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REVISION 1 TO VIEWS FROM THE CM AND LM DURING THE FLIGHT OF APOLLO 11 (MISSION G)

Flight Analysis Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER

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PROJECT APOLLO

REVISION 1 TO VIEWS FROM THE CM AND LM DURING THE FLIGHT OF APOLLO 11 (MISSION G)

By Alfred N. Lunde
Flight Analysis Branch

July 3, 1969

MISSION PLANNING AND ANALYSIS DIVISION
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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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1.0 SUMMARY AND INTRODUCTION

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VIEWS FROM THE CM AND LM DURING THE FLIGHT

OF APOLLO 11 (MISSION G) - REVISION 1

By Alfred N. Lunde

1.0 SUMMARY AND INTRODUCTION

1.1 Summary

This report supersedes MSC IN 69-FM-168, Views from the CSM and LM During the Flight of Apollo 11 (Mission G) (ref. 1). The data presented in this report is identical to the above mentioned report up to a ground elapsed time of 99 hours. Due to the recently added revolution prior to DOI, the g.e.t. changes by about 2 hours. This report reflects all changes that have been made to date, and conforms with the latest nominal mission profile.

The purpose of this report is to visually depict various aspects of the Apollo 11 (Mission G) lunar landing mission. Out-the-window views are shown for most critical maneuvers executed by the CSM and by the LM. Detailed views of the earth and the moon are shown for the translunar and transearth coast phases of the flight. Views through the scanning telescope are presented for earth parking orbit, translunar coast, moon parking orbit, and transearth coast. Views through the alinement optical telescope are presented for the lunar surface stay.

These views will prove valuable to the crew as onboard data and for simulation purposes in preparation for the flight. Some of the data presented in this report are a result of crew requests and will be incorporated into the crew flight plan.

1.2 Introduction

Because of the complex geometry associated with a lunar mission, it is difficult to visualize the various aspects of such a mission. The objective of this document is to depict what the crew will see during maneuvers and coast periods during the flight of Apollo 11 (Mission G).

Because this mission is the first lunar landing mission, considerable attention has been given to LM maneuvers while in lunar orbit. Views through the LM commander's front and docking windows have been shown for most major LM burns.

All critical CSM maneuvers have been depicted. The CM left rendezvous window has been superimposed on these views to indicate the view available to the commander while he is in a restrained couch position during a burn.

For the translunar and transearth coast periods, views are shown of the earth and the moon. Most of these are close-up views of the two celestial bodies. These views should prove useful for photography purposes.

The sections that concern views through the scanning telescope and alinement optical telescope have been added at the request of the crew.

The sequence of major events are listed in table I, and the mission REFSMMAT's are presented in table II.

The major analytical tool used to produce this report was developed by Mr. G. B. Roush of the Computation and Analysis Division.

This document and its relation to other Apollo 11 (Mission G) milestones for the Contingency Analysis Section are shown in the appendix.

The apparent motion of the earth terminator relative to the spacecraft view is caused by the assumed attitude of the spacecraft. This attitude assumes the spacecraft is pitched down 90° from the local horizontal in a plane defined by the radius vector to the spacecraft and the inertial velocity vector relative to the body being observed. As the spacecraft approaches the moon, the trajectory is warped by the moon and causes the effect depicted. The crew will not necessarily have the spacecraft oriented as stated previously. The x in the center of each view merely centers the view, except for CSM critical maneuver views where the x also denotes the projection of the CM X-axis. All X and Y scales are referenced from the center of the view, and their only purpose is to indicate the field of view. This XY coordinate system is not necessarily parallel to the CSM- or LM-body axis.

This report has the following additions or changes to MSC IN 69-FM-168:

1. New descent and ascent burn views with craters are shown.

2. Updated DOI, CSI, CDH, TPI, TEI, and post-TEI burn views are shown.

3. Transearth coast views, scanning telescope views in lunar orbit after 99 hours g.e.t., and alinement optical telescope views while on lunar surface have been updated.

2.0 SYMBOLS AND NOMENCLATURE

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2.0 SYMBOLS

AOT	alinement optical telescope
c.g.	center of gravity
CDH	constant delta height
CM	command module
CSI	concentric sequencing initiation
CSM	command and service modules
DOI	descent orbit insertion
EI	entry interface
g.e.t.	ground elapsed time
h_E	altitude above earth's surface
h_M	altitude above moon's surface
LOI	lunar orbit insertion
LM	lunar module
PDI	powered descent initiation
PTC	passive thermal control
R_E	radius from center of earth
R_M	radius from center of moon
SCT	scanning telescope
SEQ	star identification number
SM	service module

TEC	transearth coast
TEI	transearth injection
TLC	translunar coast
TLI	translunar injection
TPI	terminal phase initiation
V_i	inertial velocity

3.0 DISCUSSION OF DATA

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3.0 DISCUSSION OF DATA

3.1 General Information

For a better understanding of the data presented in this report, a brief explanation follows.

All the views of the critical maneuvers have a field of view of 100°, although the crew does not have such a large field of view.

All navigation stars, four of the largest planets (Venus, Mars, Jupiter, and Saturn), the sun, moon, and earth are named on all views where they appear. Other stars with a magnitude of +3 have been shown but are not named on the views. In views for some of the critical maneuvers and in various other views, all of the stars can be identified by the number on top of the view. The star name and location can be found in the star catalogue.

To show a close-up view of the earth and moon during the translunar and transearth coast phases, the field of view has been varied.

The CM window configuration data were obtained from the command module manufacturer and from reference 1. The LM window configuration data were obtained from reference 2.

The field of view is indicated on all views. The velocity in fps and mph as well as the radius in n. mi. and altitude in stat. mi. are indicated on many of the views.

During the descent and ascent burn phases, the outline of both the LM front windows are shown projected on the lunar surface or on the celestial sphere. Only the portion within the window outline is visible to the crew at the particular time indicated, although areas outside the window are also shown. Due to a combination of the extremely wide field of view used and the mathematical model involved, the surface of the moon appears to take on a fish-eye view in some cases. However, the distortion in these big fields of view is very minimal. The smallest craters depicted in this report have a size of 1 minute of arc (1658 ft).

3.2 Mission Geometry

The relationship of the ecliptic, equatorial, and lunar planes as they appear in the year 1969 are shown in figure 4.0-1.

The position of the earth's equatorial plane in the ecliptic plane for the month of July is shown in figure 4.0-2. The location of the sun and the moon during the major phases of the mission is depicted in figure 4.0-3.

A schematic diagram of the maneuver attitude and lighting conditions at TLI, LOI, and TEI is presented in figure 4.0-4. The Apollo 11 (Mission G) trajectory has been plotted on a map of the celestial sphere and shows the inertial position of the spacecraft with respect to the stars, sun, and moon (fig. 4.0-5).

For a comparision of the mission geometry for the two previous lunar missions, refer to references 3 and 4.

3.3 TLI Burn

The beginning, middle, and end of the TLI burn are shown in figure 5.1-1. The horizon is dark until shortly before the end of the burn, at which time the terminator can be seen.

3.4 Translunar Coast

Views of the earth and the moon during the translunar coast phase of the mission are presented in figures 5.2.1 and 5.2.2. In figure 5.2.1-1, the earth is shown as it would appear as the spacecraft recedes from it on the lunar trajectory. To show details of the earth such as continents and the terminator, the view has been enlarged in figure 5.2.1-2. These views are shown every hour during the coast period and should be helpful to determine which part of the world can be seen from the spacecraft. In figure 5.2.2-1, the moon is shown as it appears to the crew at various times on the translunar trajectory. Note that the moon is almost totally dark and that the sun is occulted by the moon for a period of time during the coast. In figure 5.2.2-2, a few enlarged views of the moon are shown. Vectors used were obtained from reference 5.

3.5 Views From the CSM During LOI Burn

The beginning, middle, and end of the LOI burn are depicted in figure 6.1-1. Because of the obstruction caused by the docked LM, the views from the rendezvous windows are severely limited. The crewmen are in the heads-down position during this burn, and the burn is performed in a retrograde attitude to brake the trajectory speed so that a lunar orbit may be achieved. (See page 99 for orientation.)

3.6 Views from the LM During Descent

The geometry associated with the LM descent phase is presented in figure 6.2.0-1. Initiation of the DOI burn is shown in figure 6.2.1-1. The docking window is mostly covered by the dark moon. However, note that the horizon of the moon can be monitored on the scribe on the window. (See page 102.)

The powered descent burn is shown in figure 6.2.2-1. The lighted lunar surface and horizon can be monitored through either the **front** windows or the docking window for the first 180 seconds of the burn. After completing the yaw maneuver, the crew loses sight of the moon until about 444 seconds into the PDI burn. After the lunar horizion is visible through the front windows, very few craters are visible because of the flatness of the approach area to landing site 2 and because of the oblique look angle to the horizon. It is of interest to note the apparent motion of the sun through the docking window. At the end of the burn, both the earth and Saturn are visible through the docking window.

3.7 Views from the LM During Ascent Phase

The geometry of the ascent phase is shown in figure 6.3.0-1. The ascent burn is depicted in figure 6.3.1-1. Again, shortly after leaving landing site 2, very few craters are visible due to the scarcity of large craters close to the landing site. However, due to the LM attitude during the ascent phase, the lunar surface and horizon can be monitored through the front windows and docking window, respectively.

3.8 TEI Burn

The beginning, middle, and end of the TEI burn are shown in the correct burn attitude in figure 7.1-1. This maneuver is a posigrade burn designed to free the spacecraft from the lunar gravitational attraction.

3.9 Post-TEI

The two post-TEI views (figs. 7.2-1 and 7.2-2) depict the view from the spacecraft as the earth comes into view after the TEI maneuver. At this time, the crew are looking at the middle of the Pacific Ocean.

3.10 Transearth Coast

As with the translunar coast, the views of the earth and moon are shown at various times during the transearth coast period (figs. 7.3.1-1, 7.3.1-2, 7.3.2-1, and 7.3.2-2). The moon is nearly three-quarters full as seen by the crew, and half of the earth facing the crew is in darkness.

3.11 Views from the CM During Entry Phase

The entry phase is shown in figure 8.0-1. The SM is jettisoned at approximately 15 minutes prior to entry interface, and the CM is in a heatshield-forward attitude. The angle between the spacecraft X-axis and the earth horizon is held at $+31.7^\circ$, which can be monitored on the 31.7° scribe on the window. The entry is made in darkness, and the moon is visible during part of the entry phase. The gimbal angles used for the entry phase were obtained from reference 6.

3.12 Views Through the Scanning Telescope

The times and location of the SCT sightings in this report are shown in figure 9.0-1. The SCT location and its field of view are shown in figure 9.0-2. The view along the CM X-axis during the PTC mode is shown in figure 9.0-3. The x in the middle of the view denotes the spacecraft X-axis projected on the star field background. The CM left rendezvous window outline is shown for a zero roll attitude.

In figure 9.1-1, the view is presented as seen through the SCT approximately at the beginning, middle, and end of the darkness period during earth parking orbit. The spacecraft is in a heads-down position with pitch 0°, yaw 0°, roll 180° with respect to the local horizontal.

The SCT views at indicated g.e.t. times during the translunar coast are shown in figures 9.2-1 through 9.2-9. In each case, a view as seen through the SCT is presented at a roll increment of 60°, while pitch and yaw remain at their initial value.

The SCT view from the evasive maneuver attitude is presented in figure 9.2-1. Because no attitude was available and because PTC was not started at a g.e.t. of 11 hours, an initial attitude of 0°,0°,0° was used for the inner, middle, and outer gimbal angles.

The next five figures assume a PTC attitude with an initial attitude of +90°,0°,0° for the inner middle and outer gimbal angles. A LOI-1 attitude is assumed in figures 9.2-8 and 9.2-9.

The SCT views during lunar orbit are shown in figures 9.3-1 through 9.3-12. All of these views are shown at the beginning, middle, and end of the darkness period in the revolution indicated. The REFSMMAT and the gimbal angles used are stated on each view. The gimbal angles were obtained from reference 7.

The view through the SCT during the transearth phase of the mission is shown in figures 9.4-1 through 9.4-5. Again, the views are presented at a roll increment of 60°.

All times for the SCT were obtained from reference 8.

3.13 View Through Alinement Optical Telescope (AOT)

The attitude constraint geometry of the AOT is shown in figure 10.0-1. The various detent positions are shown as well as the location of the AOT (ref. 8).

The views through the AOT and the six detent positions at 2 hours after lunar landing and 2 hours prior to lunar lift-off are shown in figures 10.0-2 and 10.0-3, respectively. The quarter-moon shape in each view is an obstruction to the sightings. The lunar surface can be seen at the extreme center bottom of each of the views.

TABLE I.- SEQUENCE OF MAJOR EVENTS

Event	Time, hr:min:sec, g.e.t.	Burn duration, sec
Earth parking orbit	00:11:24	--
Translunar injection	02:44:18	321.0
Lunar orbit insertion	75:55:03	365.4
DOI	101:38:48	28.4
PDI	102:35:40	692.0
Ascent	124:23:21	
CSI	125:21:20	44.8
CDH	126:19:40	2.0
TPI	126:58:26	22.3
TEI	135:24:34	149.2
Entry interface	195:05:03	--

TABLE II.- MISSION REFSMMATS[a]

(a) Launch pad REFSMMAT[b]

-.87505508	.40084951	.27128990
-.0067739375	.55029242	-.83494452
-.48397589	-.73246016	-.47882088

(b) PTC REFSMMAT[c]

.866025404	-.45872739	-.19892002
-.5000000	-.79453916	-.34453958
0.00000	.39784004	-.91745480

(c) Lunar landing site REFSMMAT[b]

.78005170	.57655390	.24311512
.00374215	-.39283134	.91960294
.62570309	-.71642806	-.30858630

(d) CSM preferred plane change REFSMMAT[b]

.002798289	-.39330923	.9194020
-.65180536	-.69797995	-.29660368
.75838113	-.59844117	-.25831421

(e) Lunar lift-off REFSMMAT[b]

.63482512	.71274759	.29830852
.00595964	-.39058739	.92054658
.77263288	-.58260827	-.25220240

[a] All REFSMMAT's are listed in the following format

xx	xy	xz
yx	yy	yz
zx	zy	zz

[b] Ref. 10.

[c] Ref. 11.

(f) Entry REFSMMAT[b]

.00541143	.76825450	.64012164
-.07168836	.63878201	-.76604068
-.99741240	-.04174389	.05853164

[a]All REFSMMAT's are listed in the following format.

xx	xy	xz
yx	yy	yz
zx	zy	zz

[b]Ref. 10.
[c]Ref. 11.

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4.0 MISSION GEOMETRY

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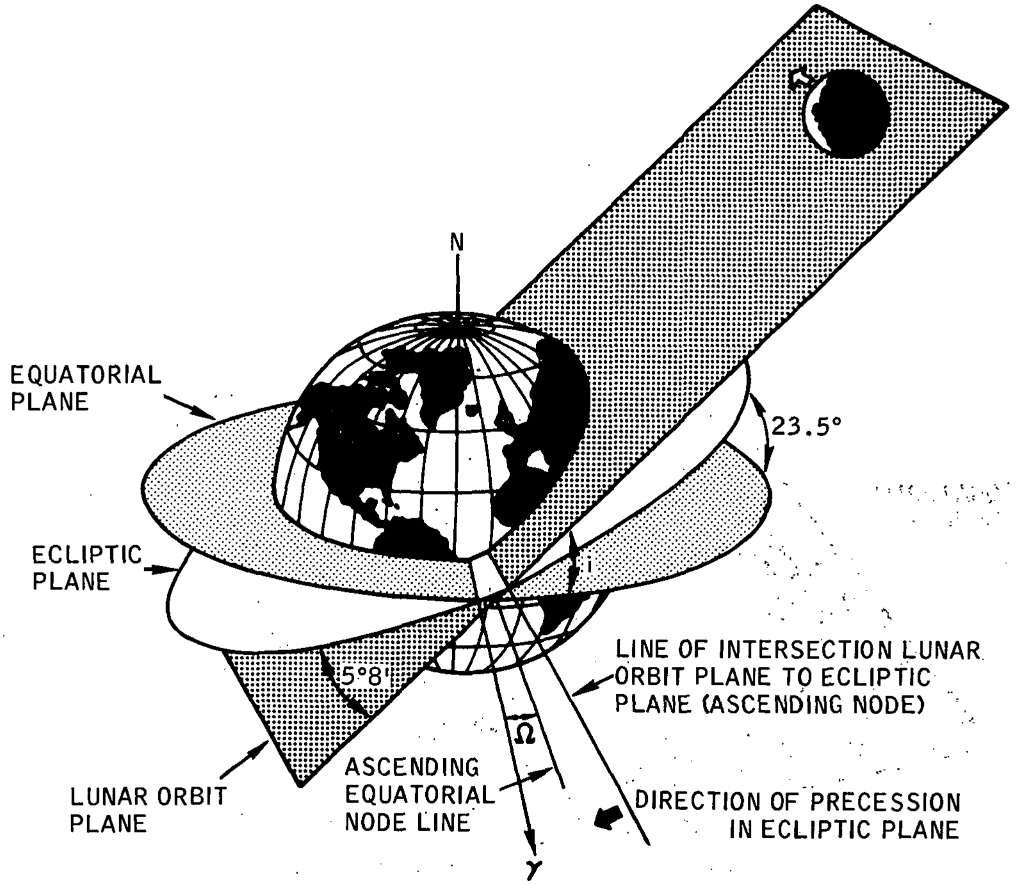

Figure 4.0-1.- Illustration of lunar orbit plane in year 1969 - inclination angle (i) $\approx$ 28°, right ascension of ascending equatorial node (Ω) = 5°.

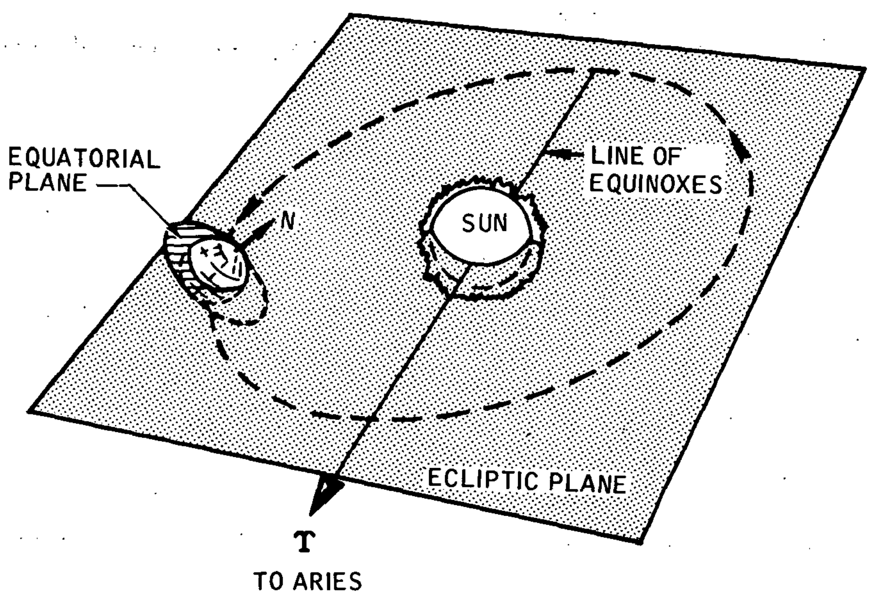

Figure 4.0-2.- Sun-centered inertial geometry of Apollo 11 (Mission G).

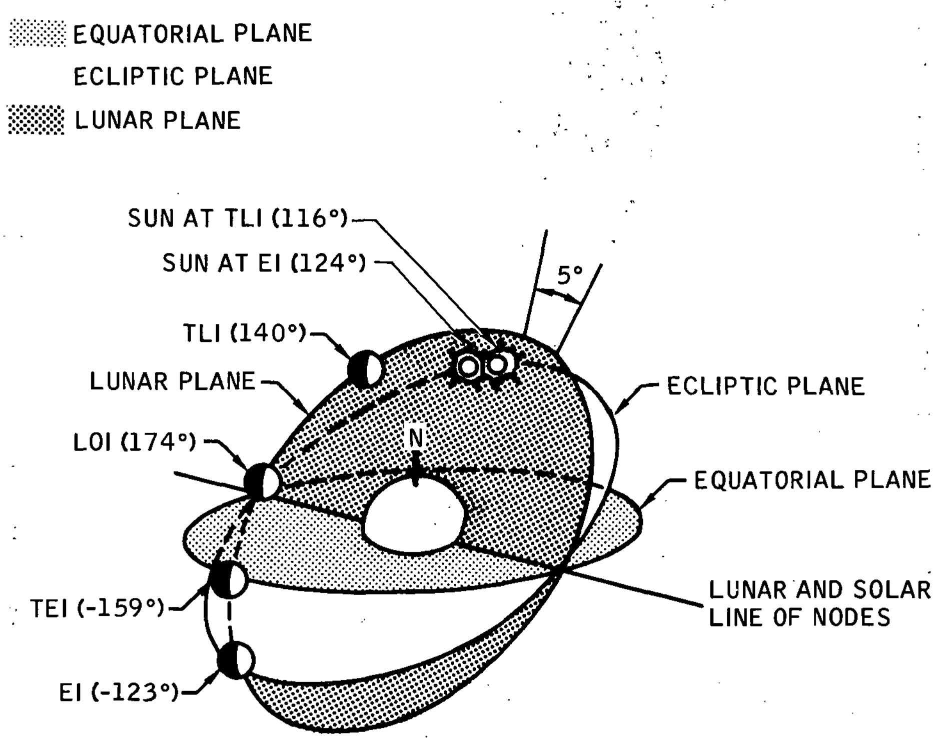

Figure 4.0-3.- Location of the sun and moon at major phases of Apollo (Mission G).

NOTE: For all maneuvers crew in heads-down position relative to the earth or moon

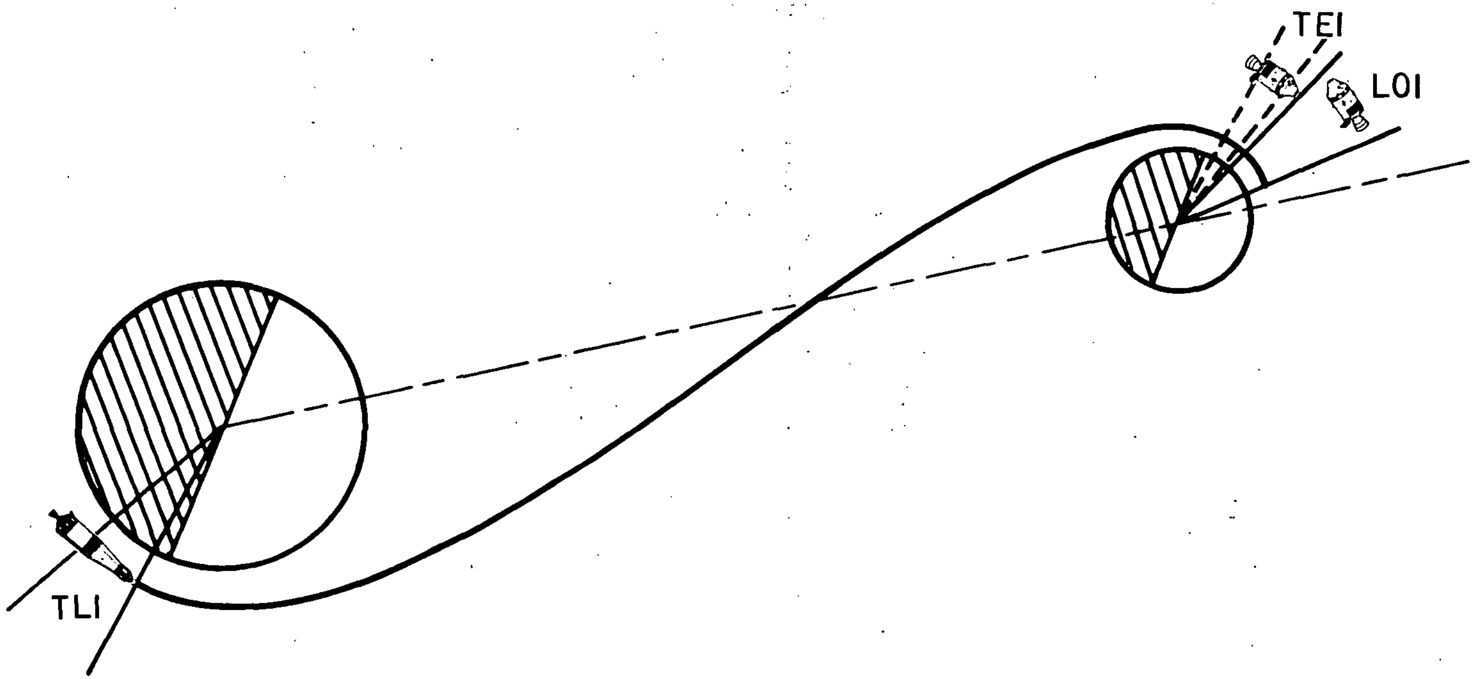

Figure 4.0-4.- A schematic of the maneuver attitudes and lighting conditions for the nominal Apollo 11 (Mission G).

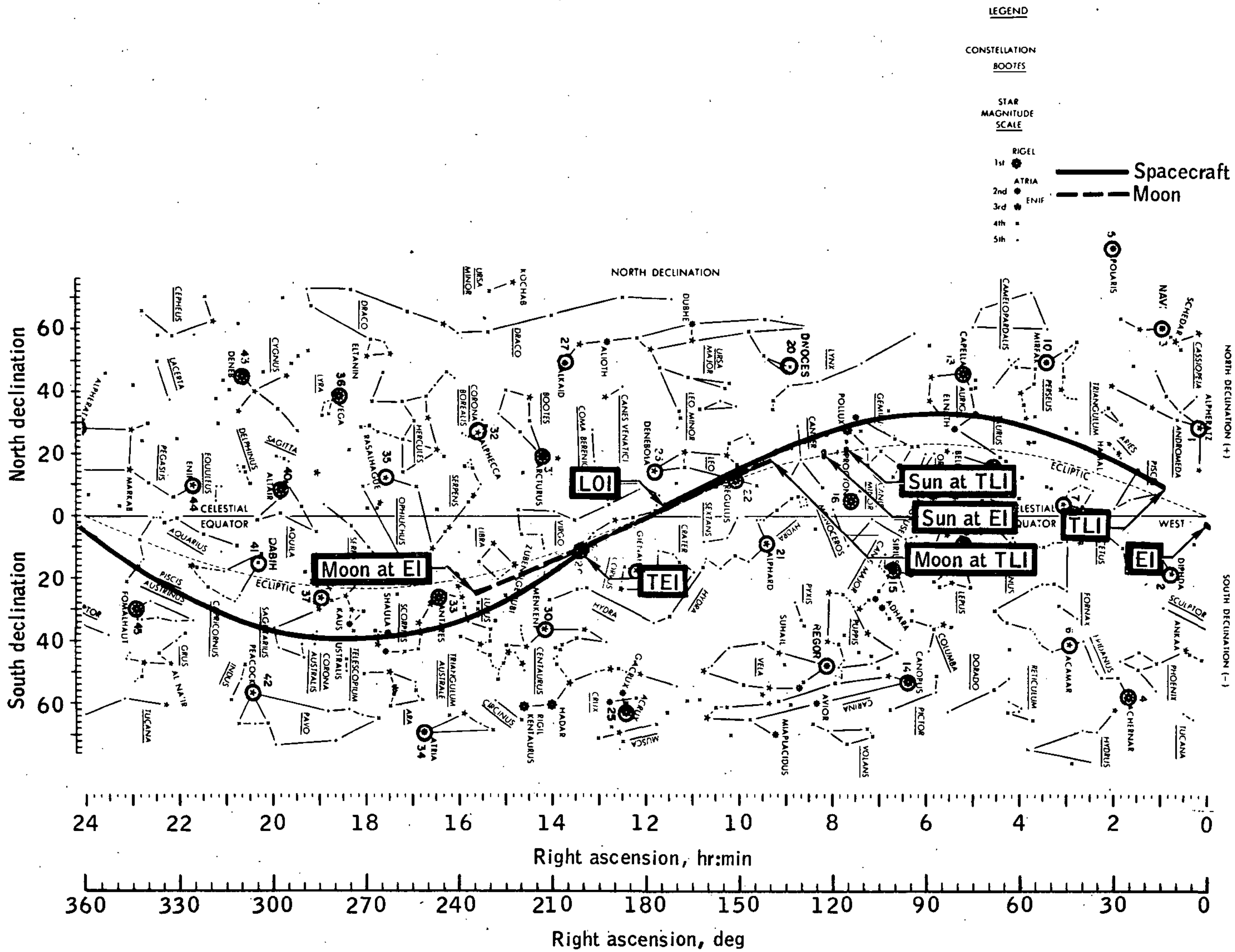

Figure 4.0-5.- Flight of Apollo 11 (Mission G) projected on a map of the celestial sphere.

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5.0 VIEWS FROM CSM DURING TRANSLUNAR PHASE

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5.1 TLI BURN

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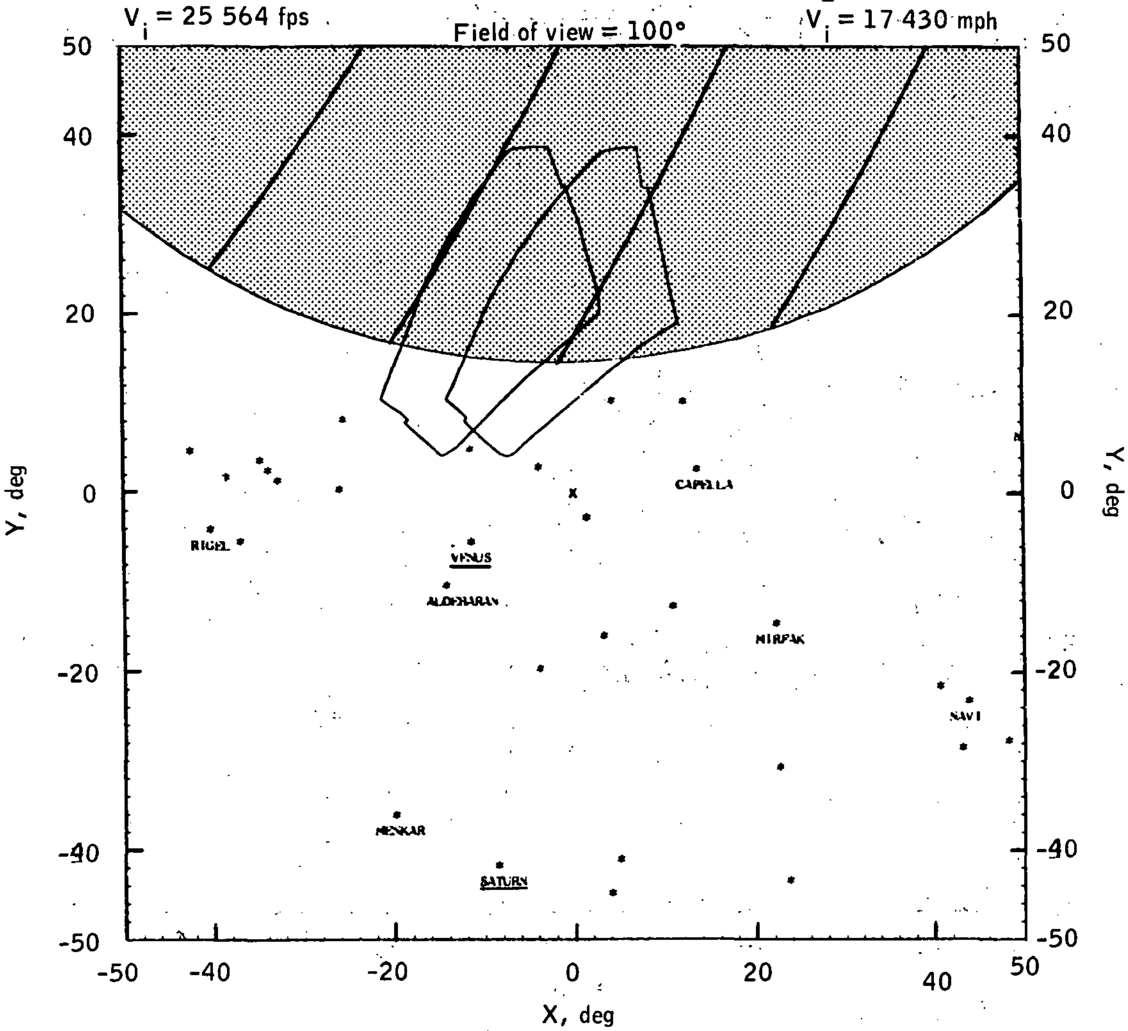
SEQ	1	4	3	7	8	9	10	11	38	45	47	48
X	-5	-4	21	-9	11	-7	-20	6	2	-12	-12	-1
Y	-2	-20	-11	-18	-7	-5	-2	1	-20	4	0	1

SEQ	49	50	64	66	67	68	69	70	82	88	89	90
X	-16	-17	24	11	11	-16	-21	6	21	20	2	-1
Y	1	1	-13	-21	-15	0	2	5	-14	-10	-22	-9

SEQ	93	91	92	94	97	98	100
X	0	1	5	-18	-19	-5	2
Y	-1	-8	-6	-2	0	2	5

R_E = 3550 n. mi.
V_i = 25 564 fps

h_E = 122 stat. mi.
V_i = 17 430 mph



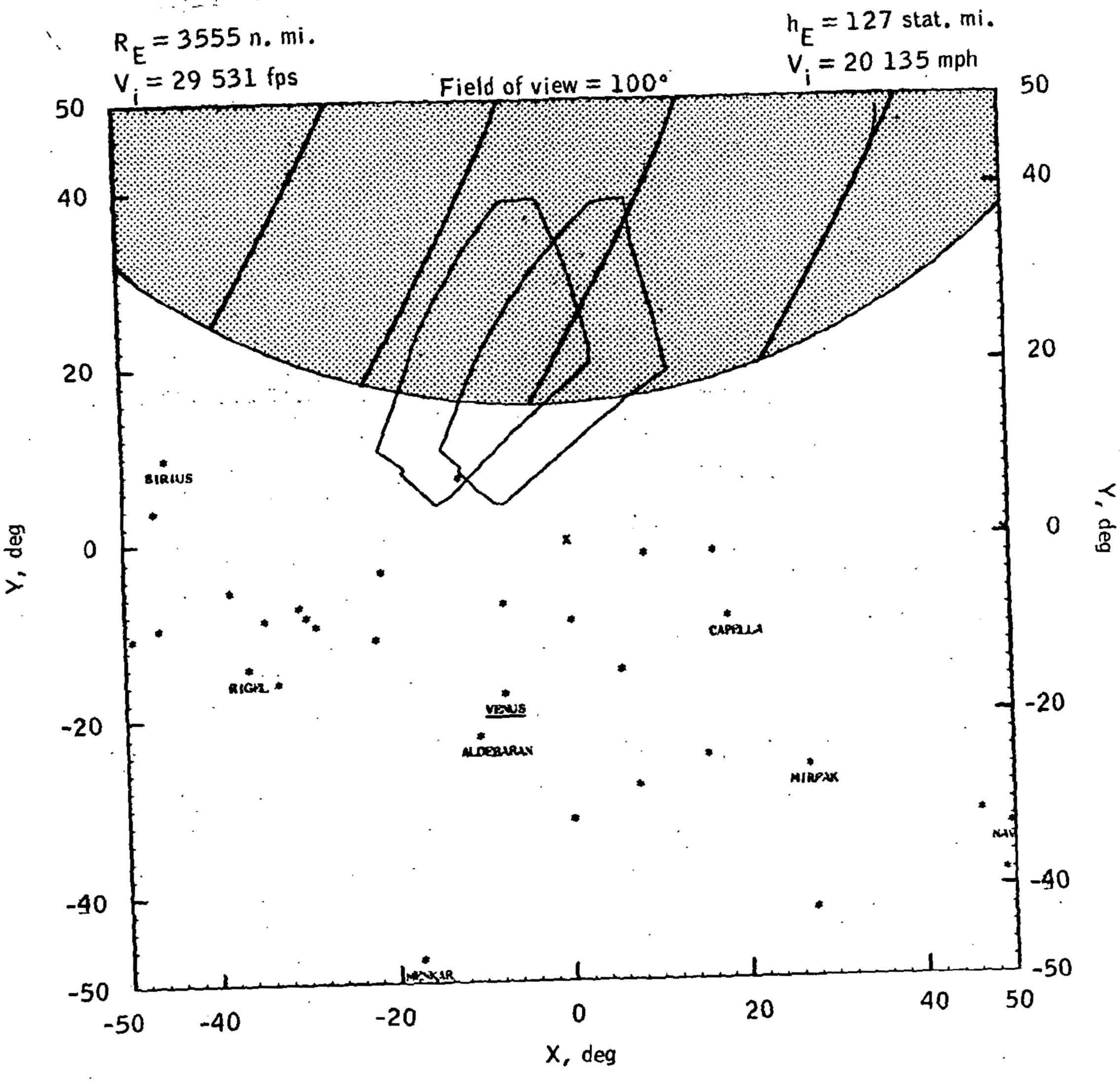
(a) Begin TLI burn (g.e.t. = 2:44:11).

Figure 5.1-1.- Translunar injection burn.

SEQ	1	3	7	8	9	10	11	13	45	47	48	49
X	-3	24	-8	13	-5	-18	9	-22	-10	-10	0	-19
Y	-8	-16	-23	-12	-11	-7	-4	4	-1	-5	-4	-4

SEQ	50	51	52	67	68	69	70	82	88	90	91	92
X	-15	-23	-6	13	-14	-19	8	24	23	0	3	7
Y	-3	1	3	-21	-4	-2	0	-19	-15	-15	-13	-12

SEQ	93	94	95	96	97	98	100
X	2	-16	-24	-23	-17	-3	4
Y	-7	-7	-5	-4	-4	-3	0



(b) Middle TLI burn (g.e.t. = 2:47:06).

Figure 5.1-1.- Continued.

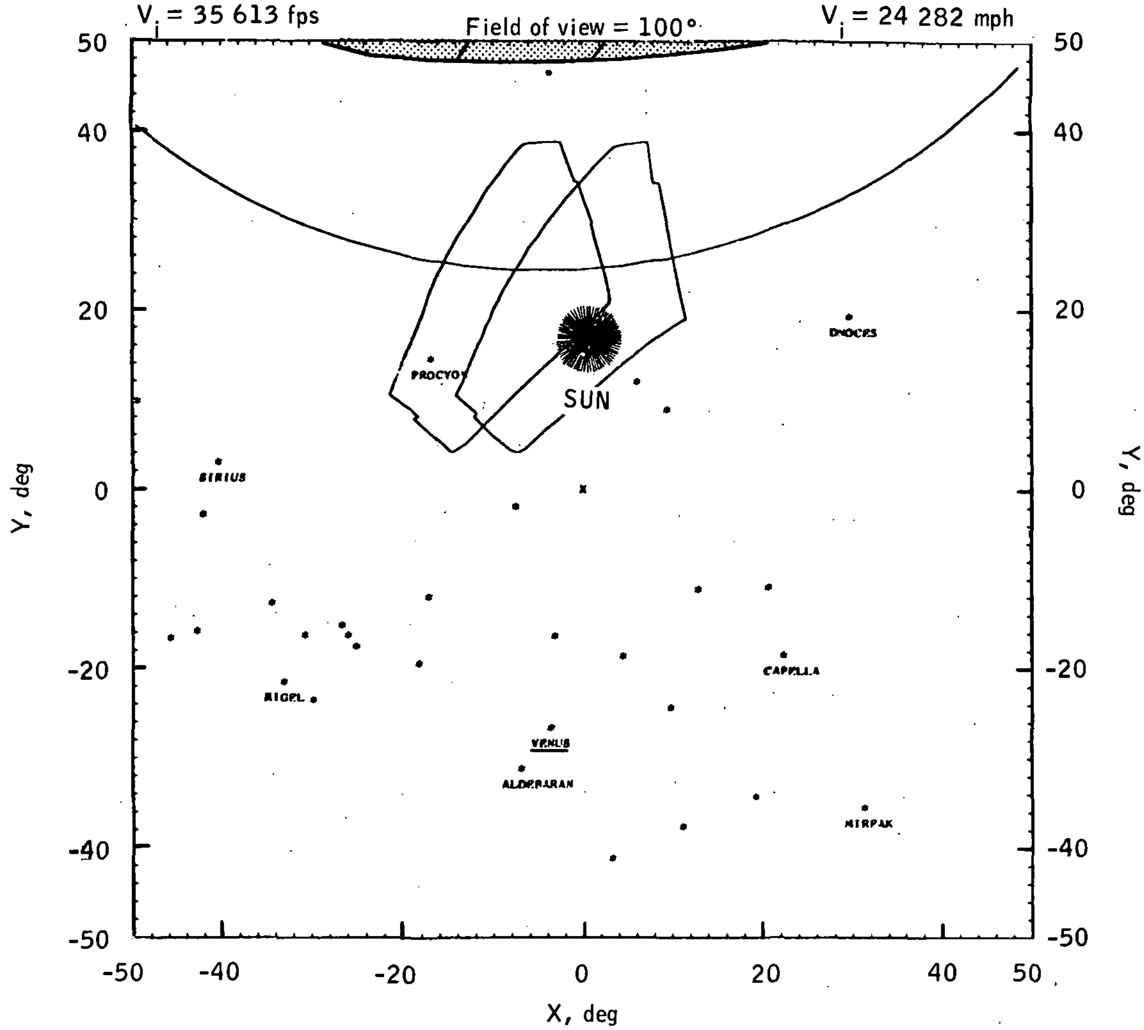
SEQ	1	8	9	10	11	13	14	16	40	45	47	48
X	-1	15	-3	-16	11	-20	-8	14	3	-8	-9	2
Y	-13	-17	-15	-10	-9	1	7	9	5	-5	-9	-9

SEQ	49	50	51	52	54	55	68	69	70	90	91	92
X	-12	-13	-21	-3	-24	4	-12	-17	10	1	5	9
Y	-8	-7	-1	0	4	4	-8	-6	-5	-20	-18	-17

SEQ	93	94	95	96	97	98	100
X	4	-14	-22	-21	-15	-1	6
Y	-12	-11	-8	-7	-8	-8	-5

R_E = 3610 n. mi. h_E = 192 stat. mi.

V_i = 35 613 fps V_i = 24 282 mph



(c) End TLI burn (g.e.t. = 2:50:02).

Figure 5.1-1.- Concluded.

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5.2 TRANSLUNAR COAST

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5.2.1 EARTH VIEWS

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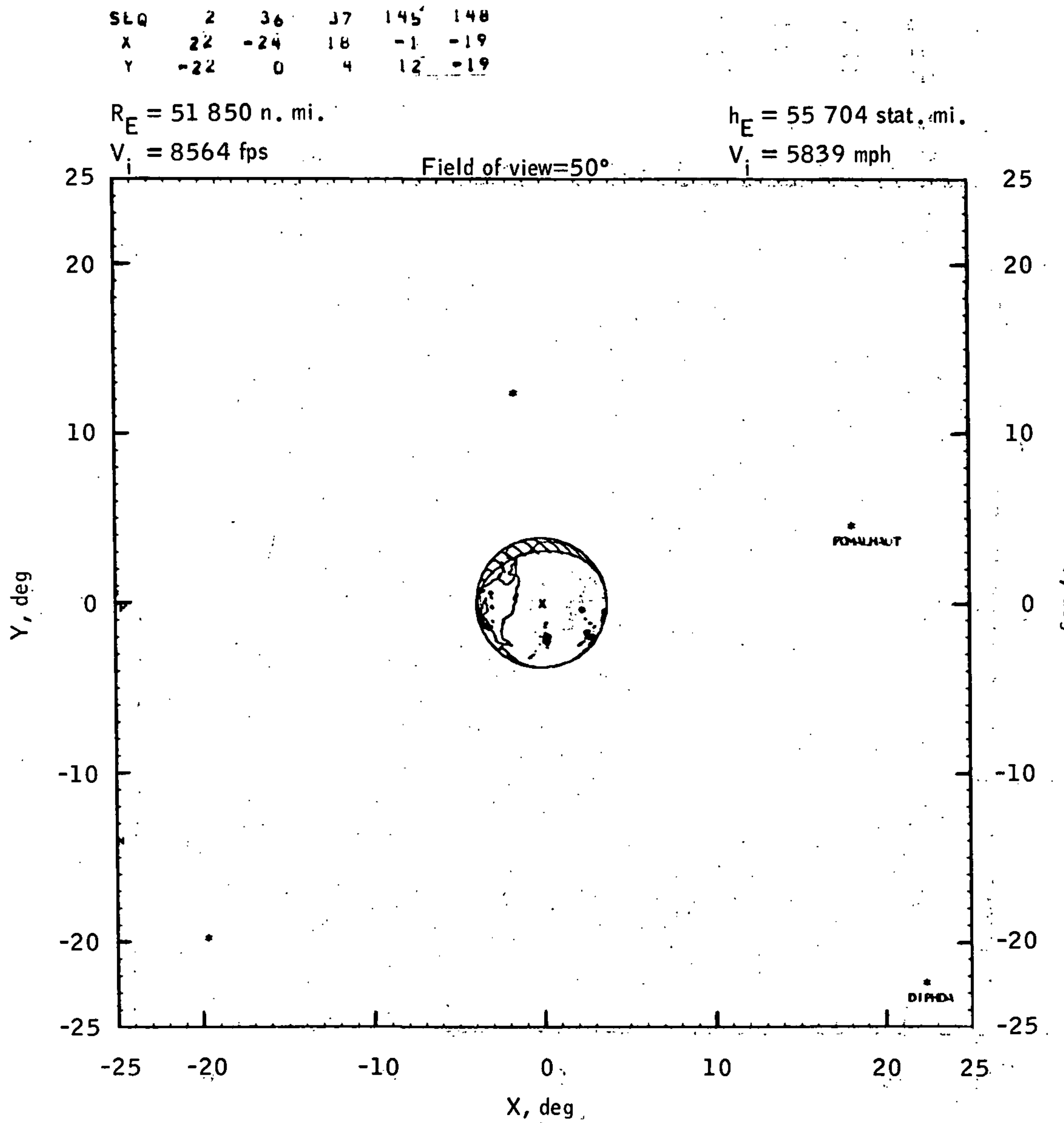
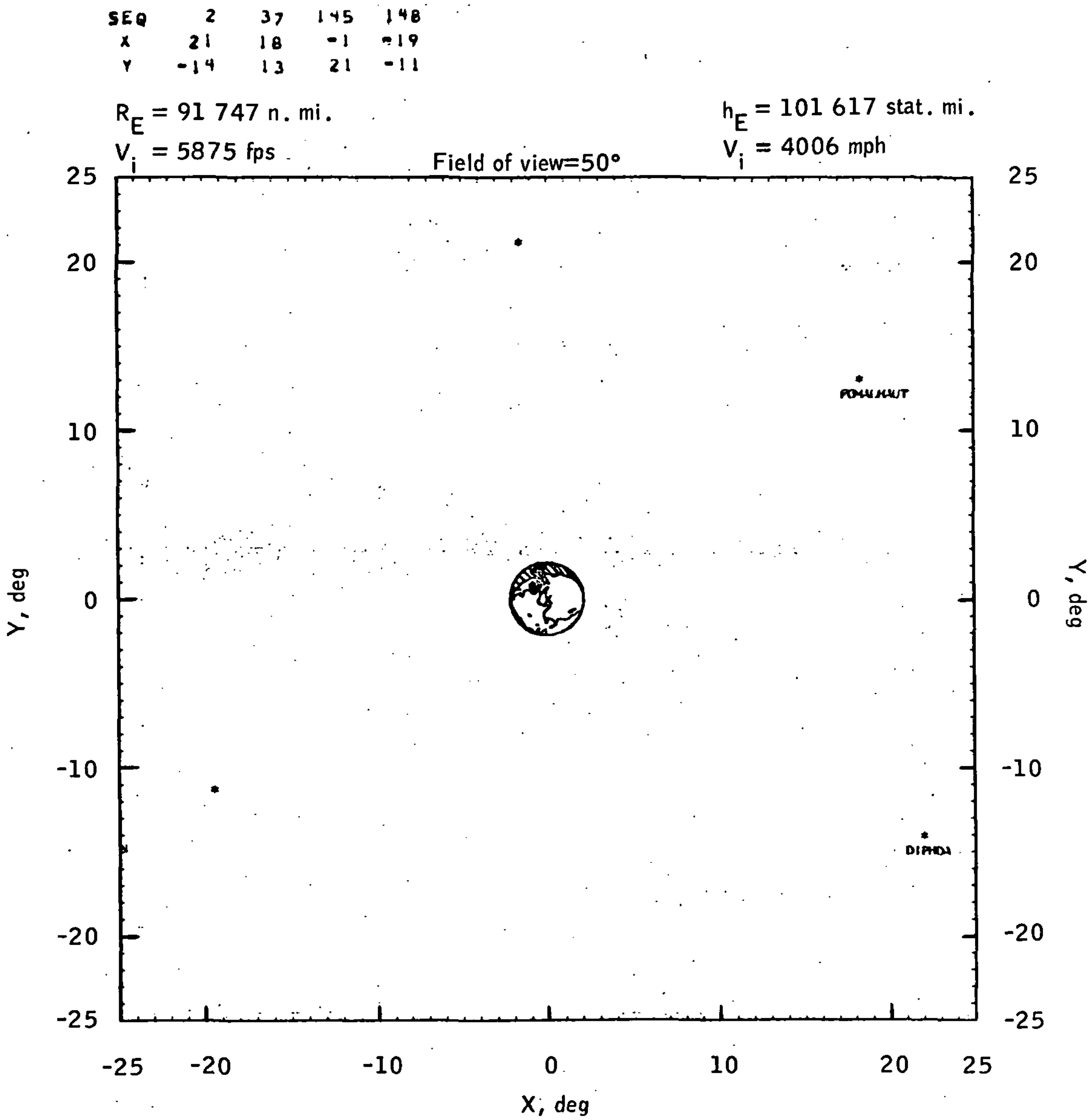


(a) g.e.t. = 10 hours.

Figure 5.2.1-1.- Translunar coast–constant field of view (earth).



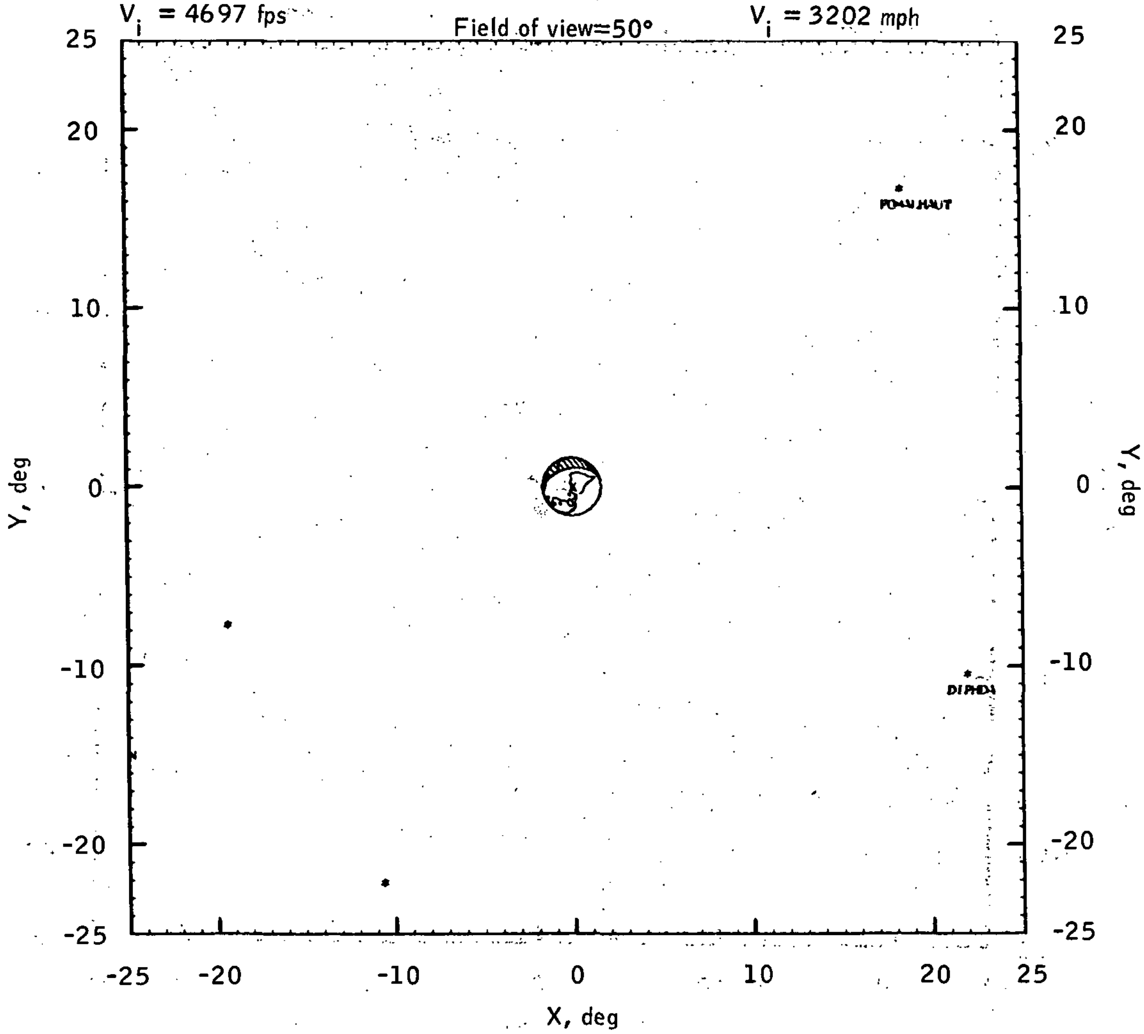
(b) g.e.t. = 20 hours.

Figure 5.2.1-1.- Continued.

SEQ	2	37	86	145	148
X	21	18	-10	-1	-19
Y	-10	16	-22	24	-7

R_E = 121 920 n. mi. h_E = 136 339 stat. mi.

V_i = 4697 fps V_i = 3202 mph



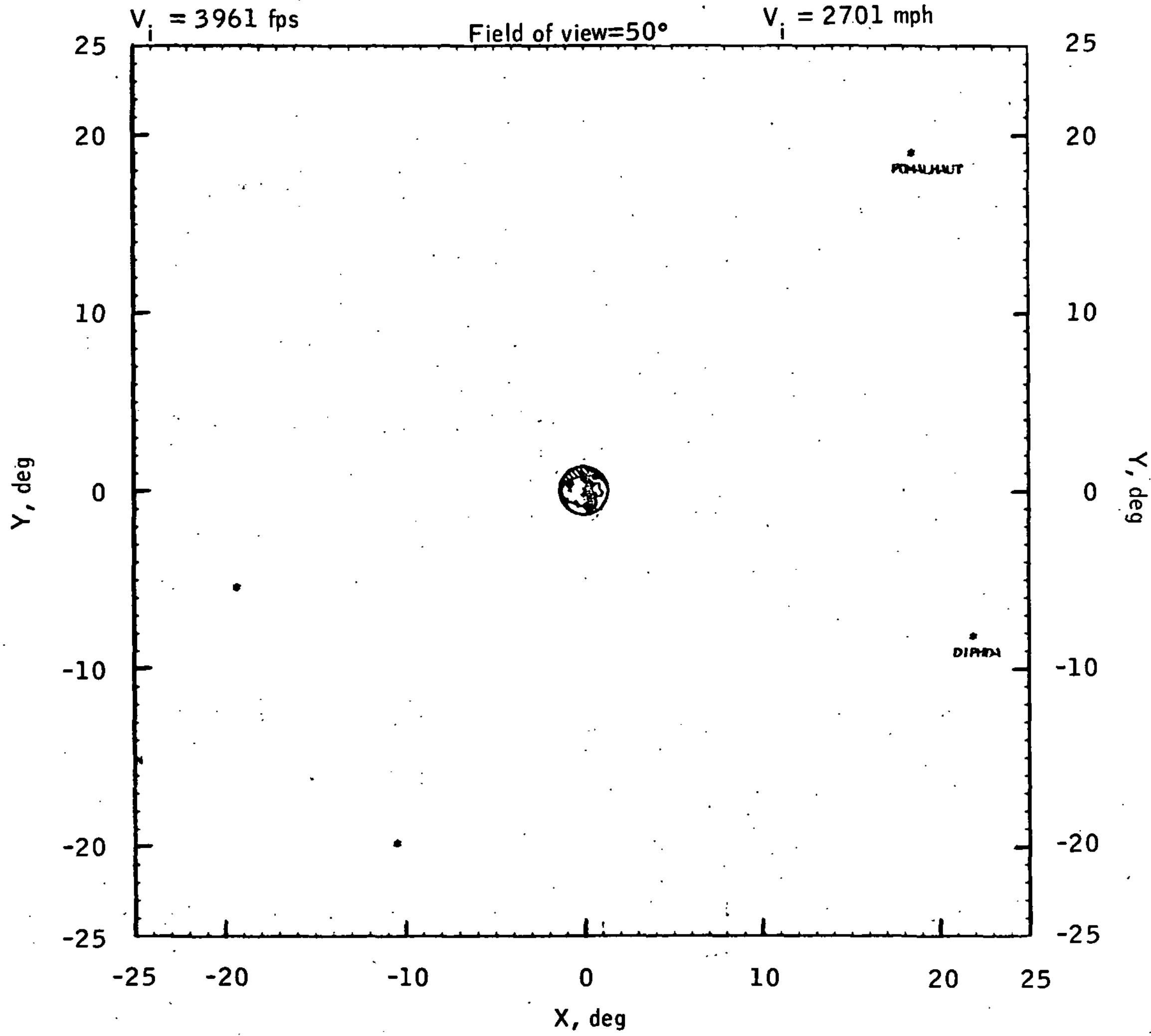
(c) g.e.t. = 30 hours.

Figure 5.2.1-1.- Continued.

SEQ	2	37	86	148
X	21	18	-10	-19
Y	-8	18	-19	-5

R_E = 146 817 n. mi. h_E = 164 990 stat. mi.

V_i = 3961 fps V_i = 2701 mph



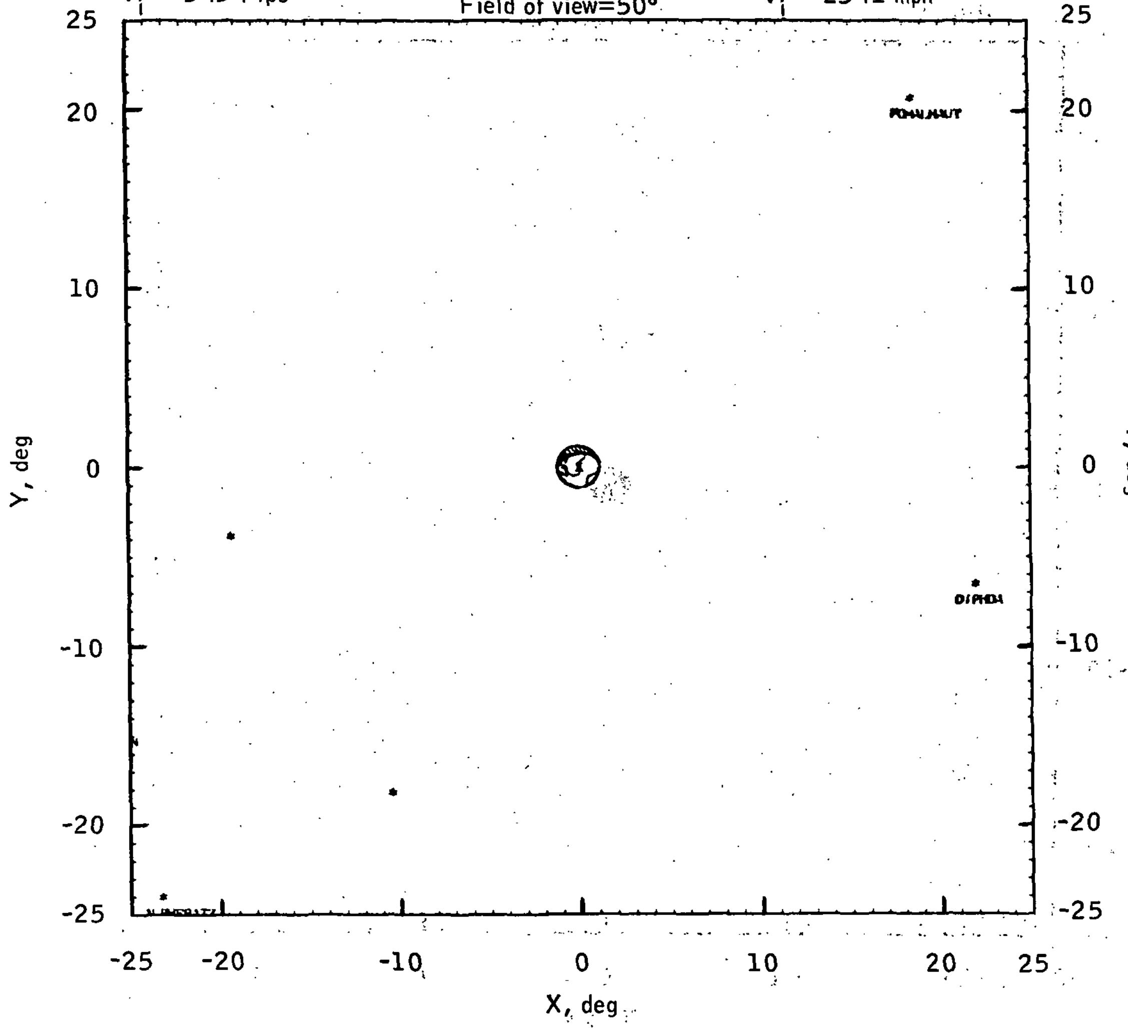
(d) g.e.t. = 40 hours.

Figure 5.2.1-1.- Continued.

SEQ	1	2	37	86	148
X	-23	21	18	-10	-19
Y	-24	-6	20	-18	-3

R_E = 168 146 n. mi. h_E = 189 534 stat. mi.

V_i = 3434 fps V_i = 2341 mph



(e) g.e.t. = 50 hours.

Figure 5.2.1-1.- Continued.

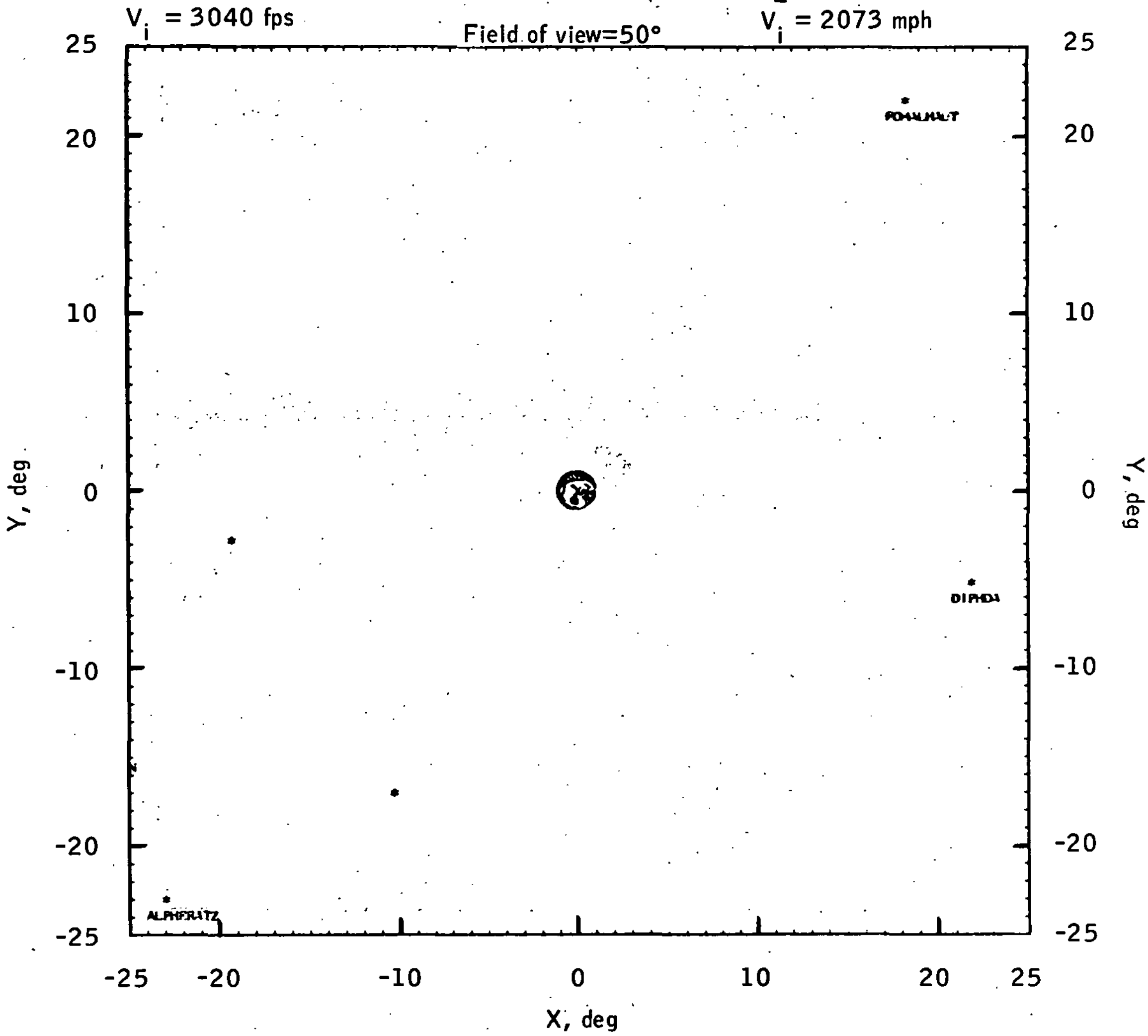
SEQ	1	2	37	86	140
X	-22	21	18	-10	-19
Y	-23	-5	21	-17	-2

R_E = 186 861 n. mi.

V_i = 3040 fps

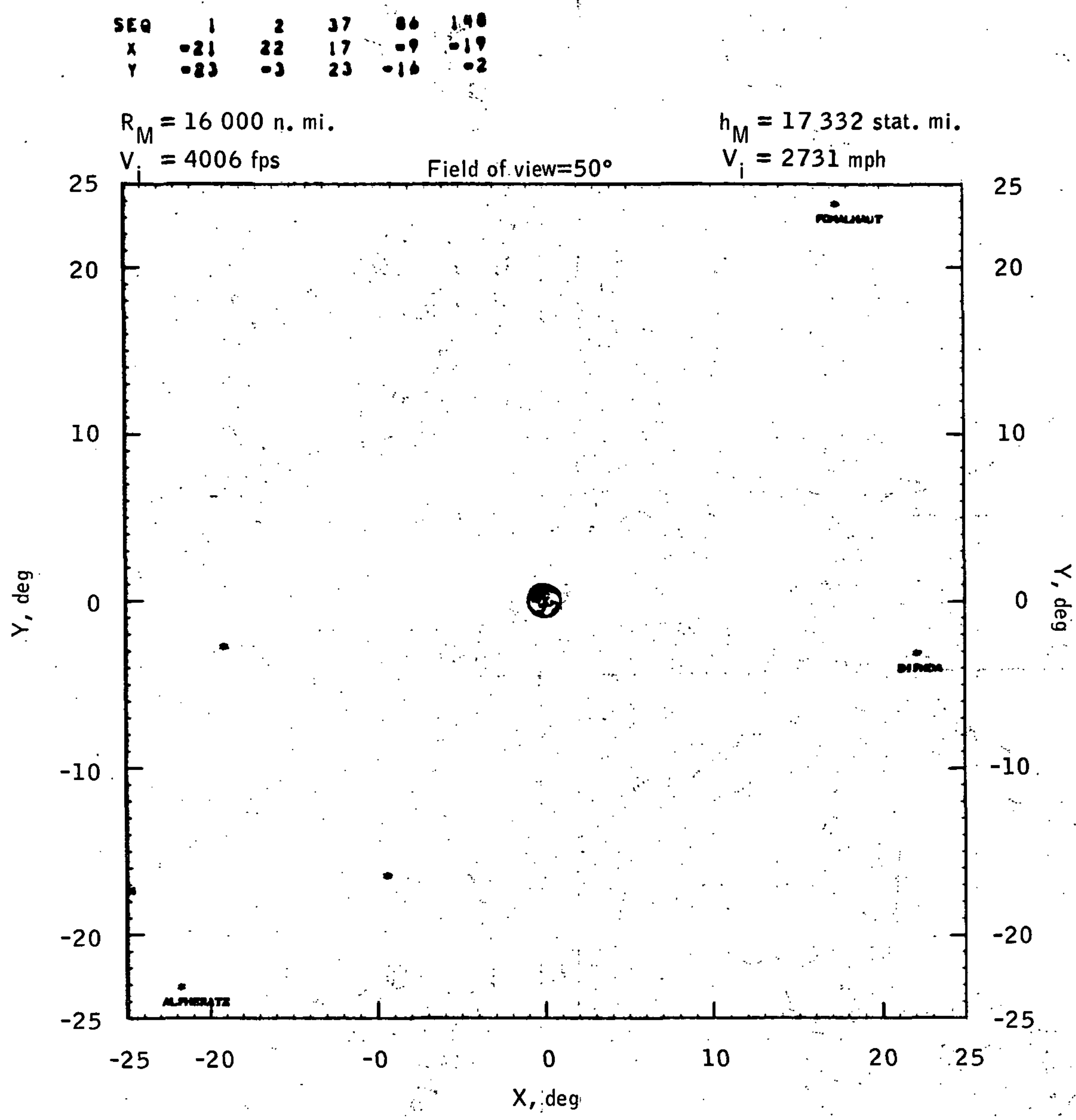
h_E = 211 071 stat. mi.

V_i = 2073 mph



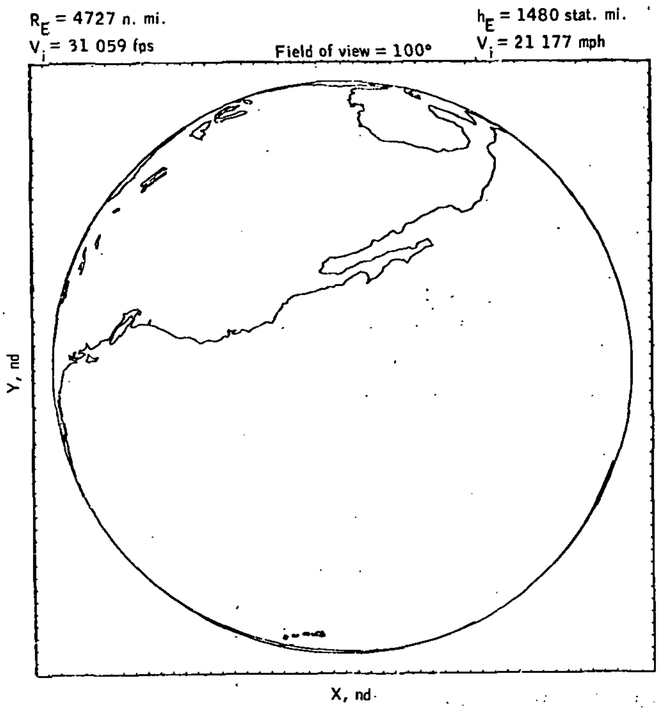
(f) g.e.t. = 60 hours.

Figure 5.2.1-1.- Continued.

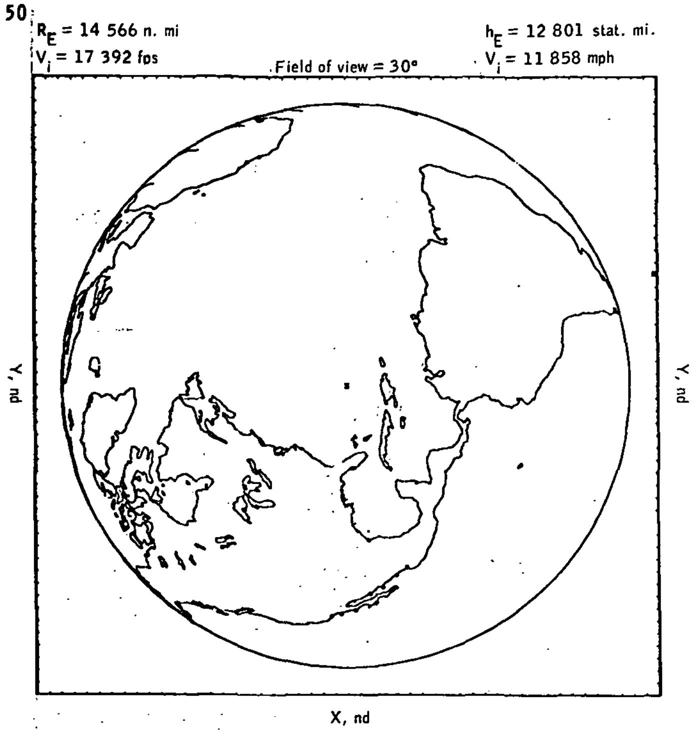


(g) g.e.t. = 70 hours.

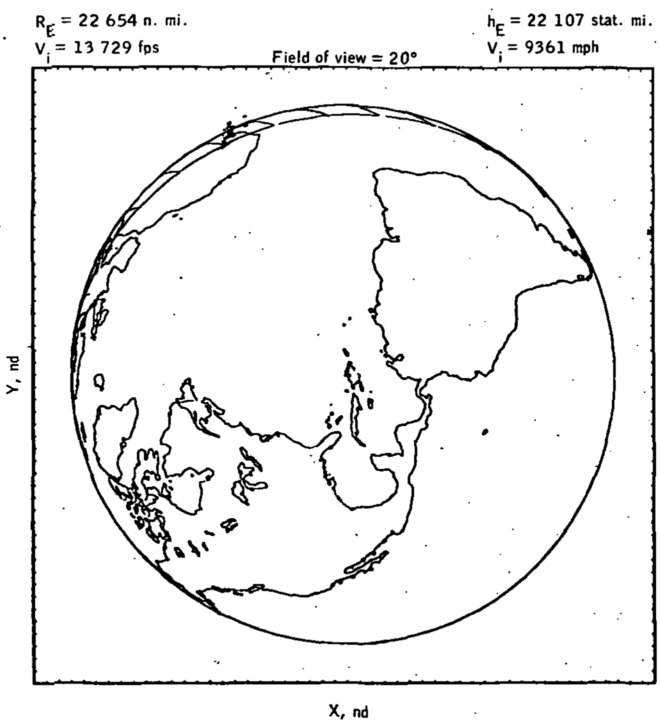
Figure 5.2.1-1.- Concluded.



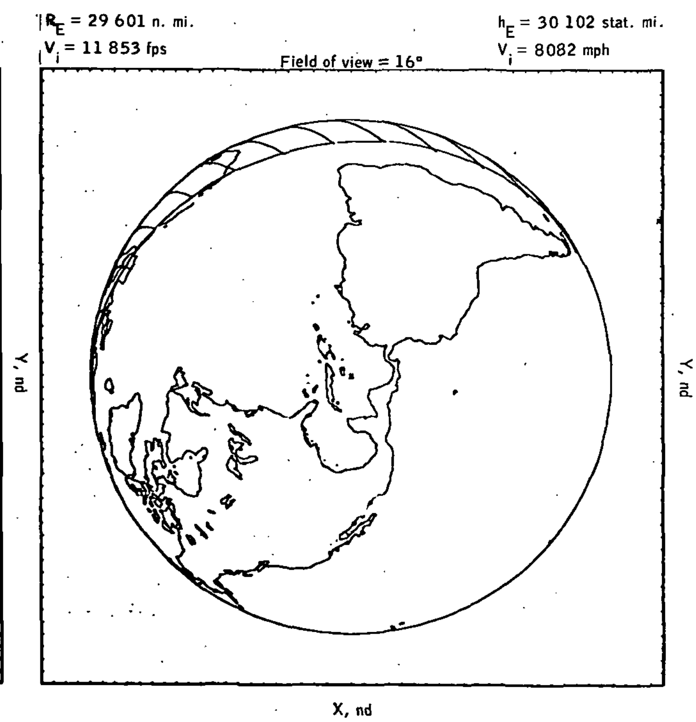
(a) g.e.t. = 3 hours.



(b) g.e.t. = 4 hours.

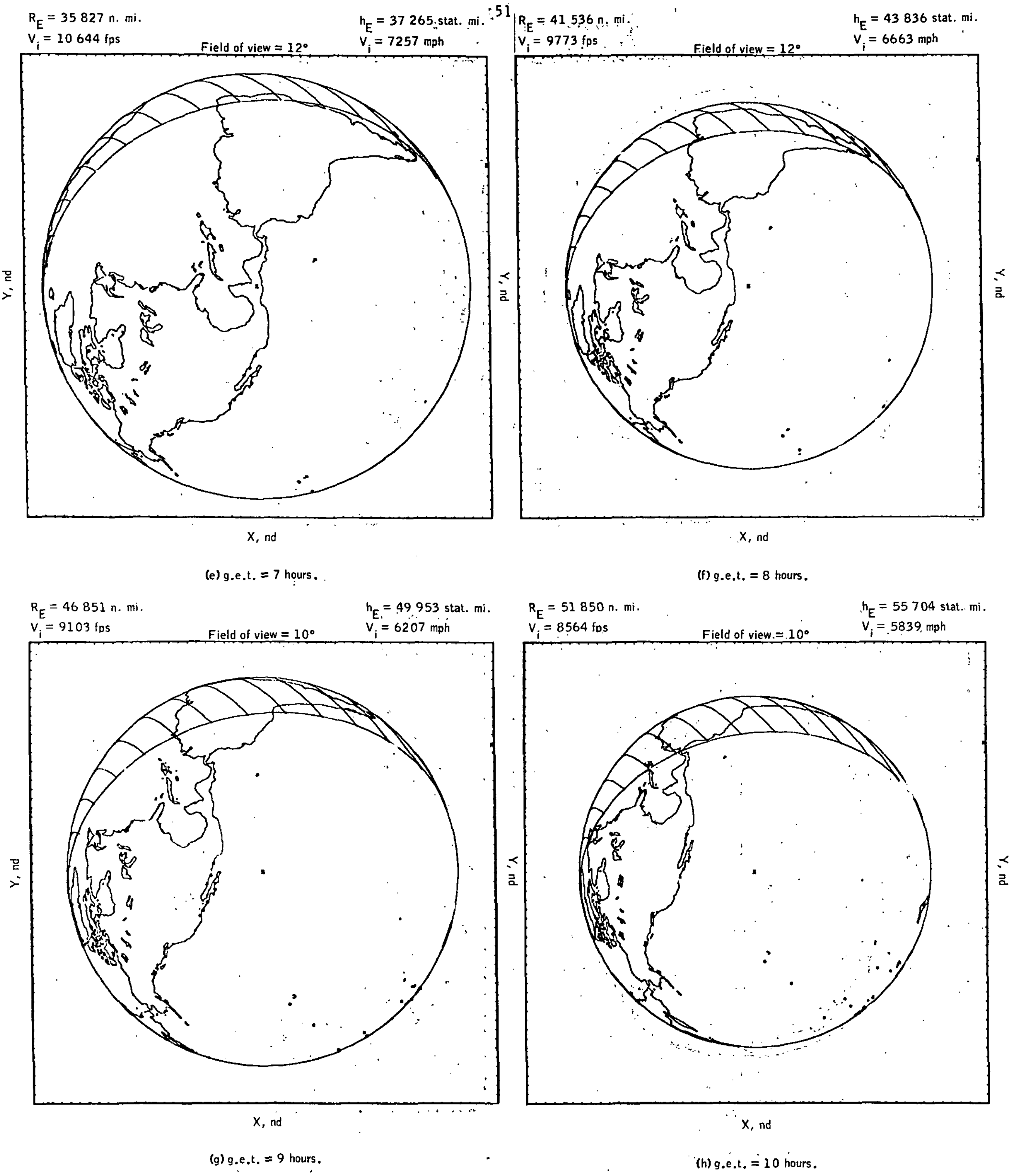


(c) g.e.t. = 5 hours.



(d) g.e.t. = 6 hours.

Figure 5.2.1-2.- Translunar coast-variable field of view (earth).



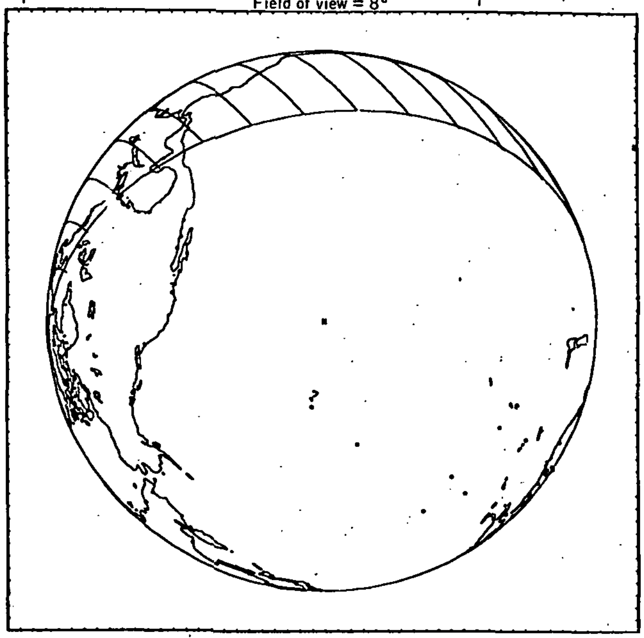
(e) g.e.t. = 7 hours.

(f) g.e.t. = 8 hours.

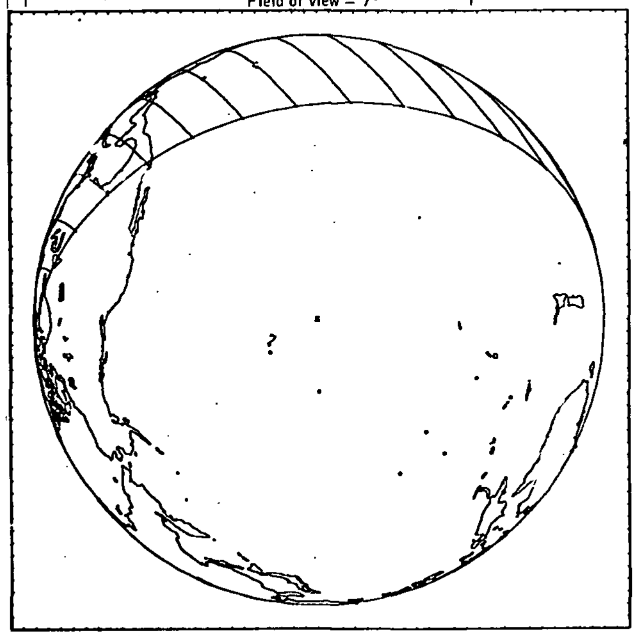
(g) g.e.t. = 9 hours.

(h) g.e.t. = 10 hours.

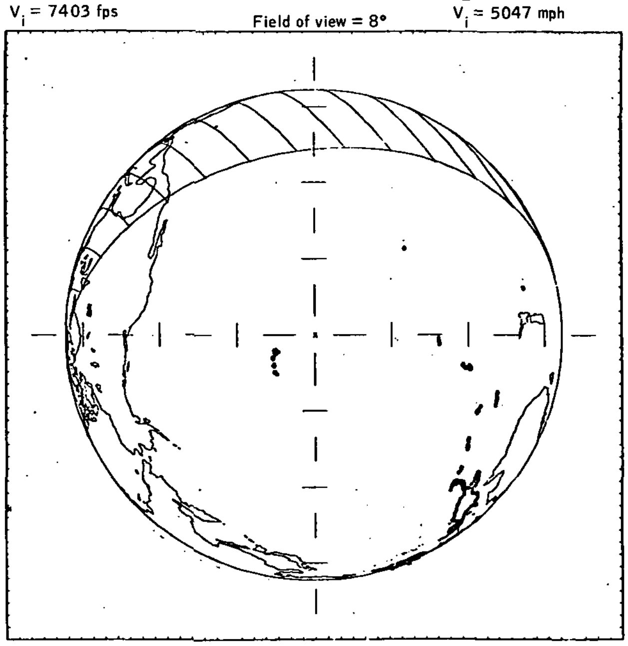
Figure 5.2.1-2.- Continued.



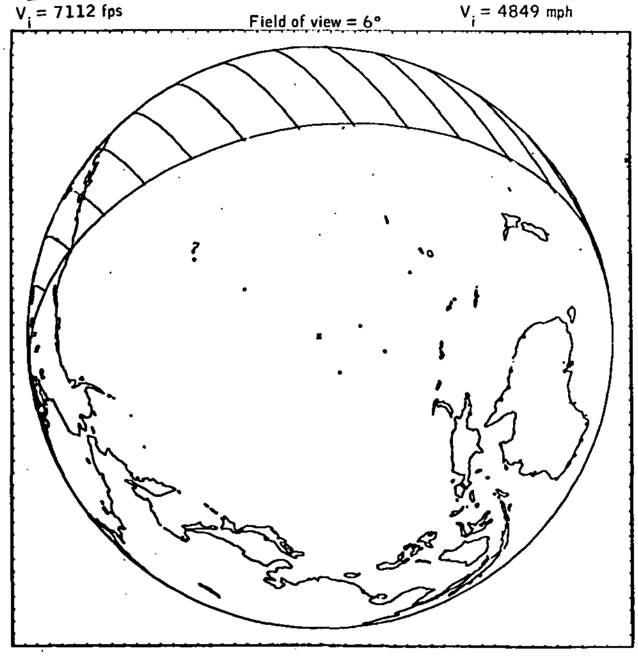
(i) g.e.t. = 11 hours.



(j) g.e.t. = 12 hours.

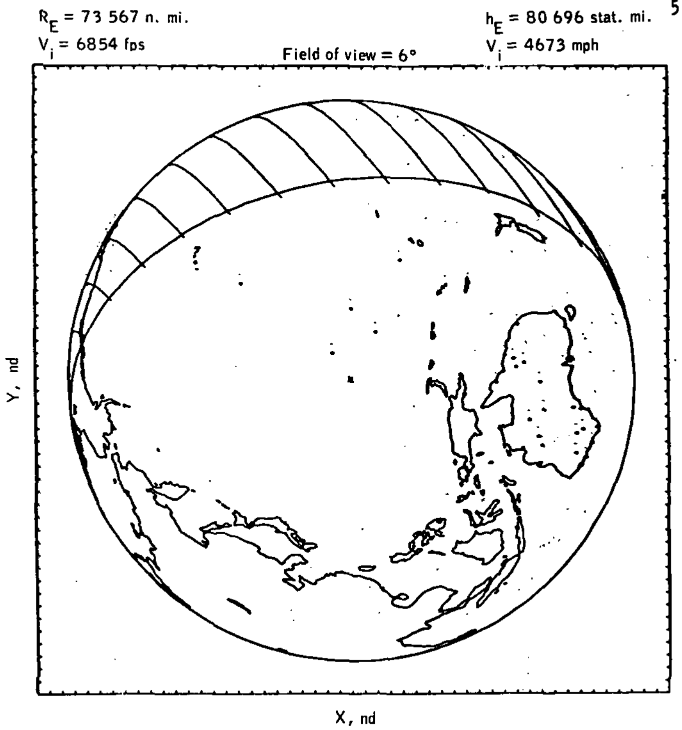


(k) g.e.t. = 13 hours.

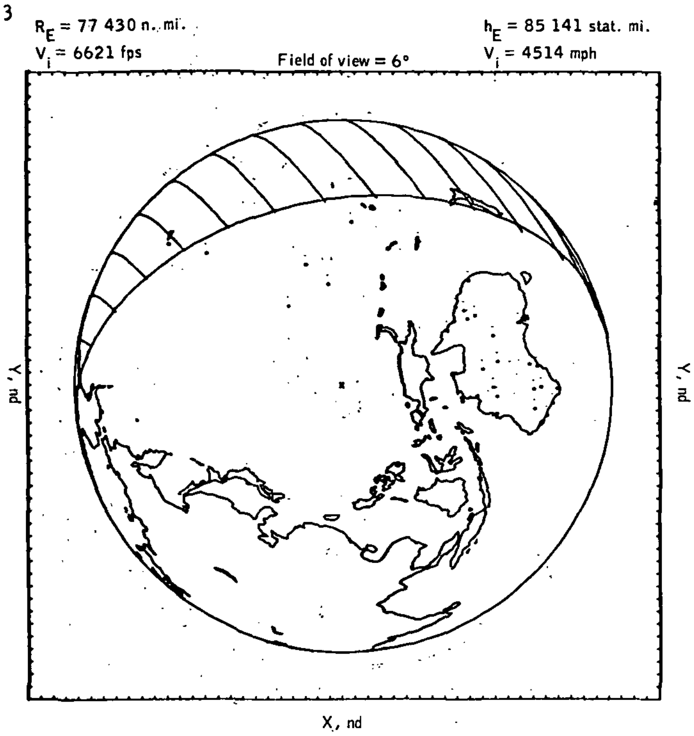


(l) g.e.t. = 14 hours.

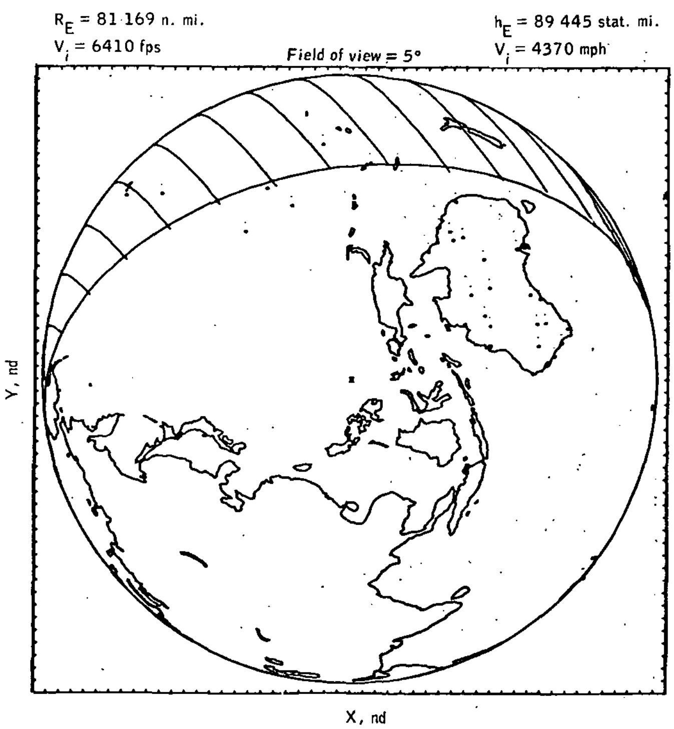
Figure 5.2.1-2.- Continued.



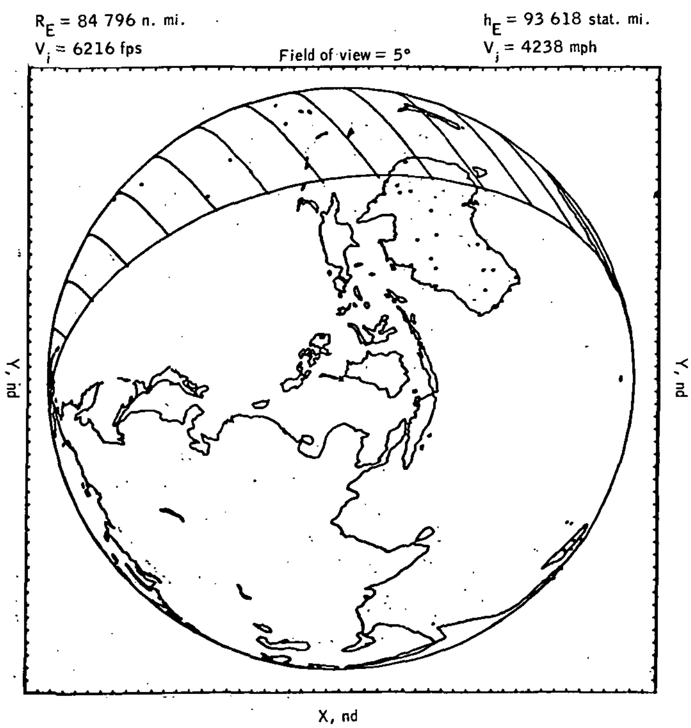
(m) g.e.t. = 15 hours.



(n) g.e.t. = 16 hours.

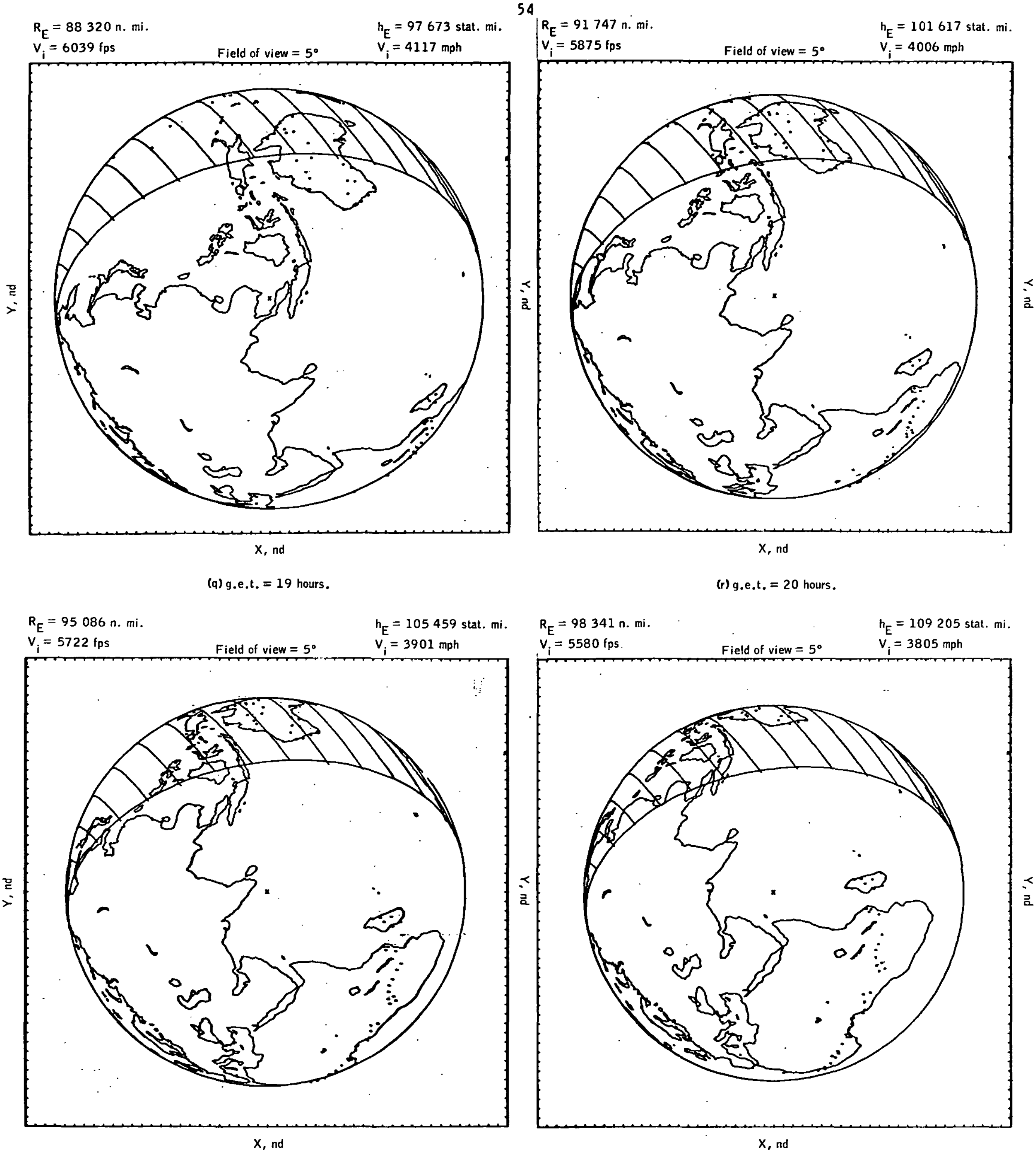


(o) g.e.t. = 17 hours.



(p) g.e.t. = 18 hours.

Figure 5.2.1-2.- Continued.



(q) g.e.t. = 19 hours.

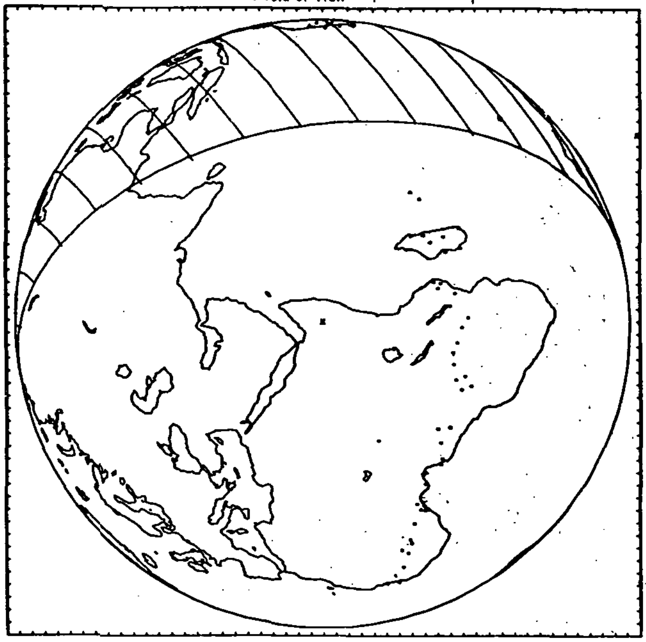
(r) g.e.t. = 20 hours.

(s) g.e.t. = 21 hours.

(t) g.e.t. = 22 hours.

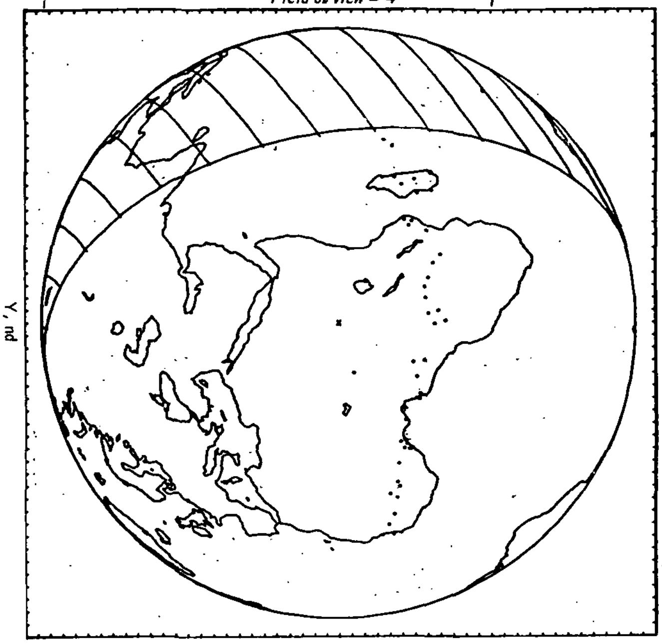
Figure 5.2.1-2.- Continued.

R_E = 101 519 n. mi.
V_i = 5446 fps
Field of view = 4°
h_E = 112 862 stat. mi.
V_i = 3713 mph



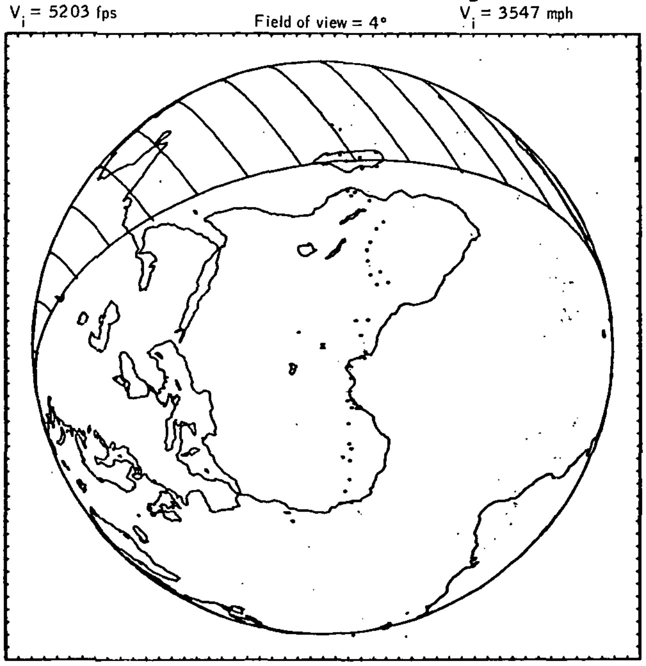
(u) g.e.t. = 23 hours.

R_E = 104 623 n. mi.
V_i = 5321 fps
Field of view = 4°
h_E = 116 434 stat. mi.
V_i = 3628 mph



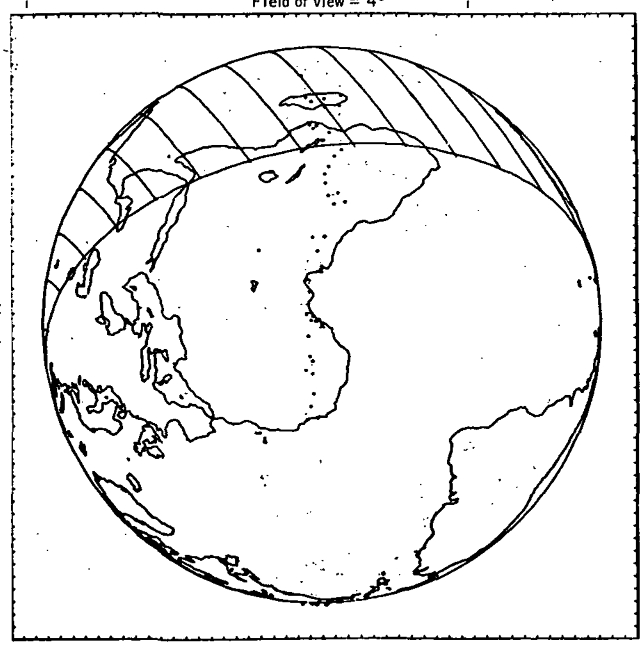
(v) g.e.t. = 24 hours.

R_E = 107 659 n. mi.
V_i = 5203 fps
Field of view = 4°
h_E = 119 928 stat. mi.
V_i = 3547 mph



(w) g.e.t. = 25 hours.

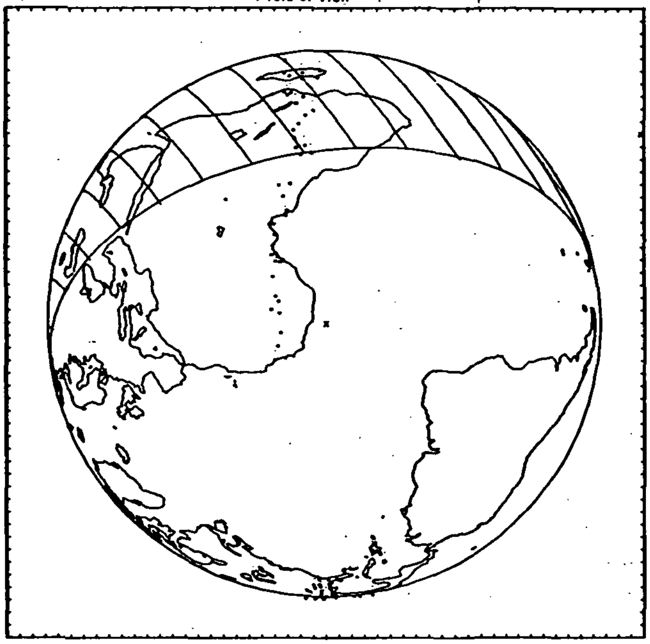
R_E = 110 629 n. mi.
V_i = 5091 fps
Field of view = 4°
h_E = 123 345 stat. mi.
V_i = 3471 mph



(x) g.e.t. = 26 hours.

Figure 5.2.1-2.- Continued.

R_E = 113 537 n. mi. h_E = 126 692 stat. mi.
V_i = 4985 fps Field of view = 4° V_i = 3399 mph

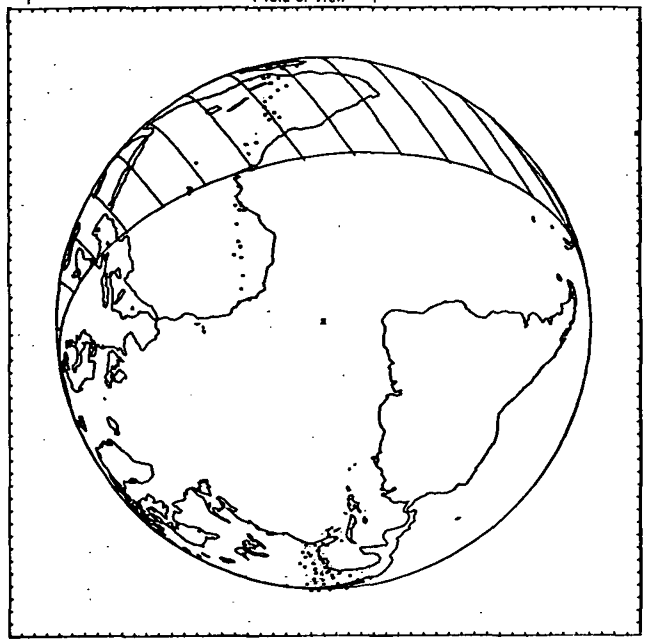


Y, nd

X, nd

(y) g.e.t. = 27 hours.

R_E = 116 387 n. mi. h_E = 129 972 stat. mi.
V_i = 4884 fps Field of view = 4° V_i = 3330 mph

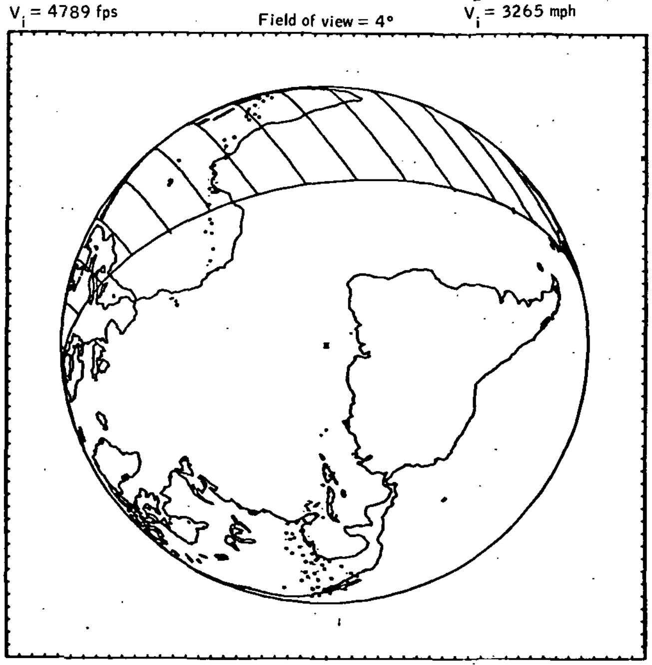


Y, nd

X, nd

(z) g.e.t. = 28 hours.

R_E = 119 180 n. mi. h_E = 133 186 stat. mi.
V_i = 4789 fps Field of view = 4° V_i = 3265 mph

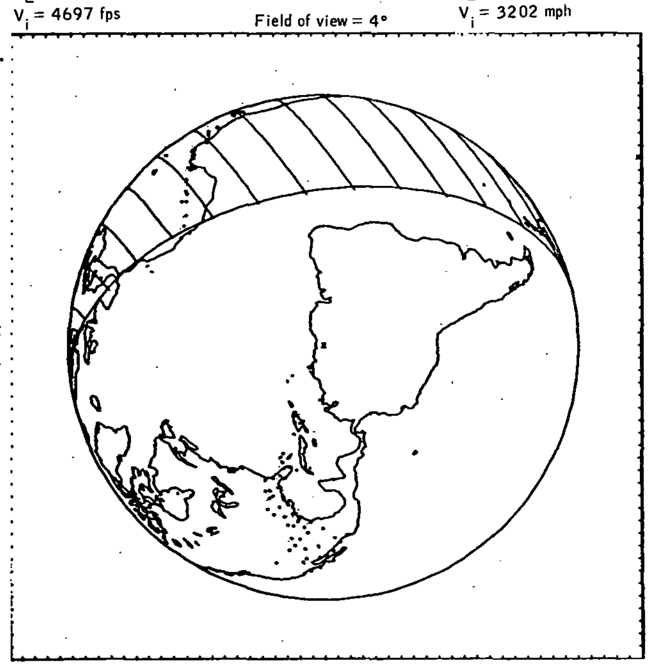


Y, nd

X, nd

(aa) g.e.t. = 29 hours.

R_E = 121 920 n. mi. h_E = 136 339 stat. mi.
V_i = 4697 fps Field of view = 4° V_i = 3202 mph

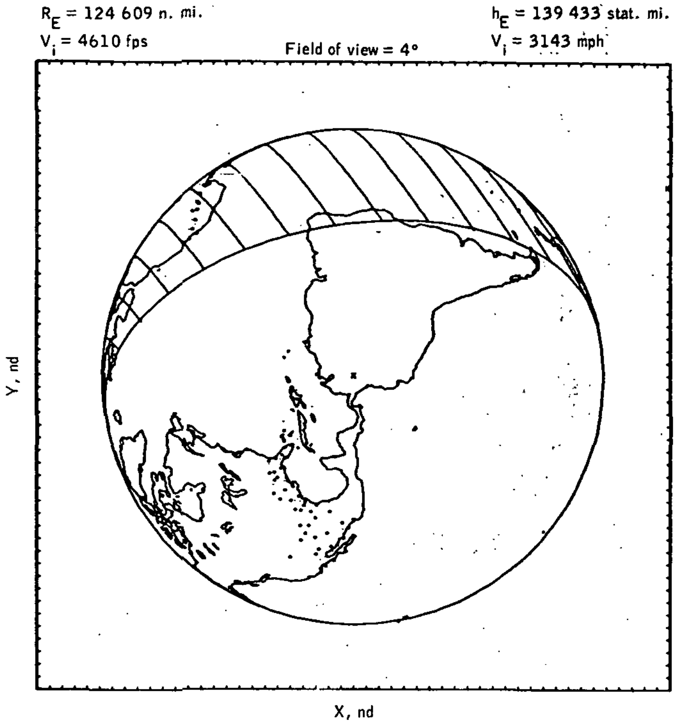


Y, nd

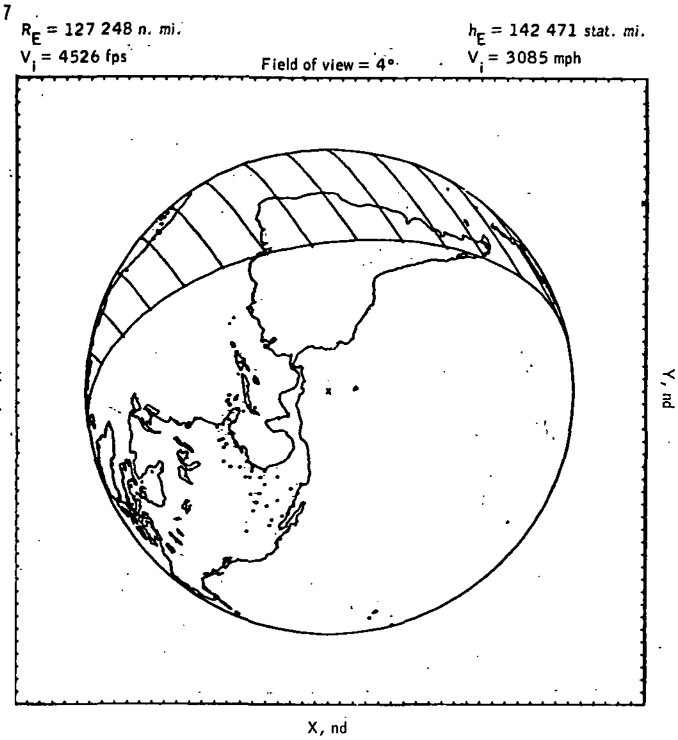
X, nd

(bb) g.e.t. = 30 hours.

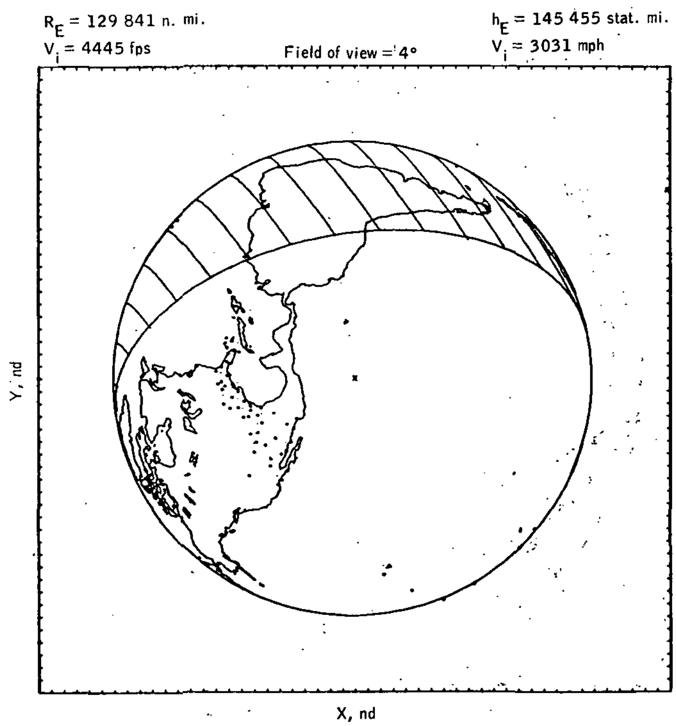
Figure 5.2.1-2.- Continued.



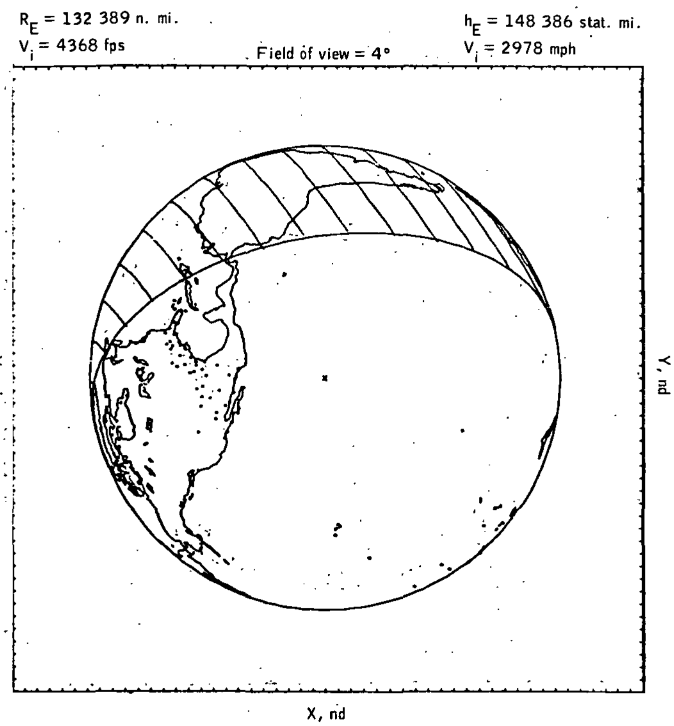
(cc) g.e.t. = 31 hours.



(dd) g.e.t. = 32 hours.

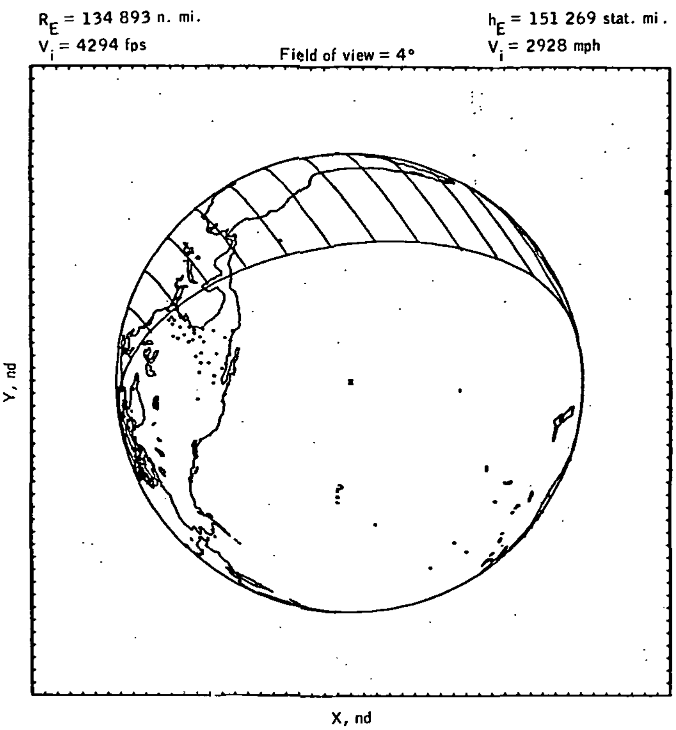


(ee) g.e.t. = 33 hours.

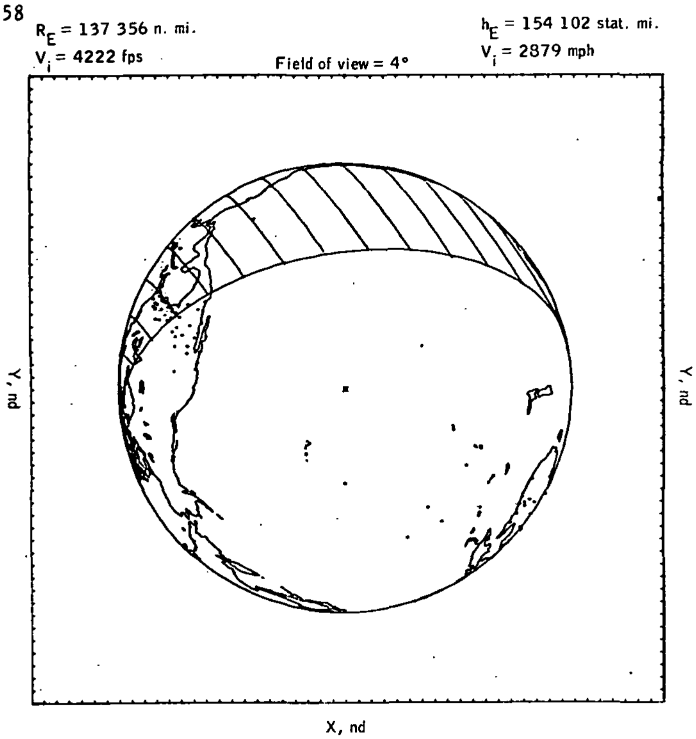


(ff) g.e.t. = 34 hours.

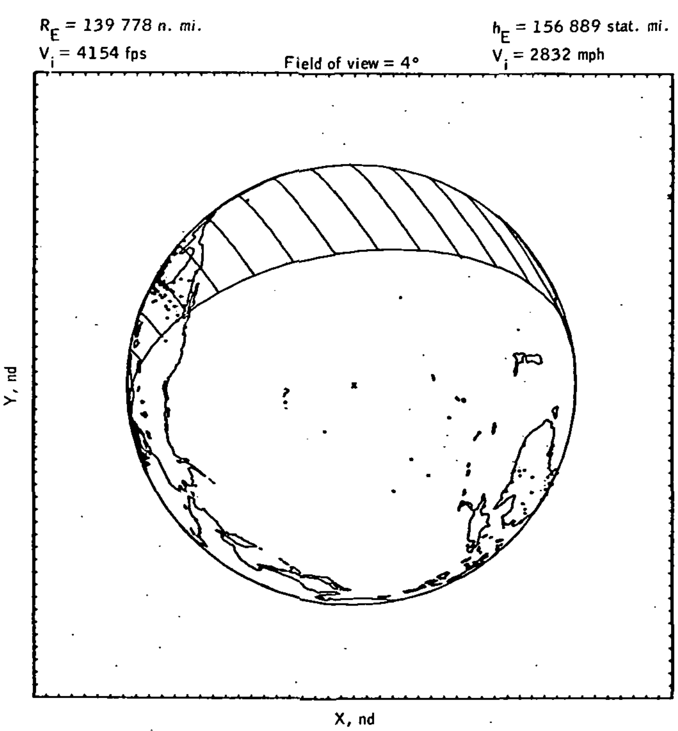
Figure 5.2.1-2.- Continued.



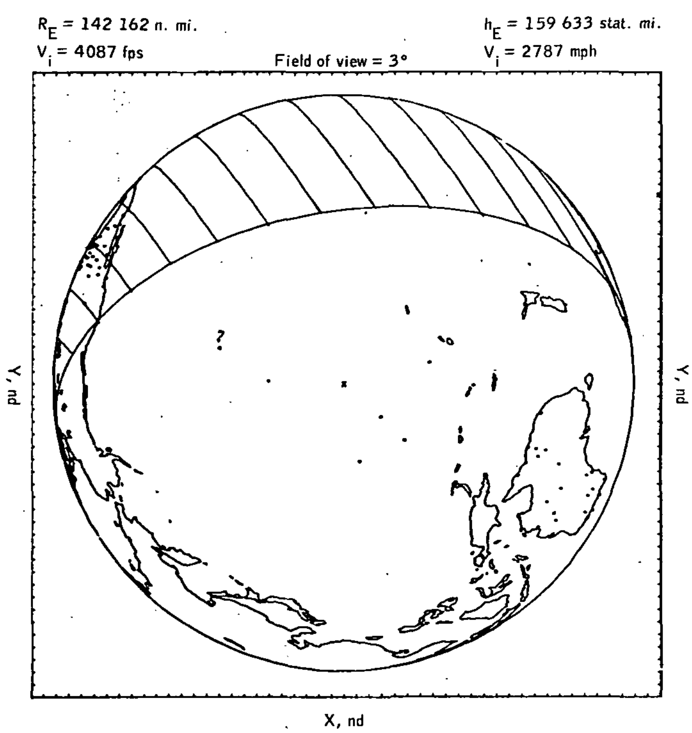
(gg) g.e.t. = 35 hours.



(hh) g.e.t. = 36 hours.

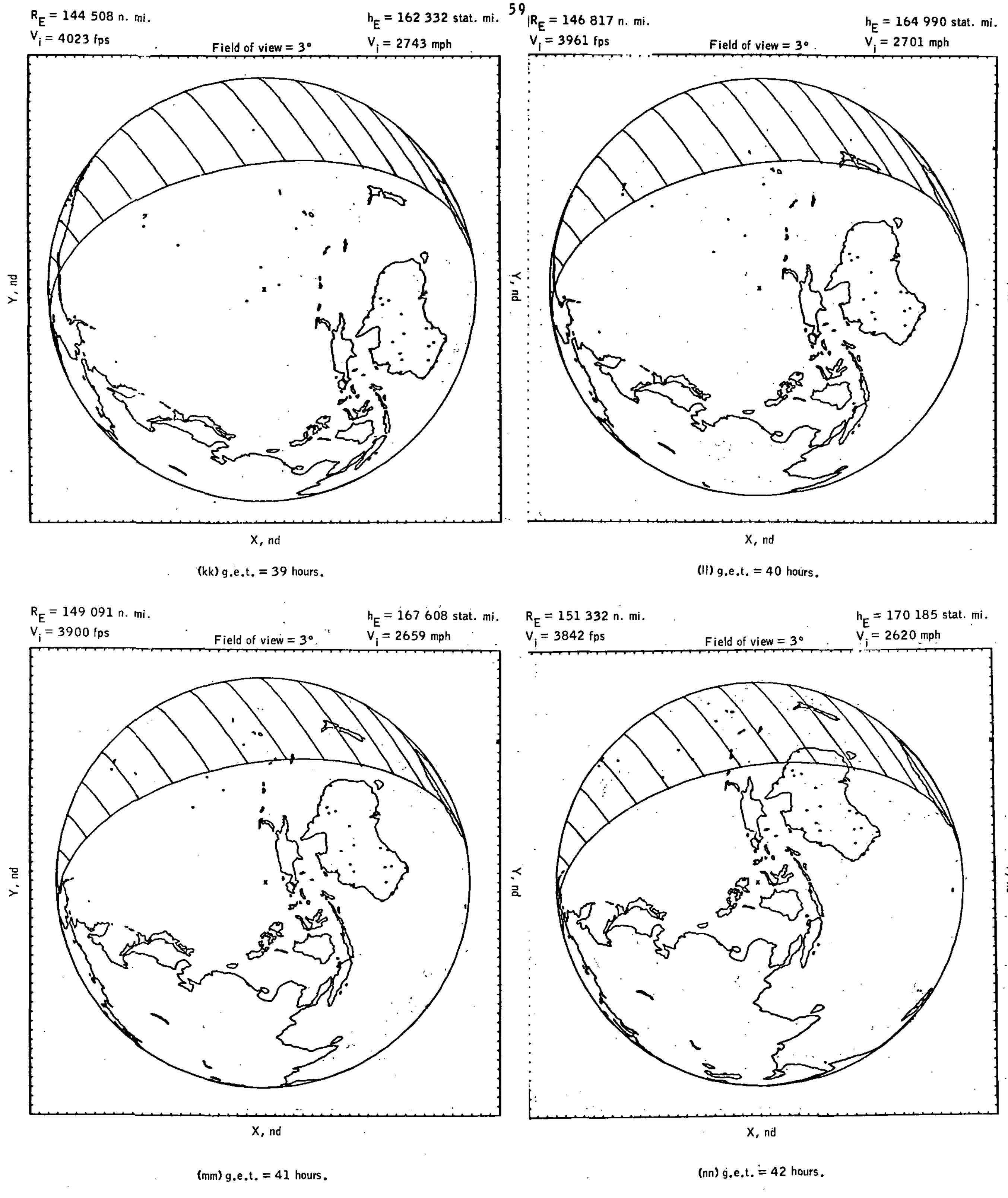


(ii) g.e.t. = 37 hours.



(jj) g.e.t. = 38 hours.

Figure 5.2.1-2.- Continued.



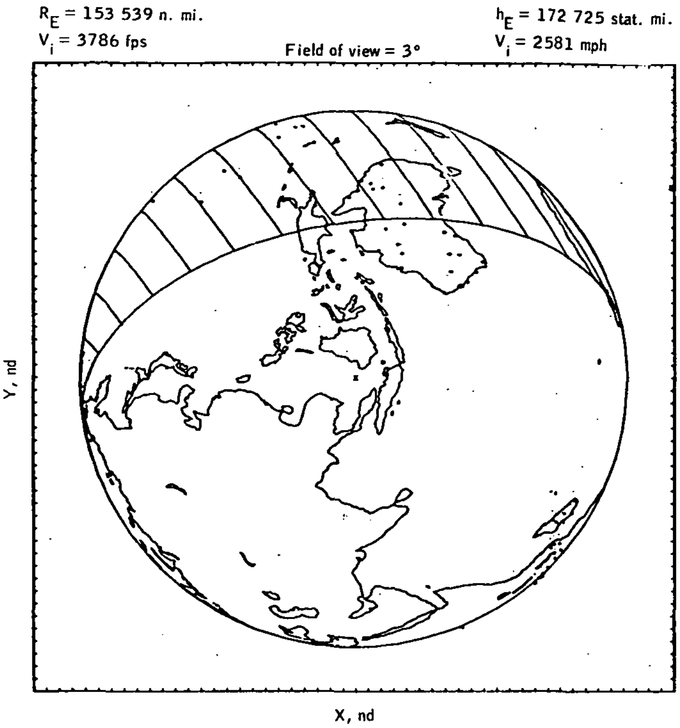
(kk) g.e.t. = 39 hours.

(ll) g.e.t. = 40 hours.

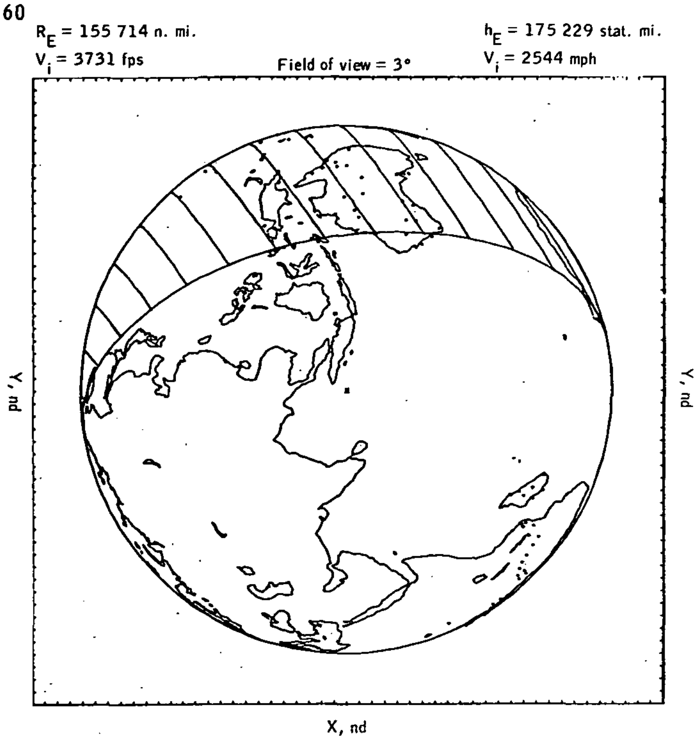
(mm) g.e.t. = 41 hours.

(nn) g.e.t. = 42 hours.

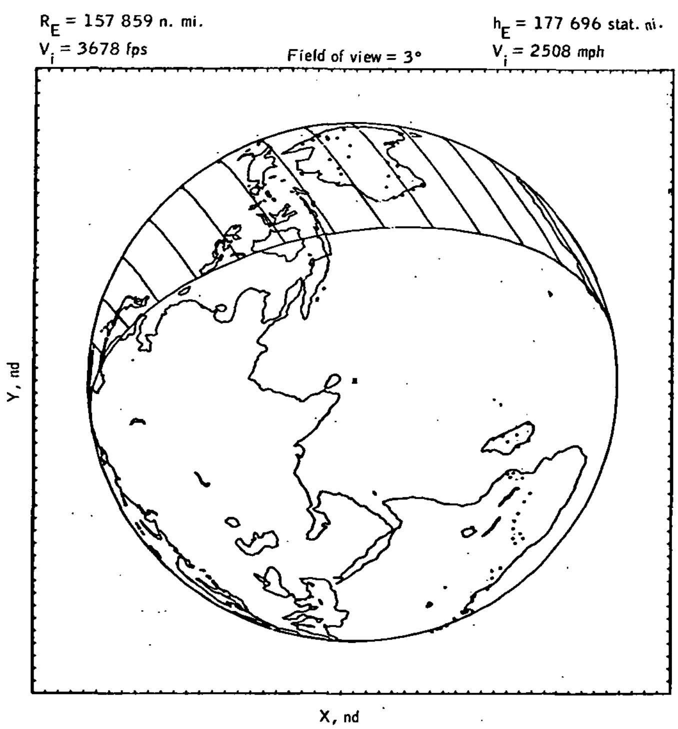
Figure 5.2.1-2.- Continued.



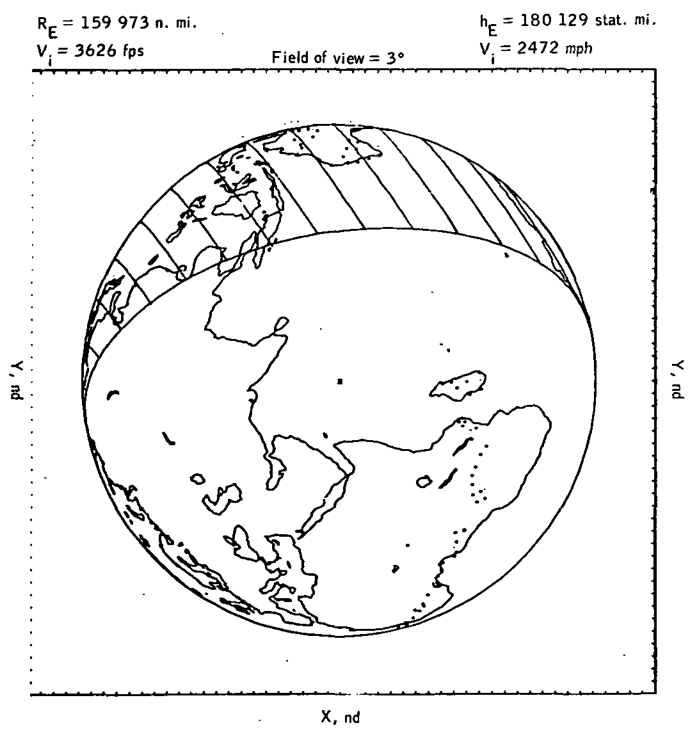
(oo) g.e.t. = 43 hours.



(pp) g.e.t. = 44 hours.



(qq) g.e.t. = 45 hours.



(rr) g.e.t. = 46 hours.

Figure 5.2.1-2.- Continued.

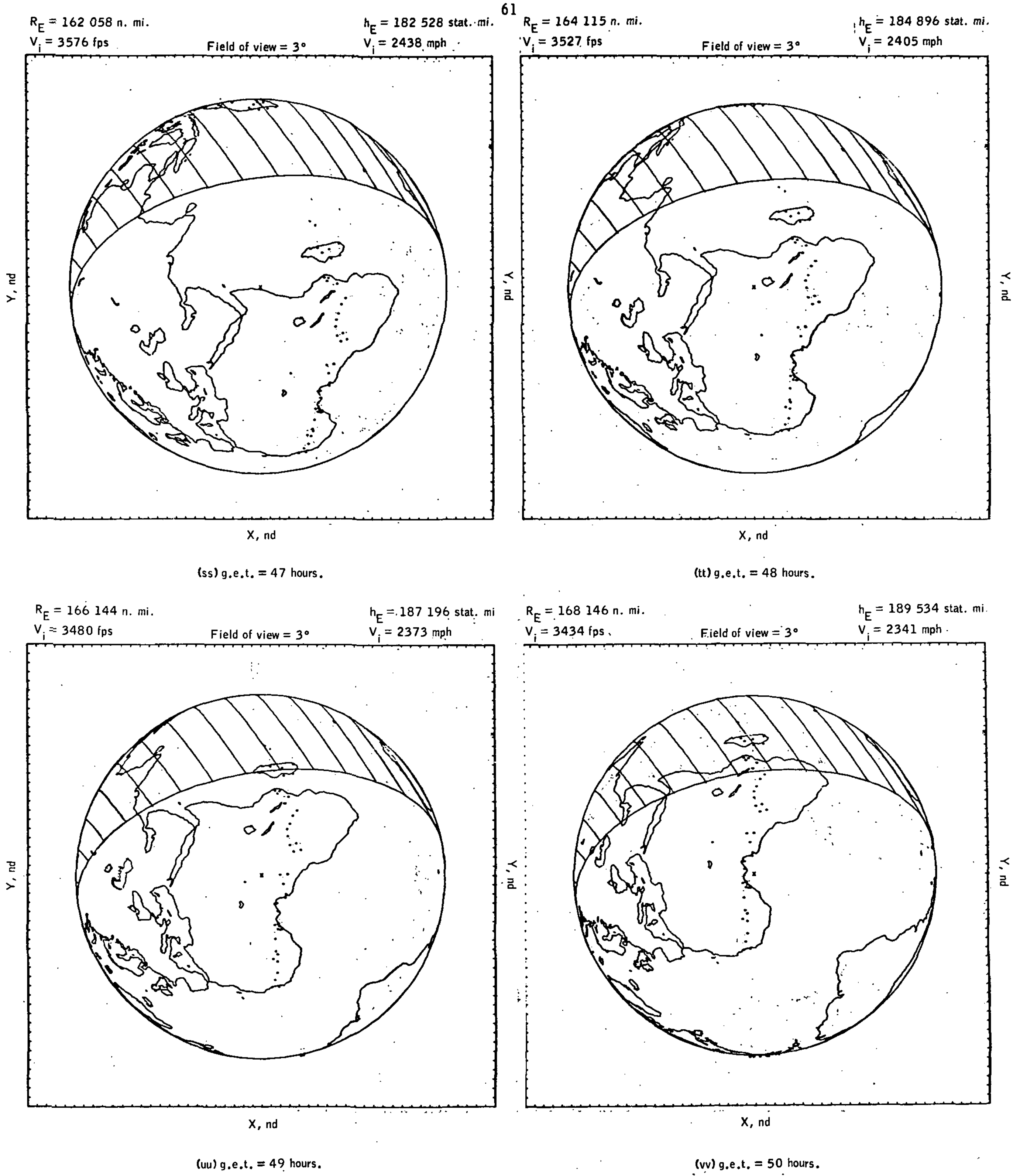
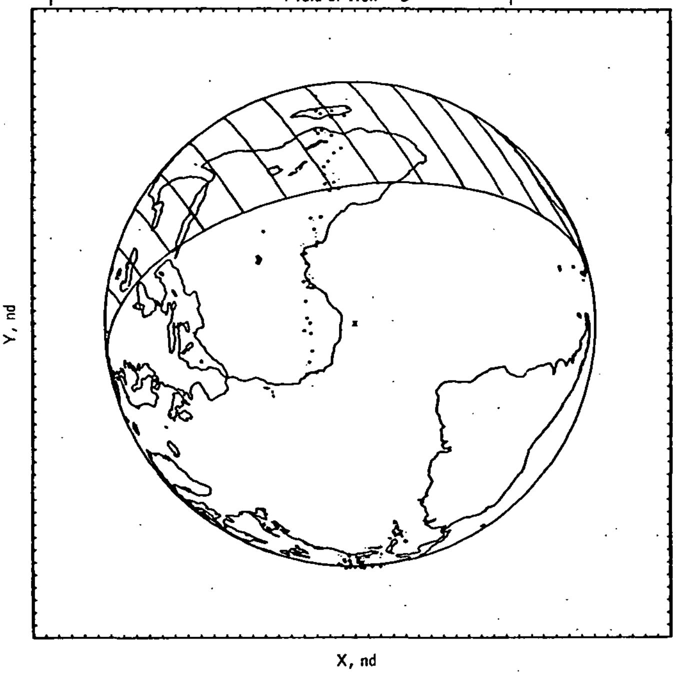


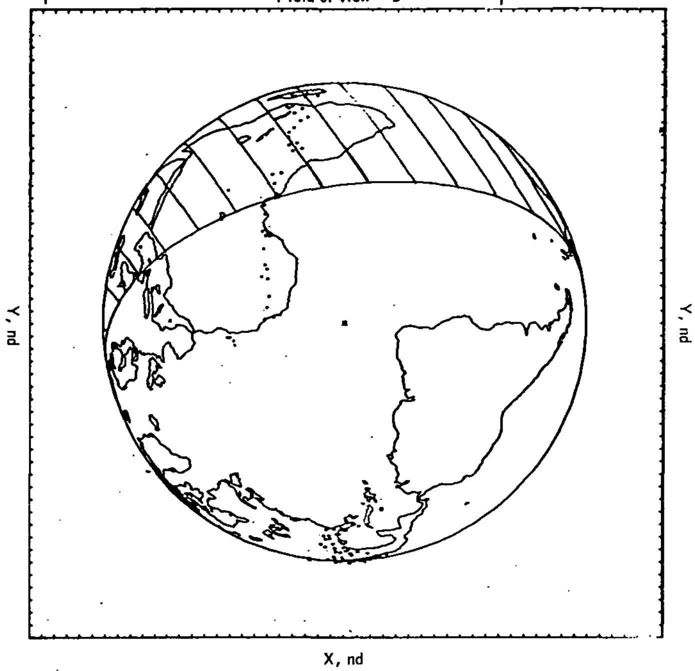
Figure 5.2.1-2.- Continued.

R_E = 170 122 n. mi. h_E = 191 809 stat. mi.
V_i = 3389 fps Field of view = 3° V_i = 2311 mph



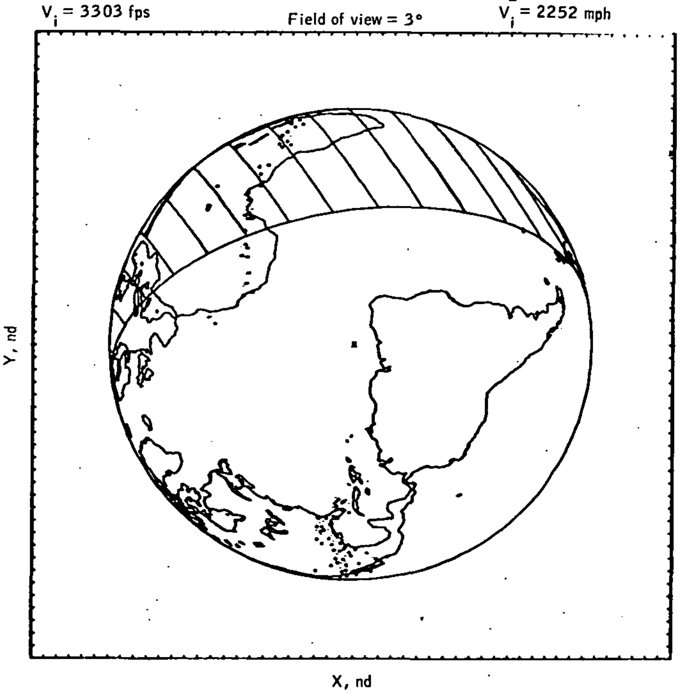
(ww) g.e.t. = 51 hours.

R_E = 172 074 n. mi. h_E = 194 055 stat. mi.
V_i = 3345 fps Field of view = 3° V_i = 2281 mph



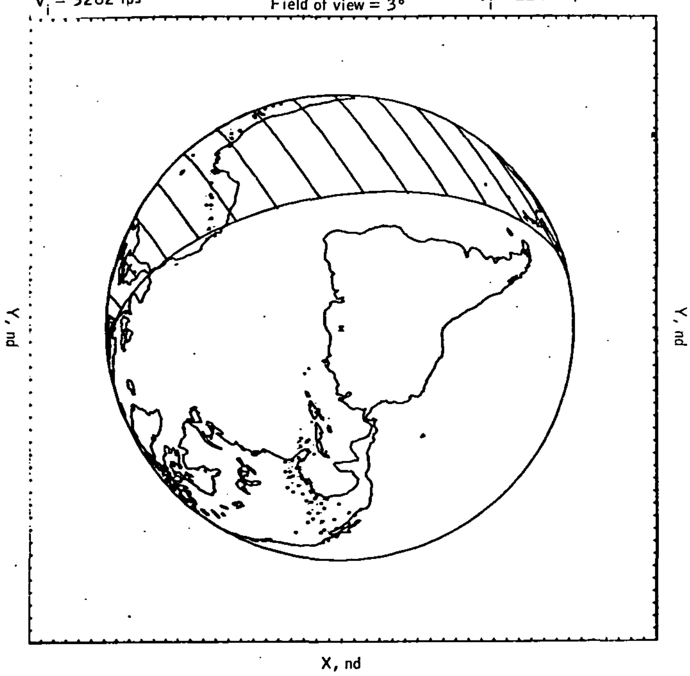
(xx) g.e.t. = 52 hours.

R_E = 174 000 n. mi. h_E = 196 271 stat. mi.
V_i = 3303 fps Field of view = 3° V_i = 2252 mph



(yy) g.e.t. = 53 hours.

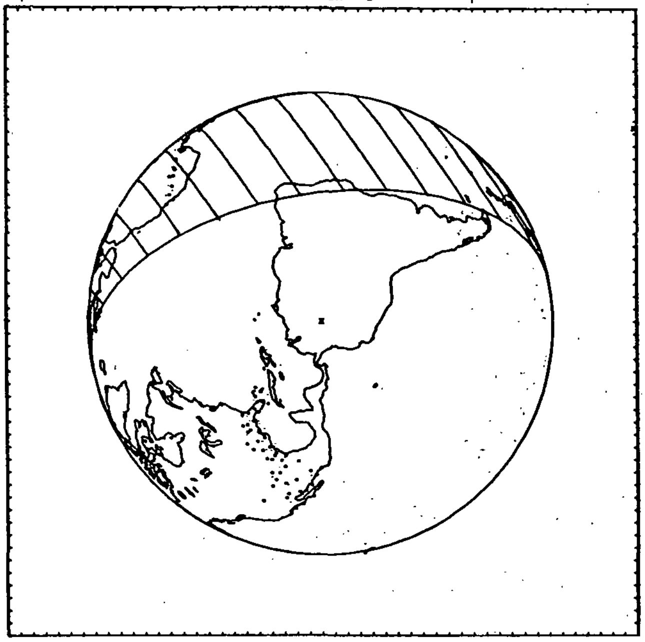
R_E = 175 903 n. mi. h_E = 198 461 stat. mi.
V_i = 3262 fps Field of view = 3° V_i = 2224 mph



(zz) g.e.t. = 54 hours.

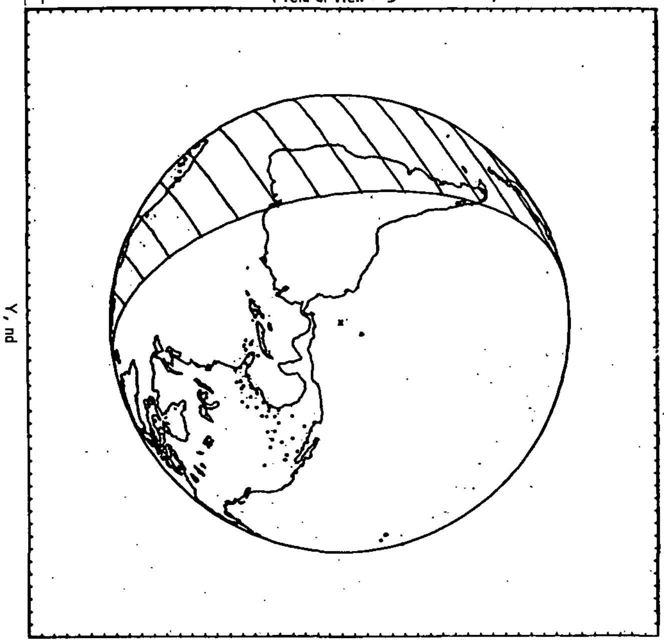
Figure 5.2.1-2.- Continued.

R_E = 177 783 n. mi.
V_i = 3222 fps
Field of view = 3°
h_E = 200 624 stat. mi.
V_i = 2197 mph



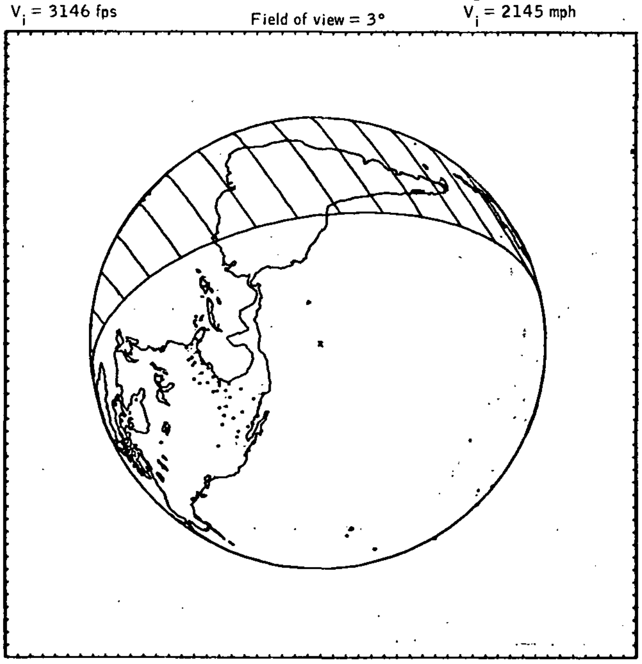
(aaa) g.e.t. = 55 hours.

R_E = 179 640 n. mi.
V_i = 3183 fps
Field of view = 3°
h_E = 202 761 stat. mi.
V_i = 2170 mph



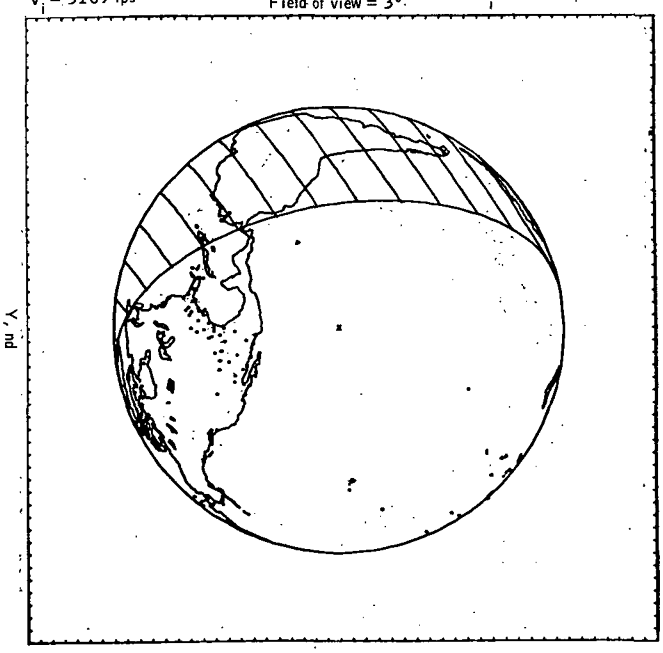
(bbb) g.e.t. = 56 hours.

R_E = 181 476 n. mi.
V_i = 3146 fps
Field of view = 3°
h_E = 204 874 stat. mi.
V_i = 2145 mph



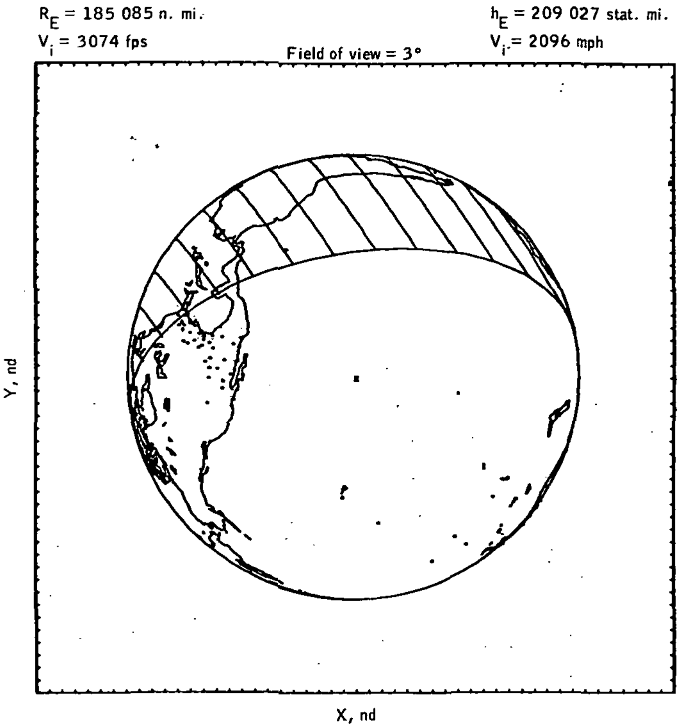
(ccc) g.e.t. = 57 hours.

R_E = 183 291 n. mi.
V_i = 3109 fps
Field of view = 3°
h_E = 206 963 stat. mi.
V_i = 2120 mph

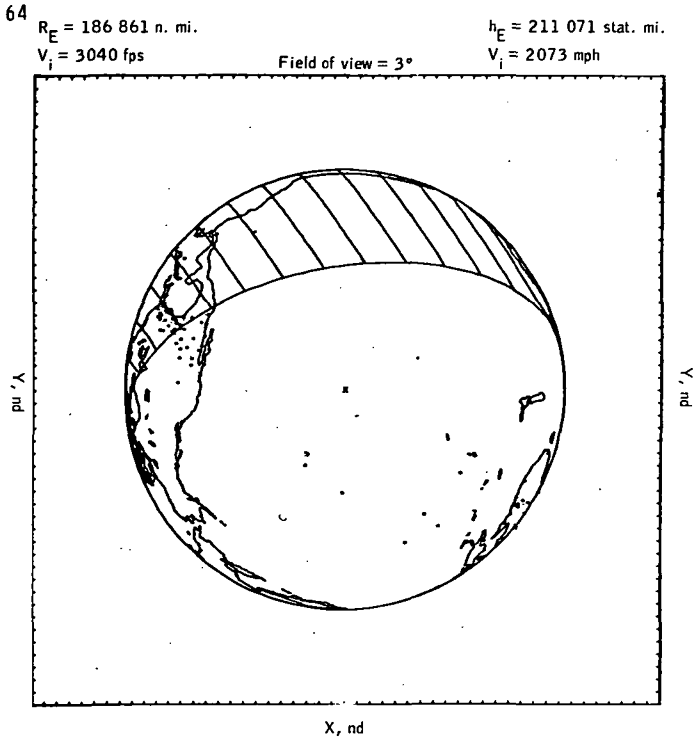


(ddd) g.e.t. = 58 hours.

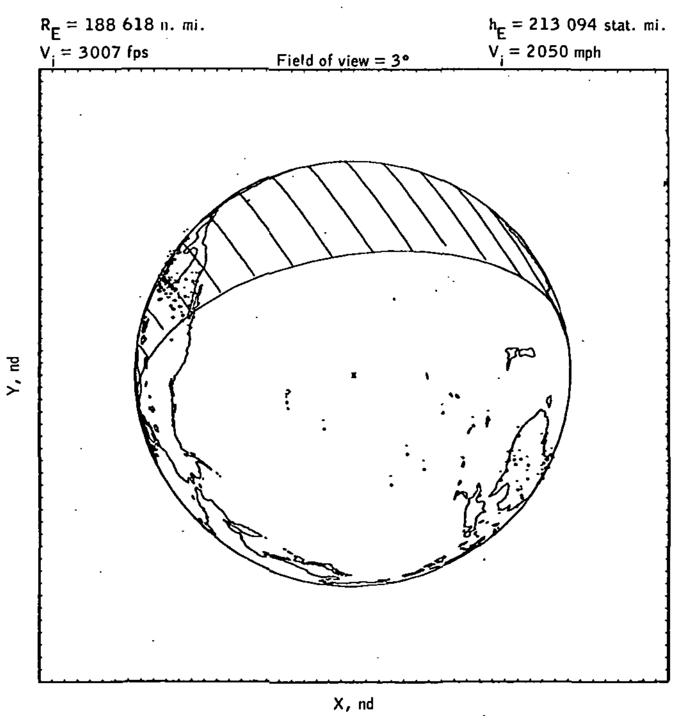
Figure 5.2.1-2.- Continued.



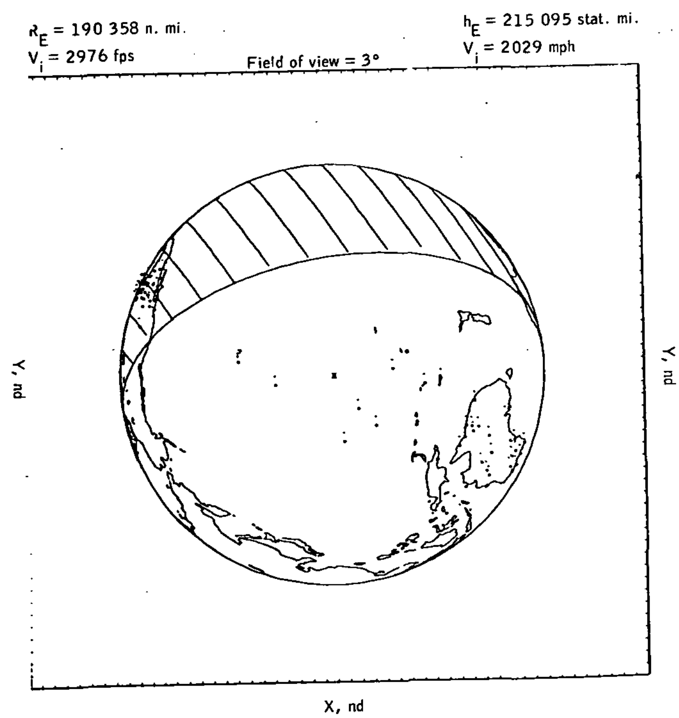
(eee) g.e.t. = 59 hours.



(fff) g.e.t. = 60 hours.

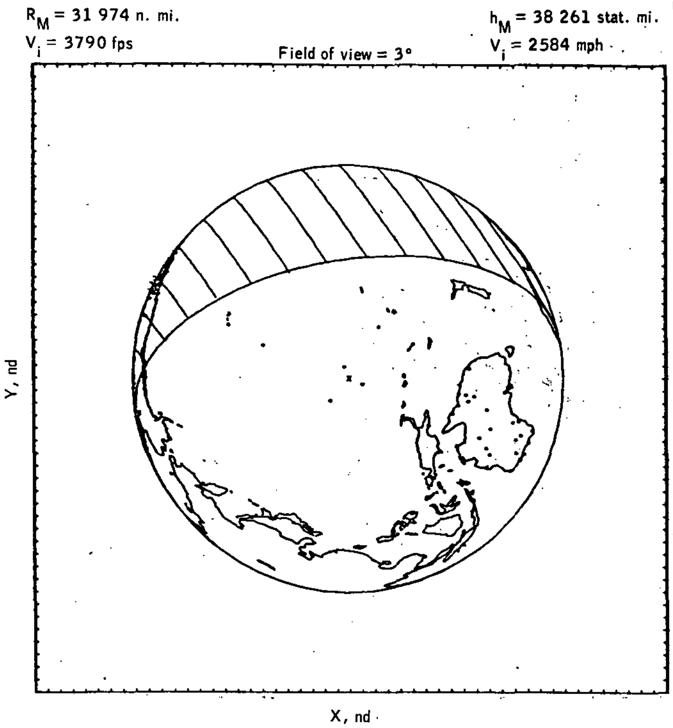


(ggg) g.e.t. = 61 hours.

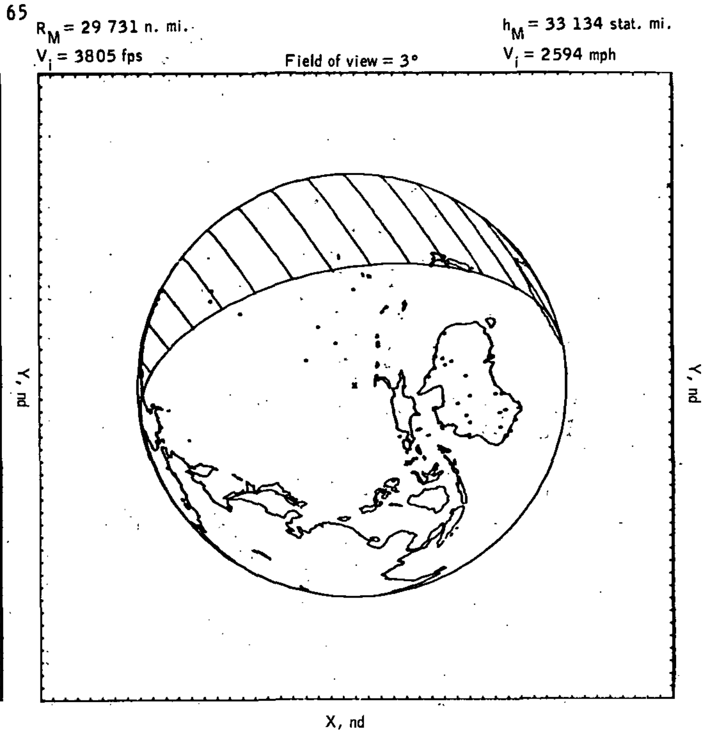


(hhh) g.e.t. = 62 hours.

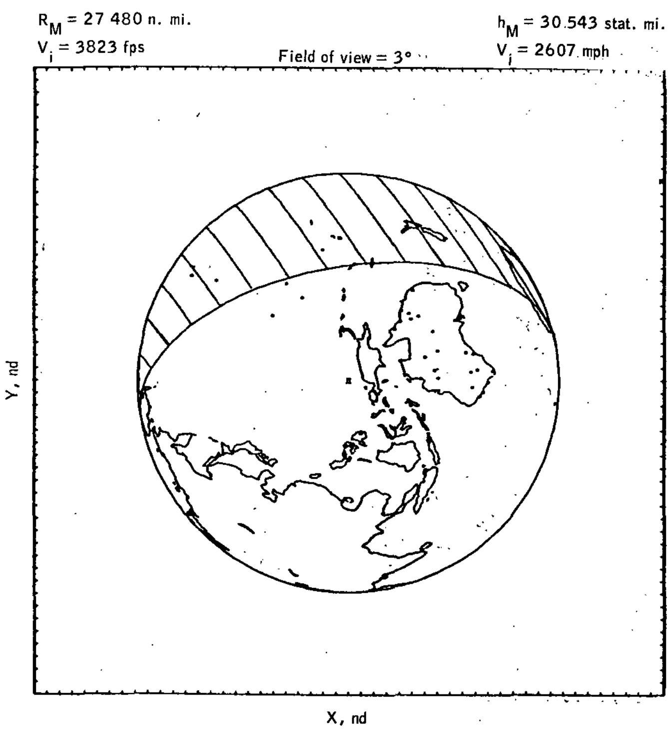
Figure 5.2.1-2.- Continued.



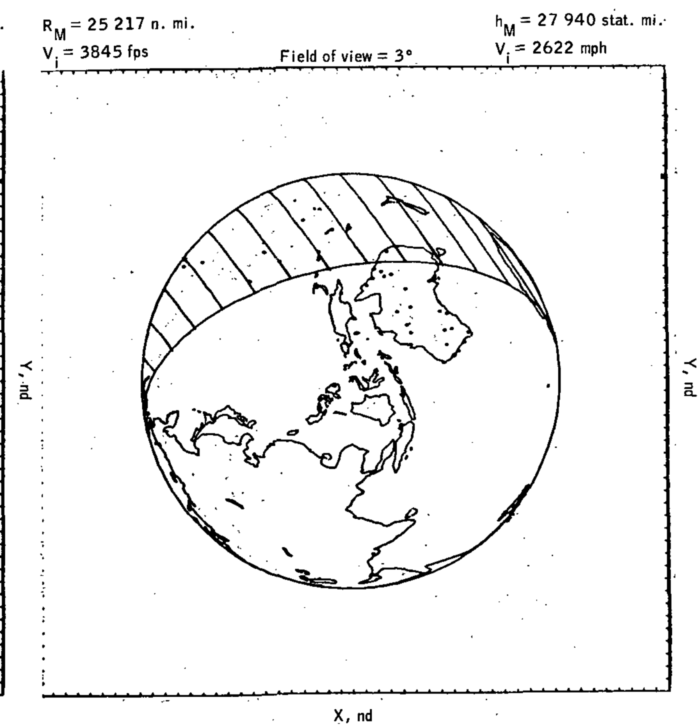
(iii) g.e.t. = 63 hours.



(jjj) g.e.t. = 64 hours.



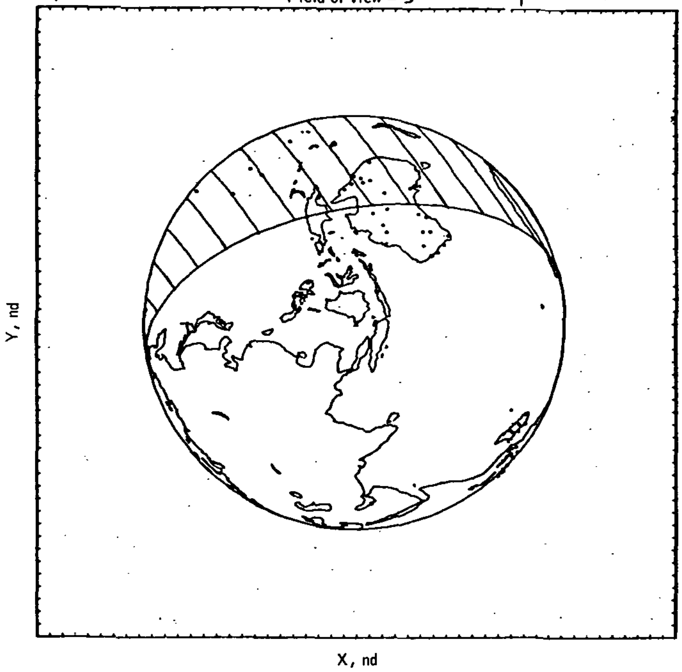
(kkk) g.e.t. = 65 hours.



(lll) g.e.t. = 66 hours.

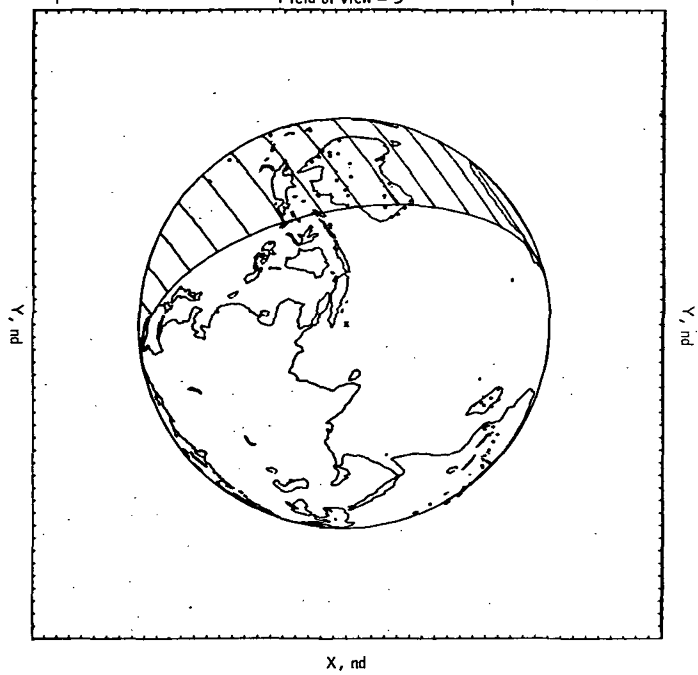
Figure 5.2.1-2.- Continued.

R_M = 22 942 n. mi.
V_i = 3872 fps
Field of view = 3°
h_M = 25 320 stat. mi.
V_i = 2640 mph



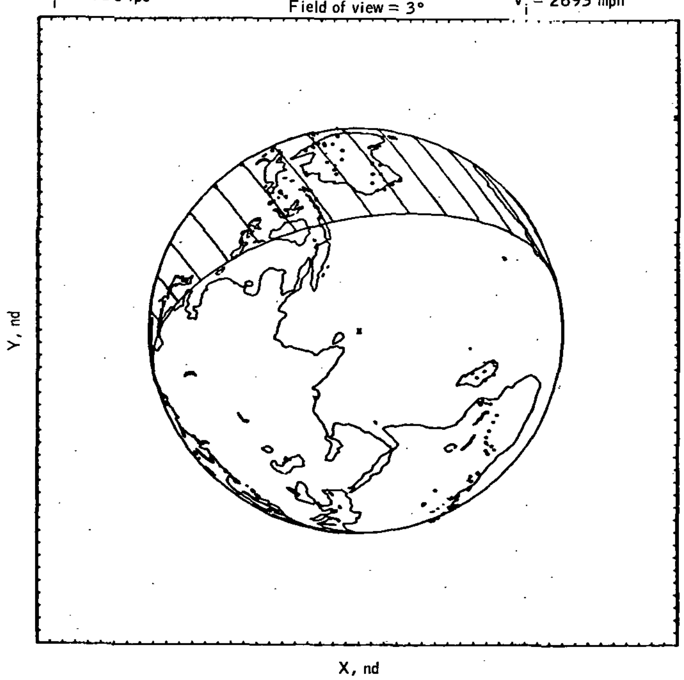
(mmm) g.e.t. = 67 hours.

R_M = 20 649 n. mi.
V_i = 3907 fps
Field of view = 3°
h_M = 22 683 stat. mi.
V_i = 2664 mph



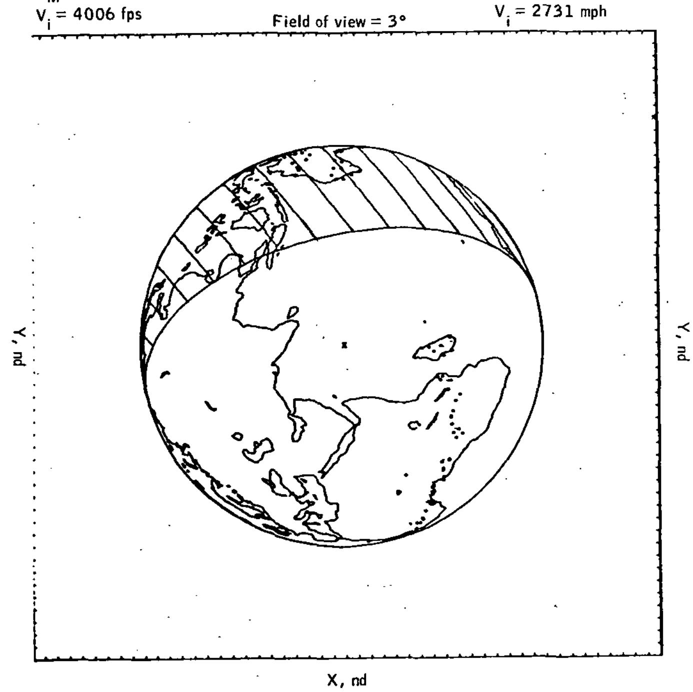
(nnn) g.e.t. = 68 hours.

R_M = 18 337 n. mi.
V_i = 3950 fps
Field of view = 3°
h_M = 20 349 stat. mi.
V_i = 2693 mph



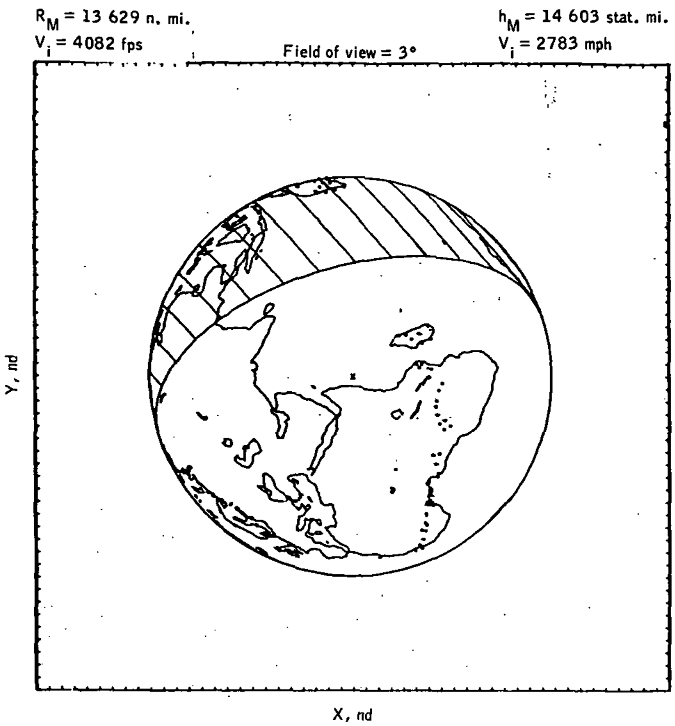
(ooo) g.e.t. = 69 hours.

R_M = 16 000 n. mi.
V_i = 4006 fps
Field of view = 3°
h_M = 17 332 stat. mi.
V_i = 2731 mph

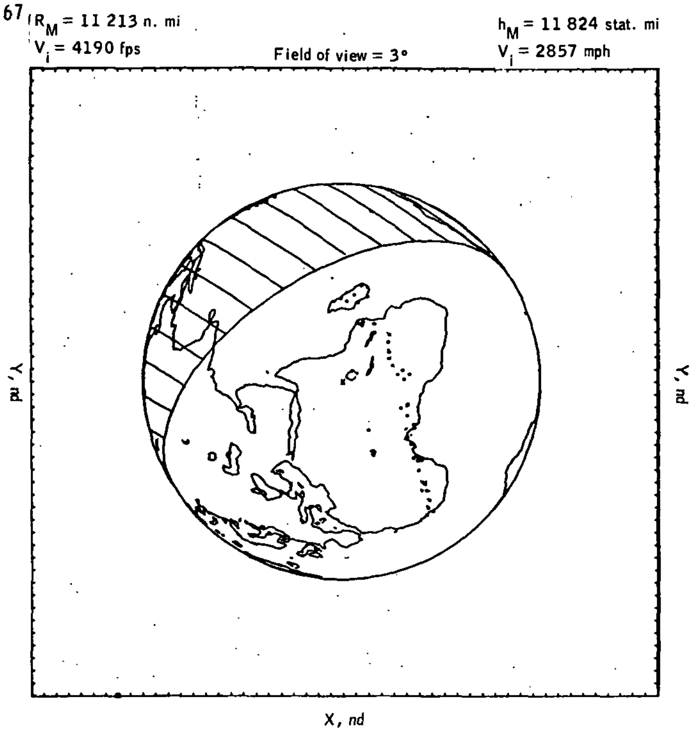


(ppp) g.e.t. = 70 hours.

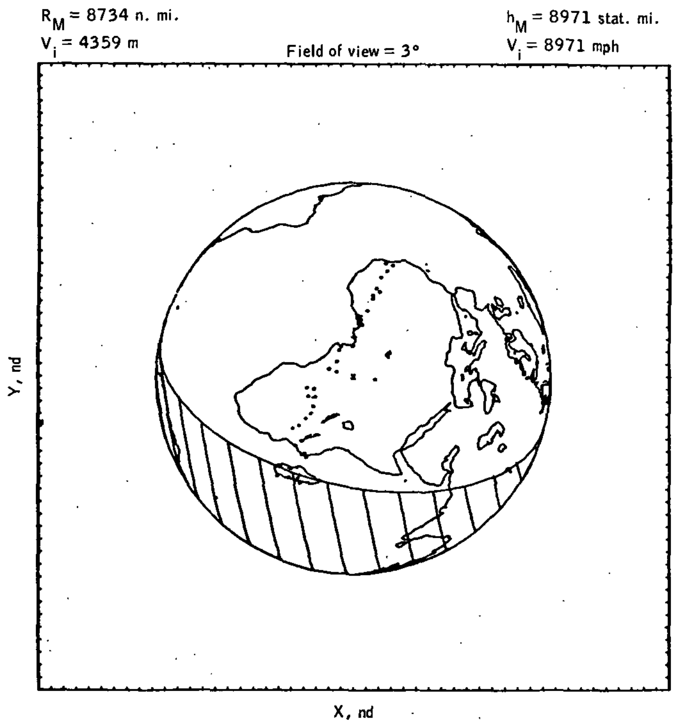
Figure 5.2.1-2.- Continued.



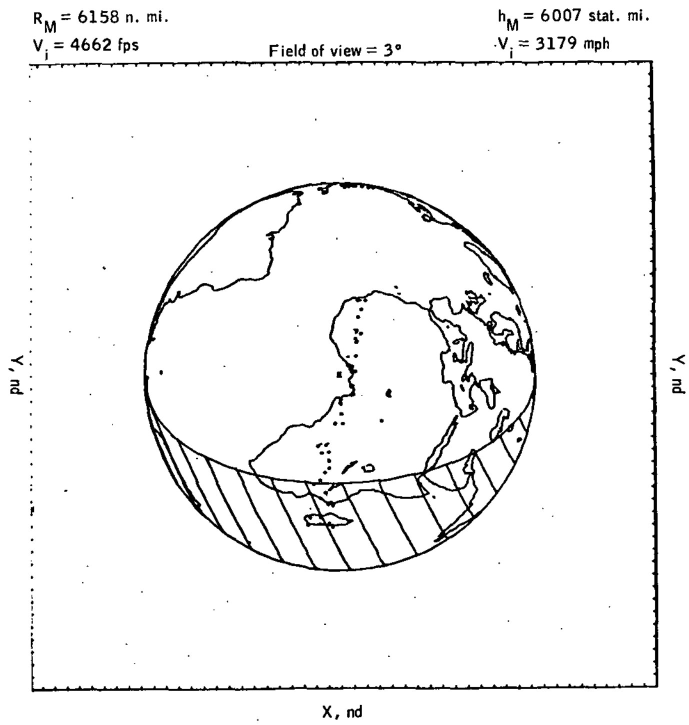
(qqq) g.e.t. = 71 hours.



(rrr) g.e.t. = 72 hours.



(sss) g.e.t. = 73 hours.



(ttt) g.e.t. = 74 hours.

Figure 5.2.1-2.- Concluded.

5.2.2 MOON VIEWS

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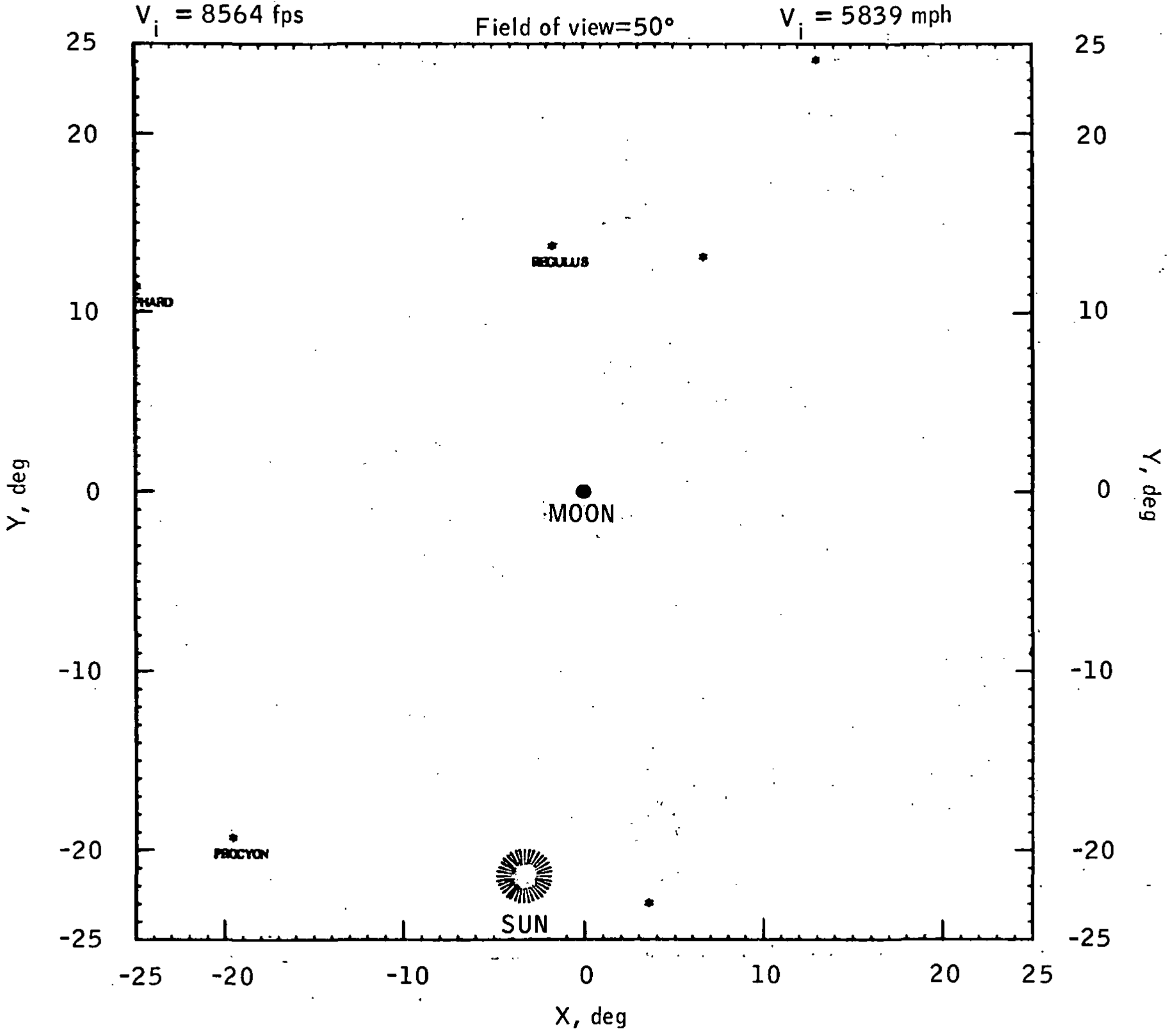
SEQ	14	17	18	40	105	107
X	-19	-24	-1	3	6	13
Y	-19	11	13	-22	13	24

R_E = 51 850 n. mi.　　　　h_E = 55 704 stat. mi.

V_i = 8564 fps　　　　V_i = 5839 mph



(a) g.e.t. = 10 hours.

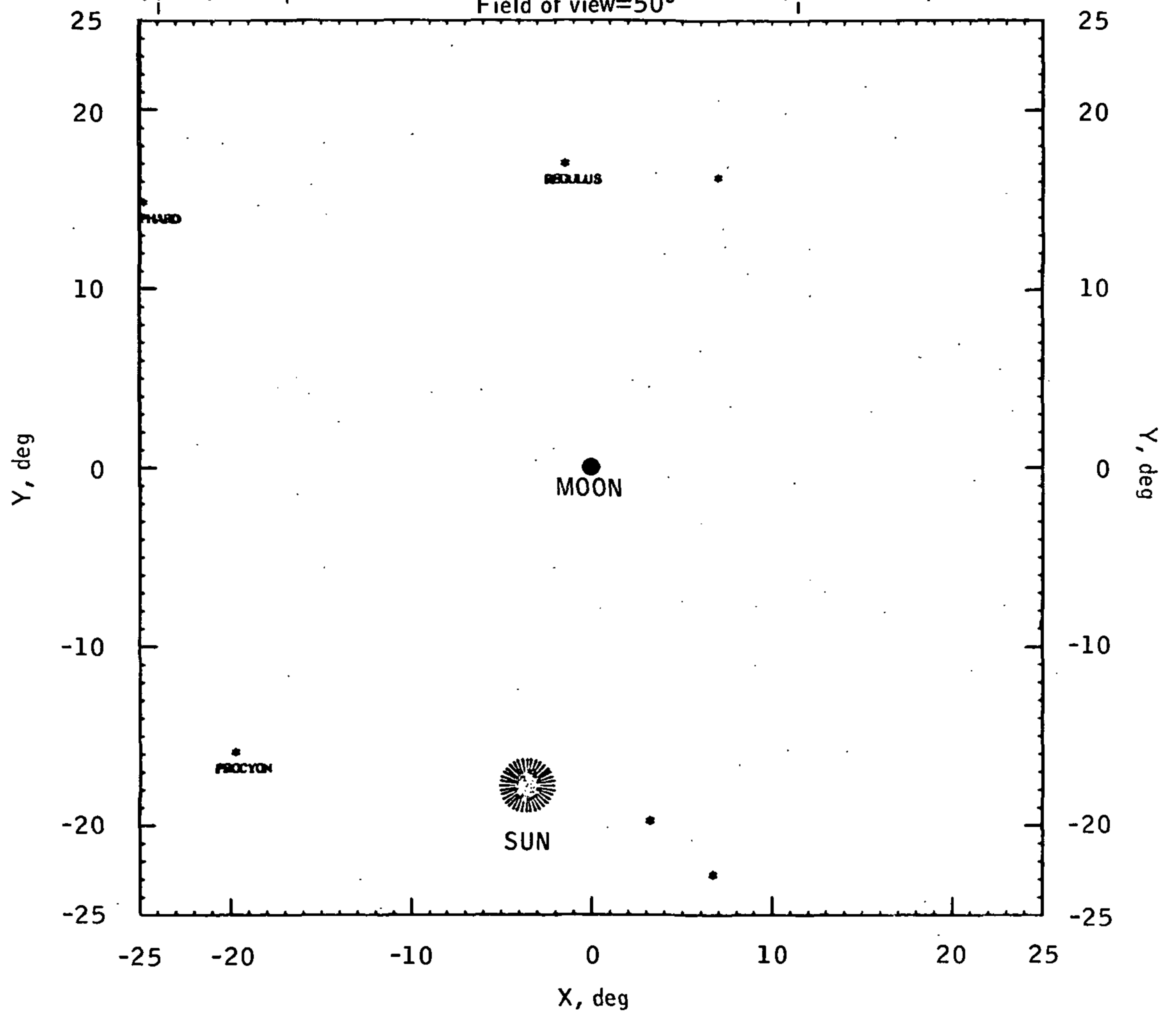
Figure 5.2.2-1.- Translunar coast - constant field of view (moon).

SEQ	14	17	13	40	55	105
X	-17	-24	-1	3	6	6
Y	-15	14	15	-19	-22	16

R_E = 91 747 n. mi. h_E = 101 617 stat. mi.

V_i = 5875 fps V_i = 4006 mph

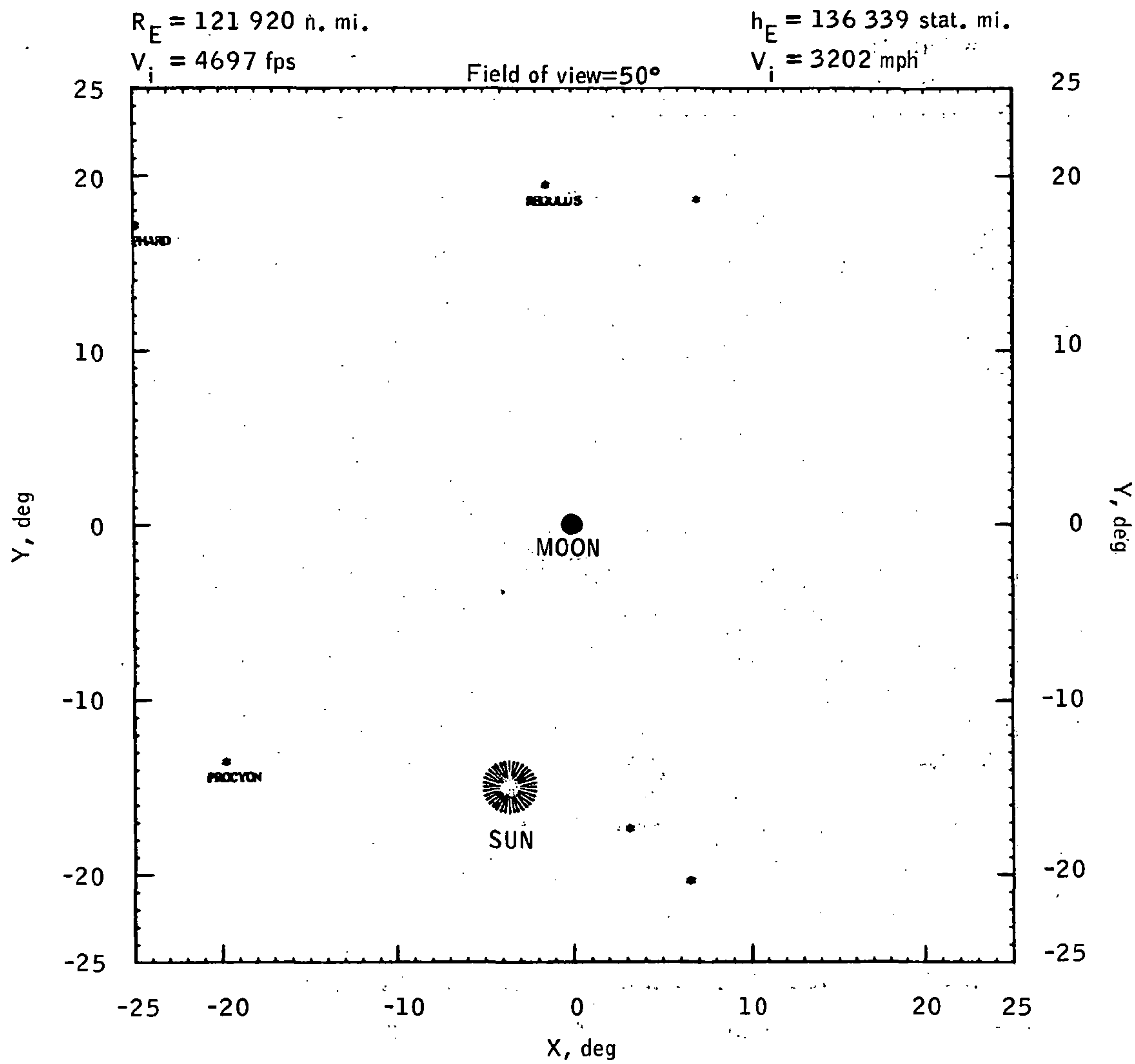
Field of view=50°



(b) g.e.t. = 20 hours.

Figure 5.2.2-1.- Continued.

SEQ	14	17	18	40	55	105
X	-19	-24	-1	3	6	6
Y	-13	17	17	-17	-20	18



(c) g.e.t. = 30 hours.

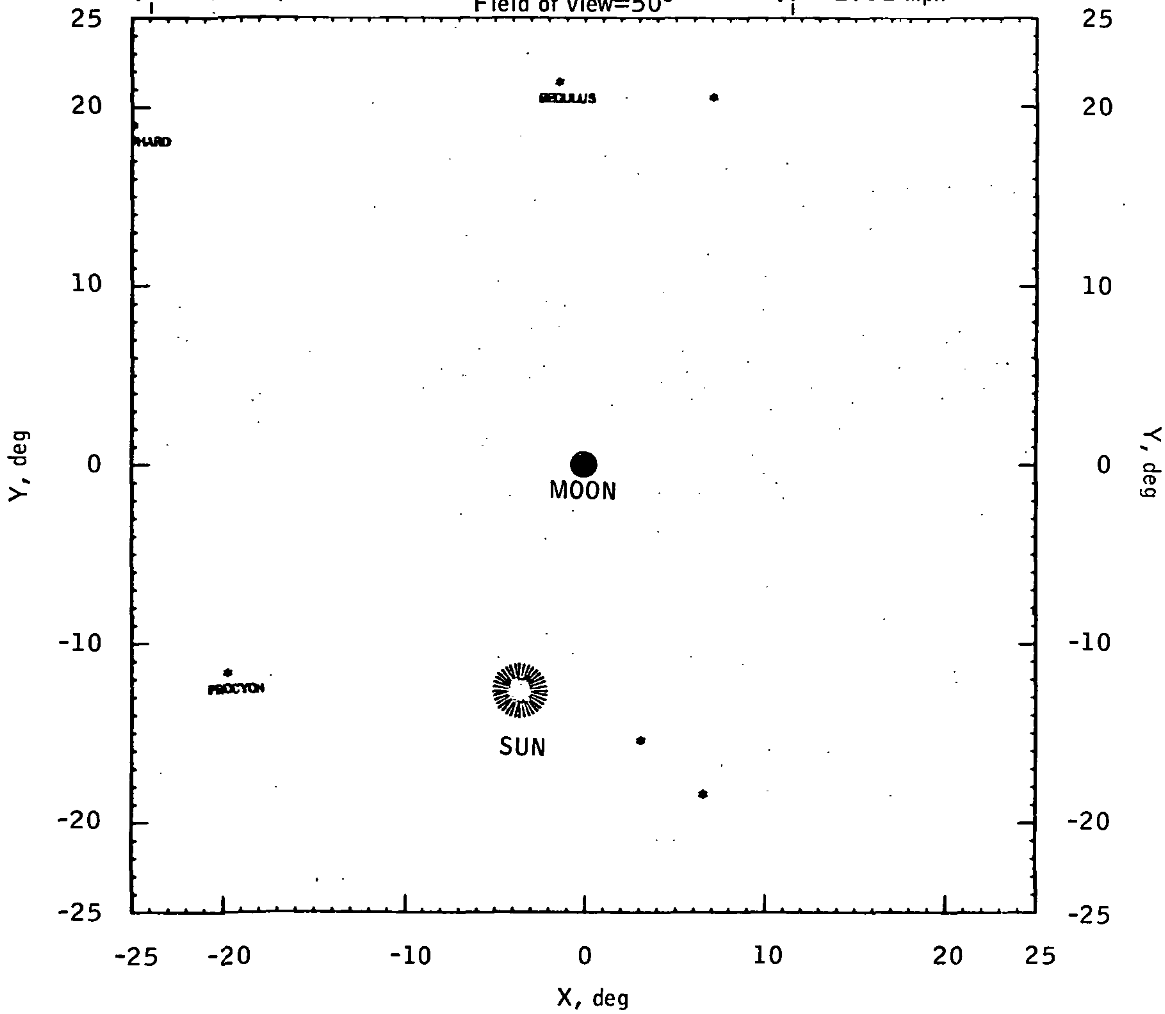
Figure 5.2.2-1.- Continued.

SEQ	14	17	13	40	55	105
X	-19	-24	-1	3	6	7
Y	-11	18	21	-15	-18	20

R_E = 146 817 n. mi. h_E = 164 990 stat. mi.

V_i = 3961 fps V_i = 2701 mph

Field of view=50°



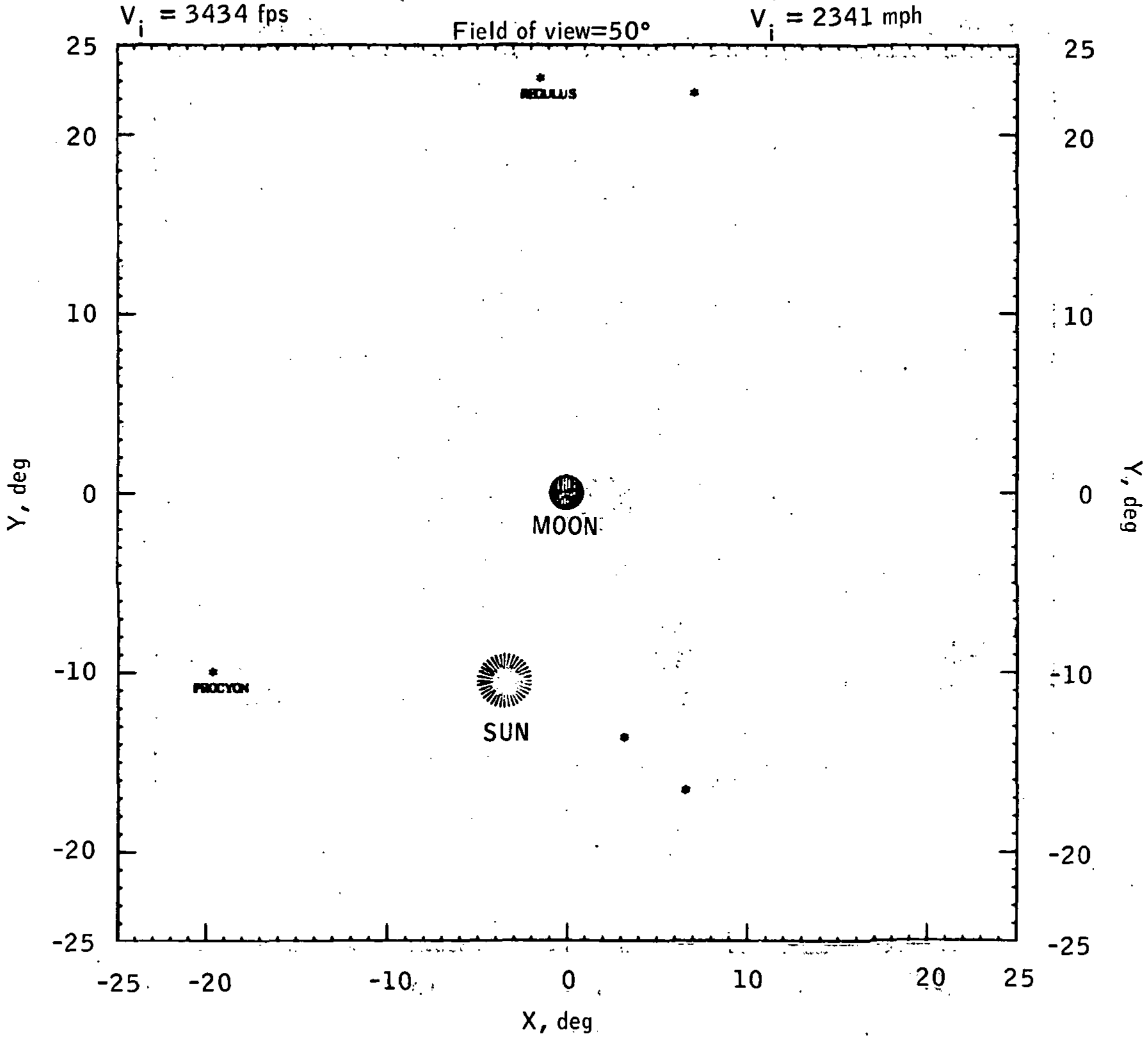
(d) g.e.t. = 40 hours.

Figure 5.2.2-1.- Continued.

SEQ	14	18	40	55	105
X	-19	-1	3	6	7
Y	-9	23	-13	-16	22

R_E = 168 146 n. mi. h_E = 189 534 stat. mi.

V_i = 3434 fps V_i = 2341 mph



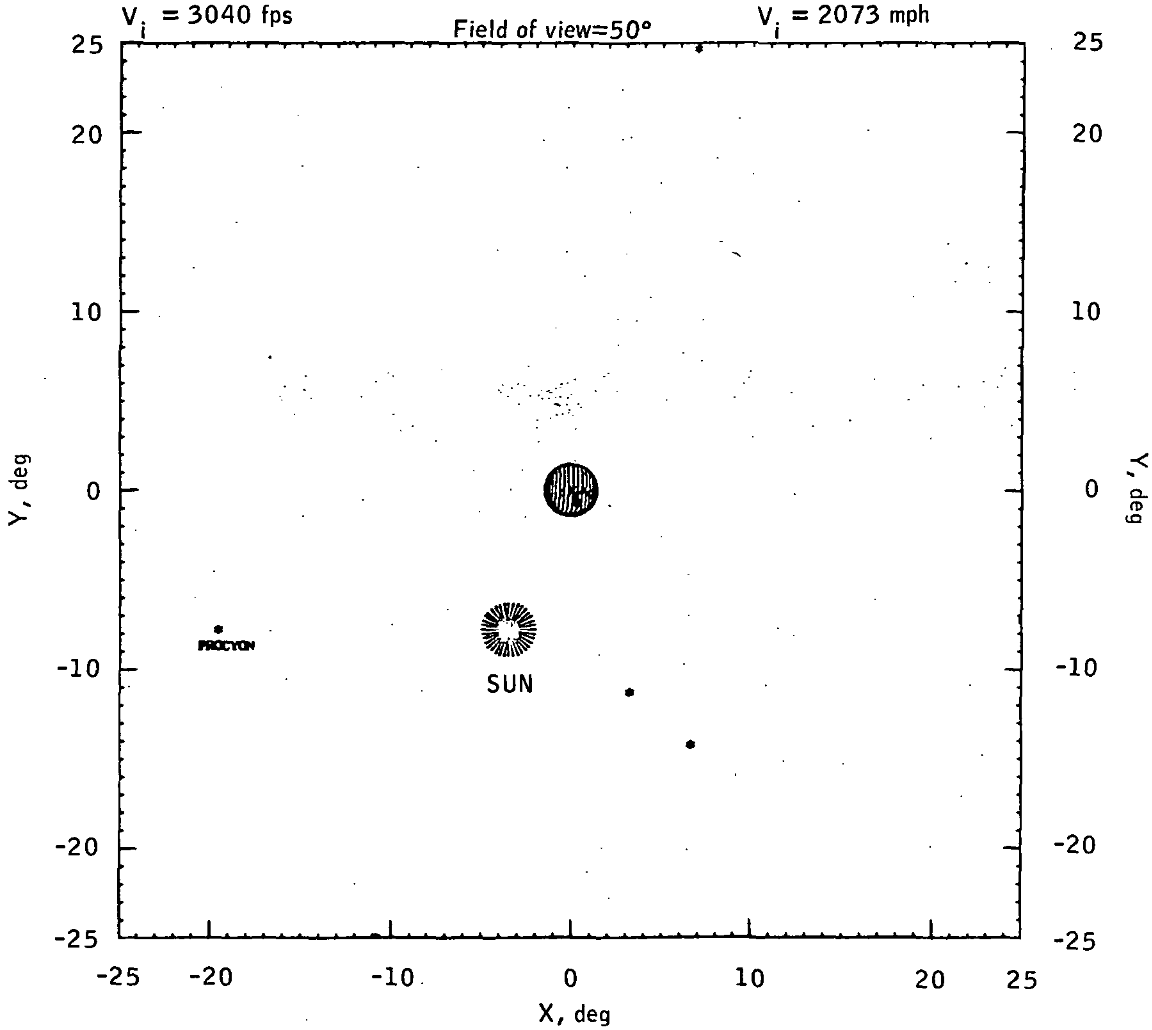
(e) g.e.t. = 50 hours.

Figure 5.2.2-1.- Continued.

SEQ	14	40	52	55	105
X	-19	3	-10	6	6
Y	-7	-11	-24	-14	27

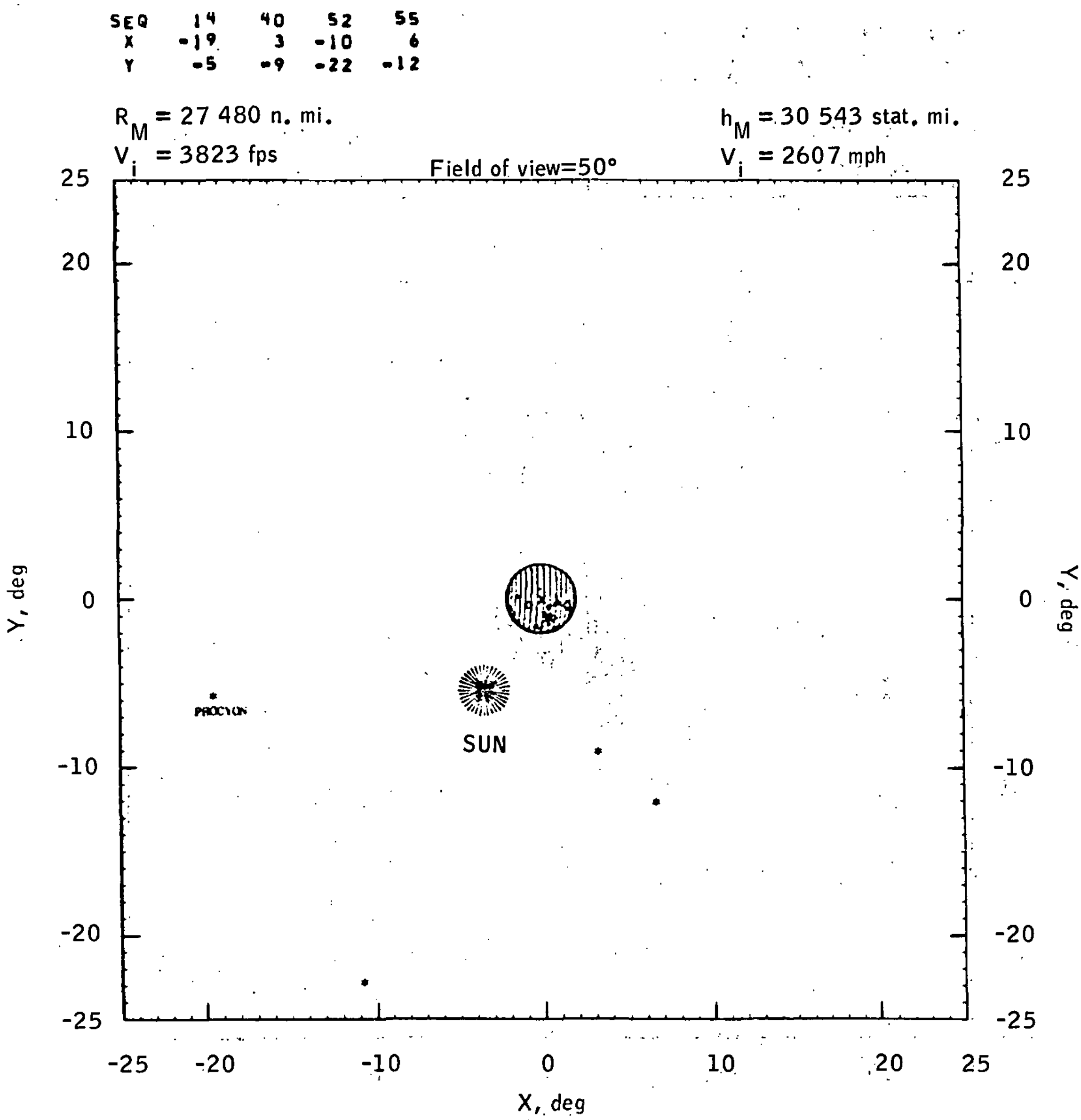
R_E = 186 861 n. mi. h_E = 211 071 stat. mi.

V_i = 3040 fps V_i = 2073 mph



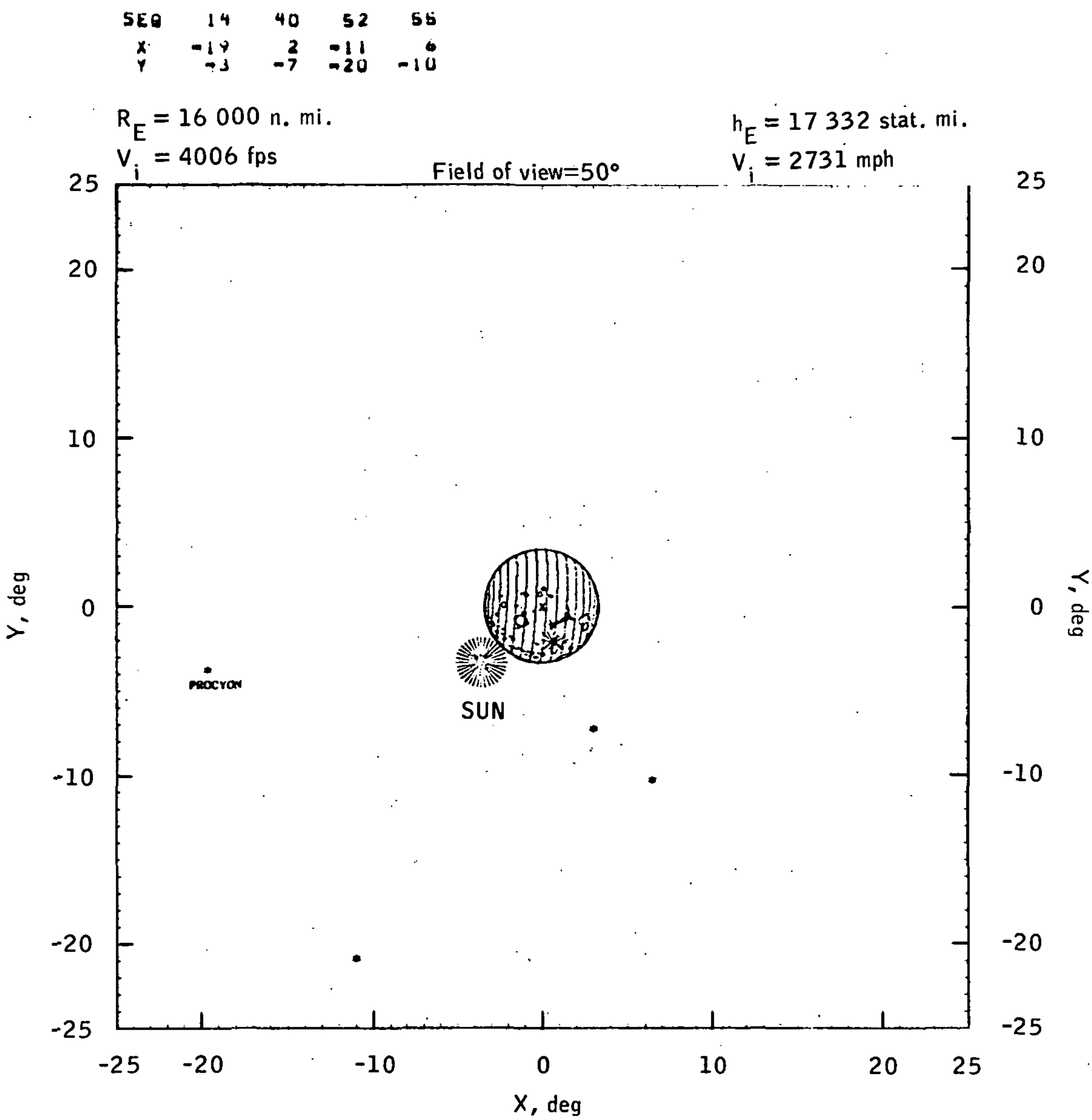
(f) g.e.t. = 60 hours.

Figure 5.2.2-1.- Continued.



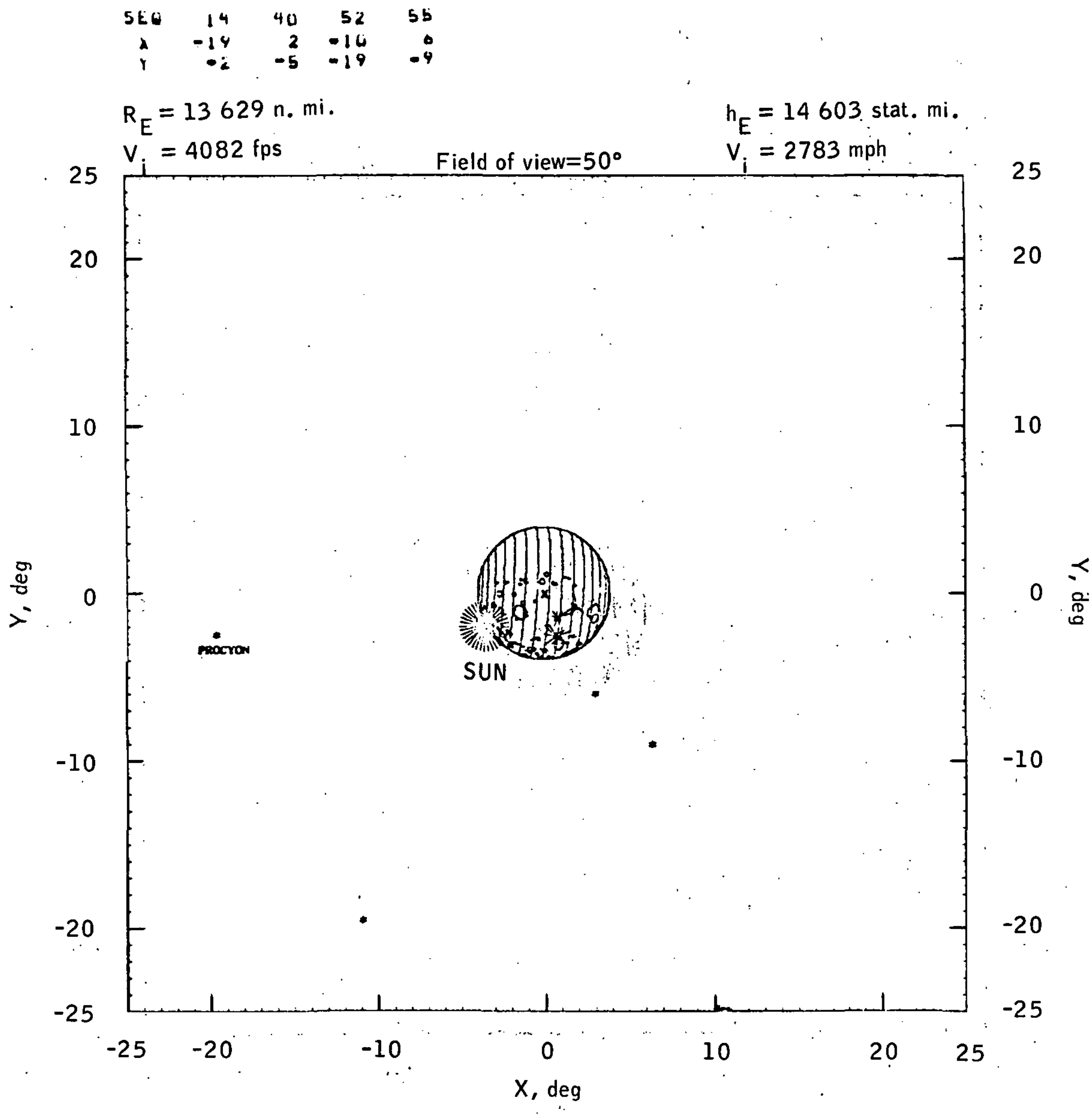
(g) g.e.t. = 65 hours.

Figure 5.2.2-1.- Continued.



(h) g.e.t. = 70 hours.

Figure 5.2.2-1.- Continued.



(i) g.e.t. = 71 hours.

Figure 5.2.2-1.- Continued.

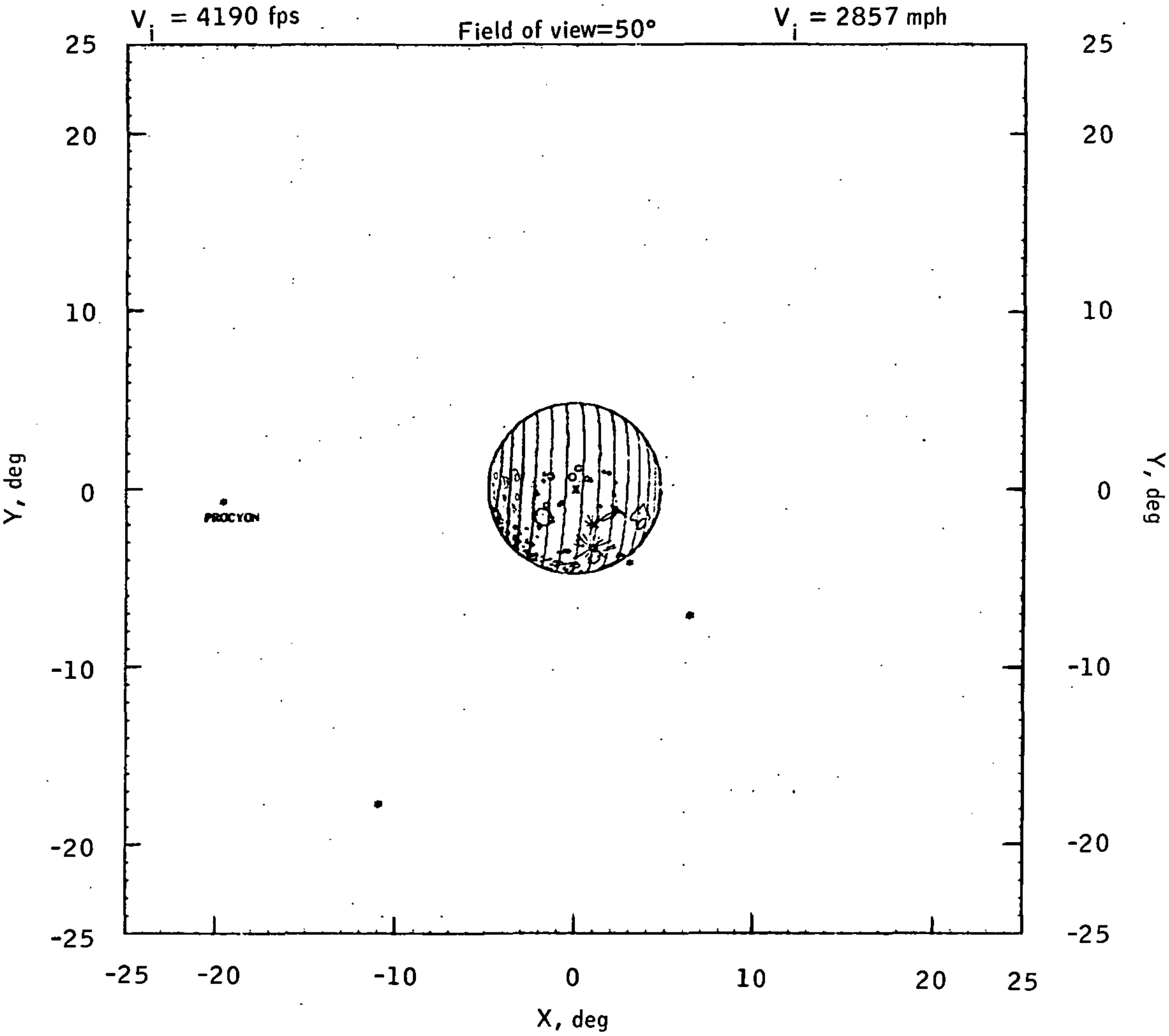
SEQ	14	40	52	55
X	-19	2	-10	6
Y	0	-4	-17	-7

R_E = 11 213 n. mi.

V_i = 4190 fps

h_E = 11 824 stat. mi.

V_i = 2857 mph



(j) g.e.t. = 72 hours.

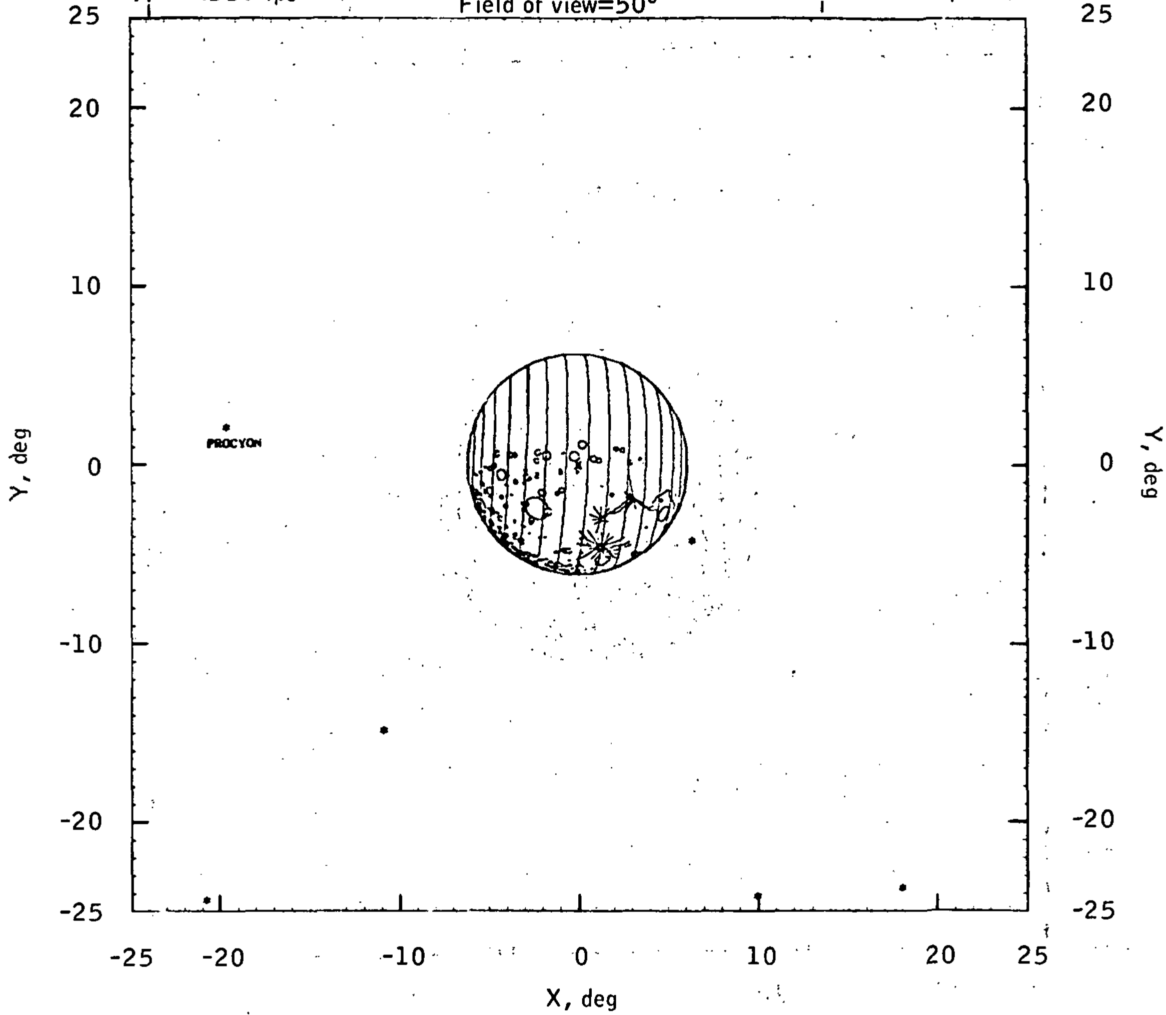
Figure 5.2.2-1.- Continued.

SEQ	14	45	52	55	70	100
X	-19	-20	-10	6	17	9
Y	2	-24	-14	-4	-23	-24

R_E = 8734 n. mi. h_E = 8971 stat. mi.

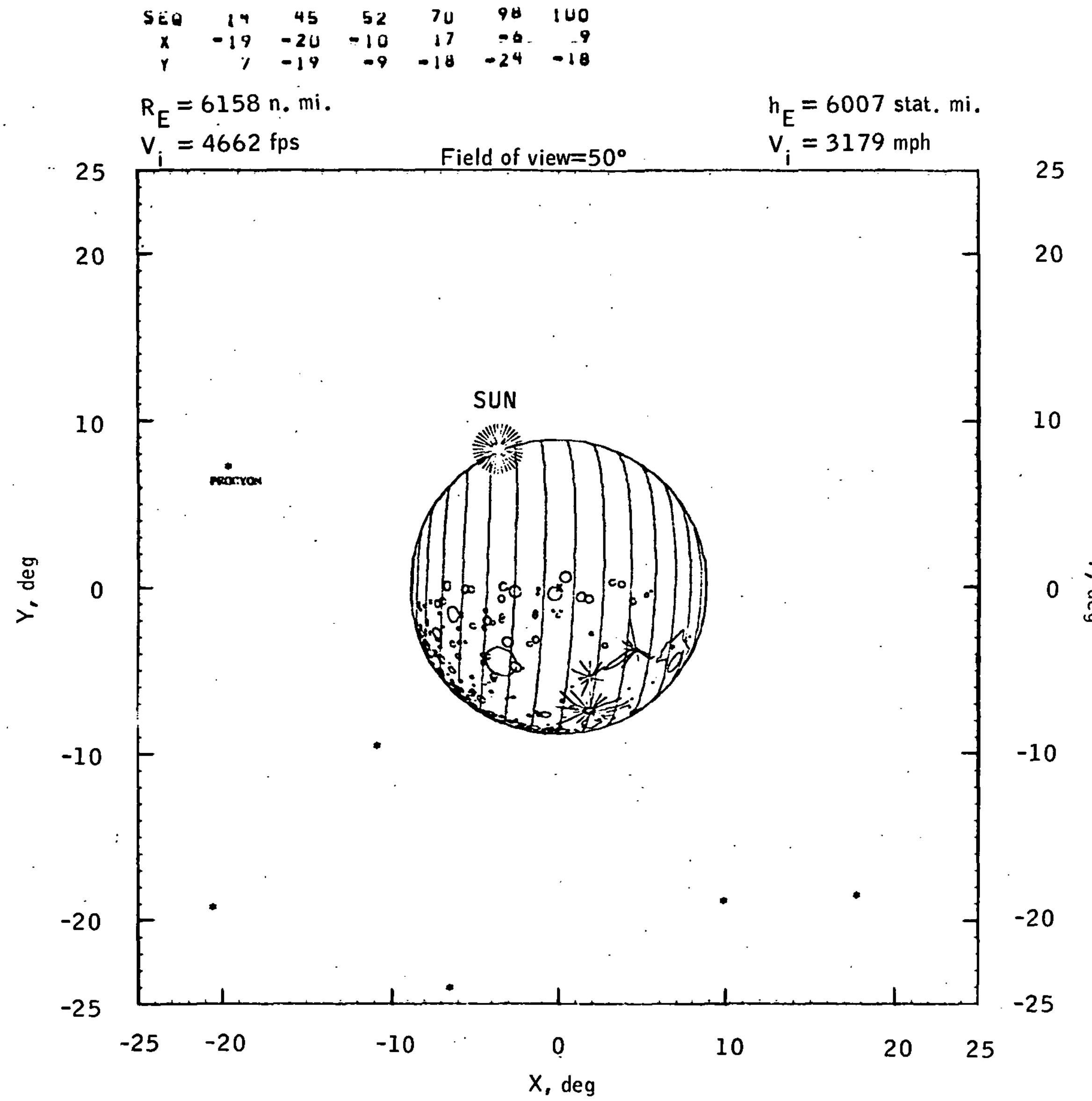
V_i = 4359 fps V_i = 2972 mph

Field of view=50°



(k) g.e.t. = 73 hours.

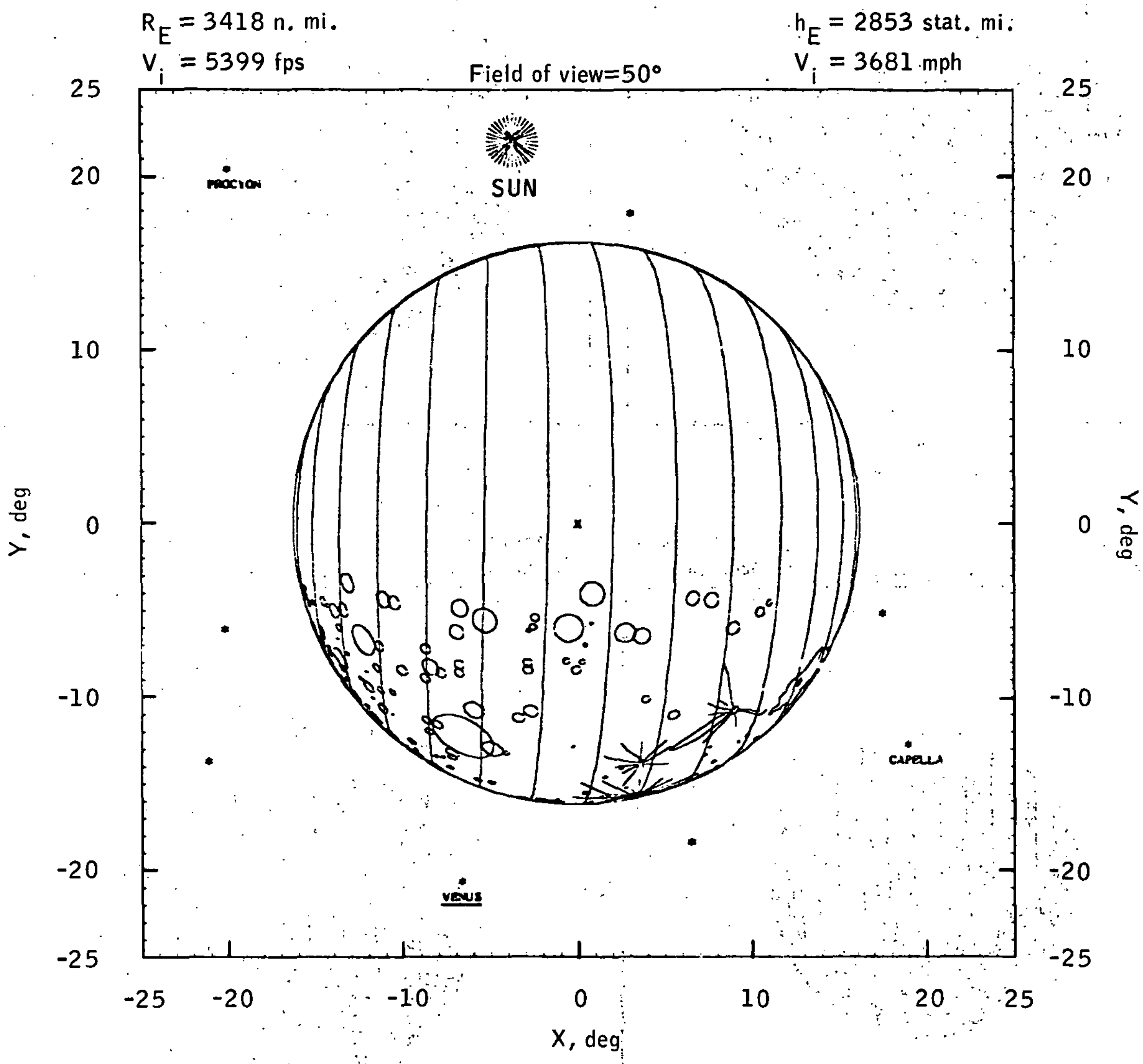
Figure 5.2.2-1.- Continued.



(l) g.e.t. = 74 hours.

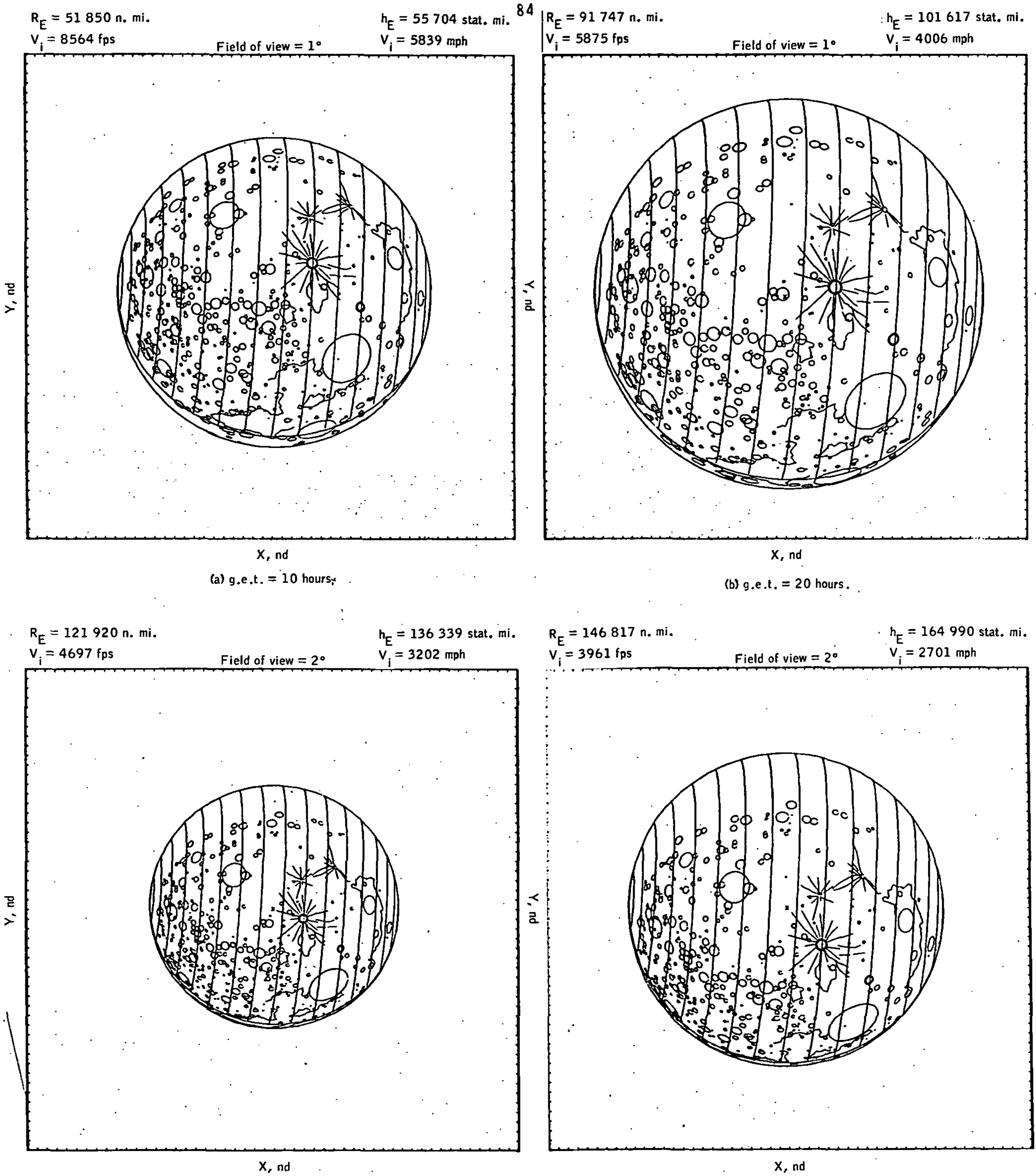
Figure 5.2.2-1.- Continued.

SEQ	11	14	40	45	47	70	93	1
X	18	-20	3	-20	-21	17	6	-6
Y	-12	20	17	-6	-13	-5	-18	-20



(m) g.e.t. = 75 hours.

Figure 5.2.2-1.- Concluded.



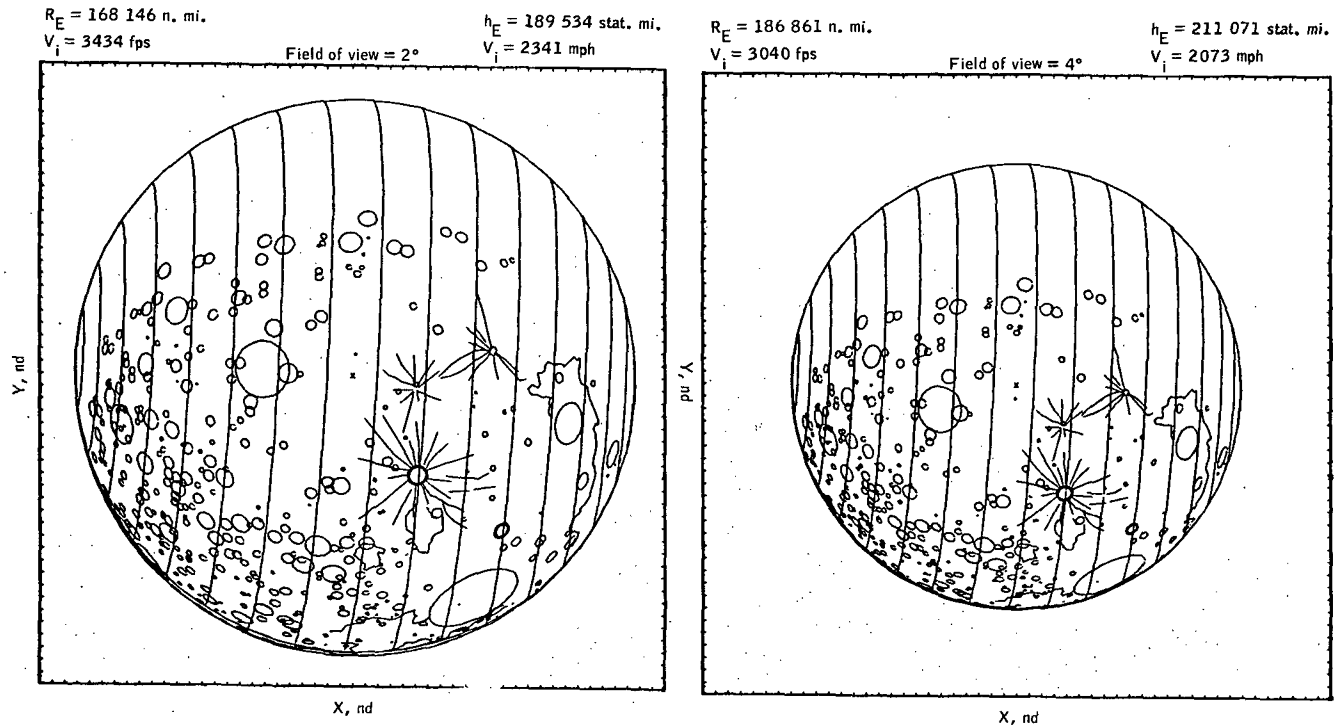
(a) g.e.t. = 10 hours.

(b) g.e.t. = 20 hours.

(c) g.e.t. = 30 hours.

(d) g.e.t. = 40 hours.

Figure 5.2.2-2.- Translunar coast - variable field of view (moon).



(e) g.e.t. = 50 hours.

(f) g.e.t. = 60 hours.

Figure 5.2.2-2.- Concluded.

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6.0 VIEWS FROM CSM AND LM DURING LUNAR ORBIT PHASE

6.1 VIEWS FROM CSM DURING LOI BURN

6.2 VIEWS FROM LM DURING DESCENT PHASE

6.2.1 DOI BURN

6.2.2 PDI BURN

6.3 VIEWS FROM LM DURING ASCENT PHASE

6.3.1 ASCENT BURN

6.3.2 CSI MANEUVER

6.3.3 CDH MANEUVER

6.3.4 TPI MANEUVER

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6.0 VIEWS FROM CSM AND LM DURING LUNAR ORBIT PHASE

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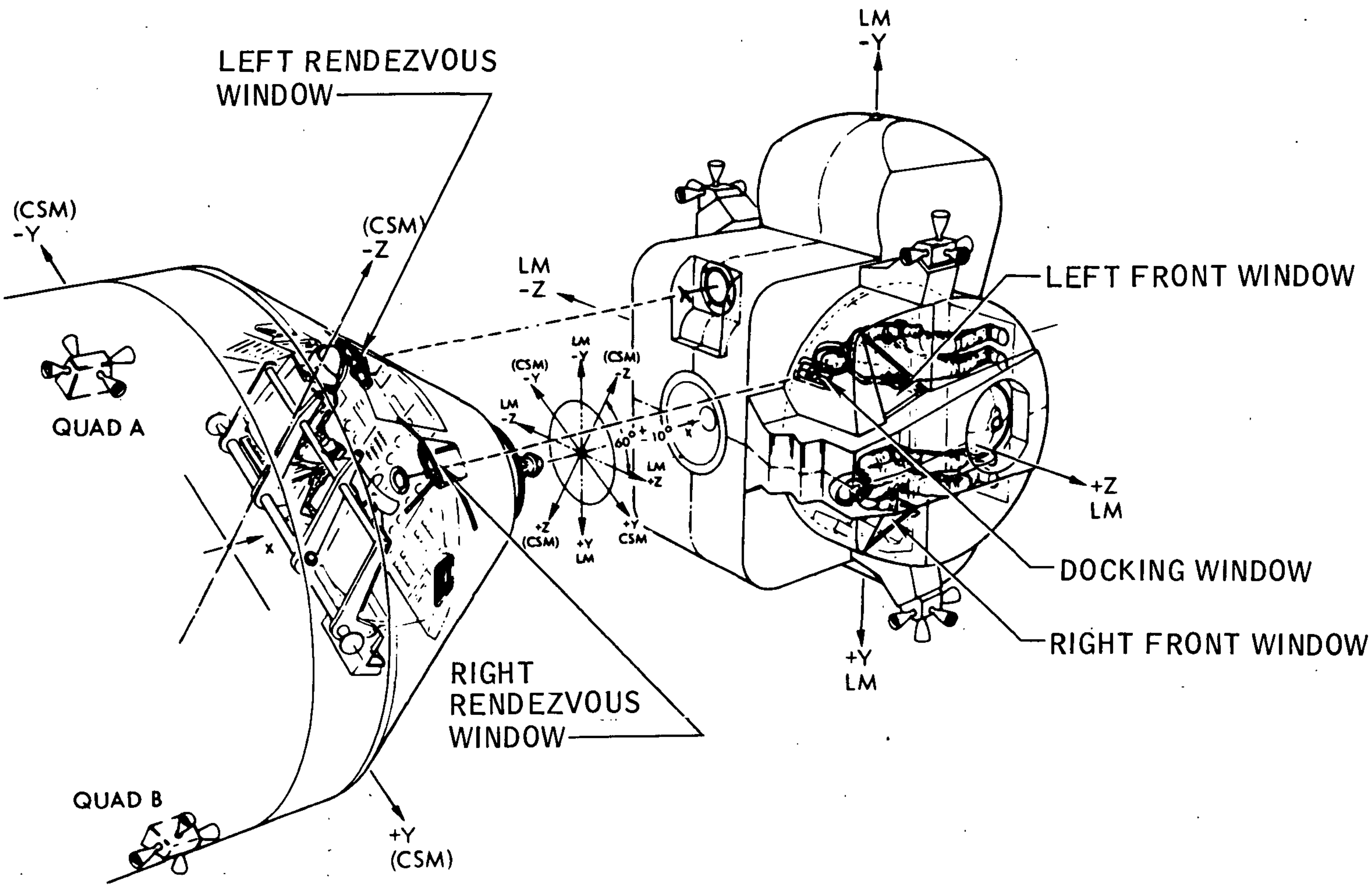

Figure 6.0-1.- LM/CSM docked orientation.

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6.1 VIEWS FROM CSM DURING LOI BURN

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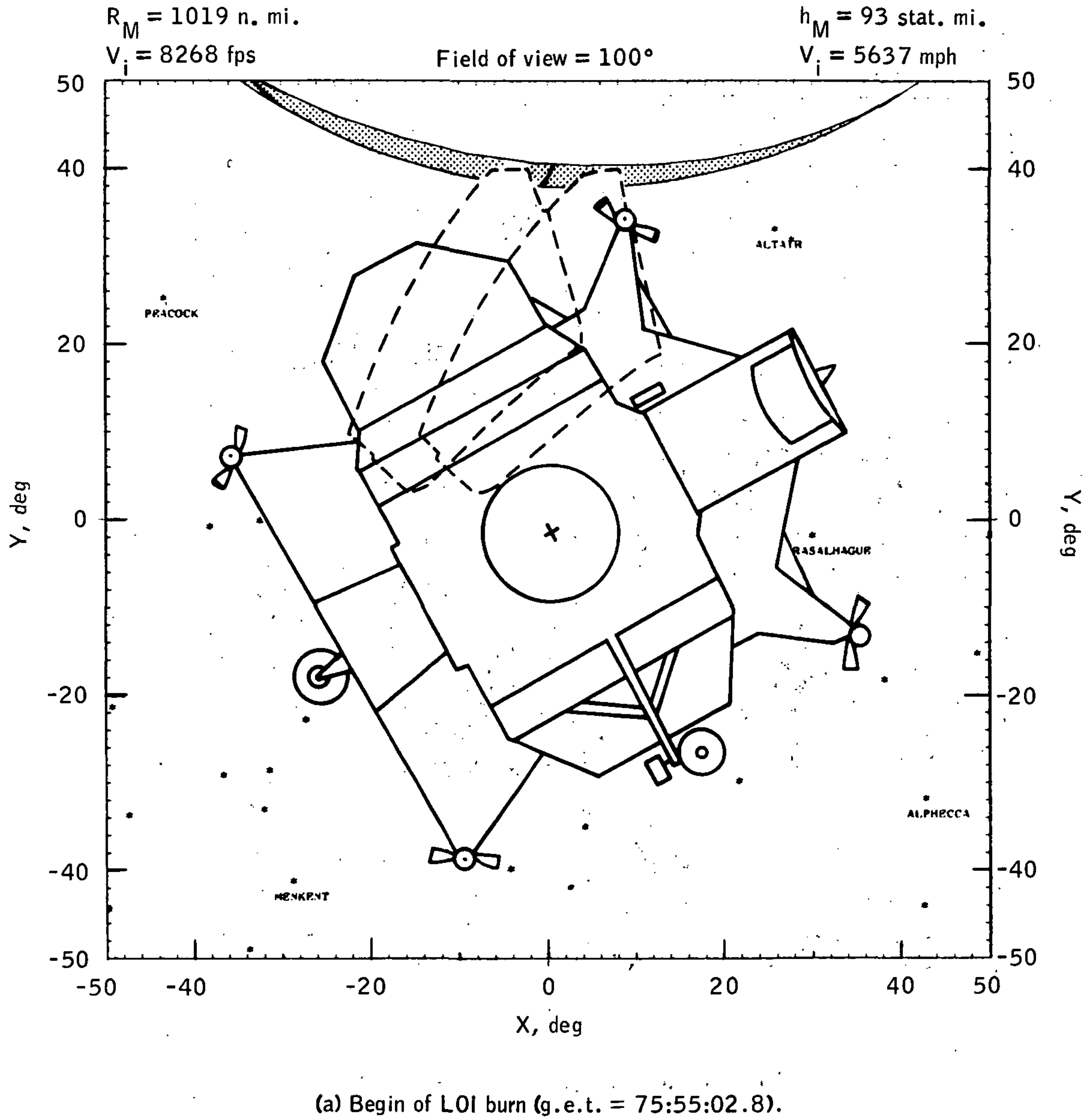
SEG	24	26	29	32	34	43	44	113	114	117	118
X	-14	21	14	12	-21	-24	-24	-16	-23	-16	-18
Y	-20	-15	0	16	12	-22	-10	-24	-16	-16	-14

SEG	119	120	121	122	123	124	128	131	133	135	142
X	21	-2	-15	2	-13	10	19	24	-19	-16	13
Y	-22	-19	-14	-17	-11	-14	-9	-7	0	0	15

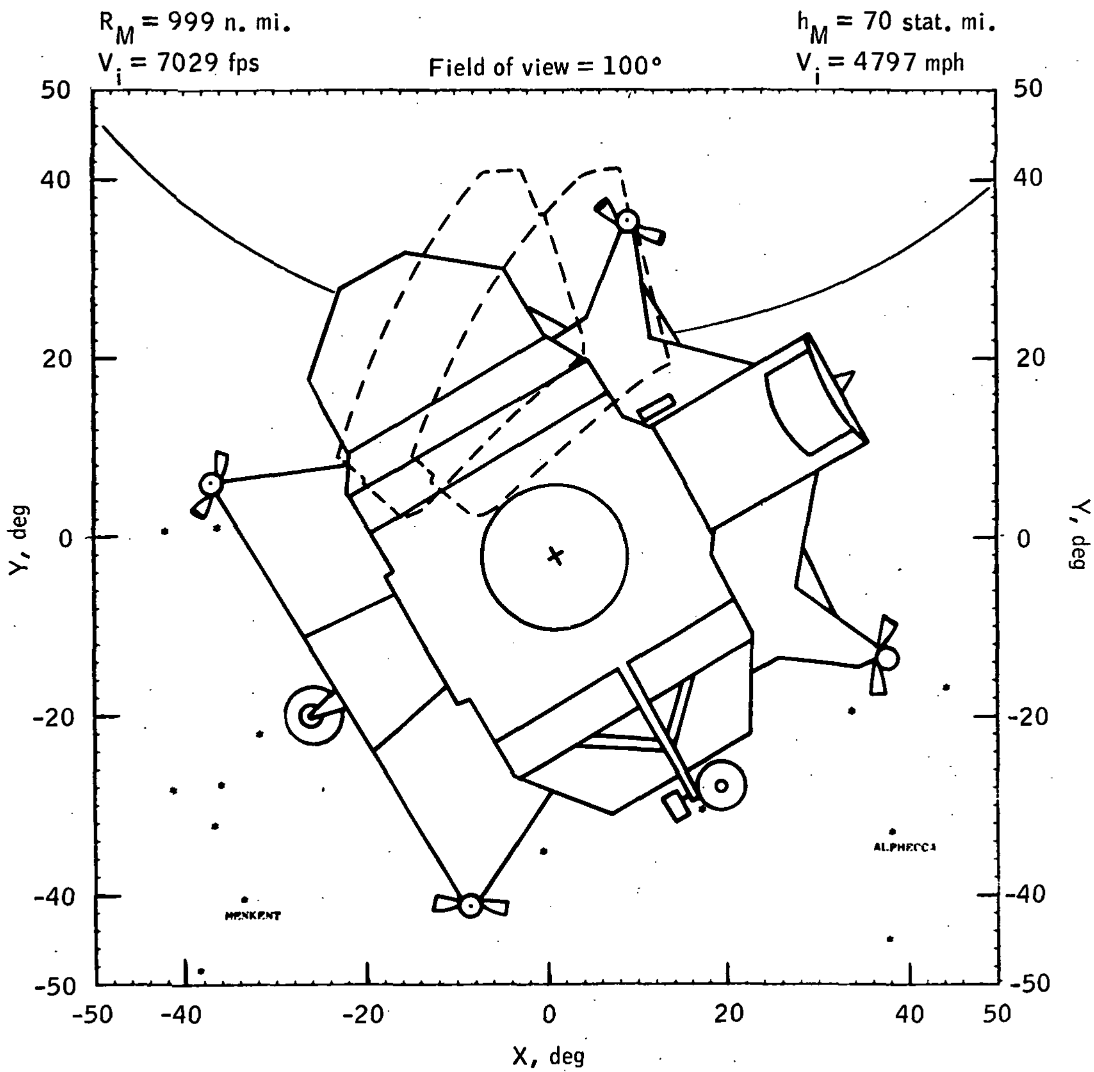


(a) Begin of LOI burn (g.e.t. = 75:55:02.8).

Figure 6.1-1.- Lunar orbit insertion burn.

SEQ	24	26	113	117	118	119	121	122	123	124
X	-16	19	-19	-18	-20	18	-17	0	-15	8
Y	-20	-16	-24	-16	-14	-22	-13	-17	-11	-15

SEQ	128	131	133	135
X	16	22	-21	-18
Y	-9	-8	0	0

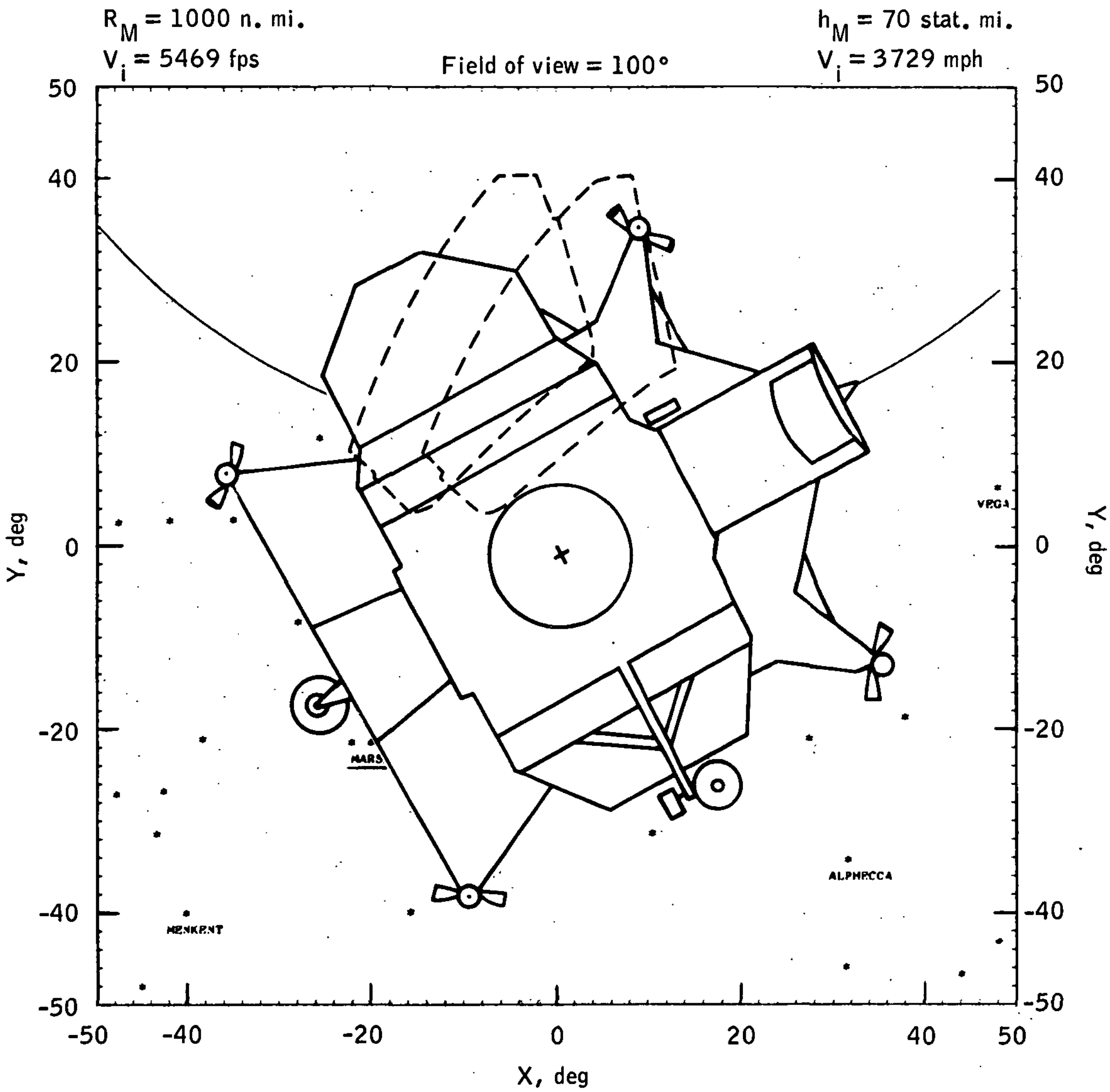


(b) Middle of LOI burn (g.e.t. = 75:58:02.8).

Figure 6.1-1.- Continued.

SEG	24	26	30	61	63	85	113	116	117	118	119
X	-20	15	23	-14	-12	-13	-22	22	-21	-23	15
Y	-20	-17	3	0	5	-4	-24	-23	-15	-13	-22

SEG	120	121	123	124	125	126	128	131	133	135
X	-7	-21	-19	5	-11	-7	13	18	-23	-20
Y	-19	-13	-10	-15	-10	-10	-10	-9	1	1



(c) End of LOI burn (g.e.t. = 76:01:08.2).

Figure 6.1-1.- Concluded.

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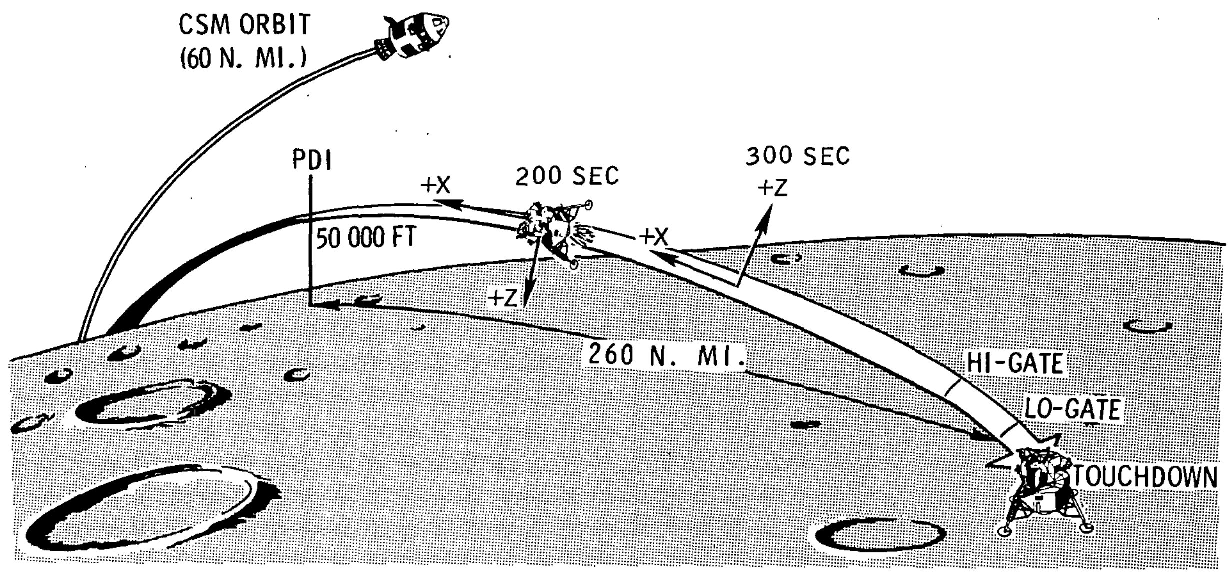
6.2 VIEWS FROM LM DURING DESCENT PHASE

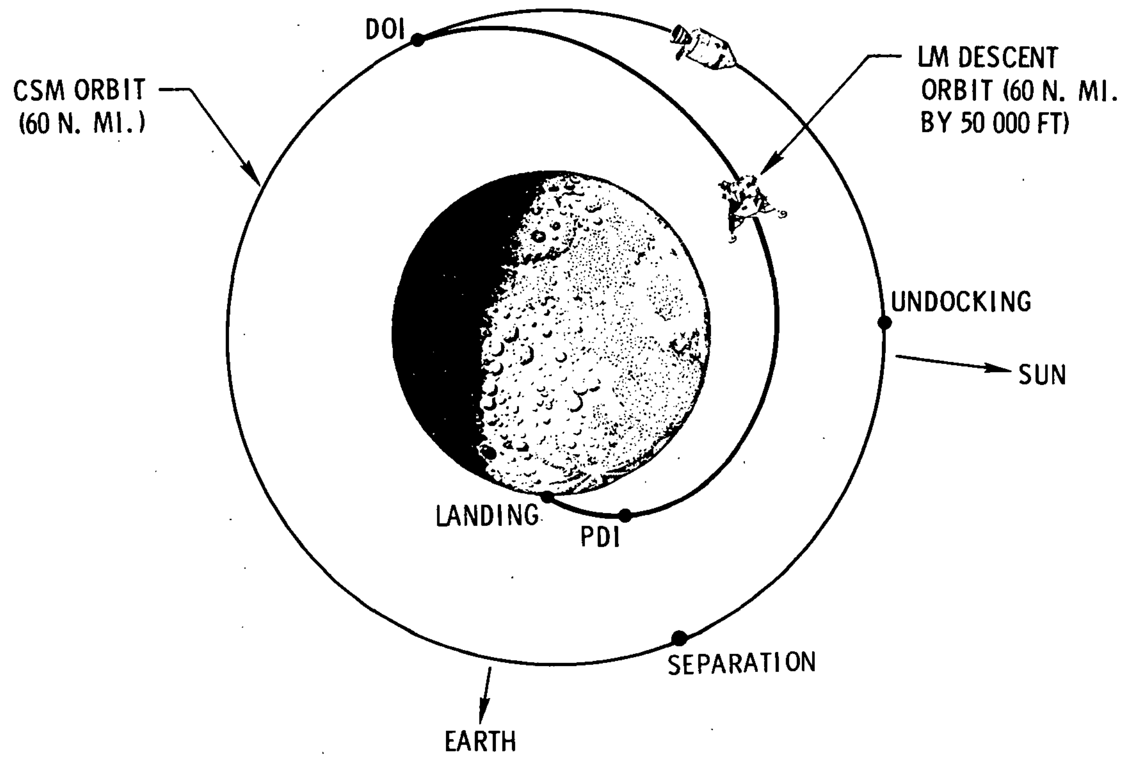


DESIGN CRITERIA

- BRAKING PHASE (PDI TO HI-GATE) - EFFICIENT REDUCTION OF ORBITAL VELOCITY
- FINAL APPROACH PHASE (HI-GATE TO LO-GATE) - CREW VISIBILITY (SAFETY OF FLIGHT AND SITE ASSESSMENT)
- LANDING PHASE (LO-GATE TO TOUCHDOWN) - MANUAL CONTROL TAKEOVER

(b) Operational phases of powered descent.

Figure 6.2.0-1.- Concluded.



(a) LM descent phase geometry.

Figure 6.2.0-1.- Descent phase.

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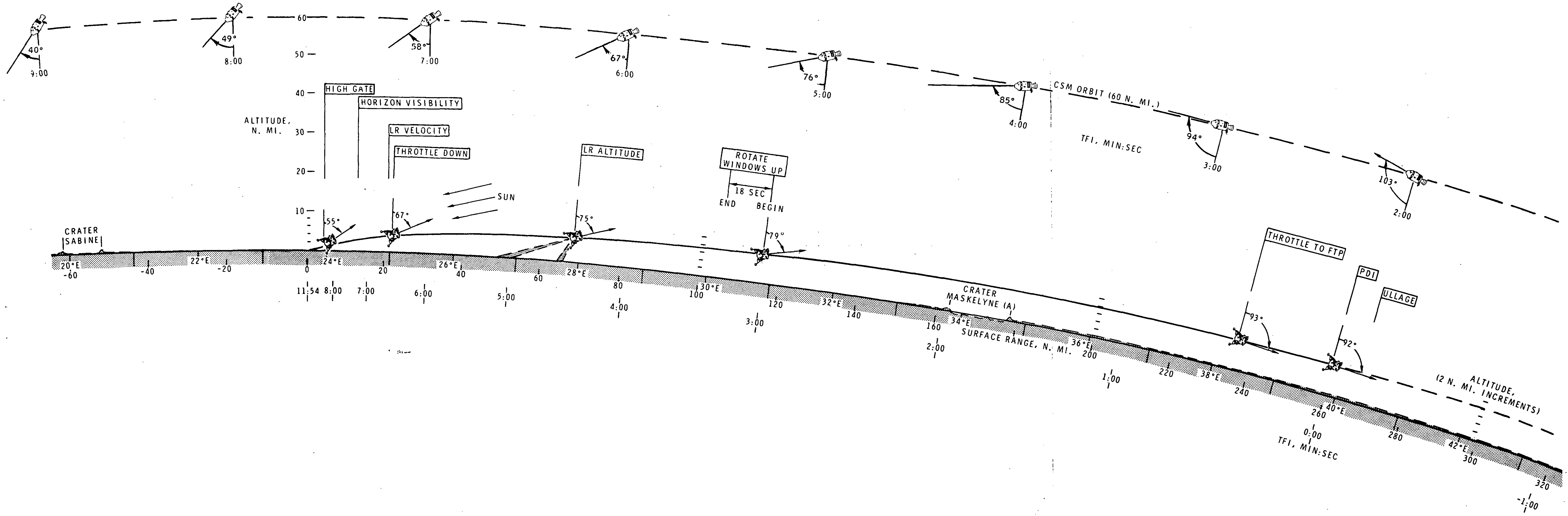

(b) Powered descent profile.

Figure 6.2.0-1.- Concluded.

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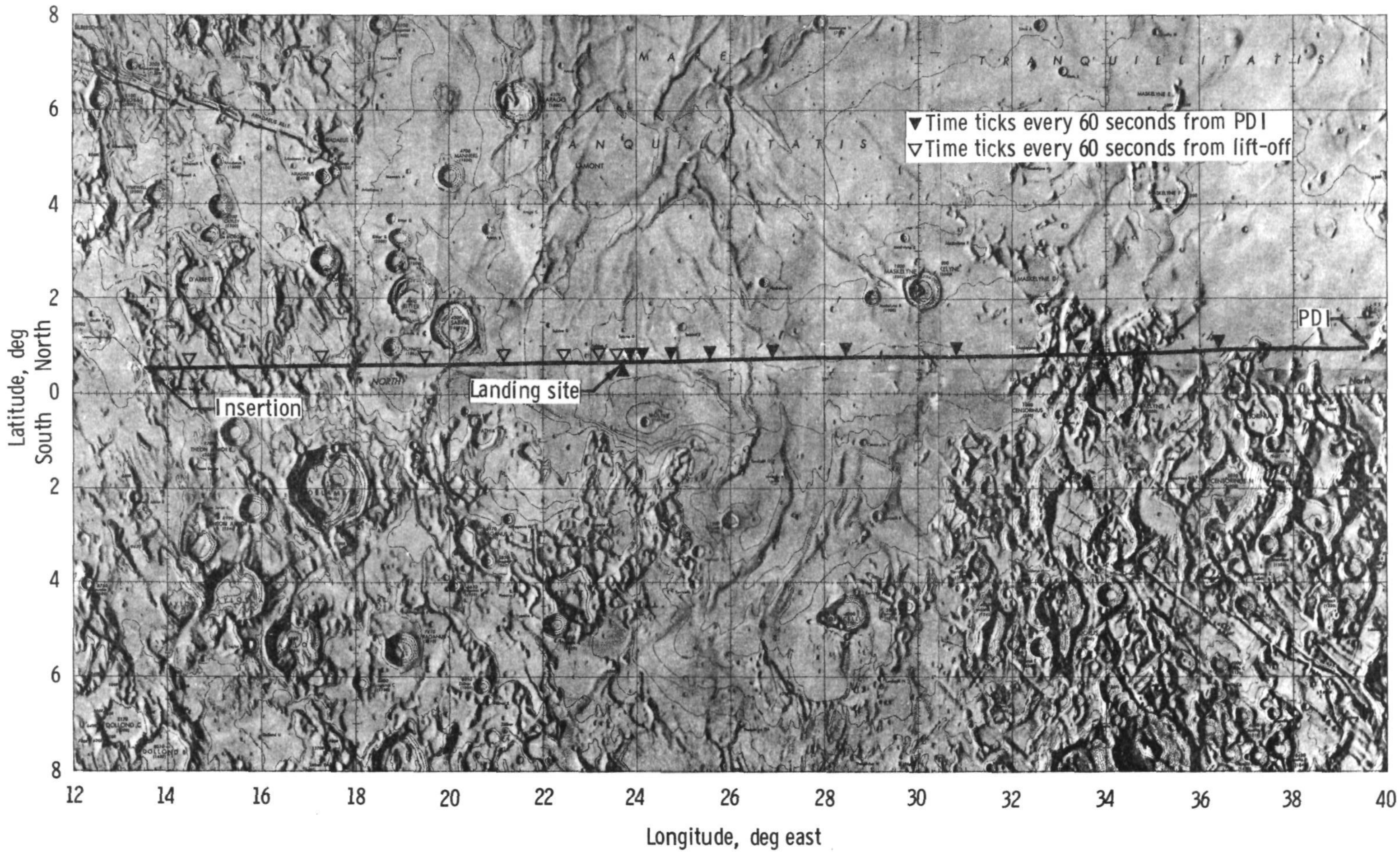

Figure 6.2.0-2. - LM groundtrack during descent and ascent.

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6.2.1 DOI BURN

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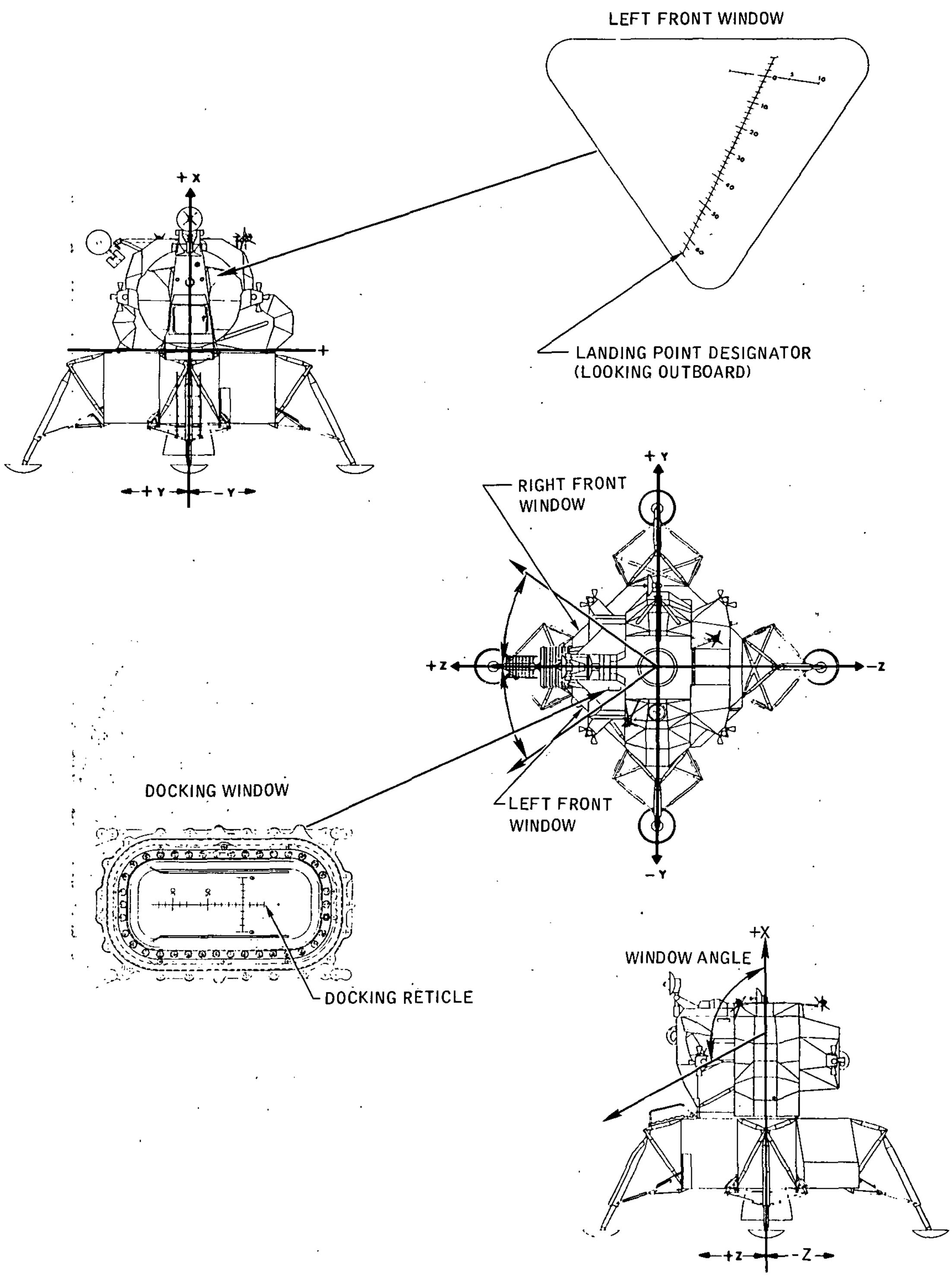

Figure 6.2.1-1.- LM window and body axes geometry.

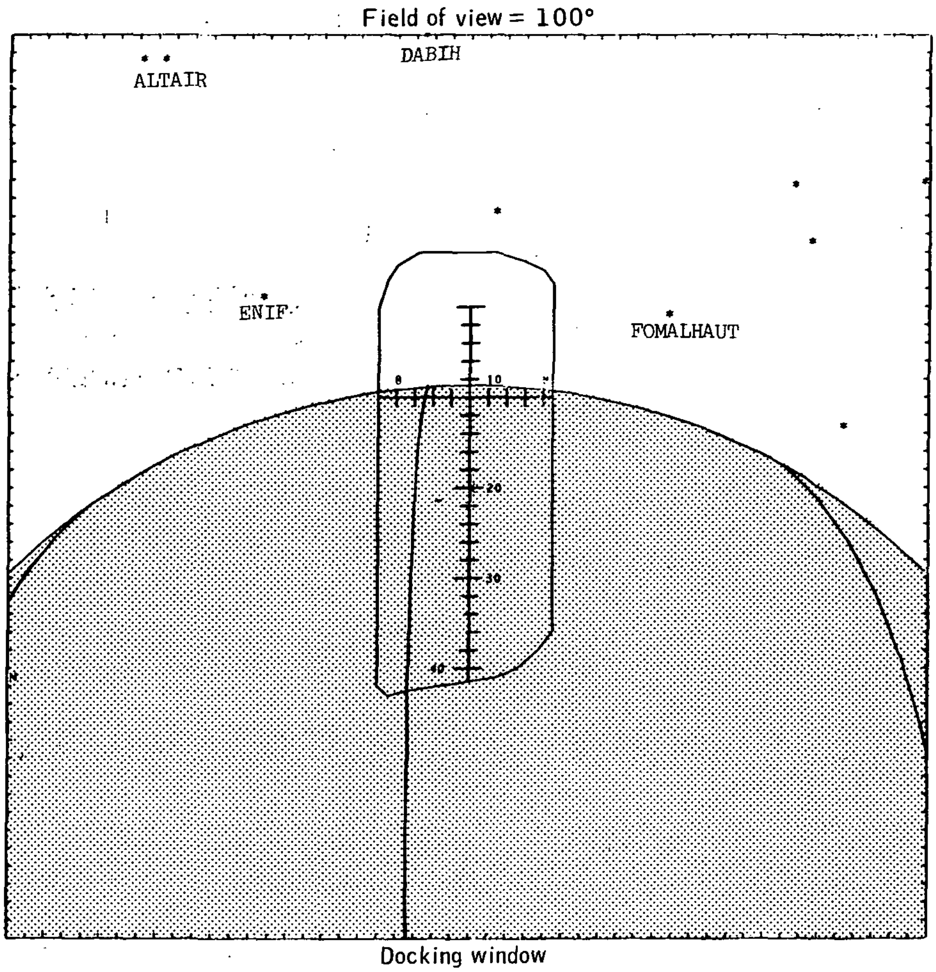

Figure 6.2.1-2.- DOI burn (g.e.t. = 101:38:48).

6.2.2 PDI BURN

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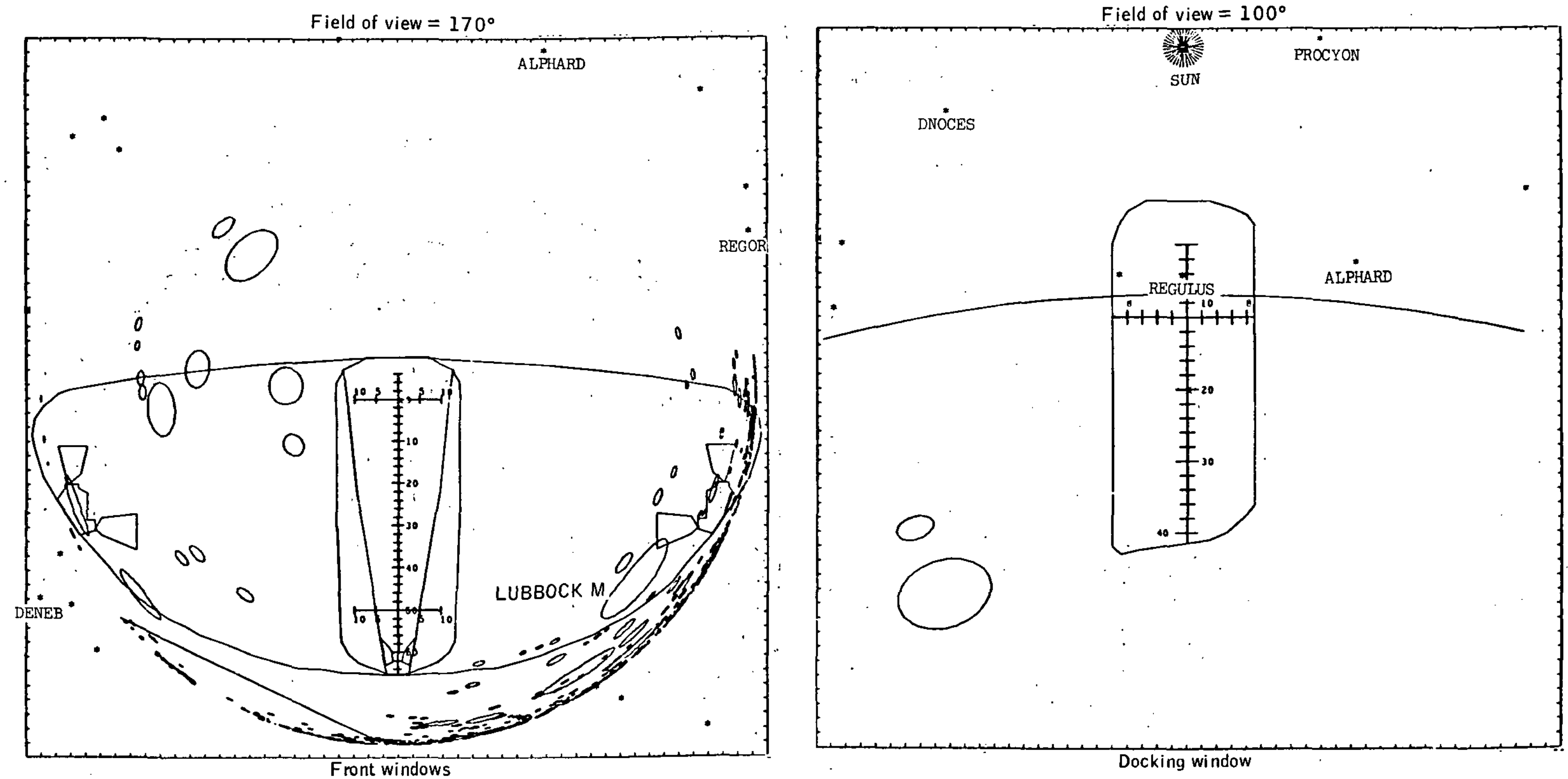
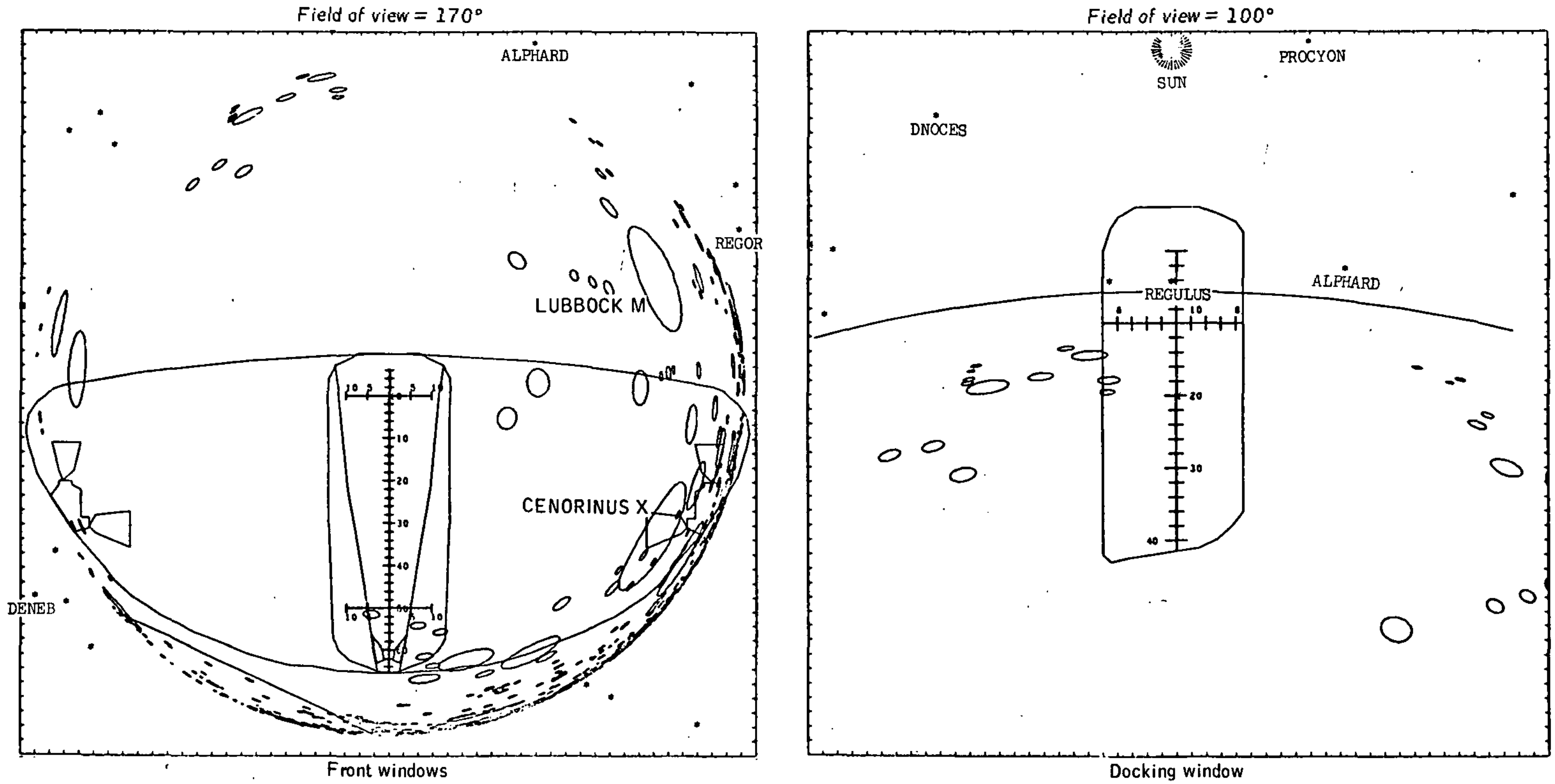


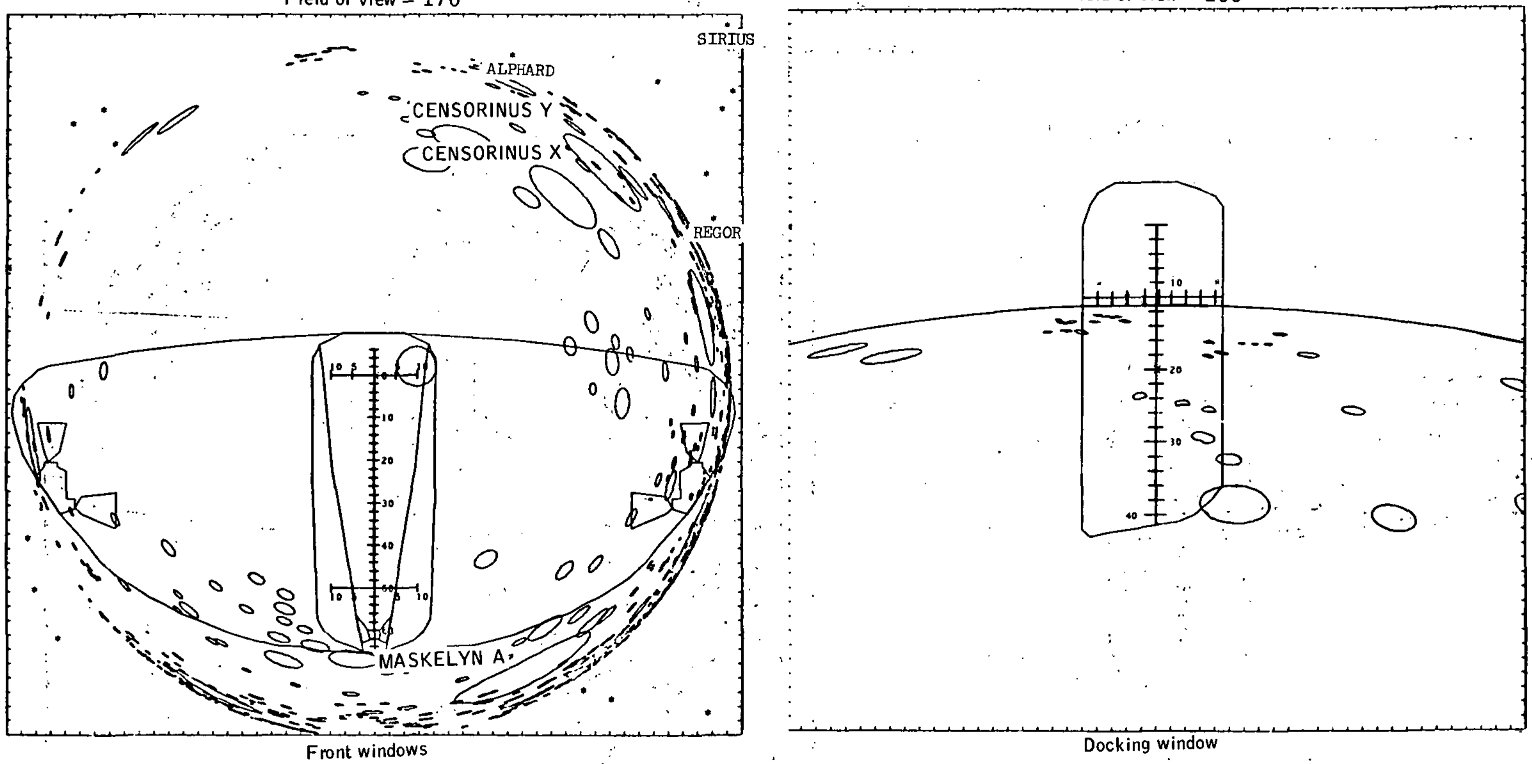
(a) Begin descent burn.

Figure 6.2.2-1.- PDI burn.



(b) 26 seconds into descent burn.

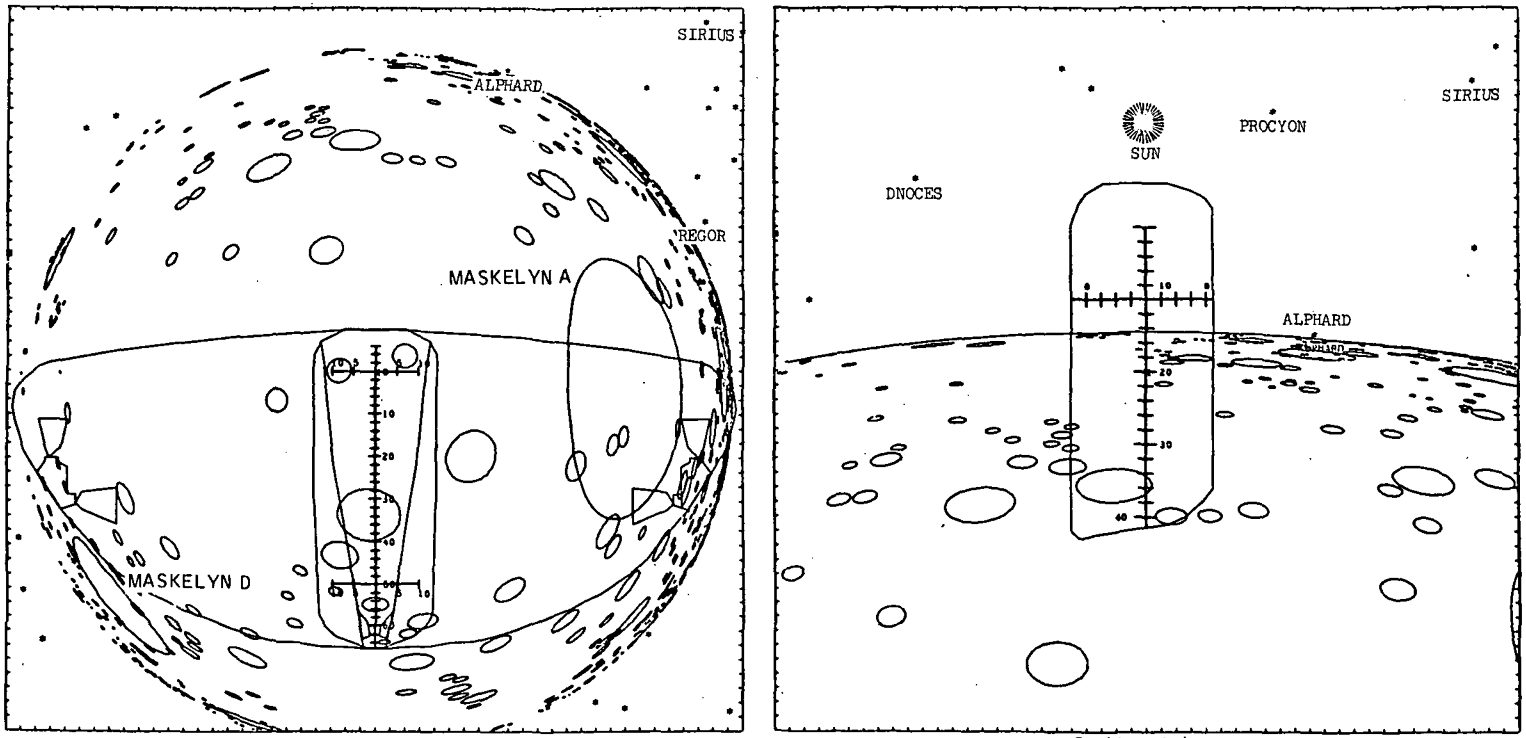
Figure 6.2.2-1.- Continued.



(c) 1 minute 6 seconds into descent burn.

Figure 6.2.2-1.- Continued.

Field of view = 170° Field of view = 100°

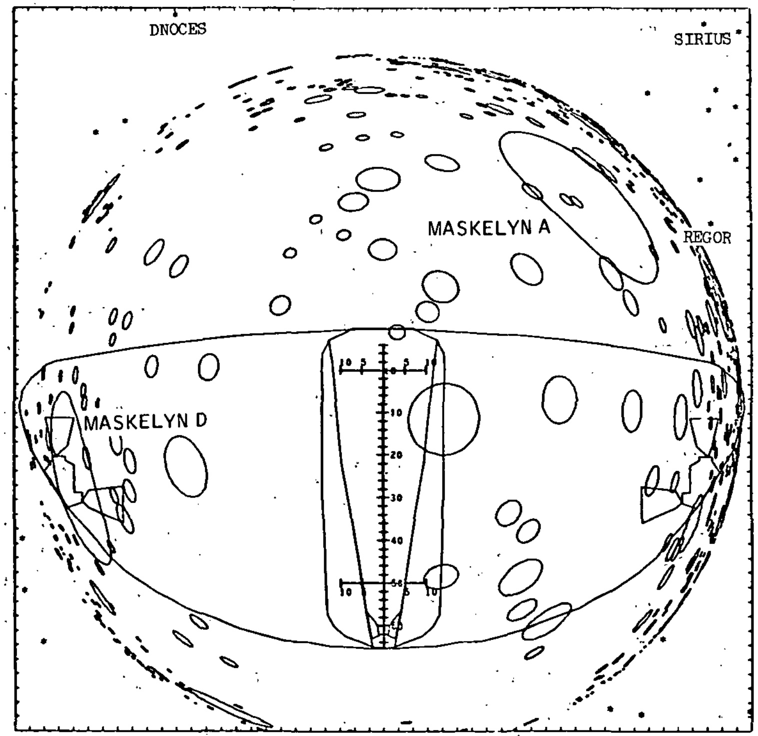


Front windows Docking window

(d) 1 minute 46 seconds into descent burn.

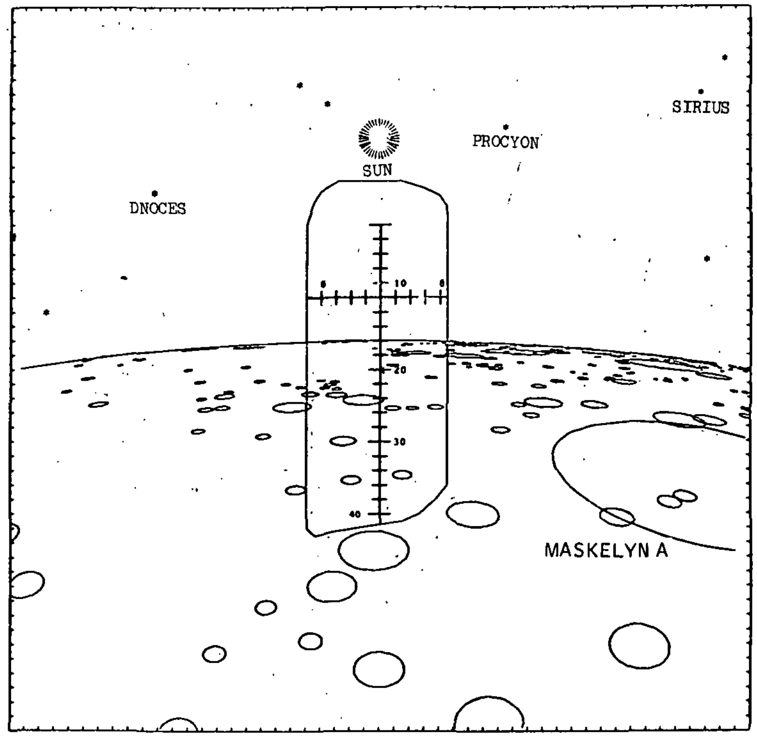
Figure 6.2.2-1.- Continued.

Field of view = 170°



Front windows

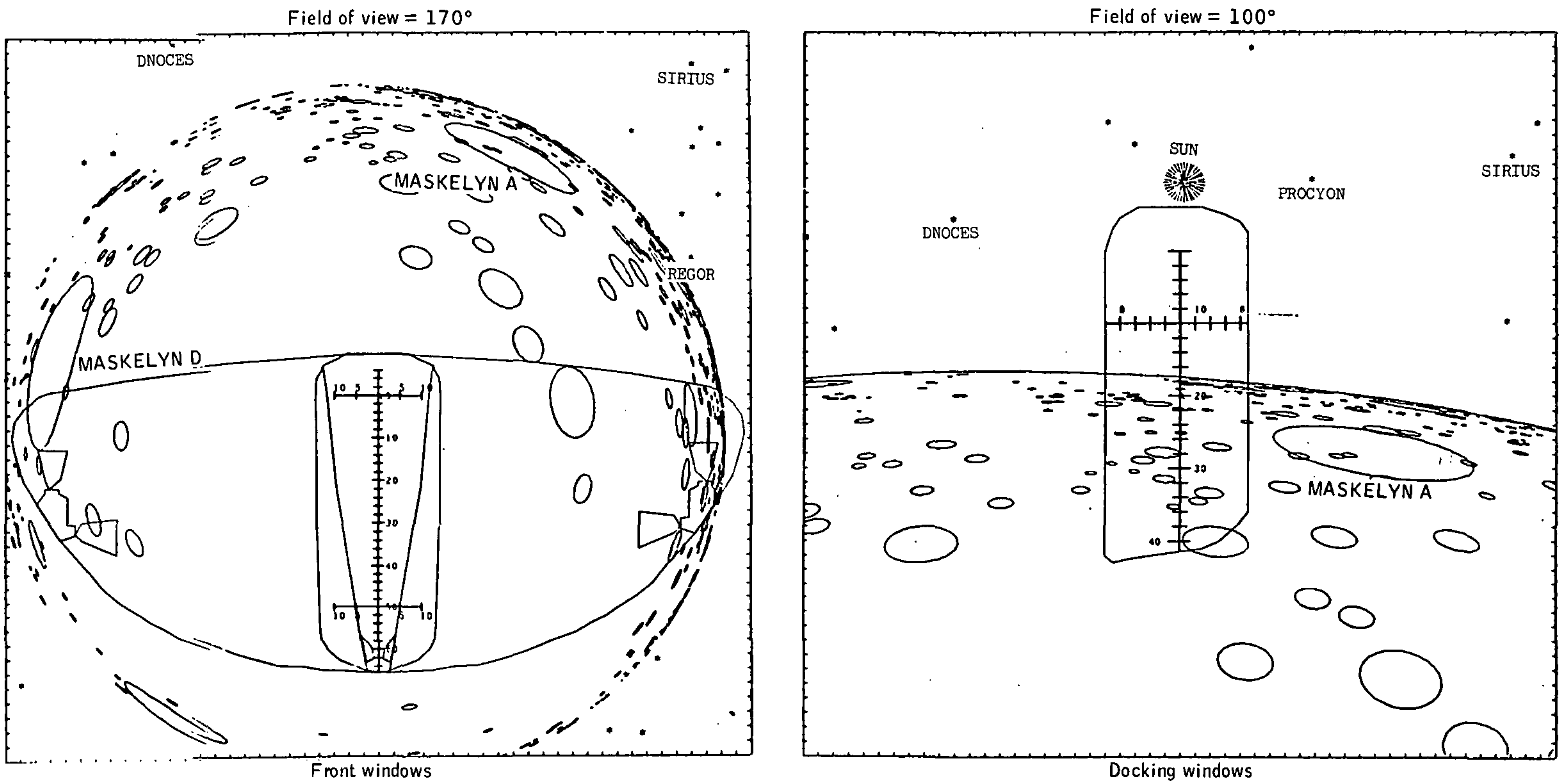
Field of view = 100°



Docking window

(e) 2 minutes 6 seconds into descent burn.

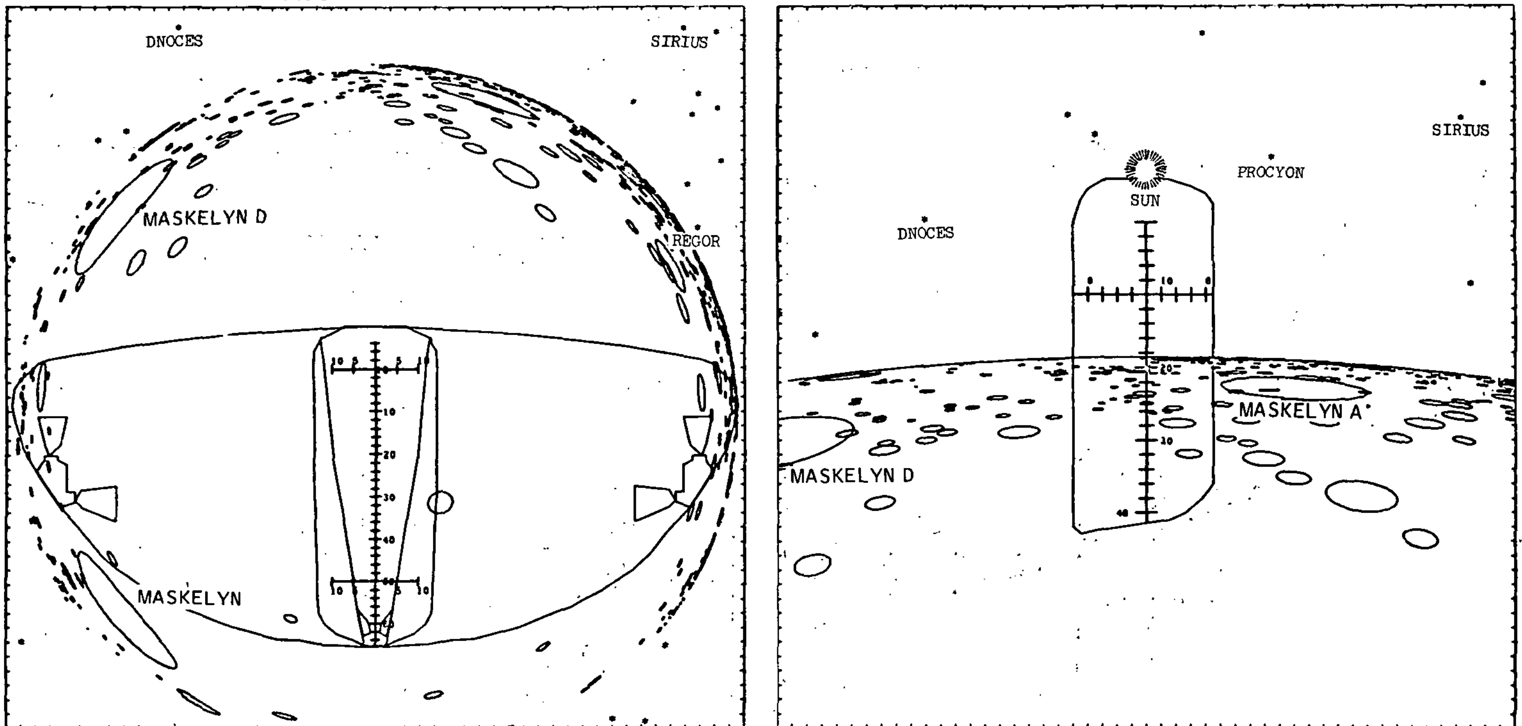
Figure 6.2.2-1.- Continued.



(f) 2 minutes 26 seconds into descent burn.

Figure 6.2.2-1.- Continued.

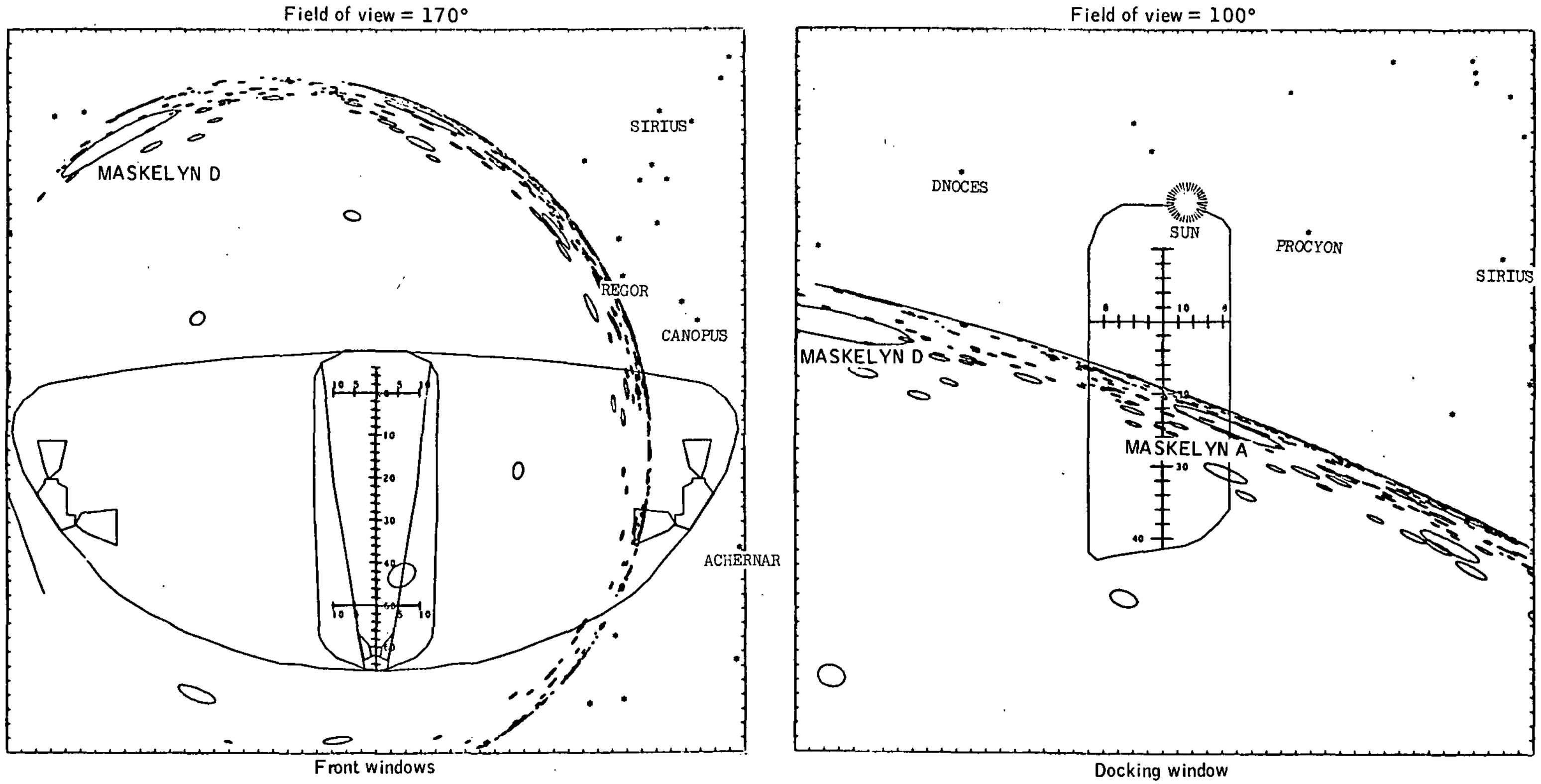
Field of view = 170°   Field of view = 100°



Front windows   Docking window

(g) 2 minutes 46 seconds into descent burn.

Figure 6.2.2-1.- Continued.

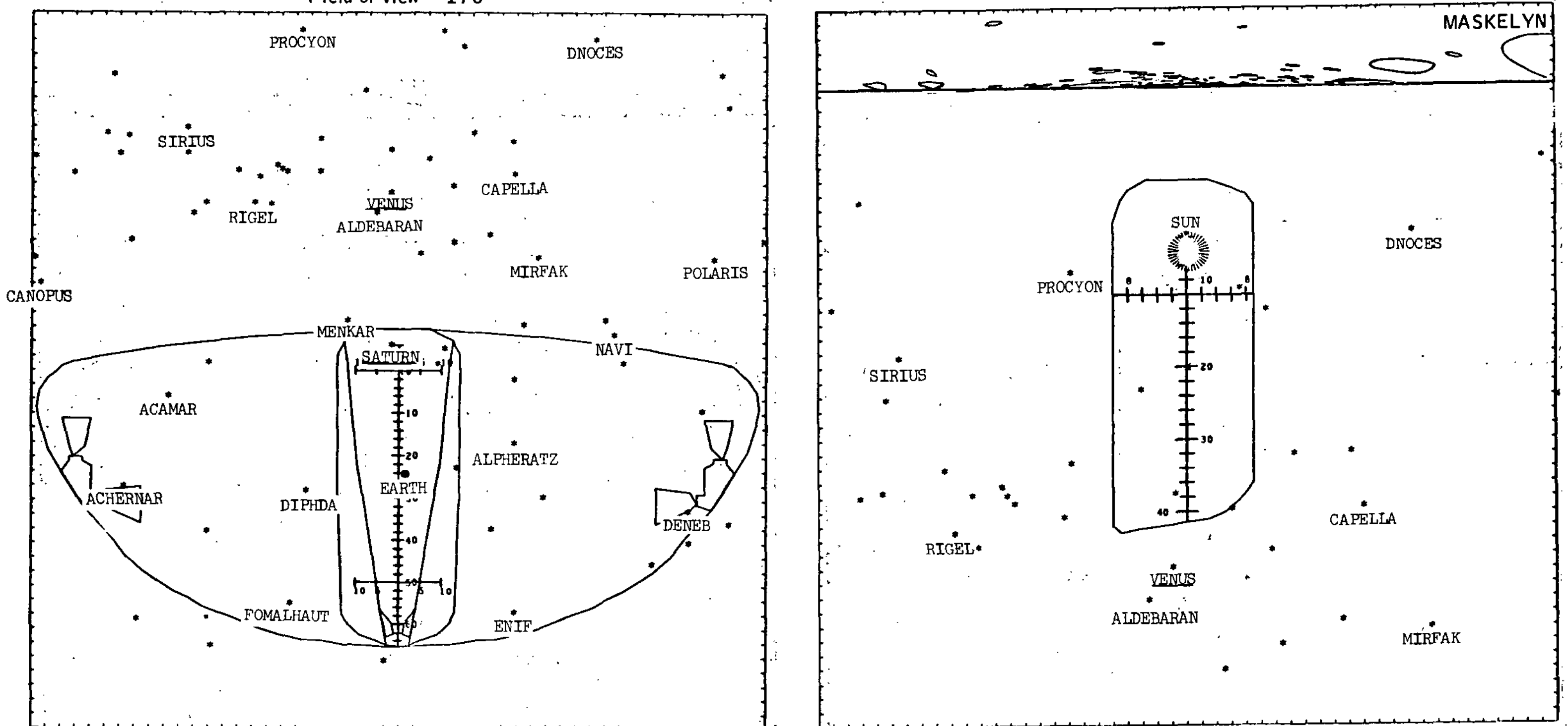


(h) 3 minutes 6 seconds into descent burn.

Figure 6.2.2-1.- Continued.

Field of view = 170°

Field of view = 100°

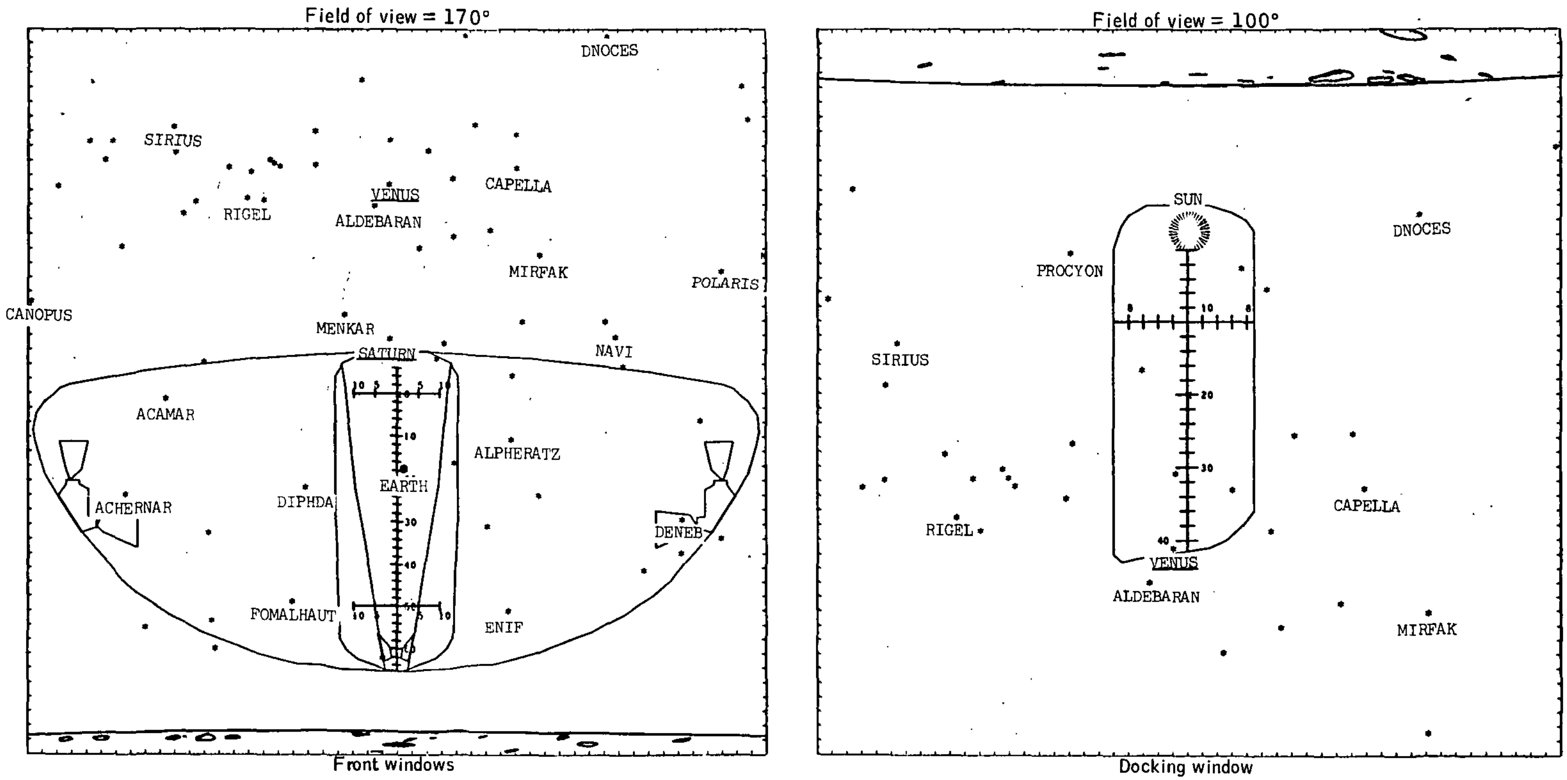


Front windows

Docking window

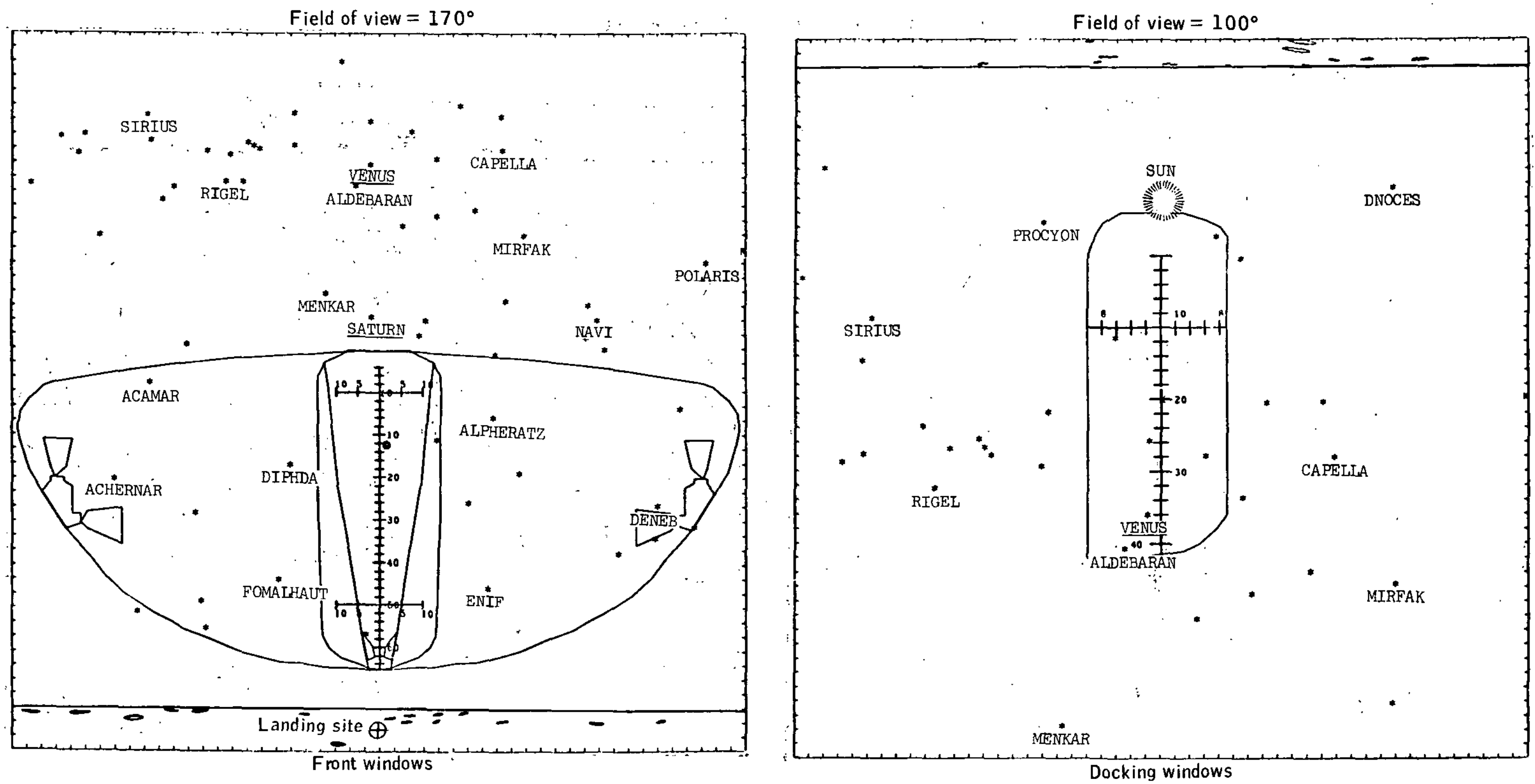
(i) 3 minutes 46 seconds into descent burn.

Figure 6.2.2-1.- Continued.



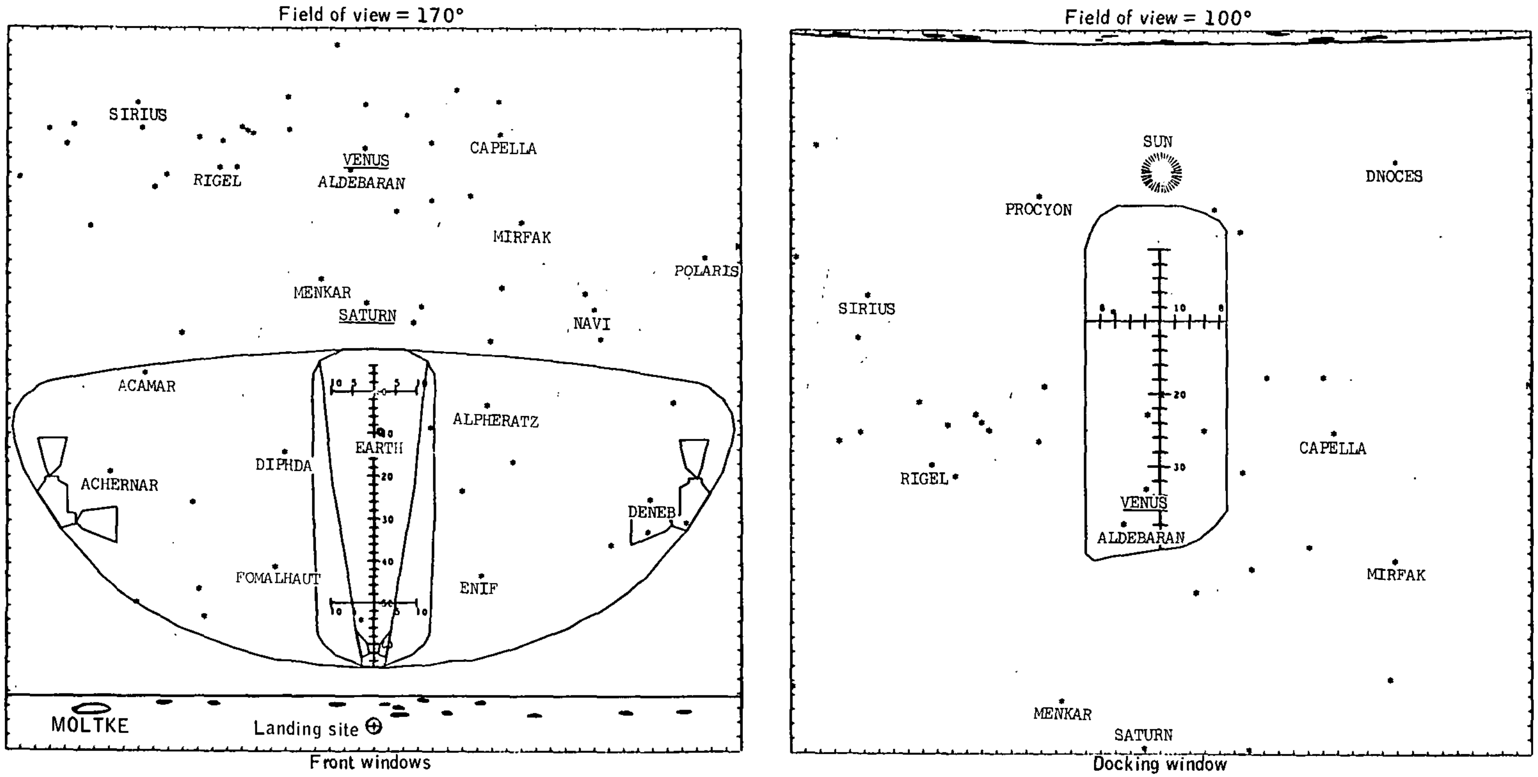
(i) 5 minutes 26 seconds into descent burn.

Figure 6.2.2-1.- Continued.



(k) 6 minutes 6 seconds into descent burn.

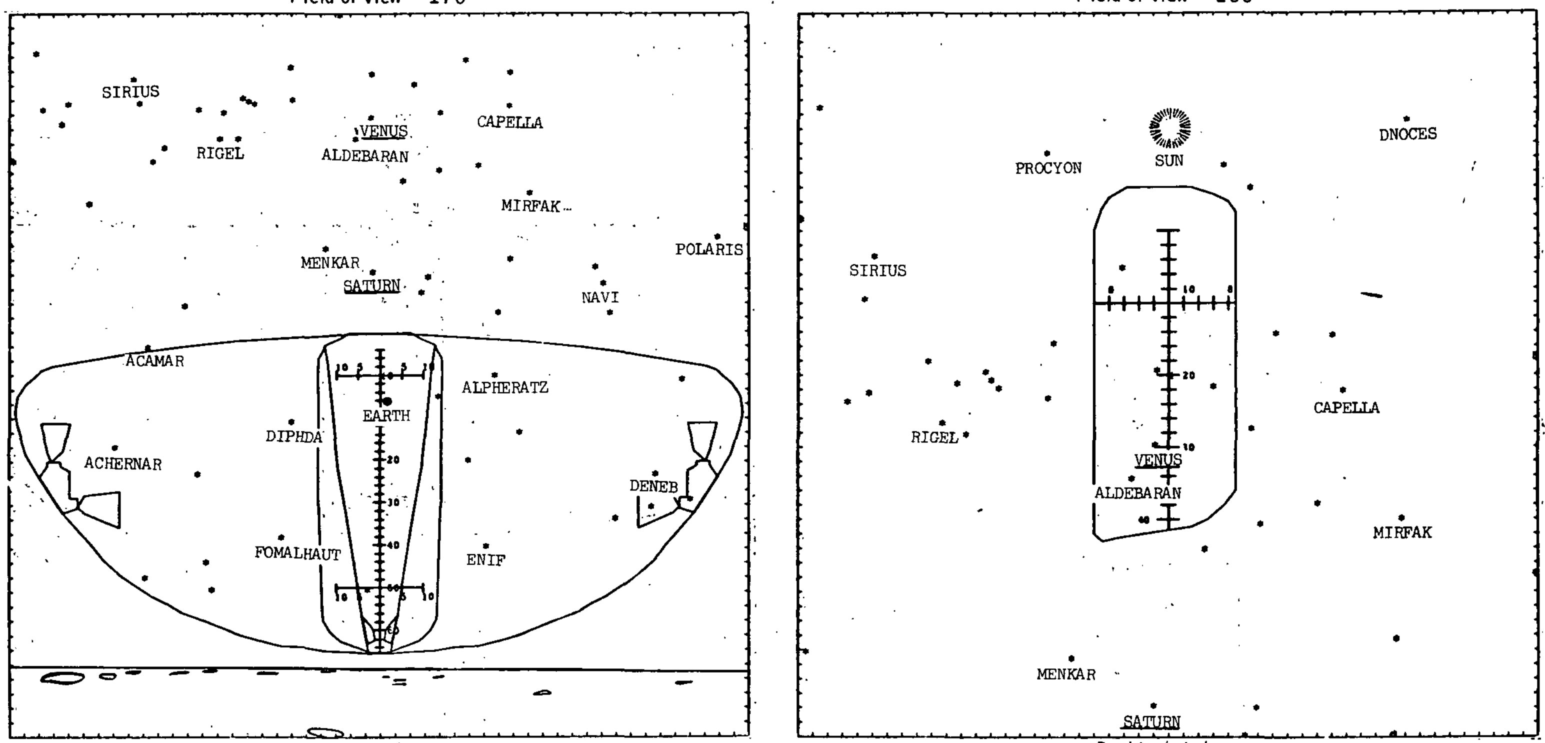
Figure 6.2.2-1.- Continued.



(l) 6 minutes 26 seconds into descent burn.

Figure 6.2.2-1.- Continued.

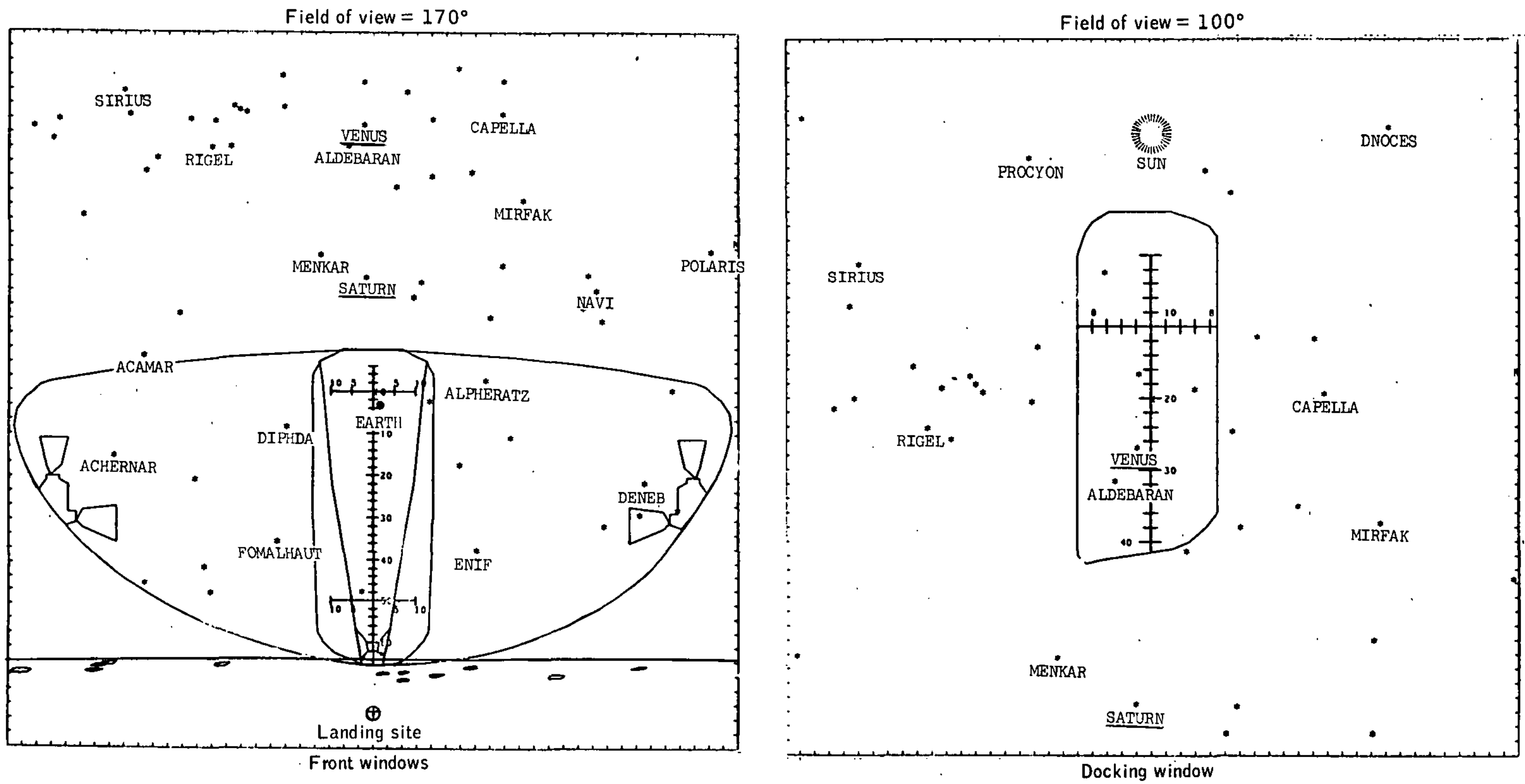
Field of view = 170° | Field of view = 100°



Front windows | Docking window

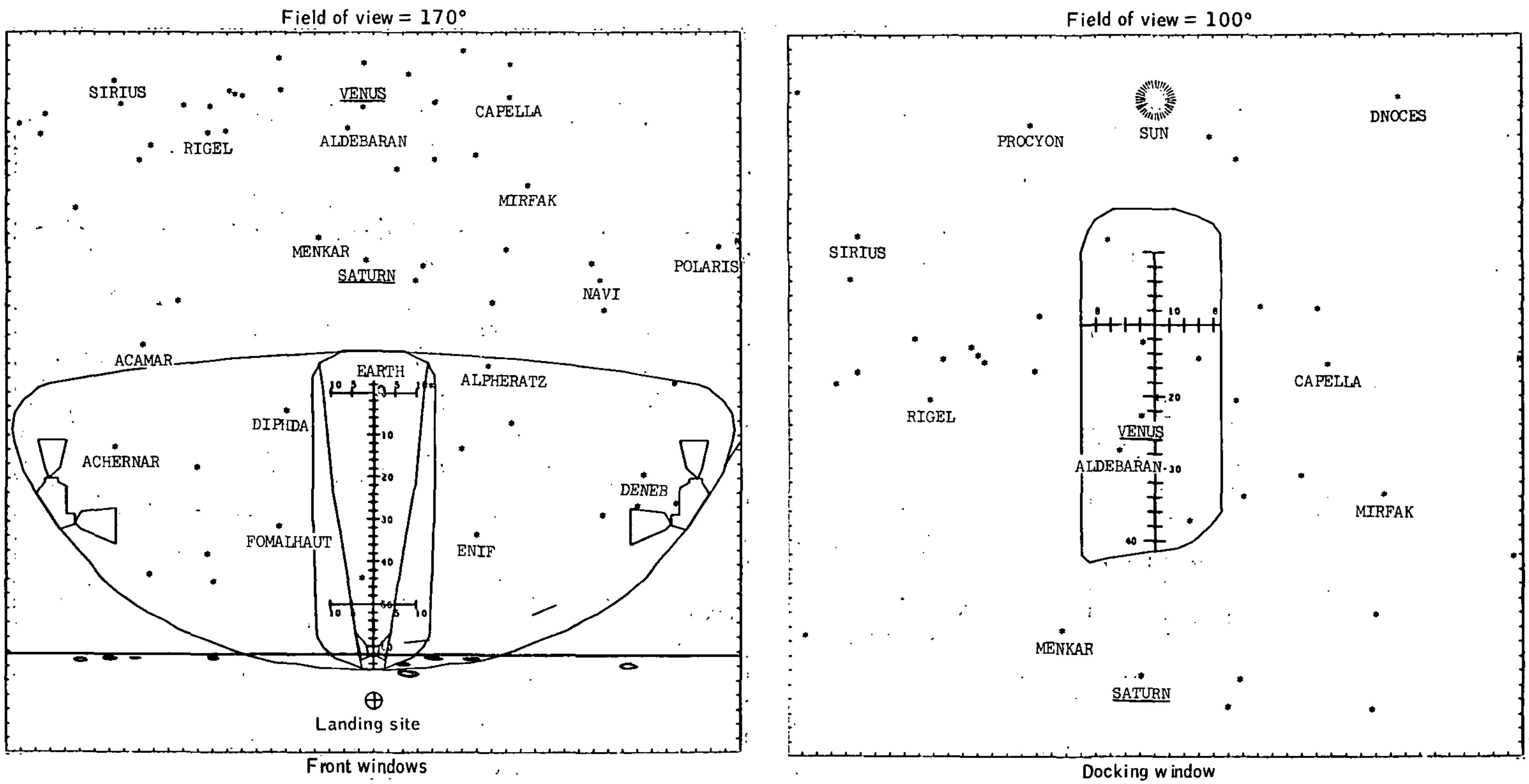
(m) 6 minutes 46 seconds into descent burn.

Figure 6.2.2-1.- Continued.



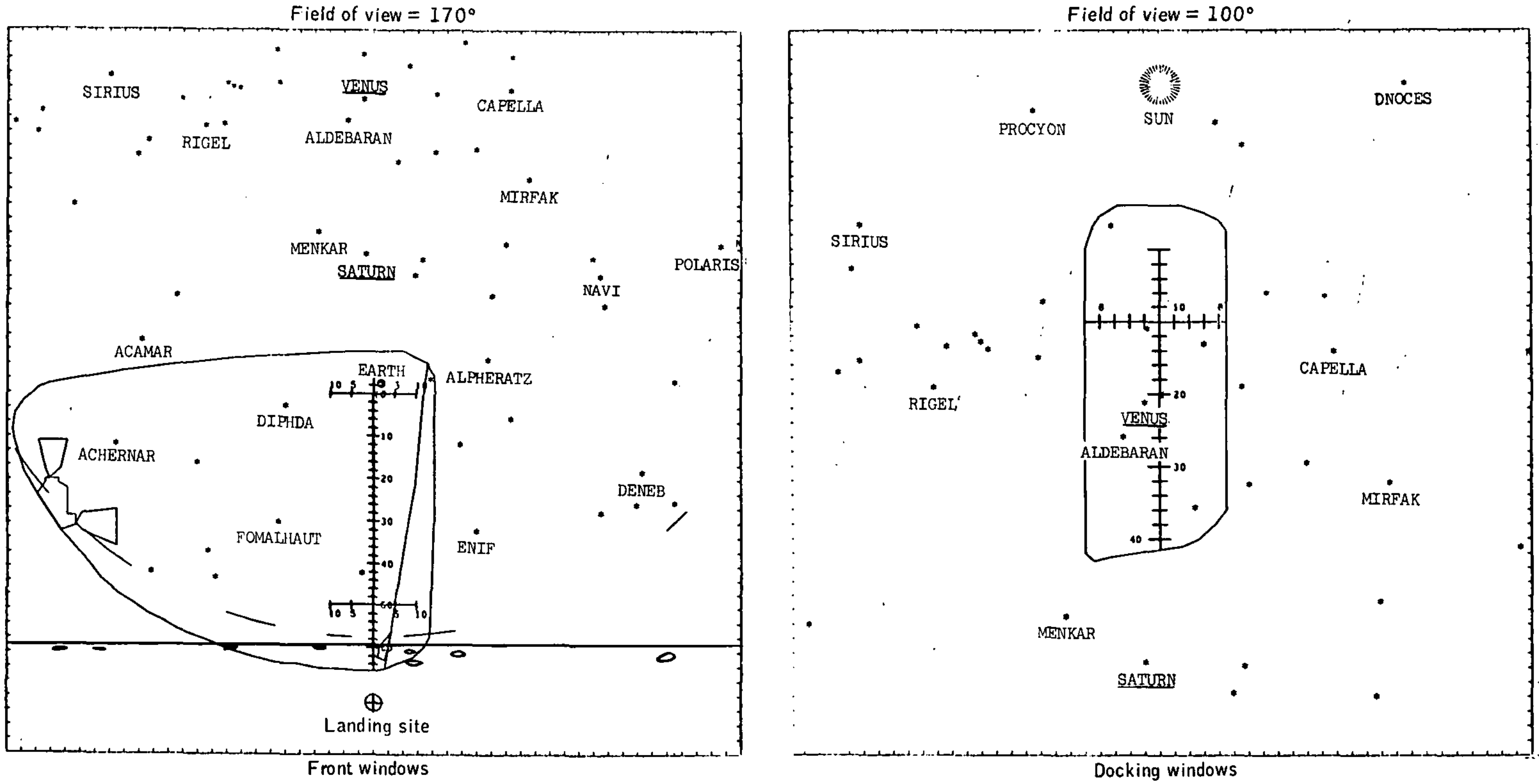
(n) 7 minutes 6 seconds into descent burn.

Figure 6.2.2-1.- Continued.



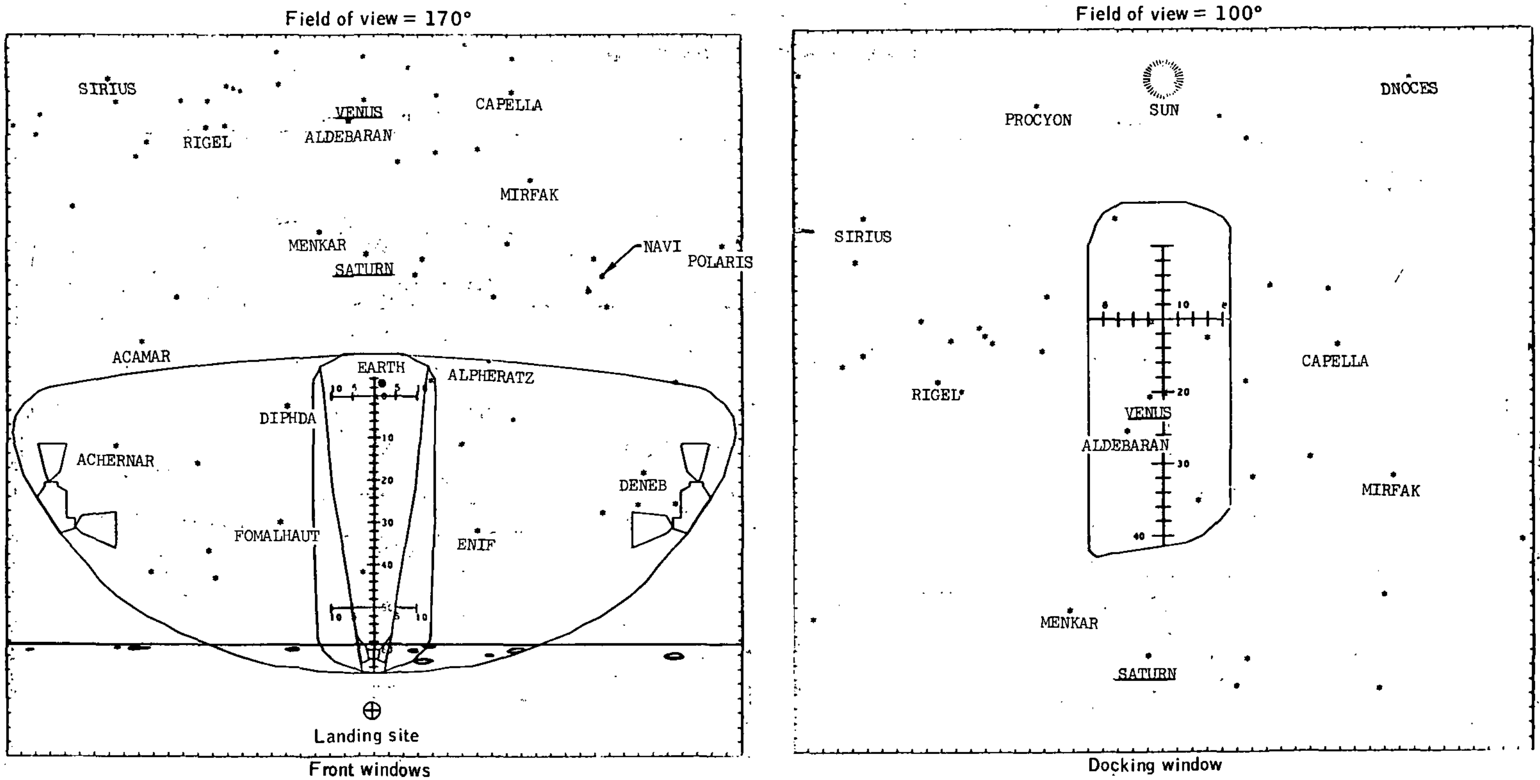
(o) 7 minutes 46 seconds into descent burn.

Figure 6.2.2-1.- Continued.



(p) 8 minutes 6 seconds into descent burn.

Figure 6.2.2-1.- Continued.

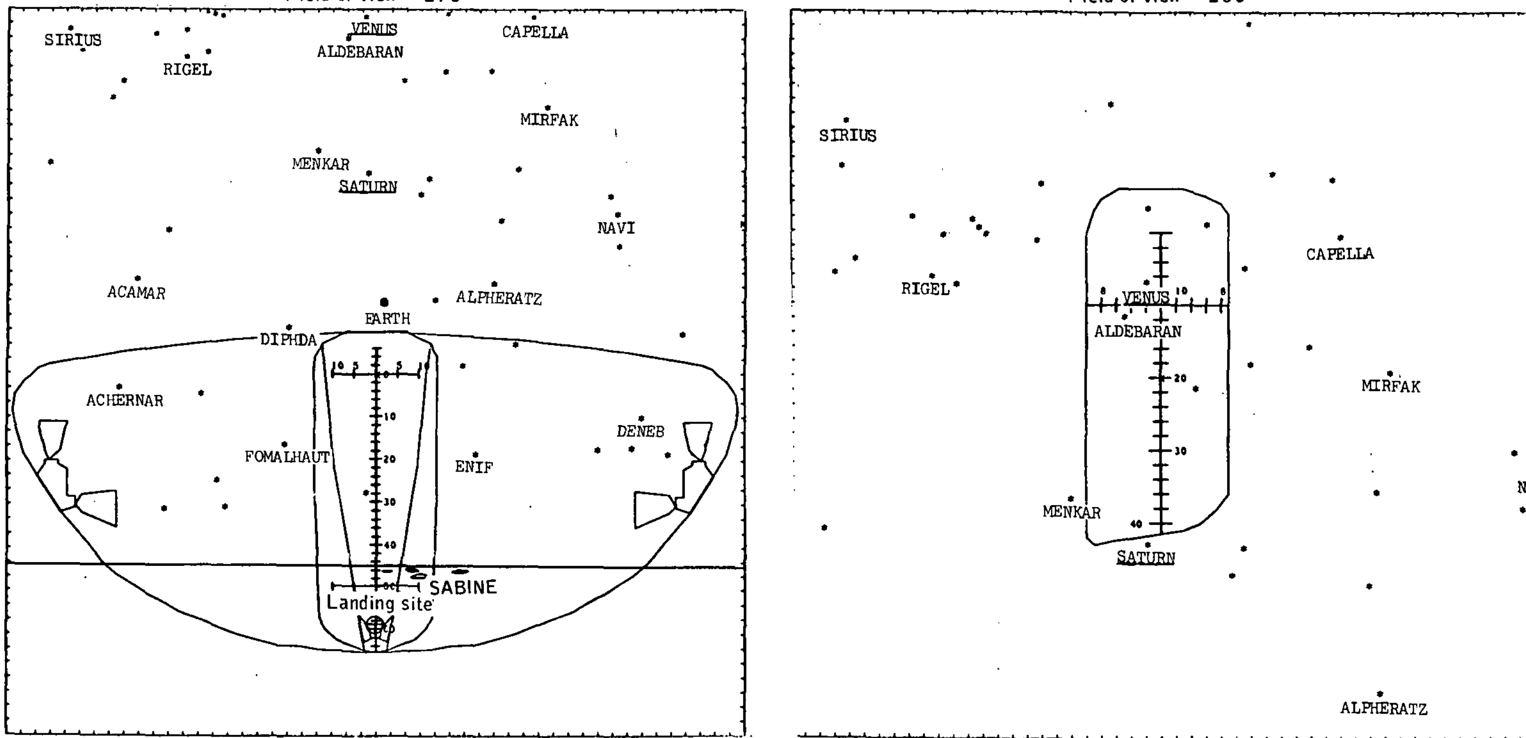


(q) 8 minutes 26 seconds into descent burn.

Figure 6.2.2-1.- Continued.

Field of view = 170°

Field of view = 100°

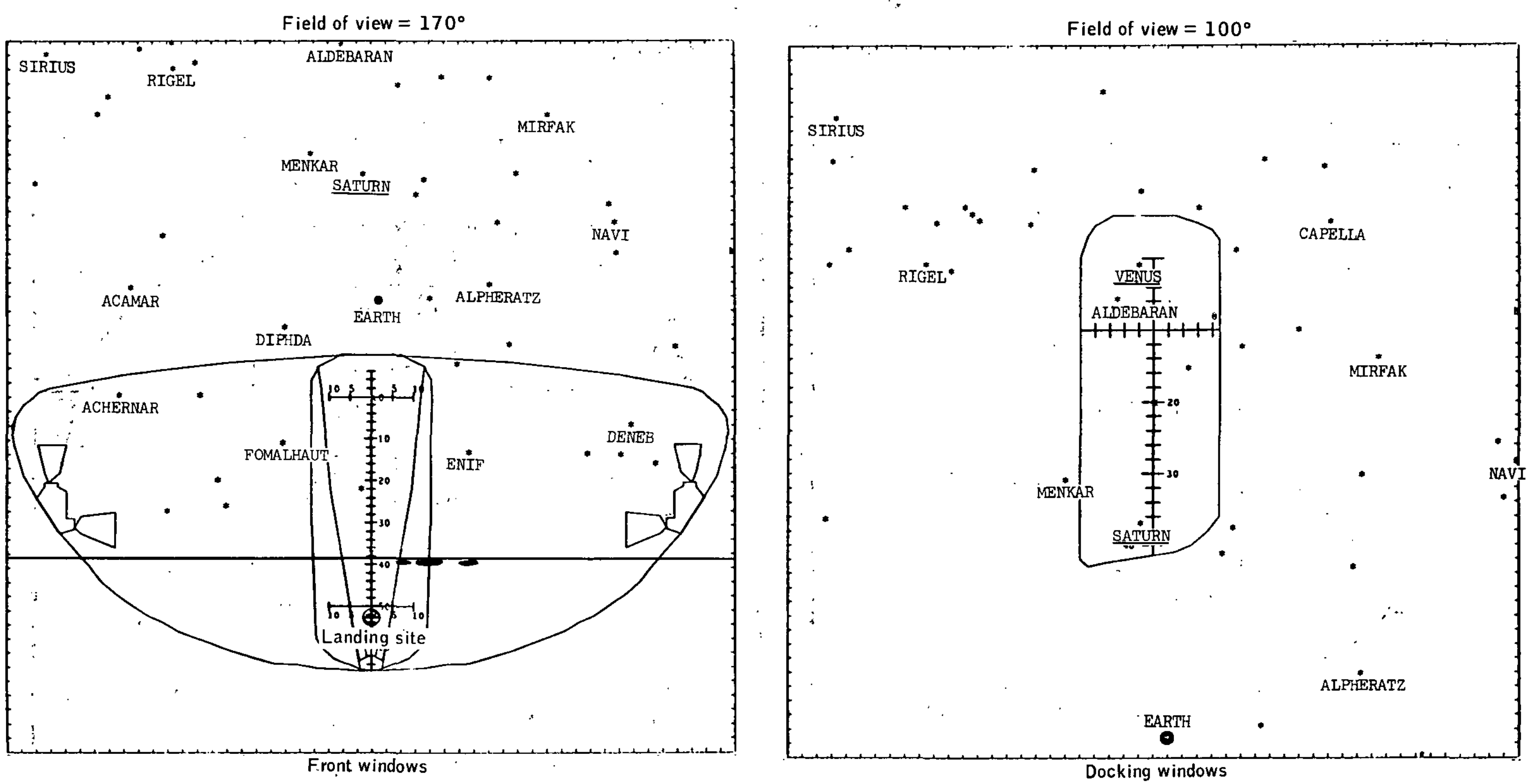


Front windows

Docking window

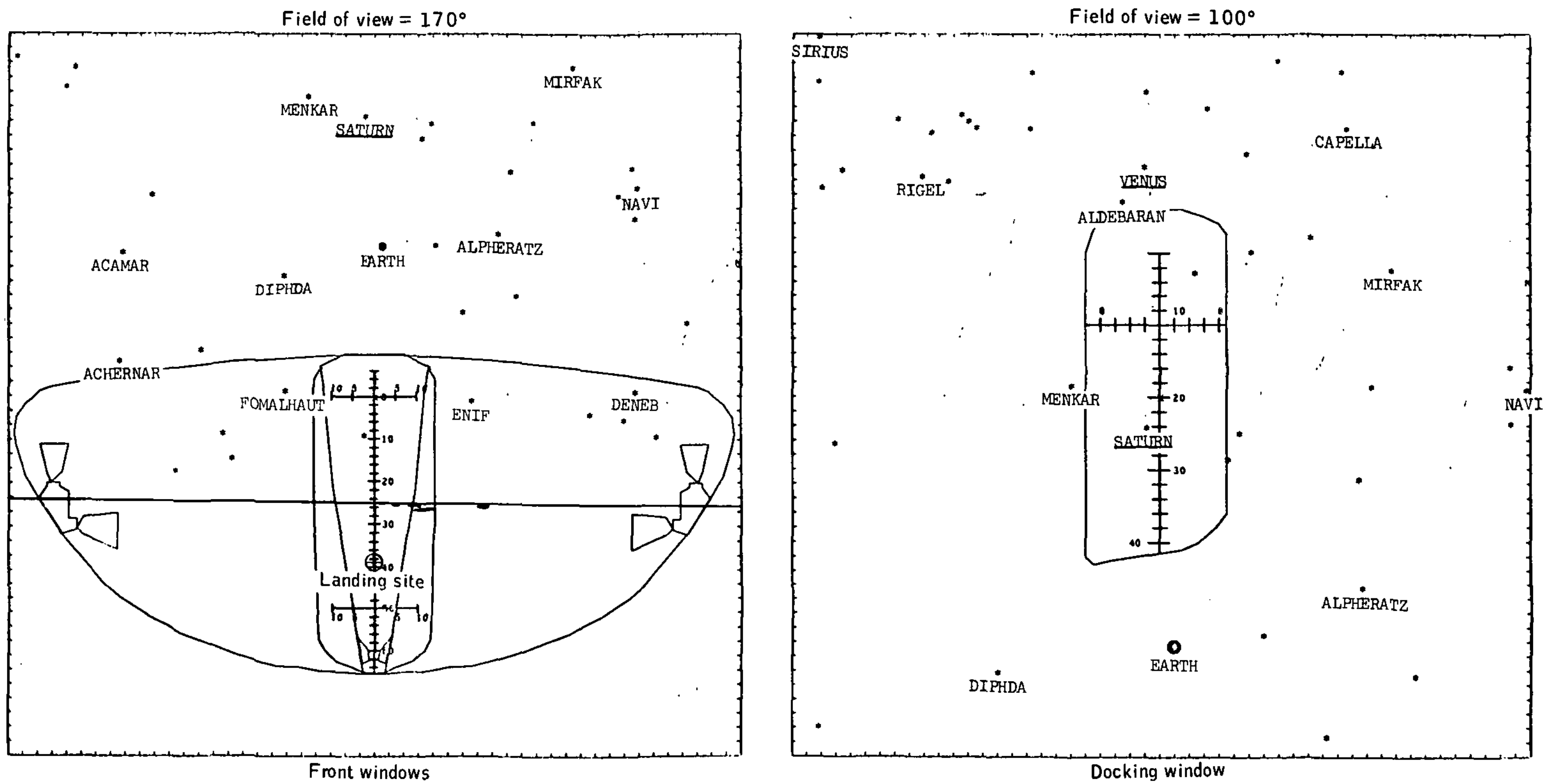
(r) 8 minutes 46 seconds into descent burn.

Figure 6.2.2-1.- Continued.



(s) 9 minutes 6 seconds into descent burn.

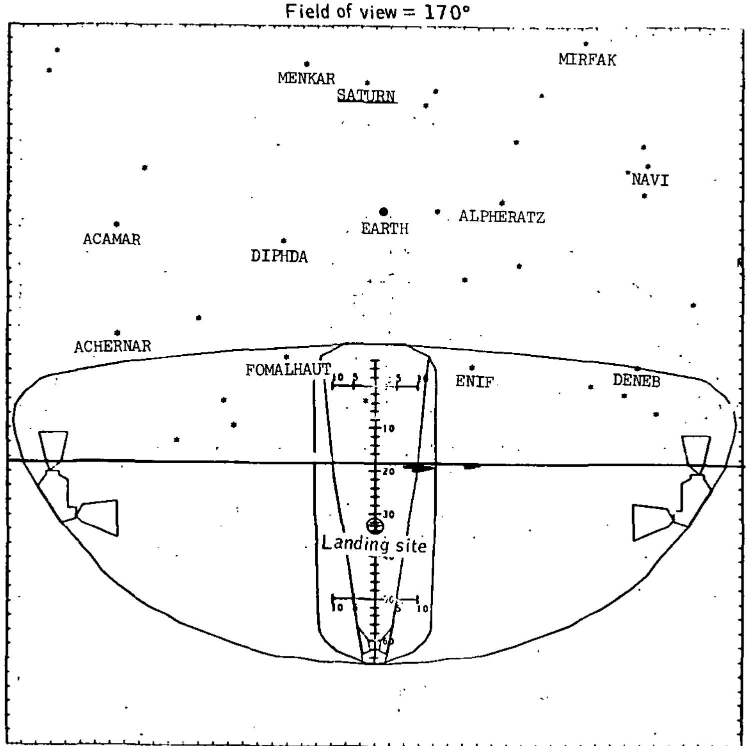
Figure 6.2.2-1.- Continued.



(t) 9 minutes 46 seconds into descent burn.

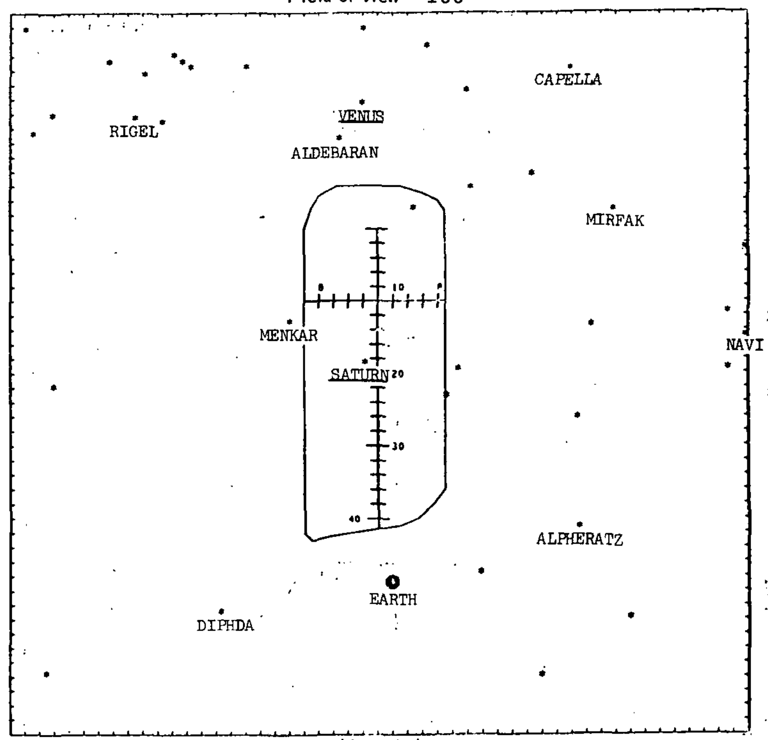
Figure 6.2.2-1.- Continued.

Field of view = 170°



Front windows

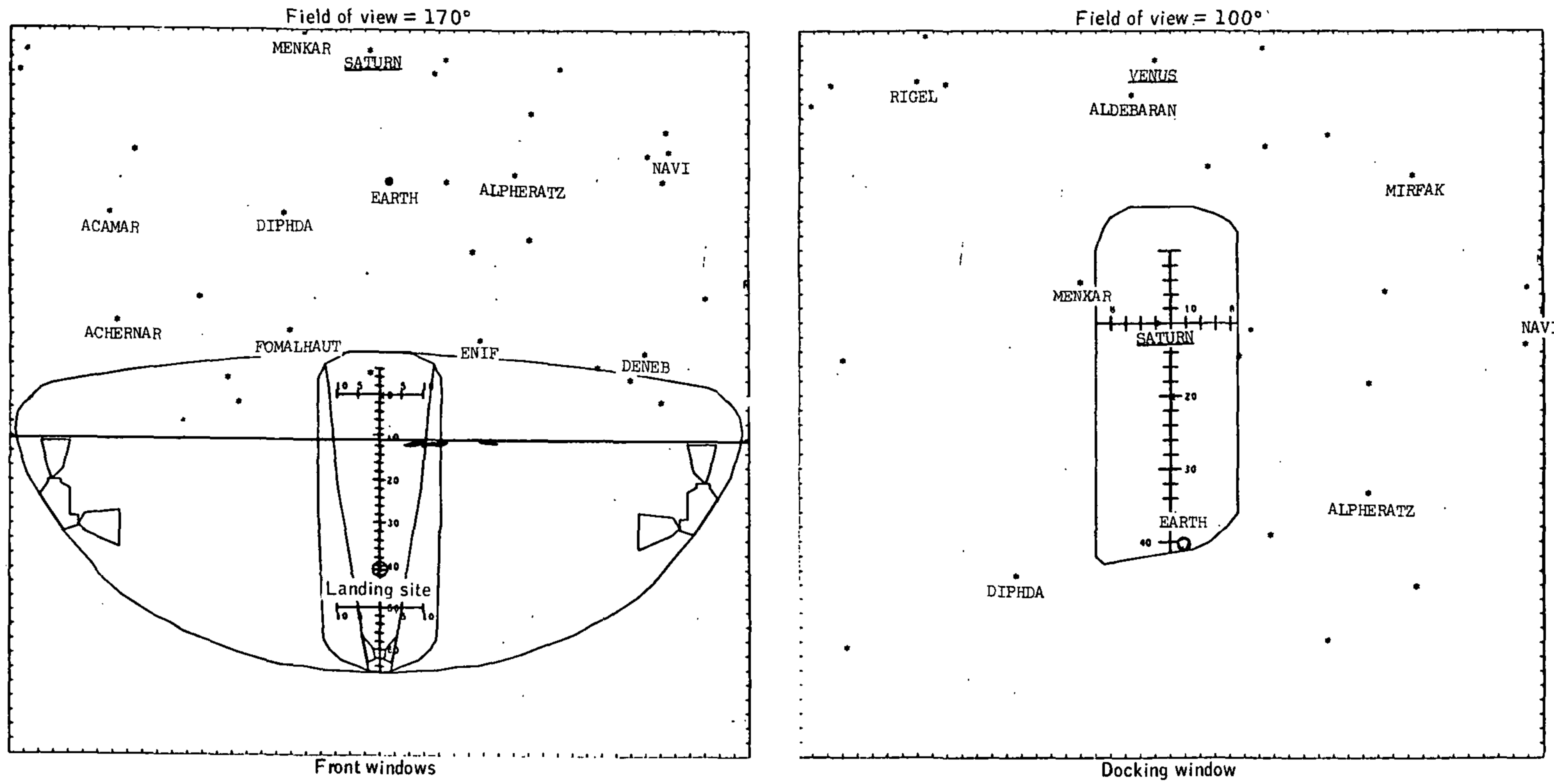
Field of view = 100°



Docking window

(u) 10 minutes 6 seconds into descent burn.

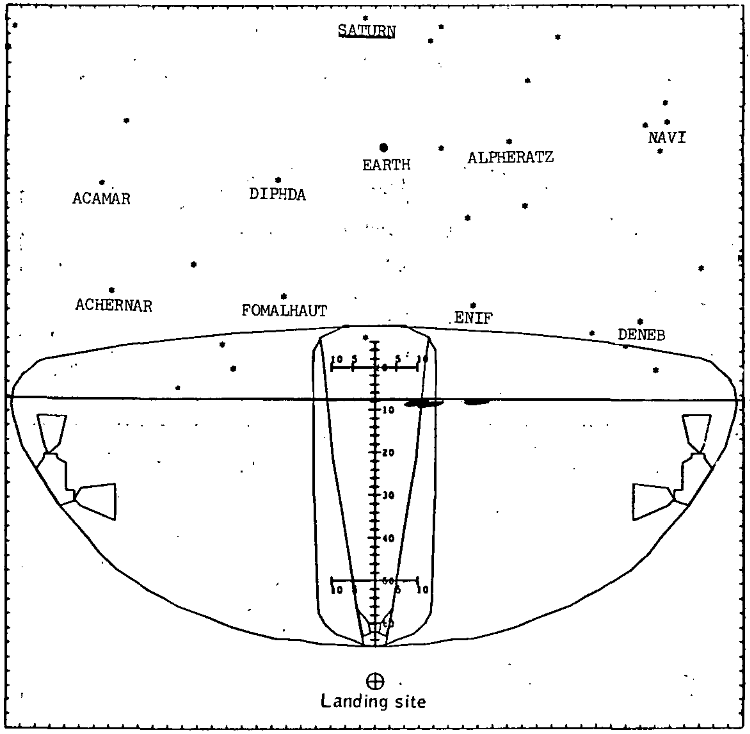
Figure 6.2.2-1.- Continued.



(v) 10 minutes 46 seconds into descent burn.

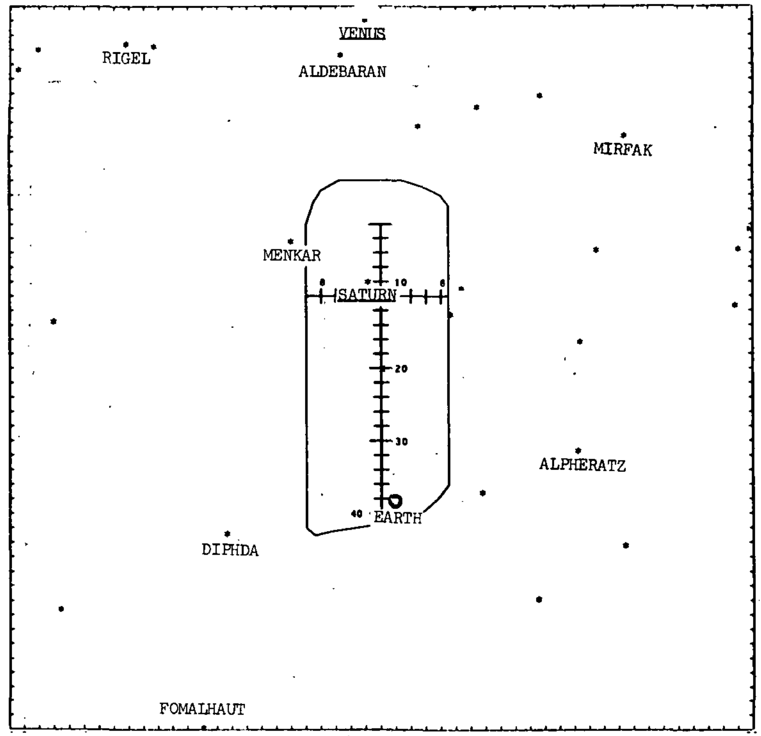
Figure 6.2.2-1.- Continued.

Field of view = 170°



Front windows

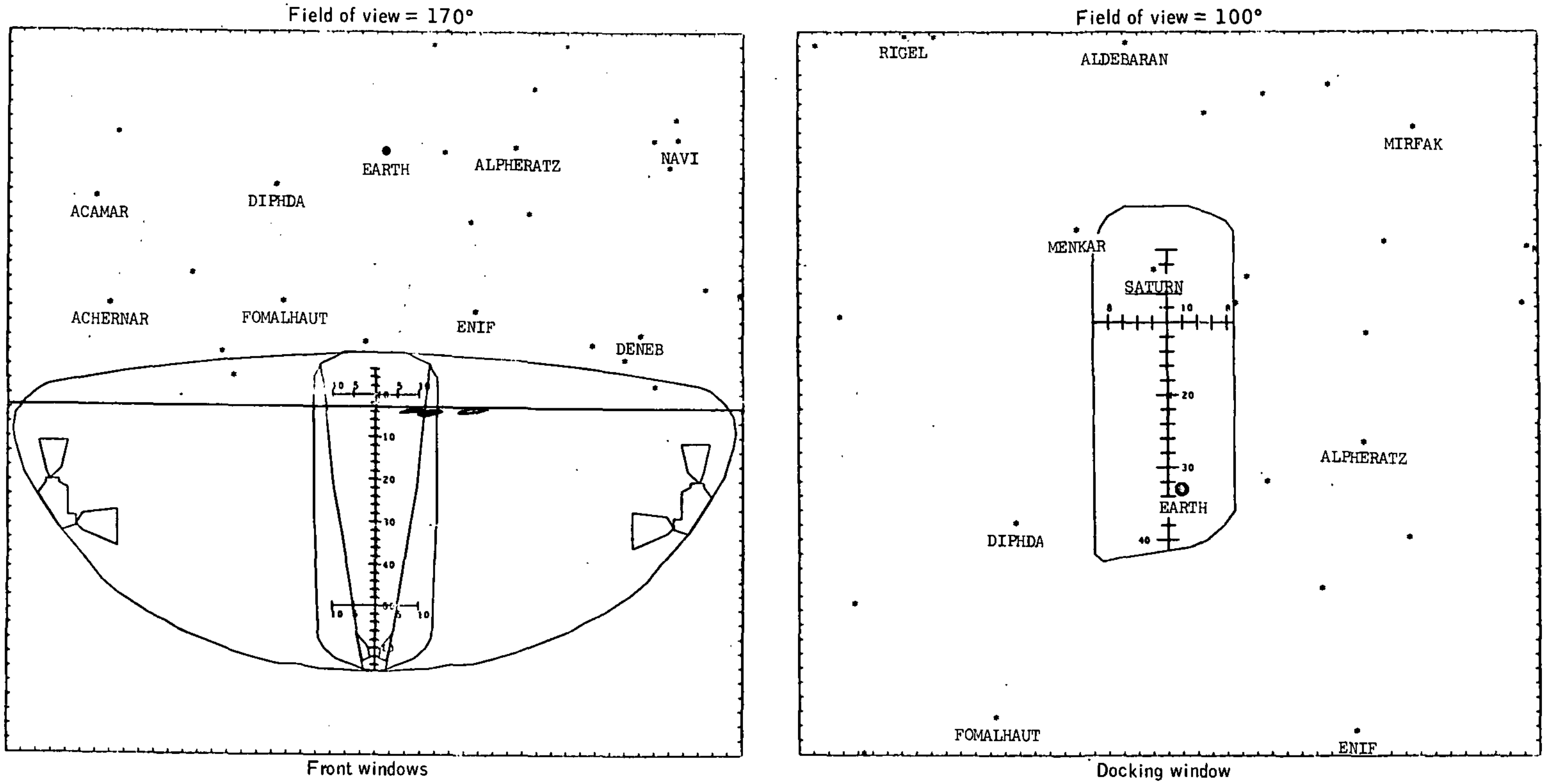
Field of view = 100°



Docking window

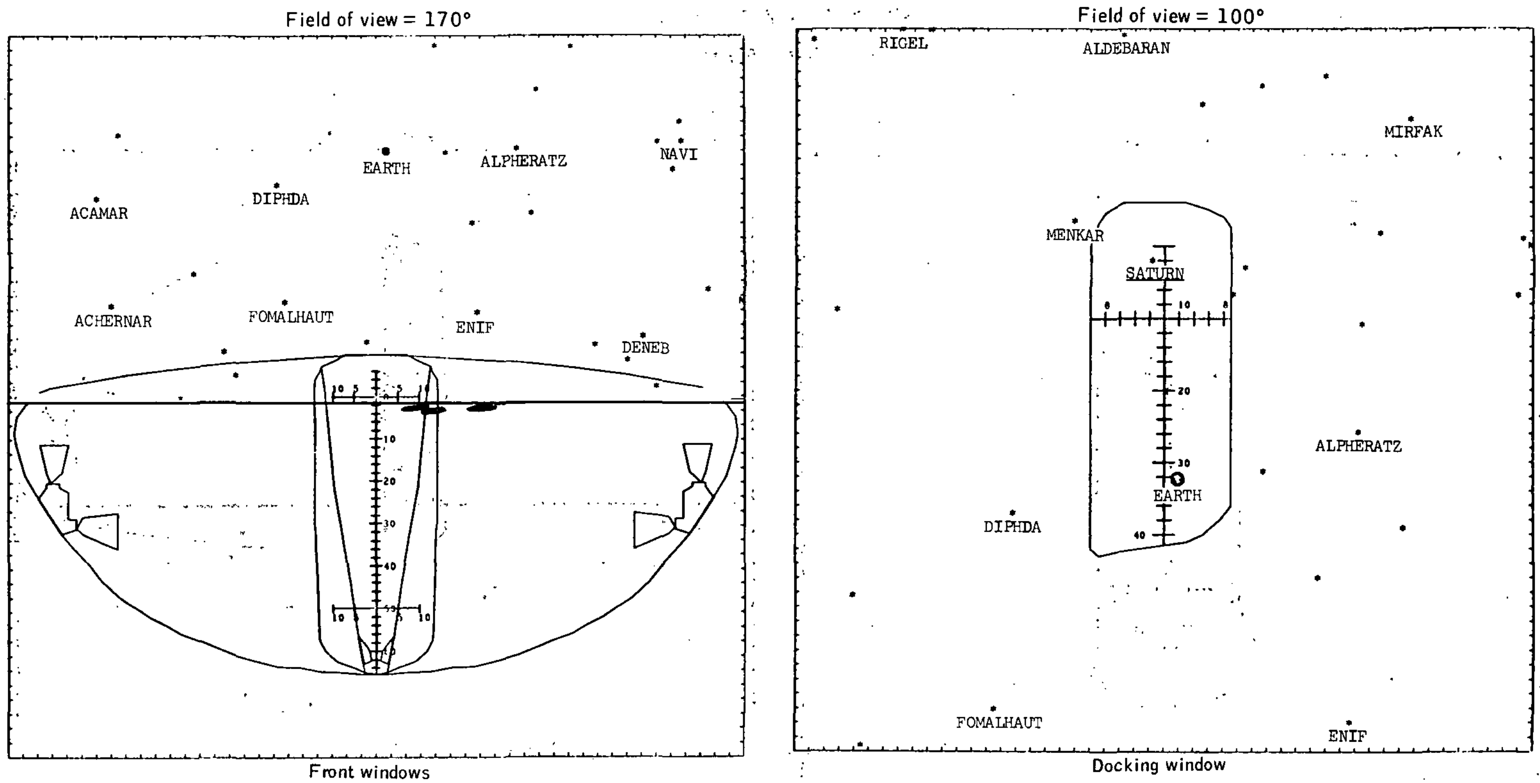
(w) 11 minutes 6 seconds into descent burn.

Figure 6.2.2-1.- Continued.



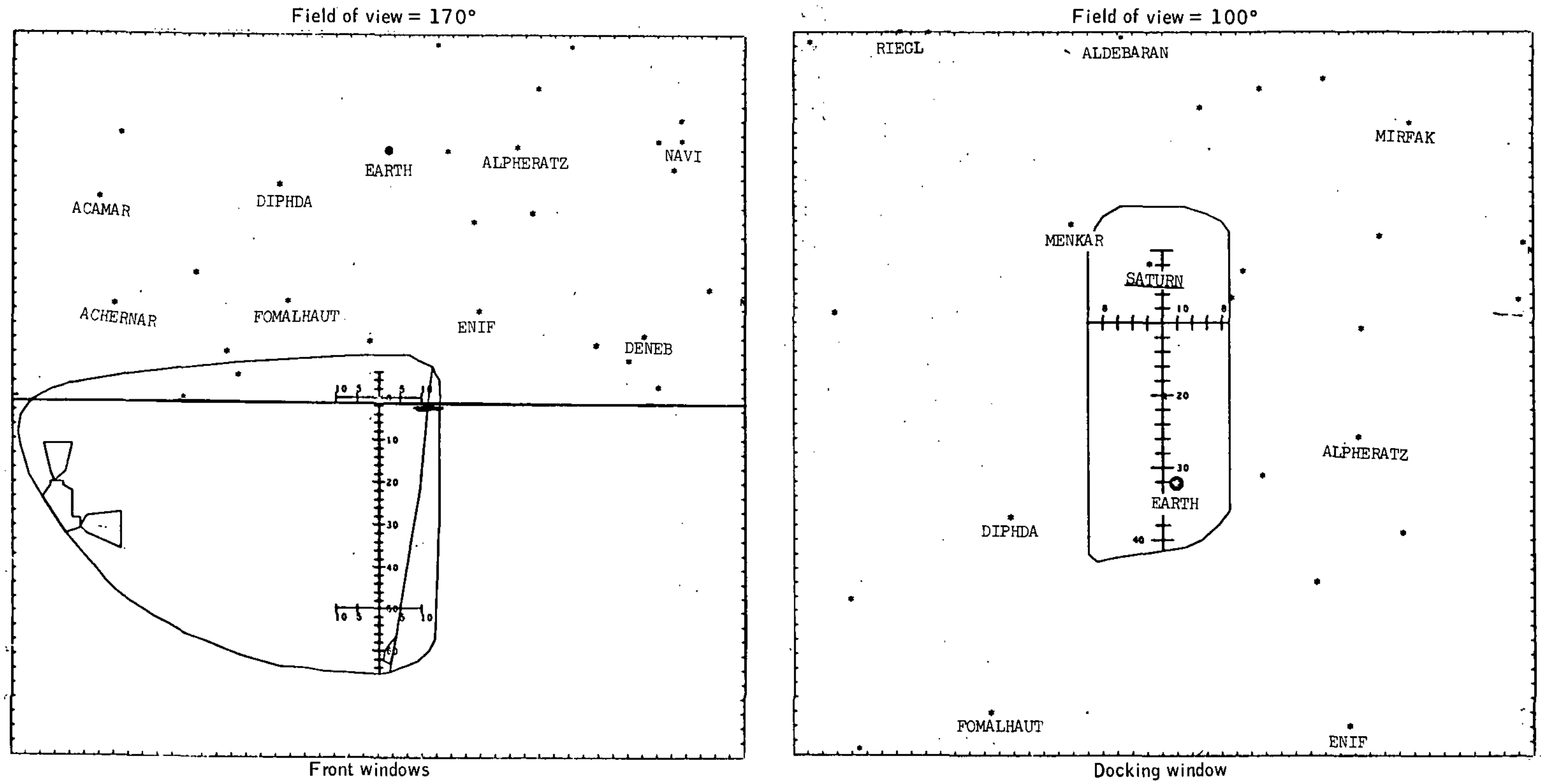
(x) 11 minutes 26 seconds into descent burn.

Figure 6.2.2-1.- Continued.



(y) 11 minutes 46 seconds into descent burn.

Figure 6.2.2-1.- Continued.



(z) End of descent burn.

Figure 6.2.2-1.- Concluded.

6.3 VIEWS FROM LM DURING ASCENT PHASE

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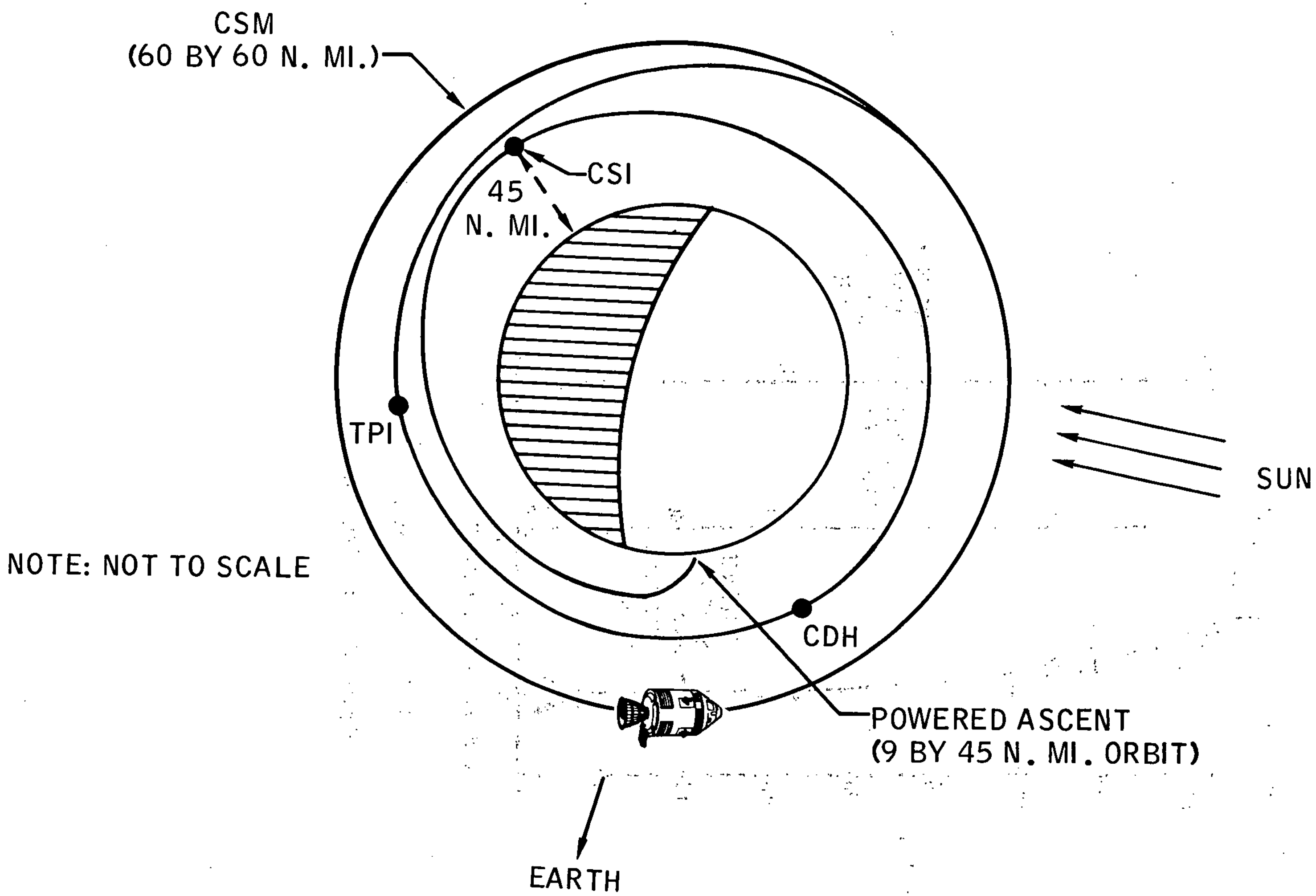
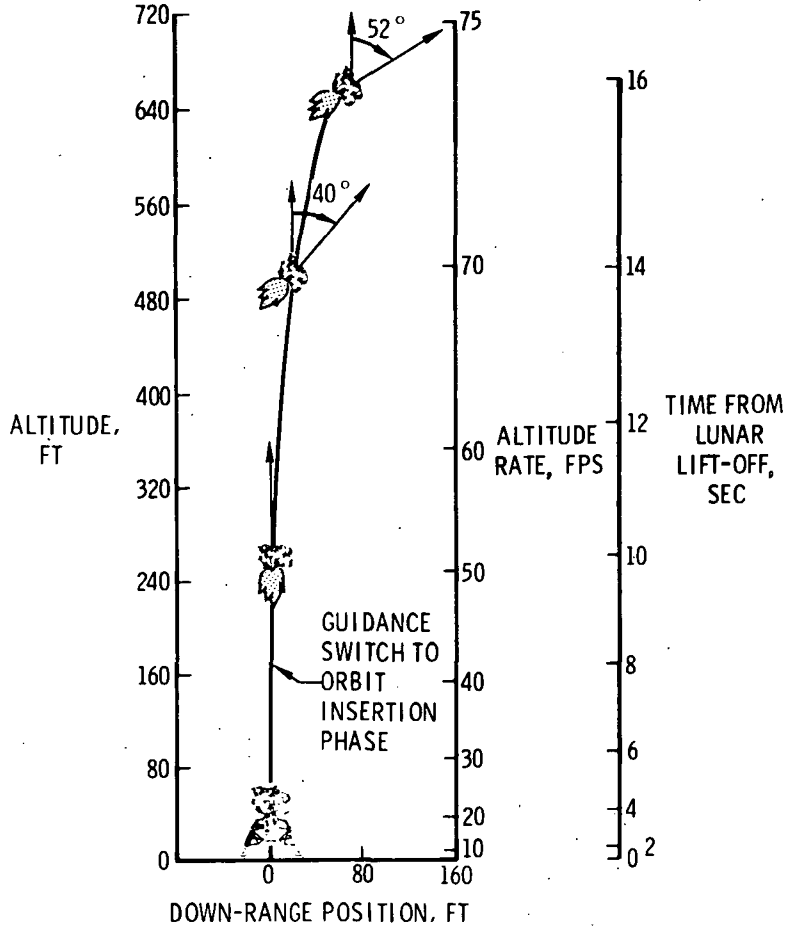


(a) LM ascent phase geometry.

Figure 6.3.0-1.- Ascent phase.



(b) Vertical rise phase.

Figure 6.3.0-1.- Concluded.

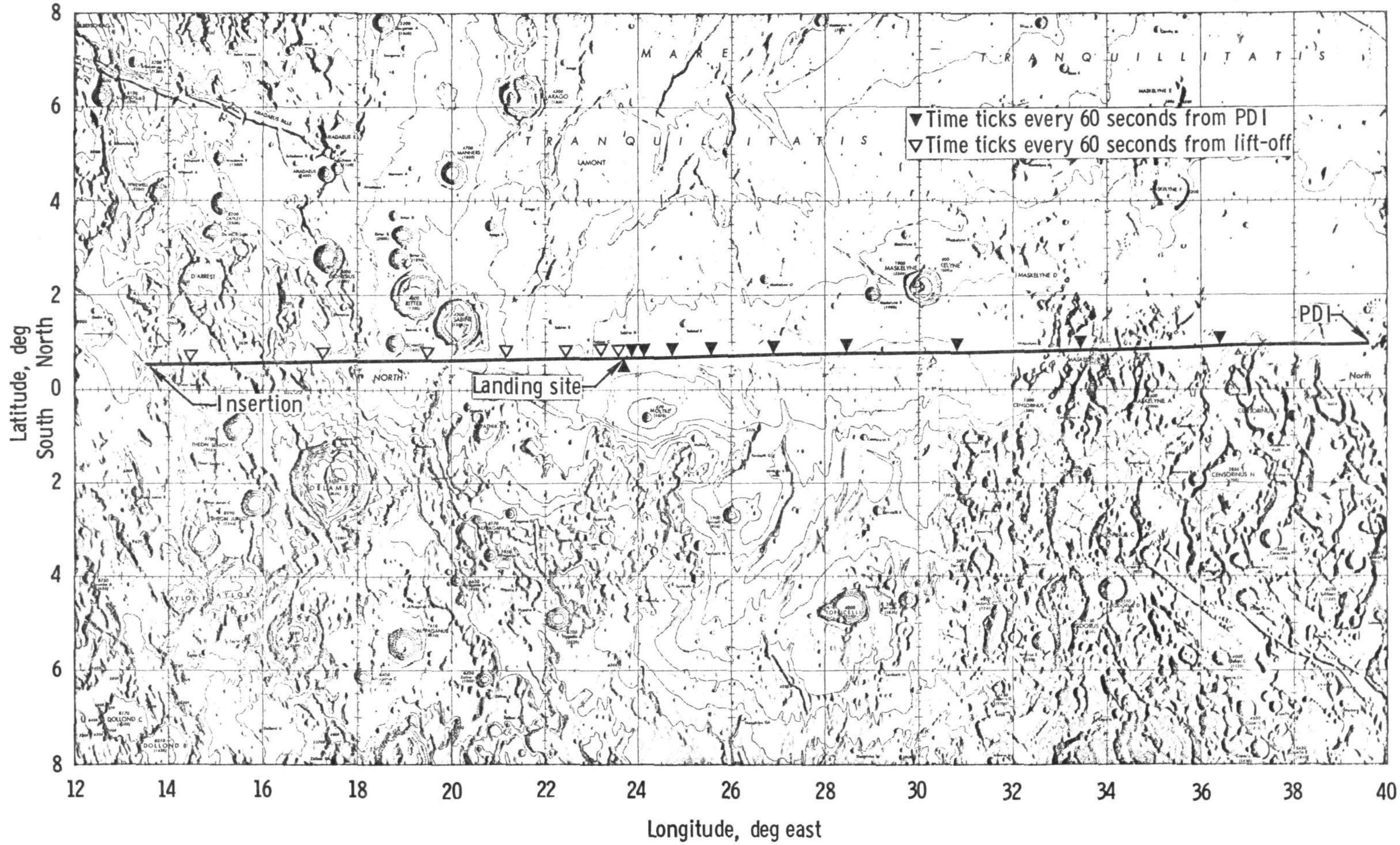


Figure 6.3.0-2.- LM groundtrack during descent and ascent.

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6.3.1 ASCENT BURN

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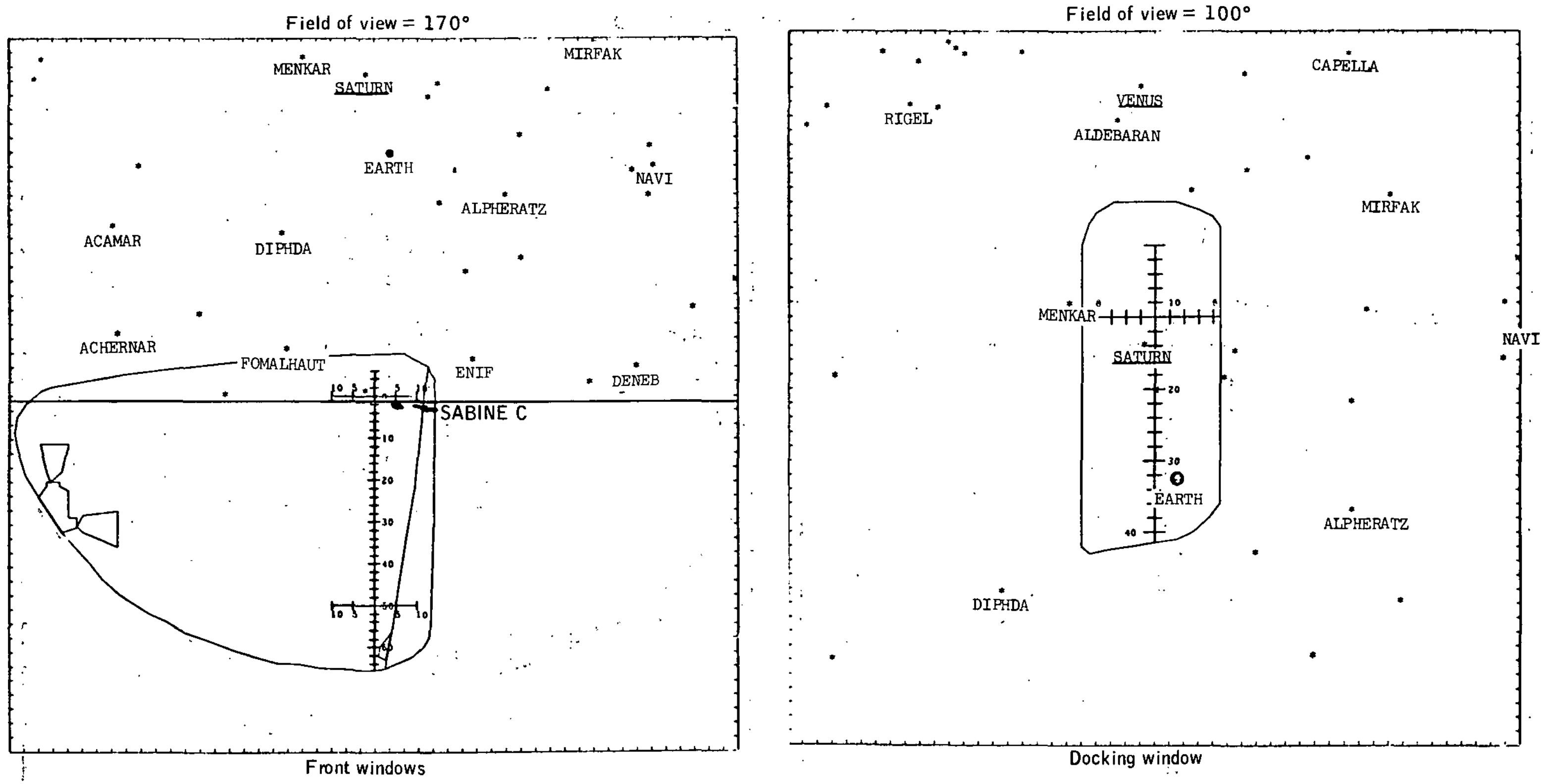
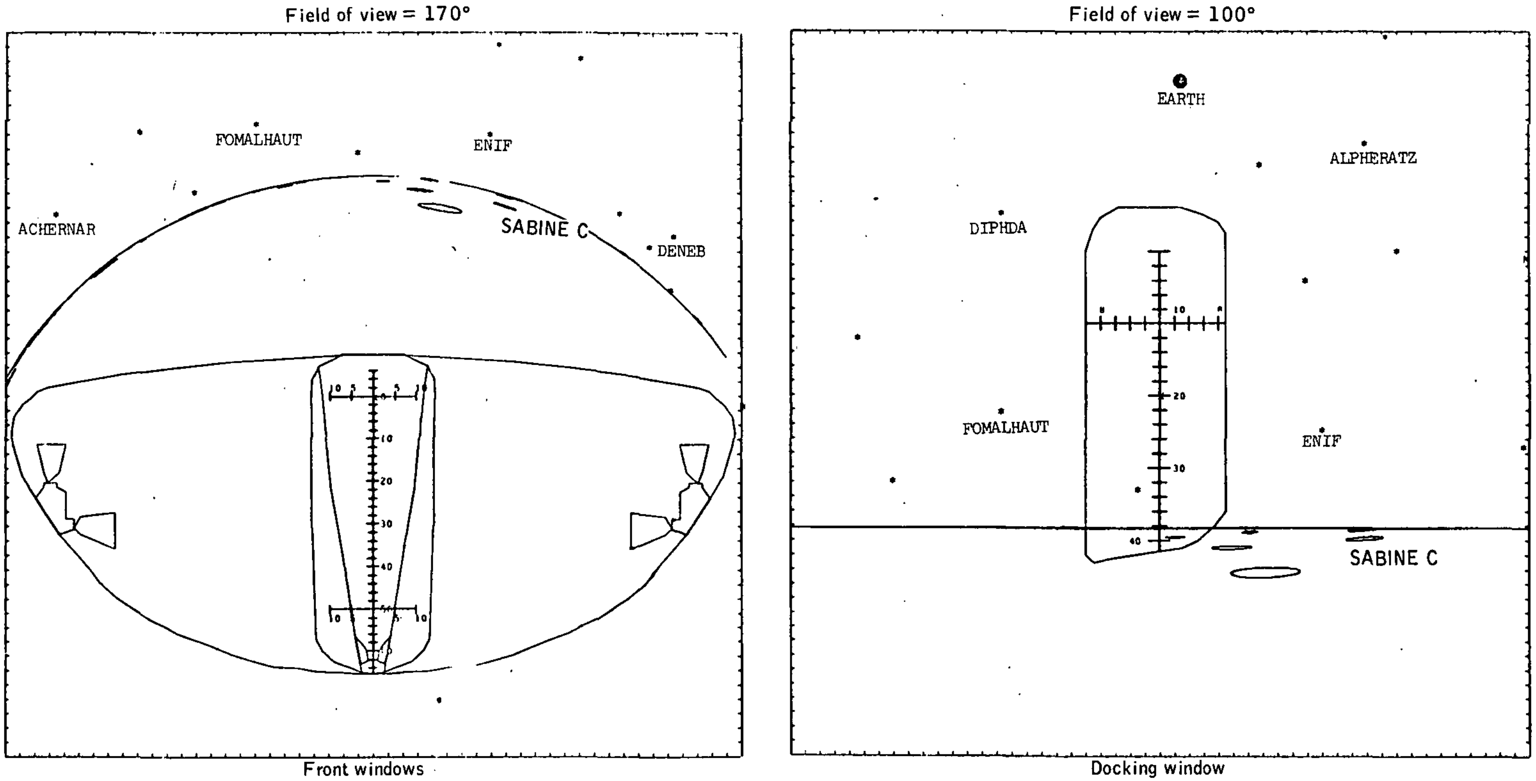


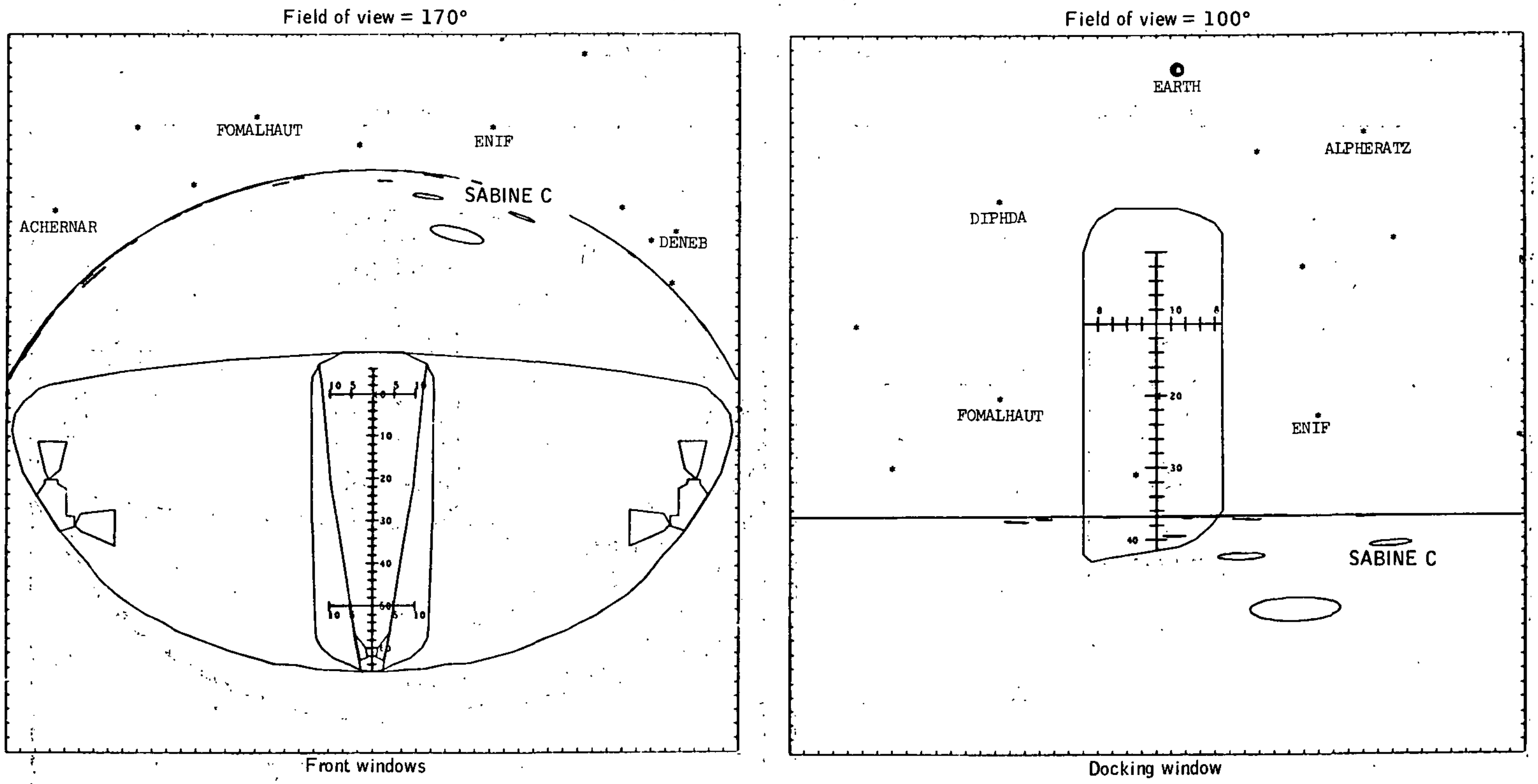
(a) Begin ascent burn.

Figure 6.3.1-1.-Ascent burn.



(b) 1 minute 0 secc nds into ascent burn.

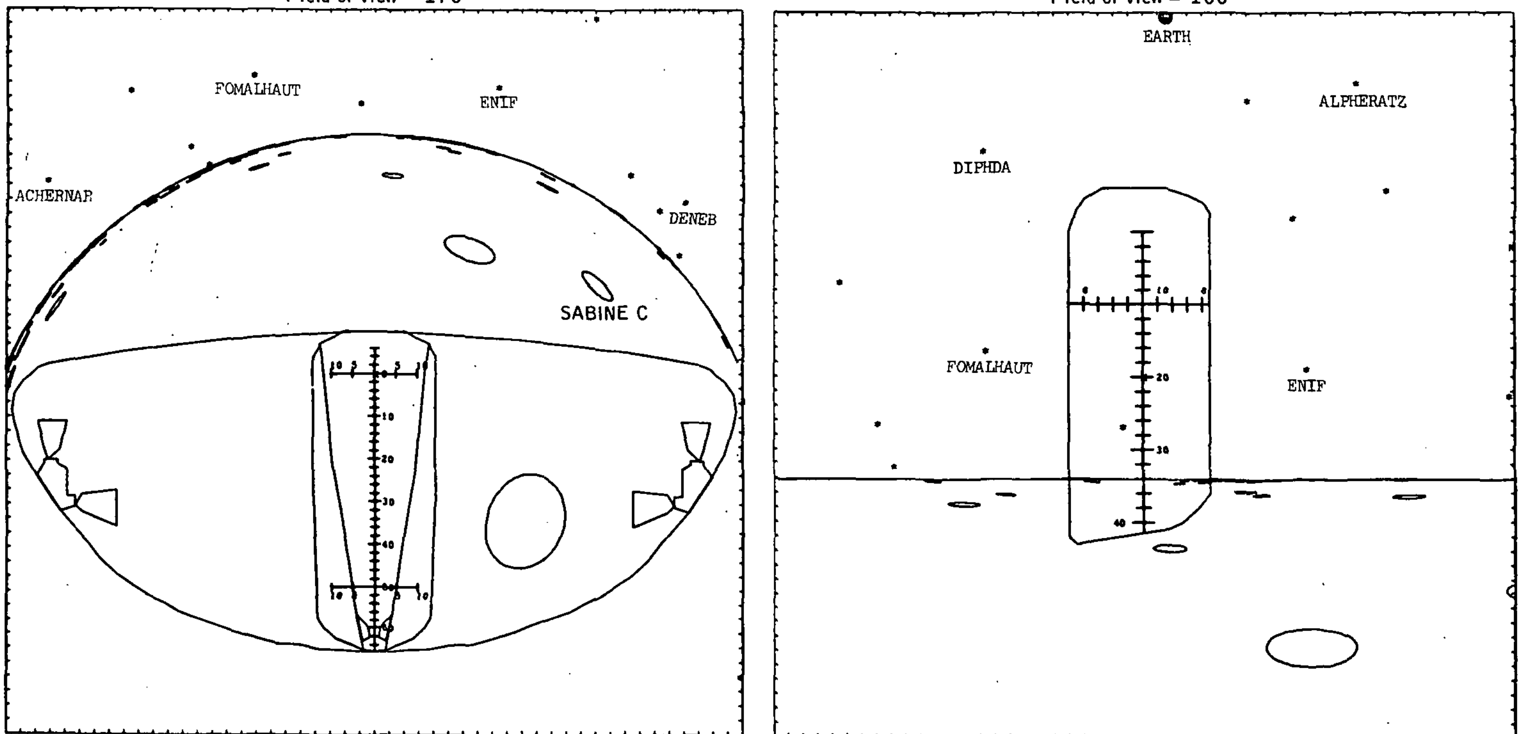
Figure 6.3.1 -1.-Continued.



(c) 1 minute 20 seconds into ascent burn.

Figure 6.3.1-1.- Continued.

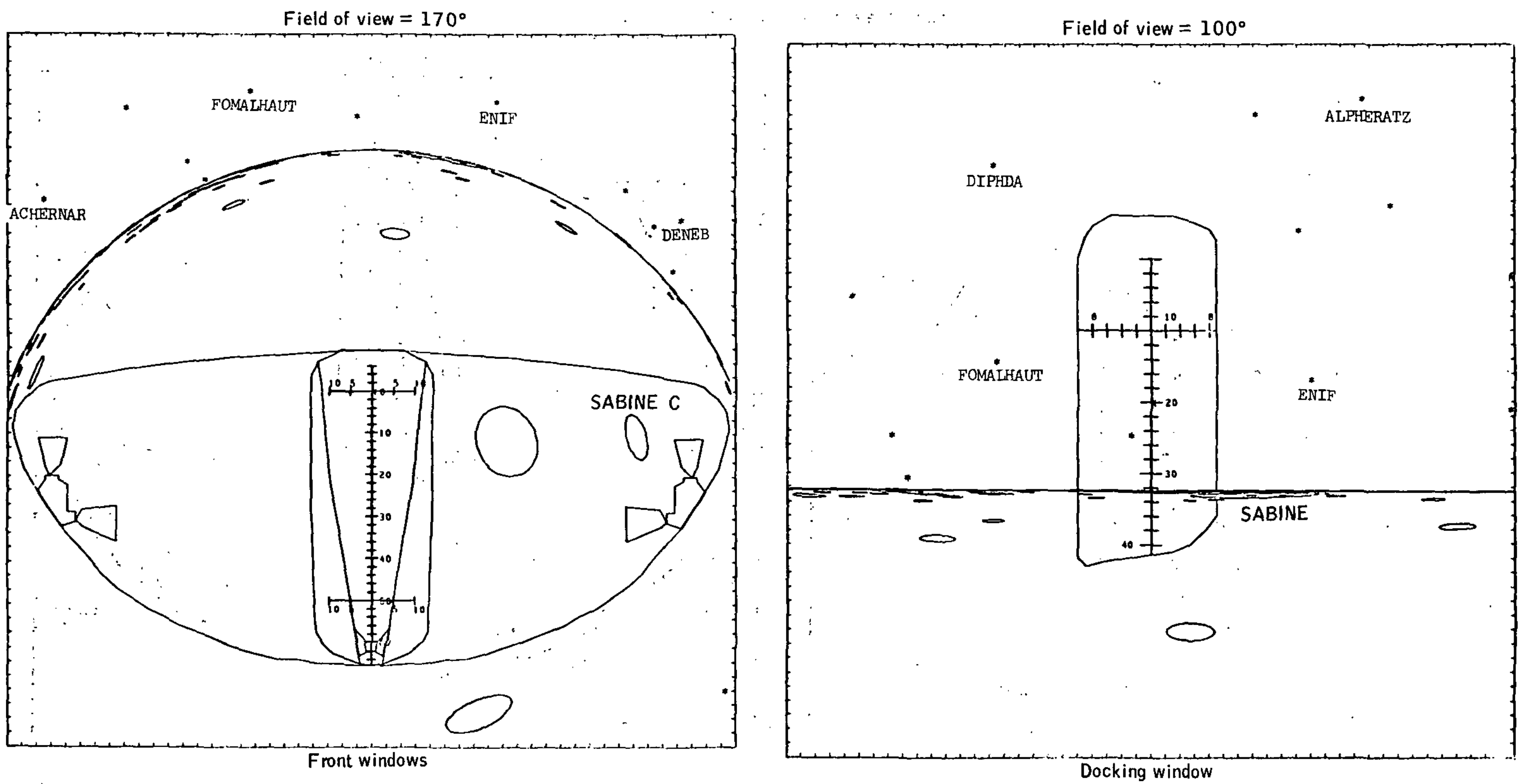
Field of view = 170° Field of view = 100°



Front windows Docking window

(d) 2 minutes 0 seconds into ascent burn.

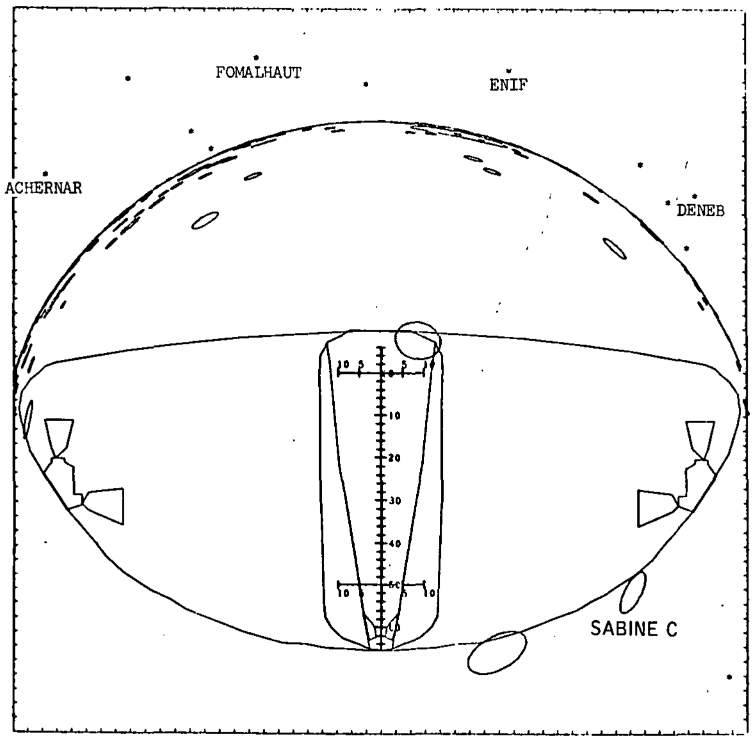
Figure 6.3.1-1.- Continued.



(e) 2 minutes 20 seconds into ascent burn.

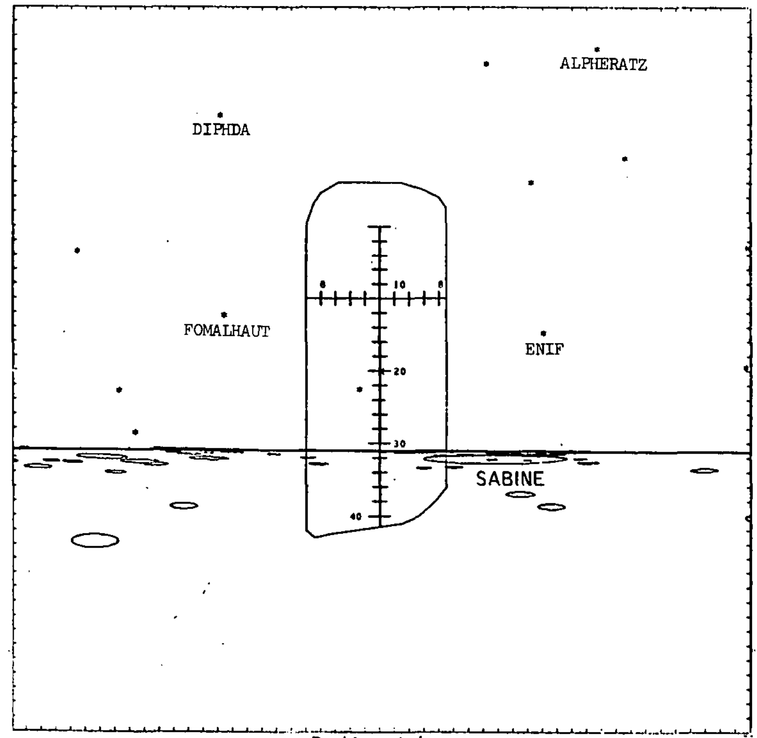
Figure 6.3.1-1.- *Continued.*

Field of view = 170°



Front windows

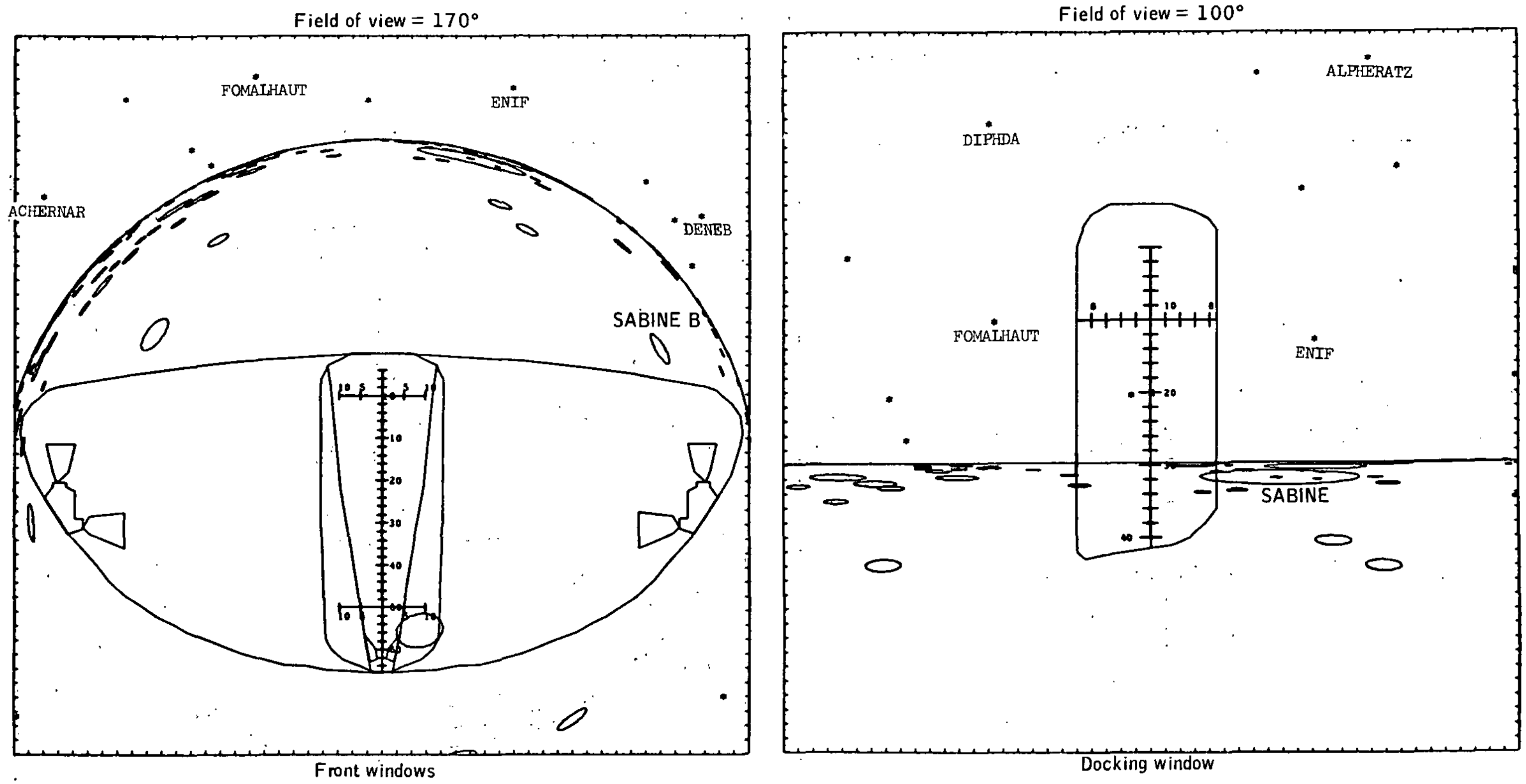
Field of view = 100°



Docking window

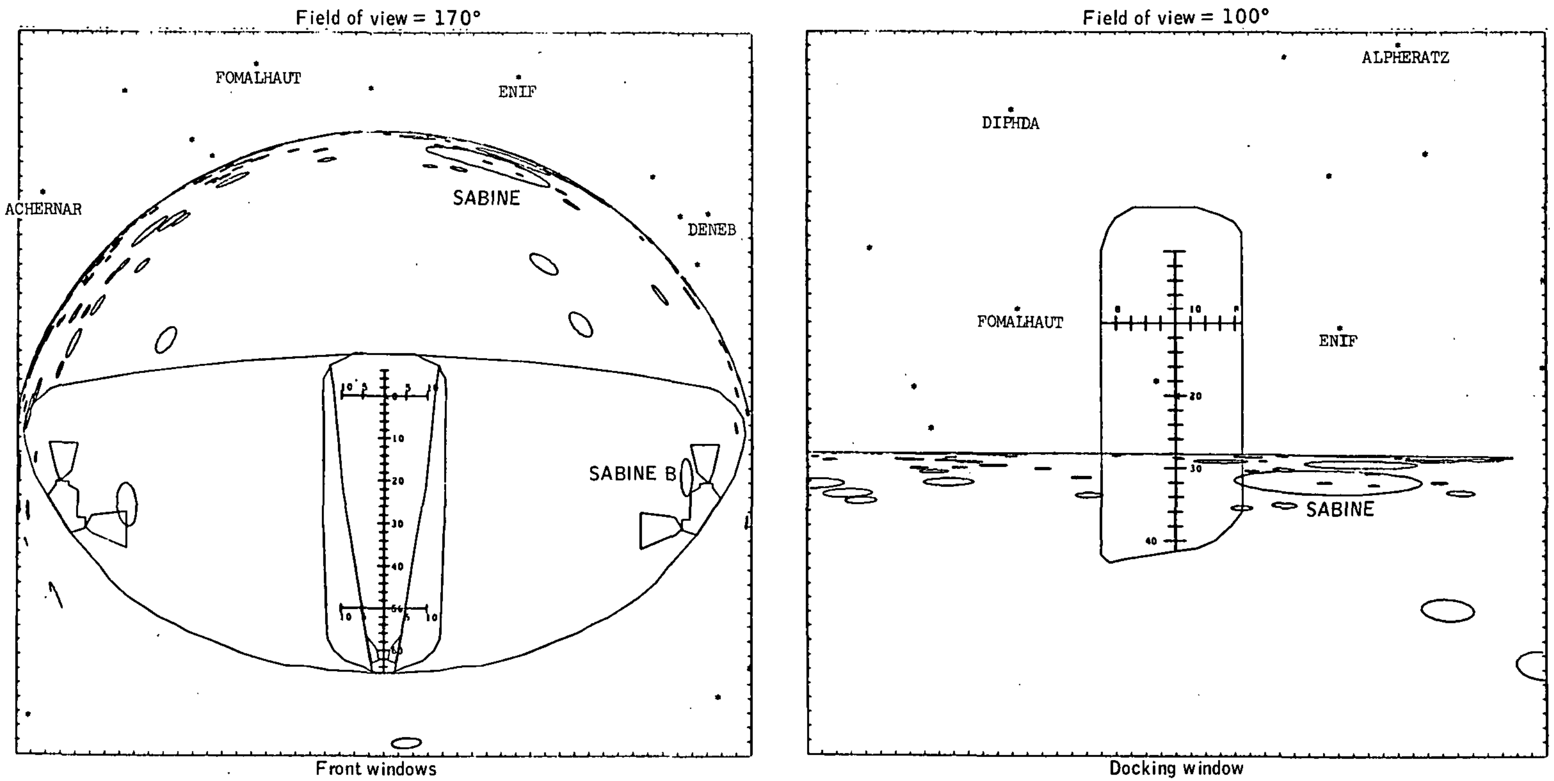
(f) 2 minutes 40 seconds into ascent burn.

Figure 6.3.1-1.- Continued.



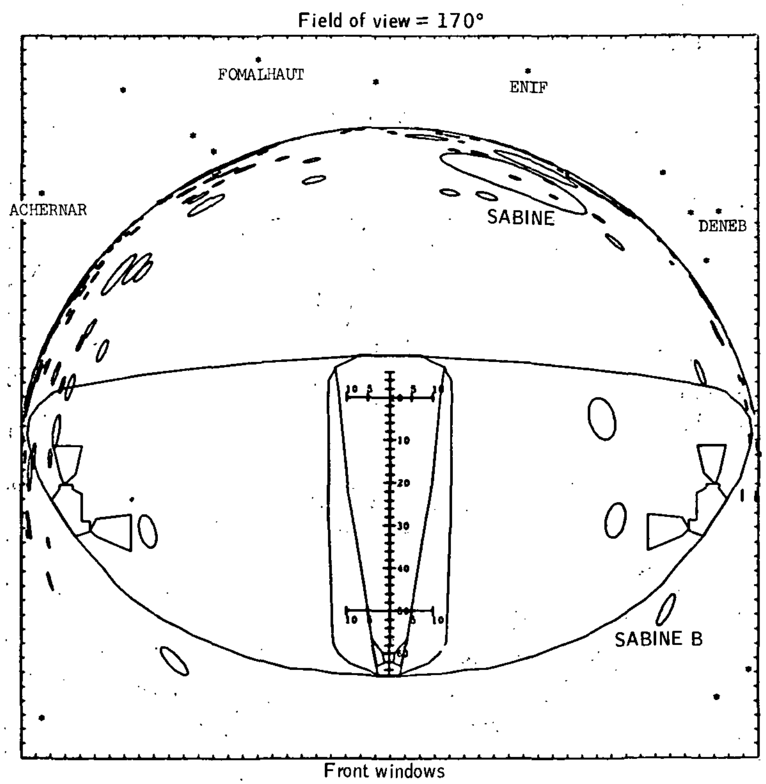
(g) 3 minutes 0 seconds into ascent burn.

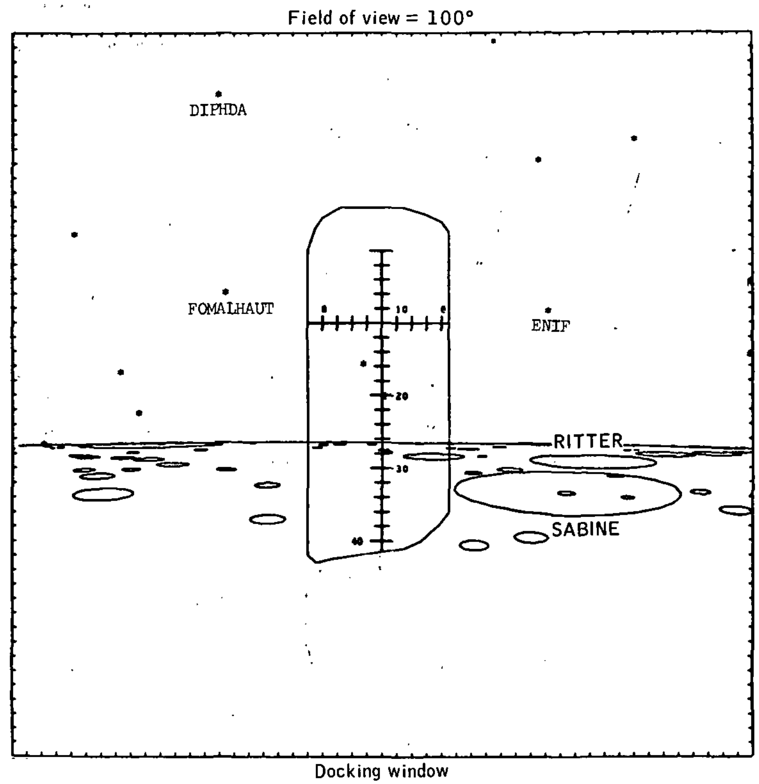
Figure 6.3.1-1.- Continued.



(h) 3 minutes 20 seconds into ascent burn.

Figure 6.3.1-1.- Continued.



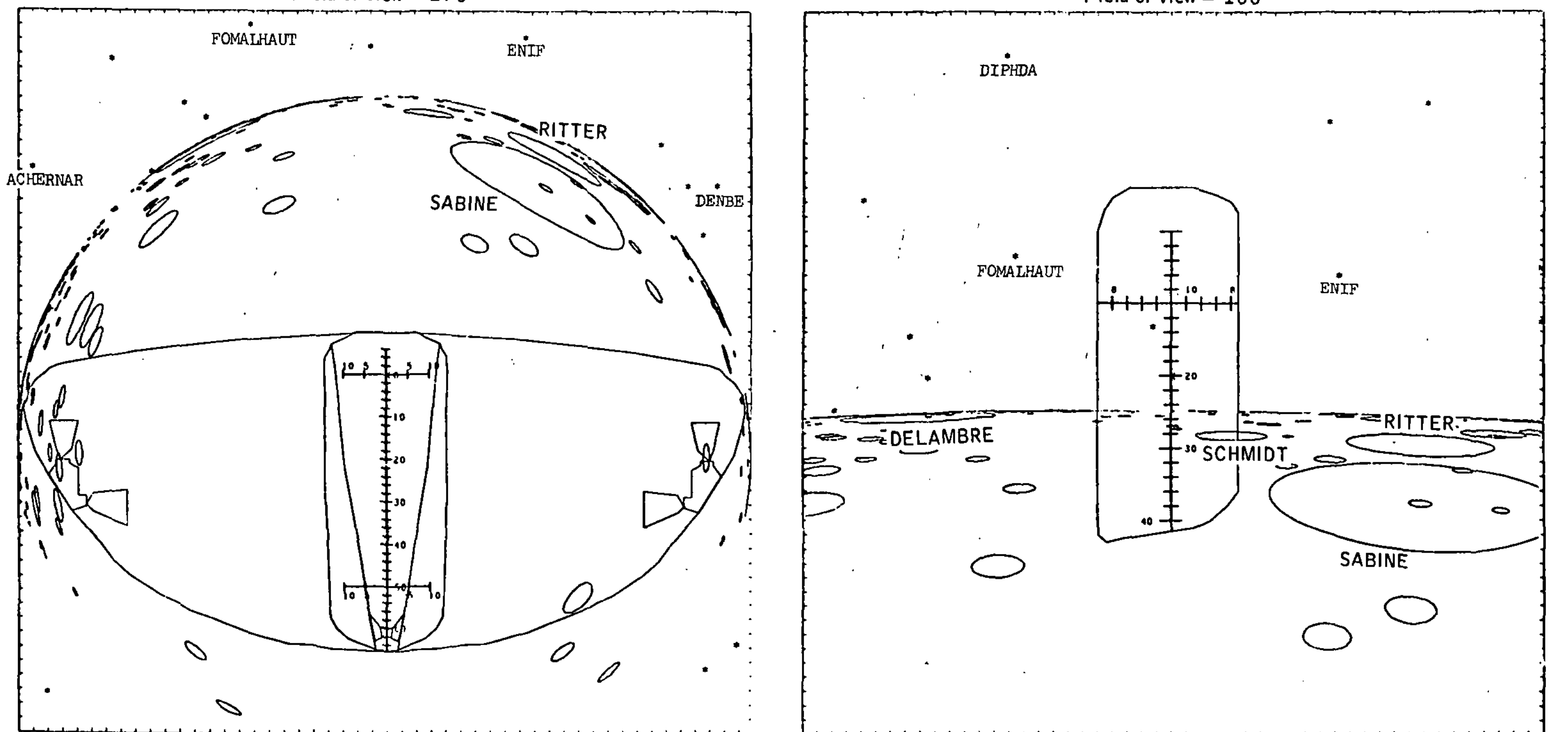


(i) 3 minutes 40 seconds into ascent burn.

Figure 6.3.1-1.- Continued.

Field of view = 170°

Field of view = 100°

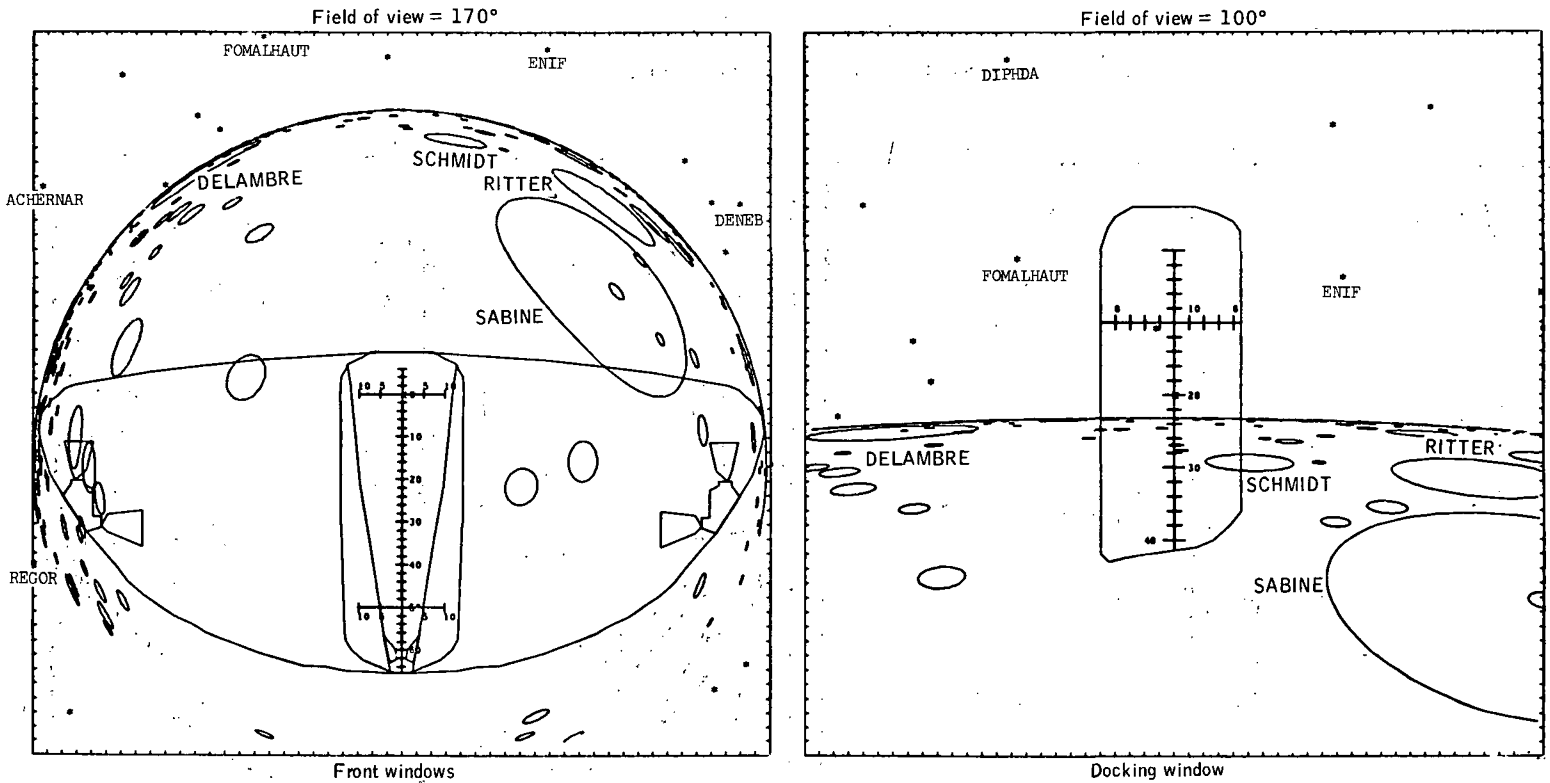


Front windows

Docking window

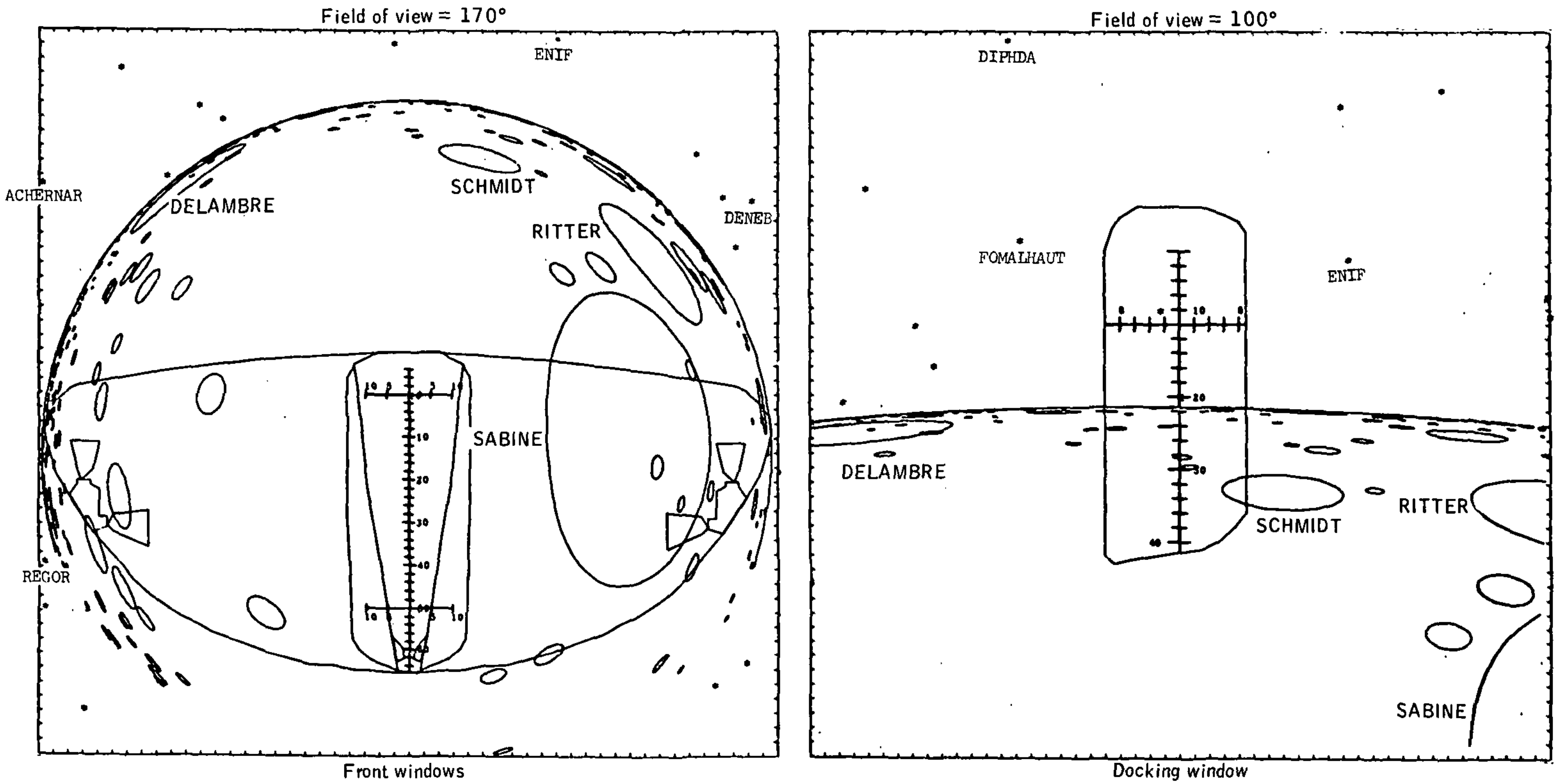
(i) 4 minutes 0 seconds into ascent burn.

Figure 6.3.1-1.- Continued.



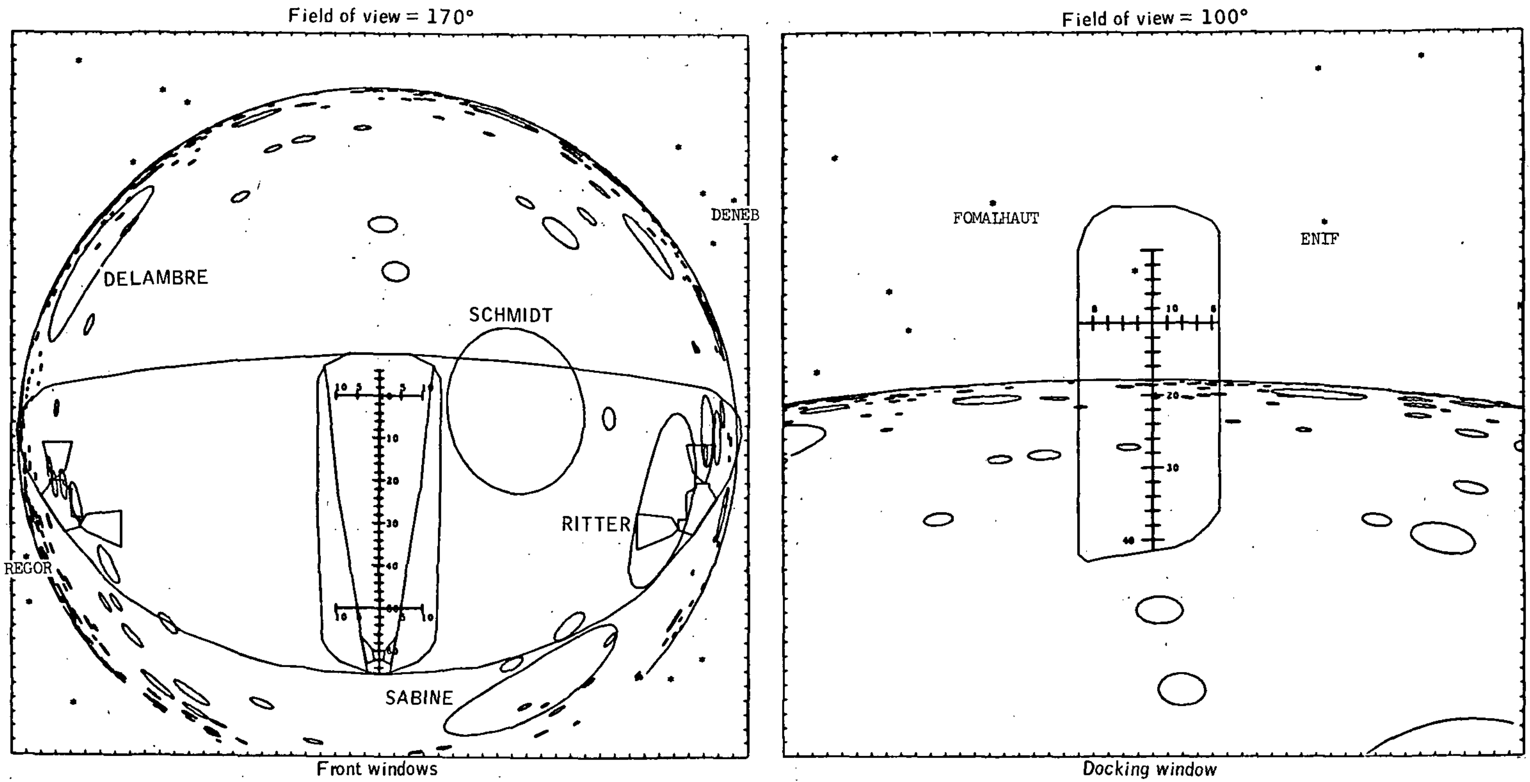
(k) 4 minutes 20 seconds into ascent burn.

Figure 6.3.1-1.- Continued.



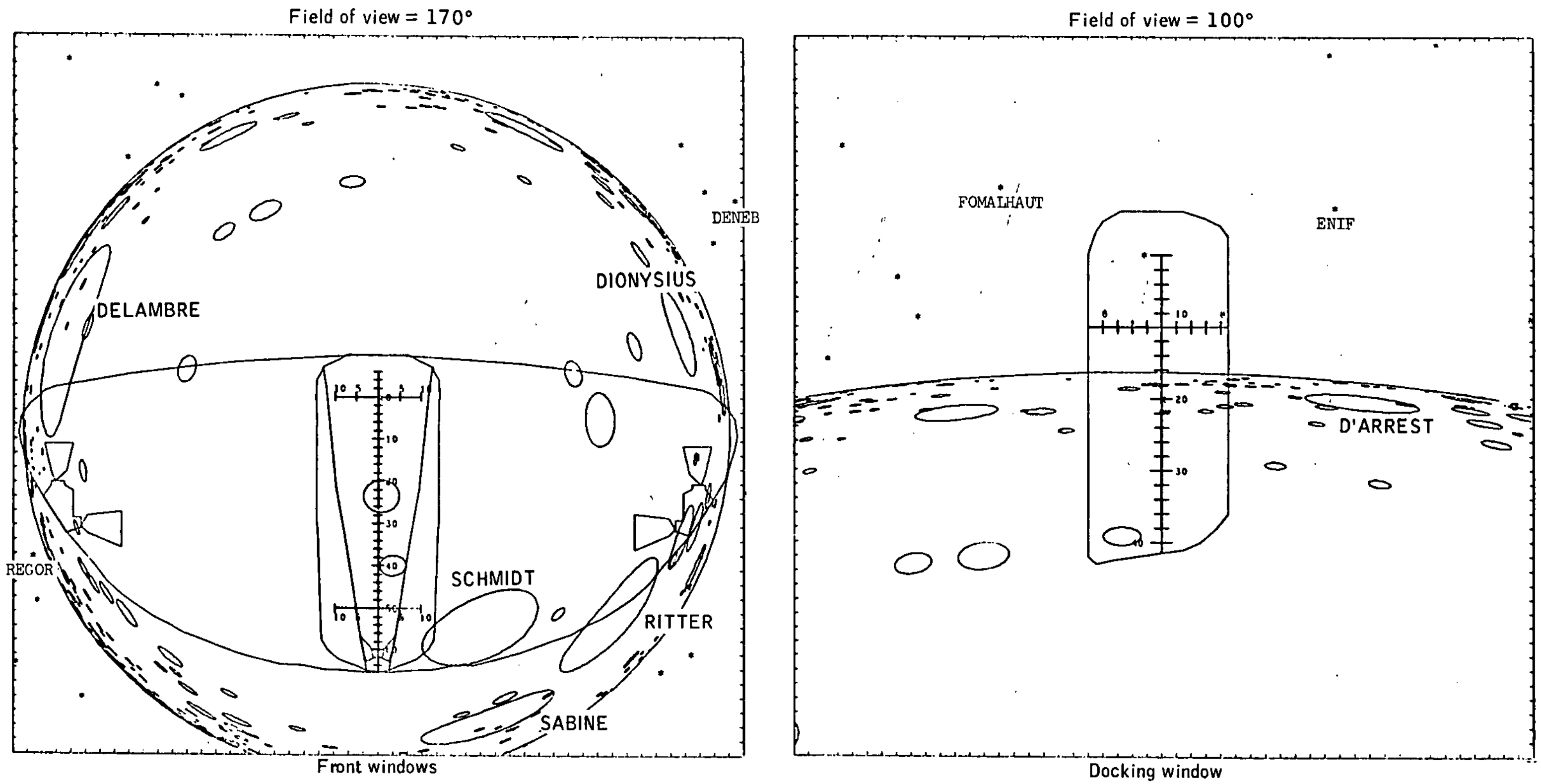
(l) 4 minutes 40 seconds into ascent burn.

Figure 6.3.1-1.- Continued.



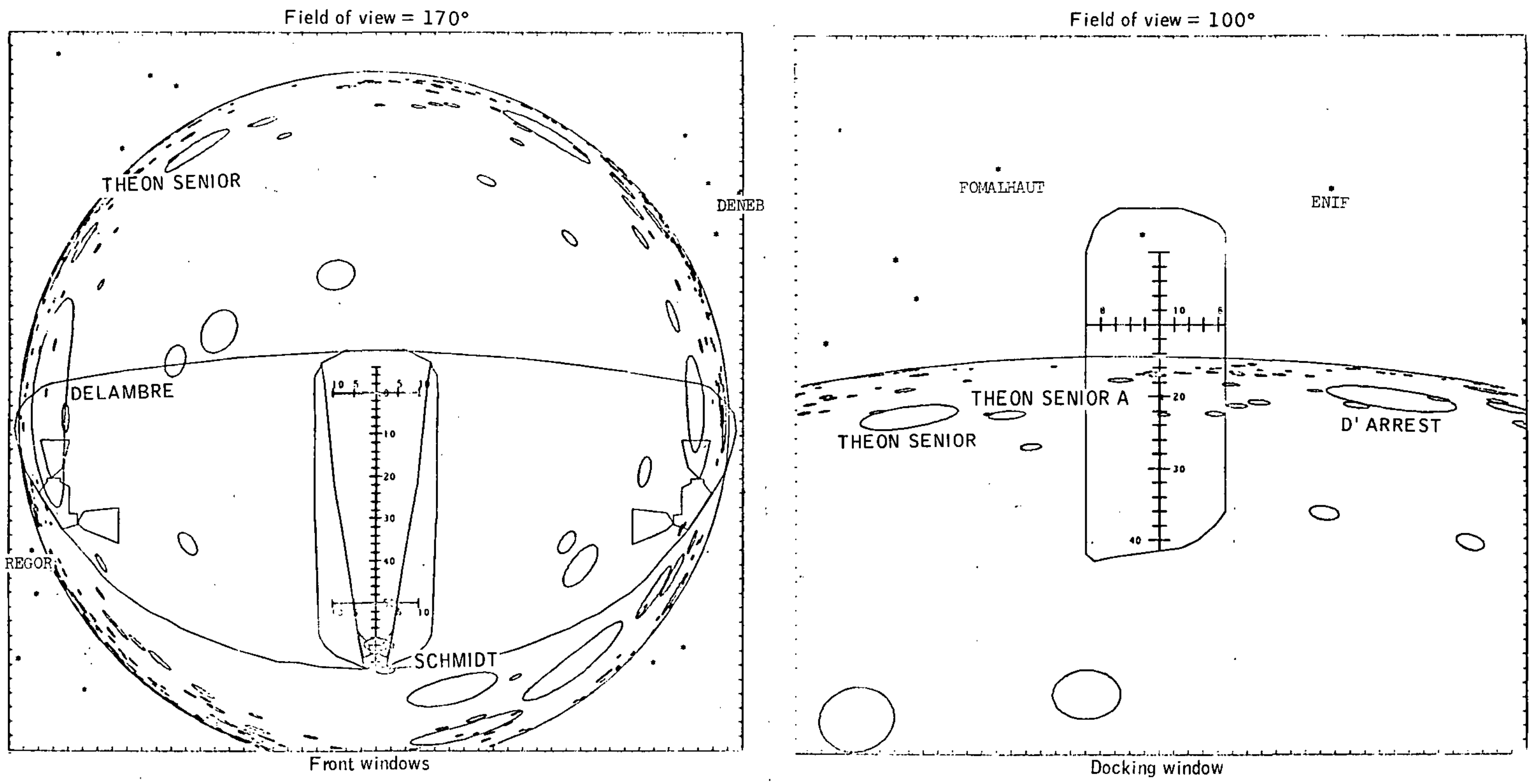
(m) 5 minutes 20 seconds into ascent burn.

Figure 6.3.1-1.- Continued.



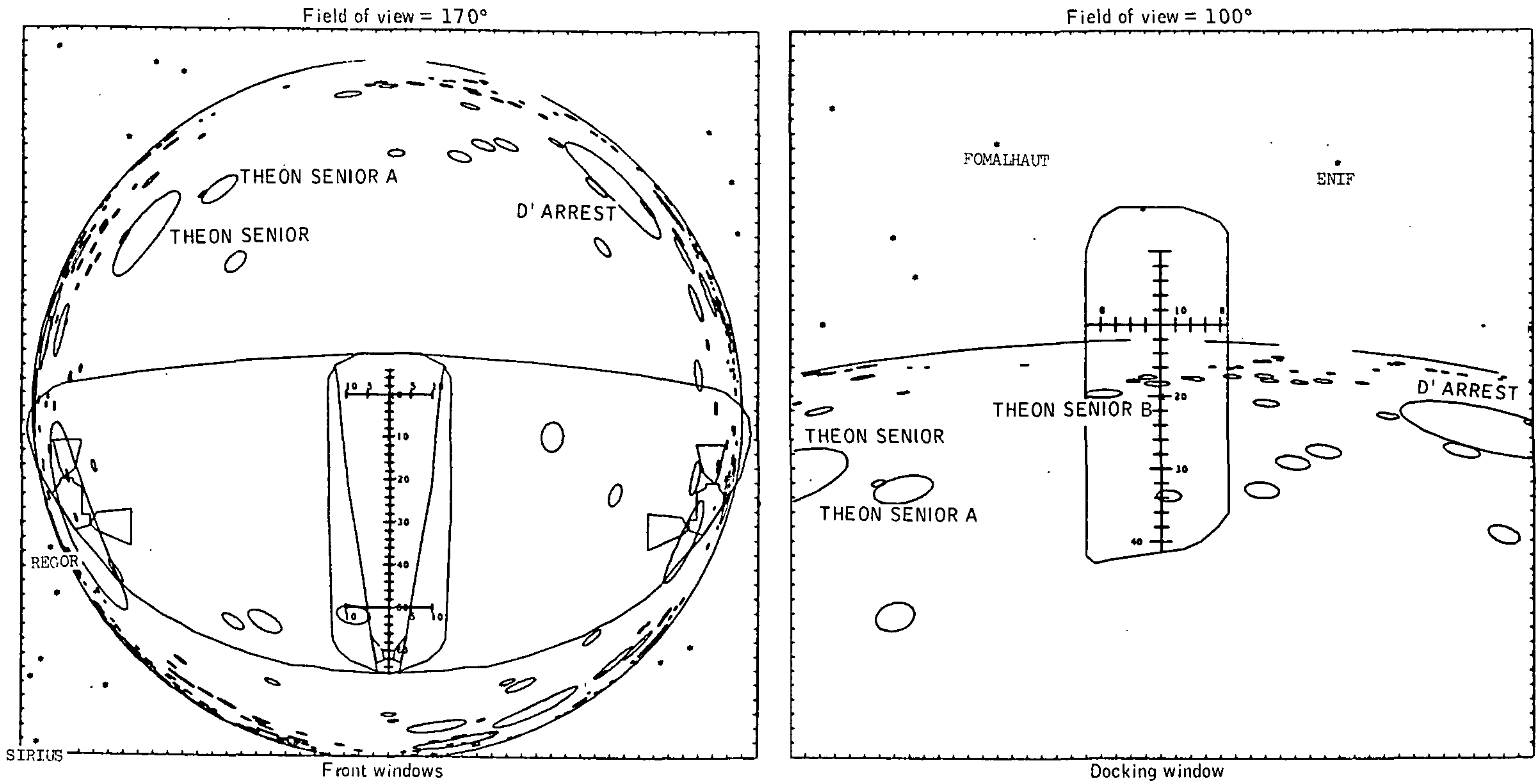
(n) 5 minutes 40 seconds into ascent burn.

Figure 6.3.1-1.- Continued.



(o) 6 minutes 0 seconds into ascent burn.

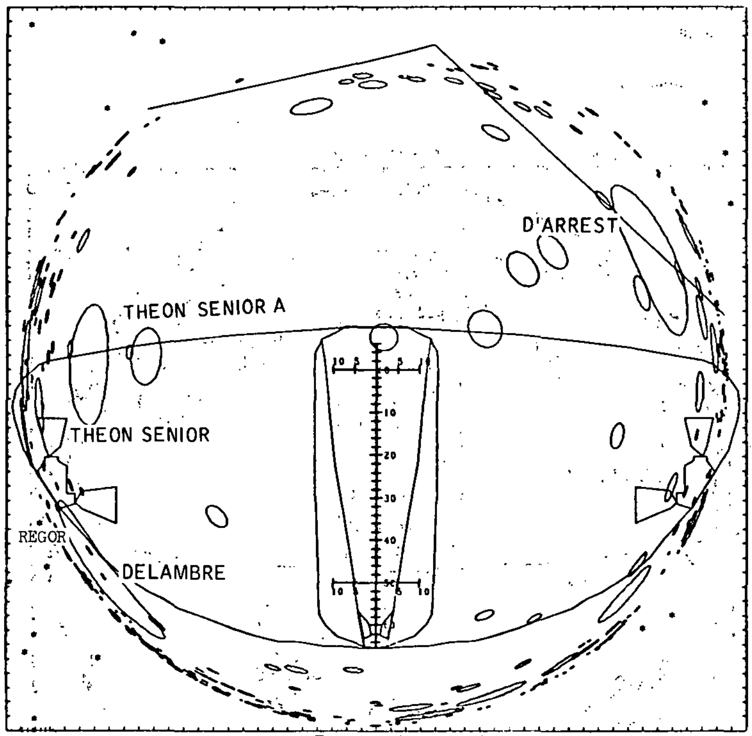
Figure 6.3.1-1.- Continued.



(p) 6 minutes 20 seconds into ascent burn.

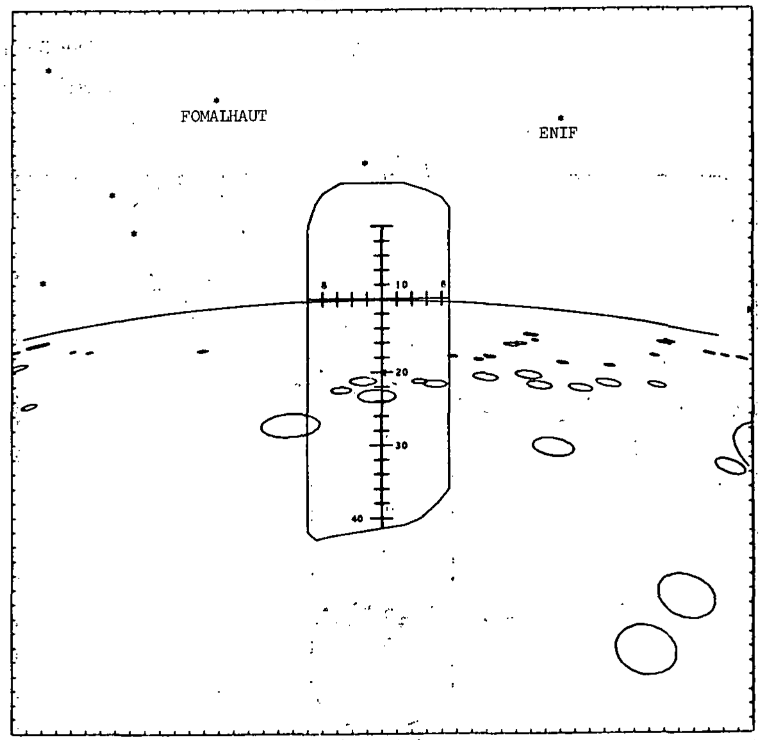
Figure 6.3.1-1.- Continued.

Field of view = 170°



Front windows

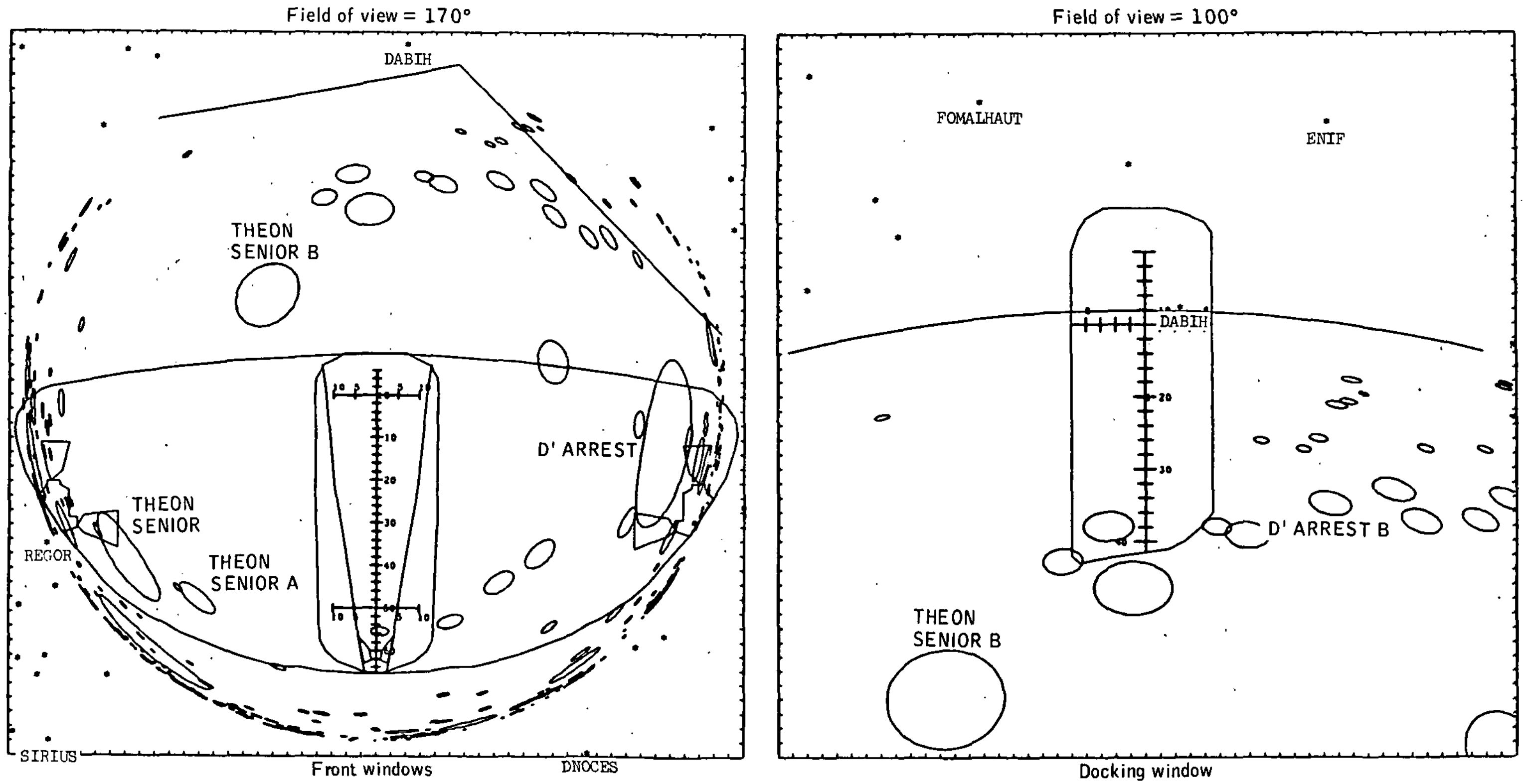
Field of view = 100°



Docking window

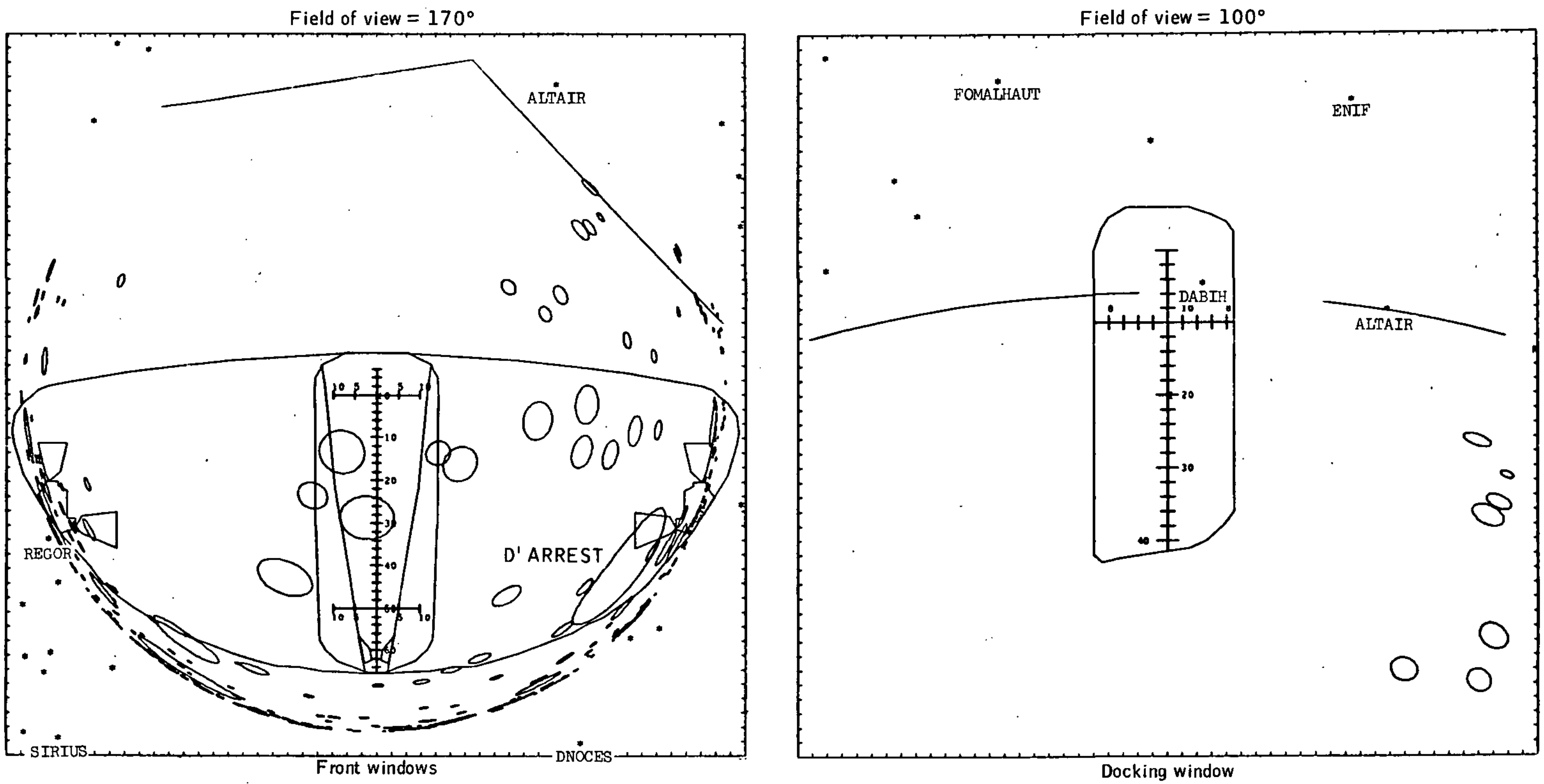
(q) 6 minutes 40 seconds into ascent burn.

Figure 6.3.1-1. - Continued.



(r) 7 minutes 0 seconds into ascent burn.

Figure 6.3.1-1.- Continued.



(s) End ascent burn.

Figure 6.3.1-1.- Concluded.

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6.3.2 CSI MANEUVER

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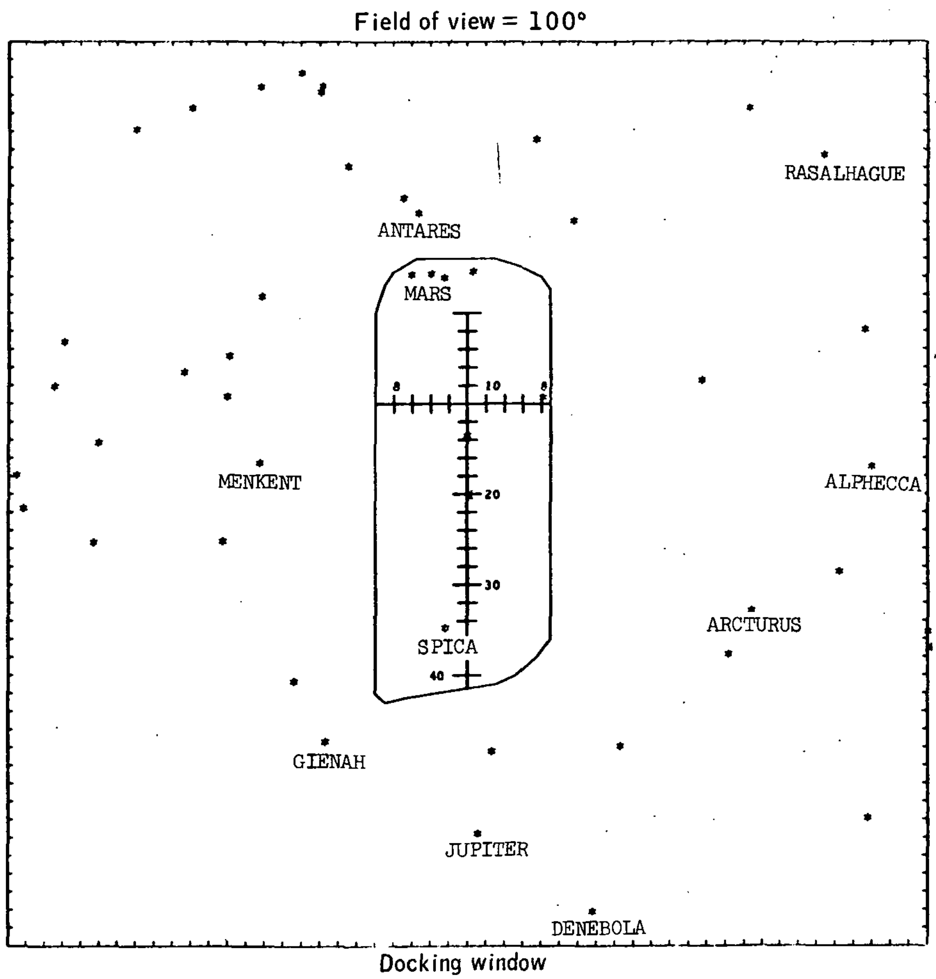

Figure 6.3.2-1.- CSI burn (g.e.t. = 125:21:20).

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6.3.3 CDH MANEUVER

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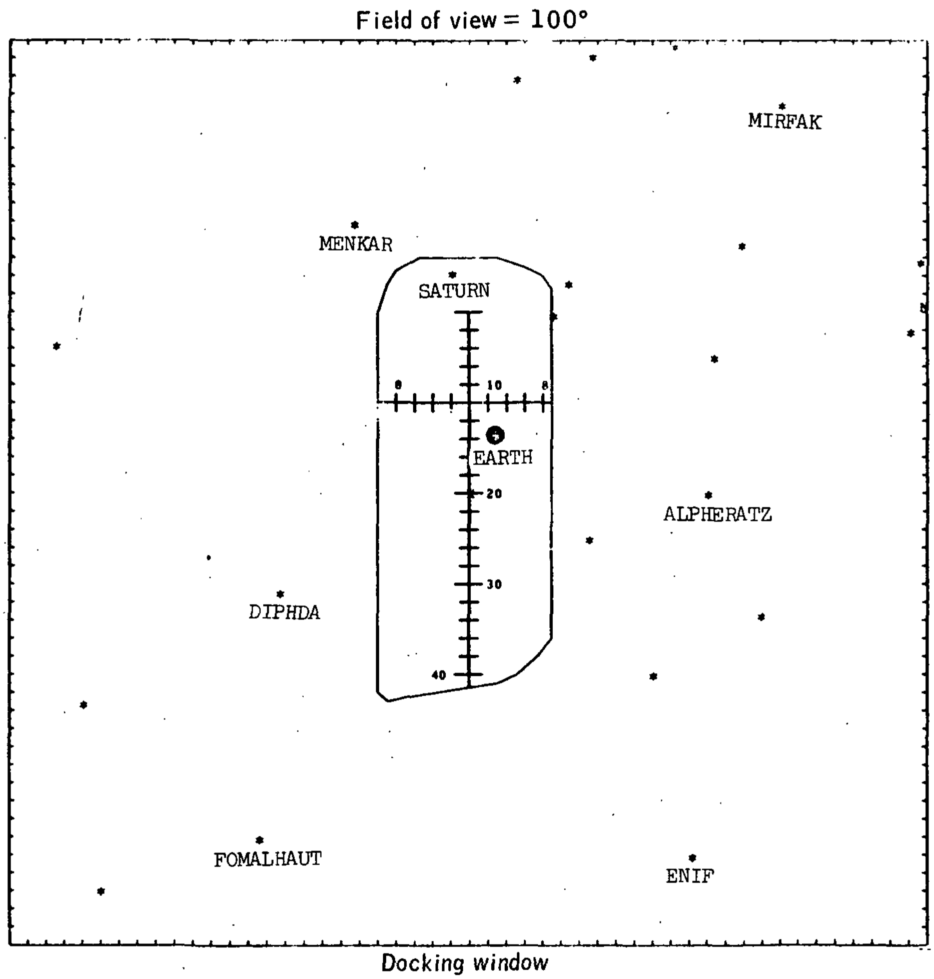

Figure 6.3.3-1.- CDH burn (g.e.t. = 126:19:40).

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6.3.4 TPI MANEUVER

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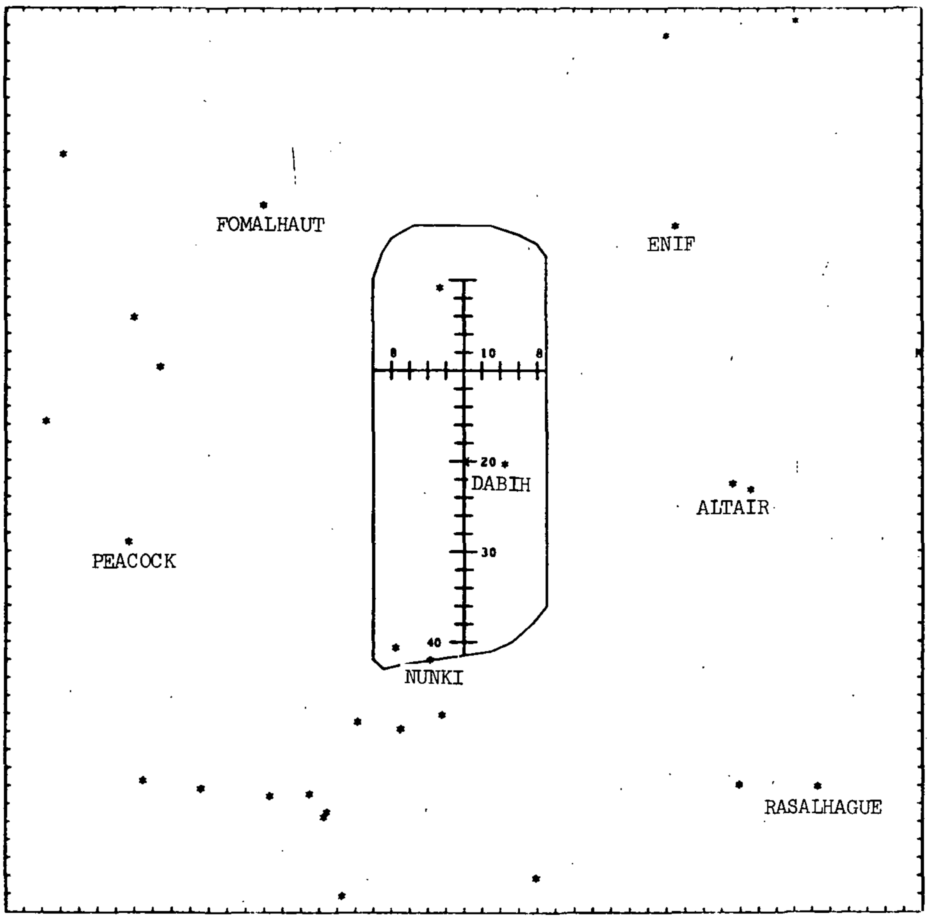
Field of view = 100°



Docking window

Figure 6.3.4-1.- TPI burn (g.e.t. = 126:58:26).

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7.0 VIEWS FROM CSM DURING TRANSEARTH PHASE

7.1 TEI BURN

7.2 POST TEI

7.3 TRANSEARTH COAST

7.3.1 MOON VIEWS

7.3.2 EARTH VIEWS

8.0 VIEWS FROM CM DURING ENTRY PHASE

9.0 VIEWS THROUGH SCANNING TELESCOPE

9.1 EARTH PARKING ORBIT PHASE

9.2 TRANSLUNAR COAST PHASE

9.3 LUNAR ORBIT COAST PHASE

9.4 TRANSEARTH COAST PHASE

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7.0 VIEWS FROM CSM DURING TRANSEARTH PHASE

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7.1 TEI BURN

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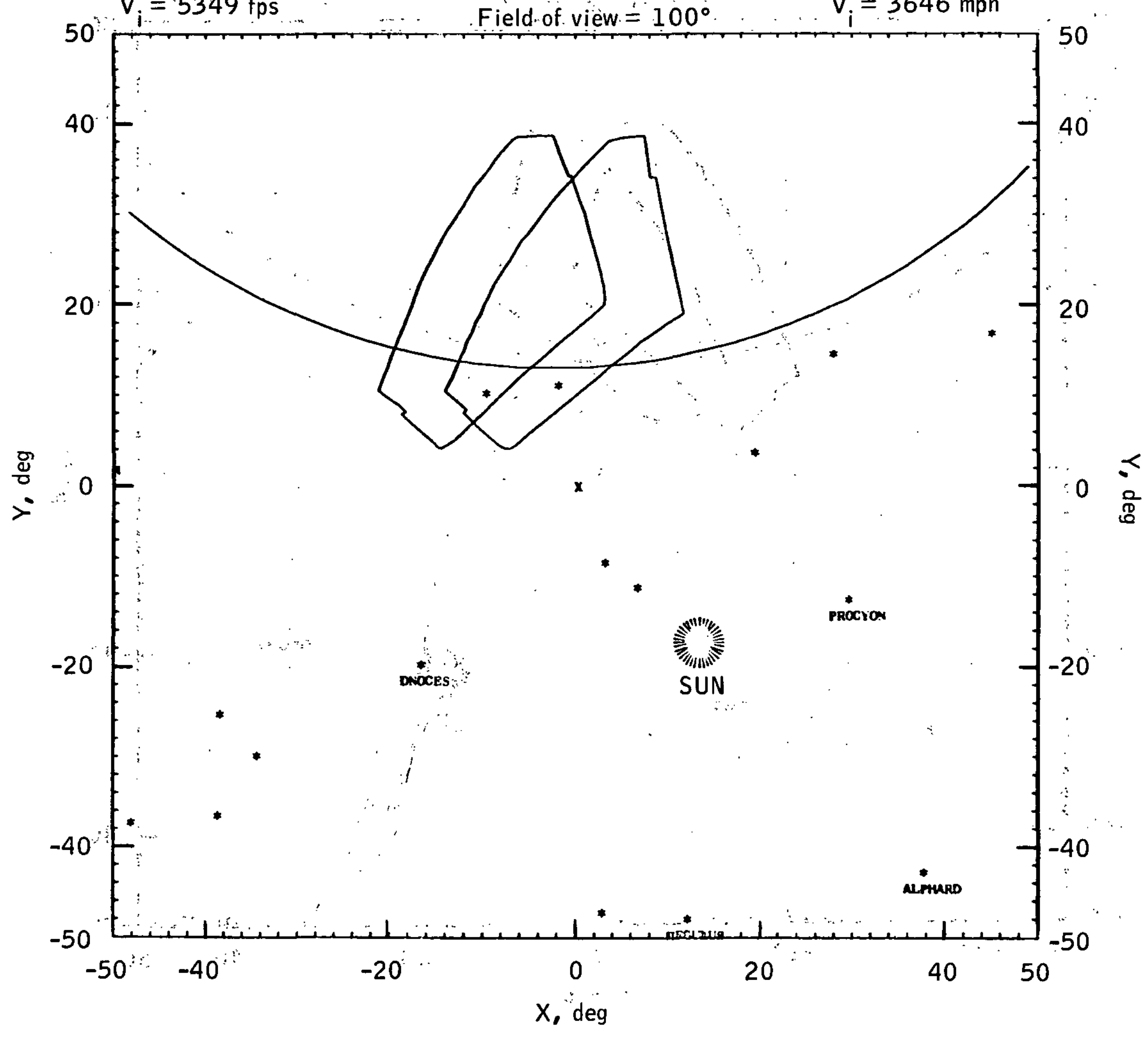
SEQ	14	16	17	18	40	42	45	52	55	60	69	70	75
X	14	-8	18	6	3	-19	13	9	1	-24	22	-4	-17
Y	-6	-9	-21	-24	-5	-12	7	1	-4	-18	8	5	-14

SEQ	83	100	105
X	-19	0	1
Y	-18	5	-23

$R_M = 996$ n. mi. $h_M = 66$ stat. mi.

$V_i = 5349$ fps $V_i = 3646$ mph



(a) Begin TEI burn (g.e.t. = 135:24:34).

Figure 7.1-1.- Transearth injection burn.

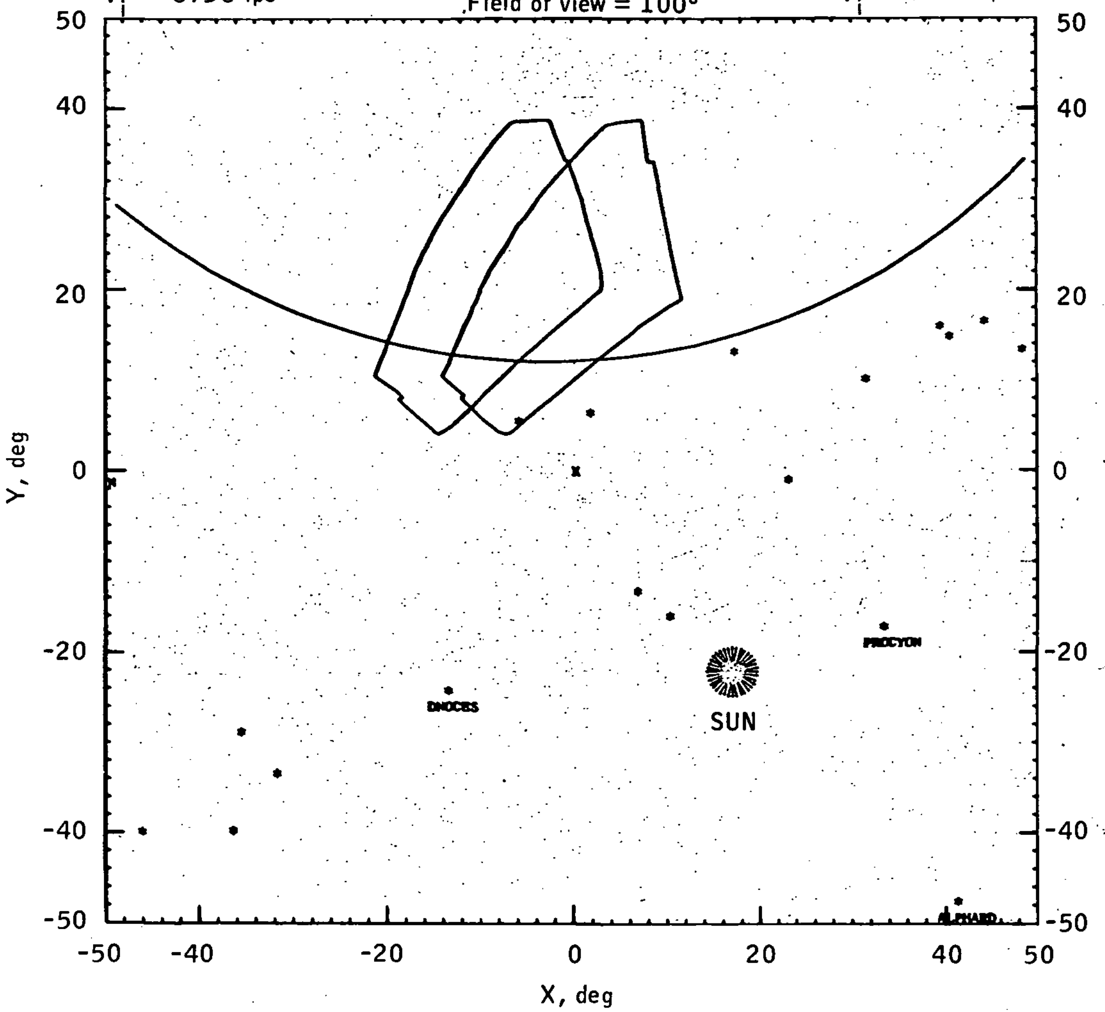
SEQ	14	16	17	40	42	45	49	50	52	55	60	69	70
X	16	-6	20	5	-17	15	19	20	11	3	-23	24	-2
Y	-8	-12	-23	-8	-14	5	7	7	0	-6	-19	6	2

SEQ	75	83	97	98	100
X	-15	-18	22	8	0
Y	-16	-19	8	6	3

R_M = 996 n. mi. h_M = 66 stat. mi.

V_i = 6736 fps V_i = 4592 mph

Field of view = 100°



(b) Middle of TEI burn (g.e.t. = 135:25:43.7).

Figure 7.1-1.- Continued.

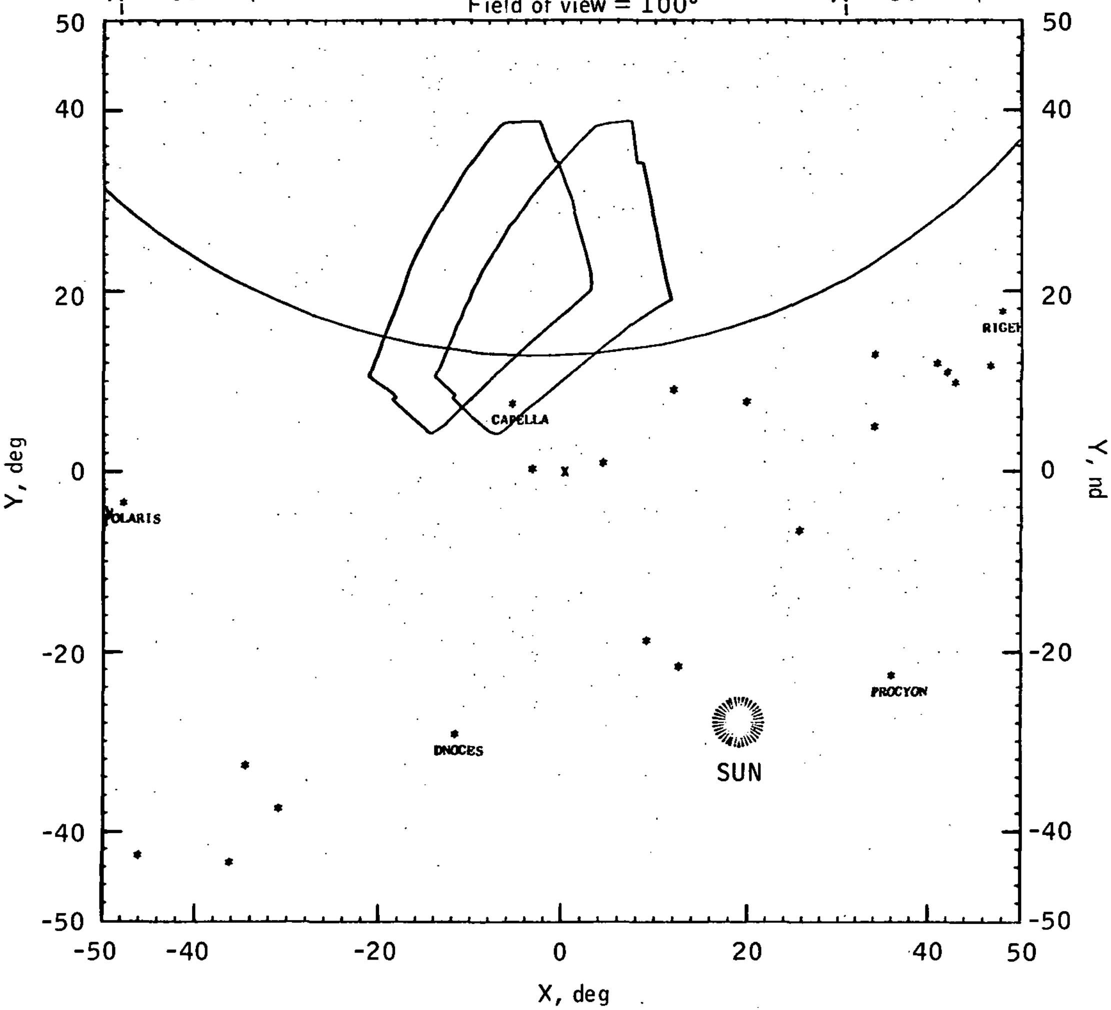
SEQ	5	10	11	14	16	40	42	45	47	48	49	50
X	-23	23	-2	17	-5	6	-17	16	16	5	20	21
Y	-1	8	3	-11	-14	-10	-16	2	6	4	5	4

SEQ	52	55	60	68	70	75	83	97	98	100
X	12	4	-23	20	-1	-15	-18	23	9	2
Y	-3	-9	-21	5	0	-18	-21	5	3	0

R_M = 1000 n. mi. h_M = 71 stat. mi.

V_i = 8577 fps V_i = 5847 mph

Field of view = 100°



(c) End TEI burn (g.e.t. = 135:27:03).

Figure 7.1-1.- Concluded.

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7.2 POST TEI

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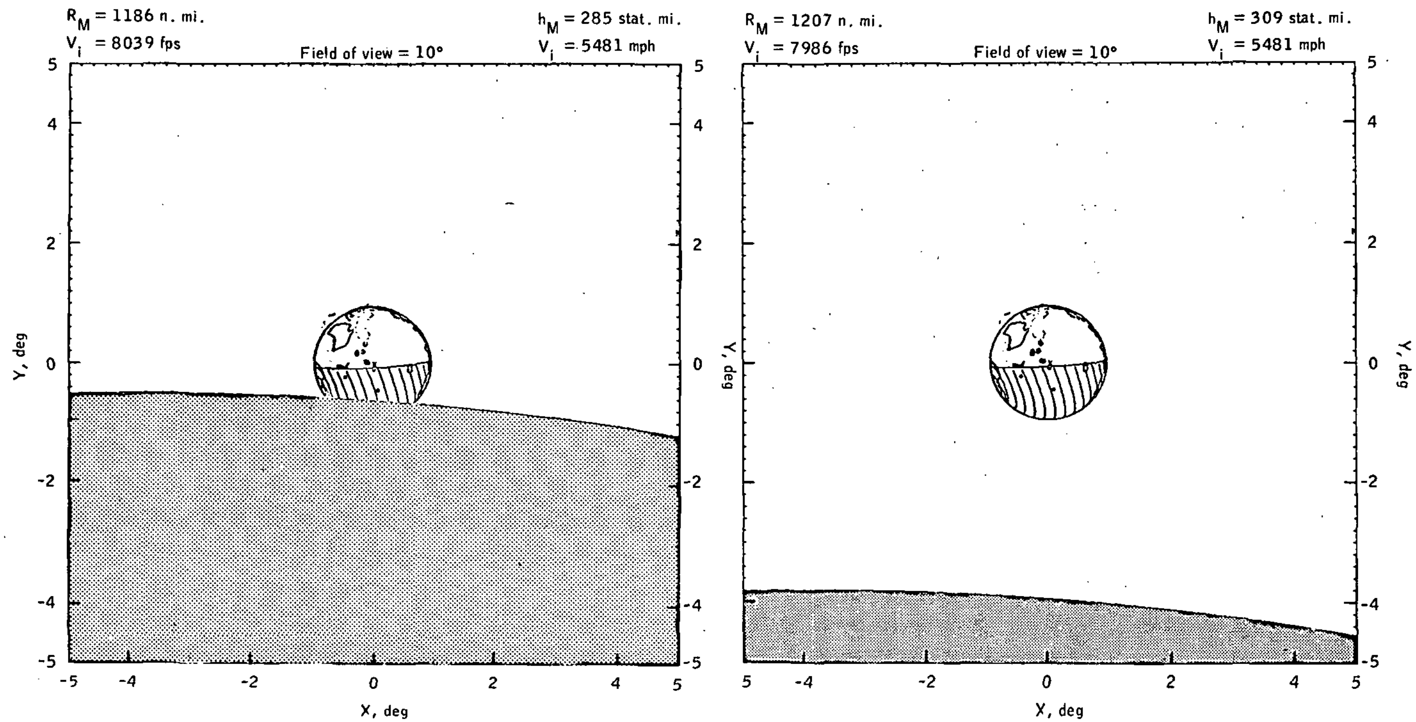

(a) g.e.t. = 135:35:27.

(b) g.e.t. = 135:36:03.

Figure 7.2-1.- Post TEI.

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7.3 TRANSEARTH COAST

7.3.1 MOON VIEWS

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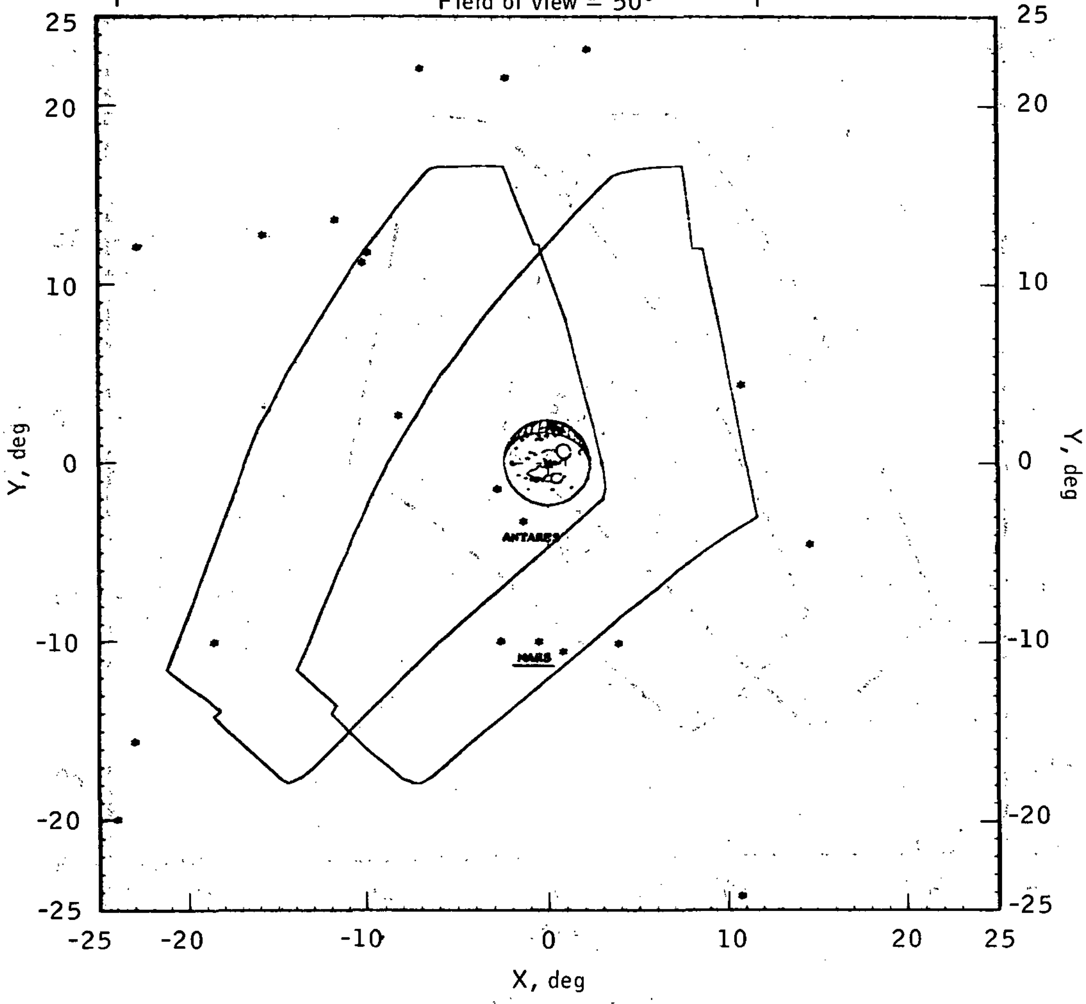
SEQ	27	61	62	63	84	85	87	117	121	122	123	125
X	-1	-9	-15	-7	0	-8	-11	-24	-23	10	-18	-2
Y	-3	11	12	22	-10	2	13	-19	-15	-24	-10	-9

SEQ	126	129	130	132	134	135	138	139	2
X	3	-2	14	10	-10	-22	-2	2	0
Y	-10	-1	-4	4	11	12	21	23	-9

R_M = 13 718 n. mi. h_M = 14 706 stat. mi.

V_i = 4 555 fps V_i = 3 106 mph

Field of view = 50°



(a) g.e.t. = 140 hours.

Figure 7.3.1-1.- Transearth coast - constant field of view (moon).

SEQ	27	61	62	63	84	85	87	117	121	122	123	125
X	-1	-10	-16	-7	0	-8	-12	-23	-22	11	-18	-2
Y	0	14	15	24	-7	5	16	-17	-13	-20	-7	-6

SEQ	126	124	130	132	134	135	138	2
X	3	-2	14	10	-10	-23	-2	0
Y	-6	1	-1	7	13	14	24	-6

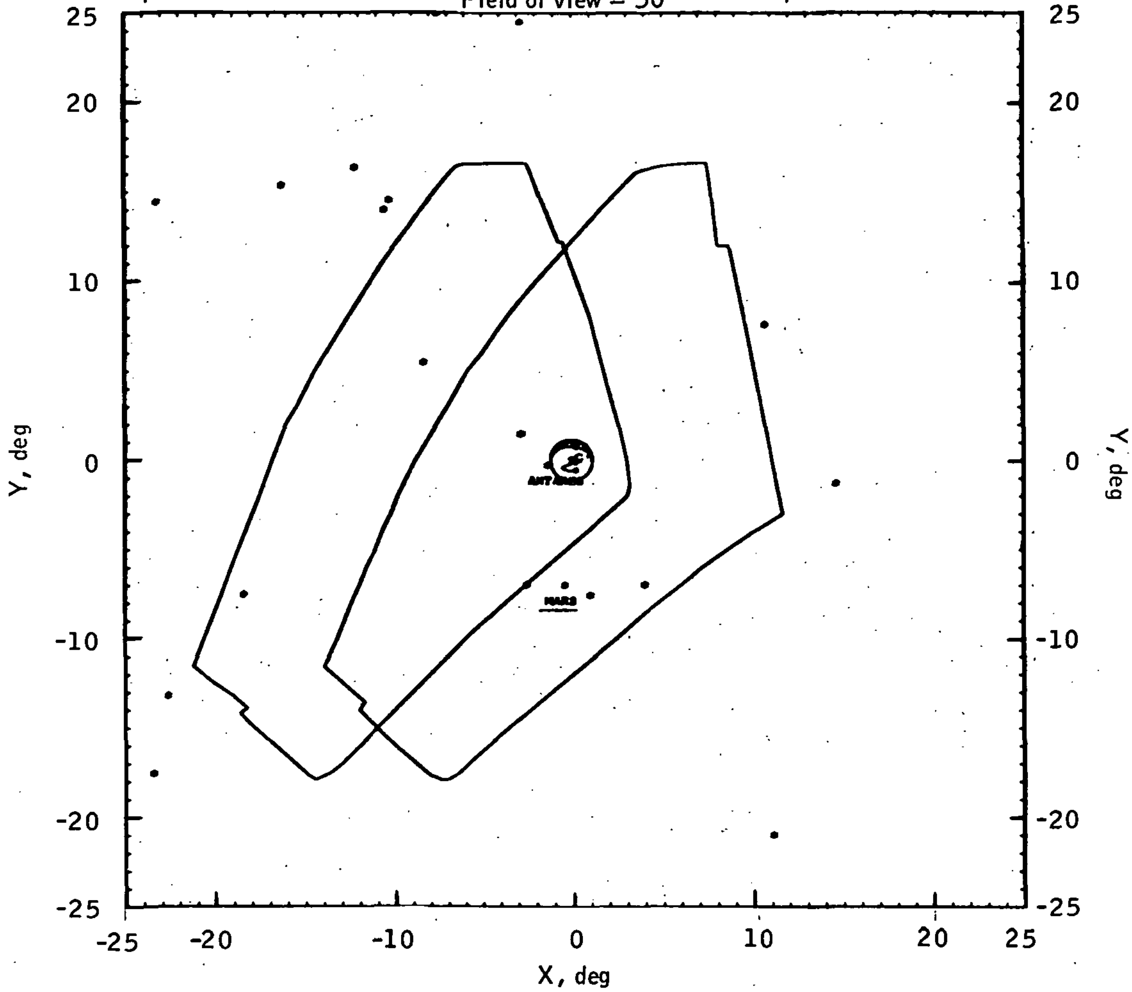
R_E = 173 780 n. mi.

V_i = 4 052 fps

h_E = 196 019 stat. mi.

V_i = 2 763 mph

Field of view = 50°



(b) g.e.t. = 150 hours.

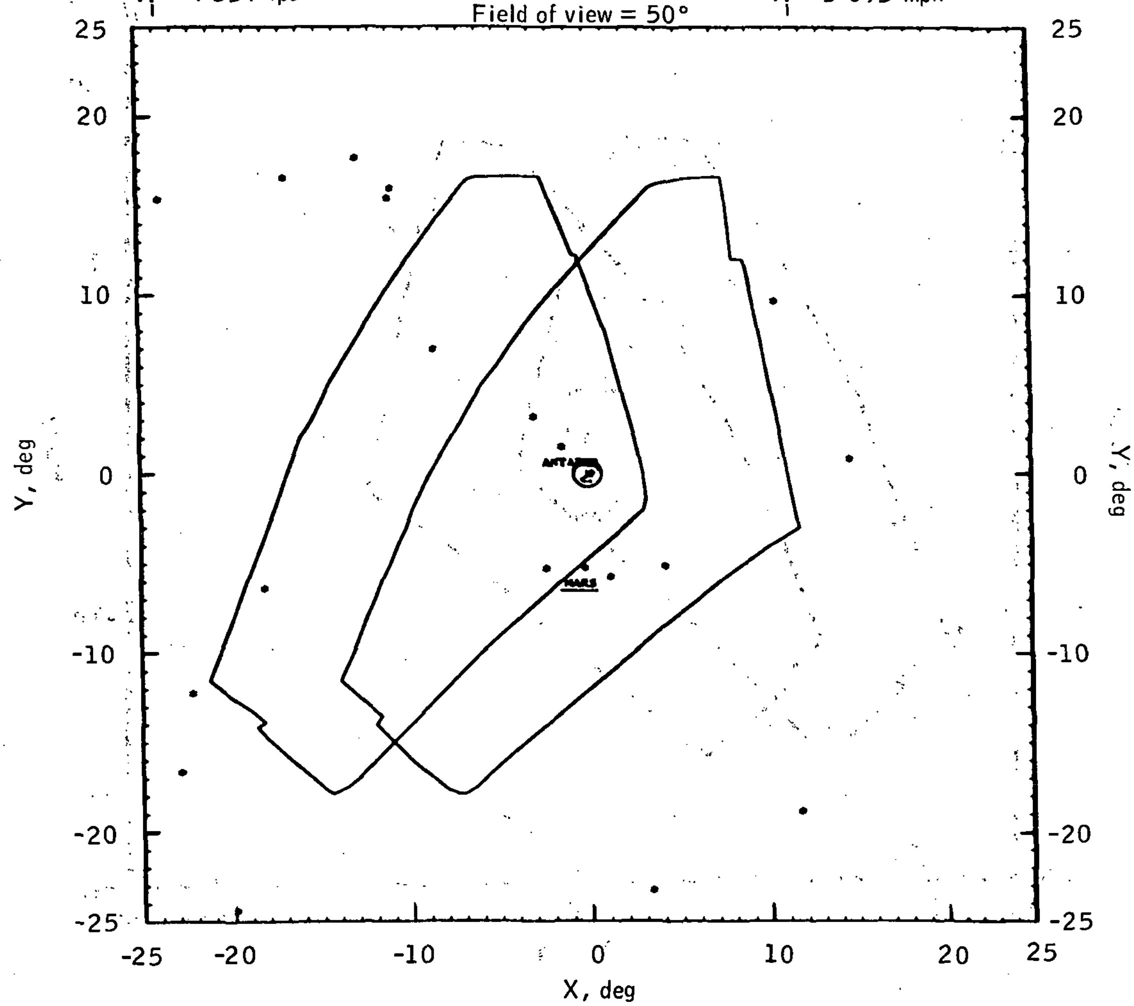
Figure 7.3.1-1.- Continued.

SEQ	24	27	61	62	84	85	87	117	120	121	122	123
X	-19	-1	-10	-16	1	-8	-12	-22	3	-22	11	-18
Y	-24	1	15	16	-5	6	17	-16	-23	-12	-18	-6

SEQ	125	126	129	130	132	134	135	2
X	-2	4	-2	14	10	-11	-23	0
Y	-5	-5	3	0	9	15	15	-5

R_E = 148 825 n. mi. h_E = 167 301 stat. mi.

V_i = 4 537 fps V_i = 3 093 mph



(c) g.e.t. = 160 hours.

Figure 7.3.1-1.- Continued.

SEQ	24	27	61	62	84	85	87	117	120	121	122	123	125
X	-19	-1	-11	-17	1	-8	-13	-22	3	-21	12	-17	-2
Y	-23	3	17	17	-3	8	19	-15	-21	-11	-16	-5	-3

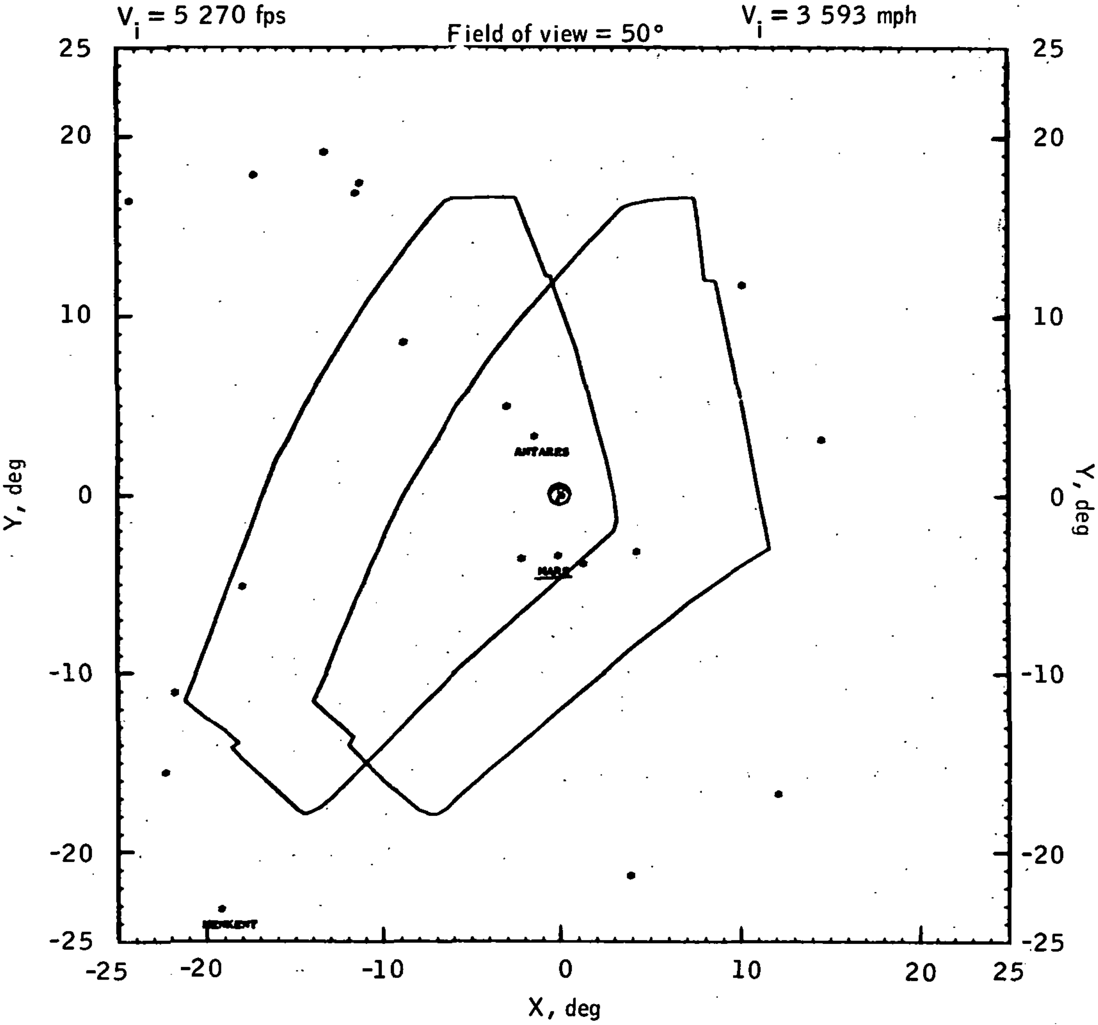
SEQ							
X	126	129	130	132	134	136	2
Y	4	-3	14	10	-11	-24	0
	-3	4	3	11	16	16	-3

R_E = 120 459 n. mi.

V_i = 5 270 fps

h_E = 134 659 stat. mi.

V_i = 3 593 mph



(d) g.e.t. = 170 hours.

Figure 7.3.1-1.- Continued.

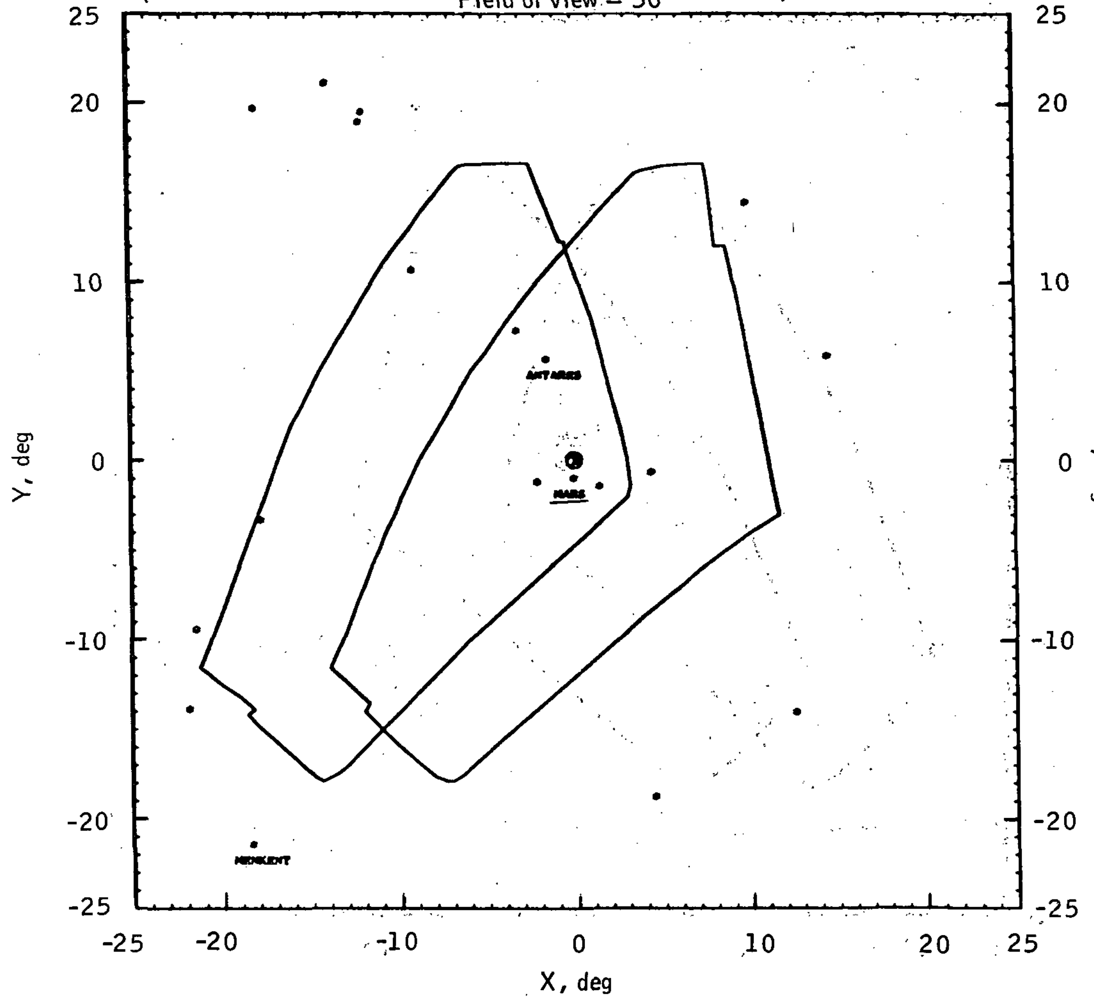
SEQ	24	27	61	62	84	85	87	117	120	121	122	123
X	-18	-1	-11	-17	1	-9	-13	-21	4	-21	12	-17
Y	-21	5	19	19	-1	10	21	-13	-18	-9	-14	-3

SEQ	125	126	129	130	132	134	135
X	-2	4	-3	14	9	-12	-24
Y	-1	0	7	5	14	18	17

$R_E \doteq 86\ 662$ n. mi. $h_E = 95\ 766$ stat. mi.

$V_i = 6\ 534$ fps $V_i = 4\ 455$ mph

Field of view = 50°



(e) g.e.t. = 180 hours.

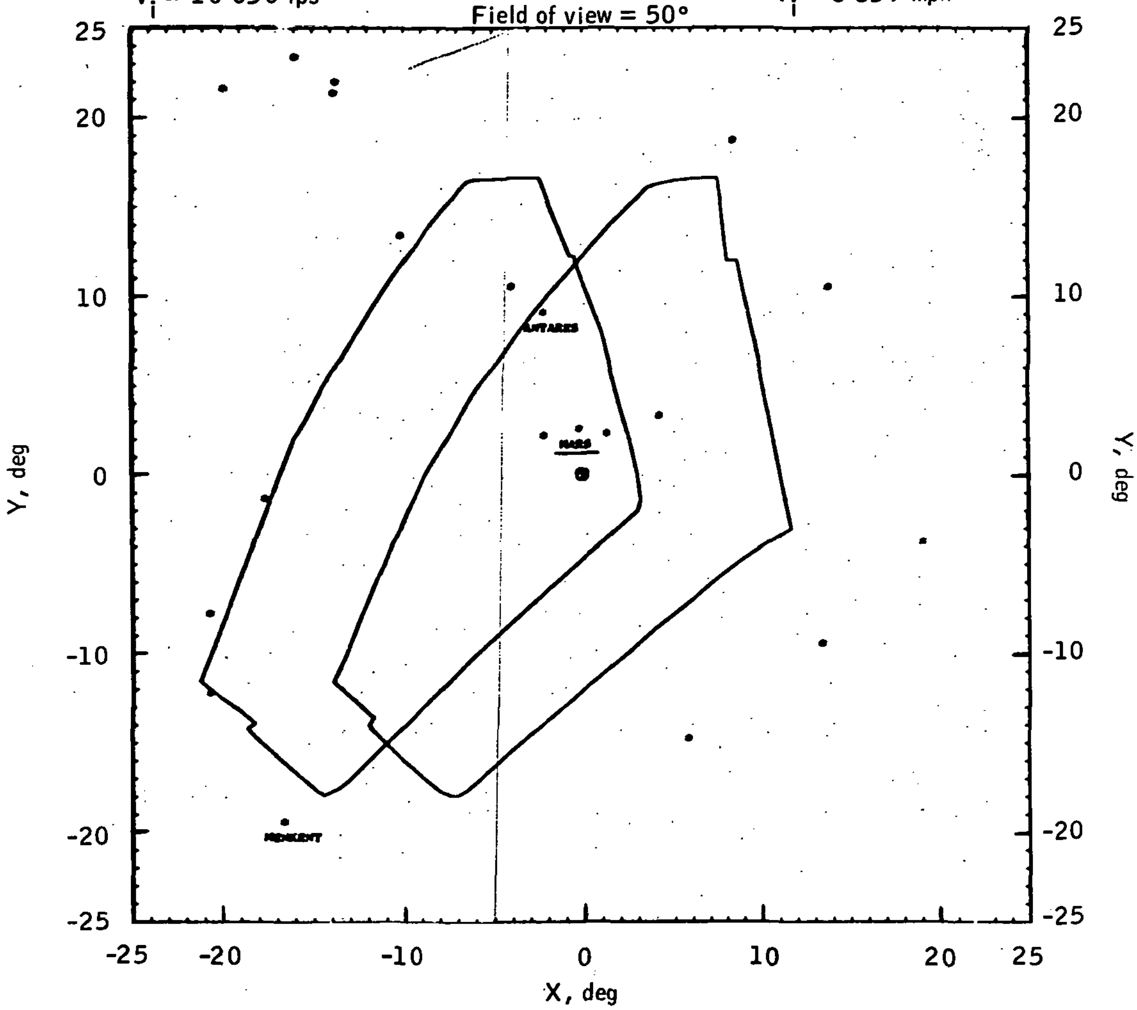
Figure 7.3.1-1.- Continued.

SEQ	24	27	61	62	84	85	87	117	120	121	122	123
X	-16	-2	-13	-19	1	-10	-15	-20	5	-20	13	-17
Y	-19	9	21	21	2	13	23	-12	-14	-7	-9	-1

SEQ	125	126	129	130	132	134
X	-2	4	-4	13	8	-13
Y	2	3	10	10	18	21

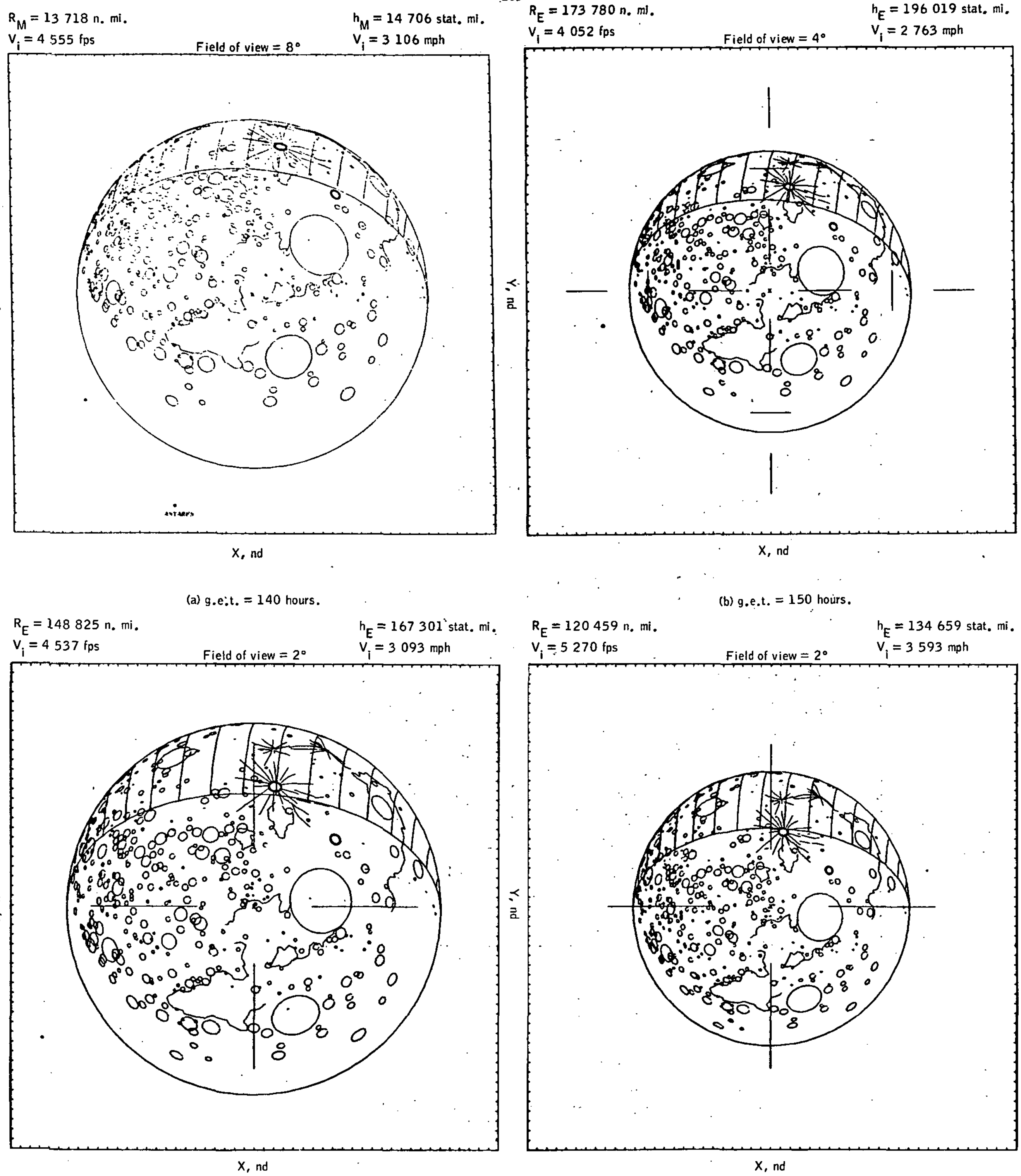
R_E = 41 589 n. mi. h_E = 43 898 stat. mi.

V_i = 10 030 fps V_i = 6 839 mph



(f) g.e.t. = 190 hours.

Figure 7.3.1-1.- Concluded.



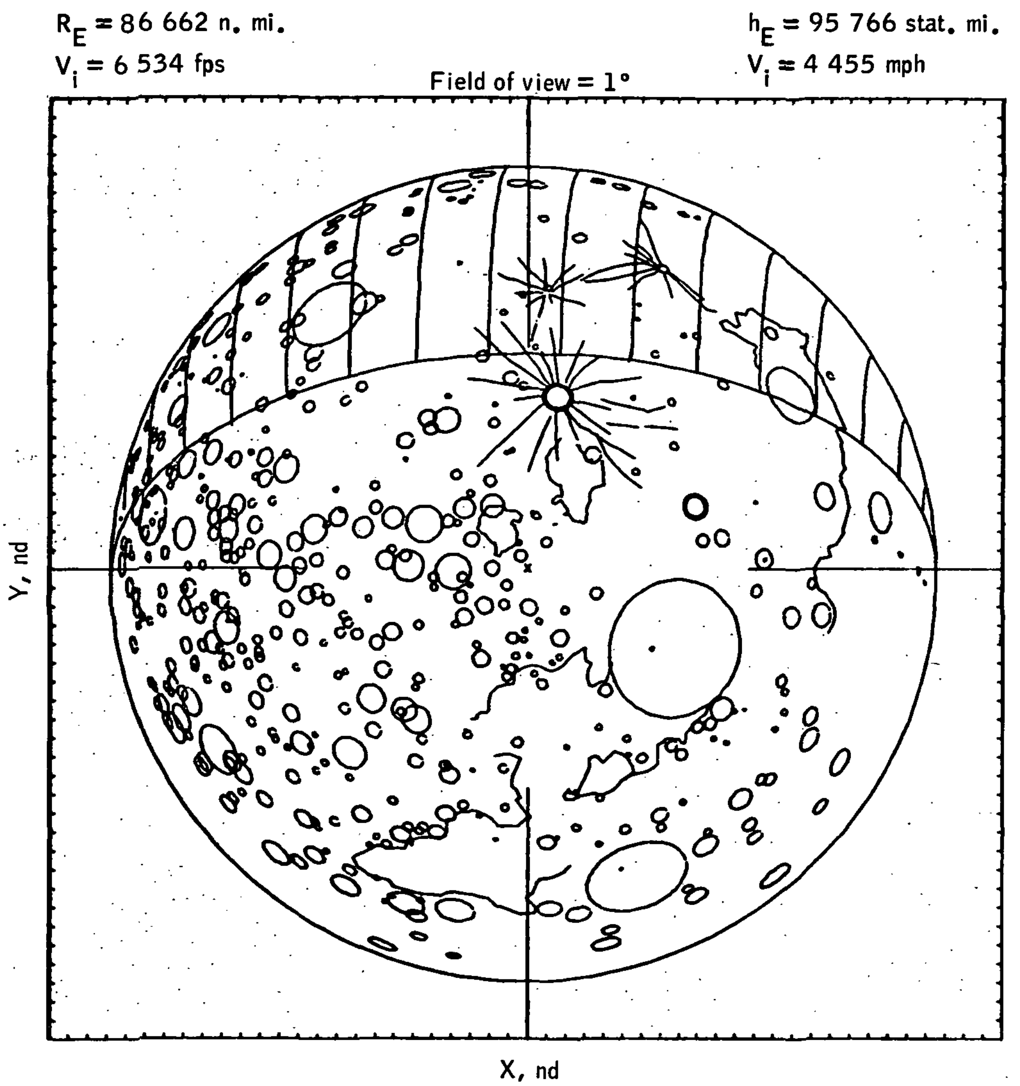
(a) g.e.t. = 140 hours.

(b) g.e.t. = 150 hours.

(c) g.e.t. = 160 hours.

(d) g.e.t. = 170 hours.

Figure 7.3.1-2.- Transearth coast - variable field of view (moon).



(e) g.e.t. = 180 hours.

Figure 7.3.1-2.- Concluded.

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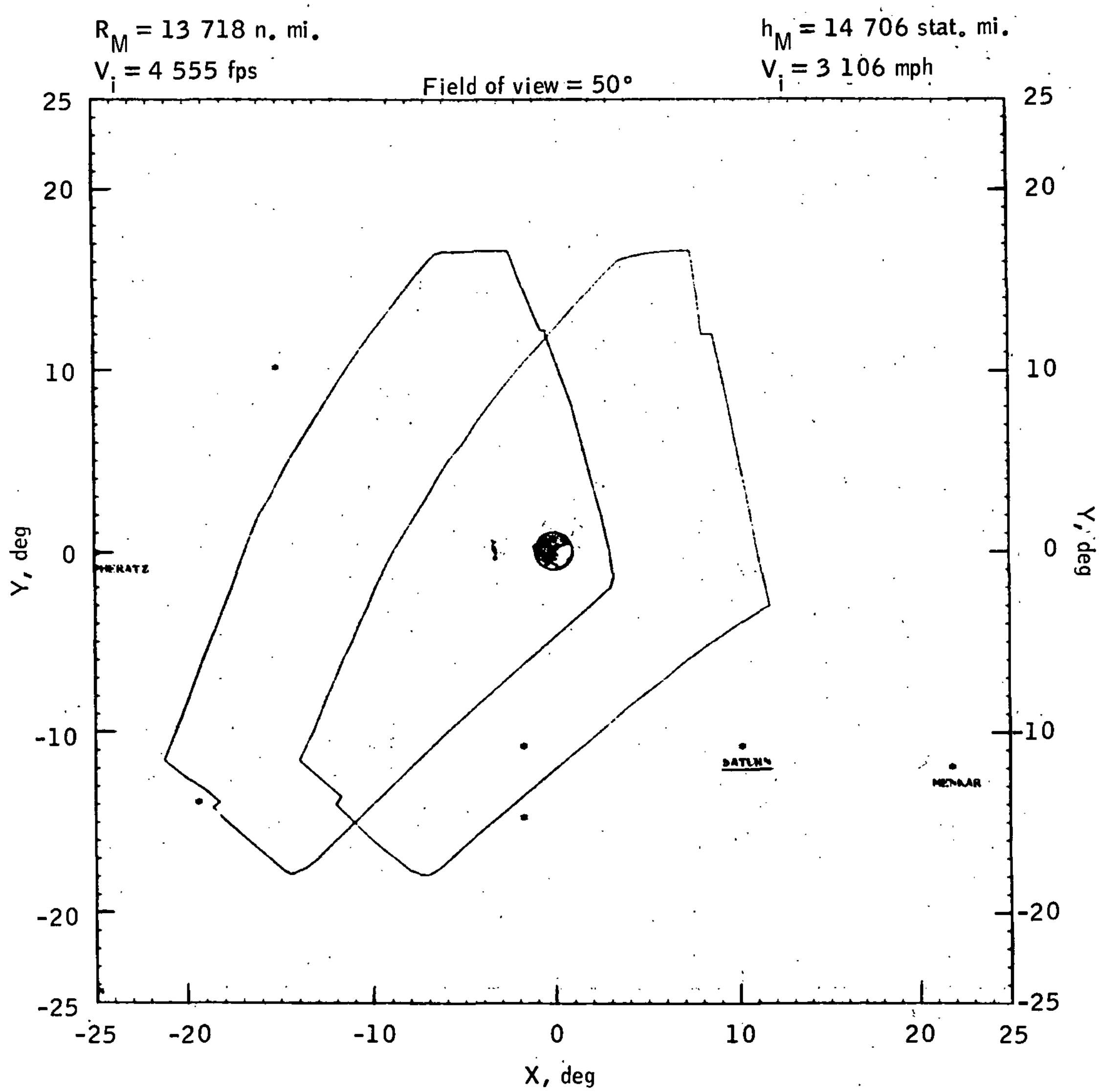
7.3.2 EARTH VIEWS

SEQ	4	7	41	63	75	80	108	1082
X	-24	-14	-19	-1	-2	20	21	9
Y	0	10	-13	-11	-15	0	-13	-11



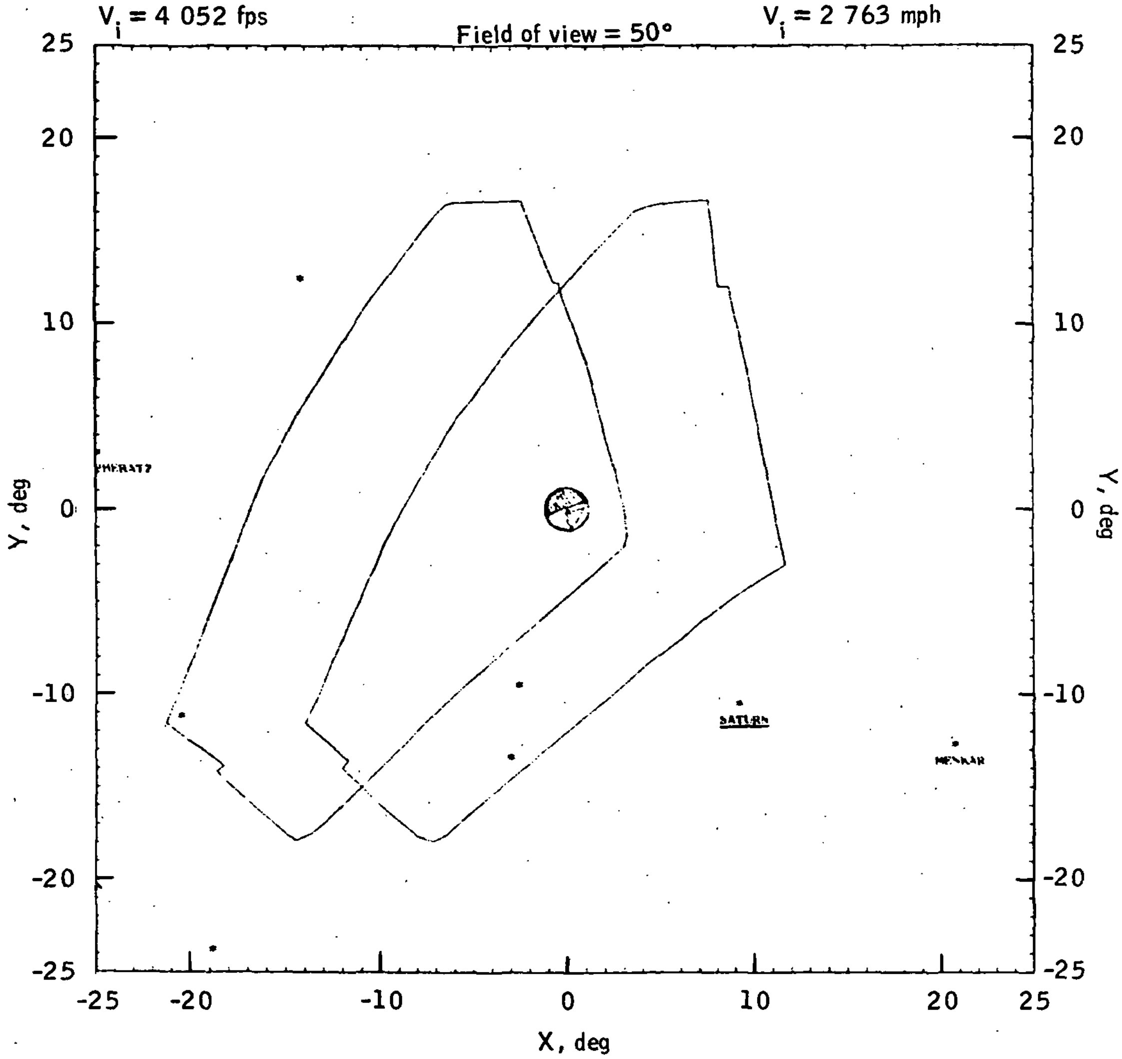
(a) g.e.t. = 140 hours.

Figure 7.3.2-1.- Transearth coast - constant field of view (earth).

SEQ	1	7	38	66	67	86	89	4
X	-24	20	-2	-20	-18	-14	-2	9
Y	3	-12	-13	-11	-23	12	-9	-10

R_E = 173 780 n. mi. h_E = 196 019 stat. mi.

V_i = 4 052 fps V_i = 2 763 mph



(b) g.e.t. = 150 hours.

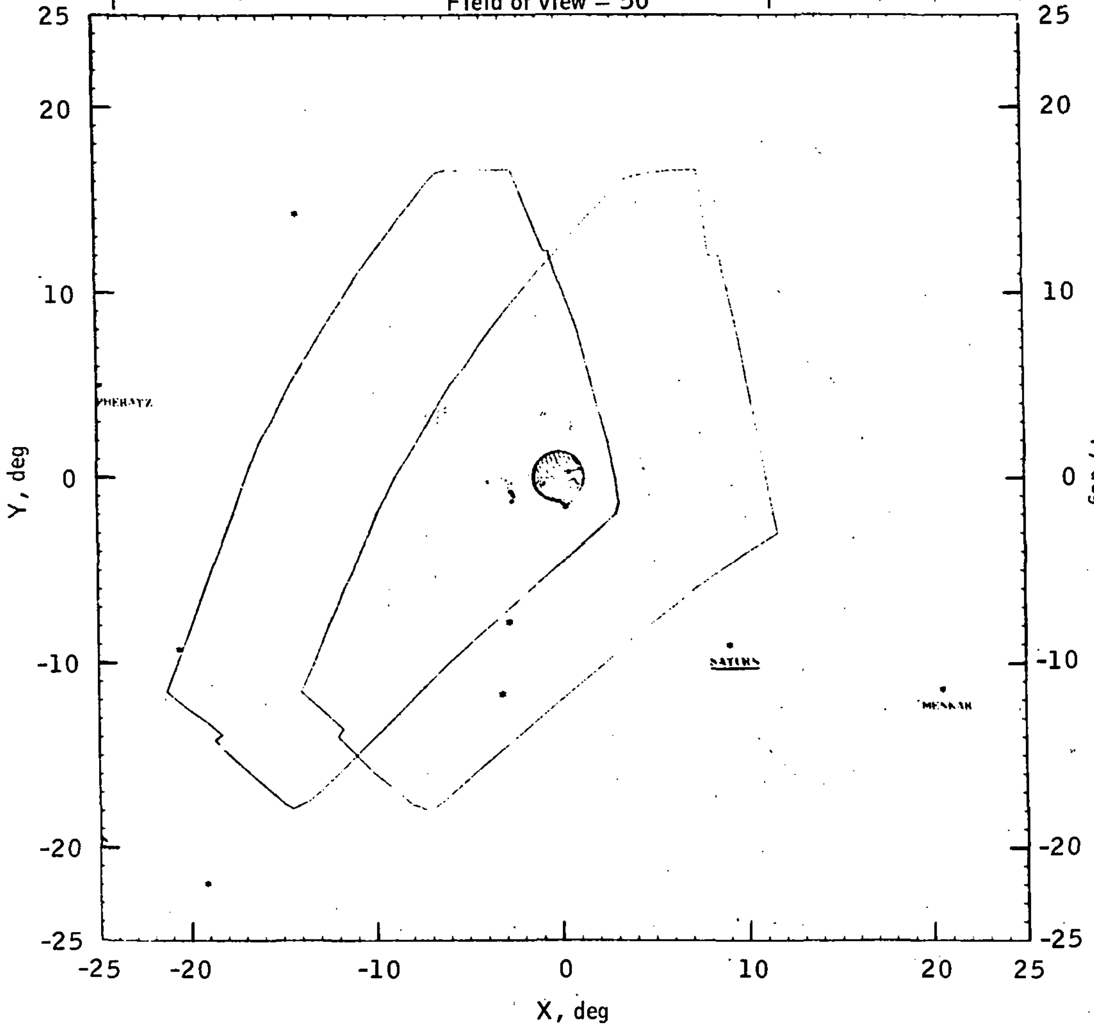
Figure 7.3.2-1.- Continued.

SEQ	1	7	38	66	67	86	89	4
X	-24	20	-3	-20	-19	-13	-2	9
Y	4	-11	-11	-9	-21	14	-7	-9

R_E = 148 825 n. mi. h_E = 167 301 stat. mi.

V_i = 4 537 fps V_i = 3 093 mph

Field of view = 50°



(c) g.e.t. = 160 hours.

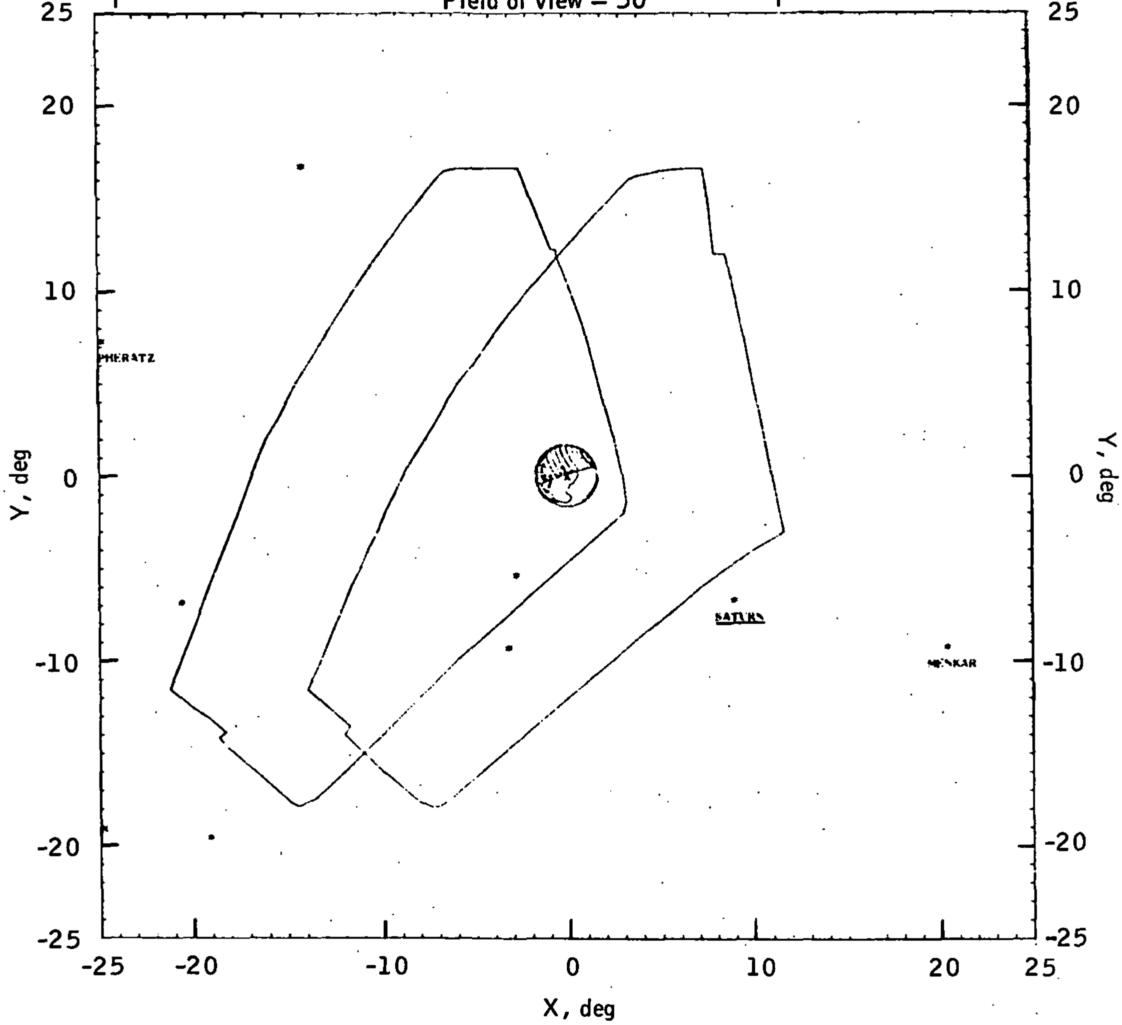
Figure 7.3.2-1.- Continued.

SEQ	1	7	38	66	67	86	89	4
X	-24	20	-3	-20	-19	-13	-2	9
Y	7	-9	-9	-6	-19	16	-5	-6

R_E = 120 459 n. mi. h_E = 134 659 stat. mi.

V_i = 5 270 fps V_i = 3 593 mph

Field of view = 50°



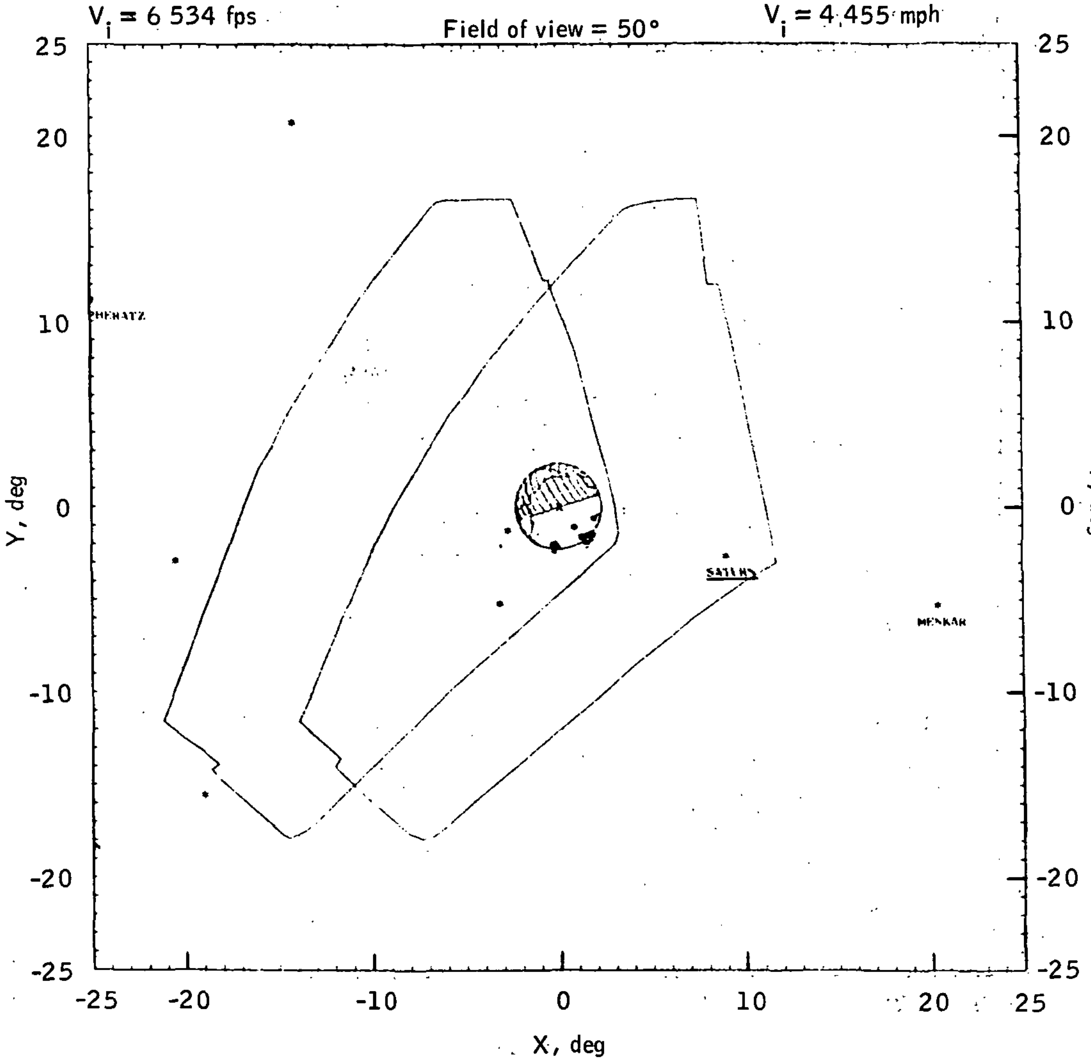
(d) g.e.t. = 170 hours.

Figure 7.3.2-1.- Continued.

SEQ	1	7	38	66	67	86	89	4
X	-24	20	-3	-20	-18	-14	-2	9
Y	11	-5	-5	-2	-15	20	-1	-2

R_E = 86 662 n. mi. h_E = 95 766 stat. mi.

V_i = 6 534 fps V_i = 4 455 mph



(e) g.e.t. = 180 hours.

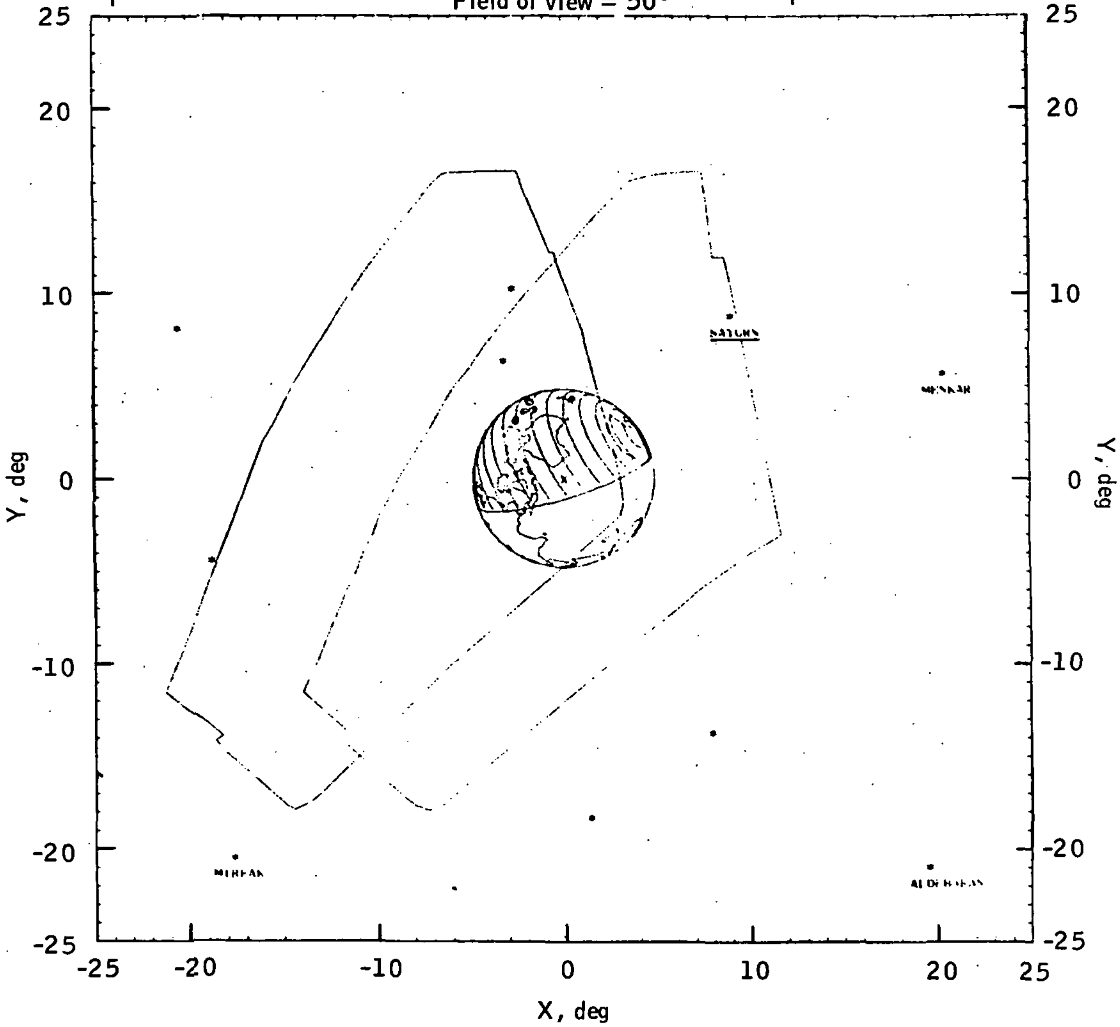
Figure 7.3.2-1.- Continued.

SEQ	7	8	9	38	66	67	89	90	91	92	4
X	20	-17	19	-3	-20	-18	-2	7	1	-5	9
Y	5	-20	-20	6	8	-4	10	-13	-18	-22	8

R_E = 41 589 n. mi. h_E = 43 898 stat. mi.

V_i = 10 030 fps V_i = 6 839 mph

Field of view = 50°



(f) g.e.t. = 190 hours.

Figure 7.3.2-1.- Concluded.

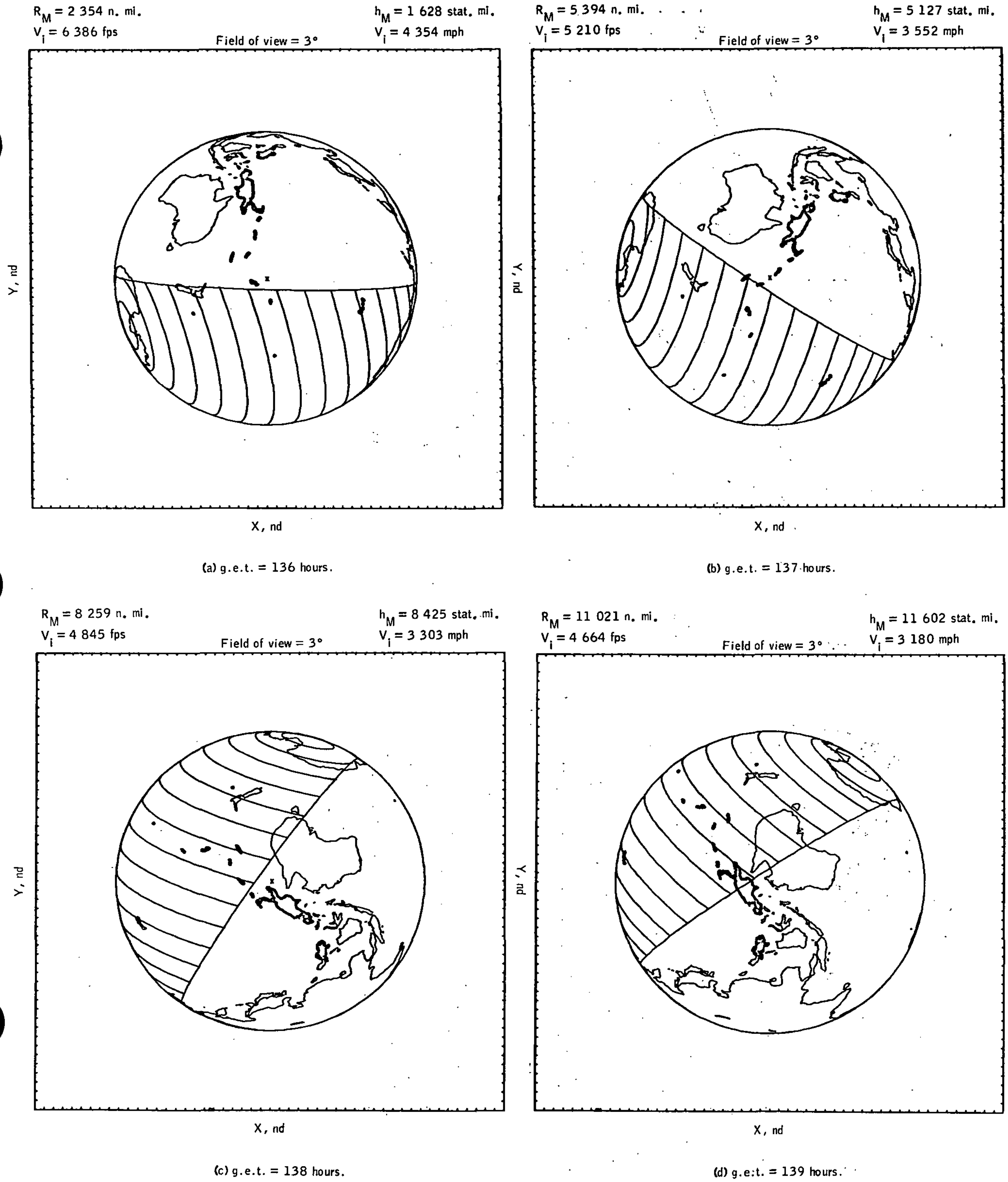
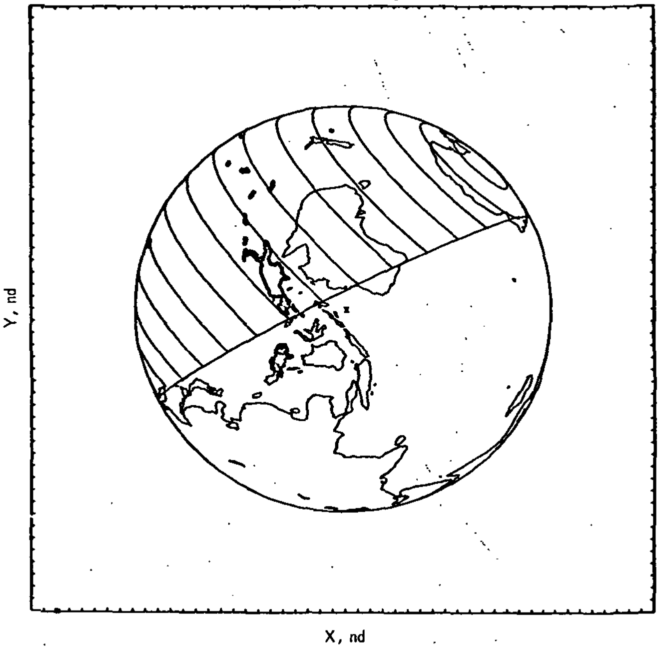


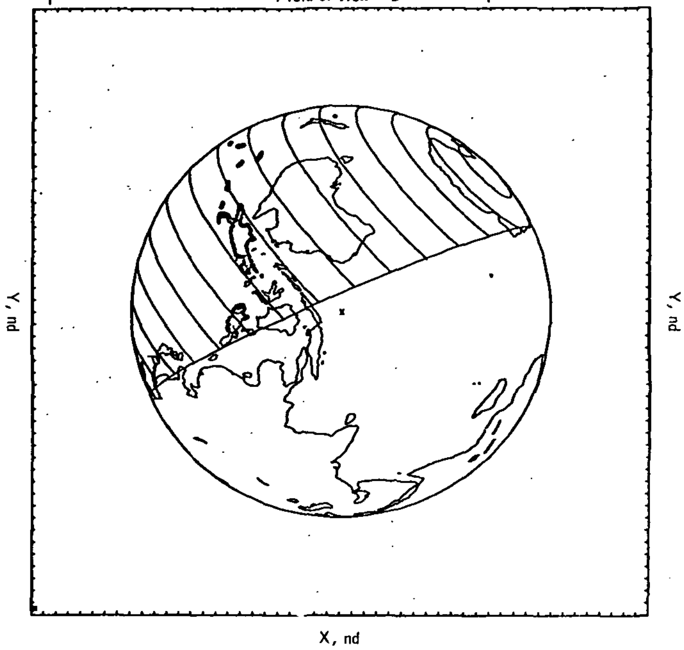
Figure 7.3.2-2.- Transearth coast - variable field of view (earth).

R_M = 13 718 n. mi.
V_i = 4 555 fps
Field of view = 3°
h_M = 14 706 stat. mi.
V_i = 3 106 mph



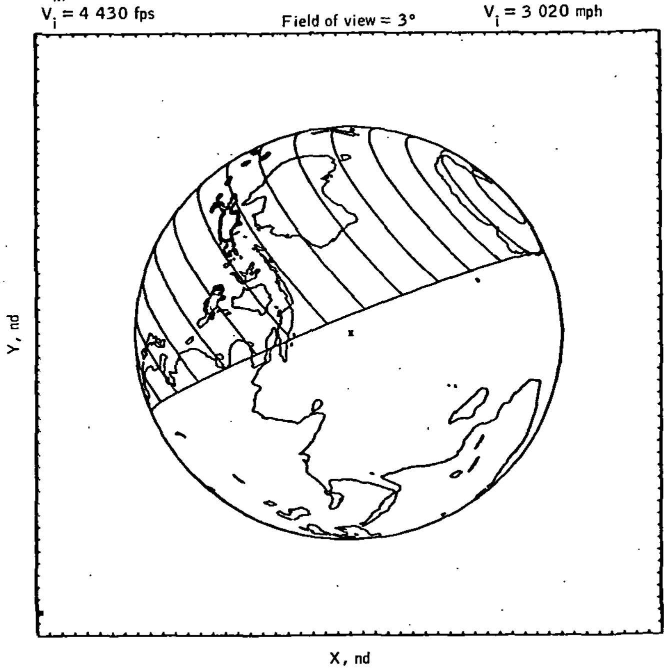
(e) g.e.t. = 140 hours.

R_M = 16 372 n. mi.
V_i = 4 482 fps
Field of view = 3°
h_M = 17 760 stat. mi.
V_i = 3 056 mph



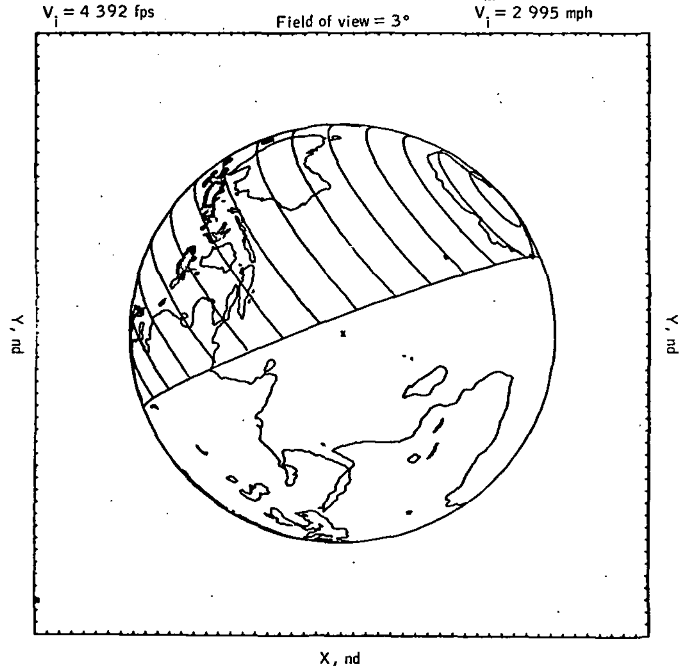
(f) g.e.t. = 141 hours.

R_M = 18 995 n. mi.
V_i = 4 430 fps
Field of view = 3°
h_M = 20 778 stat. mi.
V_i = 3 020 mph



(g) g.e.t. = 142 hours.

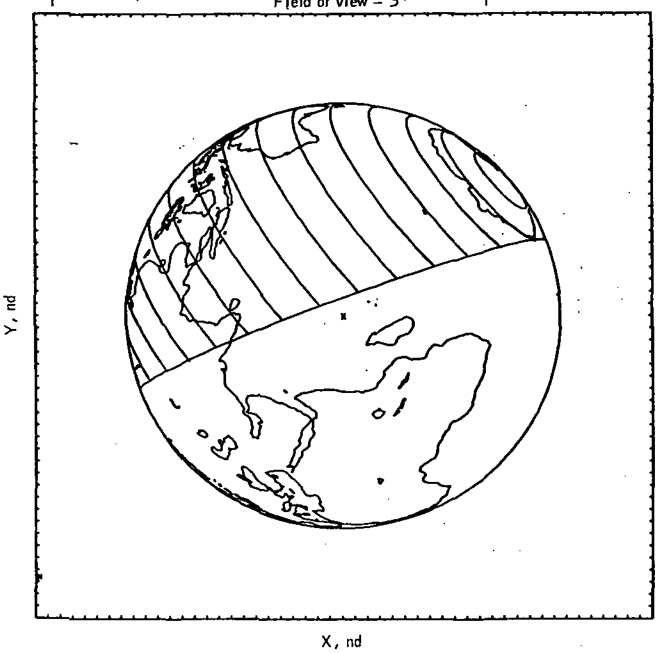
R_M = 21 595 n. mi.
V_i = 4 392 fps
Field of view = 3°
h_M = 23 770 stat. mi.
V_i = 2 995 mph



(h) g.e.t. = 143 hours.

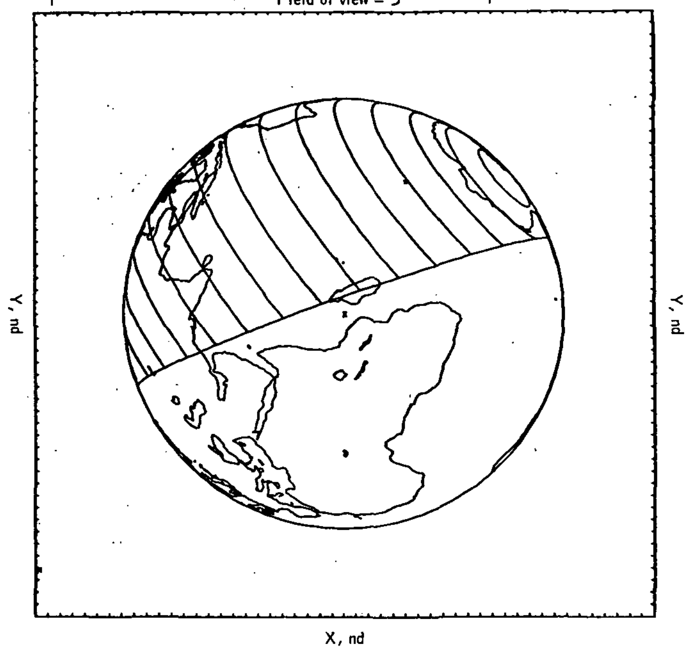
Figure 7.3.2-2.- Continued.

R_M = 24 177 n. mi.
V_i = 4 363 fps
h_M = 26 743 stat. mi.
V_i = 2 975 mph
Field of view = 3°



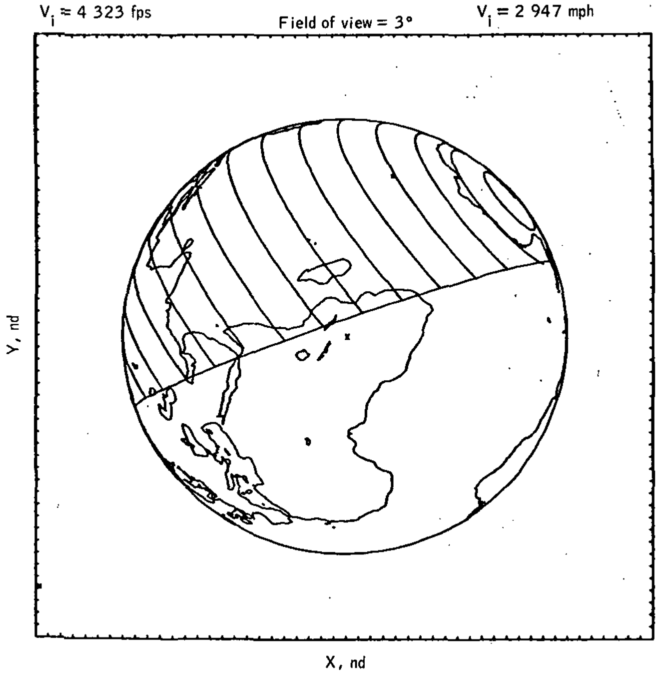
(i) g.e.t. = 144 hours.

R_M = 26 746 n. mi.
V_i = 4 340 fps
h_M = 29 699 stat. mi.
V_i = 2 959 mph
Field of view = 3°



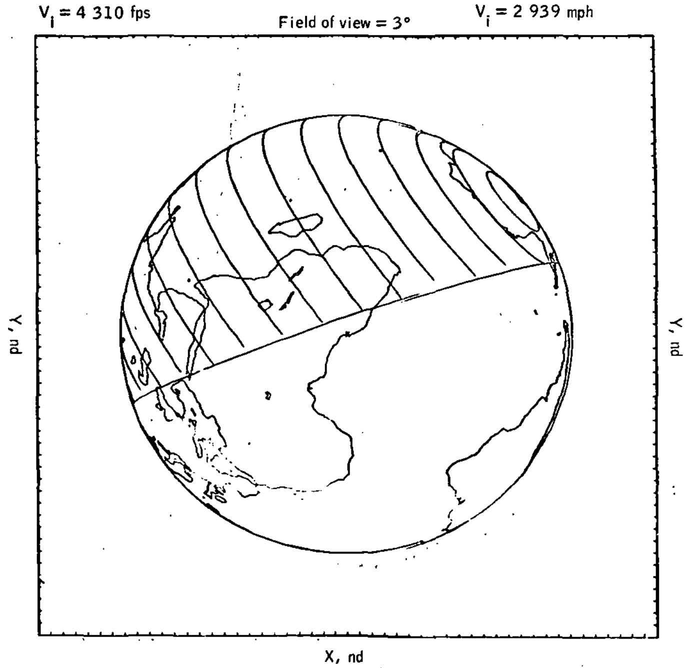
(j) g.e.t. = 145 hours.

R_M = 29 305 n. mi.
V_i = 4 323 fps
h_M = 32 644 stat. mi.
V_i = 2 947 mph
Field of view = 3°



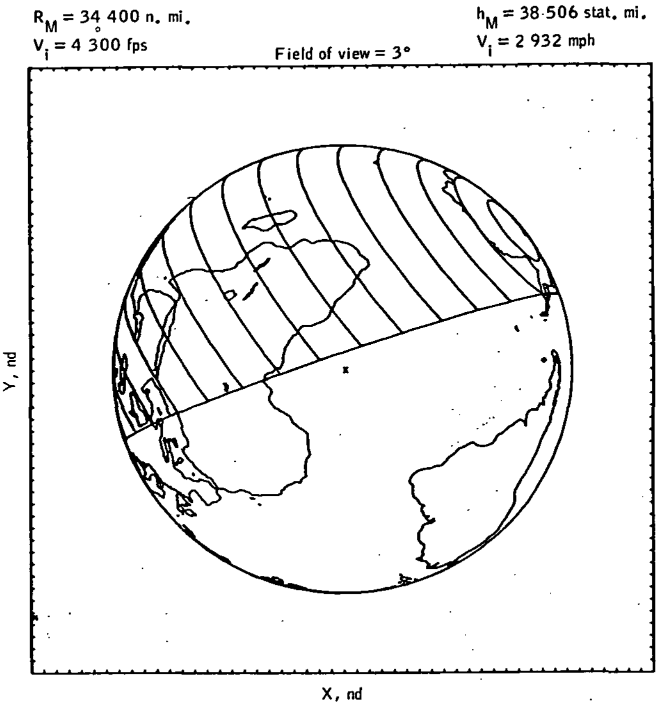
(k) g.e.t. = 146 hours.

R_M = 31 855 n. mi.
V_i = 4 310 fps
h_M = 35 578 stat. mi.
V_i = 2 939 mph
Field of view = 3°

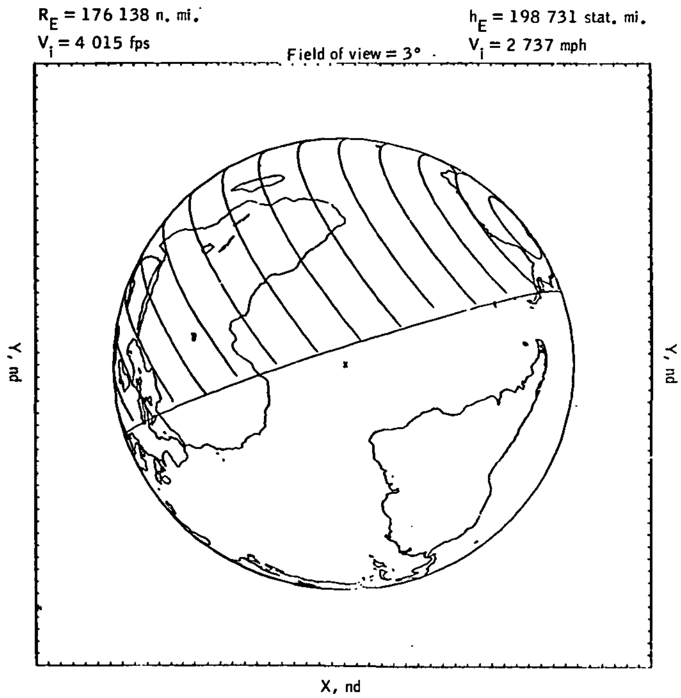


(l) g.e.t. = 147 hours.

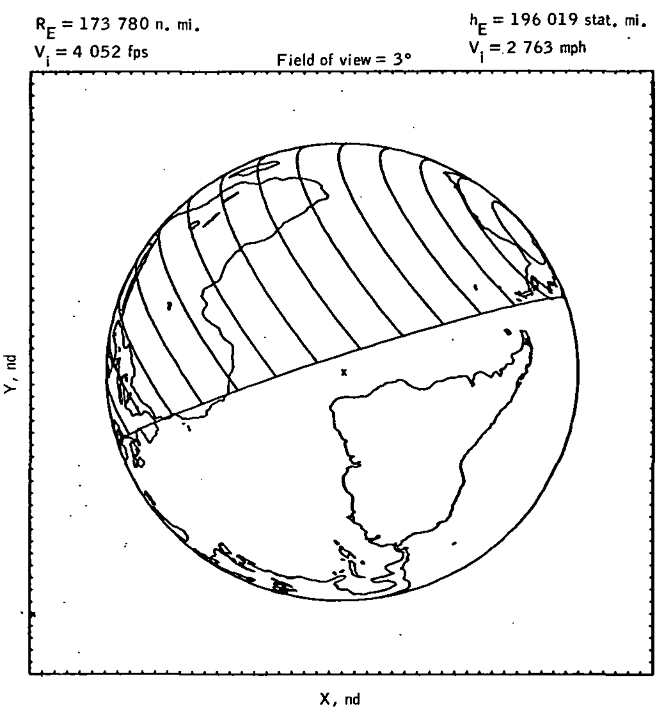
Figure 7.3.2-2.- Continued.



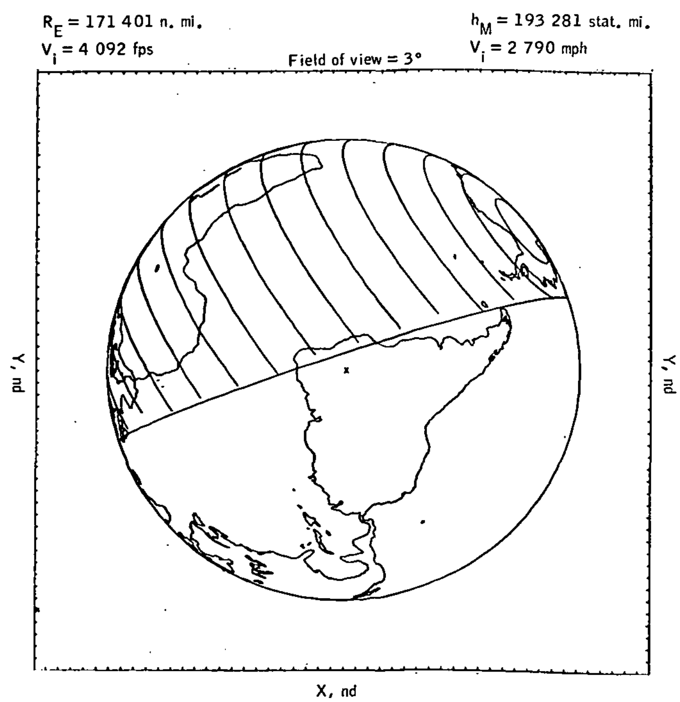
(m) g.e.t. = 148 hours.



(n) g.e.t. = 149 hours.

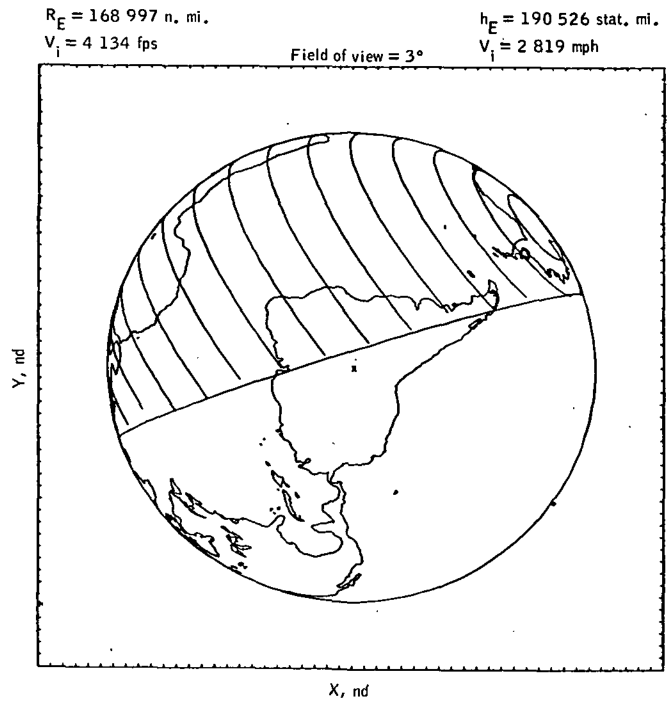


(o) g.e.t. = 150 hours.

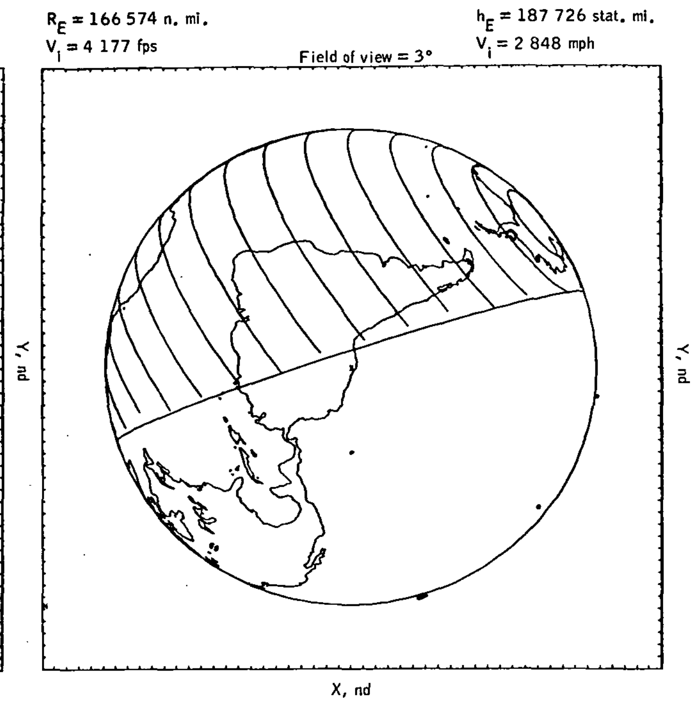


(p) g.e.t. = 151 hours.

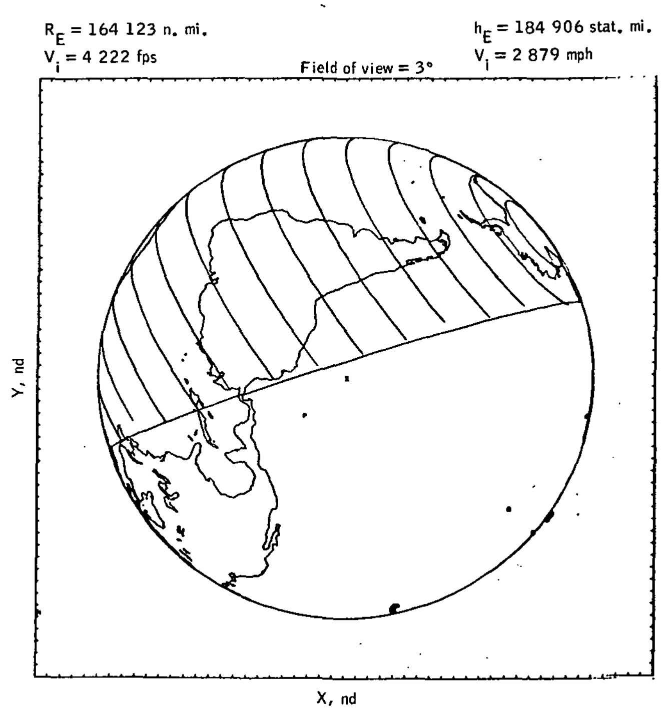
Figure 7.3.2-2.- Continued.



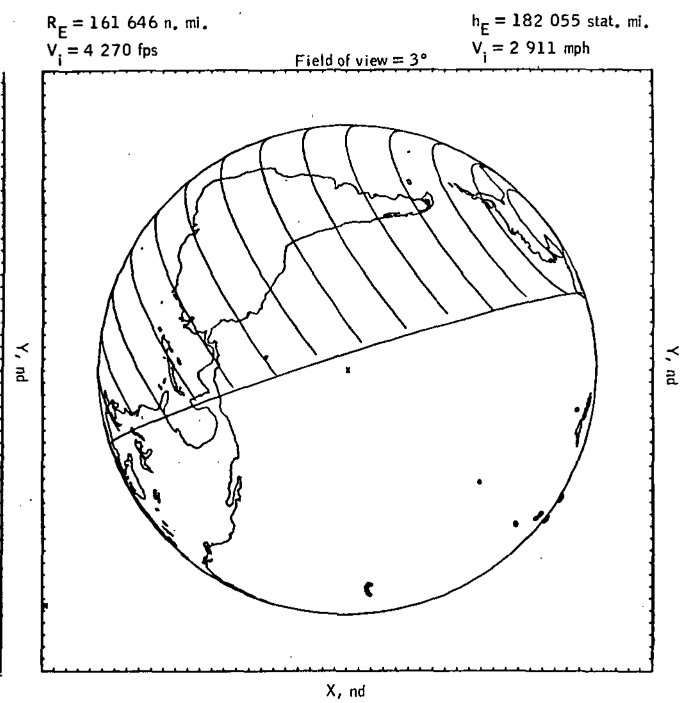
(q) g.e.t. = 152 hours.



(r) g.e.t. = 153 hours.



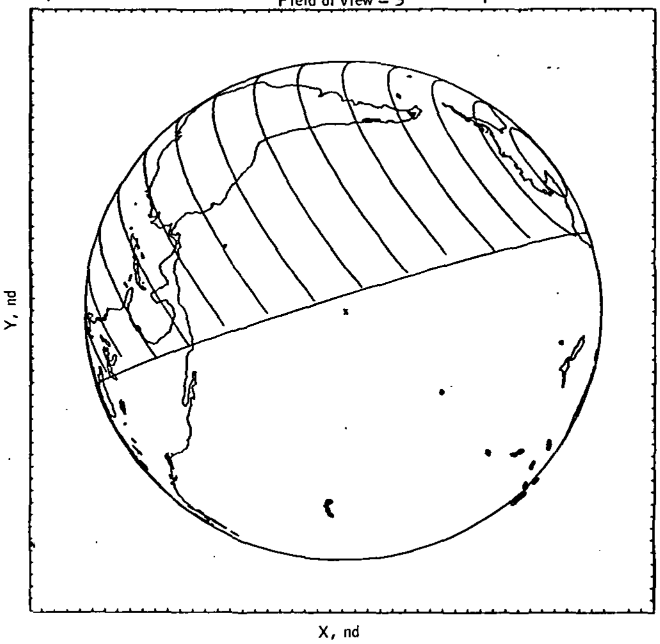
(s) g.e.t. = 154 hours.



(t) g.e.t. = 155 hours.

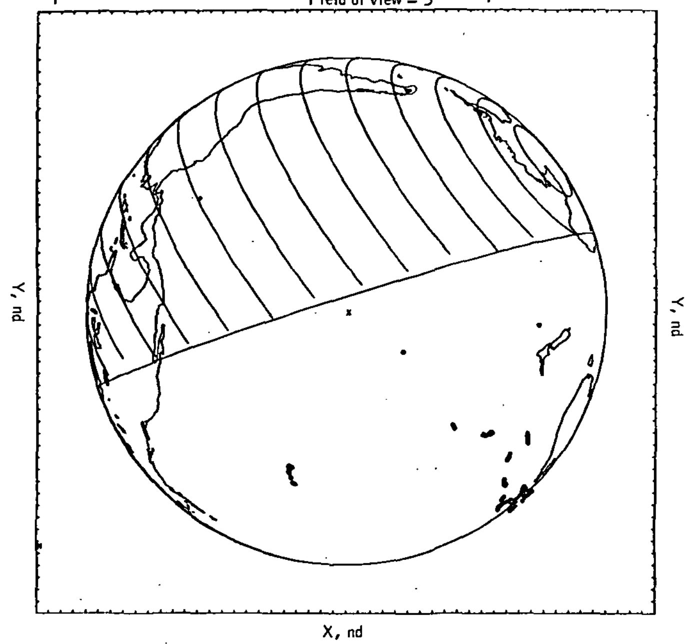
Figure 7.3.2-2.- Continued.

R_E = 159 141 n. mi.
V_i = 4 319 fps
Field of view ≈ 3°
h_E = 179 173 stat. mi.
V_i = 2 945 mph



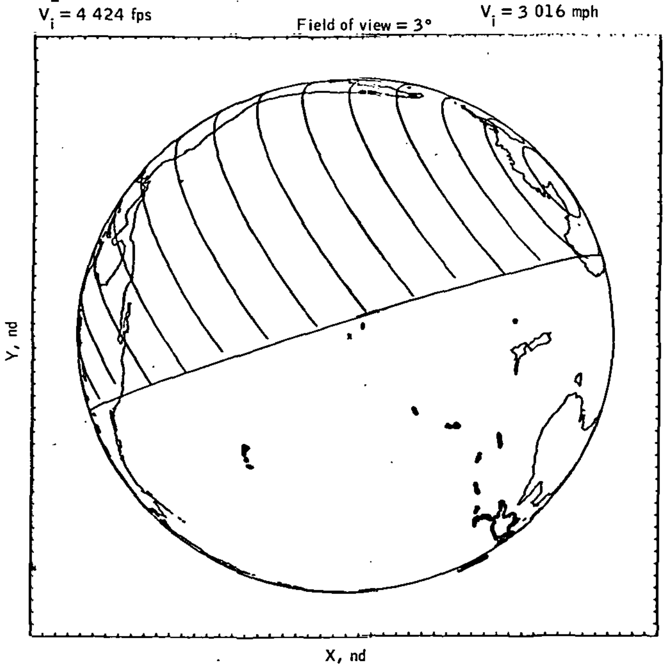
(u) g.e.t. = 156 hours.

R_E = 156 608 n. mi.
V_i = 4 370 fps
Field of view = 3°
h_E = 176 258 stat. mi.
V_i = 2 980 mph



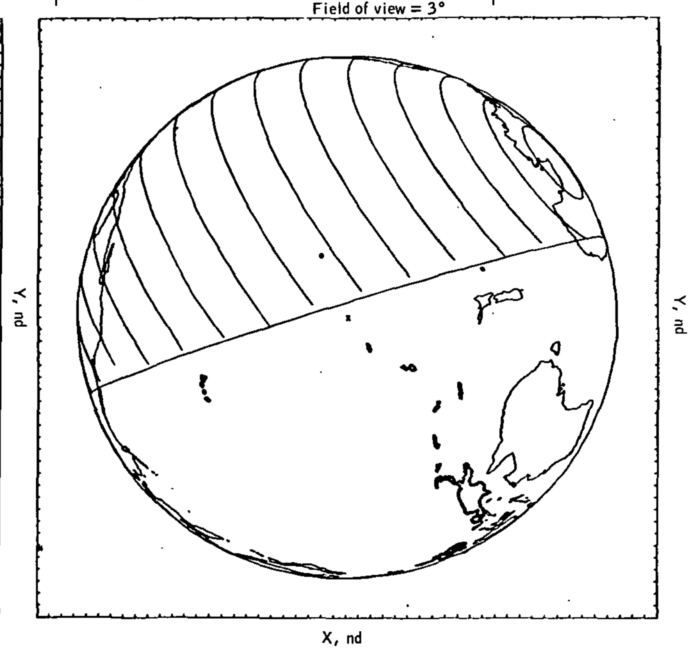
(v) g.e.t. = 157 hours.

R_E = 154 045 n. mi.
V_i = 4 424 fps
Field of view = 3°
h_E = 173 308 stat. mi.
V_i = 3 016 mph



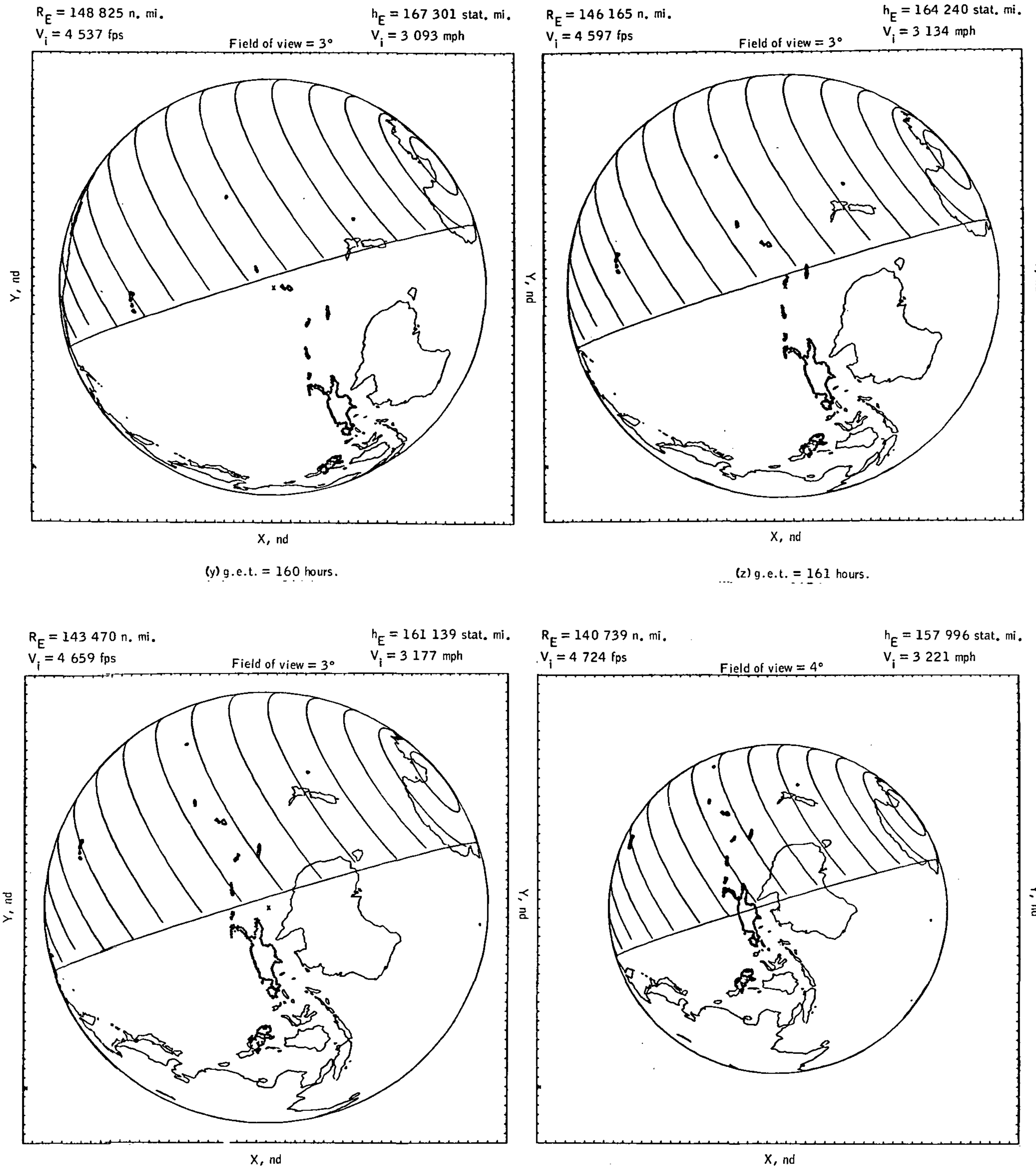
(w) g.e.t. = 158 hours.

R_E = 151 451 n. mi.
V_i = 4 479 fps
Field of view = 3°
h_E = 170 323 stat. mi.
V_i = 3 054 mph



(x) g.e.t. = 159 hours.

Figure 7.3.2-2.- *Continued.*



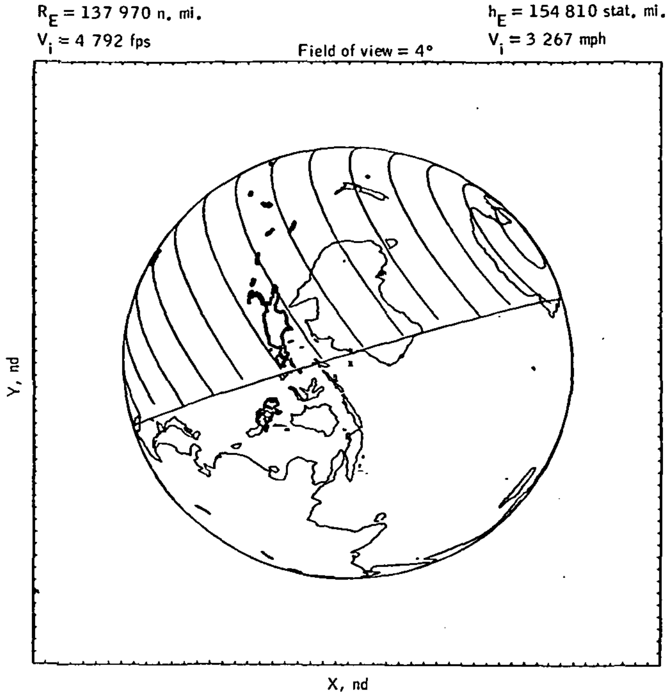
(y) g.e.t. = 160 hours.

(z) g.e.t. = 161 hours.

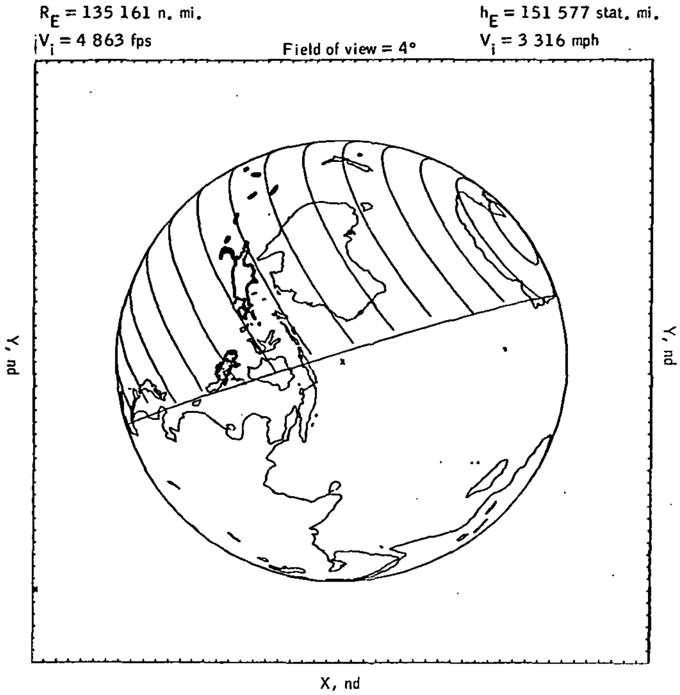
(aa) g.e.t. = 162 hours.

(bb) g.e.t. = 163 hours.

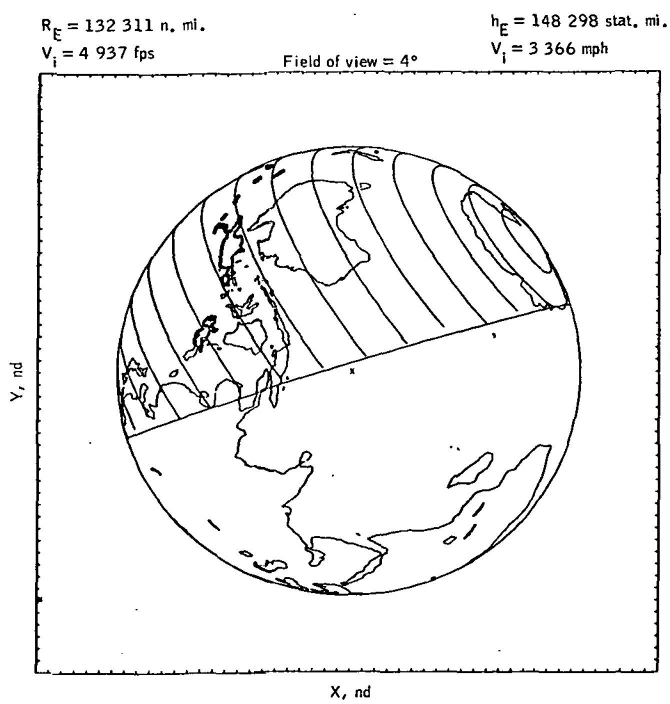
Figure 7.3.2-2.- Continued.



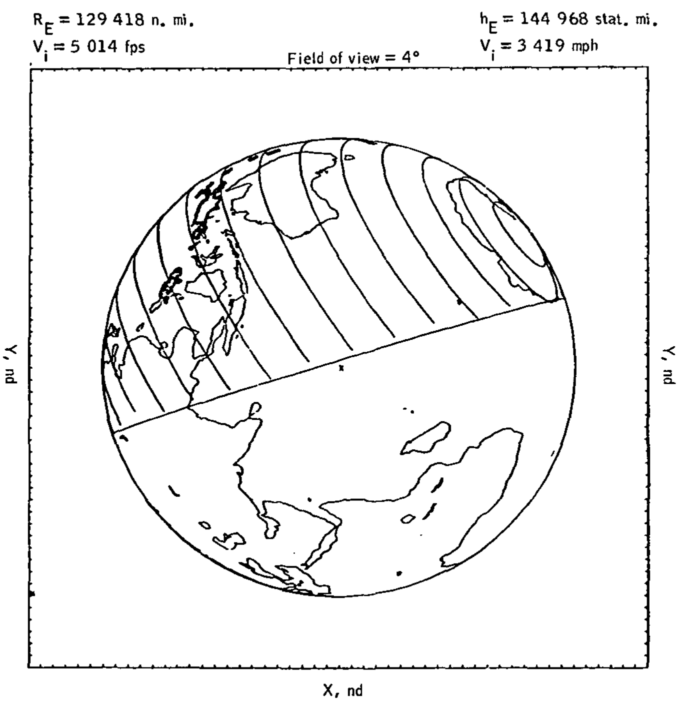
(cc) g.e.t. = 164 hours.



(dd) g.e.t. = 165 hours.

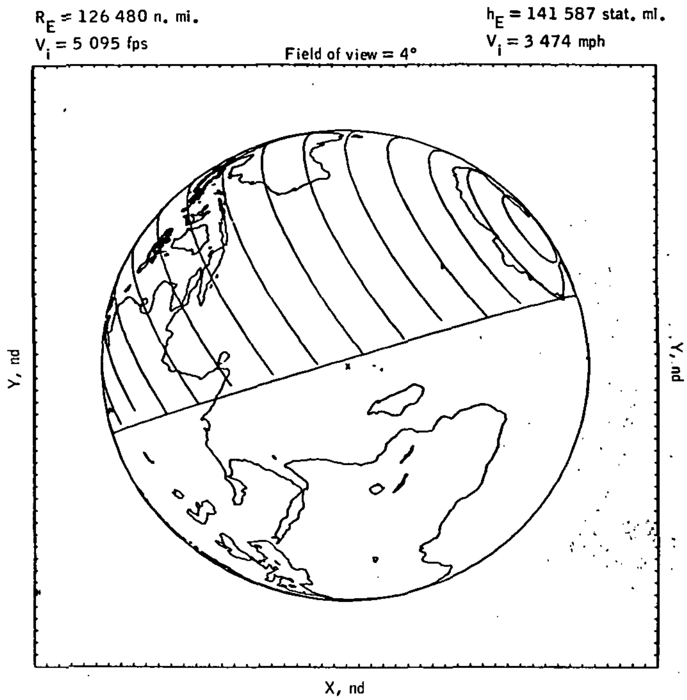


(ee) g.e.t. = 166 hours.

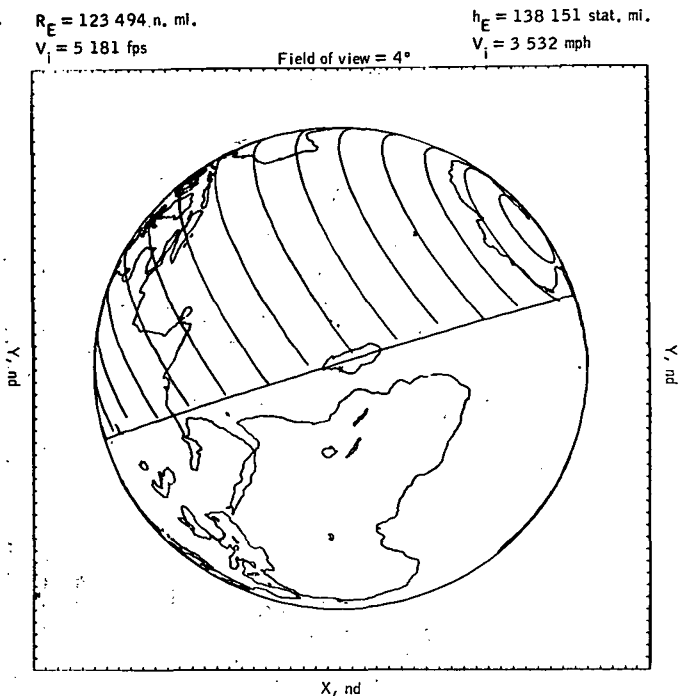


(ff) g.e.t. = 167 hours.

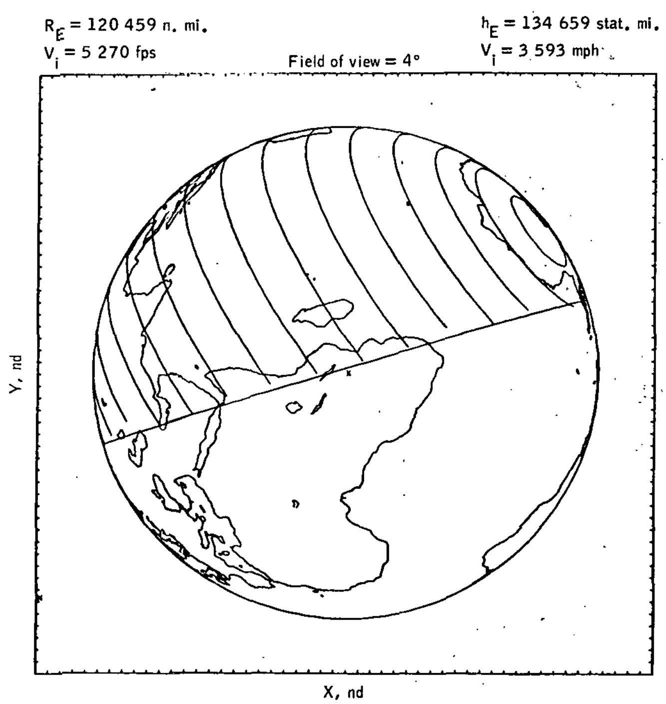
Figure 7.3.2-2.- Continued.



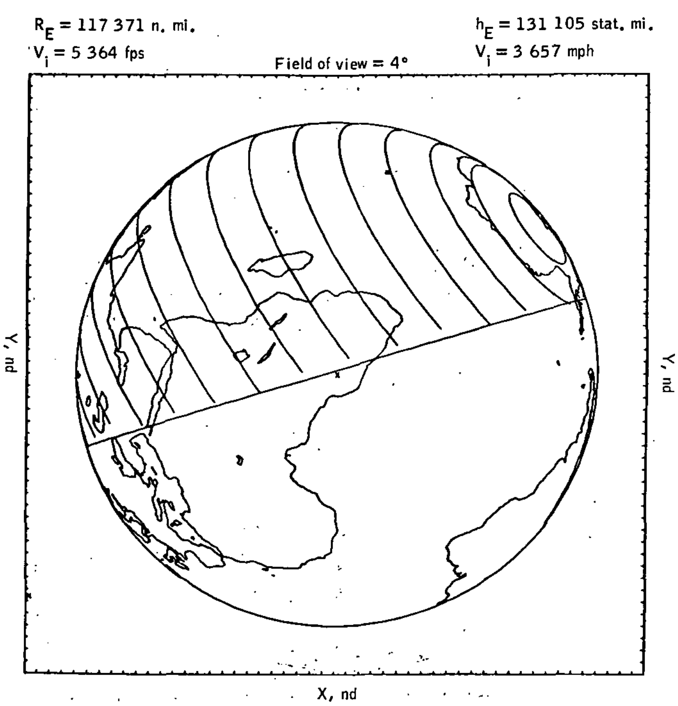
(gg) g.e.t. = 168 hours.



(hh) g.e.t. = 169 hours.



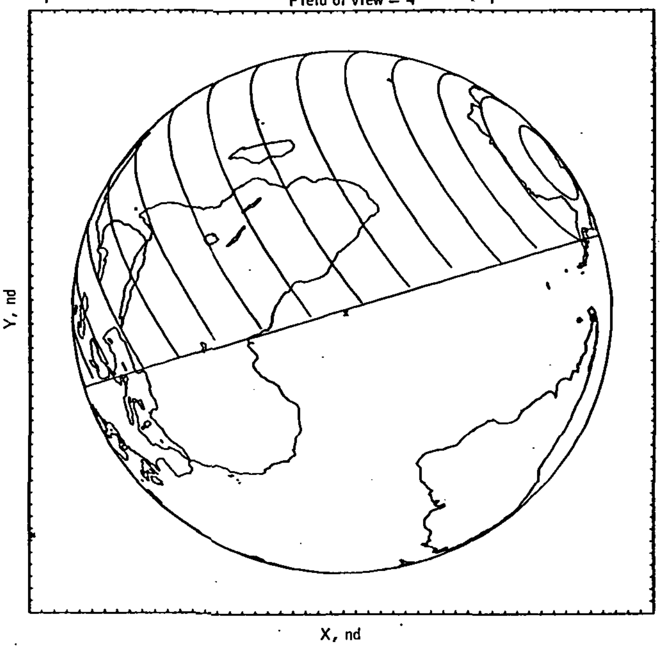
(ii) g.e.t. = 170 hours.



(jj) g.e.t. = 171 hours.

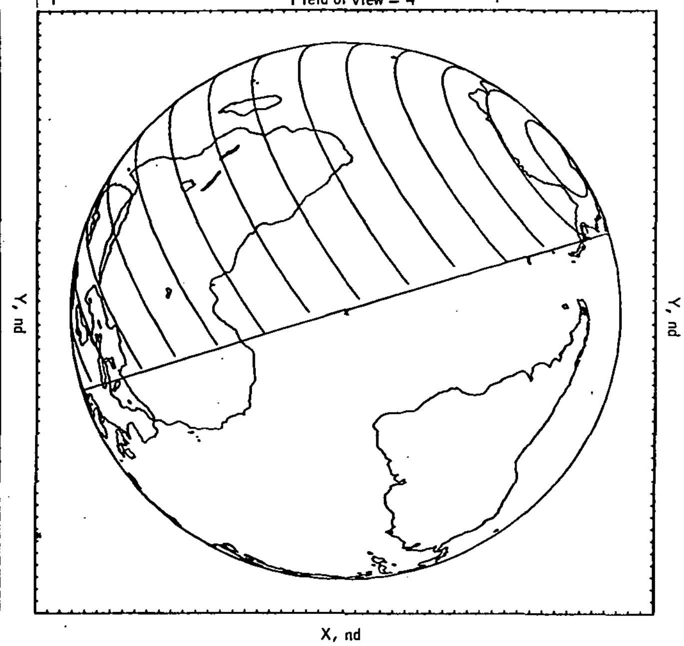
Figure 7.3.2-2.- Continued.

R_E = 114 229 n. mi.
V_i = 5 464 fps
Field of view = 4°
h_E = 127 489 stat. mi.
V_i 3 725 mph



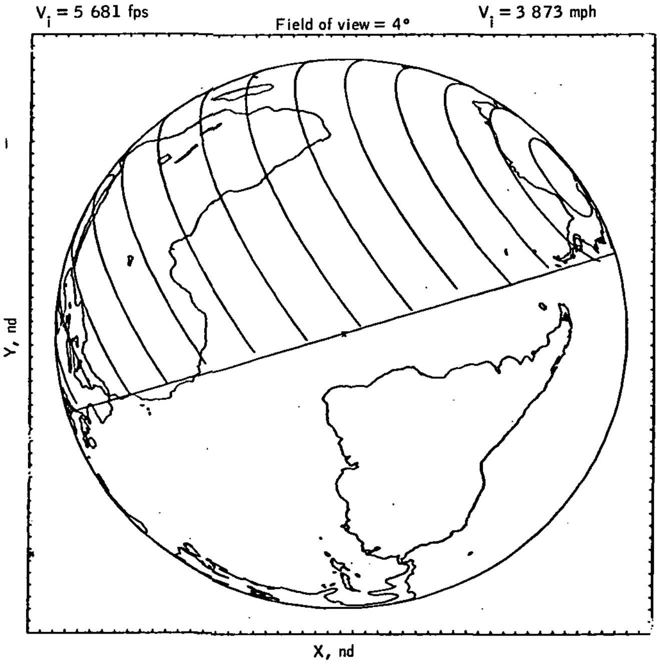
(kk) g.e.t. = 172 hours.

R_E = 111 028 n. mi.
V_i = 5 569 fps
Field of view = 4°
h_E = 123 806 stat. mi.
V_i = 3 797 mph



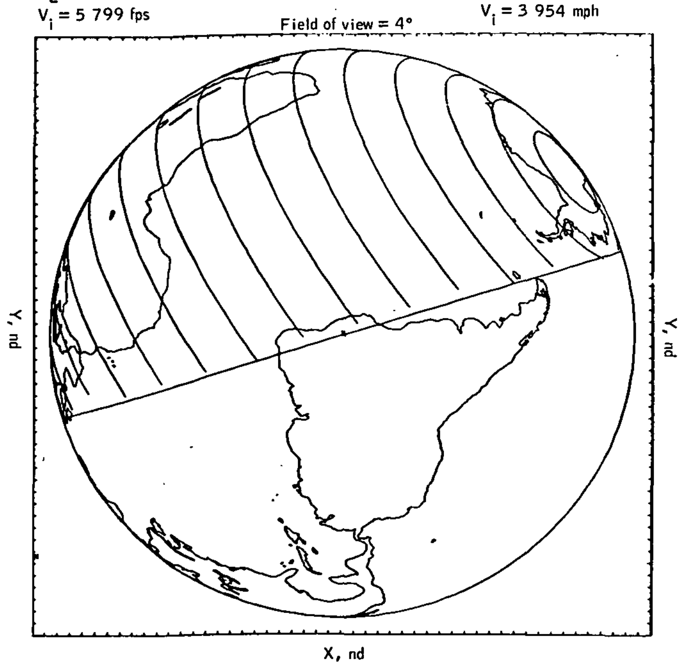
(ll) g.e.t. = 173 hours.

R_E = 107 766 n. mi.
V_i = 5 681 fps
Field of view = 4°
h_E = 120 052 stat. mi.
V_i = 3 873 mph



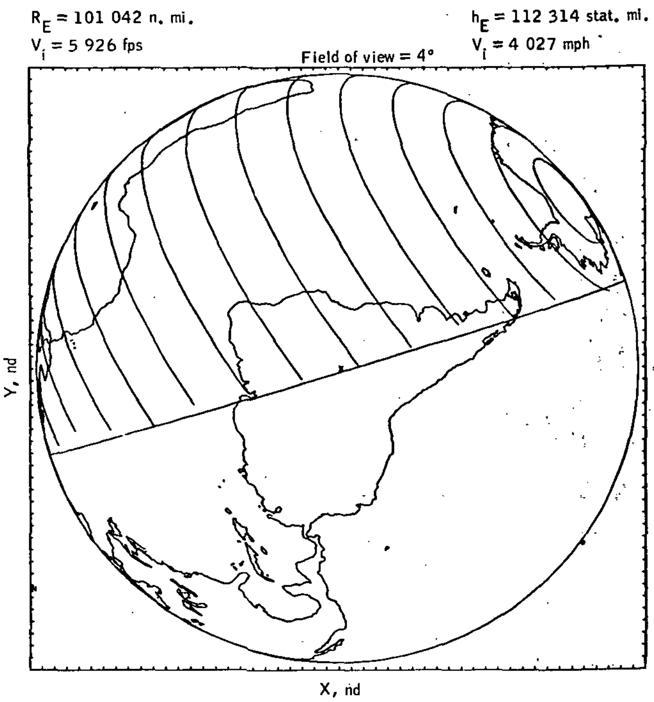
(mm) g.e.t. = 174 hours.

R_E = 104 439 n. mi.
V_i = 5 799 fps
Field of view = 4°
h_E = 116 223 stat. mi.
V_i = 3 954 mph

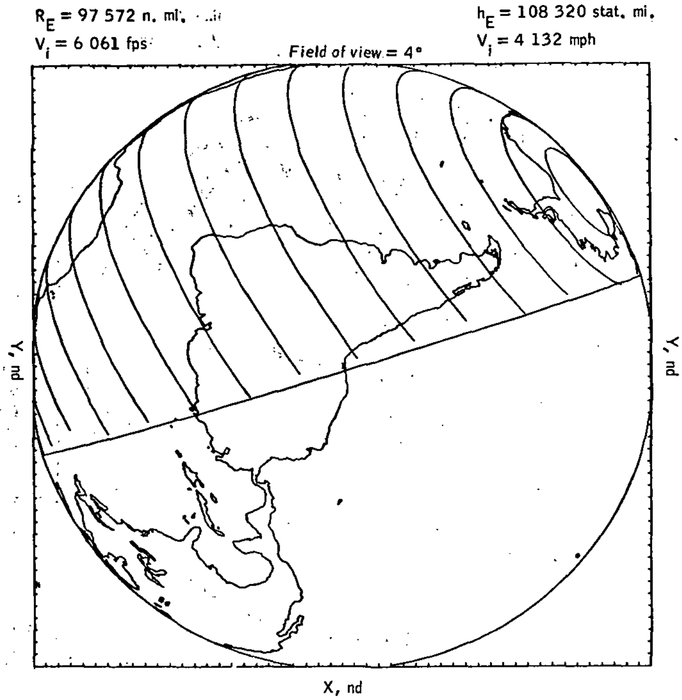


(nn) g.e.t. = 175 hours.

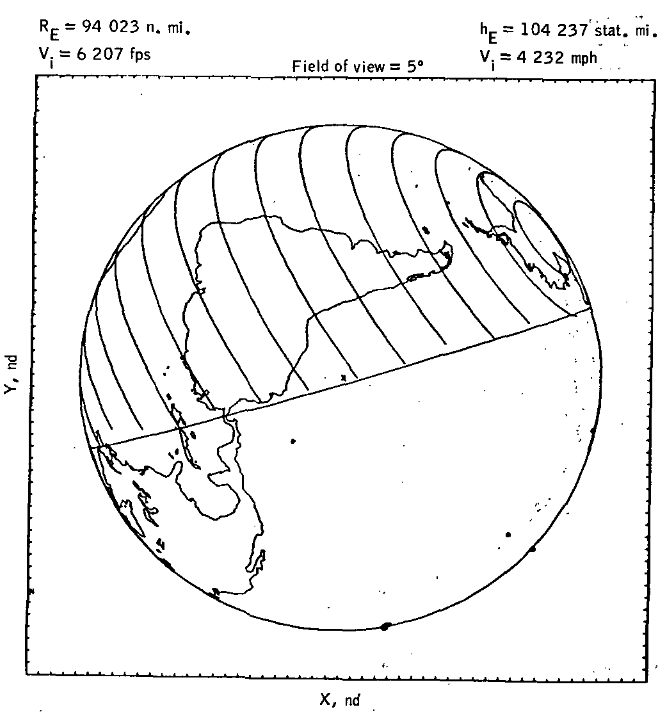
Figure 7.3.2-2.- Continued.



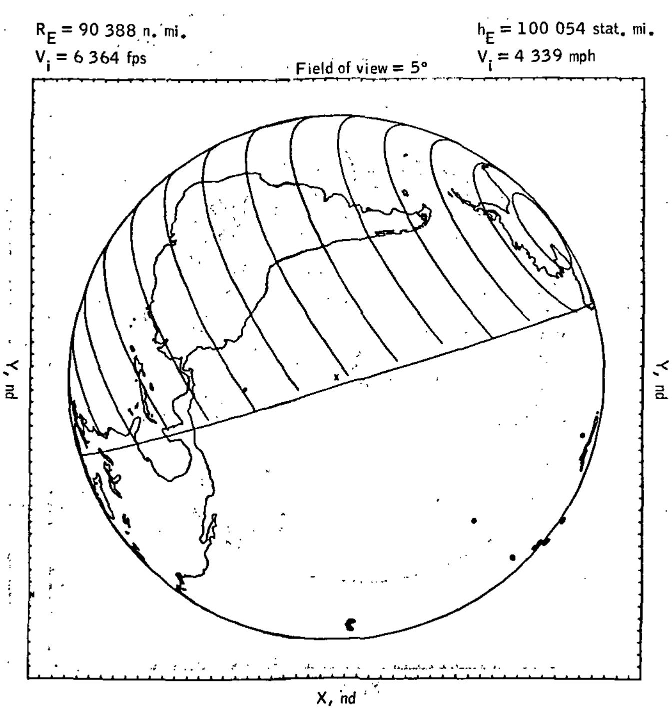
(oo) g.e.t. = 176 hours.



(pp) g.e.t. = 177 hours.

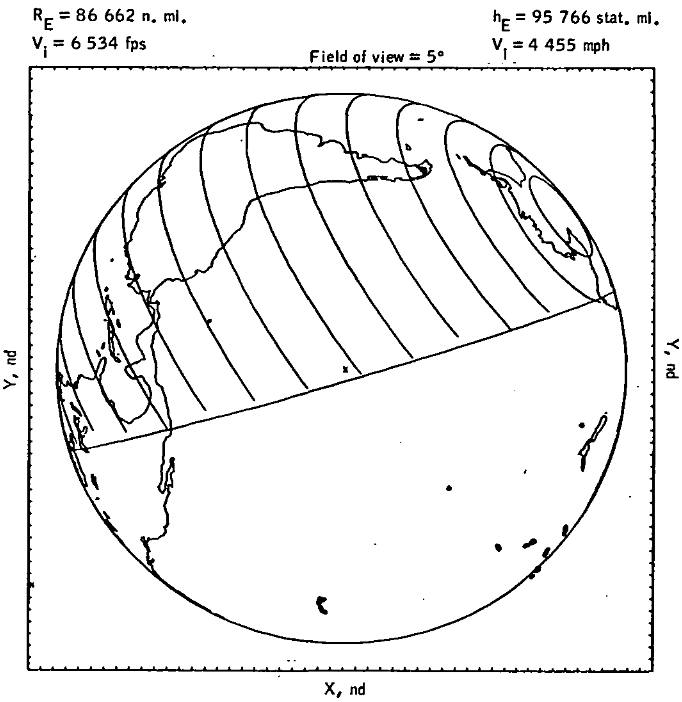


(qq) g.e.t. = 178 hours.

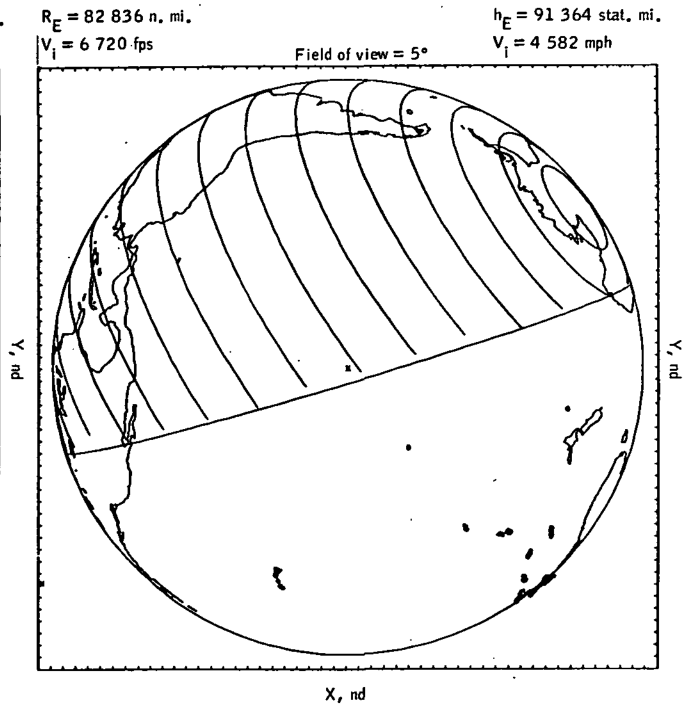


(rr) g.e.t. = 179 hours.

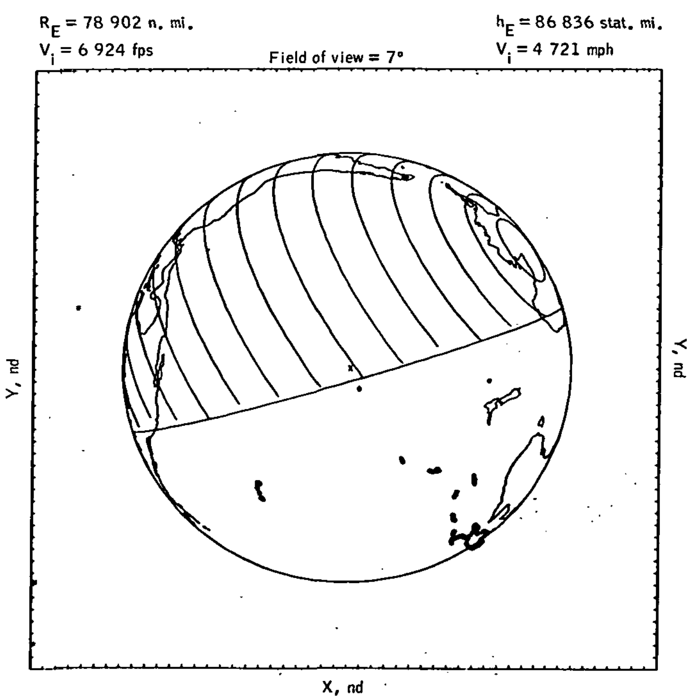
Figure 7.3.2-2.- Continued.



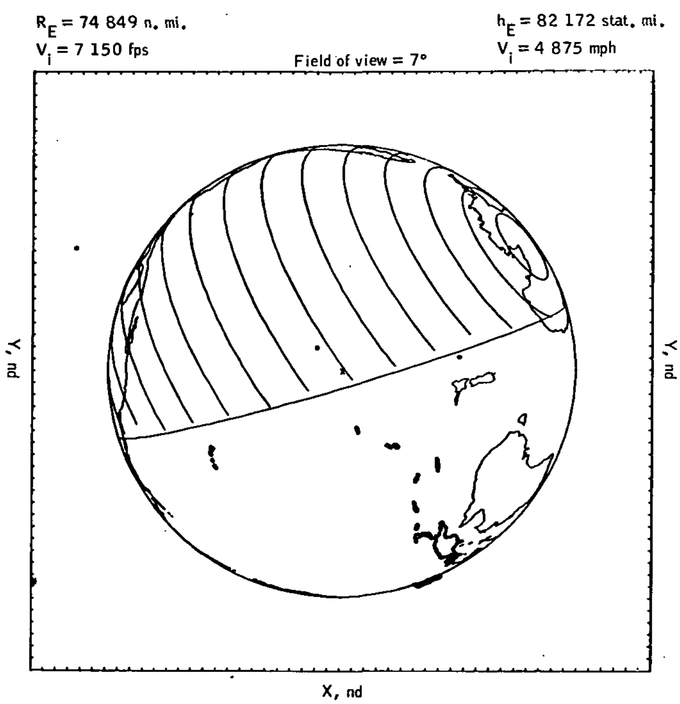
(ss) g.e.t. = 180 hours.



(tt) g.e.t. = 181 hours.



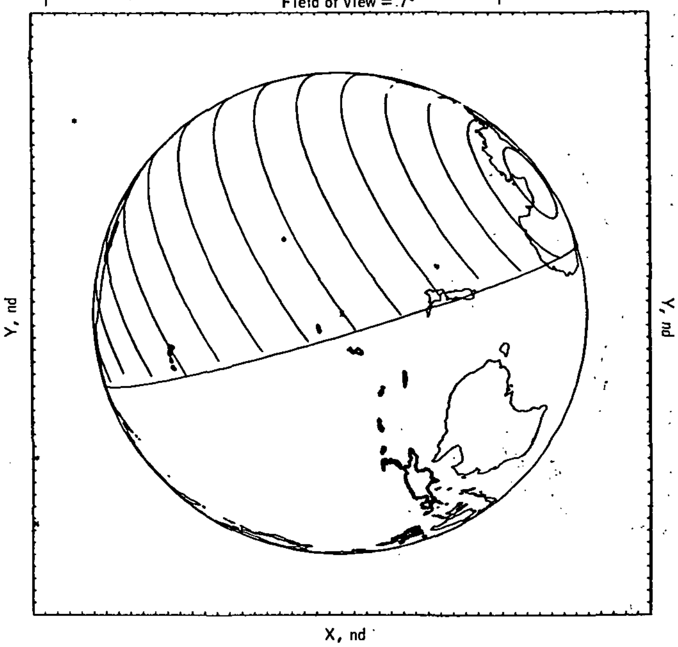
(uu) g.e.t. = 182 hours.



(vv) g.e.t. = 183 hours.

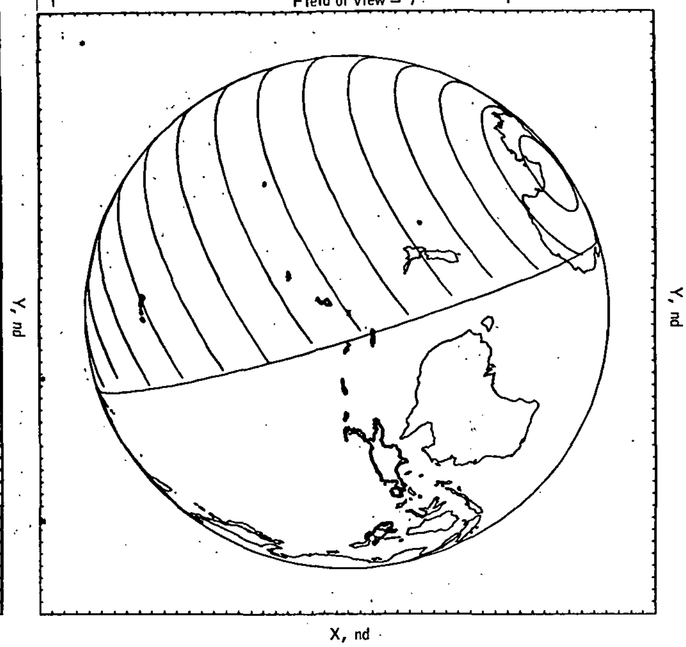
Figure 7.3.2-2.- Continued.

R_E = 70 664 n. mi.
V_i = 7 402 fps
Field of view = 7°
h_E = 77 356 stat. mi.
V_i = 5 047 mph



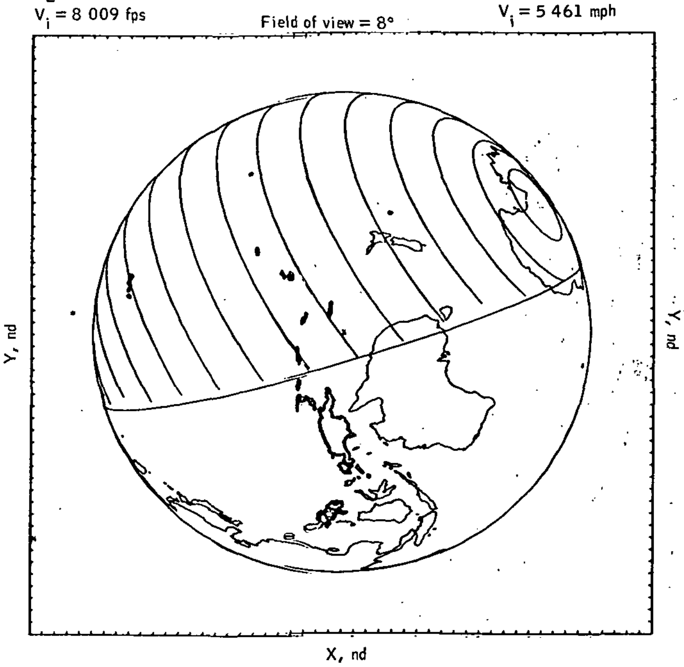
(ww) g.e.t. = 184 hours.

R_E = 66 331 n. mi.
V_i = 7 685 fps
Field of view = 7°
h_E = 72 371 stat. mi.
V_i = 5 240 mph



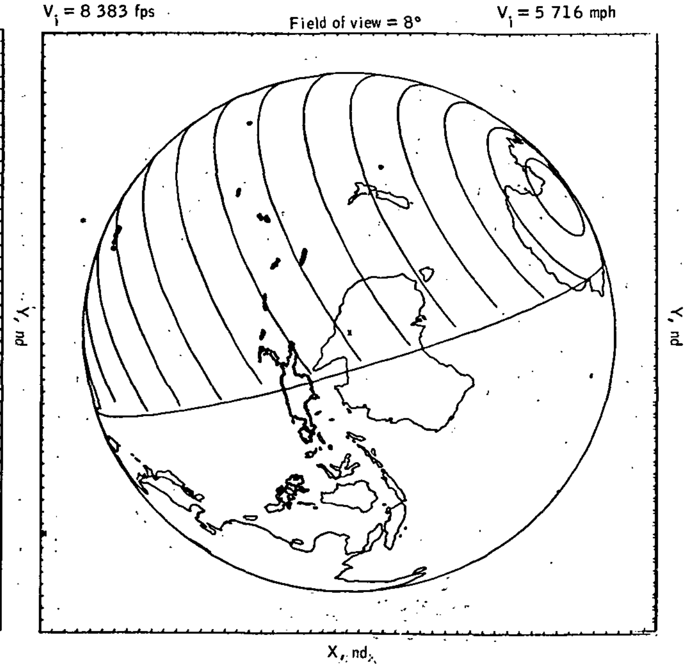
(xx) g.e.t. = 185 hours.

R_E = 61 833 n. mi.
V_i = 8 009 fps
Field of view = 8°
h_E = 67 195 stat. mi.
V_i = 5 461 mph



(yy) g.e.t. = 186 hours.

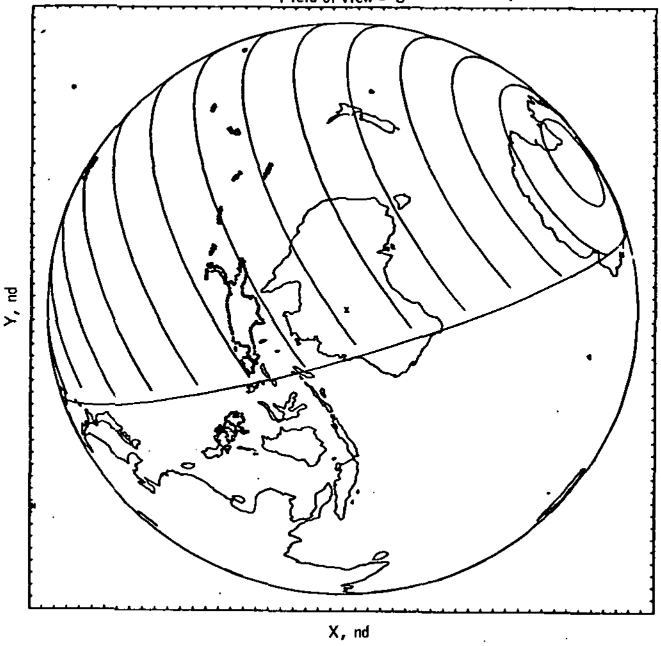
R_E = 57 146 n. mi.
V_i = 8 383 fps
Field of view = 8°
h_E = 61 800 stat. mi.
V_i = 5 716 mph



(zz) g.e.t. = 187 hours.

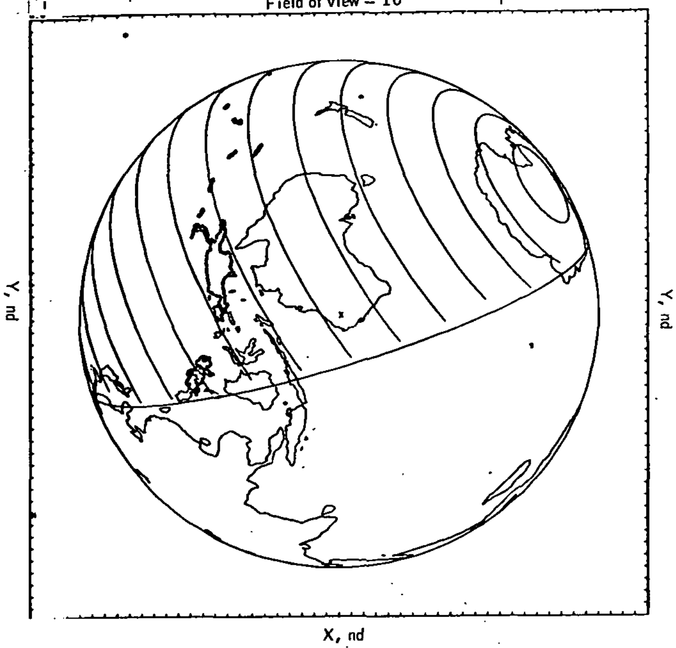
Figure 7.3.2-2.- Continued.

R_E = 52 238 n. mi.
V_i = 8 826 fps
Field of view = 8°
h_E = 56 153 stat. mi.
V_i = 6 018 mph



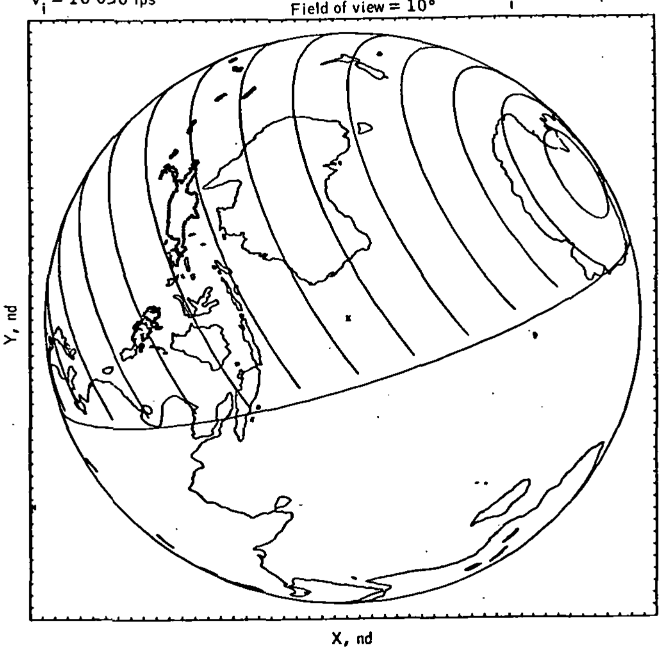
(aaa) g.e.t. = 188 hours.

R_E = 47 071 n. mi.
V_i = 9 361 fps
Field of view = 10°
h_E = 50 207 stat. mi.
V_i = 6 382 mph



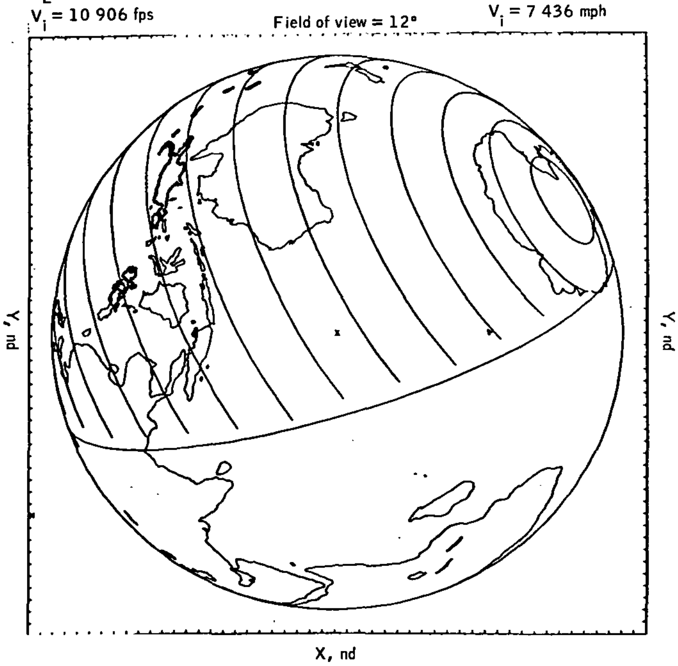
(bbb) g.e.t. = 189 hours.

R_E = 41 589 n. mi.
V_i = 10 030 fps
Field of view = 10°
h_E = 43 898 stat. mi.
V_i = 6 839 mph



(ccc) g.e.t. = 190 hours.

R_E = 35 103 n. mi.
V_i = 10 906 fps
Field of view = 12°
h_E = 37 133 stat. mi.
V_i = 7 436 mph



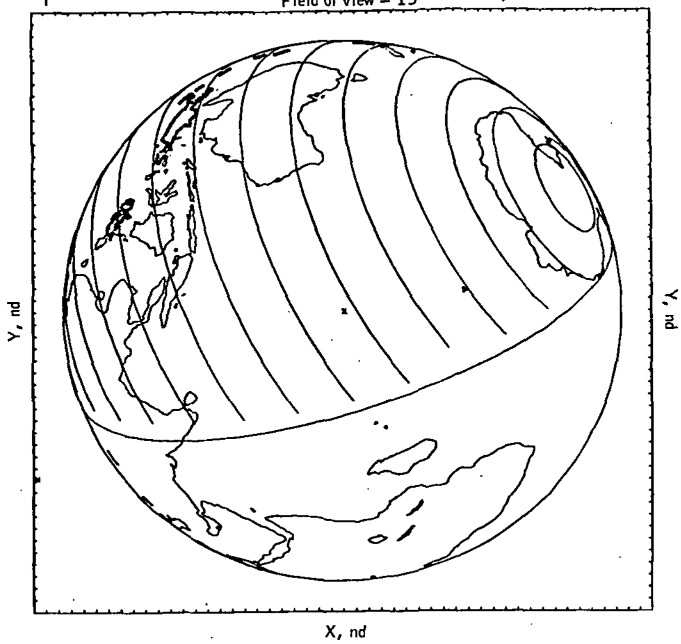
(ddd) g.e.t. = 191 hours.

Figure 7.3.2-2.- Continued.

R_E = 29 310 n. mi.
V_i = 12 135 fps

h_E = 29 769 stat. mi.
V_i = 8 274 mph

Field of view = 15°

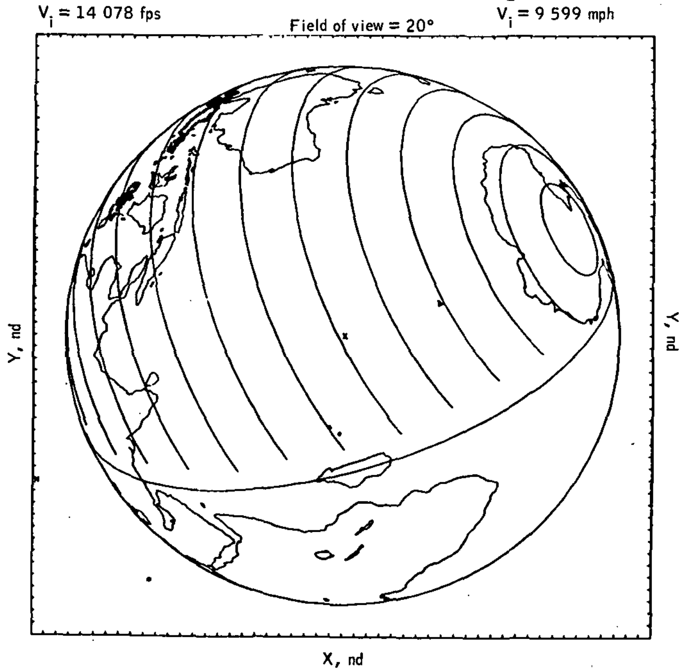


(eee) g.e.t. = 192 hours.

R_E = 22 169 n. mi.
V_i = 14 078 fps

h_E = 21 552 stat. mi.
V_i = 9 599 mph

Field of view = 20°

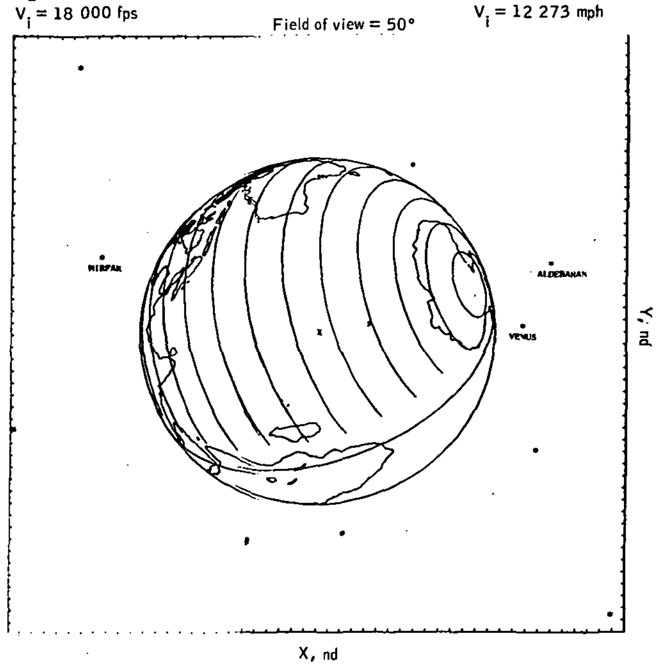


(fff) g.e.t. = 193 hours.

R_E = 13 839 n. mi.
V_i = 18 000 fps

h_E = 11 967 stat. mi.
V_i = 12 273 mph

Field of view = 50°



(ggg) g.e.t. = 194 hours.

Figure 7.3.2-2.- Concluded.

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8.0 VIEWS FROM CM DURING ENTRY PHASE

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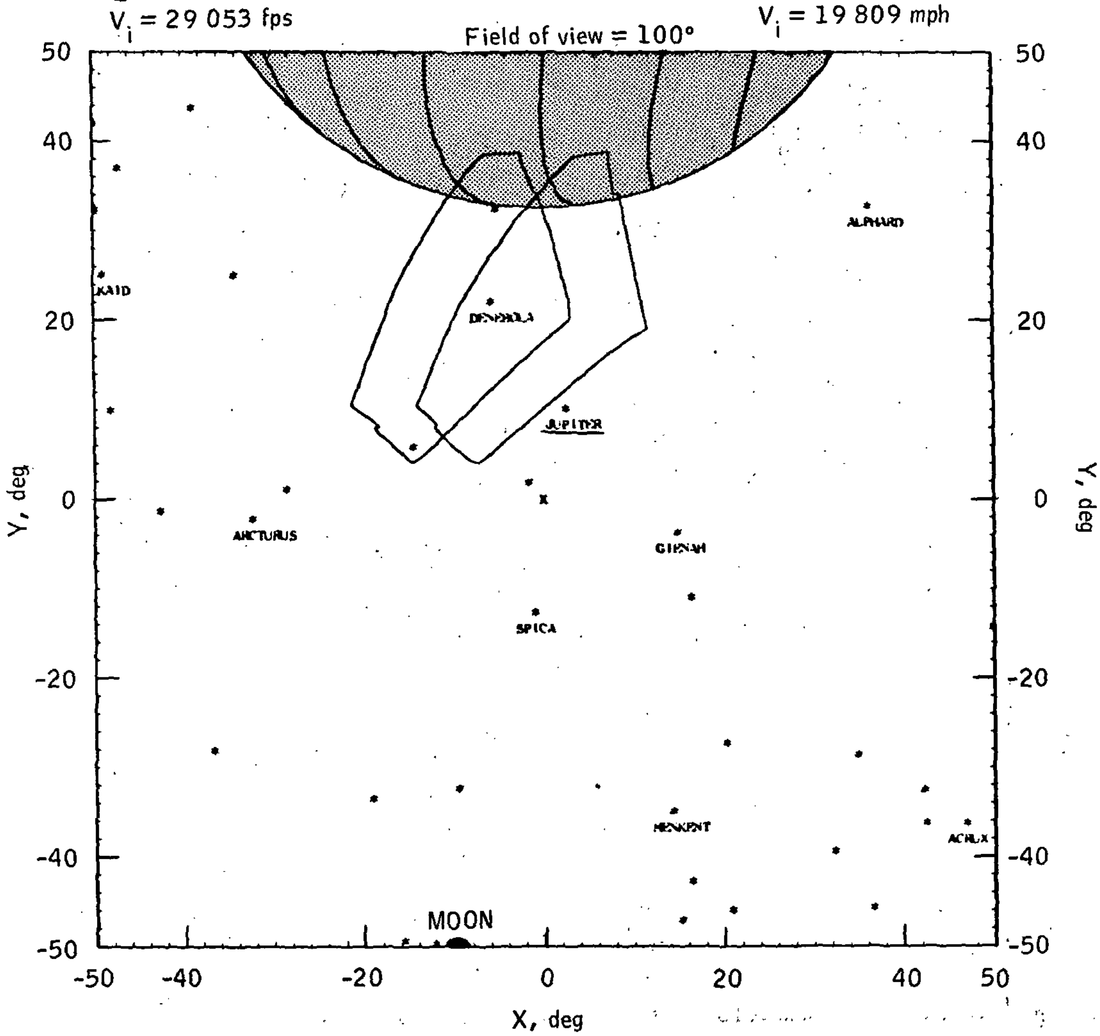
SEQ	17	19	20	21	22	23	24	25	43	46	58	59	60
X	18	-2	7	23	0	-24	7	-16	17	-18	21	21	-23
Y	16	11	-1	-18	-6	12	-17	-1	-14	-22	-16	-18	18

SEQ	76	83	84	106	107	108	110	111	112	113	114	115
X	-24	-19	-6	24	-2	8	0	-17	-7	10	16	-14
Y	16	21	-24	-7	16	-5	0	12	2	-13	-19	0

SEQ	116	117	118	119	120	121	122	124	126	3
X	-24	8	10	-21	-4	7	-9	-18	-7	1
Y	4	-21	-22	0	-16	-23	-16	-14	-24	5

R_E = 5404 n. mi.
V_i = 29 053 fps

h_E = 2260 stat. mi.
V_i = 19 809 mph



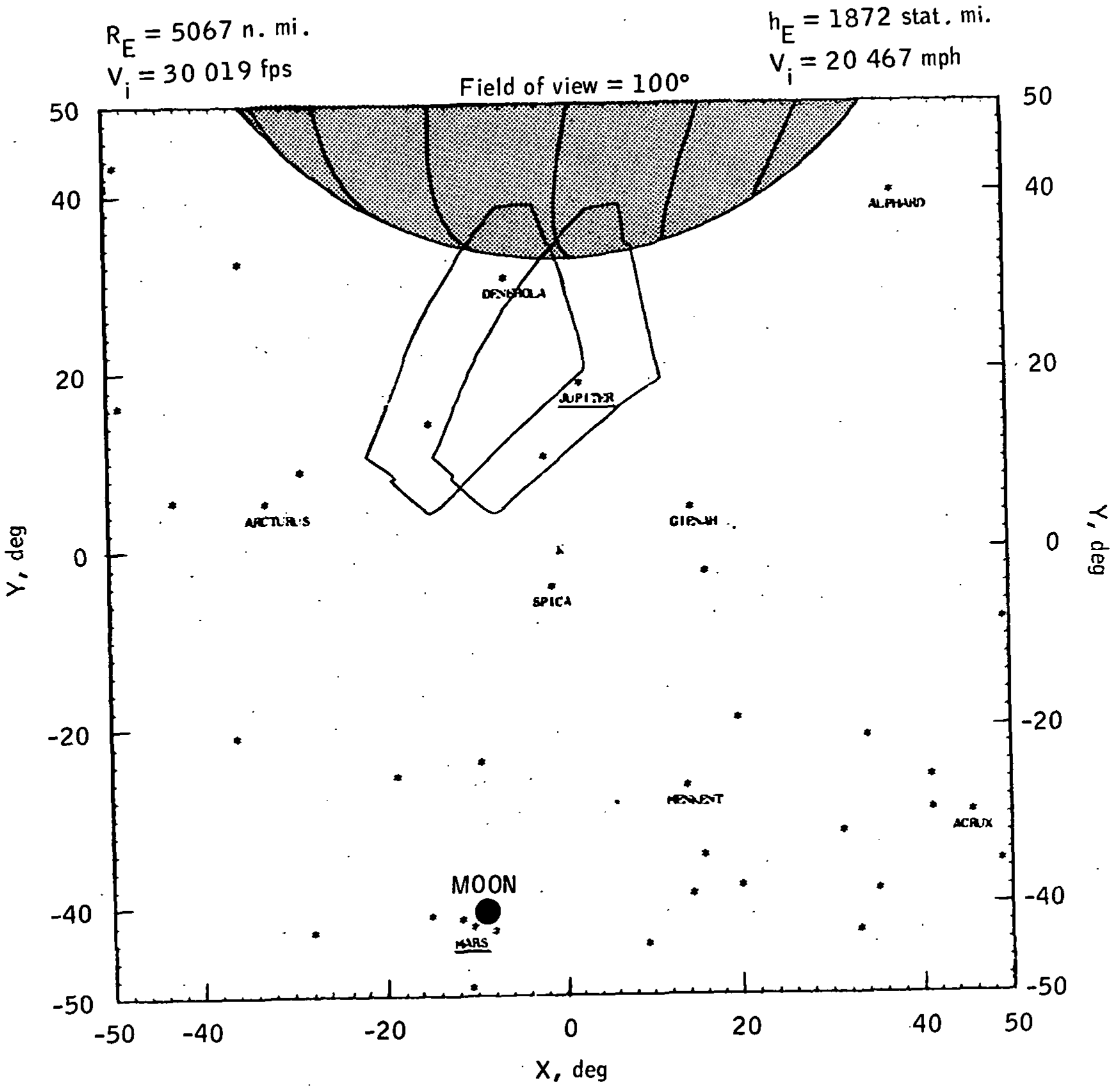
(a) 15 minutes prior to entry (g.e.t. = 194:46:12).

Figure 8.0-1.- Entry phase.

SEQ	17	19	20	21	22	24	25	27	43	44	46	58	59
X	18	-2	7	22	0	6	-16	-5	17	16	17	20	20
Y	19	15	2	-14	-2	-13	2	-24	-10	-21	-19	-12	-14

SEQ	60	84	106	108	109	110	111	112	113	114	115	116
X	-29	-5	24	8	24	0	-17	-7	9	15	-14	-24
Y	21	-20	-4	-1	-17	5	16	7	-9	-15	4	8

SEQ	117	118	119	120	121	122	123	124	125	126	130	2	3
X	7	-10	-21	-4	7	-9	4	-17	-3	-7	-13	-5	1
Y	-17	-18	2	-11	-19	-12	-22	-10	-21	-20	-21	-21	9



(b) 13 minutes prior to entry (g.e.t. = 194:48:12).

Figure 8.0-1.- Continued.

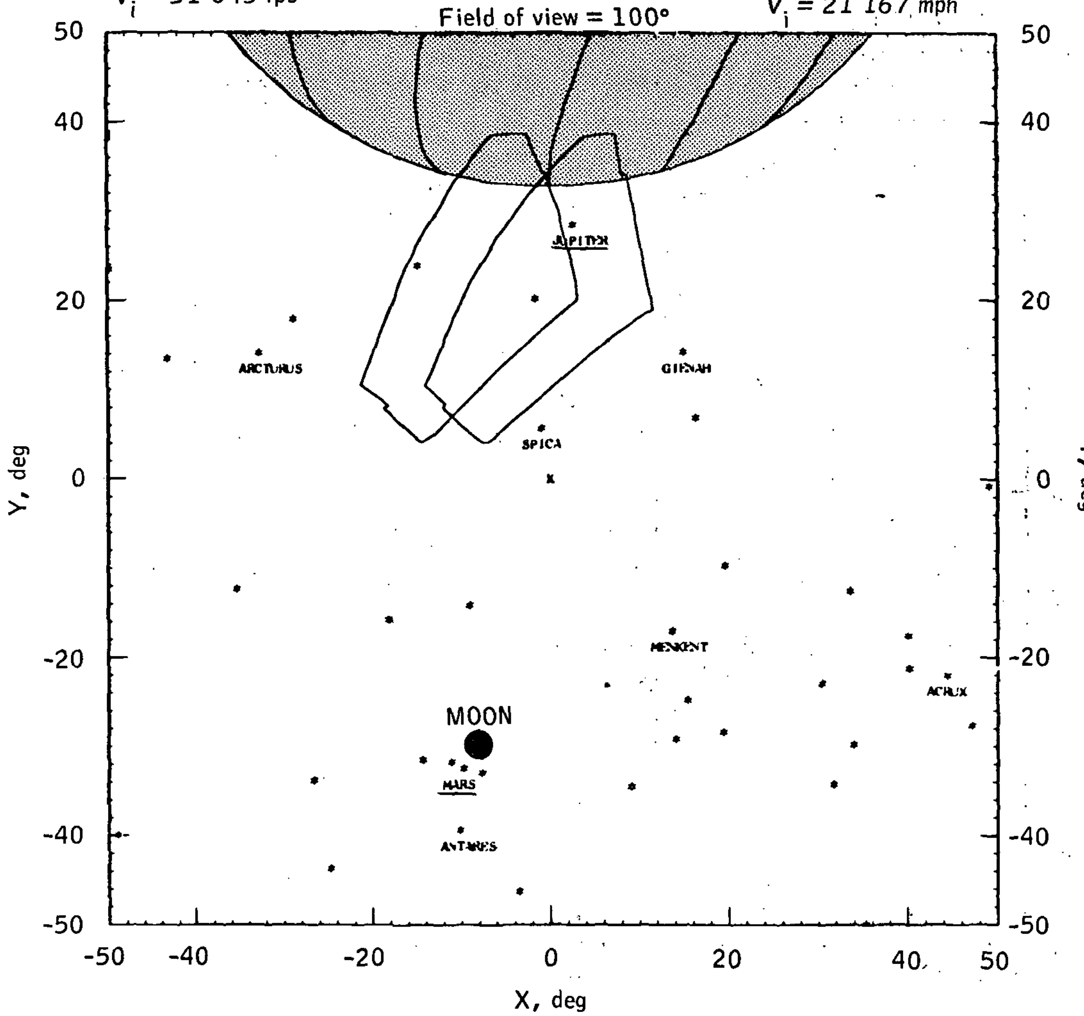
SEQ	20	21	22	24	25	27	28	43	44	46	58	59	84
X	7	22	0	6	-16	-5	17	16	15	16	20	20	-5
Y	7	-11	2	-8	7	-19	-24	-6	-17	-14	-8	-10	-15

SEQ	85	106	108	109	110	112	113	114	115	116	117	118	119
X	-1	24	8	23	0	-7	9	15	-14	-24	7	9	-21
Y	-23	0	3	-13	10	11	-4	-11	8	11	-12	-14	6

SEQ	120	121	122	123	124	125	126	129	130	132	137	2	3
X	-4	7	-9	4	-17	-3	-7	-4	-13	-12	-24	-4	1
Y	-7	-14	-7	-17	-6	-16	-15	-20	-16	-21	-19	-16	14

R_E = 4742 n. mi.
V_i = 31 045 fps

h_E = 1497 stat. mi.
V_i = 21 167 mph



(c) 11 minutes prior to entry (g.e.t. = 194:50:12).

Figure 8.0-1.- Continued.

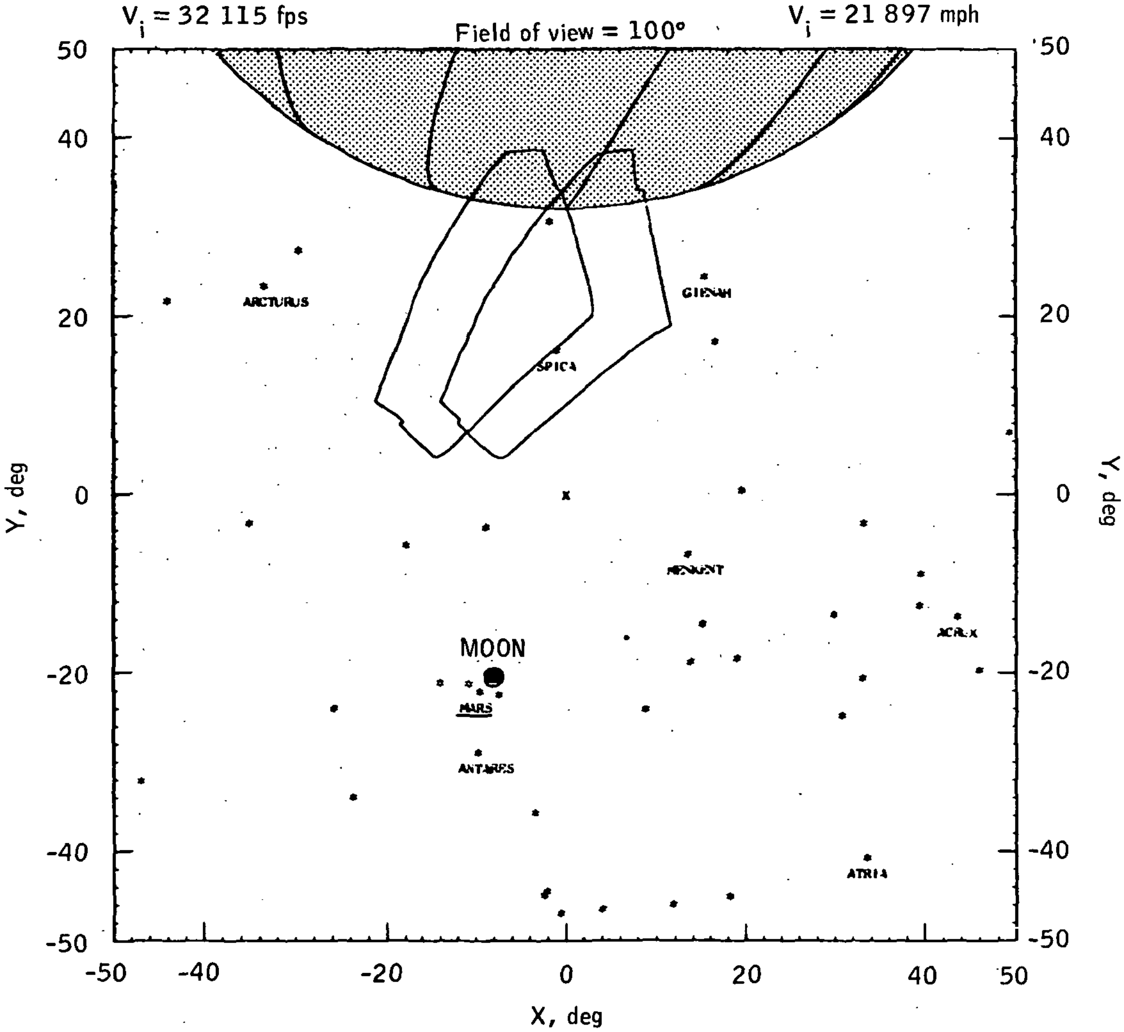
SEQ	20	21	22	24	25	27	28	43	44	46	58	59	61	62
X	7	21	0	6	-16	-4	16	16	15	16	19	19	-1	2
Y	12	-6	8	-3	11	-14	-20	-1	-12	-10	-4	-6	-22	-23

SEQ	84	85	87	106	108	109	110	113	114	115	117	118	119	120
X	-5	-1	0	24	8	22	0	9	14	-14	7	9	-21	-4
Y	-10	-17	-23	3	8	-9	15	0	-6	13	-7	-9	10	-1

SEQ	121	122	123	124	125	126	129	130	132	133	134	135	137	2
X	6	-8	4	-17	-3	-7	-4	-12	-11	9	-1	5	-23	-4
Y	-9	-2	-12	-1	-11	-10	-15	-12	-16	-22	-22	-22	-16	-11

R_E = 4436 n. mi. h_E = 1145 stat. mi.

V_i = 32 115 fps V_i = 21 897 mph



(d) 9 minutes prior to entry (g.e.t. = 194:52:12).

Figure 8.0-1.- Continued.

SEQ	21	22	24	25	27	28	31	43	44	46	58	59
X	21	0	6	-17	-4	15	-7	16	14	16	19	19
Y	-1	14	3	17	-8	-14	-24	4	-6	-4	0	0

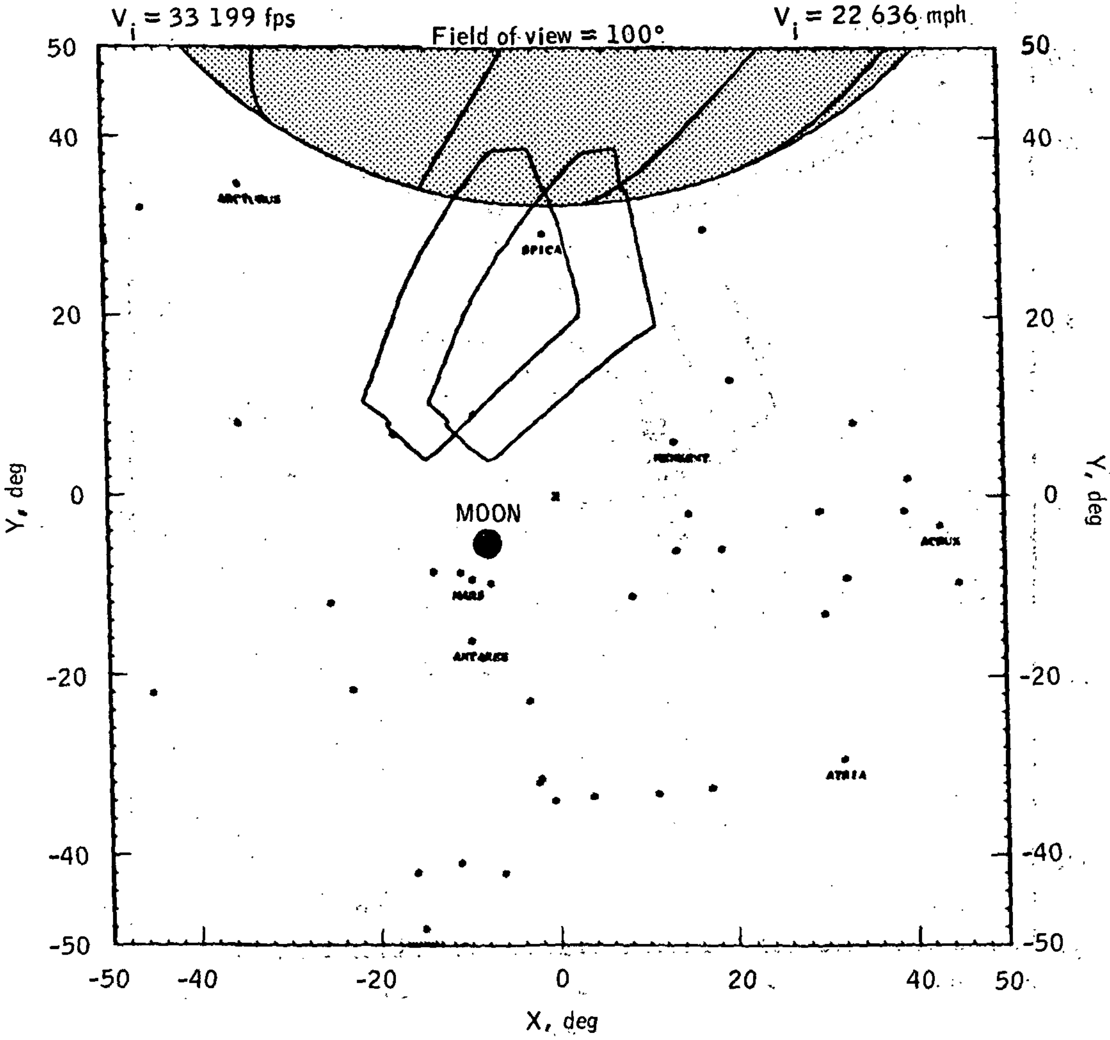
SEQ	61	62	63	84	85	87	108	109	113	114	117	118
X	-1	1	-3	-5	-1	0	8	22	9	14	7	9
Y	-15	-16	-20	-4	-11	-16	14	-4	6	0	0	-2

SEQ	119	120	121	122	123	124	125	126	129	130	132	133
X	-22	-4	6	-8	4	-17	-3	-6	-4	-12	-11	6
Y	16	4	-3	3	-5	4	-4	-4	-9	-5	-10	-16

SEQ	134	135	137	138	139	140	2
X	0	5	-22	-5	-7	-6	-4
Y	-15	-16	-11	-20	-20	-24	-4

R_M = 4154 n. mi. h_E = 821 stat. mi.

V_i = 33 199 fps V_i = 22 636 mph



(e) 7 minutes prior to entry (g.e.t. = 194:54:12).

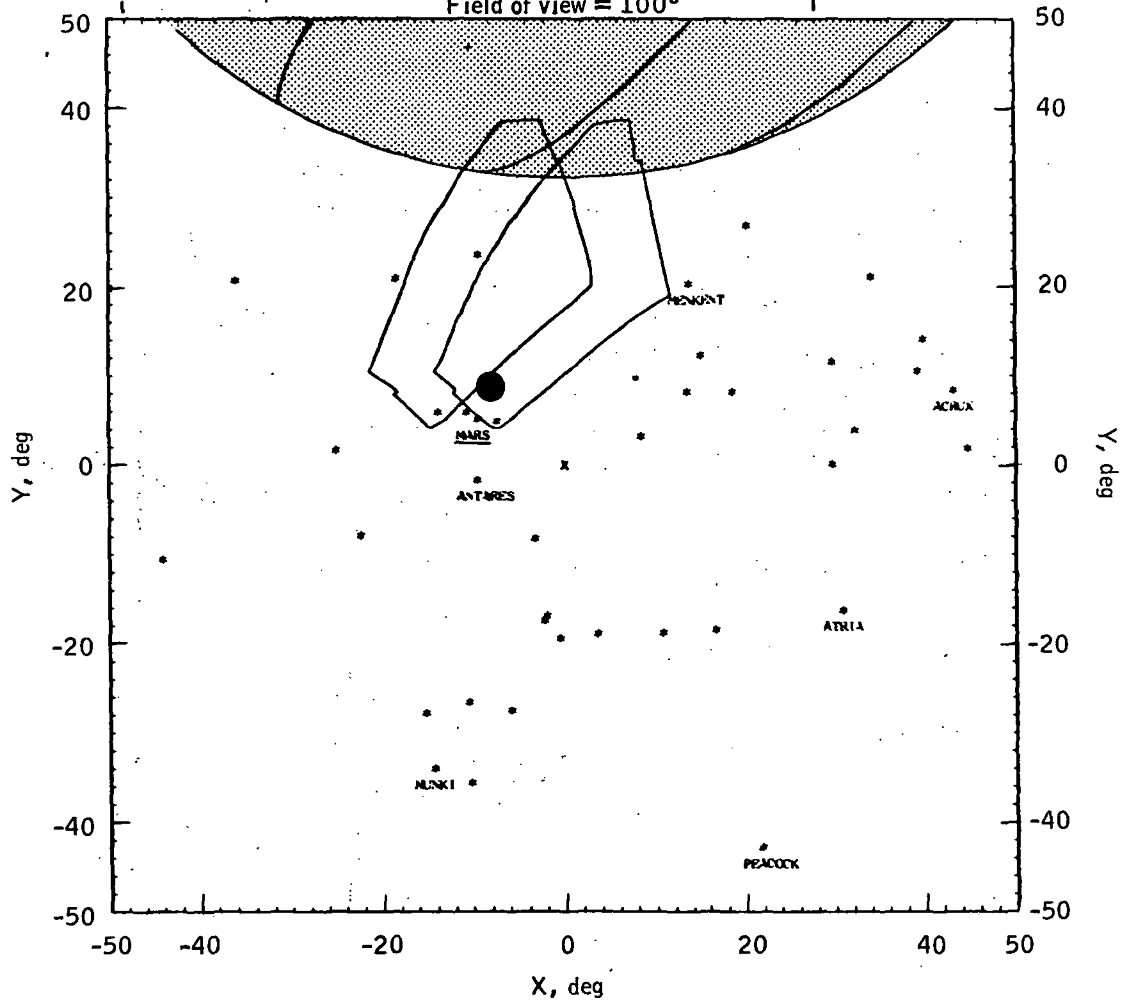
Figure 8.0-1.- Continued.

21	24	27	28	31	34	43	44	46	58	59	61
21	6	-4	15	-7	10	17	14	16	19	19	-1
4	10	0	-8	-17	-21	10	0	1	7	5	-8
62	63	84	85	87	109	113	114	117	118	120	121
1	-2	-5	-1	0	22	10	14	7	9	-4	6
-9	-13	2	-4	-9	0	13	5	6	4	11	4
122	123	124	125	126	129	130	132	133	134	135	137
-9	4	-17	-3	-6	-4	-12	-11	8	0	5	-22
10	1	10	2	2	-1	0	-3	-9	-8	-9	-5
138	139	140	2								
-5	-7	-5	-4								
-13	-13	-17	2								

R_E = 3907 n. mi. h_E = 535 stat. mi.

V_i = 34 246 fps V_i = 23 350 mph

Field of view = 100°



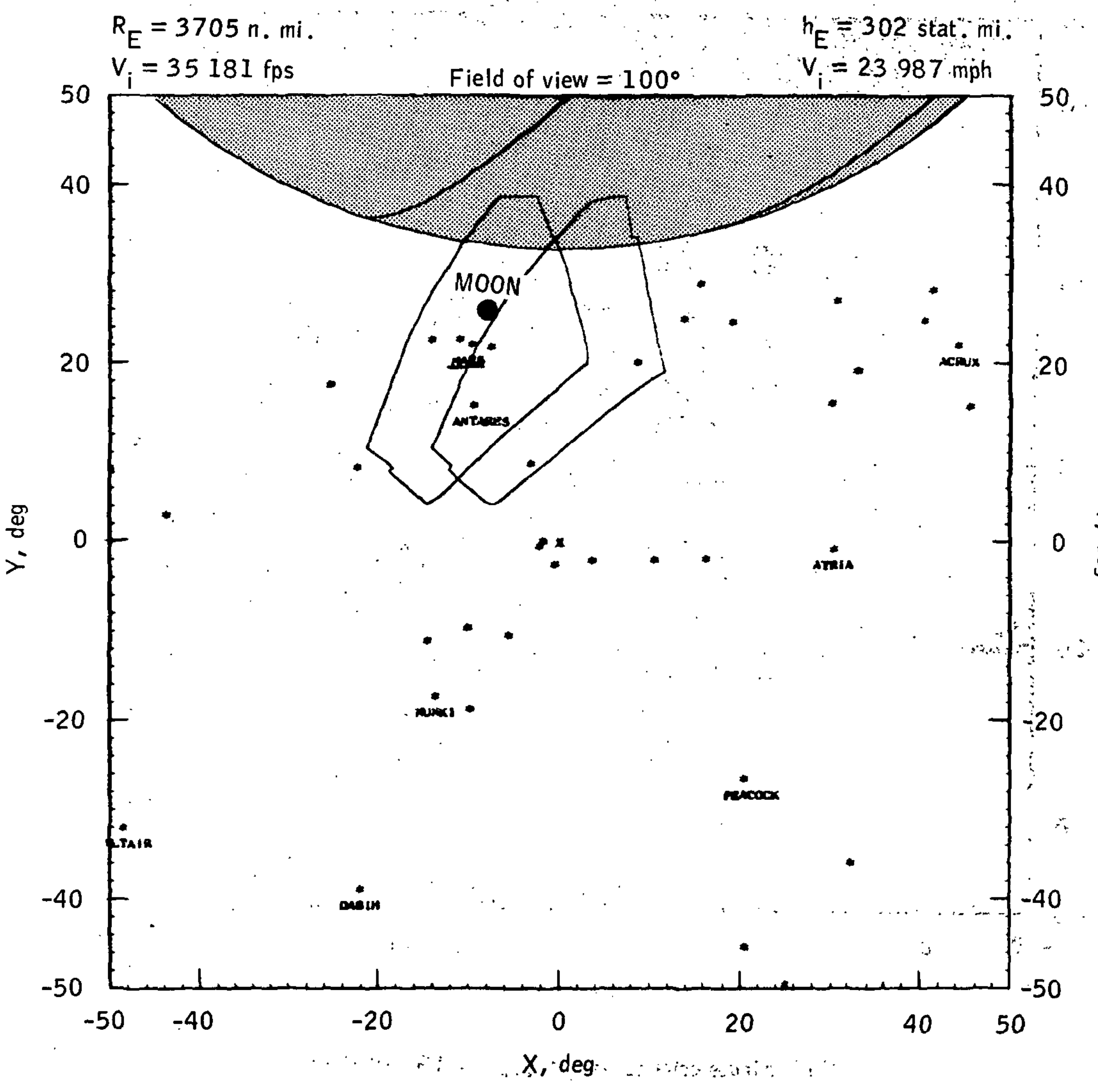
(f) 5 minutes prior to entry (g.e.t. = 194:56:12).

Figure 8.0-1.- Continued.

SEQ	21	27	28	31	32	33	34	44	46	58	59	61	62
X	22	-4	15	-6	-24	-11	10	15	16	20	20	-1	1
Y	10	7	0	-8	-16	-19	-13	7	9	14	12	0	-1

SEQ	63	80	81	84	85	87	109	114	117	118	121	123	125
X	-2	10	12	-5	-1	0	22	15	7	9	6	4	-3
Y	-5	-22	-24	11	4	-1	7	13	14	12	12	10	10

SEQ	126	129	130	132	133	134	135	137	138	139	140	146	2
X	-7	-4	-12	-11	8	0	5	-21	-5	-7	-4	16	-4
Y	11	6	8	4	0	0	-1	1	-4	-5	-9	-17	10



(g) 3 minutes prior to entry (g.e.t. = 194:58:12).

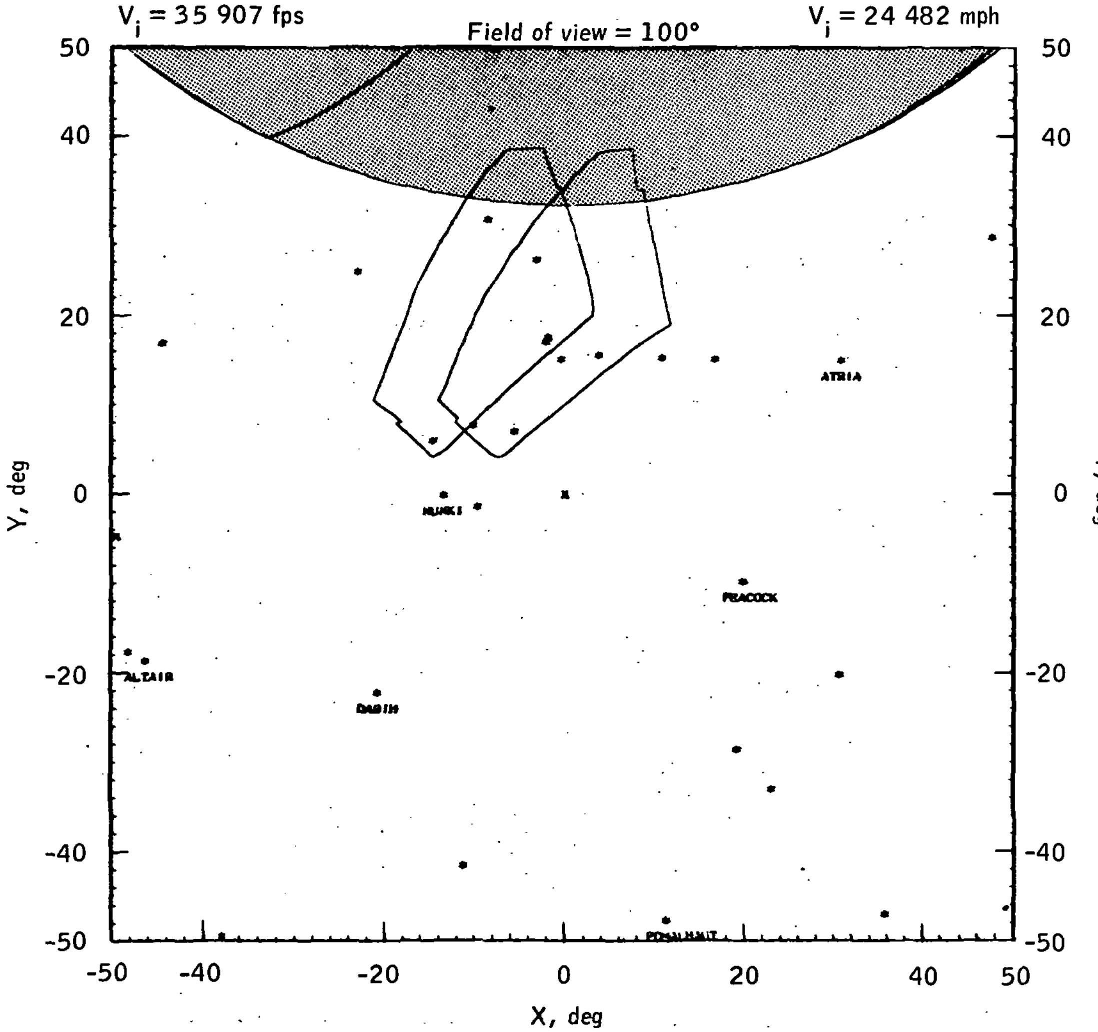
Figure 8.0-1.- Continued.

SEQ	28	31	32	33	34	36	37	61	62	63	65	80	81	85
X	15	-6	-23	-10	9	-18	5	-1	1	-2	17	9	11	-1
Y	7	0	-9	-11	-4	-24	-23	8	7	3	-23	-14	-16	13

SEQ	87	109	129	132	133	134	135	137	138	139	140	142	145	146
X	0	23	-4	-11	8	0	5	-22	-5	-7	-4	-24	-5	15
Y	7	14	15	12	7	8	7	8	3	2	0	-8	-20	-10

R_E = 3558 n. mi. h_E = 132 stat. mi.

V_i = 35 907 fps V_i = 24 482 mph



(h) 1 minute prior to entry (g.e.t. = 195:00:12).

Figure 8.0-1.- Continued.

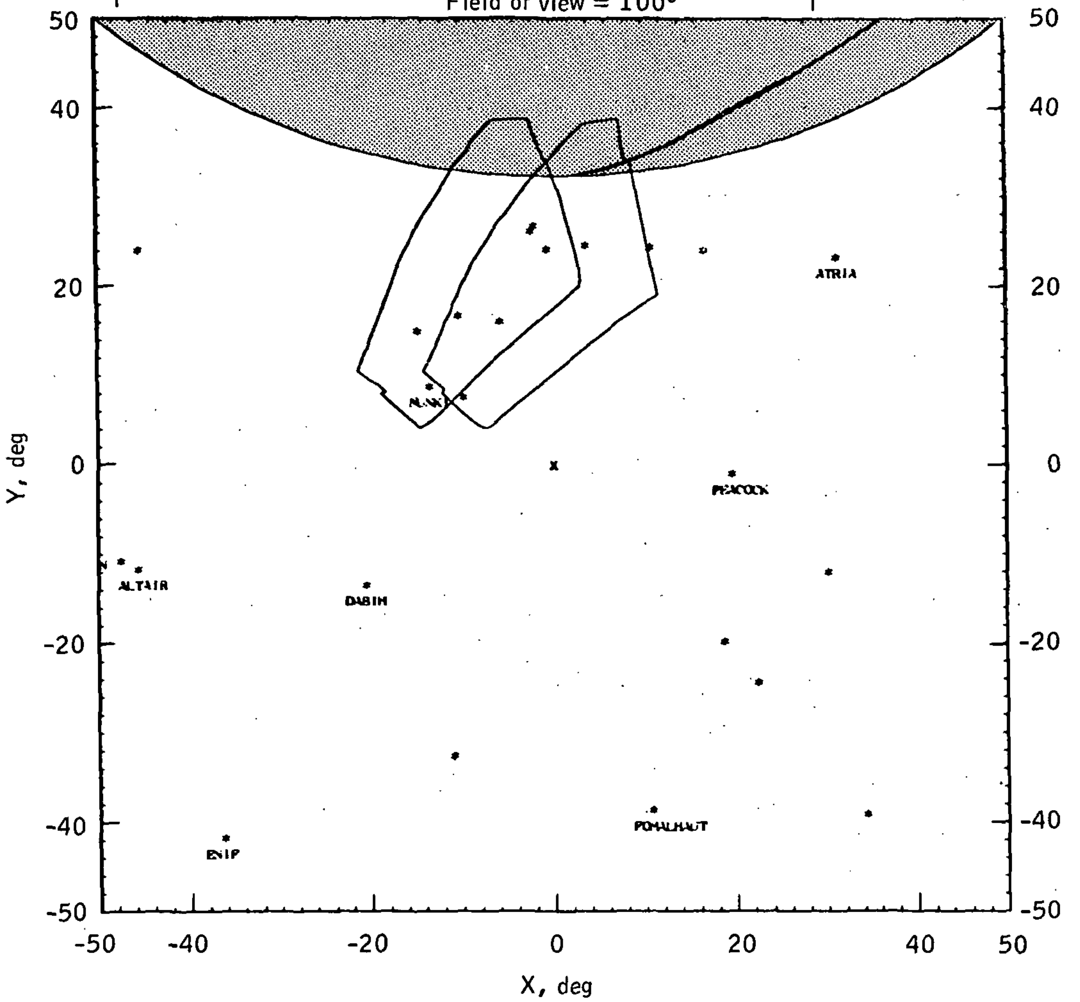
SEQ	28	31	32	33	34	36	37	61	62	63	65	80
X	15	-6	-22	-10	9	-18	5	-1	1	-2	17	9
Y	11	4	-5	-6	0	-20	-19	13	12	7	-19	-9

SEQ	81	87	133	134	135	137	138	139	140	142	145	146
X	11	0	8	0	5	-22	-5	-7	-4	-23	-5	15
Y	-12	12	11	13	12	11	8	7	3	-5	-16	-6

R_E = 3509 n. mi.
V_i = 36 160 fps

h_E = 76 stat. mi.
V_i = 24 655 mph

Field of view = 100°



(i) Entry interface (g.e.t. = 195:01:12).

Figure 8.0-1.- Concluded.

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9.0 VIEWS THROUGH SCANNING TELESCOPE

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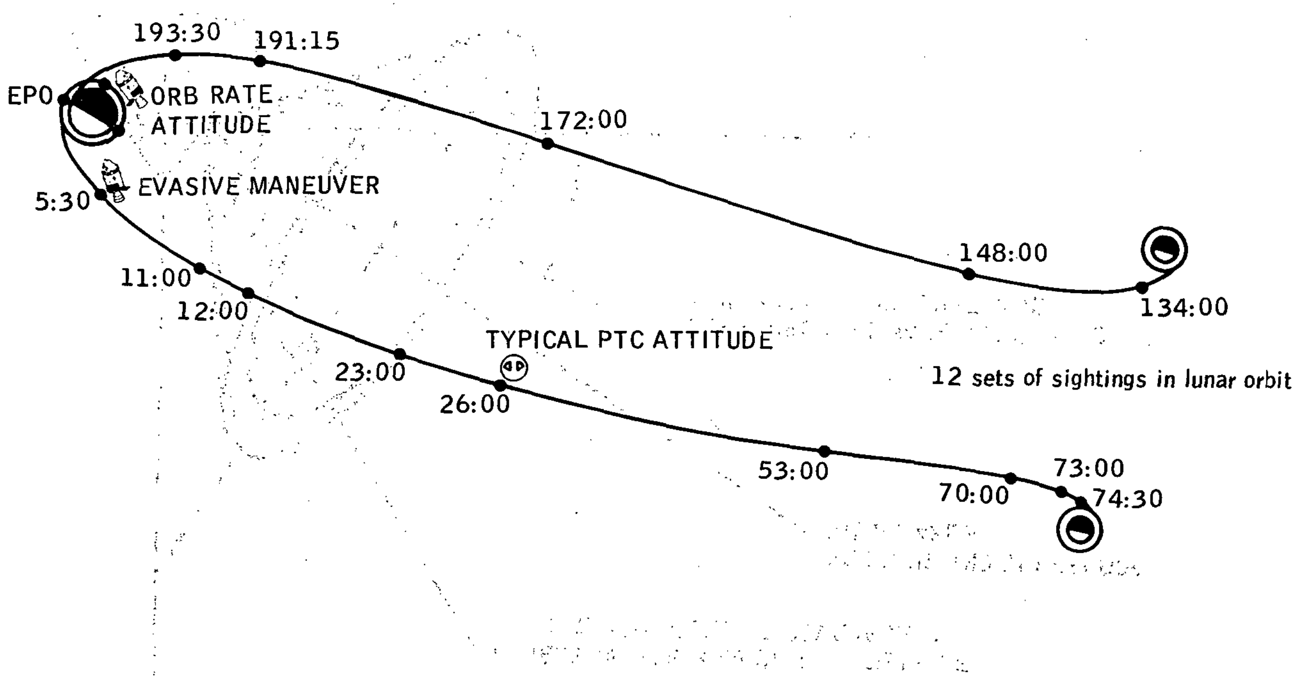

Figure 9.0-1.- Approximate location of scanning telescope sightings.

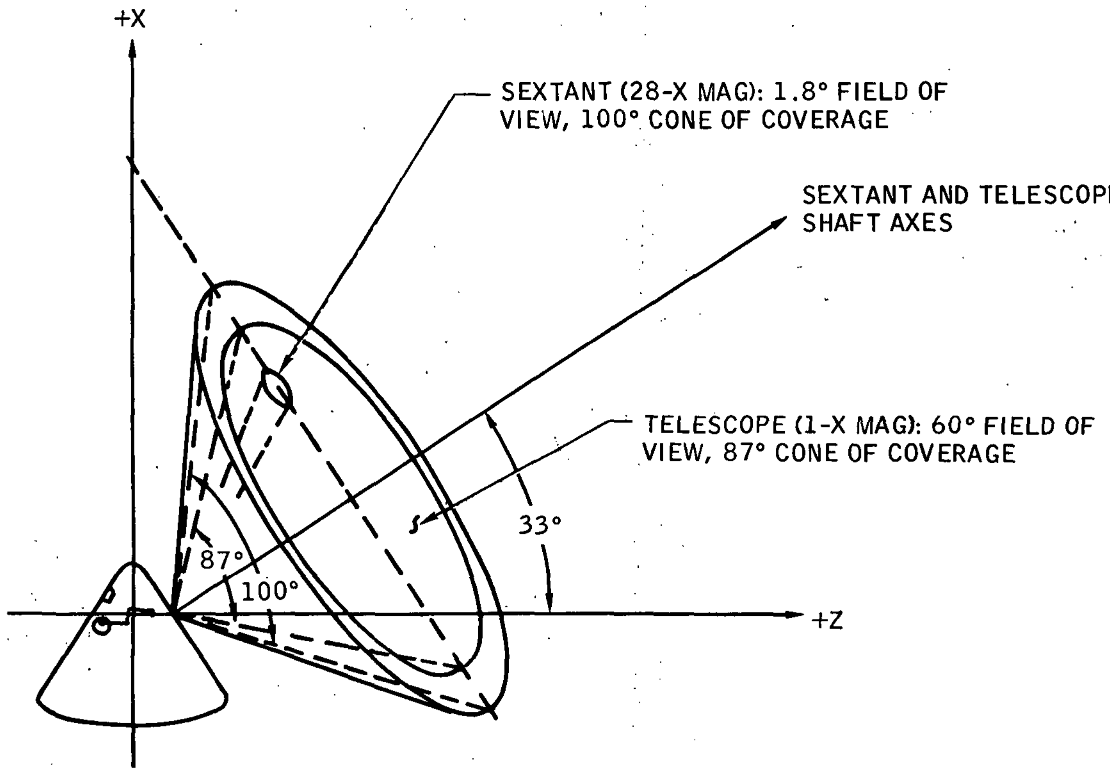

Figure 9.0-2.- General CM optics field of coverage.

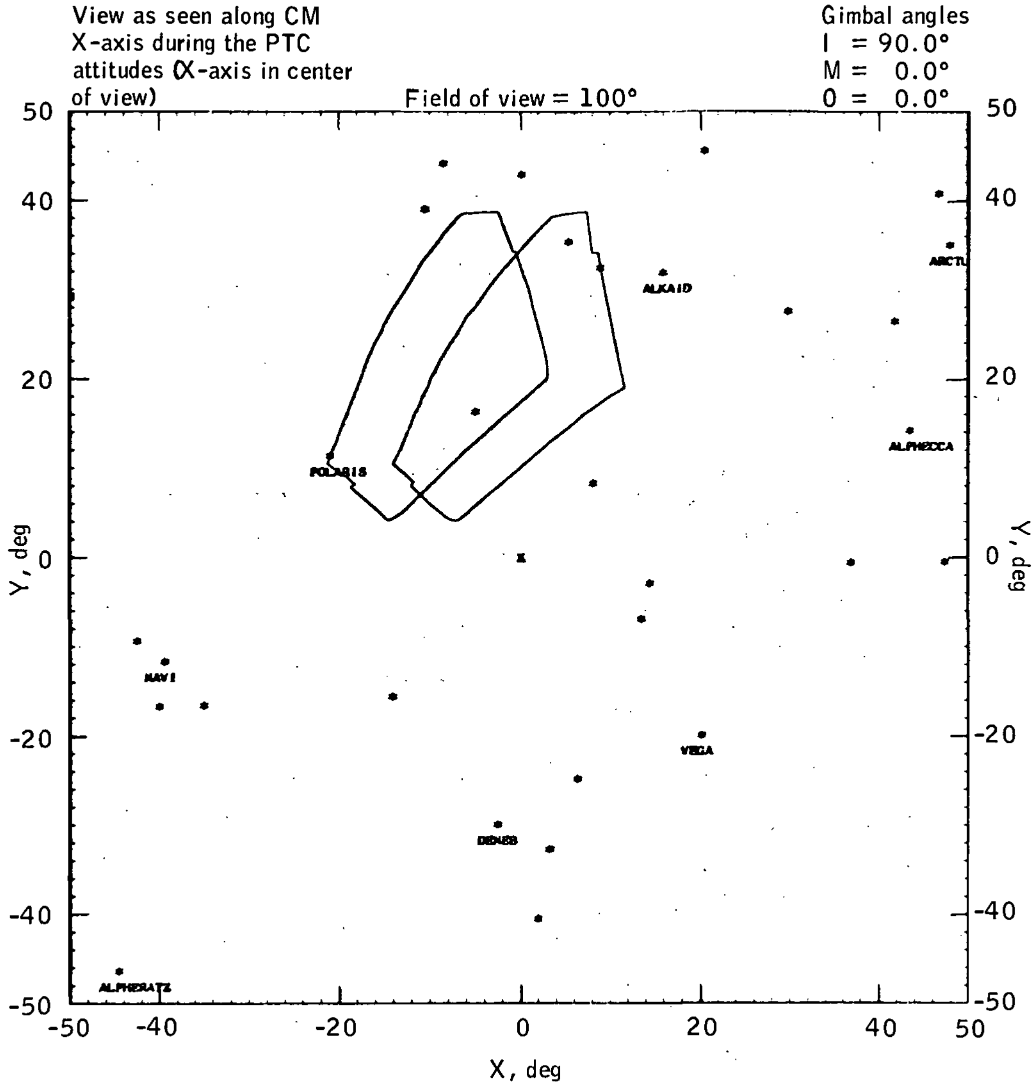

Figure 9.0-3.- PTC mode.

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9.1 EARTH PARKING ORBIT PHASE

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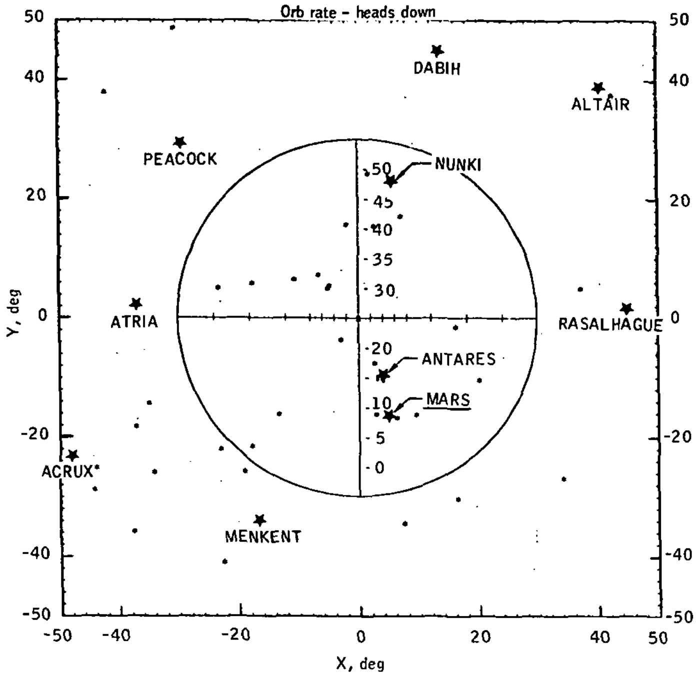
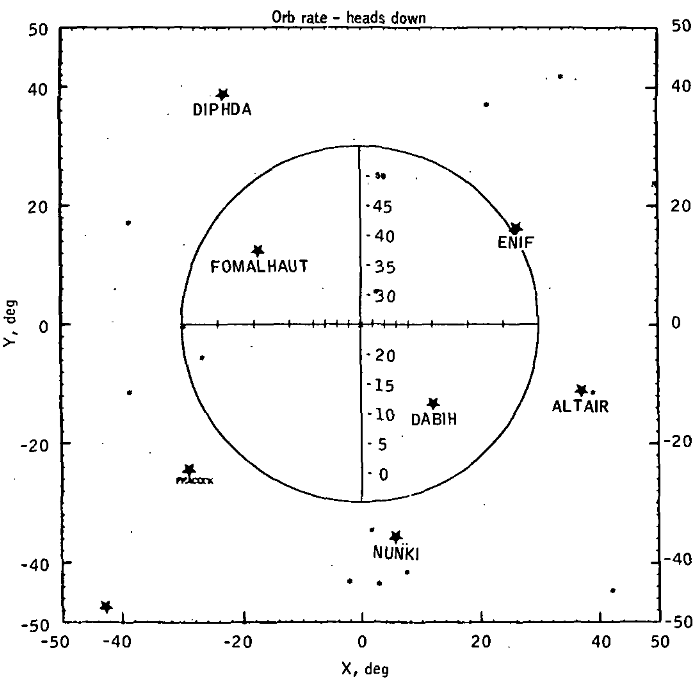
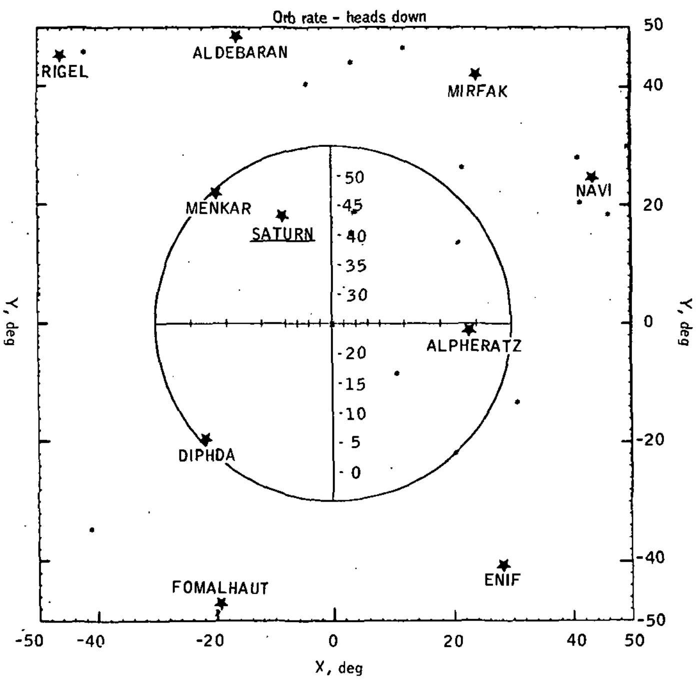


(a) g.e.t. = 00:45:00.



(b) g.e.t. = 01:00:00.



(c) g.e.t. = 01:15:00.

Figure 9.1-1.- Scanning telescope - earth parking orbit - rev 1.

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9.2 TRANSLUNAR COAST PHASE

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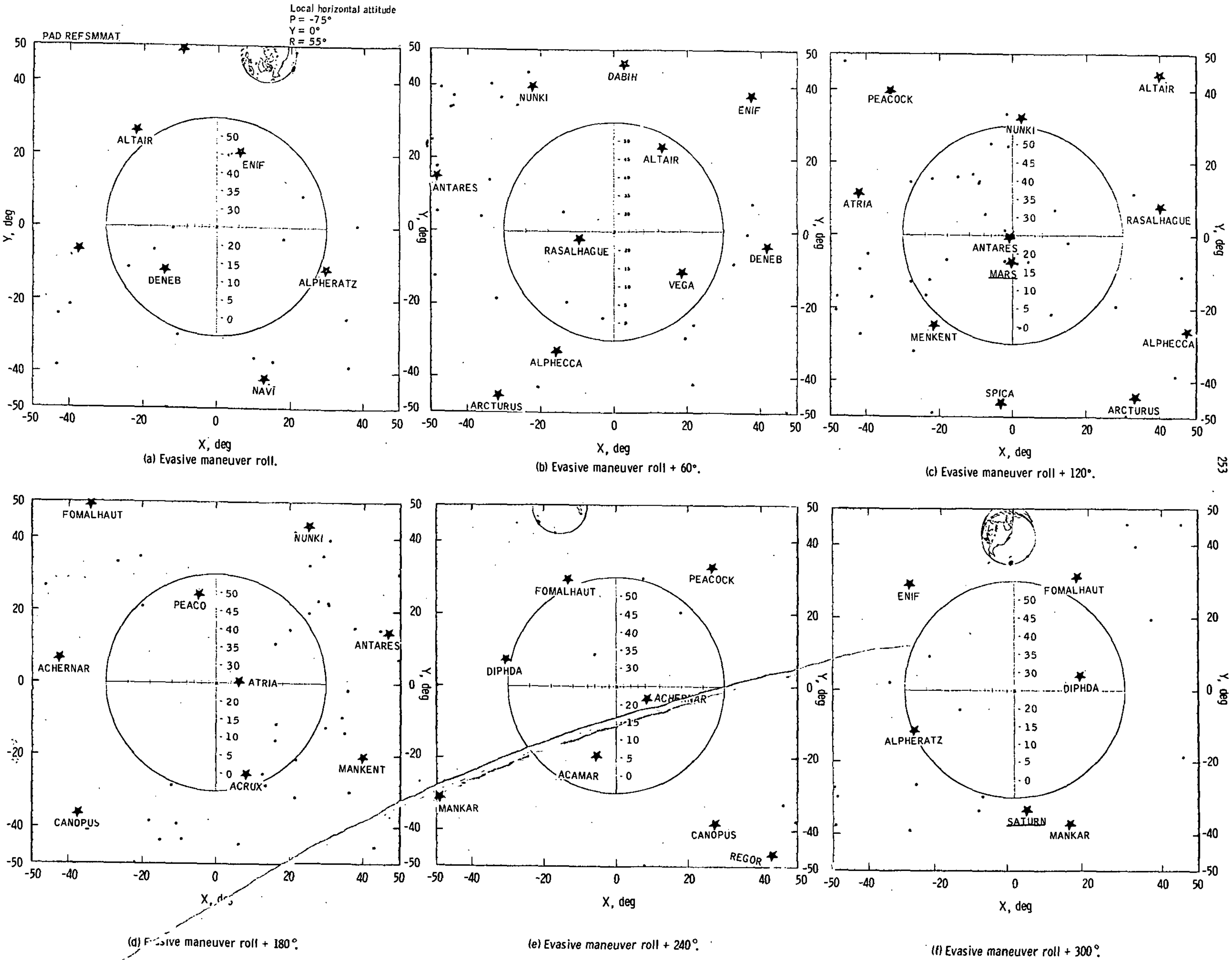


Figure 9.2-1.- Scanning telescope - evasive maneuver attitude - (g.e.t. = 05:30:00).

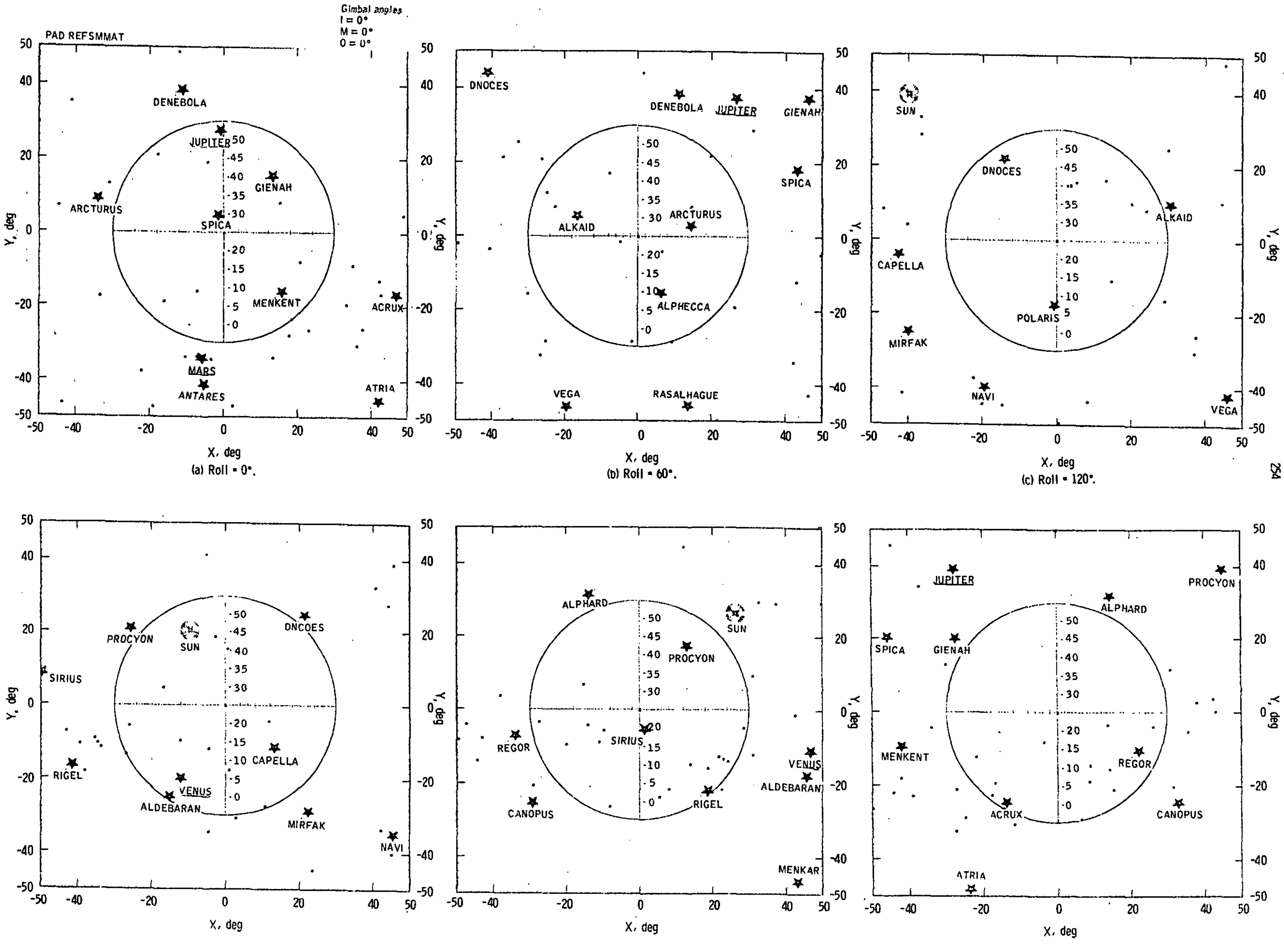


Figure 9.2-2. - Scanning telescope - translunar coast - (g.e.t. = 11:00:00).

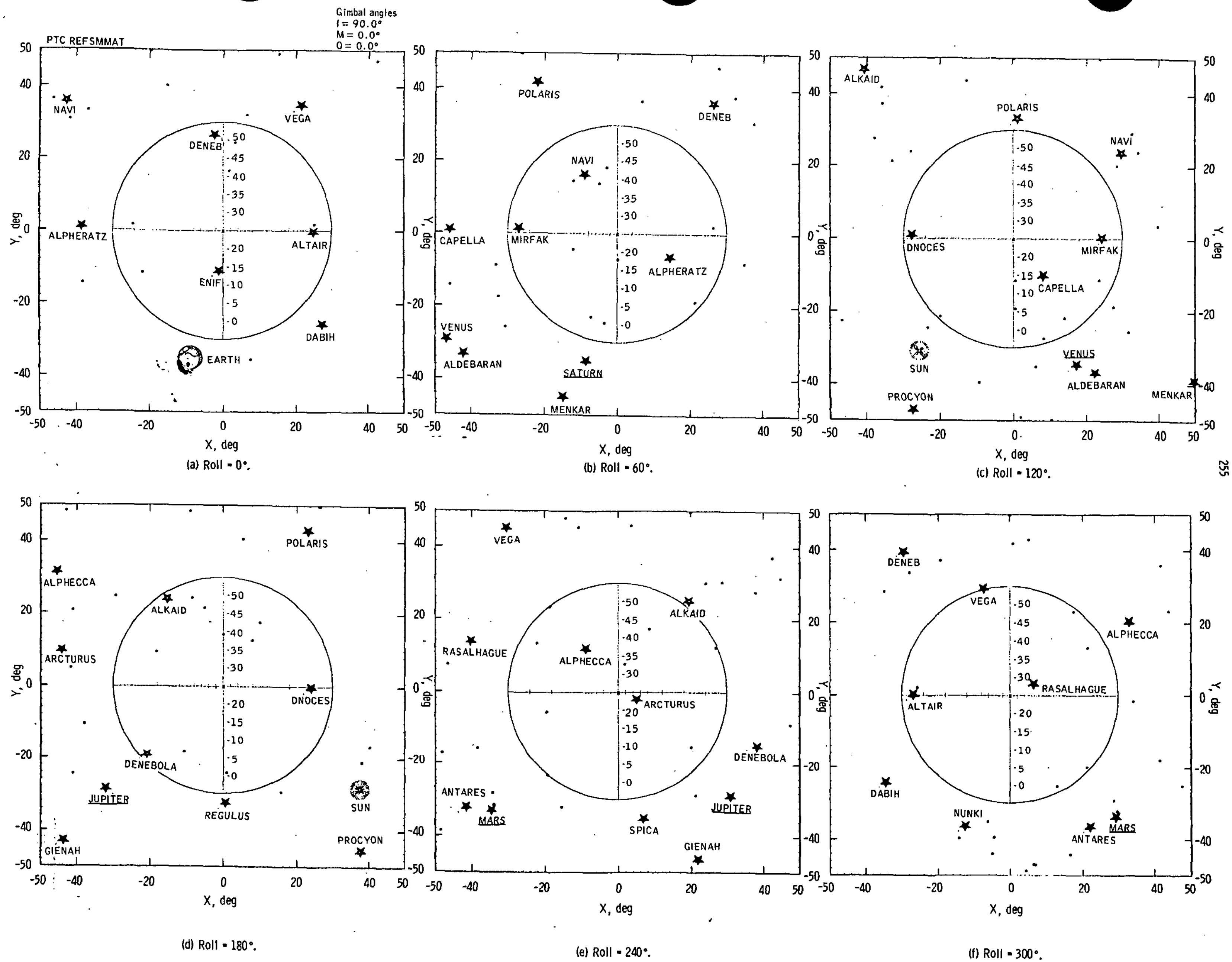


Figure 9.2-3. - Scanning telescope - PTC attitude - (g.e.t. = 12:00:00).

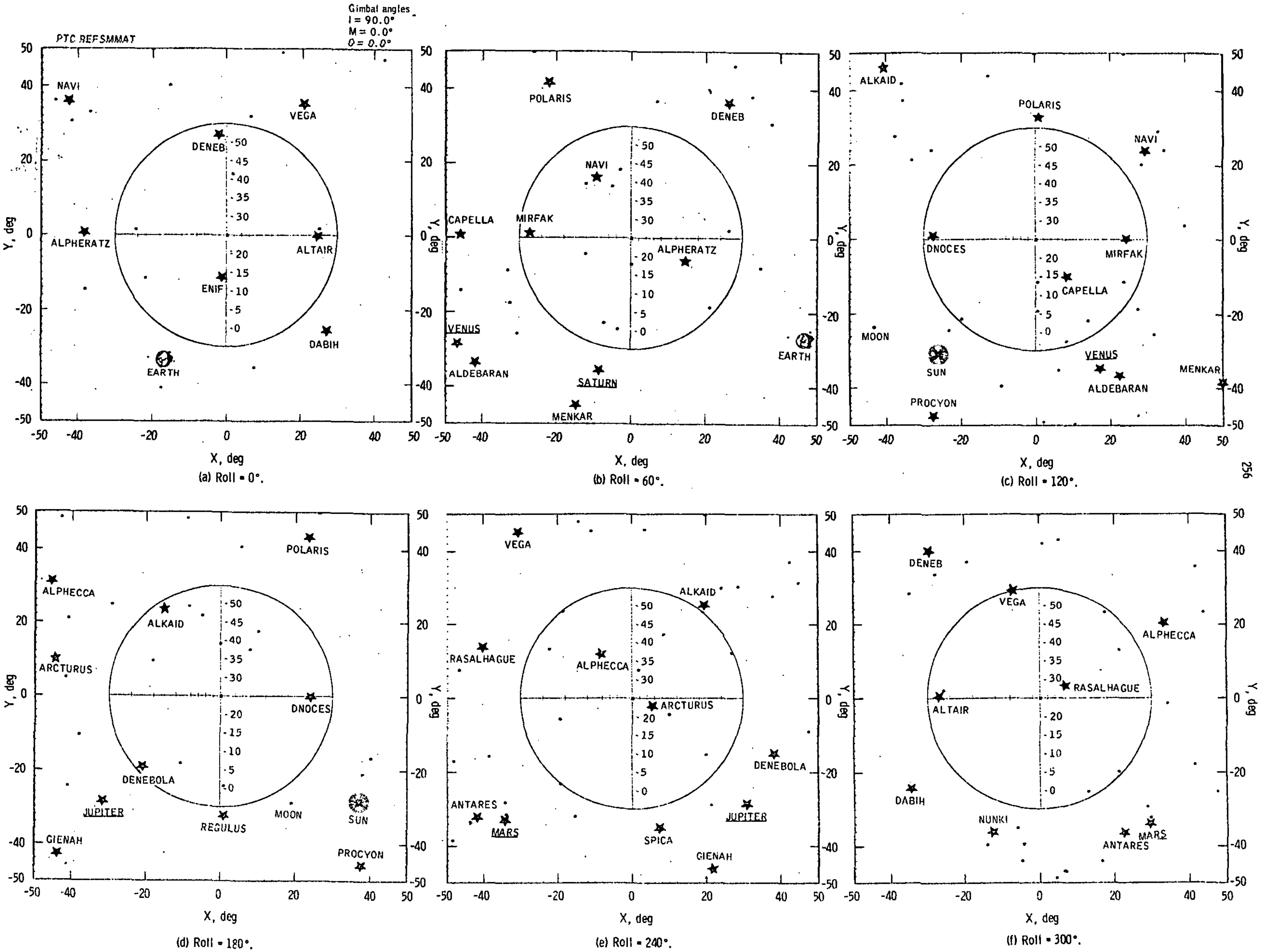
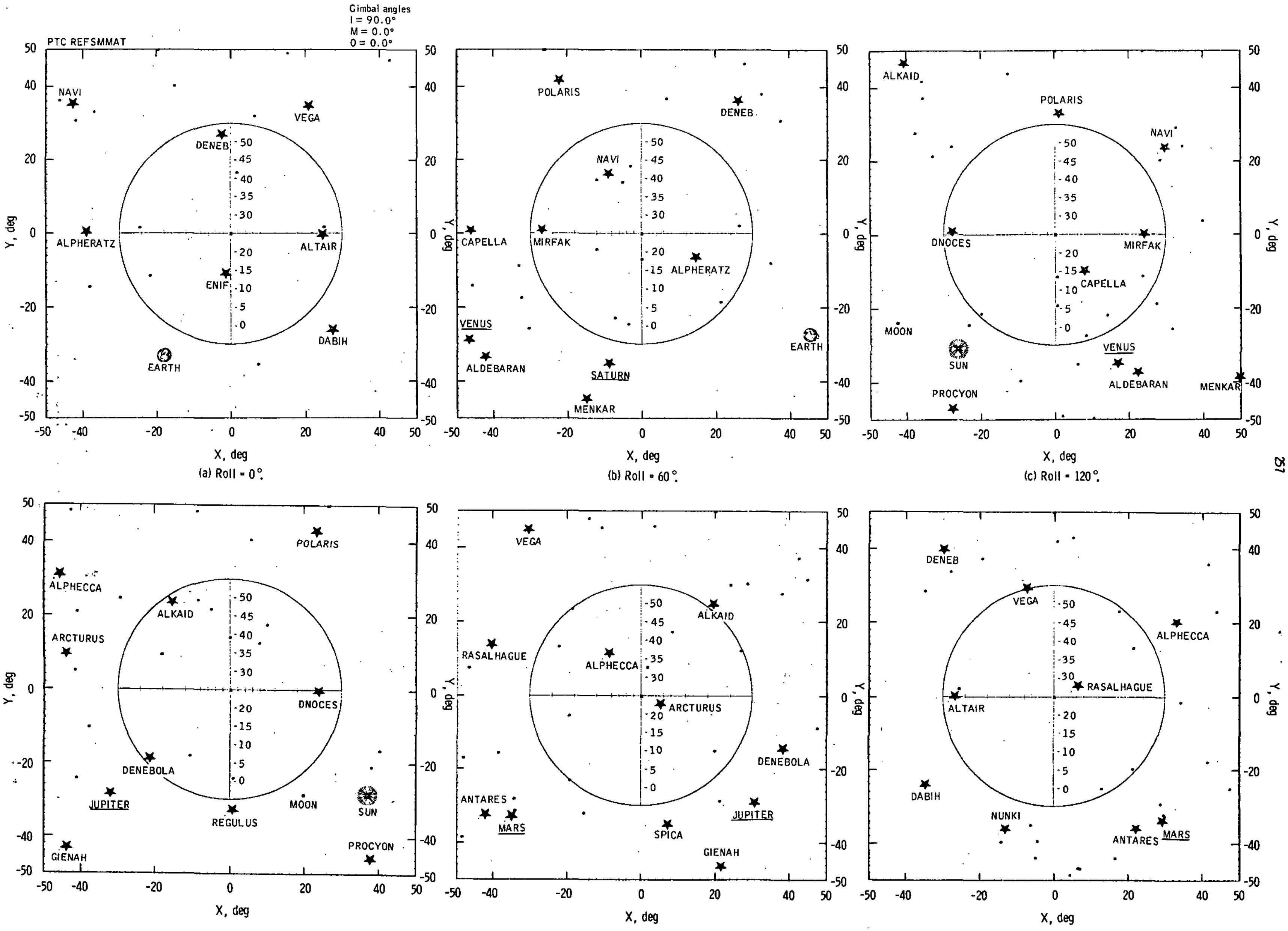


Figure 9.2-4. - Scanning telescope - PTC attitude - (g.e.t. = 23:00:00).



(a) Roll = 0°.

(b) Roll = 60°.

(c) Roll = 120°.

(d) Roll = 180°.

(e) Roll = 240°.

(f) Roll = 300°.

Figure 9.2-5. - Scanning telescope - PTC attitude - (g.e.t. = 26:00:00).

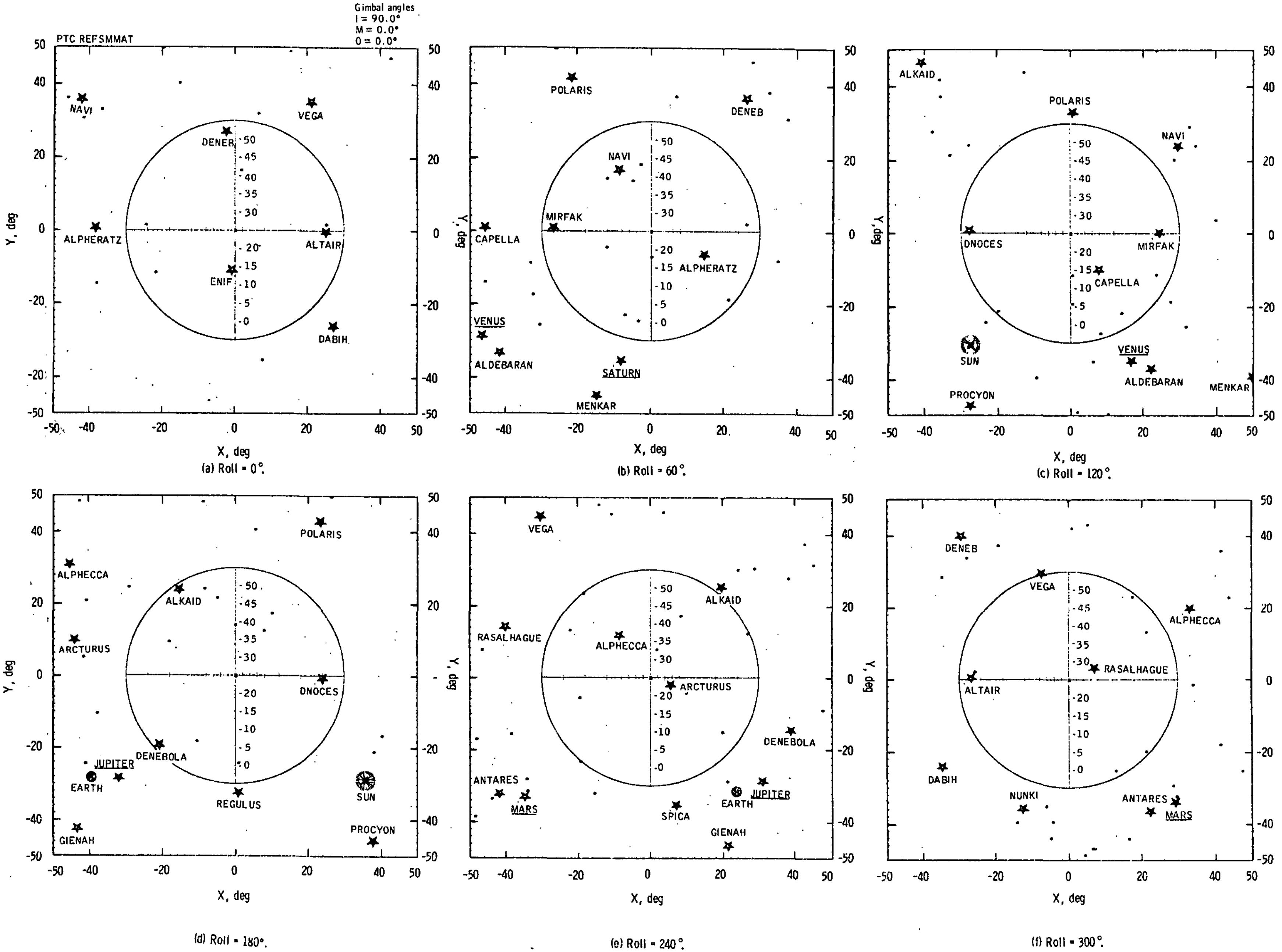
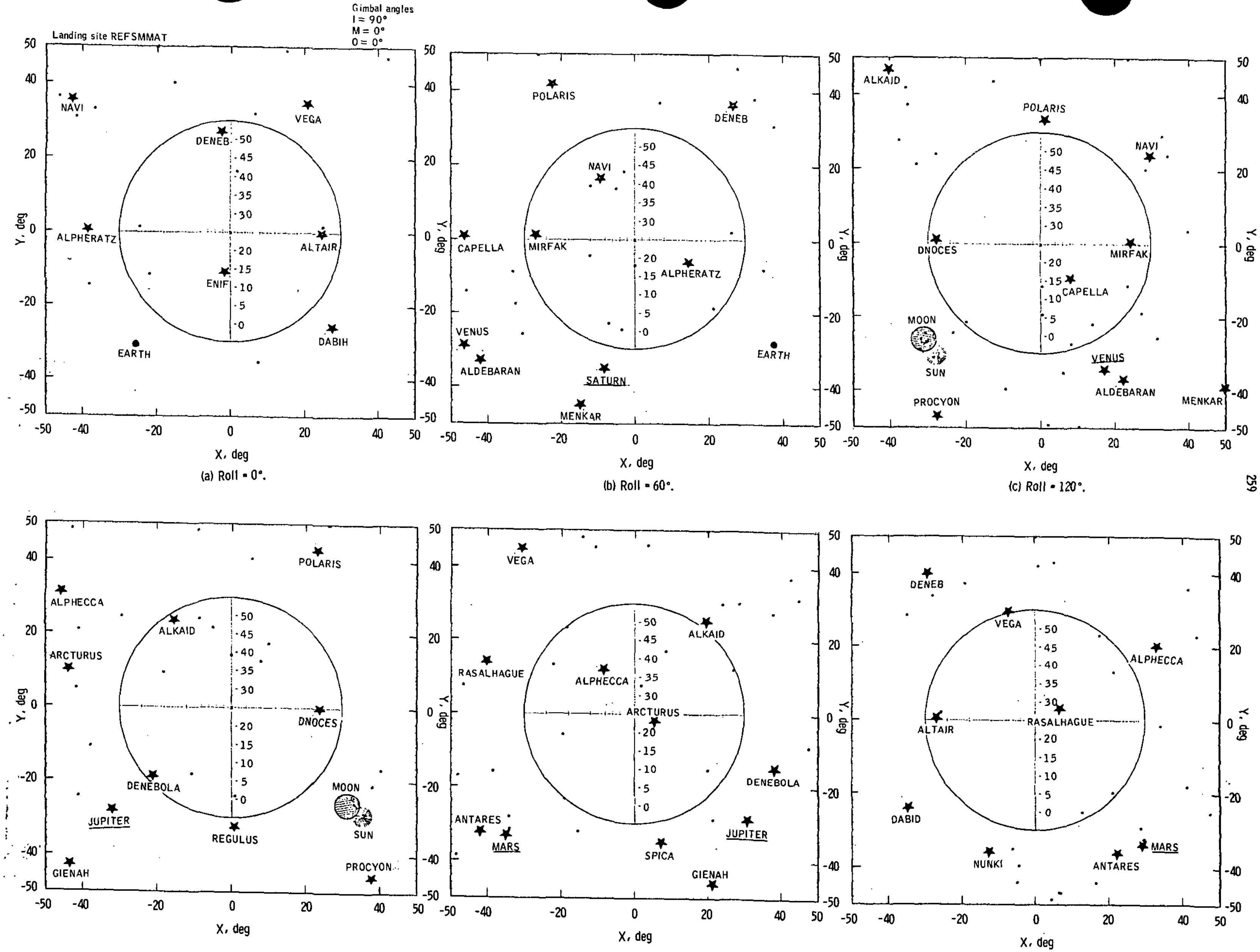


Figure 9.2-6. - Scanning telescope - PTC attitude - (g.e.t. = 53:00:00).



(a) Roll = 0°.

(b) Roll = 60°.

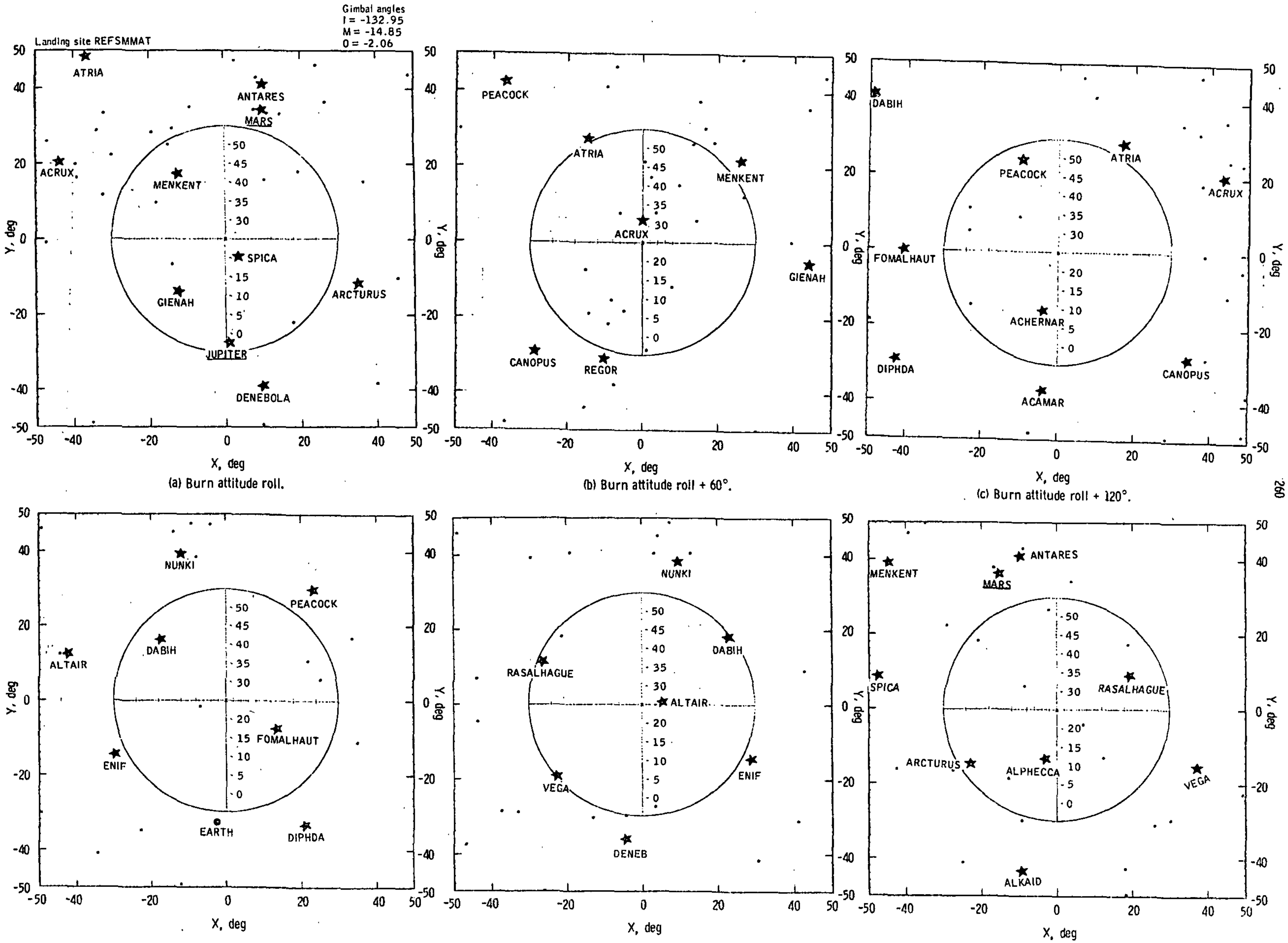
(c) Roll = 120°.

(d) Roll = 180°.

(e) Roll = 240°.

(f) Roll = 300°.

Figure 9.2-7. - Scanning telescope - PTC attitude - (g.e.t. ≈ 70:00:00).



(a) Burn attitude roll.

(b) Burn attitude roll + 60°.

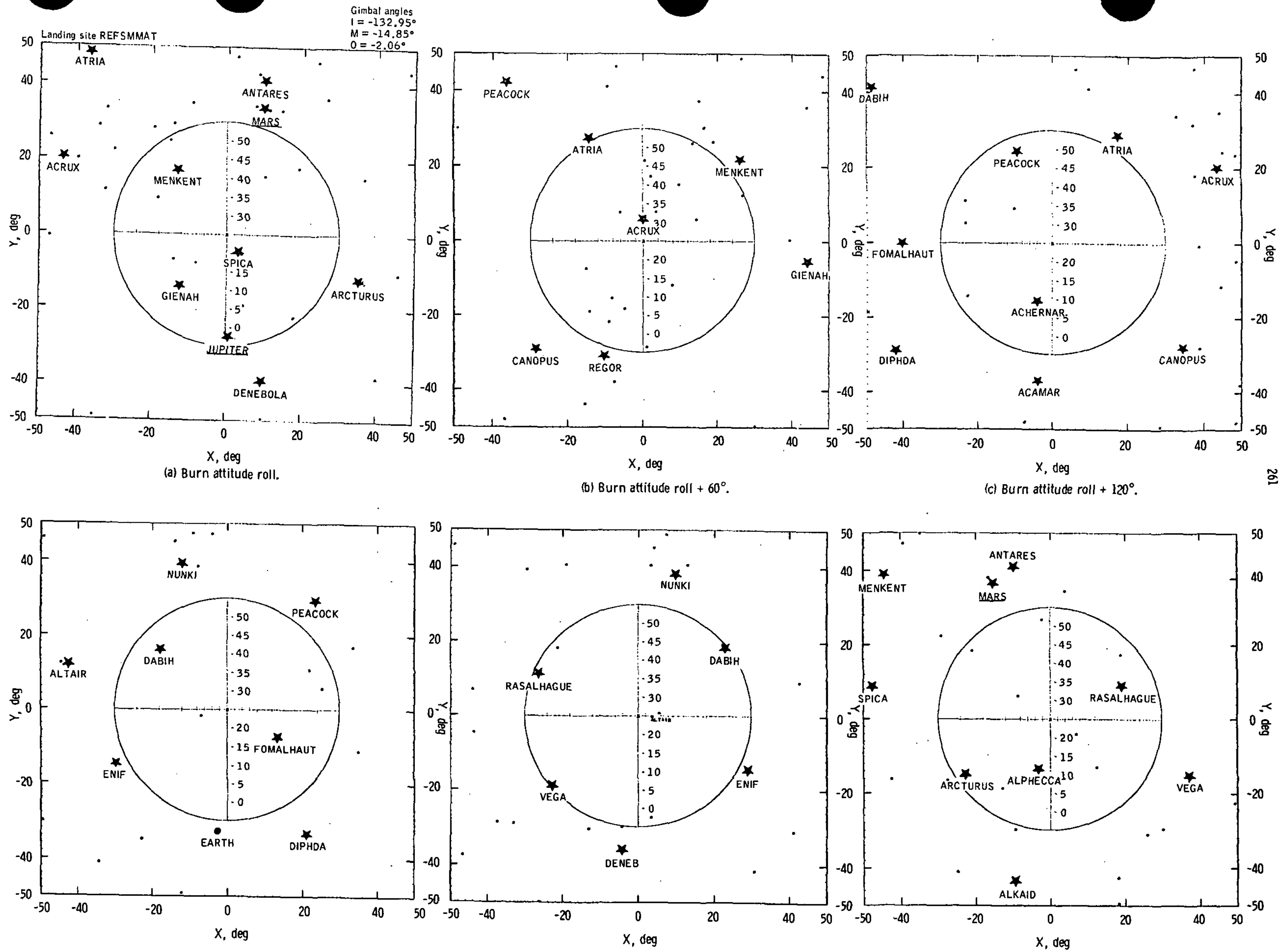
(c) Burn attitude roll + 120°.

(d) Burn attitude roll + 180°.

(e) Burn attitude roll + 240°.

(f) Burn attitude roll + 300°.

Figure 9.2-8. - Scanning telescope - LOI burn attitude - (g.e.t. = 73:00:00).



(a) Burn attitude roll.

(b) Burn attitude roll + 60°.

(c) Burn attitude roll + 120°.

(d) Burn attitude roll + 180°.

(e) Burn attitude roll + 240°.

(f) Burn attitude roll + 300°.

Figure 9.2-9. - Scanning telescope - LOI burn attitude - (g.e.t. = 74:30:00).

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9.3 LUNAR ORBIT COAST PHASE

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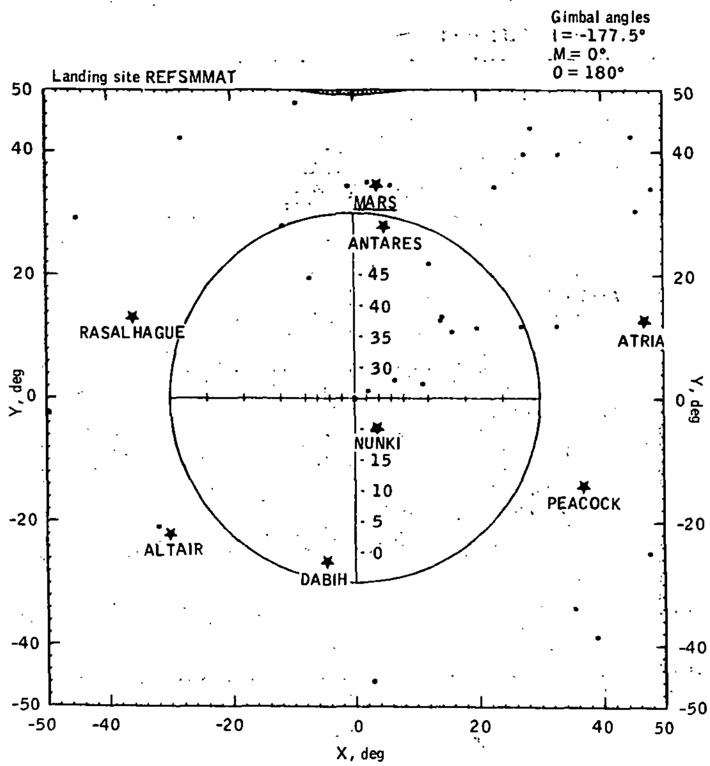
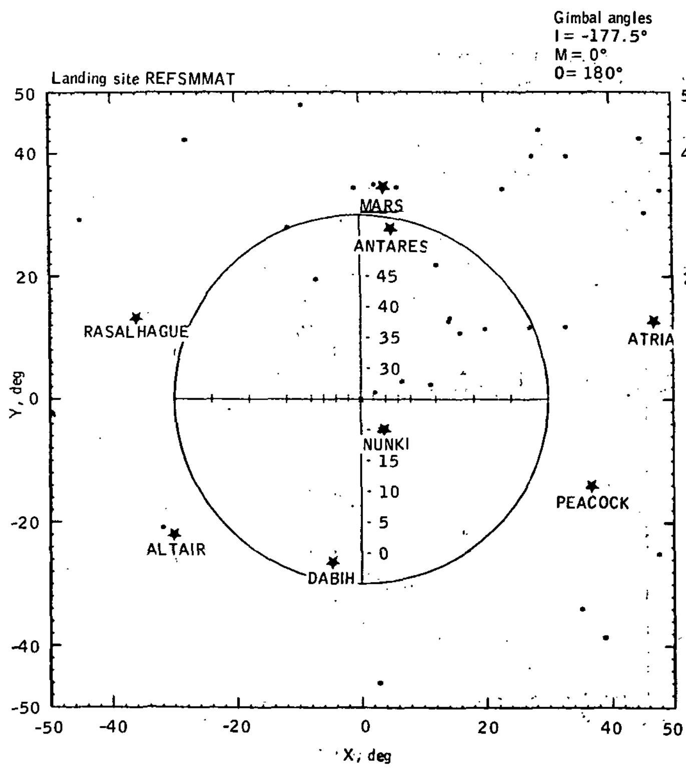
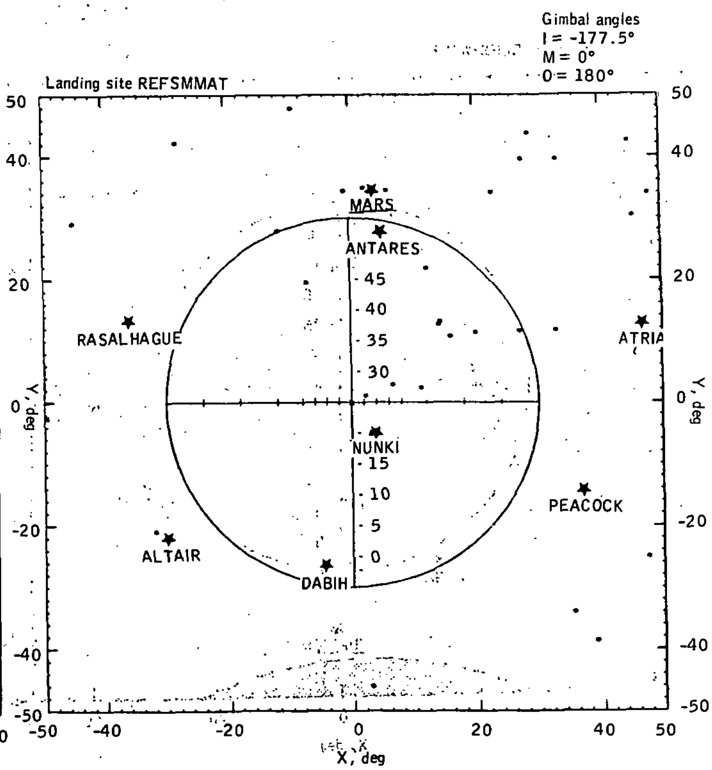


(a) g.e.t. = 77:00:00.



(b) g.e.t. = 77:25:00.



(c) g.e.t. = 77:45:00.

Figure 9.3-1.- Scanning telescope - rev 1.

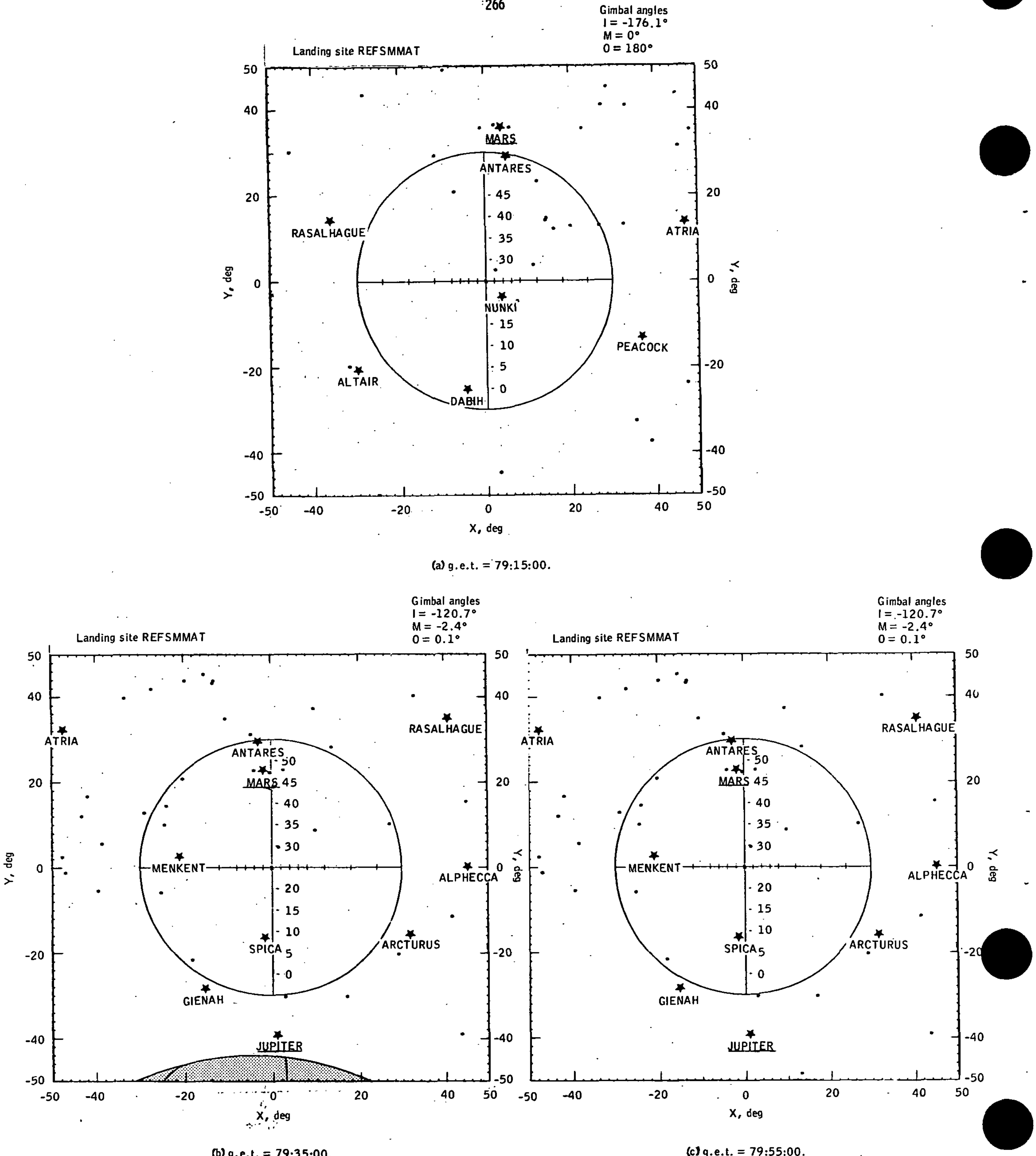


Figure 9.3-2.- Scanning telescope - rev 2.

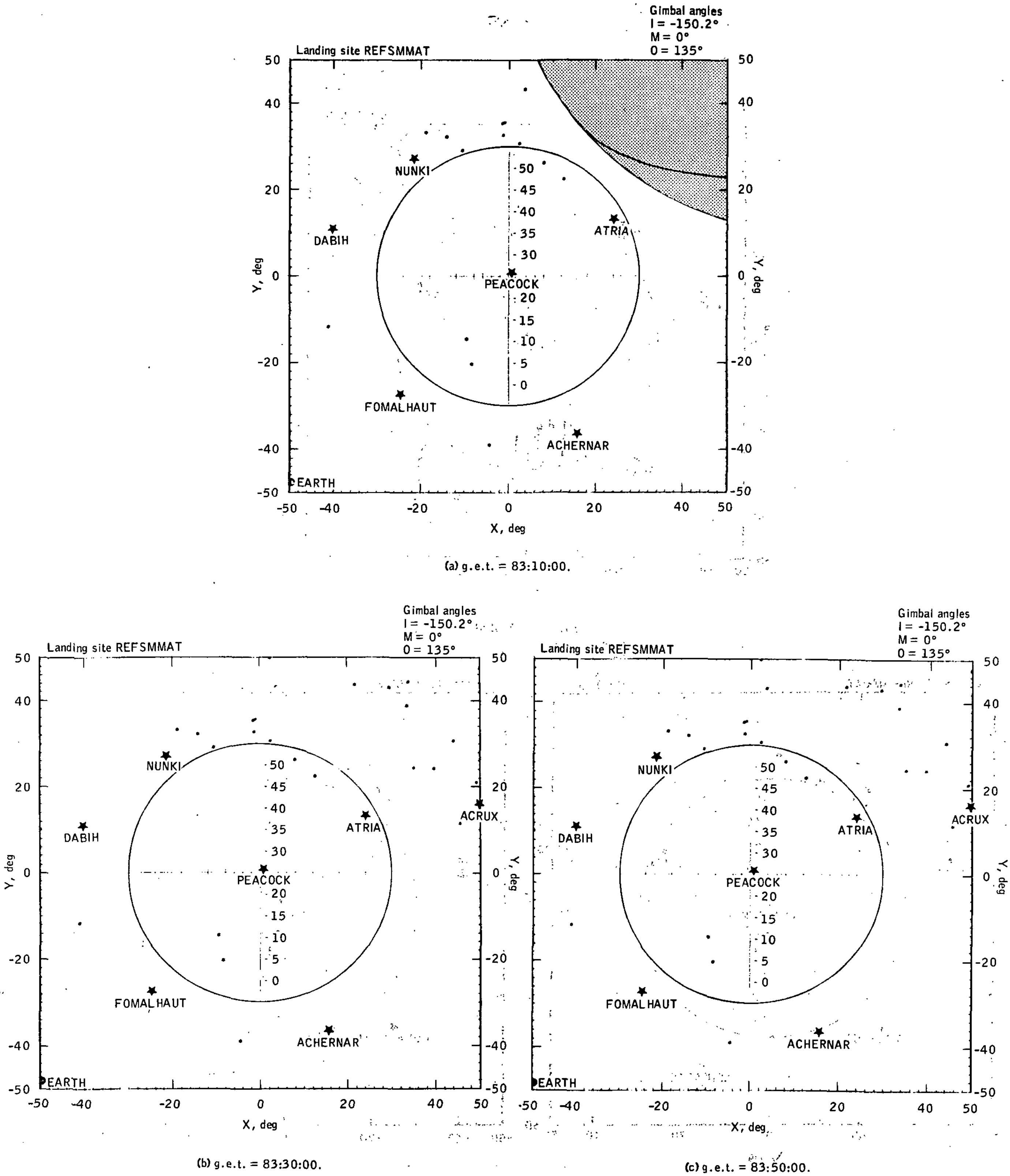
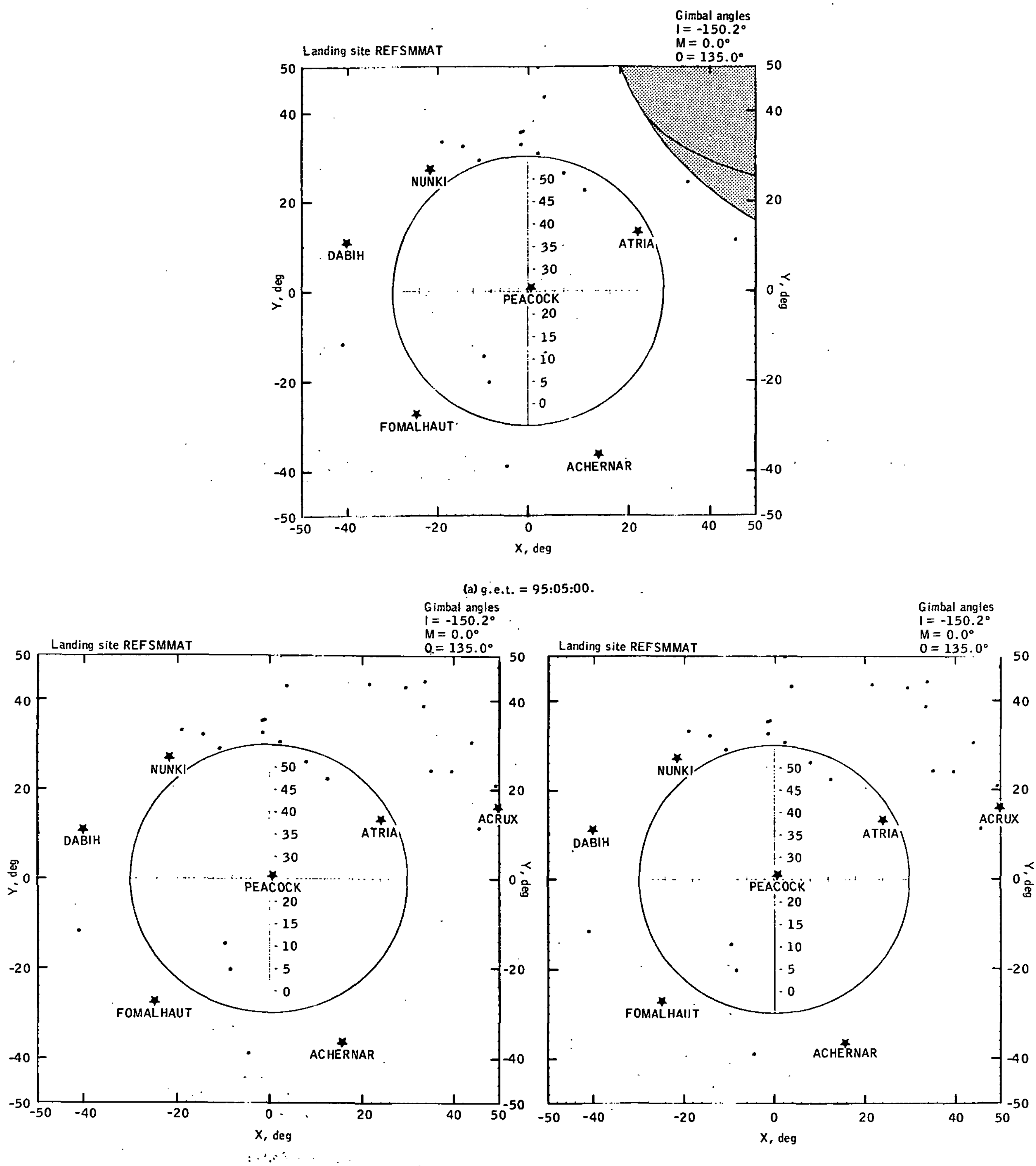


Figure 9.3-3.- Scanning telescope - rev 4.

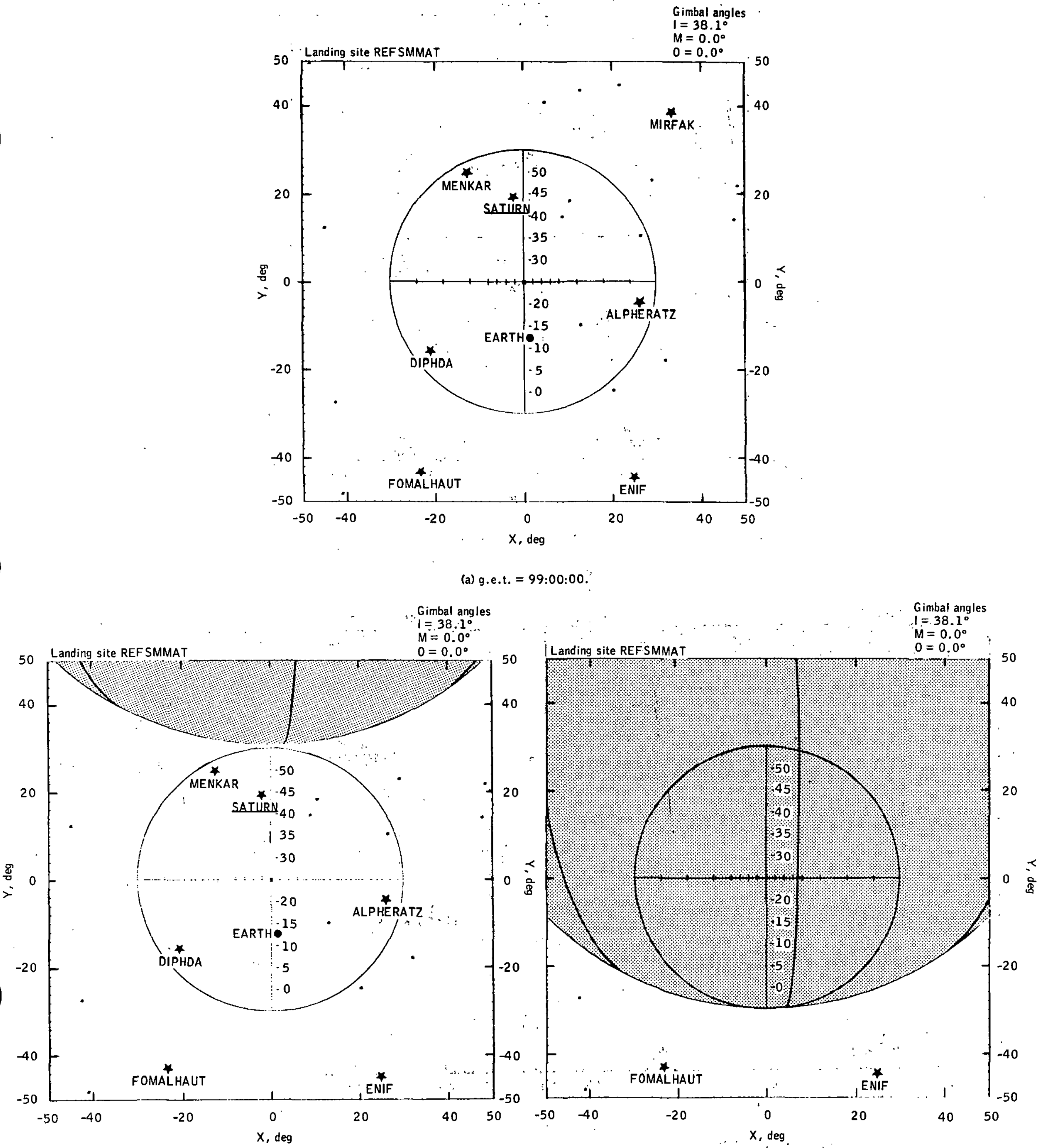


(a) g.e.t. = 95:05:00.

(b) g.e.t. = 95:25:00.

(c) g.e.t. = 95:40:00.

Figure 9.3-4.- Scanning telescope - rev 10.

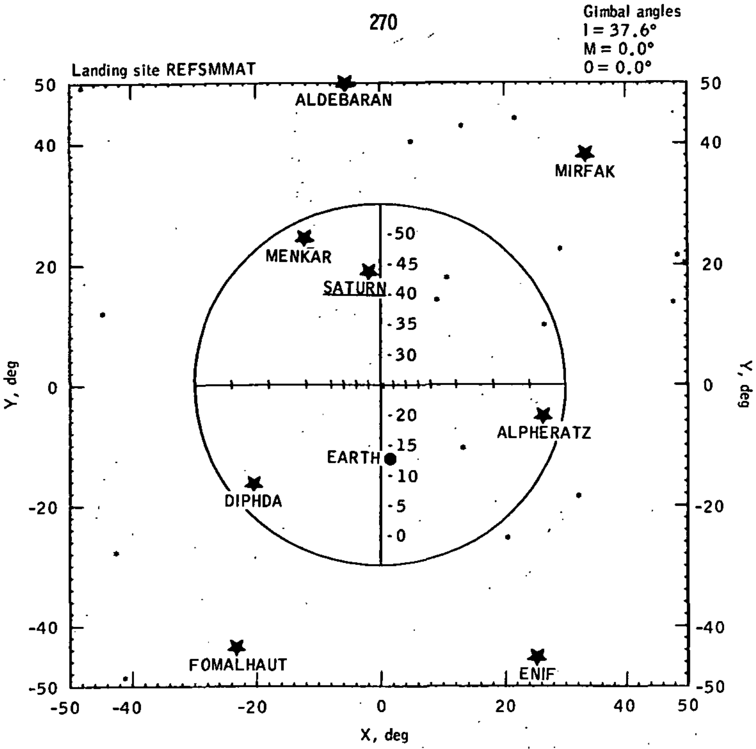


(a) g.e.t. = 99:00:00.

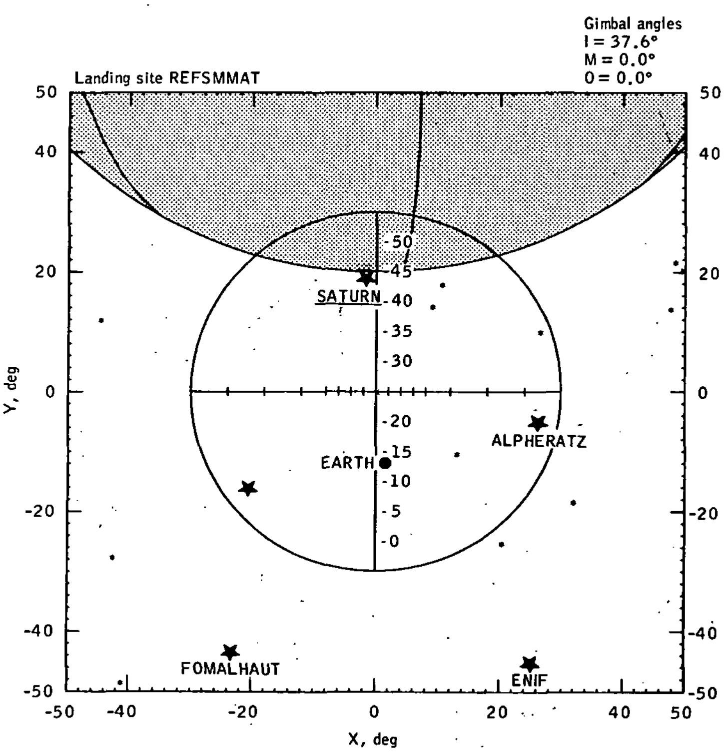
(b) g.e.t. = 99:20:00.

(c) g.e.t. = 99:40:00.

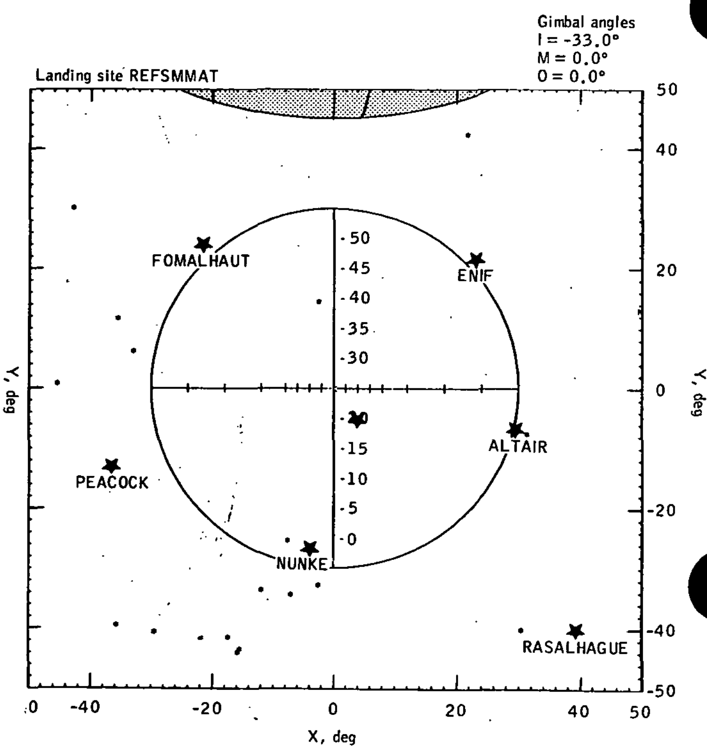
Figure 9.3-5.- Scanning telescope - rev 12.



(a) g.e.t. = 101:00:00.

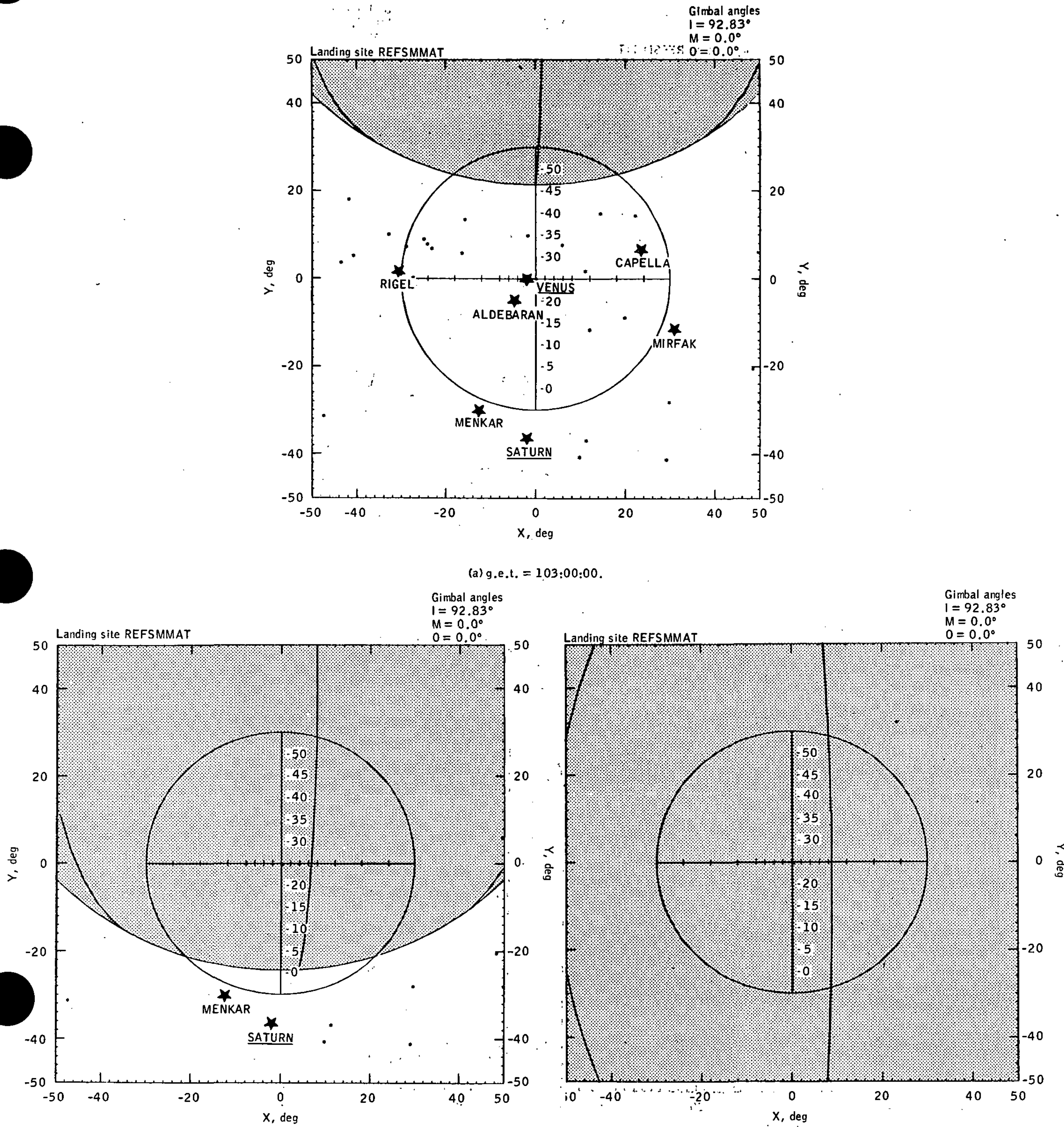


(b) g.e.t. = 101:20:00.



(c) g.e.t. = 101:35:00.

Figure 9.3-6.- Scanning telescope - rev 13.

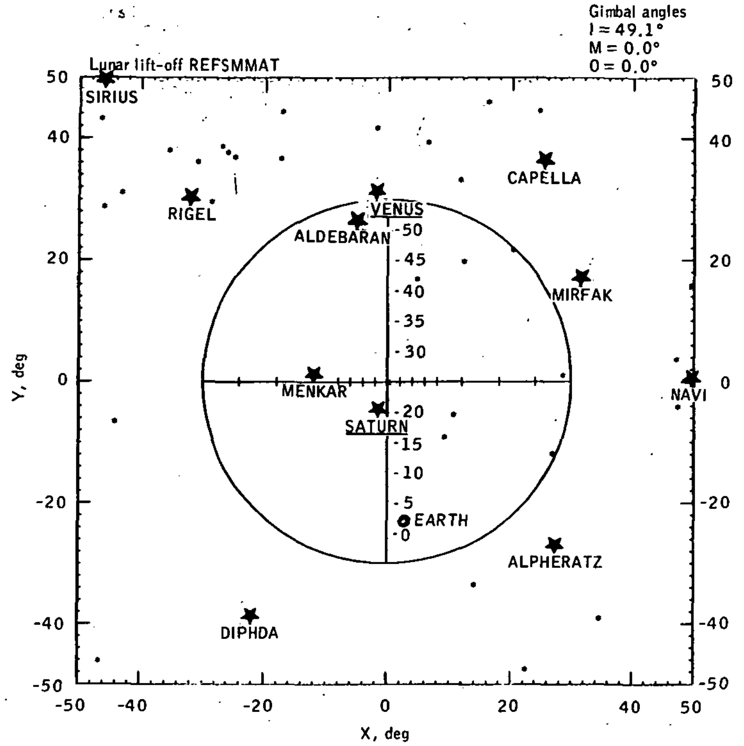


(a) g.e.t. = 103:00:00.

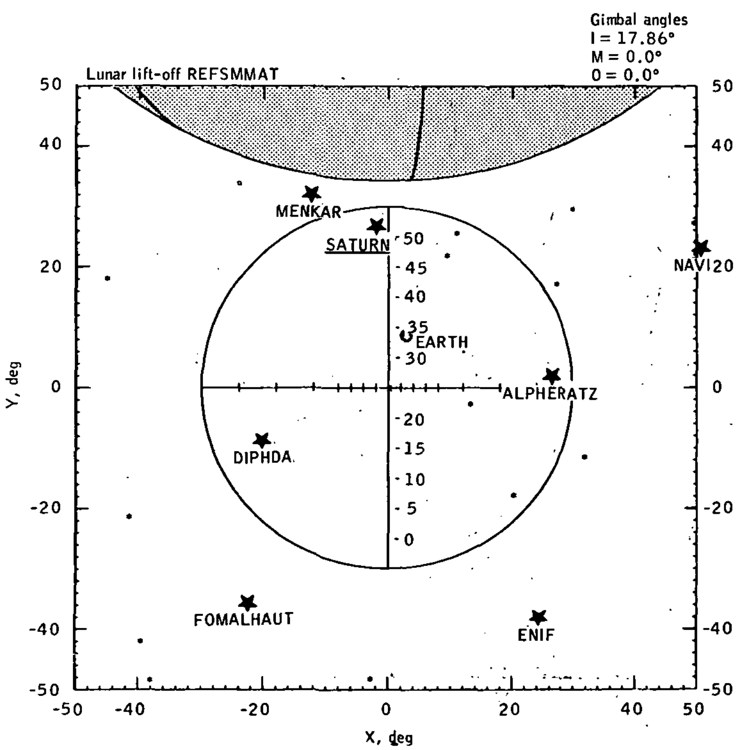
(b) g.e.t. = 103:15:00.

(c) g.e.t. = 103:30:00.

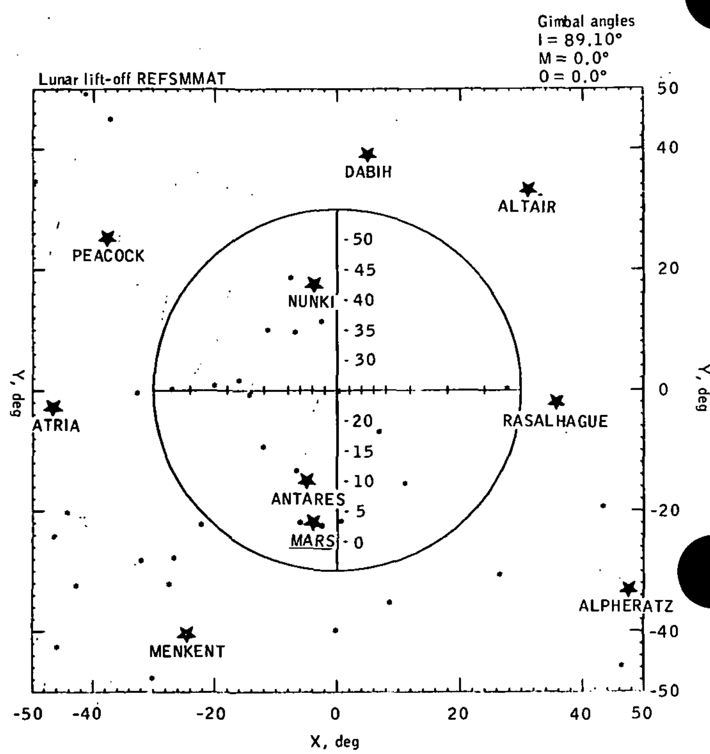
Figure 9.3-7.- Scanning telescope - rev. 14.



(a) g.e.t. = 124:40:00.

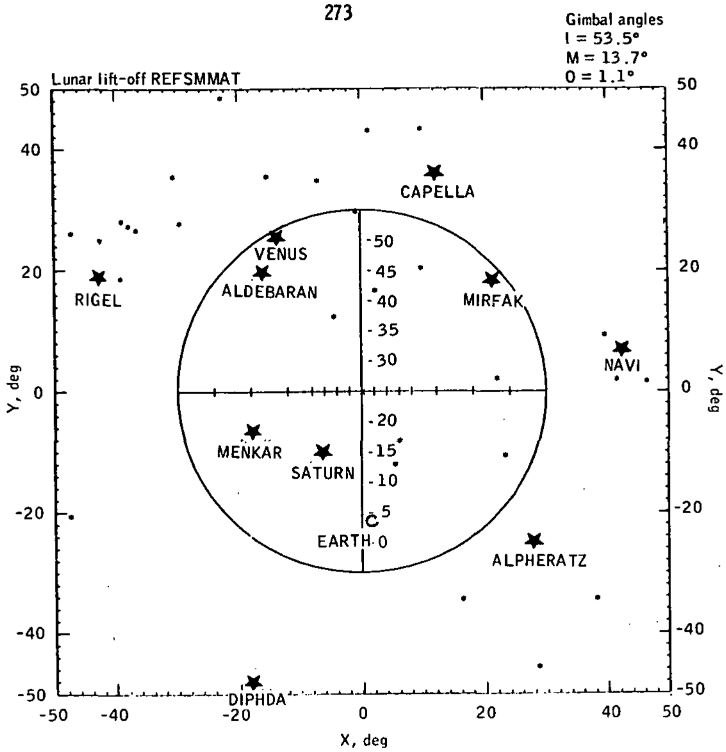


(b) g.e.t. = 125:00:00.

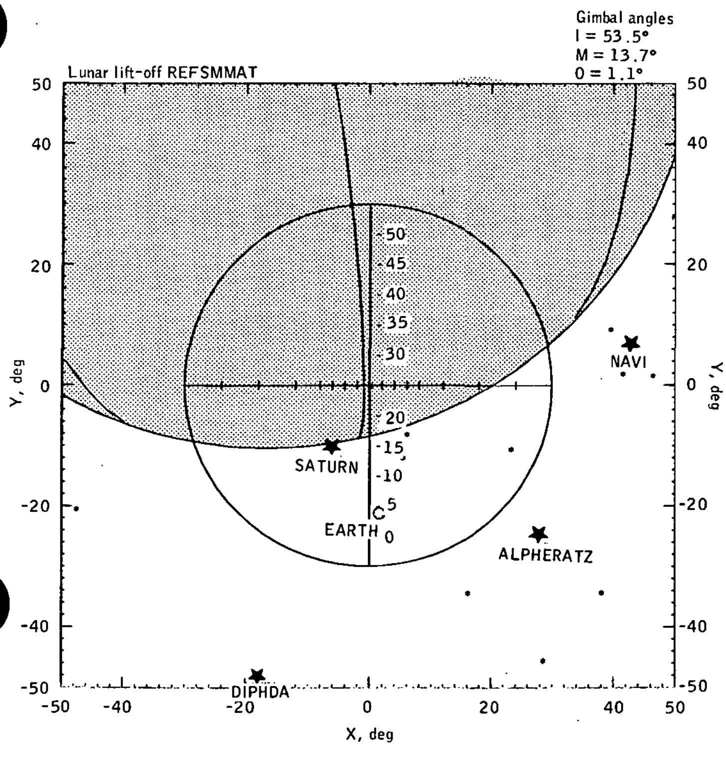


(c) g.e.t. = 125:15:00.

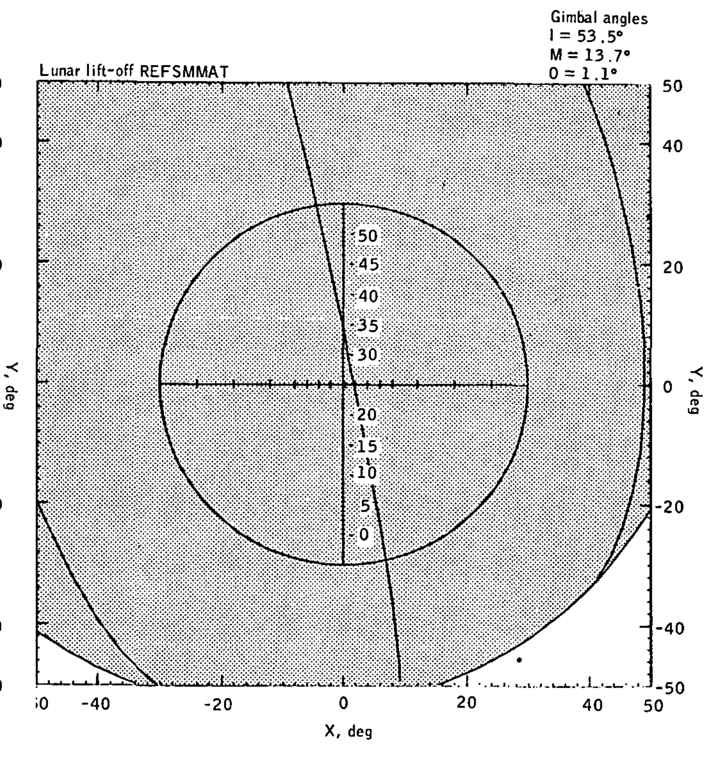
Figure 9.3-8.- Scanning telescope - rev 30.



(a) g.e.t. = 134:35:00.



(b) g.e.t. = 134:55:00.



(c) g.e.t. = 135:10:00.

Figure 9.3-9.- Scanning telescope - rev 30.

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9.4 TRANSEARTH COAST PHASE

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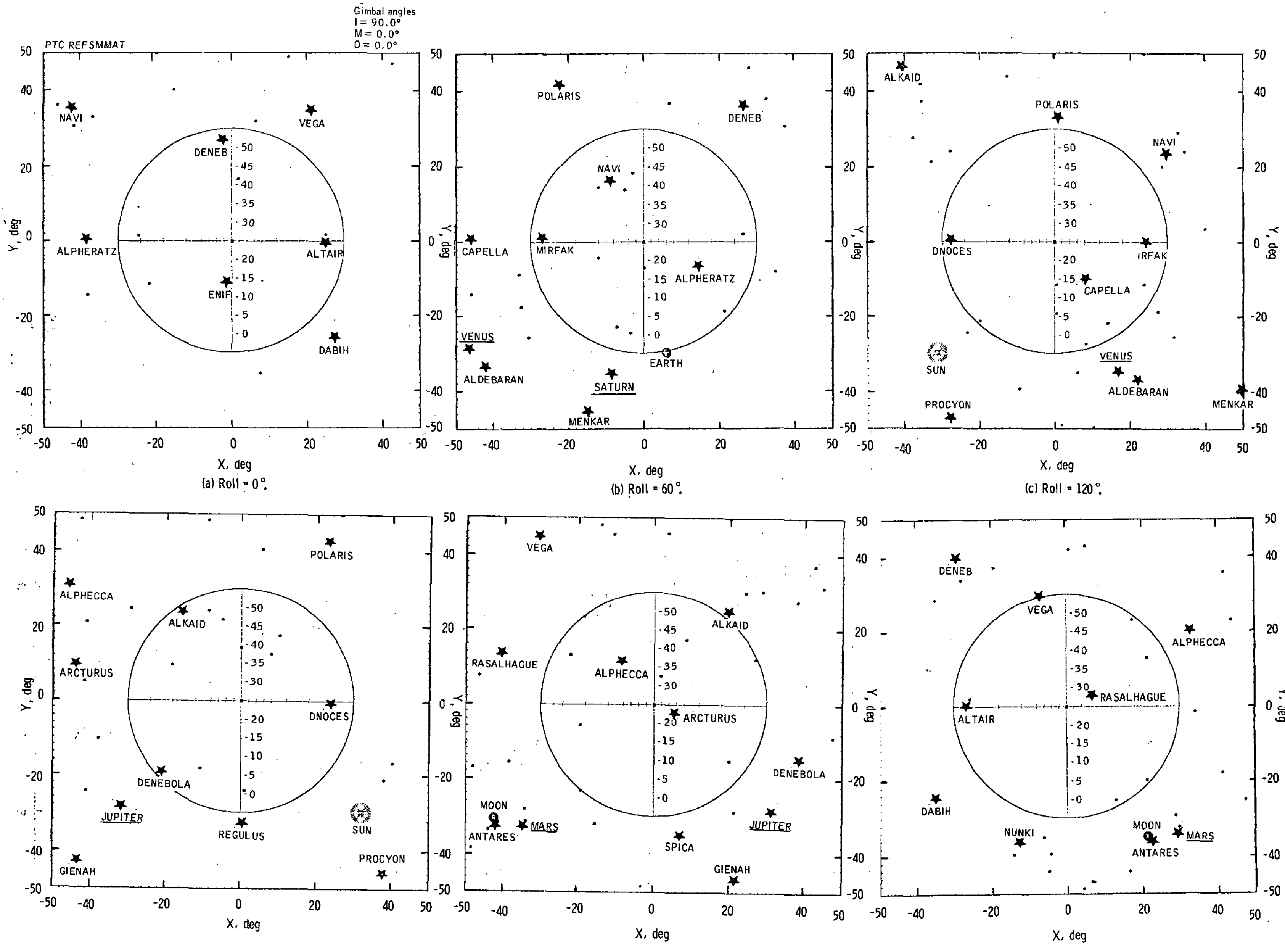


(a) Roll = 0°.

(b) Roll = 60°.

(c) Roll = 120°.

(d) Roll = 180°.

(e) Roll = 240°

(f) Roll = 300°.

Figure 9.4-2. - Scanning telescope - PTC attitude (g.e.t. = 148:00:00).

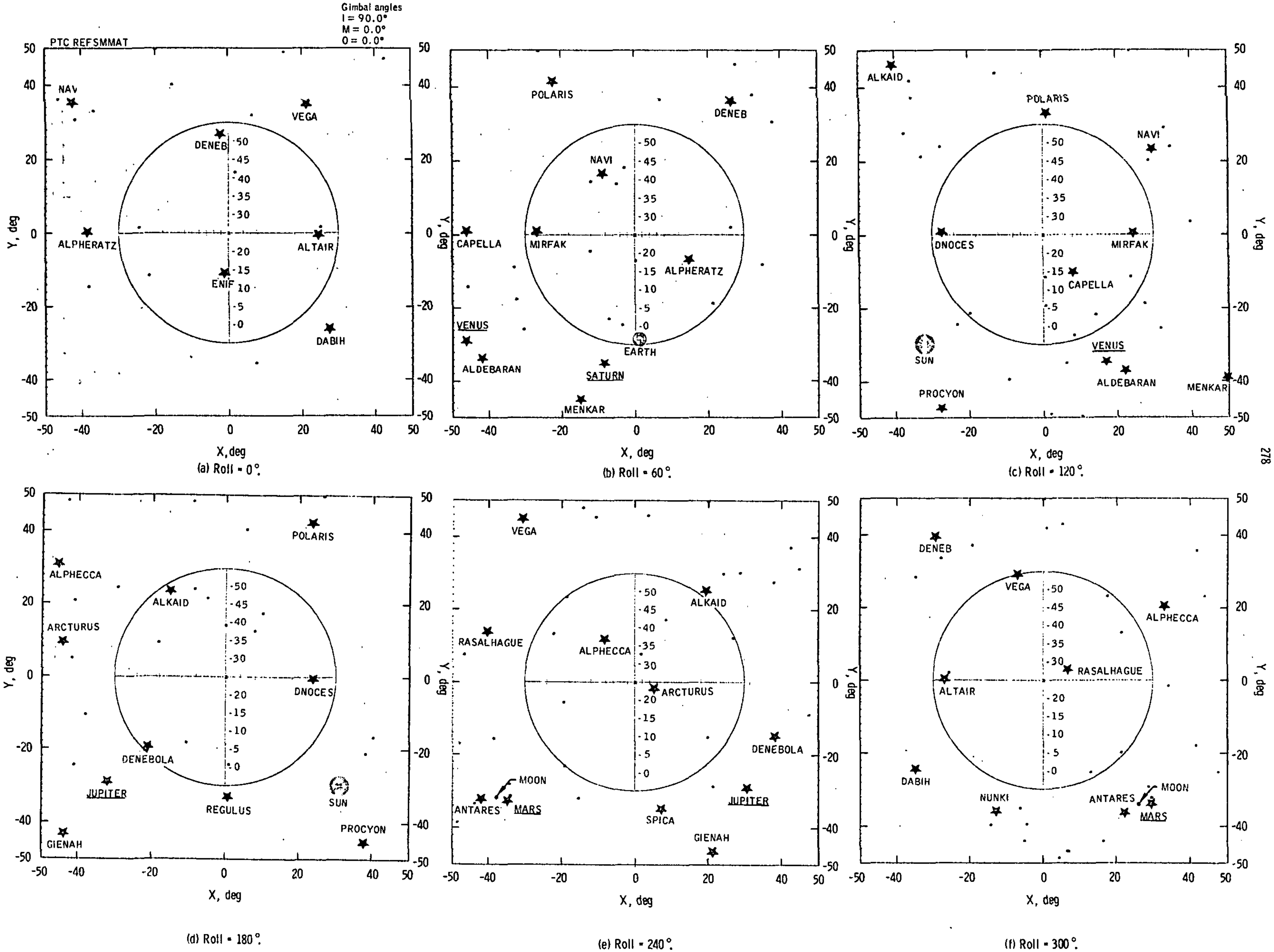
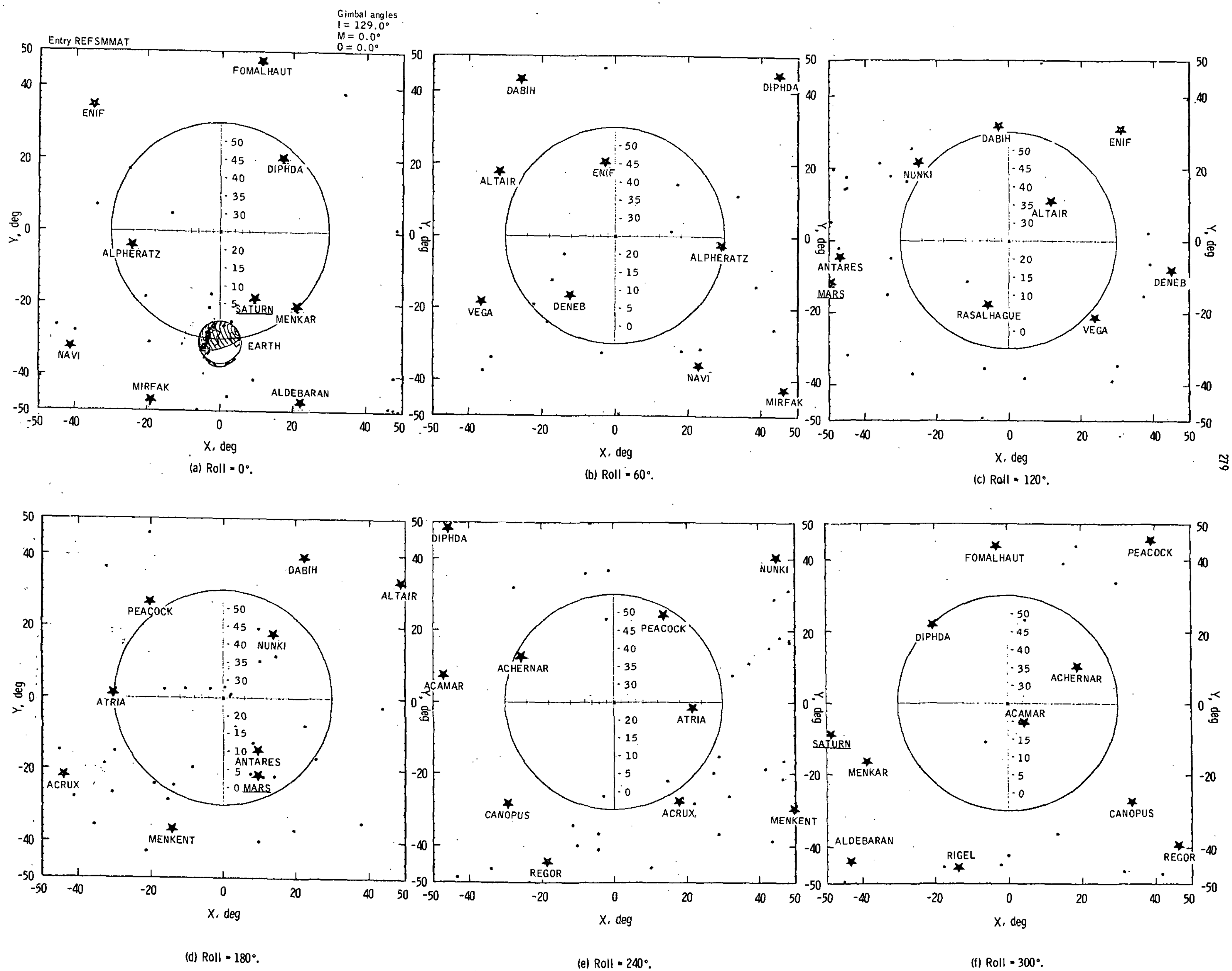


Figure 9.4-3. - Scanning telescope - PTC attitude (g.e.t. = 172:00:00).



(a) Roll = 0°.

(b) Roll = 60°.

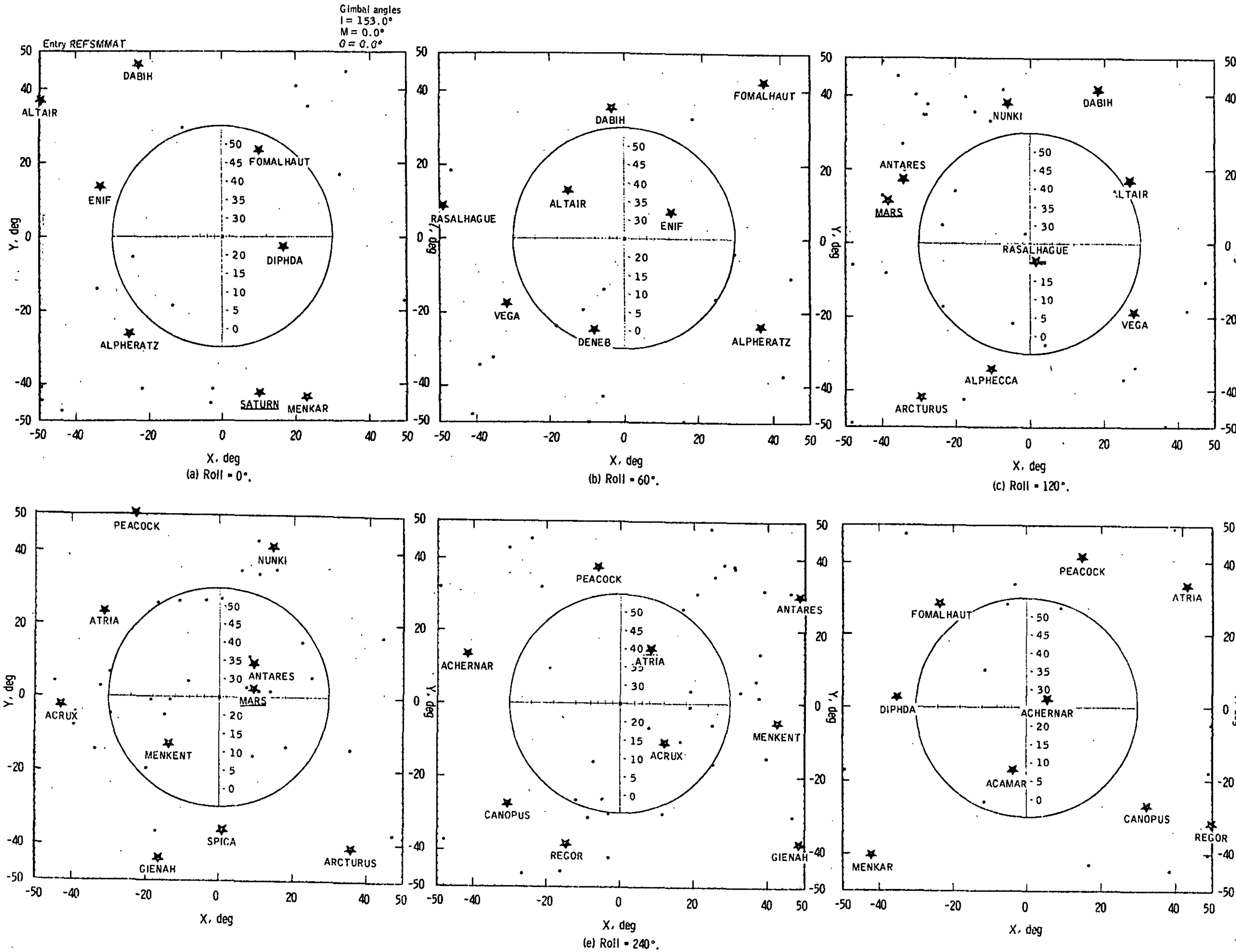
(c) Roll = 120°.

(d) Roll = 180°.

(e) Roll = 240°.

(f) Roll = 300°.

Figure 9.4-4.- Scanning telescope - E1 - ≈ 4 hours (g.e.t. = 191:15:00).



(a) Roll = 0°.

(b) Roll = 60°.

(c) Roll = 120°.

(d) Roll = 180°.

(e) Roll = 240°.

(f) Roll = 300°.

Figure 9.4-5.- Scanning telescope - EI -1.5 hours (g.e.t. = 193:30:00).

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10.0 VIEWS THROUGH ALINEMENT OPTICAL TELESCOPE

11.0 STAR IDENTIFICATION CATALOGUE

12.0 REFERENCES

10.0 VIEWS THROUGH ALINEMENT OPTICAL TELESCOPE

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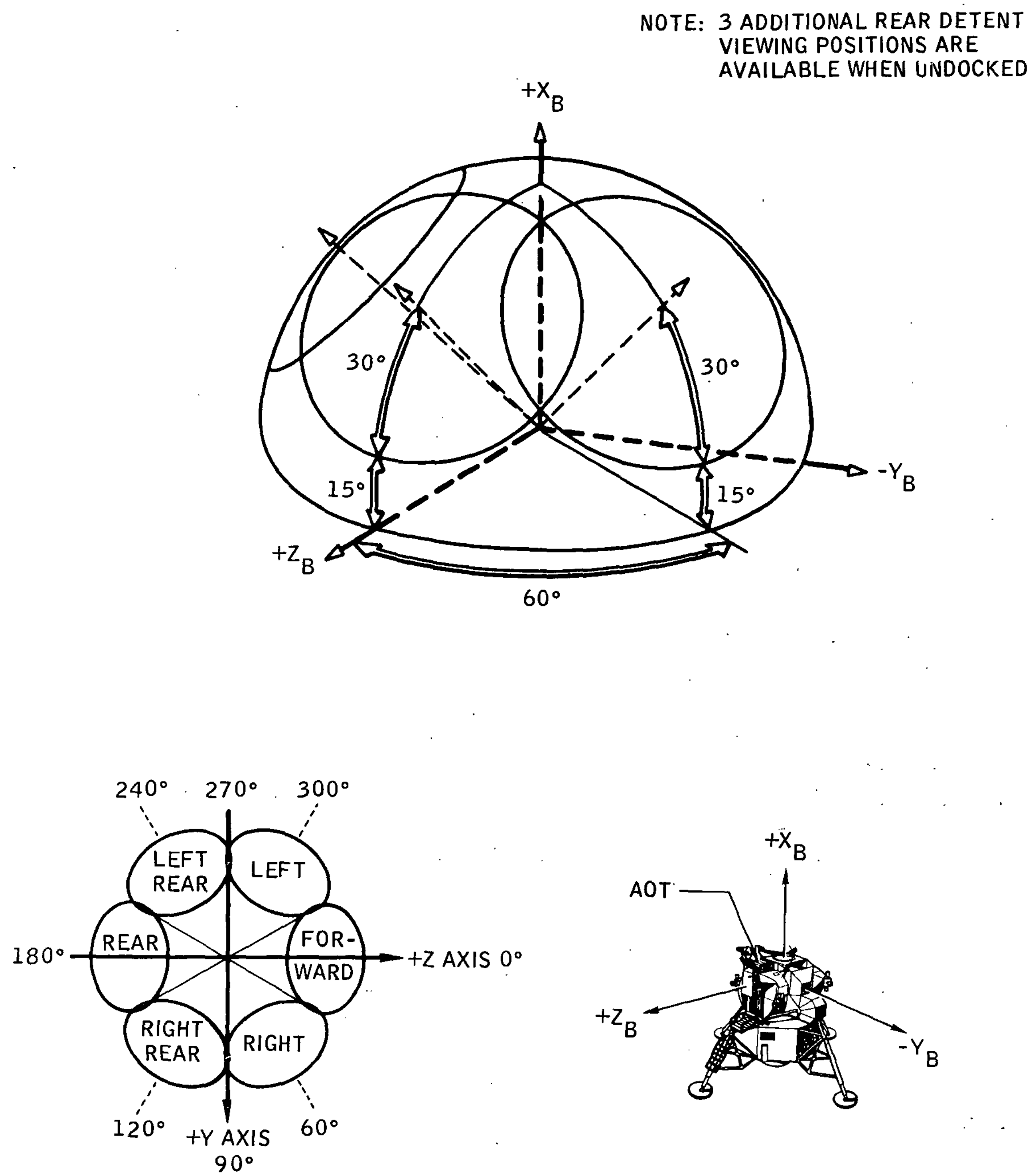
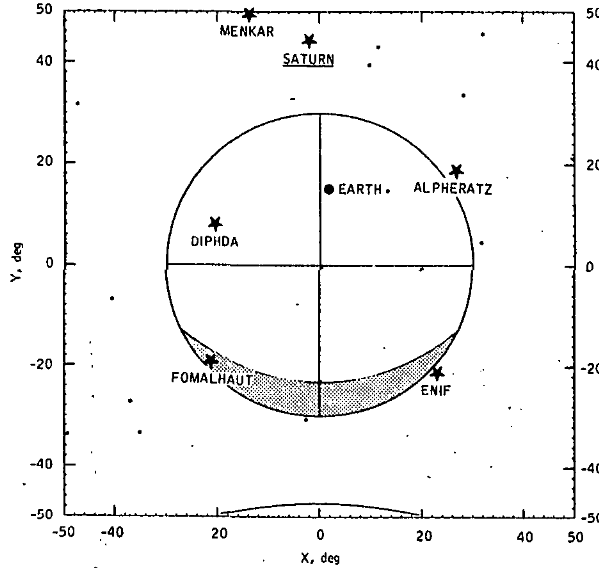
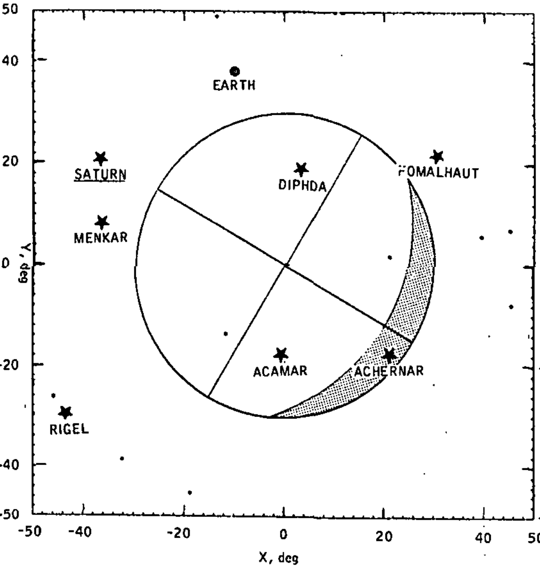


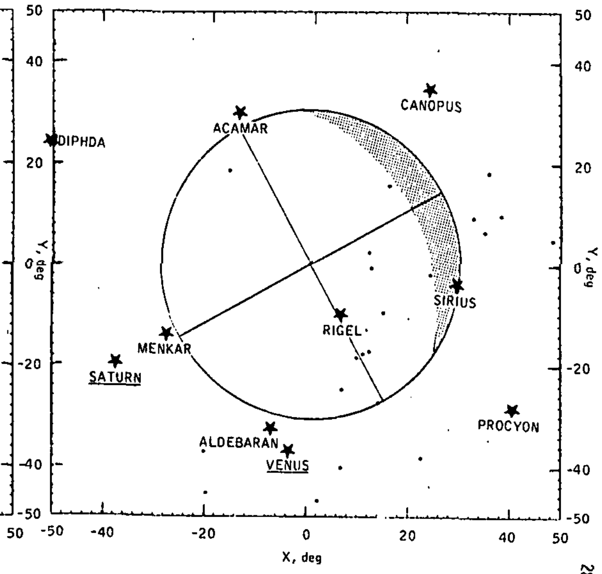
Figure 10.0-1.- Attitude constraint geometry of AOT viewing positions.



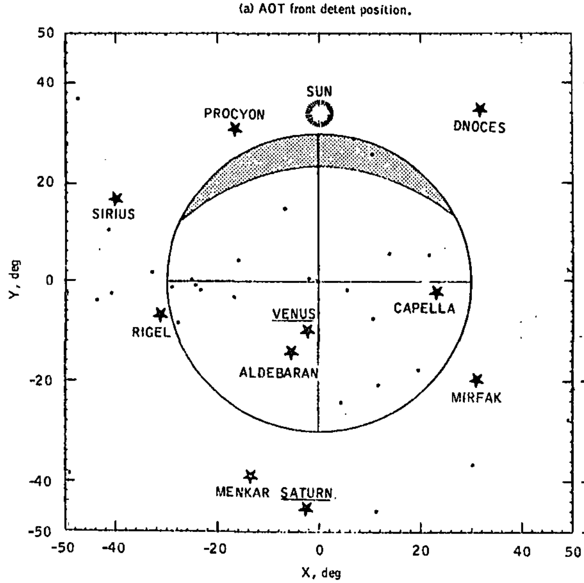
(a) AOT front detent position.



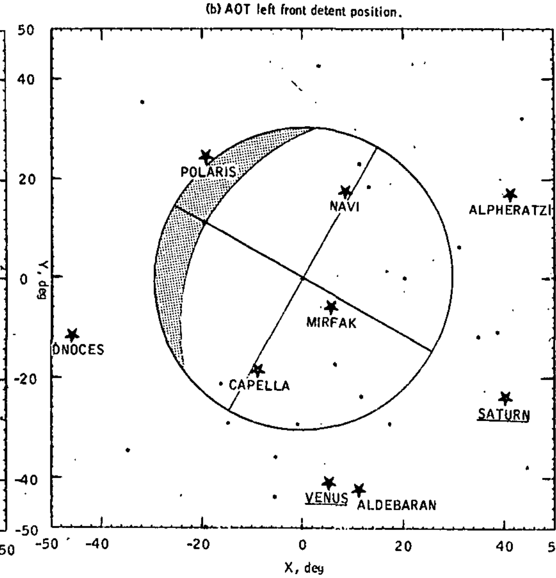
(b) AOT left front detent position.



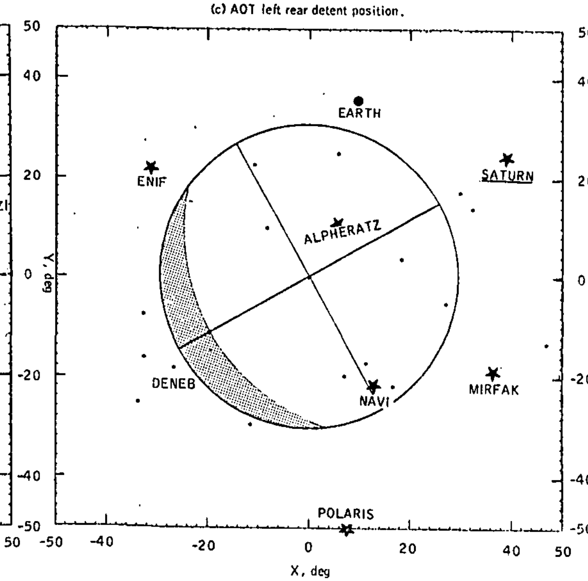
(c) AOT left rear detent position.



(d) AOT rear detent position.

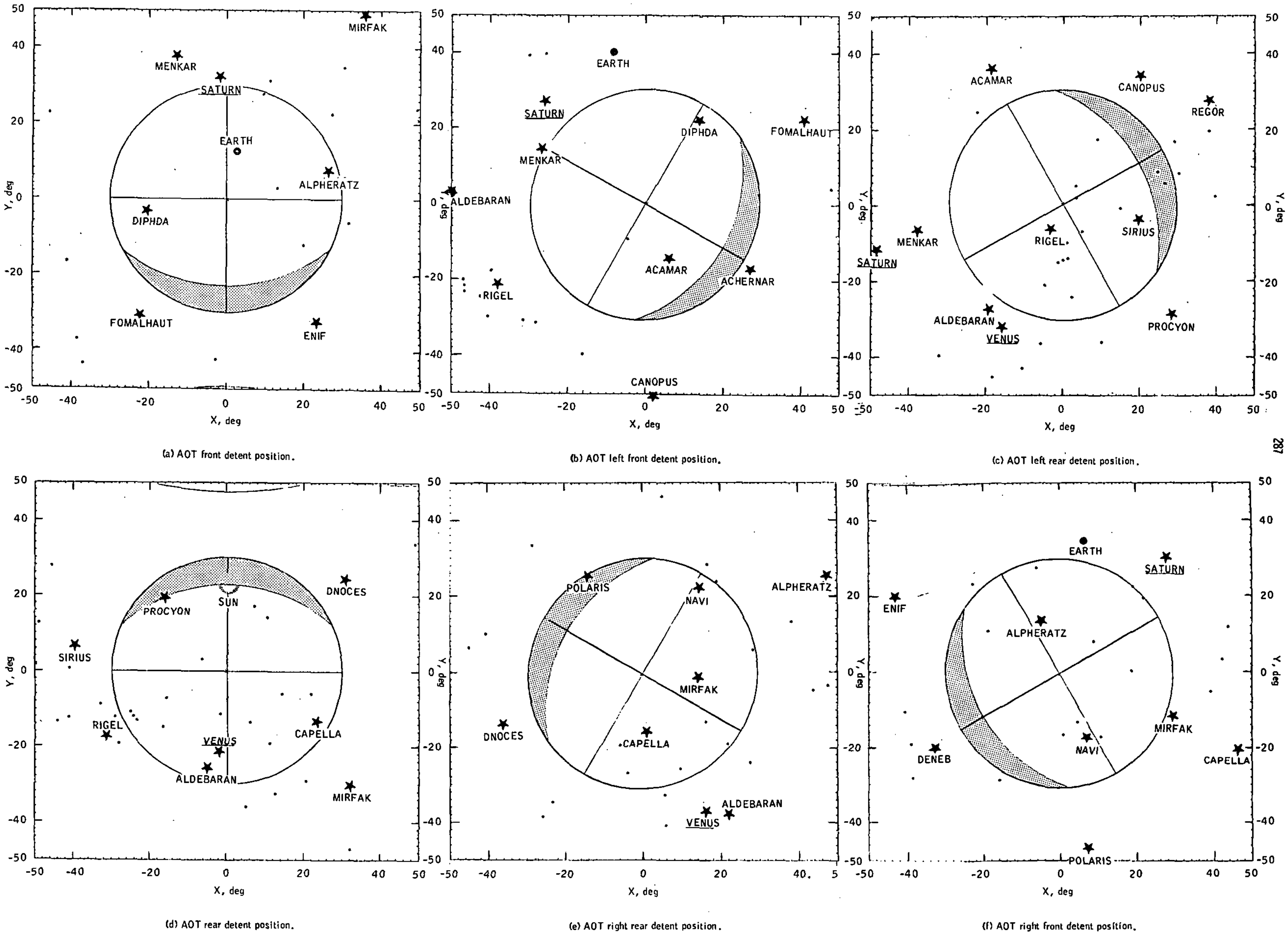


(e) AOT right rear detent position.



(f) AOT right front detent position.

Figure 10.0-2.- AOT views 2 hours after lunar landing.



(a) AOT front detent position.

(b) AOT left front detent position.

(c) AOT left rear detent position.

(d) AOT rear detent position.

(e) AOT right rear detent position.

(f) AOT right front detent position.

Figure 10.0-3.- AOT views 2 hours prior to lunar lift-off.

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11.0 STAR IDENTIFICATION CATALOGUE

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(a) RTCC star catalogue for Besselian year 1970

Star no.	Name			Right ascension, hr:min:sec	Declination, deg:min:sec	Magnitude
	IAU designation	Relative brightness and constellation[a]	Common name			
1	α And	α Andromedae	Alpheratz	0:06:49.9	+28:55:29	2.1
2	β Cet	β Ceti	Diphda	0:42:05.0	-18:09:04	2.2
3	γ Cas	γ Casseopeiae	--	0:54:53.0	+60:33:17	Varies
4	α Eri	α Eridani	Achernar	1:36:35.9	-57:23:20	0.6
5	α UMi	α Ursae Minoris	Polaris	2:03:18.9	+89:07:34	2.1
6	θ Eri	θ Eridani	Acamar	2:57:07.4	-40:25:27	3.4
7	α Cet	α Ceti	Menkar	3:00:42.5	+3:58:23	2.8
8	α Per	α Percei	Mirfak	3:22:10.3	+49:45:21	1.9
9	α Tau	α Tauri	Aldebaran	4:34:11.8	+16:27:01	1.1
10	β Ori	β Orionis	Rigel	5:13:05.7	-8:14:06	0.3
11	α Aur	α Aurigae	Capella	5:14:28.2	+45:58:10	0.2
12	α Car	α Carinae	Canopus	6:23:17.1	-52:40:44	-0.9
13	α CMa	α Canis Majoris	Sirius	6:43:49.6	-16:40:25	-1.6
14	α CMi	α Canis Minoris	Procyon	7:37:43.9	+5:18:11	0.5
15	γ^2 Vel	γ^2 Velorum	--	8:08:36.4	-47:14:51	1.9
16	ι UMa	ι Ursar Majoris	--	8:57:09.7	+48:09:38	3.1
17	α Hya	α Hydrae	Alphard	9:26:06.8	-8:31:40	2.2
18	α Leo	α Leois	Regulus	10:06:46.5	+12:06:52	1.3
19	β Leo	β Leois	Denebola	11:47:31.8	+14:44:23	2.2
20	γ Crv	γ Corvi	--	12:14:15.6	-17:22:32	2.8
21	α^1 Cru	α^1 Crucis	Acrux	12:24:59.4	-62:55:59	1.0
22	α Vir	α Virginis	Spica	13:23:36.6	-11:00:19	1.2
23	η UMa	η Ursae Majoris	Alkaid	13:46:21.6	+49:27:45	1.9
24	θ Cen	θ Centauri	Menkent	14:04:54.6	-36:13:23	2.3
25	α Boo	α Boötis	Arcturus	14:14:17.5	+19:20:16	0.2
26	α CrB	α Coronae Borealis	Alphecca	15:33:25.0	+26:48:53	2.3
27	α Sco	α Scorpii	Antares	16:27:33.9	-26:22:01	1.2
28	α TrA	α Trianguli Australis	Atria	16:45:28.3	-68:58:31	1.9
29	α Oph	α Ophiuchi	Rasalague	17:33:32.4	+12:34:50	2.1
30	α Lyr	α Lyrae	Vega	18:35:55.3	+38:45:17	0.1
31	σ Sgr	σ Sagittarii	Nunki	18:53:24.3	-26:20:08	2.1
32	α Aql	α Aquilae	Altair	19:49:19.1	+8:47:16	0.9
33	β Cap	β Capricorni	--	20:19:19.6	-14:52:38	3.2
34	α Pav	α Pavonis	Peacock	20:23:17.0	-56:49:58	2.1
35	α Cyg	α Cygni	Deneb	20:40:24.4	+45:10:21	1.3

[a]The earlier Greek letters are assigned to the stars roughly in order of brightness; there are exceptions. Magnitudes should be used for mission planning.

TABLE STAR AND PLANET CATALOGUE - Continued

(a) RTCC star catalogue for Besselian year 1970 - Continued

Name				Right ascension, hr:min:sec	Declination, deg:min:sec	Magnitude
Star no.	IAU designation	Relative brightness and constellation[a]	Common name			
36	ε Peg	ε Pegasi	Enif	21:42:42.7	+9:44:12	2.5
37	α PsA	α Piscis Austrini	Formalhaut	22:55:59.7	-29:46:54	1.3
38	α Ari	α Arietis	Hamal	2:05:28.6	+23:19:17	2.2
39	α For	α Fornacis	--	3:10:47.7	-29:06:16	3.9
40	β Gem	β Geminorum	Pollux	7:43:29.0	+28:06:00	1.2
41	β Car	β Carinae	Miaplacidus	9:12:52.8	-69:35:37	1.8
42	α U Ma	α Ursae Majoris	Dubhe	11:01:53.4	+61:54:48	1.9
43	γ Cen	γ Centauri	--	12:39:51.2	-48:47:43	2.4
44	α Cen	α Centauri	Rigil Kent	14:37:32.9	-60:42:46	0.1
45	α Ori	α Orionis	Betelgeuse	5:53:32.8	+7:24:10	0 to 1.
46	β Cen	β Centauri	Hadar	14:01:41.4	-60:13:45	0.9
47	γ Ori	γ Orionis	Bellatrix	5:23:31.2	+6:19:26	1.7
48	β Tau	β Tauri	El Nath	5:24:23.6	+28:35:01	1.8
49	ε Ori	ε Orionis	Alni Lam	5:34:41.4	-1:13:11	1.7
50	ζ Ori	ζ Orionis	Alnitak	5:39:14.6	-1:57:26	2.0
51	β CMa	β Canis Majoris	Murzim	6:21:22.7	-17:56:24	2.0
52	γ Gem	γ Geminorum	Alhena	6:35:58.8	+16:25:35	1.9
53	ε CMa	ε Canis Majoris	Adhera	6:57:26.8	-28:55:49	1.6
54	δ CMa	δ Canis Majoris	Al Wazor	7:07:10.3	-26:20:40	2.0
55	α Gem	α Geminorum	Castor	7:32:41.2	+31:57:19	1.6
56	ε Car	ε Carinae	Avior	8:21:54.0	-59:24:45	1.7
57	δ Vel	δ Velorum	--	8:43:52.5	-54:35:53	2.0
58	γ Cru	γ Crucis	Gacrux	12:29:29.4	-56:56:44	1.6
59	β Cru	β Crucis	Becrux	12:45:57.3	-59:31:30	1.5
60	ε UMa	ε Ursae Majoris	Alioth	12:52:42.8	+56:07:20	1.7
61	λ Sco	λ Scorpii	Shaula	17:31:34.1	-37:05:01	1.7
62	θ Sco	θ Scorpii	--	17:35:09.6	-42:58:50	2.0
63	ε Sgr	ε Sagittarii	Kaus Aust	18:22:10.8	-34:24:02	1.9
64	β Cas	β Cassiopeiae	Caph	0:07:33.9	+58:59:04	2.4
65	α Phe	α Phoenicis	Ankaa	0:24:48.2	-42:28:08	2.4
66	β And	β Andromedae	Mirach	1:08:02.7	+35:27:43	2.4
67	γ^1 And	γ^1 Andromedae	Almach	2:02:03.0	+42:11:12	2.3
68	δ Ori	δ Orionis	Mintaka	5:30:28.4	-0:19:12	2.5
69	κ Ori	κ Orionis	Saiph	5:46:20.0	-9:40:45	2.2
70	β Aur	β Aurigae	Menkalinan	5:57:19.7	+44:56:47	2.1

[a]The earlier Greek letters are assigned to the stars roughly in order of brightness; there are exceptions. Magnitudes should be used for mission planning.

STAR AND PLANET CATALOGUE - Continued

(a) RTCC star catalogue for Besselian year 1970 - Continued

Star no.	IAU designation		Relative brightness and constellation[a]		Common name	Right ascension, hr:min:sec	Declination, deg:min:sec	Magnitude
71	η	CMa	η	Canis Majoris	Aludra	7:22:54.5	-29:14:37	2.4
72	ζ	Pup	ζ	Puppis	--	8:02:31.8	-39:55:04	2.3
73	λ	Vel	λ	Velorum	Suhail	9:06:53.5	-43:18:39	2.2
74	ι	Car	ι	Carinae	--	9:16:17.3	-59:08:57	2.2
75	β	UMa	β	Ursae Majoris	Merak	11:00:02.5	+56:32:37	2.4
76	ζ	UMa	ζ	Ursae Majoris	Mizar	13:22:43.2	+55:04:53	2.4
77	β	UMi	β	Ursae Minoris	Kochab	14:50:46.5	+74:16:41	2.2
78	γ	Dra	γ	Draconis	Eltanin	17:55:54.5	+51:29:30	2.4
79	γ	Cyg	γ	Cygni	Sadr	20:21:09.0	+40:09:35	2.3
80	α	Gru	α	Gruis	Al Na'ir	22:06:20.9	-47:06:26	2.2
81	β	Gru	β	Gruis	--	22:40:52.9	-47:02:32	2.2
82	α	Cas	α	Cassiopeiae	Schedar	0:38:47.6	+56:22:23	2.3
83	γ	UMa	γ	Ursae Majoris	Phecda	11:52:15.6	+53:51:41	2.5
84	δ	Sco	δ	Scorpii	--	15:58:33.3	-22:32:16	2.5
85	ε	Sco	ε	Scorpii	--	16:48:13.0	-34:14:25	2.4
86	γ	Peg	γ	Pegasi	--	0:11:41.3	+15:01:01	2.9
87	κ	Sco	κ	Scorpii	--	17:40:24.5	-39:00:59	2.5
88	δ	Cas	δ	Cassiopeiae	--	1:23:50.2	+60:04:48	2.8
89	β	Ari	β	Arietis	--	1:52:58.7	+20:39:43	2.7
90	η	Tau	η	Taurui	--	3:45:41.8	+24:00:49	3.0
91	ζ	Per	ζ	Persei	--	3:52:14.5	+31:47:45	2.9
92	ε	Per	ε	Persei	--	3:55:50.1	+39:55:30	3.0
93	ι	Aur	ι	Aurigae	--	4:55:02.2	+33:07:13	2.9
94	β	Eri	β	Eridani	--	5:06:22.4	-5:07:26	2.9
95	β	Lep	β	Leporis	--	5:26:57.6	-20:46:56	3.0
96	α	Lep	α	Leporis	--	5:31:24.4	-17:50:33	2.7
97	ι	Ori	ι	Orionis	--	5:33:57.9	-5:55:42	2.9
98	ζ	Tau	ζ	Tauri	--	5:35:51.0	+21:07:33	3.0
99	α	Col	α	Columbae	--	5:38:33.7	-34:05:21	2.7
100	θ	Aur	θ	Aurigae	--	5:57:40.5	+37:12:44	2.7
101	τ	Pup	τ	Puppis	--	6:49:11.4	-50:34:42	2.8
102	π	Pup	π	Puppis	--	7:16:05.0	-37:02:34	2.7
103	ρ	Pup	ρ	Puppis	--	8:06:15.9	-24:13:01	2.9
104	κ	Vel	κ	Velorum	--	9:21:11.0	-54:52:56	2.6
105	γ^1	Leo	γ^1	Leois	--	10:18:19.3	+19:59:38	2.6
106	μ	Vel	μ	Velorum	--	10:45:28.5	-49:15:41	2.8

[a]The earlier Greek letters are assigned to the stars roughly in order of brightness; there are exceptions. Magnitudes should be used for mission planning.

TABLE STAR AND PLANET CATALOGUE - Continued

(a) RTCC star catalogue for Besselian year 1970 - Continued

	Name					
Star no.	IAU designation	Relative brightness and constellation[a]	Common name	Right ascension, hr:min:sec	Declination, deg:min:sec	Magnitude
107	δ Leo	δ Leois	--	11:12:30.9	+20:41:18	2.6
108	β Crv	β Corvi	--	12:32:48.4	-23:13:52	2.8
109	α Mus	α Muscae	--	12:35:22.6	-68:58:14	2.9
110	γ Vir	γ Virgo	--	12:40:08.3	-1:17:07	2.9
111	α^2 CVn	α^2 Canes Venatici	--	12:54:37.6	+38:28:48	2.9
112	ϵ Vir	ϵ Virginis	--	13:00:41.0	+11:07:12	2.9
113	ι Cen	ι Centauri	--	13:18:54.2	-36:33:17	2.9
114	ϵ Cen	ϵ Centauri	--	13:37:58.5	-53:18:52	2.6
115	η Boo	η Boötis	--	13:53:15.3	+18:32:51	2.8
116	γ Boo	γ Boötis	--	14:30:52.2	+38:26:19	3.0
117	η Cen	η Centauri	--	14:33:35.6	-42:01:37	2.6
118	α Lup	α Luporis	--	14:39:55.5	-47:15:38	2.9
119	ϵ Boo	ϵ Boötis	--	14:43:40.6	+27:11:59	2.7
120	α^2 Lib	α^2 Librae	Zuben'ubi	14:49:12.9	-15:55:05	2.9
121	β Lup	β Lupi	--	14:56:33.5	-43:00:52	2.8
122	β Lib	β Librae	--	15:15:23.3	-9:16:24	2.7
123	γ Lup	γ Lupi	--	15:33:08.0	-41:04:02	2.9
124	α Ser	α Serpentis	----	15:42:47.3	+6:31:08	2.7
125	π Sco	π Scorpii	--	15:57:01.9	-26:01:45	3.0
126	β^1 Sco	β^1 Scorpii	--	16:03:41.3	-19:43:29	2.9
127	η Dra	η Draconis	--	16:23:34.8	+61:34:54	2.9
128	β Her	β Herculis	--	16:28:55.7	+21:33:14	2.8
129	τ Sco	τ Scorpii	--	16:34:00.6	-28:09:19	2.9
130	ζ Oph	ζ Ophiuchi	--	16:35:30.2	-10:30:28	2.7
131	ζ Her	ζ Herculis	--	16:40:09.3	+31:39:22	3.0
132	η Oph	η Ophiuchi	Sabik	17:08:39.3	-15:41:22	2.6
133	β Ara	β Arae	--	17:22:48.0	-55:30:13	2.8
134	ν Sco	ν Scorpii	--	17:28:43.3	-37:16:25	2.8
135	α Ara	α Arae	--	17:29:31.1	-49:51:16	3.0
136	β Dra	β Draconis	--	17:29:45.2	+52:19:22	3.0
137	β Oph	β Ophiuchi	--	17:41:59.3	+4:34:42	2.9
138	δ Sgr	δ Sagittarii	--	18:19:04.4	-29:50:33	2.8
139	λ Sgr	λ Sagittarii	--	18:26:07.1	-25:26:24	2.9
140	ζ Sgr	ζ Sagittarii	--	19:00:42.2	-29:55:29	2.7
141	δ Cyg	δ Cygni	--	19:44:02.1	+45:03:24	3.0
142	γ Aql	γ Aquilae	--	19:44:49.9	+10:32:20	2.8

[a]The earlier Greek letters are assigned to the stars roughly in order of brightness; there are exceptions. Magnitudes should be used for mission planning.

STAR AND PLANET CATALOGUE - Concluded

(a) RTCC star catalogue for Besselian year 1970 - Concluded

Name				Right ascension, hr:min:sec	Declination, deg:min:sec	Magnitude
Star no.	IAU designation	[a] Relative brightness and constellation	Common name			
143	ε Cyg	ε Cygni	--	20:44:59.7	+33:51:25	2.6
144	α Cep	α Cephei	--	21:17:51.8	+62:27:29	2.6
145	δ Cap	δ Capricorni	--	21:45:23.2	-16:15:51	3.0
146	α Tuc	α Tucanae	--	22:16:27.6	-60:24:36	2.9
147	β Peg	β Pegasi	--	23:02:19.0	+27:55:11	2.6
148	α Peg	α Pegasi	Markab	23:03:15.8	+15:02:36	2.6

(b) Planets

No.	Name	Right ascension, hr:min:sec	Declination, hr:min:sec
1	Venus	4:52:16.98	20:01:45.2
2	Mars	15:59:22.95	-24:01:01.5
3	Jupiter	12:04:13.881	0:52:22.31
4	Saturn	2:25:56.208	11:54:00.30

[a]The earlier Greek letters are assigned to the stars roughly in order of brightness; there are exceptions. Magnitudes should be used for mission planning.

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12.0 REFERENCES

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APPENDIX

MAJOR APOLLO F AND G MILESTONES

FOR THE CONTINGENCY ANALYSIS SECTION

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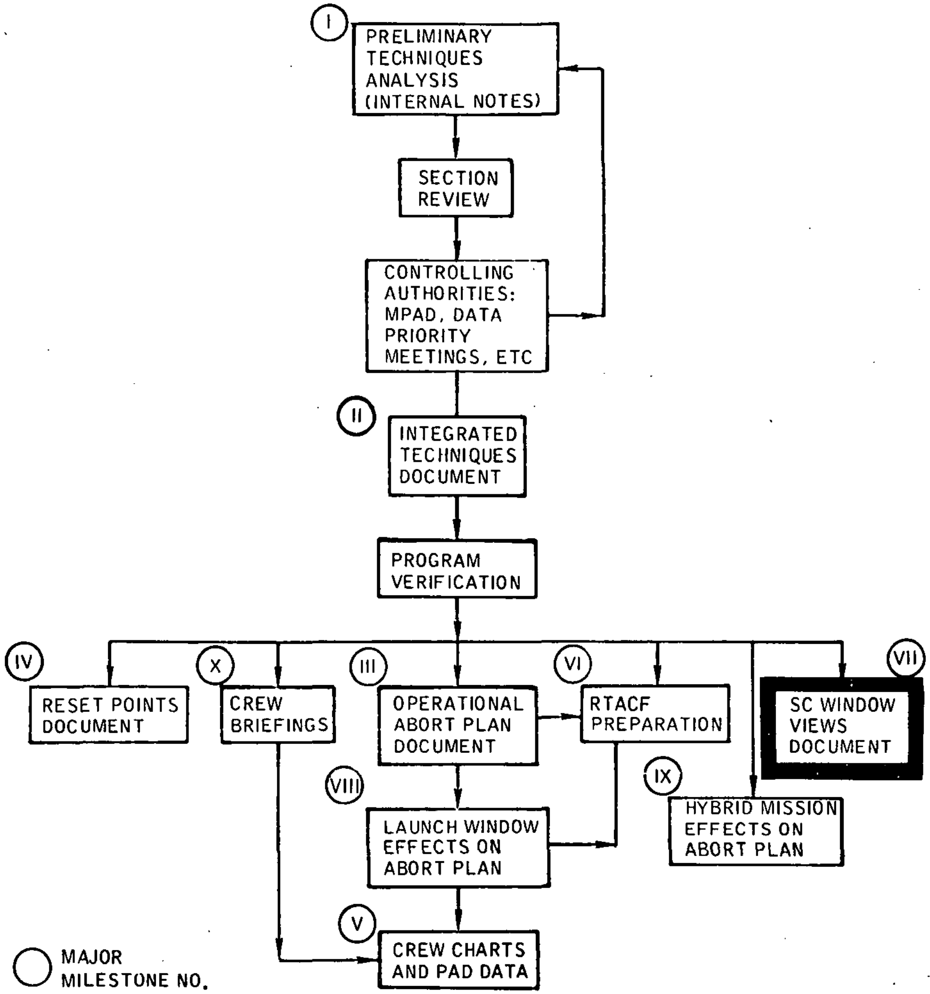

MAJOR MILESTONES

I. PRELIMINARY CONTINGENCY TECHNIQUES
(PRELIMINARY PROCEDURES TO BE FOLLOWED BY CREW AND GROUND)

II. INTEGRATED CONTINGENCY (ABORT) TECHNIQUES DOCUMENT
(DEFINES DETAILED PROCEDURES TO BE FOLLOWED BY CREW AND GROUND)

III. OPERATIONAL ABORT PLAN DOCUMENT
(PROVIDES DETAILED ABORT SOLUTIONS AND ASSOCIATED DATA FOR THE PRIMARY LAUNCH OPPORTUNITY)

IV. RESET POINTS DOCUMENT
(INSURES CREW/RTCC SIMULATION OF ABORTS ARE COMPATIBLE AND PROVIDES DRIVER FOR SIMULATION)

V. CREW CHARTS AND PAD DATA
(PROVIDES FINAL PLOTS AND CHARTS CREW NEEDS TO CARRY OUT OPERATIONAL ABORT PLAN; INCLUDES LAUNCH, TLI MONITOR, TLI + 10 MIN ABORT AND LOI 15 MIN ABORT CHARTS)

VI. RTACF PREPARATION
(INSURES REAL TIME OPERATIONAL COMPUTER SUPPORT REQUIREMENTS WILL BE MET)

VII. SC WINDOW VIEWS DOCUMENT
(PROVIDES STARFIELD, EARTH-MOON TERMINATOR, AND HORIZON SCHEMATICS FOR CREW FAMILIARIZATION AND INDEPENDENT MANEUVER ATTITUDE CHECKS)

VIII. LAUNCH WINDOW EFFECTS ON THE OPERATIONAL ABORT PLAN (DOCUMENT)
(INSURES ADEQUACY OF ABORT PLAN FOR LAUNCH WINDOW VARIATIONS)

IX. HYBRID MISSION EFFECTS ON THE OPERATIONAL ABORT PLAN
(SUPPLEMENTS ABORT PLAN FOR TRAJECTORY AND PROCEDURE CHANGES DUE TO A HYBRID PROFILE)

X. CREW BRIEFINGS
(EXPLANATION OF PROCEDURES AND ONBOARD ABORT CHARTS)

Flow chart 1.- Major Apollo F and G milestones for the Contingency Analysis Section.