NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

EARLY APOLLO SCIENTIFIC EXPERIMENTS PACKAGE

30-DAY REPORT

PREPARED BY THE

LUNAR SURFACE OPERATIONS & PLANNING OFFICE

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
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30-DAY REPORT

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Passive Seismic Experiment Package

Normal operation of the Passive Seismic Experiment Package (PSEP) was re-initiated 19 August 1969 by command from Mission Control Center approximately 20 hours after sunrise at Tranquility Base on the second lunar day, thus accomplishing secondary mission objectives. All data received, including seismometer measurements, were consistent with those recorded at corresponding sun elevation angles on the first lunar day.

After six days of successful operation, the data subsystem did not respond to a transmitted command at 03:50 CDT on 25 August. After numerous unsuccessful attempts to reestablish command capability, and after the seismometer was automatically switched to standby mode, full-time operations in Mission Control Center were discontinued at 19:00 CDT on 27 August.

Valid telemetry data continued to be received and recorded at the remoted sites until loss of transmitted signal was reported at lunar sunset due to the expected loss of solar power.

Operational Evaluation

Sunrise at Tranquility Base occurred at approximately 05:30 CDT on 18 August which was the beginning of the second lunar day for Passive Seismic Experiment Package. Since it had been agreed not to energize the transmitter until its temperature was above freezing, the Manned Space Flight Network (MSFN) was requested only to monitor the downlink carrier frequency for inadvertent transmissions. None occurred. At 01:00 CDT on 19 August a "Transmitter ON" command was sent and data was immediately received by MSFN. The seismic sensor, which had been placed in standby mode at the close of the first lunar day, was commanded ON fifteen minutes later. It was soon apparent that only the short-period seismometer channel was functioning at that time but by 08:00 CDT all channels were active and the measurements were consistent with first lunar day values.

Operation was nominal for the next six days requiring only periodic relevelling of the long-period seismic sensors and programming of reserve power with the commandable load resistors. Some trouble was encountered on the morning of 23 August with data drop-outs in the downlink. A commanded transfer of PSEP data processing to Processor 'X' ended the trouble and it did not reoccur. An extensive test was being conducted at this time at the request of Dr. Latham to determine if a large-amplitude oscillation, which had been observed on the long-period, Y-axis seismic channel, was electronic in origin. After 185 commands to various PSE functions, the oscillation was induced.

Early on the morning of 25 August an unsuccessful attempt was made to send a routine set of PSE levelling commands. No command has been accepted by PSEP since that time despite repeated attempts under a wide variety of conditions. The MSFN provided excellent assistance in this effort by varying the characteristics of the uplink to determine if the fault was associated with receiver degradation. The nature and extent of the changes in uplink characteristics are shown in Table I. In addition to these efforts, dual uplinks were established (Guam and Carnarvon) and simultaneous commands sent to each command decoder address. All efforts were without success and full-time support of PSEP in Mission Control Center was suspended at 19:00 CDT on 26 August.

Table I

Variations Made to Uplink Characteristics to Re-Establish Command Capability

Uplink Parameter	Nominal Value	Change Made During Uplink Test
Carrier Frequency	2119 MC	-180 kc to +180 kc (in 10 kc steps)
Relative Phase of 1 kc & 2 kc Carrier Modulations	0	-125 usec to +137 usec (in 12 steps)
1 kc Modulation Frequency	1000 Hz	875 Hz to 1125 Hz (in 14 steps)
Carrier Power Using 85' Antenna (MADRID)	2 kw	10 kw and 20 kw
Modulation Index	3 radians	-2, -1, & +1 radian

All downlink data was still valid at this time and hence remoted sites continued to record all signals. In addition, every 30 minutes the MSFN operator decoded ten critical parameters and reported their values to Houston by teletype once per day. Real-time monitoring of PSEP data was maintained for two hours each day through 31 August with continued attempts to reestablish command contact with the package. On 1 September, PSEP data were continuously monitored in MCC from 11:40 CDT until sunset at Tranquility Base which occurred (in terms of valid data) at 18:08 CDT.

A summary timetable of the outstanding events of this second lunar day for PSEP is presented in Table II. The command activity through the various MSFN sites (during that part of the second lunar day when commands were being executed by PSEP) is shown in Table III for comparison with first day activity. While the command decoder was operating, spurious command verifications continued to be received, as follows:

With MSFN Carrier	141	(109 during 1st lunar day)
Without MSFN Carrier	309	(382 during 1st lunar day)

Table II

Time of Occurrence of Major Events

Event	Time GMT	Time CDT
Sunrise	8/18 10:30	8/18 05:30
Transmitter On Command	8/19 06:00:00	8/19 01:00:00
Initial Data in MSC	8/19 06:03:03	8/19 01:03:03
PSE Turn-On Command	8/19 06:15:27	8/19 01:15:27
PSE Long-Period Channels Operating	8/19 12:55:00	8/19 07:55:00
Data Processor X Selected	8/23 14:43:30	8/23 09:43:30
Last Valid Command Implemented	8/25 02:40:50	8/24 21:40:50
Last Spurious Cmd. Verif. Word	8/25 03:08:54	8/24 22:08:64
MCC Full-Time Support Terminated	8/26 24:00:00	8/26 19:00:00
PSE to Standby Mode	8/27 05:40:44	8/27 00:40:44
Last Second-Day Data	9/1 23:08:37	9/1 18:08:37
Loss of PSEP Carrier	9/1 23:25:20	9/1 18:25:20

During the period of lost command capability, 637 commands were initiated from MCC and rejected by PSEP.

Performance Evaluation

The measurements transmitted to earth from PSEP indicate that its thermal and electrical power performance were the same on both lunar days (Figures 1 and 2). Because of interest in the thermal operations of the system, the approach to power budgeting during the early part of the second lunar day was less stringent and as a result, the temperature of the electronics was 3° F to 4° F higher than at comparable sun angles during the first day. At approximately 77 degrees sun elevation the electrical dissipation in the electronics thermal bay was reduced by the commandable 10-watt load and the temperatures were essentially the same as on day one throughout the rest of the day.

Table III

Passive Seismic Experiment Package Commands by Manned Space Flight Network Sites

Manned Space Flight Network Site	Commands Implemented by Passive Seismic Experiment Package	
	Lunar Day 1	Lunar Day 2
Ascension	116	156
Bermuda	2	-
Carnarvon	313	54
Canary	53	28
Goldstone	46	-
Guam	3	214
Hawaii	84	-
Honeysuckle	56	19
Madrid	74	-
Merrit Island	46	-
Texas	123	144
Total	916	615

The same consistency of measurement value was seen in the solar panel temperatures (Figure 3) and in those within the electronic units (Figure 4). This latter figure indicates the temperature within the command decoder. Although it is assumed that a failure of some circuit element at the input of the command decoder caused the loss of command capability, no direct telemetered measurement has indicated the exact cause of failure. It is interesting to note that the spurious command verification words, which have caused much concern over the past months, have not occurred since half an hour after the last valid command was implemented.

The initial impact of the loss of command capability was the inability to re-level the long-period seismic sensors. As a result all three axes became so unbalanced that the data was meaningless; however, meaningful data continued to be received from the short-period sensor. Eventually an oscillation appeared on each long-period channel similar to that which had been the subject of the PSE test described above.

As shown in Figure 2, the reserve power was reduced to zero early on 27 August causing the "ripple-off" circuit to place the PSE in standby mode. Although scientific data is no longer being provided by PSEP the engineering information being transmitted is exceedingly valuable in what it reveals about the lunar environment and its effect on the optical and thermal finish materials used on the package. Sunrise for the third lunar day is predicted to occur at 22:24 GMT on 16 September. Real-time monitoring of the data in MCC is planned for at least the first 24 hours with continued efforts to establish command capability.

Laser Ranging Retro-Reflector

The Laser-Ranging Retro-Reflector was deployed approximately 45 feet south-southwest of the lunar module in one of the smoothest areas in the deployment sector. The deployment sequence decals were visible and were useful as confidence builders in the deployment of the experiment. There was no difficulty in levelling the reflector using the liquid bubble level. The bubble was not precisely in the center of the levelling device, but between the center and the innermost division in the southwest direction. This position indicates an off-level condition of less than 30 minutes of arc. The shadow lines and sun compass markings were clearly visible and the crew reported that the alignment was precise (without deviation) using these devices. Inspection of the reflector after deployment indicated no dust or debris apparent on the surfaces.

On August 1, the Lick Observatory obtained reflected signals from the Laser Ranging Retro-Reflector. The signal continued to appear for the remainder of the night. Between 5 and 8 joules per pulse were transmitted at 6943 angstroms. Using the 120-inch telescope, each returned signal contained, on the average, more than one photo-electron, a value that indicates that the condition of the reflector on the lunar surface is entirely satisfactory.

On August 20, the McDonald Observatory obtained reflected signals from the Laser Ranging Retro-Reflector. The first high confidence level return was recorded for a 50-shot run at about 2:50 GMT on August 20. A part of the corresponding printouts are displayed as a histogram in the upper part of Figure 5. Here the origin of the time axis is at the predicted range. The lower histogram shows a portion of the printouts for a 50-shot run taken a few minutes later in which a 5 microsecond internal delay was introduced. (This has been subtracted in the drawing). Noise scans in which the laser was fired into a calorimeter displayed no buildup. Four other scans recording signals were made in the 50 minutes before the moon sank too low in the sky. Operation earlier in the night had been prevented by cloud cover.

The randomness of the difference between the printout and the Mulholland ephemeris prediction enabled a statistical reduction of the data. The result is a measured round trip travel time in excess of the Mulholland prediction by 127 $\pm$ 15ns time at 3:00 GMT August 20, 1969 from the intersection of the declination and polar axes of the 107-inch telescope. The uncertainty corresponds to $\pm$ 2.5 meters in one-way distance.

These observations, made a few days before lunar sunset and a few days after lunar sunrise, show that the thermal design of the reflector permits operation during sun-illuminated periods and that the reflector survived the lunar night satisfactorily. They also indicate no serious degradation of optical performance from Kapton debris, dust, or rocket exhaust occurred during lunar module liftoff.

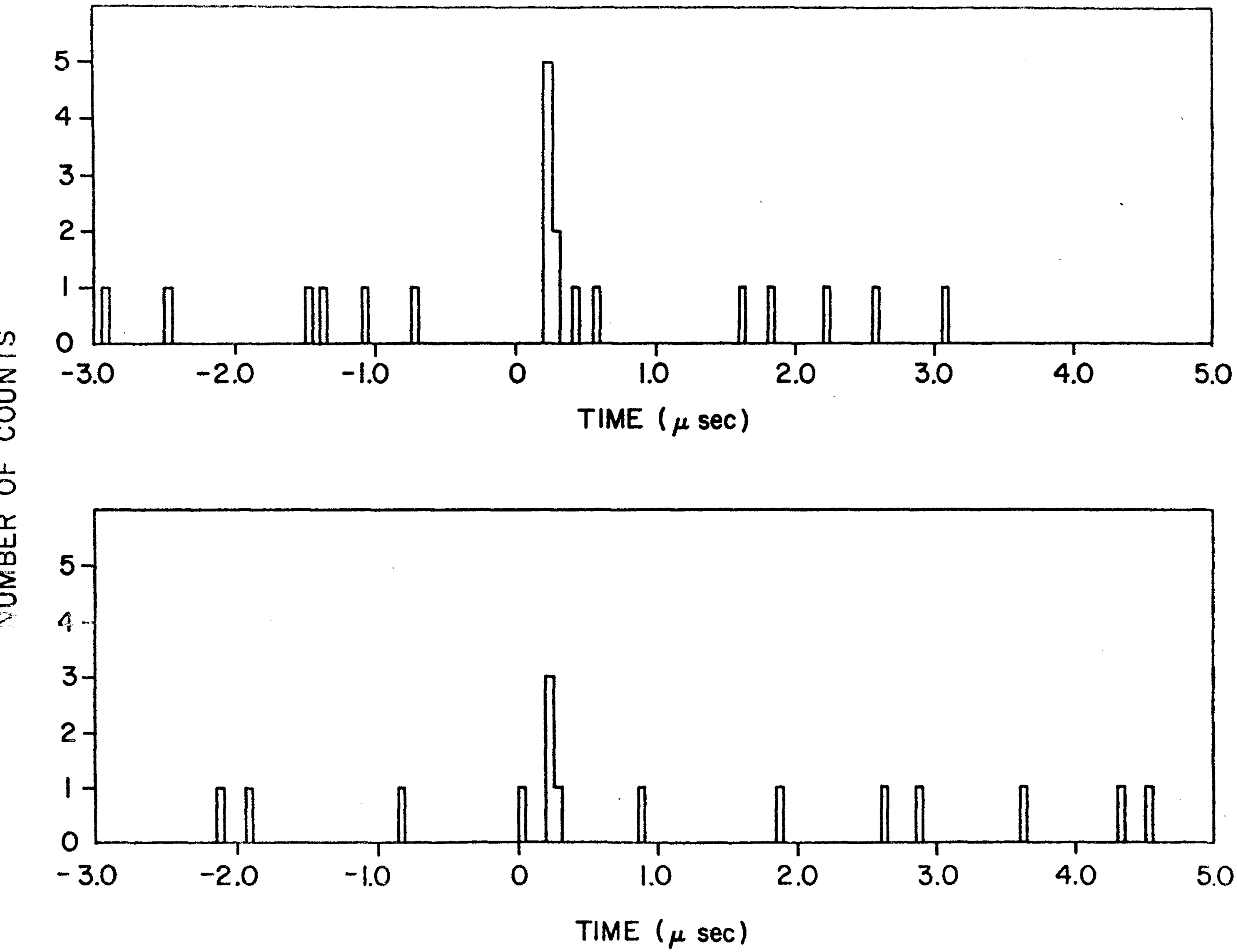


Figure 5. - Histogram for Two Successive 50-Shot Runs on August 20, 1969.

Return signals were again recorded on September 3 and 4 with equivalent uncertainty. They also showed round trip travel times in excess of the prediction by 497 ± 15ns on 3 September at 11:10 GMT, and by 797 ± 24 on 4 September at 10:10 GMT. During these observations, Tranquility Base was in darkness and the computer-controlled drive of the telescope was used successfully to offset from visible craters and track the reflector.

The scientific objectives of the lunar ranging experiment -- studies of gravitation and relativity, the physics of the earth, and the physics of the moon -- will only be achieved by successfully monitoring the changes in the distances from stations on earth to the laser beam reflector on the moon with an uncertainty of about 6 inches over a period of many years. The McDonald Observatory is being instrumented to make daily observations with the above uncertainty and it is expected that several other stations capable of this ranging precision will be established.

Figure 1

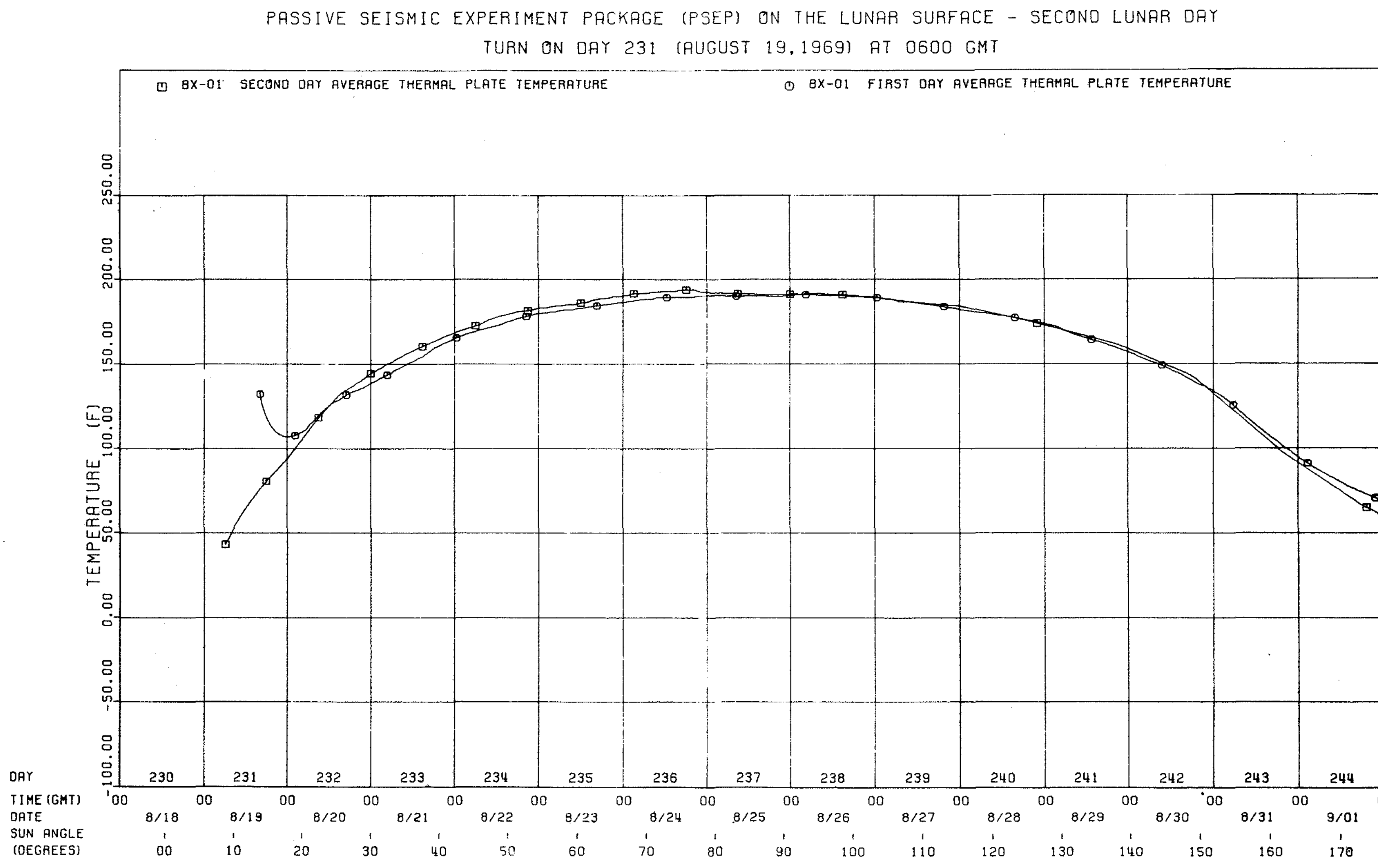
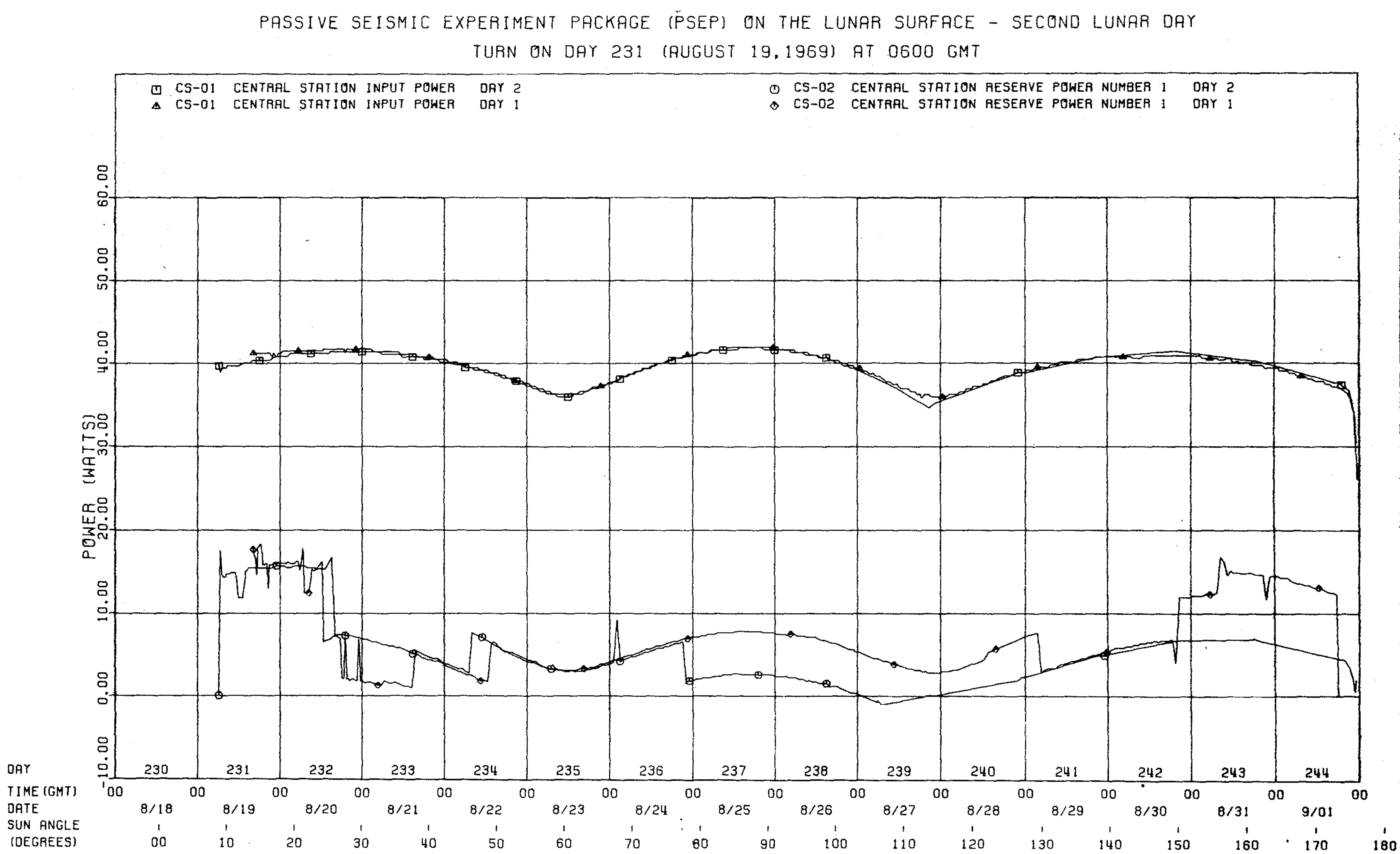


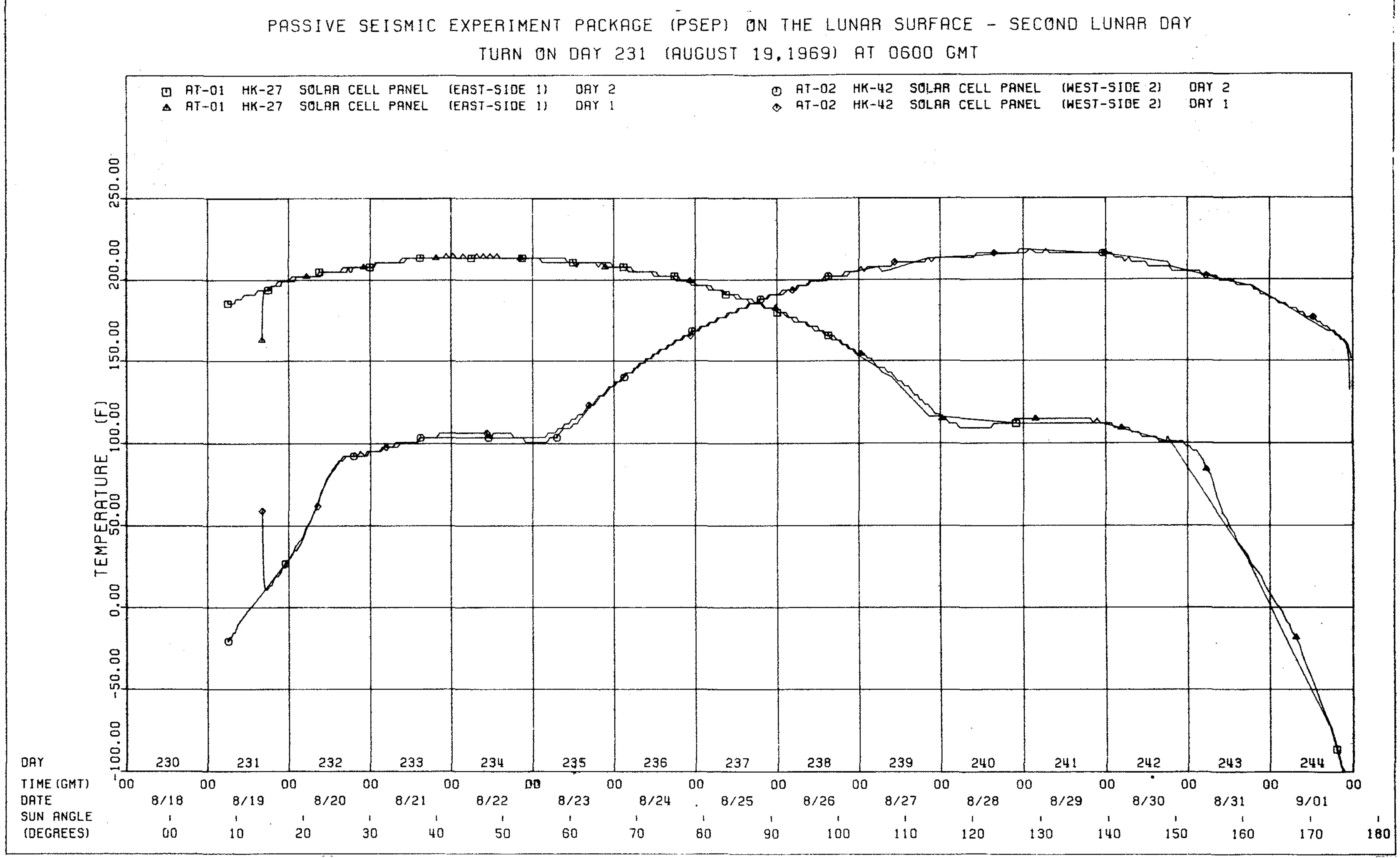
CHART NO. 300 FIGURE 907 CALIFORNIA COMPUTER PRODUCTS INC. ANAHEIM, CALIFORNIA CHART NO. 300

Figure 2



PASSIVE SEISMIC EXPERIMENT PACKAGE (PSEP) ON THE LUNAR SURFACE - SECOND LUNAR DAY
TURN ON DAY 231 (AUGUST 19,1969) AT 0600 GMT
CS-01 CENTRAL STATION INPUT POWER DAY 2
CS-01 CENTRAL STATION INPUT POWER DAY 1
CS-02 CENTRAL STATION RESERVE POWER NUMBER 1 DAY 2
CS-02 CENTRAL STATION RESERVE POWER NUMBER 1 DAY 1
POWER (WATTS)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
DAY 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244
TIME (GMT) 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
DATE 8/18 8/19 8/20 8/21 8/22 8/23 8/24 8/25 8/26 8/27 8/28 8/29 8/30 8/31 9/01
SUN ANGLE (DEGREES) 00 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

Figure 3



NASA — MSC — Coml., Houston, Texas

Figure 2

Figure 4

PASSIVE SEISMIC EXPERIMENT PACKAGE (PSEP) ON THE LUNAR SURFACE - SECOND LUNAR DAY

TURN ON DAY 231 (AUGUST 19,1969) AT 0600 GMT

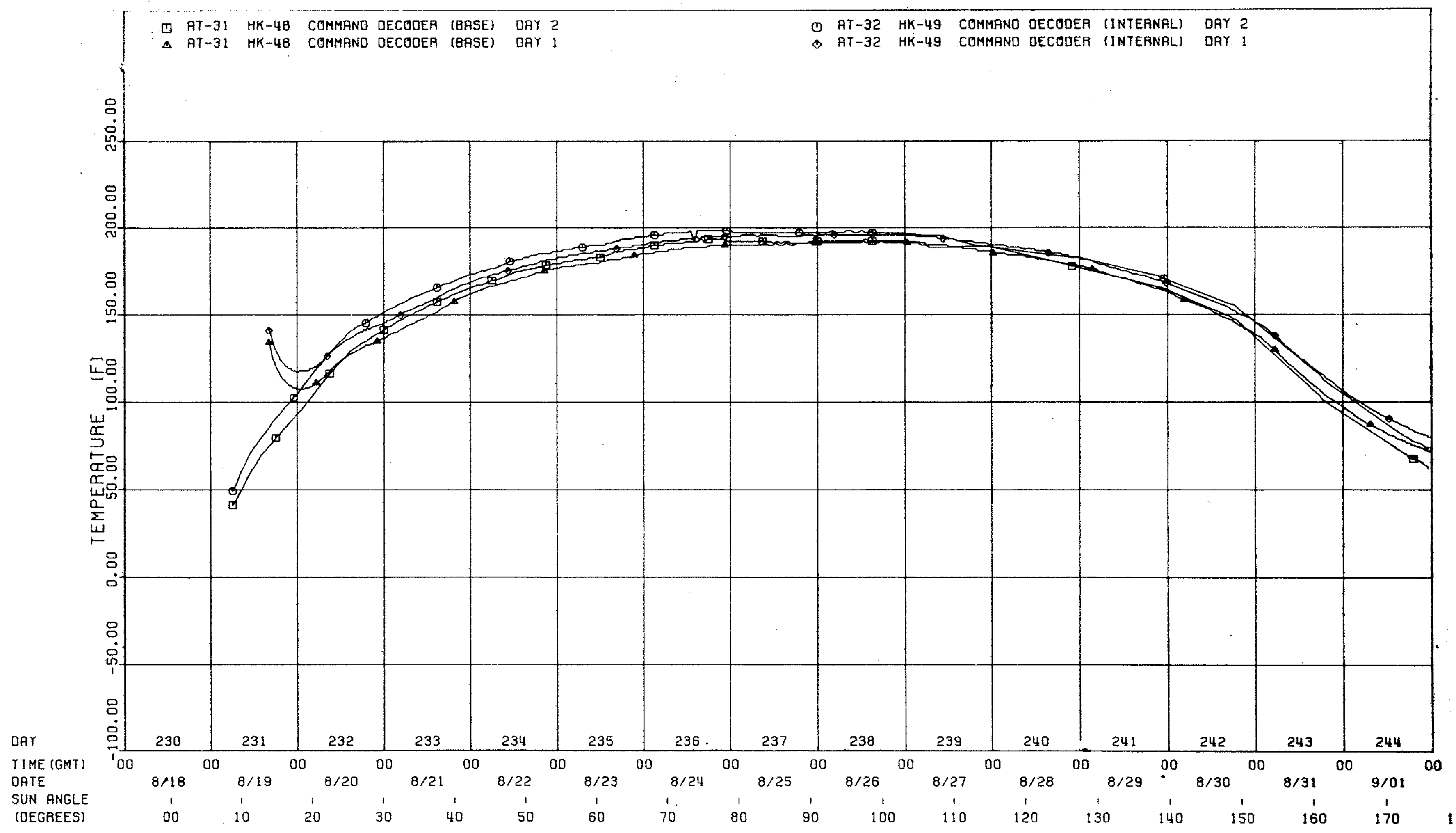


Figure 4

CALIFORNIA COMPUTER PRODUCTS, INC. ANAHEIM, CALIFORNIA