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APOLLO SCIENTIFIC EXPERIMENTS DATA HANDBOOK

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LYNDON B. JOHNSON SPACE CENTER

HOUSTON, TEXAS 77058

LYNDON B. JOHNSON SPACE CENTER MEMORANDUM

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SUBJ: Update to the Apollo Scientific Experiments Data Handbook

The enclosed is an update to the Apollo Scientific Experiments Data Handbook (TMX-58131). This is not a complete reprint, but the changes are to be made in accordance with the attached changed pages.

Questions about these changes should be directed to Mr. W. W. Lauderdale, TC3, JSC Houston, Texas.

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16. Abstract

This publication presents a brief description of each of the Apollo scientific experiments together with the operational history, the data content and formats, and the availability of the data. The lunar surface experiments described are the passive seismic, active seismic, lunar surface magnetometer, solar wind spectrometer, suprathermal ion detector, heat flow, charged particle, cold cathode gage, lunar geology, laser ranging retroreflector, cosmic ray detector, lunar portable magnetometer, traverse gravimeter, soil mechanics, far UV camera (lunar surface), lunar ejecta and meteorites, surface electrical properties, lunar atmospheric composition, lunar surface gravimeter, lunar seismic profiling, neutron flux, and dust detector. The orbital experiments described are the gamma-ray spectrometer, X-ray fluorescence, alpha-particle spectrometer, S-band transponder, mass spectrometer, far UV spectrometer, bistatic radar, IR scanning radiometer, particle shadows, magnetometer, lunar sounder, and laser altimeter. Also included are a brief listing of the mapping products available and information on the sample program.

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APOLLO SCIENTIFIC EXPERIMENTS DATA HANDBOOK

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29. LUNAR ORBITAL MASS SPECTROMETER (NASA EXPERIMENT S-165)

NSSDC IDENTIFICATION NUMBERS:

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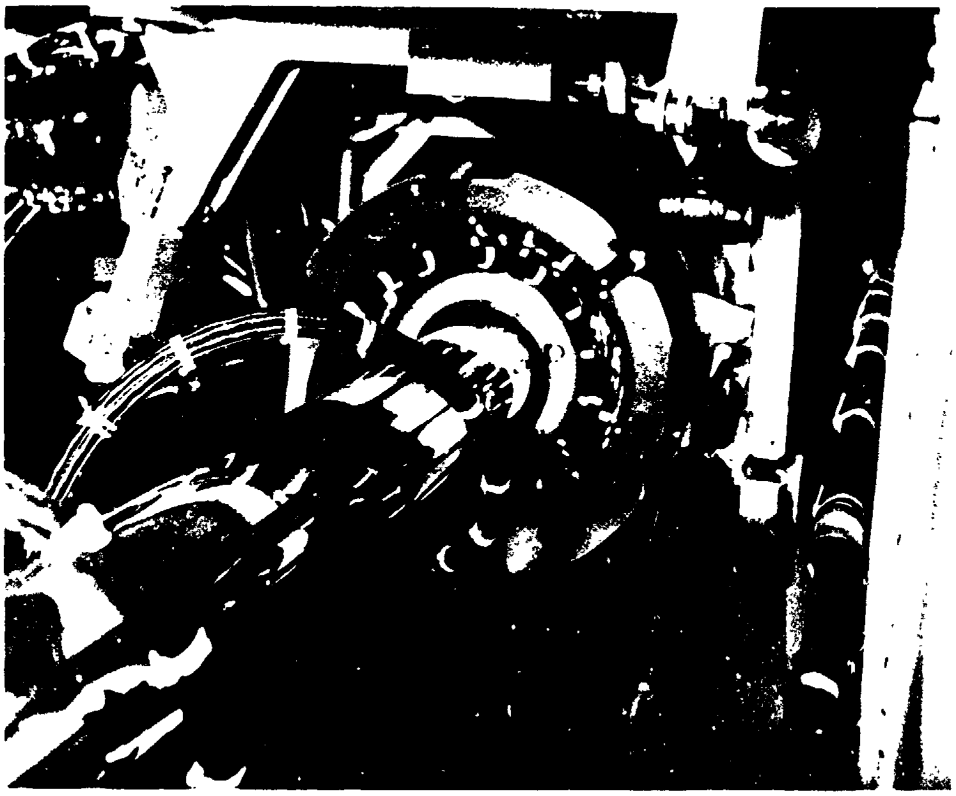

CONTENTS - SECTION 29

29. LUNAR ORBITAL MASS SPECTROMETER

The lunar orbital mass spectrometer, flown on the Apollo 15 and 16 missions as part of the orbital science payload, measured the concentration of gas molecules it encountered both in lunar orbit and during transearth coast (TEC) for the purpose of studying the sources, sinks, and transport mechanisms of the lunar atmosphere. Nearly 80 hr of operation in lunar orbit and 50 hr in TEC produced some 8000 spectra of gases in the vicinity of the instrument entrance aperture.

INSTRUMENT DESCRIPTION

The instrument, a sector-field, dual-collector mass spectrometer, was mounted on a boom stowed in the scientific instrument module bay of the service module, which was capable of extending the instrument to a distance of 7.3 m from the spacecraft. The purpose of the boom mount was to extend the instrument a reasonable distance from the spacecraft so that it would be beyond the interacting cloud of outgassing molecules from the spacecraft and in a collisionless, outwardly, free-streaming region. The instrument is shown in figure 29-1. The instrument package was a rectangular box, 30 by 32 by 23 cm, weighing 11 kg, and bisected by a baseplate; the electronics portion was on one side, the mass analyzer on the other. A plenum, in the form of a scoop, was mounted on the outboard side of the package and directed along the -X axis of the spacecraft (i.e., opposite the command module end). When the flightpath was oriented so that the velocity vector was in the -X direction, the gas inlet was in the ram direction with respect to native gases in the lunar atmosphere, whereas the reverse direction of flight (+X) produced a wake condition at the inlet.

The plenum contains the mass spectrometer ion source with redundant tungsten (with 1 percent rhenium) filaments mounted on either side of the ionization chamber. Ions formed by electron bombardment are collimated into a beam and accelerated into the mass analyzer, a single focusing permanent magnet, giving a mass resolution of more than a 1-percent valley between peaks at 40 and 41 amu. Two collector systems permit simultaneous scanning of two mass ranges, 12 to 28 amu and 28 to 66 amu.

Voltage scan is employed by using a stepping high-voltage power supply. The ion accelerating voltage sweep is generated by varying the sweep high voltage in a series of 590 steps from 620 V to 1560 V with a dwell time of 0.1 sec/step. Between each sweep, 30 additional steps at zero V are used to determine the background-counting rate and to apply an internal calibration frequency. Therefore, the entire spectrum is obtained every 62 sec, giving a spatial resolution of each mass peak of approximately 100 km. A sweep-start flag indicates data or background and serves as a marker for the start of each sweep. The mass number of the ion being detected is determined by the voltage step number at which the peak is detected. This step number is advanced by an enable pulse from the data-handling system. The minimum number of steps between adjacent mass peaks below mass 54 is 12.

Electron multipliers, preamplifiers, and discriminators, which count the number of ions that pass through each collector slit on each of the sweep voltage steps, are used in the detector systems. The ion-count numbers are stored in 21-bit accumulators (one for each channel) until sampled by the data-handling system. Just before sampling, each data word is converted to a floating-point number in base 2, reducing the data to a 10-bit word consisting of a 6-bit number and a 4-bit multiplier. The data-handling system maintains 7-bit accuracy throughout the 21-bit range of data counts.

Instrument parameters, such as certain internal voltages, electron emission in the ion source, filament currents (to determine which filament is operating), multiplier voltages, sweep voltages, temperatures, multiplier and discriminator settings, and instrument current, are monitored by a housekeeping circuit. The instrument parameters are as follows:

Mass range:	12 to 66 amu
Spectrum scan time:	62 sec
Spatial resolution:	100 km
Mass resolution:	1 percent valley at 40 amu
Sensitivity:	10^{-11} N/m^2 (10^{-13} torr)
Dynamic range:	10^{-11} to 10^{-6} N/m^2 (10^{-13} to 10^{-8} torr)

Initial calibration of the mass spectrometers, performed in a high-vacuum chamber at the University of

Texas at Dallas, verified that the proper mass ranges were scanned and tested the resolution, linearity, mass discrimination, and dynamic range of the analyzer. Neon was introduced into the vacuum chamber by using isotopic partial pressures ranging from 10^{-9} to 10^{-5} N/m^2 (10^{-11} to 10^{-7} torr). The instrument response was linear up to 10^{-6} N/m^2 (10^{-8} torr) where the onset of saturation of the data-counting system occurred. The sensitivity of the instrument was verified to be greater than 2×10^{-7} A/N/m^2 (3×10^{-5} A/torr), enabling the instrument to measure partial pressures down to 10^{-11} N/m^2 (10^{-13} torr). The final absolute calibration was made at the NASA Langley Research Center Molecular Beam Facility in the same manner as for the lunar atmospheric composition experiment (S-205) also described in this handbook.

OPERATIONAL HISTORY

The operational history of the Apollo 15 lunar orbital mass spectrometer is given in the following tabulation. Time is in terms of ground elapsed time (GET) and is measured in hours from lift-off at 13:34:00.79 G.m.t. on July 26, 1971.

Time, hr:min	Spacecraft attitude
85:05 to 95:15	-X
108:55 to 119:20	-X
130:30 to 141:00	-X
195:50 to 200:25	+X
202:00 to 211:40	-X
211:40 to 214:15	+X
224:30 to 238:00	TEC
245:50 to 288:05	TEC

A similar tabulation of the operation of the Apollo 16 experiment follows. The GET is measured from lift-off at 17:54:00.57 G.m.t. on April 16, 1972.

Time, hr:min	Spacecraft attitude
81:10 to 92:03	-X
108:00 to 121:20	-X
121:20 to 124:40	+X (oblique photographs)
124:40 to 131:10	+X
131:10 to 142:10	-X
142:10 to 143:15	antisolar hold
143:15 to 144:15	-X
144:15 to 146:20	+X (oblique photographs)
146:20 to 151:20	+X
151:20 to 152:50	+X (oblique photographs)
152:50 to 164:20	+X
164:20 to 167:00	+X
167:00 to 168:10	+X (oblique photographs)
180:05 to 193:45	-X

FORMAT OF DATA

Data processing has resulted in the blocking of data into complete mass spectra on magnetic tape. Brief time gaps in the data, caused by telemetry dropouts, are filled with flag words to ensure proper location of the good measurements in the spectra. Reduced data also include the background-count level of each analyzer channel, the amplitude of each mass peak, the decommutated housekeeping data, and the pertinent spacecraft-trajectory information.

Microfilm records are formatted outputs of the data on magnetic tape. The format gives sequential pairs of mass spectra (high- and low-mass channels) together with background, peak amplitude, housekeeping, and trajectory data. Periodic tabulated summaries of the peak amplitudes, housekeeping, and trajectory data are also given. Each summary covers several hours of experiment operation.

SAMPLES OF DATA

Computer printouts showing examples of each type of data are given in figures 29-2 to 29-6. The codes and definitions are as follows:

Low Mass

GET TIME	GET from lift-off
APOLLO 16	Apollo mission number
A0, A1, B0, B1	Peak-location coefficients for high-mass channel
REV	Orbit number
SUN HR	Longitude - subsolar longitude
LONG	Subsatellite longitude
LAT	Subsatellite latitude
SUN A	Angle from command and service module (CSM) X axis to Sun
SUN B	Azimuth of Sun from -Z axis
TEMP	Ion-source temperature monitor
ALT	CSM altitude (kilometers)
VEL ALPHA	Angle of attack from X axis
VEL	CSM velocity (km/sec)
BACKGROUND	Background data
CALIBRATE	Interval calibrate data
HOUSEKEEPING	
+12	+12 V monitor
+5	+5 V monitor
-12	-12 V monitor
-15	-15 V monitor

EM	Emission current monitor
F1	Filament 1 current monitor
F2	Filament 2 current monitor
LM	Low-mass multiplier, high-voltage monitor
HM	High-mass multiplier, high-voltage monitor
SW	Sweep high-voltage monitor
T1	Electronics temperature monitor
T2	Ion-source temperature monitor
MF	Multiplier high-voltage HI/LO flag
DF	Discriminator HI/LO flag
IC	Instrument current
PEAK AMPLITUDES	Mass number and peak amplitude
PRE BKG	Background counts at start of sweep
CUR BKG	Background counts at end of sweep
NUM	Number data points used in calculating BKG
	High Mass
GET TIME	GET from lift-off
APOLLO 16	Apollo mission number
24 October 1972	Date data tapes were processed
A0, A1, B0, B1	Peak-location coefficients for high mass channel
STEP NO	A0 + A1/mass step <400 B0 + B1/mass step >400

SYNC START	Data count at start of sweep
SYNC END	Data count at end of sweep
PBKG	Background count at start of sweep
BKG	Background count at end of sweep
N	Number data points used in calculating BKG
BACKGROUND	Background data
CALIBRATE	Internal calibrate data
PEAK AMPLITUDES	Mass number and peak amplitude
STAR	Incorrect peak shape

Apollo 16 Peak Summary

GET TIME	GET from lift-off
SUN HR	longitude - subsolar longitude
C	Peak-error code. If code greater than zero, previous peak-location coefficients are used
27 → 39	Mass number
L	Low-mass BKG
H	High-mass BKG
GAP	Time gap in data
STAR	Incorrect peak shape
CSM DIRECTION	Minus (-) denotes -X orientation

Apollo 16 Trajectory Summary

GET TIME	GET from lift-off

REV	Orbit number
SUN HR	Longitude - subsolar longitude
LONG	Subsatellite longitude
LAT	Subsatellite latitude
RADIUS	Orbit radius (kilometers)
VELOCITY	CSM velocity (km/sec)
ALTITUDE	CSM altitude (kilometers)
SS LONG	Subsolar longitude
SS LAT	Subsolar latitude
SUN A	Angle from CSM X axis to Sun
SUN B	Azimuth of Sun from -Z axis
VEL ALPHA	Angle of attack from X axis
VEL BETA	Azimuth of Vel vector from -Z axis

Apollo 16 Housekeeping Summary

GET TIME	GET from lift-off
+12	+12 V monitor
+5	+5 V monitor
-12	-12 V monitor
-15	-15 V monitor
EMISSION	Emission current monitor
FIL 1	Filament 1 current monitor
FIL 2	Filament 2 current monitor
LM HV	Low-mass multiplier, high-voltage monitor
HM HV	High-mass multiplier, high-voltage monitor

S HV	Sweep high-voltage monitor
ETEMP	Electronics temperature monitor
STEMP	Ion source temperature monitor
M LO/HI	Multiplier high-voltage LO/HI flag
D HI/LO	Discriminator HI/LO flag
I	Instrument current (total)

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C.7

Figure 29-1.- Apollo 16 mass spectrometer.

GET TIME APOLLO 16 A0 A1 B0 B1 REV SUN HR LONG LAT SUM A SUM B TEMP ALT VEL ALPHA VEL
187 26 50 LOW MASS -505.32 34644.32 -55.41 17427.50 -0.48 -40.89 7.28 -?.23 40.11 215.33 7.37 122.28 177.71 1.62

1	1423	291	55	53	116	201	63487	44543	9471	53	45	911	3232	
2	1503	307	45	84	167	195	63999	44513	9597	55	49	1037	520	
3	1471	343	52	113	109	219	64511	44543	9471	46	110	1103	120	
4	1455	331	54	116	195	343	64511	44543	9343	55	107	1071	2	
5	1407	339	57	107	229	503	65023	44031	9343	52	219	1103	0	
6	1167	319	48	114	231	599	65023	44031	9715	43	229	1119	0	
7	871	323	59	105	235	591	65023	44031	9037	47	217	1135	0	
8	551	327	49	112	239	631	64511	43519	8031	42	217	1135	1	
9	535	307	46	109	233	607	64511	43007	8447	45	215	1135	1	Background
10	1391	335	40	103	259	631	64511	[illegible]	7999	45	215	1071	0	
11	4095	343	43	111	253	639	64511	[illegible]	6527	65	227	1103	1	
12	6143	323	40	112	249	623	63999	[illegible]	3551	112	219	1037	2	
13	6555	351	34	121	249	655	63999	41903	1567	407	209	1039	1	
14	6783	299	27	115	249	623	62975	41903	543	711	211	1119	0	
15	6655	247	24	101	259	607	62975	41471	233	863	229	903	1	
16	6591	201	30	119	397	631	62463	40447	135	903	213	823	1616	
17	6463	115	22	131	599	631	62463	35039	113	807	203	567	1616	
18	6527	83	25	99	711	639	60927	27647	105	847	175	339	1616	
19	6399	64	26	91	735	615	55295	19199	103	839	111	203	1616	
20	6335	67	23	76	687	615	49543	12031	87	823	62	131	1616	
21	6335	63	20	53	607	599	30719	6703	98	839	46	69	1616	
22	6335	73	24	41	695	591	10431	1615	105	839	38	65	1616	
23	6143	97	21	47	703	503	9343	1775	91	823	29	78	1616	
24	5695	99	18	40	679	503	4479	967	92	831	31	82	1616	Calibrate
25	4223	110	21	51	671	403	2527	631	84	801	37	82	1616	
26	2207	105	17	44	655	371	1711	403	111	703	30	79	1616	
27	871	119	19	47	639	339	1167	351	167	503	37	82	1616	
28	347	104	26	44	599	207	911	295	679	337	37	81	1616	
29	333	110	21	45	623	267	719	271	1567	179	30	70	1616	
30	591	99	23	51	567	279	567	263	1055	87	34	70	1616	
31	751	107	20	49	623	203	535	243	1951	59	39	77		
32	759	91	20	47	567	299	463	229	1903	33	29	65		
33	751	103	18	45	591	323	463	225	1919	30	50	69		
34	727	113	21	49	607	323	423	227	1951	45	39	67	HOUSE	
35	711	94	27	42	543	343	379	219	1951	42	36	66	KEEPING	
36	759	91	27	54	427	359	355	231	1055	35	49	70	3.00+12	
37	735	104	27	43	271	423	367	237	1951	41	51	67	2.43+ 5	
38	719	78	25	51	179	423	395	253	1935	37	43	63	2.94-12	
39	735	63	24	56	133	503	463	393	1071	37	53	60	4.67-15	
40	695	57	25	51	103	527	567	435	1775	41	49	53	2.00 EM	
41	695	52	25	49	119	623	1119	631	1471	47	63		3.12 F1	
42	679	50	20	44	93	863	2943	839	863	39	57		.14 F2	
43	639	45	29	50	129	1919	9903	1015	415	35	49		2.61 LM	
44	535	45	19	47	133	6143	25599	1103	157	35	70		2.71 HM	Housekeeping
45	299	50	24	60	177	19199	30399	1423	88	37	65		2.29 SU	
46	173	46	24	57	263	45055	43519	1503	75	49	64		2.04 T1	
47	104	49	28	60	391	60415	45055	3263	62	42	70		2.37 T2	
48	86	53	29	64	395	63407	45055	5503	55	39	102		.02 [illegible]	
49	105	58	26	85	303	63999	45055	7551	47	44	233		2.47 C?	
50	205	52	39	112	237	63487	45055	8031	56	34	591		1.63 IC	
28	6447 25	79 23	0 22	77 20	540 19	396 17	43622 16	9022 15	1848 14	707 13	174			
27	701 24	27	21	0	18	64142				12	1059			Peak amplitudes
26	303													

PDKG	BKG	N
1	1	10
PRE BKG	CUR BKG	NUM

Figure 29-2.- Low-mass data format.

SYNC start — SYNC end

GET TIME APOLLO 16 24 OCTOBER 1972 DATA C FLAG 00000000 PBKG BKG N
187 26 50 HIGH MASS A0 -505.32 A1 34644.32 B0 -55.41 B1 17427.50 DATA C SYNC 11000011 6 6 10

1	26	9	204	34	26	69	866	27	27	18	56	174	264	
2	28	9	248	21	27	44	690	14	65	20	60	192	48	
3	45	16	214	11	29	31	538	20	87	13	124	210	14	
4	42	11	176	12	20	25	338	17	65	19	298	230	4	
5	50	16	100	11	23	33	198	34	51	25	634	220	8	
6	33	11	58	14	13	45	113	36	31	39	874	190	6	
7	23	10	22	15	9	42	61	59	22	43	874	105	6	
8	18	19	22	22	12	78	47	84	20	53	666	109	4	Background
9	31	6	20	37	10	146	34	111	21	35	302	150	7	
10	58	11	63	39	11	366	26	146	20	29	208	158	8	
11	71	16	107	44	6	962	35	144	14	26	97	150	5	
12	71	20	148	37	13	1002	38	136	19	24	68	240	5	
13	77	21	174	40	13	2506	35	112	24	19	59	618	6	
14	45	24	160	31	17	3034	60	104	40	27	58	2522	5	
15	28	13	112	16	21	2650	98	67	53	17	53	6505	5	
16	23	10	70	10	32	2106	178	39	57	21	55	11002	1616	
17	14	7	36	11	22	1306	254	25	33	25	68	12090	1616	
18	19	9	26	14	22	762	346	30	30	21	73	9466	1616	
19	29	15	23	15	18	378	386	19	19	35	67	6202	1616	
20	26	35	32	17	20	154	354	23	18	35	60	3322	1616	
21	30	54	81	26	14	87	306	17	15	83	72	1370	1616	
22	23	61	148	60	10	80	232	15	21	111	182	442	1616	
23	16	50	254	68	9	74	158	17	22	84	538	205	1616	Calibrate
24	14	37	314	78	14	55	101	22	20	64	1002	150	1616	
25	16	21	306	63	16	70	57	28	16	58	1402	138	1616	
26	21	12	224	54	22	114	37	25	22	44	1250	117	1616	
27	29	11	144	39	32	228	21	40	32	39	834	122	1616	
28	36	19	88	26	71	746	22	67	75	34	494	93	1616	
29	28	29	30	16	132	1834	23	103	81	37	224	113	1616	
30	25	51	23	11	212	3674	25	146	67	35	119	100	1616	
31	15	67	21	6	278	5498	24	216	41	40	86	100		
32	9	73	23	11	248	6394	36	250	26	38	81	96		
33	5	58	16	15	194	5946	37	250	21	33	73	103		
34	15	47	44	21	119	4474	78	250	15	47	77	96		
35	18	25	55	20	76	3066	136	202	19	73	79	142		
36	33	19	56	44	42	1706	270	190	22	266	82	234		
37	33	12	49	58	25	950	382	126	20	1290	79	514		
38	23	16	37	58	25	370	502	95	14	3258	100	930		
39	10	55	26	48	19	144	546	59	16	4410	89	1226		
40	8	121	15	35	22	96	530	27	20	3770	100	1178		
41	12	168	13	26	24	65	490	18	26	2362	160			
42	13	178	13	22	24	70	346	19	31	1066	362			
43	15	164	13	10	36	65	282	19	35	398	1010			
44	14	100	15	11	60	72	172	16	34	119	1786			
45	18	46	29	18	103	126	91	25	28	69	2330			
46	18	23	33	8	176	228	48	18	15	62	2266			
47	13	24	55	10	208	466	40	13	15	52	1002			
48	11	30	50	13	238	706	23	12	19	42	1162			
49	7	62	63	17	176	826	23	17	24	47	594			
50	11	150	52	17	115	898	21	13	22	45	282			

Peak amplitudes

67	54•61	15 56	151 52	32•48	14•45	2980 42	359 39	242 37	38 33	81 30	1344 28	11831	
66	12•60	51 55	295 51	68 47	264 44	[illegible]39 41	525 38	68 36	60 32	4306 29	2237 27	0•	Star
65	25 59	62 54	39 50	48 46	209 43	846 40	131	35	15 31	854			
64	25 58	180 53	51•49	15•				34	32				
63	10•57	225											
62	8•												

Figure 29-3.- High-mass data format.

CSM direction

Low mass

High mass

Mass number

APOLLO 16 PEAK SUMMARY

GET	TIME		SUN HR	C	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	L	H
-187	2	3	33.1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	209
-187	3	5	30.0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	232
-187	4	7	26.9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	203
-187	5	9	23.9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	206
-187	6	11	20.8	0	624	93	361	486	4593	26011	51526	149	216	0	39	0	10	30	120	5	170
-187	7	13	17.7	1	605	70	376	529	4768	27543	54879	185	282	0	45	0	11	36	146	6	152
-187	8	15	14.7	0	627	75	398	596	5120	29717	57715	184	300	0	45	0	12	37	141	4	135
-187	9	17	11.6	0	592	80	388	607	5141	29026	58205	215	326	0	42	0	15	40	158	2	25
-187	10	19	8.5	0	685	89	445	707	5778	32151	56877	213	304	0	49	0	15	41	149	2	34
-187	11	21	5.4	0	646	80	431	765	5404	20077	5717[illegible]	255	370	0	51	0	11	41	171	2	146
-187	12	22	2.4	0	830	112	547	1123	7202	35711	60594	261	379	0	52	0	15	46	163	1	148
-187	13	24	-.7	0	810	119	567	1222	7207	37175	61595	355	488	0	71	2	17	59	215	2	166
-187	14	26	-3.8	0	753	116	553	1341	7227	40525	62756	352	476	0	72	1	17	58	219	1	229
-187	15	28	-6.8	0	985	152	737	1858	8915	41390	61919	312	420	0	67	0	17	54	202	1	224
-187	16	30	-9.9	0	1034	171	801	2099	9243	44340	65062	448	597	0	81	0	16	70	285	2	249
-187	17	32	-13.0	1	1005	162	783	2056	8540	37625	64340	454	631	0	85	0	23	77	304	1	217
-187	18	34	-16.1	0	1007	177	802	2254	9142	43600	64907	458	600	0	82	0	25	77	288	1	114
-187	19	36	-19.2	1	766	136	623	1799	7464	42190	64821	458	610	0	86	0	18	73	310	1	64
-187	20	38	-22.3	0	964	171	780	2216	8643	41784	64676	340	423	0	64	0	21	64	232	2	35
-187	21	40	-25.3	0	1075	201	869	2457	9820	46670	65065	424	562	0	84	0	23	85	303	1	24
-187	22	42	-28.4	0	1041	181	835	2199	8698	37946	63481	449	598	0	83	0	26	80	322	2	21
-187	23	44	-31.6	0	1149	210	924	2412	10195	40145	63461	464	603	0	89	0	24	88	328	1	10
-187	24	46	-34.7	1	891	154	701	1770	8092	40096	64293	492	644	0	87	0	25	93	353	1	6
-187	25	48	-37.8	0	970	172	764	1827	8629	41609	64478	355	499	0	77	0	23	73	279	1	6
-187	26	50	-40.9	0	1059	174	787	1848	9022	43622	64142	396	540	0	77	0	27	79	303	1	6
-187	27	52	-44.0	0	1006	176	773	1720	9053	42387	62693	395	551	0	83	0	26	83	318	1	5
-187	28	54	-47.1	0	825	141	628	1314	7492	39743	63180	369	535	0	80	0	26	81	315	1	4
-187	29	56	-50.3	0	1005	170	743	1496	8637	39137	63445	293	442	0	68	2	25	73	256	1	3
-187	30	58	-53.4	0	845	146	622	1235	7460	37642	62275	366	533	0	69	0	23	84	305	1	3
-187	32	0	-56.5	0	921	147	653	1181	7607	36127	63287	289	442	0	67	0	23	71	263	1	3
-187	33	1	-59.7	0	971	153	703	1226	8036	37665	62930	312	450	0	66	0	25	73	277	1	3
-187	34	3	-62.8	0	923	147	664	1128	7455	38191	61889	312	468	0	73	0	25	80	287	1	2
-187	35	5	-65.9	0	770	122	556	934	6371	34847	61412	305	453	0	74	0	24	80	281	1	6
-187	36	7	-69.1	0	817	129	569	950	6521	34919	59675	233	357	0	61	0	21	68	221	1	7
-187	37	9	-72.2	0	783	129	568	932	6558	34932	59813	235	392	0	60	0	20	66	245	0	3
-187	38	11	-75.4	0	618	99	440	698	5218	31730	58027	229	362	0	61	0	20	62	237	0	4
-187	39	13	-78.5	0	862	138	590	953	6604	33328	57986	192	277	0	51	1	19	49	182	1	6
-187	40	15	-81.6	0	714	114	509	800	5744	32474	58537	256	389	0	62	0	21	68	257	1	6
-187	41	17	-84.8	0	770	122	535	838	5887	31010	59368	218	310	0	59	0	18	56	213	1	14
-187	42	19	-87.9	0	846	128	596	914	6261	32916	57398	238	344	0	63	0	22	61	237	1	3
-187	43	21	-91.0	0	788	125	547	867	5877	30517	56231	241	363	0	61	0	18	58	243	1	2
-187	44	23	-94.2	0	769	112	542	831	5691	29898	57548	235	345	0	60	0	20	59	235	0	2
-187	45	25	-97.3	0	676	108	407	748	5245	29038	57425	219	324	0	58	0	17	58	226	1	1
-187	46	27	-100.4	0	867	133	577	892	6207	32525	56188	197	268	0	54	0	16	55	200	1	4
-187	47	29	-103.5	0	667	103	48[illegible]	710	5165	29000	57413	229	351	0	68	0	20	64	249	1	2
-187	48	31	-106.6	0	665	105	460	682	4963	27503	54956	187	265	0	51	1	16	49	195	1	4
-187	49	33	-109.7	0	815	116	544	812	5751	28797	55240	188	265	0	51	0	17	56	196	1	34
-187	50	35	-112.8	0	677	104	456	653	4694	25686	54220	215	319	0	59	0	20	59	236	0	54
-187	51	37	-115.9	0	688	102	457	649	4682	25151	51393	177	249	0	52	0	16	47	193	1	54
-187	52	39	-119.0	0	774	109	499	707	5123	25945	52927	185	256	0	51	0	15	52	197	1	72
-187	53	41	-122.1	0	761	113	484	680	4997	26931	54227	193	293	0	60	0	14	53	214	1	12

Figure 29-4.- Peak summary format.

APOLLO 16 TRAJECTORY SUMMARY

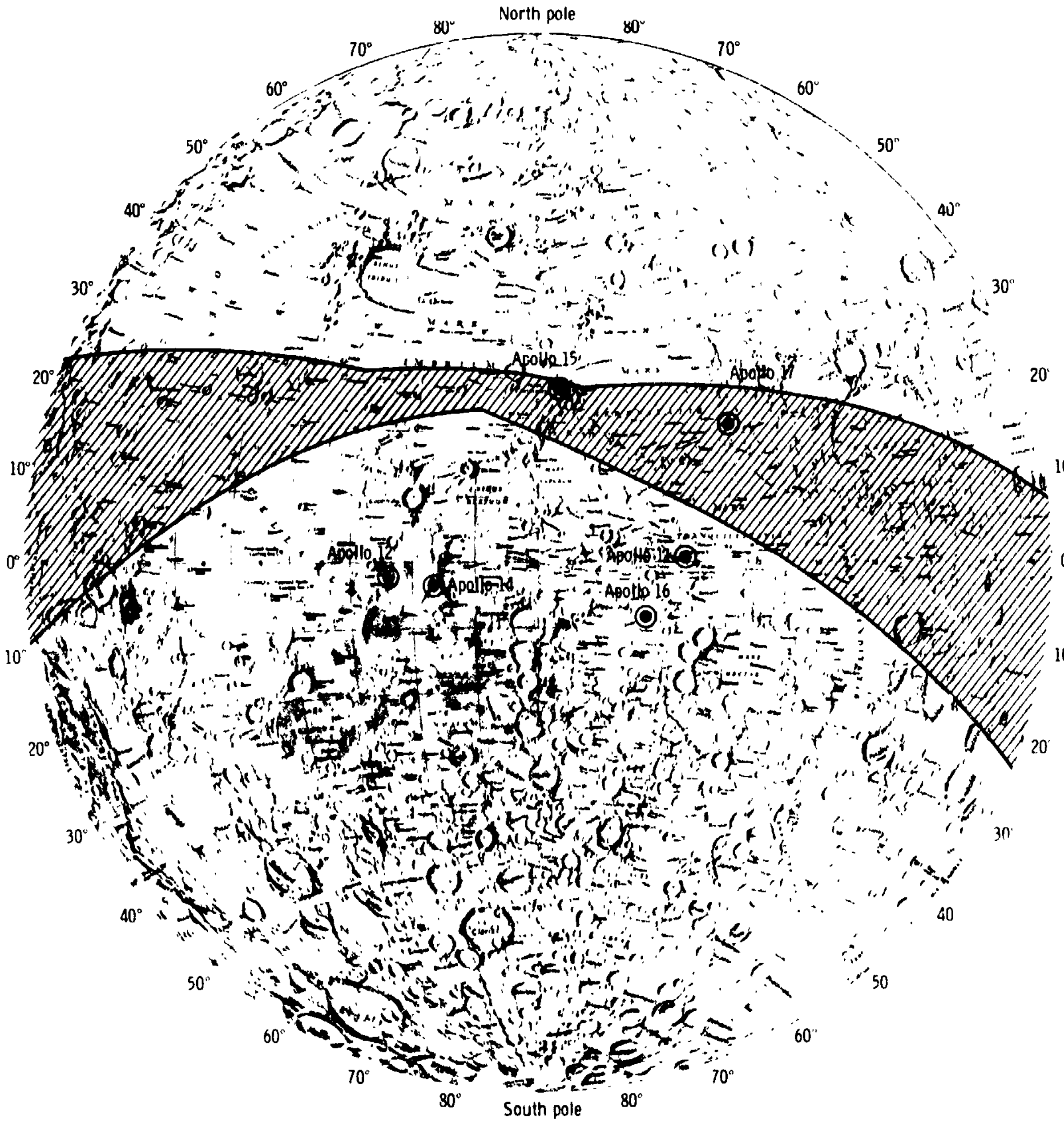
GET	TIME	REV	SUN HR	LONG	LAT	RADIUS	VELOCITY	ALTITUDE	SS LONG	SS LAT	SUN A	SUN B	VEL ALPHA	VEL BETA
187	2 3	58.27	33.10	81.48	2.41	1847.55	1.6301	109.72	48.39	1.57	120.42	214.18	177.48	219.06
187	3 5	58.28	30.02	78.39	1.85	1848.16	1.6295	110.33	48.38	1.57	116.91	214.83	177.09	217.87
187	4 7	58.29	26.94	75.31	1.28	1848.78	1.6290	110.95	48.37	1.57	113.71	214.52	176.65	215.58
187	5 9	58.30	23.86	72.22	.71	1849.40	1.6284	111.57	48.36	1.57	112.63	214.42	176.47	215.17
187	6 11	58.31	20.79	69.14	.14	1850.03	1.6279	112.20	48.35	1.57	105.94	213.84	175.45	213.71
187	7 13	58.32	17.72	66.06	-.43	1850.65	1.6273	112.82	48.34	1.57	102.68	213.84	175.29	218.17
187	8 15	58.33	14.65	62.98	-1.00	1851.27	1.6268	113.44	48.33	1.57	99.61	213.82	175.31	219.81
187	9 17	58.33	11.58	59.91	-1.56	1851.[illegible]	1.6263	114.05	48.32	1.57	96.65	213.84	175.46	219.60
187	10 19	58.34	8.52	56.83	-2.12	1852.49	1.6257	114.66	48.32	1.57	93.64	213.92	175.56	219.61
187	11 21	58.35	5.45	53.75	-2.68	1853.10	1.6252	115.27	48.31	1.57	90.57	214.11	175.60	219.92
187	12 22	58.36	2.38	50.68	-3.22	1853.69	1.6247	115.86	48.30	1.57	87.48	214.35	175.62	220.39
187	13 24	58.37	-.69	47.60	-3.76	1854.27	1.6242	116.44	48.29	1.57	84.35	214.65	175.59	220.67
187	14 26	58.38	-3.76	44.52	-4.29	1854.84	1.6237	117.01	48.28	1.57	81.10	214.95	175.52	220.81
187	15 28	58.38	-6.84	41.44	-4.80	1855.40	1.6233	117.57	48.27	1.57	78.01	215.30	175.46	220.29
187	16 30	58.39	-9.91	38.35	-5.30	1855.94	1.6228	118.11	48.26	1.57	75.55	215.51	176.06	209.62
187	17 32	58.40	-12.99	35.26	-5.78	1856.46	1.6224	118.63	48.25	1.57	73.76	215.58	176.92	183.59
187	18 34	58.41	-16.08	32.17	-6.25	1856.96	1.6219	119.13	48.25	1.57	71.89	215.75	176.92	152.89
187	19 36	58.42	-19.16	29.07	-6.70	1857.44	1.6215	119.61	48.24	1.57	69.67	215.80	176.49	133.14
187	20 38	58.43	-22.25	25.97	-7.13	1857.90	1.6211	120.07	48.23	1.57	66.85	215.83	176.41	127.91
187	21 40	58.44	-25.35	22.87	-7.53	1858.33	1.6208	120.50	48.22	1.57	63.84	215.76	176.51	126.43
187	22 42	58.45	-28.45	19.76	-7.92	1858.74	1.6204	120.91	48.21	1.57	60.85	215.72	176.60	124.68
187	23 44	58.45	-31.55	16.65	-8.28	959.13	1.6201	121.30	48.20	1.57	57.74	215.65	176.80	124.78
187	24 46	58.46	-34.66	13.53	-8.62	1859.40	1.6198	121.65	48.19	1.57	54.57	215.55	177.07	126.24
187	25 48	58.47	-37.77	10.41	-8.94	1859.81	1.6195	121.90	48.18	1.57	51.34	215.44	177.40	129.44
187	26 50	58.48	-40.89	7.28	-9.23	1860.11	1.6193	122.28	48.18	1.57	48.11	215.38	177.71	133.73
187	27 52	58.49	-44.01	4.15	-9.49	1860.38	1.6190	122.55	48.17	1.57	44.90	215.36	177.98	139.62
187	28 54	58.50	-47.14	1.02	-9.72	1860.61	1.6188	122.78	48.16	1.57	41.64	214.53	178.17	145.36
187	29 56	58.51	-50.26	-2.11	-9.93	1860.82	1.6186	122.99	48.15	1.57	38.37	213.32	178.32	153.62
187	30 58	58.51	-53.39	-5.25	-10.10	1860.99	1.6185	123.16	48.14	1.57	35.10	212.04	178.42	163.97
187	32 0	58.52	-56.53	-8.40	-10.25	1861.13	1.6184	123.30	48.13	1.57	31.81	210.65	178.46	176.44
187	33 1	58.53	-59.66	-11.54	-10.36	1861.23	1.6183	123.40	48.12	1.57	28.49	209.04	178.37	190.30
187	34 3	58.54	-62.80	-14.69	-10.45	1861.30	1.6182	123.47	48.11	1.57	25.15	207.08	178.16	202.77
187	35 5	58.55	-65.94	-17.83	-10.50	1861.34	1.6182	123.51	48.11	1.57	21.83	204.58	177.86	212.73
187	36 7	58.56	-69.08	-20.98	-10.53	1861.35	1.6181	123.52	48.10	1.57	18.55	201.29	177.50	219.05
187	37 9	58.57	-72.22	-24.13	-10.52	1861.31	1.6181	123.49	48.09	1.57	15.36	196.74	177.13	224.75
187	38 11	58.58	-75.36	-27.28	-10.48	1861.25	1.6182	123.42	48.08	1.57	12.28	189.84	176.70	228.16
187	39 13	58.58	-78.49	-30.42	-10.42	1861.15	1.6183	123.32	48.07	1.57	9.48	178.93	176.29	230.21
187	40 15	58.59	-81.63	-33.57	-10.32	1861.02	1.6184	123.19	48.06	1.57	7.22	163.42	176.22	228.94
187	41 17	58.60	-84.77	-36.71	-10.19	1860.86	1.6185	123.03	48.05	1.57	5.76	141.04	176.42	224.76
187	42 19	58.61	-87.90	-39.85	-10.03	1860.67	1.6186	122.84	48.04	1.57	5.59	111.81	176.55	220.01
187	43 21	58.62	-91.03	-42.99	-9.84	1860.44	1.6188	122.61	48.04	1.57	6.83	86.69	176.63	214.32
187	44 23	58.63	-94.16	-46.13	-9.62	1860.18	1.6190	122.35	48.03	1.57	8.98	70.43	176.61	207.13
187	45 25	58.64	-97.28	-49.26	-9.38	1859.89	1.6193	122.06	48.02	1.57	11.58	60.54	176.54	199.97
187	46 27	58.65	-100.40	-52.39	-9.11	1859.58	1.6195	121.75	48.01	1.57	14.19	56.54	176.91	199.00
187	47 29	58.65	-103.52	-55.51	-8.81	1859.23	1.6198	121.40	48.00	1.57	16.48	57.44	178.01	220.87
187	48 31	58.66	-106.63	-58.64	-8.48	1858.86	1.6201	121.03	47.99	1.57	18.63	59.66	178.49	276.31
187	49 33	58.67	-109.73	-61.75	-8.13	1858.46	1.6205	120.63	47.98	1.57	20.83	61.19	177.57	321.62
187	50 35	58.68	-112.84	-64.86	-7.76	1858.04	1.6209	120.21	47.97	1.57	23.43	60.25	177.00	332.26
187	51 37	58.69	-115.94	-67.97	-7.36	1857.59	1.6212	119.76	47.97	1.57	26.34	58.05	177.00	333.04
187	52 39	58.70	-119.03	-71.08	-6.95	1857.12	1.6217	119.29	47.96	1.57	29.35	55.68	177.06	332.25
187	53 41	58.71	-122.12	-74.18	-6.51	1856.63	1.6221	118.80	47.95	1.57	32.44	53.09	177.16	329.80

Figure 29-5.- Trajectory summary format.

APOLLO 16 HOUSEKEEPING SUMMARY

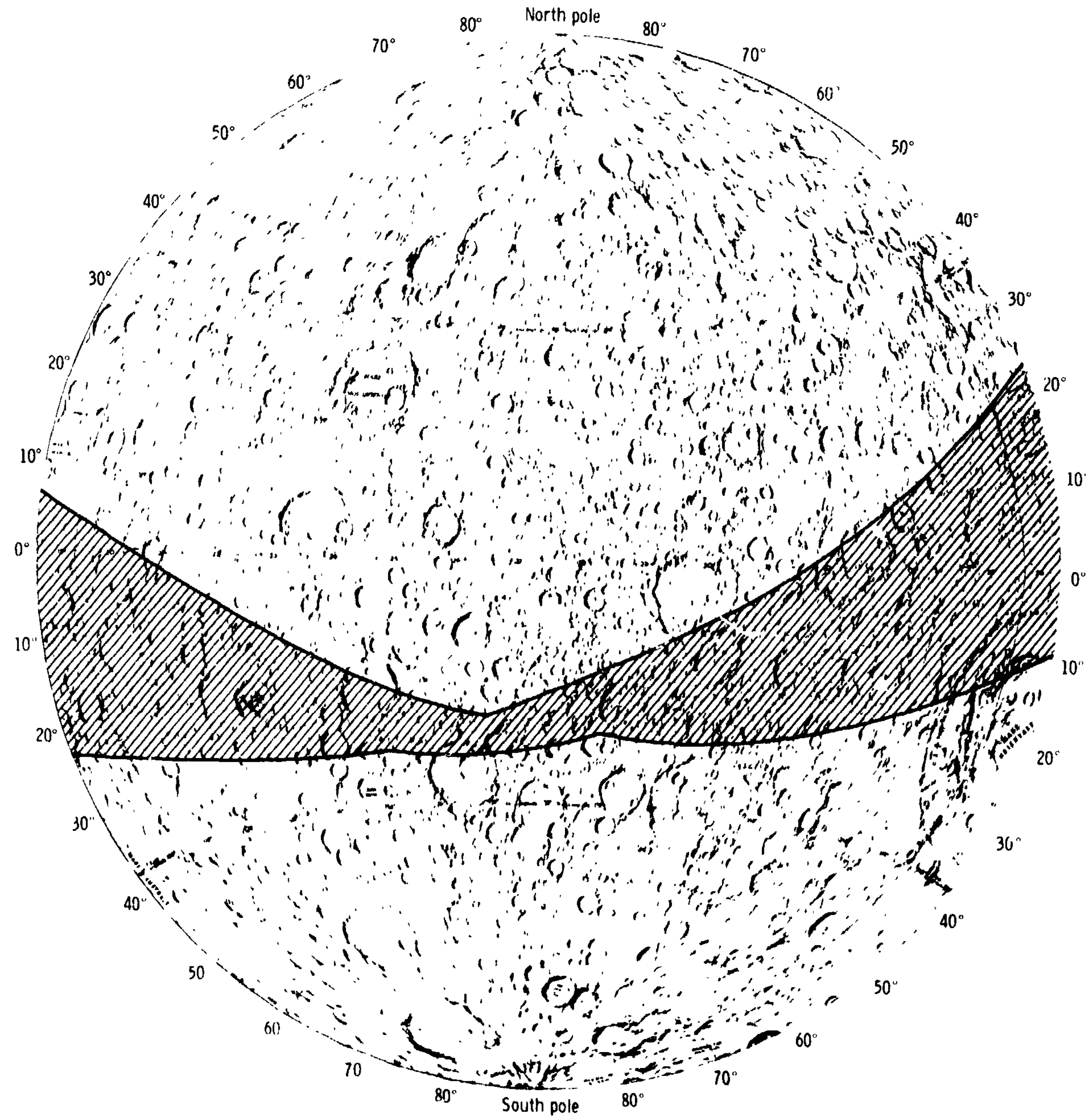
GET	TIME	+12	+ 5	-12	-15	EMISSION	FIL 1	FIL 2	LM HV	HM HV	S HV	ETEMP	STEMP	M LO/HI	D HI/LO	I
107	2 3	3.88	2.43	2.96	4.67	2.06	3.12	.16	2.59	2.69	2.31	2.75	2.35	.02	2.49	2.00
107	3 5	3.88	2.43	2.96	4.67	2.04	3.10	.16	2.59	2.69	1.75	2.75	2.35	.02	2.49	1.92
107	4 7	3.86	2.43	2.96	4.67	2.06	3.10	.16	2.59	2.69	1.02	2.75	2.37	.02	2.47	1.86
107	5 9	3.86	2.43	2.96	4.67	2.04	3.10	.16	2.59	2.69	1.90	2.75	2.35	.04	2.47	1.80
107	6 11	3.86	2.43	2.96	4.67	2.00	3.10	.16	2.57	2.69	1.53	2.75	2.35	.02	2.47	1.78
107	7 13	3.86	2.43	2.96	4.67	2.06	3.10	.16	2.59	2.69	2.05	2.76	2.35	.02	2.47	1.82
107	8 15	3.88	2.43	2.94	4.67	2.06	3.10	.16	2.59	2.67	2.16	2.76	2.35	.04	2.47	1.80
107	9 17	3.83	2.43	2.94	4.67	2.06	3.10	.10	2.57	2.71	2.22	2.76	2.35	.02	2.47	1.92
107	10 19	3.86	2.45	2.96	4.67	2.06	3.10	.16	2.59	2.69	2.31	2.76	2.35	.04	2.49	1.94
107	11 21	3.86	2.43	2.96	4.67	2.06	3.10	.16	2.59	2.69	1.73	2.78	2.35	.02	2.49	1.90
107	12 22	3.86	2.41	2.96	4.67	2.10	3.10	.16	2.59	2.69	1.80	2.78	2.37	.02	2.47	1.80
107	13 24	3.88	2.43	2.96	4.67	2.10	3.10	.16	2.57	2.69	1.90	2.78	2.35	.02	2.47	1.76
107	14 26	3.86	2.43	2.96	4.67	2.06	3.10	.18	2.59	2.71	1.90	2.78	2.37	.02	2.49	1.73
107	15 28	3.86	2.45	2.96	4.67	2.04	3.10	.16	2.59	2.69	2.06	2.78	2.37	.02	2.47	1.69
107	16 30	3.86	2.43	2.96	4.67	2.04	3.12	.18	2.59	2.69	2.16	2.80	2.33	.02	2.47	.67
107	17 32	3.88	2.43	2.96	4.69	2.06	3.12	.16	2.61	2.69	2.22	2.80	2.37	.02	2.47	1.67
107	18 34	3.88	2.43	2.96	4.67	2.04	3.12	.16	2.59	2.69	2.31	2.80	2.37	.02	2.47	1.69
107	19 36	3.86	2.43	2.94	4.67	2.06	3.10	.16	2.59	2.69	1.75	2.82	2.37	.02	2.47	1.69
107	20 38	3.66	2.43	2.96	4.67	2.04	3.12	.16	2.59	2.71	1.82	2.80	2.37	.02	2.47	1.67
107	21 40	3.86	2.43	2.96	4.67	2.06	3.10	.18	2.59	2.69	1.90	2.82	2.35	.02	2.47	1.67
107	22 42	3.86	2.43	2.96	4.67	2.04	3.12	.18	2.59	2.71	1.90	2.82	2.35	.02	2.47	1.67
107	23 44	3.88	2.43	2.96	4.65	2.06	3.10	.10	2.59	2.69	2.06	2.84	2.35	.02	2.47	1.69
107	24 46	3.86	2.43	2.94	4.65	2.06	3.10	.16	2.59	2.71	2.14	2.86	2.35	.02	2.47	1.63
107	25 48	3.88	2.45	2.96	4.67	2.04	3.10	.16	2.59	2.71	2.22	2.84	2.37	.04	2.47	1.63
107	26 50	3.88	2.43	2.94	4.67	2.00	3.12	.14	2.61	2.71	2.29	2.84	2.37	.02	2.47	1.63
107	27 52	3.86	2.43	2.94	4.67	2.02	3.10	.16	2.59	2.69	1.75	2.86	2.35	.02	2.47	1.63
107	28 54	3.88	2.43	2.96	4.67	2.04	3.10	.16	2.61	2.71	1.84	2.86	2.37	.02	2.47	1.63
107	29 56	3.88	2.43	2.96	4.67	2.04	3.10	.16	2.59	2.71	1.90	2.86	2.35	.02	2.47	1.61
107	30 58	3.88	2.43	2.94	4.67	2.06	3.10	.16	2.59	2.71	1.98	2.86	2.35	.02	2.45	1.65
107	32 0	3.88	2.43	2.96	4.67	2.00	3.10	.16	2.59	2.71	2.06	2.80	2.35	.02	2.47	1.61
107	33 1	3.86	2.43	2.96	4.67	2.04	3.10	.18	2.59	2.71	2.14	2.80	2.35	.02	2.47	1.63
107	34 3	3.86	2.45	2.96	4.67	2.04	3.14	.16	2.59	2.71	2.24	2.80	2.35	.04	2.47	1.67
107	35 5	3.86	2.43	2.96	4.67	2.00	3.12	.18	2.59	2.71	2.31	2.80	2.35	.02	2.47	1.76
107	36 7	3.88	2.43	2.96	4.67	2.02	3.10	.10	2.59	2.69	1.75	2.90	2.35	.02	2.45	1.70
107	37 9	3.88	2.43	2.94	4.67	2.06	3.12	.10	2.59	2.69	1.82	2.90	2.37	.02	2.47	1.02
107	38 11	3.88	2.43	2.96	4.65	1.96	3.10	.10	2.59	2.69	1.90	2.90	2.35	.02	2.47	1.80
107	39 13	3.88	2.43	2.96	4.67	2.02	3.12	.18	2.59	2.69	1.90	2.90	2.35	.02	2.47	1.86
107	40 15	3.88	2.43	2.96	4.67	2.00	3.10	.16	2.59	2.69	2.00	2.90	2.35	.02	2.45	1.80
107	41 [illegible]	3.86	2.43	2.96	4.67	2.00	3.10	.18	2.57	2.69	2.16	2.90	2.35	.02	2.45	1.86
107	42 19	3.88	2.45	2.96	4.67	2.00	3.10	.18	2.59	2.69	2.24	2.90	2.35	.02	2.45	1.86
107	43 21	3.86	2.43	2.96	4.67	2.04	3.10	.18	2.59	2.69	2.31	2.90	2.35	.04	2.45	1.90
107	44 23	3.88	2.43	2.96	4.67	2.02	3.10	.16	2.57	2.69	1.75	2.90	2.35	.02	2.45	.90
107	45 25	3.88	2.43	2.96	4.67	2.04	3.10	.18	2.59	2.69	1.84	2.90	2.35	.02	2.45	1.80
107	46 27	3.88	2.43	2.94	4.67	2.02	3.10	.16	2.59	2.69	1.90	2.80	2.33	.02	2.45	1.80
107	47 29	3.86	2.43	2.96	4.67	2.04	3.12	.18	2.59	2.69	2.00	2.88	2.33	.02	2.45	1.80
107	48 31	3.88	2.43	2.96	4.67	2.04	3.12	.16	2.59	2.69	2.00	2.90	2.35	.02	2.45	1.80
107	49 33	3.86	2.45	2.96	4.65	2.04	3.12	.18	2.59	2.69	2.16	2.88	2.33	.02	2.45	1.90
107	50 35	3.88	2.43	2.94	4.67	2.02	3.12	.18	2.59	2.69	2.24	2.80	2.35	.02	2.47	1.94
107	51 37	3.88	2.45	2.96	4.67	2.02	3.12	.18	2.59	2.67	2.29	2.00	2.33	.04	2.45	1.90
107	52 39	3.88	2.43	2.96	4.65	2.04	3.10	.18	2.57	2.69	1.75	2.88	2.33	.02	2.45	2.00
107	53 41	3.86	2.45	2.96	4.65	2.06	3.10	.10	2.57	2.71	1.82	2.88	2.35	.02	2.45	1.90

Figure 29-6.- Housekeeping summary format.



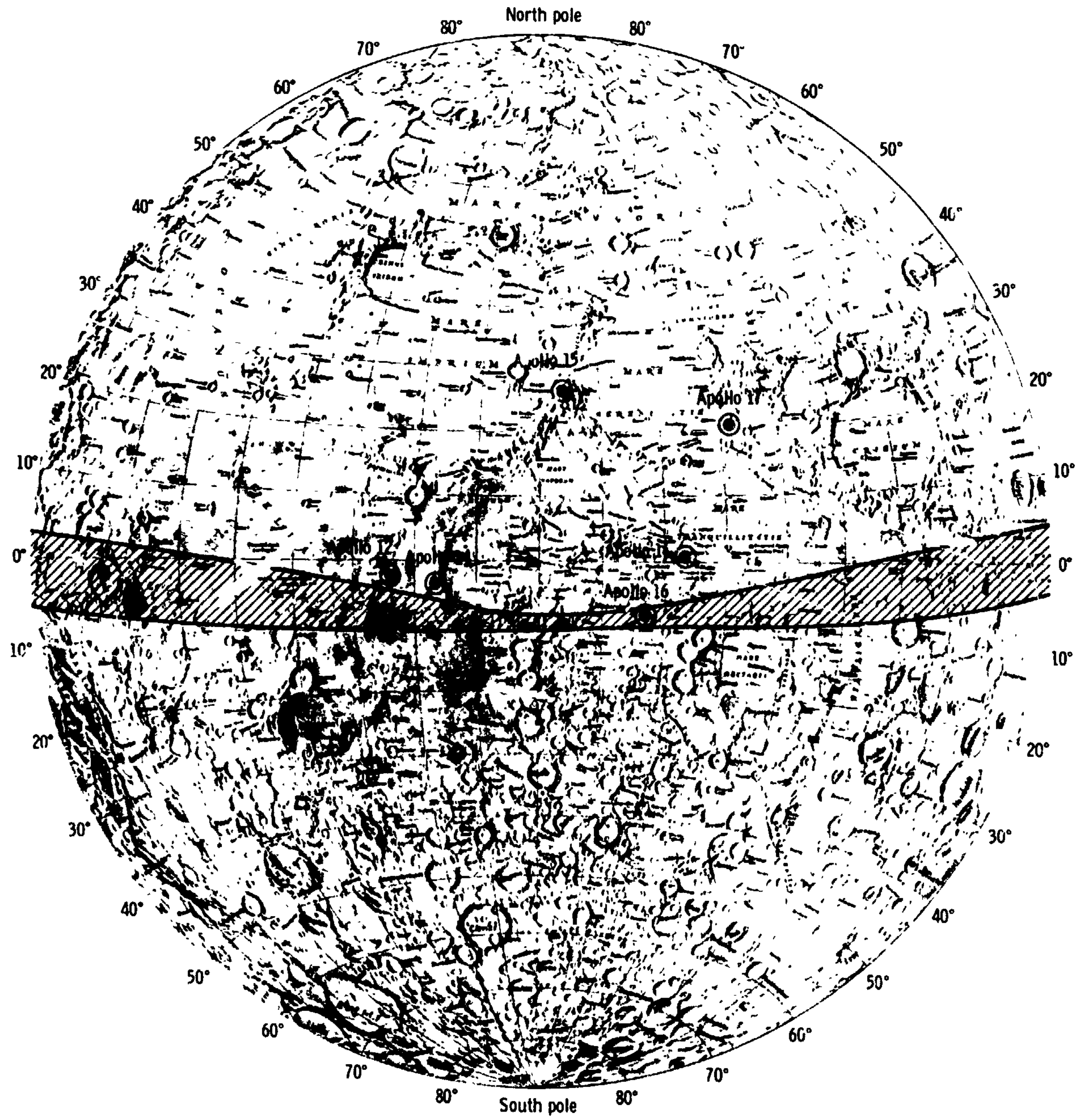
(a) Near side.

Figure B-6.- Lunar surface groundtrack envelope of the Apollo 15 orbiting spacecraft for revolutions 1 to 74. Areas of additional data coverage outside the envelope are determined by the fields of view of experiment instruments and photographic cameras.



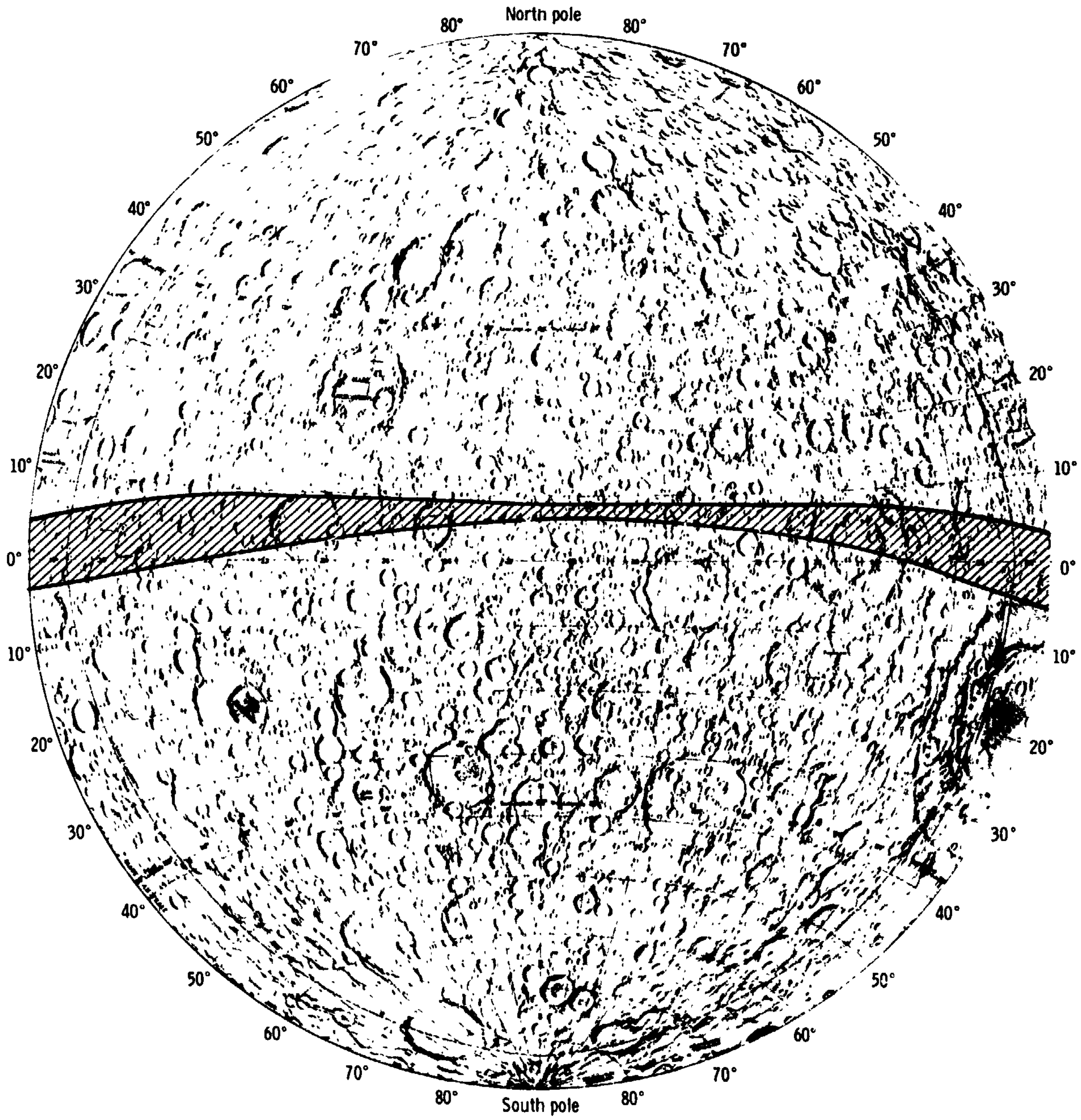
(b) Far side.

Figure B-6.- Concluded.



(a) Near side.

Figure B-7.- Lunar surface groundtrack envelope of the Apollo 16 orbiting spacecraft for revolutions 1 to 65. Areas of additional data coverage outside the envelope are determined by the fields of view of experiment instruments and photographic cameras.



(b) Far side.

Figure B-7.- Concluded.

APPENDIX C

LIST OF ACRONYMS

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LIST OF ACRONYMS

ADC	analog-to-digital converter
AET	Apollo elapsed time
AGRS	Apollo gamma-ray spectrometer
AIC	Apollo intermediate charts
ALSE	Apollo lunar sounder experiment
ALSEP	Apollo lunar surface experiments package
ASE	active seismic experiment
ATS	Applied Technology Satellite
AXRS	Apollo X-ray spectrometer
AZ	azimuth
BCD	binary coded decimal
CCGE	cold cathode gage experiment
CCIG	cold cathode ion gage
CDC	Control Data Corporation
CDR	commander
c.g.	center of gravity
CPLEE	charged-particle lunar environment experiment
CRT	cathode ray tube
CSAR	coherent synthetic aperture radar
CSM	command and service module
CTE	computer time elapsed
Cyg	Cygnus
dec	declination
DRNM	Deep River Neutron Monitor
DSN	Deep Space Network
DTREM	dust thermal radiation engineering measurement
EASEP	early Apollo scientific experiments package
E-frame	electronic frame
EL	elevation
EMI	electromagnetic interference
EOF	end of file
EOT	end of tape
EP	explosive package
ERIM	Environmental Research Institute of Michigan
EVA	extravehicular activity
FET	field effect transistor
FFT	fast Fourier transform
FM	frequency modulation
FOV	field of view
FWHM	full width, half maximum
GCR	galactic cosmic ray
GE	General Electric
GET	ground elapsed time

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G.m.t.	Greenwich mean time
GRS	gamma-ray spectrometer
GSFC	Goddard Space Flight Center
HF	high frequency
HFE	heat flow experiment
HV	high voltage
IMP	Interplanetary Monitoring Platform
IR	infrared
ISR	infrared scanning radiometer
JPL	Jet Propulsion Laboratory
JSC	Lyndon B. Johnson Space Center
LAC	lunar astronautical charts
LACE	lunar atmospheric composition experiment
L-DGO	Lamont-Doherty Geological Observatory
LEAM	lunar ejecta and meteorites
LLT	local lunar time
LM	lunar module
LMC	large Magellanic Cloud
LNPE	lunar neutron probe experiment
LP	long period
LPM	lunar portable magnetometer
LPX	long period horizontal (X-axis) or long-period horizontal seismometer
LPY	long period horizontal (Y-axis) or long-period horizontal seismometer
LPZ	long period vertical (Z-axis) or long-period vertical seismometer
LRC	Langley Research Center
LRV	lunar roving vehicle
LSAPT	Lunar Sample Analysis Planning Team
LSG	lunar surface gravimeter
LSI	Lunar Science Institute
LSM	lunar surface magnetometer
LSPE	lunar seismic profiling experiment
LURE	Lunar Laser Ranging Experiment
LVPS	low-voltage power supply
MA	mass analyzer
MESA	modularized equipment stowage assembly
MET	modularized equipment transporter
MPA	mortar package assembly
MRO	memory readout
NAT	NASA Apollo trajectory
NBS	National Bureau of Standards
NSSDC	National Space Science Data Center
OAO-2	Orbiting Astronomical Observatory 2
OGO IV	Orbiting Geophysical Observatory IV
PA	post amplifier
PCM	pulse code modulation
PFS	particles and fields subsatellite
PMT	photomultiplier tube
PSD	pulse shape discriminator
PSE	passive seismic experiment

PSEP	passive seismic experiments package
RA	right ascension
rev	revolution
RFI	radiofrequency interferometry
RLC	Ranger VII lunar charts
rms	root mean square
RT	real time
RTG	radioisotope thermoelectric generator
SA	SIM attitude
SAO	Smithsonian Astrophysical Observatory
SB	standby
Sco	Scorpius
SE	solar ecliptic
SEM	scanning electron microscope
SEP	surface electrical properties
SIDE	suprathermal ion detector experiment
SIM	scientific instrument module
SIVB	Saturn IVB
SM	solar magnetospheric
SP	short period
SRI	Stanford Research Institute
SRP	self-recording penetrometer
SWS	solar-wind spectrometer
TCE	telemetry conversion error
TEC	transearth coast
TEI	transearth injection
TGE	traverse gravimeter experiment
TID	total ion detector
TSF	telemetry-store fast
TSN	telemetry-store normal
UCLA	University of California at Los Angeles
USGS	U.S. Geological Survey
UTD	University of Texas at Dallas
UV	ultraviolet
UVS	ultraviolet spectrometer
VCO	voltage-controlled oscillator
VHF	very high frequency
VLBI	very long baseline interferometry
VSA	vibrating string accelerometer
WDC-A-R&S	World Data Center A for Rockets and Satellites