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TRAJECTORIES OF EXPLORERS 33, 34 AND 35 JULY 1966 - APRIL 1969

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FEBRUARY 1970

GSFC
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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Increased use of data from several satellites for correlative studies of the outer magnetosphere, magnetosheath, bow shock and interplanetary shocks, discontinuities and general properties has made it highly desirable to have plots available of the relative locations of the satellites potentially of interest. Beginning in July 1966, three IMP class satellites have been launched which are well suited for such correlative studies in or near cislunar space. They are:

(1) Explorer 33, launched into a high apogee-perigee orbit on July 1, 1966;

(2) Explorer 34, placed in a high inclination orbit on May 24, 1967;

(3) Explorer 35, launched on July 19, 1967 and injected into lunar orbit on July 22.

This document consists primarily of solar ecliptic plane projections of the orbits of these three satellites. The orbits of Explorer 33 from launch through June 1967 are summarized in Figures 1 and 2. Day numbers used on those figures are decimal day of the year, where January 1 is day 0 and July 1 is day 181 (or 182 in the case of leap year). Figure 3 shows segments of Explorer 33 orbits of interest for near earth studies in the night side magnetosphere. They correspond to passes during December 1966 to February 1967. The begin and end points of each segment are identified by decimal day and Universal Time. In addition, the distance from the ecliptic plane of the midnight meridian plane crossing point is given in earth radii for each pass.

The approximate positions and orientations of Explorer 34 orbits 1-50 (May 24 to December 26, 1967) are summarized in Figure 4. The period of the Explorer 34 orbit is 4-1/3 days. Table 1 lists apogee and perigee times for orbits 1-13 for use in correlating the Explorer 34 position with that of Explorer 33 during May to July 1967.

With the launch of Explorer 35 the three satellites were in orbit simultaneously, and the remaining figures (5-30) show the projections of the orbits for successive periods of one month. Near January 20, 1969, Explorer 33 experienced a close encounter with the moon. As a result, its orbital inclination increased to about 35 degrees from the ecliptic plane, its apogee increased to about 137 earth radii and its period increased to 43 days. To determine the position of Explorer 33 in the geomagnetic field after January 20, 1969 requires knowledge of its Z coordinate in addition to its position in the ecliptic plane. Thus additional figures of the orbit of Explorer 33 and the moon in a plane perpendicular to the ecliptic are shown after the end of 1968. These figures collectively cover the period from July 1967 to April 1969. The plots of Explorer 34 orbits 130-151 are predicted trajectories. Orbit numbers are circled numbers.

Experimental data from Explorers 33 and 35 are processed on a weekly basis while Explorer 34 data are processed by orbit. To assist in the use of data from these spacecraft, Tables 2-4 give the begin date for each week of 33 and 35 data through April 1969 and for each of the orbits of 34, respectively. In addition to month and day of month, the corresponding decimal day of the year is also given for each date.

The GSFC Magnetometer Experiment on Explorer 33 ceased operation on October 10, 1968 (week 119). The only experiments on Explorer 33 still operating between that date and the end of the period covered by this document were the MIT plasma detector, the University of Iowa energetic particle detectors, and the Ames Research Center magnetometer.

On March 4, 1969 the Explorer 34 optical aspect sensor failed during an apogee shadow. This failure precludes a determination of the direction of the field perpendicular to the spin axis and hence only field magnitudes are available subsequent to this date. The Explorer 34 spacecraft continued to transmit data until it re-entered the atmosphere on May 3, 1969.

It is anticipated that this document will serve as an initial attempt to stimulate collaboration not only between experimenters on these satellites but also with those on the Vela and OGO spacecraft as well as on other Explorers. Also we believe that this document will serve as a useful reference for investigators using ground based observations of geophysical and solar phenomena and thereby provide an encouragement to their direct solicitation of explicit spacecraft data for similar correlative studies. Several publications by the GSFC group conducting magnetic field experiments on these satellites have already appeared which include some of these data. These are included in the bibliography.

It may be of interest to users of this document that IMP 3 was also operating during 1965-1967. IMP 3 was on Orbit 69 when Explorer 33 was launched. Apogee of IMP 3 was near the dusk meridian at a distance

of 37 R_E in July 1966. Apogee was located near the noon meridian in early October 1966 and near the dawn meridian in early January 1967. This spacecraft continued to provide experimental data through orbit 117, up to mid-April 1967, when apogee was in the geomagnetic tail near the midnight meridian.

The Explorer 41 (IMP 5, IMP G) spacecraft was launched on June 21, 1969 into an Explorer 34 type polar orbit with initial apogee near 29 R_E in the sunward direction. This satellite continues to provide high quality data at the time of this writing.

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TABLE 1

EXPLORER 34 PERIGEE AND APOGEE TIMES AND DISTANCES

ORBIT	PERIGEE TIME		PERIGEE DISTANCE(KM)	APOGEE TIME		APOGEE DISTANCE(KM)
1	5/24/67	1406	LAUNCH	5/26/67	1801-1813	211024
2	5/28/67	2157	278	5/31/67	0143-0154	211077
3	6/2/67	0542	310	6/4/67	0925-0939	210992
4	6/6/67	1322	328	6/8/67	1659-1714	210849
5	6/10/67	2050	330	6/13/67	0032-0048	210979
6	6/15/67	0439	458	6/17/67	0822-0837	210657
7	6/19/67	1218	628	6/21/67	1554-1609	210540
8	6/23/67	1947	636	6/25/67	2332-2344	210682
9	6/28/67	0330	669	6/30/67	0717-0726	210642
10	7/2/67	1113	698	7/4/67	1453-1508	210518
11	7/6/67	1846	704	7/8/67	2226-2235	210475
12	7/11/67	0219	756	7/13/67	0626-0638	210954
13	7/15/67	1046	1078	7/17/67	1436-1437	210384

TABLE 2

EXPLORER 33 CALENDAR

Week	Begin Date	Decimal Day	Week	Begin Date	Decimal Day
1	1966 July 1	181	23	1966 Dec. 3	336
2	9	189	24	10	343
3	16	196	25	17	350
4	23	203	26	24	357
5	30	210	27	31	364
6	Aug. 6	217	28	1967 Jan. 7	6
7	13	224	29	14	13
8	20	231	30	21	20
9	27	238	31	28	27
10	Sept. 3	245	32	Feb. 4	34
11	10	252	33	11	41
12	17	259	34	18	48
13	24	266	35	25	55
14	Oct. 1	273	36	Mar. 4	62
15	8	280	37	11	69
16	15	287	38	18	76
17	22	294	39	25	83
18	29	301	40	Apr. 1	90
19	Nov. 5	308	41	8	97
20	12	315	42	15	104
21	19	322	43	22	111
22	26	329	44	29	118

Week	Begin Date	Decimal Day	Week	Begin Date	Decimal Day
45	1967 May 6	125	68	1967 Oct. 14	286
46	13	132	69	21	293
47	20	139	70	28	300
48	27	146	71	Nov. 4	307
49	June 3	153	72	11	314
50	10	160	73	18	321
51	17	167	74	25	328
52	24	174	75	Dec. 2	335
53	July 1	181	76	9	342
54	8	188	77	16	349
55	15	195	78	23	356
56	22	202	79	30	363
57	29	209	80	1968 Jan. 6	5
58	Aug. 5	216	81	13	12
59	12	223	82	20	19
60	19	230	83	27	26
61	26	237	84	Feb. 3	33
62	Sept. 2	244	85	10	40
63	9	251	86	17	47
64	16	258	87	24	54
65	23	265	88	Mar. 2	61
66	30	272	89	9	68
67	Oct. 7	279	90	16	75

Week	Begin Date	Decimal Day	Week	Begin Date	Decimal Day
91	Mar. 23	82	113	24	236
92	30	89	114	31	243
93	Apr. 6	96	115	Sept. 7	250
94	13	103	116	14	257
95	20	110	117	21	264
96	27	117	118	28	271
97	May 4	124	119	Oct. 5	278
98	11	131	120	12	285
99	18	138	121	19	292
100	25	145	122	26	299
101	June 1	152	123	Nov. 2	306
102	8	159	124	9	313
103	15	166	125	16	320
104	22	173	126	23	327
105	29	180	127	30	334
106	July 6	187	128	Dec. 7	341
107	13	194	129	14	348
108	20	201	130	21	355
109	27	208	131	28	362
110	Aug. 3	215	132	1969 Jan. 4	003
111	10	222	133	11	010
112	17	229	134	18	017

Week	Begin Date	Decimal Day
135	25	024
136	Feb. 1	031
137	8	038
138	15	045
139	22	052
140	Mar. 1	059
141	8	066
142	15	073
143	22	080
144	29	087
145	Apr. 5	094
146	12	101
147	19	108
148	26	115

TABLE 3

EXPLORER 35 CALENDAR

Week	Begin Date	Decimal Day	Week	Begin Date	Decimal Day
1	1967 July 19	199	25	1968 Jan. 4	3
2	27	207	26	11	10
3	Aug. 3	214	27	18	17
4	10	221	28	25	24
5	17	228	29	Feb. 1	31
6	24	235	30	8	38
7	31	242	31	15	45
8	Sept. 7	249	32	22	52
9	14	256	33	29	59
10	21	263	34	Mar. 7	66
11	28	270	35	14	73
12	Oct. 5	277	36	21	80
13	12	284	37	28	87
14	19	291	38	Apr. 4	94
15	26	298	39	11	101
16	Nov. 2	305	40	18	108
17	9	312	41	25	115
18	16	319	42	May 2	122
19	23	326	43	9	129
20	30	333	44	16	136
21	Dec. 7	340	45	23	143
22	14	347	46	30	150
23	21	354	47	June 6	157
24	28	361			

Week	Begin Date	Decimal Day	Week	Begin Date	Decimal Day
48	June 13	164	71	21	325
49	20	171	72	28	332
50	27	178	73	Dec. 5	339
51	July 4	185	74	12	346
52	11	192	75	19	353
53	18	199	76	26	360
54	25	206	77	1969 Jan. 2	001
55	Aug. 1	213	78	9	008
56	8	220	79	16	015
57	15	227	80	23	022
58	22	234	81	30	029
59	29	241	82	Feb. 6	036
60	Sept. 5	248	83	13	043
61	12	255	84	20	050
62	19	262	85	27	057
63	26	269	86	Mar. 6	064
64	Oct. 3	276	87	13	071
65	10	283	88	20	078
66	17	290	89	27	085
67	24	297	90	Apr. 3	092
68	31	304	91	10	099
69	Nov. 7	311	92	17	106
70	14	318	93	24	113

TABLE 4

EXPLORER 34 CALENDAR

Orbit	Begin Date	Decimal Day	Orbit	Begin Date	Decimal Day
1	1967 May 24	143	24	1967 Sept. 1	243
2	28	147	25	5	247
3	June 2	152	26	9	251
4	6	156	27	14	256
5	10	160	28	18	260
6	15	165	29	22	264
7	19	169	30	26	268
8	23	173	31	Oct. 1	273
9	28	178	32	5	277
10	July 2	182	33	10	282
11	6	186	34	14	286
12	11	191	35	18	290
13	15	195	36	23	295
14	19	199	37	27	299
15	24	204	38	31	303
16	28	208	39	Nov. 5	308
17	Aug. 1	212	40	9	312
18	6	217	41	13	316
19	10	221	42	18	321
20	14	225	43	22	325
21	19	230	44	26	329
22	23	234	45	Dec. 1	334
23	27	238	46	5	338

Orbit	Begin Date	Decimal Day	Orbit	Begin Date	Decimal Day
47	1967 Dec. 9	342	70	18	77
48	13	346	71	22	81
49	18	351	72	26	85
50	22	355	73	31	90
51	26	359	74	Apr. 4	94
52	31	364	75	8	98
53	1968 Jan. 4	3	76	13	103
54	8	7	77	17	107
55	13	12	78	21	111
56	17	16	79	26	116
57	21	20	80	30	120
58	26	25	81	May 4	124
59	30	29	82	9	129
60	Feb. 3	33	83	13	133
61	8	38	84	17	137
62	12	42	85	22	142
63	16	46	86	26	146
64	21	51	87	30	150
65	25	55	88	June 4	155
66	29	59	89	8	159
67	Mar. 5	64	90	12	163
68	9	68	91	17	168
69	13	72	92	21	172

Orbit	Begin Date	Decimal Day	Orbit	Begin Date	Decimal Day
93	25	176	116	Oct. 3	276
94	30	181	117	7	280
95	July 4	185	118	11	284
96	8	189	119	16	289
97	13	194	120	20	293
98	17	198	121	24	297
99	21	202	122	29	302
100	26	207	123	Nov. 2	306
101	30	211	124	6	310
102	Aug. 3	215	125	11	315
103	8	220	126	15	319
104	12	224	127	19	323
105	16	228	128	24	328
106	20	232	129	28	332
107	25	237	130	Dec. 2	336
108	29	241	131	7	341
109	Sept. 2	245	132	11	345
110	7	250	133	15	349
111	11	254	134	20	354
112	15	258	135	24	358
113	20	263	136	28	362
114	24	267	137	1969 Jan. 2	1
115	28	271	138	6	5

Orbit	Begin Date	Decimal Day	Orbit	Begin Date	Decimal Day
139	10	9	152	8	66
140	15	14	153	12	70
141	19	18	154	16	74
142	23	22	155	21	79
143	28	27	156	25	83
144	Feb. 1	31	157	29	87
145	5	35	158	Apr. 3	92
146	10	40	159	7	96
147	14	44	160	11	100
148	18	48	161	16	105
149	23	53	162	20	109
150	27	57	163	24	113
151	Mar. 3	61	164	29	118

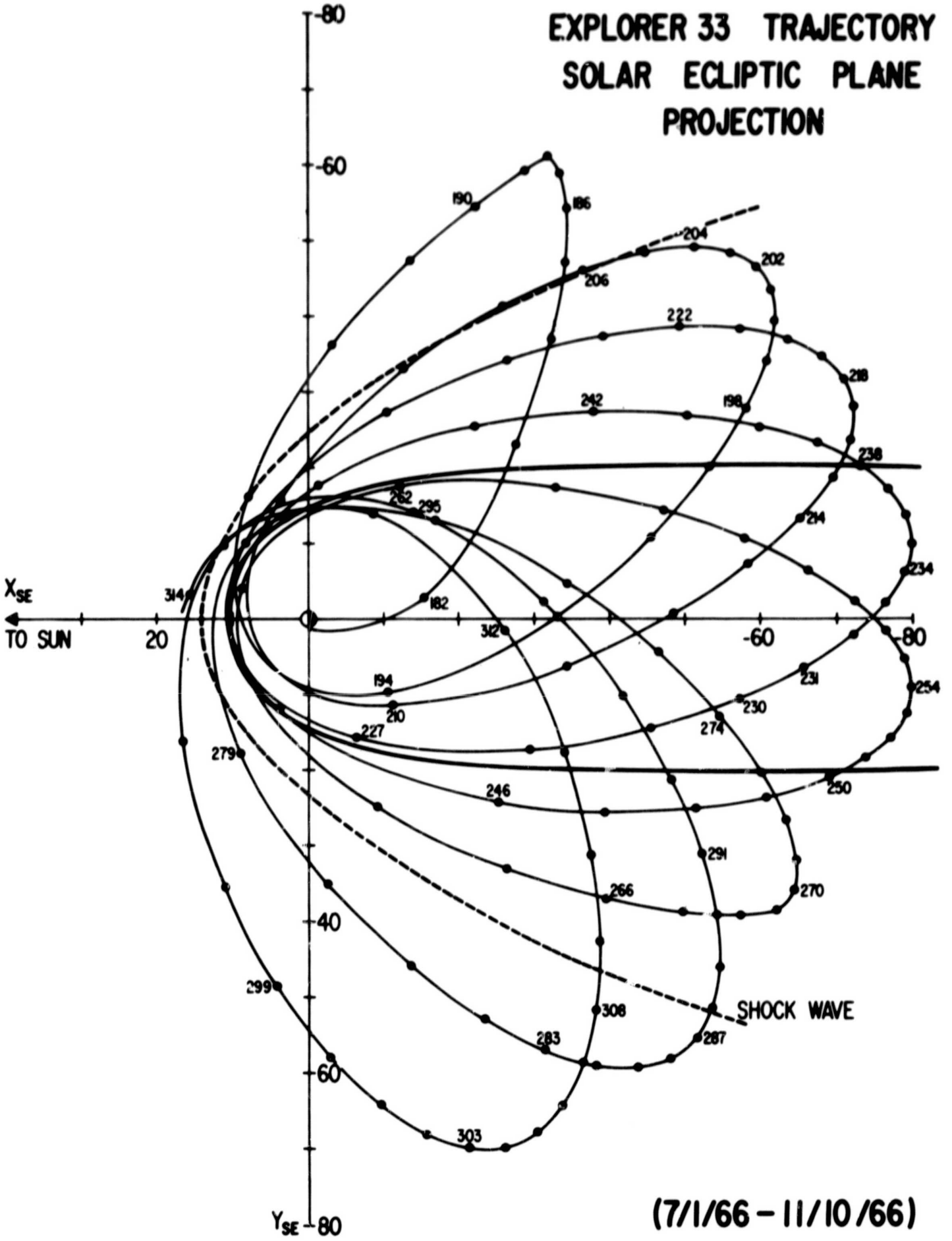

EXPLORER 33 TRAJECTORY
SOLAR ECLIPTIC PLANE
PROJECTION
-80
-60
40
60
80
20
TO SUN
X_{SE}
Y_{SE}
SHOCK WAVE
(7/1/66 - 11/10/66)
190
186
204
202
206
222
218
242
198
238
252
235
214
234
314
182
312
194
231
254
210
230
227
274
279
246
250
291
266
270
299
308
283
287
303

FIGURE 1

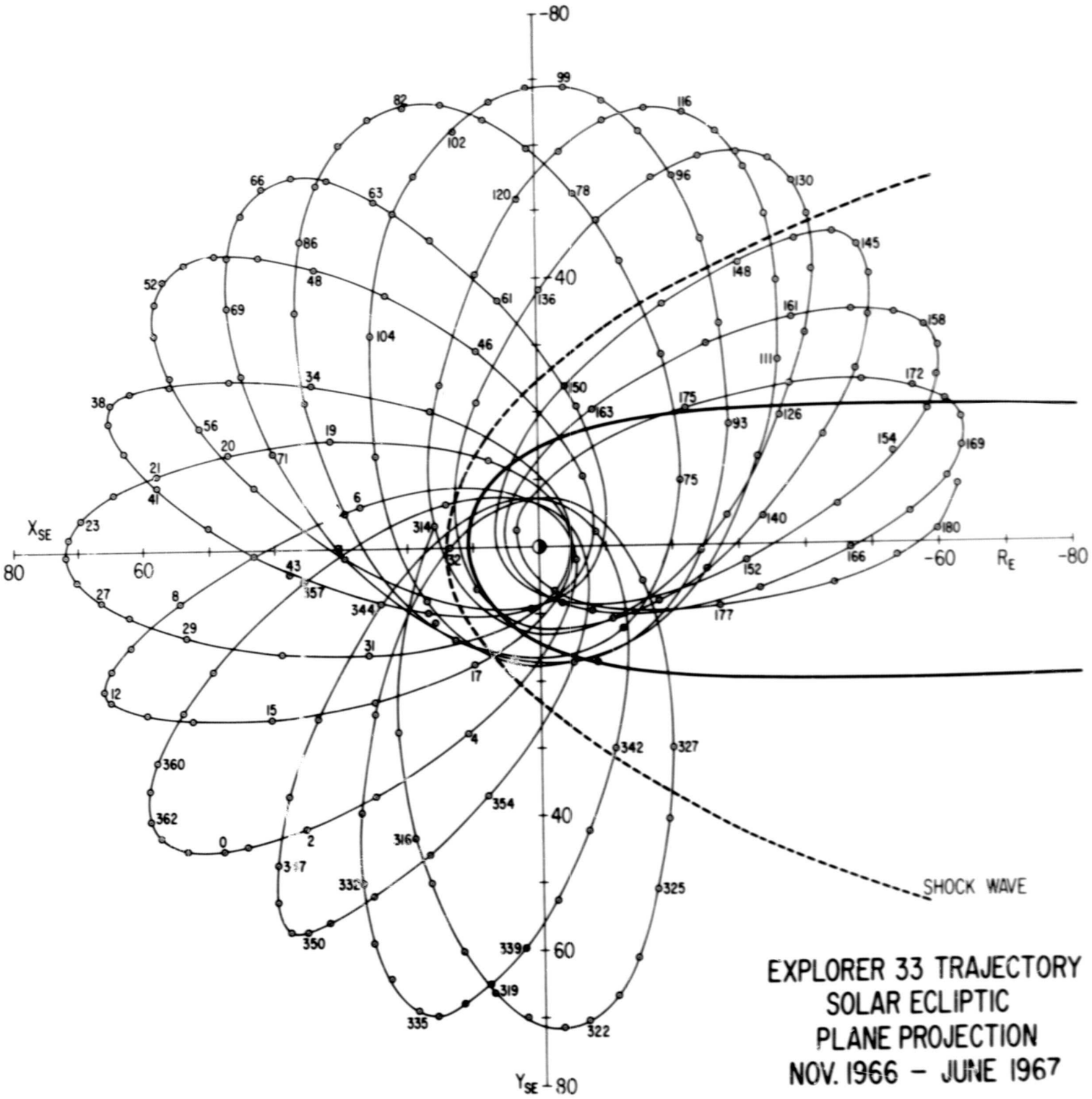
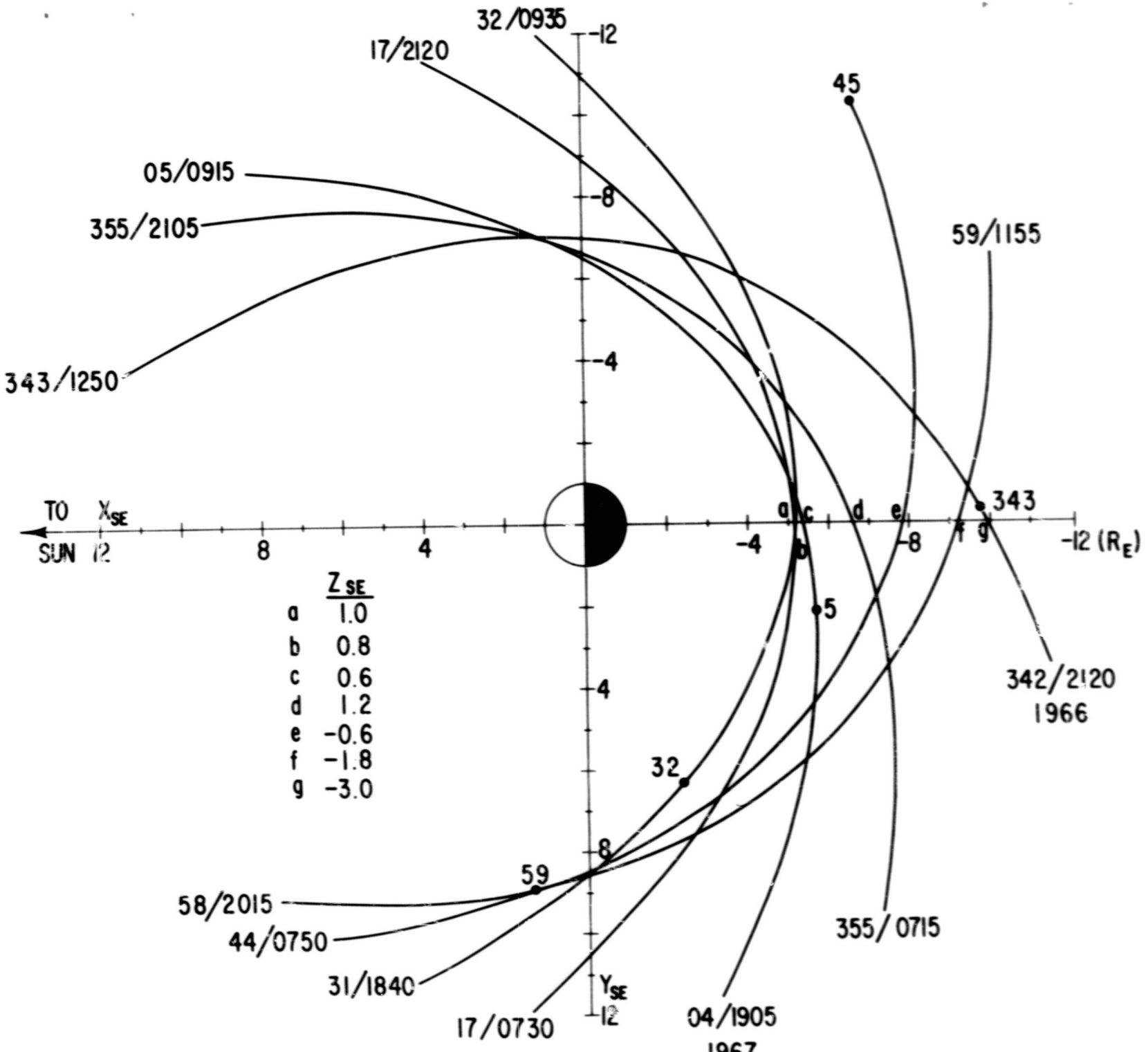

-80
-40
40
60
80
X_{SE}
Y_{SE}
R_E
SHOCK WAVE
EXPLORER 33 TRAJECTORY
SOLAR ECLIPTIC
PLANE PROJECTION
NOV. 1966 - JUNE 1967

FIGURE 2


32/0935
17/2120
45
05/0915
355/2105
59/1155
343/1250
-12
-8
-4
TO SUN
X_{SE}
12
8
4
-4
-8
-12 (R_E)
a
b
c
d
e
f
g
343
5
342/2120
1966
32
59
58/2015
44/0750
31/1840
17/0730
355/0715
04/1905
1967
Y_{SE}
12
Z_{SE}
a 1.0
b 0.8
c 0.6
d 1.2
e -0.6
f -1.8
g -3.0

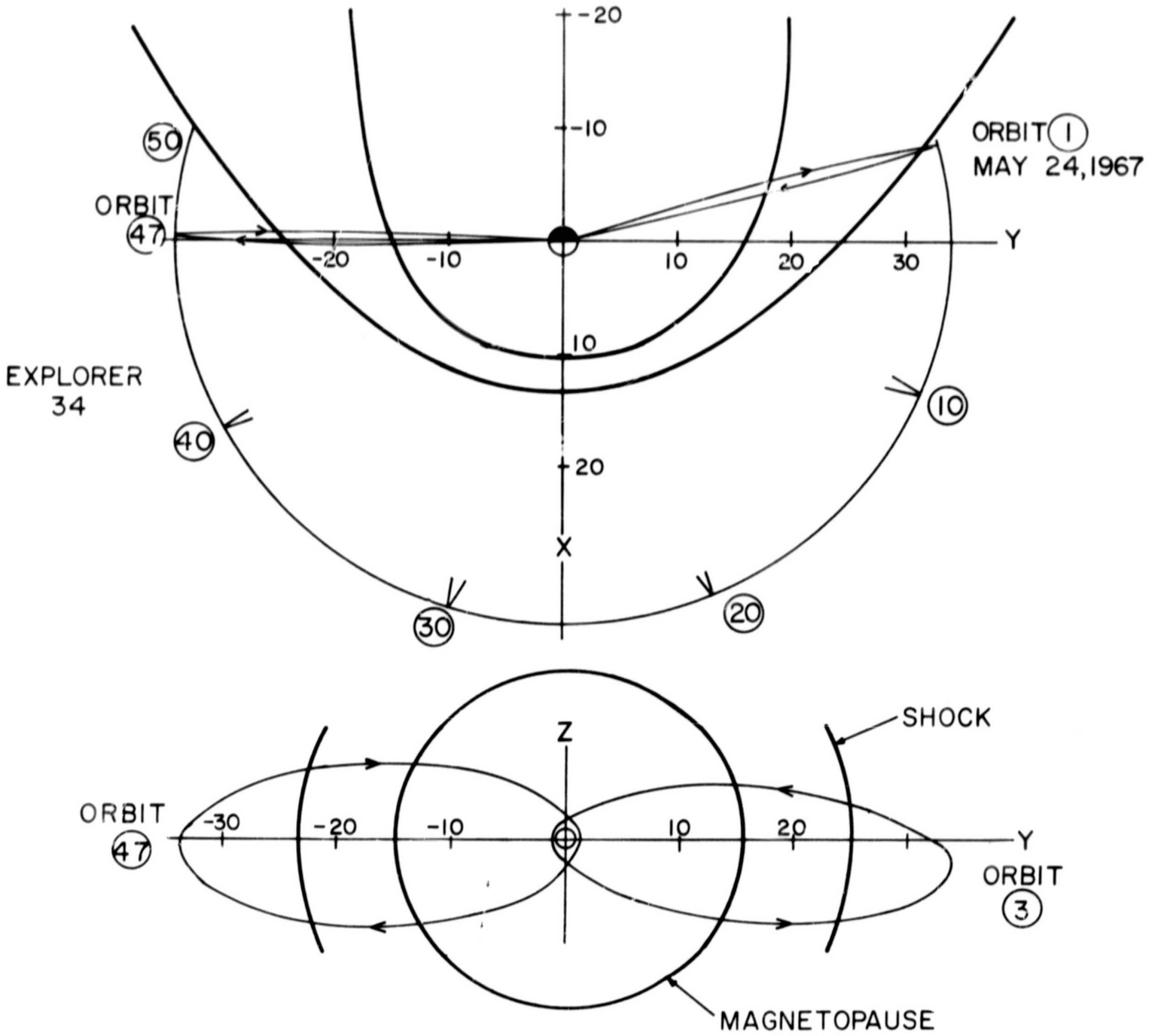
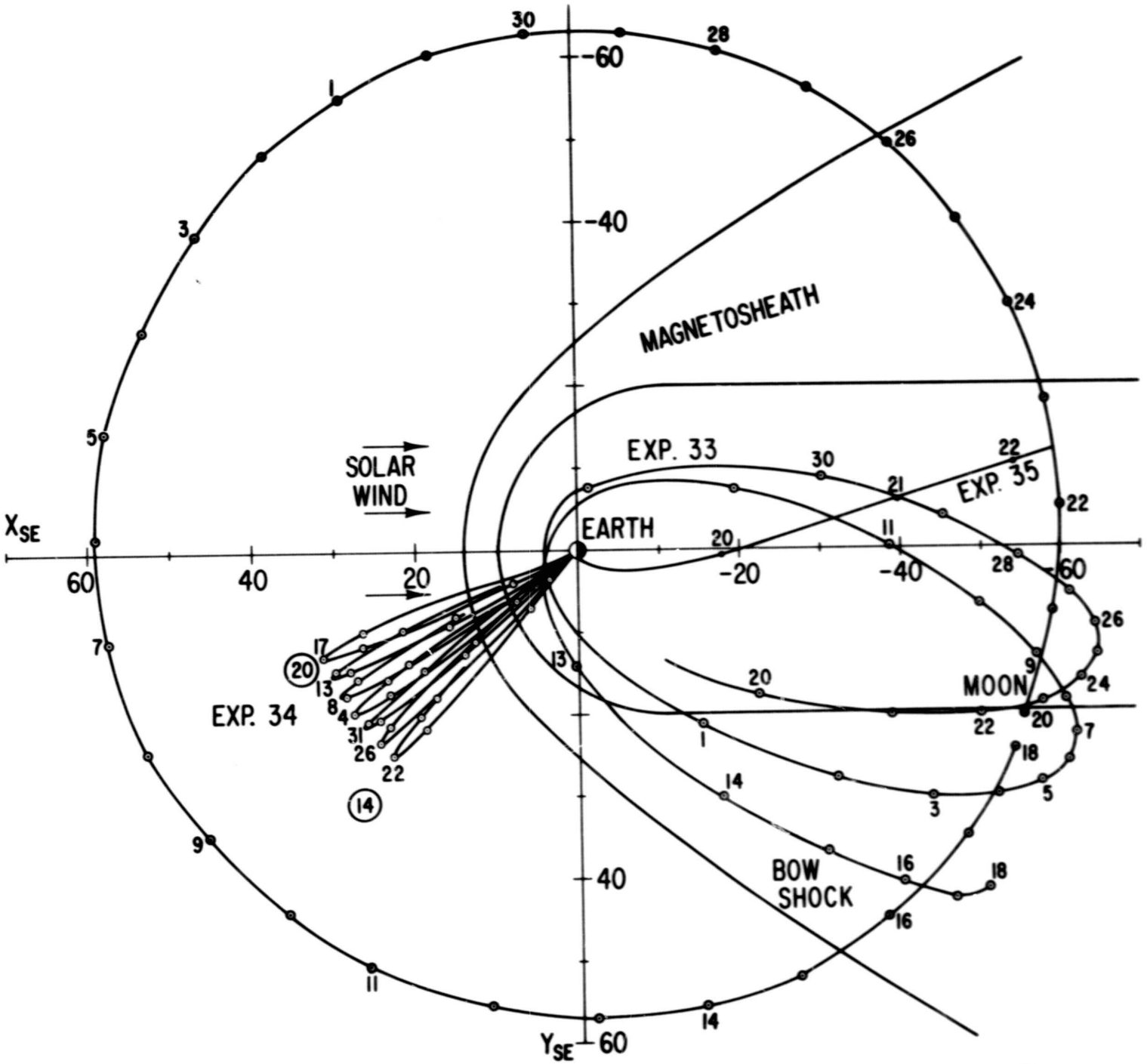
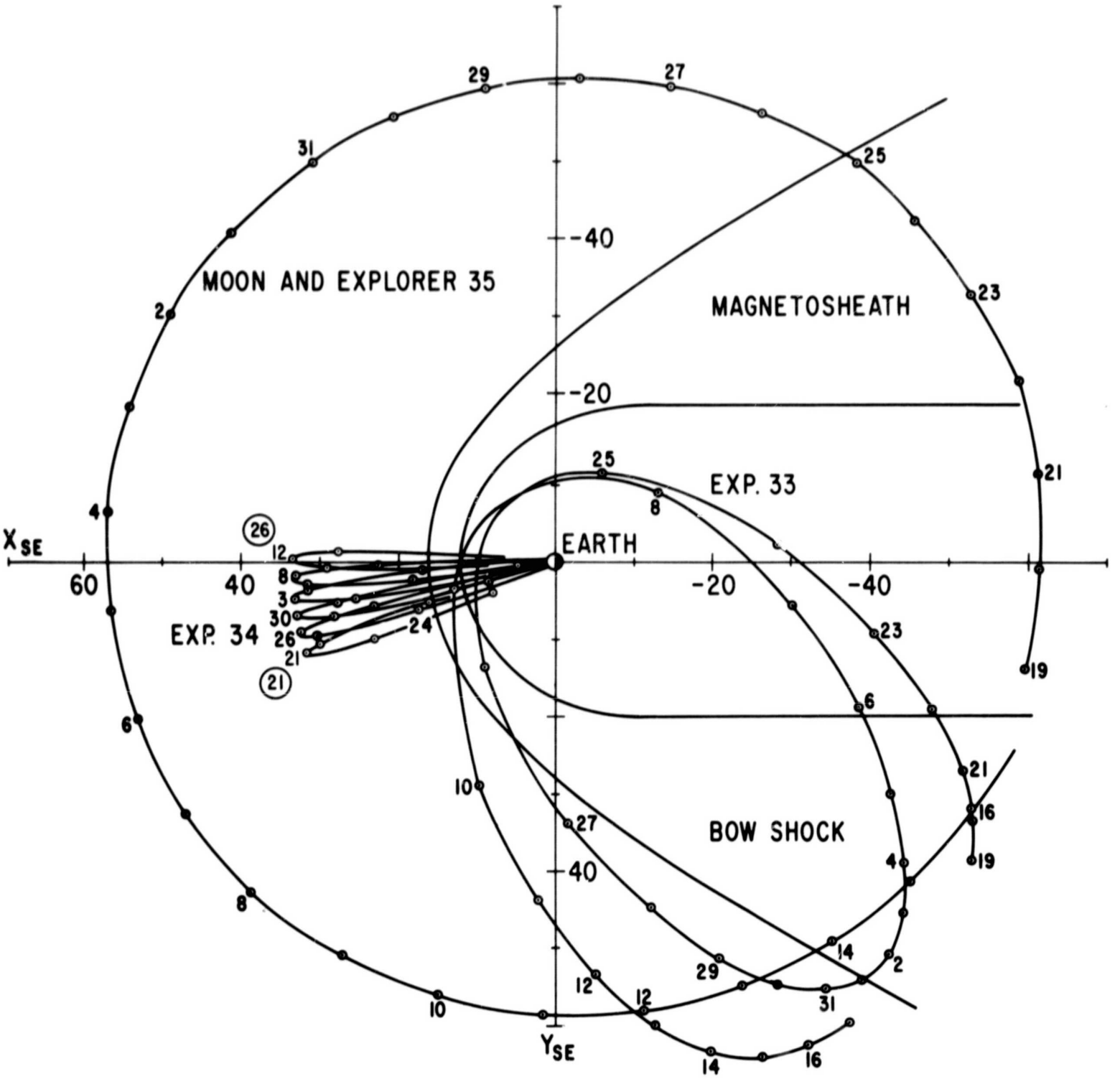

-20
-10
ORBIT 1
MAY 24, 1967
50
ORBIT
47
-20
-10
10
20
30
Y
10
EXPLORER
34
40
10
20
X
30
20
SHOCK
Z
ORBIT
47
-30
-20
-10
10
20
Y
ORBIT
3
MAGNETOPAUSE

FIGURE 4

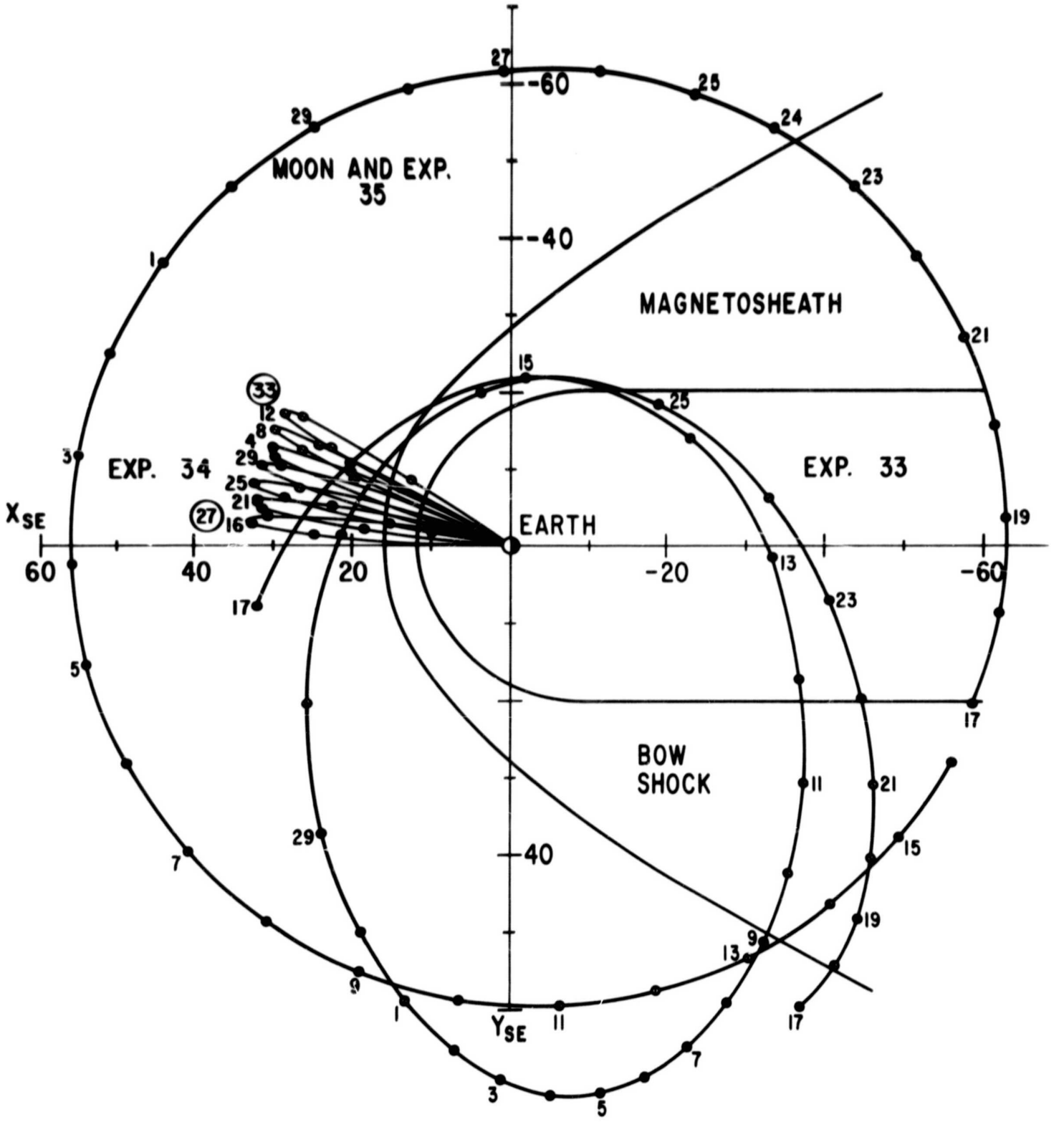


MOON AND EXPLORERS 33, 34, 35 - JULY - AUGUST 1967



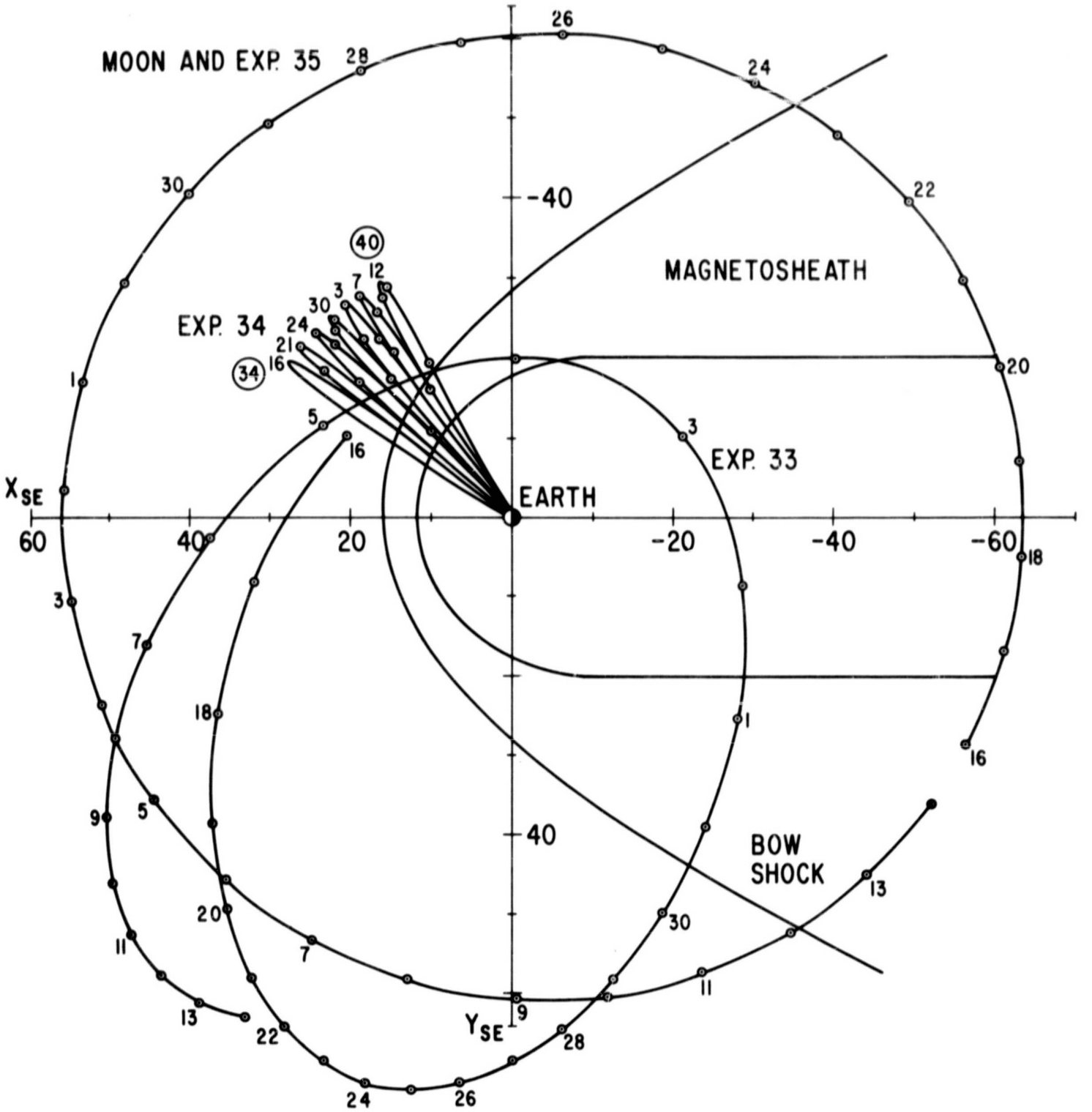
AUGUST-SEPTEMBER 1967

FIGURE 6



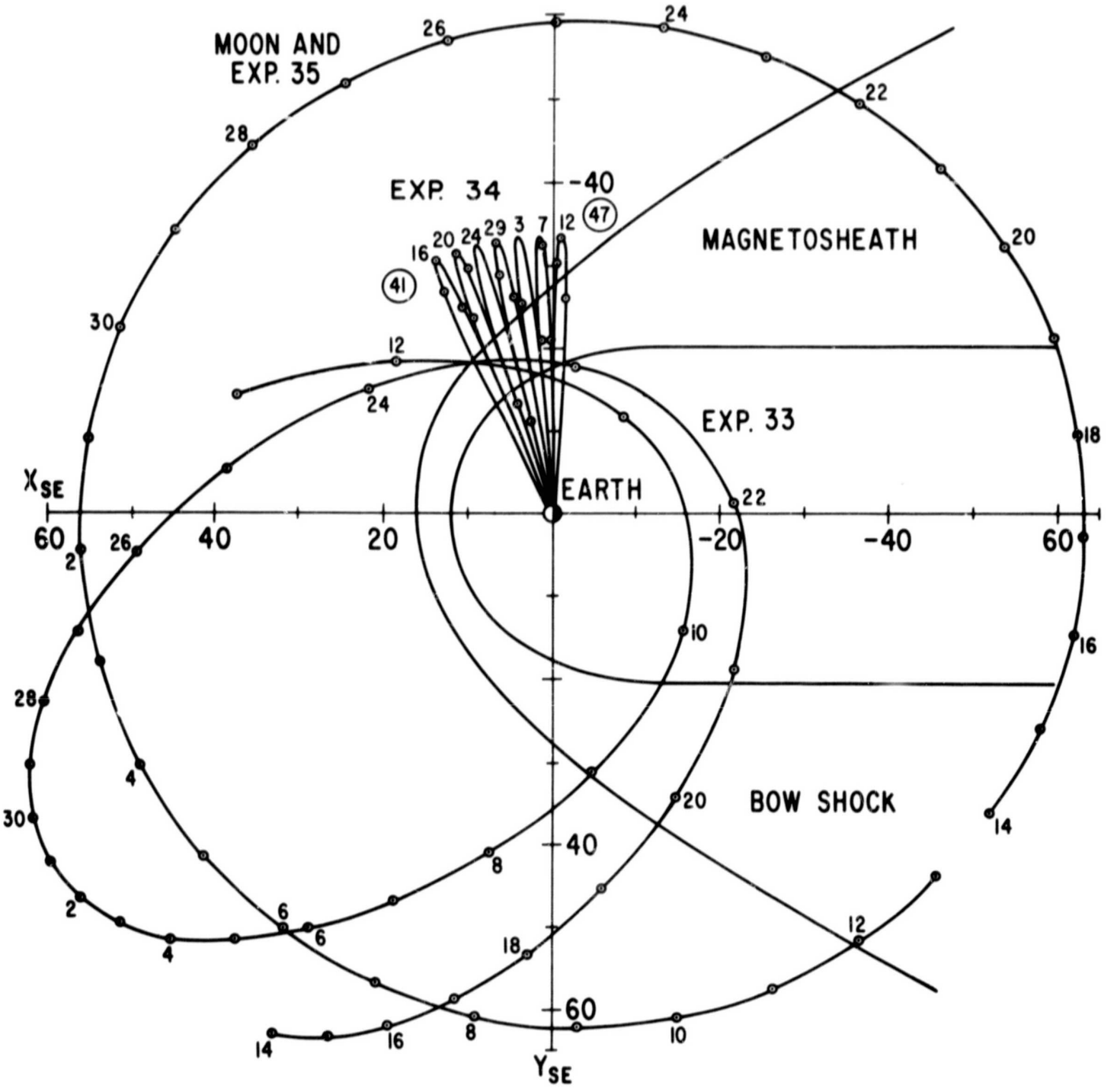
SEPTEMBER-OCTOBER 1967

FIGURE 7



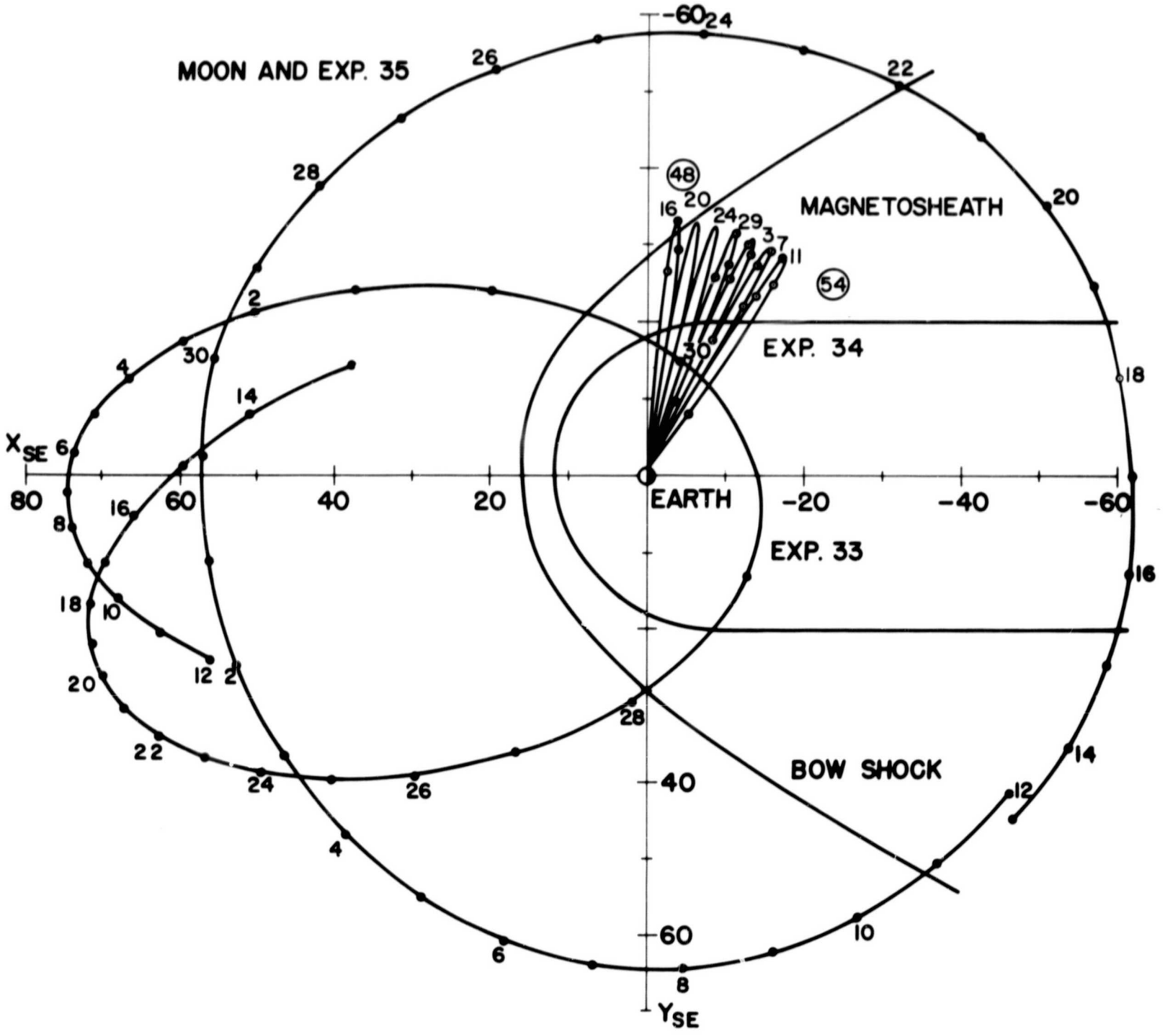
OCTOBER-NOVEMBER 1967

FIGURE 8



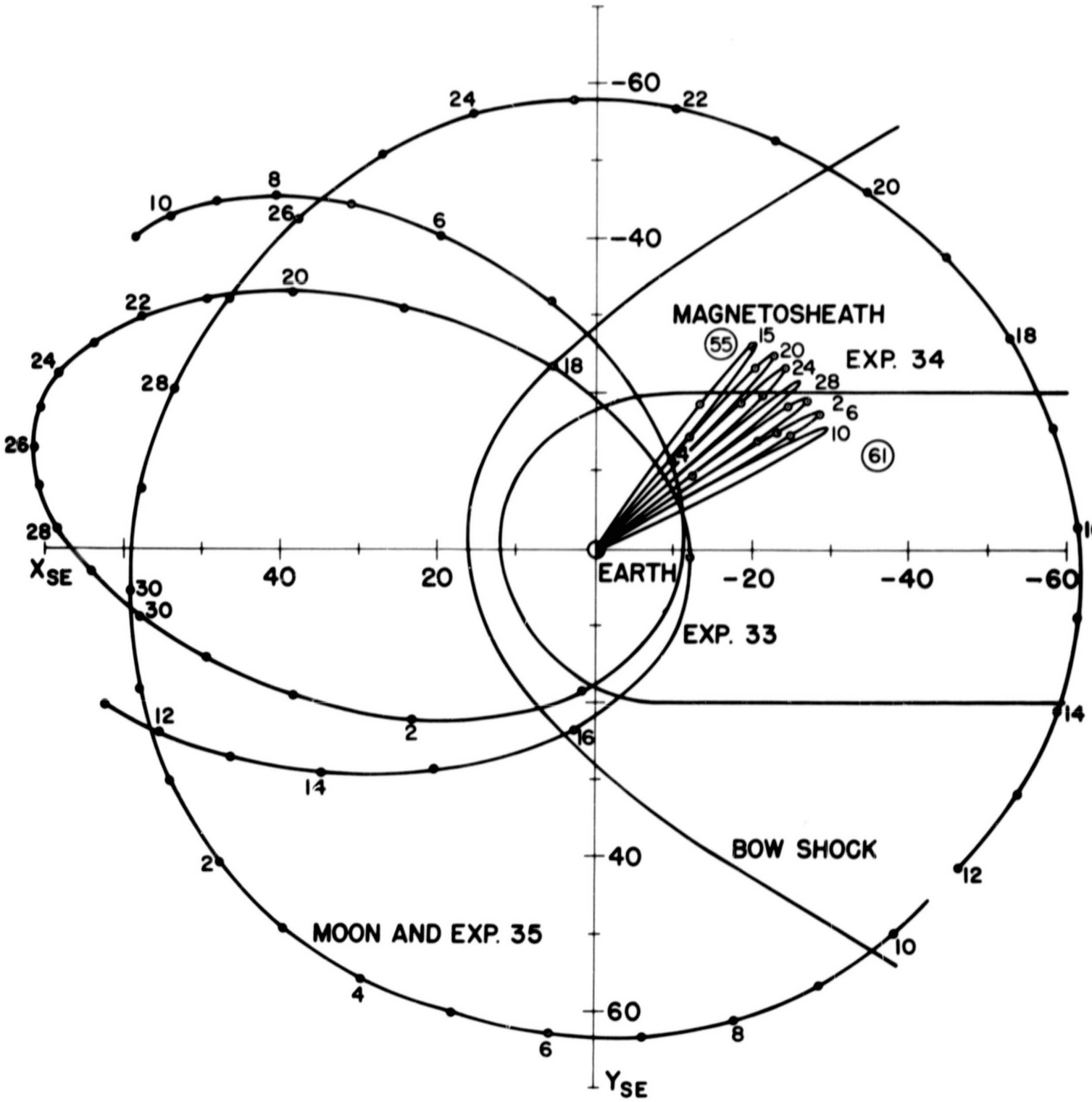
NOVEMBER-DECEMBER 1967

FIGURE 9



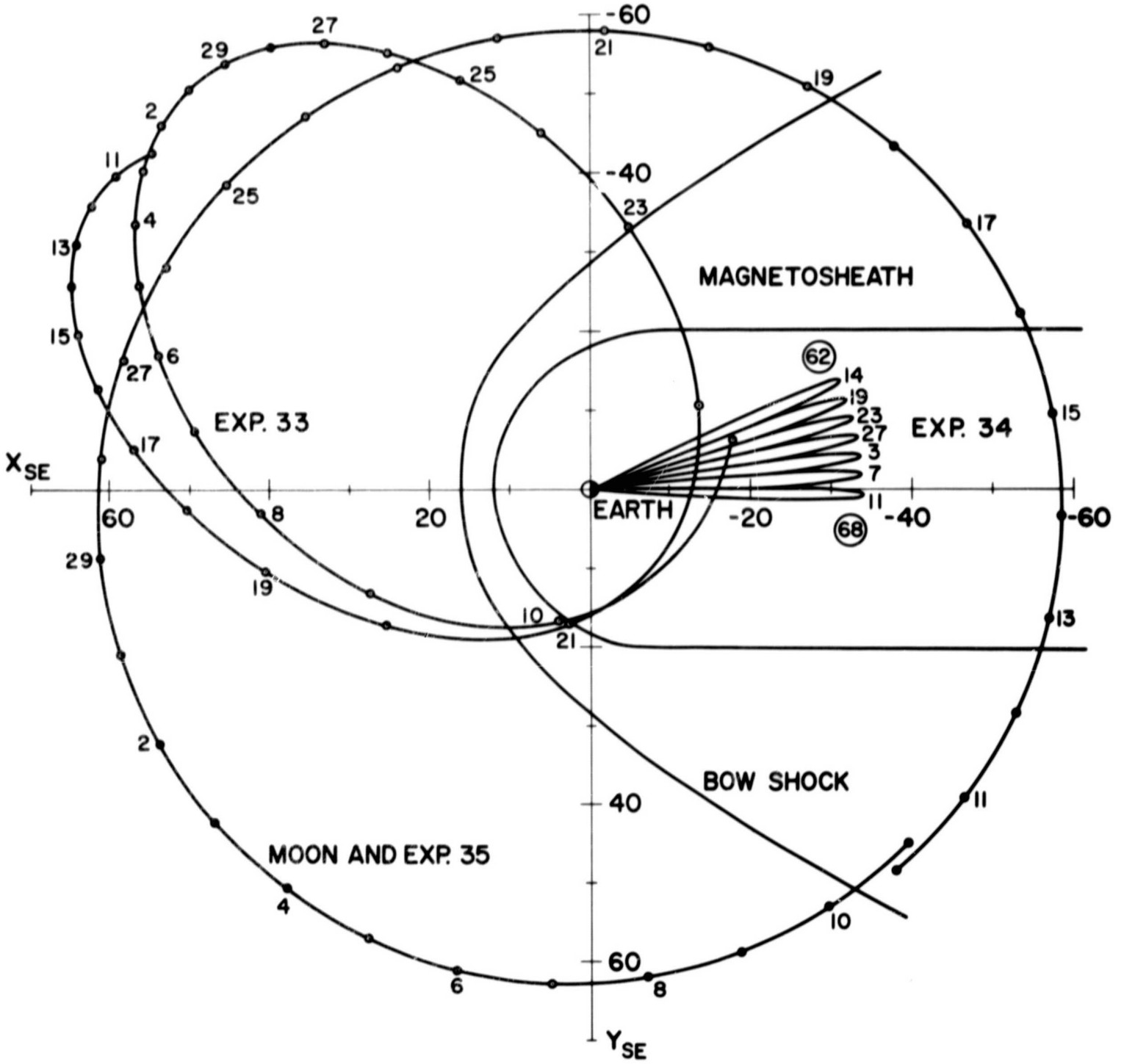
DECEMBER 1967–JANUARY 1968

FIGURE 10



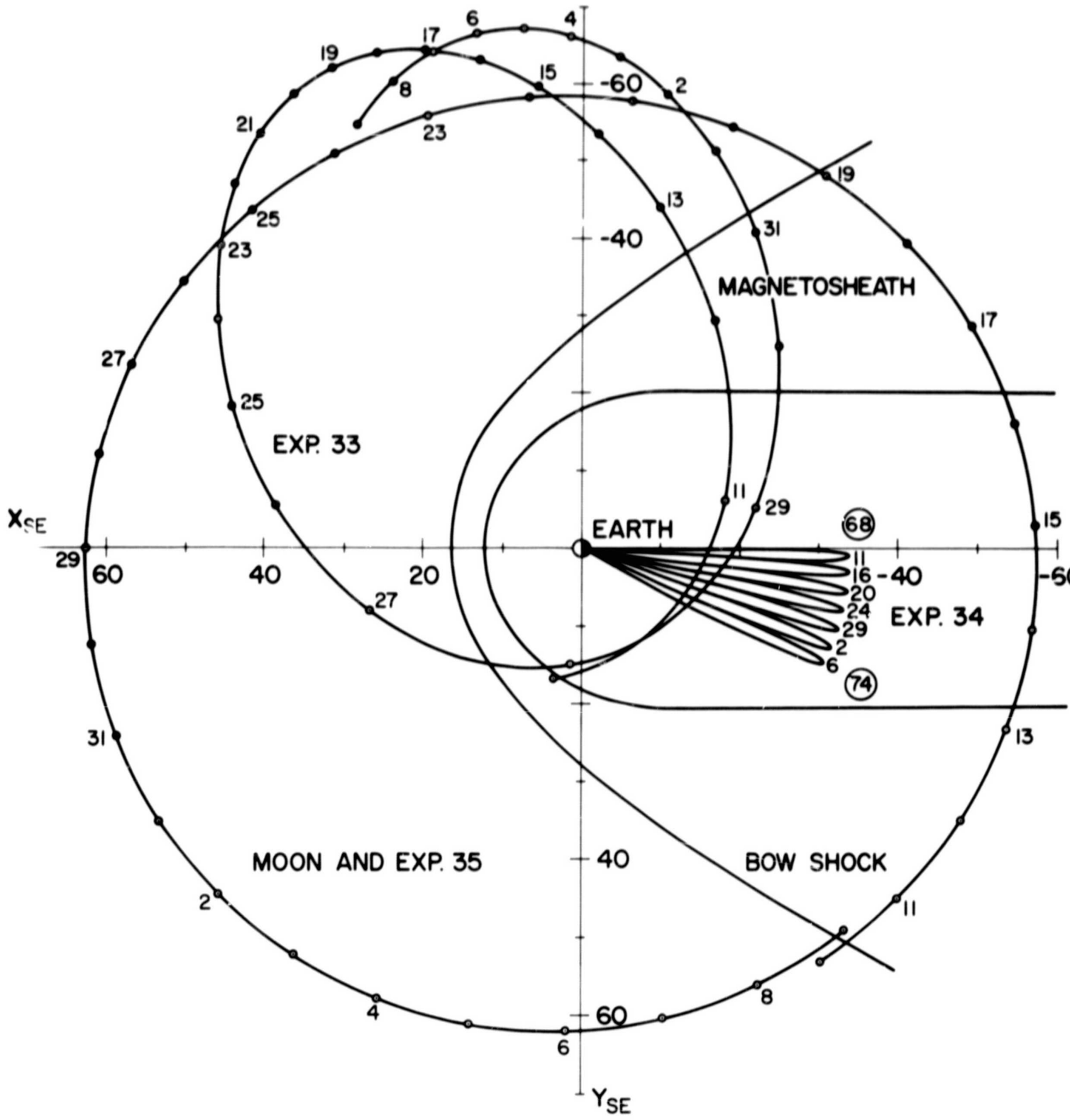
JANUARY-FEBRUARY 1968

FIGURE 11



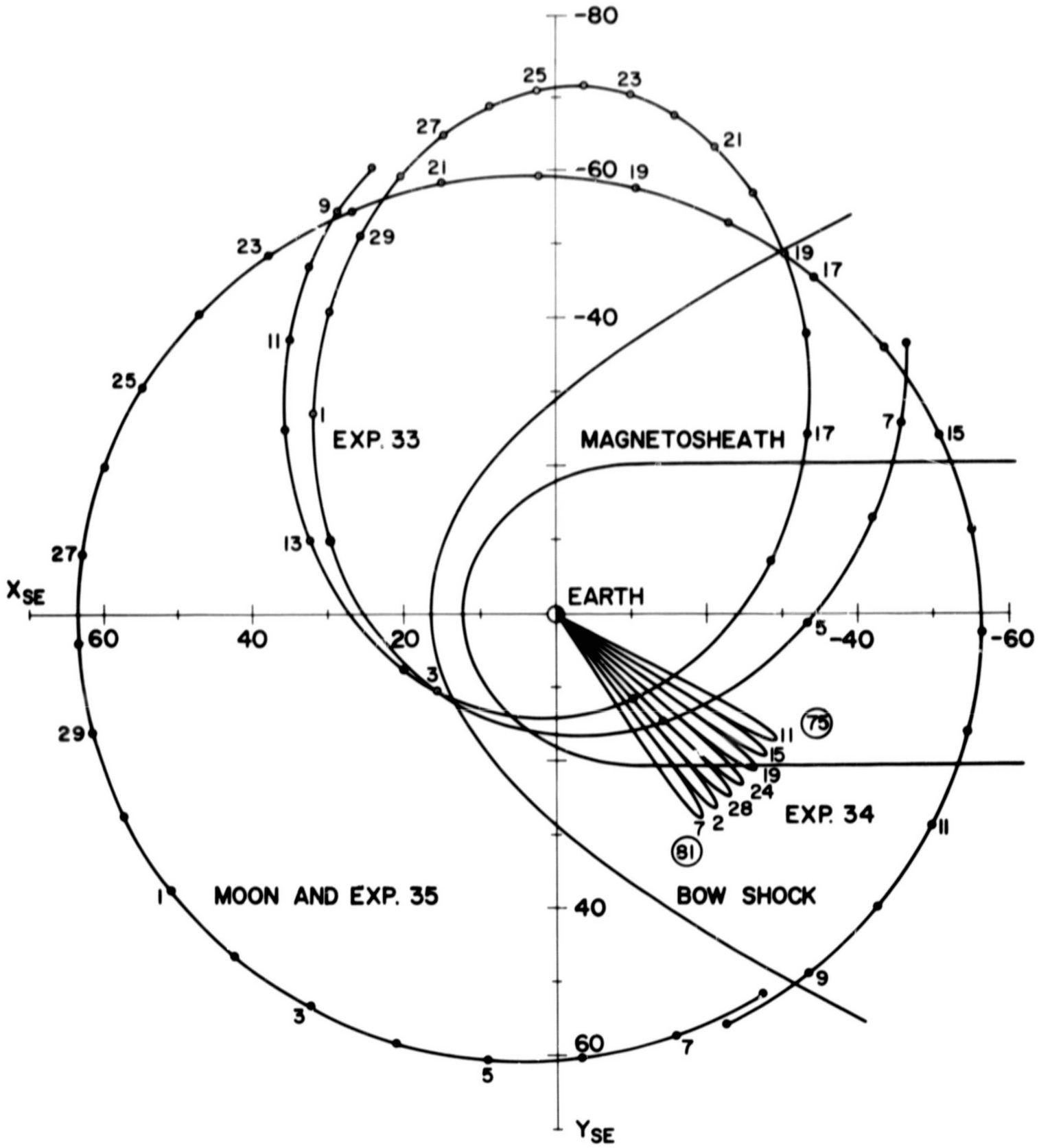
FEBRUARY-MARCH 1968

FIGURE 12



MARCH - APRIL 1968

FIGURE 13



APRIL-MAY 1968

FIGURE 14

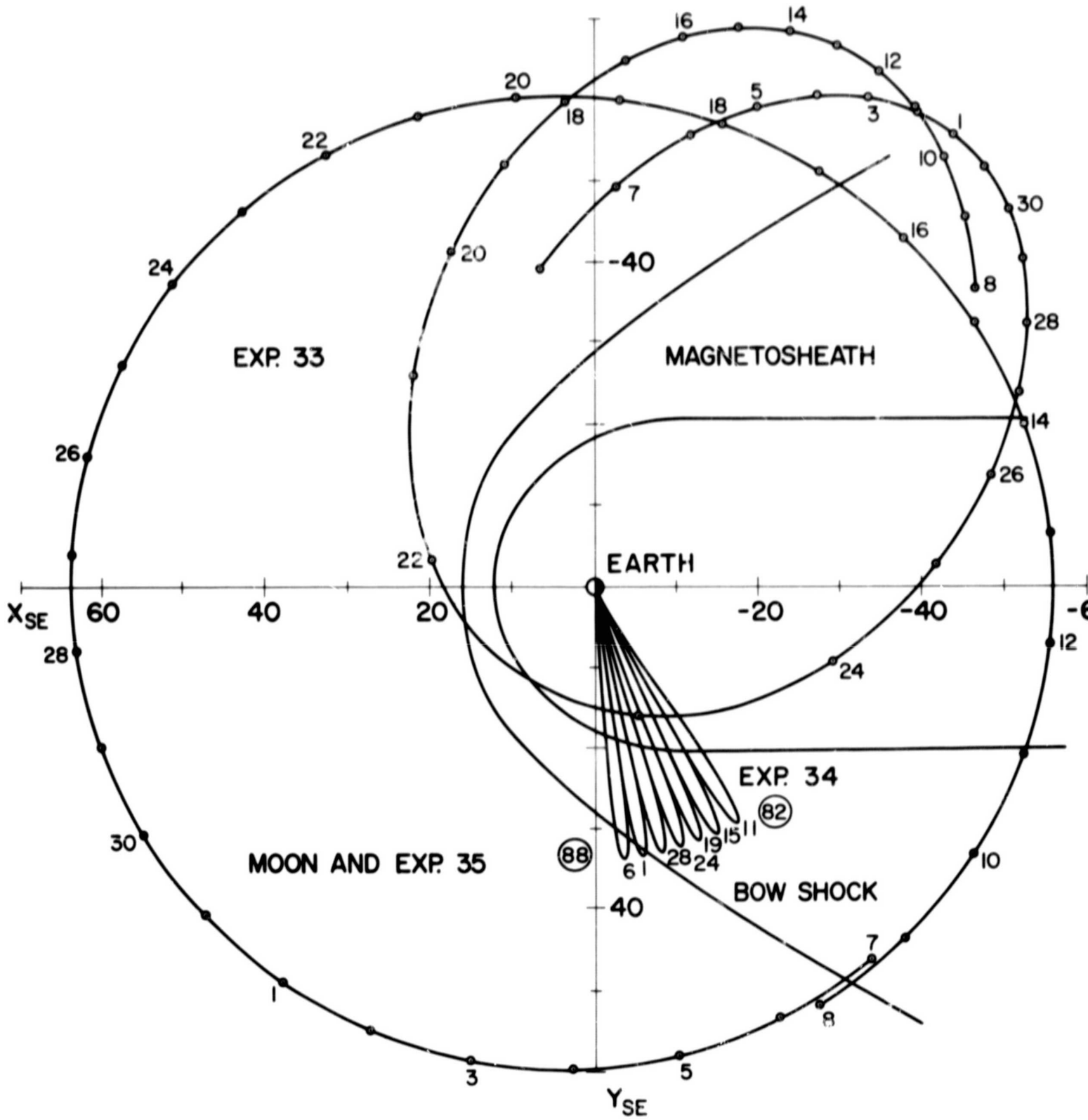

EXP. 33
MAGNETOSHEATH
EARTH
EXP. 34
MOON AND EXP. 35
BOW SHOCK
X_{SE}
Y_{SE}
MAY-JUNE 1968

FIGURE 15

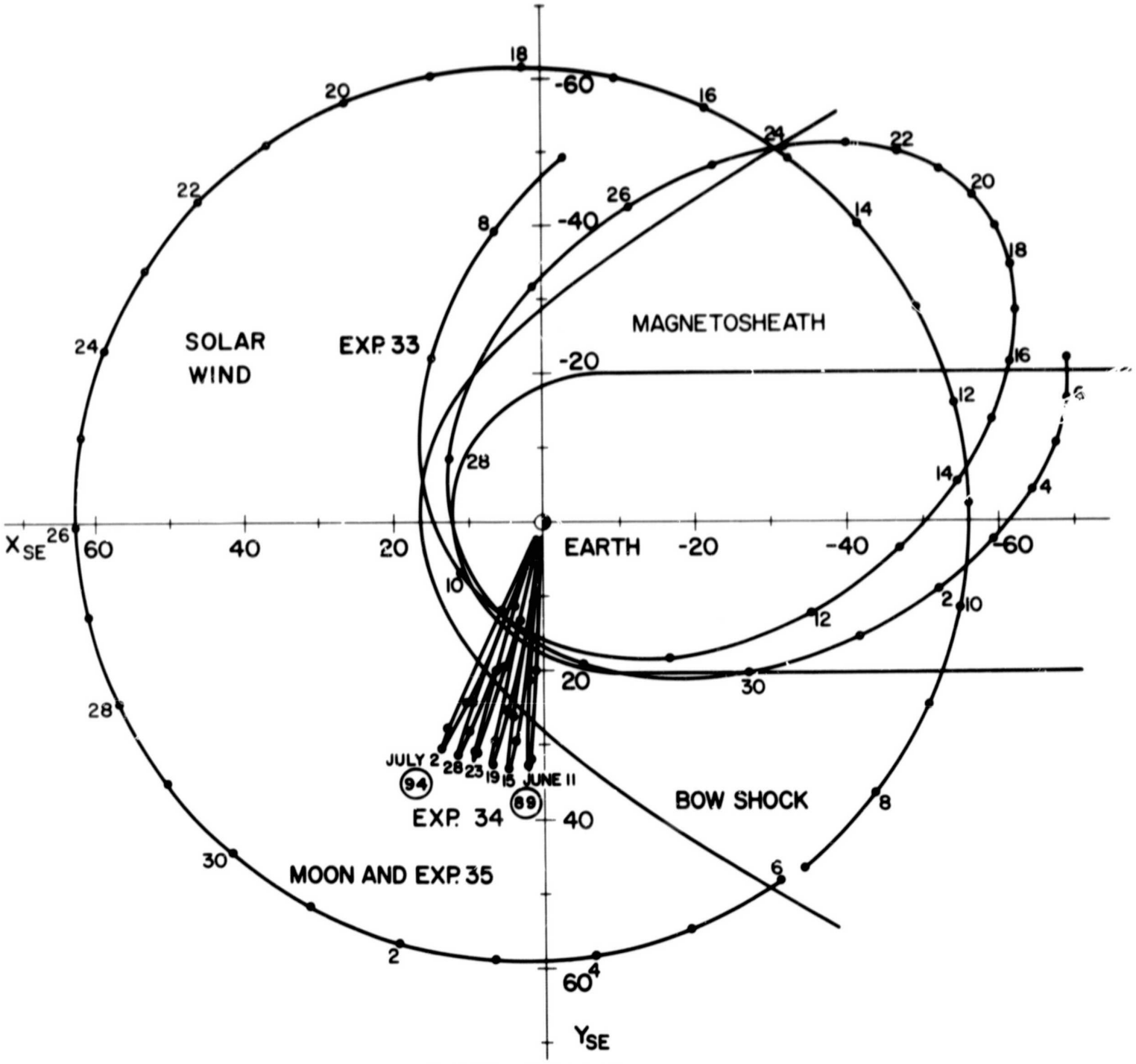
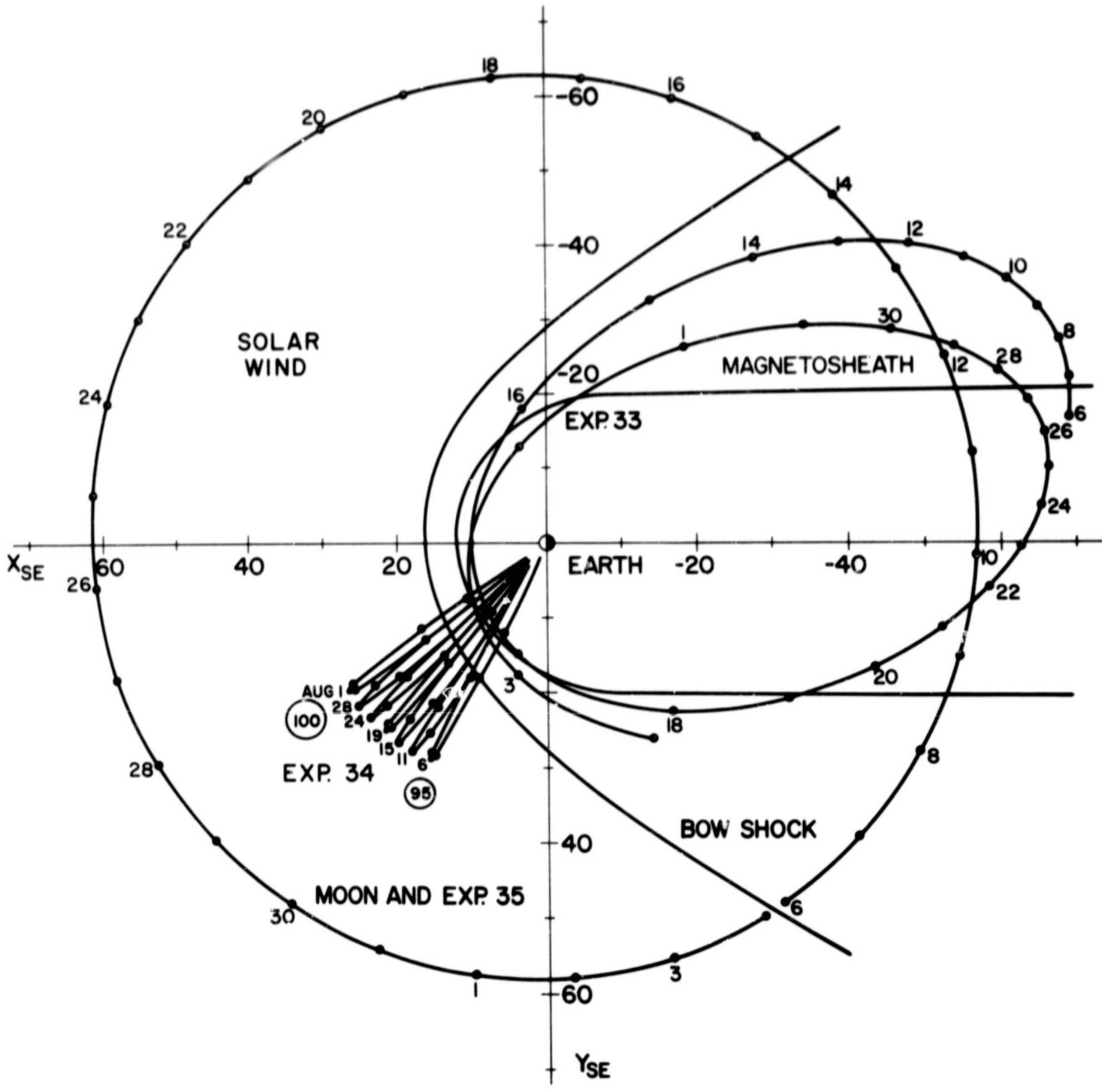
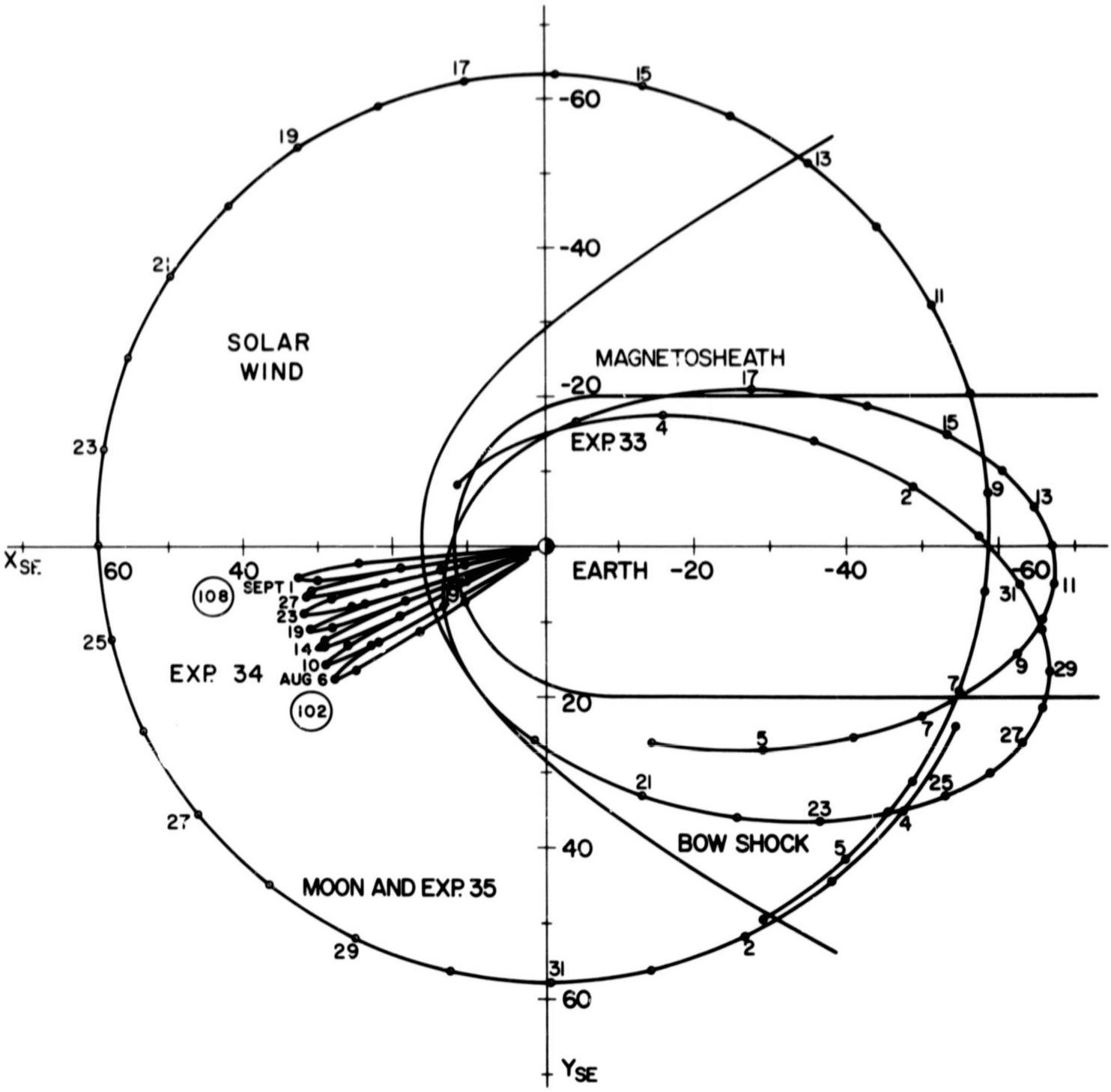

SOLAR WIND
EXP. 33
MAGNETOSHEATH
EARTH
BOW SHOCK
EXP. 34
MOON AND EXP. 35
JULY 2
28
23
19
15
JUNE 11
94
89
X_{SE}
Y_{SE}
JUNE-JULY 1968

FIGURE 16



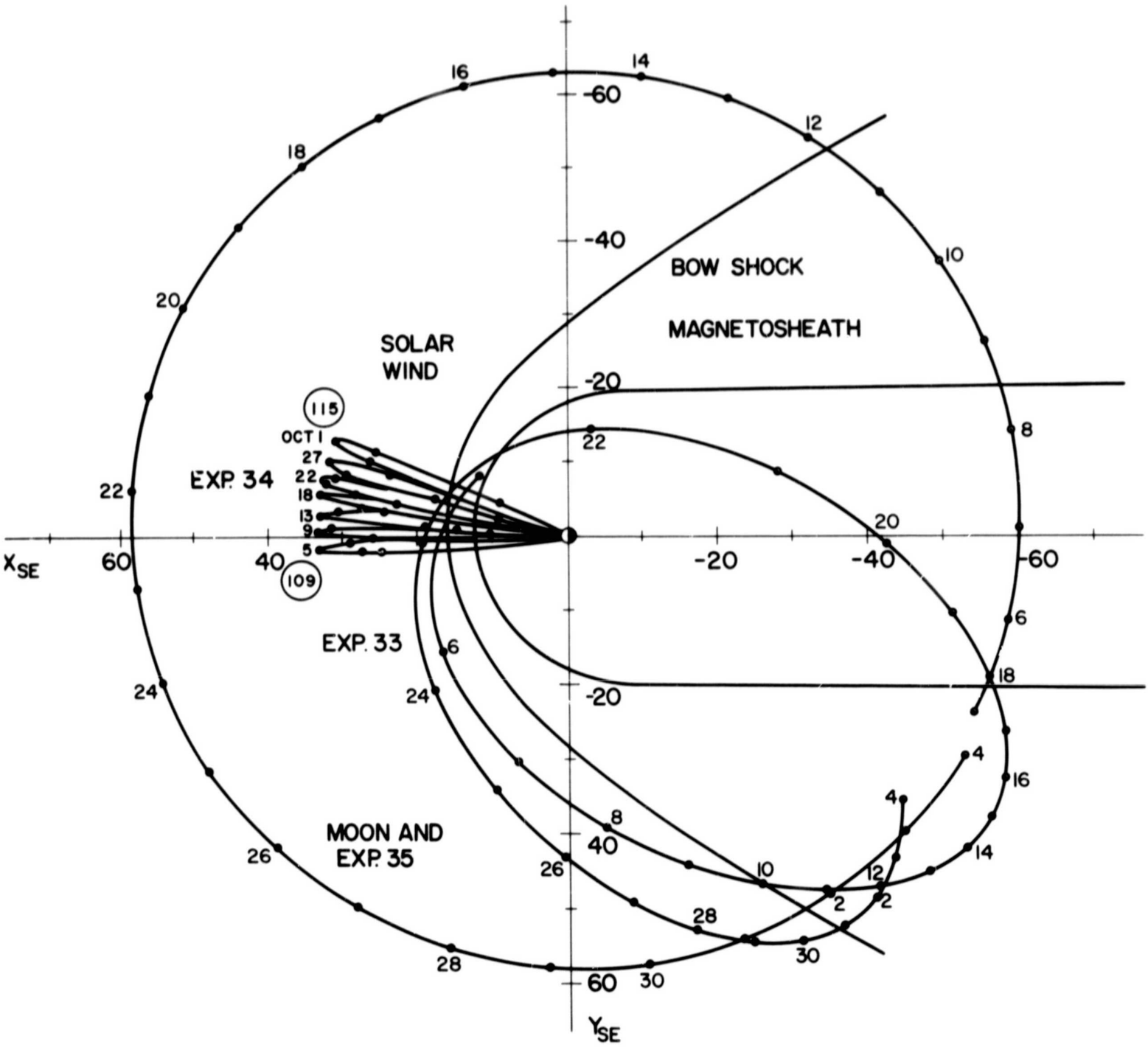
JULY-AUGUST 1968

FIGURE 17



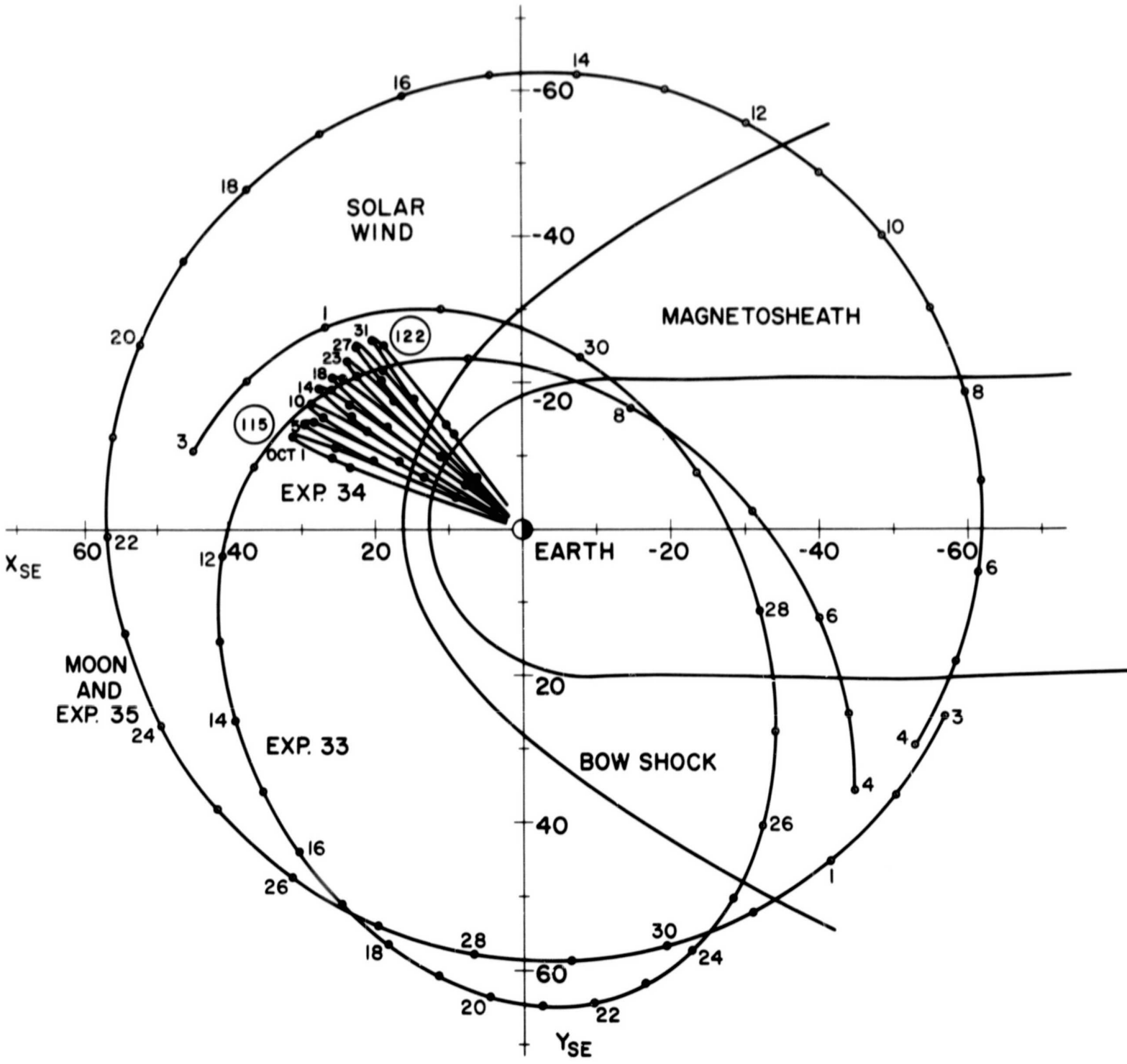
AUGUST-SEPTEMBER 1968

FIGURE 18



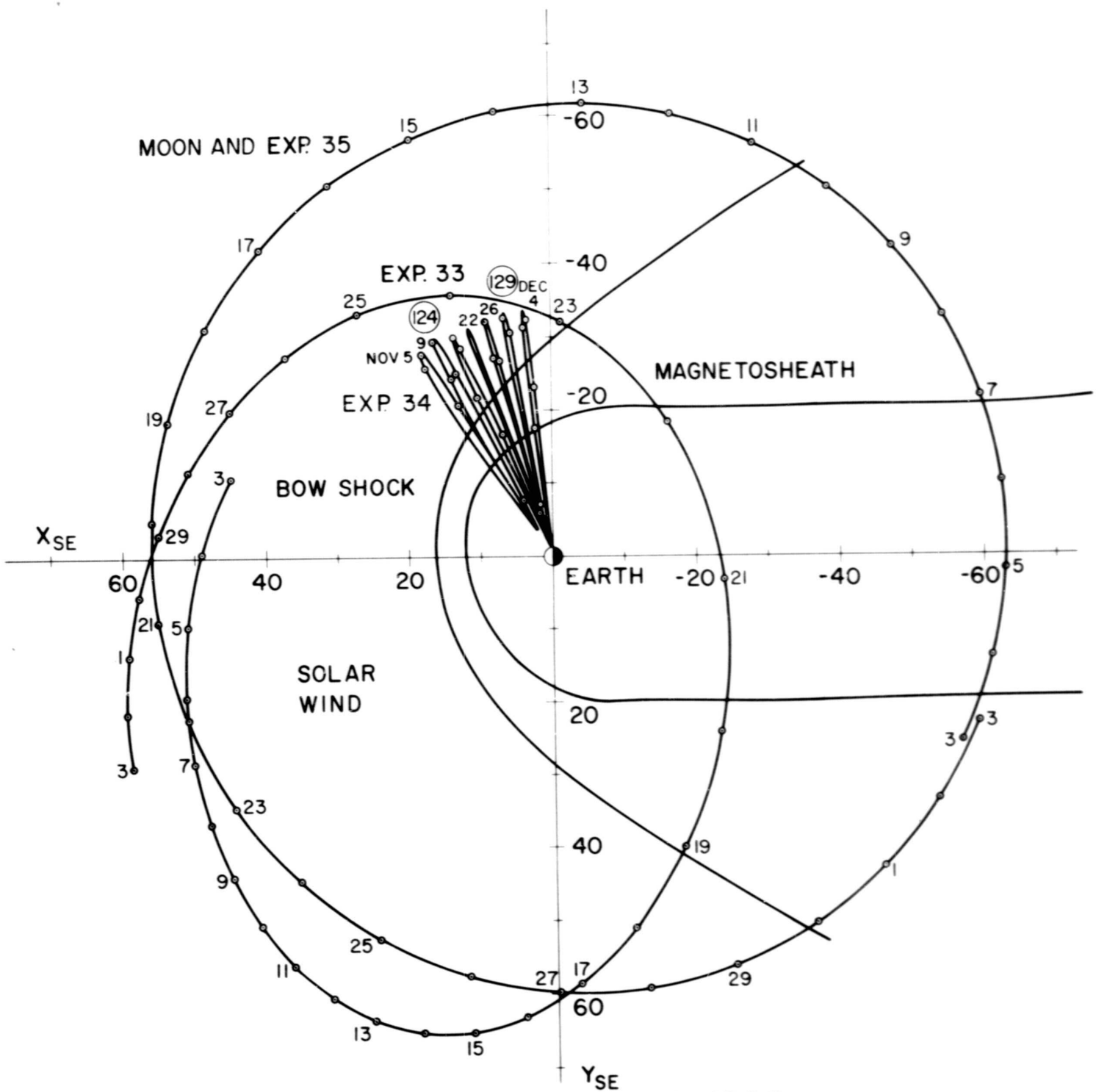
SEPTEMBER-OCTOBER 1968

FIGURE 19



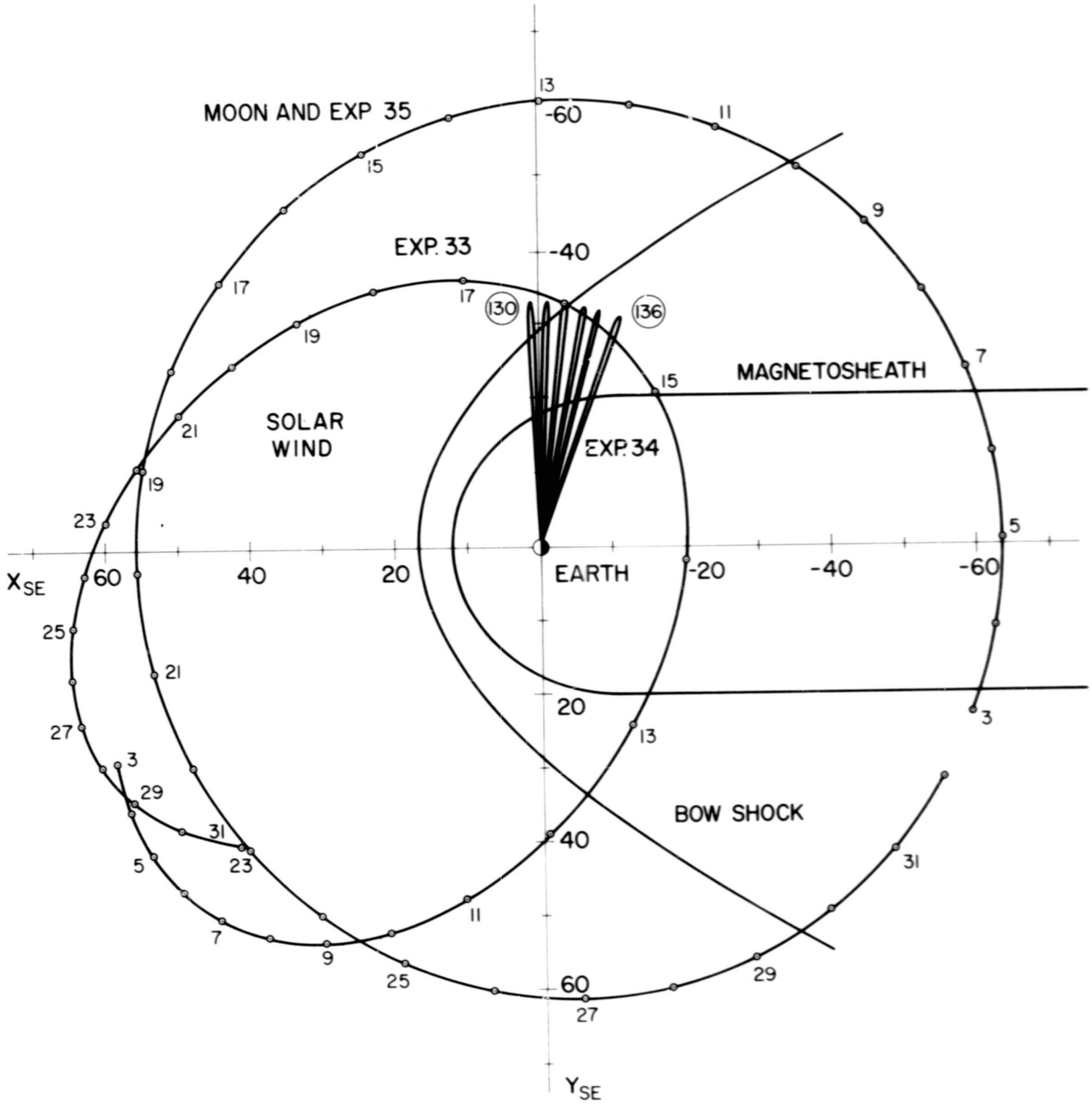
OCTOBER-NOVEMBER 1968

FIGURE 20



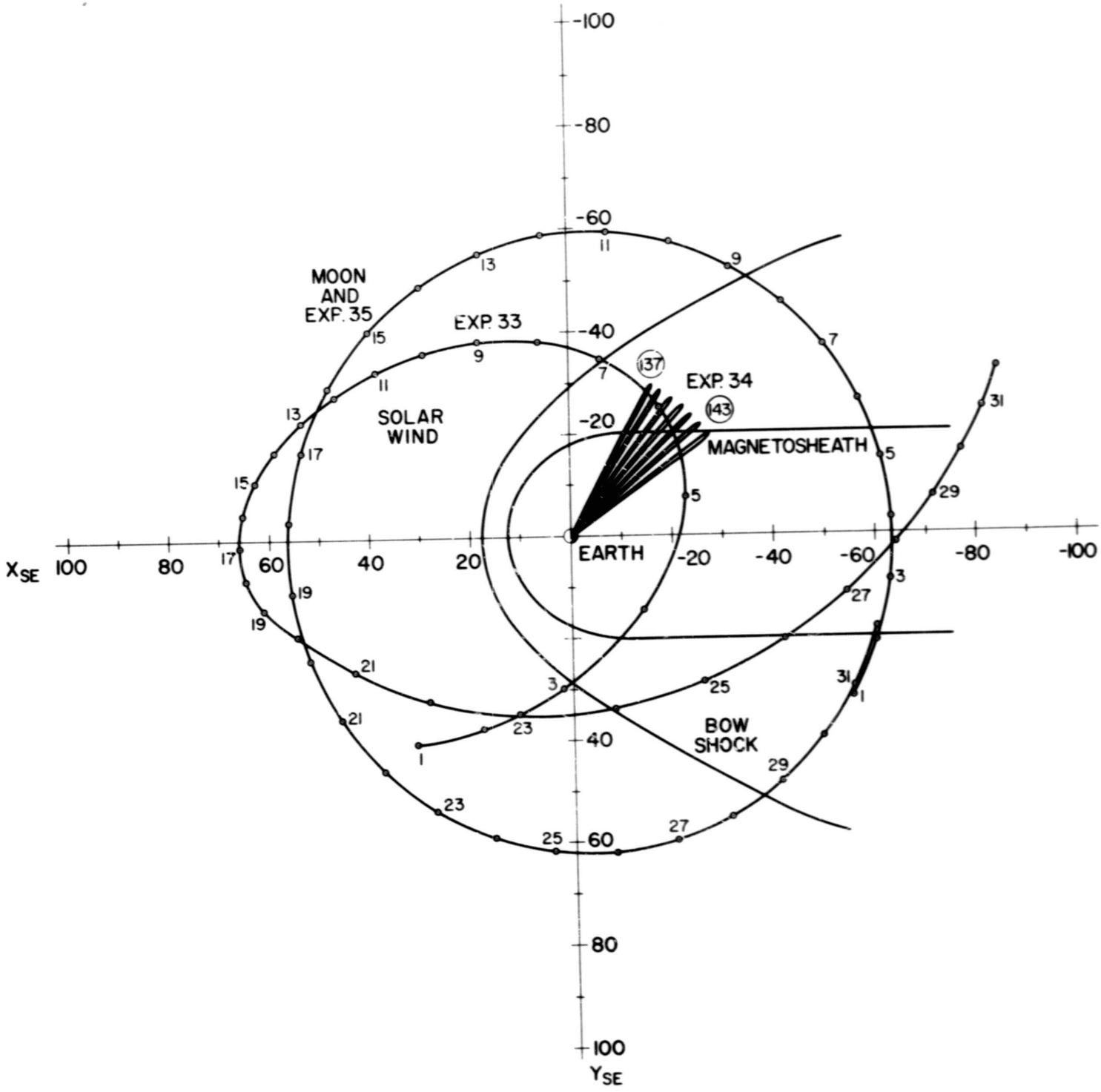
NOVEMBER-DECEMBER 1968

FIGURE 21



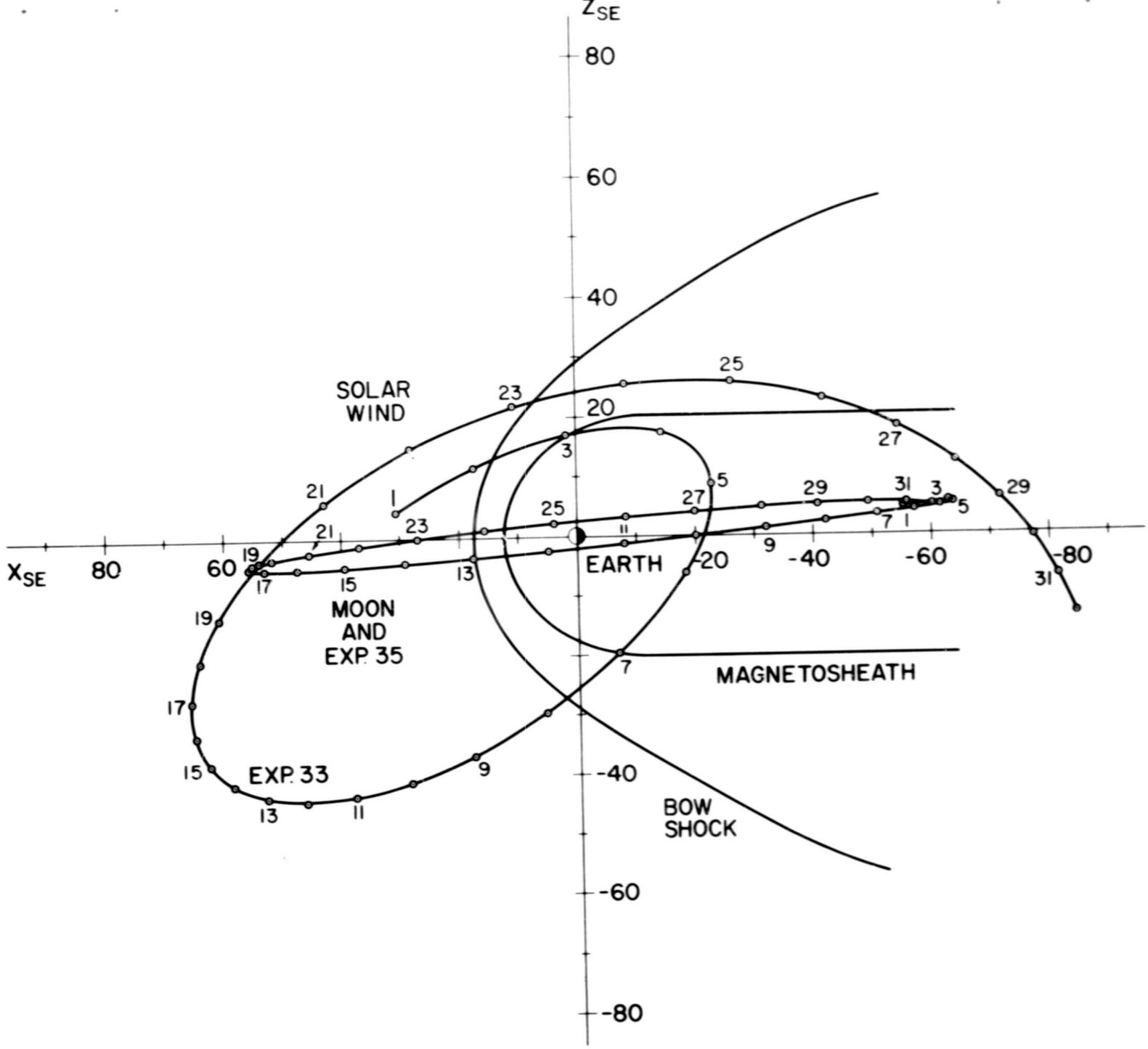
DECEMBER 1968

FIGURE 22



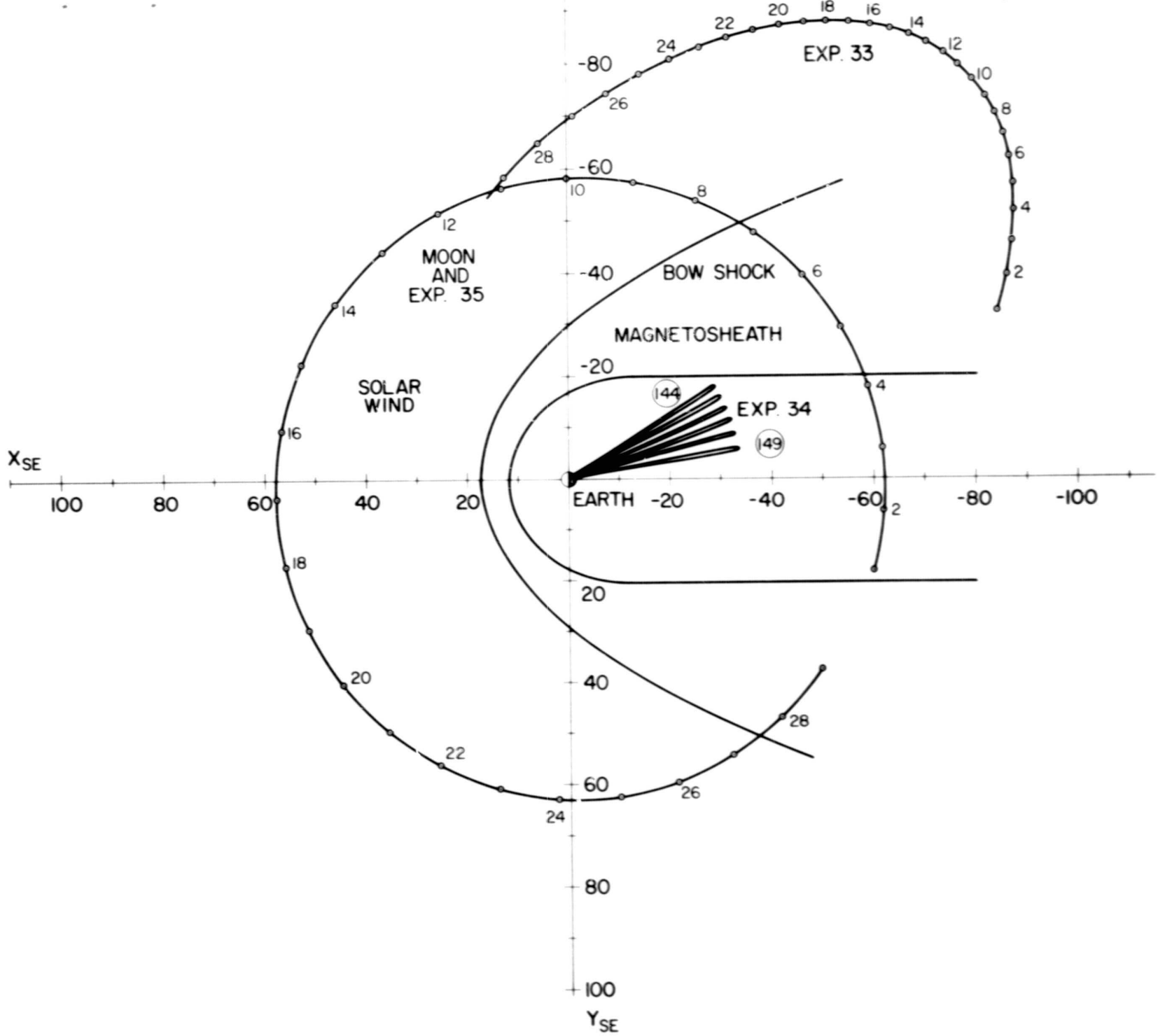
JANUARY 1969

FIGURE 23



JANUARY 1969

FIGURE 24



FEBRUARY 1969

FIGURE 25

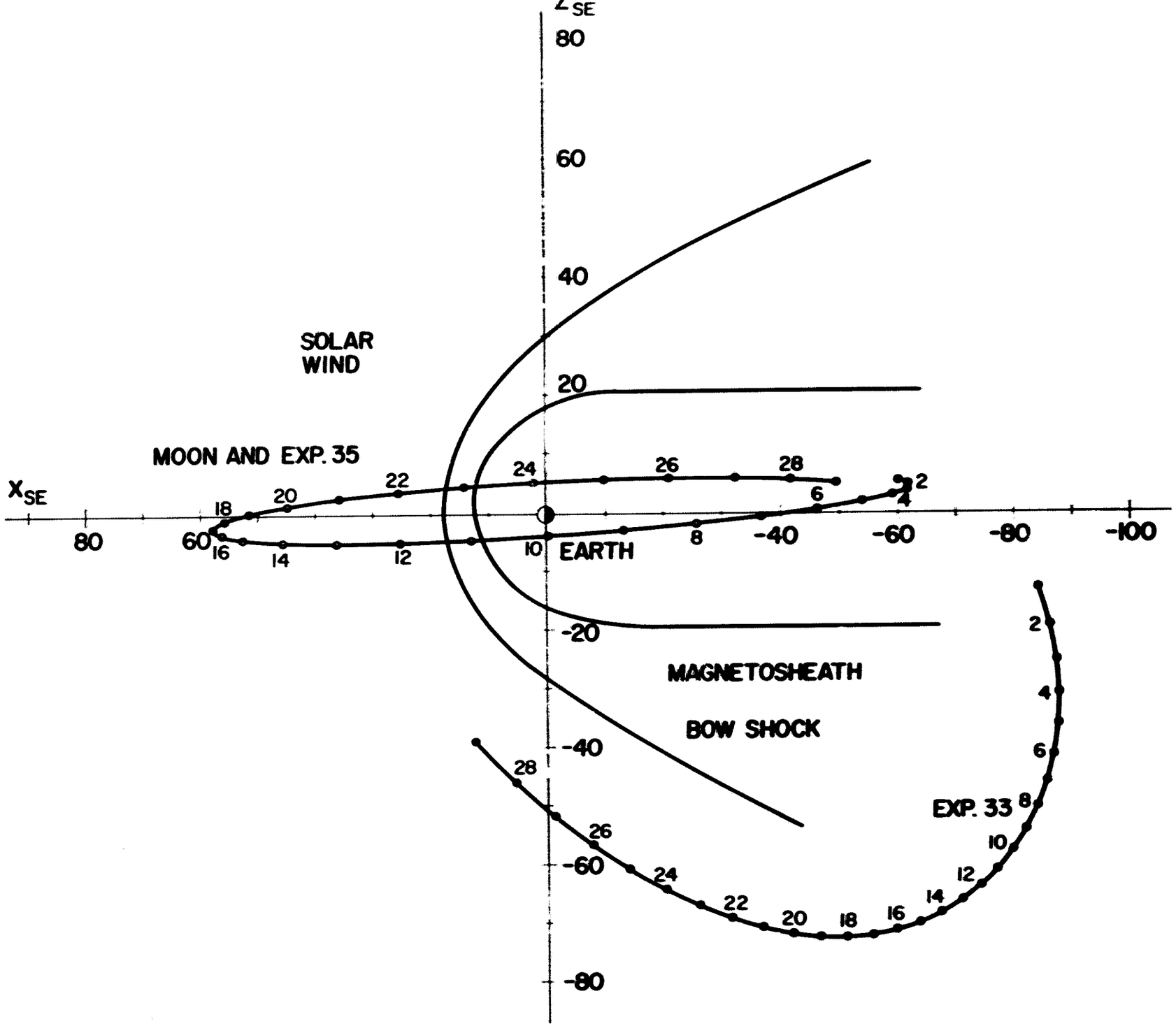
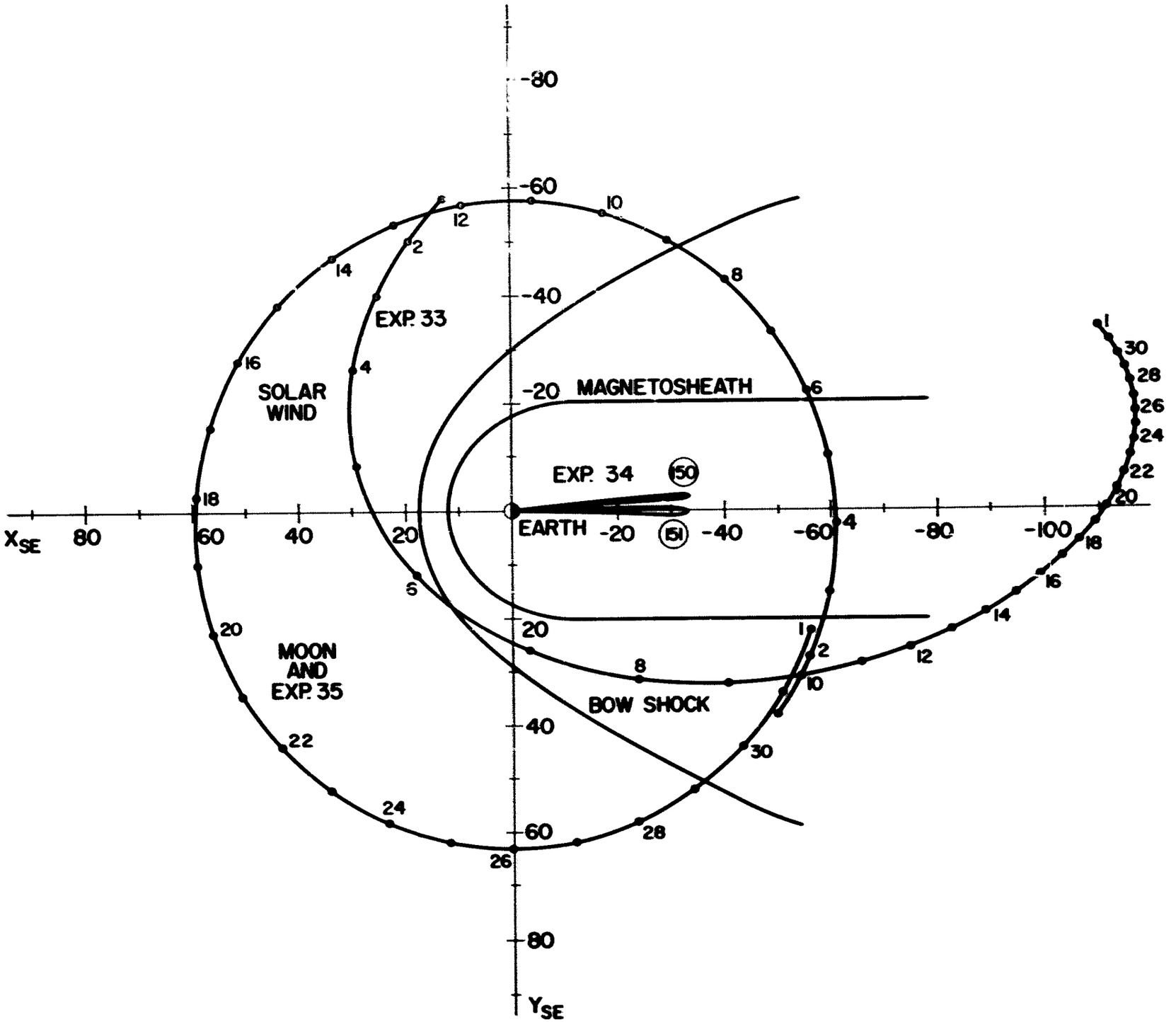
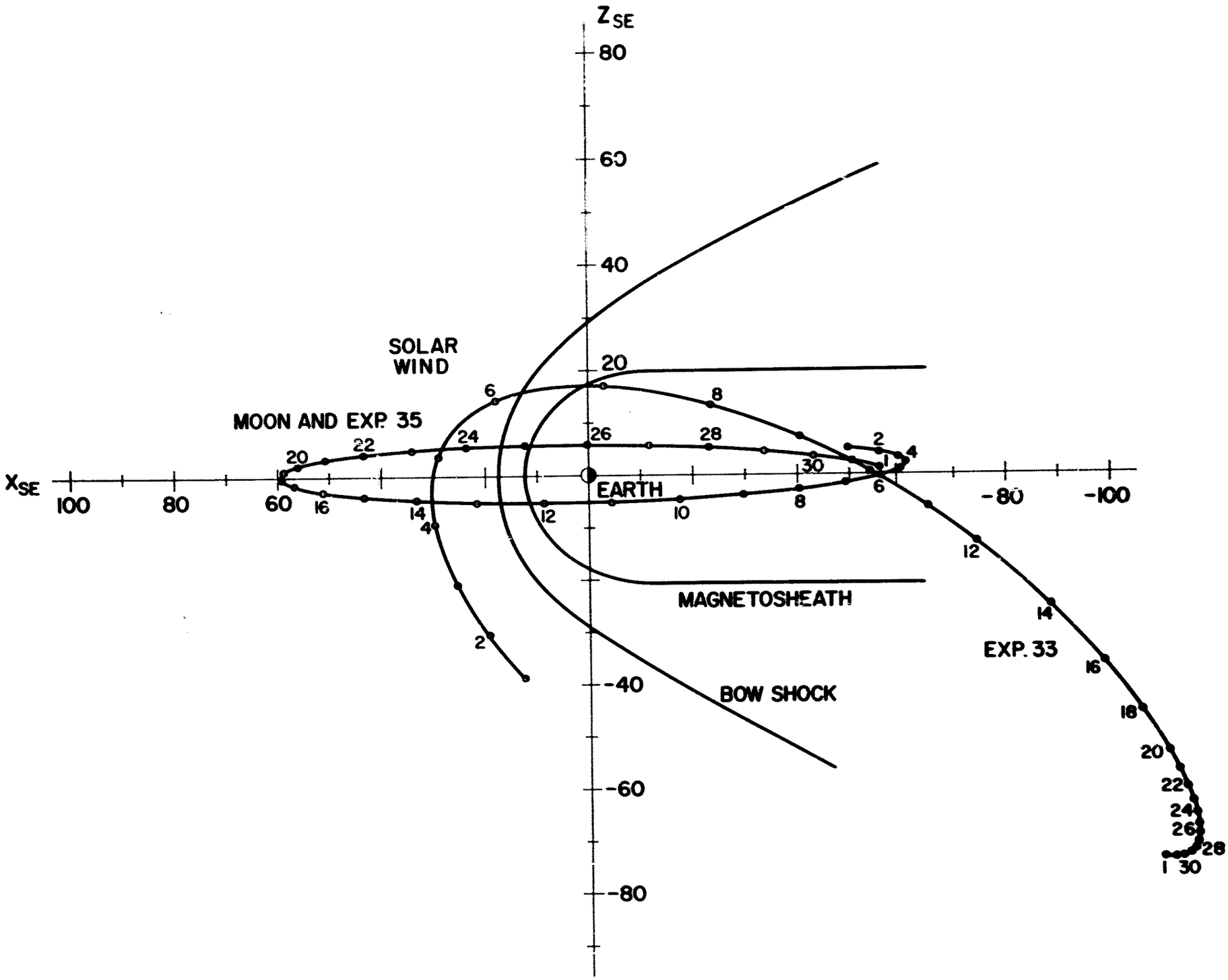

Z SE
80
60
40
20
-20
-40
-60
-80
SOLAR
WIND
MOON AND EXP. 35
X SE
80
60
40
20
EARTH
-40
-60
-80
-100
MAGNETOSHEATH
BOW SHOCK
EXP. 33
FEBRUARY 1969

FIGURE 26



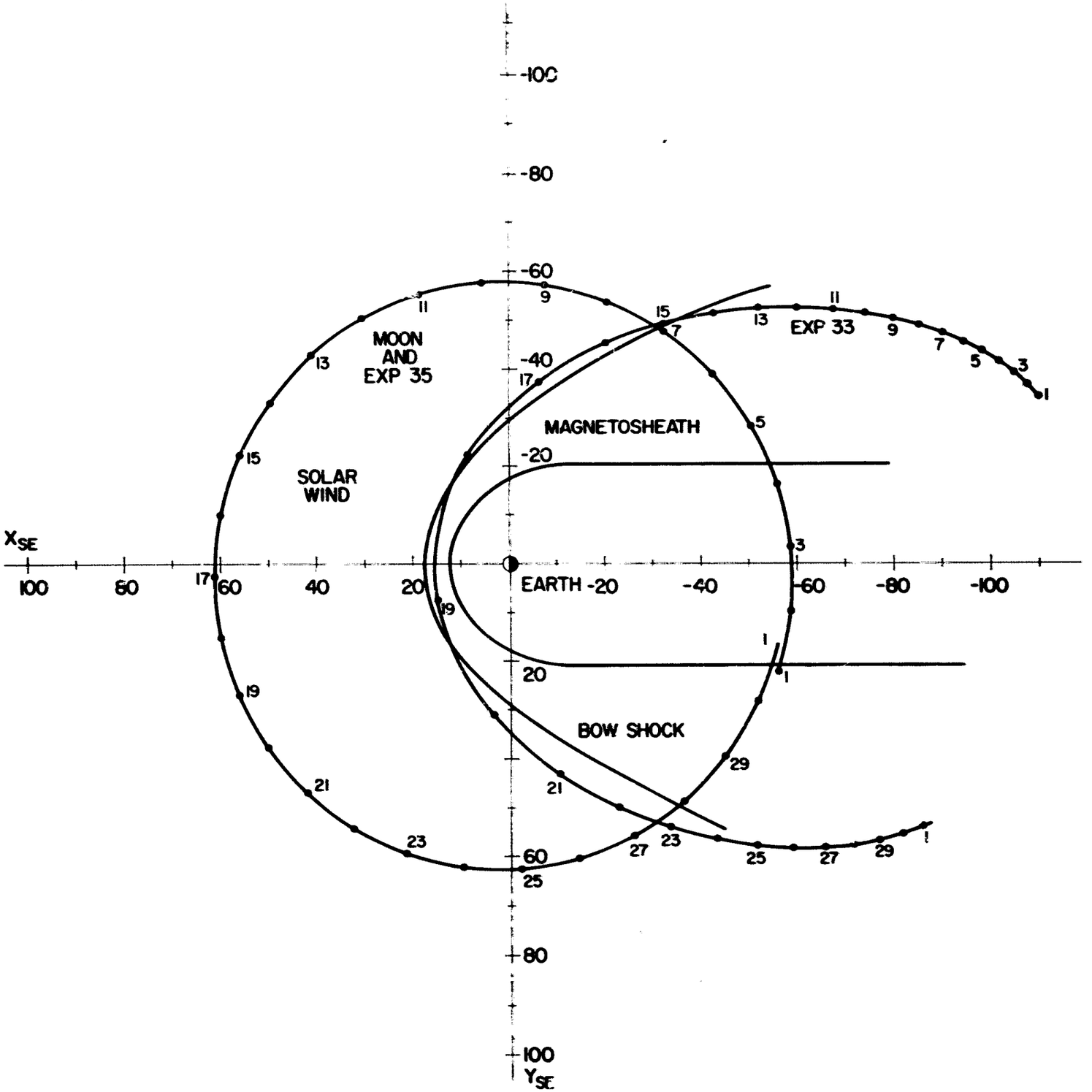
MARCH 1969

FIGURE 27



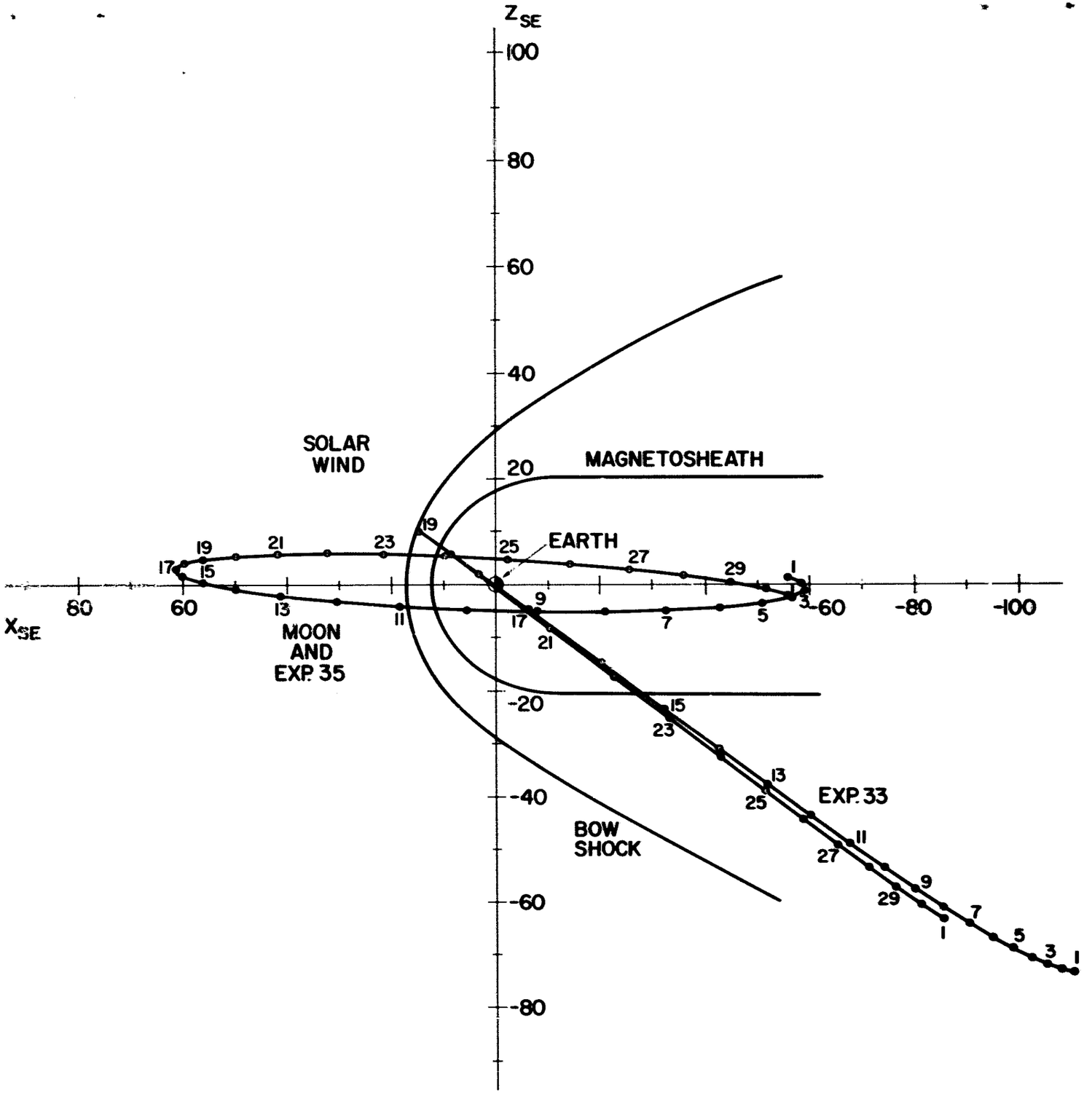
MARCH 1969

FIGURE 28



APRIL 1969

FIGURE 29



APRIL 1969

FIGURE 30