection). P80 was thoroughly cleaned and checked-out and the SIDE re-installed in the chamber. The Central Station was turned on and the following commands transmitted:

1. Transmitted octal command 104 and observed CIR (Word 6) was 001 in Frame 77



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2. Transmitted 105 and observed CIR was 003 in Frame 93,
3. Transmitted 106 and observed CIR was 007 in Frame 109,
4. Transmitted 107 and observed CIR was 015 in Frame 1.

This status indicated correct operation of CIR, so SIDE IST was started at Section 6.7.3.1.

At Section 6.7.11 (Dust Cover Blow Command) the Dust Cover did not blow although CIR, MR and other status were correct. Retransmitted the commands but dust cover still did not blow. The cover was manually opened and left that way for the remainder of the Thermal/Vacuum test. There were no additional discrepancies during the Ambient IST.

DISCREPANCIES:

1. SIDE connector J80 was reversed 180° at Central Station. Manufacturing has rectified print error. Connector orientation to be clarified.
2. SIDE flat cable connector P80 had dirty contacts. Connectors will be inspected for cleanliness prior to insertion.



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C. TEST ITEM: SIDE EXPERIMENT

TEST METHOD: VACUUM IST

PERFORMANCE:

The SIDE experiment was subjected to a 17 hour vacuum soak at a pressure of less than 1×10^{-4} torr before turn on. The Vacuum IST was started with a chamber pressure of 3.1×10^{-6} torr.

At Section 6.7.16, CCIG Hi-Voltage On-Off (+4.5kV), the experiment functioned correctly. However, at Section 6.7.17, (Channeltron Hi-Voltage On-Off (-3.5kV), Word 2 telemetry indicated that the -3.5 kV did not turn off (DR 6304), although science data indicated that the supply was off.

The IST was completed successfully, with only previously noted discrepancies of the unit. At the end of the IST, the -3.5 kV and +4.5 kV supplies were both turned off, and the telemetry indicated correct status, i.e. both supplies Off. The experiment was left in this operating power mode for the Lunar night excursion and warm-up to Lunar morning.

DISCREPANCIES:

With +4.5 kV supply on, telemetry indicated -3.5 kV Channeltron high voltage was still on after transmission of commands to turn it off had been sent. However, science data indicated supply was off. Rice to investigate and take corrective action on possible interaction at measuring points for +4.5 kV and -3.5 kV voltages.



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C. TEST ITEM: SIDE

TEST METHOD: Lunar Night Temperature Excursion

PERFORMANCE:

The environmental reference test started at approximately 10.54 hours on 16 December 1967. The SIDE temperatures were constantly monitored during the test. The SIDE #3 temperature was approximately $+53^{\circ}\text{C}$ at the start of the test. The low point occurred at approximately 23.30 hours on 16 December 1967 when SIDE Temperature #3 was approximately $+2^{\circ}\text{C}$. Warm-up to Lunar morning was complete by 04.30 hours on 17 December 1967, at which time SIDE Temperature #3 was approximately $+18^{\circ}\text{C}$. At no time did the experiment exceed red-line limits (-40°C to $+80^{\circ}\text{C}$).

DISCREPANCIES: None



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C. TEST ITEM: SIDE EXPERIMENT

TEST METHOD: Lunar Morning Turn On

PERFORMANCE:

The SIDE's temperature #3 was $+18^{\circ}\text{C}$ prior to Lunar Morning turn-on and switch-over to the RTG. The experiment thermostat is set at $+20^{\circ}\text{C}$ and, hence, the internal heater was on. By the time the RTG turn-on had been accomplished, the SIDE temperature #3 had fallen to approximately $+4^{\circ}\text{C}$ (thermal loss to cold shroud). The experiment was then turned on per Section 6.3.4.2.4. An attempt to turn the high voltages off per Section 6.3.4.2.5, (Commands 104, 106, 107, 110) resulted in the experiment blowing its circuit breaker in the PDU and reverting to STANDBY. The cause for this is as follows:

1. Internal heater was on. Power dissipated by experiment + heater = 9.5 watts.
2. As experiment had just been turned on, the "one-time" command to blow the dust cover (5.5 watts) was primed.
3. Transmission of high voltage off commands 104, 106, 107, and 110 included one-time command sequence (107, 110) to blow dust cover. Hence, experiment tried to draw $9.5 + 5.5 = 15$ watts.
4. PDU circuit breaker for SIDE is set at 13 watts; thus, as soon as the 15 watt load was applied, the breaker blew, and reverted the SIDE experiment to STANDBY.

Thus, as long as the experiment's heater was on, it was impossible to turn the high voltages off: each time this was attempted, the experiment was switched to STANDBY, and when transmitted to "on" the "one-time" commands were once again primed ready to blow the dust cover.

The problem was solved by gradually applying I.R. heating, up to 150 volts on the controller, to the SIDE experiment for a period of half an hour. The reserve power meter (Sanborn) was monitored during this procedure and eventually a step increase of approximately 4.5 watts was observed, indicating that the internal thermostat had warmed sufficiently to turn off the heater. The dust cover commands



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107 and 110 were then transmitted, and it was also possible to transmit 104, 106, 107, 110, 105, 106, 107, and 110 to shut off the +4.5 kV and -3.5 kV supplies. This was accomplished satisfactorily, with the SIDE, temperature #3 at approximately 18°C.

DISCREPANCIES:

(DR 6330) SIDE draws too much power when internal heater is on and one-time commands involving Dust Cover blow are transmitted, resulting in PDU circuit breaker trip and experiment being sent to STANDBY power. Hence, it is impossible to turn off high voltage supplies if experiment is turned on with heater operational. Rice Univ. to investigate and take corrective action on command sequence. / NOTE: internal thermostat on this unit was set at +20°C, will be set at 0°C in future SIDE units.



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C. TEST ITEM: SIDE EXPERIMENT

TEST METHOD: Lunar Noon IST

PERFORMANCE:

The experiment was left operating with high voltages off during the warming period to Lunar noon. Between 12.00 and 22.30 on 17 December 1967, SIDE temperature #3 rose from approximately +18°C to approximately +42°C. At approximately 22.40, one of the SIDE legs collapsed and the experiment fell on its side, striking the base of the I.R. array support. Damage was caused to the dust cover and thermal coating. It is thought that a Nylon bolt in the leg assembly (designed for 1/6 g) sheared and caused the collapse. Rice is analyzing and will rectify this problem.

After the fall, the I.R. array above the experiment was turned off and SIDE temperatures were monitored every 15 minutes (danger limits -40°C to +80°C). The slope of the temperature plot became noticeably steeper after the fall, and at 07.47 on 18 December, 1967, the SIDE temperature #3 reached +80°C and the experiment was turned off.

The SIDE experiment was turned on again at 15.30 on 18 December 1967 for the Lunar Noon IST. The #3 temperature was approximately +60°C at the start of the IST and leveled out at approximately +72°C for the duration of the test. The chamber pressure at the start of the IST was 8.6×10^{-7} torr. When the experiment was commanded on, the P.E. noticed science data discrepancies which indicated a possible high voltage malfunction, such as arcing. Telemetry indicated that both -3.5 kV and +4.5 kV supplies were on, but, as discussed in the Vacuum IST, monitoring interaction possibly masked the true -3.5 kV state; and, in fact, the -3.5 kV supply had turned off by itself. The +4.5 kV was then commanded off as a precaution and telemetry indicated both supplies were off.

The -3.5 kV was then commanded on and telemetry indicated this was on. The -3.5 kV supply then shut off by itself and the experiment went into a continuous calibration mode with the frame counter cycling 120 thru 127 and the software causing sync. loss flags. A master reset (107, 110) command sequence was transmitted and the telemetry got back in step and showed both high voltages off. The +4.5 kV was commanded on and, once software sync. was re-established



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after a brief tracking loss, telemetry showed both high voltages on, though as previously discussed, the -3.5 kV supply was, in fact, off. The velocity filter had also turned off by itself and was commanded on, and the test continued in the above conditions. At Section 6.7.16, CCIG (+4.5 kV) On/Off command, the +4.5 kV commanded off correctly. However, upon transmission of the +4.5 kV On command sequence, the experiment blew its PDU circuit breaker and went to STANDBY. The experiment was commanded on (both high voltages on) followed by commanding the -3.5 kV supply off, followed by a Master Reset Command sequence. The +4.5 kV was then turned off, and the test was continued at Section 6.7.18 (C.I.R. Reset). The IST was completed with the high voltages off, and then the experiment was turned off for the remaining duration of the Lunar Noon IST in case of overheating: maximum temperature reached was approximately +72° C.

DISCREPANCIES:

1. (DR 6343). The -3.5 kV supply turned off by itself. When the +4.5 kV supply was on, the telemetry indicated both high voltages were on, though the -3.5 kV was off. When both supplies were off, telemetry gave correct indication. Rice to analyze fault and take corrective action with regard to possible monitoring interaction.
2. (DR 6344) The +4.5 kV supply would command off correctly, but transmission of the +4.5 kV on sequence caused experiment circuit breaker to blow and revert experiment to Standby power. Rice to investigate and take corrective action.
3. Just prior to Lunar noon one of the legs collapsed, causing experiment to fall over on its side. Rice to study cause of failure and take corrective action on supporting leg construction.



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C. TEST ITEM: SIDE EXPERIMENT

TEST METHOD: Lunar Night IST

PERFORMANCE:

The SIDE Experiment was turned on at approximately 05.45 on 19 December 1967 for the cool down to Lunar night; both high voltages were commanded off. Lunar night stabilization was achieved at 03.00 on 20 December 1967, with SIDE temperature #3 indicating approximately +4°C. The lowest internal temperature recorded during the Lunar night IST was SIDE temperature #6 (-7°C), the monitor located just above the CCIG stowage point. The auxiliary thermocouple added for this test near the top of the experiment (measured on Daystrom recorder) indicated a SIDE #2 minimum temperature of -19°C during the IST. All other internal telemetry monitors indicated a little above 0°C during the test.

Just prior to the IST, a deviation was performed to gather engineering data (DR 6371) which involved quickly switching SIDE to Standby, OFF and then ON. Chamber pressure at entry to SIDE Lunar night IST was 1.3×10^{-6} torr.

The IST proceeded normally up to Section 6.7.11.3 (Dust cover blow, one-time command). At this point, the experiment blew its PDU circuit breaker as previously discussed and reverted to Standby power. The rest of the IST was aborted as further progress was impossible with the heater on. The experiment was then commanded ON, and shortly afterwards, to Standby power while the P.E. examined thermal performance in this mode. During the period 09.30 to 18.30 on 20 December 1967 the Daystrom monitor of SIDE #2 temperature in the Power Standby mode showed a drop from Lunar night stabilization of approximately -19°C to a new stabilization of approximately -33°C, at which point the temperature began to rise as warm-up to ambient was initiated.

DISCREPANCIES:

(DR 6371) Part of test was aborted as it was impossible to send one-time Dust Cover Blow commands while internal heater was on. Rice to determine solution to this command sequence anomaly.

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C. TEST ITEM: SIDE EXPERIMENT

TEST METHOD: Return to Ambient After Lunar Night

PERFORMANCE:

SIDE was turned on at 7:40 P.M. on 20 December 1967 and the LN₂ was vented from the chamber cooling system for the warm-up to ambient. At 11:30 P.M. a leak developed in the LN₂ vent and chamber pressure rose to 8×10^{-6} torr; the experiment was immediately commanded to Standby. At 3:36 A.M. on 21 December 1967 the pressure was 3.5×10^{-6} torr and SIDE was turned on. The reserve power was observed to step-increase as the experiment heater turned off at 3:43 A.M. At this point, the "one-time" dust cover blow sequence was accomplished by transmitting commands 107, and 110, and the portion of the SIDE IST aborted at Lunar night was performed from Section 6.7.11.4 to completion. The CCIG high voltage (+4.5 kV) was commanded off satisfactorily but tripped the experiment circuit breaker when turned on. The experiment was commanded on again and the -3.5 kV was commanded off; the telemetry indicated that the supply was still on. These conditions were thus the same as were observed at the Lunar noon IST. The test was completed with the +4.5 kV on and the -3.5 kV off. The ALSEP System was then turned off while chamber pressure was returned to ambient.

DISCREPANCIES:

Same as noted in Lunar noon test.



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C. TEST ITEM: SIDE EXPERIMENT

TEST METHOD: Post-Test Ambient IST

PERFORMANCE:

Upon opening the chamber, the experiment was physically inspected and photographed. The high voltage inhibit connector and SIDE seals were installed, the dust cover was relatched, the legs were folded and the experiment was placed on support blocks in an upright position. The experiment was turned on at 2:17 P.M. on 21 December 1967 for the Ambient IST. At Section 6.7.11, the dust cover failed to blow, as in the pre-test ambient IST. There were no additional discrepancies; the IST was completed at 4:35 P.M. on 21 December 1967 and the ALSEP System was turned off at 8:50 P.M. on 21 December 1967 at the completion of the Thermal Vacuum Test.

DISCREPANCIES: None



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D. TEST ITEM: PASSIVE SEISMIC EXPERIMENT

TEST METHOD:

Thermal Vacuum Procedure TP 2333032, Paragraph 6.8 for Ambient, Vacuum, Lunar Noon, Lunar Night and Post-Ambient Environmental conditions.

PERFORMANCE:

Performance of the Passive Seismic Experiment throughout the changes in environmental conditions was normal with exception of a thermal problem.

Ambient IST was performed with all experiments in STANDBY OFF since the device had not been operated after mechanically caging the sensor prior to Thermal Vacuum testing. The Short period signal amplitude at 0 db gain read low, as it did throughout the remainder of the Thermal Vacuum test, and the step response of the Cal. LP command (via the tide X channel) read low also. No other discrepancies were noted during the environmental conditions which involved the PSE experiment directly. At the start of the ambient IST, however, the status of the PSE sensor exciter was quite sensitive to noise transients generated in the STS test area. Both the Daystrom temperature plotter and Sanborn recorder time markers were secured for the duration of the Ambient IST to reduce interference. The exciter, intermittently, remained sensitive to electrical transients throughout the remainder of the test.

During the Vacuum IST, the test proceeded smoothly with no significant problem noted until the uncage command response. After the first command, the caging circuit is armed and housekeeping data via H/K 69 increases to a value of 51 to 76. The circuit did not respond to the initial command, however, after the command was sent a second time, the proper response was obtained (Ref: DR 6266). No additional problems were noted during the Vacuum IST.

The experiment performed properly during the Lunar Noon IST up to the thermal control command sequence. No output was present from the sensor temperature channel which initiated a low, off scale temperature. This problem had been anticipated earlier in the test since it was not desired to perform the IST without the sensor operating within its temperature range. The surface temperature was originally reduced from the $70 \pm 2^{\circ}\text{F}$ (specified in TP 233040) prior to the start of the Lunar Moon environment, to $40 \pm 2^{\circ}\text{F}$. As temperatures stabilized the surface temperatures were raised to the following sequences:



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<u>TIME</u>	<u>TEMPERATURE INCREASED TO</u>	<u>SENSOR DAYSTROM</u>
0940	$50^{\circ} \pm 2^{\circ}\text{F}$	85°F
1145	$58^{\circ} \pm 2^{\circ}\text{F}$	88°F
1920	$70^{\circ} \pm 2^{\circ}\text{F}$	95°F
2321	$100^{\circ} \pm 2^{\circ}\text{F}$	97°F

In an effort to allow the sensor to stabilize, the Magnetometer IST was performed out of sequence at 1920, at 2330 the Daystrom indicated the PSE "at" temperature and the PSE Lunar Noon IST was started. During the test, on-scale readout was achieved approximately three-fourths thru the IST. No additional problems were noted during the Lunar Noon IST.

The Lunar Night IST was not performed because of the thermal problem. The surface temperature was reduced to $60^{\circ} \pm 2^{\circ}\text{F}$ at 0848 on the 19th of December. At 1910 it was reduced to Lunar Night conditions of $10^{\circ} \pm 2^{\circ}\text{F}$. The Lunar Night IST for the PSE was not attempted since the sensor temperature was not on scale (Ref: DR 6376).

One additional discrepancy of significance was noted on 19 December (Ref: DR 6360). The uncage status channel HK-69 indicated an armed condition without the command executed. The caging command was transmitted to return the status to normal.

DISCREPANCIES:

The PSE exciter is sensitive to noise. Throughout the Thermal Vacuum test the status of the exciter changed intermittently. (Ref: DR 6251)

The temperature of the sensor did not reach operating values for the predicted Lunar Surface reference temperature. The Lunar Surface temperature was increased as high as 100°F before an on scale response was noted. Initial investigation indicates the Sensor Exciter Cable heat leak may have been excessive and prevented proper operation.



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E. TEST ITEM: LUNAR SURFACE MAGNETOMETER

TEST METHOD:

Thermal Vacuum TP 2333032, Paragraph 6.9, during the environmental conditions of: ambient, vacuum, Lunar Noon, Lunar Night, and post-test ambient.

PERFORMANCE:

Ambient IST was performed on 13 December. No significant problems were noted up to the flip calibrate sequence. Analysis of the data after the sequence indicated the Z axis flip had not been completed correctly. The status bits of LSM Word 3 did not change. The Z axis science data shifted from -502 to approximately +113, indicating the sensor had partially flipped (Ref: DR 6249). It was suspected that the Z axis electrical cable was mechanically interfering with the flip cable at the hinge as had occurred previously during experiment integration (Ref: DR 5114). Visual inspection confirmed this fault and the mechanical interference was manually eliminated after the chamber door had been opened. Correct status was then observed via the STS printer readout. No further problems occurred during ambient IST.

During Vacuum IST after initial turn-on, the LSM engineering data, ALSEP Word 5, printed continuous ones (i.e. data read 127 for all 16 frames) as the Proto model had, on occasion, previously operated. This fault was cleared by switching the experiment on and off twice. The remainder of the Vacuum IST, including flip calibrate, was conducted without further problems.

The Lunar Noon IST was started on 18 December at 7:30 P.M. Stability goals for the LSM, listed in TP 2333032, were:

1. Delta temperature of less than 5°C between sensors,
2. Delta temperature of less than 10°C between sensor and electronics,
3. All temperature readouts between the limits of -30 and $+65^{\circ}\text{C}$.

At the start of the lunar noon IST, the temperatures, as converted from the LSM data, were:



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Z Sensor (LSM/WD3) = 4°C

X Sensor (LSM/WD1) = 12°C

LSM Electronics (LSMWD5) = 51°C

Data from the external TCS monitored on the Daystrom recorder indicated:

Y Sensor = -16°C (3°F)

LSM Electronics = 39°C (103°F)

The Lunar Noon IST proceeded smoothly without a discrepancy through the X site survey. During the Y Site Survey, the Z axis failed to flip from 180° to 0° . The science data indicated the sensor partially flipped. The site survey sequencer, recognizing the failure, discontinued the survey sequence. Because of the failure, the Z site survey was not performed. Instead, a Flip/Calibrate sequence was performed to aid in determining the cause of the survey failure. Results of the calibrate sequence were that the X and Y axes flipped from 0° to 180° . The Z axis indicated no change in status, remaining at 180° ; however, the science data for the Z axis showed the sensor did perform a partial flip. (Ref: DR 6349) No additional problems were noted during the Lunar Noon IST. The Lunar Night IST was performed on 20 December. At the start of this IST, the temperatures of the LSM were:

Z Sensor = -44°C

X Sensor = -28°C

LSM Electronics = -6°C .

The Z axis heater did not appear to function properly since the temperature did not stabilize. Lowest temperature recorded was -48°C initially, after leveling off from the Lunar Noon excursion. The sensor temperature rose to as high as -38°C during the lunar night IST. No additional problems were noted during the Lunar Night IST. The Flip/Calibrate sequence was not performed because of the temperature differences.

The Post-ambient IST was conducted satisfactorily except for the Flip/Calibrate sequence. During this sequence, the X axis failed to flip from 180° to 0° . Status data indicated the sensor was stopped at 90° . One additional Flip/Calibrate was performed, a deviation from the test, with satisfactory results.



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DISCREPANCIES:

- a. The flip calibrate and site survey sequences continued to be a source of discrepancies. This problem has been noted throughout prototype testing.
- b. Temperatures of the sensor were lower than expected. However, the Qual. Model will incorporate higher wattage heaters.
- c. The Z sensor heater did not operate correctly.



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F. TEST ITEM: MODEL 14 RTG

TEST METHOD:

Thermal/Vacuum

PERFORMANCE:

During the first parts of the test, power for the system was provided by the RTG simulator. After the chamber was stabilized at the lunar morning condition the system was turned off and remotely connected to the Model 14 generator through a switching box inside the chamber. The generator was then turned on by applying 1400 watts to the electric fuel capsule simulator (EFCS).

During this warm-up transient the generator was essentially open circuited because the central station was not on. When the open circuit voltage reached slightly over 20 watts the hold-off circuit in the PCU fired allowing the system to come on. At this point the generator voltage dropped to the regulated value of 16.3 volts. Turn-on occurred at 49 minutes and 39 seconds after the 1400 watts were applied to the EFCS. At this point the average hot and cold frame temperatures were 968°F and 295°F respectively. Thermal steady state at 1078°F and 382°F was reached about two hours later.

The lunar noon operating temperatures were about 1105°F and 420°F for the hot and cold frames. The power output for these 1400 watt input conditions was about 62.5 watts.

Near the end of the lunar night test, the EFCS power was increased to 1500 watts. The power output increased to 68.9 watts and the hot and cold junction temperatures were 1109°F and 392°F respectively.

The generator performance was entirely satisfactory and within expected limits.



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G. TEST ITEM: SYSTEM TEST SET AND SOFTWARE S/N 2

TEST METHOD:

Thermal/Vacuum

PERFORMANCE:

During the test, the S. T. S. was operated continuously during two periods of time. First period was the pre-test ambient I. S. T. from the day 346, 09.00 hours to day 347, 08.30 hours.

The second period was from turn-on prior to Vacuum I. S. T. through Vacuum I. S. T., Lunar Night excursion, Lunar Morning turn-on, Lunar Noon I. S. T., Lunar Night I. S. T. and post test ambient I. S. T. The duration of continuous operation was day 349, 15.30 hours and day 355, 20.50 hours.

The S. T. S. performance was excellent throughout the thermal vacuum test. Previous use and burn-in with continual use in a controlled environment paid off.

A back-up S. T. S. was installed ready for use, but was only needed in two instances:

- 1) Rewinding magnetic tapes, in order to avoid time waste on the active system test set.
- 2) The Solar Wind Software for S/N 2 S. T. S. was loaded into the backup set and run with a known-good S. W. S. tape; this proved the software was good during the periods of troubleshooting the S. W. E. failure.

DISCREPANCIES:

- 1) Hi-speed printer failed towards end of Lunar Night test. Printer S/N 3 (back-up) test set was installed, and served for the rest of the test.
- 2) Switching power to appended systems such as the typewriter or tape recorder would occasionally produce main frame sync. loss momentarily. These transients have been noted previously and should be cleared when new power filters are retrofitted to the S. T. S.



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- 3) Random sync. losses occurred momentarily at a frequency of two or three per day. These are probably caused by power-borne external transients, and have been noticed previously with the plant electrical distribution system.
- 4) An electrical storm occurred early in the morning of 21 December 1967, and caused a transient power failure for approximately 10 seconds. This power failure resulted in a loss of computer memory, and required reloading of all programs. Operation was normal after reloading of programs.
- 5) When running the SIDE software and hardware, the two recognized idiosyncrasies occurred:
 - a. SIDE sync loss when mode commands 2, 3, 4, 5, 6 or 12 followed by toggle commands 1, 7, 9, 10, 11, 13 or 14.
 - b. SIDE sync loss when experiment commanded to begin operation in X10 mode.

Both (a) and (b) are normal and acceptable operation of the software and are not discrepancies.

There were no other software troubles throughout the operation.

- 6) There were three instances of "bad" software loads, two of which were due to tape misalignment on the reader, and one probably due to transient interface. In all cases, reloading cured the problem completely.



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H. TEST ITEM: THERMAL SUBSYSTEM

TEST METHOD: Thermal/Vacuum

PERFORMANCE:

In general, the Thermal Subsystem operated extremely well in the thermal vacuum environment. Central Station thermal performance was better than anticipated based on pre-test predictions, which were conservative to account for the uncertainties involved, particularly in regard to the specular reflector. The primary performance evaluation is based upon radiator (thermal plate) temperatures at the Lunar noon and Lunar night conditions since the radiator directly controls the component temperatures, and Lunar noon and Lunar night are the worst case conditions. The Lunar night prediction correlated relatively well with the test results (average night radiator temperature was within 5°F of the predicted value -16°F) while the Lunar noon test results showed an average radiator temperature approximately 20 - 25°F lower than originally predicted (+130°F).

It was expected that the Lunar noon predictions would deviate more than the Lunar night, since radiation interchange is more important during the Lunar day. Temperature gradients within the radiator plate and temperature differences between components and the thermal plate both agreed generally with expected results.

One of the prime purposes of the Thermal Vacuum test was to refine analytical predictions of the thermal subsystem; the "quick look" data certainly reveal that this was accomplished. More detailed analysis, which is in progress, will allow a more accurate prediction of future thermal subsystem operation.



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I. TEST ITEM: LUNAR ENVIRONMENT SIMULATION

TEST METHOD: ALSEP Prototype System Thermal Vacuum Test

PERFORMANCE:

A picture of the overall test configuration for an ALSEP Prototype System Thermal Vacuum Test is presented in Figure 2. This figure presents a plan view of the Space Simulation Chamber Room in Bendix Systems Test Laboratory. All supporting test equipment is identified and relative positions indicated.

The simulated lunar environment was keyed to the following four environmental parameters:

1. Pressure
2. Cold Sink of Deep Space
3. Lunar Surface Temperatures
4. Radiant Solar/Thermal Energy

The system performance of these parameters is discussed in the following paragraphs.

1. Pressure

The performance of the chamber's vacuum system was excellent throughout the test. The vacuum specification of 5×10^{-6} torr was reached approximately 15 hours after pumpdown initiation and was then maintained for the duration of the test.

The only vacuum system difficulty occurring during the test was due to a minute, high pressure leak in the LN_2 lines for the lunar surfaces. This apparent problem was circumvented by reducing the 80 psi, LN_2 line pressure for the lunar surfaces to near ambient pressure. This pressure reduction, reduced the leak rate sufficiently to enable the chamber's pumping system to maintain an internal chamber pressure of approximately 2×10^{-6} torr and less for the duration of the Lunar Night tests.

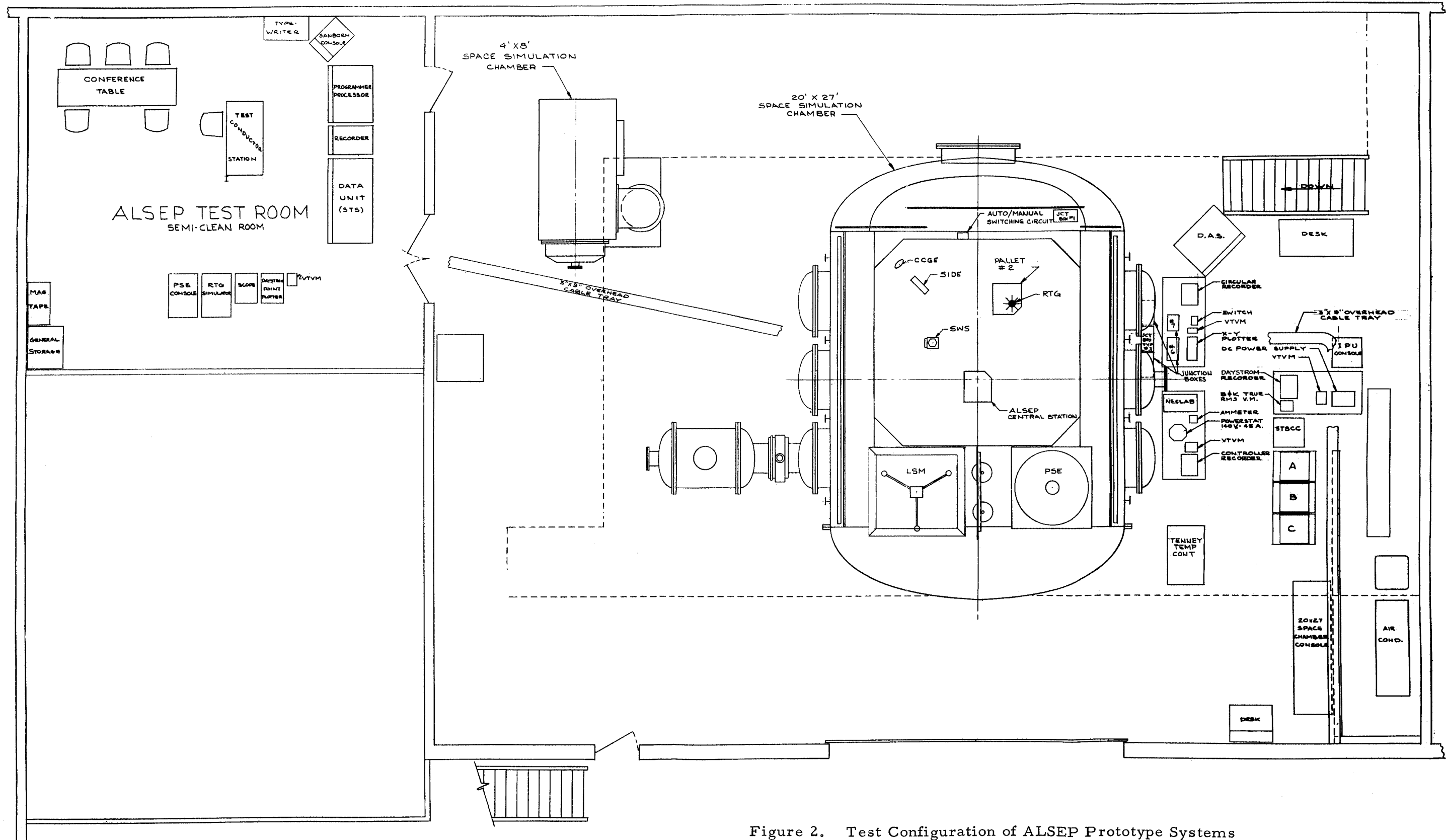


Figure 2. Test Configuration of ALSEP Prototype Systems
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2. Cold Sink of Deep Space

The cold sink of deep space was simulated with the chamber's liquid nitrogen cold shroud. The average temperature of this shroud remained at -265°F and lower for the duration of the test. This average temperature, which is slightly warmer than the test specification of $-300^{\circ}\text{F} \pm 20^{\circ}\text{F}$, was due, primarily, to a few random cold shroud panels. These panels never received an adequate flow of liquid nitrogen during the test. It should be emphasized, however, that the cold shroud's arch, which provides the primary view of space for the ALSEP subsystems, maintained an average temperature of -290°F or less throughout the test.

The effect of the few, random "warm" panels of the chamber's cold shroud would have a very minimal effect on the ALSEP subsystems; however, a detailed evaluation of this effect will be included in a later, detailed analysis.

3. Lunar Surface Temperatures

The temperature performance of the simulated Lunar surfaces was extremely good throughout the test. The average surface temperatures for each test phase were all within the required test specification of $-300^{\circ}\text{F} \pm 20^{\circ}$ for Lunar night and $+250^{\circ}\text{F} \pm 10^{\circ}$ for Lunar noon.

During the Lunar night tests, both the $14' \times 14'$ and the LSM Lunar surfaces were at -320°F , the temperature of liquid nitrogen. During the Lunar noon tests, the average temperature of the $14' \times 14'$ Lunar surface was $+248^{\circ}\text{F}$ and that of the LSM Lunar surface was $+244^{\circ}\text{F}$.

The damped temperature extremes expected under the PSE thermal shroud were to be $+10^{\circ}\text{F}$ and $+40^{\circ}\text{F}$ respectively, for Lunar night and Lunar noon. These values were changed during the performance of the test several times in order to gain added engineering thermal data. However, for each Lunar surface temperature selected by Engineering, the average temperature varied by no more than $\pm 2^{\circ}\text{F}$ with respect to time and by no more than $\pm 1/2^{\circ}\text{F}$ in uniformity under the seismometer.



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4. Radiant Solar/Thermal Energy

The incident solar radiation was simulated with several arrays of infra-red lamps; each ALSEP subsystem having its own, individually controlled array. Each array was provided with a matched set of G. E. 1000-T3 infra-red lamps. These lamps were arrayed so as to provide the best possible uniformity patterns over the irradiated surfaces (approximately $\pm 5\%$ uniformity achieved).

The only significant problem arising during the test performance was due to a power supply drift. This problem is currently being examined and will be reported on in more detail in the complete Thermal Vacuum Test Report.

Because of the spectral mismatch between infra-red radiation sources and a true solar spectrum, the level of energy absorbed by each irradiated surface was monitored, rather than the incident energy. Special radiometers were built and calibrated to read the absorbed energy for each ALSEP subsystem. A detailed discussion of these radiometers for application with infra-red solar simulation is currently being prepared and will be published in the coming weeks, along with other data requiring detailed analysis.

Discrepancies

There was a problem associated with the determination of the back-ground radiation level for the radiometer used with ALSEP Pallet No. 2. During the performance of the environmental reference test, the near-zero thermal, background radiation, inside the chamber was measured. These data provide the "zero-level" reading or the "zero-offset" reading for the radiometer. This data did not, however, include the radiation "seen" by the Pallet No. 2 radiometer from the RTG, because the RTG was not energized at the time the background measurements were made.

Therefore, the true, radiometer zero-offset was in error by that amount of radiated thermal energy coming from the RTG. An attempt to calculate this energy error was made during the test and the IR lamp array output adjusted accordingly. This problem is still under examination and will be discussed in more detail in the complete thermal vacuum test report.

There were a few open thermocouples recorded on the DAS during the performance of the test. This is a normal problem, and in anticipation of this a 10 to 15% redundancy in thermocouple instrumentation was provided.



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J. ENGINEERING EVALUATION TESTS

TEST ITEM: ALSEP

TEST METHOD: Thermal/Vacuum

PERFORMANCE:

1. EMI between IR Arrays and ALSEP
2.
 - a. Back-up Heater Checks
 - b. Experiment Power Profile
3.
 - a. Shunt Regulator and Dump Load Resistor Temperature Data
 - b. SIDE Power Profile
4. PSE Thermal Control Mode Operation
5. Power Reserve Cycling
6. Miscellaneous Tests

1. Before the start of pumpdown and at the completion of paragraph 6.4 of TP 2333040, ALSEP was turned ON (all experiments POWER ON) and thirty minutes of H/K and experiment data obtained. Power was then applied to the IR lamps to give a baseline of any potential EMI problems between ALSEP and the IR arrays. After an additional thirty minutes of H/K and experiment data, the IR arrays and ALSEP were turned off. Comparison of the two thirty minute runs revealed no major EMI problems; several SWE words, both calibration and science data, indicated O.T. intermittently while the IR array power was adjusted to the final values.

2.a. The performance of the backup heater was investigated during the Lunar night excursion reference test, and again during the cool-down for the Lunar night IST. In the first case, the thermostat turn-on temperature did not reach a low enough temperature to allow the thermostat to operate.

In the second case, using DAS channel 62 as the temperature monitoring point, the thermostat turned on at exactly -10°F (specified point). Reference DR 6371 for procedure deviation. Once the thermostat had closed, measurements



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of reserve power were made after transmission of both Backup Heater On and Off commands to allow analysis of the power drawn by the heater (approximately 10 watts). The Backup Heater was then commanded Off during stabilization to Lunar night.

2.b. Following backup heater investigation, some further engineering tests were carried out while waiting for stabilization at Lunar night conditions (DR 6371).

- (1) The PDM #2 load was transmitted on, then off. The reserve power change was approximately 13 watts. The PDM #1 was commanded On, then Off; reserve power changed by approximately 7 watts.
- (2) Experiment #1 (PSE) was then commanded from "On" to "Standby" to "Standby Off" to "On", while the following reserve power changes were noted:

"On" - "Standby"	approximately 2.1 watts
"Standby" - "Standby Off"	approximately 4.8 watts
"Standby Off" - "on"	approximately 6.9 watts

The experiment was then transmitted back to the correct thermal control status by sending up the Thermal Control Mode command twice and observing the reading of HK-39.

- (3) Experiment #2 (LSM) was then cycled through power "On" to "Standby" to "Standby Off" to "On" and the following reserve power changes were noted:

"On" - "Standby"	approximately 3.1 watts
"Standby" - "Standby Off"	approximately 3.1 watts
"Standby Off" - "On"	approximately 6.2 watts

- (4) Experiment #3 (SWE) was then cycled through the power switching steps, and reserve power changes were as follows:

"On" - "Standby"	approximately 3.8 watts
"Standby" - "Standby Off"	approximately 3.1 watts
"Standby Off" - "On"	approximately 6.9 watts



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An attempt was made to get SWE to function by commanding the experiment from "Standby ON" to "On" ten (10) times, but with no success; therefore, SWE was left in Standby.

- (5) Just prior to the commencement of the Lunar night IST, Experiment #4 (SIDE) was cycled through the power switching steps and the following reserve power changes were noted:

"On" - "Standby"	approximately 3.8 watts
"Standby" - "Standby Off"	approximately 5.3 watts
"Standby Off" - "On"	approximately 9.1 watts

It should be noted that the heater within the SIDE experiment was on at this point.

- (6) At the end of the Lunar night IST, the backup heater was transmitted "On" in order that the reserve power could be monitored for change when the thermostat warmed enough to open. At approximately 17.13 hours on 20 December 1967 the reserve power increased by approximately 11 watts indicating that this event had occurred. The DAS #62 temperature at this time was approximately 0°F, indicating a possible hysteresis in the thermostat operation.

3.a. At the completion of the Lunar noon IST, a deviation was performed to gather engineering data on the high temperature performance of the shunt regulator resistor and the dump load resistor (Reference DR 6359)

- (1) Regulator resistor temperature (C.S. 17, DAS 67)

The Central Station loads were removed in steps to achieve maximum reserve power, as measured on the PCU #1 reserve meter; the steps were performed at 10 minute intervals and were in the following sequence:

1. SWE to Standby Off
2. LSM to Standby
3. LSM to Standby Off

During these steps, DAS #67 was monitored at one minute intervals and the temperature rise was observed. The regulator resistor rose



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in temperature, but levelled off at a maximum of $+348^{\circ}\text{F}$, below the critical value of $+450^{\circ}\text{F}$ (Note: C.S. 17 thermocouple is mounted on the thermal plate, immediately below the resistor). After the stabilization, the Central Station loads were reinitialized to the original configuration and allowed to remain undisturbed for 10 minutes, during which time DAS 67 was monitored at one minute intervals.

(2) Dump Load Resistor (C.S. 18, DAS #68)

DAS Channel 68 was monitored at one minute intervals. PDM #2 was then commanded On, and DAS #68 (Dump Load #2 resistor) temperature rise was plotted for 15 minutes. During this time, the temperature of the resistor rose from $+219^{\circ}\text{F}$ to stabilization at $+321^{\circ}\text{F}$ (red-line limit is $+425^{\circ}\text{F}$). PDM #2 was then commanded Off.

3.b. Also, at the completion of the Lunar noon IST an engineering check was performed on the SIDE to determine power consumption when the internal heater was off. The experiment was commanded through the power switching steps, and the following measurements of reserve power change were noted (DR 6359):

"On" - "Standby"	approximately 4.8 watts
"Standby" - "Standby Off"	approximately 1.9 watts
"Standby Off" - "On"	approximately 6.7 watts

The experiment was left in the power "On" mode, and the high voltages were commanded Off for the cooling transition to Lunar night.

4. During the transition from Lunar noon to Lunar night, the PSE was operating in the automatic thermal control mode, which should have caused the sensor to stabilize at a temperature of $+125 \pm 18^{\circ}\text{F}$. However, it became apparent that the automatic control would not hold the temperature within these limits. Accordingly, when the PSE Lunar surface was $+60^{\circ}\text{F}$, it was decided to transmit the THERMAL CONTROL MODE command twice to put the sensor in the Manual Heater Control mode, such that the internal heater would remain continuously operating and thus keep the temperature up. However, the sensor temperature continued to fall, and at Lunar night stabilization had reached approximately $+99^{\circ}\text{F}$. Engineering, accordingly, gave instructions that the Lunar night IST should not be performed at



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this out-of-tolerance temperature. The probable cause of the problem is the cable from the sensor excitor to connector P31 of the sensor is contributing a 1.0 - 2.0 watt heat loss, causing this thermal control discrepancy. A guard heater blanket is to be designed to fit over the sleeve to this cable (Ref: DR 6376).

5. During the transition to Lunar night, and from Lunar night back to ambient, the reserve power was observed to change cyclically (Ref: DR 6300). The backup heater was commanded "Off" but the transient was still present. Switching of transmitters was initiated by command, but the fluctuation was still apparent. Later analysis by Systems Engineering revealed that the transient was approximately 4.5 watts, and the cycling was attributed to the SIDE internal heater turning on and off when the temperature was close to the switching point of the thermostat.

6. After completion of the Lunar night IST, a series of engineering evaluation tests were performed and are discussed in detail in the Chronological Sequence of Events - 20 December 1967 - Section III.



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APPENDIX A

TIMED SEQUENCE OF EVENTS

<u>EVENT</u>	<u>ALSEP CLOCK READING</u>	<u>CALENDER DAY</u>
1.0 Environmental Test Set-Up Verification		12/12/67
2.0 ALSEP System Test Set-Up		12/12/67
3.0 Ambient Pressure and Temperature Tests		12/12/67 12/12/67
3.1 Ambient IST		
3.1.1 System Test Set Turn-On using RTG Simulator	346-08-44-00	12/12/67
3.1.2 Central Station Verification	346-13-12-06	
3.1.3 SWS Turn-On	346-14-34-28	
3.1.4 SIDE Turn-On	347-04-21-50	12/13/67
3.1.5 PSE Turn-On	346-20-09-19	
3.1.6 LSM Turn-On	347-06-58-22	12/13/67
3.1.7 Central Station Turn-Off	347-10-00-00	
3.1.8 System Test Set Turn Off	347-10-30-00	
4.0 Pre-Test Environmental Systems Verification		12/14/67
5.0 Vacuum IST		
5.1 Pump down initiated	348-15-50-00	12/14/67
5.1.1 Vacuum less than 10 ⁻⁵ torr	348-22-50-00	



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(Table continued)

<u>EVENT</u>	<u>ALSEP CLOCK READING</u>	<u>CALENDER DAY</u>
5.1.2 17 hour soak completed pressure= 4.7×10^{-5}	349-15-50-00	12/15/67
5.2 Vacuum IST		
5.2.1 System Test Set Turn-On	349-16-00-00	
5.2.2 Central Station Verification	349-19-34-09	
5.2.3 SWS Failed to Turn-On	349-20-12-51	
5.2.4 SIDE Turn-On	349-23-20-14	
5.2.5 PSE Turn-On	350-02-58-40	
5.2.6 LSM Turn-On	350-07-06-00	
6.0 Environmental Reference Test	350-21-36-00	12/16/67
7.0 Lunar Morning Turn-On		
7.1 Lunar Morning Initiated	351-06-50-15	12/17/67
7.2 Power to ALSEP switched from RTG Simulator to IPU	351-07-44-00	
7.3 Lunar Morning Turn-On completed.	351-12-30-00	
8.0 Lunar Noon IST		
8.1 Thermal Equilibrium reached	352-12-00-00	12/18/67
8.1.1 Central Station Verification	352-14-19-26	
8.1.2 SWS failed Turn-On	352-14-44-15	



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<u>EVENT</u>		<u>ALSEP CLOCK READING</u>	<u>CALENDER DAY</u>
8.1.3	SIDE IST	352-18-25-47	
8.1.4	SIDE tipped over	351-22-15-00	
8.1.5	LSM IST	352-22-48-07	
8.1.6	PSE IST	353-02-13-00	12/19/67
9.0	Lunar Night IST		
9.1	Thermal Equilibrium reached	354-04-00-00	12/20/67
9.1.1	Central Station Verification	354-06-42-33	
9.1.2	SWS failed turn-on	354-07-00-00	
9.1.3	SIDE IST started	355-04-52-10	12/21/67
9.1.4	PSE IST - abort per Engineering Dept.		
9.1.5	LSM IST	354-11-06-00	
10.0	Vacuum Shut Down		
10.1	ALSEP turned off	355-04-58-20	12/21/67
10.2	Shut down of IPU	355-06-00-00	
10.3	System returned to Ambient Pressure & Temperature	355-08-15-00	
11.0	ALSEP Post Test Ambient IST		
11.1	Central Station Verification	355-13-51-30	
11.2	SWS - abort		
11.3	SIDE IST completed	355-16-35-36	



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(Table continued)

	<u>EVENT</u>	<u>CLOCK READING</u>	<u>CALENDER DAY</u>
11.4	PSE IST completed	355-19-17-05	
11.5	LSM IST completed	355-20-44-40	12/21/67
12.0	Proto Thermal Vacuum Test Completed	355-21-00-00	



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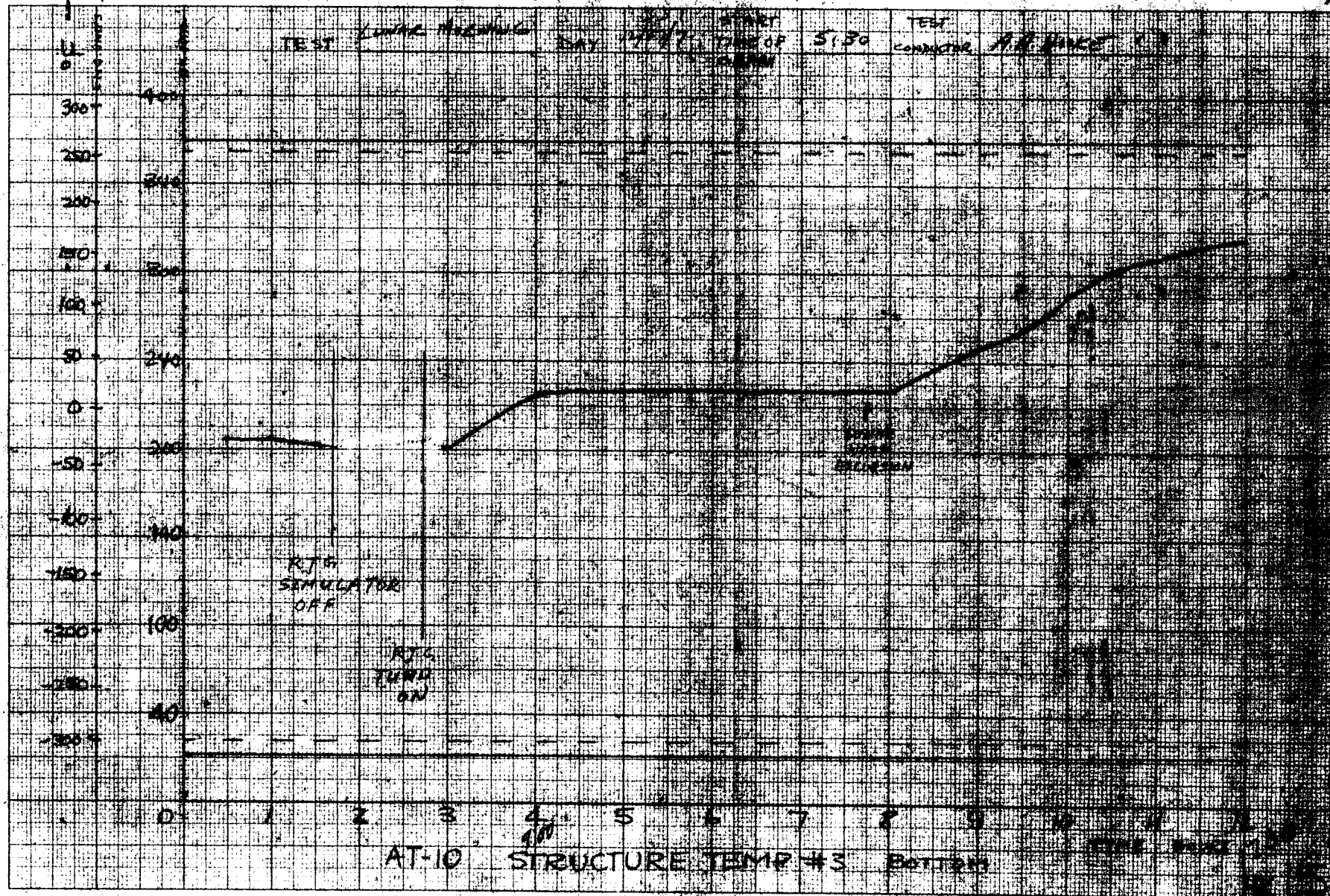
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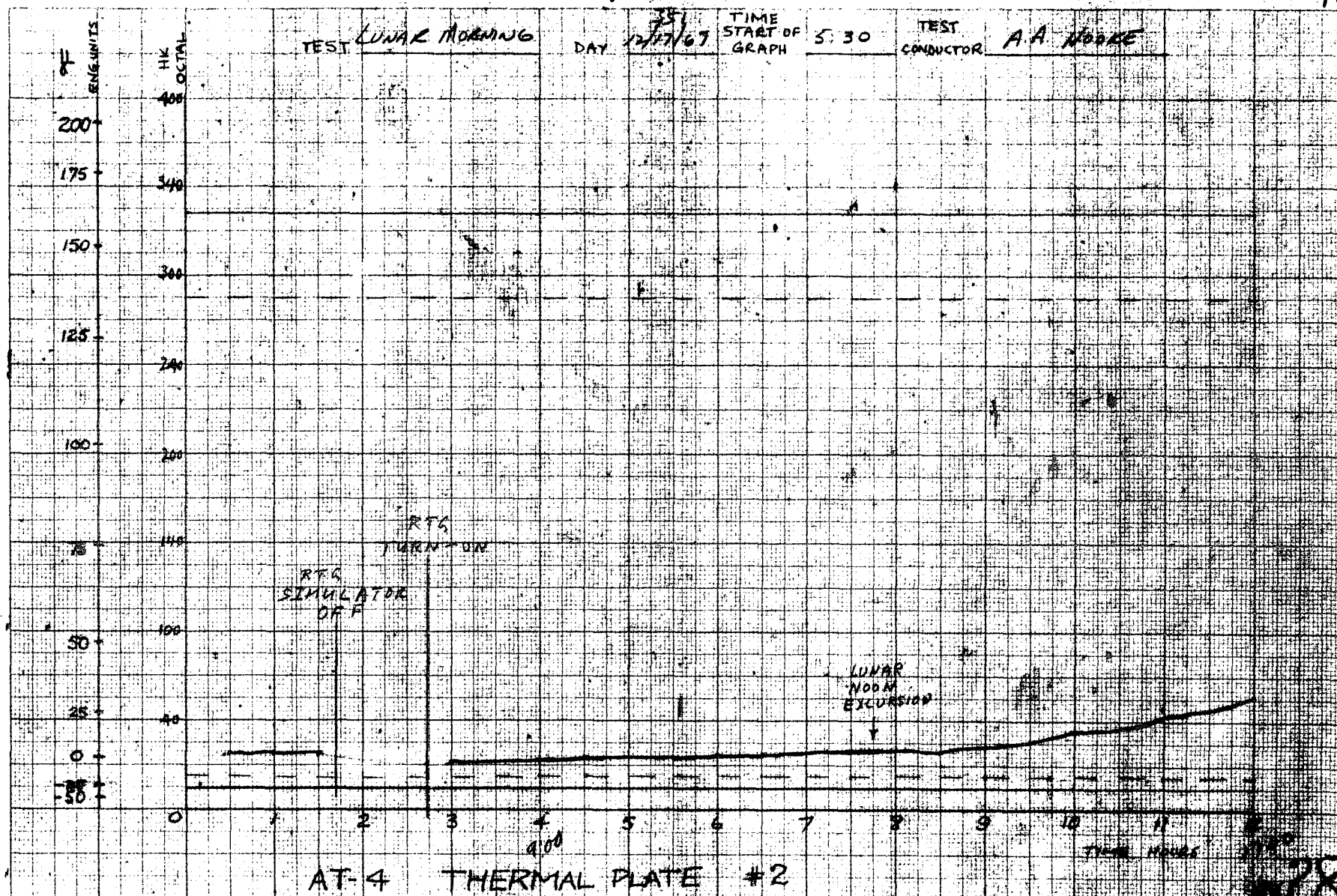
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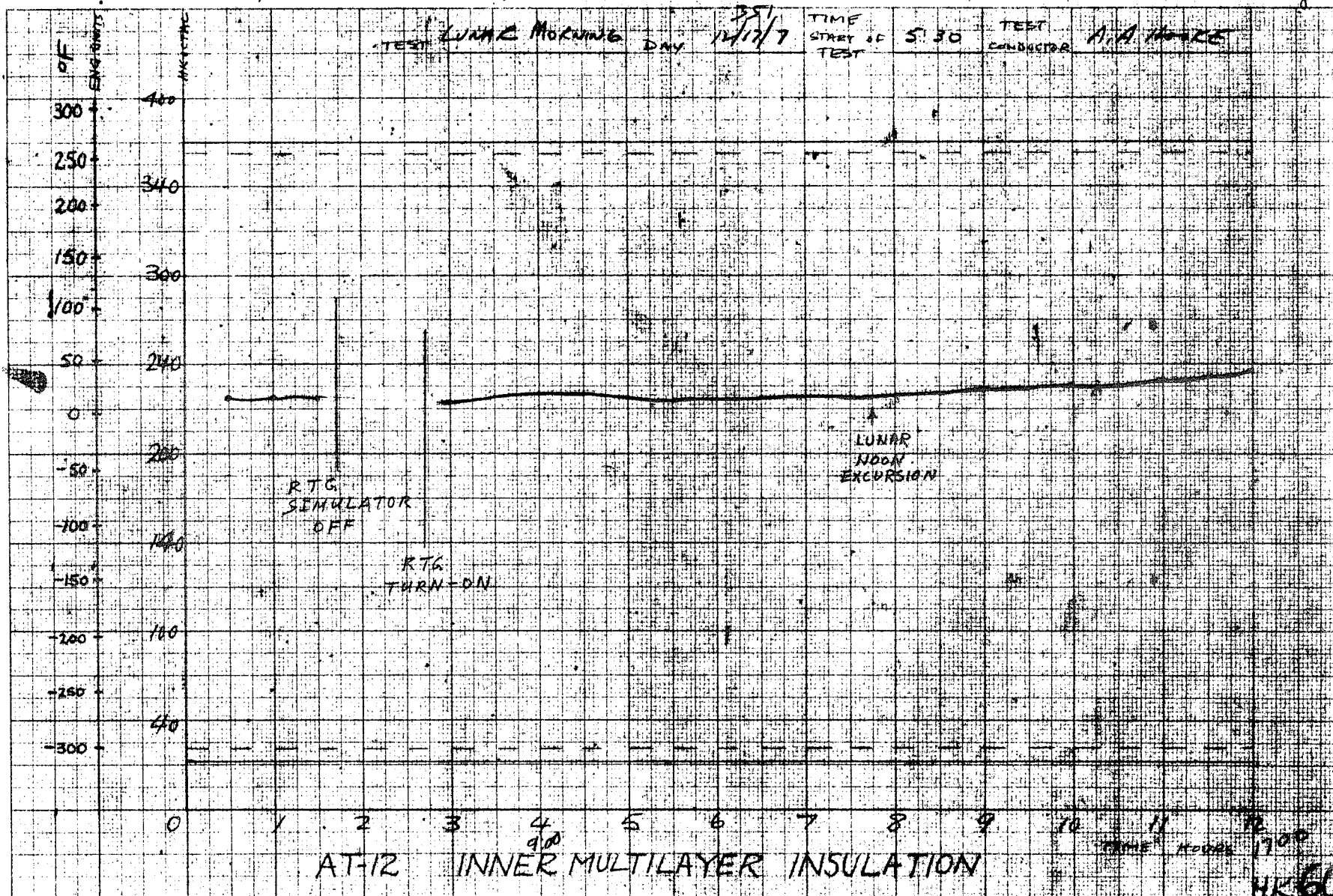
APPENDIX B

Appendix B contains representative curves (forty-eight curves) of the total of more than 50 parameters that were plotted during the Thermal Vacuum Test. The following parameters are contained for Lunar Morning, Lunar Noon, and Lunar Night conditions.

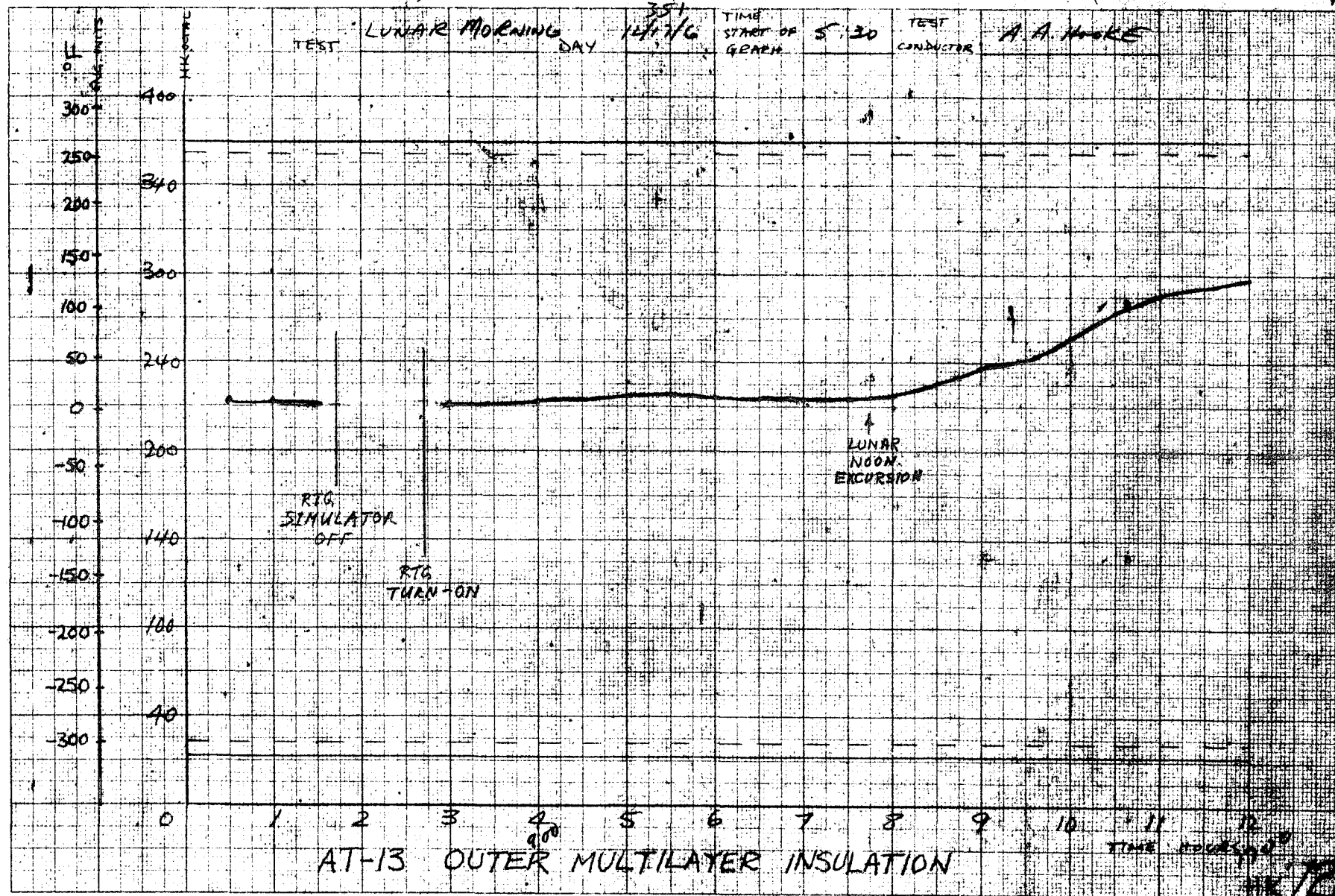
- 1) H/K 15 Structure Temp #3 (Bottom)
- 2) H/K 28 Thermal Plate #2
- 3) H/K 60 Inner Multilayer Insulation
- 4) H/K 72 Outer Multilayer Insulation
- 5) 14 x 14 Lunar Surface (Inner Rings)
- 6) Solar Wind Exp. (Daystrom)
- 7) SIDE Temp. #3
- 8) LSM #1 and #5 (Sensor & Electronics)
- 9) PSE (Daystrom)

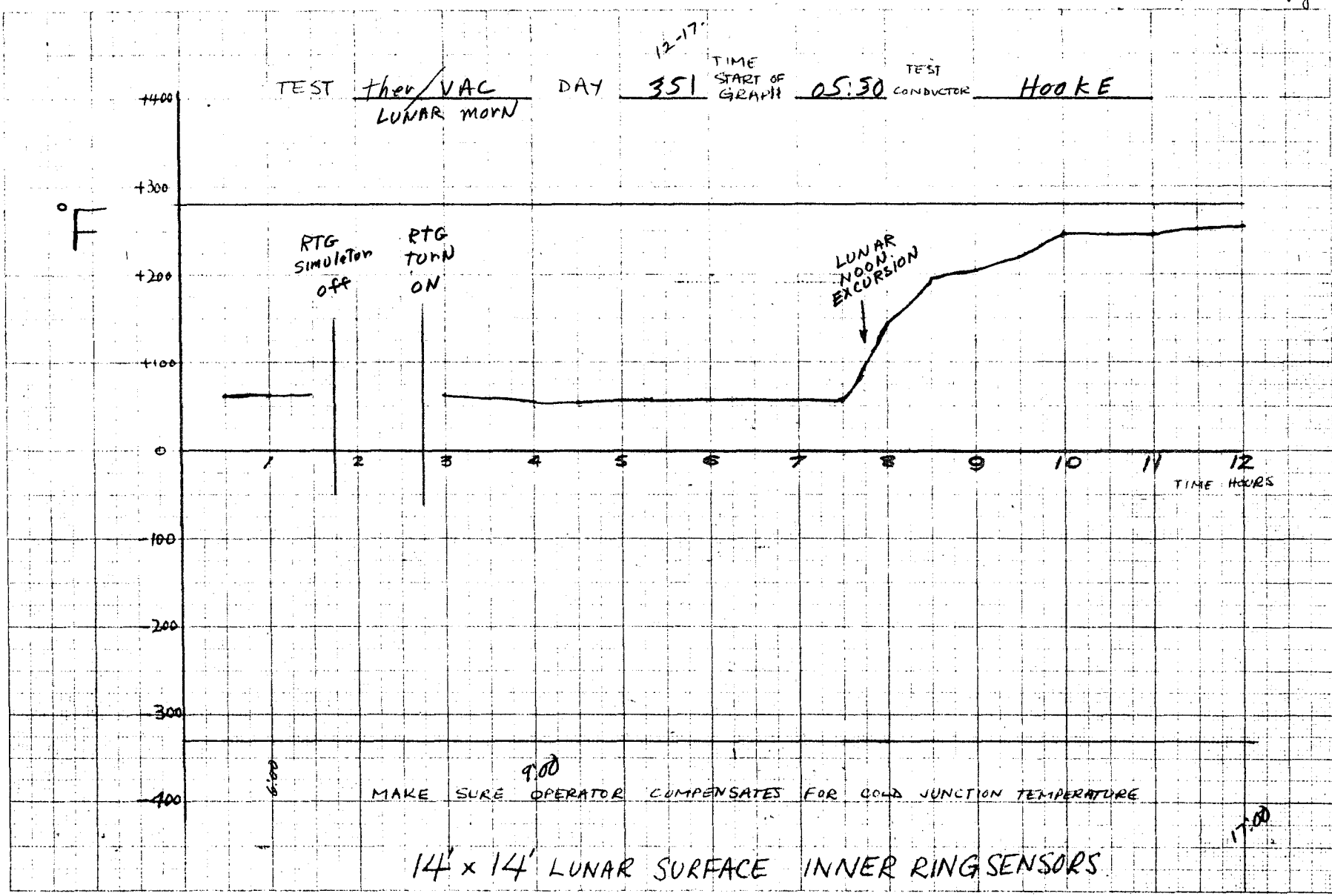


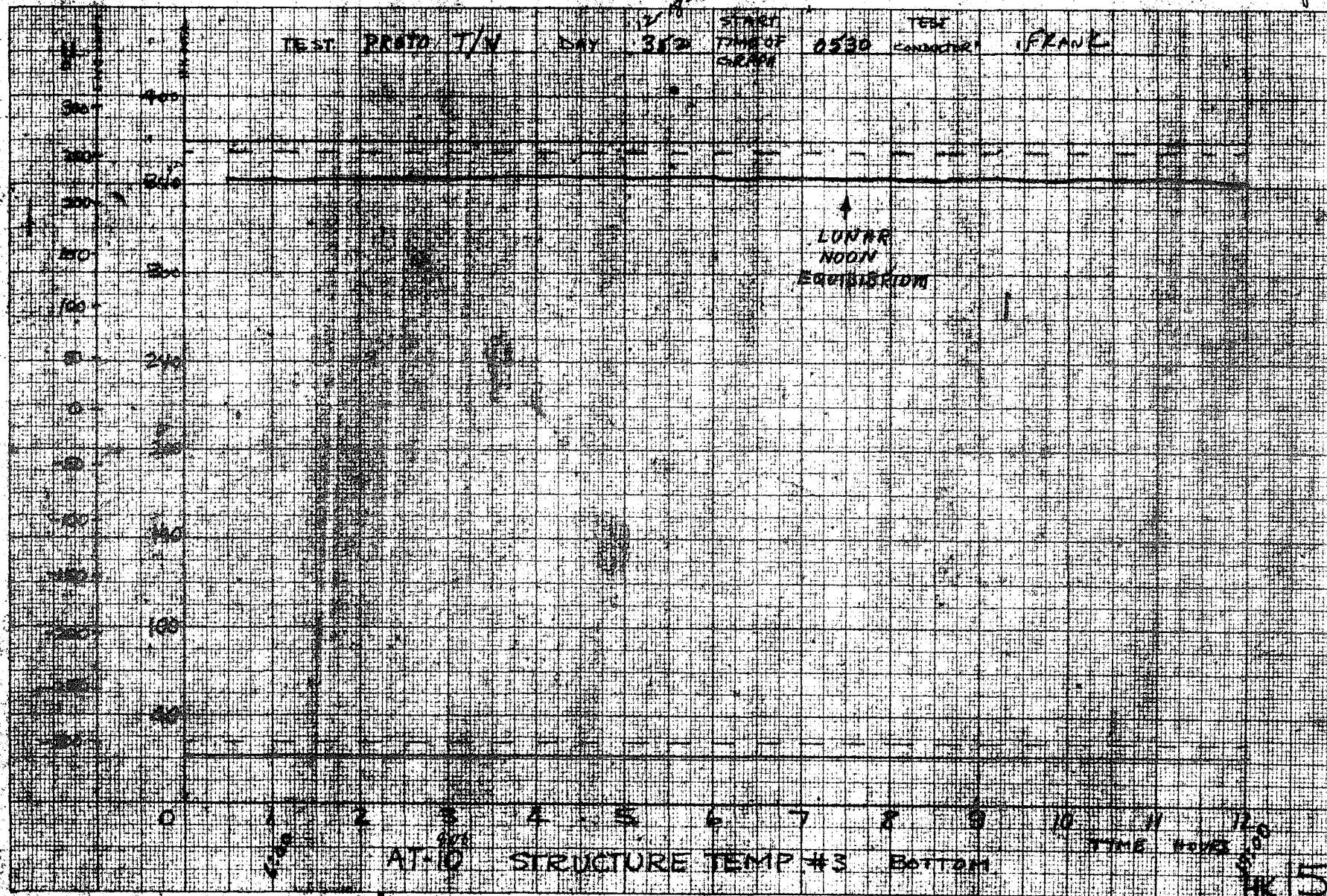


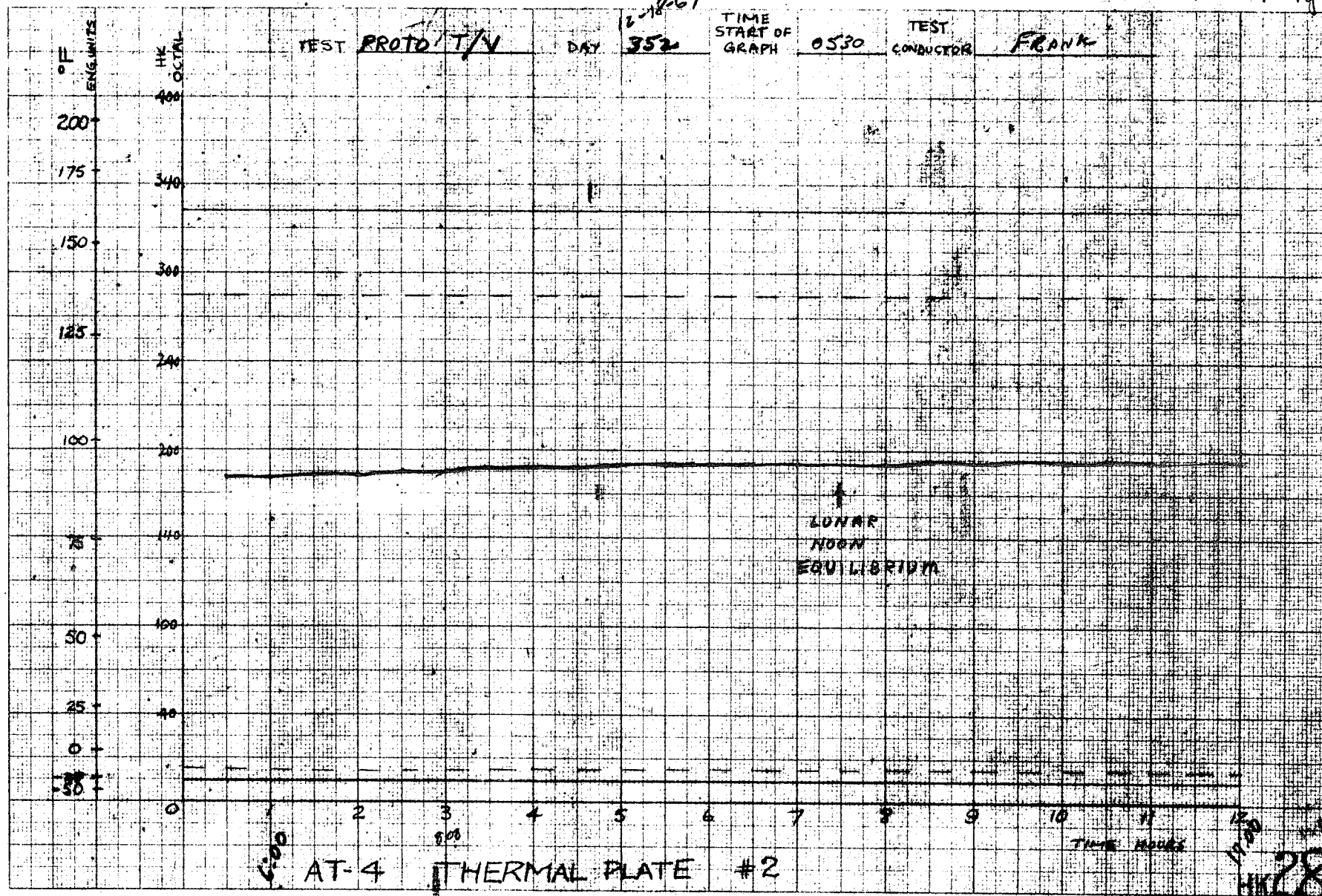


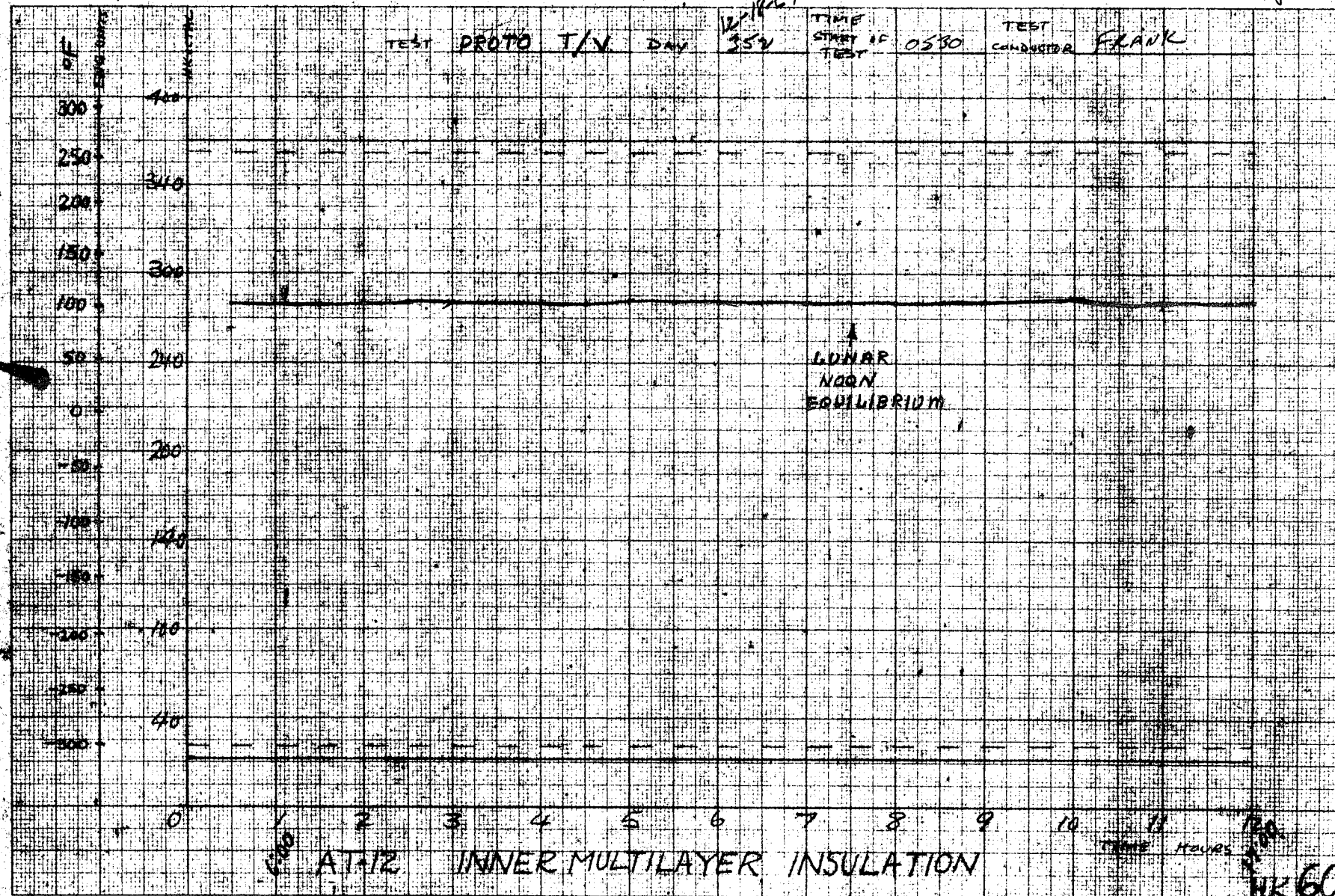
ATM 729 R. 66

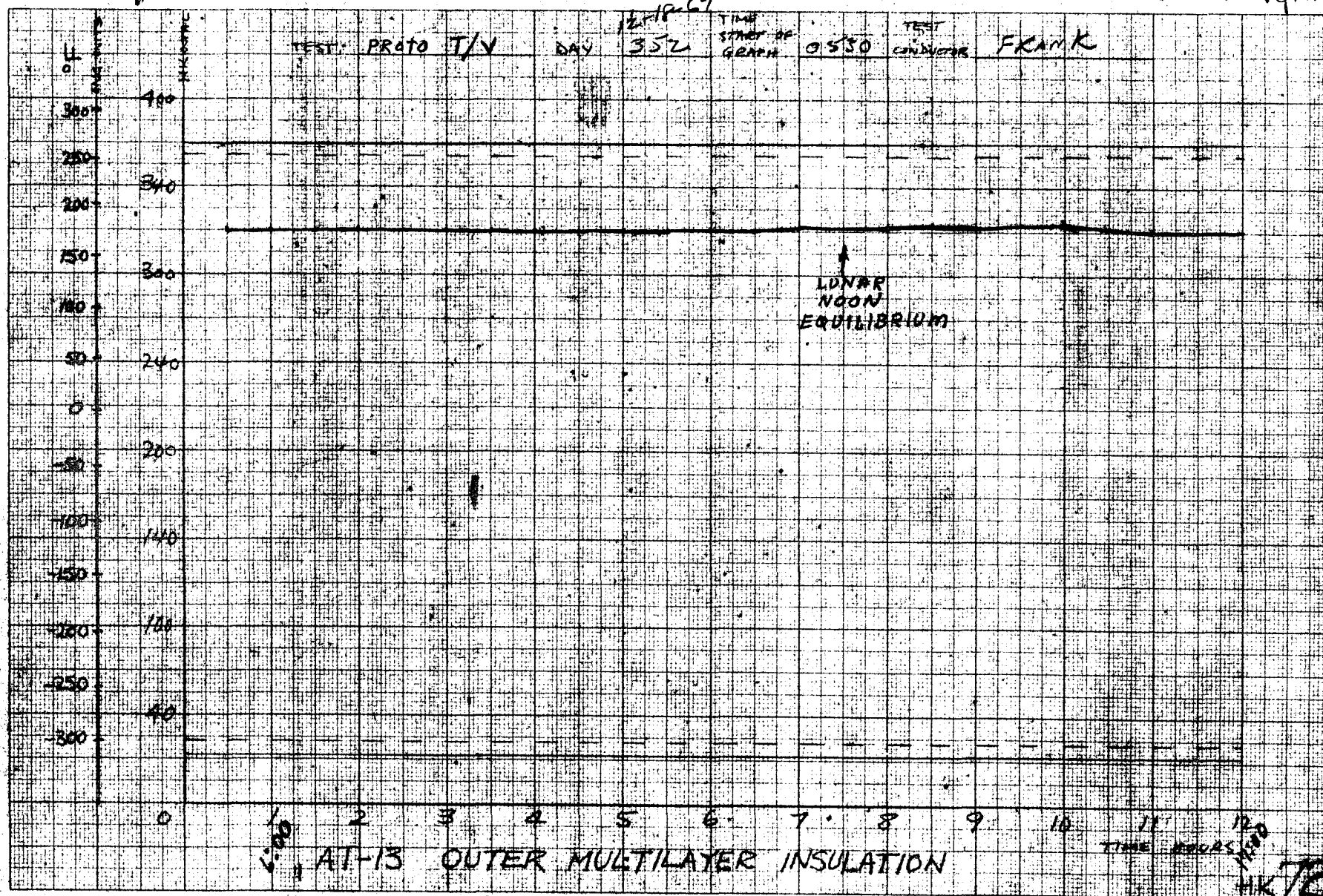


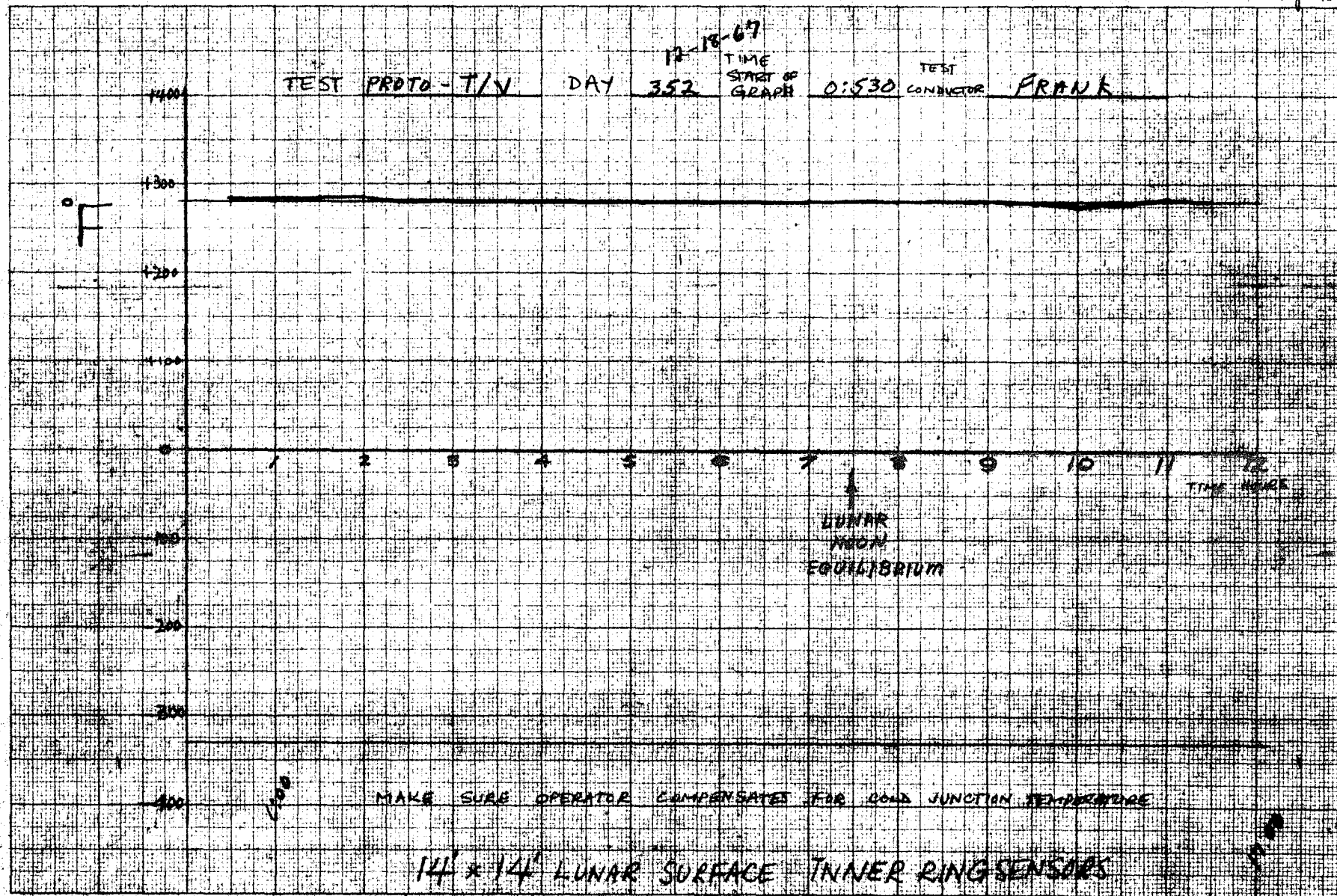


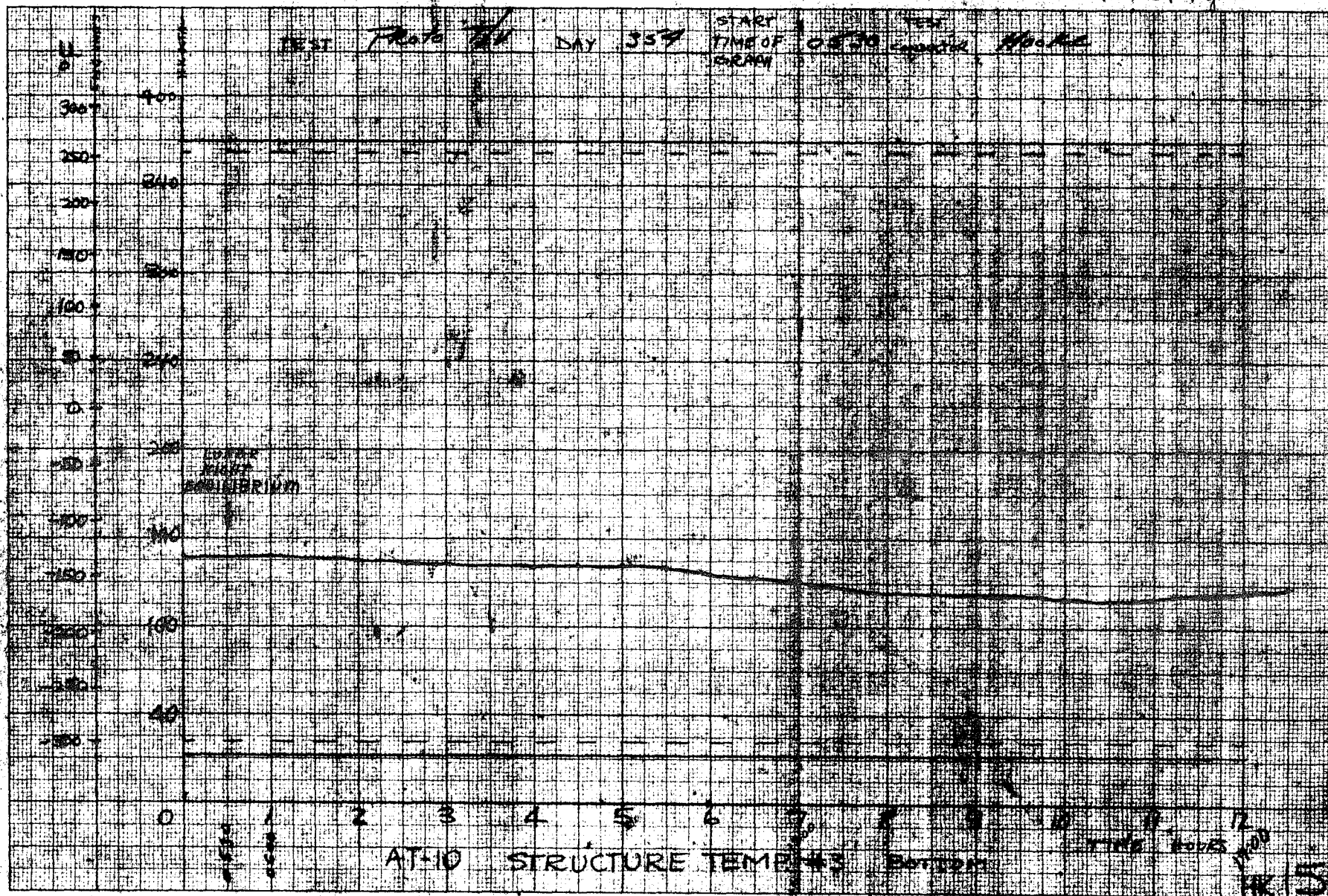




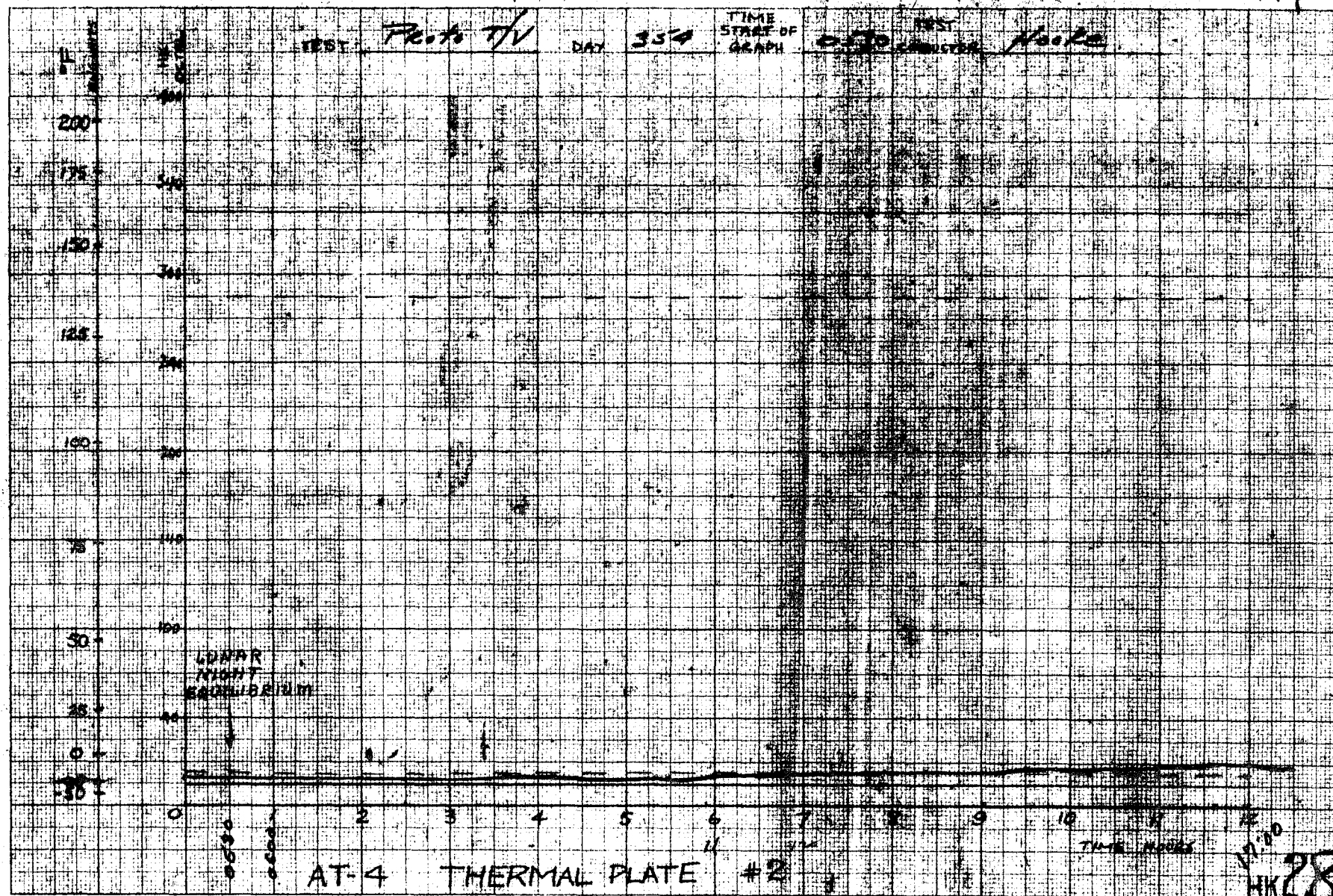


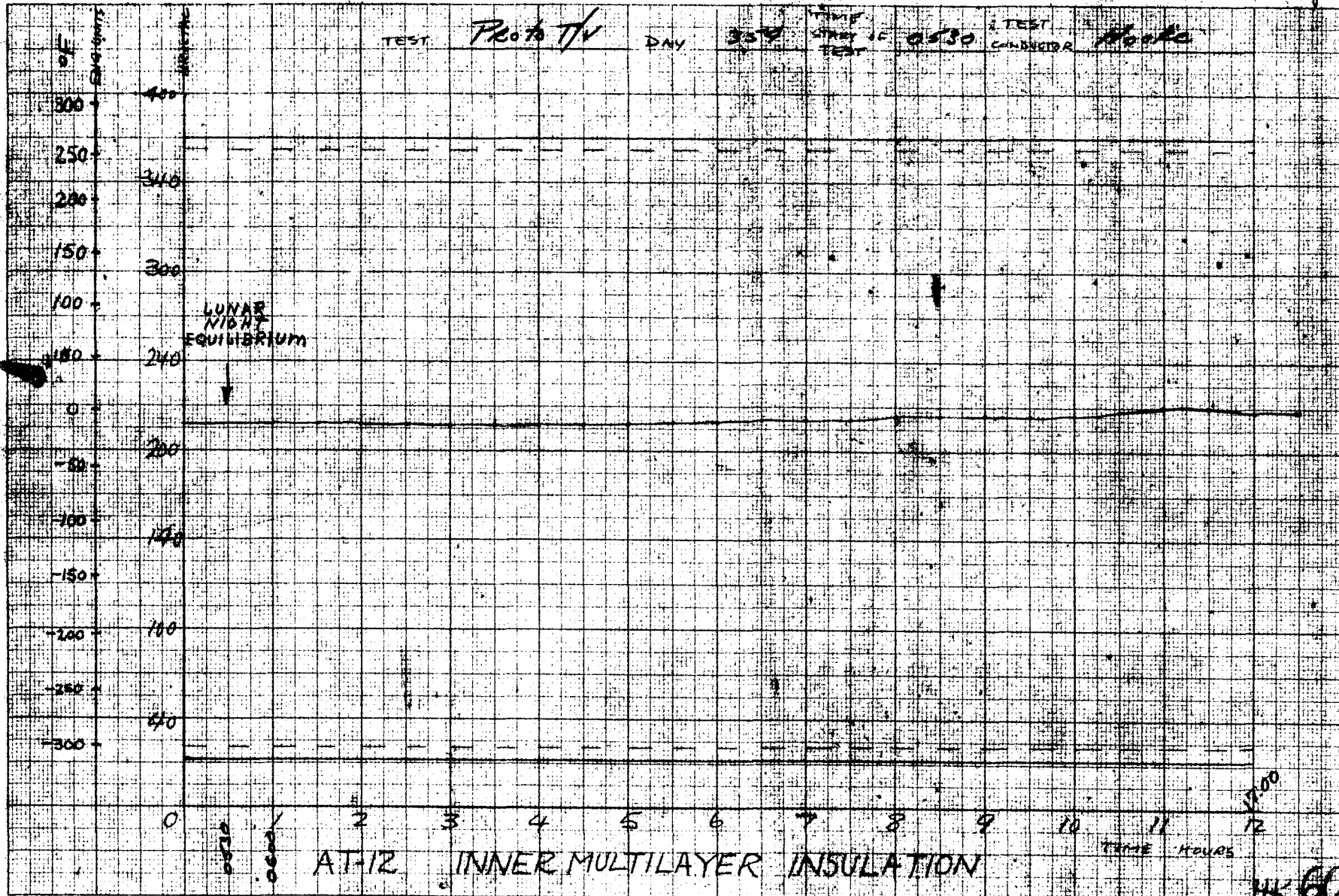




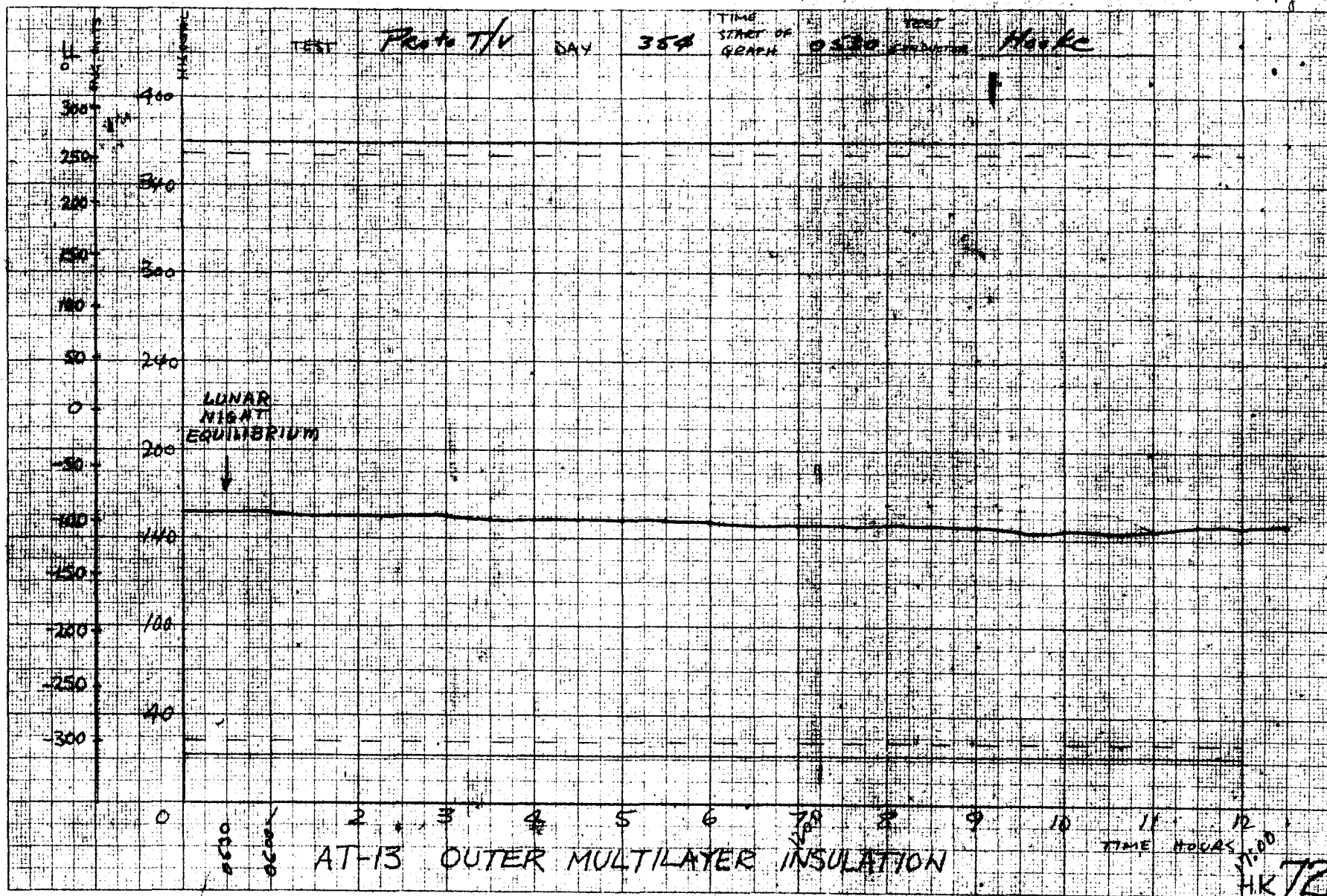


ATM 729 Pg. 14

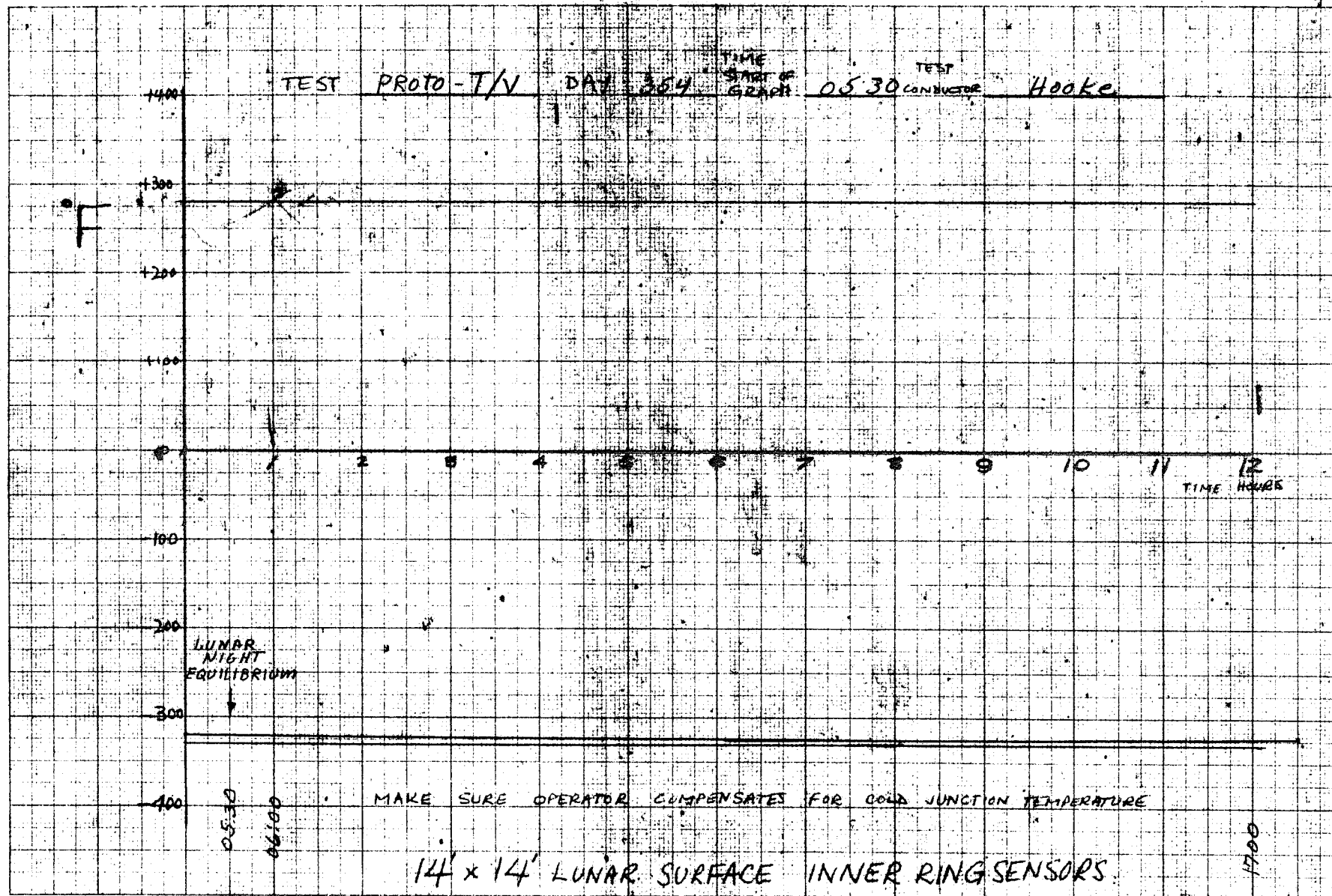




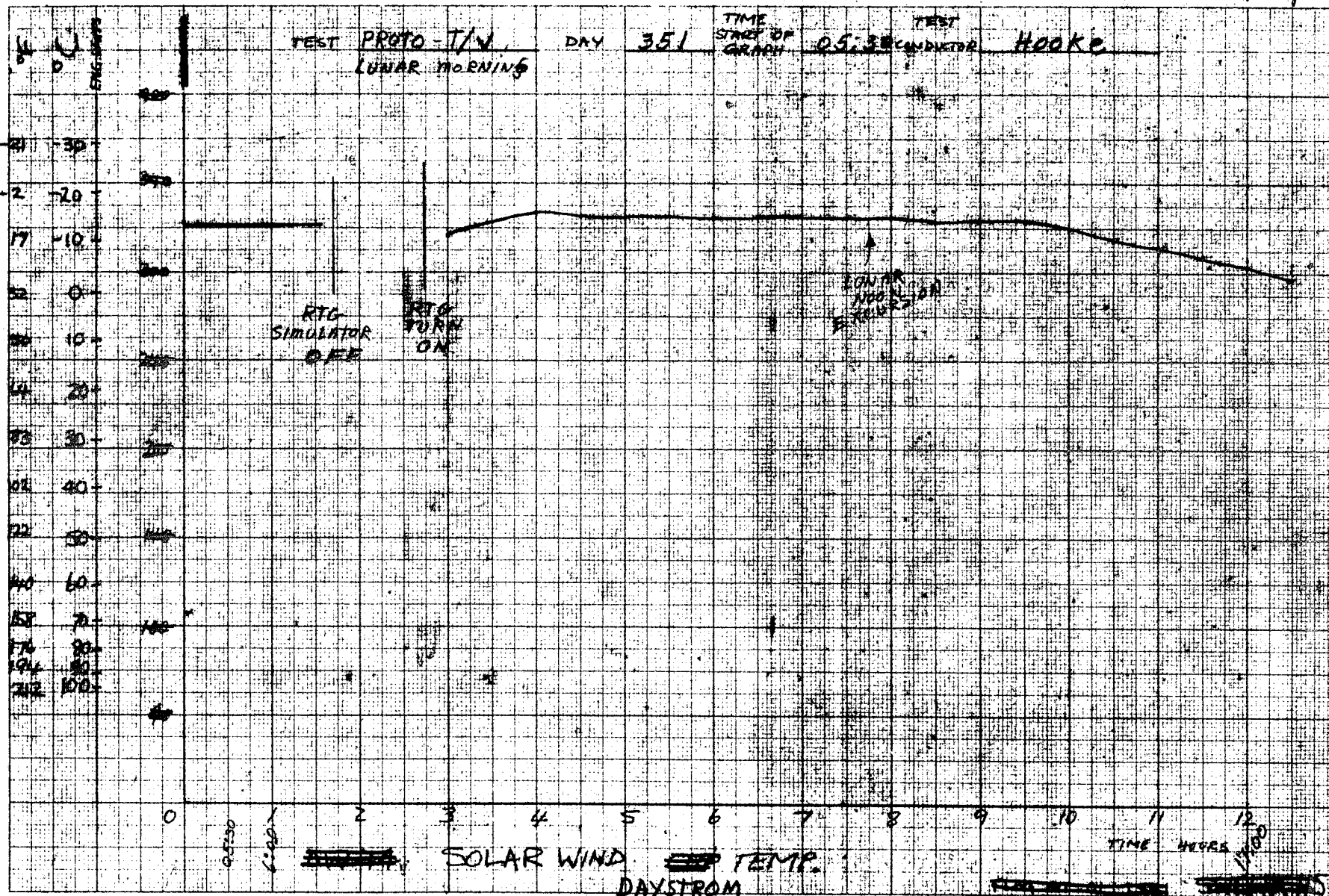
HK 60 ✓

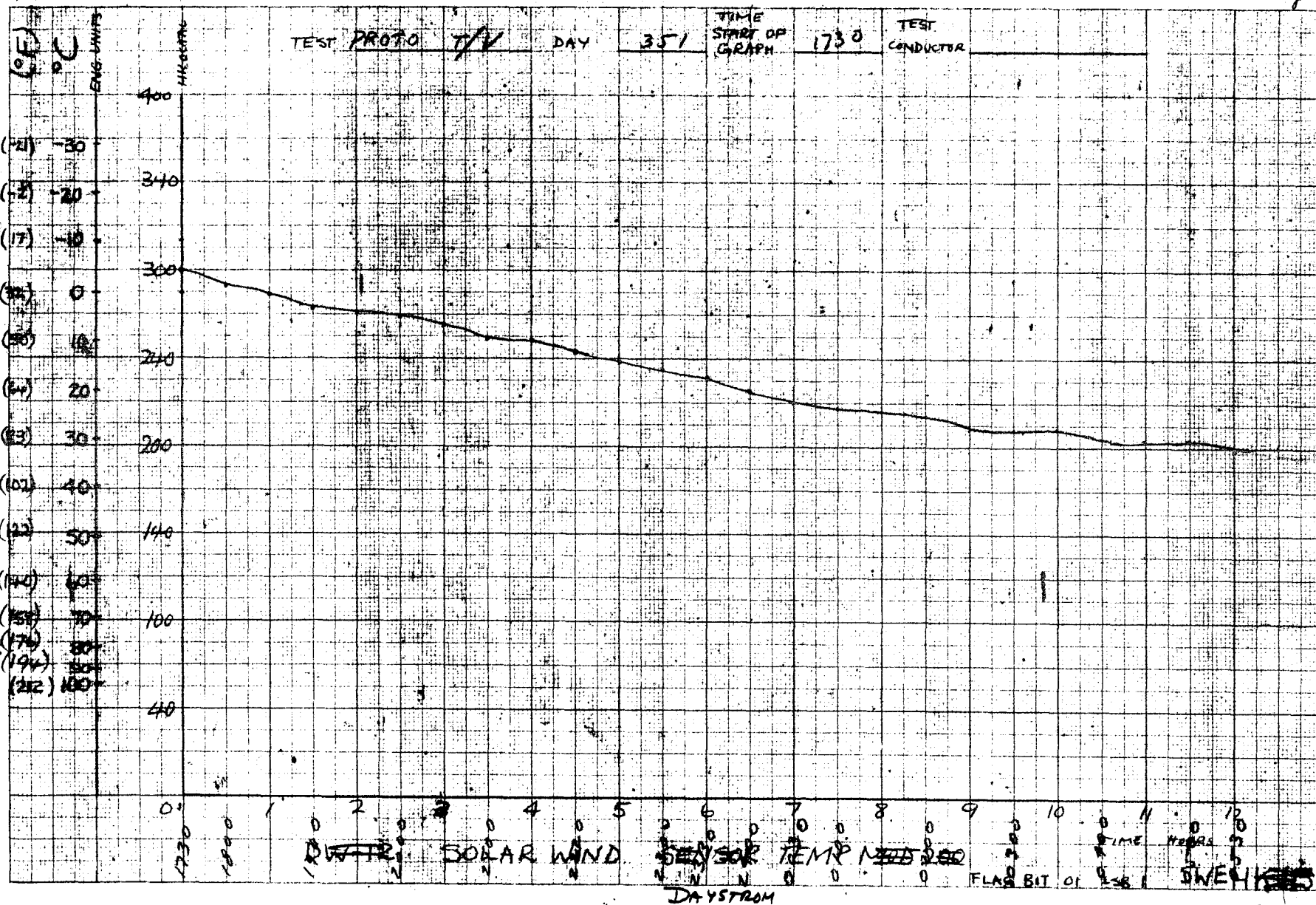


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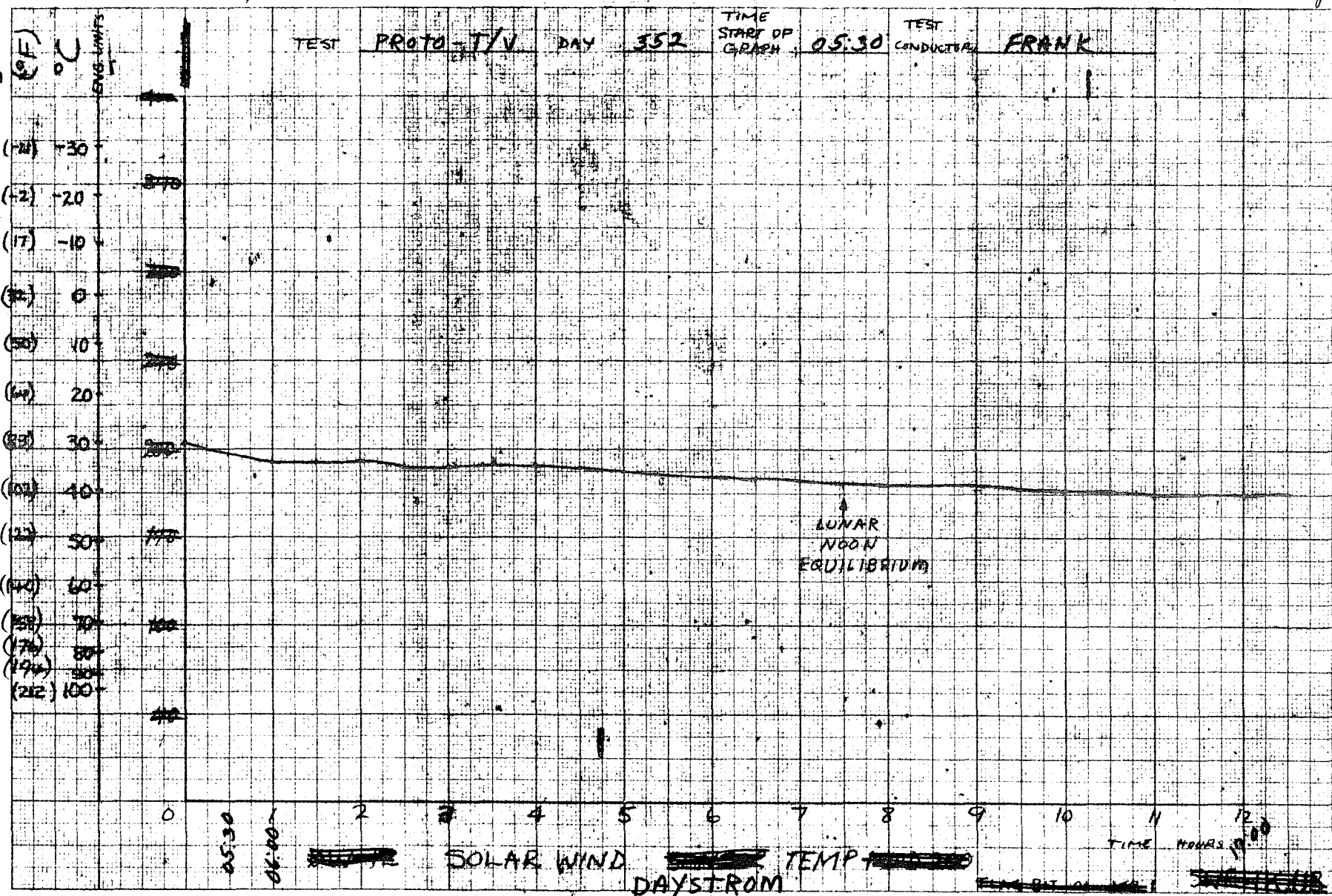
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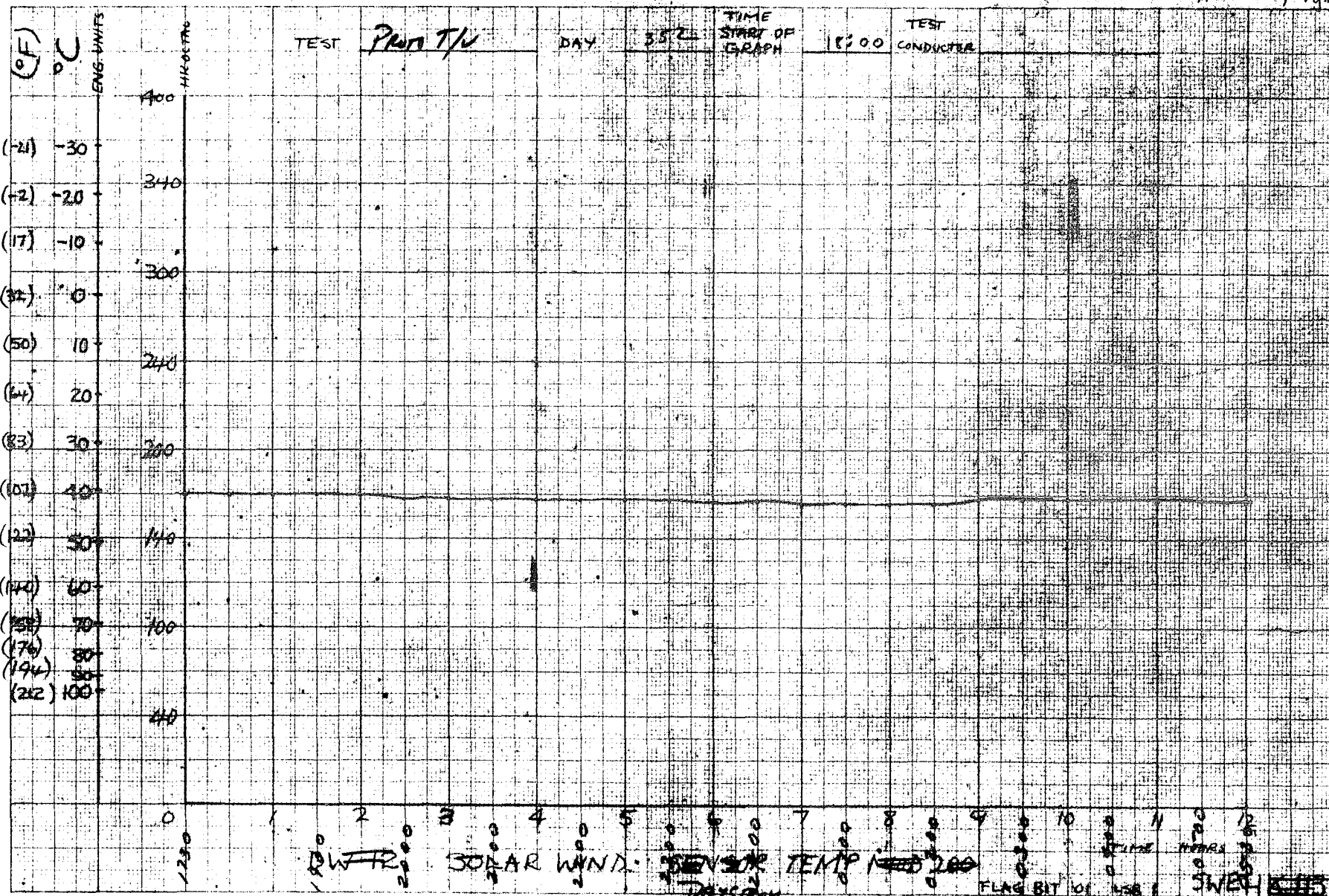


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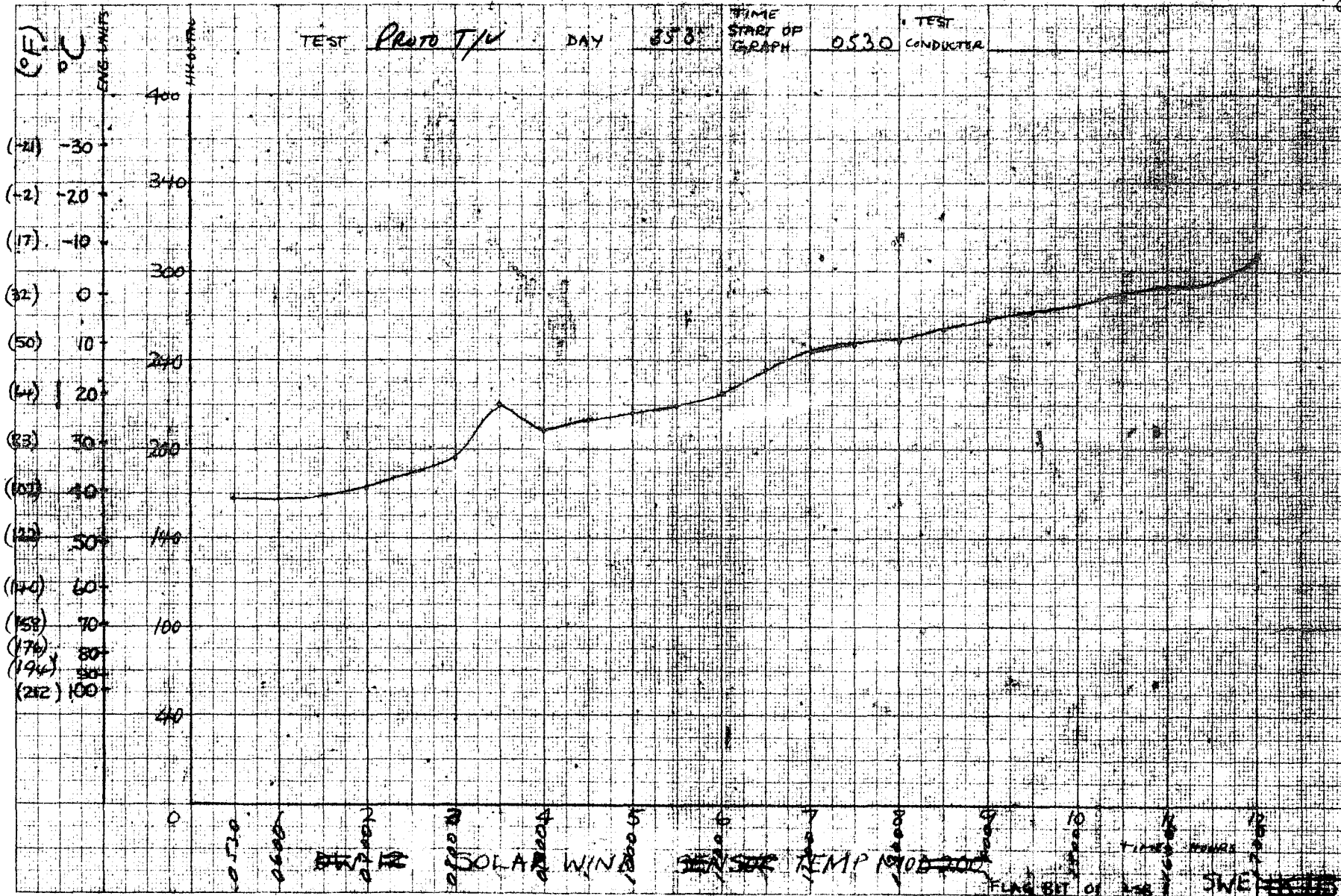
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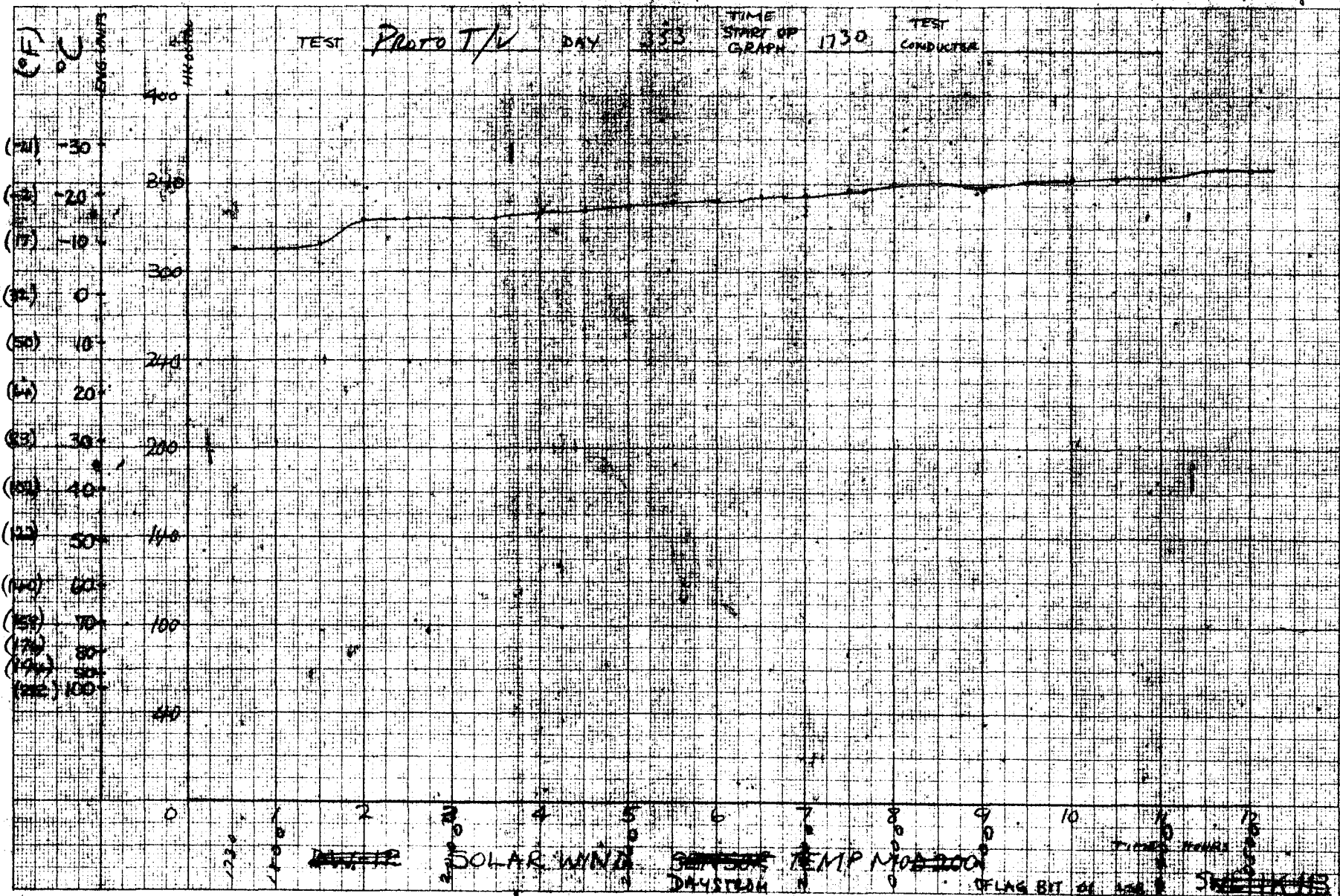


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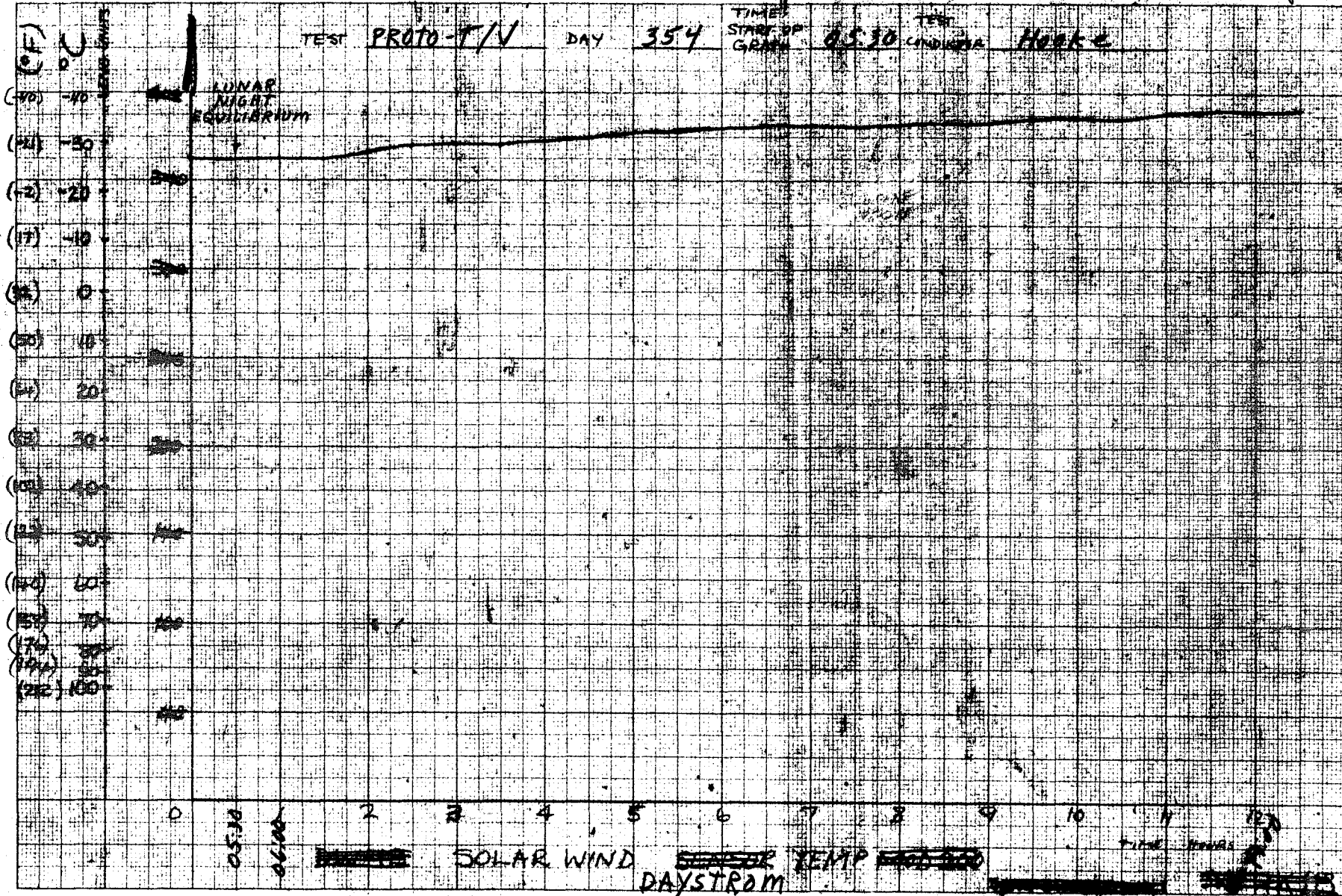


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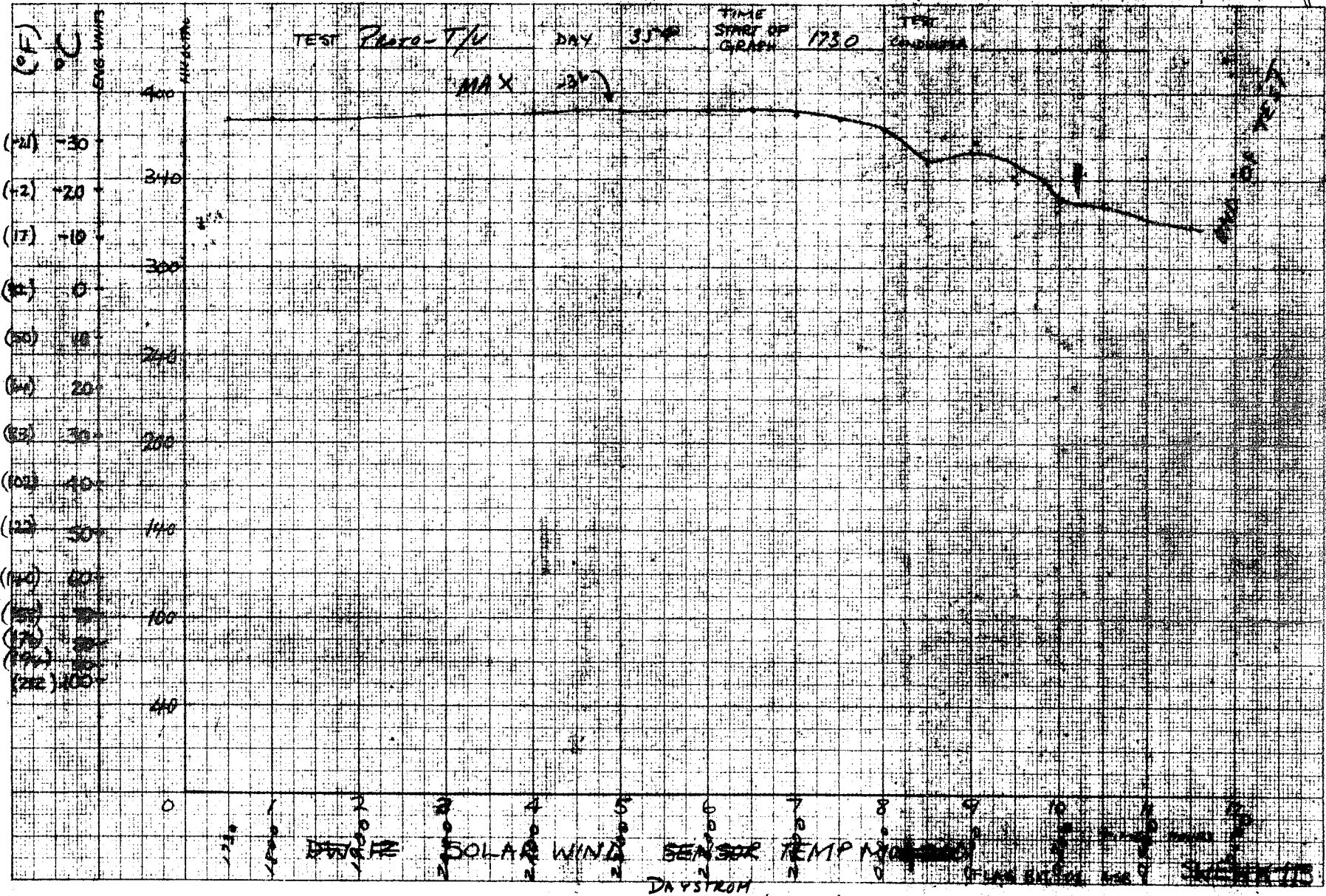


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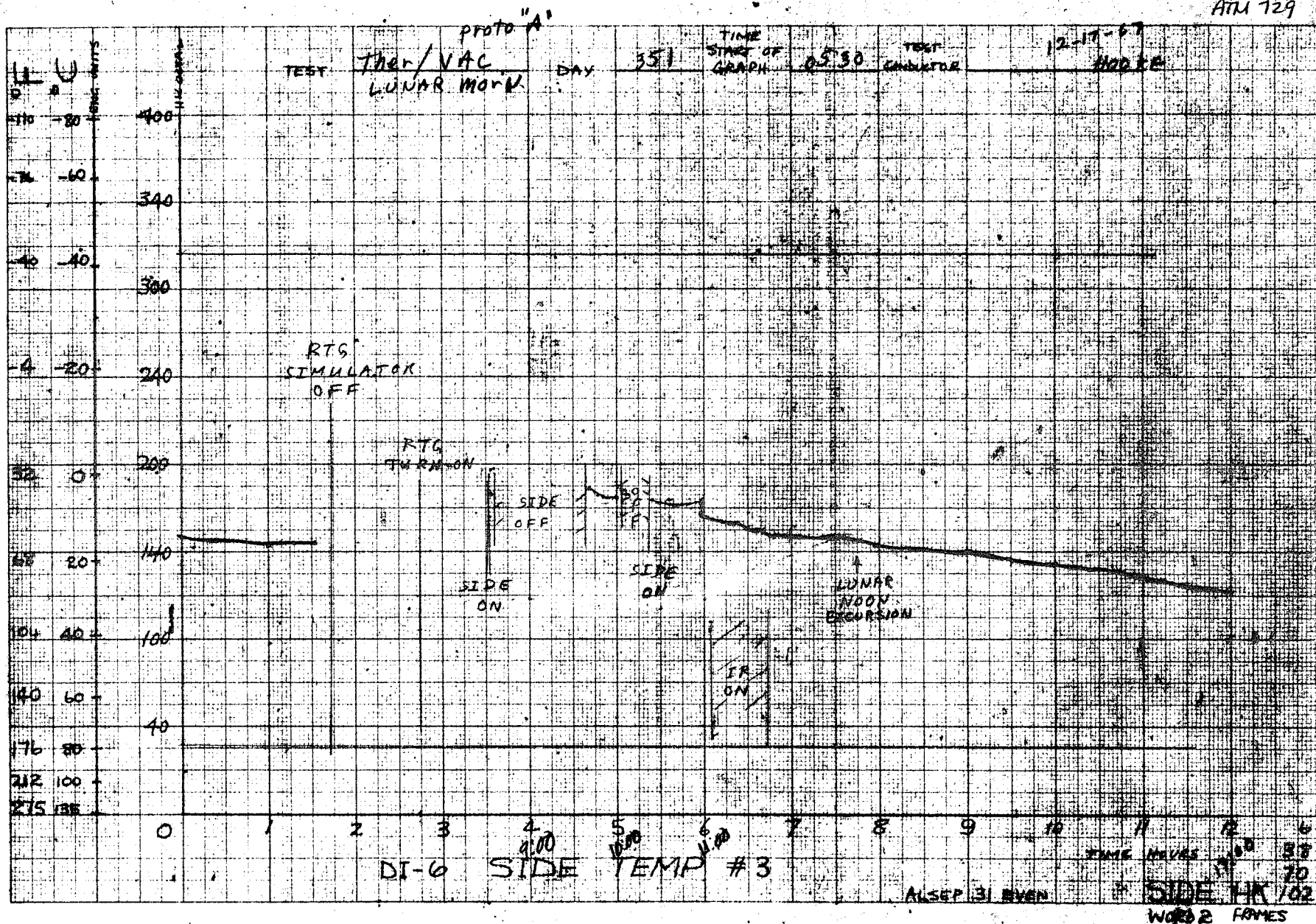
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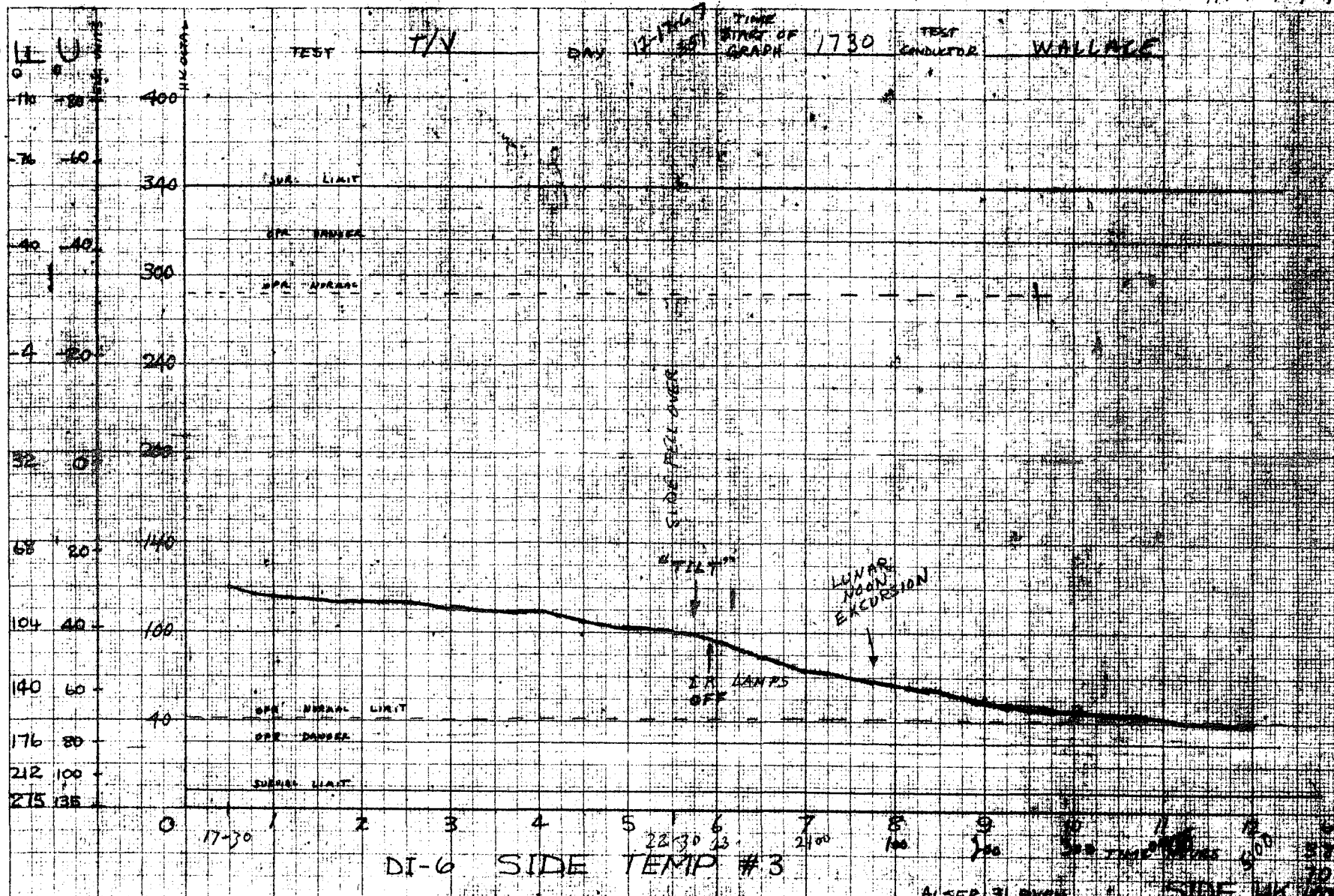
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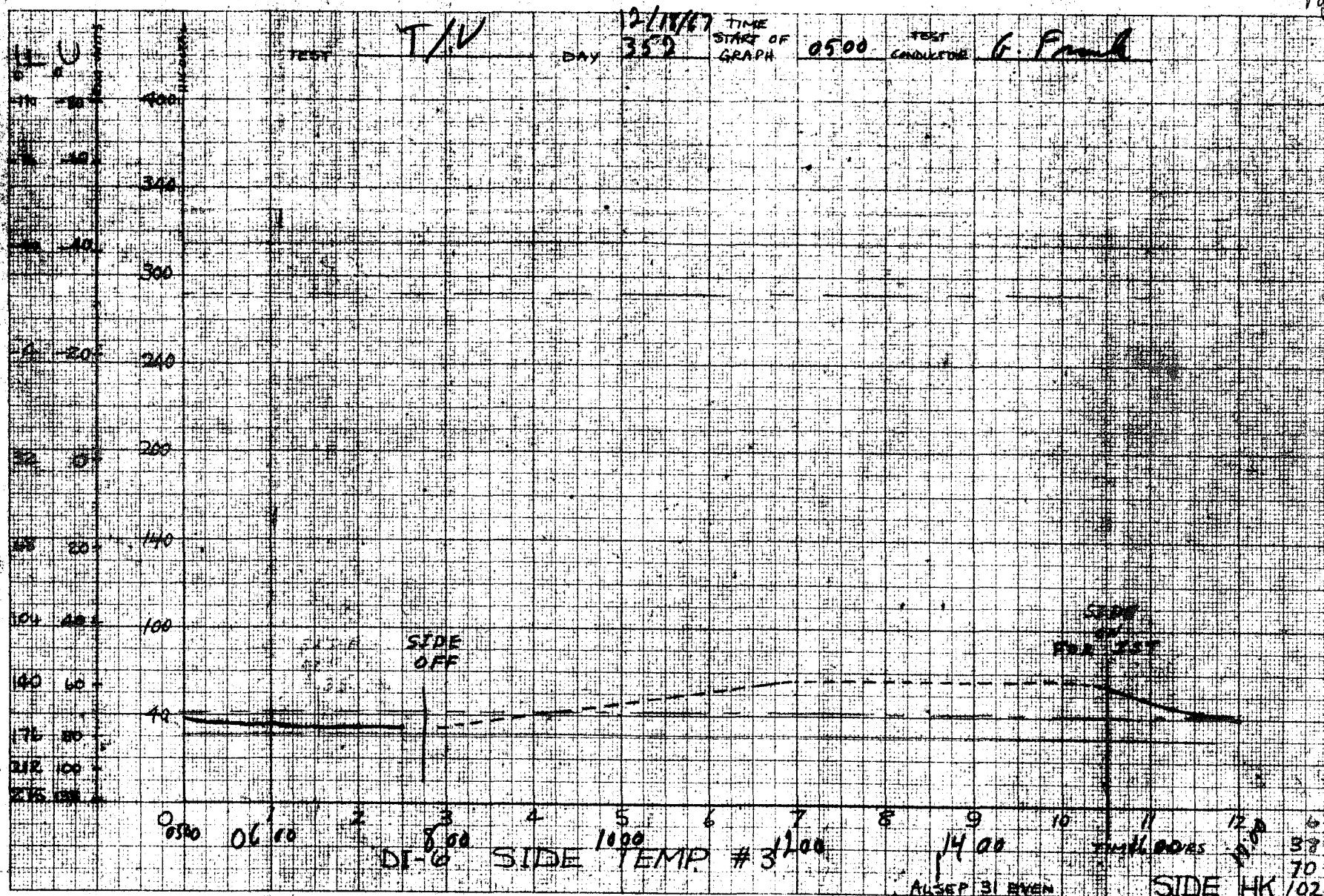




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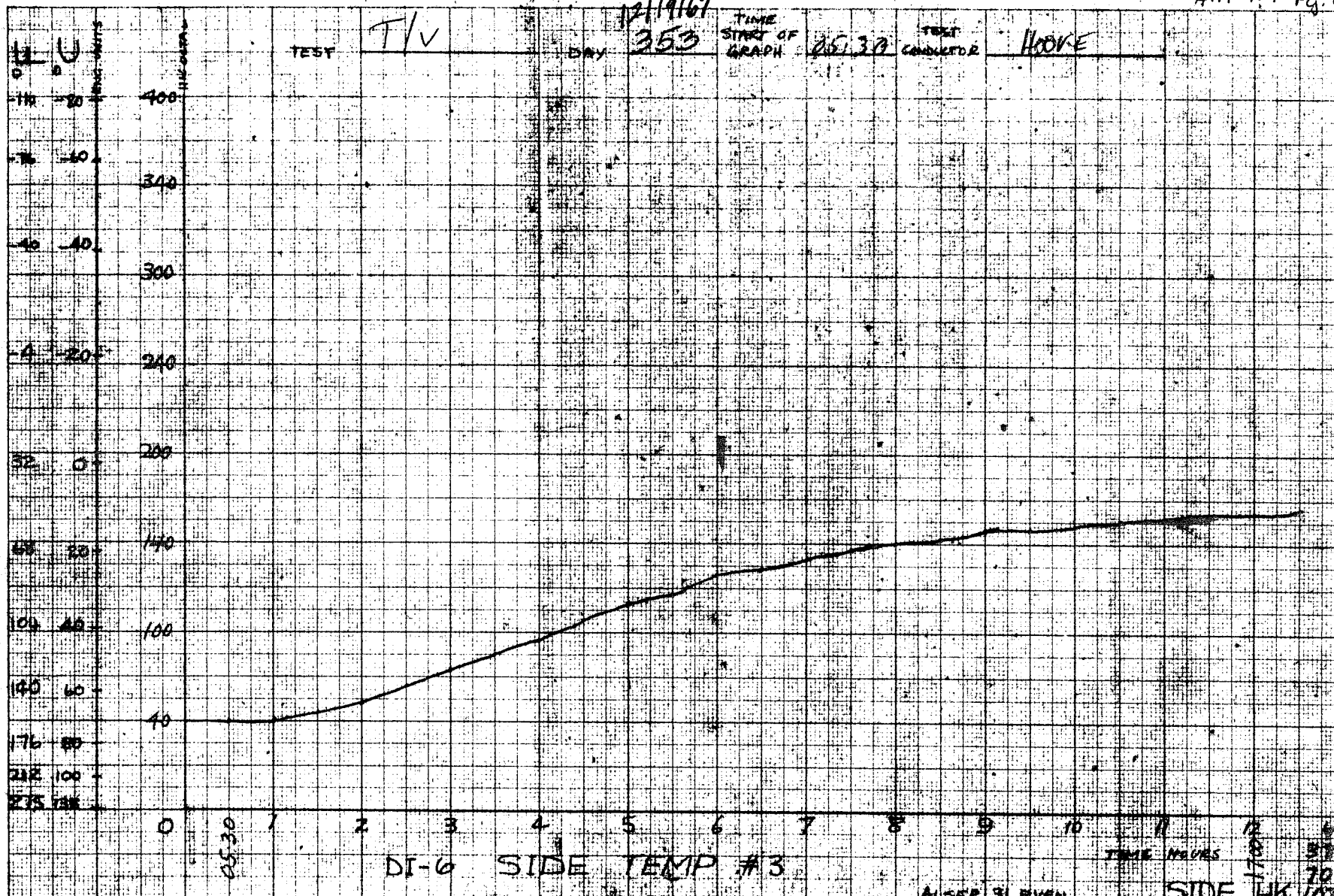
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ALSEP 31 EVEN

WORK 2 FRAMES



ALSEP 31 EVEN

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DE HK 102
02 FRAMES

DI-6 SIDE TEMP #3

TEST
ONLINE

353

TIME
START OF
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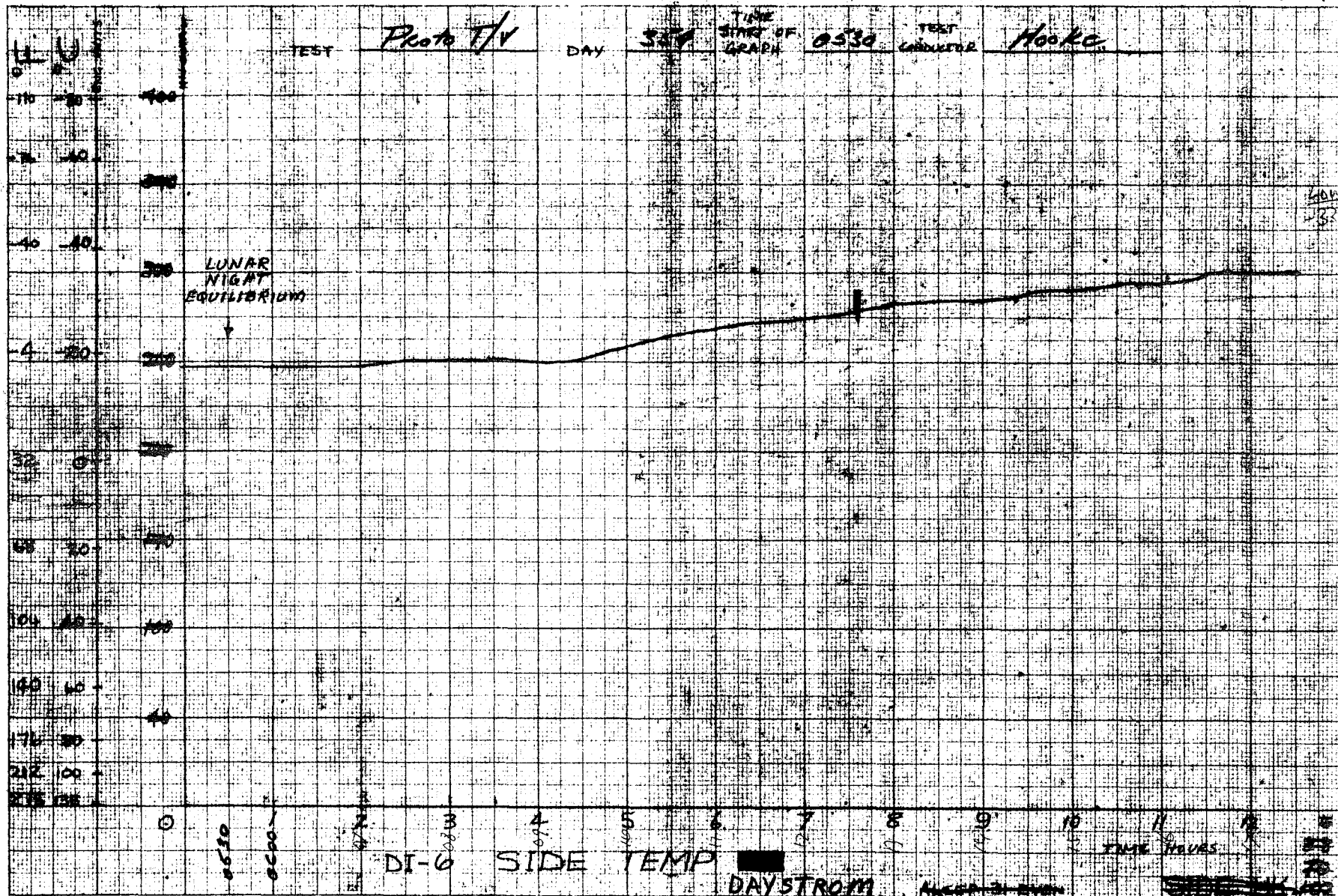
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15-00

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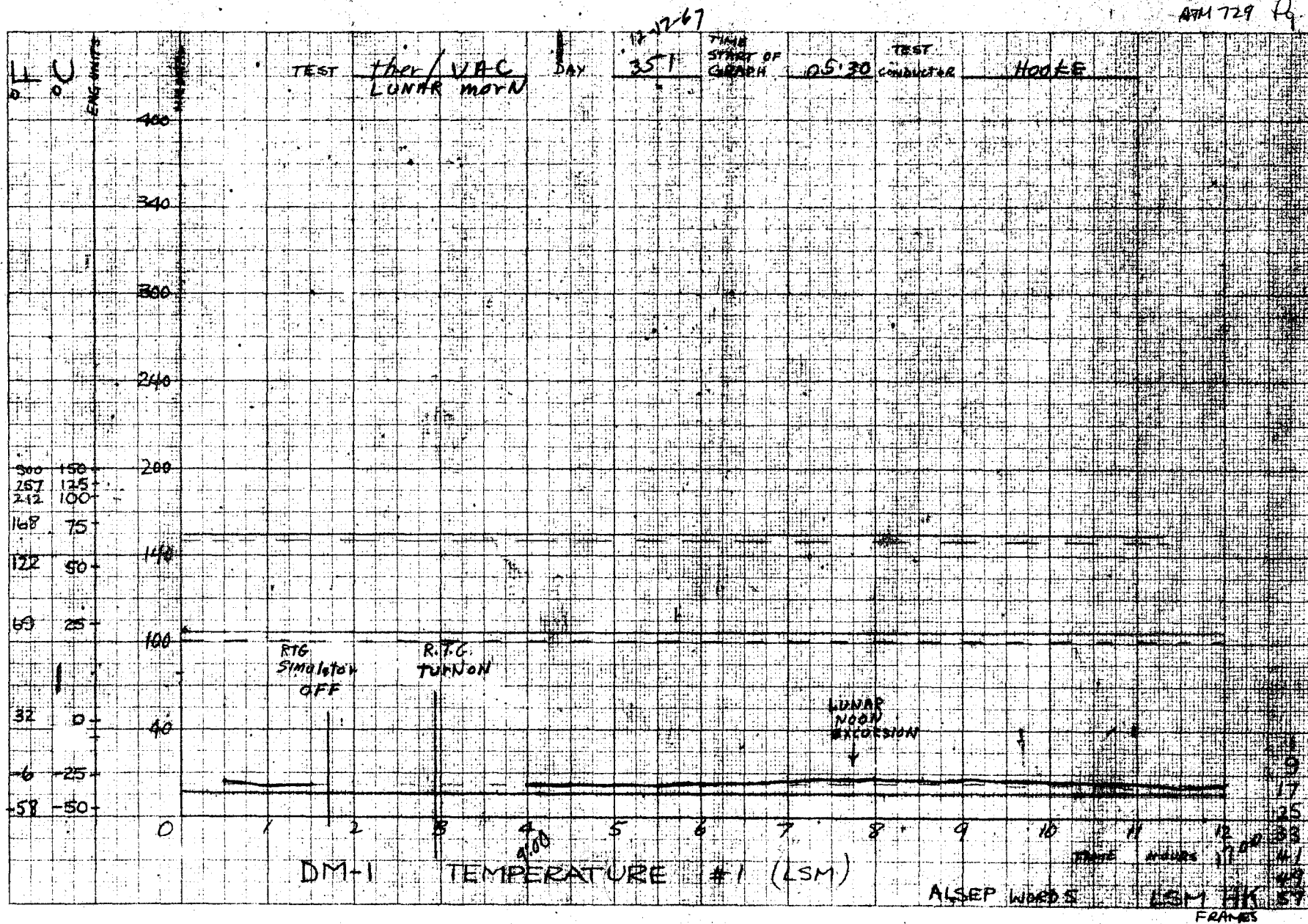
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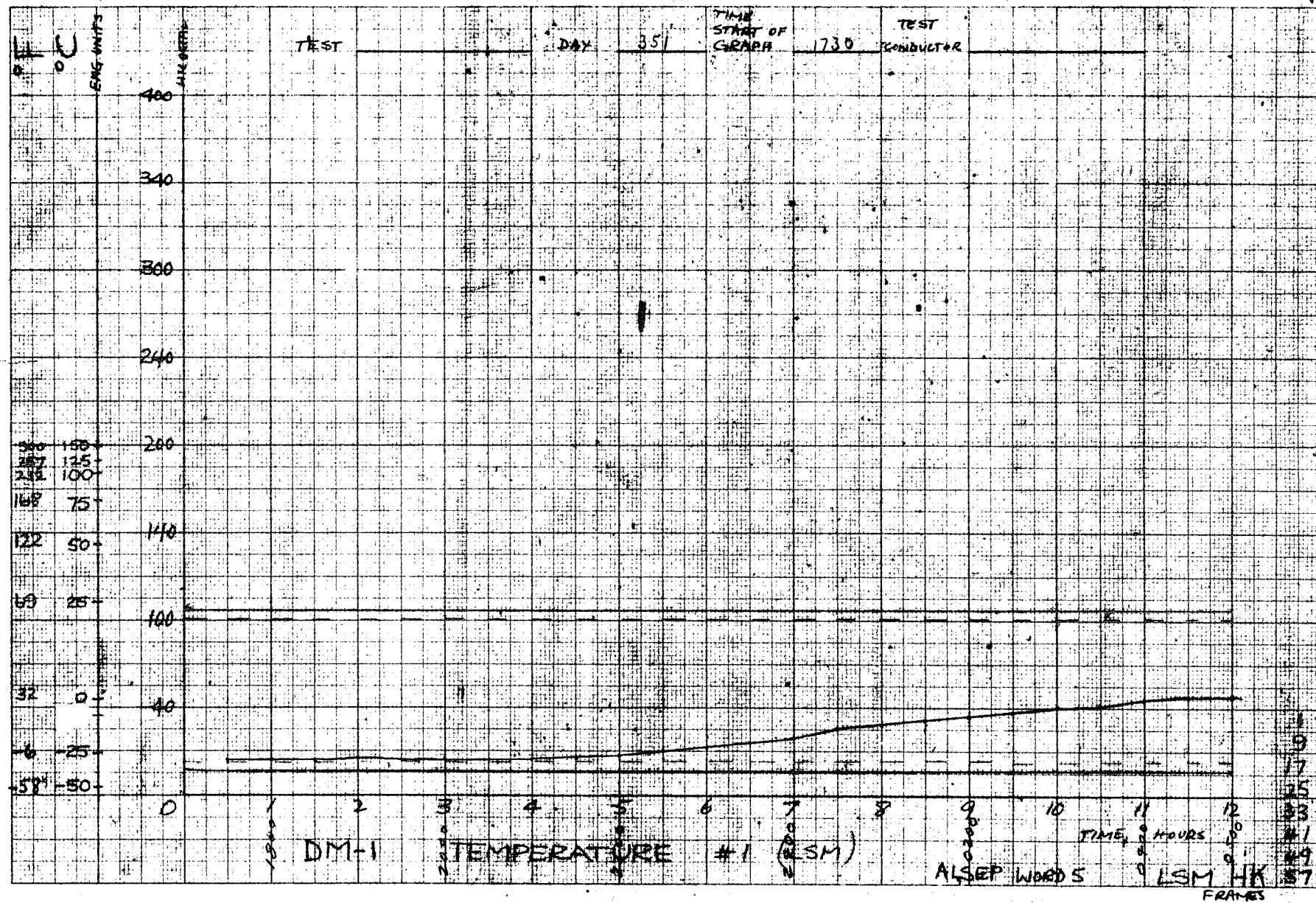
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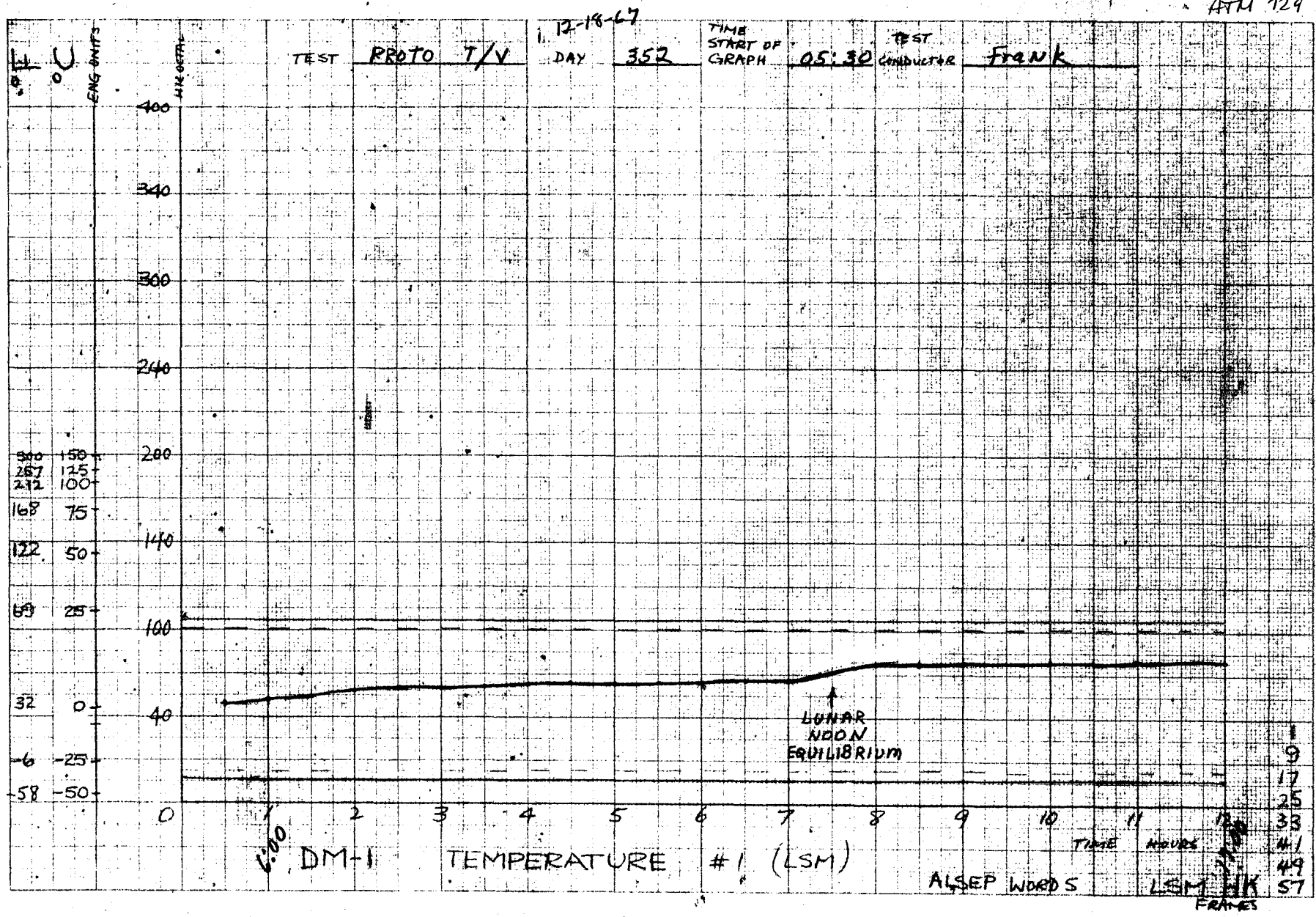
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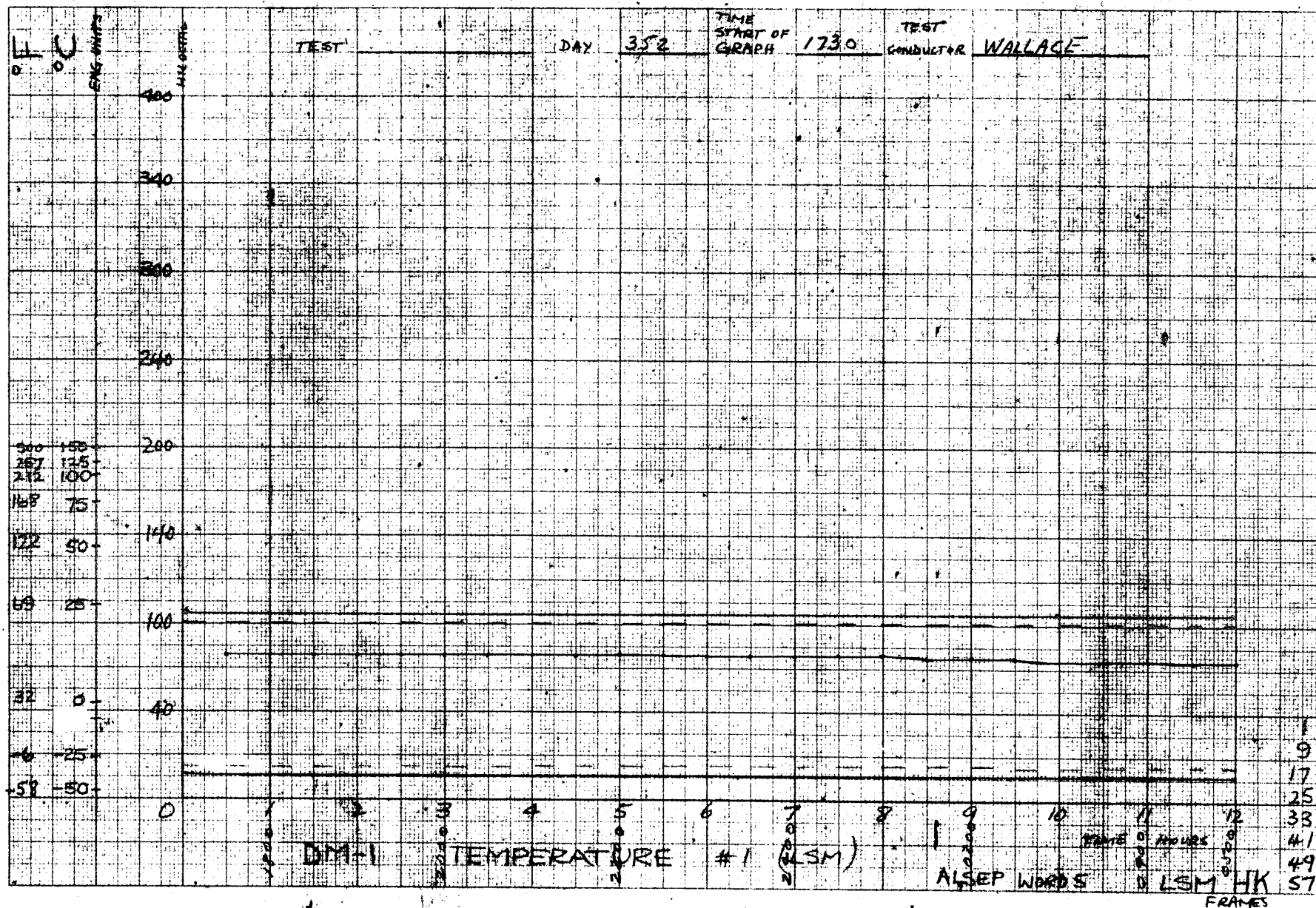


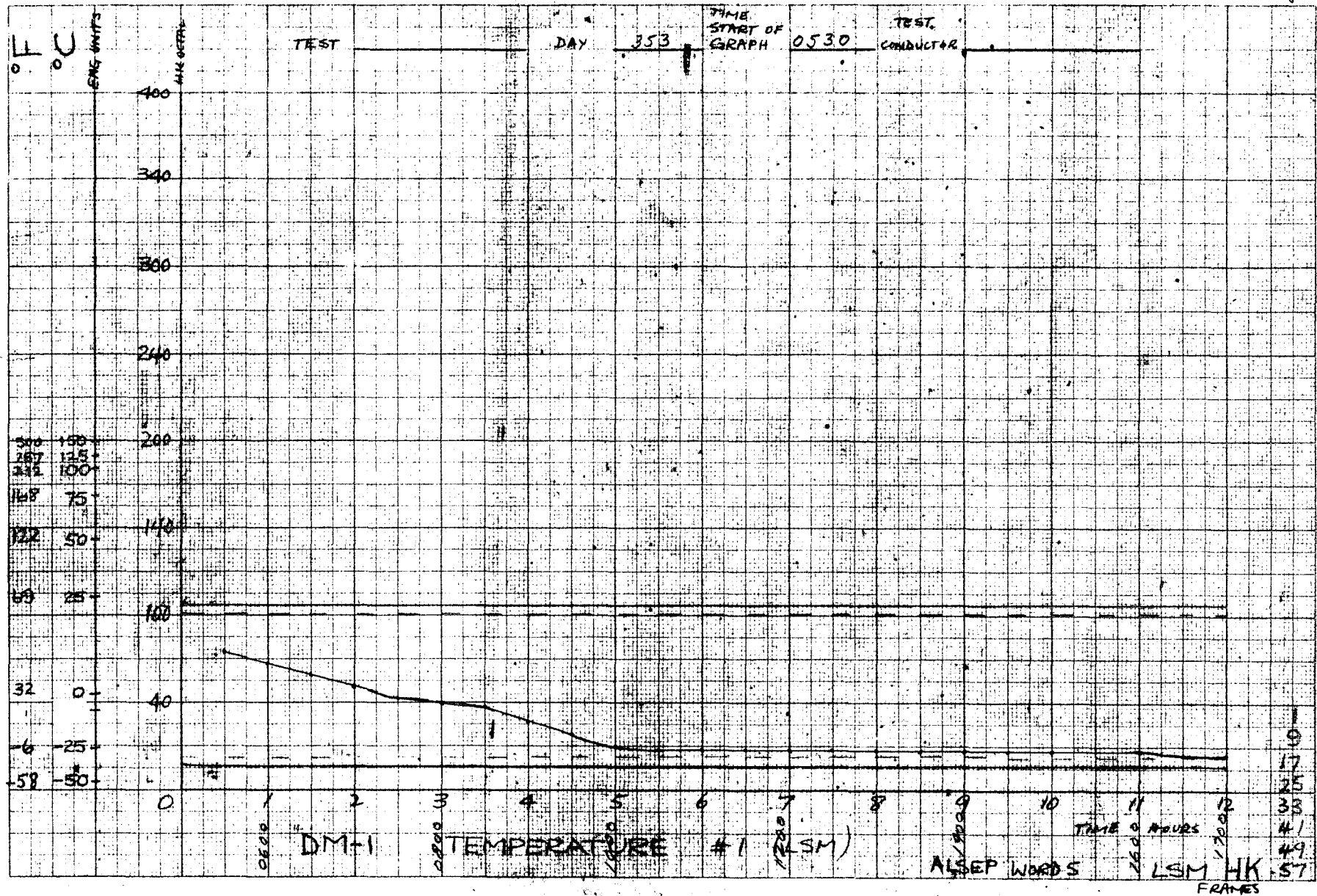


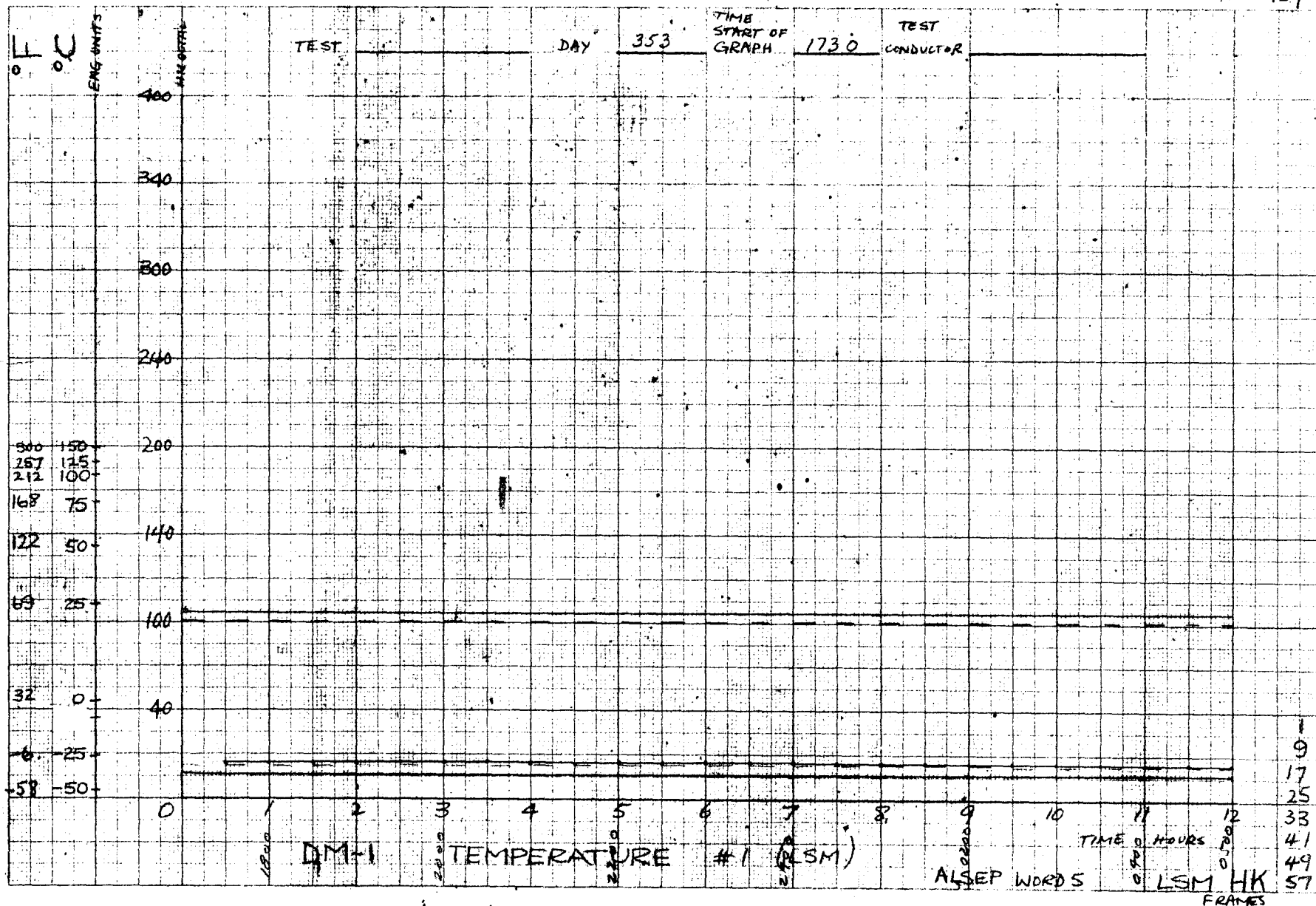
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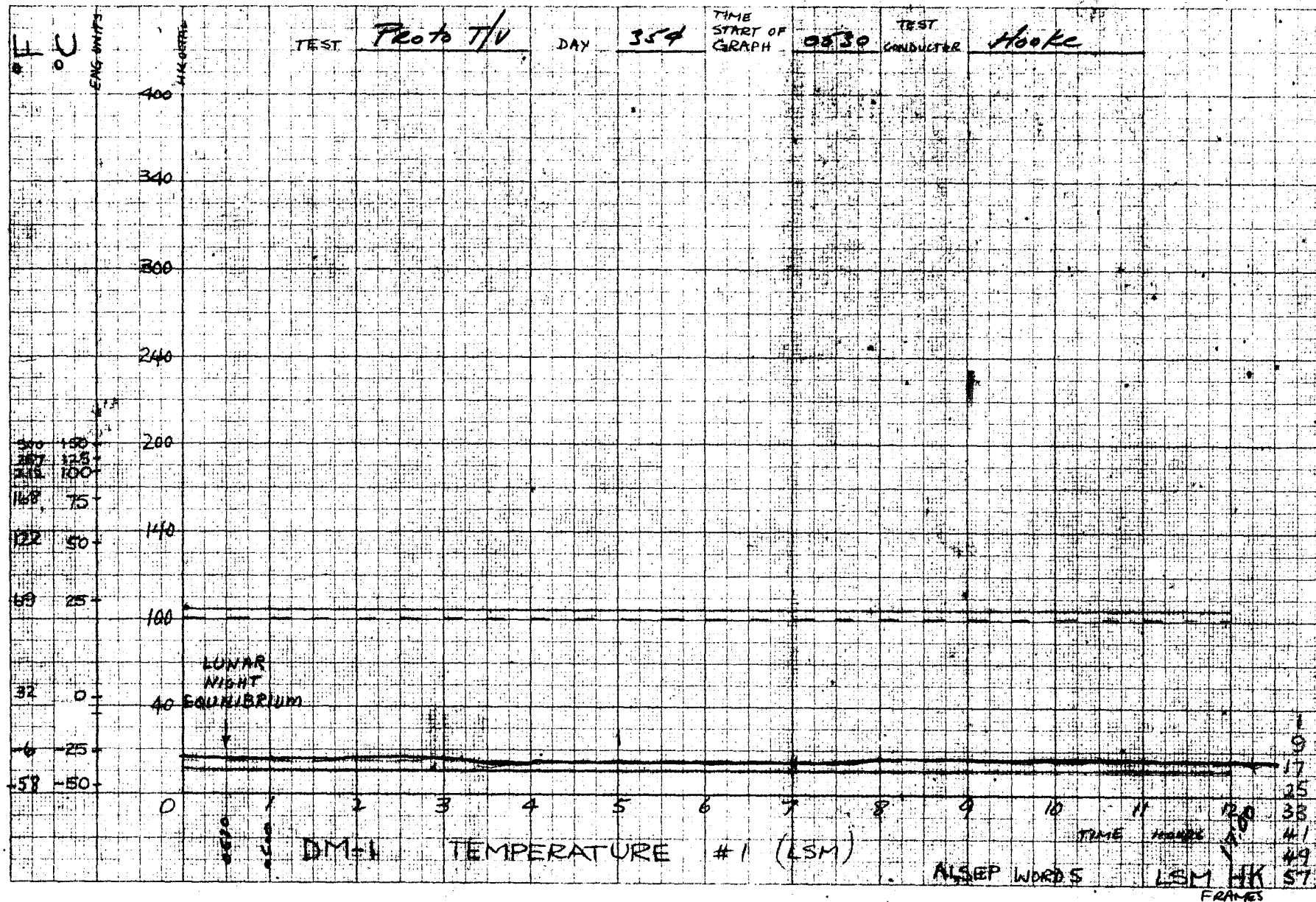
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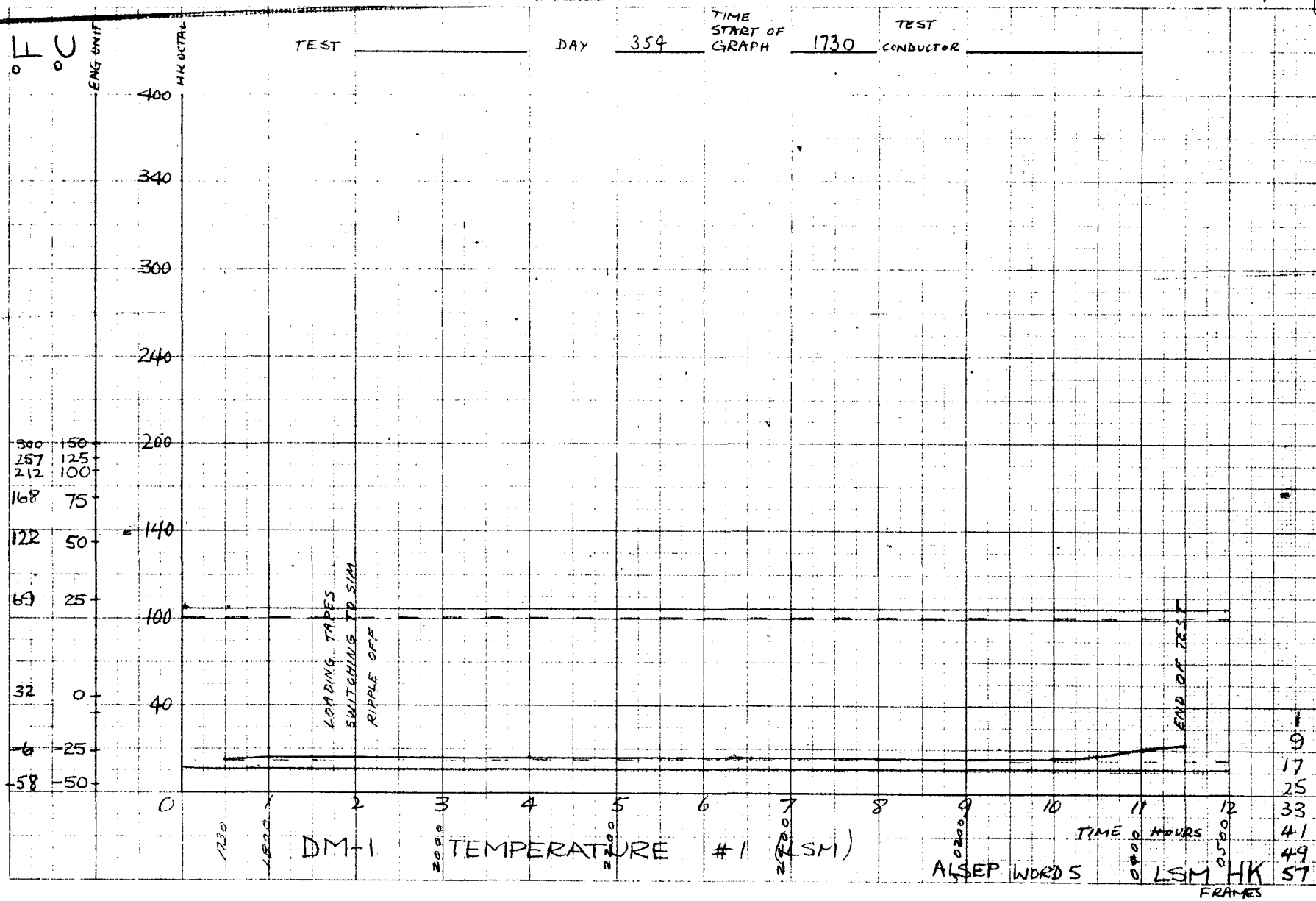


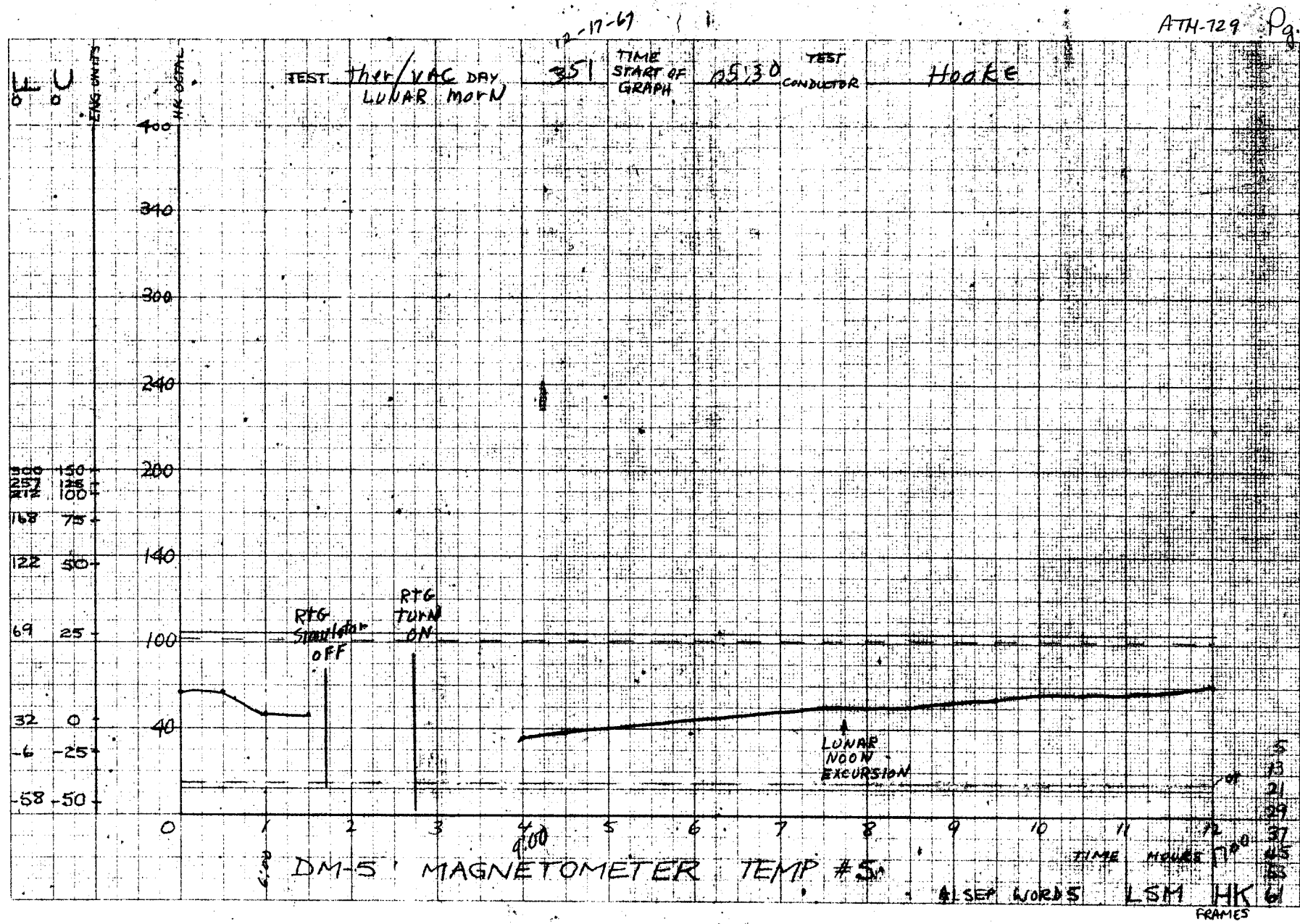


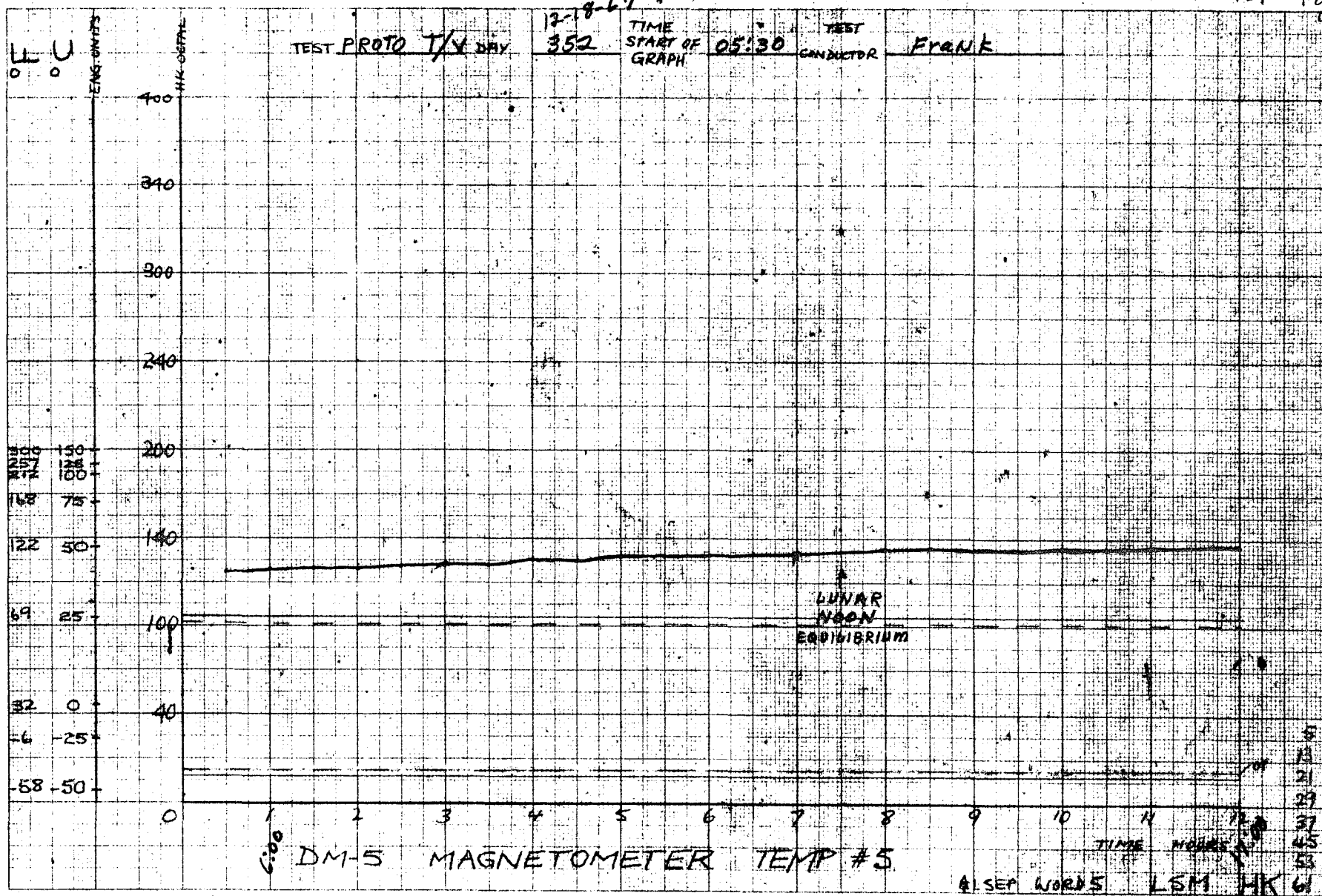




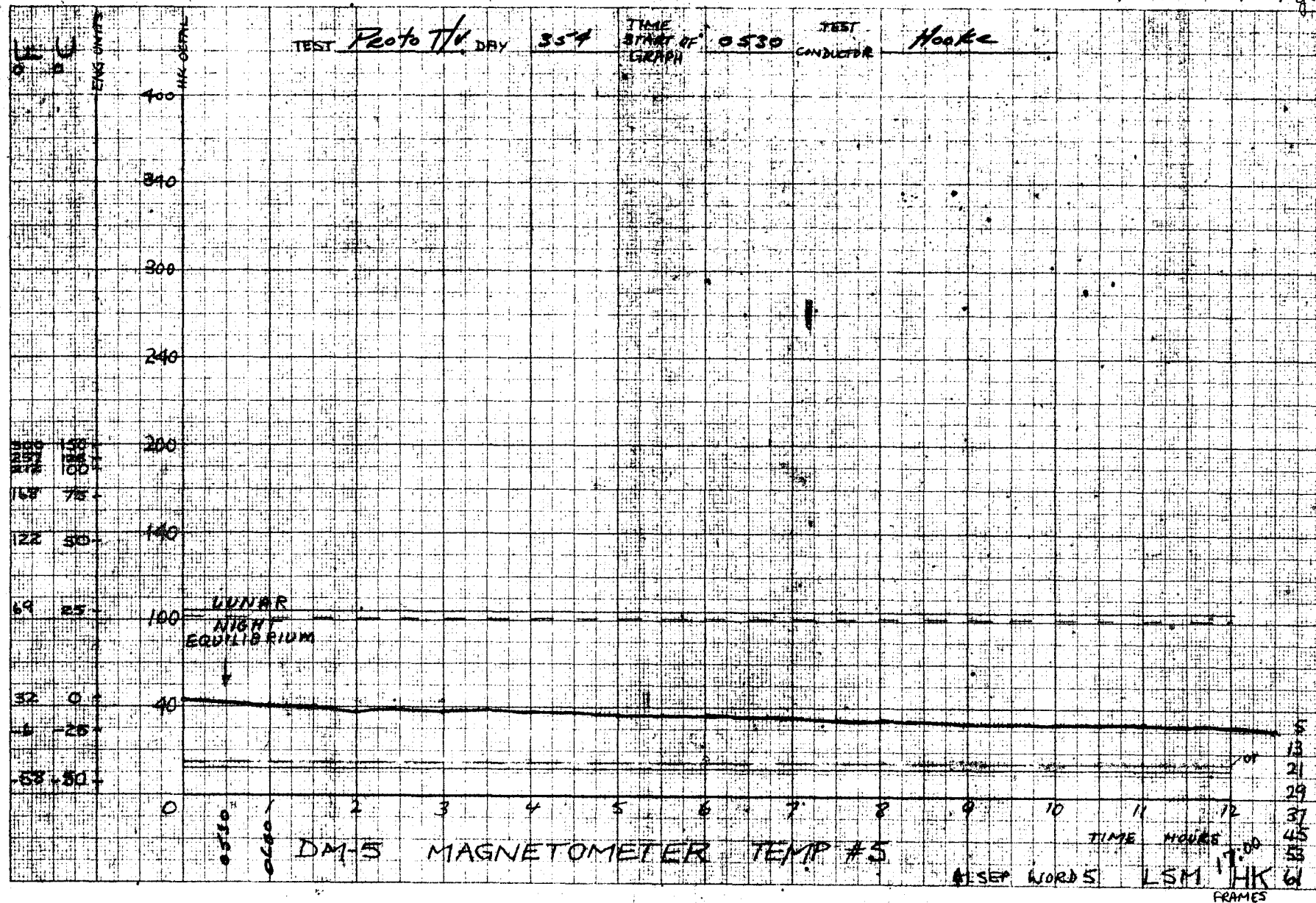
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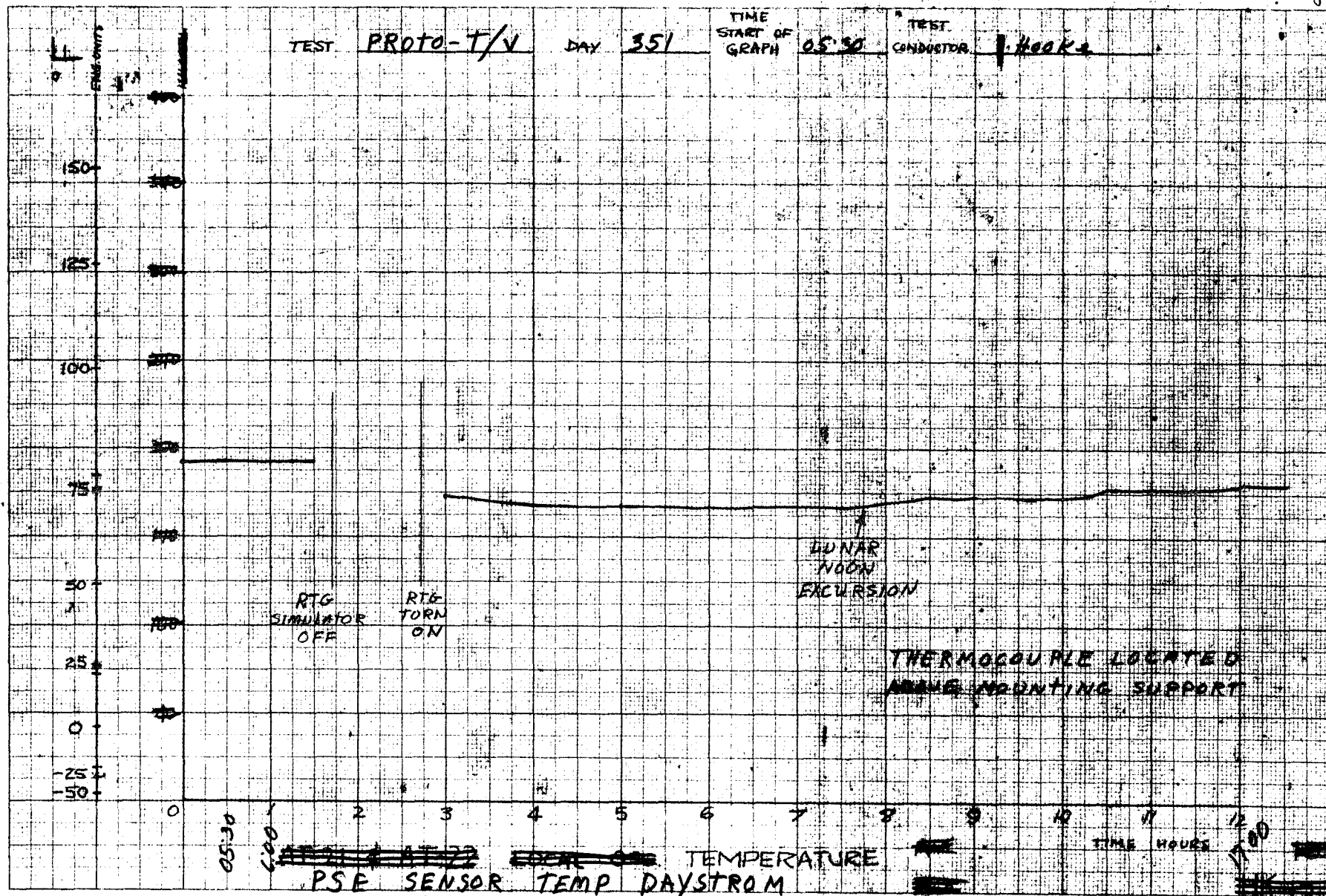




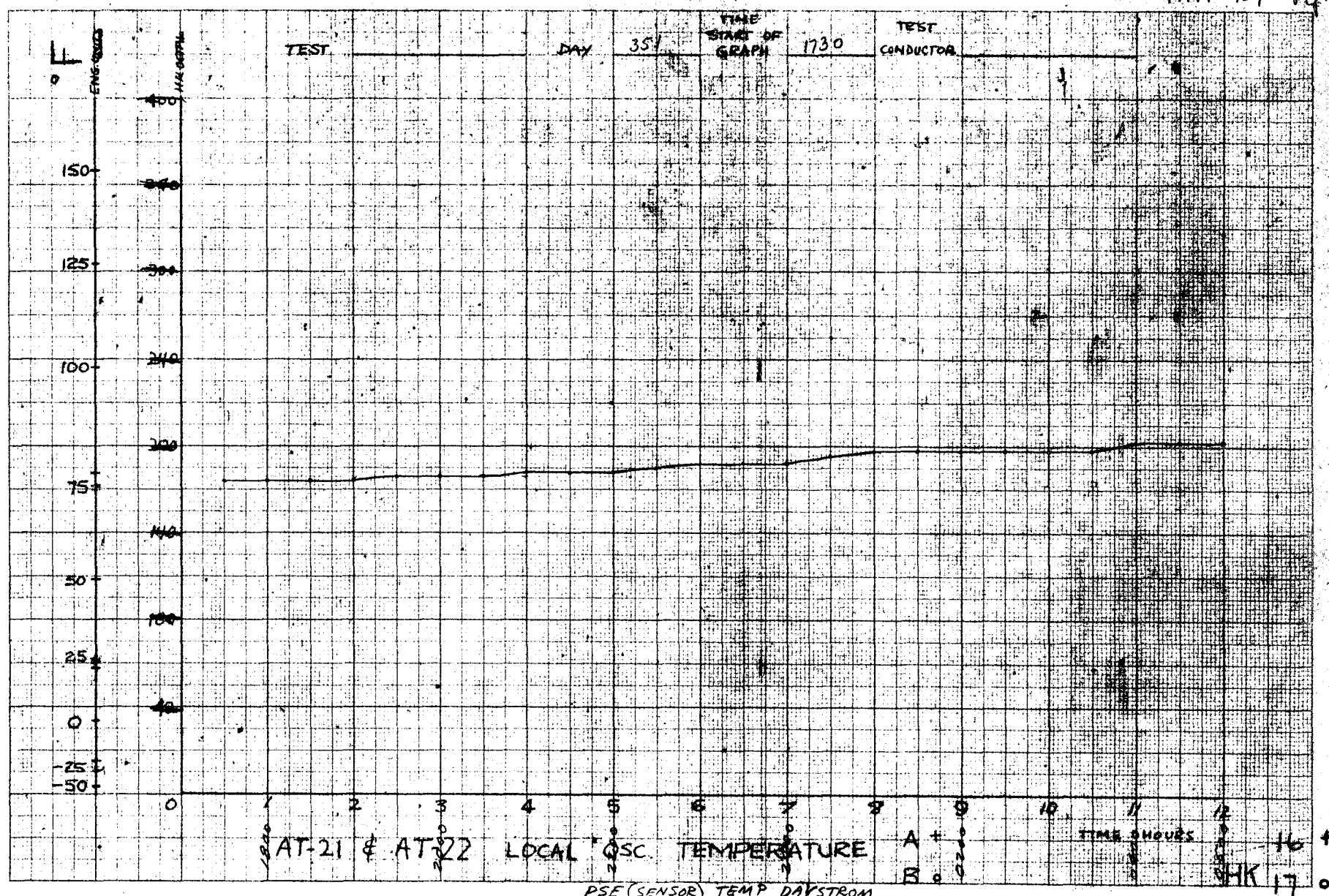


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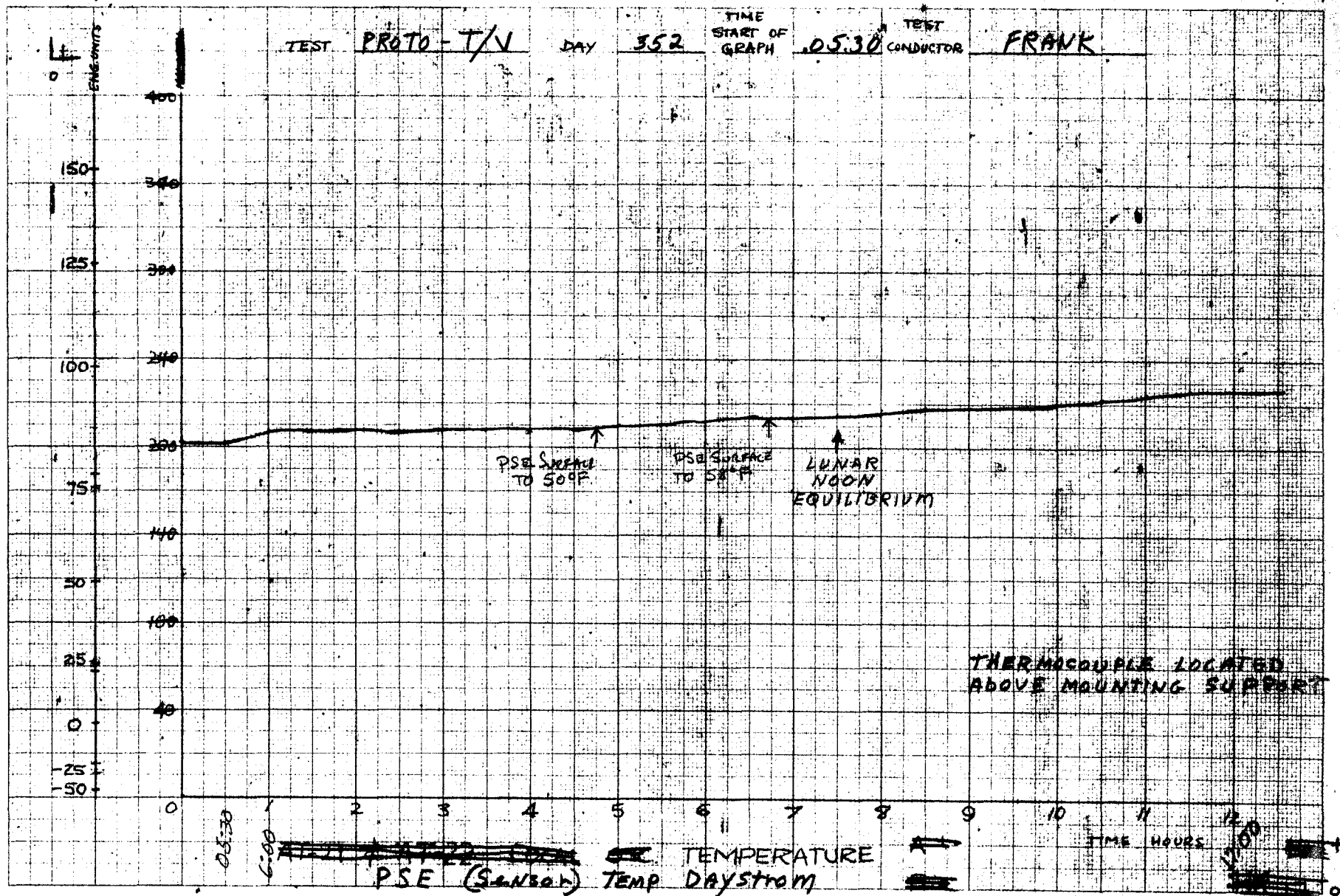


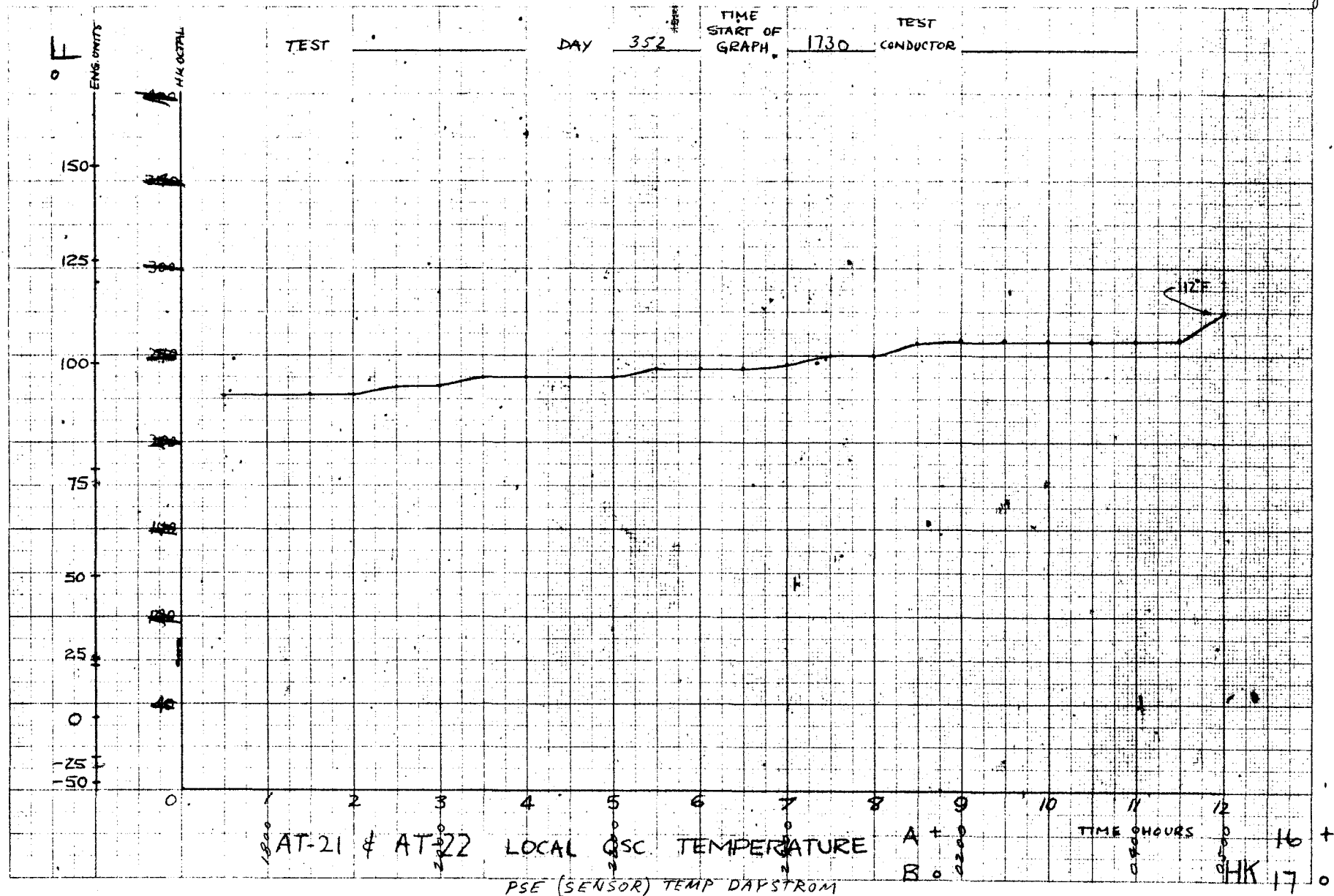
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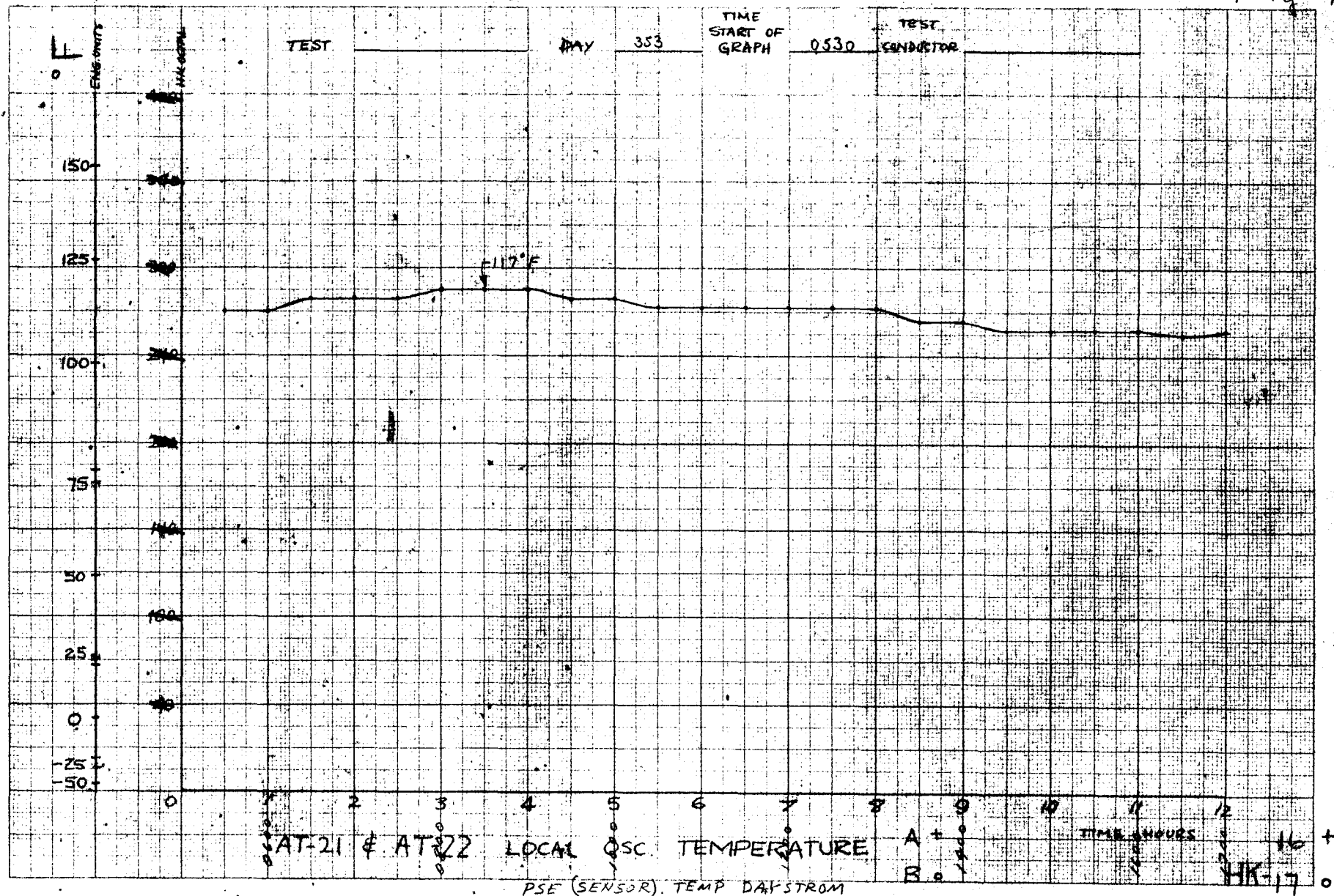
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PAGE TWO

