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PROJECT GEMINI

ORBITAL PARAMETER PLOTS FOR USE IN MISSION PLANNING

By: Charles E. Allday

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MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

October 15, 1965

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1.0 INTRODUCTION

1.1 This document presents several orbital parameter plots for use in mission planning and mission support. The plots were constructed by Flight Analysis Branch in February, 1965 and were first published in the preflight trajectory report for the Gemini III mission. Since that date, some or all of the plots have been used in various Gemini reports.

2.0 MATHEMATICAL METHOD

2.1 The equation used to generate constant apogee and perigee curves is

$$V = \left[\frac{2 R^* \mu (R-R^*)}{R (R^2 \cos^2\gamma - (R^*)^2)} \right]^{\frac{1}{2}}$$

where

h = altitude, n. mi.

R_e = earth radius = 3441. n. mi.

γ = flight-path angle incremented from -3.2° to $+3.2^\circ$

R = orbit radius = $R_e + h$

h_a = apogee altitude, n. mi.

h_p = perigee altitude, n. mi.

R^* = orbit radius at apogee $(R_e + h_a)$ or orbit radius at perigee $(R_e + h_p)$, whichever is desired

$\mu = 1.40765 \times 10^{16}\ ft^3/sec^2$

2.2 The equation used to generate the constant true anomaly curves is

$$V = \left[\frac{\mu \sin\theta \sin(\gamma-\theta)}{R \cos\gamma (\cos^2\theta - \cos^2\gamma)} \right]^{\frac{1}{2}}$$

where

θ = true anomaly, 20° to 160°

γ = flight-path angle incremented from 0° to $+3.2^\circ$

True anomaly curves for 200° to 340° are generated by symmetry with respect to the $\gamma = 0$ ($\theta = 180^\circ$, 360°) line. For example, to generate the curve $\theta = 240^\circ$, computations are made for $\theta = 120^\circ$ and $\gamma = 0^\circ$ to $+3.2^\circ$, and the points $(V, -\gamma)$ are plotted.

2.3 Keplerian period versus velocity is determined from the equation

$$T = \frac{\pi}{30} \left(\frac{a^3}{\mu}\right)^{\frac{1}{2}}$$

where

$$a = \frac{R\mu}{2\mu - RV^2}$$

3.0 RESULTS

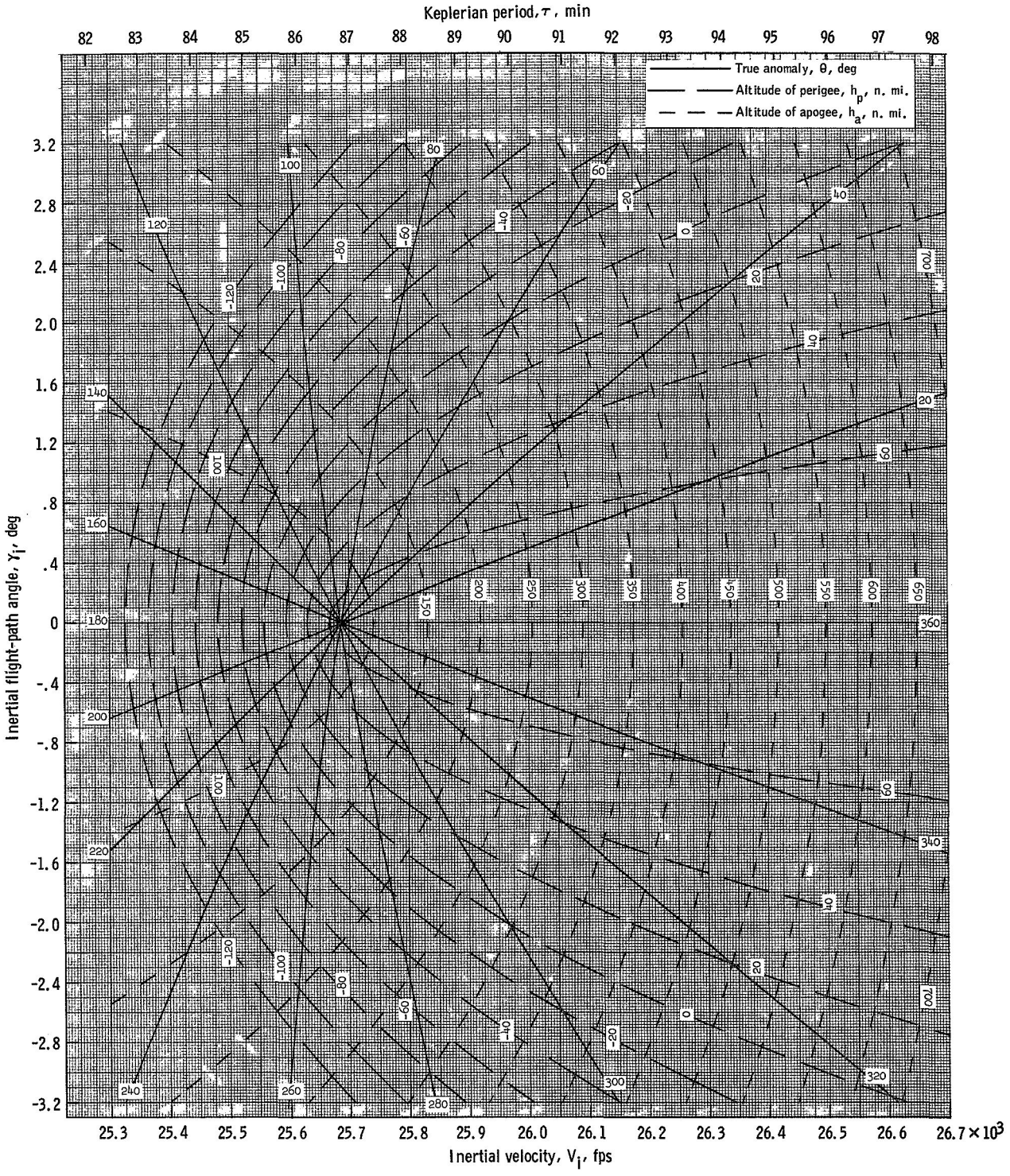
3.1 Plots of true anomaly, apogee altitude, and perigee altitude as a function of inertial velocity and inertial flight-path angle are shown in figure 1. There is one plot for each altitude.

The altitudes were chosen to be consistent with those used in the Gemini Project.

3.2 Keplerian period as a function of inertial velocity is also shown at the top of each plot.

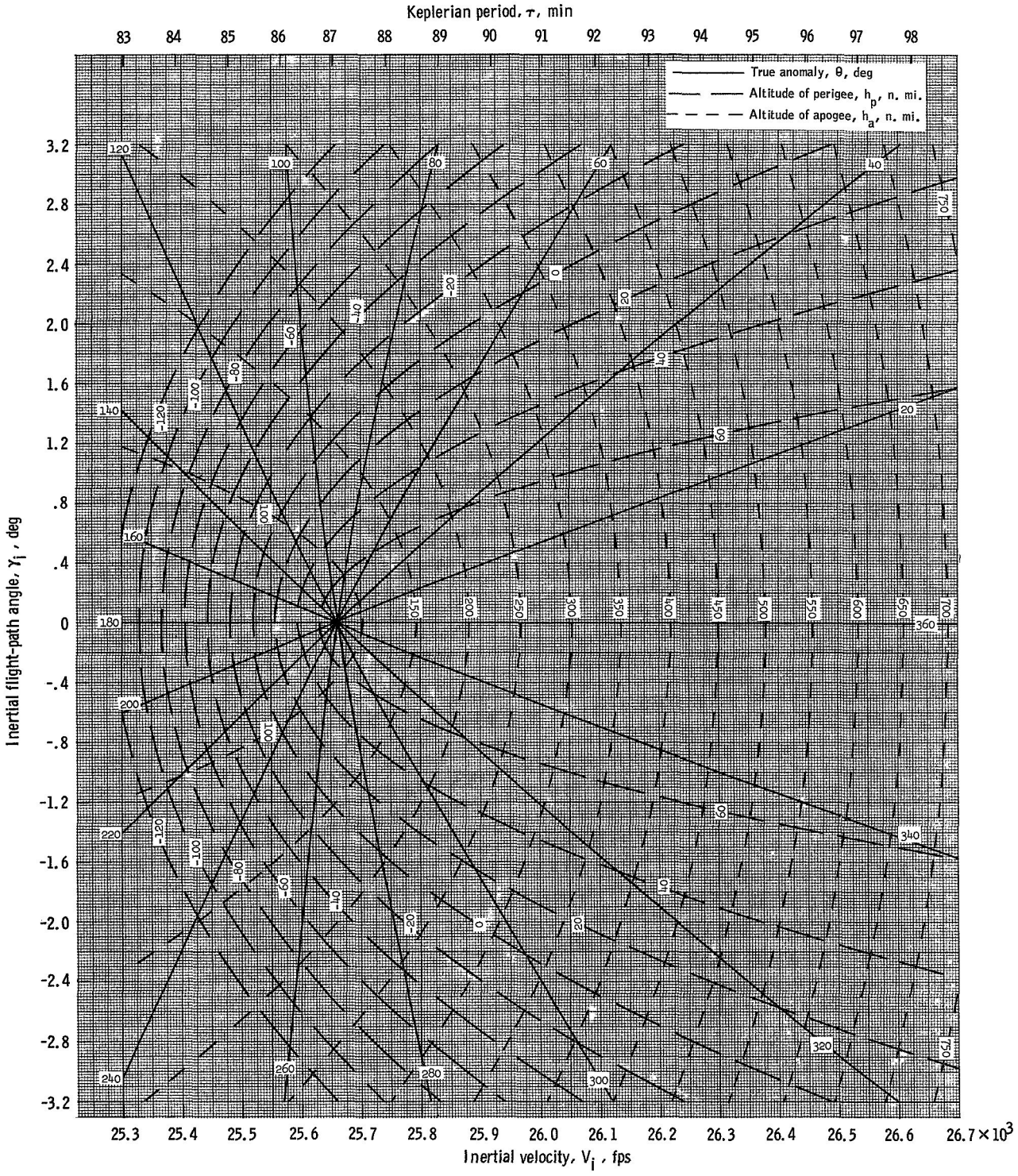
3.3 These plots can be used to determine the relationships between the six orbital parameters, h, V, γ, h_a, h_p, and θ. That is, if h, V, and γ are known, h_a, h_p, and θ can be determined. For example, if h = 70 n. mi., V = 26500 fps, and $\gamma = 1.8^\circ$, then the values h_a = 125 n. mi., h_p = 20 n. mi., and $\theta = 50^\circ$ can be read from figure 1-(a). Moreover, if h, h_a, and h_p are known, V, γ, and θ can be determined. For example, if h = 87 n. mi., h_p = 60 n. mi., and h_a = 200 n. mi., then V = 25780 fps, $\gamma = .88^\circ$, and $\theta = 53^\circ$ can be found from figure 1-(d).

It can also be noted that the Keplerian period is 86.4 minutes and 89.2 minutes, respectively, in the two examples.



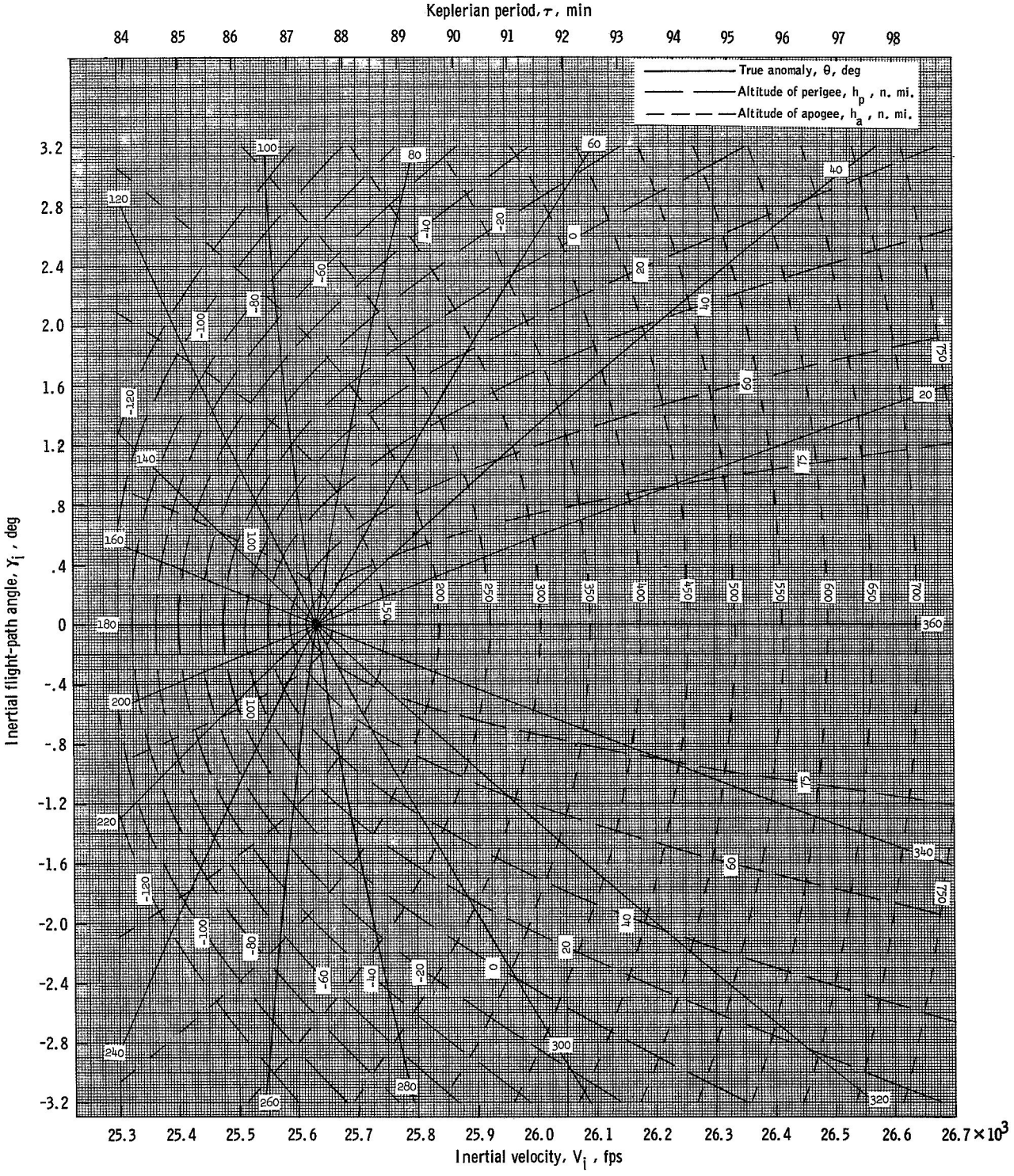
(a) 70 nautical mile altitude.

Figure 1.- True anomaly, apogee altitude and perigee altitude as a function of inertial velocity and inertial flight-path angle for various altitudes.



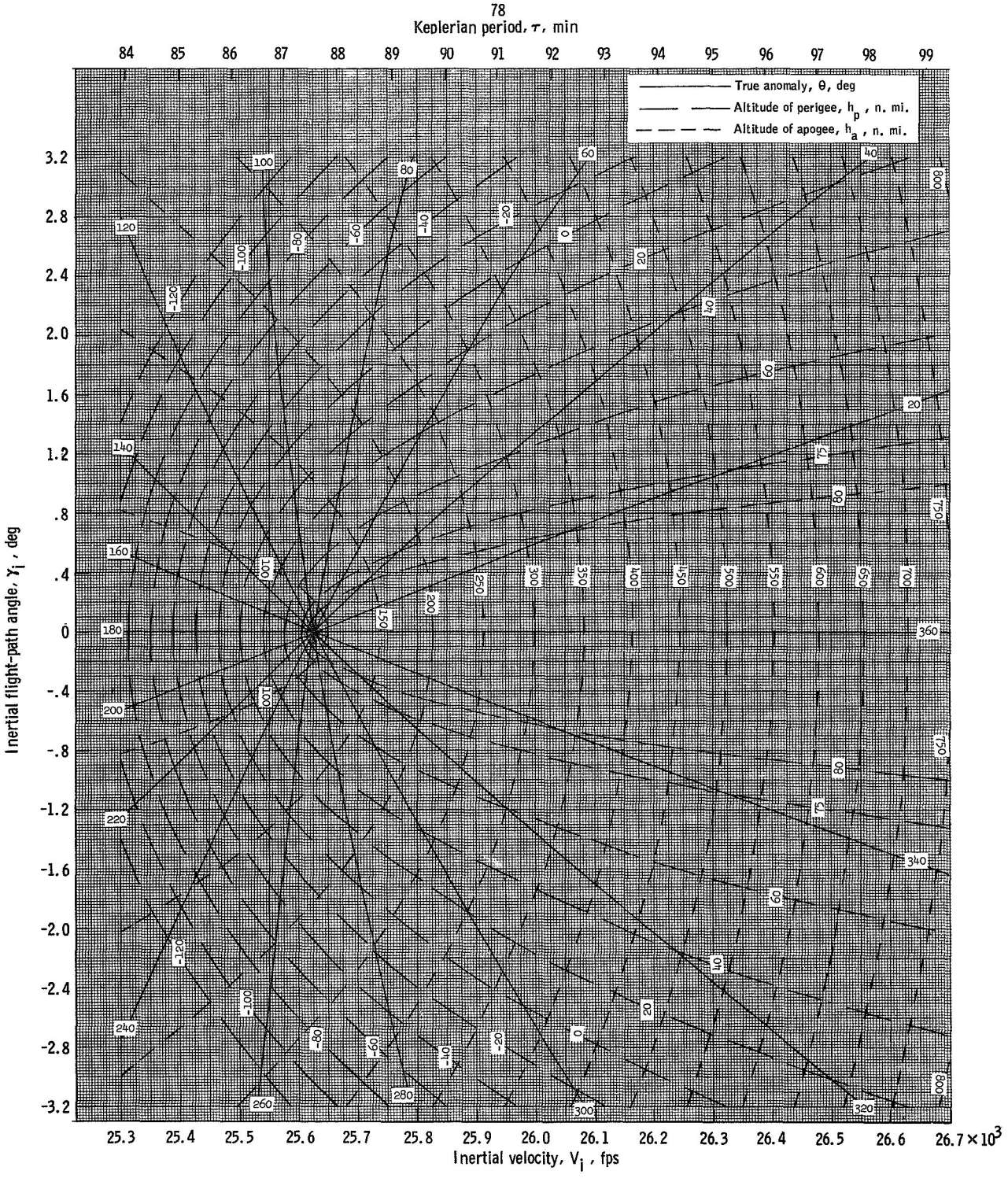
(b) 77 nautical mile altitude.

Figure 1.- Continued.



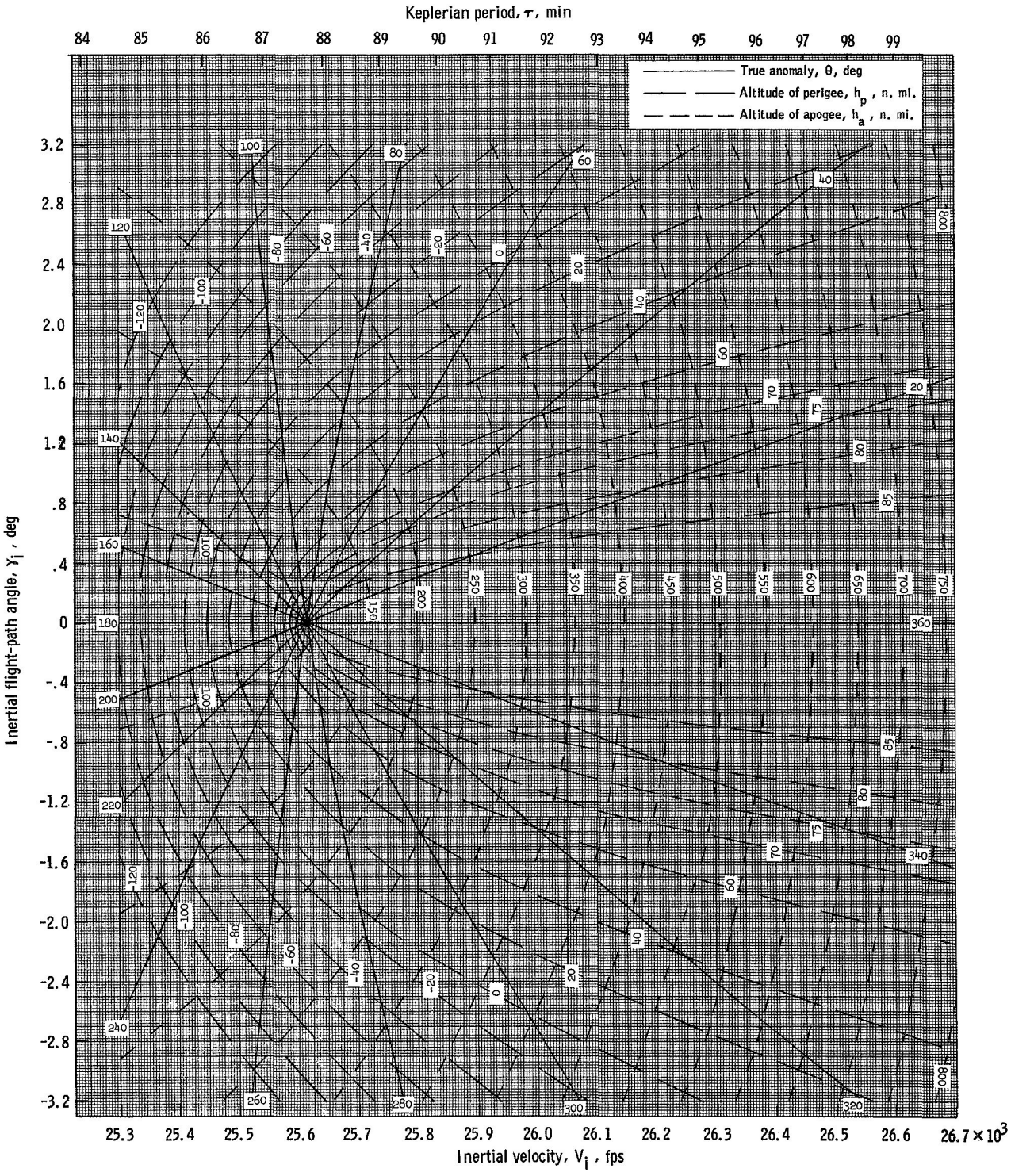
(c) 85 nautical mile altitude.

Figure 1. - Continued.



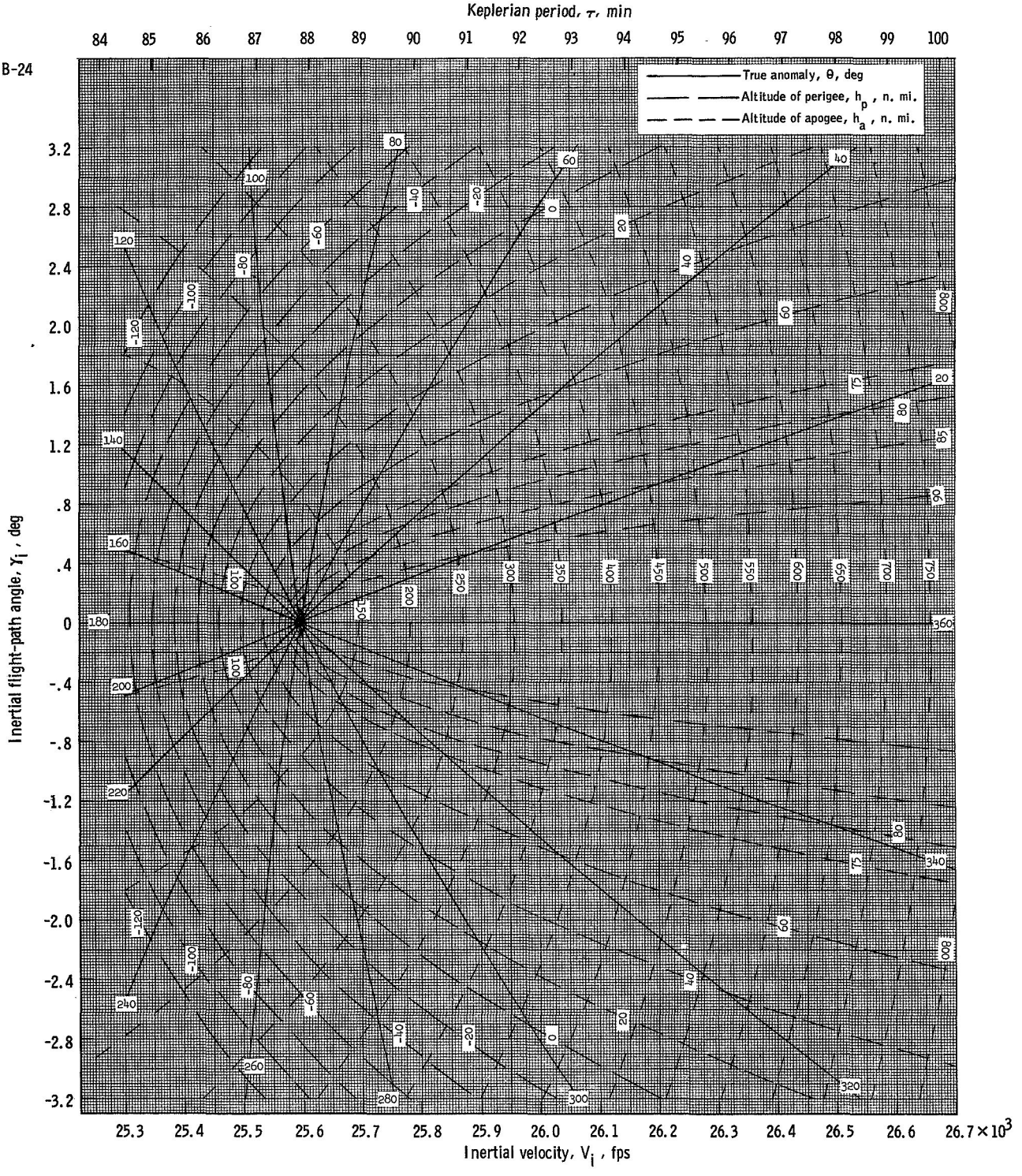
(d) 87 nautical mile altitude.

Figure 1. - Continued.



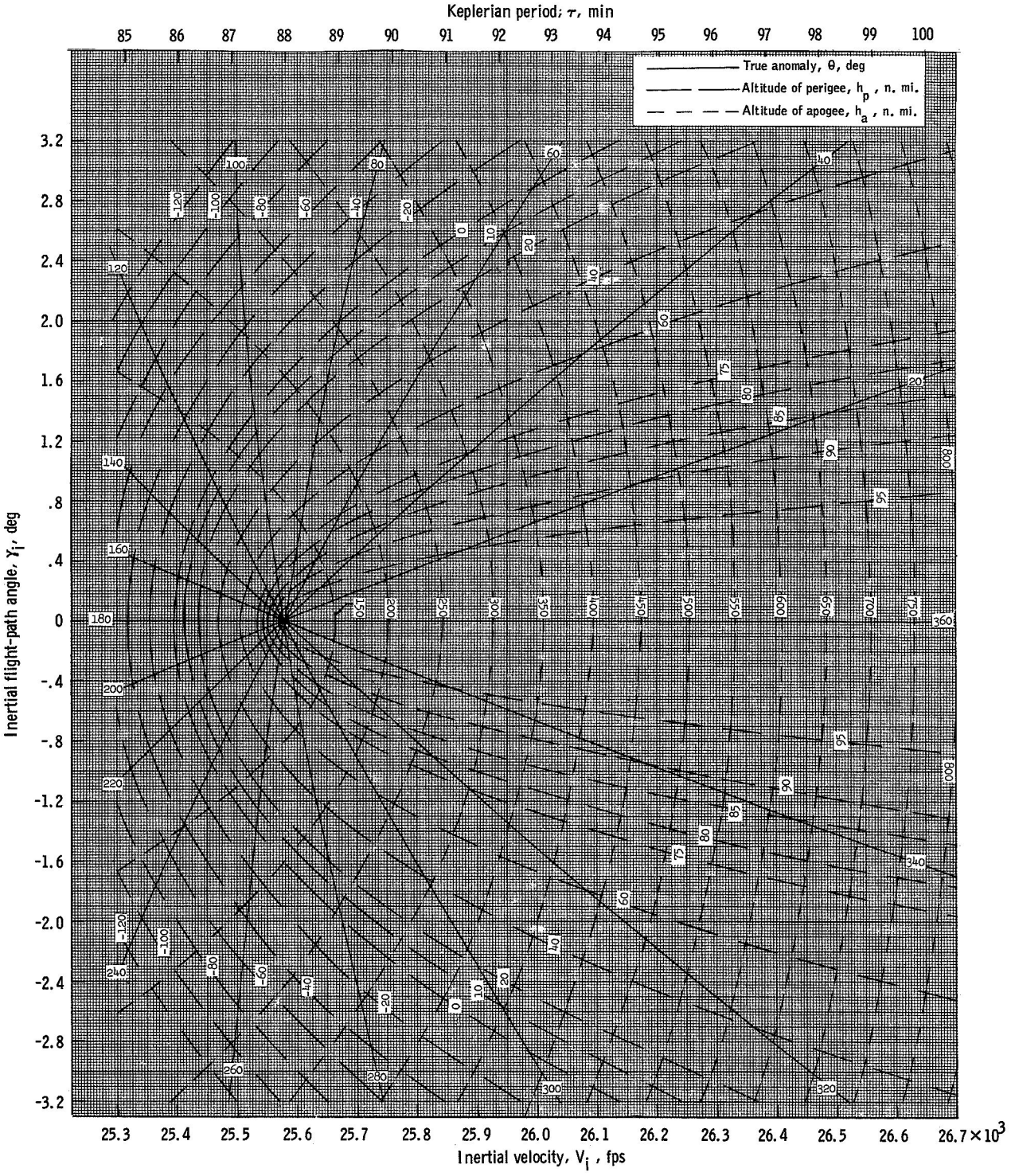
(e) 90 nautical mile altitude.

Figure 1. - Continued.



(f) 95 nautical mile altitude.

Figure 1. - Continued.



(g) 100 nautical mile altitude.

Figure 1. - Concluded.