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ELECTRONIC PERFORMANCE OF THE S-52 PROTOTYPE SPACECRAFT UNDER THERMAL-VACUUM EXPOSURE

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GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

ELECTRONIC PERFORMANCE OF THE S-52 PROTOTYPE SPACECRAFT UNDER THERMAL-VACUUM EXPOSURE

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CONTENTS

		Page
1.	SUMMARY	1
2.	PURPOSE	19
3.	ENVIRONMENTAL EXPOSURE	23
3.1	MOUNTING CONFIGURATION	23
3.2	INSTRUMENTATION	26
4.	TEST PROCEDURES	29
4.1	UNIT A PROCEDURE	34
4.1.1	CHECK OF SPACECRAFT SYSTEM VOLTAGES	34
4.1.2	CHECK 1-YEAR TIMER CURRENTS	35
4.1.3	CHECK TRANSMITTER POWER AND FREQUENCY	35
4.2	UNIT A	35
4.2.1	UNIT A_1 PROCEDURE	35
4.2.1.1	Check of Spacecraft System Voltages	35
4.2.1.2	Check of Transmitter Power and Frequency	35
4.2.1.3	Check of Spacecraft Performance Parameters	37
4.3	UNIT B	38
4.3.1	UNIT B PROCEDURE	38
4.3.1.1	Sync	38
4.3.1.2	Phase One (Ø1) and Phase Two (Ø2) Measurements	40

CONTENTS (continued)

Page

4.4 UNIT C 42

4.4.1 UNIT C PROCEDURE 42

4.4.1.1 Check of Undervoltage and Battery Switching. . . . 42

4.4.1.2 Check of Battery Switching. 45

4.4.1.3 Conclusion of Undervoltage Test 46

4.4.1.4 Dumping 46

4.5 UNIT D 48

4.5.1 UNIT D PROCEDURE 49

4.5.1.1 Command Receiver Sensitivity 49

4.6 UNIT E 50

4.6.1 UNIT E PROCEDURE. 50

4.6.1.1 Micrometeorite Experiment Calibration 52

4.6.1.2 Stimulation Lamp Check of Micrometeorite Experiment 55

4.6.1.3 Ozone Experiment Calibration 58

4.6.1.4 Galactic-Noise Experiment Calibration 62

5. PERFORMANCE-PARAMETER CALIBRATIONS AND TEST RESULTS 65

6. MICROMETEORITE EXPERIMENT TEST RESULTS. . . . 85

7. OZONE EXPERIMENT 109

ILLUSTRATIONS

Figure		Page
1-1	Thermal-Vacuum Temperature Curves	3
2-1	UK 2/S-52, International Satellite	20
2-2	UK 2/S-52 Equipment Layout, Lower Deck	21
3-1	S-52 Prototype Spacecraft Preparatory to Entering 8 by 8 Thermal-Vacuum Chamber	24
3-2	Instrumentation and Experiment-Exciter Connections Complete	25
3-3	S-52 Instrumentation Complex for the Collection and Analysis of Telemetry and Hardline Data	27
3-4	Experiment Exciter Mounted	28
4-1	Data Collection During Programmer #2 Speedup Cycle	30
4-2	Data Collection During Programmer #2 Normal Cycle	30
4-3	Sequences of Operational Modes	51
4-4	Sample Strip Chart Using Programmable Strip-Chart Recording System	64
5-1	PPO Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage	67
5-2	PP1 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage	68
5-3	PP2 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage	69
5-4	PP-11 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage	70
5-5	PP-12 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage	71

ILLUSTRATIONS (continued)

Figure		Page
5-6	PP13 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage	72
5-7	PP14 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage	73
5-8	PP7 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage	74
5-9	PP9 and PP10 Telemetry (10-Period Average) Respect to Temperature and Current	75
5-10	Battery A Discharge Cycle Thermal-Vacuum -15°C	78
5-11	Battery B Discharge Cycle Thermal-Vacuum -15°C	79
6-1	Micrometeorite Experiment Measurements at -15°C	87
6-2	Micrometeorite Experiment Measurements at Ambient	93
6-3	Micrometeorite Experiment X-Y Plot of Telemetry Response Excited From Pulse Generator +60°C	97
6-4	Response of Recovered Galactic-Noise Experiment High-Speed Telemetry and Associated Sweep at -15°C Vacuum	103
6-5	Response of Recovered Galactic-Noise Experiment High-Speed Telemetry and Associated Sweep at Ambient	105
6-6	Response of Recovered Galactic-Noise Experiment High-Speed Telemetry and Associated Sweep at +60°C Vacuum	107

TABLES

Table		Page
1-1	Performance Summary	18
2-1	UK 2/S-52 Equipment Layout, Upper Deck	22
4-1	Performance Parameter Data Sheet	31
4-2	Unit A Data Sheet	33
4-3	Unit A_1 Data Sheet	36
4-4	Unit B Data Sheet	39
4-5	Unit C Data Sheet	43
4-6	Unit C_1 Data Sheet	44
4-7	Unit D Data Sheet	48
4-8	Unit E_1 Data Sheet	52
4-9	Micrometeorite Experiment Brush Calibration, Data Sheet, E_2	53
4-10	DROD Foil Advance Detector, Unit E_3	56
4-11	Ozone Calibration, Unit E_4	59
4-12	Ozone Spectrophotometer Calibration, Unit E_5	60
4-13	Galactic Noise Experiment Calibration Data Sheet, Module E_6	63
5-1	Performance Parameters for S-52 Prototypes	65
5-2	Conversion Table	66
5-3	Spacecraft Parameter Deviations, Power System	80
5-4	Spacecraft Parameter Deviations, Programmer System	81

TABLE (Continued)

Table		Page
5-5	Undervoltage	81
5-6	Spacecraft Parameter Deviations, Telemetry System	82
5-7	Identification Frequency Deviations	83
6-1	Micrometeorite Experiments — Brush Recorder Calibrations	85
6-2	Fixed Amplitude Pulses	85
7-1	Ozone Spectrophotometer Calibration	110
7-2	Ozone Calibration	111

ABBREVIATIONS

CAL	–	calibrate
cm	–	centimeter
Chan	–	channel
Chg	–	charge
DC	–	direct current
Dischrg	–	discharge
$\overline{T}$	–	encoder clock frequency
EHT	–	extra high tension
EXT	–	external
FAP	–	foil advance pulse
GN	–	galactic noise
gnd	–	ground
GS	–	ground station
HP	–	Hewlett Packard
HS	–	high speed
$\overline{L}$	–	high speed matrix A output
$\overline{\wedge}$	–	high speed reset
HT	–	high tension
IROD	--	instantaneous readout detector
DROD	–	delayed readout detector
LS	–	low speed

ABBREVIATIONS (Continued)

Mag	–	magnetic
Mech	–	mechanism
Mc	–	megacycle
MM	–	micrometeorite
μsec	–	microseconds
ms	–	milliseconds
M1	–	mode 1
M2	–	mode 2
Mod	–	modulation
Mon (O_2)	–	monitor
Neg	–	negative
Osc	–	oscillator
Oz (O_1)	–	ozone
PP	–	performance parameter
PA	–	period average
∅	–	phase
PB	–	playback
P-2	–	Programmer 2
Proto	-	prototype
Sig	–	signal
S/C	–	spacecraft

ABBREVIATIONS (Continued)

Spect	–	spectrometer
SU	–	speedup
Stab	–	stabilizer
SR	–	sunrise
SS	–	sunset
Swp	–	sweep
SW	–	switch
Sync	–	synchronization
TR	–	tape recorder
TM	–	telemetry
temp	–	temperature
XMTR	–	transmitter
UV	–	undervoltage
Unreg.	–	unregulated
Vert	–	vertical
VAC	–	volts alternating current
WB	–	wideband

1. SUMMARY

Author

28929

The S-52 prototype spacecraft was subjected to the design qualification thermal-vacuum exposure from May 30 to June 28, 1963. Figure 1-1 is a complete time history of exposures and pertinent events.

The S-52 prototype spacecraft performed as intended, except for anomalies shown in Table 1-1. Modifications of the S-52 prototype spacecraft to correct these anomalies were verified in the subsequent solar-simulation exposure.

The data collected, calibrations performed, and analysis made, to evaluate the performance of the spacecraft throughout the exposure, are included in the appropriate sections of this report. Test procedures and instrumentation used are also covered.

Author

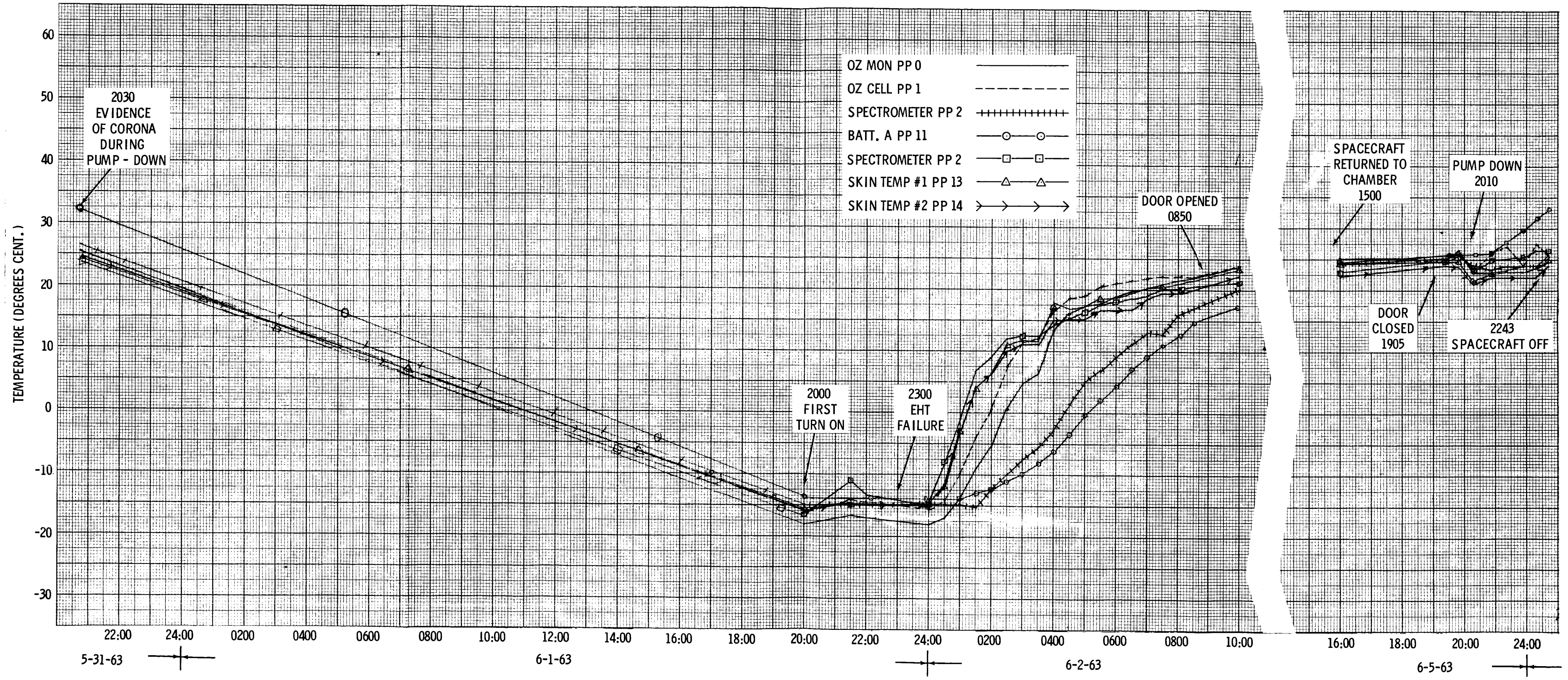


Figure 1-1—Thermal - Vacuum Temperature Curves

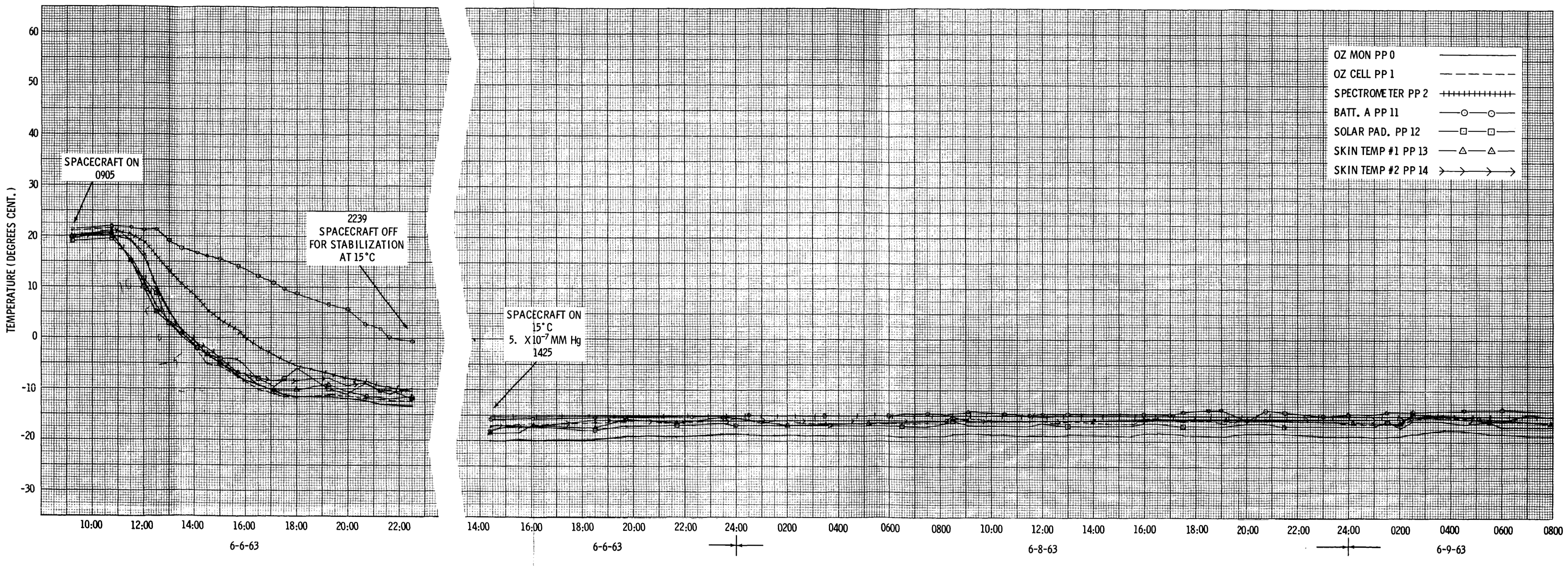


Figure 1-1—Thermal-Vacuum Temperature Curves—Continued

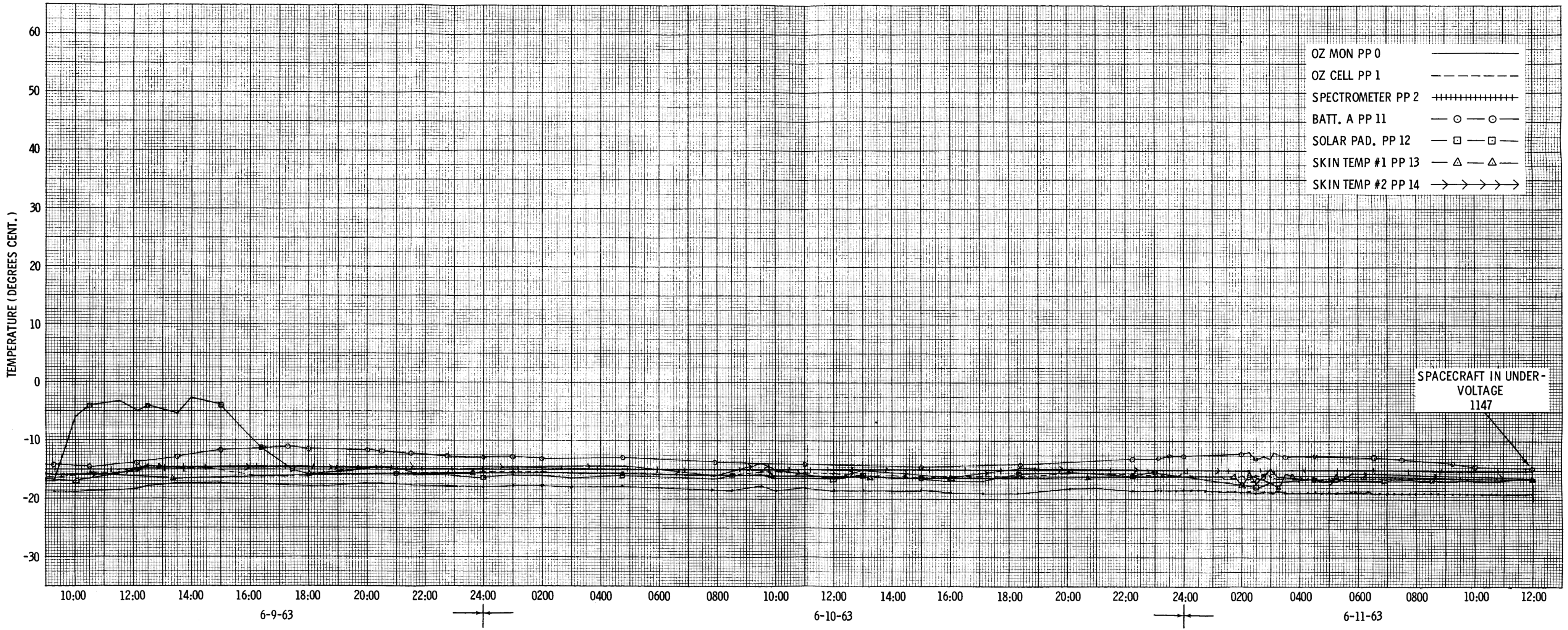


Figure 1-1—Thermal-Vacuum Temperature Curves—Continued

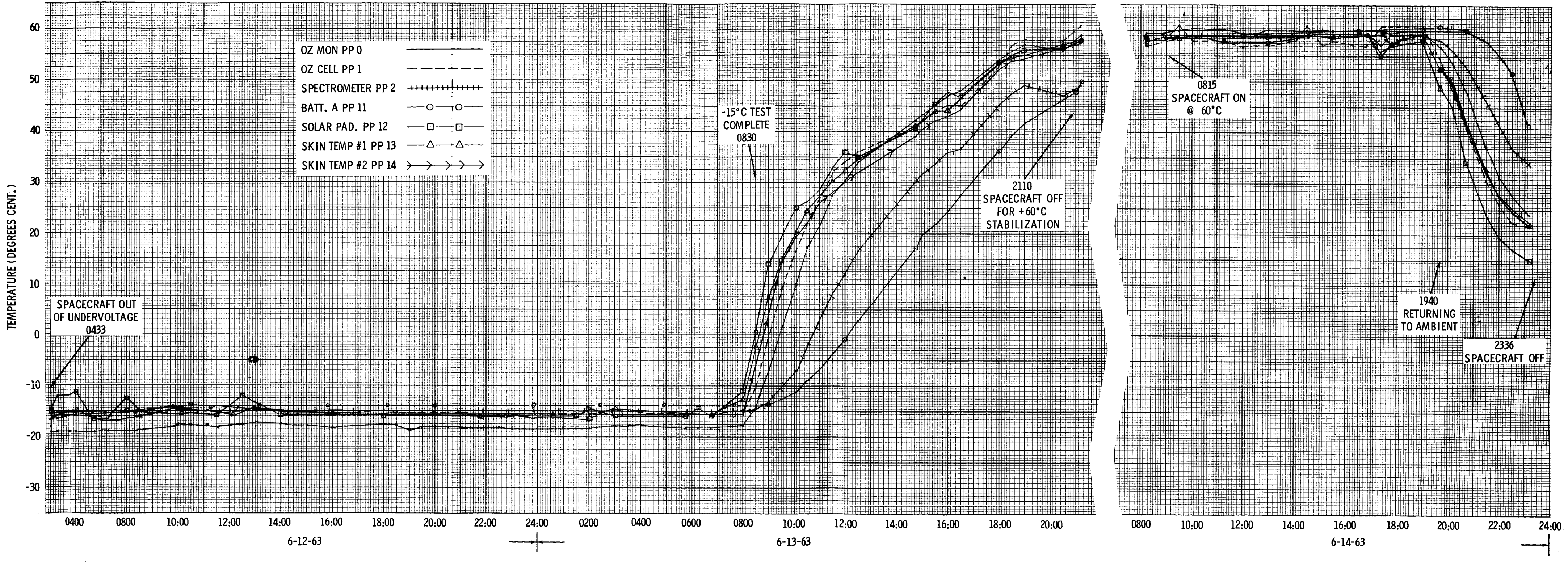
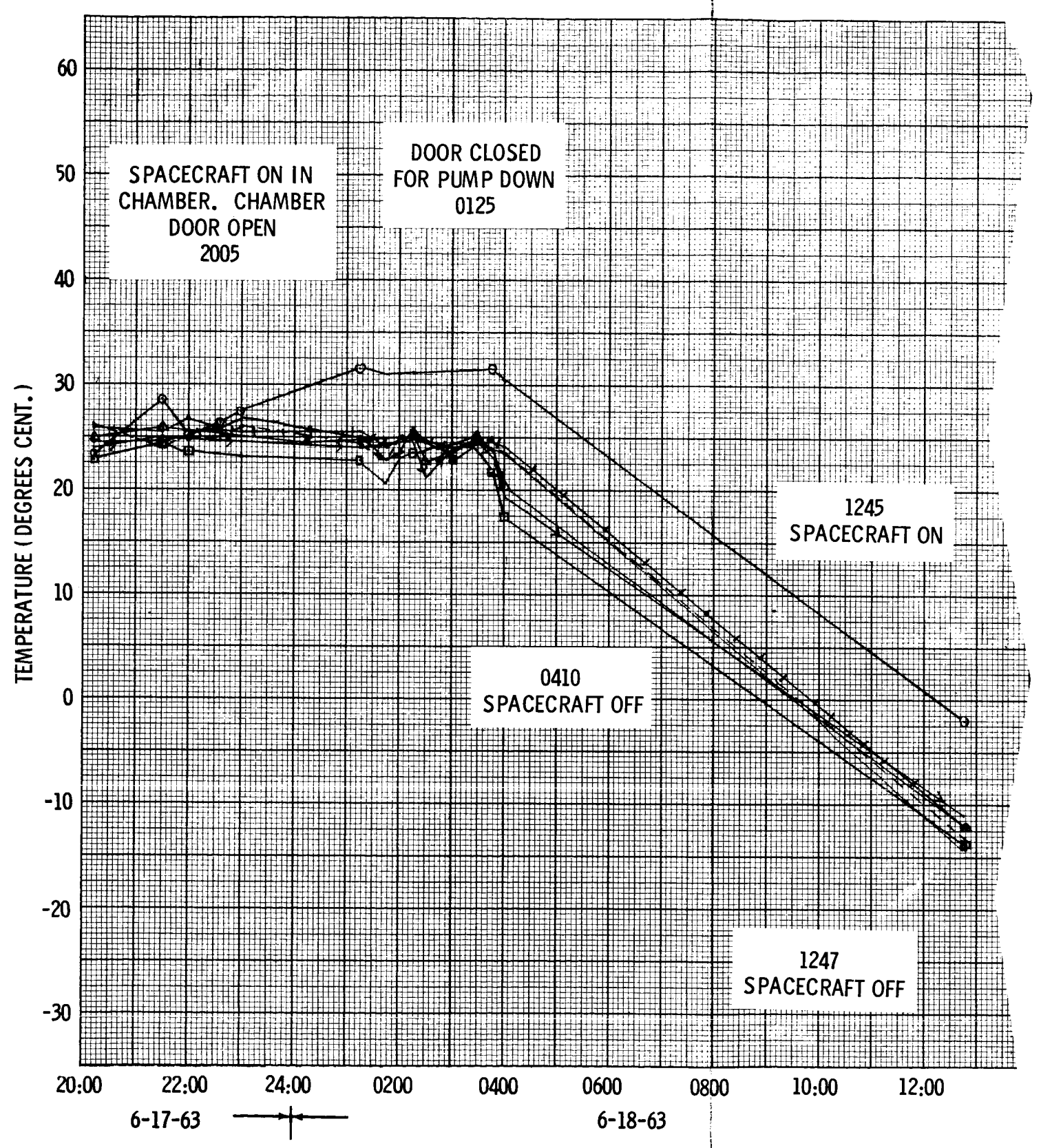


Figure 1-1—Thermal-Vacuum Temperature Curves—Continued



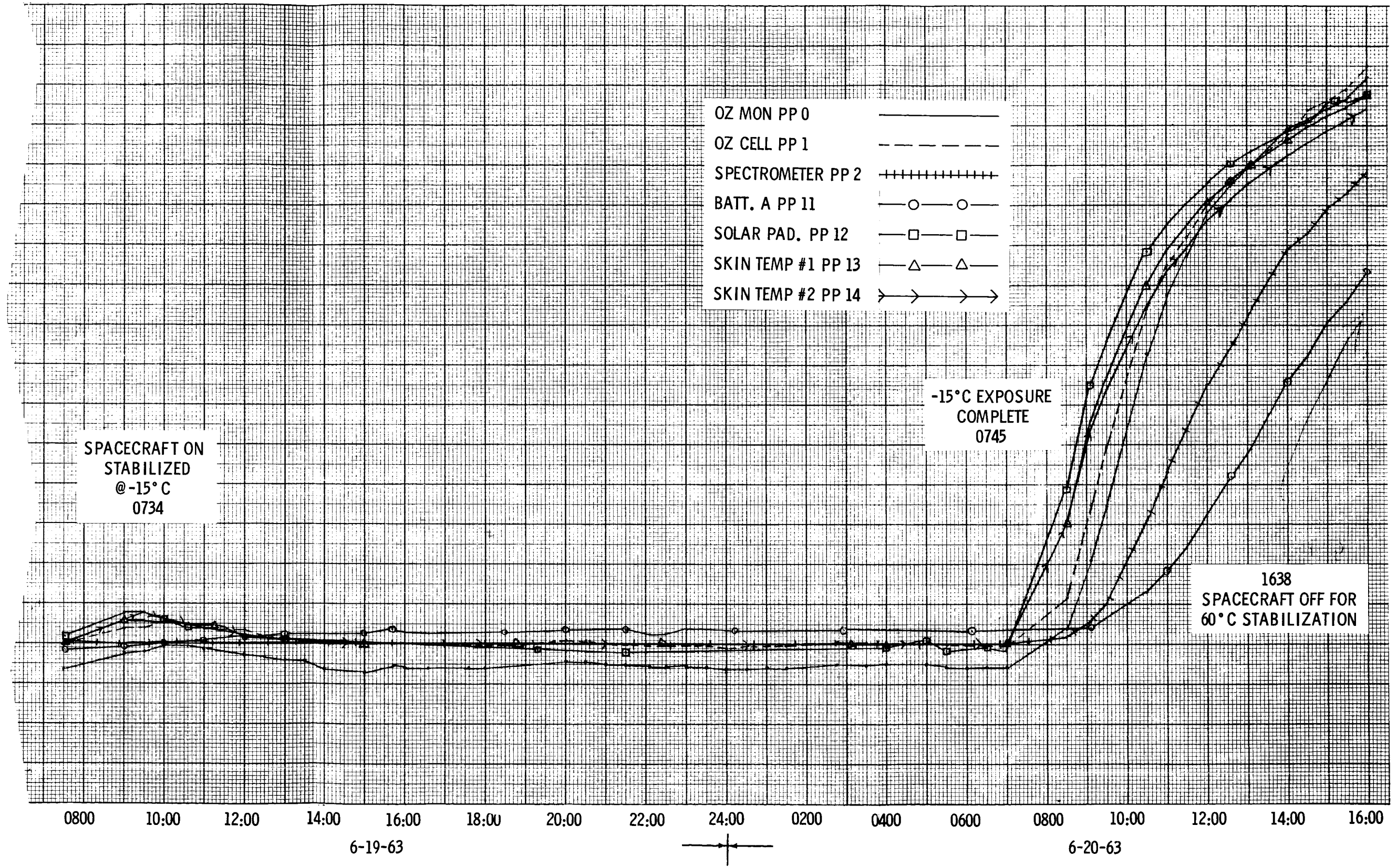


Figure 1-1—Thermal-Vacuum Temperature Curves—Continued

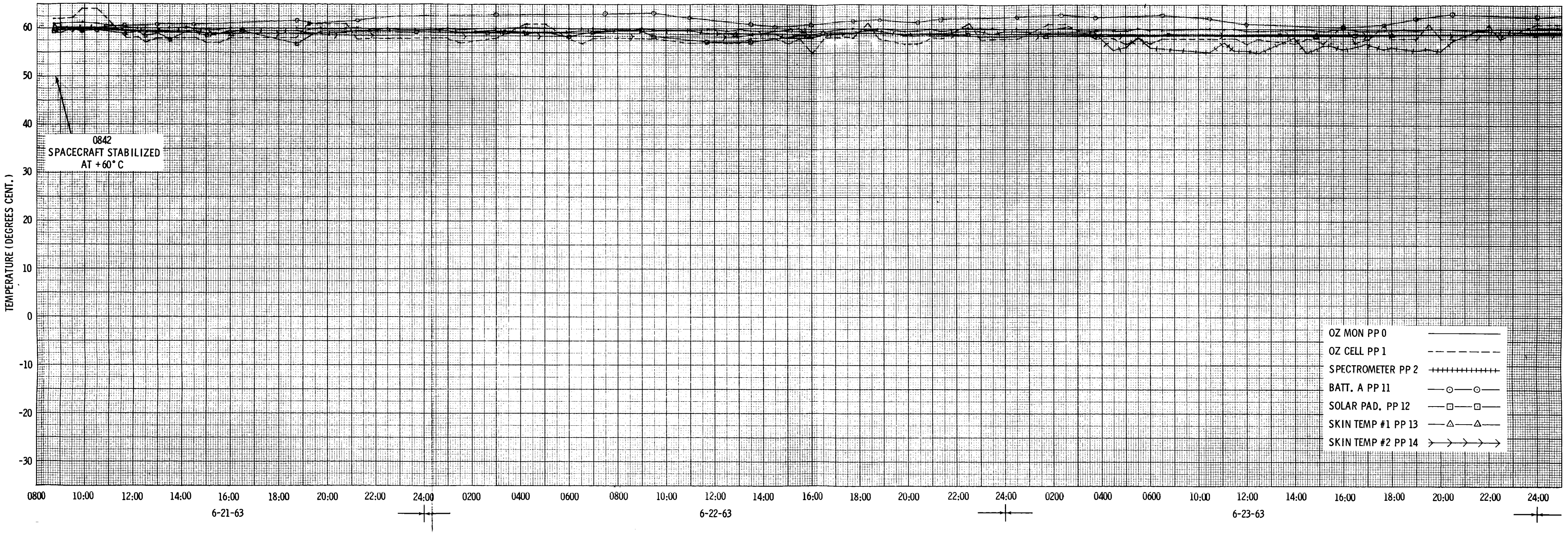


Figure 1-1—Thermal-Vacuum Temperature Curves—Continued

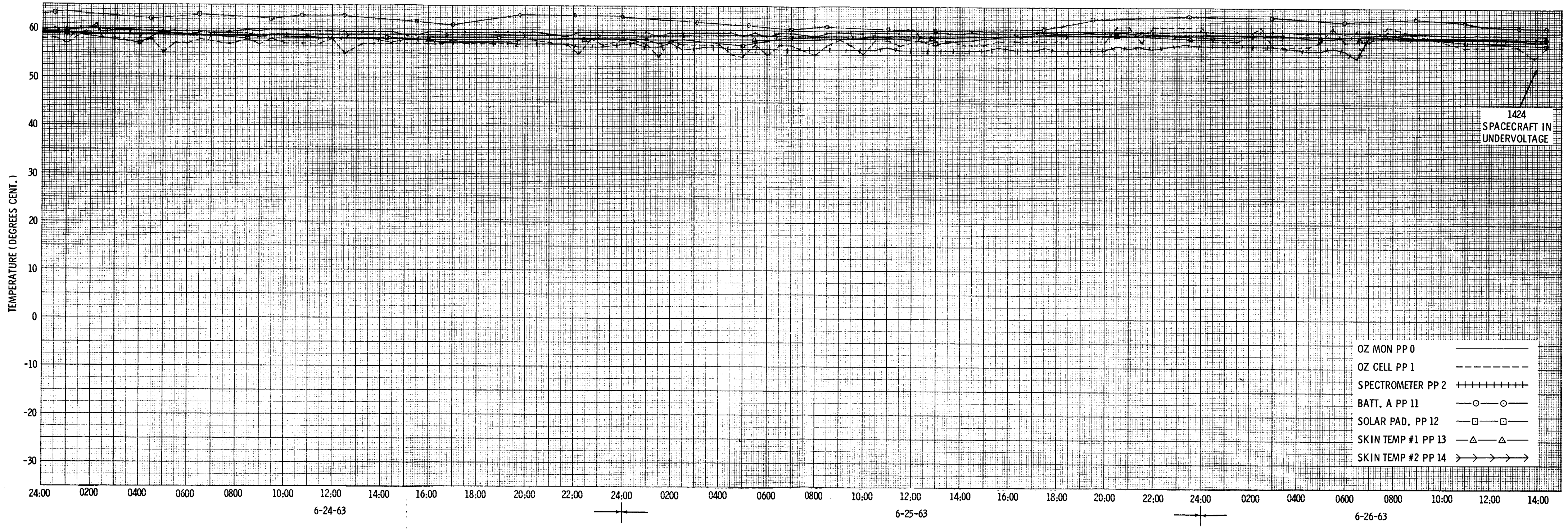


Figure 1-1—Thermal-Vacuum Temperature Curves—Continued

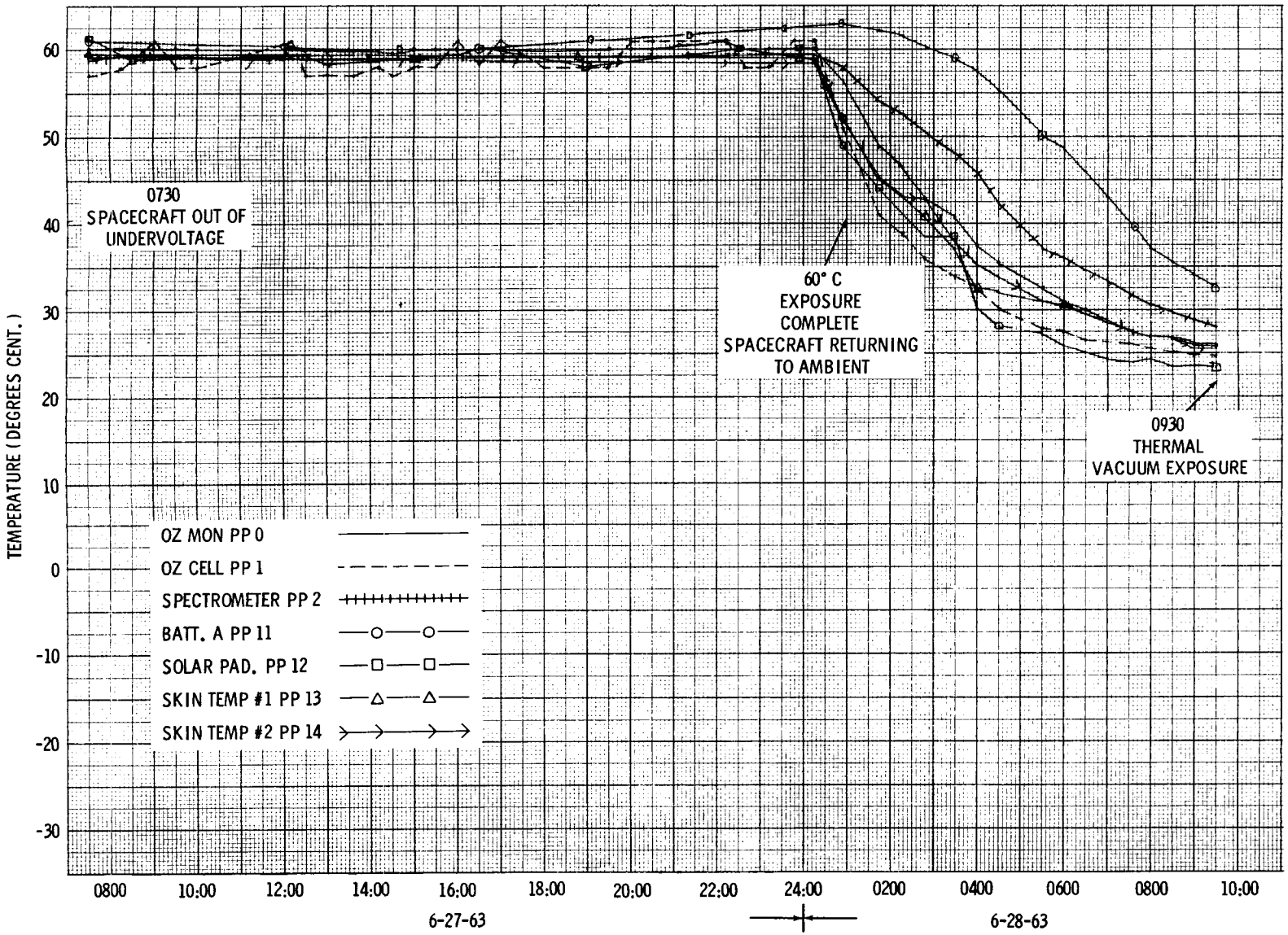


Figure 1-1—Thermal-Vacuum Temperature Curves—Concluded

TABLE 1-1

PERFORMANCE SUMMARY

Subassembly	Serial Number	Test Condition	Problem	Cause	Action Taken	Remarks
Harness	Proto	At each evacuation	Extended presence of corona discharge	Slow leakage in sealed high-voltage connector	Drilled pressure relief hole in connector	May 30, 63 From subassembly tests found could live with short term corona discharge verified in spacecraft exposure from June 18, 63
EHT card (ozone extra high tension)	2	-15°C 2×10^{-6} mm/Hg	Loss of high voltage (2kv)	Defective capacitor	Replaced all capacitors of this type	June 1, 63 Manufacturing stated capacitors not suitable for vacuum use
HT card (ozone high tension)	4		None		HT2 replaced HT4	June 17, 63 HT2 updated with new type capacitors
Programmer #1 amplifier	002	-15°C 2×10^{-6} mm/Hg	15.4-kc timing signal became erratic on playback; decommutator unable to recognize	Amplifier output set too high	External monitor point loaded with resistor to provide proper record level	June 3, 63 Amplifier will be adjusted after test
EHT card	2	+60°C 2×10^{-6} mm/Hg	Loss of high voltage	Card adjusted for minimum current @ +40°C	Pretested EHT 3, replaced EHT 2	June 18, 63 EHT3 also updated with seven new components
Data-storage control (timer)	002	-15°C 2×10^{-6} mm/Hg	Recorded playback horn absent	Timer period short	None	Adjustment to be made post test
Spectrometer "B" amplifier	5	+60°C 3×10^{-6}mm/Hg	No output from 50-kc oscillator	Defective capacitor	Replaced capacitor	June 22, 63 Apparently damaged during previous modification
Tape recorder (spacecraft)	1003	+60°C 3×10^{-6}mm/Hg	Degradation of playback high-frequency signals	Defective tape	Replaced tape	Exposure at high temperature softens tape oxide hence aggravating tape degradation. This tape recorder has about 1200 hours operation with approximately 250 hours at +60°C.
Harness	Proto	Throughout exposure	Apparent decrease in command-receiver sensitivity	Defective connector	Replaced after exposure	Connector experiences considerable handling during testing. Flight units will use a short extension to be discarded after all testing.
Micrometeorite experiment IROD's (instantaneous readout detectors)	105 and 102	Throughout exposure	Intolerable va variations in gain with respect to temperature		Subassembly tests and modifications in process	
Undervoltage detector	001	Throughout exposure	Gradual change in undervoltage level to lower value	Aging	Readjusted after test from 12.2 to 12.6 volts	
Spectrometer "A" photomultiplier tube	427	Post exposure ozone "calibration" ambient	Low output	Unknown	Replaced after exposure	Tube returned to factory for evaluation

2. PURPOSE

The purpose of these electronic tests was to qualify the S-52 prototype spacecraft for proper operation during exposure to simulated orbital environments, and to provide information to designers and other personnel involved.

Item: The S-52 spacecraft configuration is shown in Figure 2-1. The subassemblies used in the prototype spacecraft are listed in Figure 2-2 and Table 2-1. These subassemblies completed at least one temperature cycle from -15°C to +60° C. The following cards were replaced during the test:

- HT 2 replaced HT 4 June 17, 63
- EHT 3 replaced EHT 2 June 18, 63

The solar paddles and the solar-paddle temperature sensor were not exposed during this test.

In a previous deployment test, the galactic-noise long-wire antenna was unreeled and "latched in", providing connection to the receiver input. The long antenna was cut to about 15 feet in length.

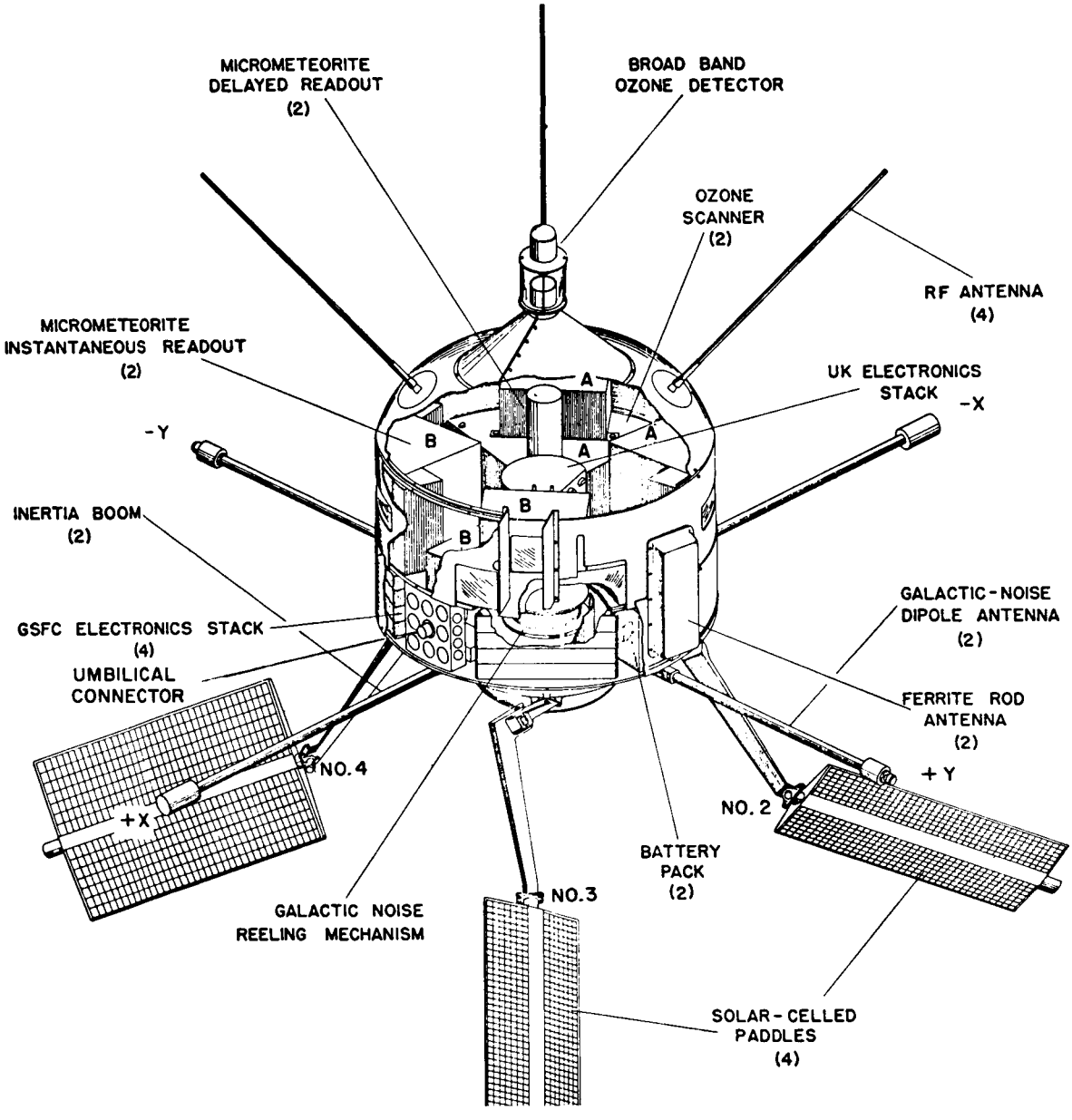
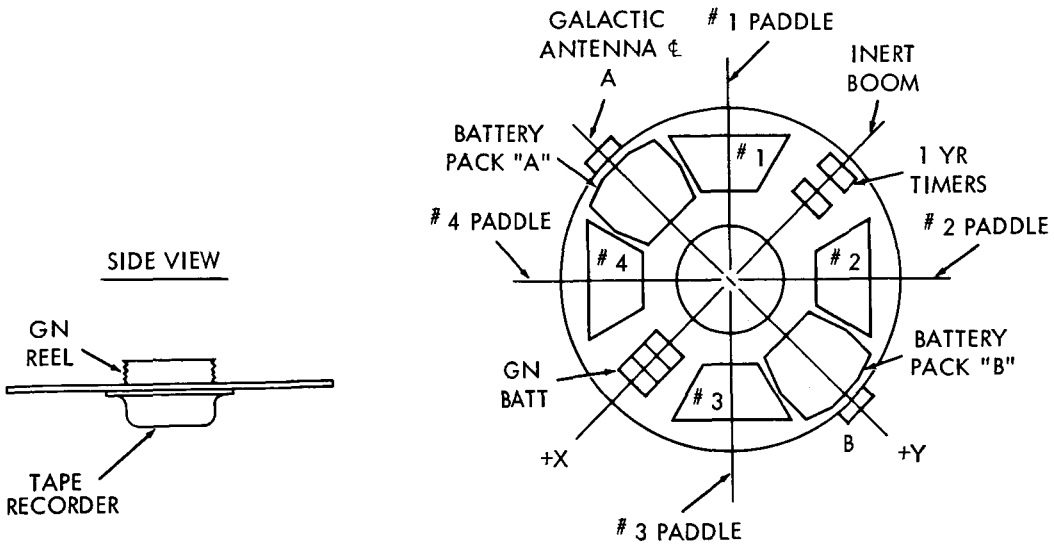


Figure 2-1—UK 2/S-52 International Satellite



Stacks start with Delta Pack "A" mounted directly on the platform and continued upward

	SERIAL No.
Stack #1 (brown)	
A - Transmitter	001
B - Decoder	001
C - Receiver	001
D - Sample and hold circuit	001
Stack #2 (red)	
A - Power supply, +regulator	002
B - Recorder converter	002
C - Data-storage control	002
D - Programmer #1	002
Stack #3 (orange)	
A - Programmer #2	PROTO
B - Telemetry encoder #3	03
C - Telemetry encoder #2	03
D - Telemetry encoder #1	03
Stack #4 (yellow)	
A - Power supply, invertor	001
B - Battery switching network	001
C - Undervoltage detector & recycle timer	001
D - Power supply, regulator	001

	SERIAL No.
Battery A	A
Battery B	B
1-yr timer A	Proto
1-yr timer B	Proto
Tape recorder	1003
RF coupler	4
Antennas a	Proto
b	Proto
c	Proto
d	Proto
Solar Paddles a, b, c, d	Not used
Solar paddle temp.	
Midskin temp.	F-2
Dome temp.	S-2

Figure 2-2—UK 2/S-52 Equipment Layout, Lower Deck

TABLE 2-1
UK2/S-52 EQUIPMENT LAYOUT,
UPPER DECK

OZONE EXPERIMENT	SERIAL #
Ozone Elect.	
a. Oz Temp Mon	3
b. Mon Amp	4
c. Oz Amp	5
d. Spect Amp A	4
e. Spect Amp B	5
f. HT Converter	2*
g. EHT Converter	3*
Photmultiplier A	427 can 10
Photmultiplier B	169 can A
Oz Spectrometer A	1
Oz Spectrometer B	2
B.B. Detector	B 50/2

GALACTIC NOISE EXPERIMENT	SERIAL #
GN Receiver	Proto
GN Batt A	Proto
GN Batt B	Proto
Ferrite Rod A	A
Ferrite Rod B	B
GN Reel Mech	001

MICROMETEORITE EXPERIMENT	SERIAL #
IROD A	105
IROD B	102
DROD A	101
DROD B	104
Volt Stab. A	3
Volt Stab. B	4
Capacitor "Z"	C110
Capacitor "U"	C104
Selector	Proto
Trigger	105

*HT-4 replaced by HT 2 after initial evacuation

*EHT-2 replaced by updated EHT-3

3. ENVIRONMENTAL EXPOSURE

Figure 1-1 shows the temperature excursions and durations of exposure experienced by the S-52 prototype spacecraft. Measurements from spacecraft temperature sensors which show up as performance parameters on the telemetry format were received and decoded at the instrumentation complex. The temperature measurements were displayed at the test stand in μsec (average period of 10-period measurements of the frequency in the data burst). These measurements were plotted concurrently against time. Correlation was made with sensor calibration curves and measurements from local hardline environmental transducers. Figure 1-1 also provides the converted temperature scale in degrees centigrade.

To complete the history of the spacecraft in this exposure, Figure 1-1 lists major events.

For detailed information on planned exposures, see T&E Specification S-1-301.

3.1 MOUNTING CONFIGURATION

The S-52 prototype spacecraft was mounted in the vertical position on a dolly-supported chamber fixture. Figure 3-1 shows the spacecraft mounted on the fixture before entering the chamber; Figure 3-2 shows the spacecraft in the chamber with all instrumentation connections complete.

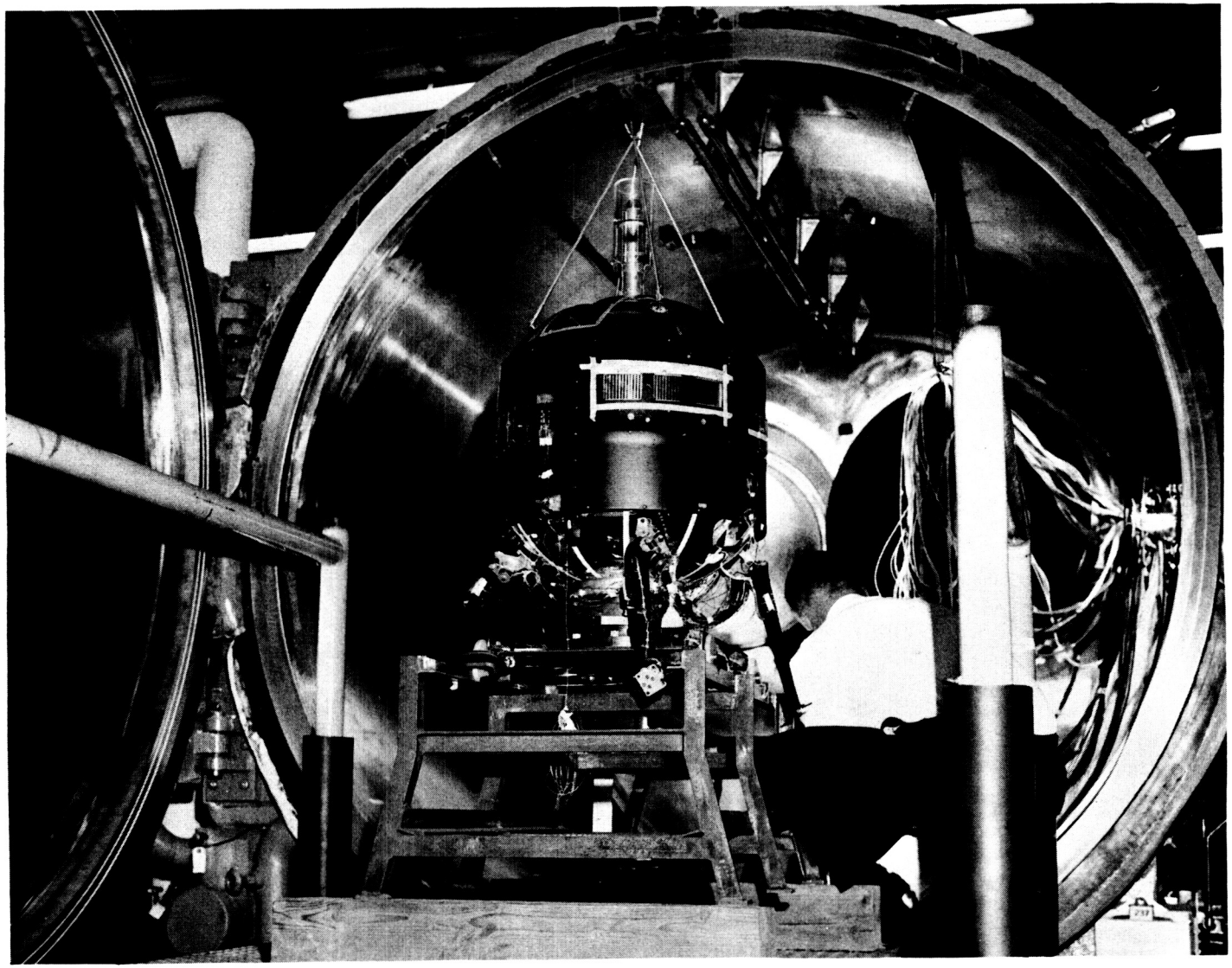


Figure 3-1—S-52 Prototype Spacecraft Preparatory to Entering 8 by 8 Thermal-Vacuum Chamber

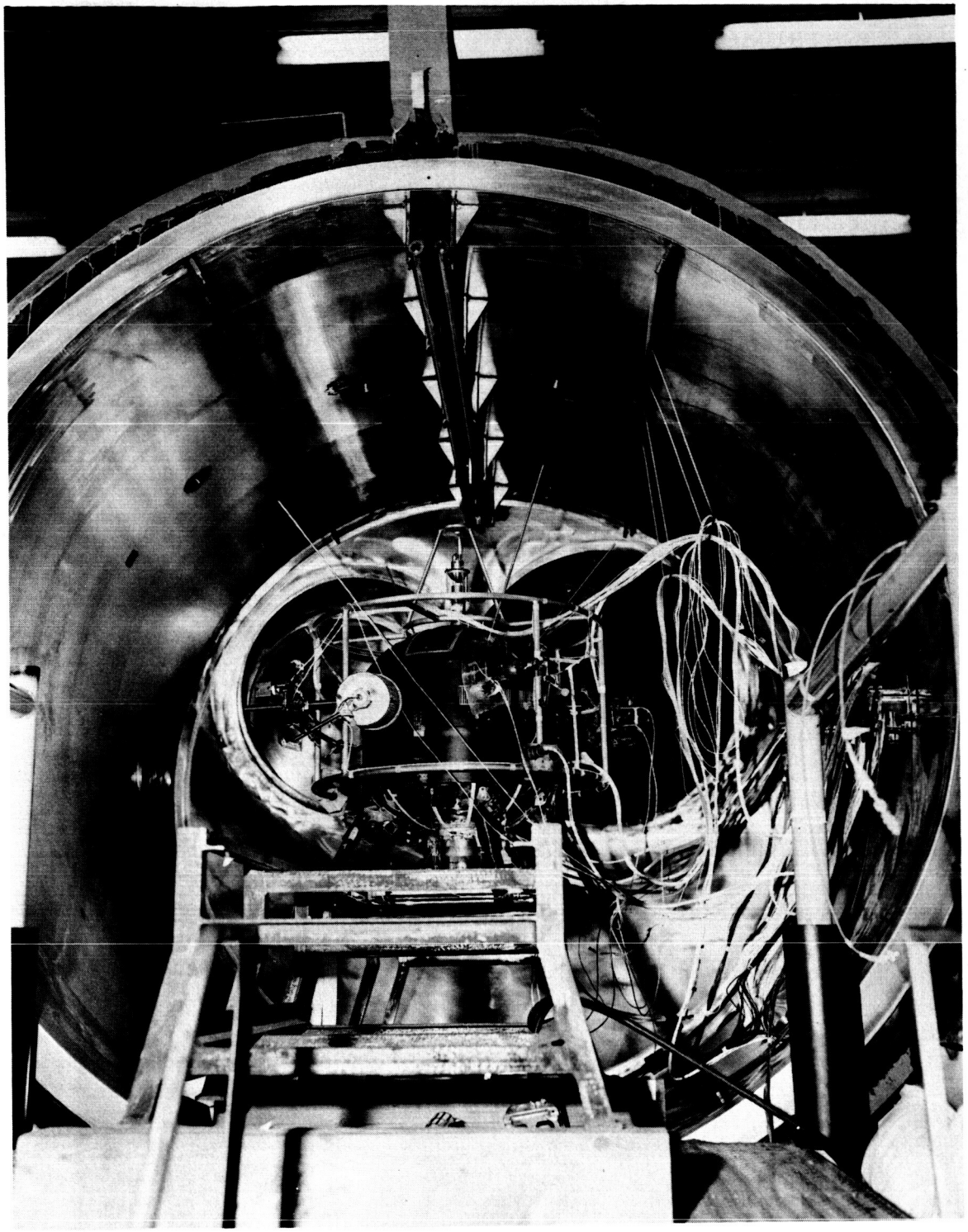


Figure 3-2—Instrumentation and Experiment-Exciter Connections Complete

3.2 INSTRUMENTATION

The S-52 instrumentation complex shown in Figure 3-3 is described in detail in "Electronic Test Procedures for the Environmental Design Qualification and Flight Testing of the UK-2/S-52" (S-324-63-113, February 15, 1963);

The instrumentation complex consists of the control, measuring, recording, and display equipment with its associated interconnections. It provides for:

a. Exercise of the spacecraft power and programmer functions

b. Stimulation of spacecraft experiments

c. Monitoring, recording, and display of subsequent operational responses

d. Surveillance of other available operating test-point parameters to determine that the spacecraft is performing as intended throughout the environmental exposure

The ozone and micrometeorite experiments were excited through the lamps shown in Figure 3-4. The galactic-noise experiment was excited through an inside antenna fed from a signal generator located outside the chamber.

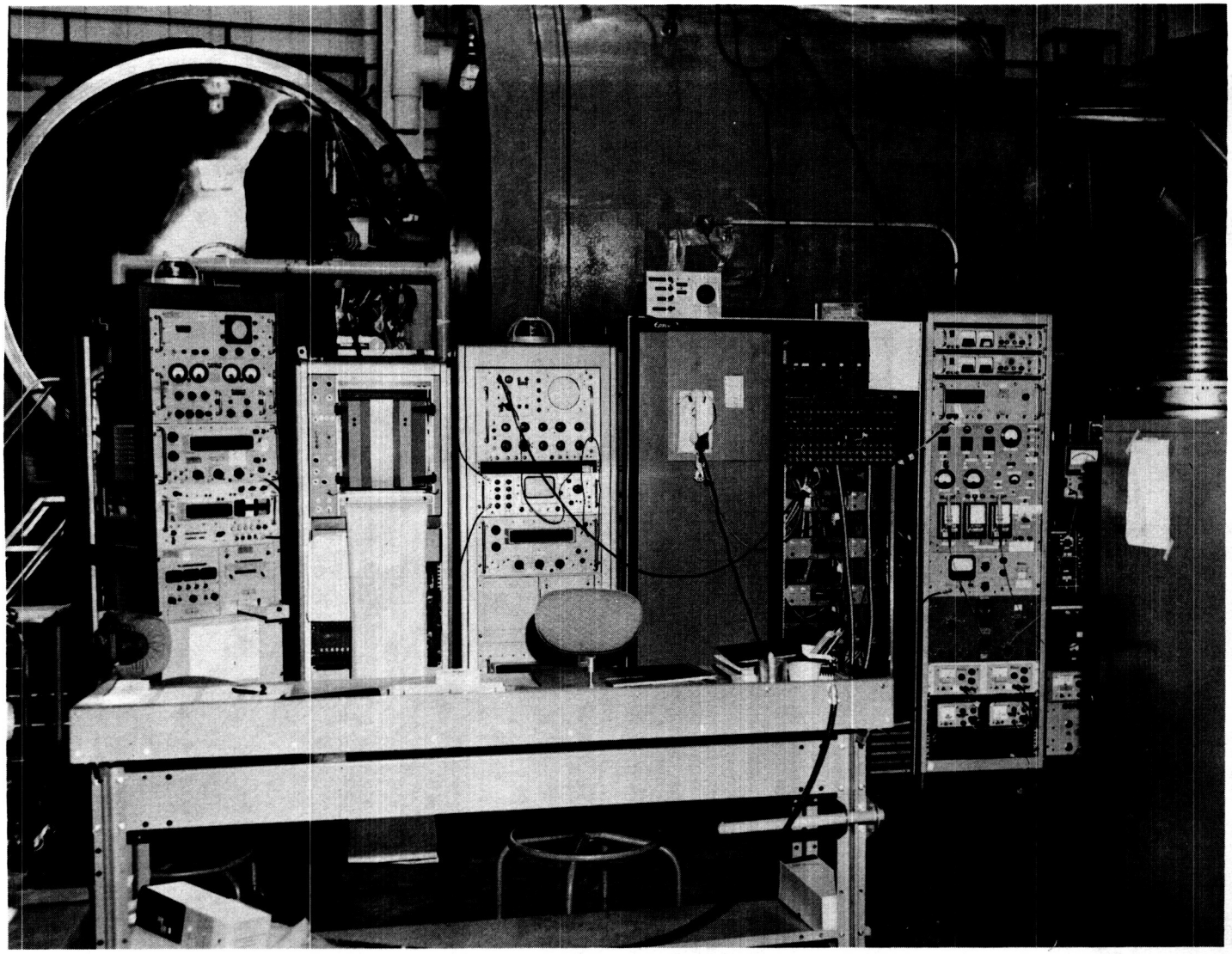


Figure 3-3—S-52 Instrumentation Complex for the Collection and Analysis of Telemetry and Hardline Data

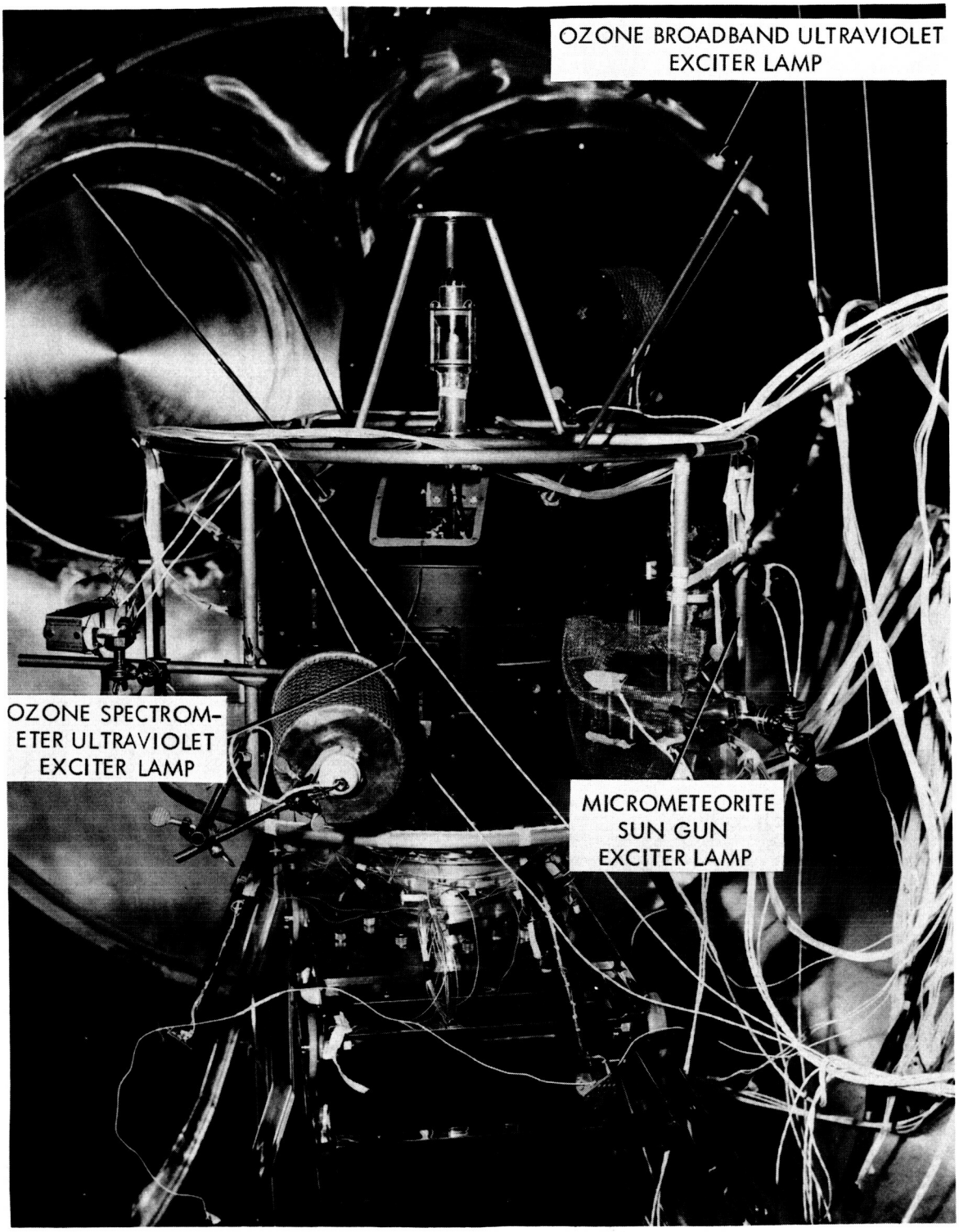


Figure 3-4—Experiment Exciter Mounted

4. TEST PROCEDURES

Unit-type test procedures, described in "Electronics Test Procedures for the Environmental Design Qualification and Flight-Acceptance Testing of the UK-2/S-52," report #X-324-63-113, were used to collect and evaluate data.

Unit-type test procedures constitute a complete electrical systems test of the spacecraft performance. However, by segmenting the complete systems test procedure into unit form, each in itself an entity, the electronics test conductor acquires the ability to institute, at his discretion, test units commensurate with the status, configuration, and exposure of the spacecraft. A complete systems test was performed at least once every 6 hours when the spacecraft was under exposure.

A continual chronological history of the normal as well as the abnormal events which were experienced by the spacecraft during the exposure was maintained in the prototype log book. At least every half-hour a magnetic tape recording was made of the received spacecraft telemetry video. All playbacks of the spacecraft recorder and any abnormal operations were recorded on the test-stand tape recorder with an accompanying voice description.

As shown in Figures 4-1 and 4-2, the test units were carried out in a manner compatible with the spacecraft programmer functions. This

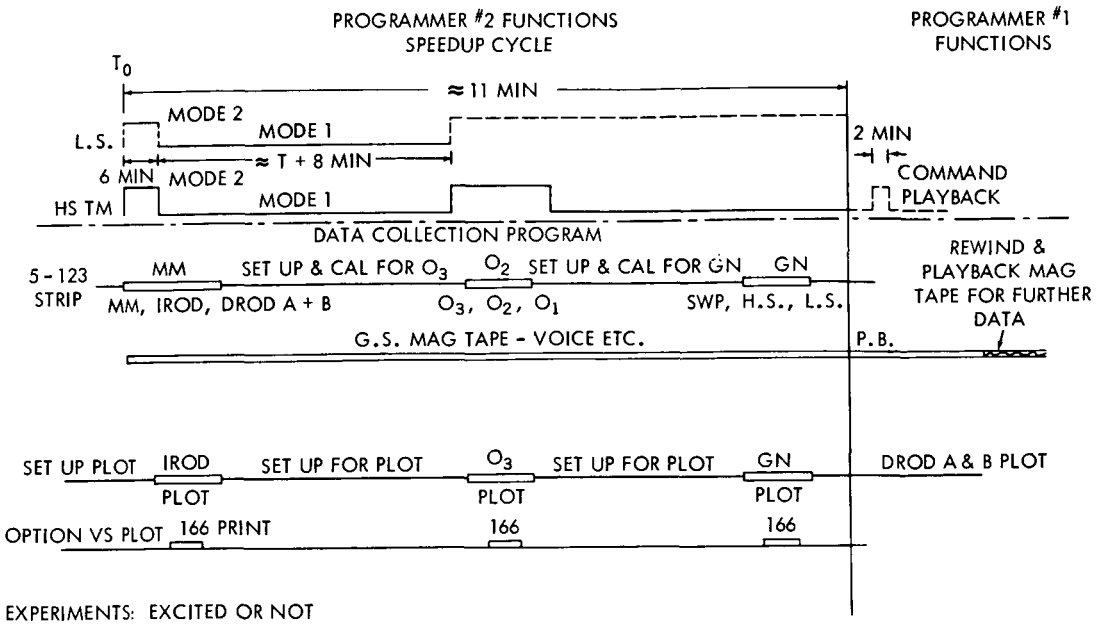


Figure 4-1—Data Collection During Programmer #2 Speedup Cycle

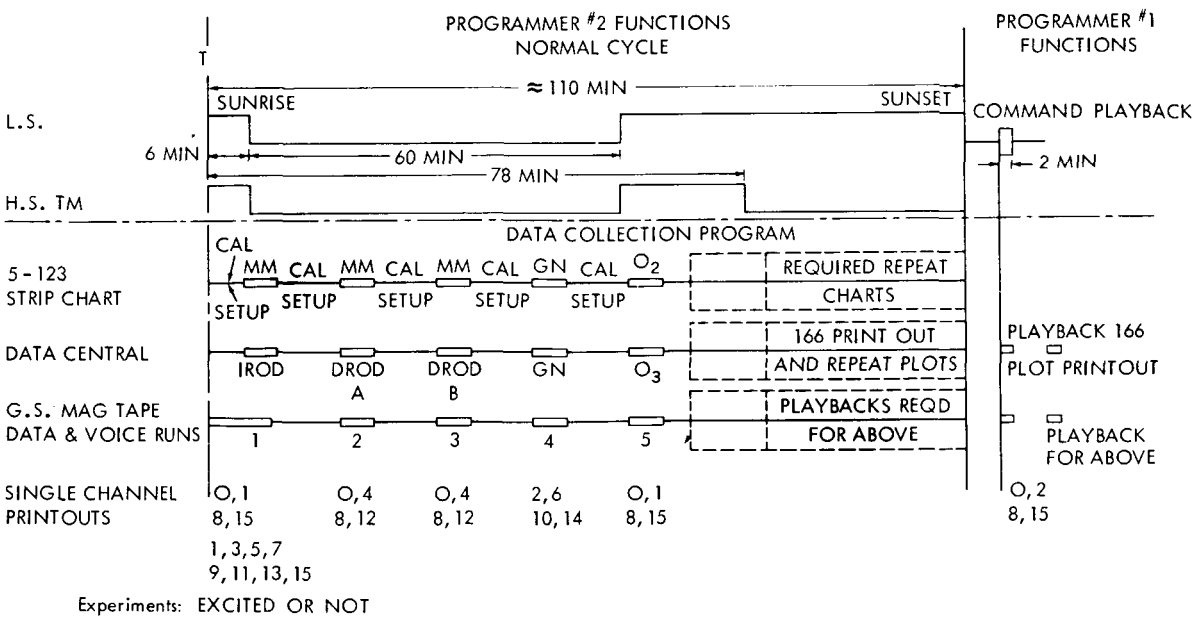


Figure 4-2—Data Collection During Programmer #2 Normal Cycle

made efficient concurrent tests of the programmer and the experiments possible.

Close surveillance of the spacecraft operation was made through the use of the performance parameter data sheet (Table 4-1), in which entries were made about every 20 minutes when the spacecraft was in mode 1 condition. These entries include: a check of the high-speed

TABLE 4-1

PERFORMANCE PARAMETER DATA SHEET

Performance Parameters		P/L Condition			P/L Condition			P/L Condition			P/L Condition			P/L Condition			P/L Condition		
		Date	Time		Date	Time		Date	Time		Date	Time		Date	Time		Date	Time	
S52—PP	Frame	μSec	Volts	Eng. Units	μSec	Volts	Eng. Units	μSec	Volts	Eng. Units	μSec	Volts	Eng. Units	μSec	Volts	Eng. Units	μSec	Volts	Eng. Units
Ozone Snout T	0																		
Monitor T	1																		
Spect Photo T	2																		
Solar Paddle T	12																		
Skin Temp #1	13																		
Skin Temp #2	14																		
Unreg Buss Volts	7																		
Solar Current	9																		
Batt A Chrg-Dischrg	10																		
Batt A Temp	11																		
EHT Mon	3																		
+ 15 Volts	4																		
GN Reel +12V	8																		
GN Swp	15																		
DROD. A F.A.P.	6																		
DROD. B F.A.P.	5																		

		Test Condition	Test Condition	Test Condition	Test Condition	Test Condition	Test Condition
		Performed by	Performed by	Performed by	Performed by	Performed by	Performed by
		L.S. Sync					
		μ sec					
		H.S. Sync	Remarks	Remarks	Remarks	Remarks	Remarks
GN Sweep 1	μsec	Frame μsec					
2		0					
3		1					
4		2					
5		3					
6		4					
		5					
		6					
Tape Recorder Temperature		7					
		8					
		9					
		10					
		11					
		12					
		13					
		14					
		15					

encoder/oscillator sync and frame indentification frequencies as acquired from a minimum of six sequences of channel zero; the average value of low-speed sync applied to the tape recorder (from 6 measurements); and the average values for the spacecraft performance parameters from six sequences of channel 8.

Spacecraft temperature performance parameters were converted to engineering units and correlated with local environmental transducer measurements. These data were then used to establish calibration curves at chamber temperature stabilization and to provide for the plotting of Figure 1-1. The temperature of the tape recorder (thermocouple #4) was also recorded to maintain close surveillance of this critical component.

The following channel 8 parameters were correlated with the respective hardwire voltage and current measurements:

- PP3 — EHT monitor
- PP4 — + 15 volts
- PP7 — unregulated buss
- PP8 — + 12 monitor
- PP9 — solar paddle currents
- PP10 — battery current
- PP15 — GN sweep monitor

Six sequential values of PP15, galactic-noise sweep monitor, were recorded on the performance parameter data sheet, coverted from sec to voltage values, and correlated with hardline strip chart and X-Y plot monitor of the galactic-noise sweep (Table 4-1).

At each stabilization temperature, calibration curves of the power performance parameters PP7, 9, 10, and 11 were established to provide data to permit more accurate determination of operation during solar simulation and orbit.

The unit A data sheet (Table 4-2) provides for the recording and performance check of all internal spacecraft system voltages available at the monitor panel. Also included are the transmitter power, frequency,

TABLE 4-2

UNIT A DATA SHEET

Spacecraft Condition:		Code:				By:	Date: Time:
		Tolerance					
Pin	Description	Lo	%	+%	Hi	Value	
25	Sig Gnd						XMTR PWR
10	+ 3.00	3.15	5	5	2.85		250 mw Nominal (Measured at Spacecraft)
11	+ 7.50	7.51	1/4	1/4	7.48		
27	+ 6.00	6.06	1	1	5.94		Value
28	+12.00	12.1	1	1	11.8		
45	+15.0	15.1	1	1	14.8		
44	+ 6.50	6.82	5	5	6.17		Method of Test (Attenuation)
46	Unreg Bus	16.5	5	5	12.5		
43	- 3.00	3.07	1/4	1/4	2.92		
26	- 4.00	4.2	5	5	3.8		
12	- 18.0	18.1	1	1	17.8		XMTR Frequency
9	- 6.00	6.06	1	1	5.94		136.56 ± 0.002%
14	- E.H.T.						+ = 136.5627312
49	GN Batt Neg						- = 136.5572688
32	GN Batt A						
33	GN Batt B						
8	) 15 VAC	15.7	5	5	14.2		Value
42	) 1700 cps						
C18	1 yr Timer A Current						
C20	1 yr Timer B Current						

and 1-year timer currents. All voltage measurements were made with an isolated input digital voltmeter, and with the charging current off to minimize the effects of ground currents. The data sheet provides the monitor panel pin designations of the described voltages and the permitted tolerances.

Under method of test the RF attenuation, and the length and type of coax cable used between the spacecraft and the measuring instruments were recorded

4.1 UNIT A PROCEDURE

4.1.1 CHECK OF SPACECRAFT SYSTEM VOLTAGES

a. Turn off spacecraft charging voltage.

b. Check calibration of isolated input digital voltmeter.

c. Connect negative lead of digital voltmeter input to pin 25 (spacecraft ground) on the monitor panel.

d. Record spacecraft conditions: date, time, environment, etc.

e. Measure and record the dc voltage values in the unit A data sheet (Table 4-2).

f. Measure and record the amplitude and frequency of the 15 vac on the scope and counter respectively.

   (1) Channel A input pins 8 and 42

   (2) Scope vertical output to counter input frequency

g. Verify that above measurements are within specified tolerances.

4.1.2 CHECK 1-YEAR TIMER CURRENTS

a. Use Simpson 269 as microammeter between C18 and 25, and C20 and 25.

b. Measure and record respective 1-year timer currents.

4.1.3 CHECK TRANSMITTER POWER AND FREQUENCY

a. Measure and record transmitter power.

b. Under "Method of Test," record type and length of cable, and attenuation used.

1. Check power meter zero before connection for measurement.

c. Measure and record transmitter frequency.

1. Check counter calibration prior to measurement.

4.2 UNIT A_1

Unit A_1 also provides for the measurement and recording of the spacecraft system voltages, transmitter power and frequency, and in addition, a recording of the high-speed and low-speed sync and the performance parameters.

Unit A_1 was performed every hour the spacecraft was in continuous operation. This provided a profile of spacecraft performance and readily displayed performance trends (Table 4-3).

4.2.1 UNIT A PROCEDURE

4.2.1.1 Check of Spacecraft System Voltages (See Unit A procedure.)

4.2.1.2 Check of Transmitter Power and Frequency (See Unit A procedure.)

TABLE 4-3

UNIT A, DATA SHEET

Spacecraft Condition:		Code:				By:	Date: Time:	
		Tolerance						
Pin	Description	Lo	Per-cent	+Per-cent	Hi	Value	High - Speed Sync	Period
25	Sig Gnd						FRAME 0	
10	+ 3.00	3.15	5	5	2.85		FRAME 1	
11	+ 7.50	7.51	1/4	1/4	7.48		FRAME 2	
27	+ 6.00	6.06	1	1	5.94		FRAME 3	
28	+12.00	12.1	1	1	11.8		FRAME 4	
45	+15.0	15.2	1	1	14.8		FRAME 5	
44	+6.50	6.82	5	5	6.17		FRAME 6	
46	Unreg Bus	16.5	5	5	12.5		FRAME 7	
43	- 3.00	3.07	1/4	1/4	2.92		FRAME 8	
26	- 4.00	4.2	5	5	3.8		FRAME 9	
12	-18.0	18.1	1	1	17.8		FRAME 10	
9	- 6.00	6.06	1	1	5.94		FRAME 11	
14	-E.H.T.						FRAME 12	
49	GN Batt Neg						FRAME 13	
32	GN Batt A						FRAME 14	
33	GN Batt B						FRAME 15	
8	) 15 VAC	15.7	5	5	14.2		Low - Speed Sync	
42	) 1700 cps						FRAME 0	
	Battery A current					Charging V		
	Charging current							
A	Channel 8 & 0 recorded check						Transmitter Frequency	
B	Rustraks time - date check						Transmitter Power	
C	Brush recorder time - date check							

4.2.1.3 Check of Spacecraft Performance Parameters

a. System charging current set consistent with exposure

NOTE: During low-temperature exposure the charging rate is applied for 60 minutes and removed for 40 minutes consistent with orbital conditions. During the high-temperature orbit, charging current is applied 100 percent of the time consistent with a full sunlight orbit. The amount of charging current may be varied at the test conductors discretion to determine effects on spacecraft operation and battery performance.

b. Measure and record battery current, charging current, and charging voltage.

c. Operate the ground station for a 30-second printout of mode 1 channel 8.

d. Time, date, and code the printout.

1. Code number:

1 ___ ___ Thermal vacuum hot

2 ___ ___ Thermal vacuum cold

Insert temperature of ozone electronics stack in blanks.

e. Record the values of the performance parameters in the appropriate spaces in the performance parameter data sheet (Table 4-1).

f. Record six sequential values of frame 15 of channel 8, the galactic-noise sweep monitor.

g. Verify that the performance parameters are proper with respect to the spacecraft operational mode and exposure.

h. Correlate the performance parameter temperature measurements with the environmental temperature measurements, if applicable.

i. Correlate the telemetry performance parameter voltage and current measurements with the hardline measurements.

j. Verify that high-speed and low-speed sync comply with encoder specifications given in Unit B Data Sheet (Table 4-4).

4.3 UNIT B

The Unit B Data Sheet (Table 4-4) provides for the recording and evaluation of waveform measurements available from the spacecraft which are indicative of the proper operation of the spacecraft telemetry and recording system. The 320.18 cps (pin 3) applied to the tape recorder was measured for correlation with the 15.4-kc signal returned from the tape recorder during playback mode.

4.3.1 UNIT B PROCEDURE

4.3.1.1 Sync

a. Set up oscilloscope:

Channel A, dc input $\overline{A}$

Gain, 5v/cm

Channel B, dc input $\overline{L}$

Gain, 2v/cm

TABLE 4-4

UNIT 8 DATA SHEET

Spacecraft Condition:		Code:		By:	Date:	Time:
Pin	Description	Amplitude		Period	High Speed Sync Tolerances (μsec)	Period sec
1	$\overline{A}$ H.S. Reset				FRAME 0 194.14 - 198.06	
18	$\overline{L}$				FRAME 1 221.08 - 221.11	
	Sync $\overline{A} \rightarrow \overline{L}$ (5ms)				FRAME 2 157.16 - 160.33	
35	$\overline{T}$				FRAME 3 221.08 - 221.11	
2	L.S. Env.	Data	Sync		FRAME 4 132.01 - 134.68	
3	L.S. Video				FRAME 5 221.08 - 221.11	
4	L.S. to T.R.				FRAME 6 113.80 - 116.10	
15	L.S. Gate B				FRAME 7 221.08 - 221.11	
19	H.S. Video				FRAME 8 100.01 - 102.03	
20	XMTR MOD				FRAME 9 221.08 - 221.11	
36	L.S.÷ 48				FRAME 10 89.20 - 91.00	
36	L.S. Sync 10 P.A.				FRAME 11 221.08 - 221.11	
24	Ø1				FRAME 12 80.50 - 82.12	
41	Ø2				FRAME 13 221.08 - 221.11	
	Ø Shift (.1ms=3.6°)				FRAME 14 73.34 - 74.82	
	Symmetry				FRAME 15 221.08 - 222.47	

Note: Encoder frequency tolerances given (μsec periods) are for ambient temperature only. For temperature range of -10°C to +60°C sync (odd frames) maximum total deviation is 1 percent. Even frames maximum total deviation is 1.5 percent.

Trigger, negative external on $\overline{A}$

Sweep, 1/2 sec/cm until scope circuit triggers

Sweep, 1 ms/cm

Mode, chopped

b. Measure and record sync delay of $\overline{L}$ from $\overline{A}$ (less than 5 ms).

c. Record period of $\overline{A}$ and $\overline{L}$ (connection by remote control).

d. Exercise encoder tuning fork kill (remote control).

e. Repeat steps (b) and (c) above.

f. Measure and record period of T.

4.3.1.2 Phase One (Ø1) and Phase Two (Ø2) Measurements

a. Waveform and amplitude measurements

1. Test scope setup:

(a) Channel A, input-Ø1 (pin 24 on the monitor panel)

(b) Channel B, input-02 (pin 41 on the monitor panel)

(c) Sweep, 1 ms/cm

(d) Amplitude 1.0 v/cm

(e) Trigger, internal

2. Observe whether waveforms are proper, and record amplitude.

b. Phase-difference measurement

PRECAUTION: Place input switch on counter (HP 523) on SEPARATE before connecting counter to Ø1 and Ø2, to preclude shorting the phases together.

1. Counter setup (HP 523CR):

(a) Counter input switch on SEPARATE

(b) Function selector on timer interval

(c) Trigger, slope

Start, positive

Stop, positive

(d) Time unit, sec

(e) Trigger, level

Start, positive (dc x 1) (0.5)

Stop, positive (dc x 1) (0.5)

2. Connect:

(a) Ø1 (pin 24) into start input

(b) Ø2 (pin 41) into stop input

3. Record counter reading in Unit A data sheet (Table 4-2).

4. Determine and record phase difference in Unit B data sheet (Table 4-4).

DISCUSSION: Since the frequency of Ø1 and Ø2 is 100 cps, their periods are 10 milliseconds. Thus 360 degrees are equal to 10 milliseconds, or, 90 degrees are equal to 2.5 milliseconds. Hence, if Ø2 went positive exactly 90 degrees after Ø1 went positive, the counter would read 2.5 milliseconds. As another example, if the counter reads 2.35 milliseconds, it indicates that Ø2 is ahead of Ø1 by 0.15 milliseconds. Then Ø2 leads 1Ø by (0.15 milliseconds x 3.6 degrees) equal to 5.4 degrees.

5. Determine and record the symmetry of phase shift in the Unit B data sheet (Table 4-4).

(a) Interchange Ø1 and Ø2 input connections to counter.

Ø2 to start input

Ø1 to stop input

(b) Trigger level

Start negative (dc x 1) (0.5)

Stop negative (dc x 1) (0.5)

(c) Trigger slope

Start negative

Stop negative

6. Record counter reading in data sheet.

7. Determine phase difference and record.

4.4 UNIT C

Unit C provides a check of the functions of undervoltage, battery switching, battery charging, and dumping. The Unit C data sheet provides for appropriately recording the measured values (Table 4-5). When this procedure is used it is assumed that the spacecraft is connected and operating.

During an actual 18-hour undervoltage cycle, Unit C_1 data sheet was used at least every one-quarter hour to provide for the recording and evaluation of the performance of operating parameters (Table 4-6).

4.4.1 UNIT C PROCEDURE

4.4.1.1 Check of Undervoltage and Battery Switching

a. Set up counter A (HP 523) on time interval to measure undervoltage oscillator rate 1 period.

b. Set up counter B (HP 523) on time interval to measure undervoltage rate 2 period.

TABLE 4-5

UNIT C DATA SHEET

Spacecraft Condition:		Code:	By:	Date:	Time:
Pin	Description	Value			
	Undervoltage Level		Chrgin E		
22	Osc Rate 1 a		Batt A I		
	b		Batt B I		
	c		R_1 E		
39	Osc Rate 2 a		R_2 E		
	b				
	c				
45	15 VDC		Chrgin E		
8/42	15 VAC amp.		Batt A I		
	freq.		Batt B I		
22	Osc Rate 1 S.U.		R_1 E		
	S/C return		R_2 E		
	Load on B				
	UV on B				
	Sw A to B				
	Sw B to A				
22	Osc Rate 2, S.U.				

c. Set up digital voltmeter (HP 405) and associated printer, if used, to monitor and record system voltage at monitor panel, pin 46.

d. Check calibration of digital voltmeter.

e. Set the current limit of external power supplied A and B to 3/4 amperes.

f. Set output voltages of external power supplies A and B to 14.0 v.

g. Set up S-52 control panel:

1. Function switch on external A and B
2. Undervoltage oscillator speedup off

TABLE 4-6

UNIT C, DATA SHEET

Spacecraft Condition:							Code:		By:			Date:		Time:		
Time	Dumping I		Battery V		Battery I		Ext. Charge		+15V	15 VAC (8 & 42)		OSC Count		OSC Period		
	J_4	J_6	A	B	A	B	Volts	Curr	Pin 45	Amp.	Freq.	1	2	1	2	

h. Verify that spacecraft system is operating on external power supply A (load current indicated on external power supply A panel meter).

i. Reset all counters.

j. Monitor digital voltmeter displaying spacecraft system unregulated buss voltage to determine potential at which undervoltage occurs.

k. Slowly lower external power supply A output voltage in 0.1-volt increments, dwelling about 5 seconds at each increment.

l. Observe and record spacecraft system voltage at the loss of full-load spacecraft system current.

m. Observe whether all undervoltage counters are operating.

n. Record average of three consecutive period measurements of each undervoltage oscillator rate.

o. Verify that all spacecraft system voltages are zero except +15 vdc and 15 vac.

p. Place undervoltage speedup of oscillator 1 "ON". (Period of the oscillator will change to 0.4 second.) Record speedup period.

q. Observe and record that in about 5 minutes the spacecraft returns to normal operation, and all spacecraft system voltages are present and proper.

r. Check and record that the spacecraft system switched from external power supply A to B (spacecraft system current displayed on external power supply B panel meter interchanges).

s. Return external power supply A to 14 v.

t. Depress undervoltage reset to reset oscillator rate 2.

u. Repeat steps (i) through (o), using external power supply B, and check that the readings are the same as the recorded values.

4.4.1.2 Check of Battery Switching

a. Initial status: Spacecraft in undervoltage on external power supply A with load current indicated on panel meter.

b. Set external power supply B to 14 v.

c. Return digital voltmeter + lead to pin 46 on monitor panel.

d. Slowly lower external power supply A output voltage.

e. Observe and record spacecraft system voltage at the change of system load current to external power supply B.

f. Record the switching potential from A to B. Switching potential is the difference between power supply A and B Terminal voltages at the instant that power supply B assumes load.

g. Set external power supply A to 14 v.

h. Slowly lower external power supply B output voltage.

i. Observe and record spacecraft system voltage at pin 46 on monitor panel at the change of system load current to external power supply A.

j. Record the switching potential from B to A.

k. Reset external power supply B to 14 v.

4.4.1.3 Conclusion of Undervoltage Test

a. Set oscillator rate 2 in speedup.

b. Place undervoltage speedup of oscillator rate 2 ON.

c. Observe and record that in approximately 5 minutes the spacecraft returns to normal operation and that all spacecraft system voltages are present and proper.

d. Reset oscillator rate 1.

4.4.1.4 Dumping

PRECAUTION: This measurement is above spacecraft ground of common return; therefore, the digital voltmeter and the printer must be a completely isolated (floating) electrical system to prevent damage to spacecraft circuitry. The ground strap on the digital voltmeter shall NOT be connected to the negative input terminal. The associated printer, if used, shall be an isolated unit such as an HP 561 printer.

a. Set the current limit of external power supply A to 1 amp.

b. Connect the digital voltmeter to S-52 control panel jacks J11 (-) and J10 (+).

c. Place the spacecraft on internal batteries (S-52 control-panel function switch on A and B.)

d. Slowly raise the voltage of external power supply A until a current of 1 amp. is being supplied to the spacecraft system as noted on the charging current meter on S-52 control panel.

e. Measure and record:

   1. Solar paddle voltage

   2. Battery A charging current

   3. Battery B trickle charging current

   4. Voltage drop across dumping resistor A from jack J5 (+) to jack J4 (-above ground) on the S-52 control panel (about 5 volts across 10 ohms, therefore 500 ma).

   5. Voltage drop across dumping resistor B from jack J5 (+) to jack J6 (-above ground) on S-52 control panel (about 5 volts across 10 ohms, therefore 500 ma).

f. Verify that the sum of the spacecraft system current, the dumping currents, and the charging currents equal the spacecraft input current.

g. Repeat steps (a) to (f) at 2 amps.

h. Readjust A to the required input and record systems current.

i. Turn charging current to OFF position. Observe and record the system current and voltage.

j. Turn ON charging current if required.

4.5 UNIT D

Unit D provides an evaluation of the performance of the spacecraft tape recording system. Except for the recording of known inputs to experiments, for example, the measurements recorded in unit D data sheet are available only during the spacecraft playback mode (Table 4-7). Periodically, during continuous testing, measured inputs were applied through the experiments and correlated against their respective outputs recovered on telemetry during the spacecraft playback mode.

TABLE 4-7

UNIT D DATA SHEET

Spacecraft Condition:		Code:		By:	Date:	Time:
Pin	Description	Amplitude	Period	Type of Data Recorded		
				Input	Playback Output	
	Manual Cmd.					
	RF Cmd.					
	Cable Configuration					
	Cmd. Rcvr. Sens.					
6	Decoder In					
40	Decoder Out					
	Horn Duration					
21	T.R. P.B.					
20	XMTR MOD					
	Osc Period					
	15.4kc Period					
	P.B. Time					
	P.B. Count					
	Recovered L.S. Sync					
	Type of Data Recorded					

Spacecraft tape-recorder speed is checked by measuring the 320.83 cps (unit B) applied to the tape recorder and comparing it with the period of the 15.4 kc recovered during the playback mode.

4.5.1 UNIT D - PROCEDURE

a. Set up oscilloscope for measurements of:

- Decoder input
- Decoder output
- Tape recorder playback
- Transmitter modulation

b. Set up counter for measurement of oscillator period.

c. Set up stopwatch for playback time.

d. If RF command, obtain command receiver sensitivity.

e. Observe and record the indicated measurements appropriately in the unit D data sheet.

4.5.1.1 Command Receiver Sensitivity

a. Ensure that command transmitter attenuator is set at maximum attenuation (132 db).

b. Turn on primary ac power to command transmitter chassis.

c. Depress command button on command transmitter.

d. Observe reception of command, evidenced by break in telemetry signal followed by presence of 320-cps modulation for 2 seconds, and then the playback telemetry modulation.

e. Record the setting of the command transmitter attenuator.

NOTE: The same RF cable interconnecting the the command transmitter and the command receiver is used for all measurements. Exceptions must be noted in the unit D data sheet.

f. If playback does not begin, reduce the command transmitter attenuator setting by 2 db. After a 2-minute delay, repeat steps from (c) above.

4.6 UNIT E

Unit E consists of an evaluation of the performance of programmer #2 and the responses of the experiments to applied stimuli. The test cycle of unit E was every 4 to 6 hours.

The unit is divided into three test sequences with data collected as shown in Figures 4-1 and 4-2.

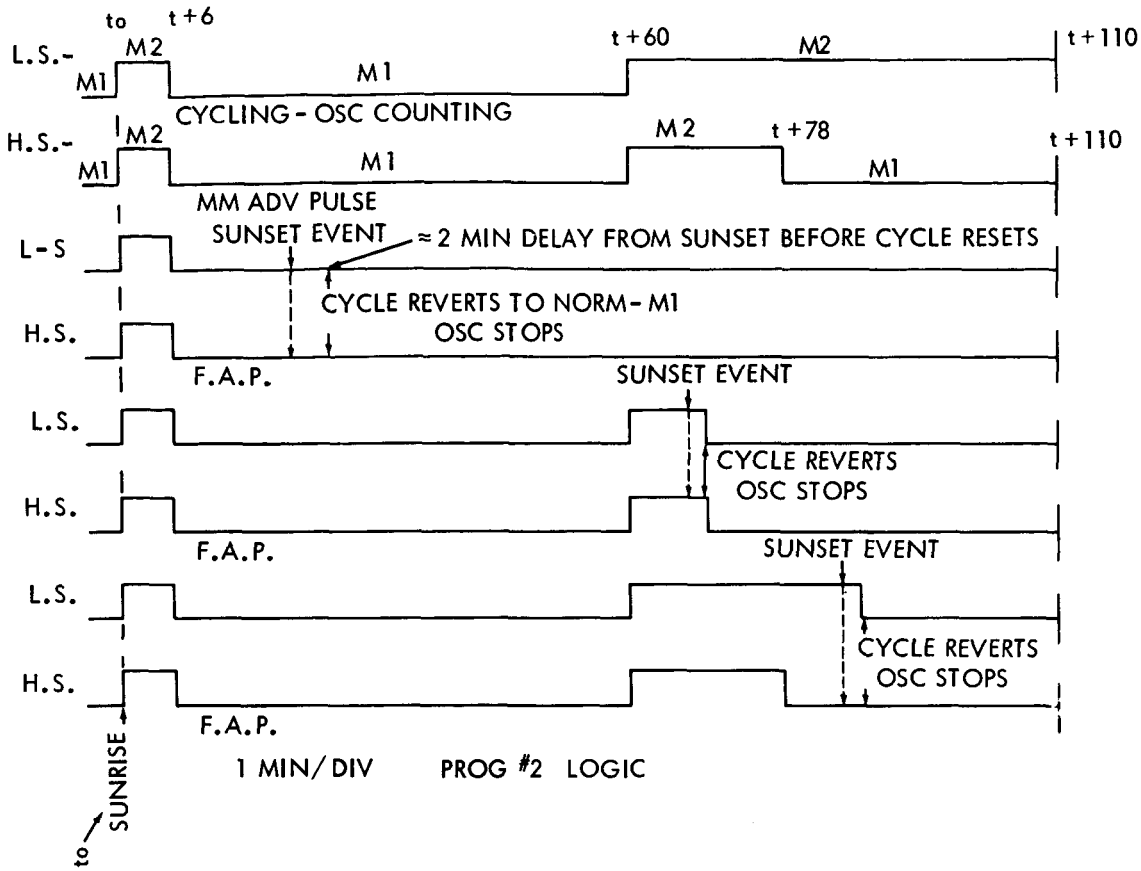
a. Programmer #2 in speedup or normal cycle; sunrise simulation, functional outputs monitored

b. Programmer #2 in speedup cycle; sunrise simulation, functional outputs monitored; data storage and readout cycle via telemetry and hardline

c. Programmer #2 in normal 110-minute cycle; sunrise simulation, functional outputs monitored, and data storage and readout cycle via telemetry and hardline.--The test sequences are modified to environmental conditions, e.g., no hardline monitoring during rotating tests, etc.

4.6.1 UNIT E PROCEDURE

Test (a), unit E, verifies via hardline the operation of the high-speed and low-speed gates which determine the encoder's mode of operation, and the presence of the foil advance pulse to the micrometeoroid experiment. (See Figure 4-3, "Sequence of Operational Modes;" see also unit E_1 data sheet, Table 4-8.)



M1 L.S. = GN ONLY ON TAPE
M1 H.S. = TM CONSISTS OF IROD-DROD-GN-PP.
M2 L.S. = OZONE
M2 L.S. = O_1 = OZONE MONITOR (O_1) ON CHAN 1-3-5-7-9-11-13-15 (O_2) ON CHAN 2-4-6-8-10-12
M2 H.S. = TM = CONSISTS OF ONLY OZONE SPECT ALL CHANELS & FRAMES

Figure 4-3—Sequences of Operational Modes

Test (b), performed with programmer #2 in speedup cycle, in addition to those parameters observed in test (a) monitors the performance of the experiments as these are stimulated, the operation of the data storage and playback functions, and the telemetry format at the ground station. Data are transmitted by RF telemetry format to the ground station, and by hardline to adjacent instrumentation. Frequent

TABLE 4-8

UNIT E_1 DATA SHEET

Spacecraft Condition:		Code:		By:		Date:	Time:
PIN	DESCRIPTION	LEVELS HL	LEVELS TM	EXCITOR	RCVD	AMPLIFIER SELECTED	MECHANICAL ADVANCE
17	DROD-A-PRE						
	DROD-A-POST						
50	DROD-B-PRE						
	DROD-B-POST						
23	IROD-A						
	IROD-B						
5	FAP						

Remarks:

GALACTIC NOISE

PIN	DESCRIPTION	LEVELS HL H.S.	LEVELS HL L.S.	LEVELS TM	10 Per Avg	EXCITOR
48	1 Mc					
and	2 Mc					
31	WB					
16	Sig					
	Swp					

Remarks:

Remarks: (Prog. #2)

OZONE

PIN	DESCRIPTION	LEVELS HL	LEVELS TM	10 Per Avg.	EXCITOR
13	Spect A				
13	Spect B				
30	Oz				
47	Mon				

Remarks:

PROGRAMMER #2

PIN	DES.	AMP.	TIME OF OCCURRENCE M1	M2	M1
	SR				
	SS				
34	HS				
15	LS				

comparisons of concurrent data samples obtained by hardline and telemetry help to establish a continuous indication of data-collection effectiveness (Figure 4-3).

Test (c) is the same as test (b), with programmer #2 in normal cycle instead of speedup.

4.6.1.1 Micrometeorite Experiment Calibration

Micrometeorite experiment calibration is shown in unit E_2 data sheet (Table 4-9).

TABLE 4 - 9

MICROMETEORITE EXPERIMENT BRUSH CALIBRATION, DATA SHEET E_2

Note: Inputs must be floating - All switches on panel in up position

	IN	OUT	GAIN	TEMP.	PRESS	TIME	DATE	REMARKS	RUN #
IROD - A									
IROD - B									
DROD - A									
PRE									
POST									
DROD - B									
PRE									
POST									
IROD - A									
IROD - B									
DROD - A									
PRE									
POST									
DROD - B									
PRE									
POST									

a. Equipment required:

1. Strip chart recorder (Brush Mark II)
2. Adjustable repetition rate pulse generator (S-52 ETB)
3. Micrometeorite interconnection panel
4. Interconnections

b. Connections:

1. Connect pulse generator B to IROD A input
2. Connect pulse generator C to DROD A preinput
3. Connect pulse generator D to DROD B preinput
4. Connect pulse generator G to IROD B input
5. Connect pulse generator H to DROD A postinput

6. Connect pulse generator J to DROD B postinput

c. Adjust pulse generators:

1. B to 5 (10-second repetition rate)

2. C to 5 (6-second repetition rate)

3. D to 5 (8-second repetition rate)

4. G to 6 (9-second repetition rate)

5. H to 6 (7-second repetition rate)

6. J to 6 (11-second repetition rate)

d. Adjust output voltage of each pulse generator to provide an experiment output of 1.5 to 3.5 volts for duration of test.

NOTE: At selected periods during the test the amplitudes of the pulse generator will be varied to determine amplifier linearity.

e. Set up recorder.

1. Correct:

(a) Input to IROD A to channel 1

(b) Output of IROD A to channel 2

2. Sensitivity:

(a) Channel 1 to 0.2 volt/chart line

(b) Channel 2 to 0.5 volt/chart line

3. Chart speed 1 mm/sec

Operate recorder for at least 1 minute. Identify chart, date, time, gains, chart speed, exposure, parameters.

Make a chart for each of the selected amplifiers of IROD and DROD's.

Initiate a programmer #2 cycle to provide for a selection of the alternate micrometeorite amplifiers.

Observe and record advancement of detector foils. Make a chart for each of the selected amplifiers of IROD and DROD's.

Calculate gain of each amplifier.

Record data in Table 4-9.

4.6.1.2 Stimulation Lamp Check of Micrometeorite Experiment

Stimulation lamp check of micrometeorite experiment is in unit data data sheet E_3 (Table 4-10).

a. Equipment required:

1. S-52 telemetry ground station
2. Sensor exciter (quartz lamps)
   (a) Handgun or
   (b) Lamps mounted on exciter cage as shown in Figure 3-4.
3. Micrometeorite stimulation control box
4. Interconnecting cabling

b. Connections:

1. Disconnect all pulse generator inputs
2. Disconnect all hardline outputs to micrometeorite experiment

TABLE 4 - 10
DROD FOIL ADVANCE DETECTOR, UNIT E_3
DROD A - PP6 DROD B - PP5

Before Foil Advance Pulse			Performance Parameter	After Foil Advance Pulse		
Date & time	Light off	Light on		Date & time	Light off	Light on
			5			
			6			
			5			
			6			
			5			
			6			
			5			
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			6			

c. Check of IROD A:

1. Select channel 1 for display on S-52 telemetry ground station.

2. Turn on ground station printer.

3. Energize IROD A exciter lamp for a few seconds.

4. Observe response on printout.

5. Identify printout, including selected active amplifiers.

6. Attach printout to unit E_3 data sheet (Table 4-10).

d. Check of DROD A:

1. Select channel 12.

2. Energize DROD A exciter lamp for a few seconds.

3. Obtain previous printout.

e. Check of DROD B:

1. Select channel 4.

2. Obtain previous printout.

f. Check of foil advance pulse

1. Obtain printout of channel 8.

2. Record PP5 and PP6 in unit E_3 (exciter lamps deenergized).

3. Obtain a printout of channel 8 with each DROD-energized in turn for a few seconds.

4. Initiate a programmer #2 cycle.

5. At T + 6 minutes, telemetry return to mode 1, repeat steps 1, 2 and 3.

6. Observe and record the foil advance pulse indication on telemetry and the physical foil advancement.

7. Repeat foregoing checks of IROD and DROD's.

4.6.1.3 Ozone Experiment Calibration

Ozone experiment calibration is shown in Table 4-11, Ozone Calibration Unit E_4.

a. Equipment required:

1. Digital voltmeter

2. Telemetry ground station (Westinghouse)

3. Ozone calibration box (ETB)

4. Monitor panel

5. Interconnecting cables

b. Set up ozone calibration box.

1. Place function switch to position 5.

2. Adjust input voltage to -33 v.

c. Check of ozone spectrometer PMA and PMB (See Table 4-12 Unit E_5.)

1. Initiate spacecraft programmer #2 cycle.

2. Place selector switch (ozone cal box) to PMA.

3. Place function switch to position 4.

4. Measure and record:

(a) Calibration box input voltage (BNC top of calibration box)

TABLE 4-11

OZONE CALIBRATION, UNIT E_4

Note: Run with charging off

CONDITIONS	INPUT		PMA			PMB			MON			OZ	
			13	TM		13	TM		47	PB TM		30	PB TM
TEMP.													
PRESS.													
DATE													
TIME													
TEMP.													
PRESS.													
DATE													
TIME													
TEMP.													
PRESS.													
DATE													
TIME													
TEMP.													
PRESS.													
DATE													
TIME													

(b) Voltage pin #13 (monitor panel)

(c) Period (μsec) of telemetry data on channel 1

5. Repeat procedures 2 through 4 for each of the remaining four function switch positions 3, 2, 1, and OFF.

6. Repeat procedures 2 through 5 for selector switch positions PMB.

TABLE 4 - 12

OZONE SPECTROPHOTOMETER CALIBRATION, UNIT E_5

PROCEDURE: Take voltage reading before turning on light. Turn on desired light for seven minutes charging current off.

Date Time		Pin #	Light Off Voltage	Light On Voltage
_____	Broadband Mon.	47	_____	_____
_____	Broadband Oz.	30	_____	_____
_____	Spectrometer A	13	_____	_____
_____	Spectrometer B	13	_____	_____
_____	Broadband Mon.	47	_____	_____
_____	Broadband Oz.	30	_____	_____
_____	Spectrometer A	13	_____	_____
_____	Spectrometer B	13	_____	_____
_____	Broadband Mon.	47	_____	_____
_____	Broadband Oz.	30	_____	_____
_____	Spectrometer A	13	_____	_____
_____	Spectrometer B	13	_____	_____
_____	Broadband Mon.	47	_____	_____
_____	Broadband Oz.	30	_____	_____
_____	Spectrometer A	13	_____	_____
_____	Spectrometer B	13	_____	_____

NOTE: As shown in Figure 4-3, the ozone experiment data is present on telemetry for only 6 minutes; however, mode 2 return in 54 minutes permitting time to complete the "calibration."

d. Check of monitor and ozone

NOTE: The telemetry output of these detectors is provided only in the spacecraft playback mode. Therefore, the low speed data will be measured and recorded, in μsec period of subcarrier-oscillator frequency, before it is applied to the S/C tape recorder for comparison with telemetry playback data.

e. Set up oscilloscope.

1. Connect:

   (a) Channel A input to monitor panel pin 36 (LS before +48)

   (b) Vertical output of oscilloscope to counter (HP 523 CR) input

   (c) External scope trigger to decom sync output

2. Place programmer #2 in "Hold" until completion of this recording.

3. Select ozone

4. Function switch to 4

5. Measure and record:

   (a) Cal box input voltage

   (b) Voltage pin 30

   (c) Period of ozone subcarrier oscillator

6. Repeat steps 3 and 4 for each selected position 3, 2, 1 and OFF dwelling 10 minutes at each position to obtain recording time.

7. Repeat steps 3 through 5 for monitor, measuring output voltage at pin 47.

8. Terminate programmer #2 cycle.
9. Command spacecraft playback mode.
10. Record telemetry on ground-station tape recorder.
11. Recover, record, and correlate telemetry data with applied values.

4.6.1.4 Galactic-Noise Experiment Calibration

Table 4-13 shows galactic-noise experiment calibration data sheet, Unit E_6.

1. Signal generator (HP 606A)
2. Exciter stub antenna (ETB) mounted adjacent to spacecraft
3. Interconnecting coax cable
4. Automatic oscillograph recording system

b. Check of galactic receiver response

1. Operate automatic oscillograph recording system to obtain chart as shown in Figure 4-4.
2. Identify chart.
3. Record at least 2 cycles of galactic-noise responses unexcited.
4. Record indicated parameter measurements in unit E_6.
5. Record at least 2 cycles of galactic-noise response for each of the following excitation frequencies from the signal generator:

kc	Mc	Mc
750	1.0	2
850	1.2	2.2
	1.4	2.5
	1.6	2.7
	1.8	3.0

TABLE 4-13

GALACTIC NOISE EXPERIMENT CALIBRATION DATA SHEET, UNIT E

Exciter Frequency	Exciter Amplitude	Response Amplitude	Sweep Amplitude	Telemetry	
				High Speed	Sweep
		Hardline pin 48		Amplitude μsec	Amplitude μsec
750					
850					
1 mc					
1.2					
1.4					
1.6					
1.8					
2.0					
2.2					
2.5					
2.7					
3.0					

6. Adjust the signal generator to 3 millivolts (-40 db) for each measurement.
7. Record sweep voltage versus excitation frequency and signal amplitude.

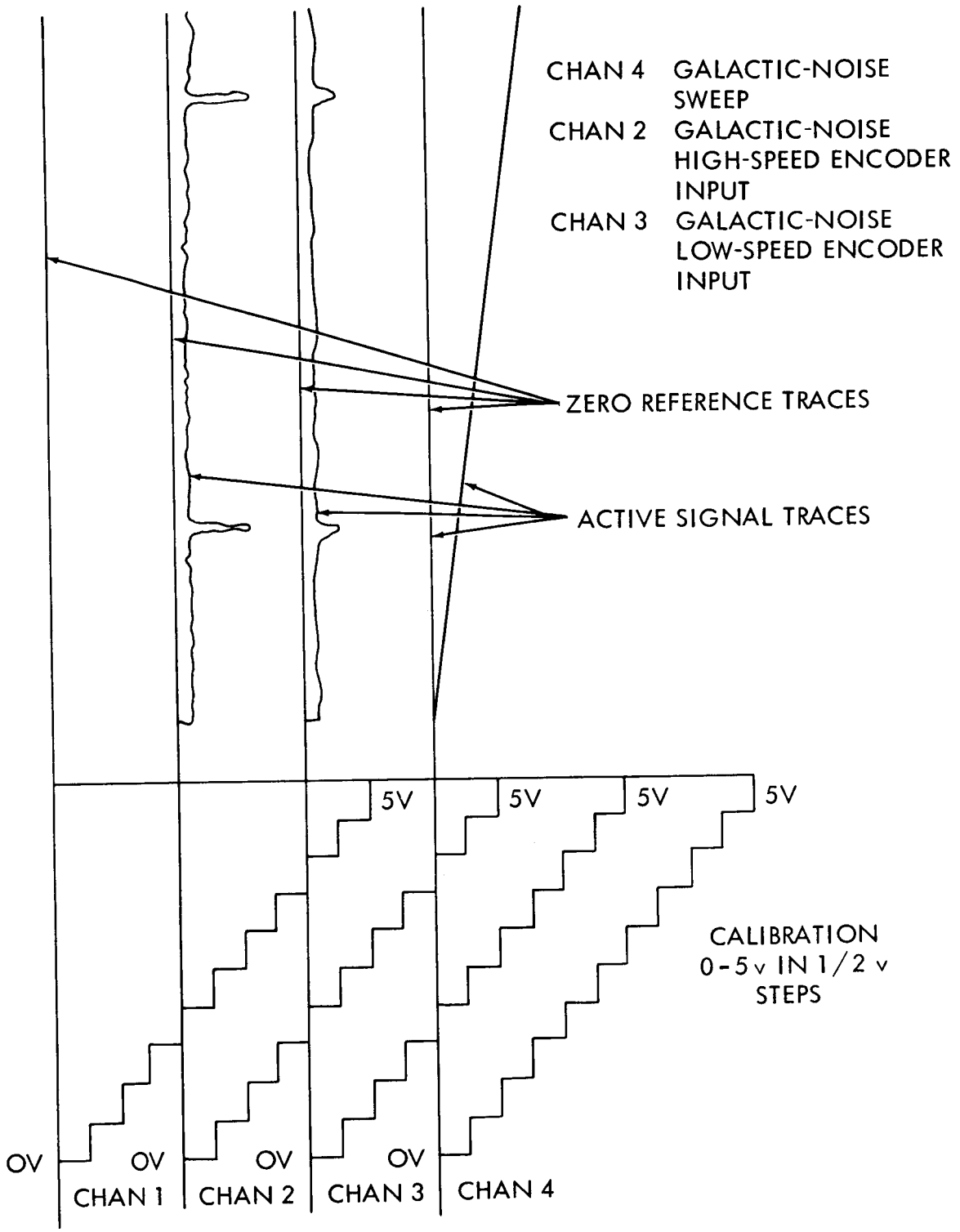

Figure 4-4—Sample Strip Chart Using Programmable Strip-Chart Recording System

5. PERFORMANCE-PARAMETER CALIBRATIONS AND TEST RESULTS

Table 5-1 lists spacecraft performance parameters which are present on the S-52 mode 1 telemetry format. Table 5-2, a conversion table, is provided for relating the normal displayed data in μsecs period to the more convenient units of frequency and voltage.

TABLE 5-1

PERFORMANCE PARAMETERS FOR S-52 PROTOTYPE

PP 00	Broad band ozone (monitor)
PP 01	Broad band ozone (ozone cell)
PP 02	Ozone spectrometer temperature (PMA)
PP 03	EHT
PP 04	+15v
PP 05	Foil advance B (DROD)
PP 06	Foil advance A (DROD)
PP 07	Unregulated buss (+11.5v to +16.5v)
PP 08	Galactic-noise reel (+12v)
PP 09	Solar paddle current
PP 10	Battery current [Charging or Discharging, Depending upon PP-09]
PP 11	Battery A temperature
PP 12	Solar paddle #4 Temperature
PP 13	Dome temperature #1
PP 14	Skin temperature #2
PP 15	Galactic-noise sweep monitor

Corrected 6-7-63

Three-point calibration curves of spacecraft temperature sensors PP0, PP1, PP2, PP11, PP12, PP13, and PP14 (Figures 5-1 through 5-7) were established, using the first valid telemetry data after initial

TABLE 5-2

CONVERSION TABLE

Volts	kc	Period	Volts	kc	Period	Volts	kc	Period	Volts	kc	Period
5.00	5.0	200.0	3.70	7.6	131.5	2.45	10.1	99.0	1.20	12.6	79.3
4.95	5.1	196.1	3.65	7.7	129.8	2.40	10.2	98.0	1.15	12.7	78.7
4.90	5.2	192.3	3.60	7.8	128.2	2.35	10.3	97.0	1.10	12.8	78.1
4.85	5.3	188.7	3.55	7.9	126.4	2.30	10.4	96.1	1.05	12.9	77.5
4.80	5.4	185.1	3.50	8.0	125.0	2.25	10.5	95.2	1.00	13.0	76.9
4.75	5.5	181.8	3.45	8.1	123.4	2.20	10.6	94.3	0.95	13.1	76.3
4.70	5.6	178.5	3.40	8.2	121.9	2.15	10.7	93.4	0.90	13.2	75.7
4.65	5.7	175.4	3.35	8.3	120.4	2.10	10.8	92.5	0.85	13.3	75.1
4.60	5.8	172.4	3.30	8.4	119.0	2.05	10.9	91.7	0.80	13.4	74.6
4.55	5.9	169.5	3.25	8.5	117.6	2.00	11.0	90.9	0.75	13.5	74.0
4.50	6.0	166.6	3.20	8.6	116.2	1.95	11.1	90.1	0.70	13.6	73.5
4.45	6.1	163.4	3.15	8.7	114.9	1.90	11.2	89.2	0.65	13.7	72.9
4.40	6.2	161.2	3.10	8.8	113.6	1.85	11.3	88.4	0.60	13.8	72.4
4.35	6.3	158.7	3.05	8.9	112.3	1.80	11.4	87.7	0.55	13.9	71.9
4.30	6.4	156.2	3.00	9.0	111.1	1.75	11.5	86.9	0.50	14.0	71.4
4.25	6.5	153.8	2.95	9.1	109.8	1.70	11.6	86.2	0.45	14.1	70.9
4.20	6.6	151.5	2.90	9.2	108.6	1.65	11.7	85.4	0.40	14.2	70.4
4.15	6.7	149.2	2.85	9.3	107.4	1.60	11.8	84.7	0.35	14.3	69.9
4.10	6.8	147.0	2.80	9.4	106.3	1.55	11.9	84.0	0.30	14.4	69.4
4.05	6.9	144.9	2.75	9.5	105.2	1.50	12.0	83.3	0.25	14.5	68.9
4.00	7.0	142.8	2.70	9.6	104.1	1.45	12.1	82.6	0.20	14.6	68.4
3.95	7.1	140.8	2.65	9.7	103.0	1.40	12.2	81.9	0.15	14.7	67.9
3.90	7.2	138.8	2.60	9.8	102.0	1.35	12.3	81.2	0.10	14.8	67.5
3.85	7.3	136.9	2.55	9.9	101.0	1.30	12.4	80.6	0.05	14.9	67.0
3.80	7.4	135.1	2.50	10.0	100.0	1.25	12.5	80.0	0.00	15.0	66.6
3.75	7.5	133.3									

spacecraft turn-on subsequent to arriving at environmental temperature stabilization. Temperature stabilization is defined as a gradient on all environmental sensors of less than 1/2°C/hour about the stabilization temperature. Correlation of the spacecraft sensor temperatures with environmental sensors showed agreement within a few percent throughout the temperature excursions.

Figures 5-8 and 5-9 show the performance of PP7, PP9, and PP10 at the three temperature-stabilization points. Note: when PP9 is at

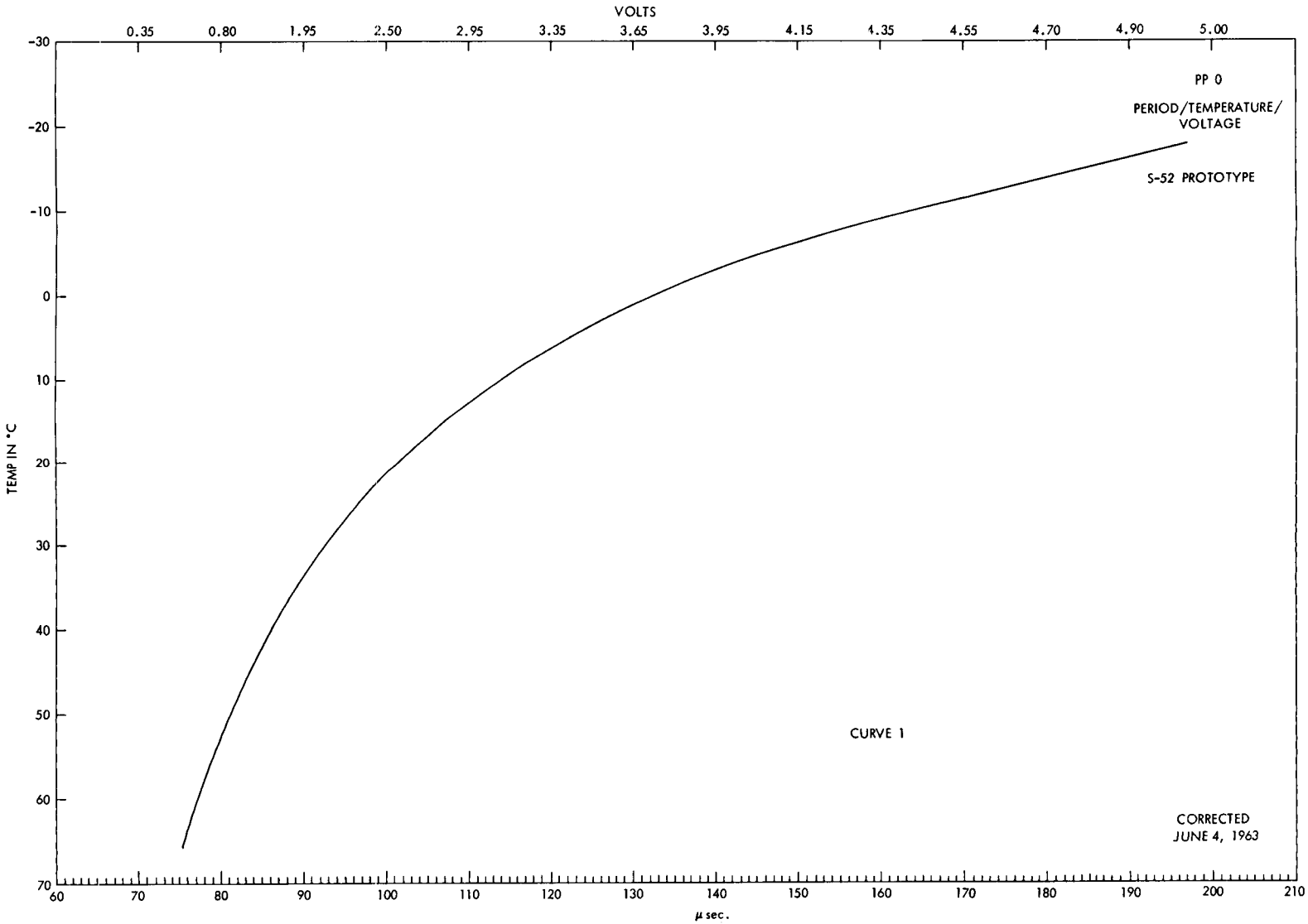

Figure 5-1—PPO Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage

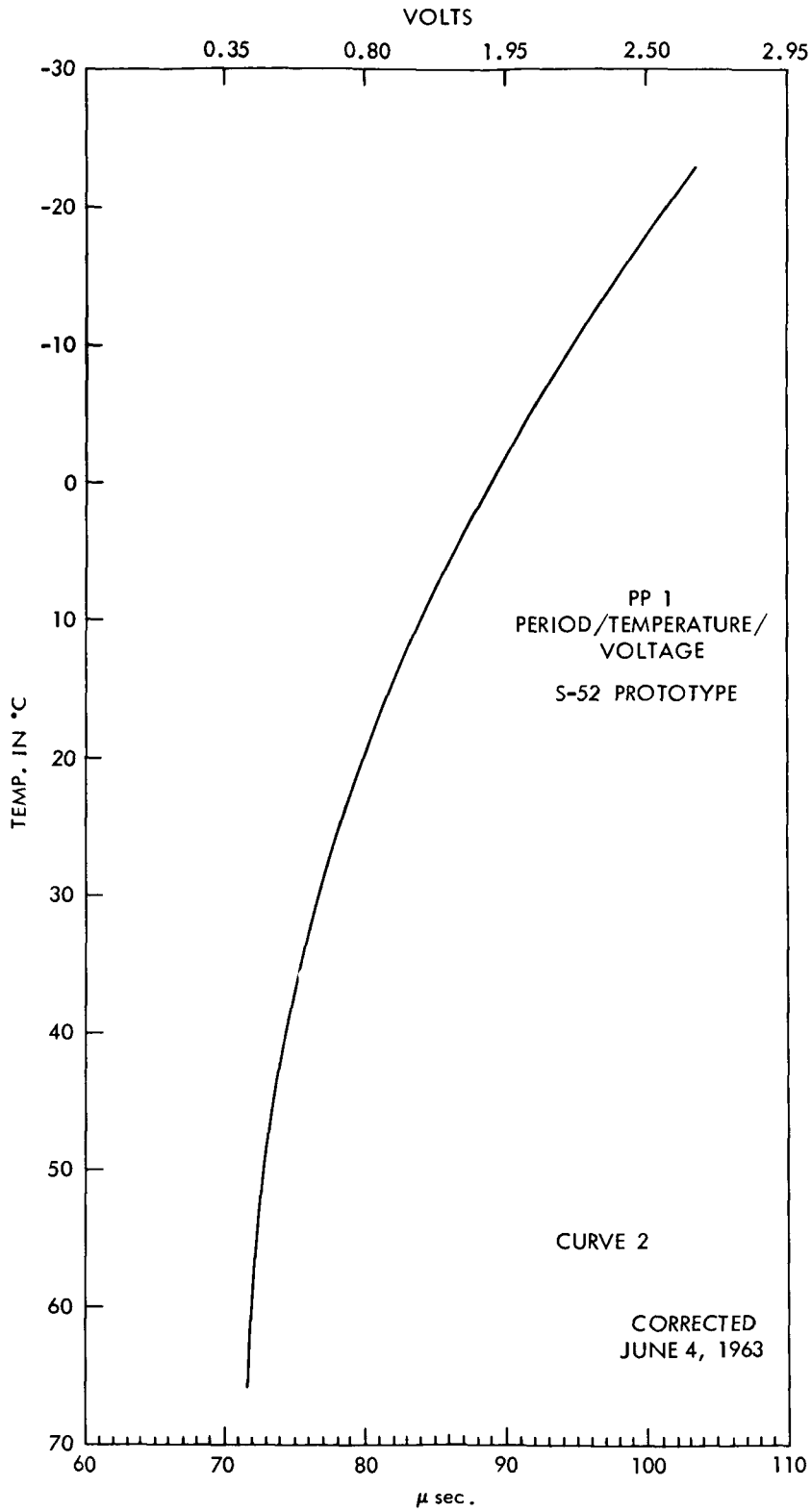

Figure 5-2—PP1 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage

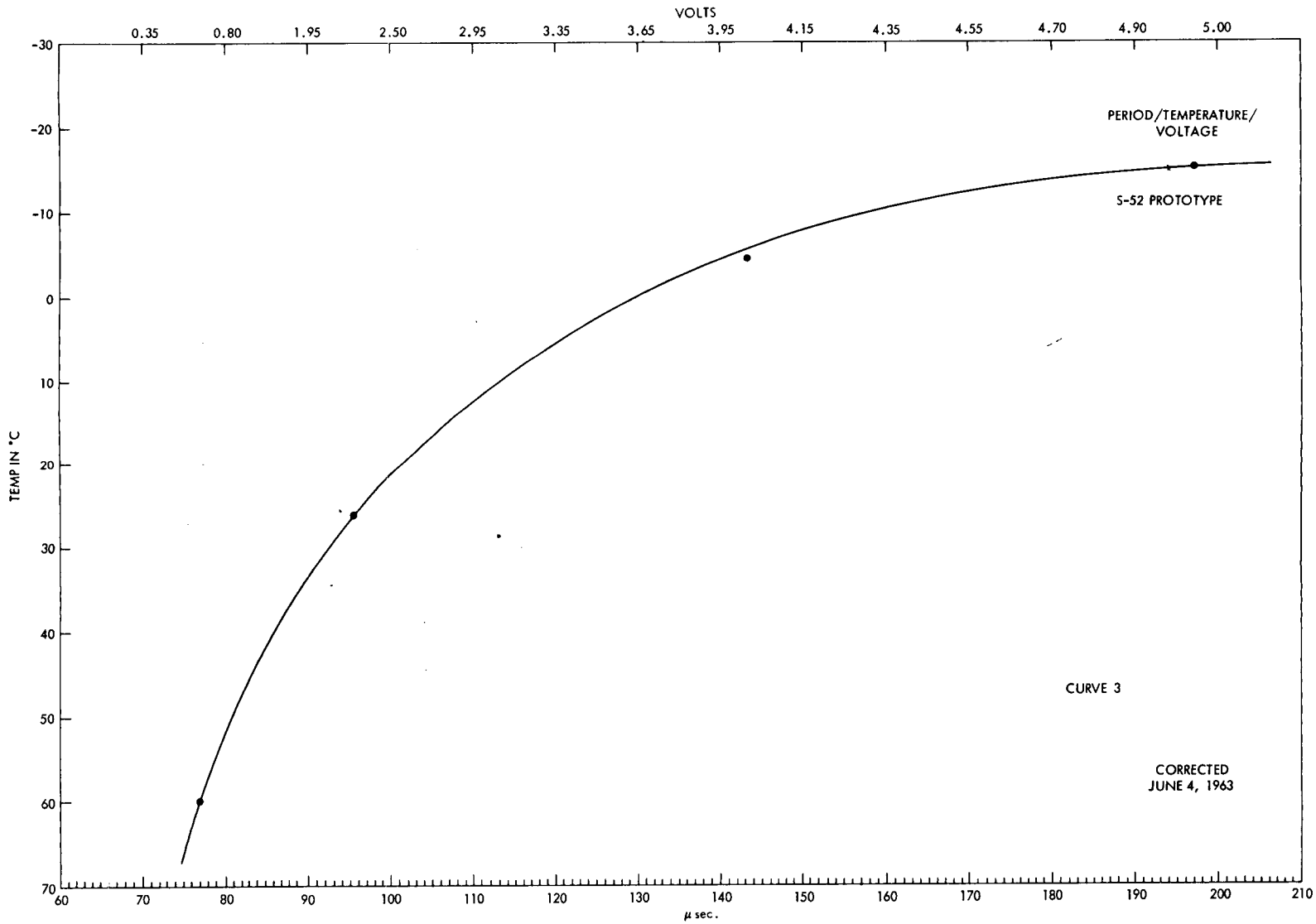

Figure 5-3—PP2 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage

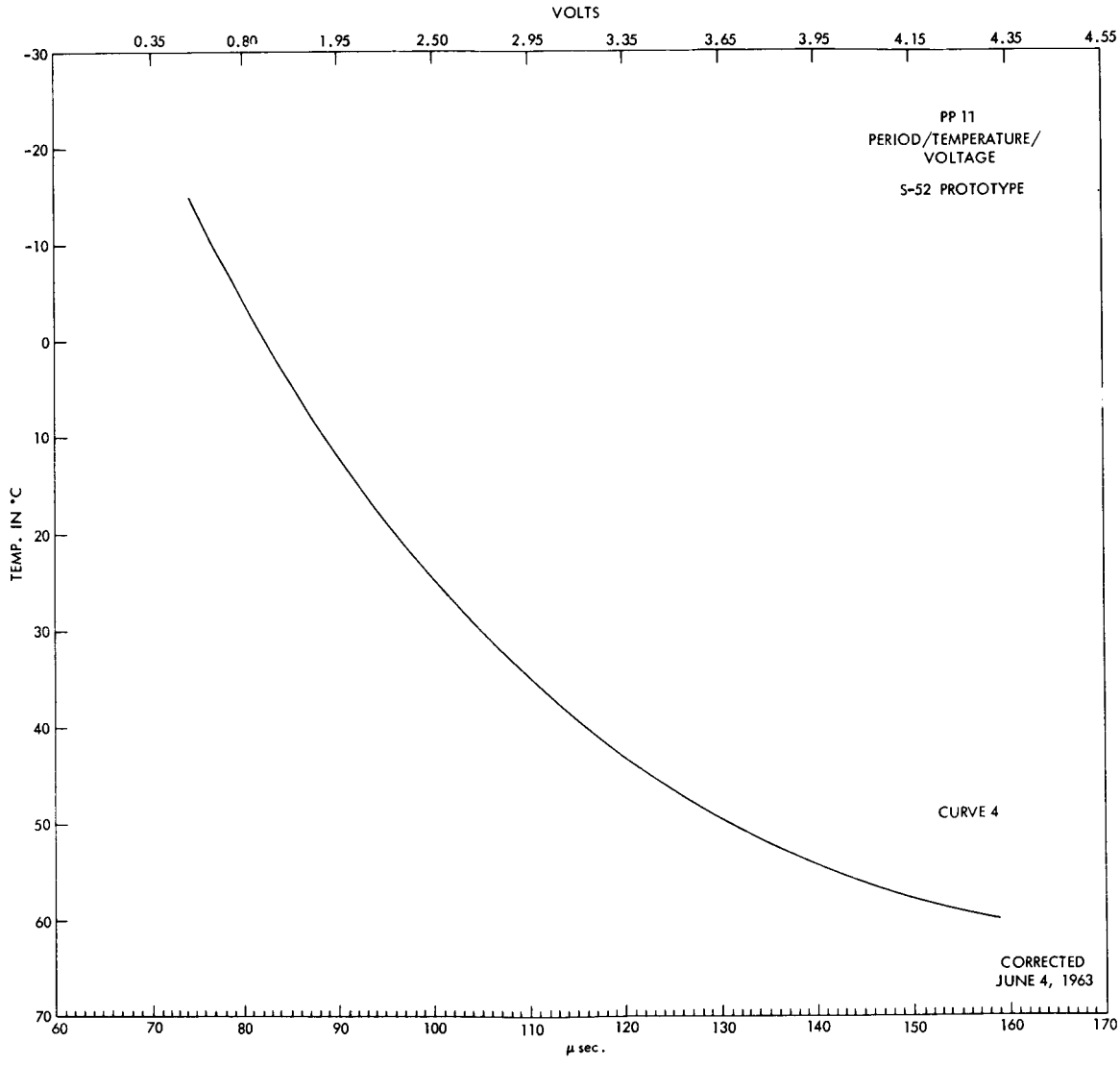

Figure 5-4—PP-11 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage

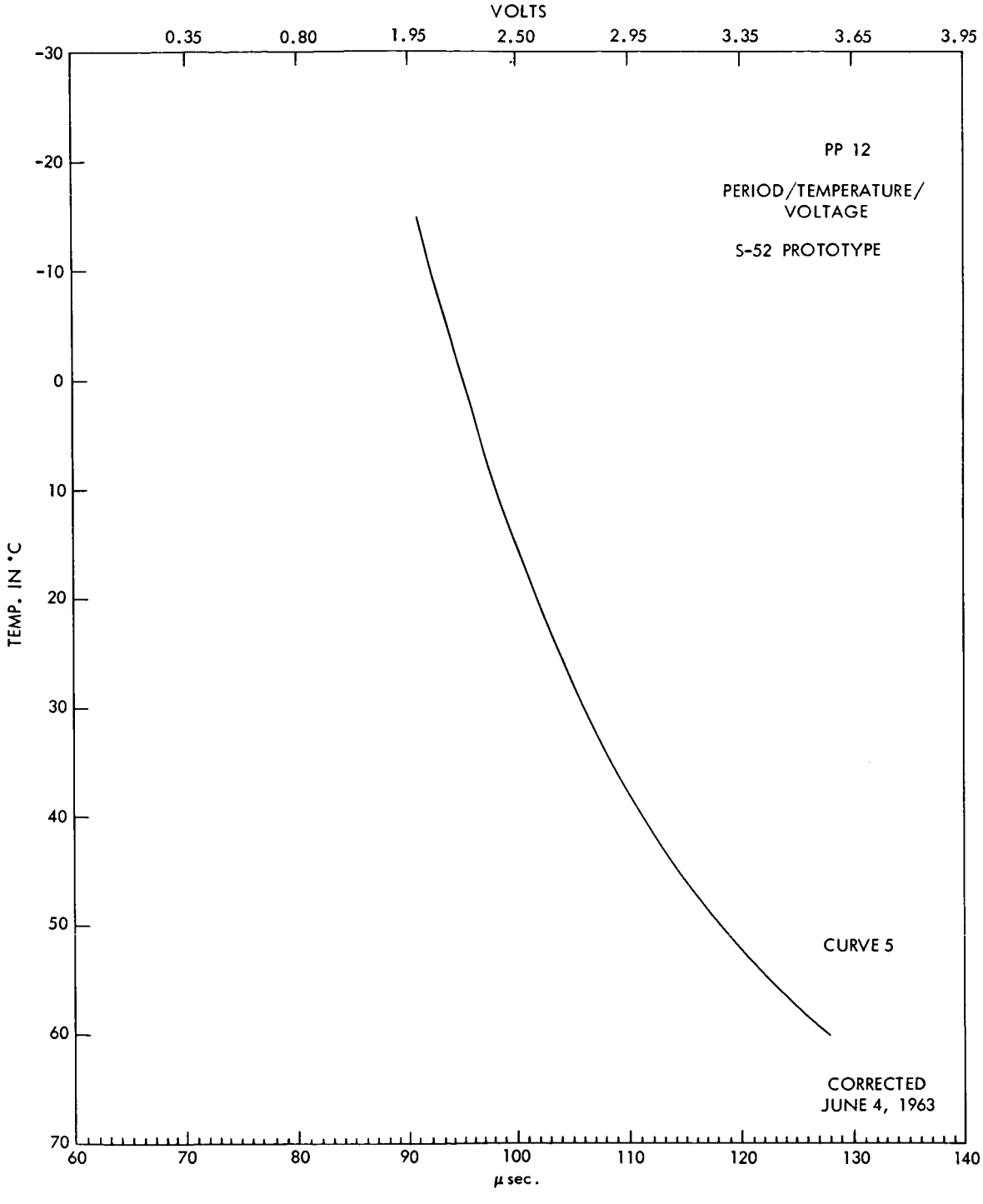

Figure 5-5—PP-12 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage

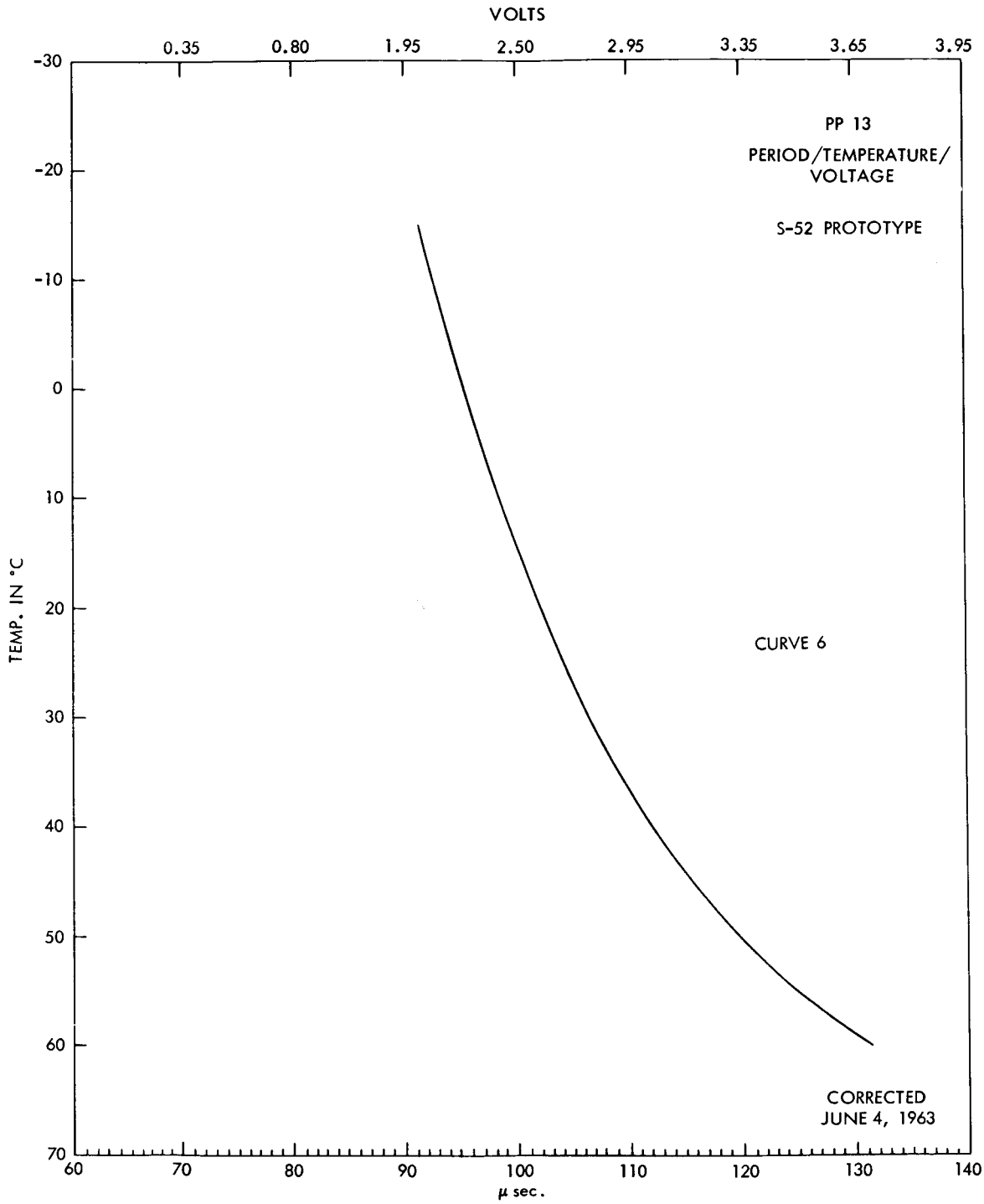

Figure 5-6—PP13 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage

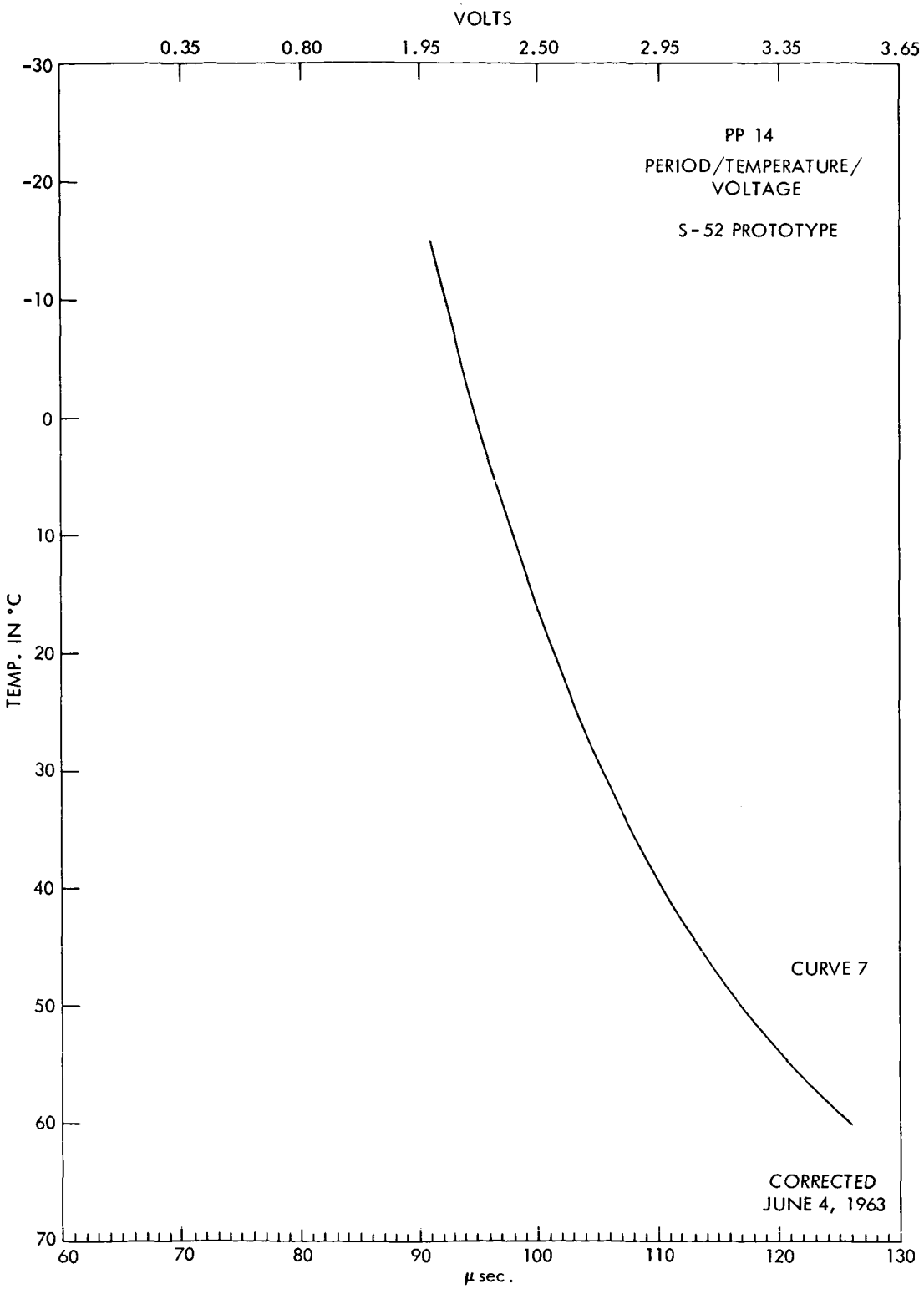

Figure 5-7—PP14 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage

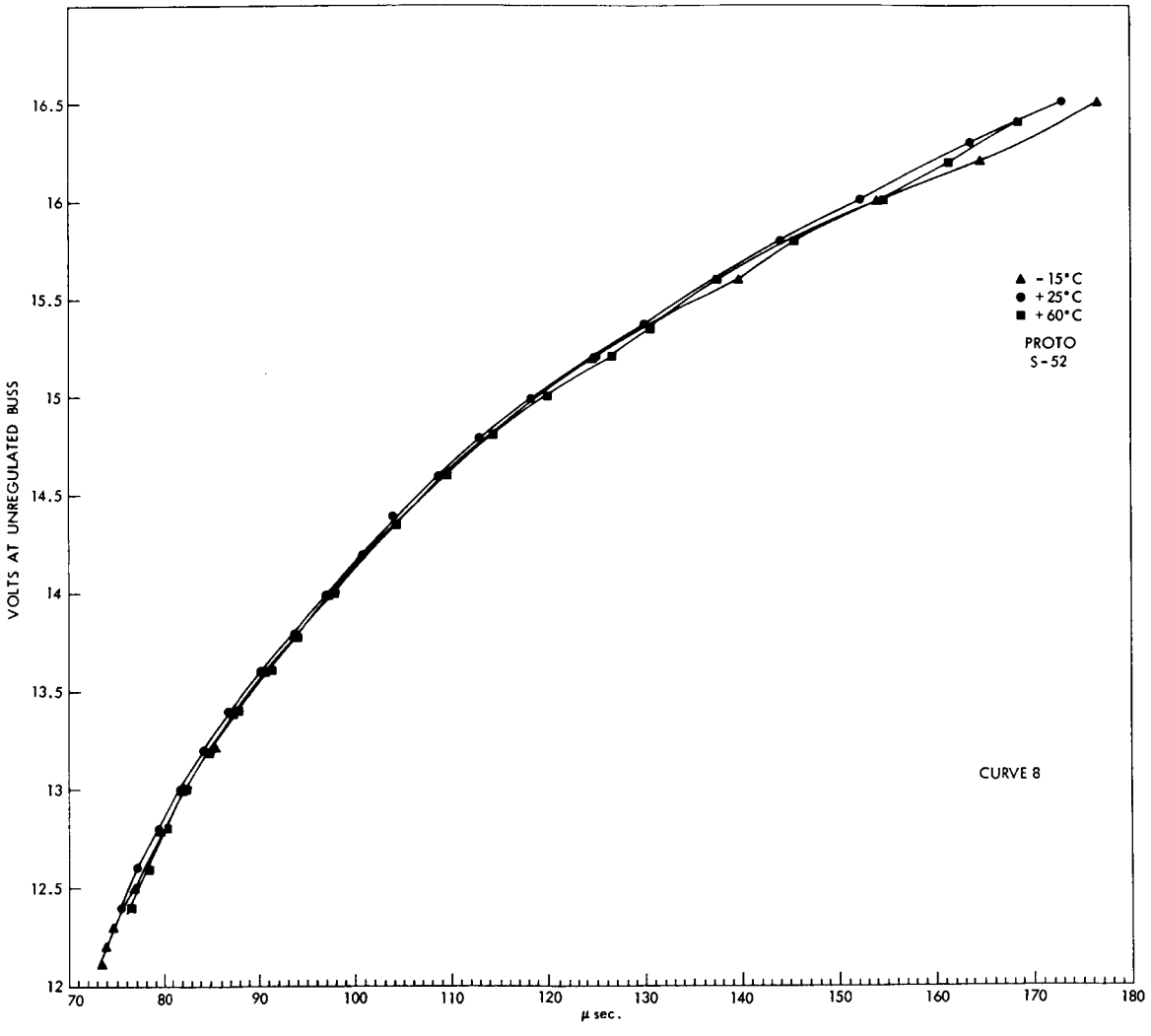

Figure 5-8—PP7 Telemetry (10-Period Average) in Microseconds in Respect to Temperature and Voltage

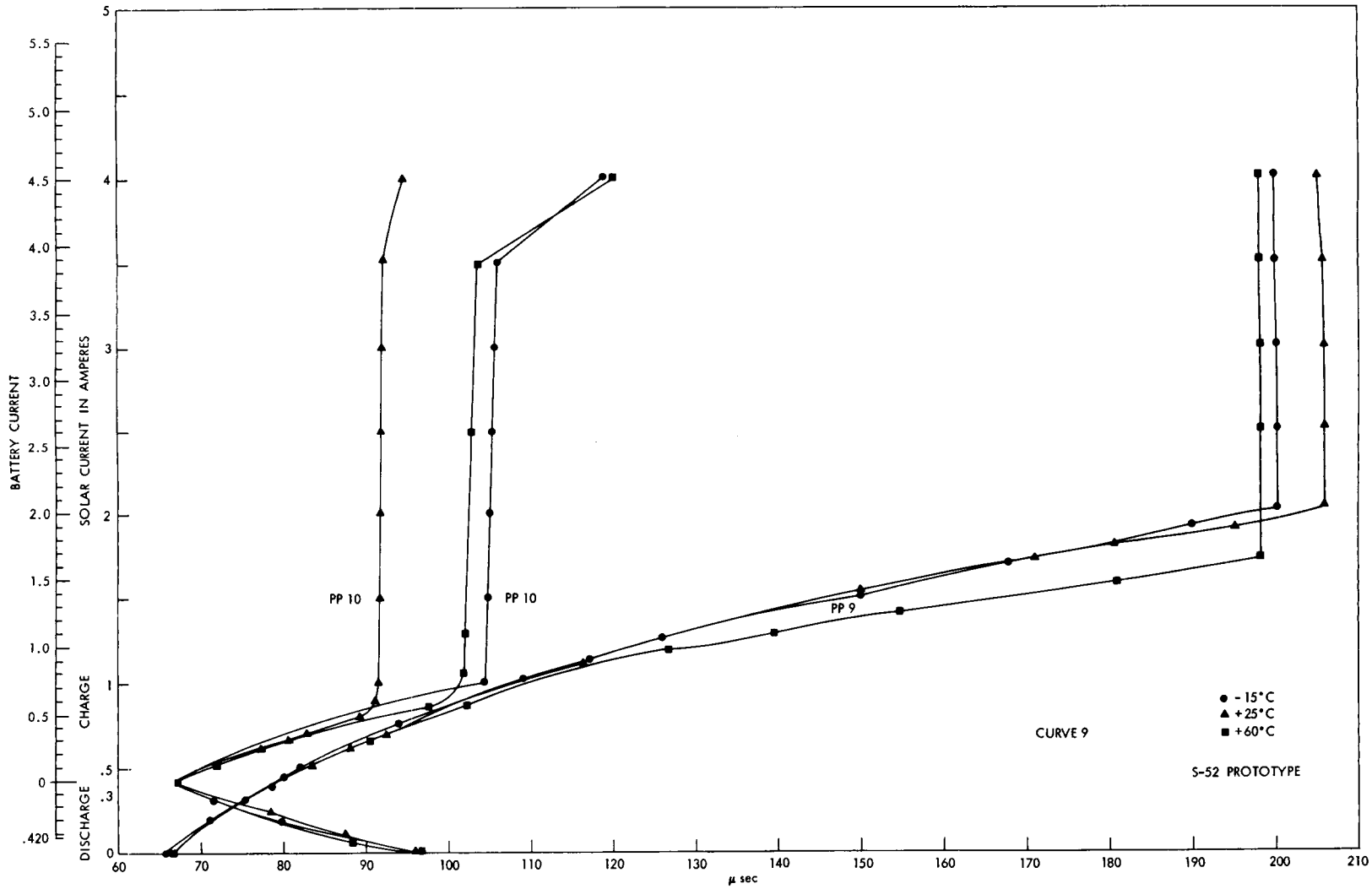

Figure 5-9—PP9 and PP10 Telemetry (10-Period Average) Respect to Temperature and Current

zero solar current, PP10 battery current indicates the spacecraft battery discharge current drain. As solar current is increased to about 420 ma, the spacecraft load is assumed by the solar (charging) current and spacecraft battery discharge current becomes zero. Continued increase in solar current provides for charging the battery (indicated by reversal of PP10) and operation of the spacecraft. The battery charging and protective circuit limits the battery-charging current to about 500 ma. (See Figure 5-9.) The current in excess of that required for battery charging and operating the spacecraft is dissipated ("dumped") in resistors. The solar-current sensor continues to indicate the increase in solar current to about 2 amperes, at which point the sensor limits and higher solar currents are not detectable. Dumping current is readily determined by subtracting spacecraft load current (nominal) and battery-charging current from the indicated solar current.

These performance curves, in conjunction with the temperature calibrations, are invaluable in order to determine the precise performance of the spacecraft in orbit and assist in evaluations during solar simulation exposures.

The remaining performance parameters (PP3, PP4, PP5, PP6, PP8, and PP15) are covered in their respective experiment sections of this report.

During the -15°C exposure, representing the colder orbit when the spacecraft spends about 40 minutes in the dark, the spacecraft operates from the batteries. To determine the spacecraft life on batteries, a charging current of 1/2 amp was applied, for 12 hours, to the spacecraft operating on battery A with battery B in standby (trickle charge) for about 12 hours. Curves 10 and 11 show that each battery maintained the spacecraft load for approximately 6 hours before the undervoltage condition occurred (Figures 5-10 and 5-11). Battery life test at 60°C was commenced but interrupted after 3 hours for designer tests of Programmer #1 and tape recorder interface. Projection of the data collected indicates the battery life to undervoltage would have been in the order of 6 hours.

Tables 5-3 through 5-7 show high and low deviations in spacecraft parameter measurements made at each of the three temperature excursions.

- Table 5-3 — Power system measurements
- Tables 5-4 and 5-5 — Programmer system
- Tables 5-6 and 5-7 — Telemetry system

Table 5-7 shows encoder sync and frame identification frequency deviations with respect to exposure. The frequencies are expressed in their reciprocal (the period in μseconds) measured on a 10-period average basis. High and low values are the extremes recorded during

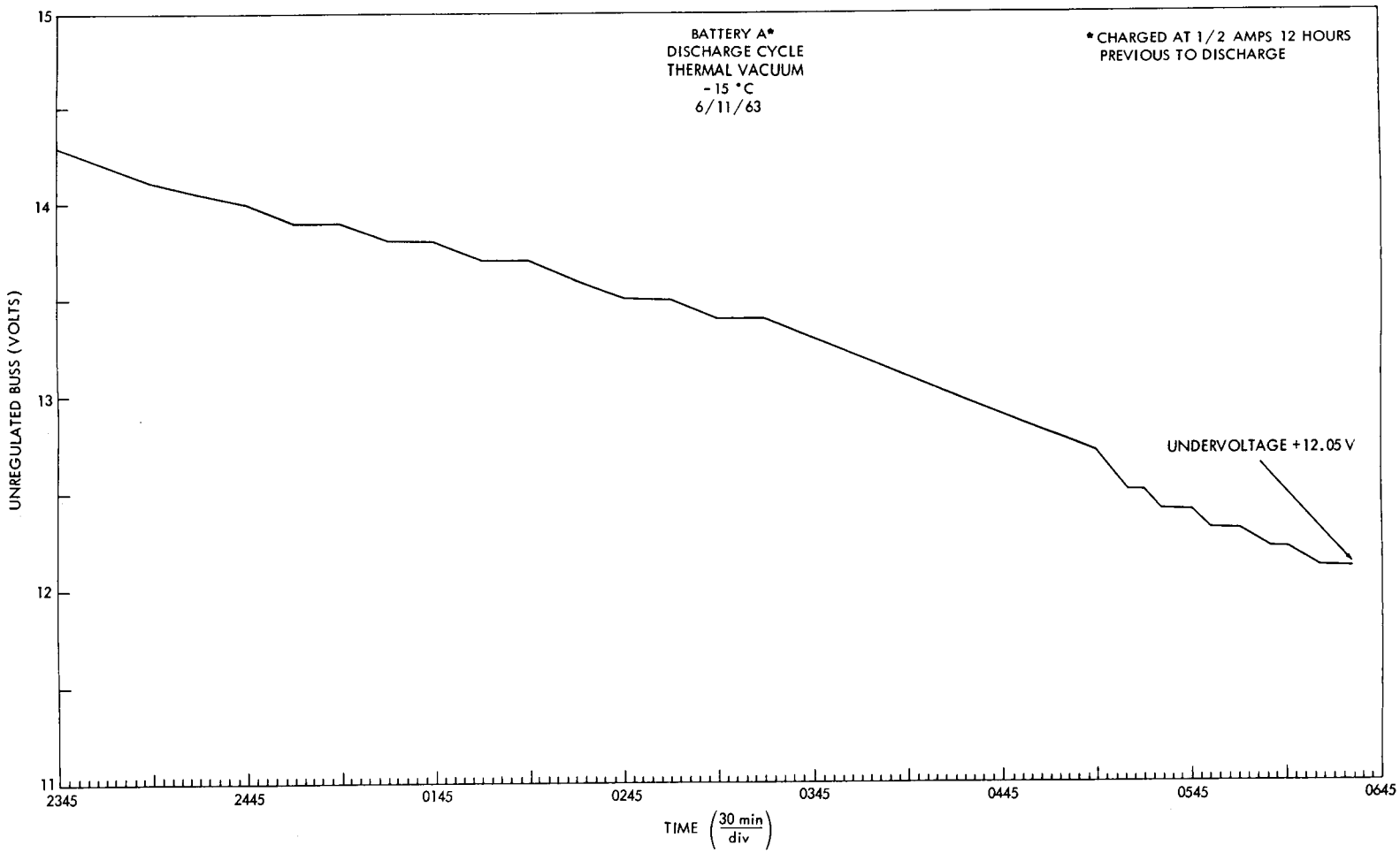

Figure 5-10—Battery A Discharge Cycle Thermal-Vacuum -15°C

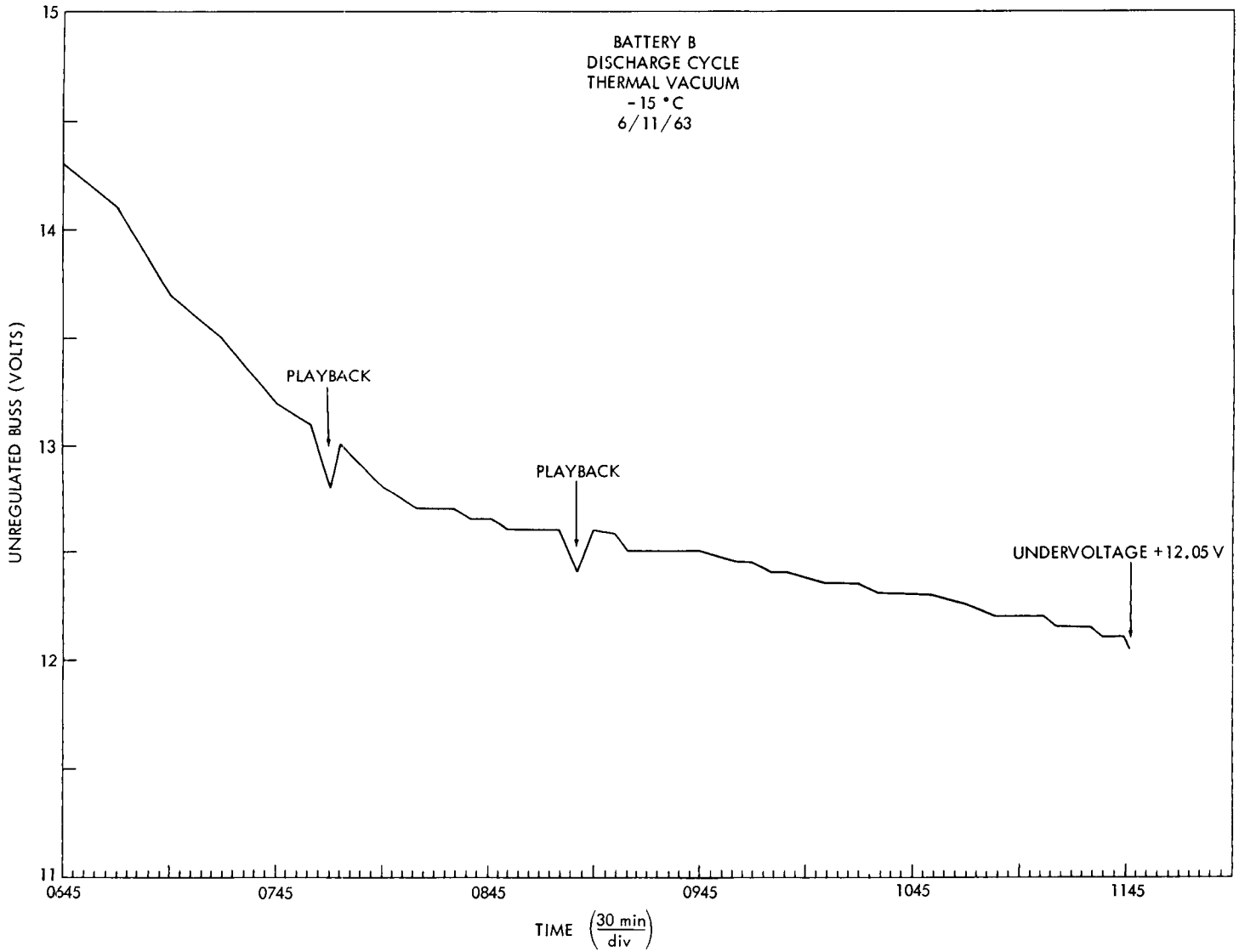

Figure 5-11—Battery B Discharge Cycle Thermal-Vacuum -15°C

TABLE 5-3

SPACECRAFT PARAMETER DEVIATIONS, POWER SYSTEM
Dates: May 30 to June 28, 1963

Spacecraft: S-52 Prototype			Exposure: Thermal-Vacuum (8X8)
Power System			
Parameter	Temperature -15° C	+25° C	+60° C
+ Regulator			
+12 Volts	11.80 – 12.00	11.9	11.90 – 12.04
+7.5 Volts	7.49 – 7.51	7.50 – 7.51	7.50 – 7.53
+6.5 Volts	6.40 – 6.45	6.41 – 6.50	6.49 – 6.57
+6.0 Volts	6.00 – 6.02	6.00 – 6.01	6.01 – 6.03
+3.0 Volts	3.02 – 3.03	3.00 – 3.03	2.97 – 3.01
- Regulator			
-18.0 Volts	-17.96 – -18.10	-18.0	-17.98 – -18.10
- 6.0 Volts	- 5.97 – - 5.99	-5.98 – -5.99	- 5.97 – - 6.00
- 4.0 Volts	- 3.90 – - 3.96	-3.91 – -4.02	- 4.00 – - 4.09
- 3.0 Volts	- 2.95 – - 2.99	-2.98 – -2.99	- 2.98 – - 3.00
Inverter			
15 Volts AC	14.5 – -15.0	14.9 – 15.0	14.9 – 15.5
Frequency cps	1776 – 1797	1766 – 1784	1745 – 1796
+15 Volts DC	14.90 – 15.00	14.9	14.50 – 15.04
System Voltage	14.5 – 14.7	13.4 – 14.2	12.7 – 15.6
System Current (H.S.) ma	400 – 410	390 – 420	395 – 420
System Current (Playback) ma			
Charging System @ 1 ampere			
Solar Paddle Volts	15.6 – 15.8	13.8 – 15.3	14.3 – 16.9
Dumping J_4 Volts	0.049 – 0.058	0.044 – 0.701	0.507 – 1.54
Dumping J_5 Volts	0.049 – 0.070	0.039 – 1.18	0.400 – 1.71
Battery Charge Current ma	540	400 – 510	– 435
Battery Trickle Charge ma	25.5 – 32.0	18.0 – 35.0	1.2 – 40.0
Charging System @ 2 ampere			
Solar Paddle Volts	15.55 – 16.0	14.7 – 15.3	14.7 – 16.9
Dumping J_4 Volts	5.09 – 5.72	0.525 – 0.585	4.51 – 7.59
Dumping J_5 Volts	5.24 – 5.93	0.502 – 0.575	4.98 – 6.37
Battery Charge Current ma	540 – 550	500 – 515	310 – 440
Battery Trickle Charge ma	31.0 – 34.0	20 – 35	1.5 – 53.0

the total period at each exposure. The percentage of deviation was determined from the difference of the high and low values divided by the minimum value. Calculations are shown for ambient and for total temperature excursions.

TABLE 5-4

SPACECRAFT PARAMETER DEVIATIONS, PROGRAMMER SYSTEM
Dates: May 30 to June 28, 1963

Spacecraft: S-52 Prototype			Exposure: Thermal-Vacuum (8X8)
	Programmer System		
Parameter	Temperature -15° C	+25° C	+60° C
Programmer #1			
H.S. Transmitter Mod Vp to p			
Sync Amplitude	5.6 – 7.5	7.0	6.0 – 7.5
Data Amplitude	2.2 – 3.0	2.8 – 3.2	2.2 – 3.5
Tape Recorder Input			
Sync Amplitude Vp to p	1.8 – 2.0		2.0 – 2.2
Rs Data Amplitude Vp to p	.75 – 1.0	1.0 – 1.1	1.0 – 1.1
Tape Recorder Playback			
Sync Amplitude Vp to p	.8 – .9	.8	.8 – .9
Data Amplitude Vp to p	–	–	–
L.S. Transmitter Modulation			
Sync Amplitude Vp to p	6.0 – 8.0	7.0 – 8.0	6.0 – 8.0
Data Amplitude Vp to p	3.0 – 4.0	3.0 – 3.5	3.0 – 5.0
Data Storage Card and Tape Recorder			
Number of Playbacks	14	2	18
Total Playback Time	32.8 min	4.68 min	42.4 min
Playback Osc Rate	1.3 – 1.4 sec	1.36 sec	1.33 – 1.36 sec
Playback Time seconds	139 – 144 sec	136 – 145 sec	135 – 140 sec
Motor $\emptyset_1$ Amplitude Volts	1.3 – 1.5	1.2 – 1.3	1.1 – 1.4
Motor $\emptyset_2$ Amplitude Volts	1.3 – 1.5	1.2 – 1.3	1.1 – 1.4
Lag $\emptyset_2 - \emptyset_1$ Amplitude degrees	2.23 – 2.38 not in degrees	2.3 – 2.394	2.20 – 2.42
Programmer #2	min sec – min sec	min sec – min sec	min sec – min sec
Sunrise Level Volts			
To + 6 Minutes	5 53 – 6	5 59 – 6 1	6 4 – 6 20
To + 60 Minutes	59 19 – 59 30	59 58 – 60 2	60 10 – 60 48
To + 78 Minutes	77 10 – 77 40	77 59 – 78	77 24 – 78 40
To + 110 Minutes	108 49 – 110	110 – 110 3	109 45 – 111 17
Timers 1 Year			
Timer A Current μa	16 – 17.5 μA	16.7 – 17 μA	16.0 – 18.5 μA
Timer B Current μa	14 – 17.5 μA	16.7 – 17 μA	16.2 – 18.5 μA
Underwattage Detector			
V.V. Level Volts	12.0 – 12.1	12.15 – 12.2	12.15 – 12.4
Osc #1 Period	63.83 – 63.916	63.179 – 64.053	64.233 – 65.111
Osc #2 Period	60.41 – 60.559	59.756 – 60.988	61.450 – 63.198
Osc #1 Count	1000 – 1001	1001	1000 – 1003
Osc #2 Count	1000	–	1000 – 1001

TABLE 5-5

UNDERVOLTAGE

		Ma B												Ma	
J_4 Dump	J_5 Dump	Batt. A	Batt. B	Batt. Ch.			A.C.	Freq.	Pin 45	E Charge	I Charge	OSC 1	OSC 2	Chg Trick	60/40
.253	.183	13.2	12.8	66	–	–	14.9	1721	14.9	14.3	1.00	63.75	60.33	17 Min	-15
.411	.297	14.6	16.5	420	–	–	15.0	1789	15.0	17.0	1.05	63.805	60.379	67 Max	
673	697	13.0	14.5	485			15.0	1739	15	14.9	2	64.247	61.519	32 Min	100
700	718	13.6	15.0	525	1001	1000	15.0		15	15.4	2	64.292	61.571	52 Max	60

No UV in TV @ amb — AMB

TABLE 5-6

SPACECRAFT PARAMETER DEVIATIONS, TELEMETRY SYSTEM
Dates: May 30 to June 28, 1963

Spacecraft: S-52 Prototype			Exposure: Thermal Vacuum (8X8)
Telemetry System			
Parameter	Temperature -15° C	+25° C	+60° C
Transmitter			
* Power mw	150 – 180	180 – 200	164 – 180
Frequency 136. mc	559898 – 559959	558880 – 559912	557655 – 557767
Command Receiver			
* Sensitivity db	55 – 58		75 – 77
Encoder			
Sync m sec	250	–	250 – 350
$\overline{A}$ amplitude	0	– 1.8	-1.7 – -1.9
period	13.95 – 14.0	13.9596 – 13.960	13.58 – 13.96
$\overline{L}$ amplitude	0 – (-3.7 – -4.0)	0–(-3.9– -4.0)	0 –(-3.9 – -4.0)
period	4.60 – 4.654	4.65 – 4.653	4.60 – 4.66
$\overline{T}$ amplitude	0 – (-3.7 – -4.0)	0– (-4)	0 – (-3.8 – -4.0)
period	18.166 – 18.177	18.1764 – 18.1766	18.13 – 18.1755
Tuning Fork Kill			
$\overline{T}$ amplitude			
period			
H.S. video amp Vp to p sync	1.5 – 1.8	1.5	1.3 – 1.6
data	.6 – 1.0	.6 – .75	.65 – .8
H.S. Gate C Volts			
L.S. Gate B Volts	-5.95 – 6.00	-5.94 – -5.95	-5.93 – -5.98
L.S. Envelope Volts	(-2.0– -3.0)-(5.0-5.5)	(-2.7– -3.0)-(5.0–5.5)	(-1.8– -3.0)–(5.0 – 5.5)
Period	871.98 – 872.5	872.0 – 872.44	872.3 – 872.5
L.S. Video	0 – (-38 – -4.0)	0 – (-3.8 – -4.0)	0 – (-3.9 – -4.0)
L.S. before ÷48 sync	(.5-1.0) – (4.2 - 6.2)	4.0	(.4-.6) – (4.0-4.8)
data	(1.0-1.5) – (2.5-3.0)	1.5	(1.0-1.6) –(2.3-2.8)
L.S. Sync μsec	222.9 – 223.9	221.2 – 221.9	222.1 – 223.6

Encoder specifications state:

a. Sync frequency 4.5 kc should be no greater than 4500 ±22 cps at ambient (±0.48 percent) and 4500 with a total deviation of 45 cps from -10° C to +60° C.

b. Frame identification frequency deviations should be no greater than +1 percent at ambient and a total deviation no greater than 1.5 percent from -10° C to +60° C.

TABLE 5-7
IDENTIFICATION FREQUENCY DEVIATIONS

$(\%\Delta = \frac{H - L}{L} \times 100\%)$

Frame	-15° Hi	-15° Low	+25° Hi	+25° Low	+25° C %Δ	+60° Hi	+60° Low	Total Deviation -15°C to +60°C Δ%
0	198.5	197.7	198.2	195.7	1.27	195.7	195.1	1.74 -15°C to +60°C all values
1	224.3	223.7	224.1	222.0	.99 all +25°C values	223.8	223.3	1.03
2	160.7	160.0	160.5	158.4	1.32	158.6	158.0	1.70
3	224.3	223.7	224.1	222.2		223.8	223.2	
4	134.9	134.0	134.7	132.9	1.35	132.8	132.6	1.73
5	224.3	223.9	224.1	222.1		223.8	223.2	
6	116.6	116.0	116.4	114.8	1.39	114.9	114.7	1.65
7	224.3	223.7	224.1	222.1		223.8	223.3	
8	101.6	101.3	101.4	100.1	1.29	100.3	100.1	1.49
9	224.3	223.7	224.2	222.0		223.8	223.2	
10	91.0	90.8	91.0	89.8	1.33	90.0	89.7	1.44
11	224.3	223.7	224.1	222.1		223.8	223.3	
12	82.5	82.2	82.3	81.2	1.35	81.6	81.3	1.59
13	224.3	223.7	224.1	222.1		223.8	223.3	
14	75.7	74.4	75.3	74.4	1.21	74.7	74.5	1.74
15	224.3	224.0	224.1	222.1		223.8	223.3	

NOTE: Two important factors must be considered in analyzing this data:

1. The test-stand ground station has an accuracy in the order of 1 percent.

2. The encoder cards experienced a temperature excursion from -14.5 to +61.5°C (reference T&E Memorandum Report #632-12 20, dated September 1963, "Results of the Thermal Vacuum Design Qualification Test of the UK-2/S-52 International Ionosphere Sattellite," by K. Rosette)

In addition, on July 3, 1963, the Data Instrumentation Development Branch at GSFC provided data reduction of a 45-minute spacecraft transmission to Litton (spacecraft ambient conditions). This reduction provided a resolution of 50 cps. All frequencies fell within their assignments.

The encoder is considered to have performed as intended.

6. MICROMETEORITE EXPERIMENT TEST RESULTS

The micrometeorite experimenter is contemplating design changes based on the wide variations in amplifier gain shown in Table 6-1, total excursions. The change in gains recorded were derived from the fixed-input pulse-generator measurements. Table 6-2 shows fixed amplitude pulses.

TABLE 6-1

MICROMETEORITE EXPERIMENTS-BRUSH RECORDER CALIBRATIONS

		25°	60°	-15°	Total Excursion
IROD A		3.5 → 6.2	1.2 → 3.44	11.0 → 14.7	1.2 → 14.7
IROD B		32.2 → 36.2	1.39 → 8.0	96 → 220	1.39 → 220
DROD A					
	PRE	19.1 → 28.4	1.70 → 8.60	27 → 41.1	1.70 → 41.1
	POST	16.1 → 29.0	1.33 → 3.08	30 → 40	1.33 → 40
DROD B					
	PRE	27.0 → 38.7	2.65 → 10.0	37.5 → 46.0	2.65 → 46.0
	POST	13.3 → 17.7	1.1 → 5.90	19.0 → 36.2	1.1 → 36.2

Recorded values are available harline voltage outputs of micrometeorite experiment amplifiers excited by fixed amplitude independent pulse generators.

TABLE 6-2

FIXED AMPLITUDE PULSES

Temperature	Performance Parameters	Before FAP		After FAP	
		Light Off	Light On	Light Off	Light On
-15	5	89.3 - 89.6	87.6 - 89.5	89.3 - 89.5	87.5 - 89.4
	6	85.3 - 85.4	83.2 - 85.3	85.2 - 85.4	79.3 - 85.4
+60		80.0 - 81.3 74.5 - 76.5	79.0 - 81.1 66.7 - 76.3	80.1 - 81.3 74.6 - 76.5	77.9 - 81.2 67.3 - 76.2

No readings at ambient

Typical X-Y plots of the micrometeorite experiment measurement of the pulse generated excitation recovered from spacecraft telemetry are shown in Figures 6-1 through 6-6 for each of the three operating temperatures. These plots were obtained from Data Central.

The galactic-noise experiment was essentially self-excited, although periodic checks were made with the test oscillator as described in the test procedures. Figures 6-4 through 6-6 are X-Y plots supplied by Data Central from the recovered spacecraft telemetry. The lower trace is a plot of all words available on channels 2, 6, 10 and 14 on the high-speed telemetry format which sample the galactic-noise experiment; the upper trace is a plot of all the words present on channel 8 in the same sampling period. The galactic-noise experiment sweep appears as word 15 on channel 8, and the sweep is indicated by the line drawn through these points.

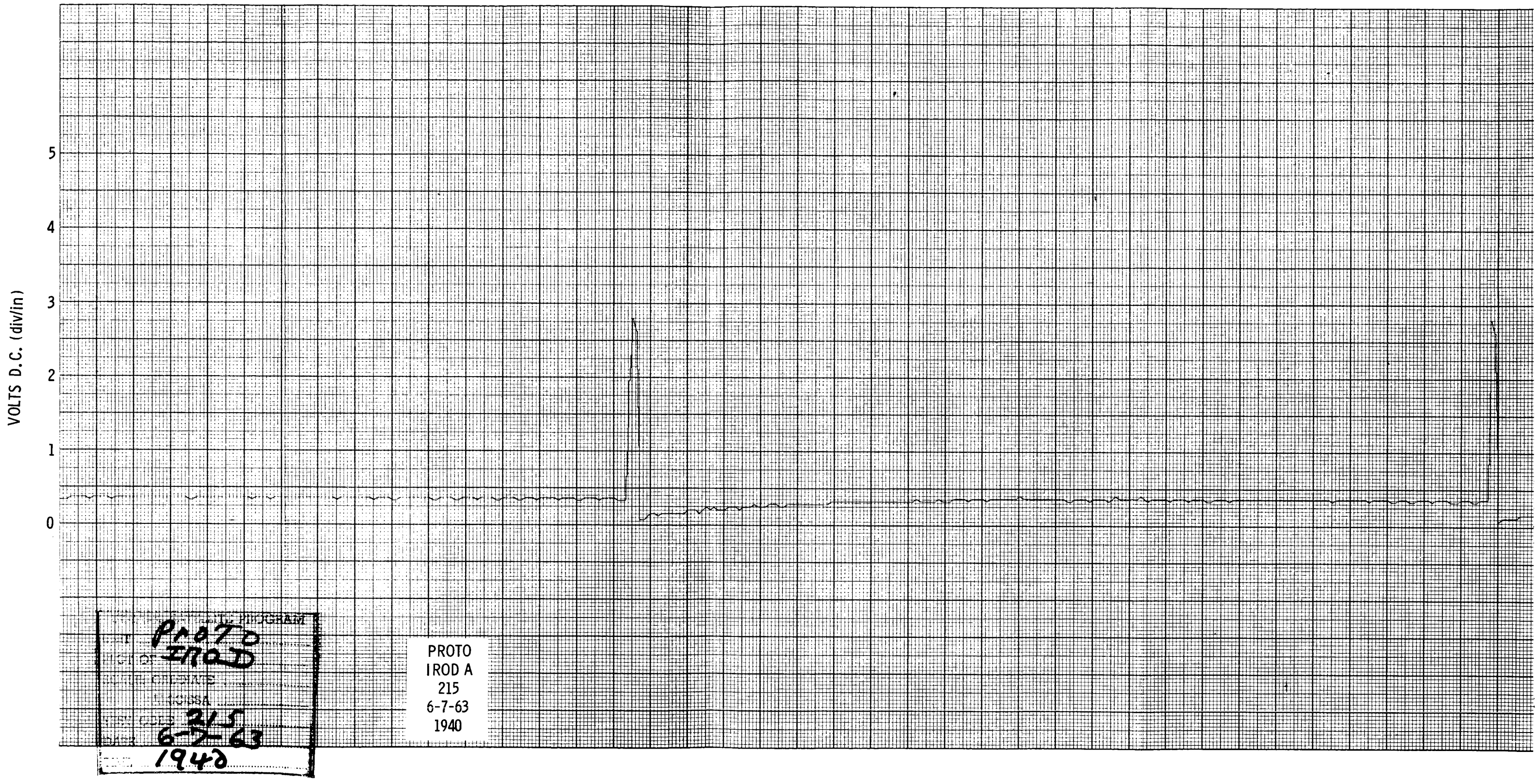

Figure 6-1—Micrometeorite Experiment Measurements at -15°C

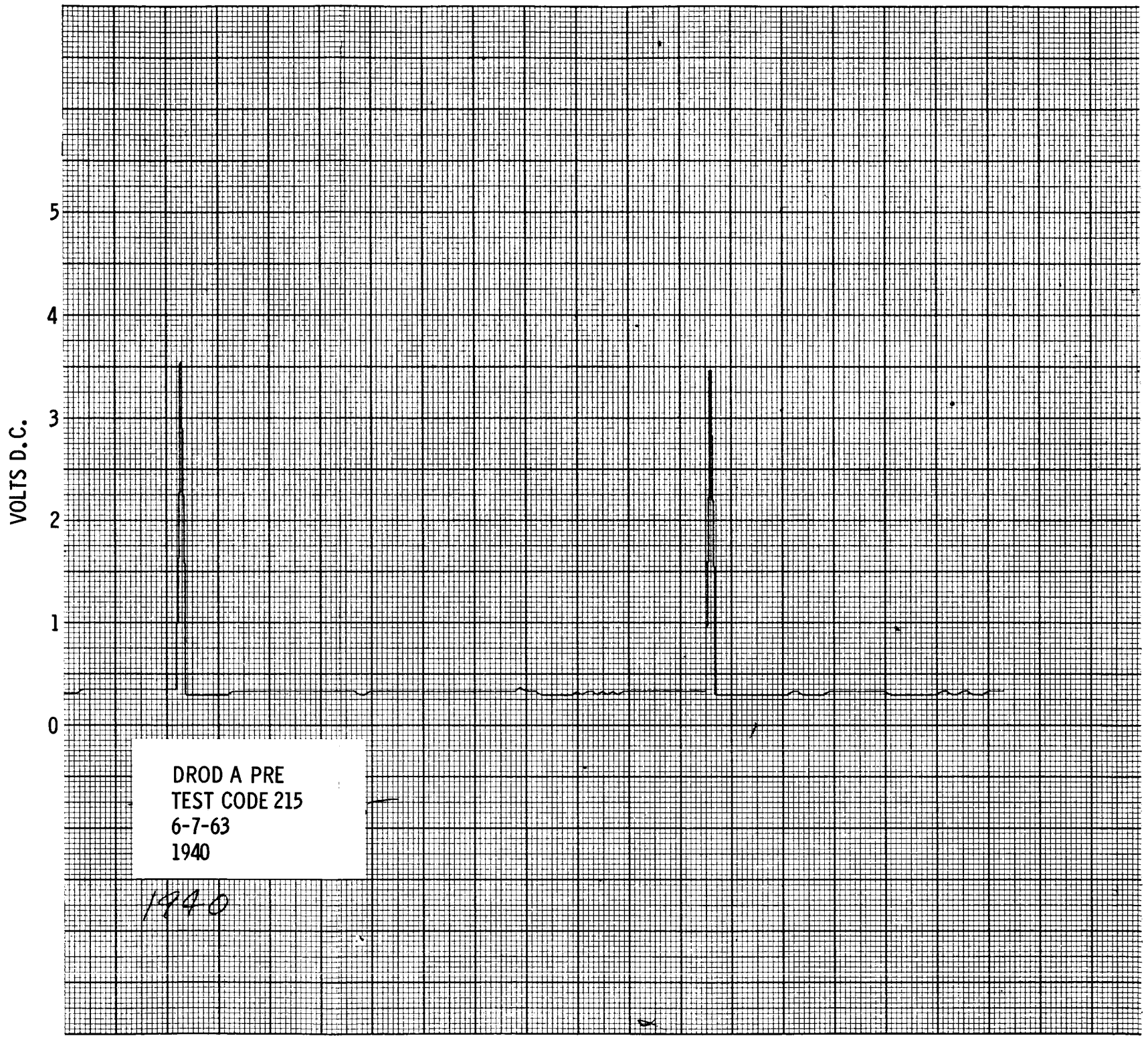

Figure 6-1—Micrometeorite Experiment Measurements at -15°C—Continued

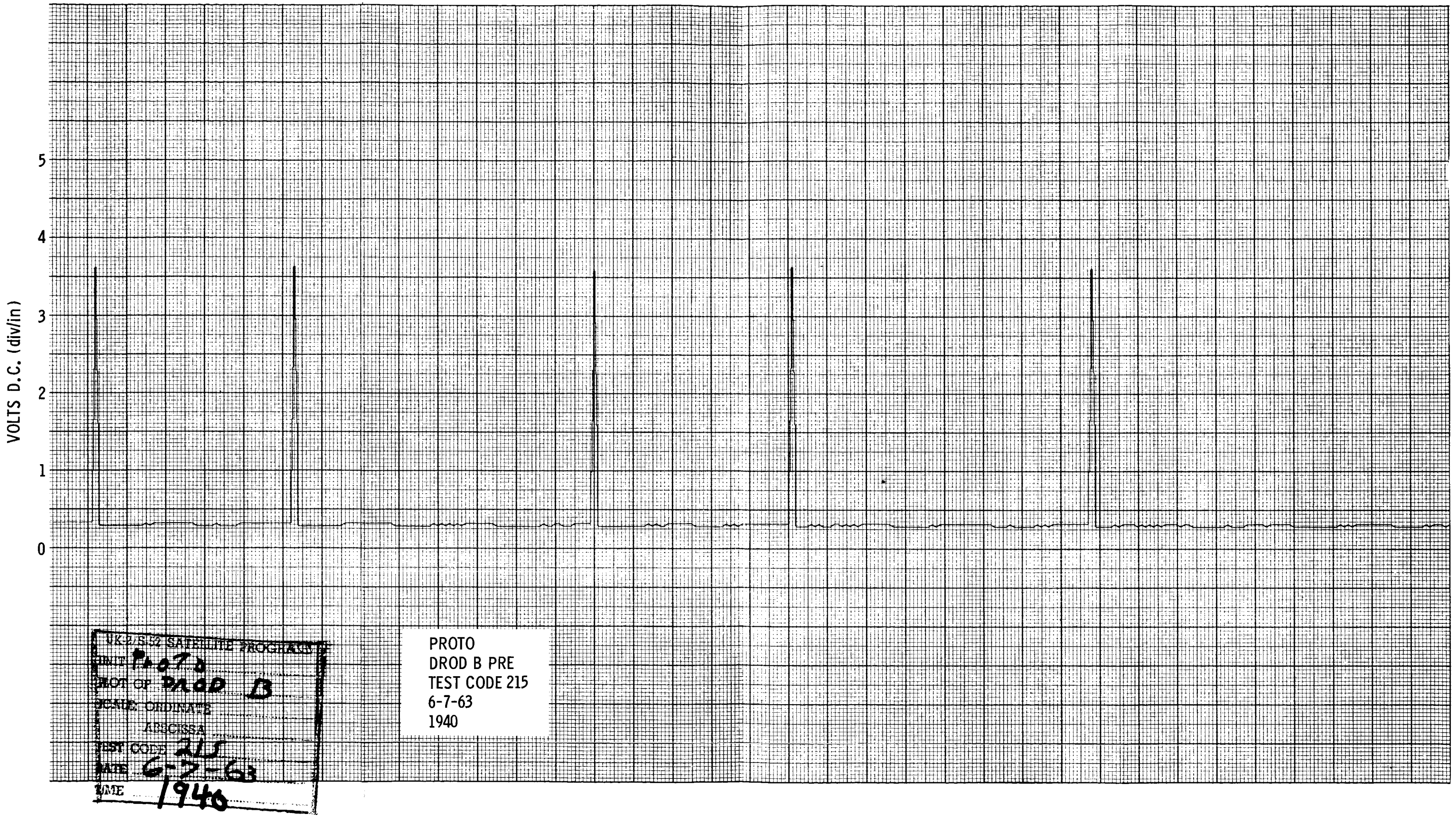

Figure 6-1—Micrometeorite Experiment Measurements at -15°C—Concluded

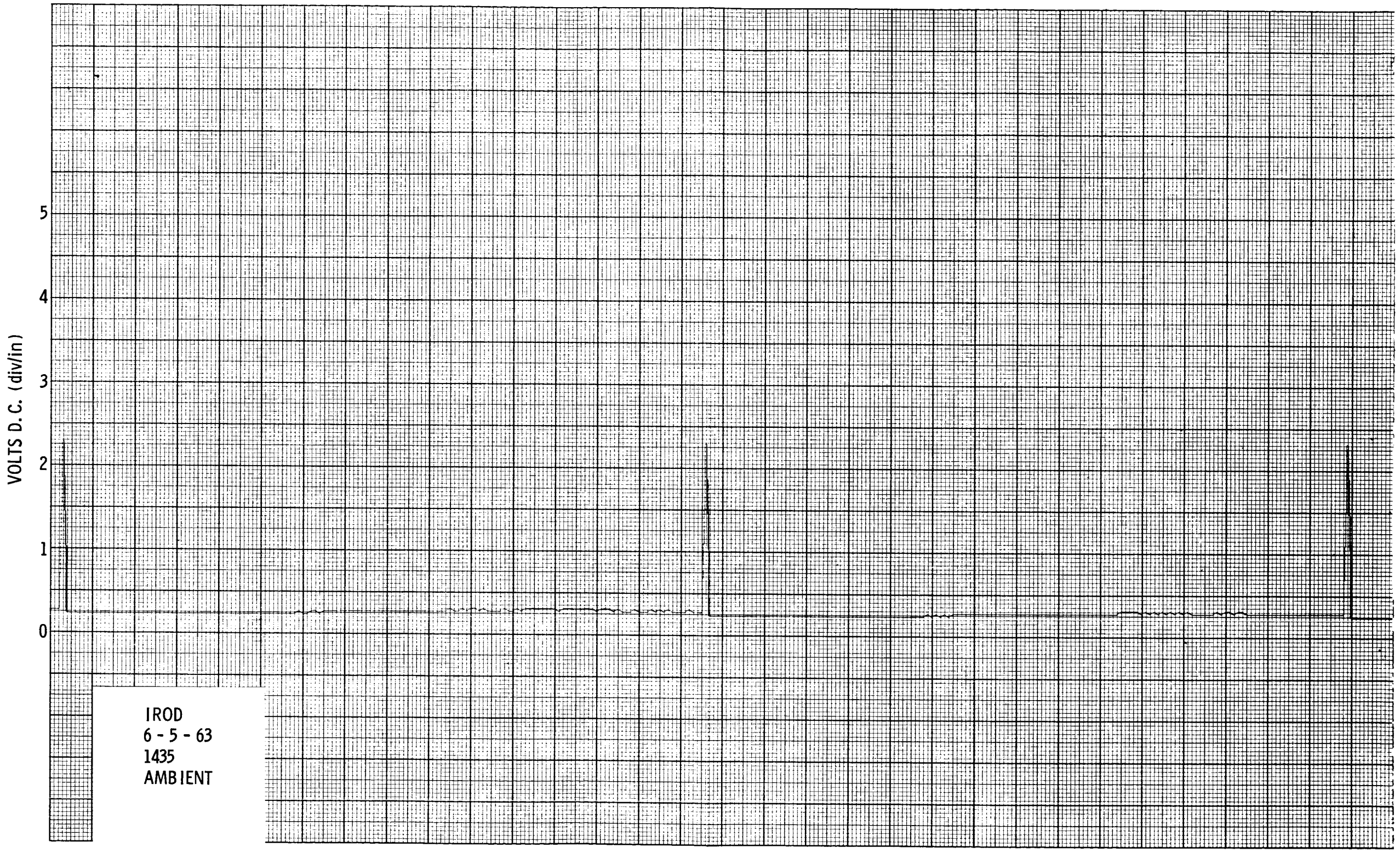

Figure 6-2—Micrometeorite Experiment Measurements at Ambient

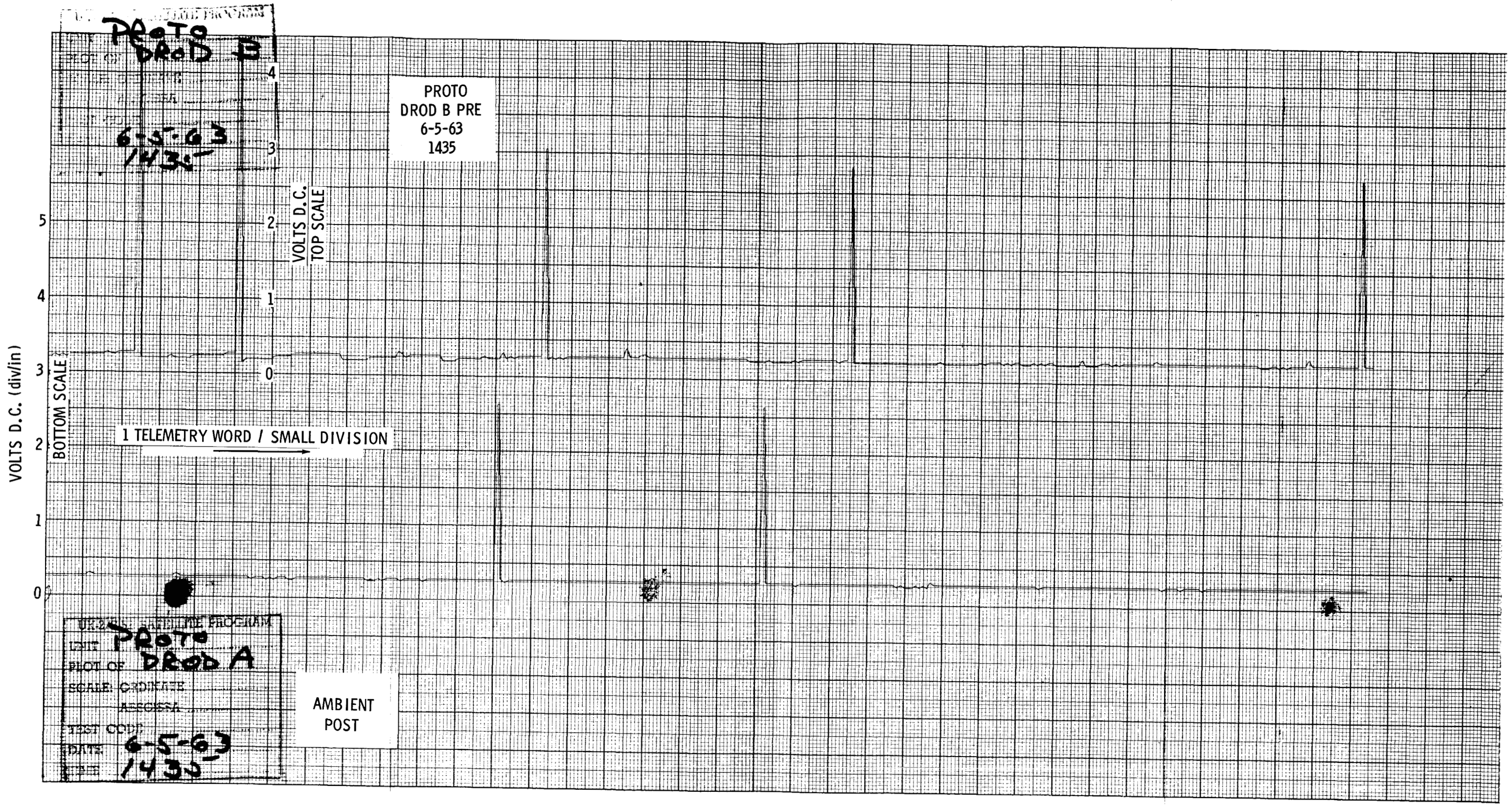

Figure 6-2—Micrometeorite Experiment Measurements at Ambient—Concluded

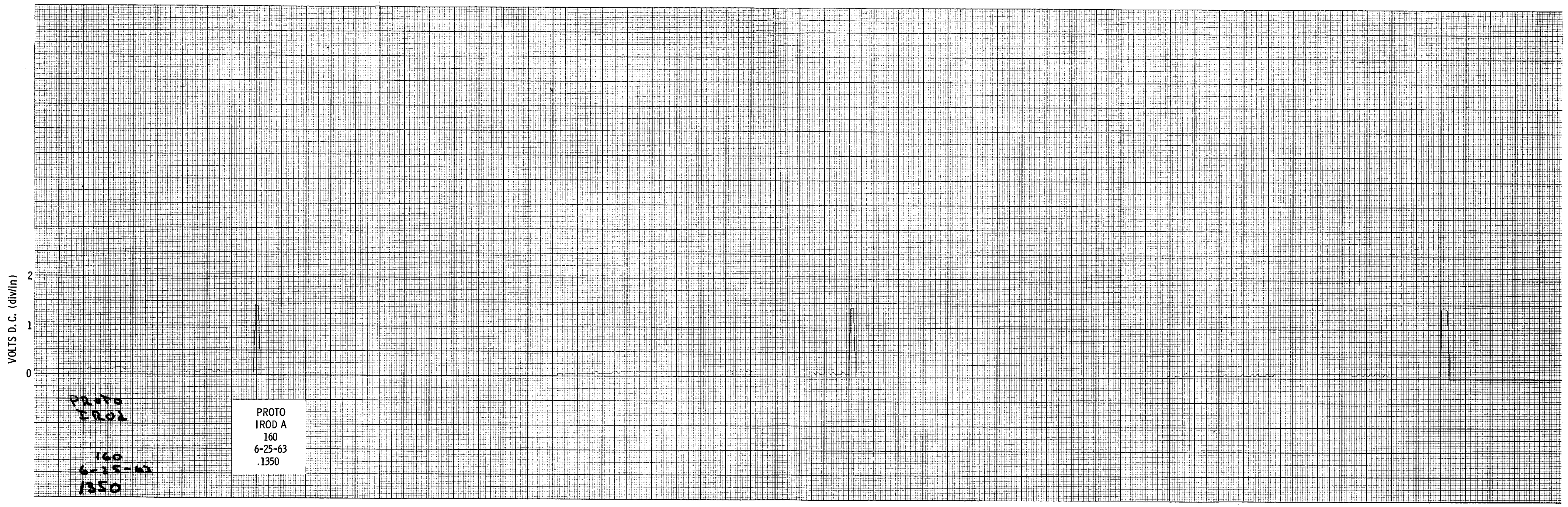

Figure 6-3—Micrometeorite Experiment X-Y Plot of Telemetry Response Excited From Pulse Generator +60°C

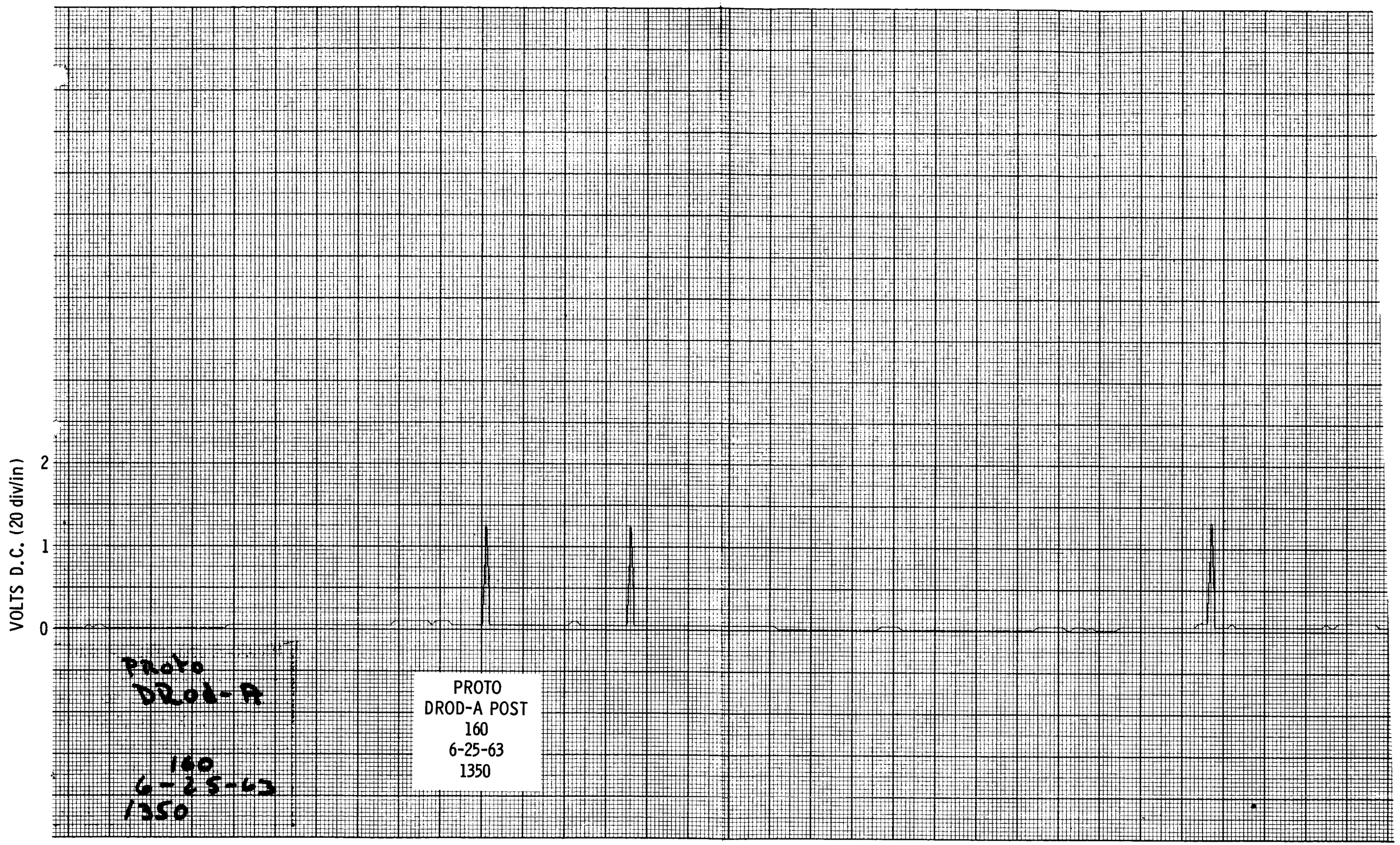

Figure 6-3—Micrometeorite Experiment X-Y Plot ot Telemetry Response Excited From Pulse Generator +60°C—Continued

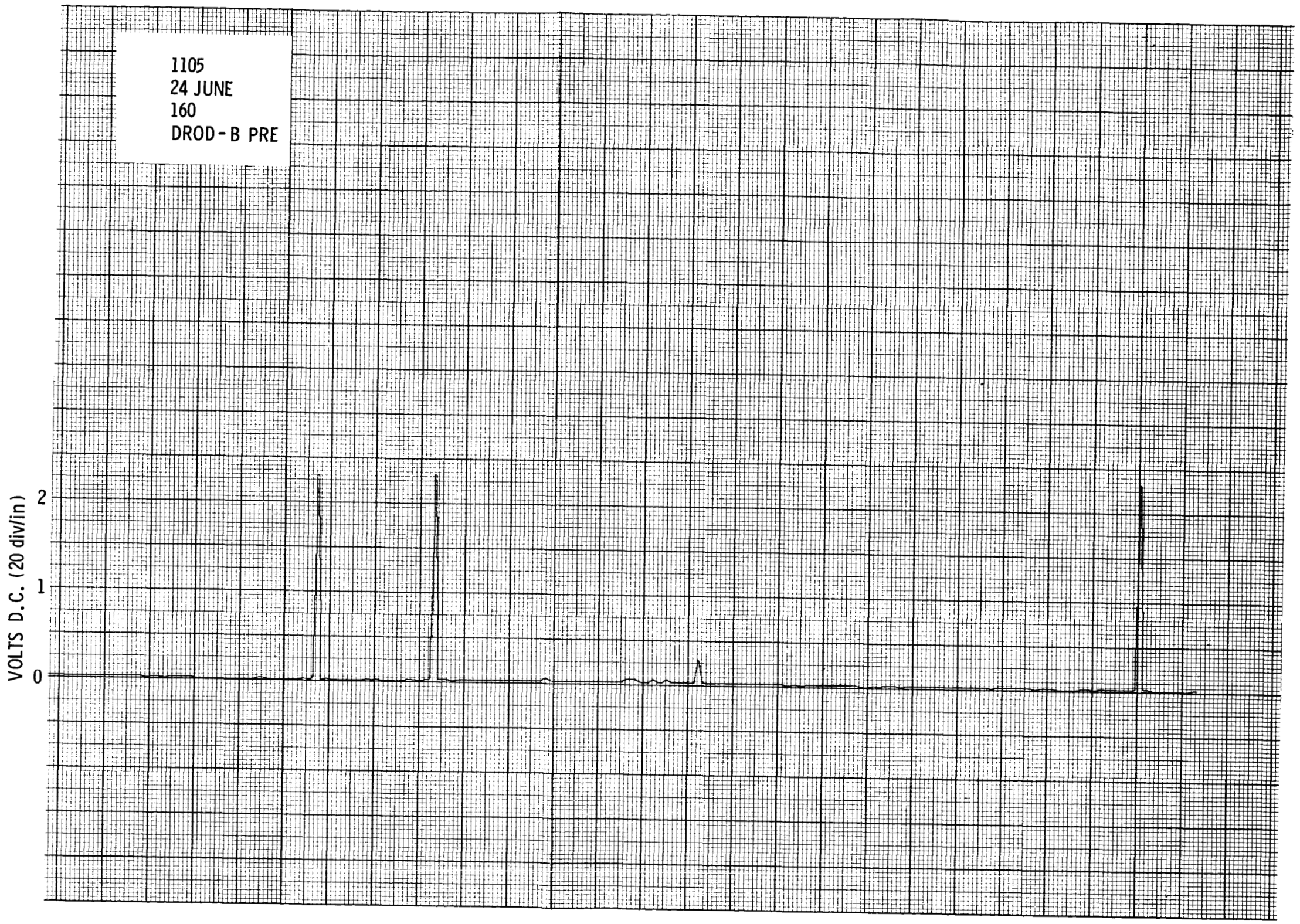

Figure 6-3—Micrometeorite Experiment X-Y Plot of Telemetry Response Excited From Pulse Generator +60°C—Concluded

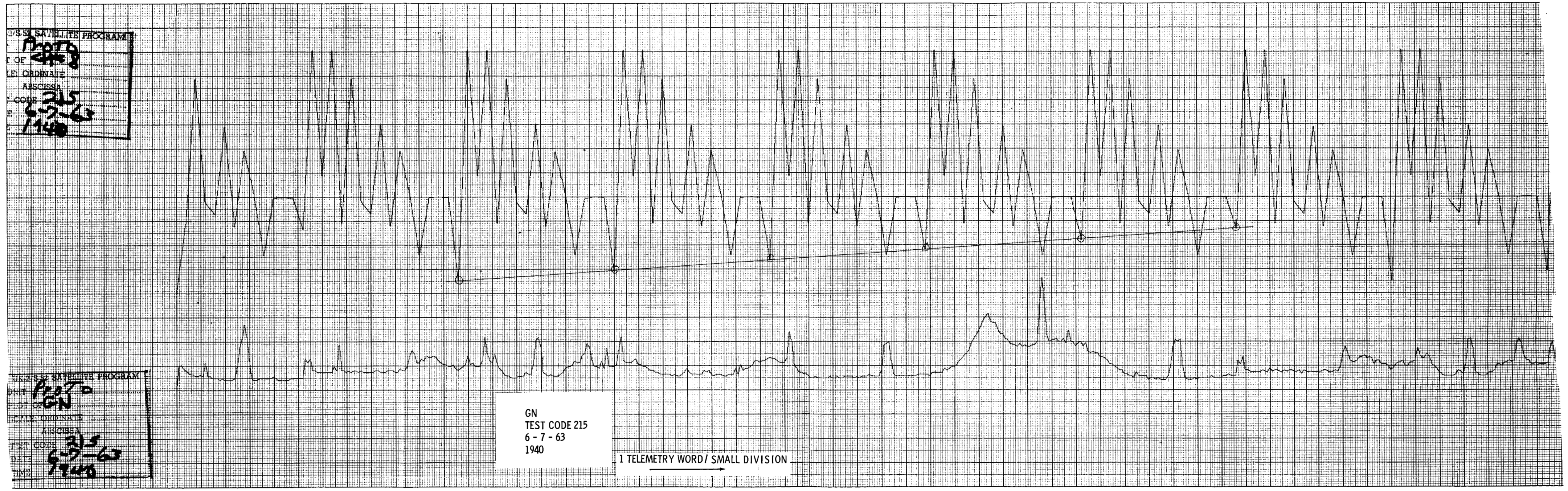

Figure 6-4—Response of Recovered Galactic-Noise Experiment High-Speed Telemetry and Associated Sweep at -15°C Vacuum

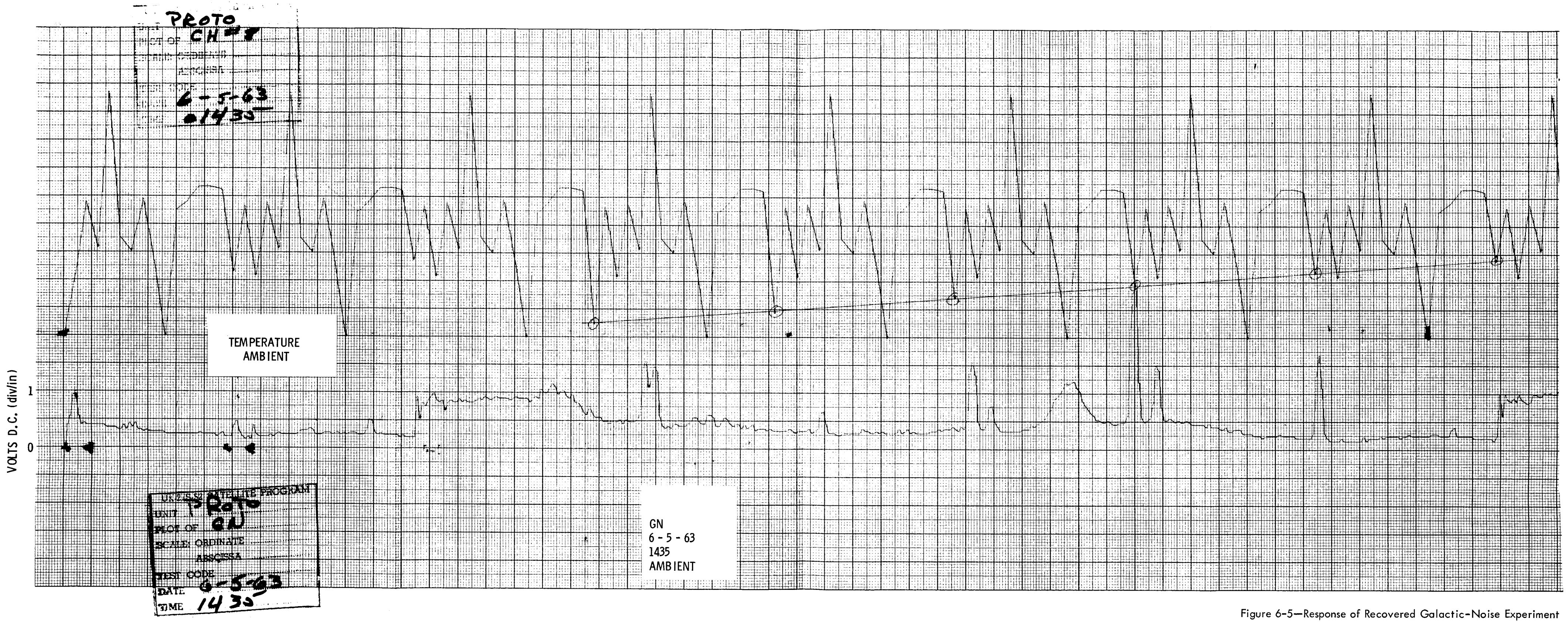

Figure 6-5—Response of Recovered Galactic-Noise Experiment High-Speed Telemetry and Associated Sweep at Ambient

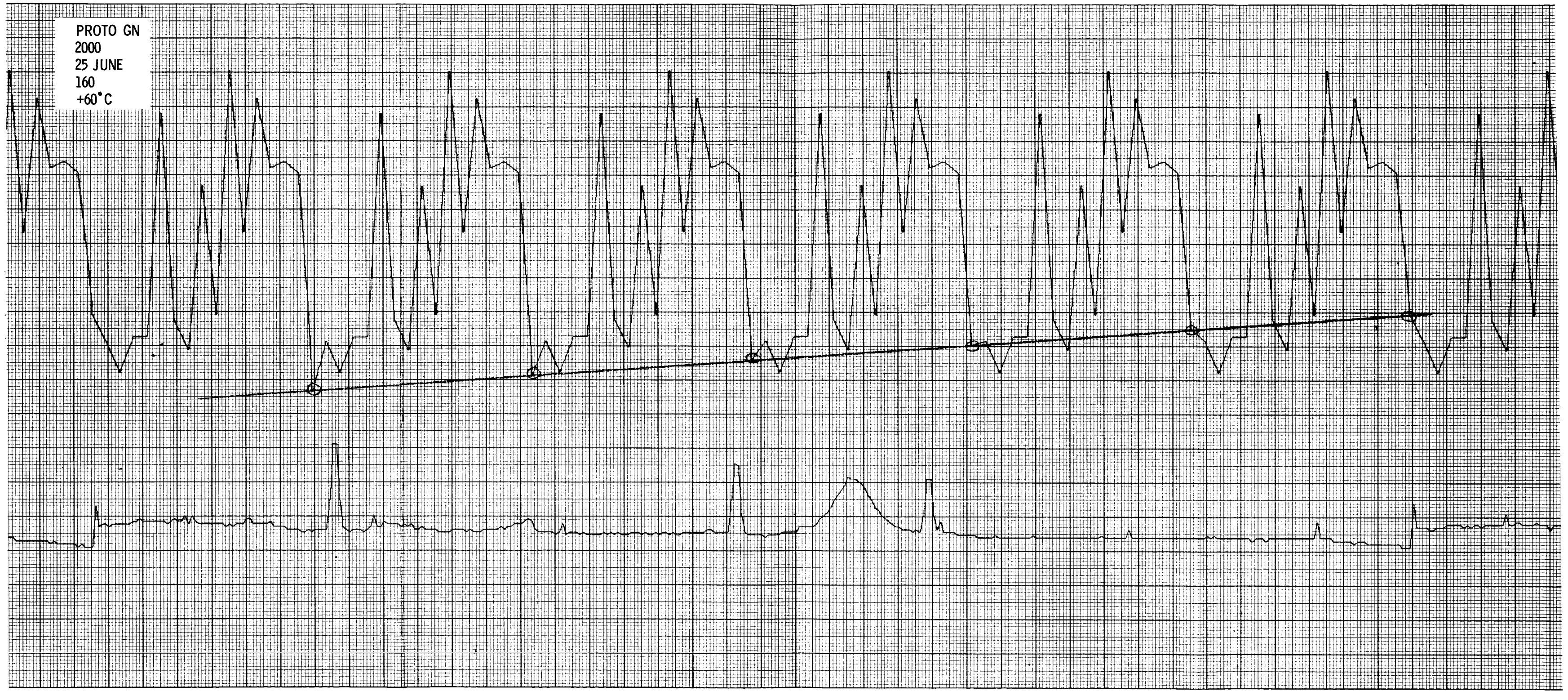

Figure 6-6—Response of Recovered Galactic-Noise Experiment High-Speed Telemetry and Associated Sweep at +60°C Vacuum

7. OZONE EXPERIMENT

The ozone experiment consists of two parts, a pair of photomultiplier spectrometers (PMA and PMB) and a broadband unit containing an ozone cell and a monitor cell. Table 7-1 shows the response of the four sensors to the ultraviolet exciter lamps pictured in Figure 3-4. The composite high-low values of the hardline output voltages measured at the test stand for each sensor in the exciter light OFF (quiescent) condition and with the exciter lamp ON are given for each temperature exposure. Included are currents from monitor test solar cells which indicate the relative intensities of the ultraviolet exciter lamps.

Using the ozone calibration box with four fixed input currents, Table 7-2 shows the high-low deviations (in volts) in the sensor hardline output voltages and corresponding changes (in μsec) in the recovered telemetry data. The values are shown for ambient and for each of the exposed temperature extremities.

TABLE 7-1

OZONE SPECTROPHOTOMETER CALIBRATION

	(Quiescent Value)		Monitor Cell of Undervoltage Exciter Lamp	
	Light Off Voltage	Light On Voltage	Cell Current (4 amp)	Temperature
B.B. Mon	-.008 → -.105	1.42 → 3.00	20 → 39	-15
B.B. Oz	-.081 → -.174	1.37 → 2.28		
STECT Pma	-.072 → -.127	1.93 → 3.23	18 → 35	
STECT Pmb	-.083 → -.135	2.07 → 2.54	20 → 48	
B.B. Mon	.302 → .543	1.90 → 2.66	36 → 39	60
B.B. Oz	.818 → .866	1.93 → 2.67		
SPECT Pma	.534 → .585	1.40 → 1.83	14.5 → 18	
SPECT Pmb	.536 → .579	.32 → .587	32 → 36	
B.B. Mon	.163	2.34	36	25
B.B. Oz	.410	2.17		
SPECT Pma	.285	1.20	15	
SPECT Pmb	.278	2.50	34	

TABLE 7-2

OZONE CALIBRATION

	Volts H.L. L.-H.	25° C PMA	μsec L.-H.	Volts H.L. L.-H.	-15° C PMA	μsec L.-H.	Volts H.L. L.-H.	60° C PMA	μsec L.-H.
	13		TM	13		TM	13		TM
4	4.82	- 4.90	185.0 - 194.0	4.82	- 4.90	184.0 - 192.8	4.91	- 4.93	187.0 - 194.7
3	3.14	- 3.34	115.8 - 117.8	3.12	- 3.19	112.4 - 114.7	3.37	- 3.40	118.3 - 120.0
2	1.39	- 1.80	83.0 - 85.5	1.39	- 1.45	80.6 - 81.3	1.82	- 1.84	86.2 - 86.7
1	.322	- .610	68.0 - 71.2	-.009	- +.050	65.5 - 66.5	.628	- .659	71.0 - 72.0
OFF	.229	- .528	67.5 - 70.3	-.133	- +.136	65.0 - 65.5	.537	- .579	70.8 - 71.1
	PMB			PMB			PMB		
	13		TM	13		TM	13		TM
4	4.70	- 4.76	181.3 - 187.3	4.60	- 4.86	173.0 - 182.0	4.63	- 4.64	168.7 - 172.0
3	3.31	- 3.28	115.8 - 117.1	3.04	- 3.14	110.8 - 113.5	3.37	- 3.38	117.3 - 118.6
2	1.59	- 1.60	82.7 - 83.0	1.20	- 1.39	78.3 - 79.5	1.86	- 1.89	86.7 - 87.1
1	.241	- .269	67.7 - 68.0	-.086	- -.142	64.9 - 69.0	.64	- .67	71.7 - 71.8
OFF	.236	- .236	67.5	-.087	- -.142	64.9 - 65.5	.548	- .58	70.9 - 71.0
	MONITOR			MONITOR			MONITOR		
	47			47		47	47		TM
4	4.35	- 4.62	154.3 - 169.5	4.44	- 4.54	162.8 - 168.1	4.34	- 4.55	155.6 - 165.8
3	2.9	- 3.10	106.0 - 110.7	2.89	- 2.98	107.6 - 109.2	2.93	- 3.09	107.6 - 111.2
2	1.44	- 1.57	81.0 - 82.5	1.32	- 1.4	80.8 - 81.5	1.56	- 1.63	82.7 - 84.7
1	.263	- .429	68.7 - 70.2	.115	- .147	67.7 - 68.0	.466	- .484	70.7 - 71.0
OFF	.095	- .258	67.7 - 68.4	-.019	- +.139	65. - 67.7	.313	- .340	69.3 - 69.7
	OZONE			OZONE			OZONE		
	30		TM	30		TM	30		TM
4	4.39	- 5.21	188.7 - 198.4	4.39	- 4.5	162.4 - 168.0	5.29	- 5.42	197.4 - 198.7
3	2.92	- 3.64	116.0 - 126.3	2.82	- 2.92	106.2 - 108.5	3.77	- 3.87	131.3 - 135.6
2	1.44	- 2.12	85.0 - 90.9	1.27	- 1.37	79.9 - 81.9	2.25	- 2.30	93.7 - 94.9
1	.263	- .880	70.5 - 74.9	.025	- .085	66.0 - 67.9	1.03	- 1.05	76.0 - 77.0
OFF	.095	- .642	69.5 - 72.0	-.124	- +.068	65.0 - 67.0	.820	- .853	74.4 - 74.8