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APRIL 6, 1967

PARAMETRIC REENTRY STUDY OF ELLIPTIC EARTH ORBITS WITH APOGEES UP TO 10 000 NAUTICAL MILES

By William R. Pruett

Flight Analysis Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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PARAMETRIC REENTRY STUDY OF ELLIPTIC

EARTH ORBITS WITH APOGEES UP TO 10 000 NAUTICAL MILES

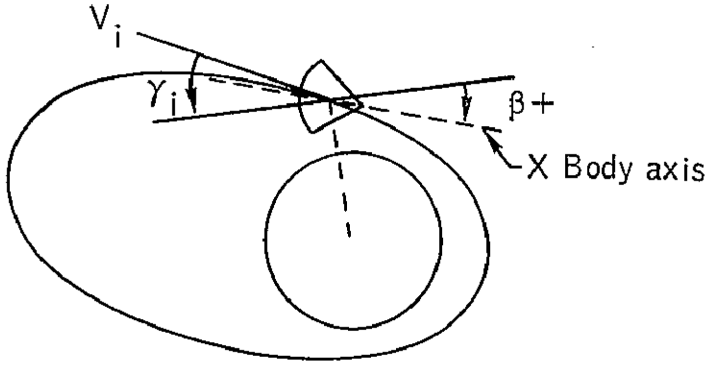
By William R. Pruett

SUMMARY AND INTRODUCTION

This document is presented as an extension of several similar internal notes which have been published as an aid in general mission planning (ref. 1 through 5). Since these earlier internal notes consider only circular and low elliptic orbits, it was thought desirable to publish a similar study on high elliptic orbits. Therefore, this document considers elliptic orbits with perigees up to 200 n. mi. and apogees up to 10 000 n. mi. For each orbit considered, various retrofire ΔV's were used every 10° in true anomaly from 0° to 360°. Also, retrograde pitch angles of 0°, 10°, 20°, 30°, 40°, and 50° were used for each ΔV.

MATHEMATICAL MODEL

Keplerian equations, a spherical rotating earth, and instantaneous velocity changes were used in this study. The Keplerian solutions were obtained from a general elliptical orbit and reentry program, E042. A reentry altitude of 400 000 ft and a circular earth with a radius of 20 907 447 ft were used. Beta angles are measured positive clockwise from the local horizontal as indicated in the figure below.

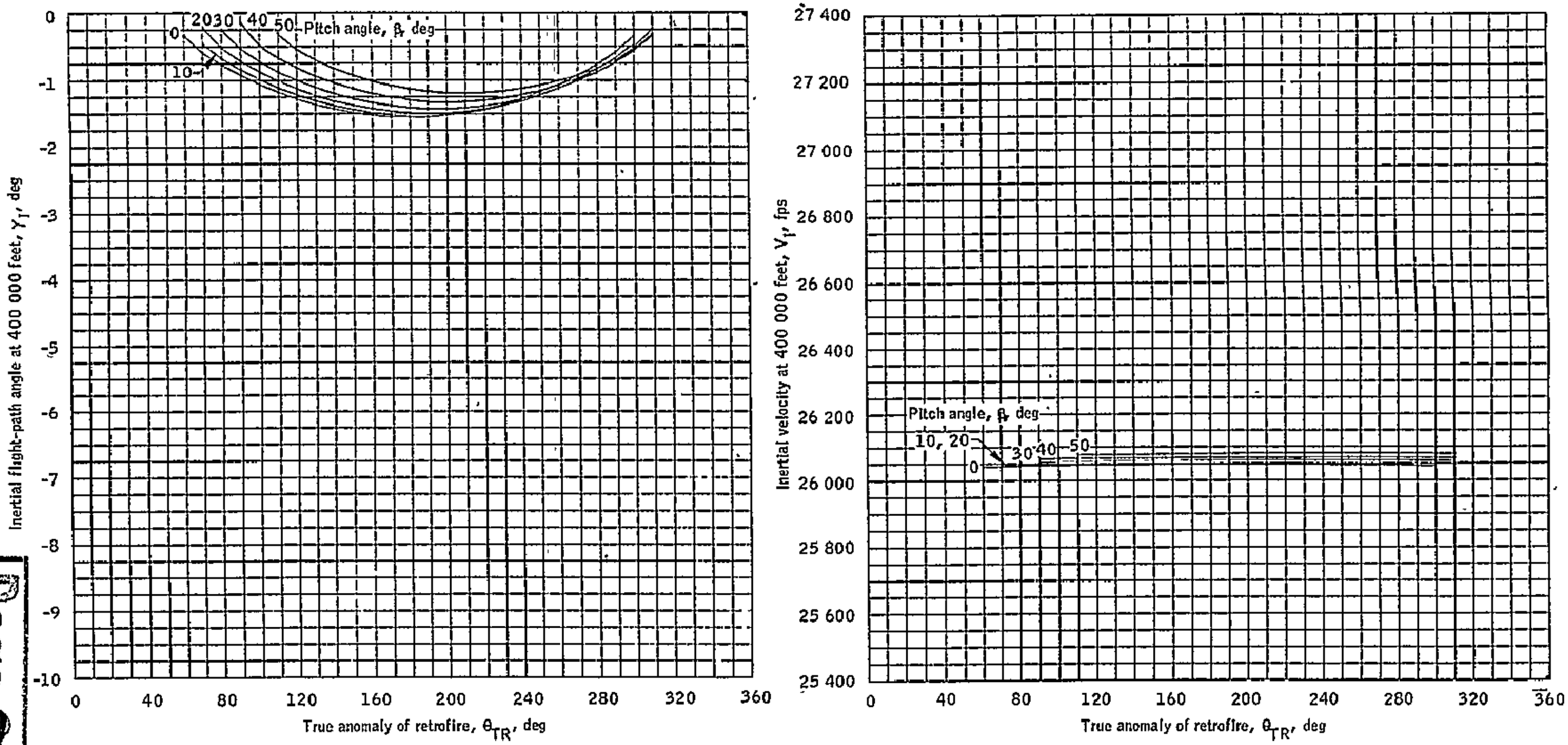


DISCUSSION OF RESULTS

The results of the study are presented in 43 figures of inertial velocity at 400 000 ft, inertial flight-path angle at 400 000 ft, time from retrofire to 400 000 ft, and central angle of travel (orbit referenced) from retrofire to 400 000 ft. All of these parameters are plotted as a function of true anomaly of retrofire. The various pitch angle curves are found on each plot. A complete set of figures is provided for each orbit and ΔV considered.

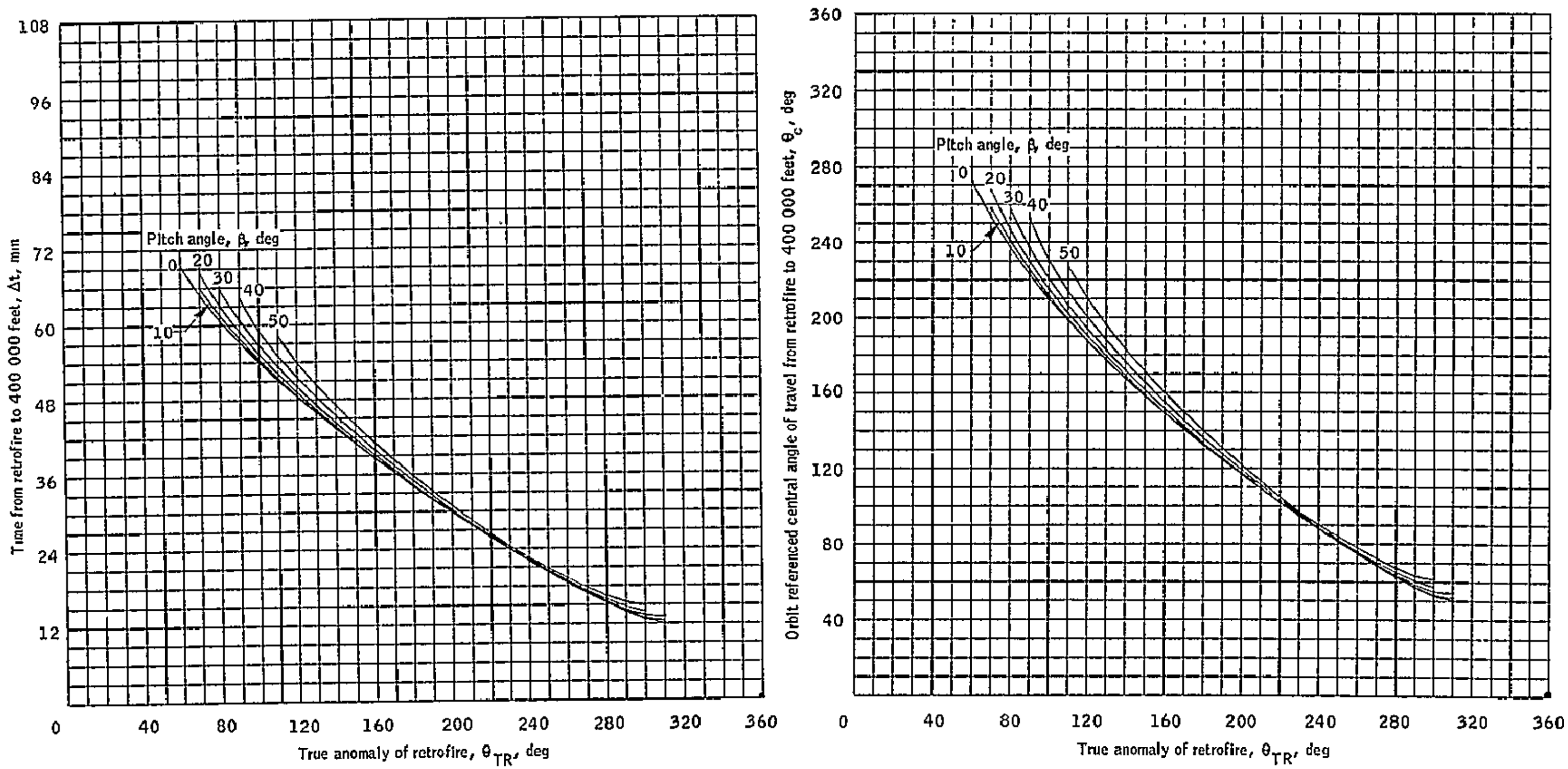
It should be noted that for the orbits with apogees less than 1000 n. mi., ΔV's of from 100 fps to 700 fps were used, while ΔV's from 100 fps to 2100 fps were used for the orbits with apogees from 2000 n. mi. to 10 000 n. mi. This was done in order to present the most valuable picture of reentries throughout the entire orbit without using unrealistic ΔV's for the orbit being considered. However, for the higher apogees, ΔV's of 2100 fps were still not sufficient to reenter from the perigee region. Therefore, figures 43 (a) through (e) were prepared to indicate the ΔV's needed in this region.

The figures present the minimum ΔV needed at perigee to achieve a reentry. There is a figure for each perigee altitude considered in the document, and the apogee altitudes are used as the parameter which ΔV is plotted against. Thus, for any of the orbits in this document, one may determine the minimum ΔV needed at perigee to reenter. Naturally, these reentries would have flight-path angles near 0° at 400 000 ft, and the ΔV needed to achieve such a reentry would be the minimum ΔV needed to be assured of reentry capability from anywhere in the orbit.



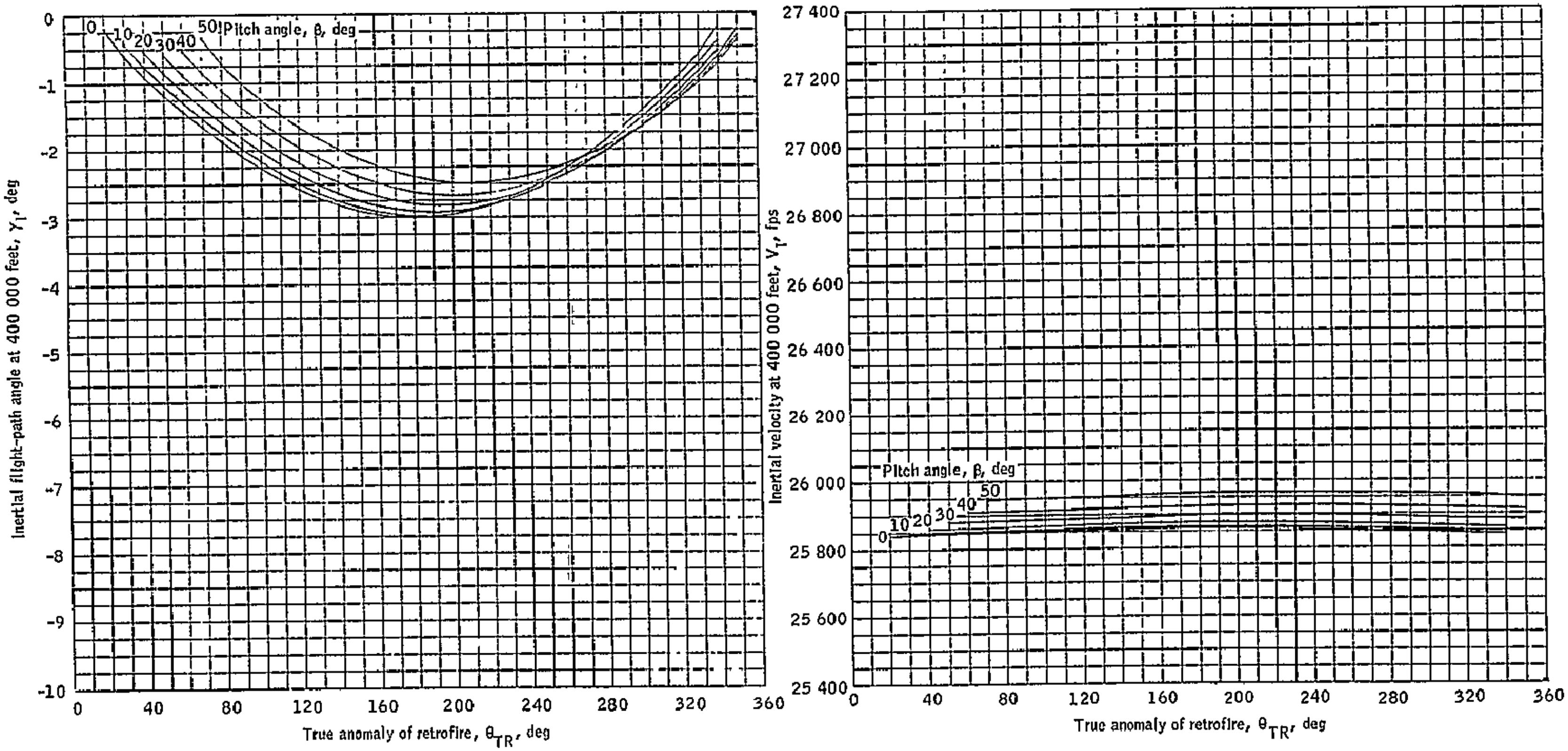
(a) Flight-path angle and velocity for retrograde ΔV = 100 feet per second.

Figure 1.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for a 80/300 nautical mile orbit.



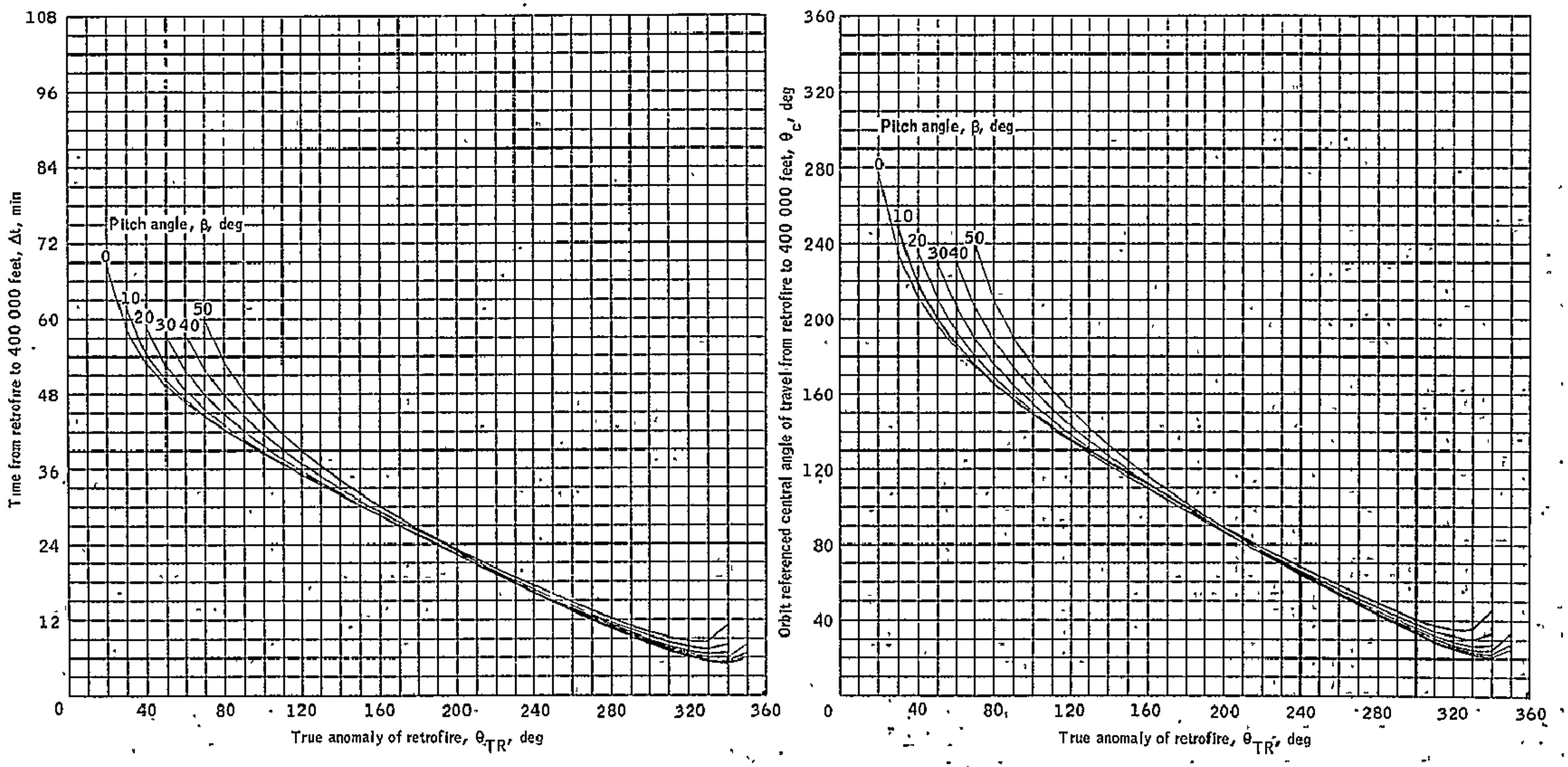
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

Figure 1.- Continued.



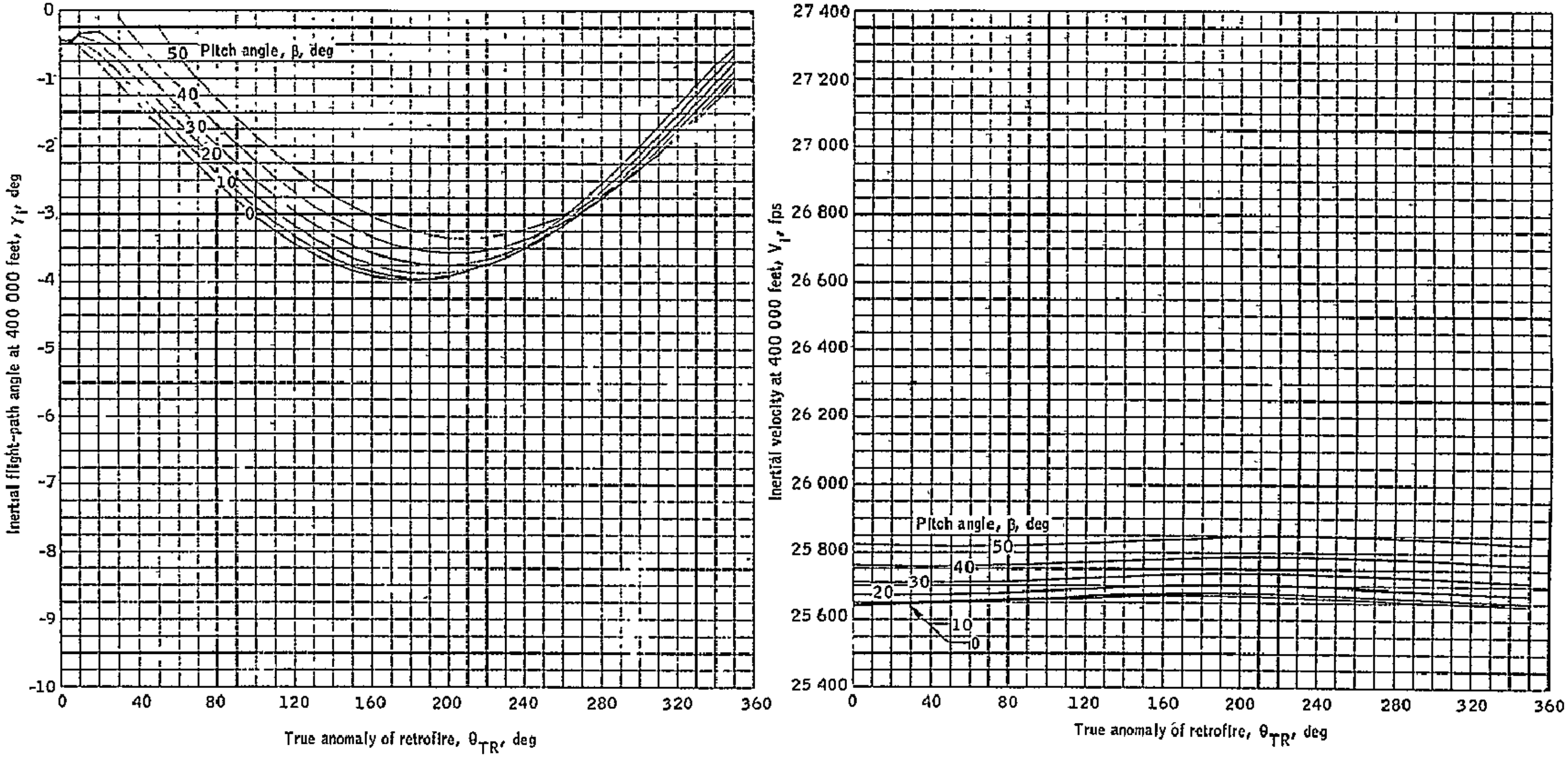
(c) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

Figure 1.- Continued.



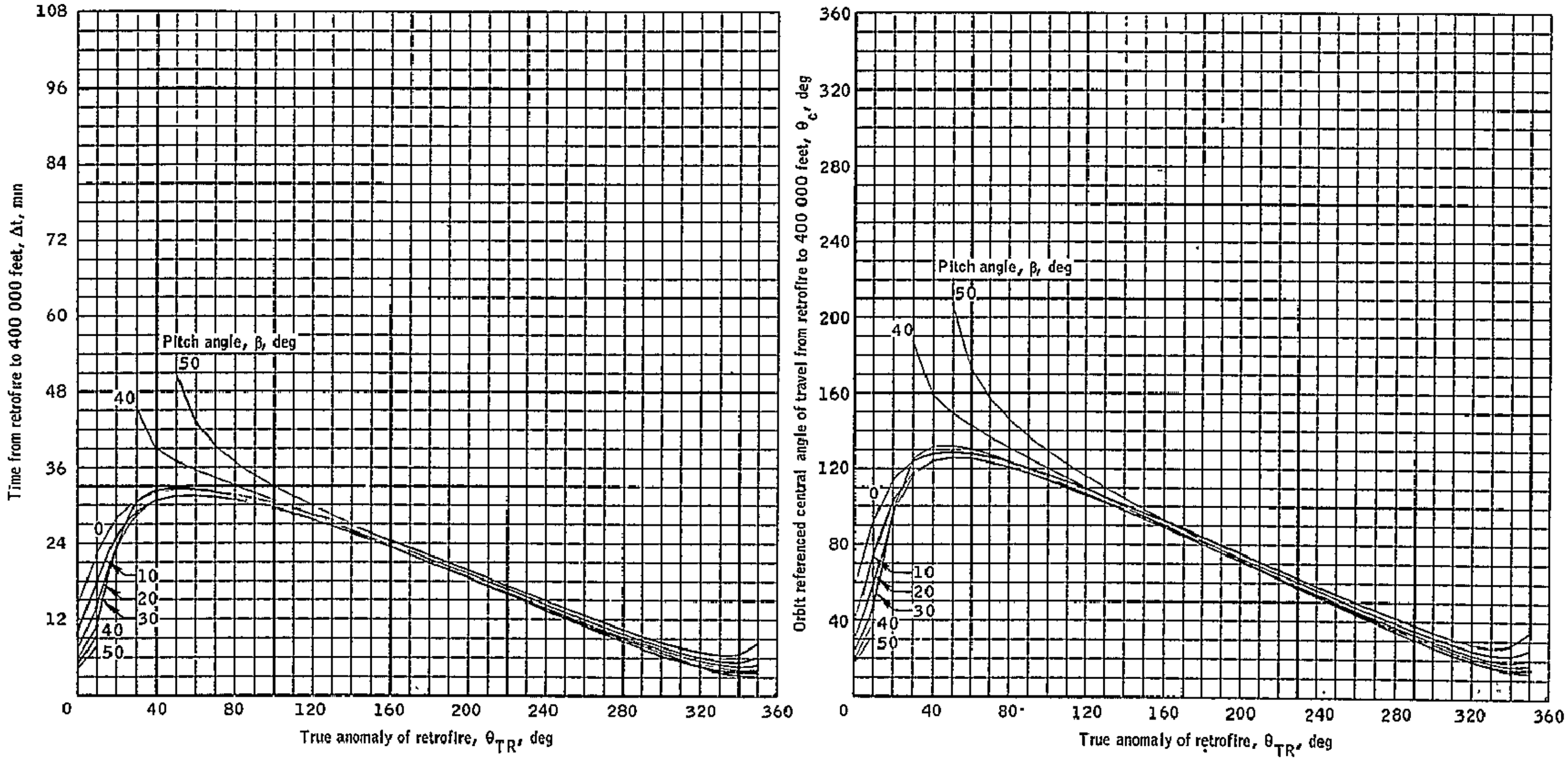
(d) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

Figure 1.- Continued.



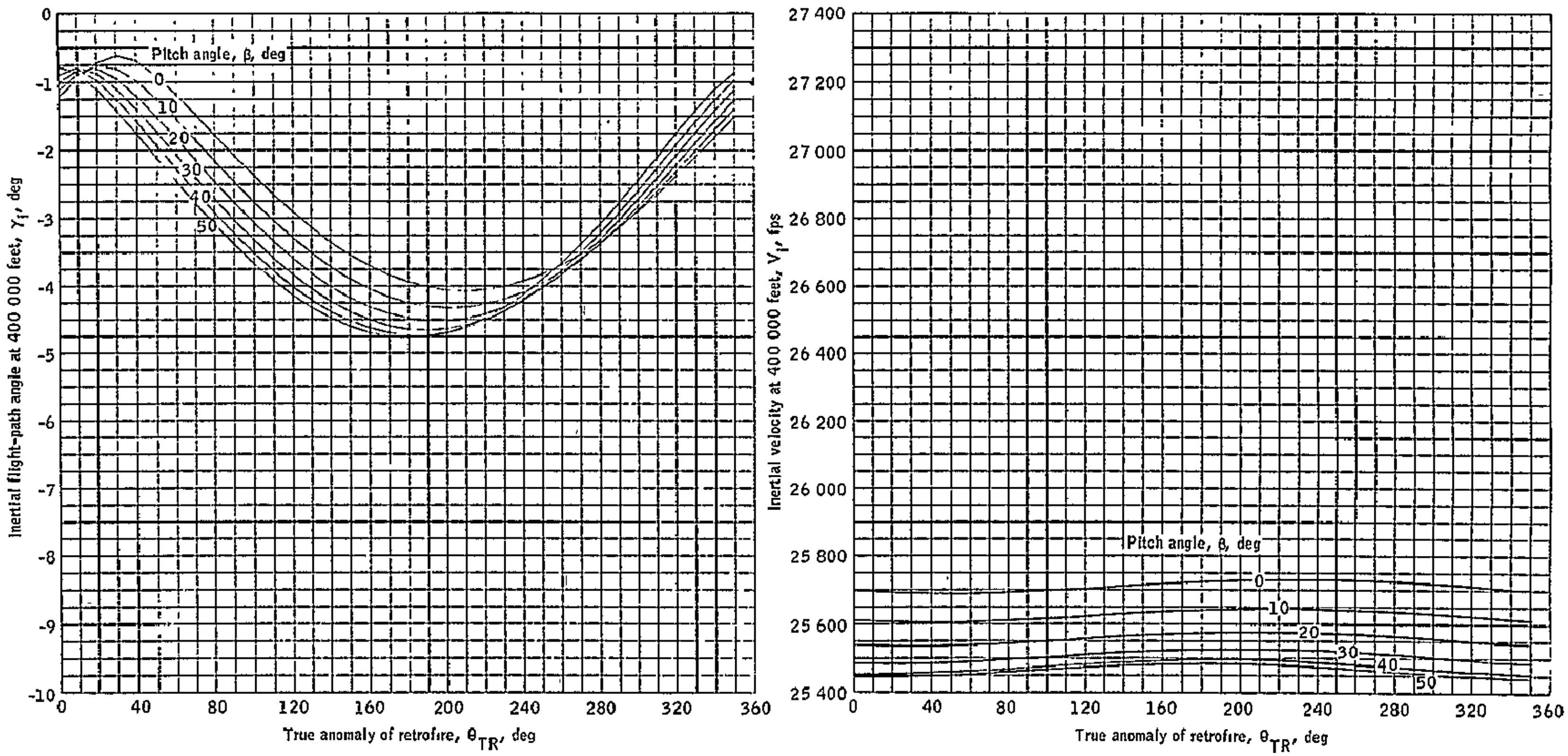
(c) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

Figure 1.- Continued.



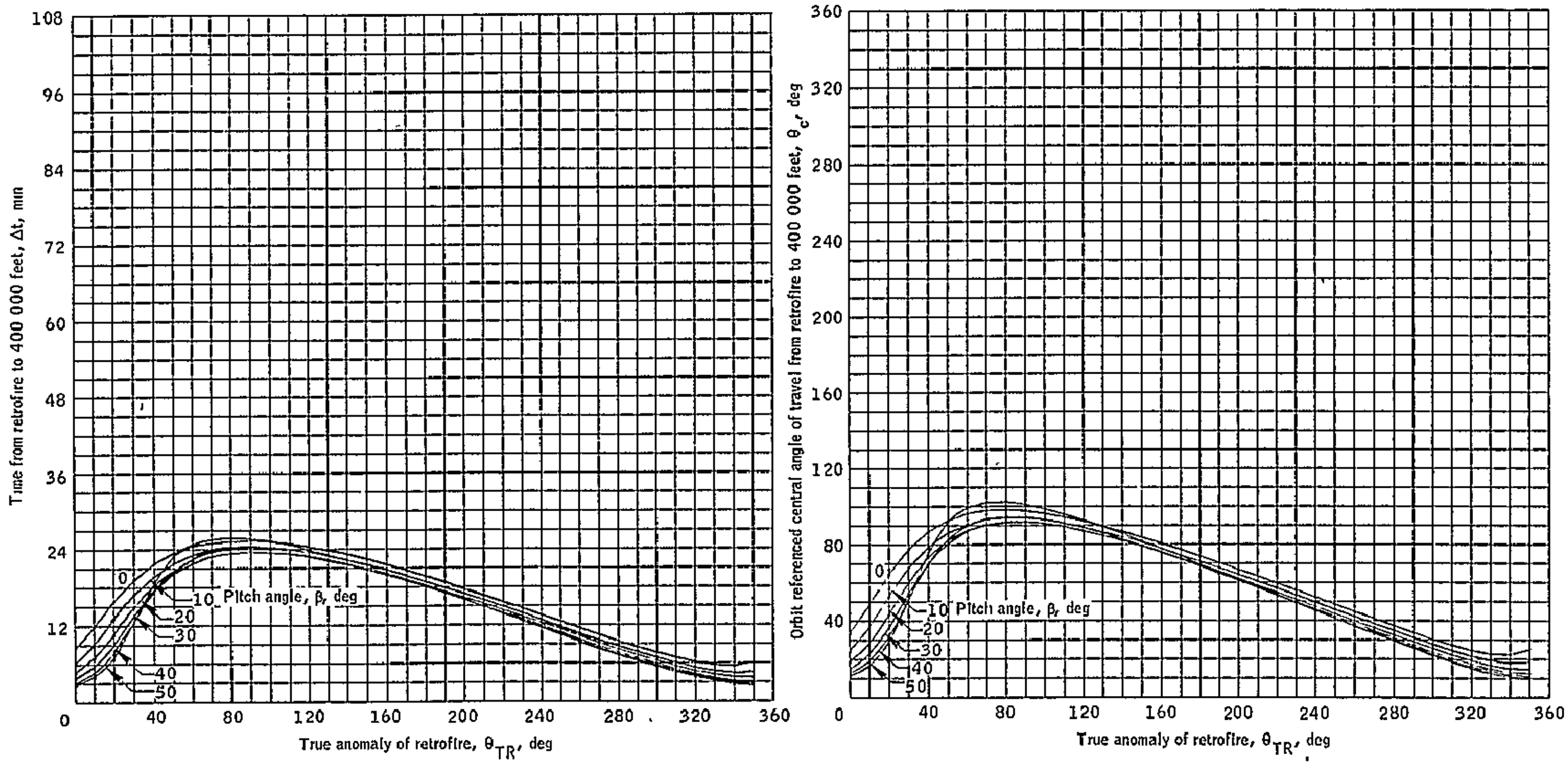
(f) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 1.- Continued.



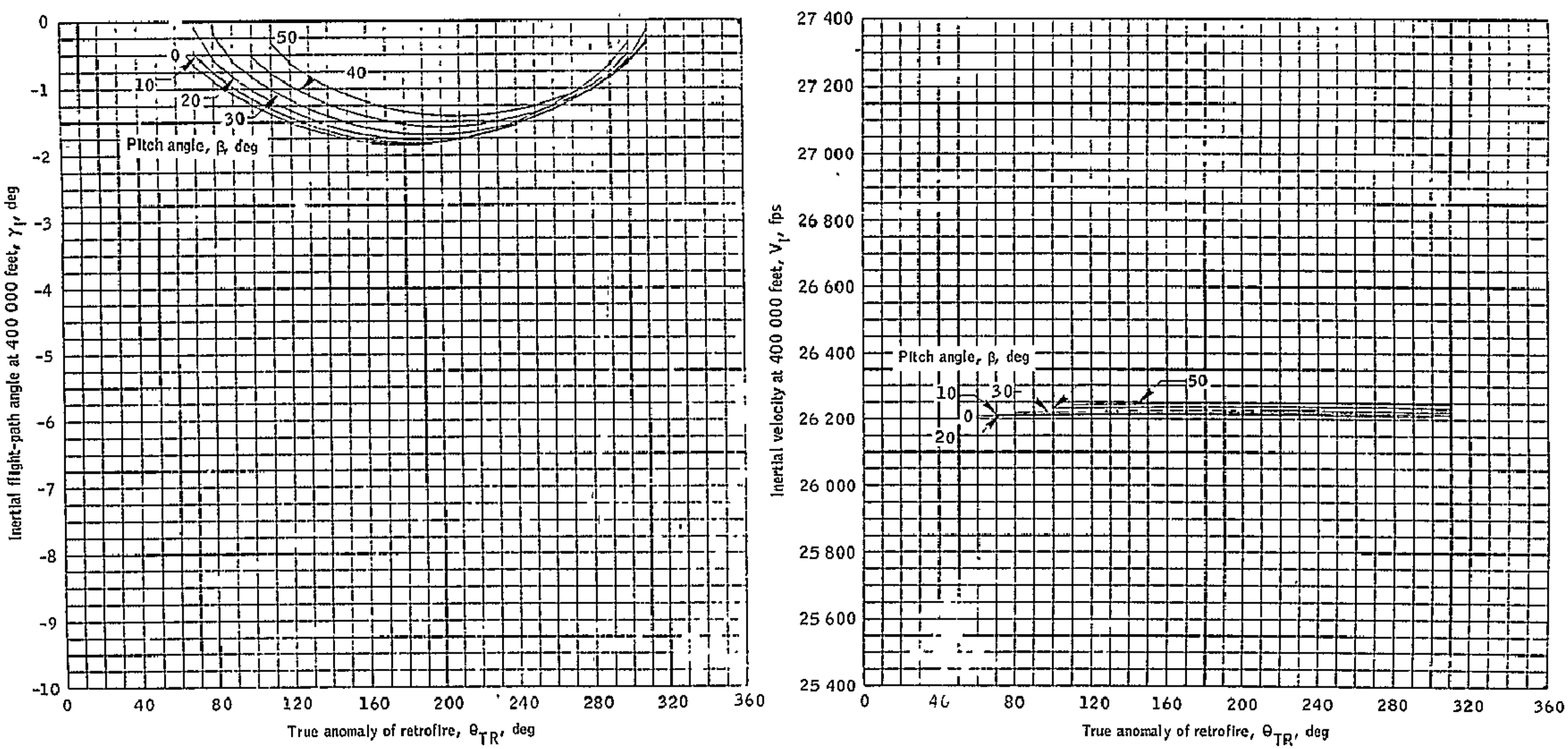
(g) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 1.- Continued.



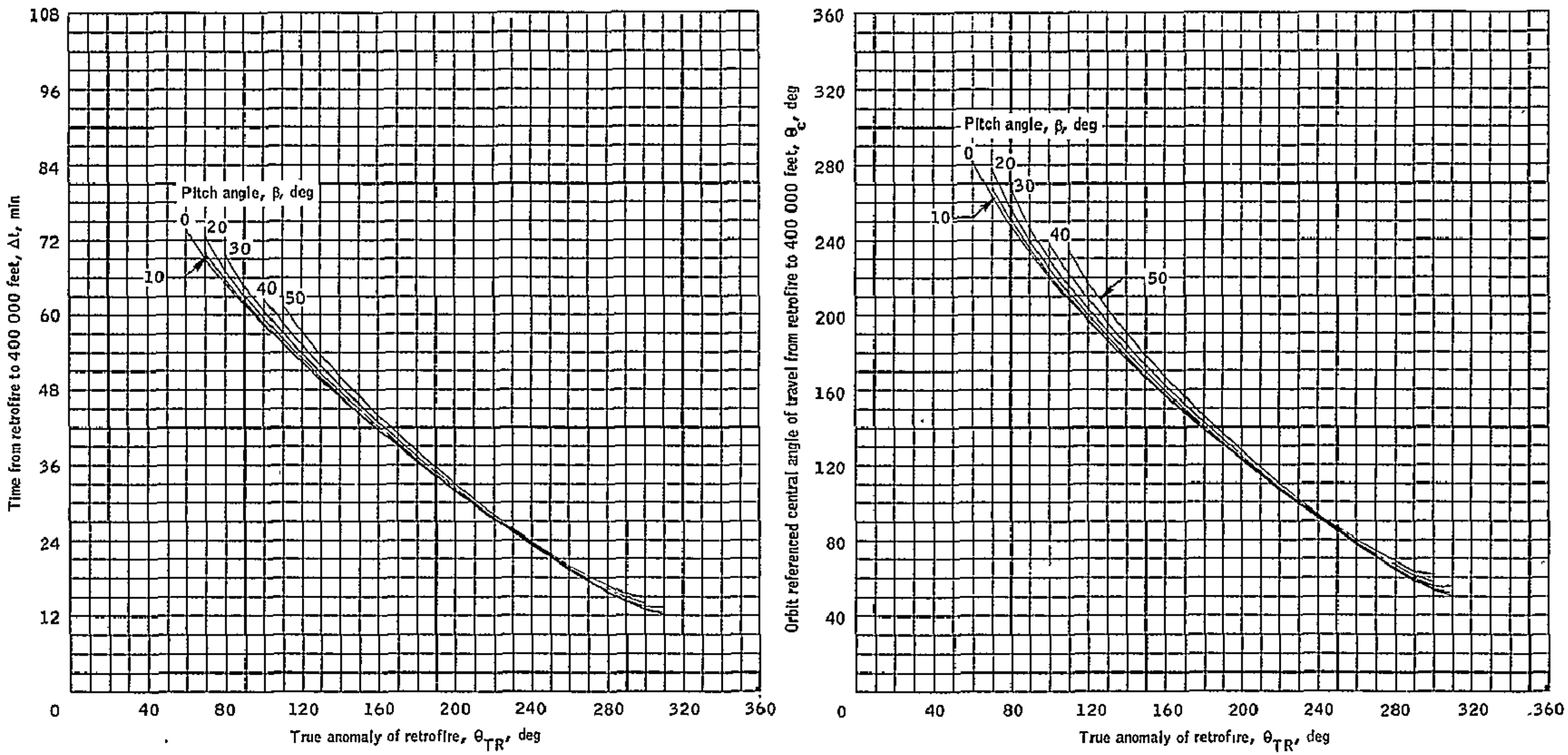
(h) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

Figure 1.- Concluded.



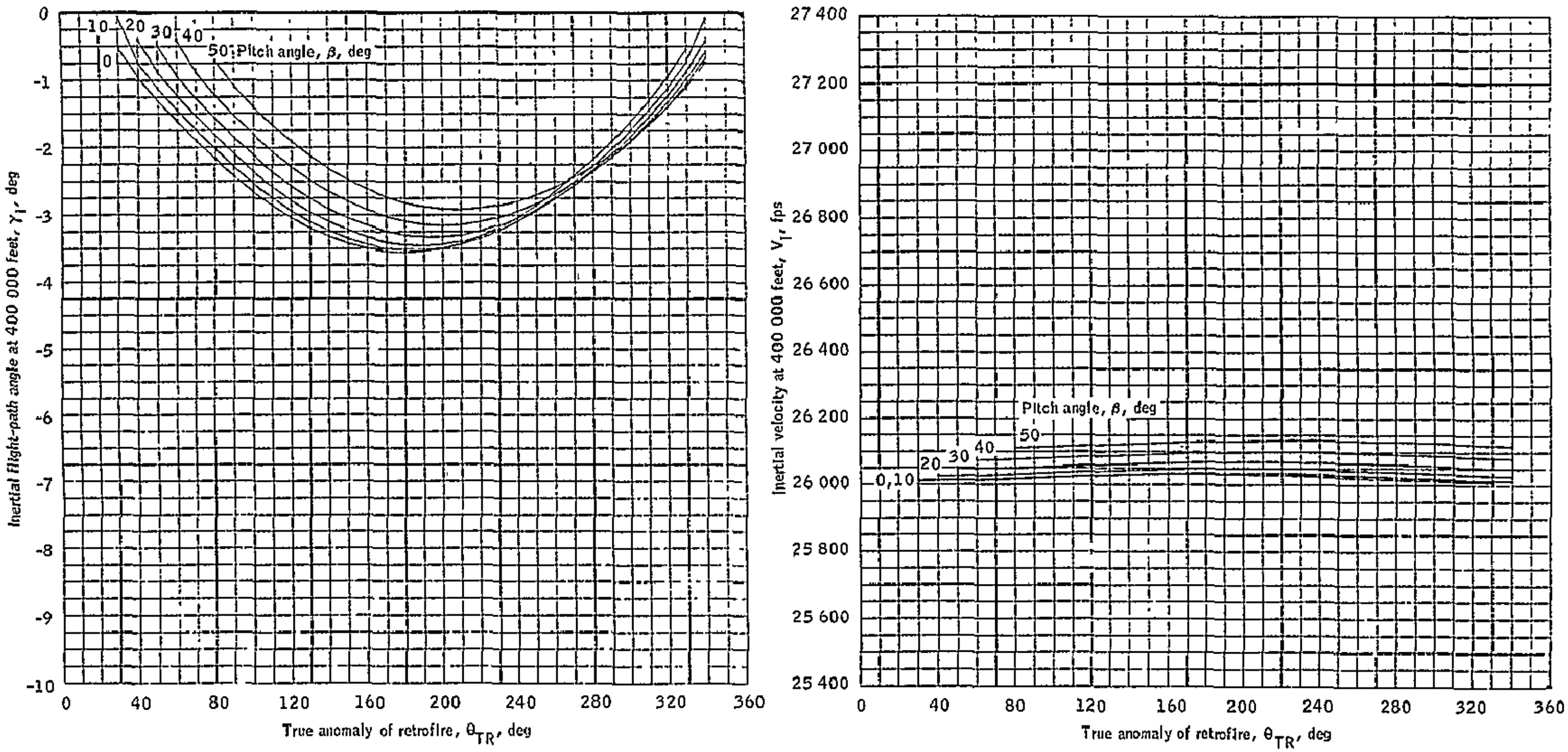
(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

Figure 2.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 80/400 nautical mile orbit.



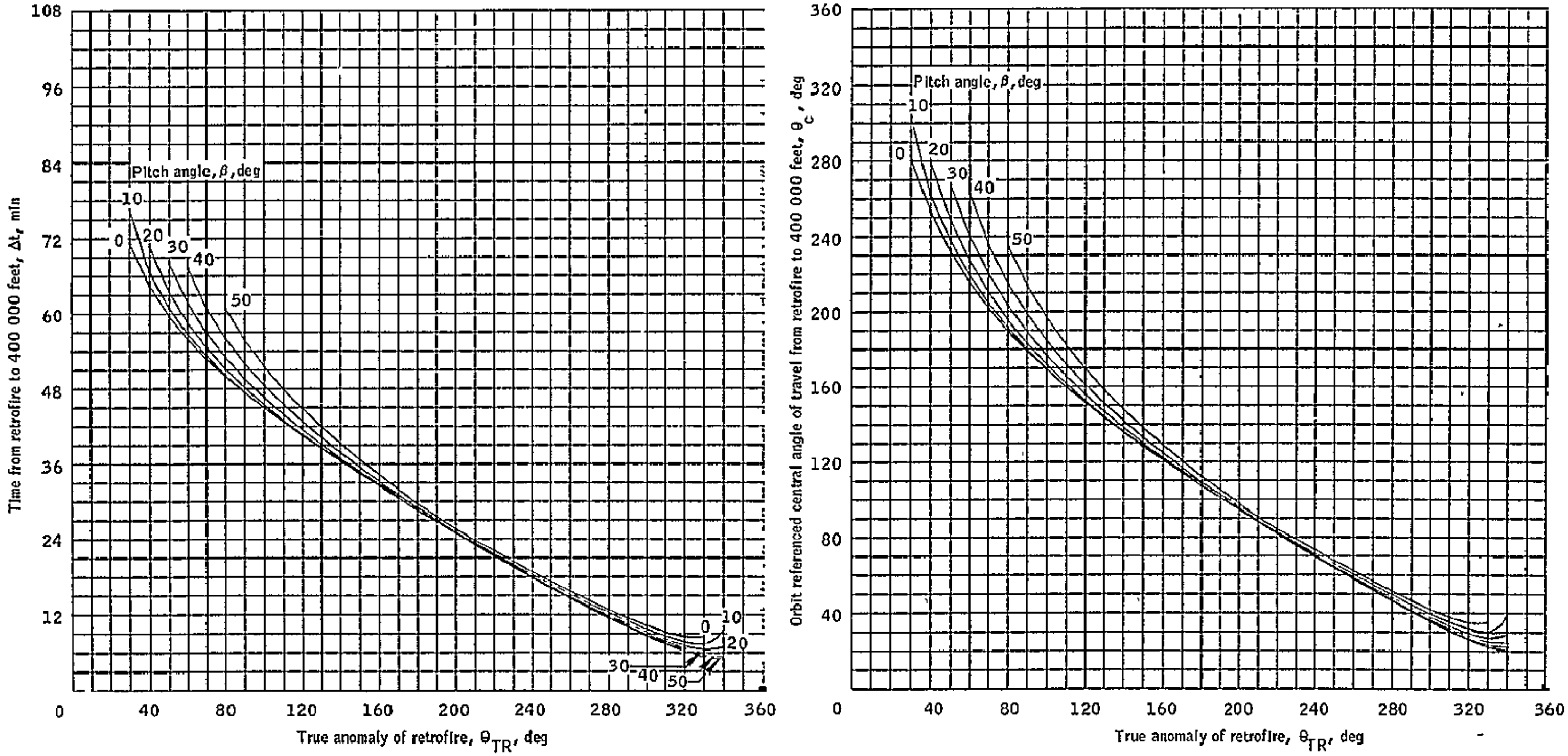
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

Figure 2.- Continued.



(c) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

Figure 2.- Continued.



(d) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

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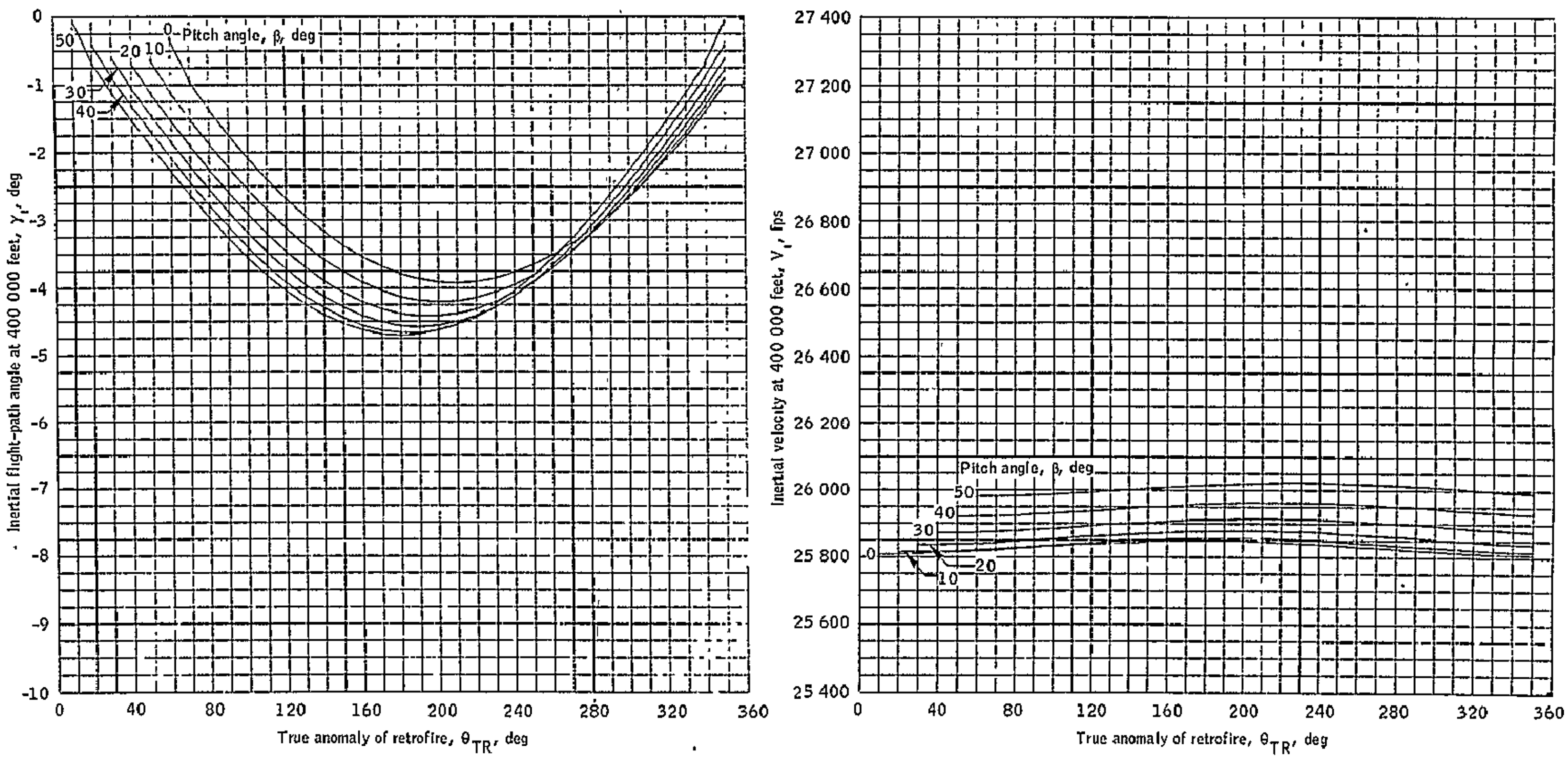
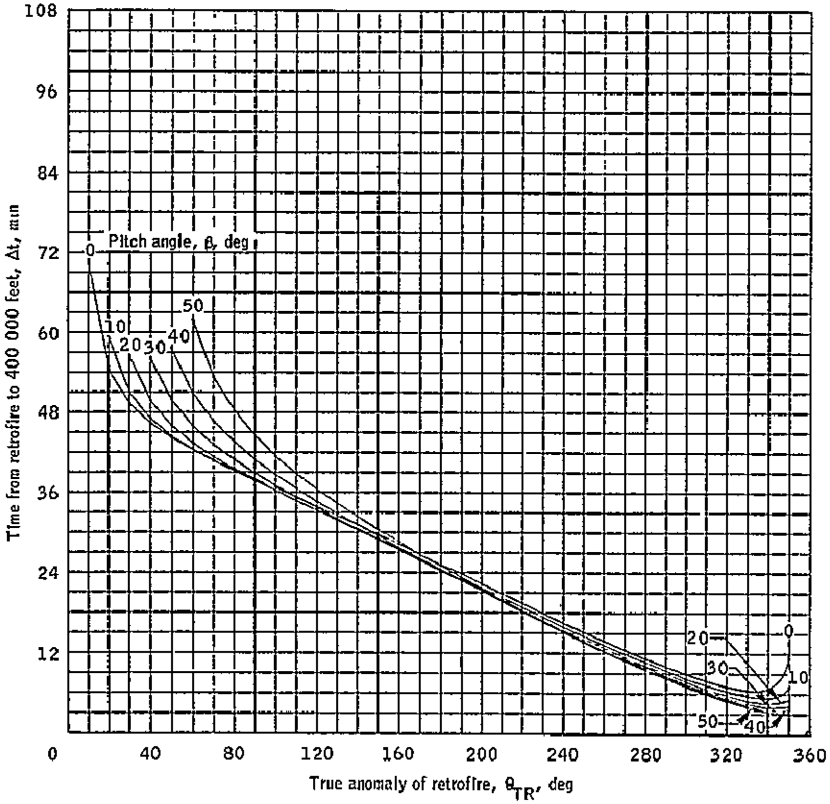
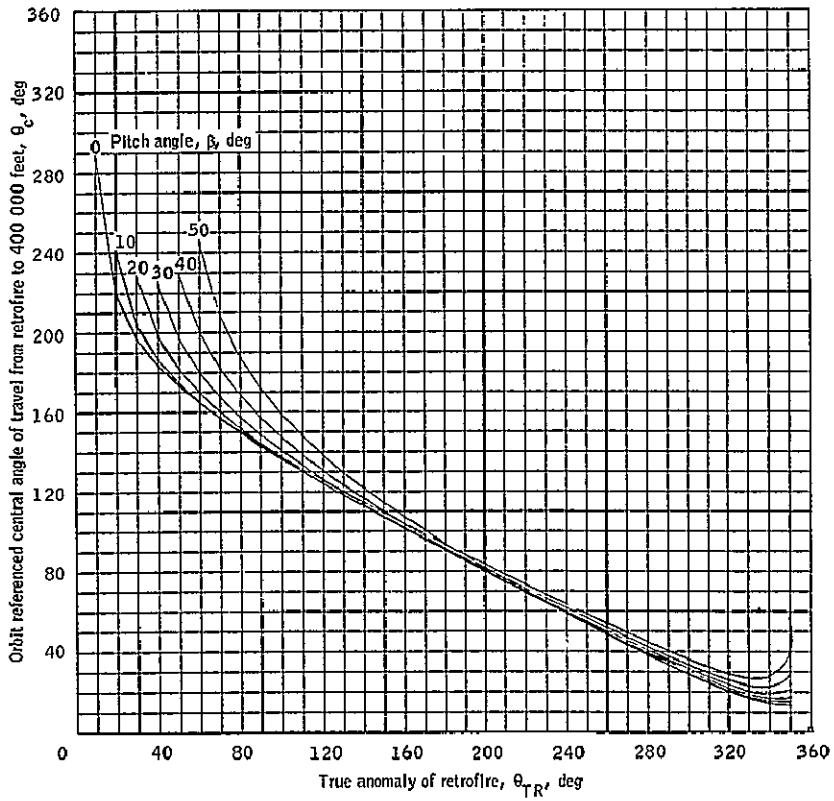


(e) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

Figure 2.- Continued.





(f) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

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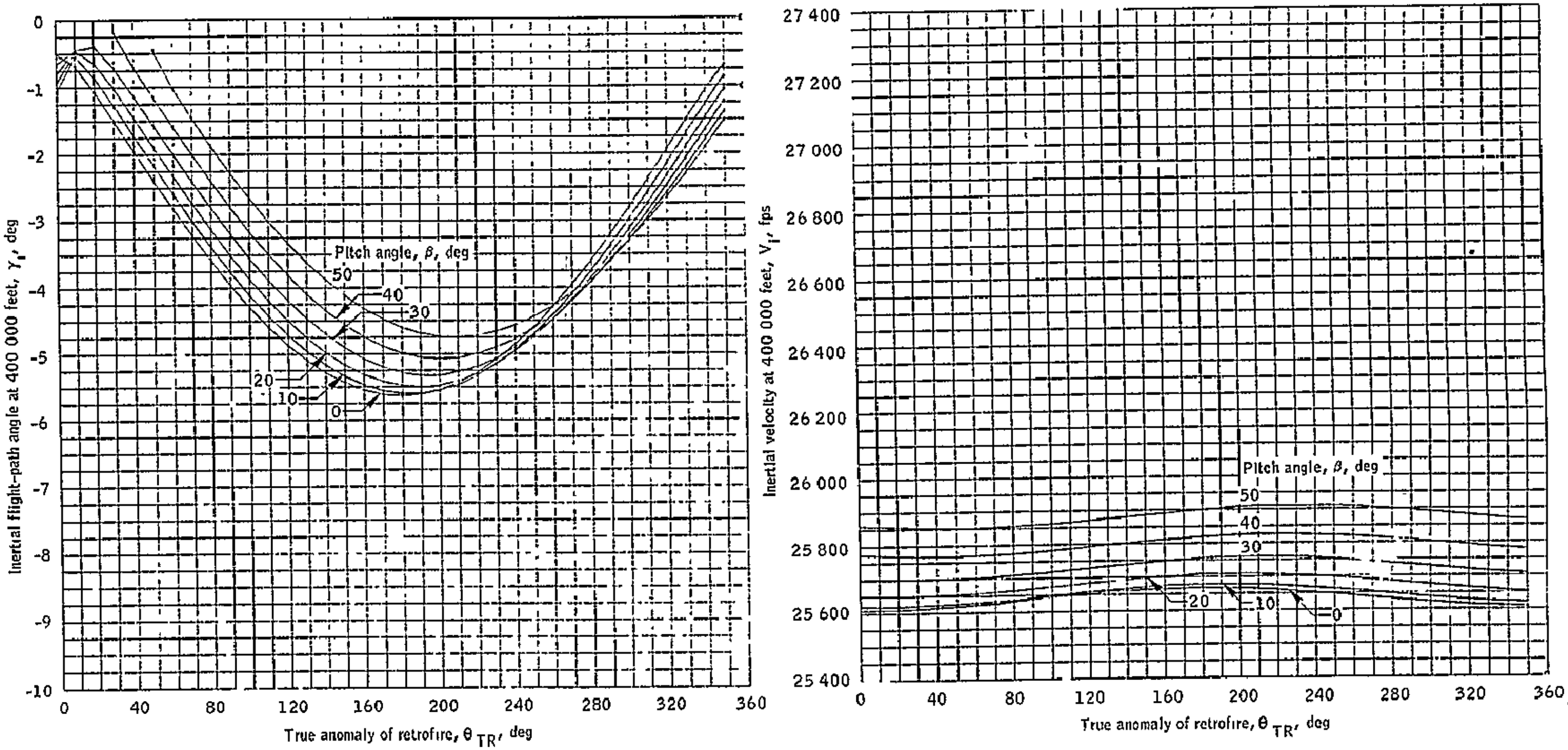
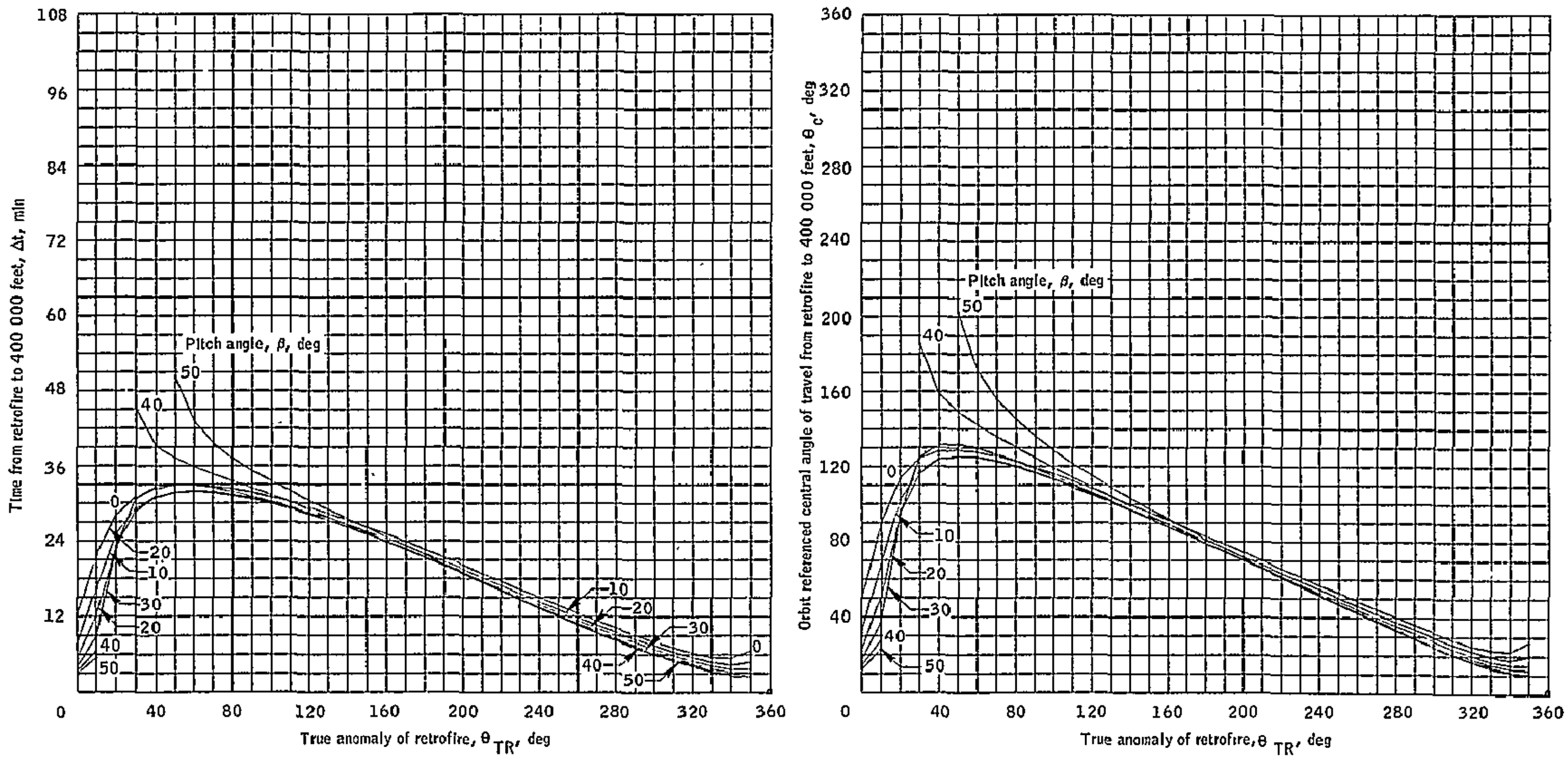


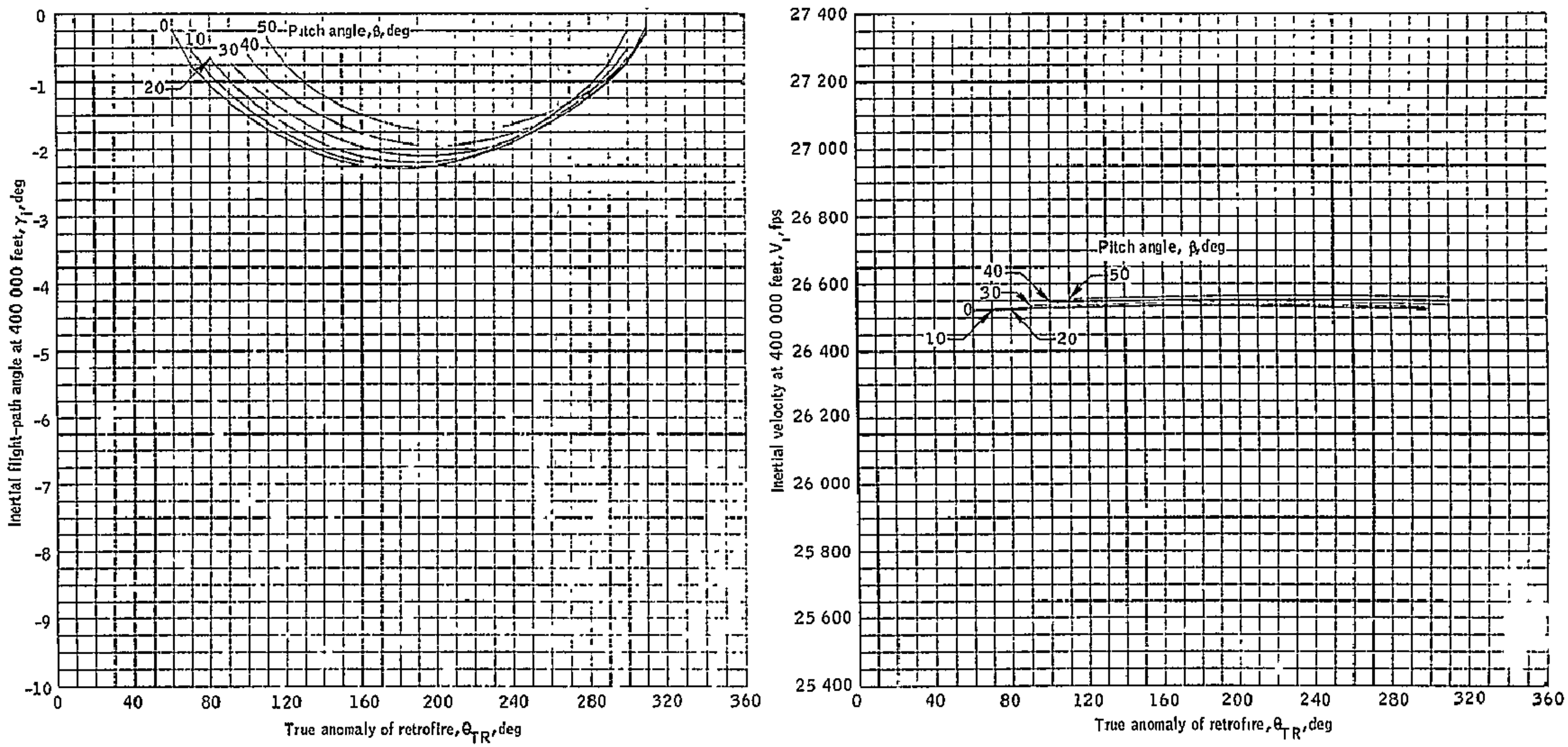
(g) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 2 - Continued.



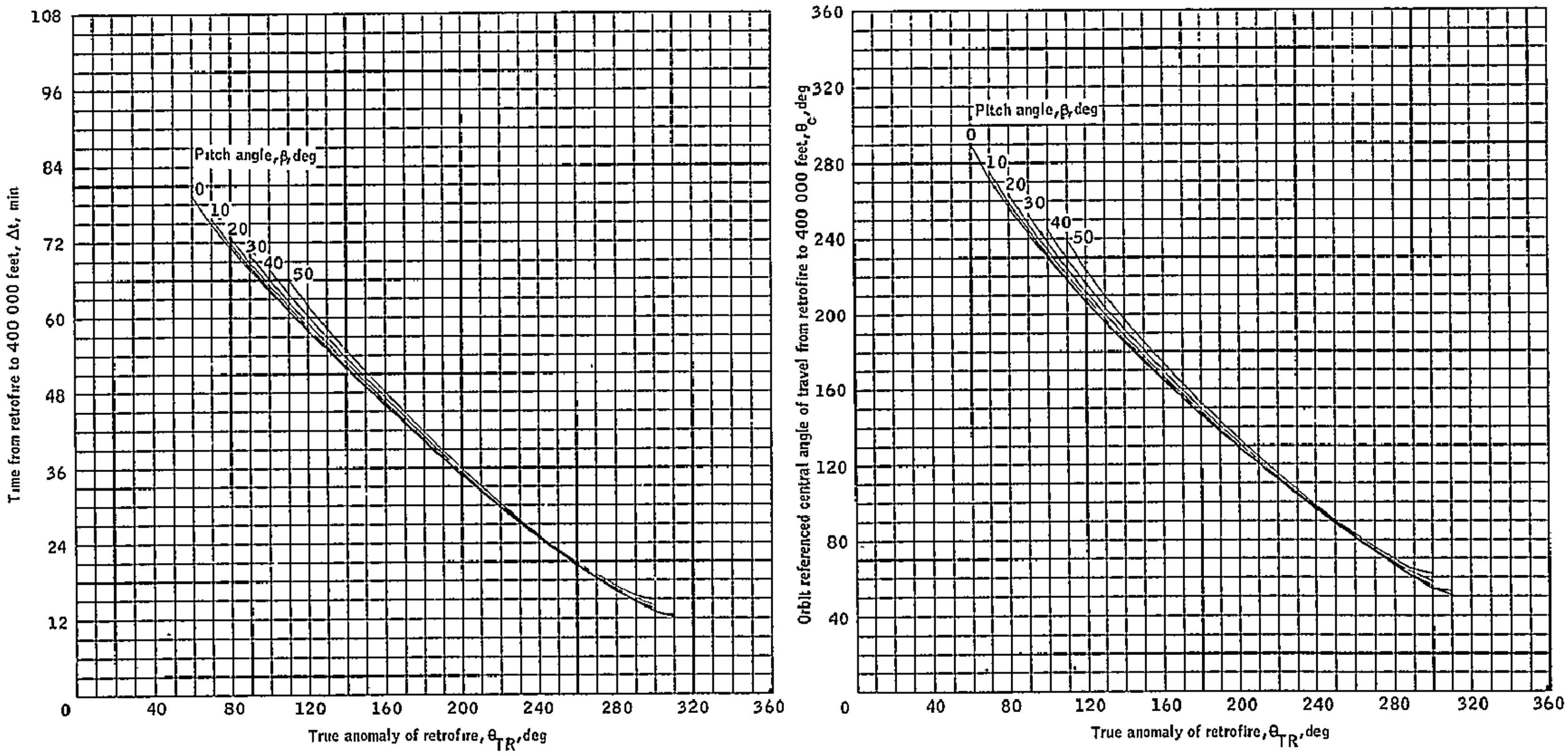
(h) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

Figure 2.- Concluded.



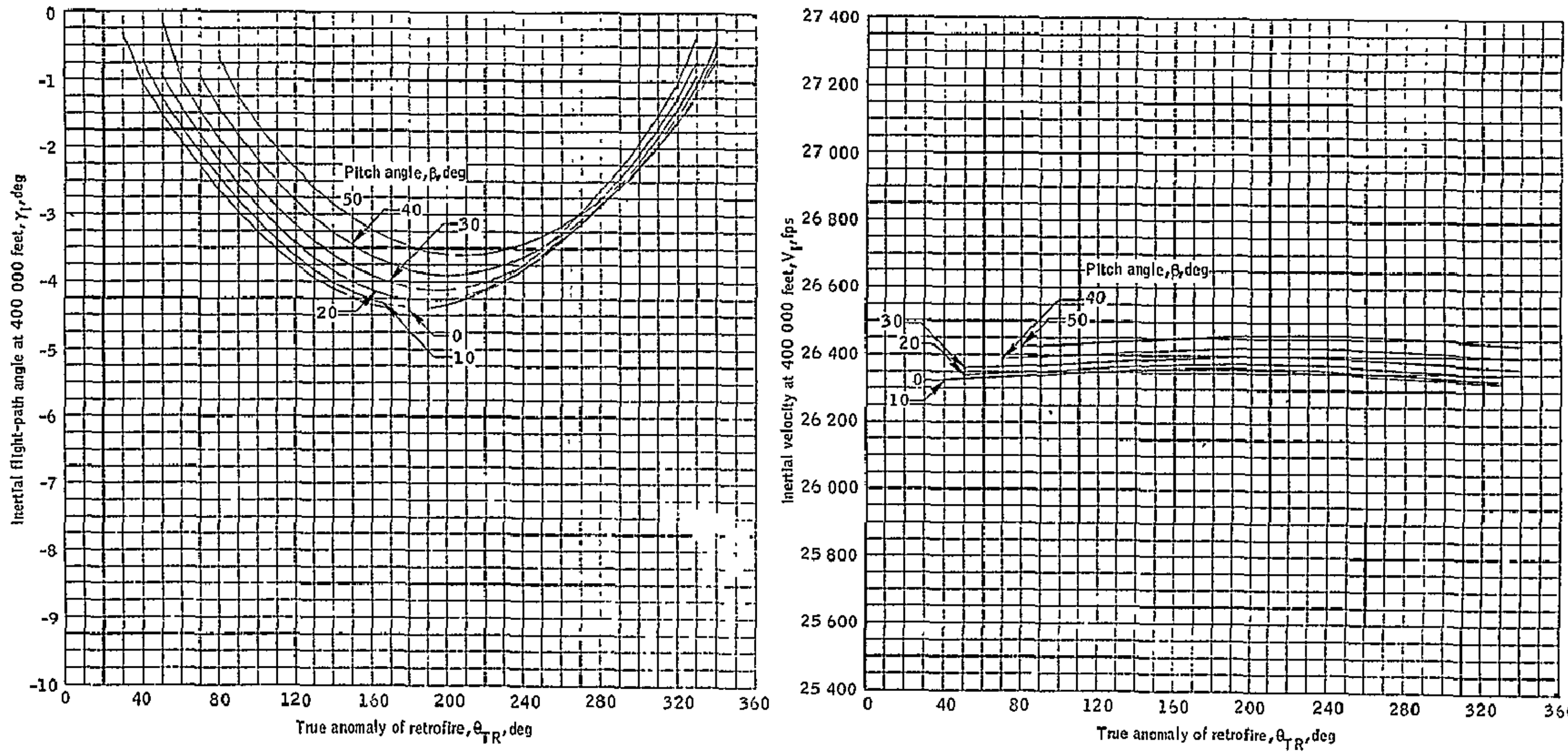
(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

Figure 3.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for a 80/600 nautical mile orbit.



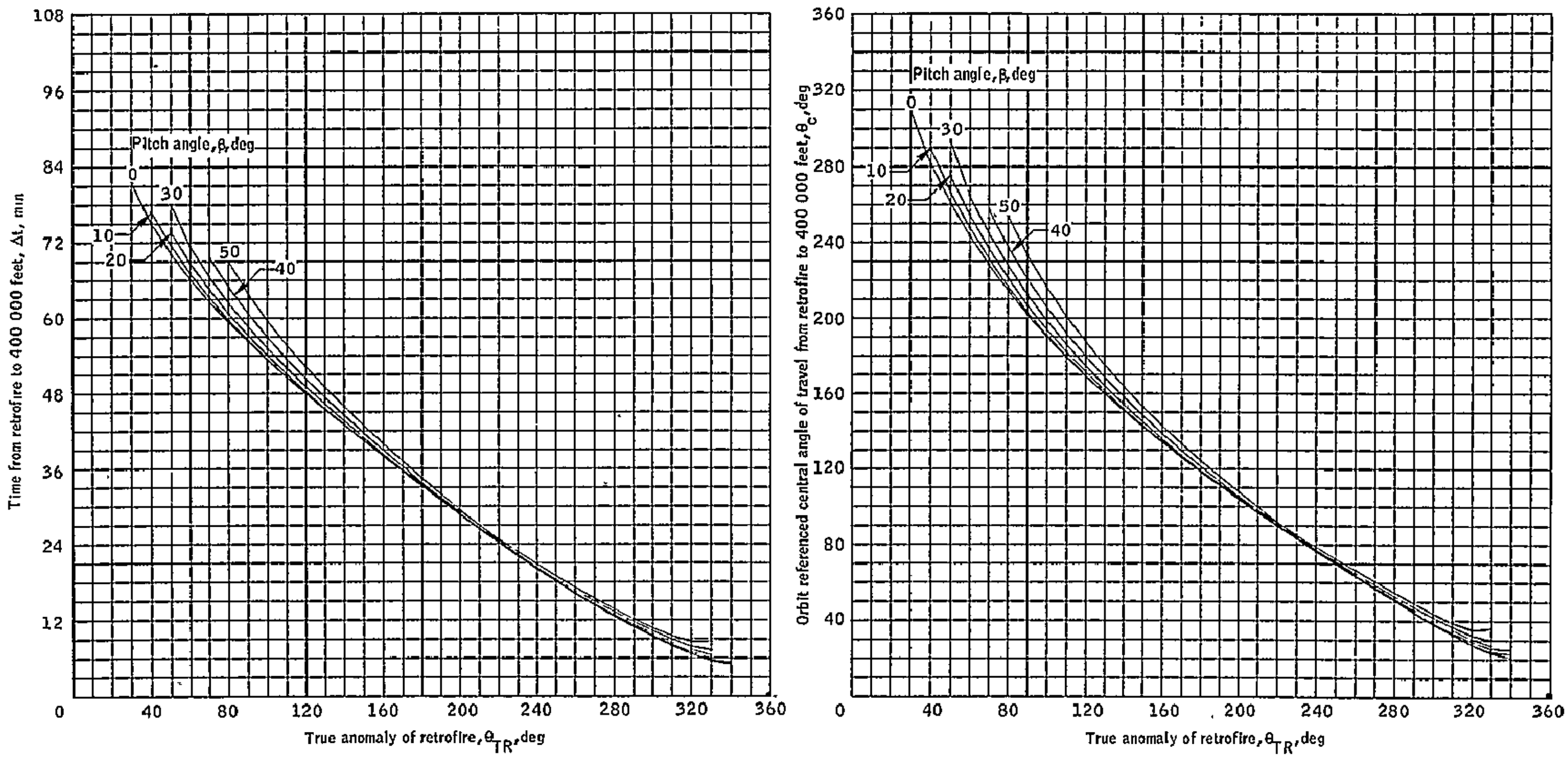
(b) Time from retrofire and central angle for retrograde ΔV = 100 feet per second.

Figure 3.- Continued.



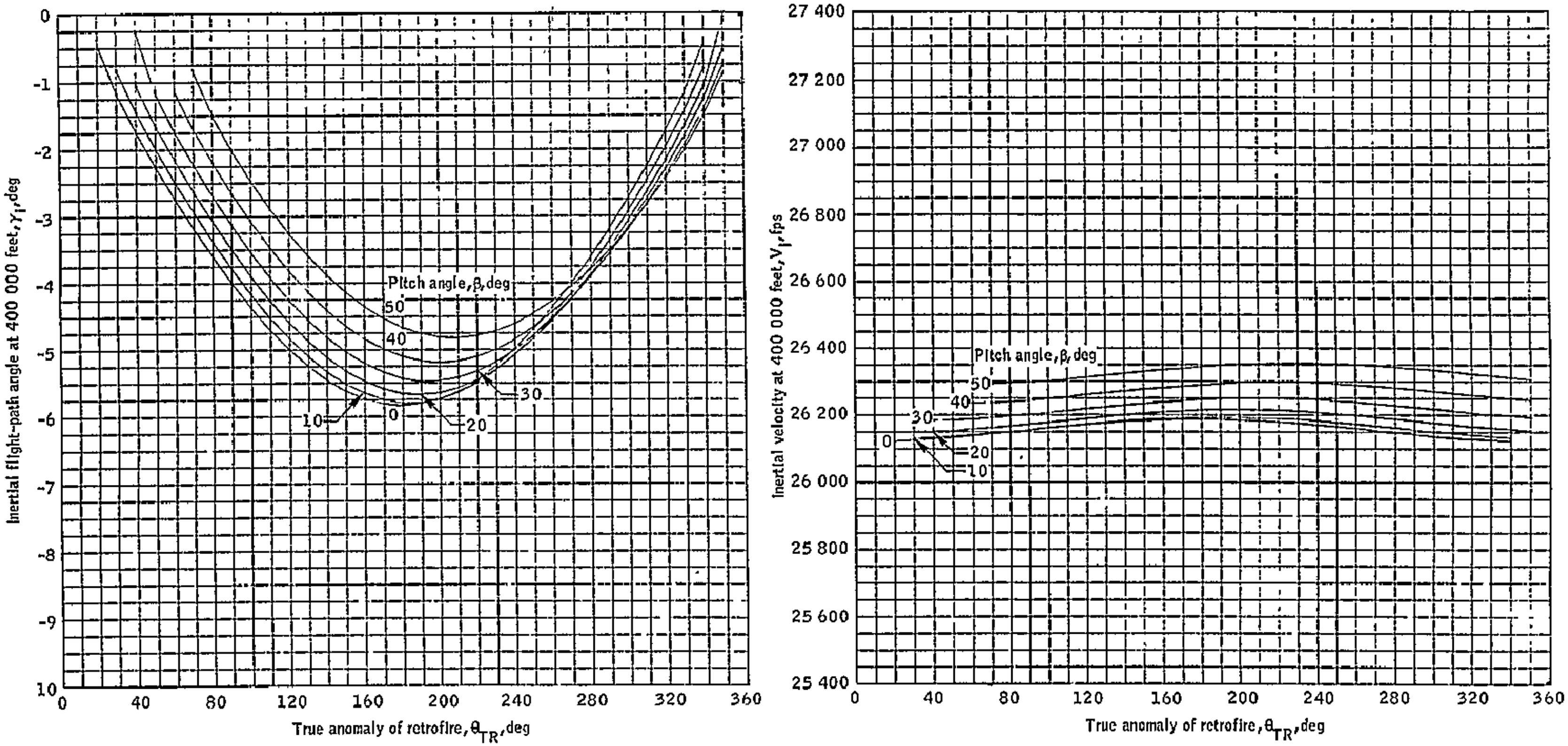
(c) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

Figure 3.- Continued



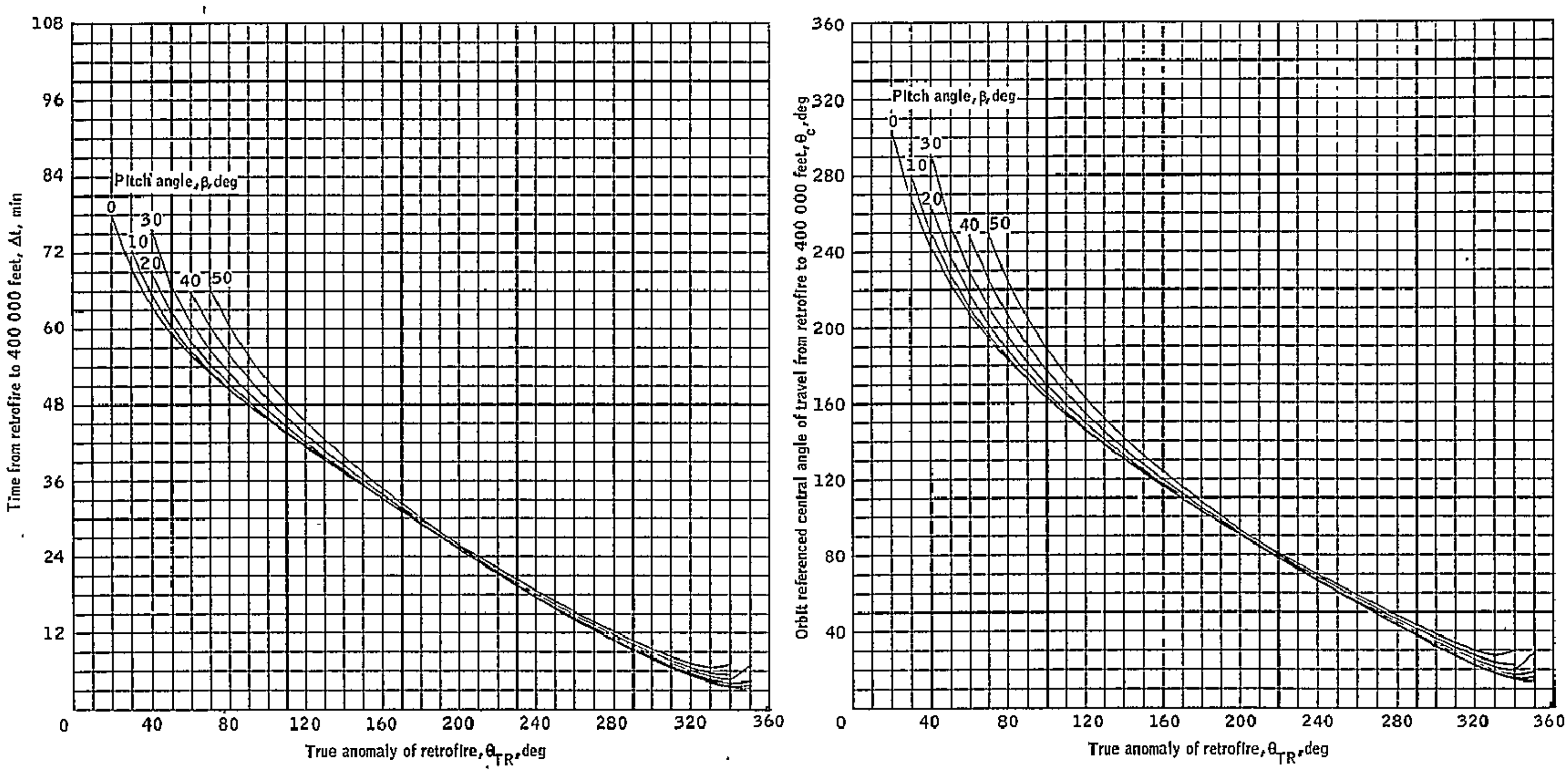
(d) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

Figure 3.- Continued.



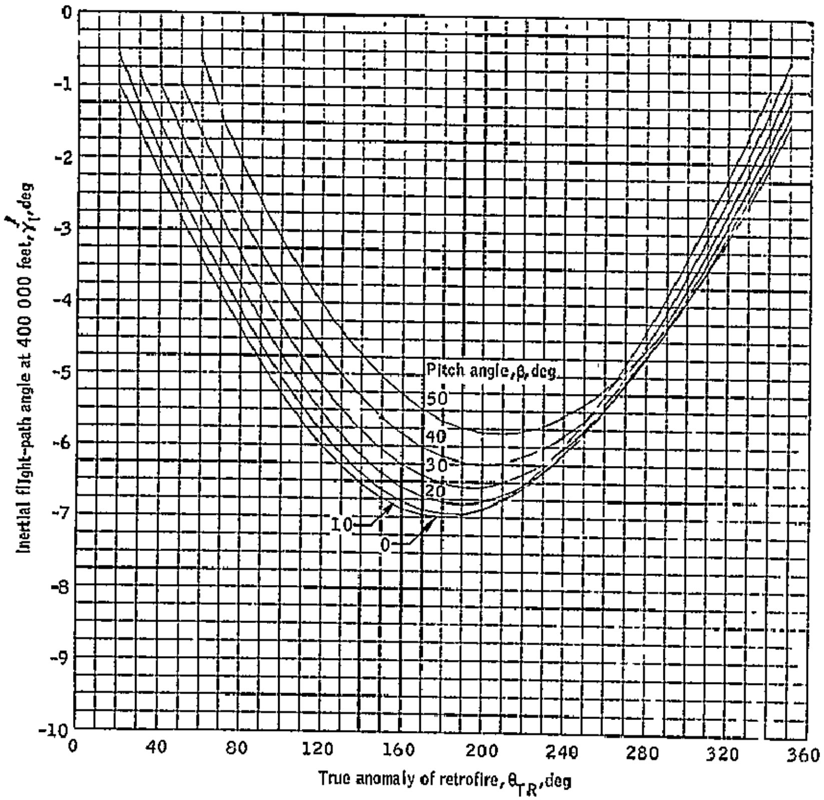
(e) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

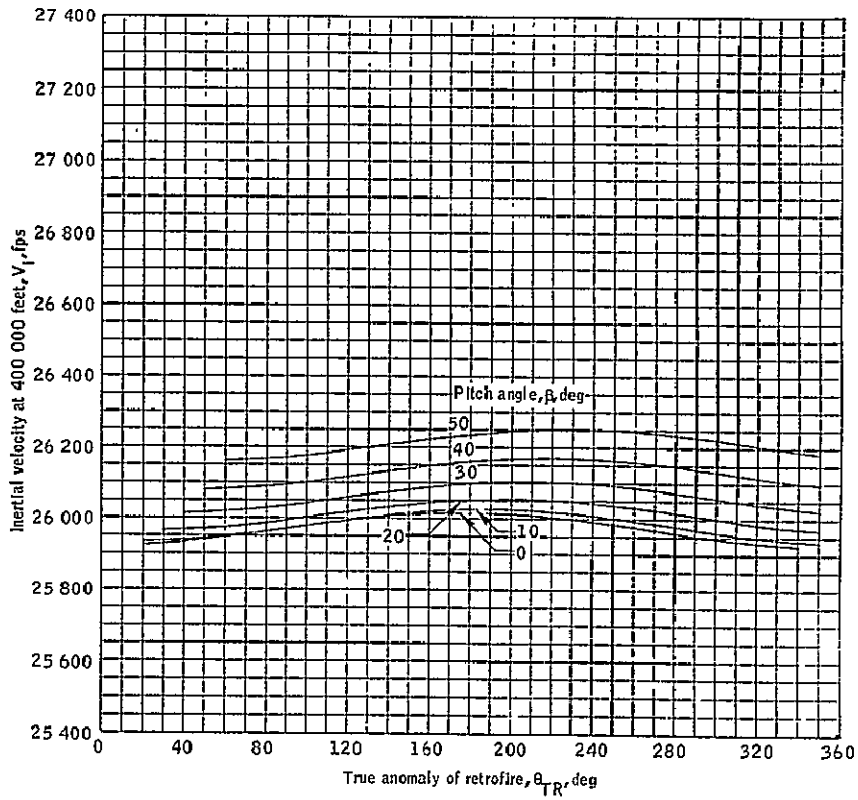
Figure 3.- Continued.



(f) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

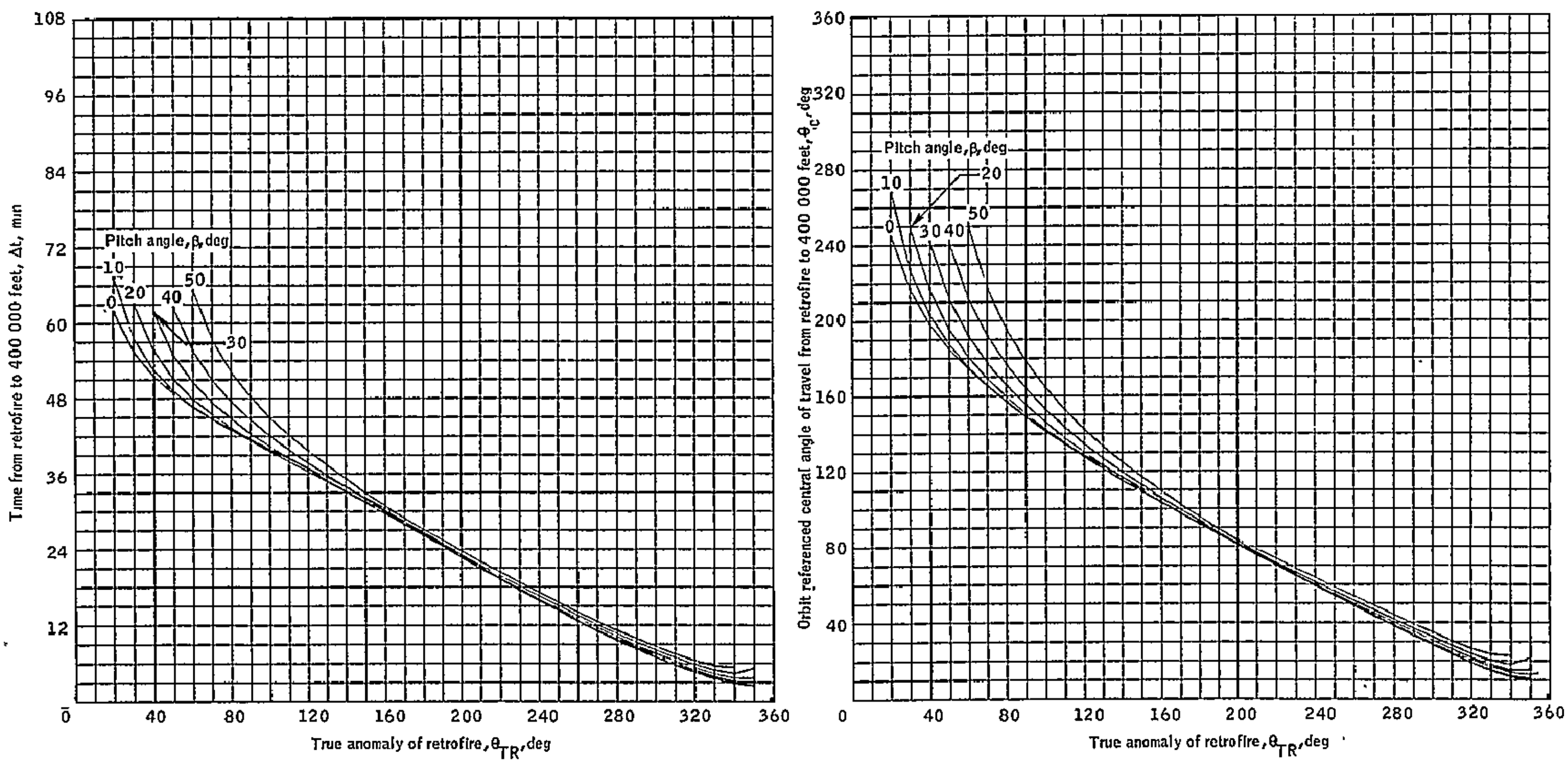
Figure 3.- Continued.





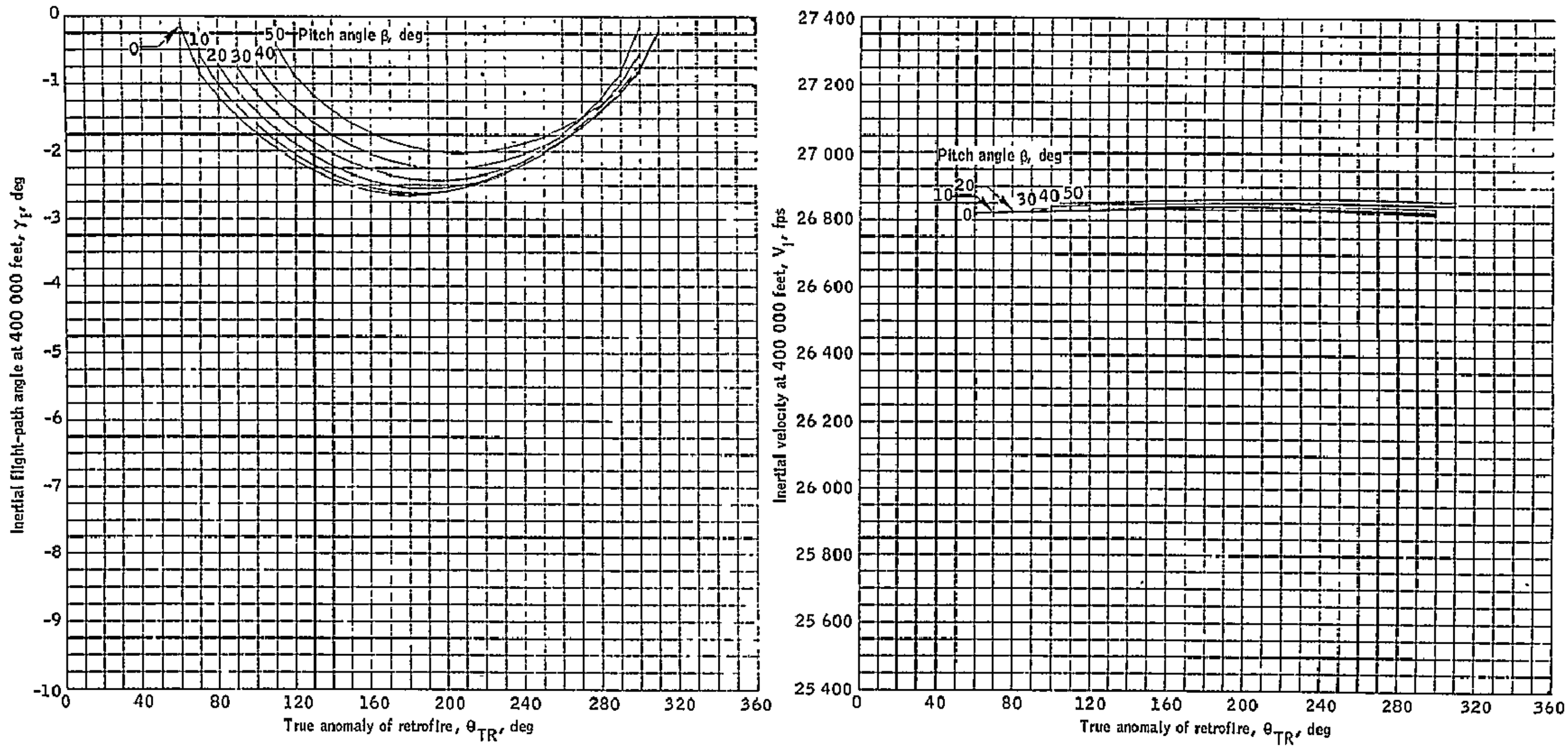
(g) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 3.- Continued.



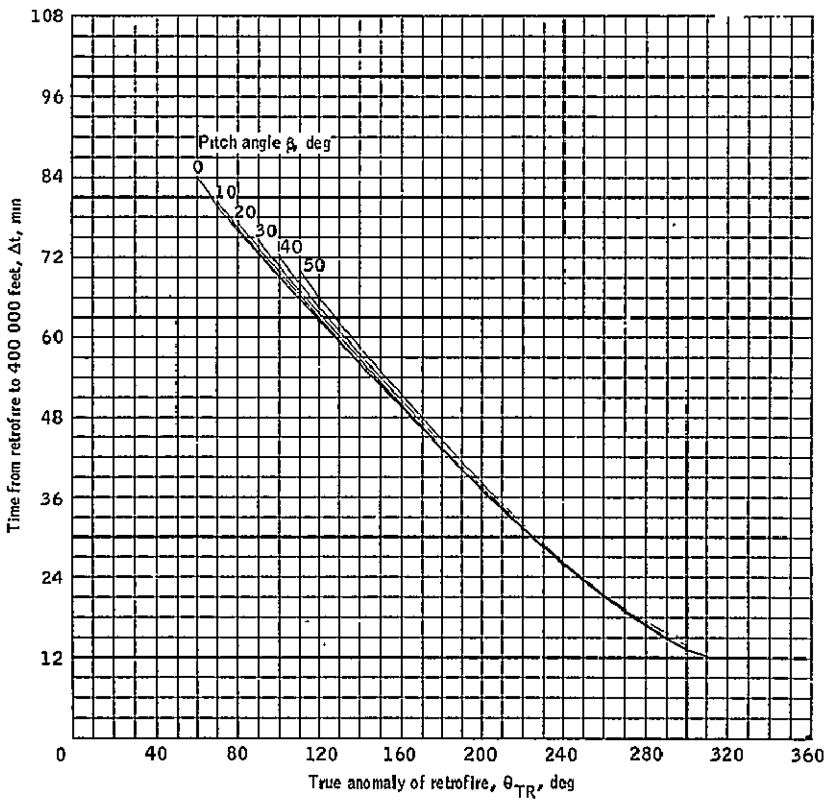
(h) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

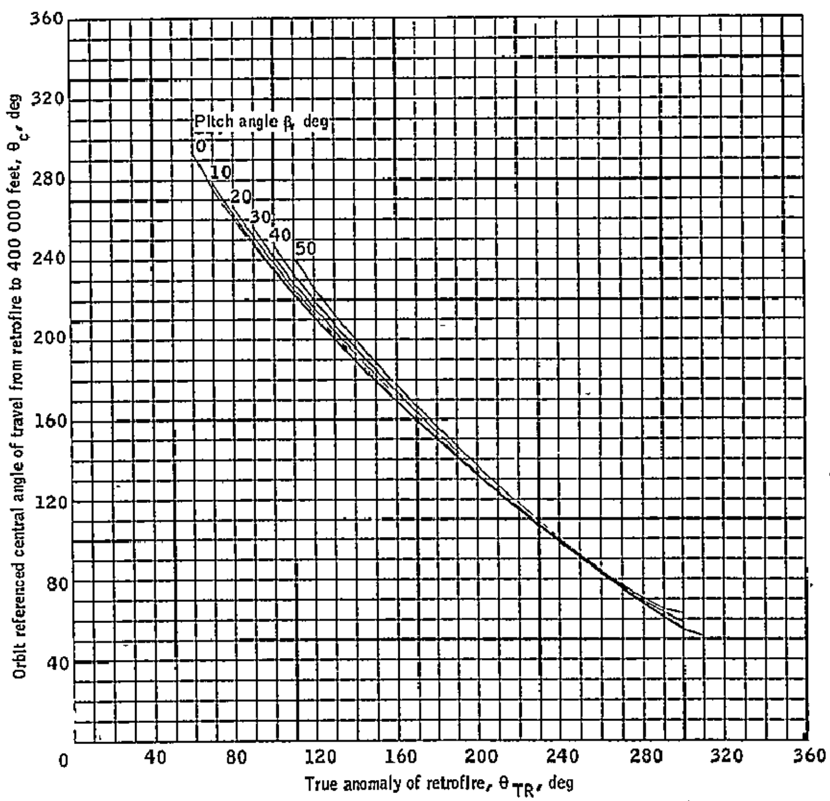
Figure 3.- Concluded.



(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

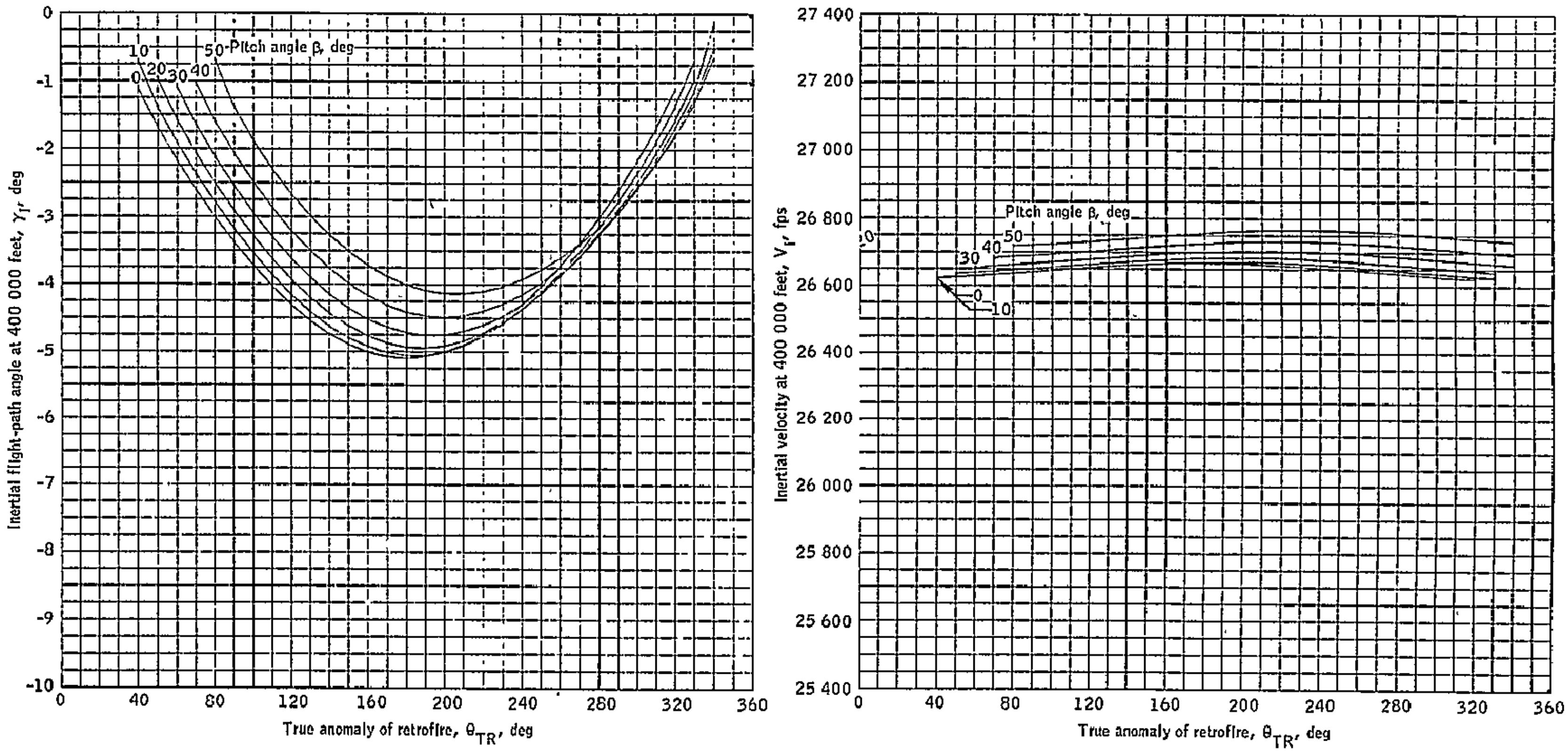
Figure 4.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 80/800 nautical mile orbit.





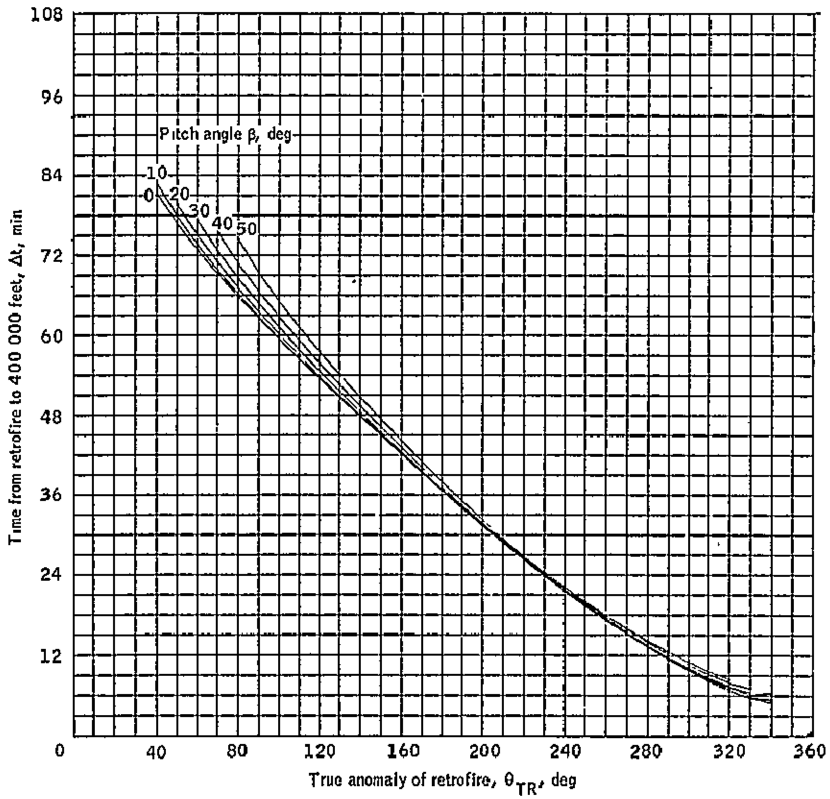
(b) Time from retrofire and central angle for retrograde ΔV = 100 feet per second.

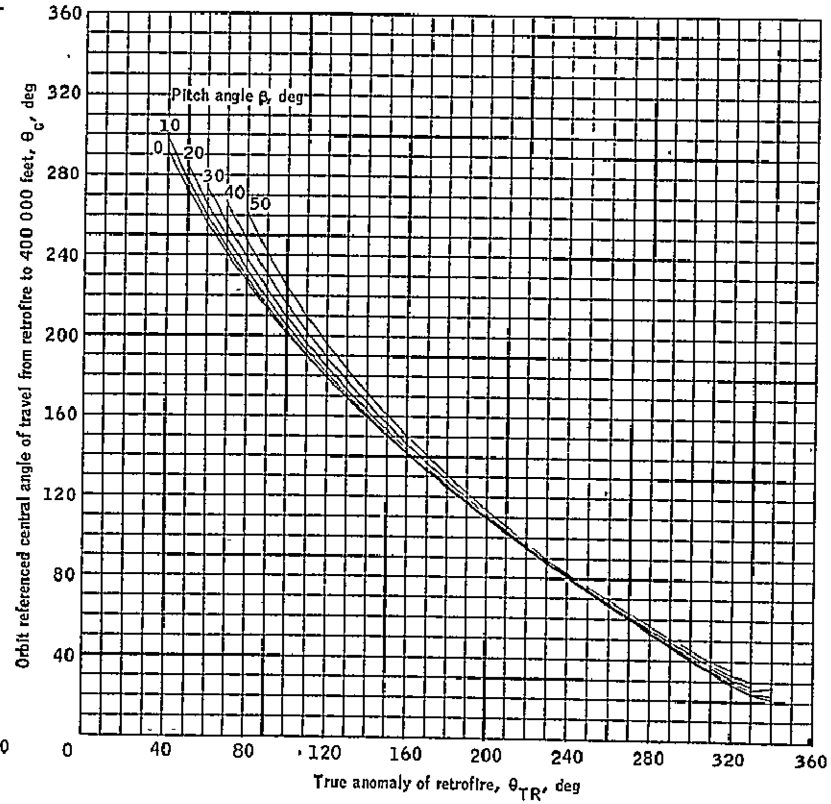
Figure 4.- Continued.



(c) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

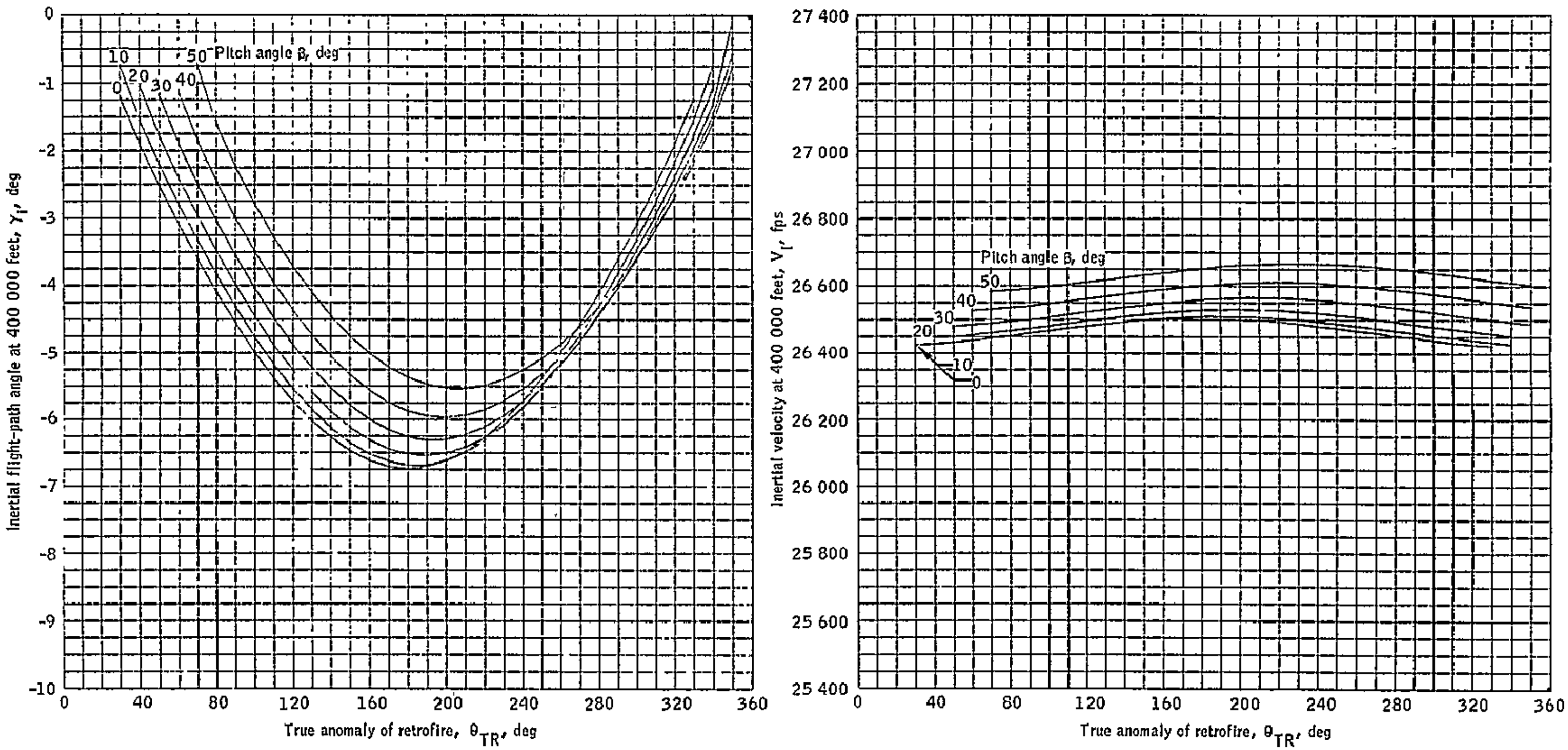
Figure 4.- Continued.





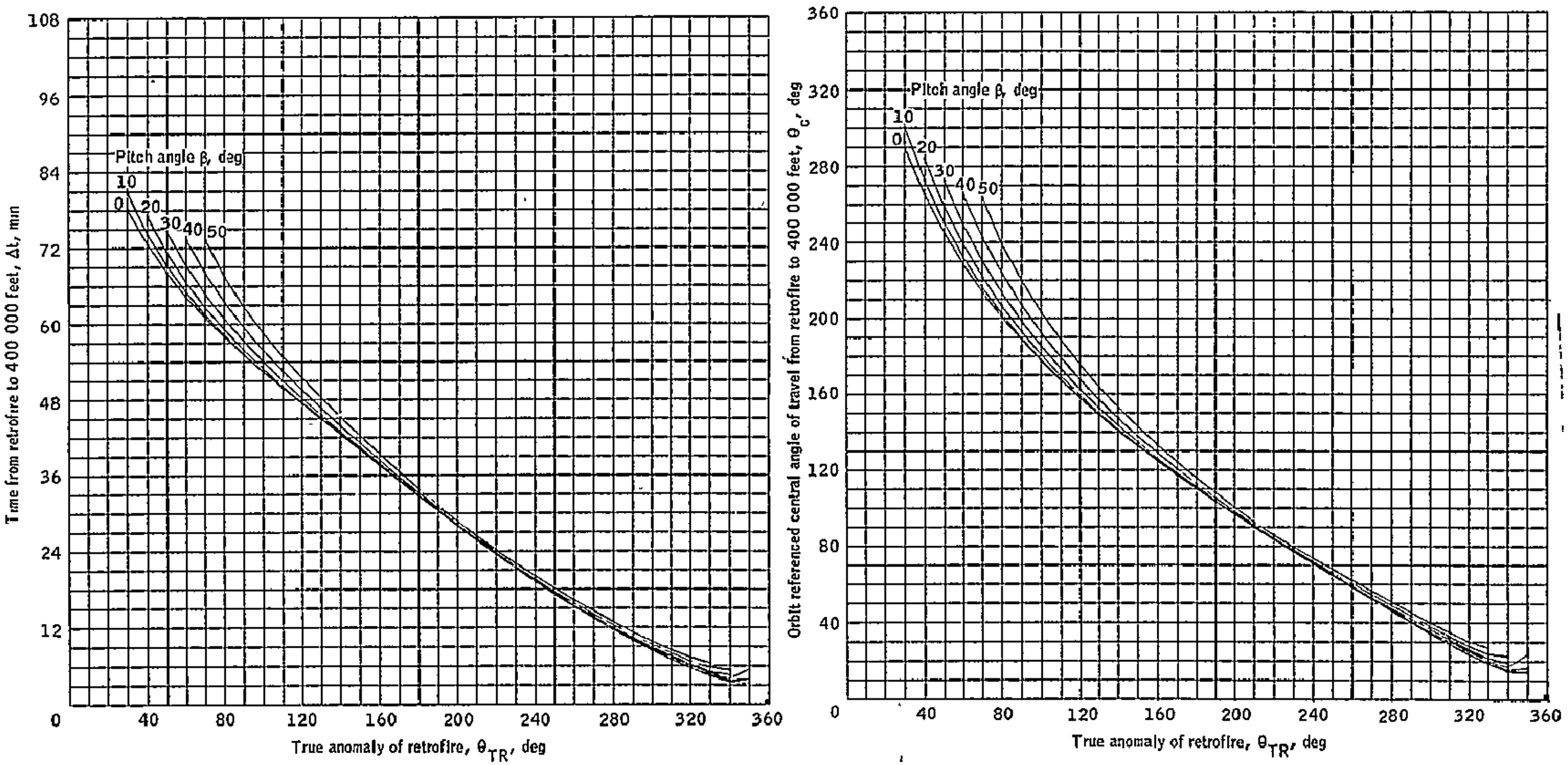
(d) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

Figure 4.- Continued.



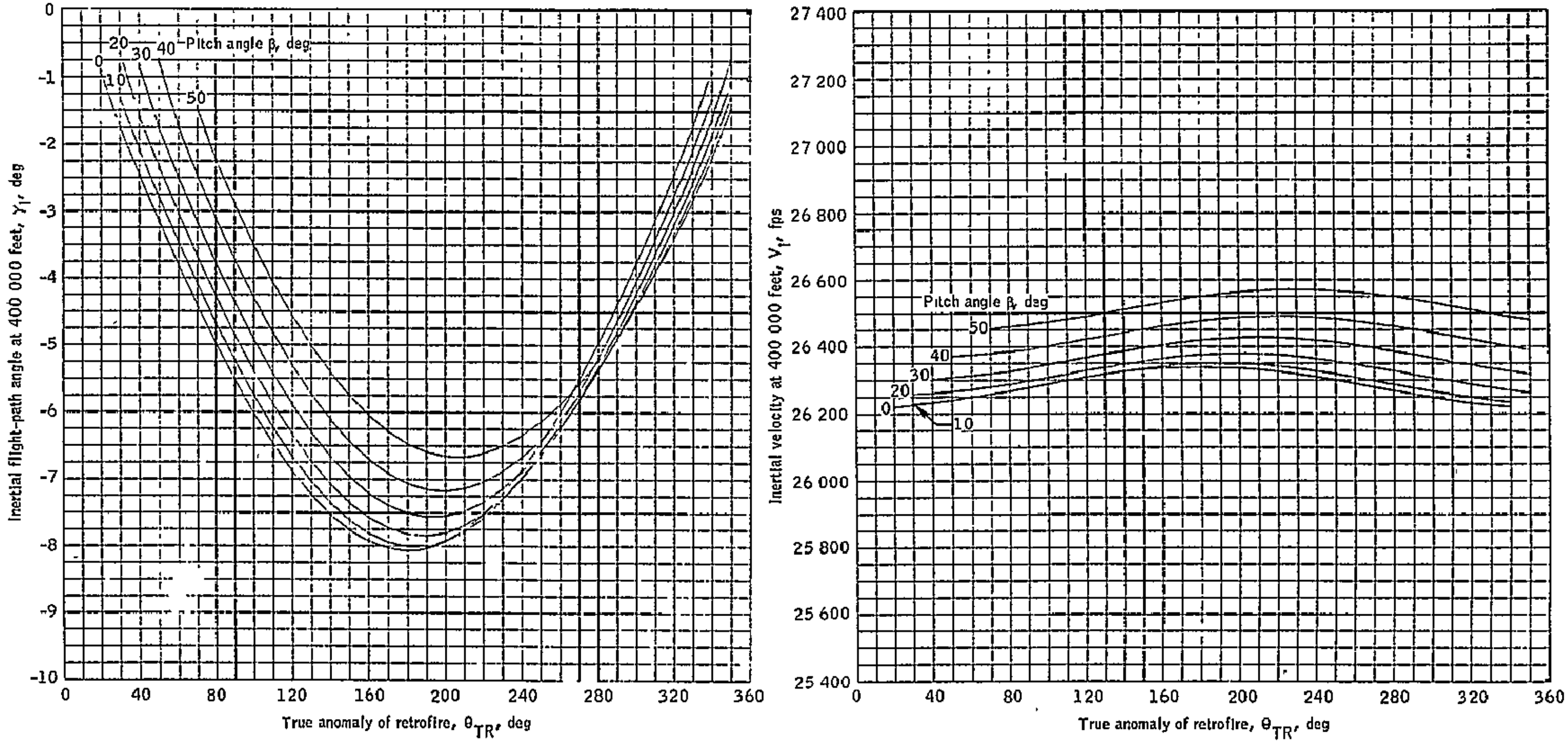
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 4.- Continued.



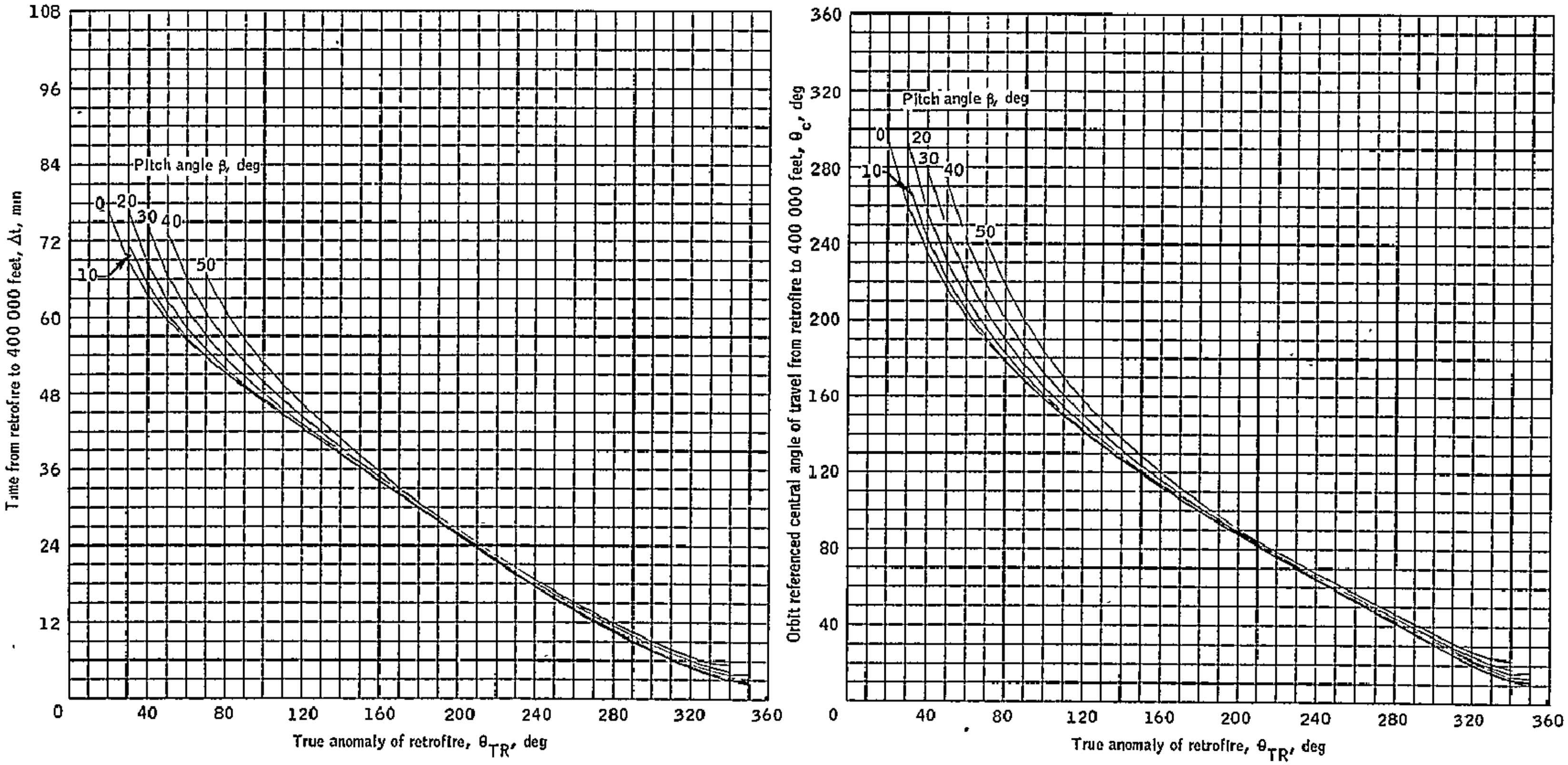
(f) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

Figure 4.- Continued.



(g) Flight-path angle and velocity for retrograde ΔV = 700 feet per second.

Figure 4.- Continued



(h) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

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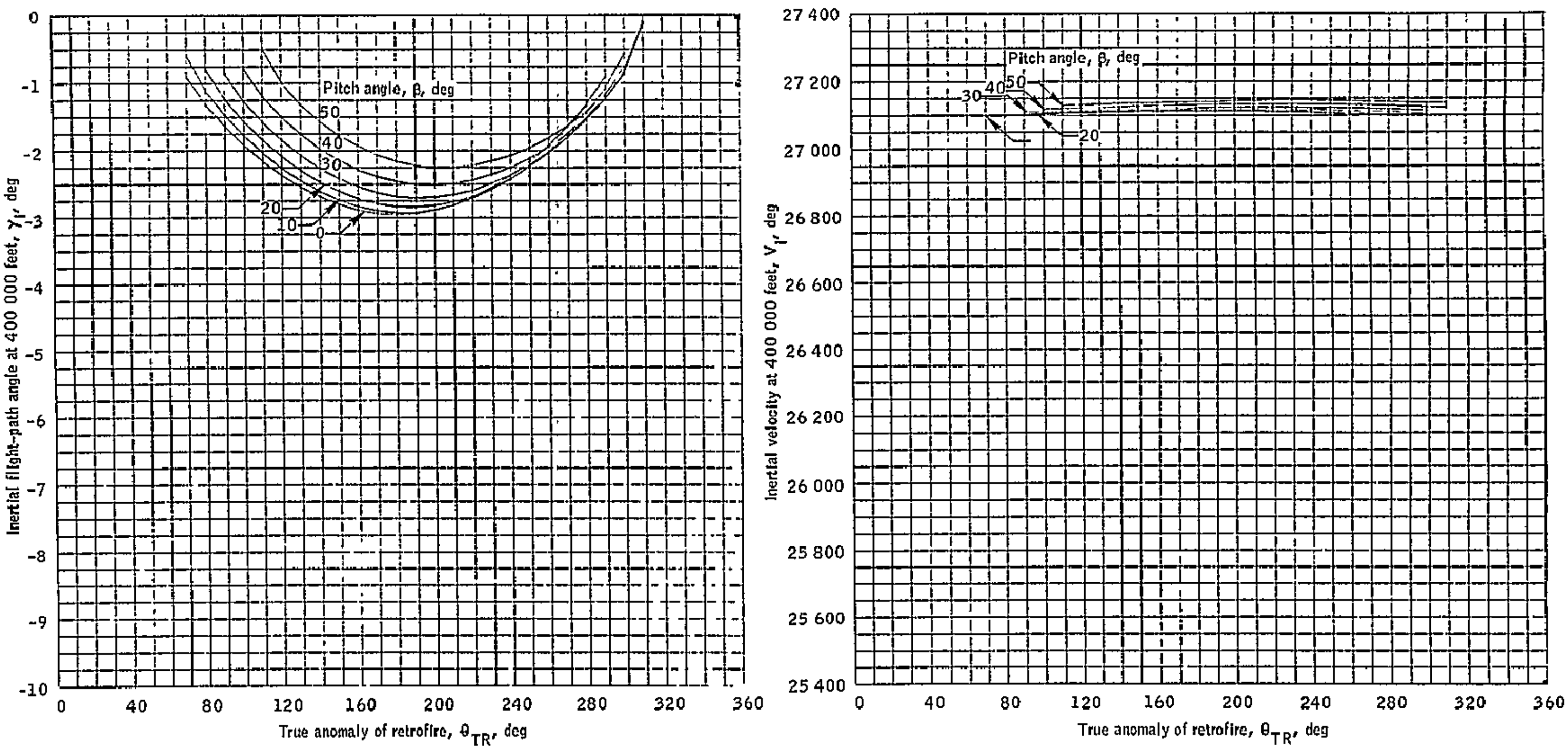
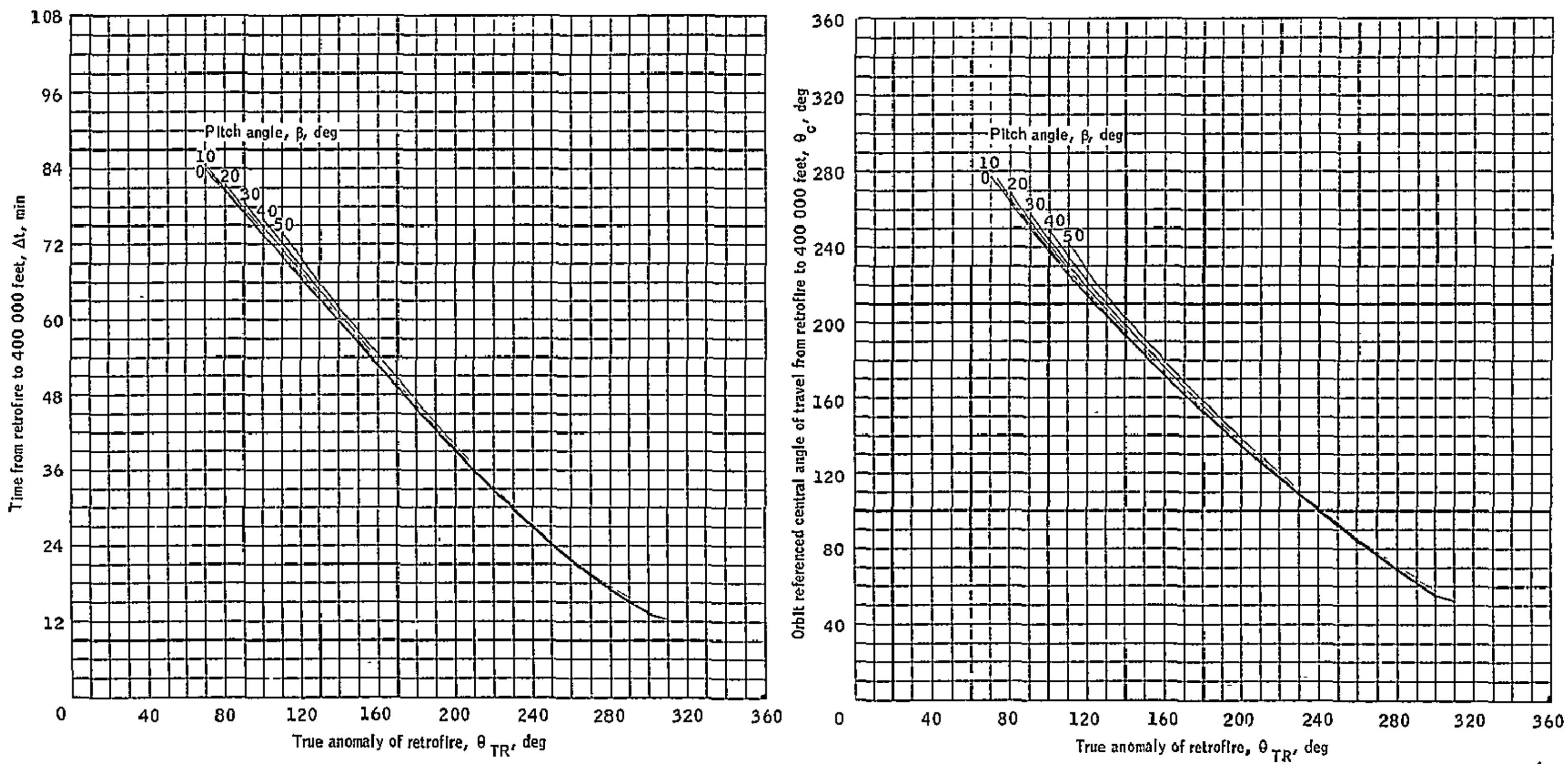


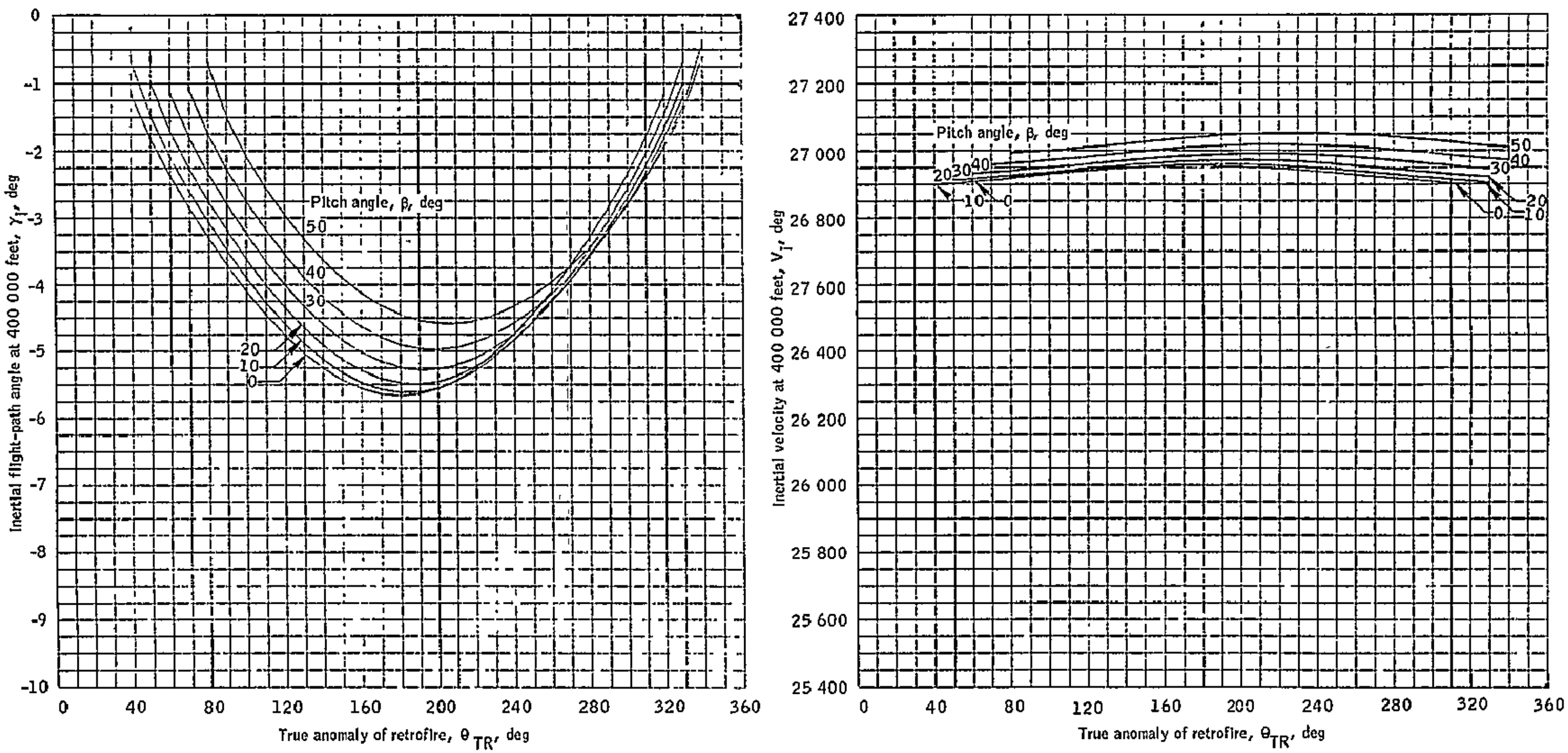
(a) Flight-path angle and velocity for retrograde ΔV = 100 feet per second

Figure 5.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 80/1000 nautical mile orbit.



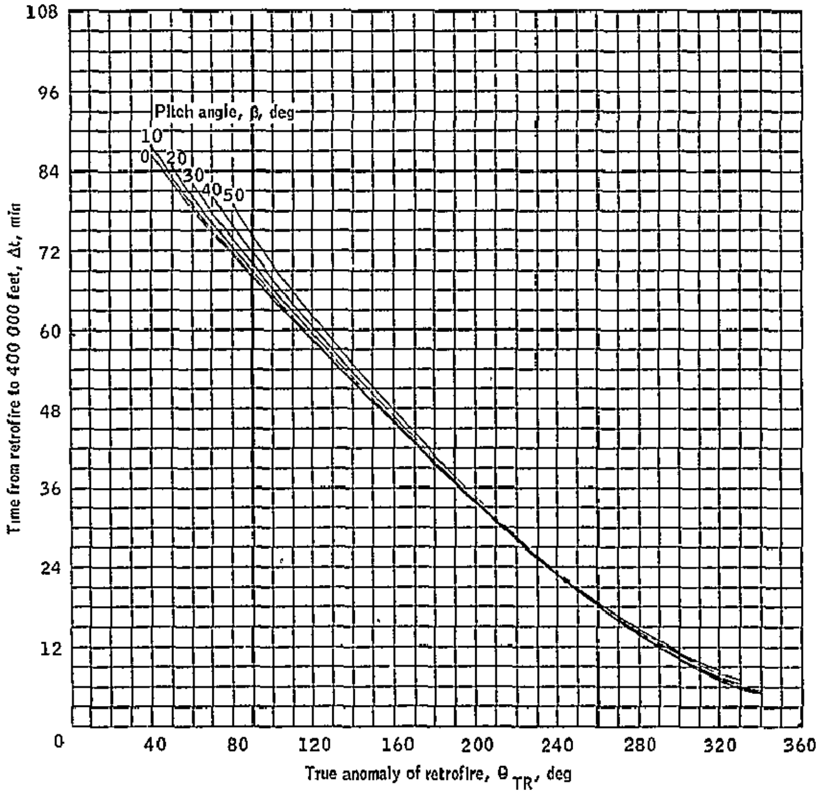
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

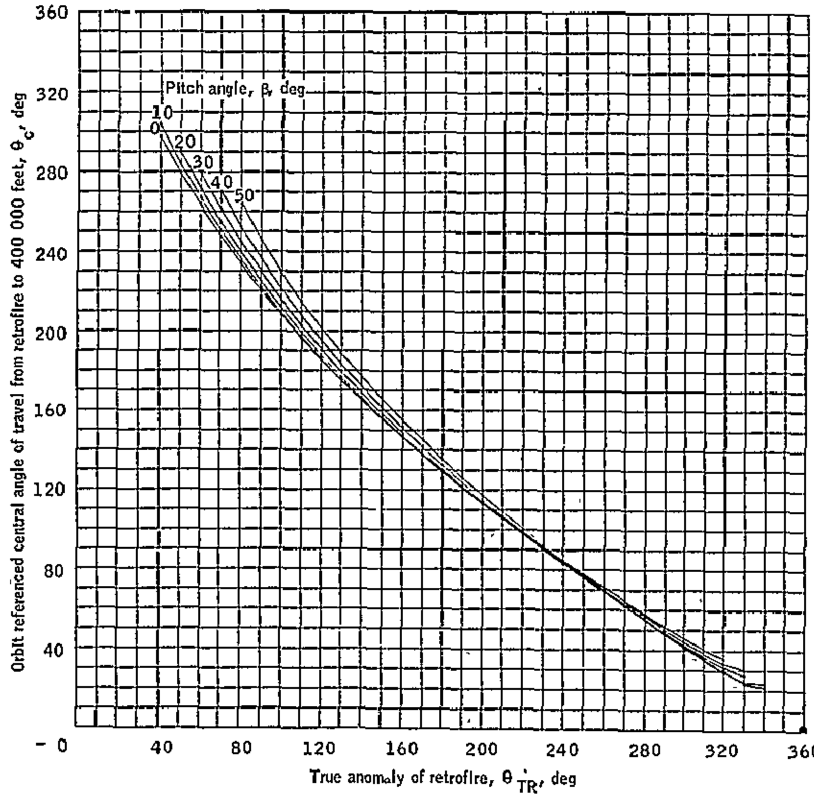
Figure 5.- Continued.



(c) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

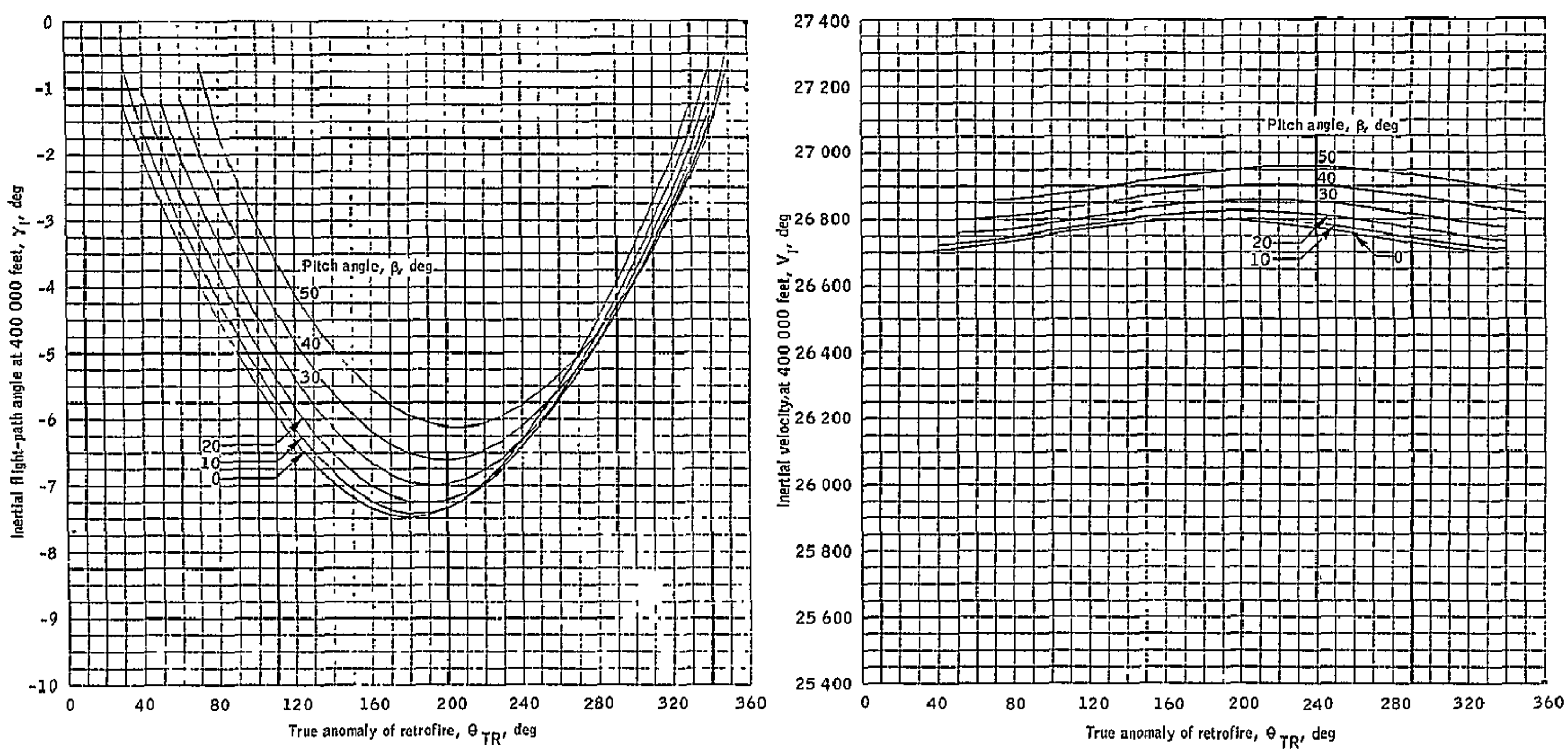
Figure 5.- Continued.





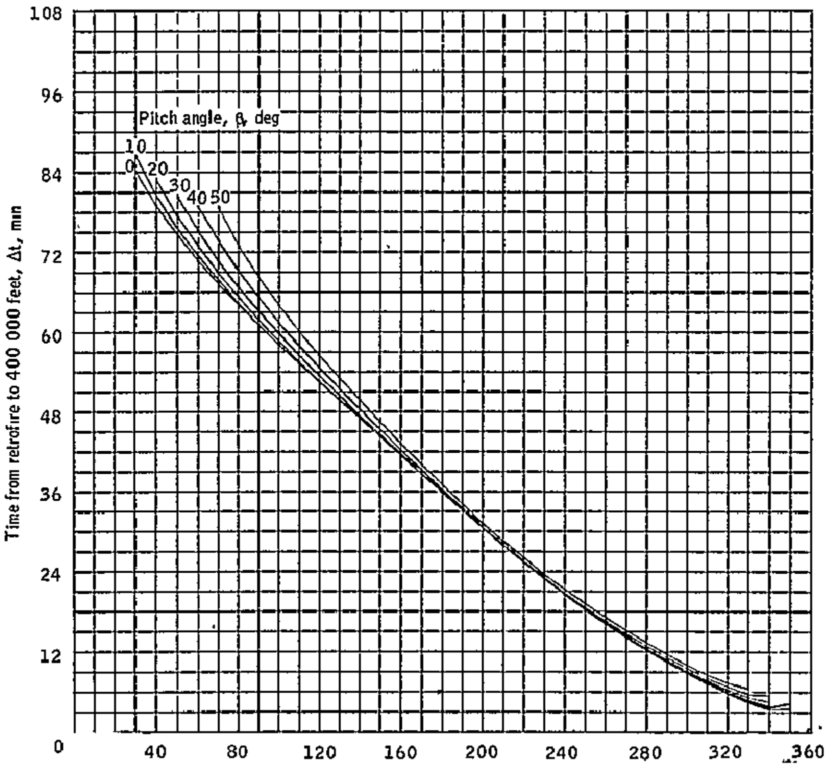
(d) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

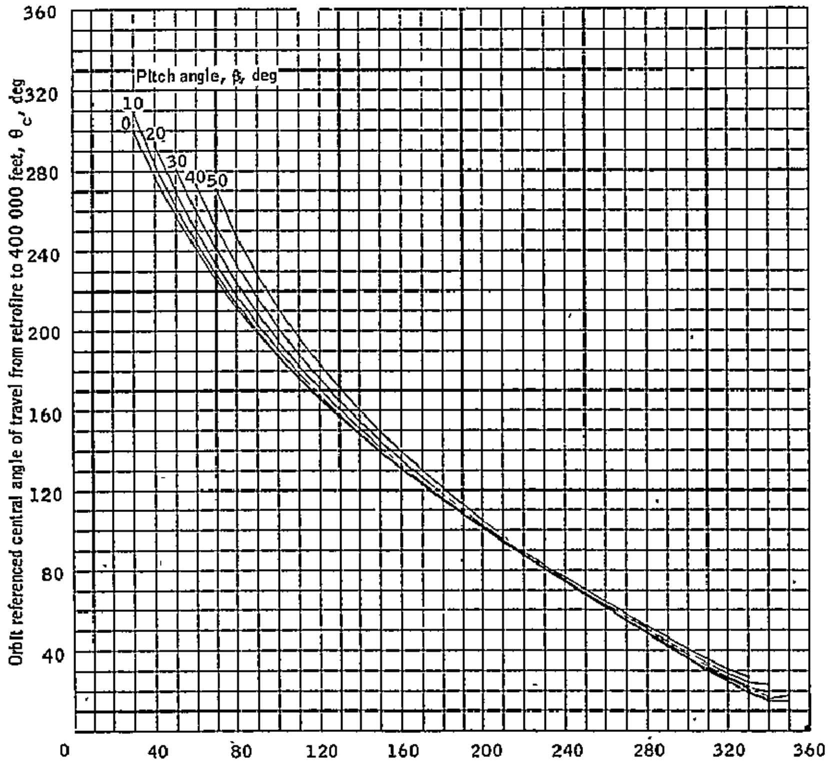
Figure 5.- Continued.



(e) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

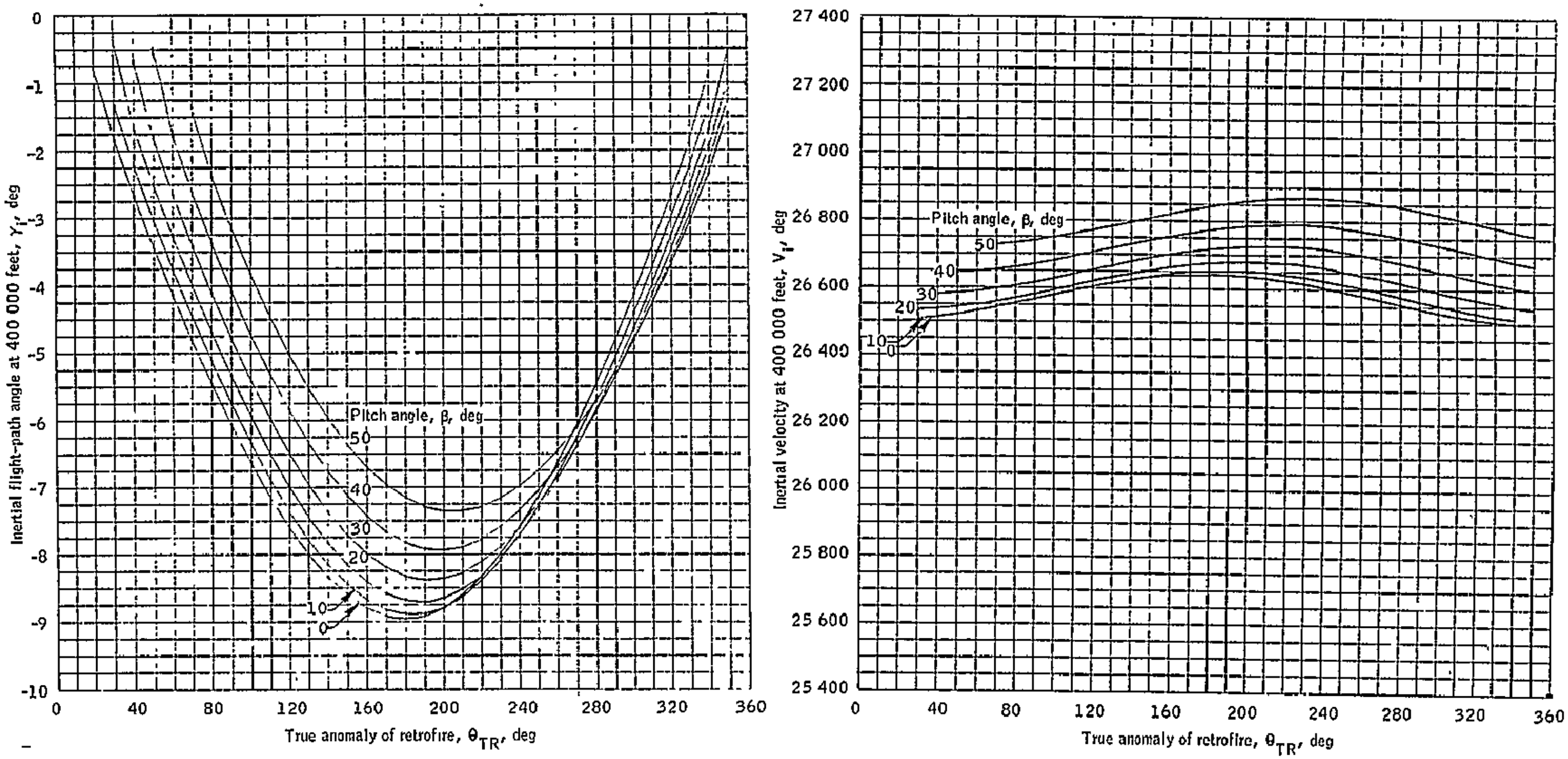
Figure 5.- Continued.





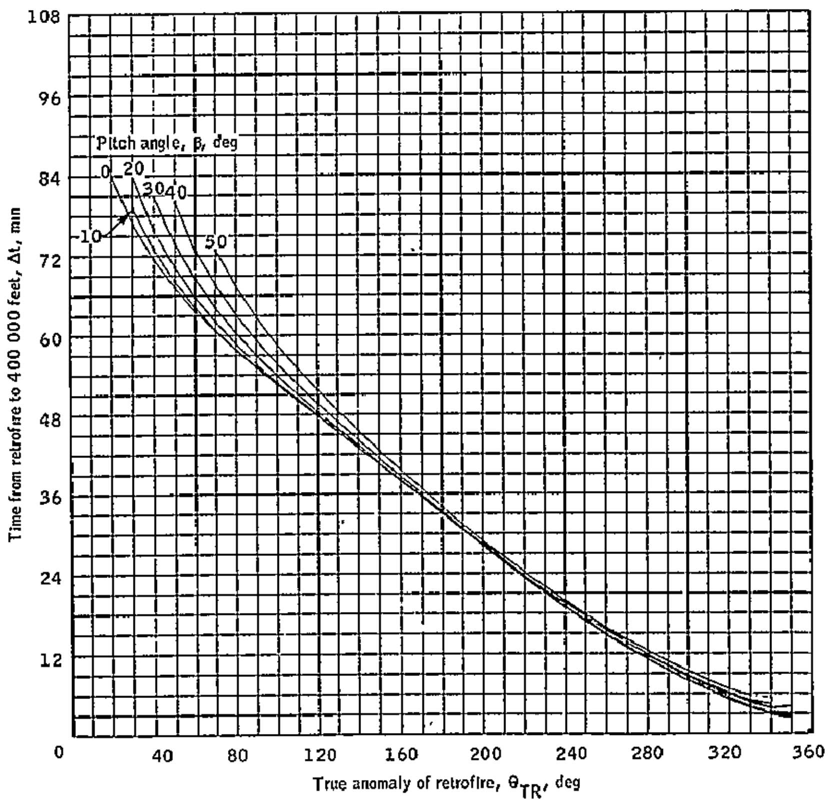
(f) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

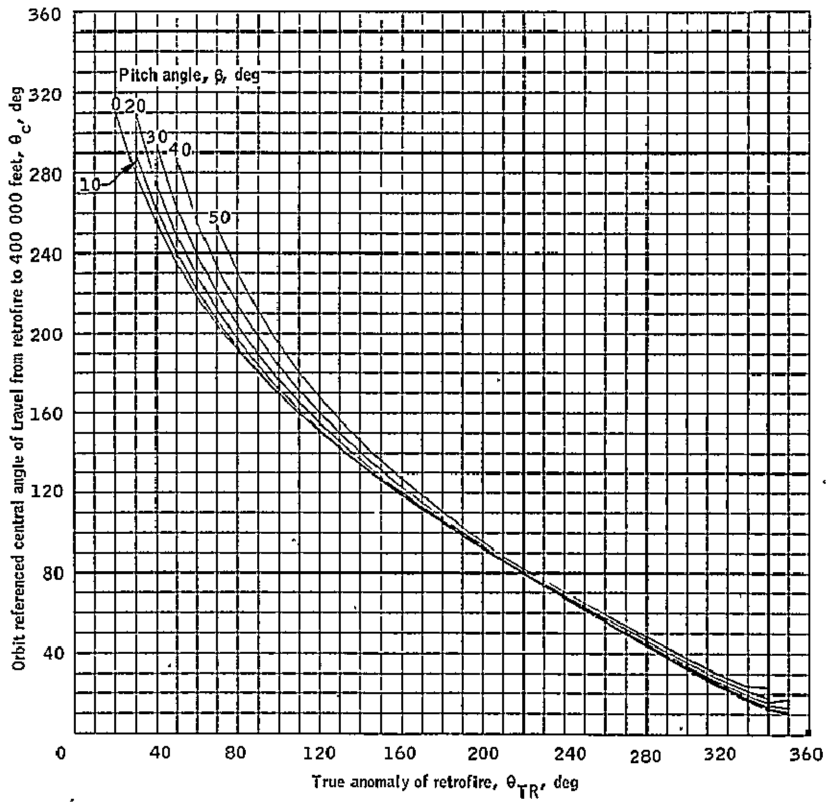
Figure 5.- Continued.



(g) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

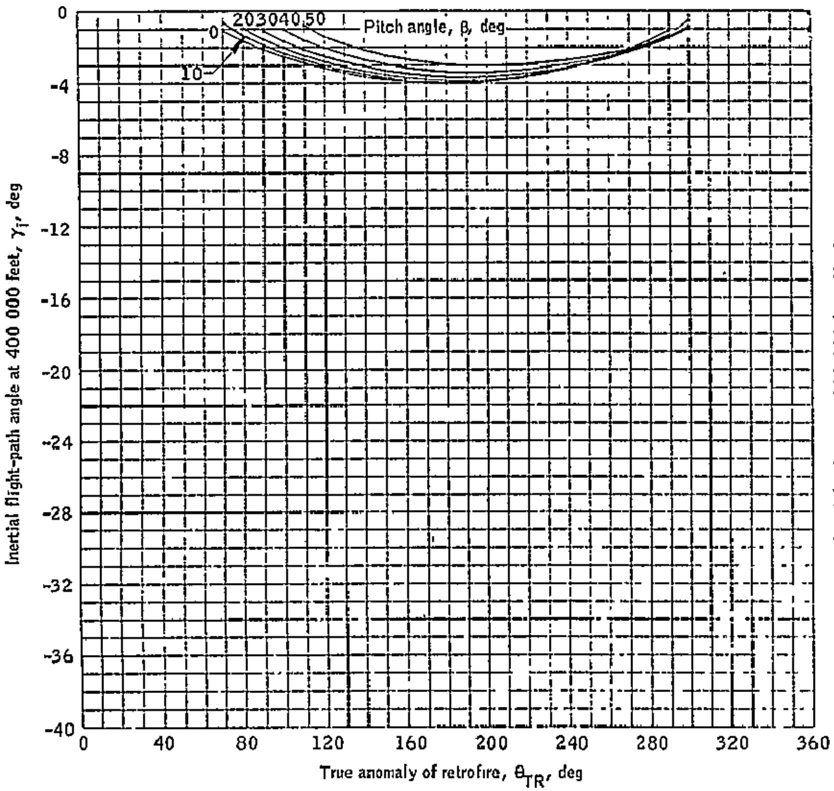
Figure 5.- Continued.

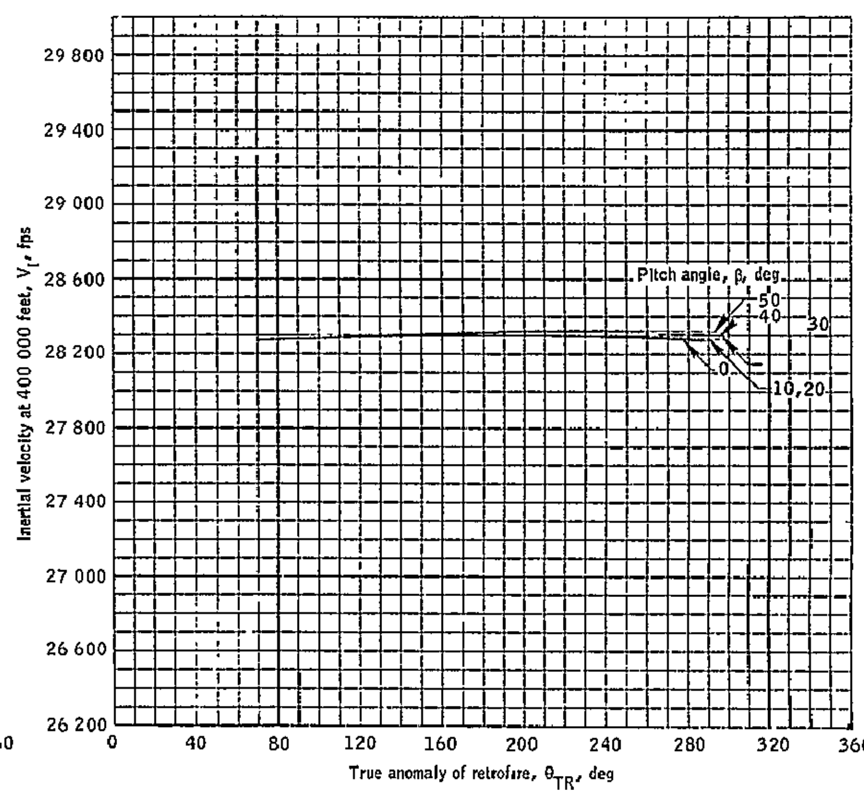




(h) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

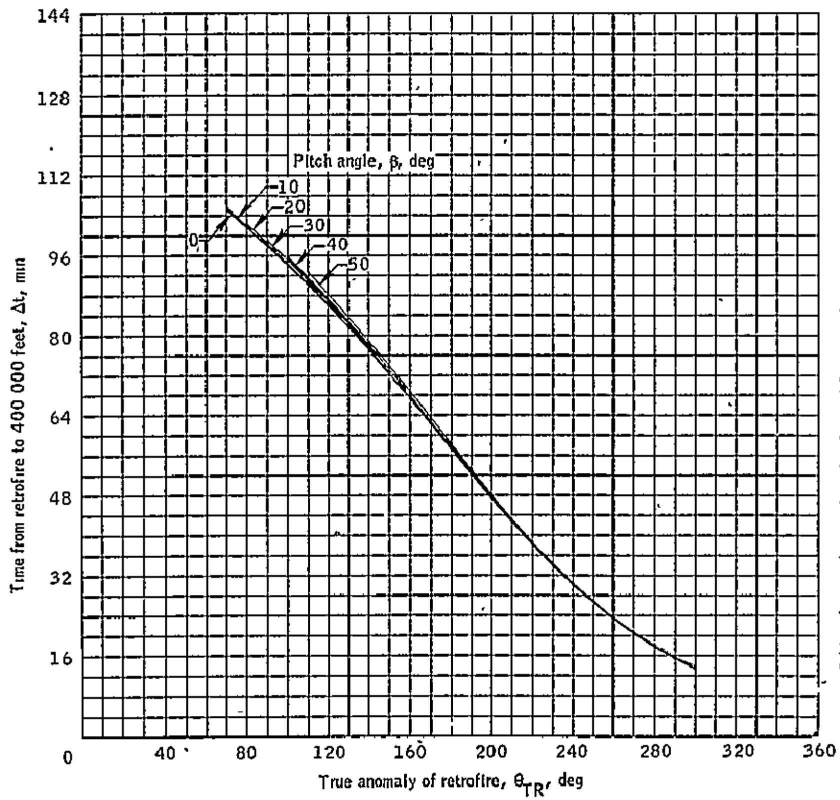
Figure 5.- Concluded.

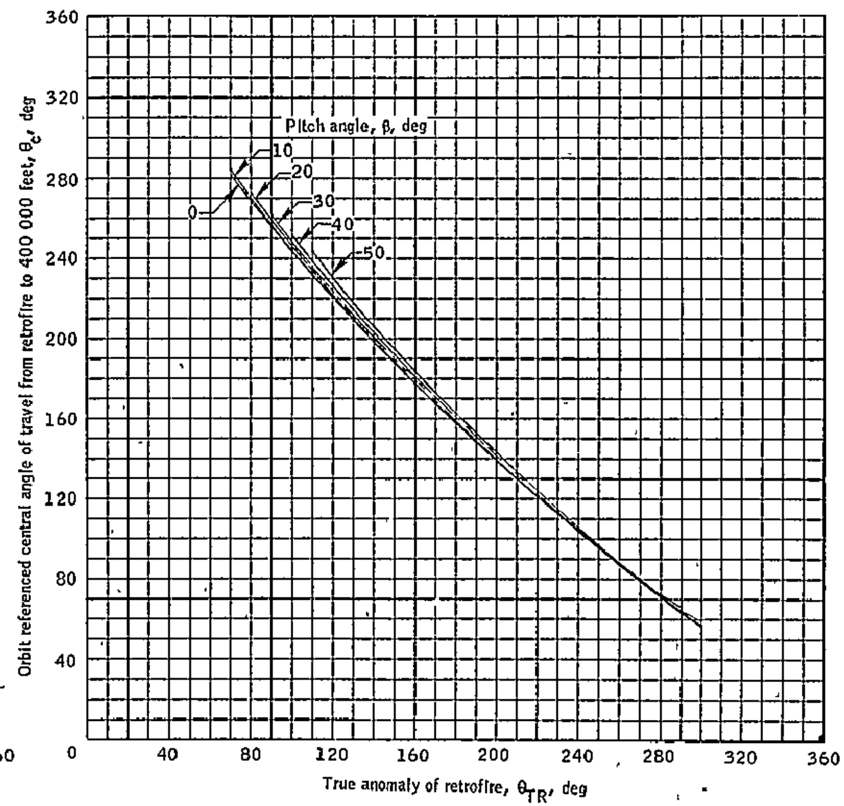




(a) Flight-path angle and velocity for retrograde ΔV = 100 feet per second.

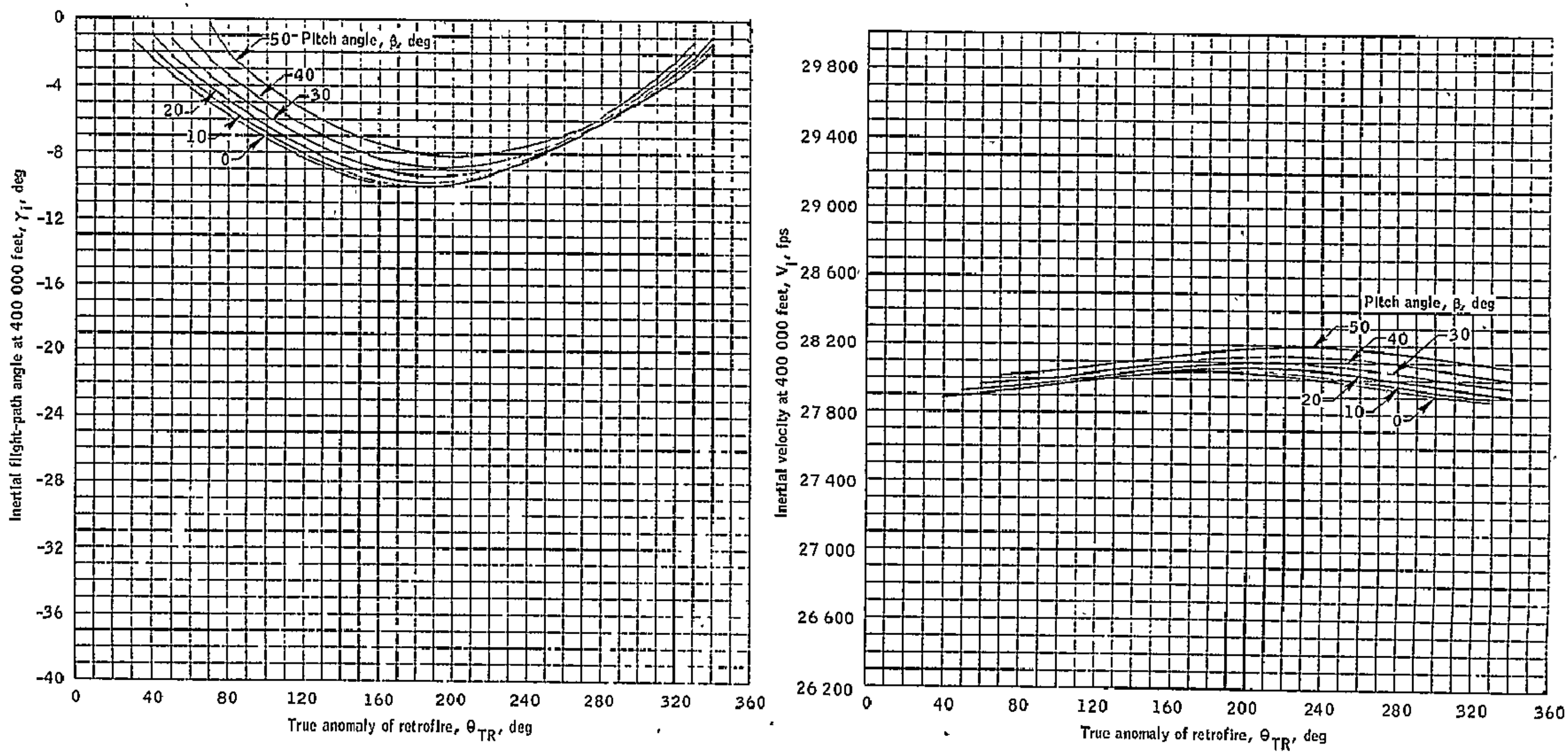
Figure 6.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 80/2000 nautical mile orbit.





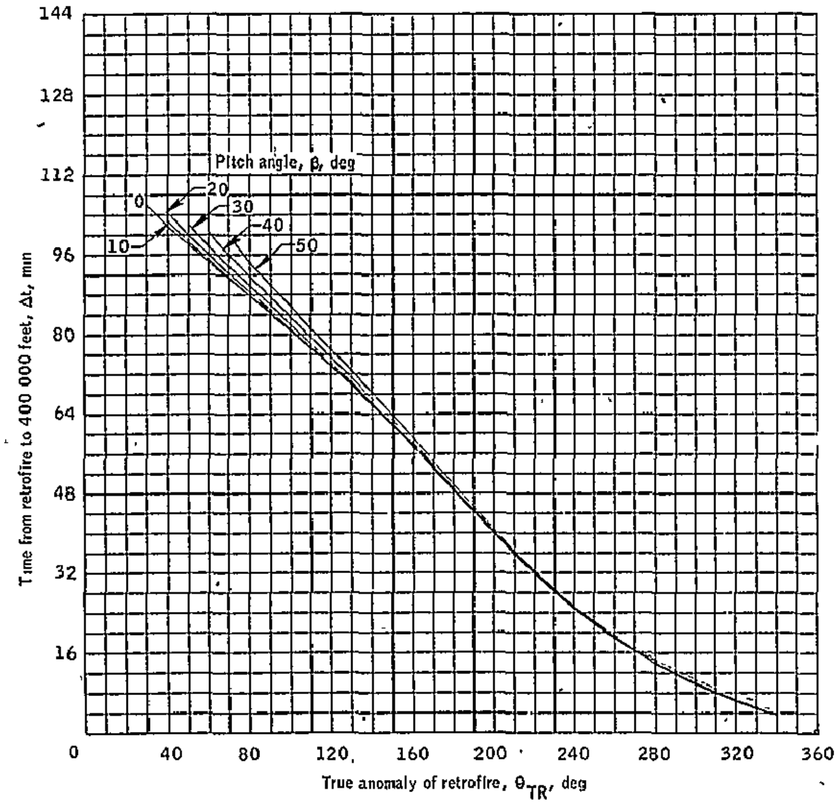
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

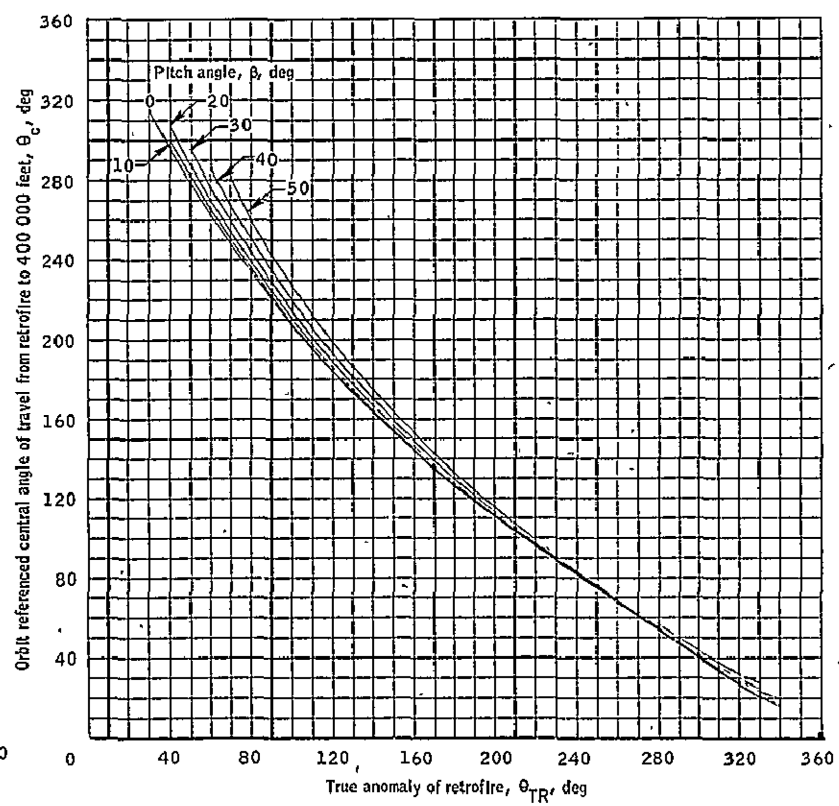
Figure 6.- Continued.



(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

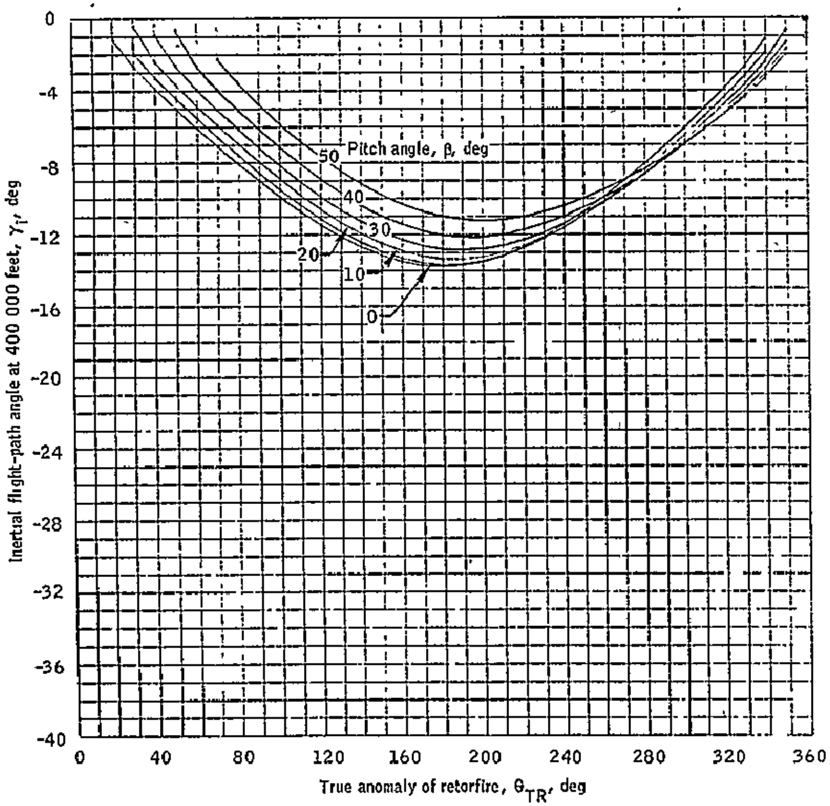
Figure 6.- Continued.

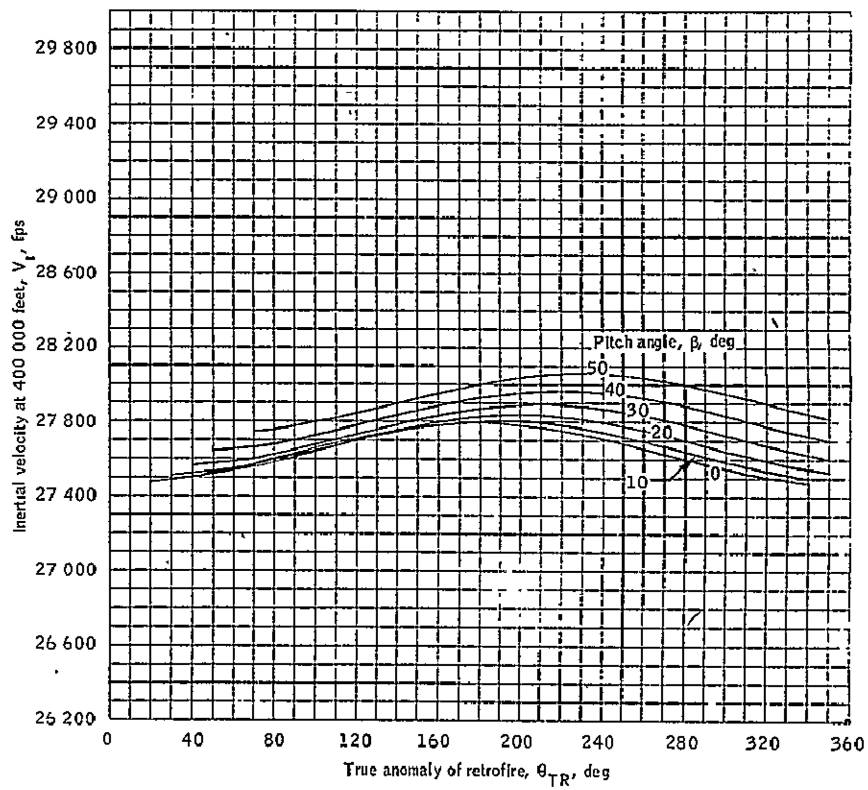




(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

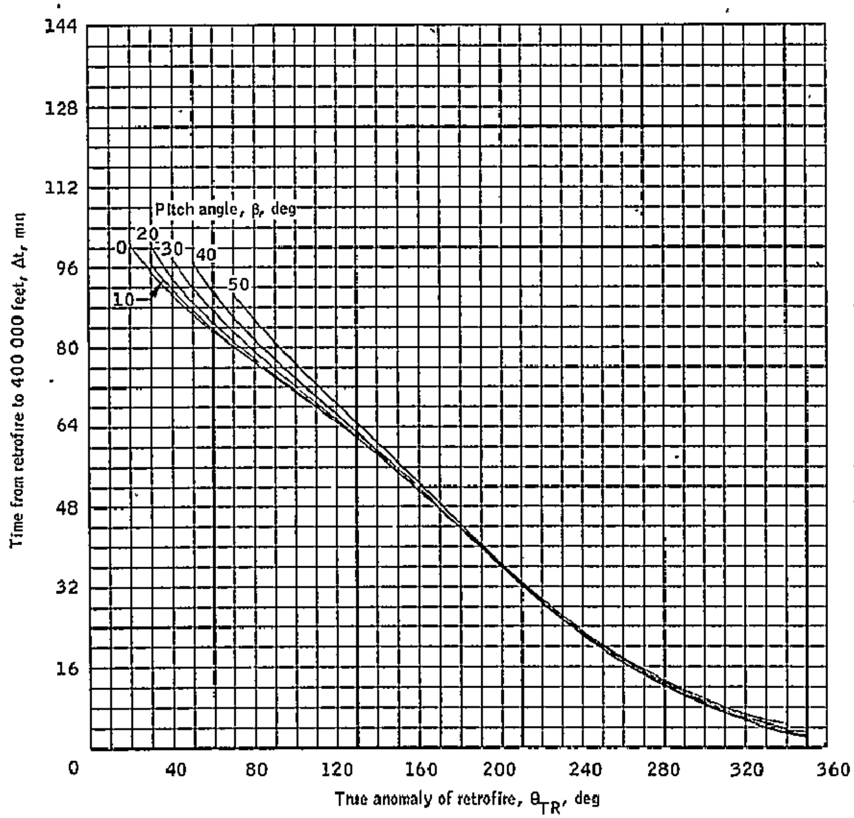
Figure 6.- Continued.

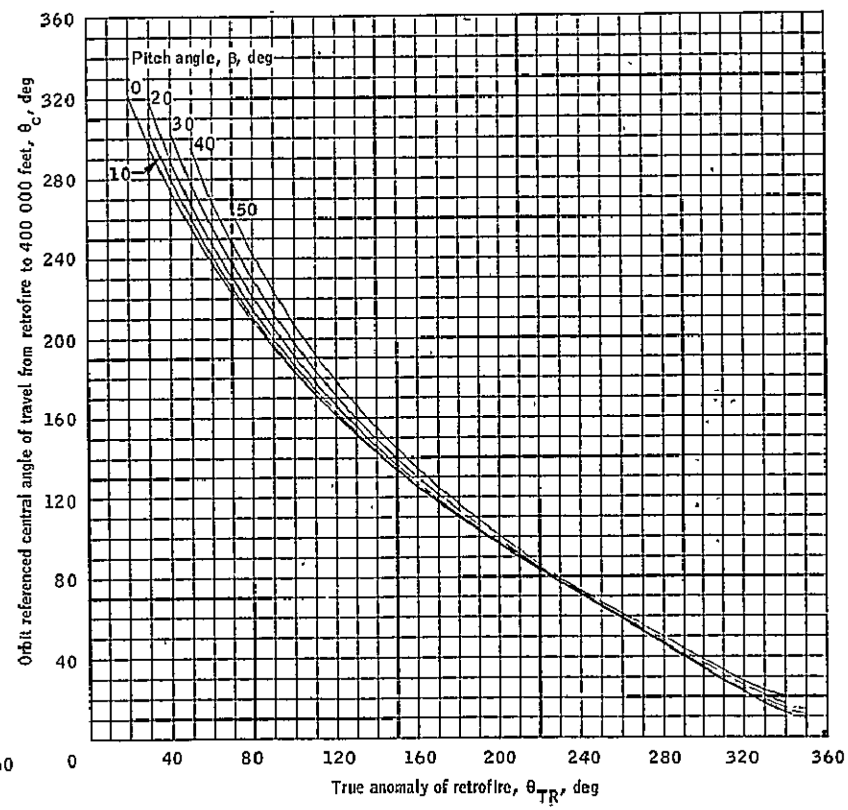




(e) Flight-path angle and velocity for retrograde $\Delta V = 900$ feet per second.

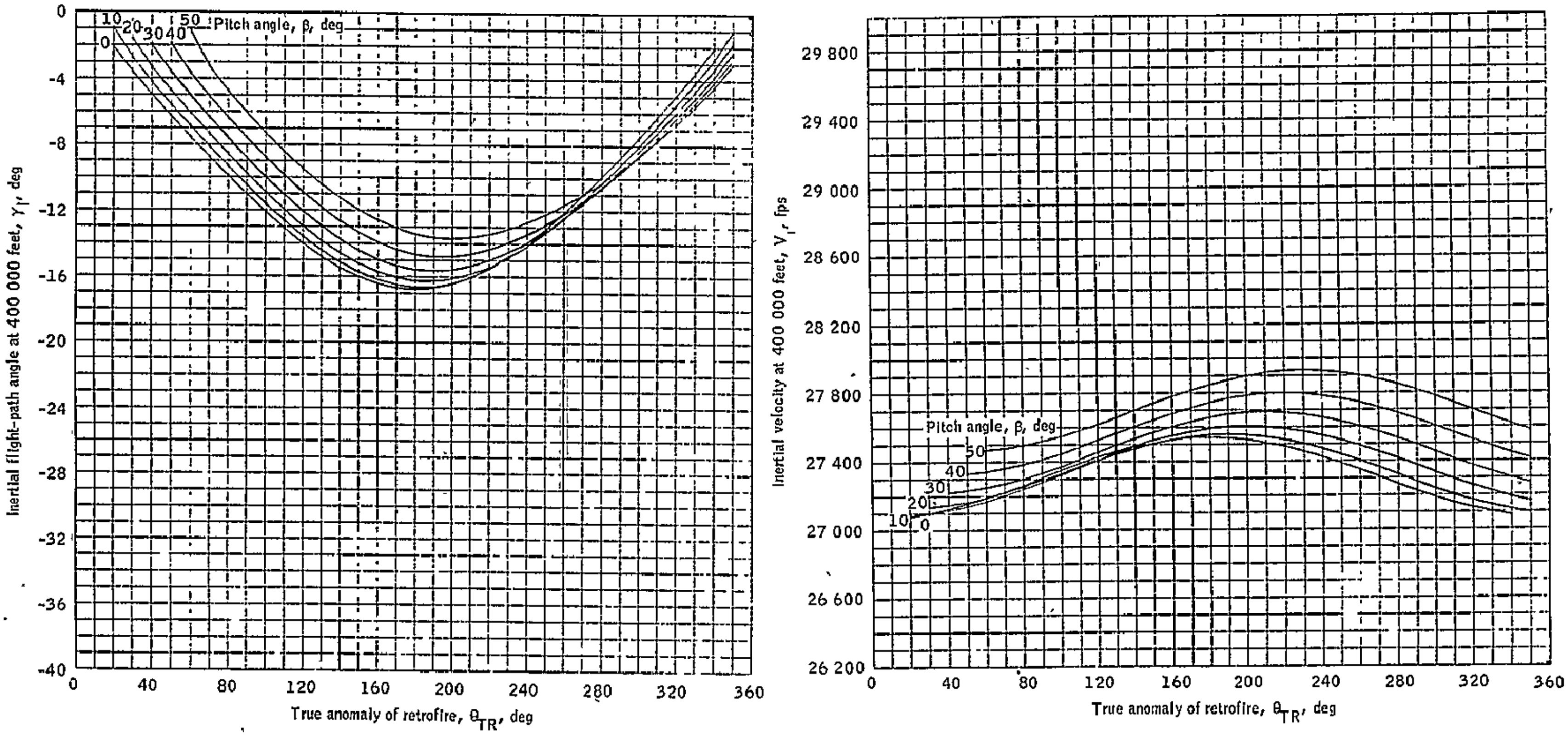
Figure 6.- Continued.





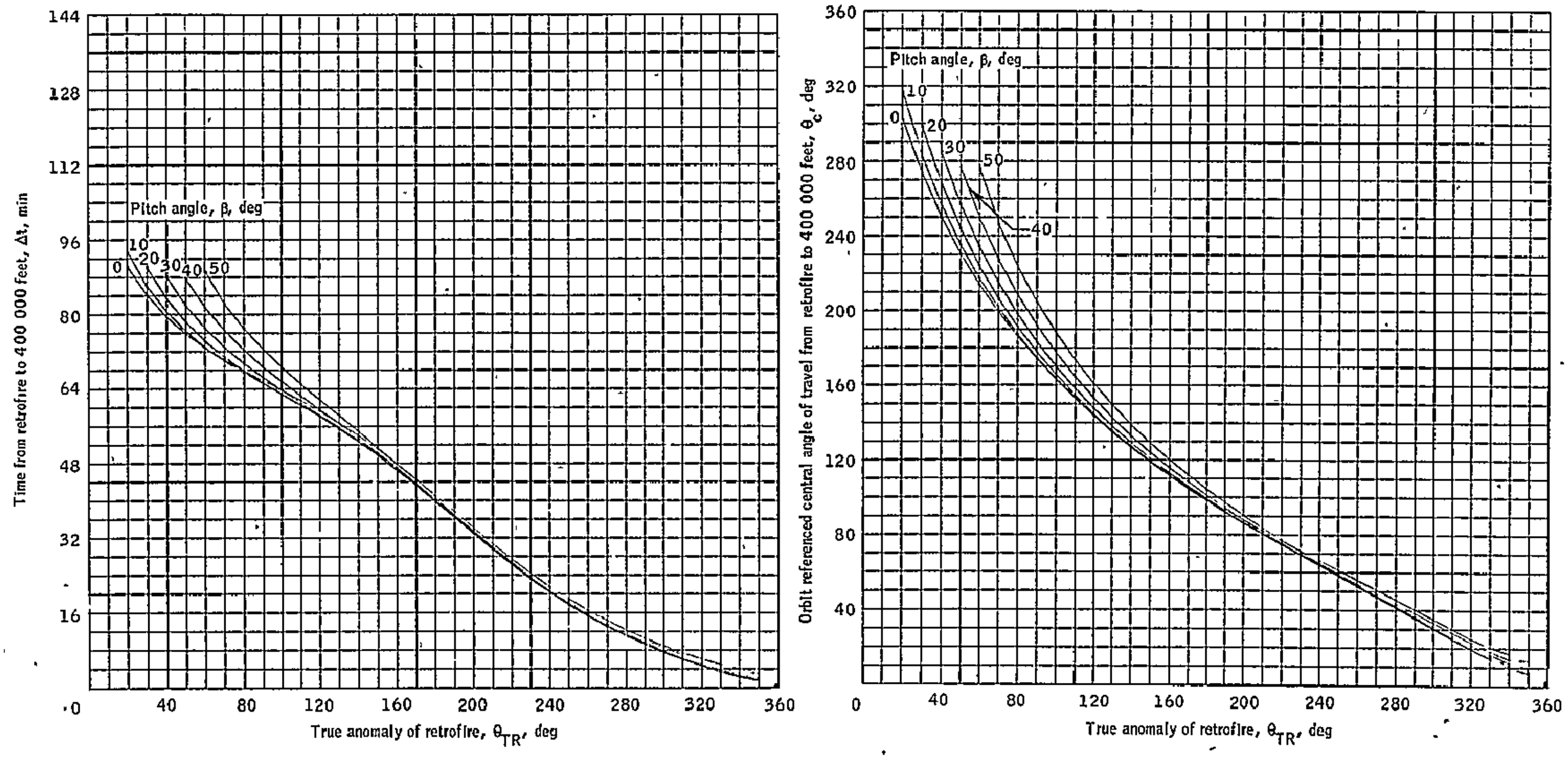
(f) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

Figure 6.- Continued.



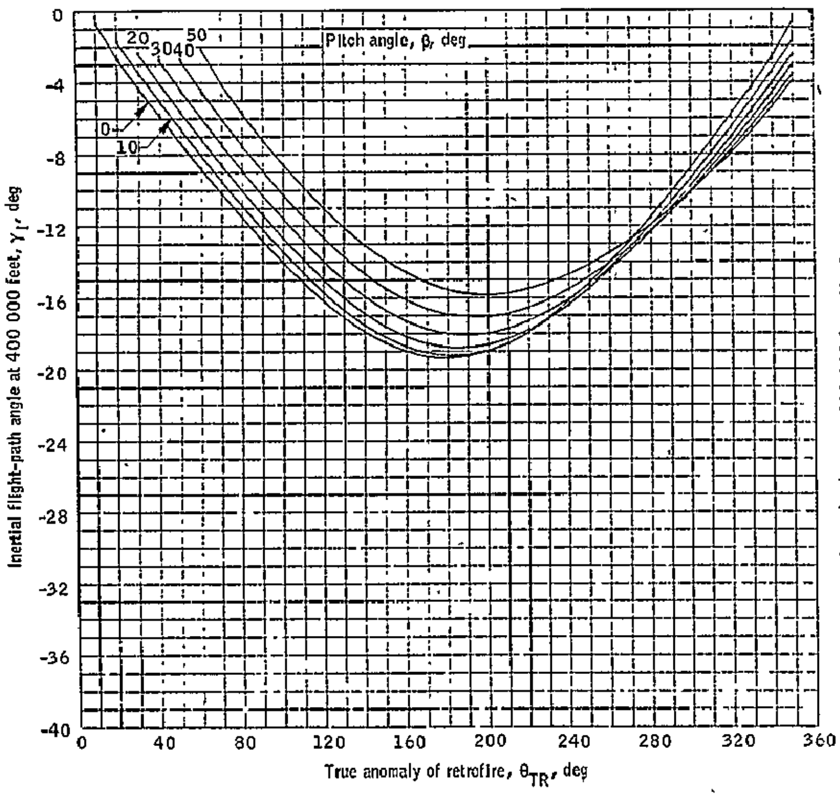
(g) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

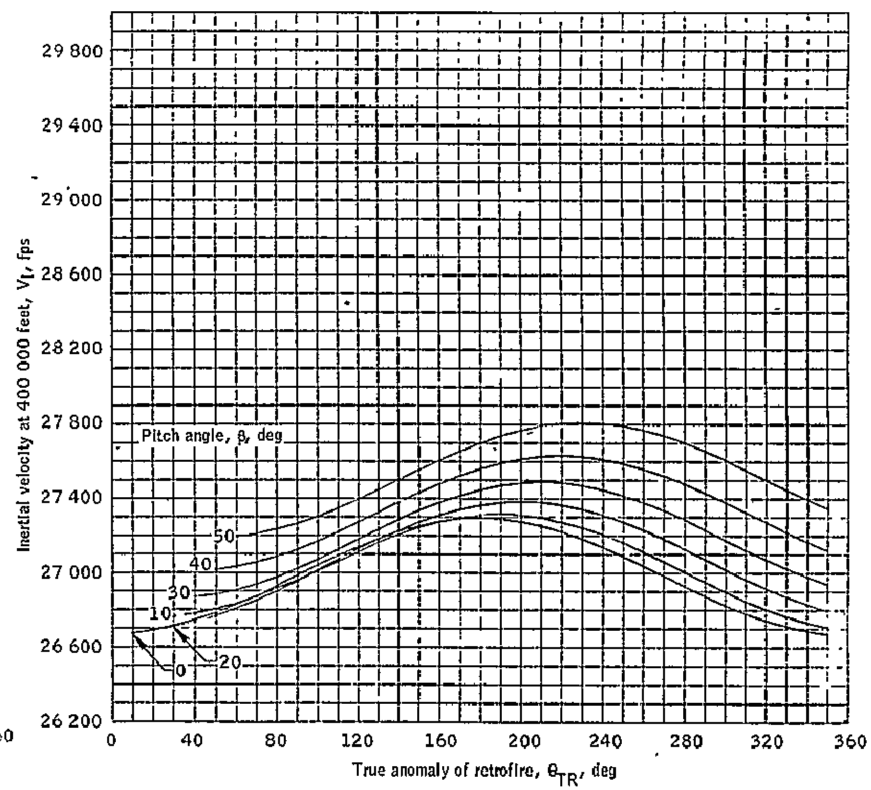
Figure 6.- Continued.



(h) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

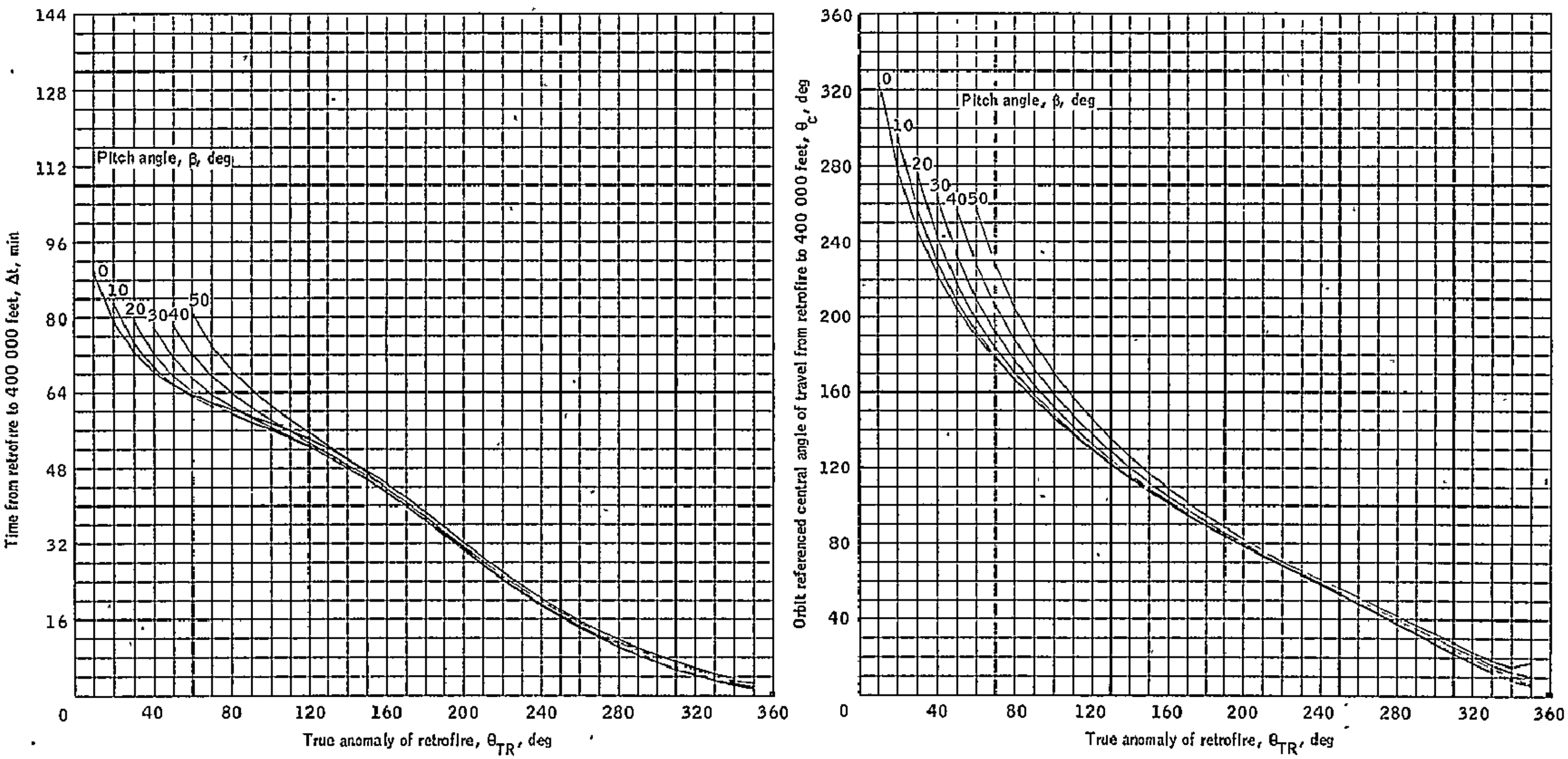
Figure 6.- Continued.





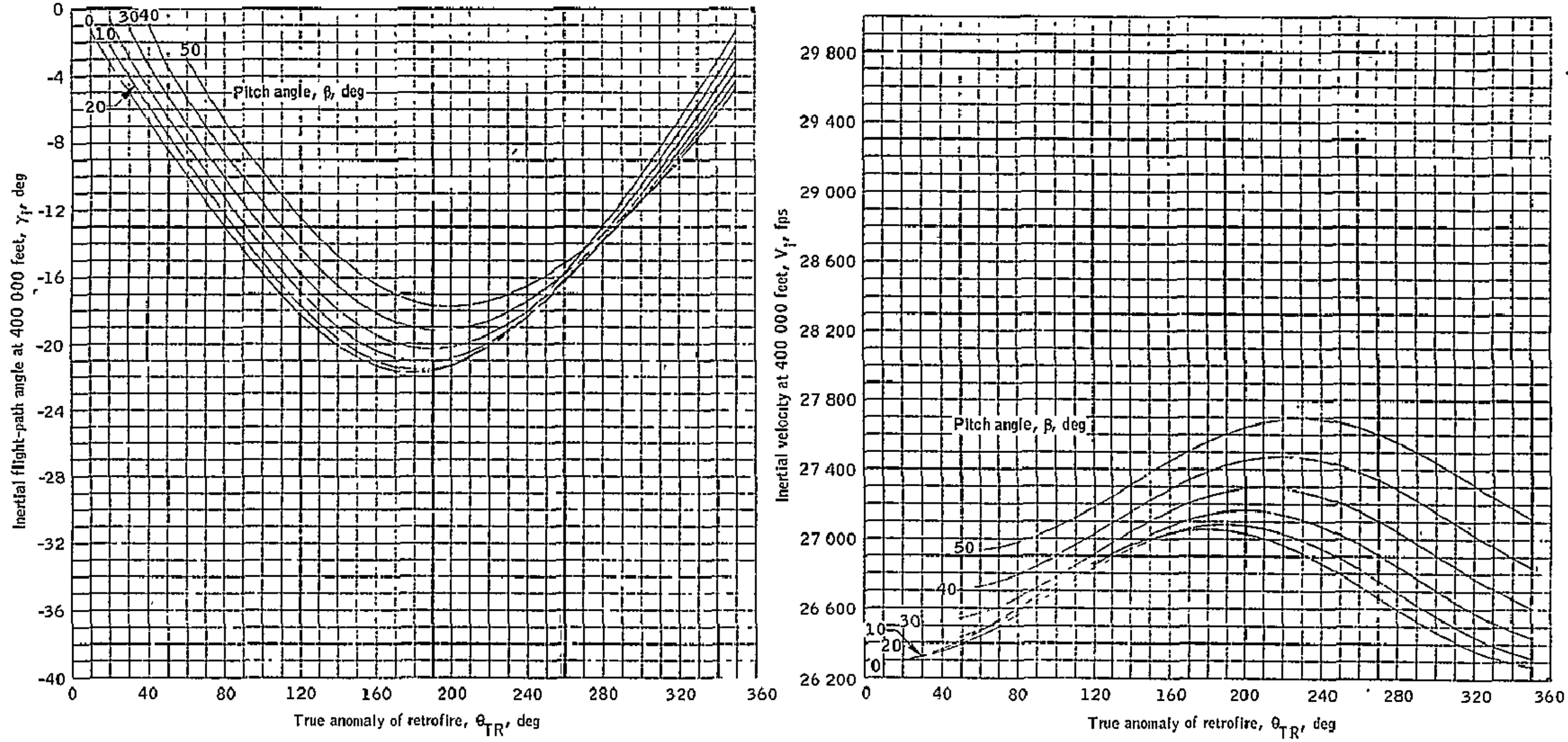
(i) Flight-path angle and velocity for retrograde ΔV = 1700 feet per second.

Figure 6.- Continued.



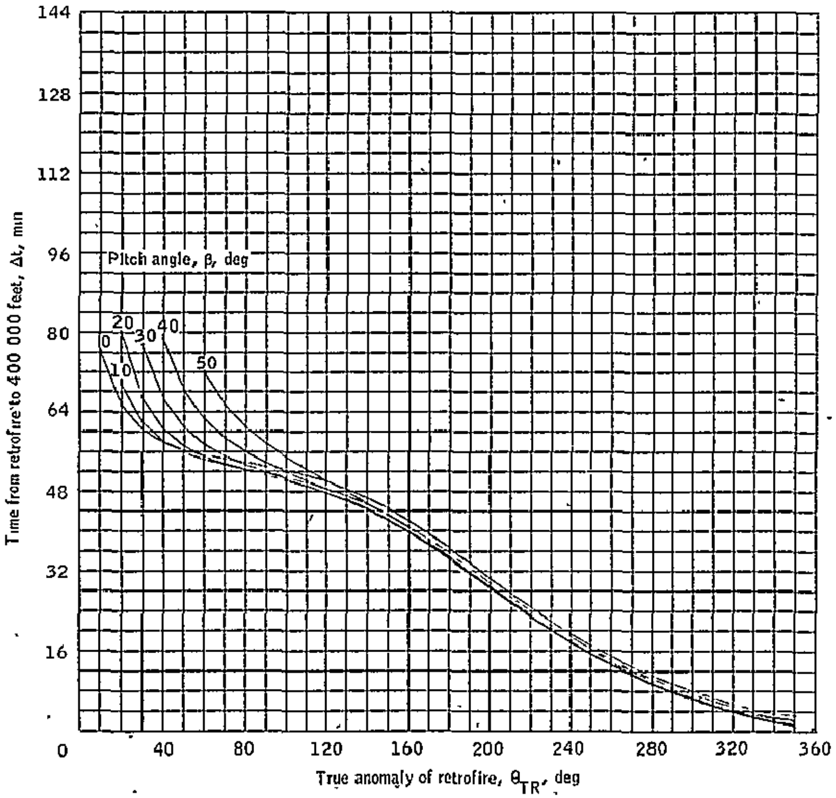
(j) Time from retrofire and central angle for retrograde ΔV = 1700 feet per second.

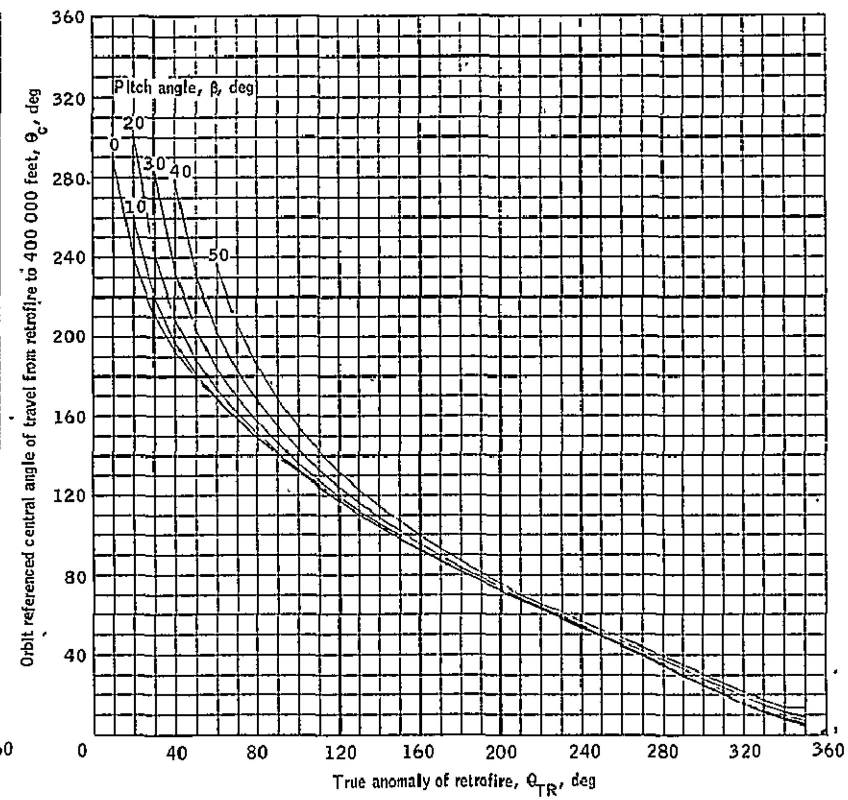
Figure 6.- Continued.



(k) Flight-path angle and velocity for retrograde ΔV = 2100 feet per second.

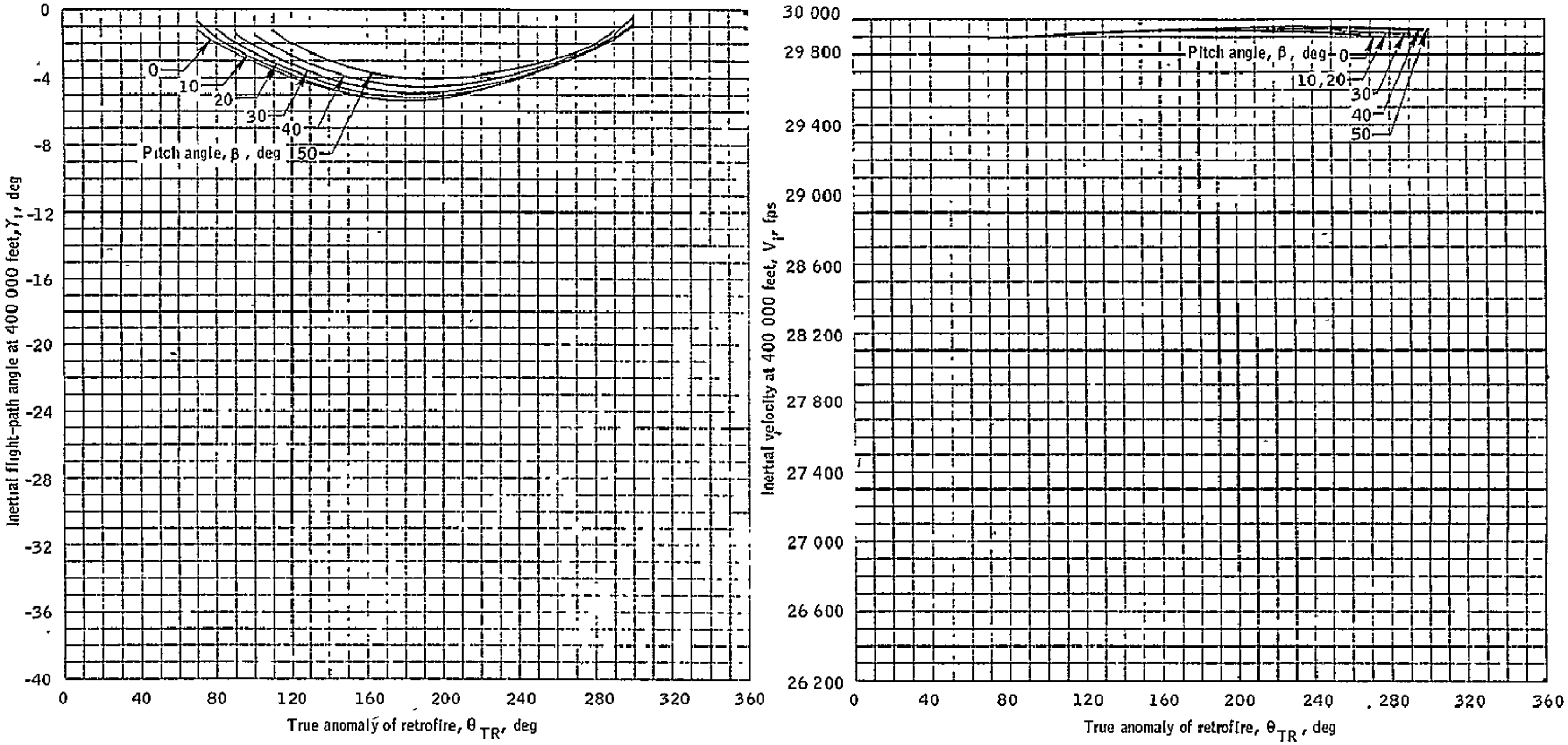
Figure 6.- Continued.





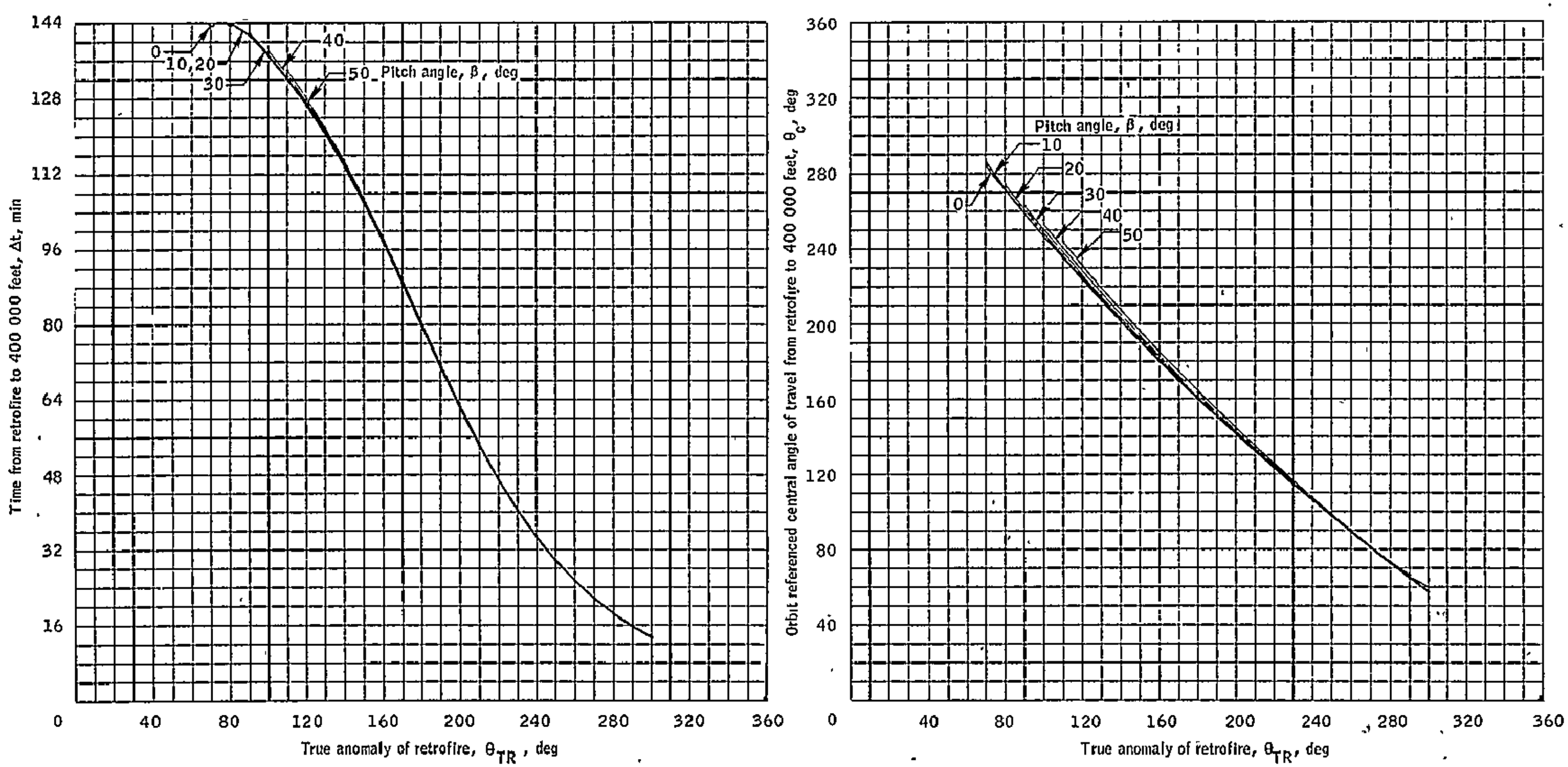
(l) Time from retrofire and central angle for retrograde ΔV = 2100 feet per second.

Figure 6.- Concluded.



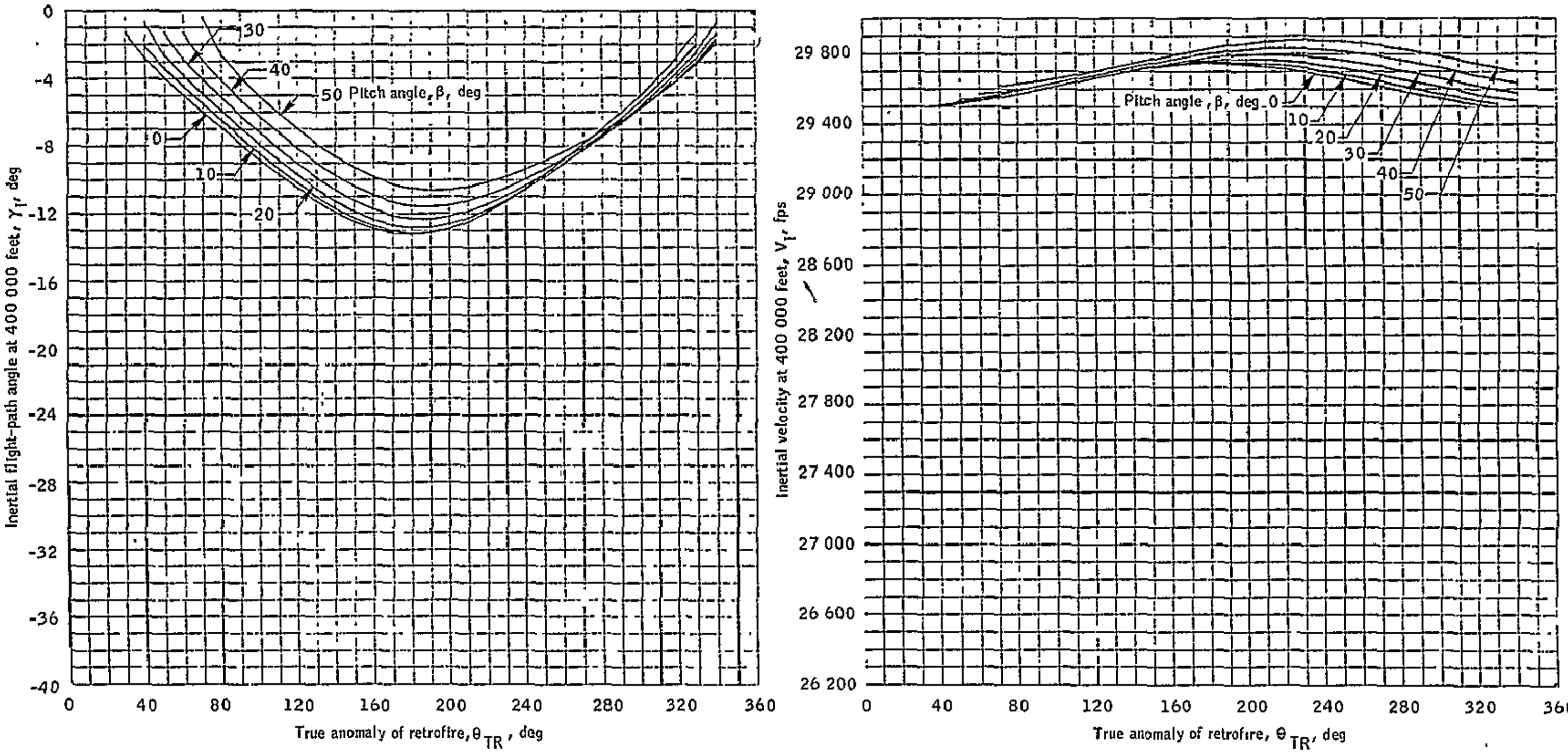
(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

Figure 7 - Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 80/4000 nautical mile orbit.



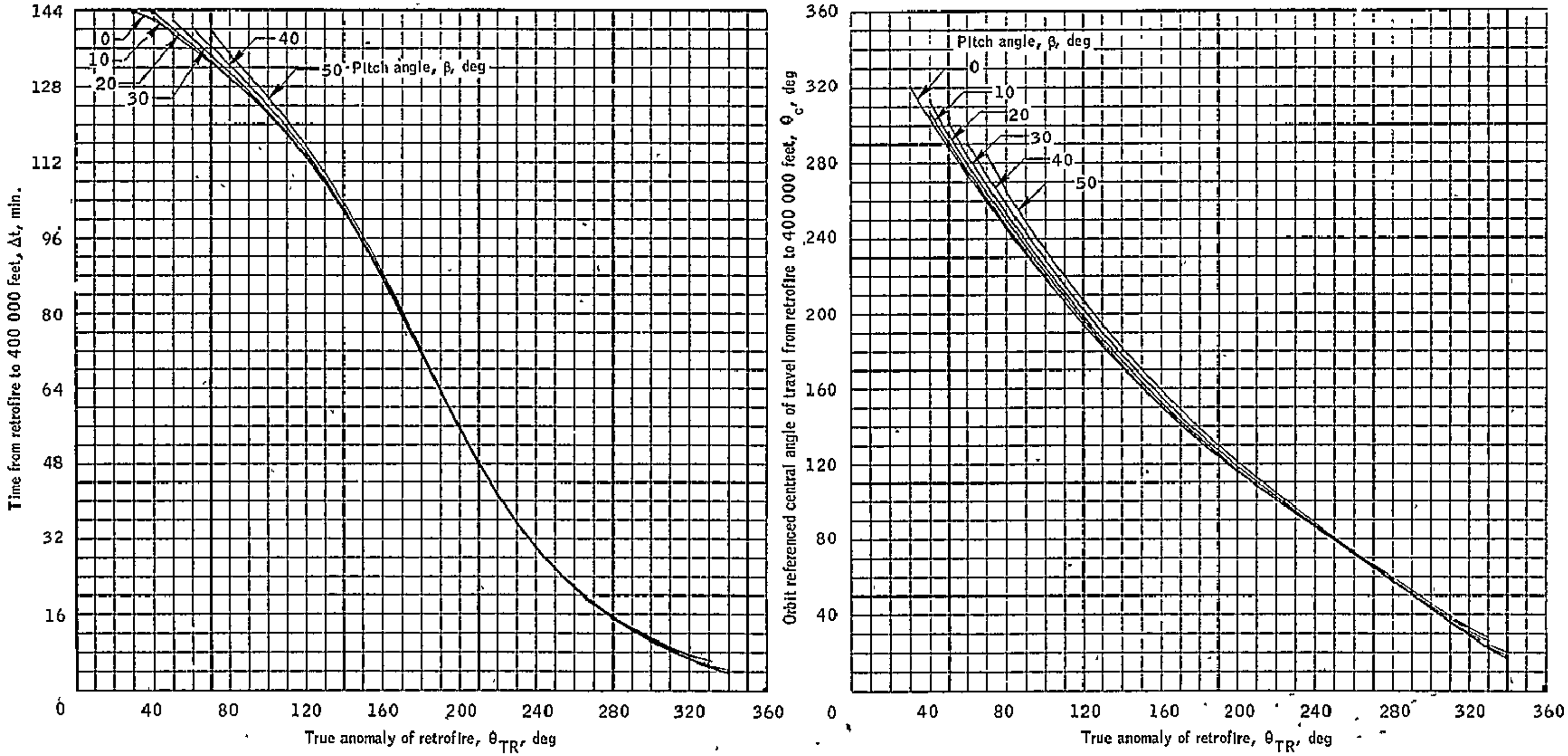
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

Figure 7.- Continued.



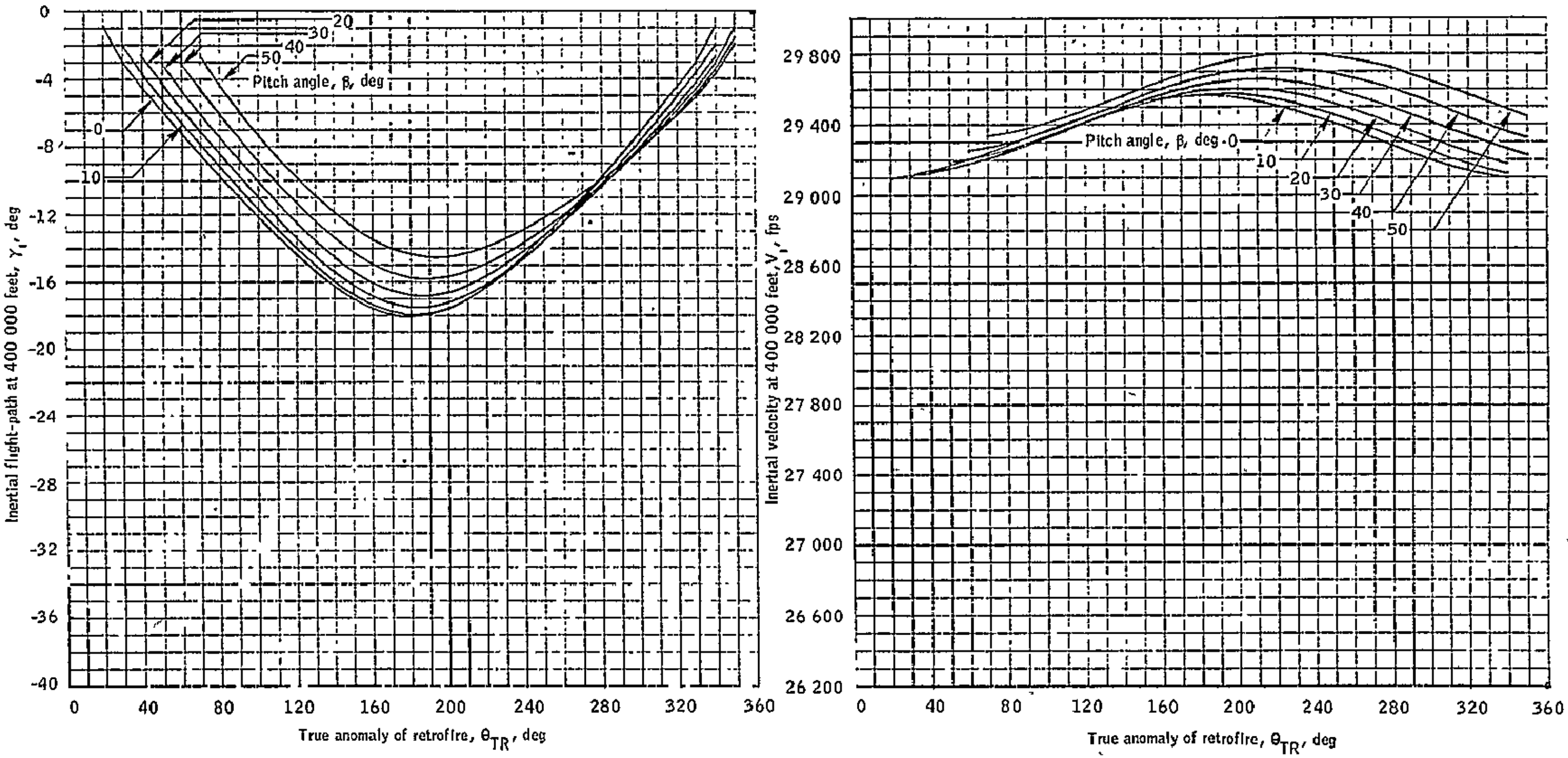
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 7.- Continued.



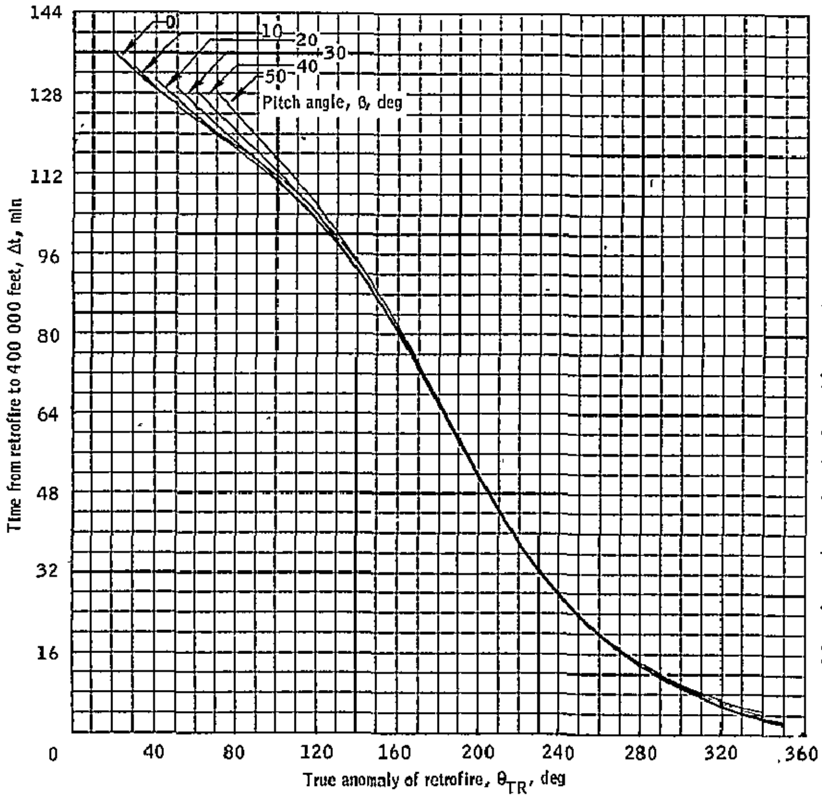
(d) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

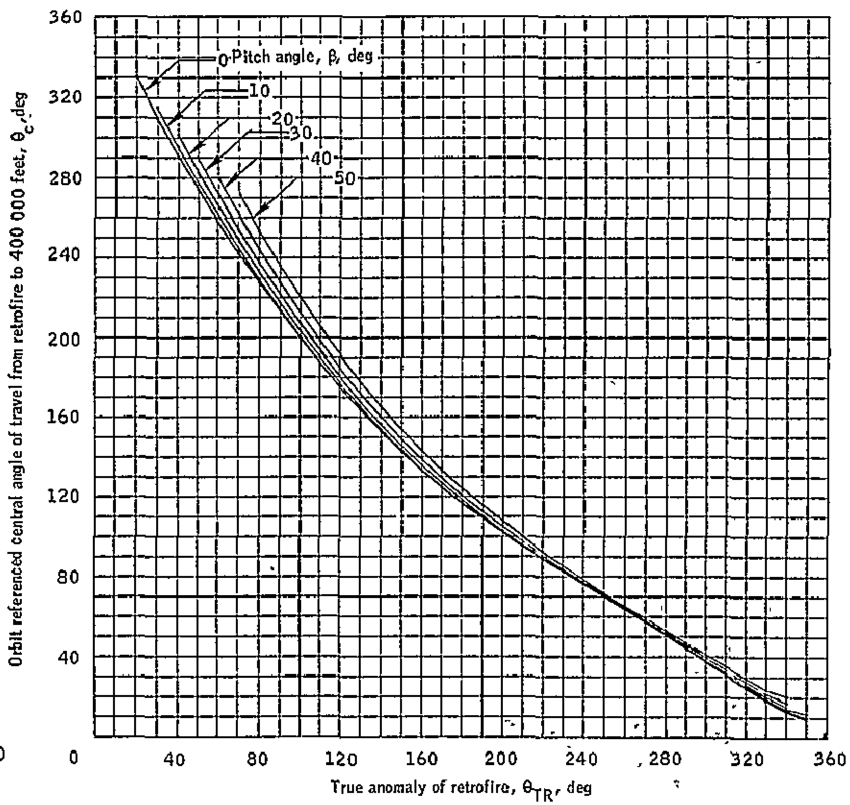
Figure 7.- Continued.



(c) Flight-path angle and velocity for retrograde ΔV=900 feet per second

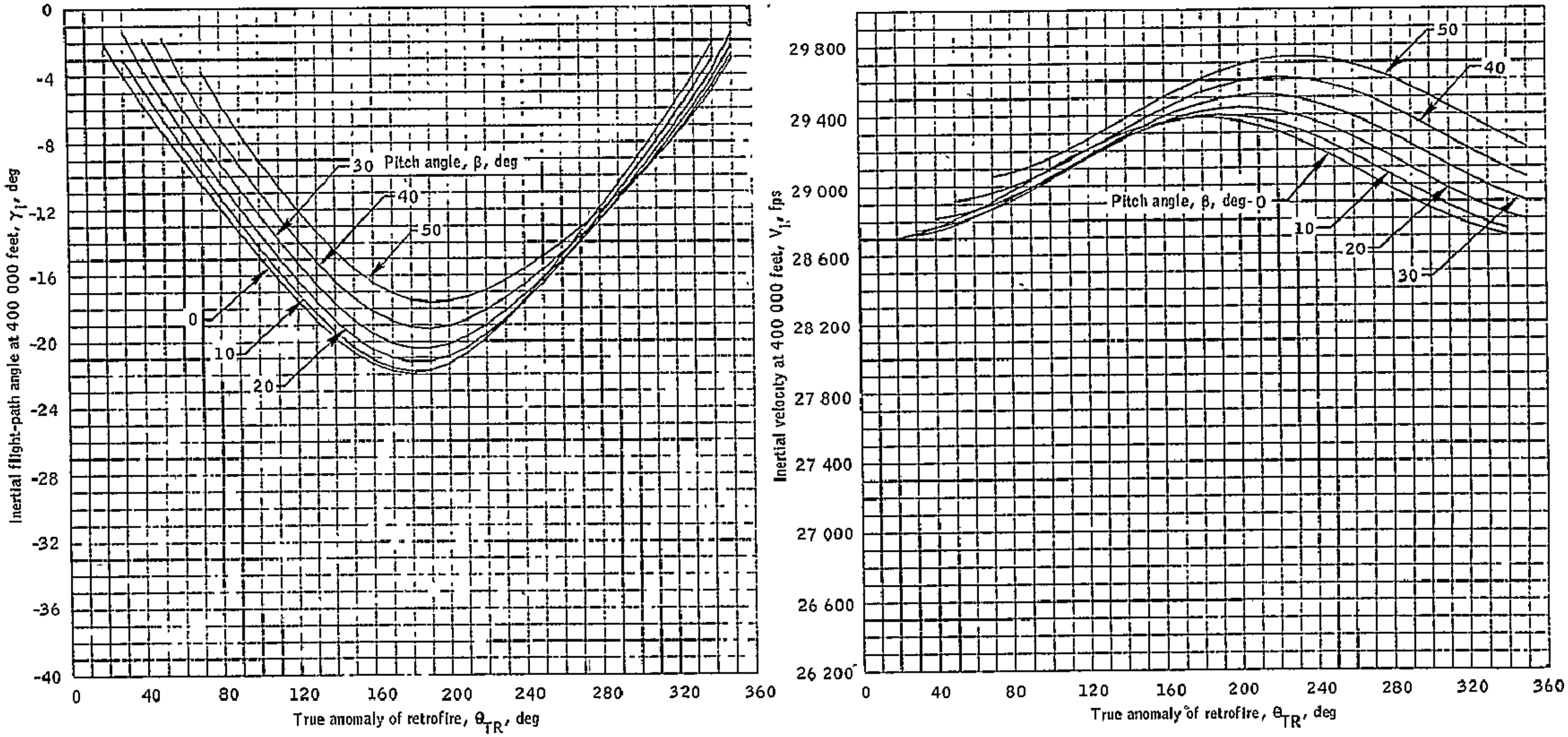
Figure 7.- Continued.





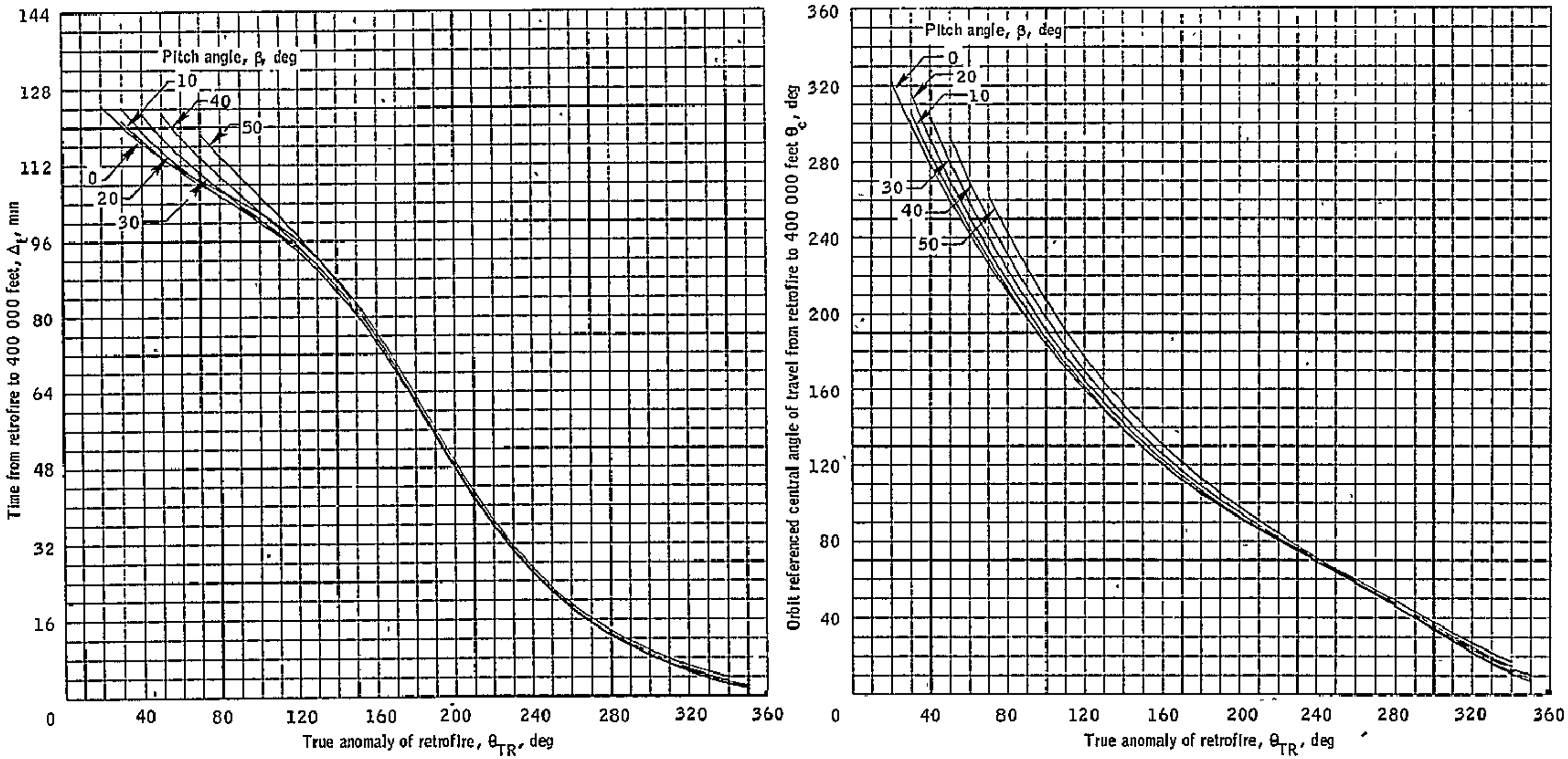
(f) Time from retrofire and central angle for retrograde ΔV=900 feet per second.

Figure 7.- Continued.



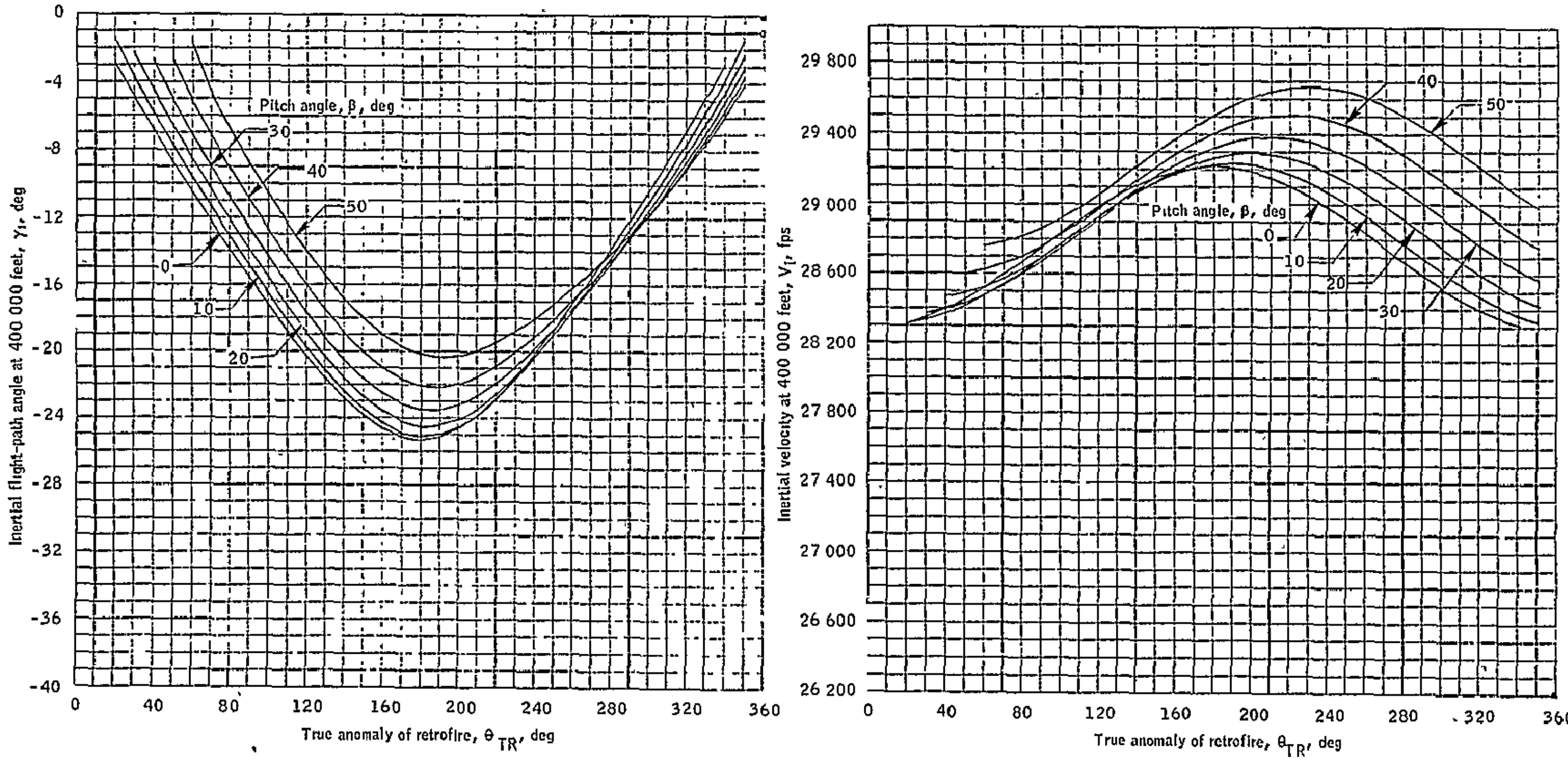
(g) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

Figure 7.- Continued.



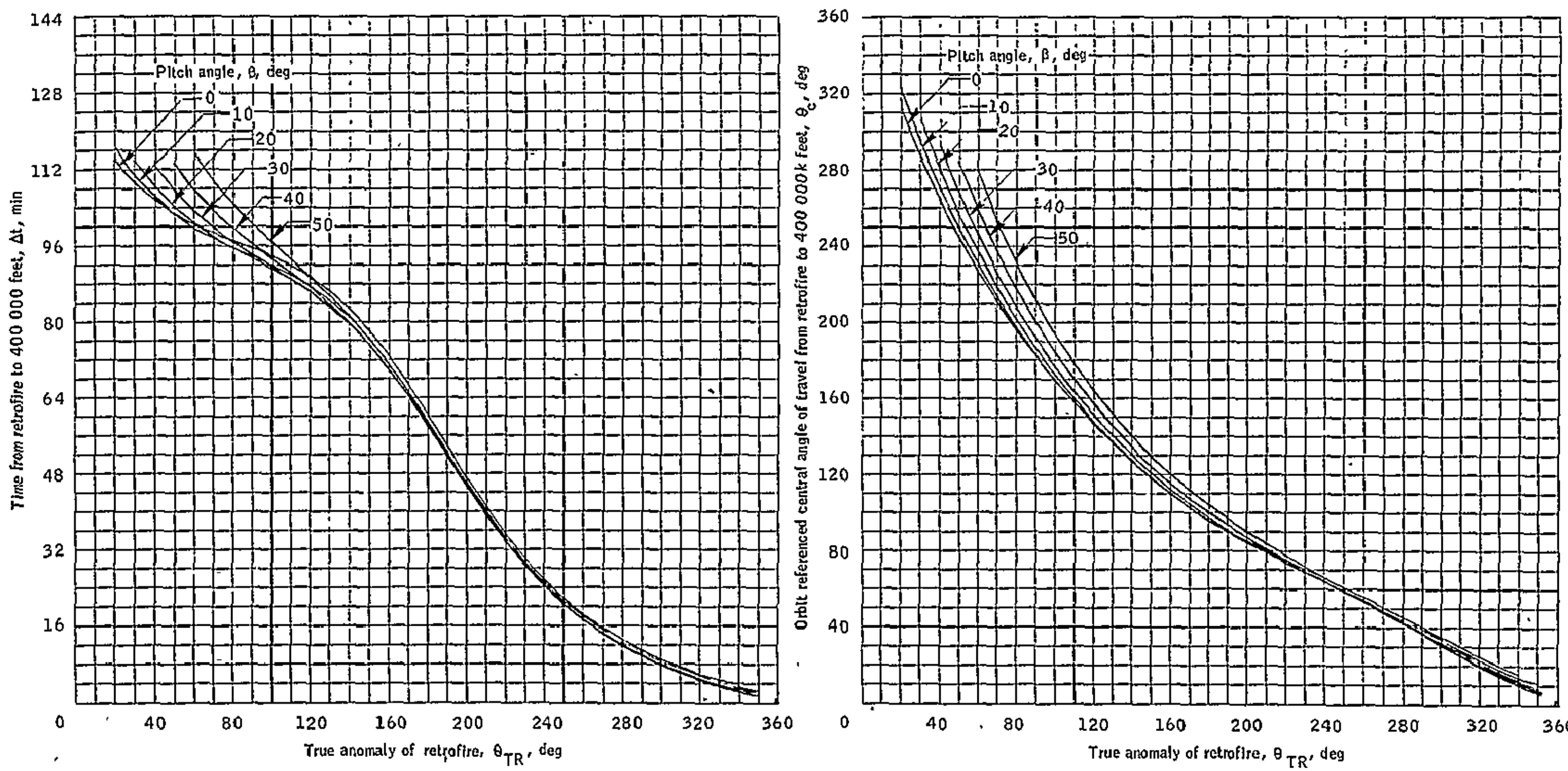
(h) Time from retrofire and central angle for retrograde ΔV=1300 feet per second.

Figure 7.- Continued.



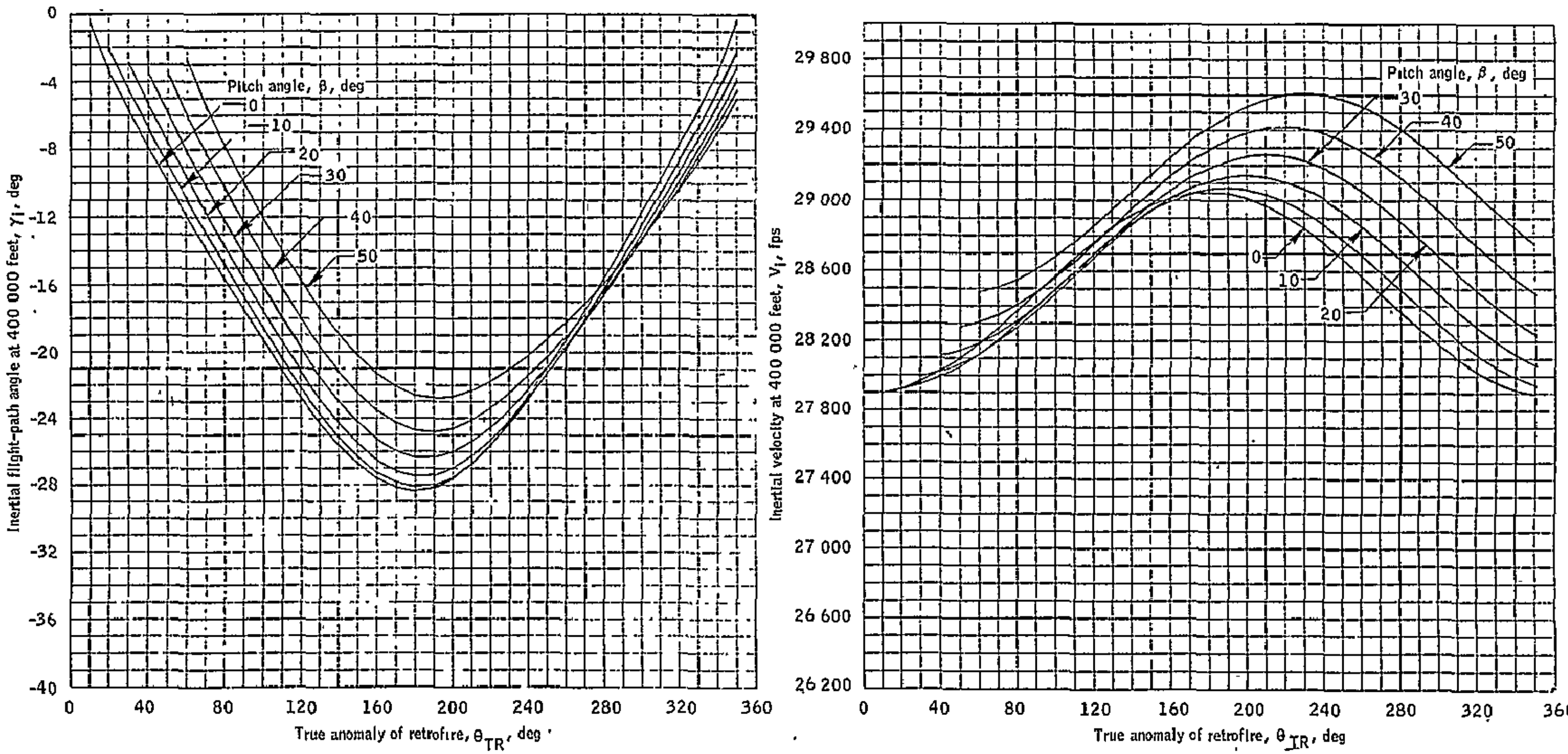
(i) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

Figure 7.- Continued.



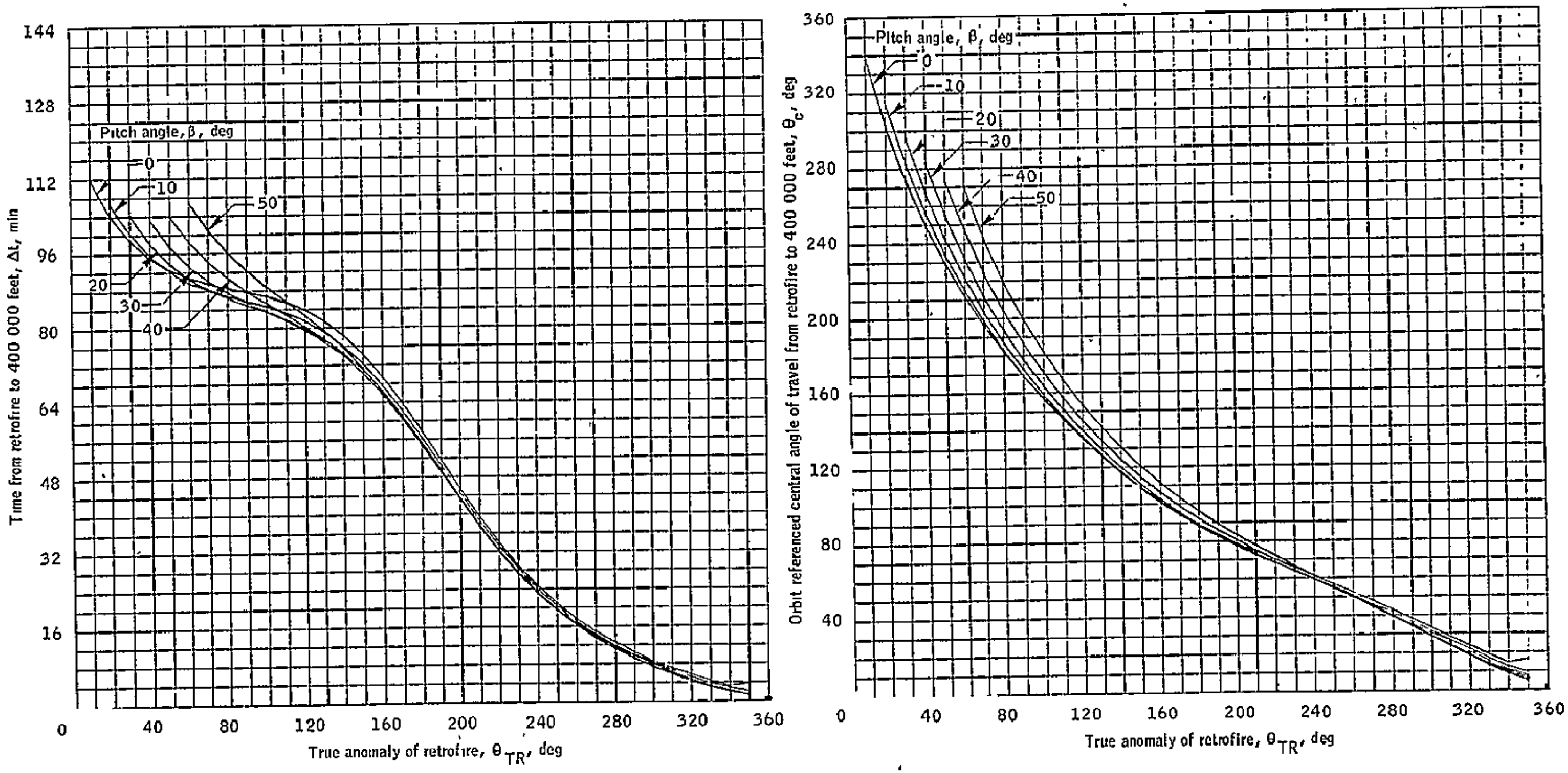
(j) Time from retrofire and central angle for retrograde ΔV=1700 feet per second.

Figure 7.- Continued.



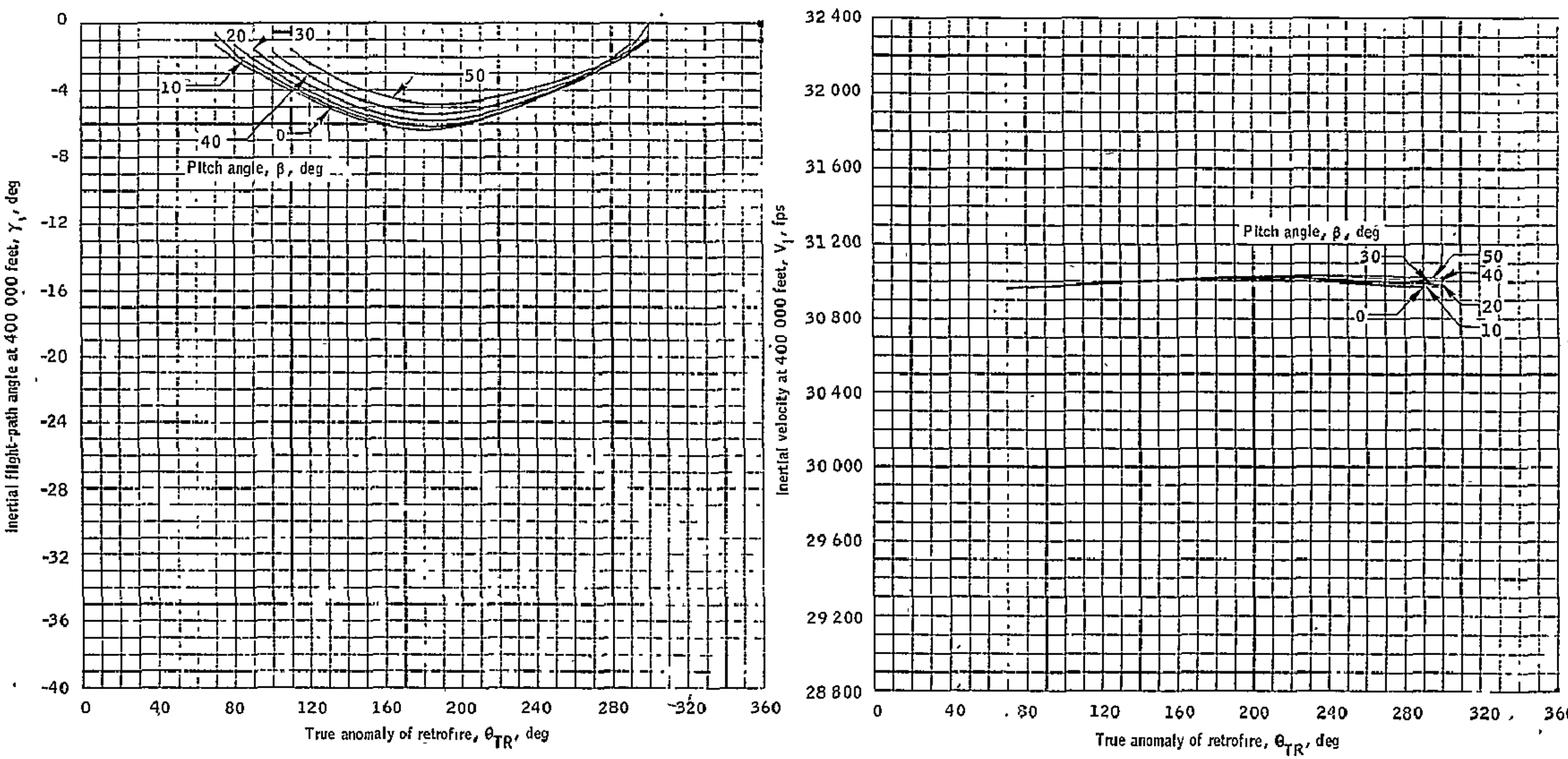
(k) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

Figure 7.- Continued.



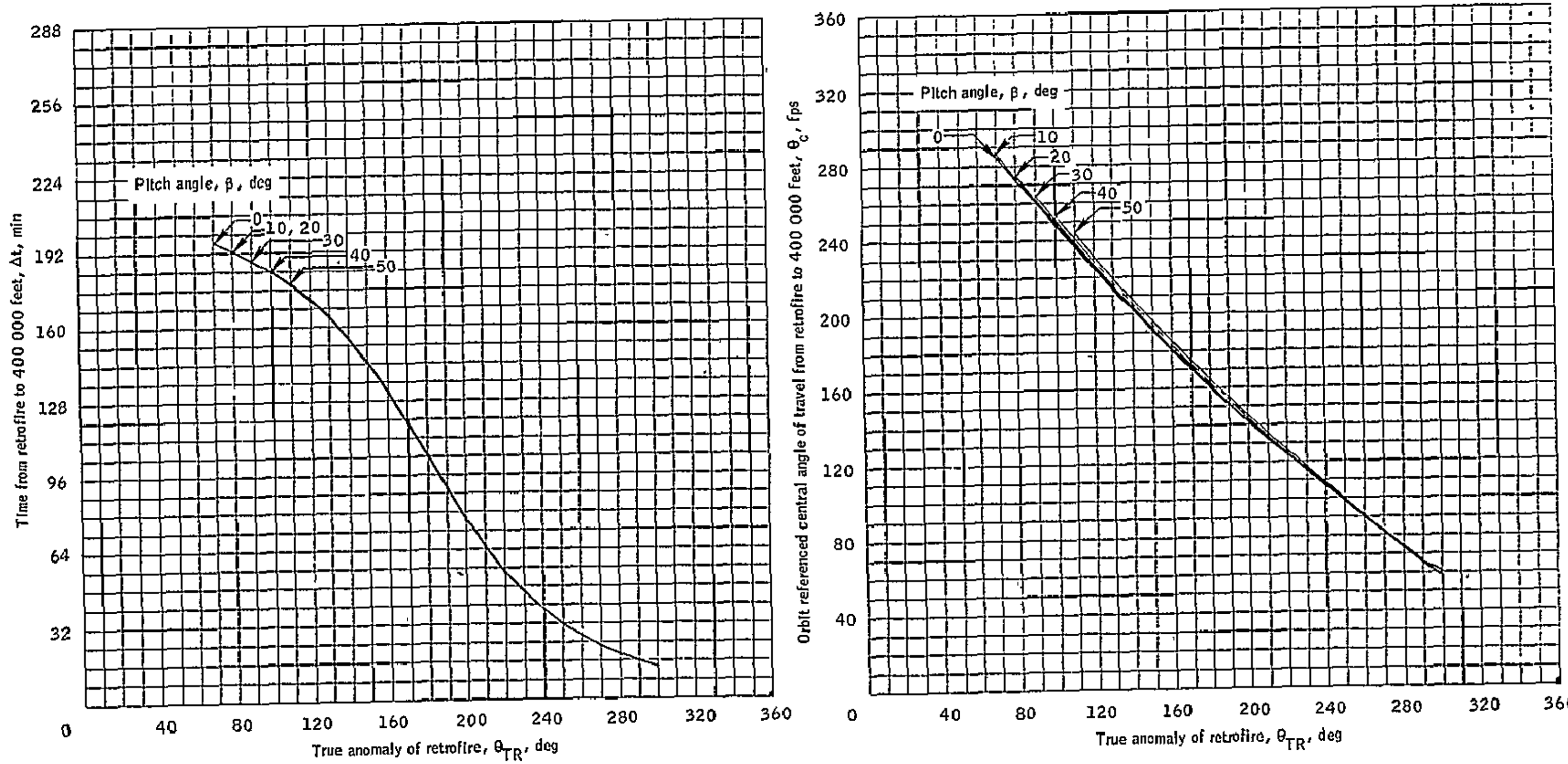
(l) Time from retrofire and central angle for retrograde ΔV=2100 feet per second.

Figure 7.- Concluded.



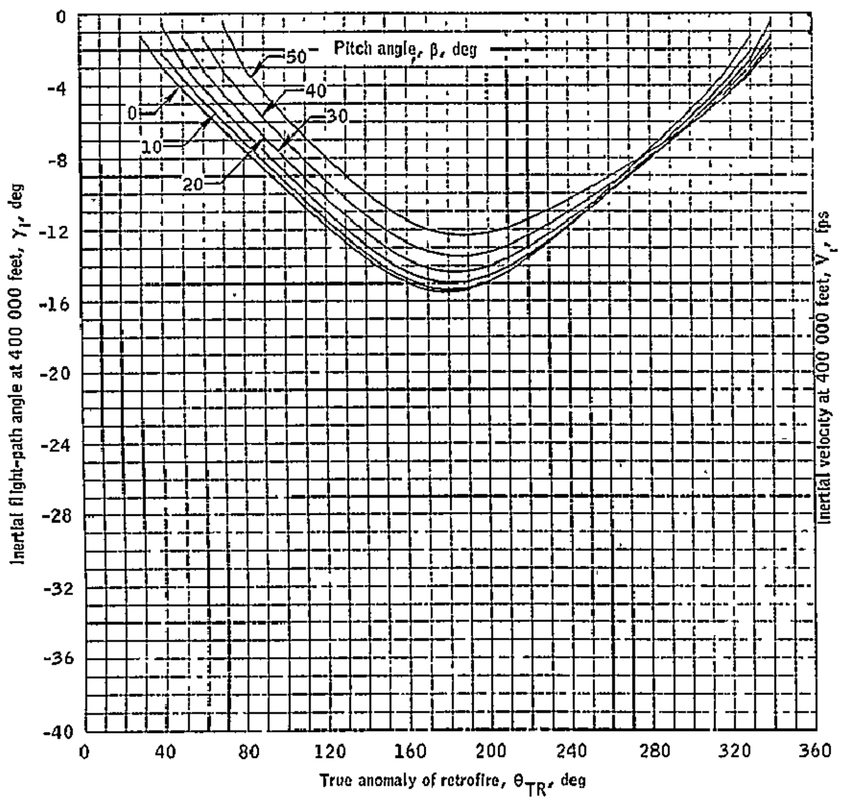
(a) Flight-path angle and velocity for retrograde ΔV = 100 feet per second.

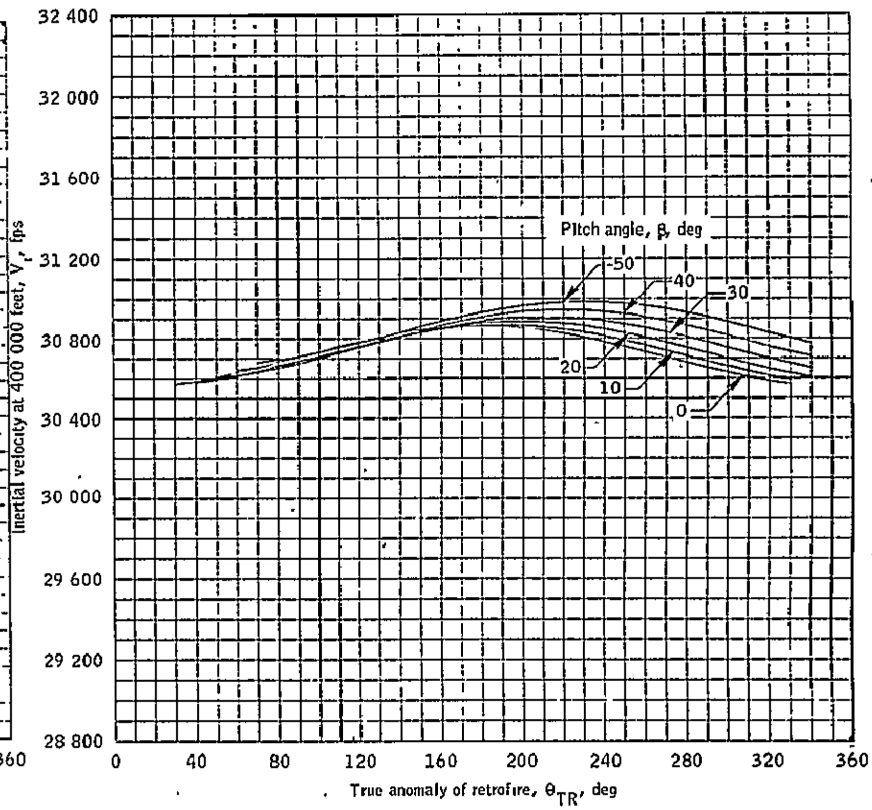
Figure 8.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 80/6000 nautical miles orbit



(b) Time from retrofire and central angle for retrograde ΔV = 100 feet per second.

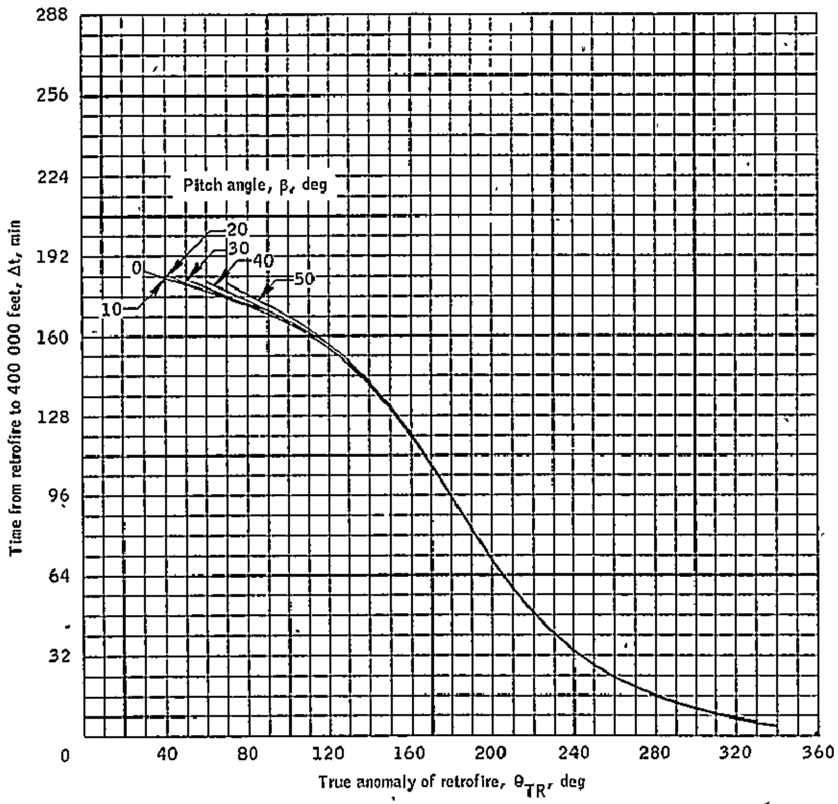
Figure 8.- Continued.

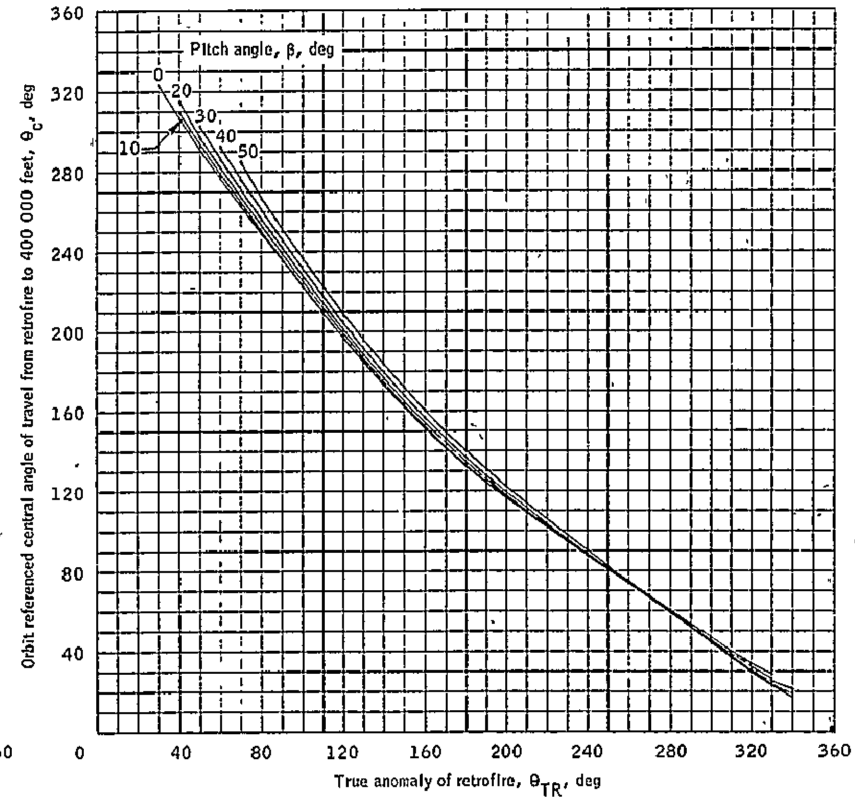




(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

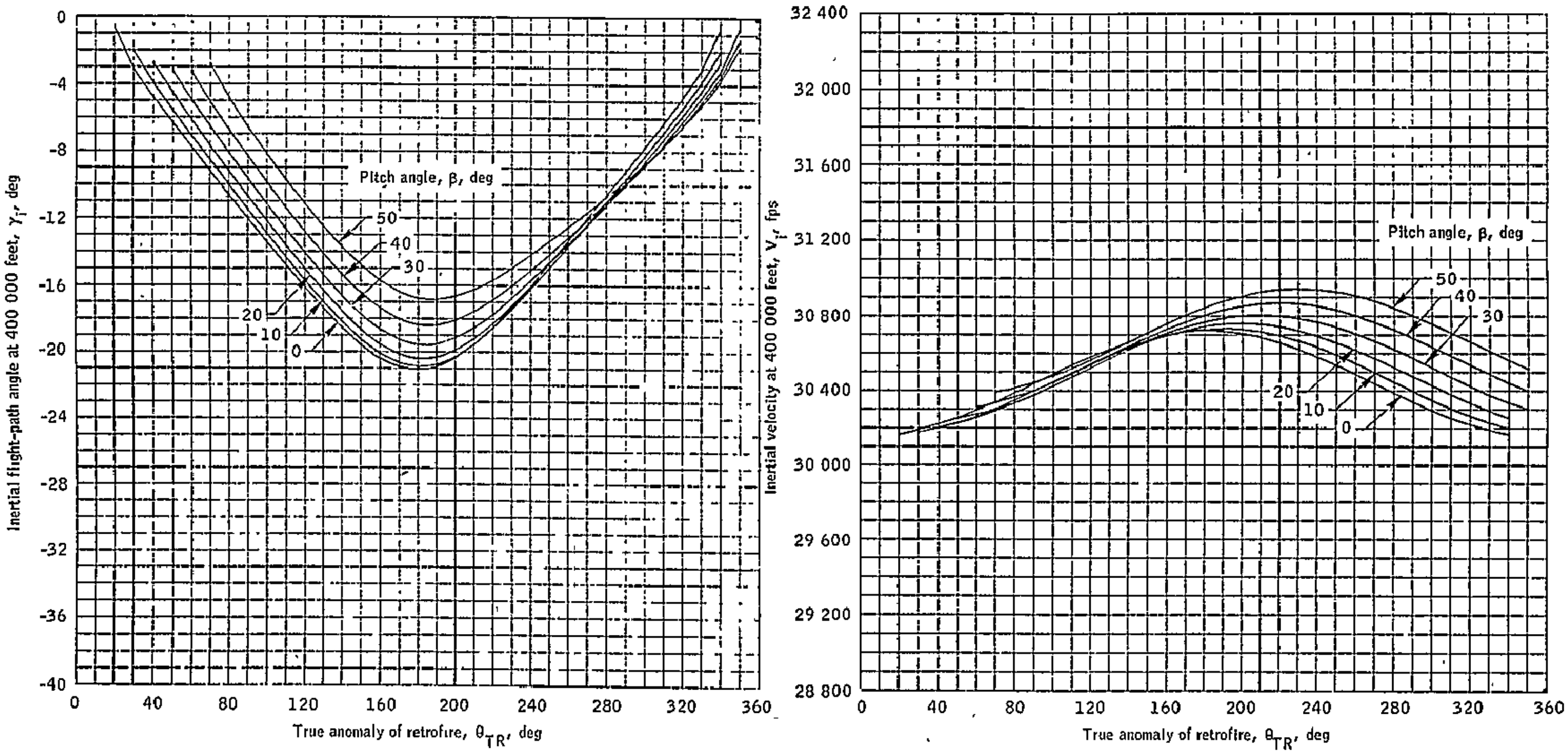
Figure 8.- Continued.





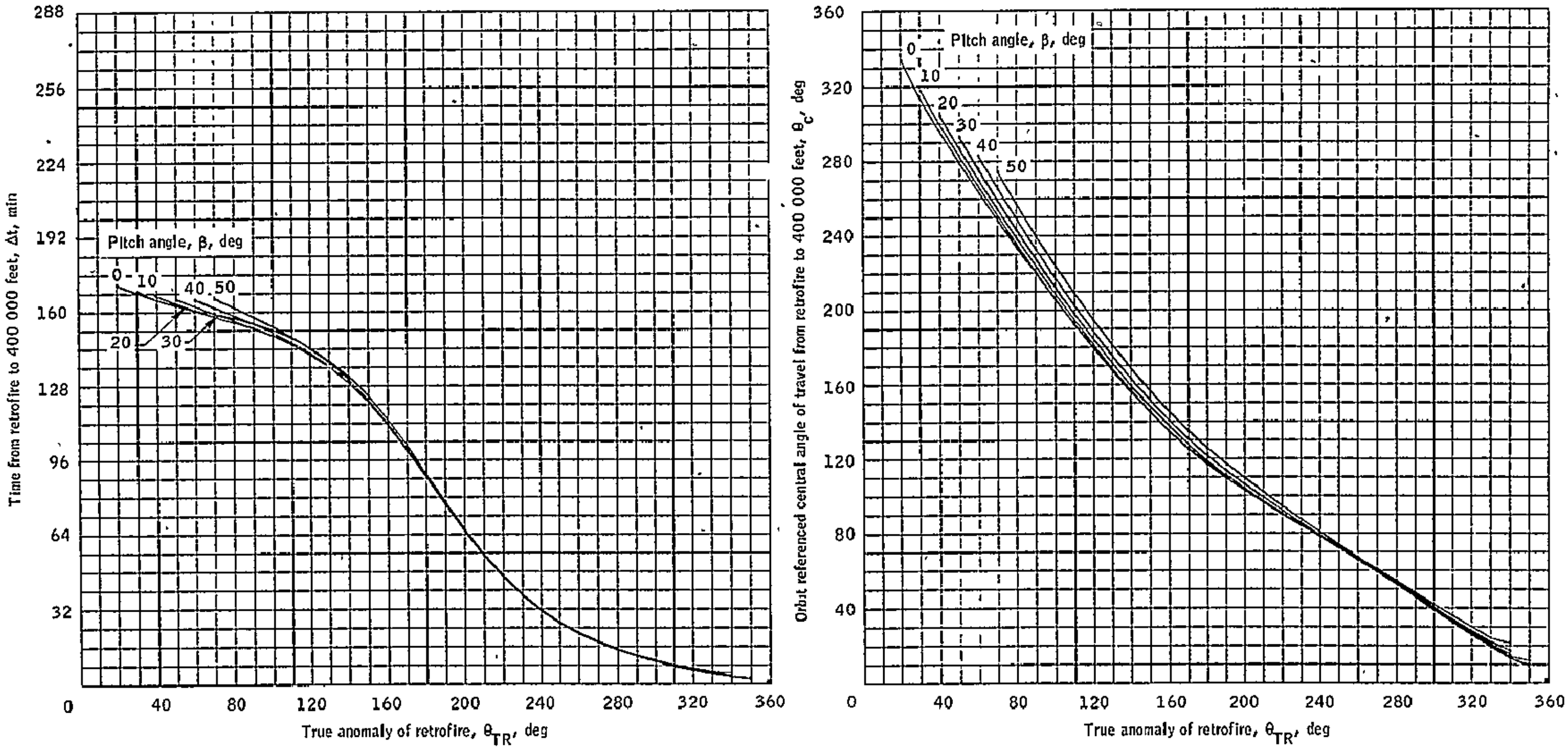
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 8.- Continued.



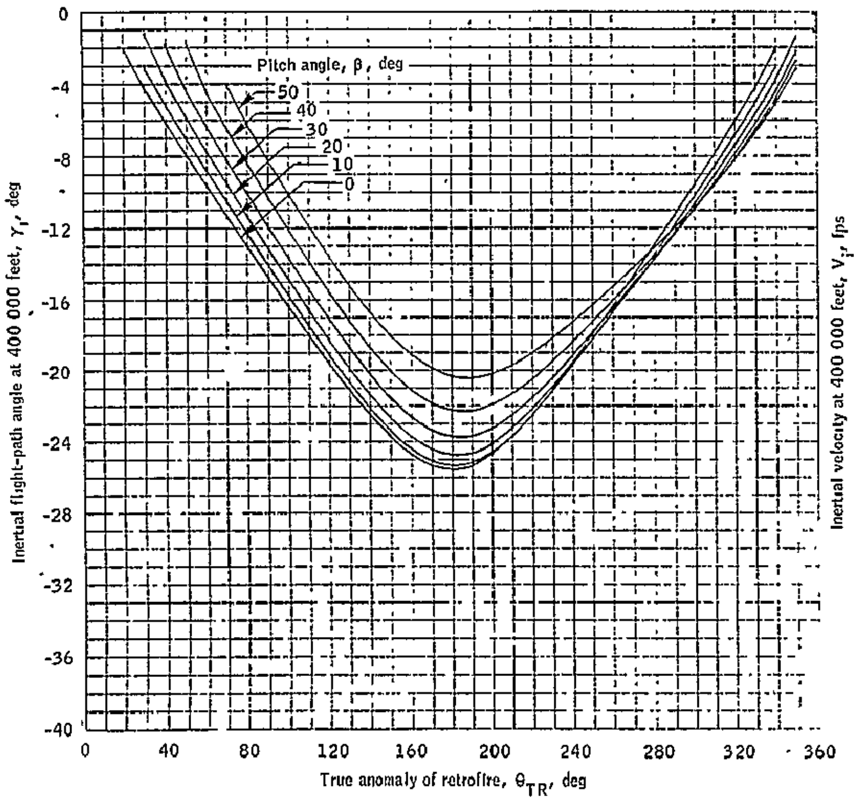
(e) Flight-path angle and velocity for retrograde ΔV = 900 feet per second.

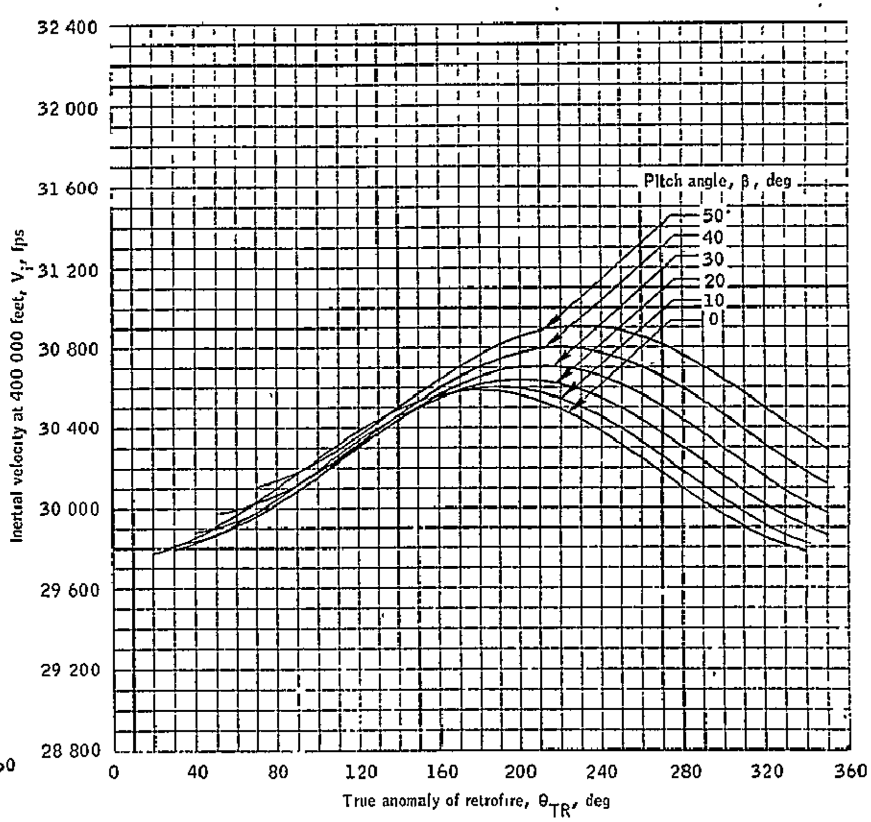
Figure 8.- Continued.



(f) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

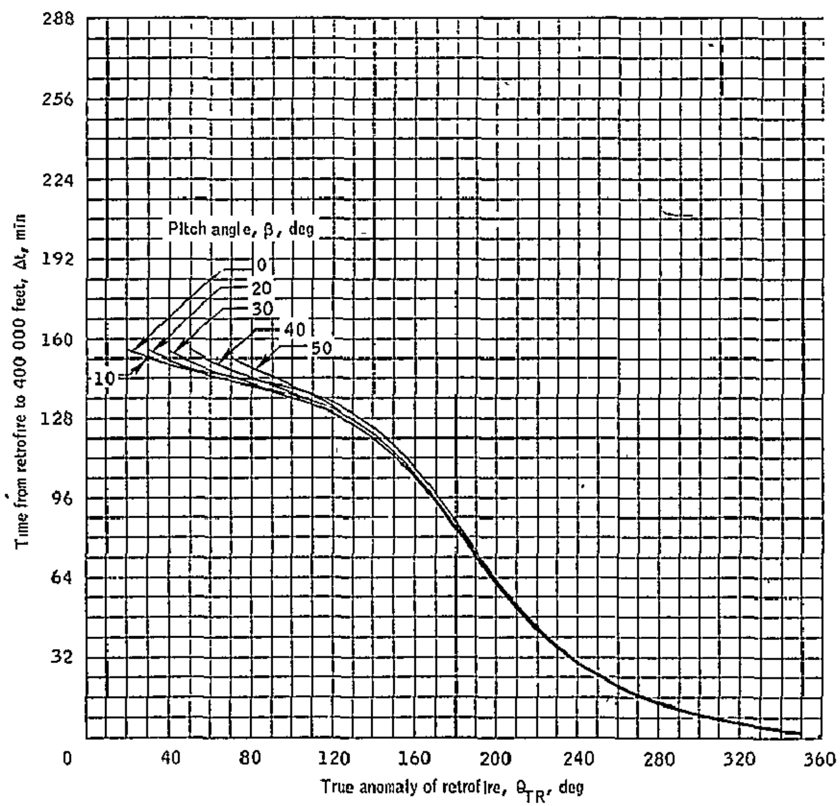
Figure 8.- Continued.

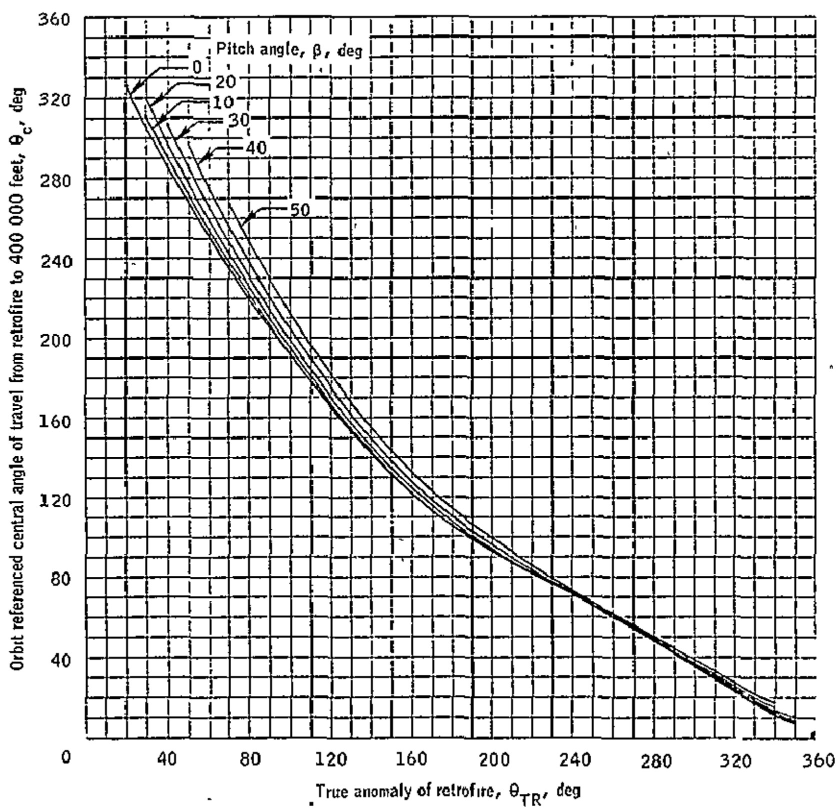




(g) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

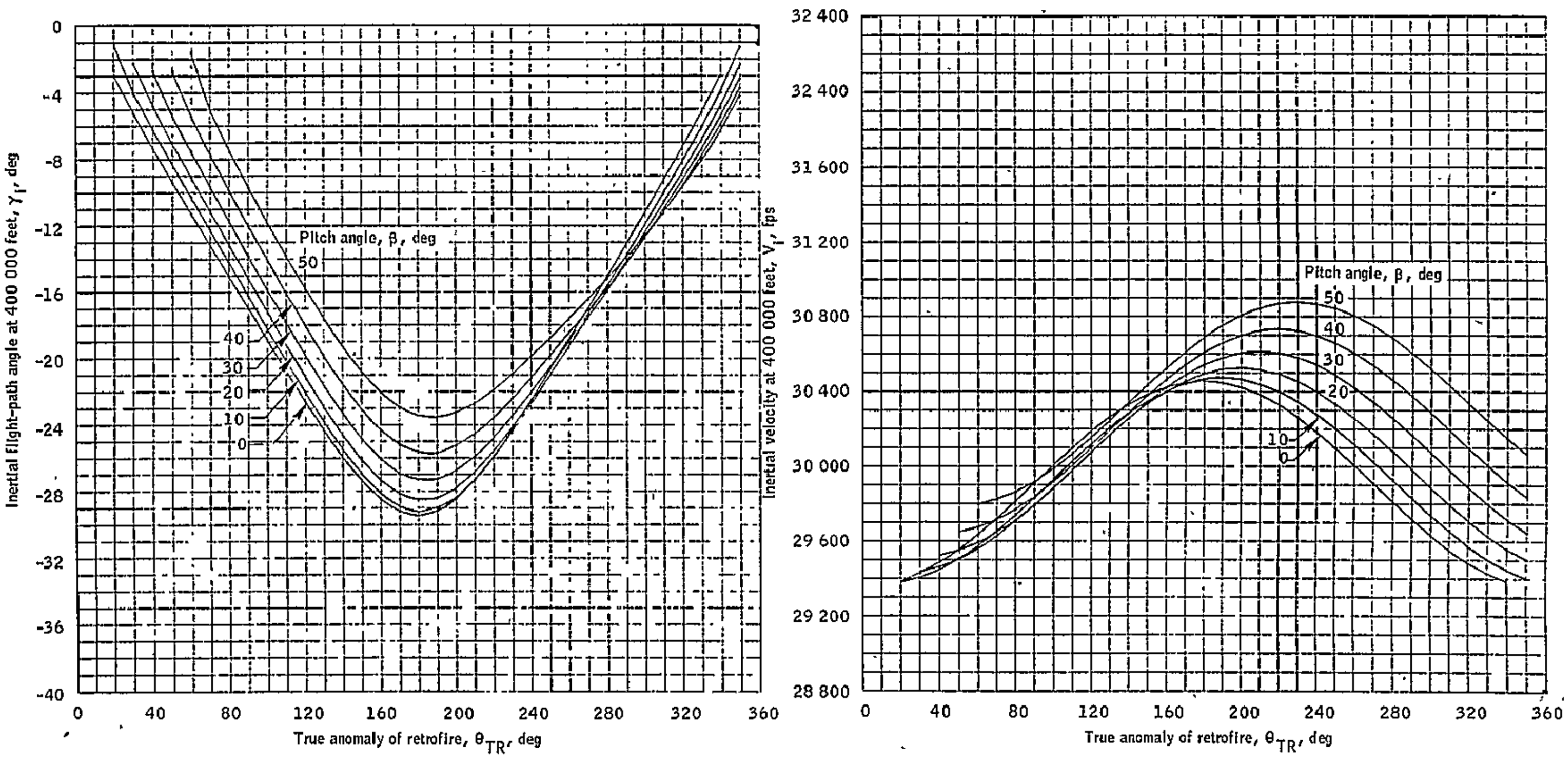
Figure 8.- Continued.





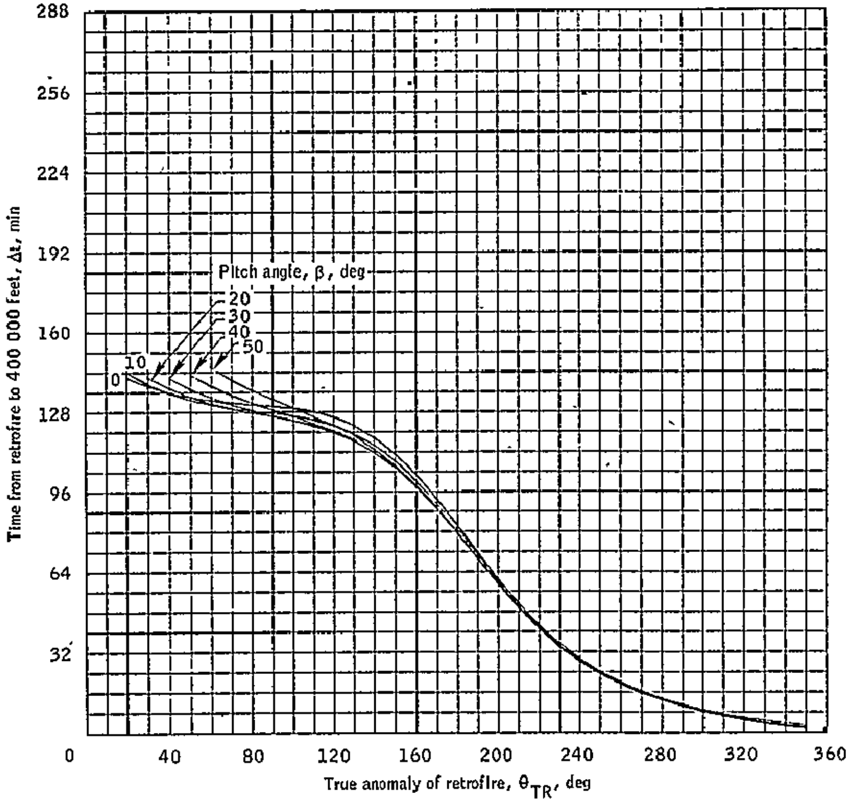
(h) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

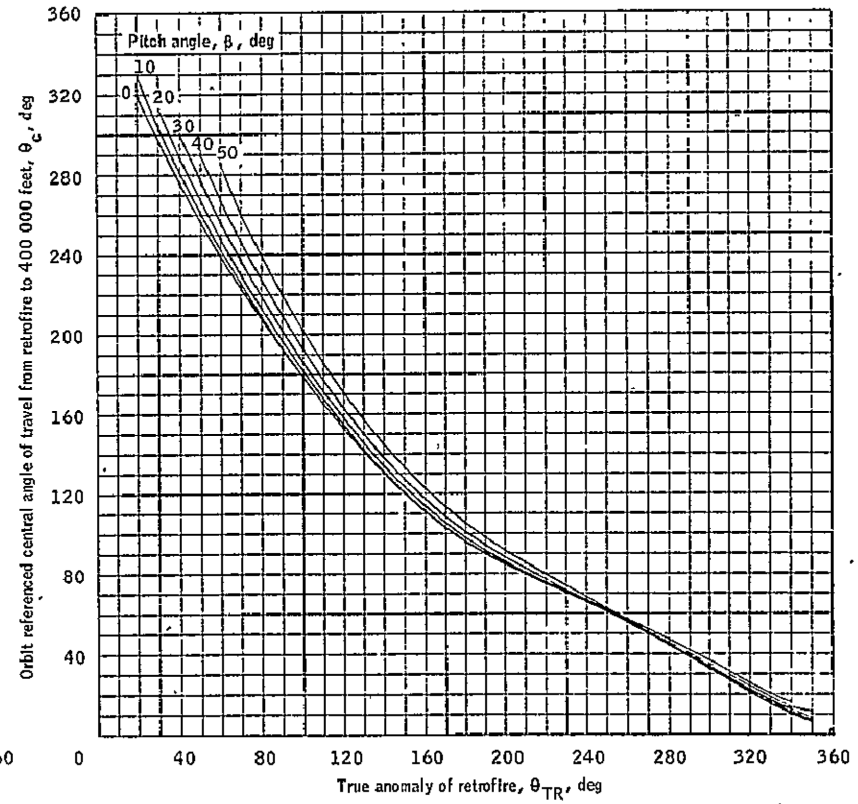
Figure 8.- Continued.



(l) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

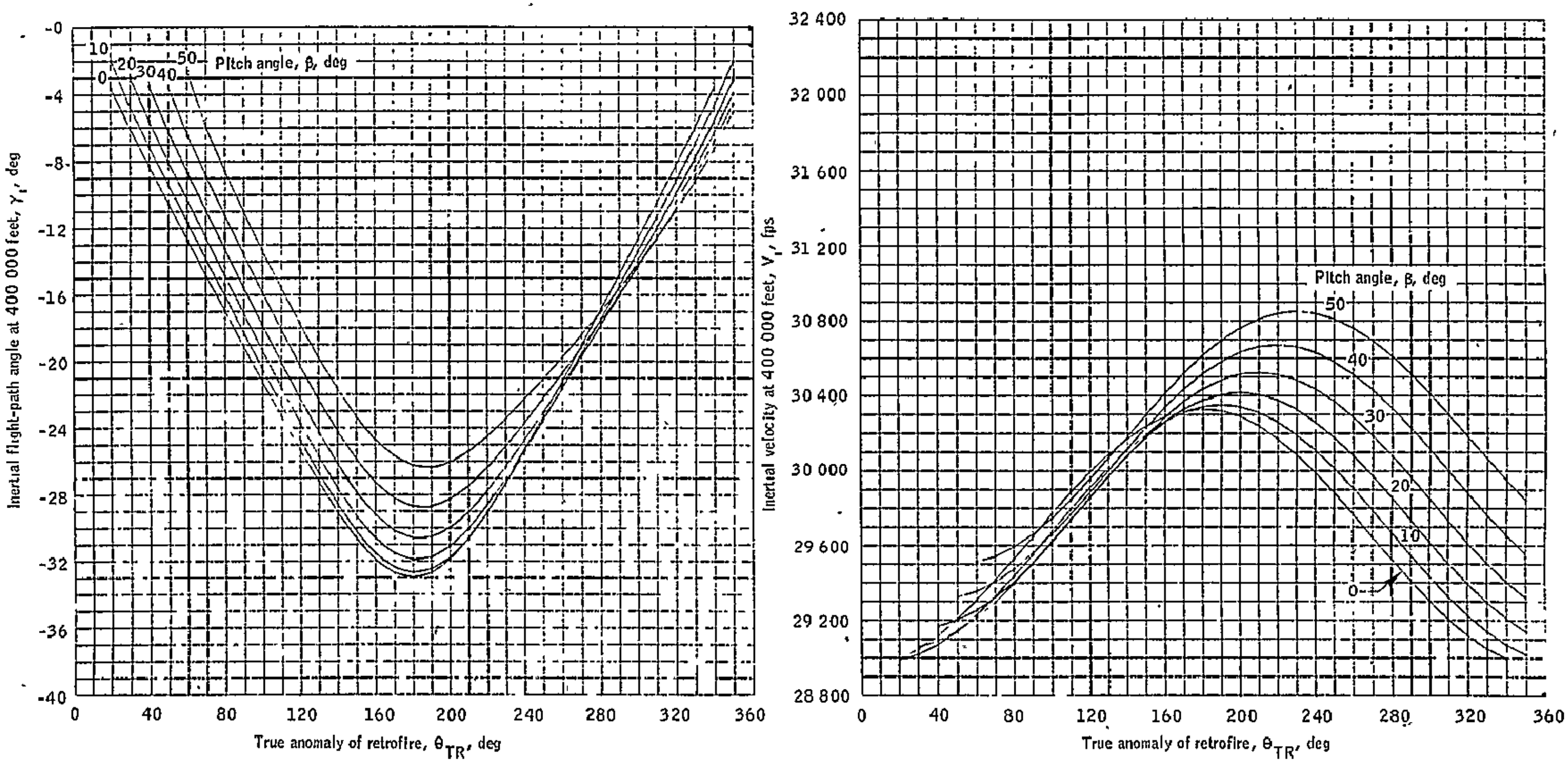
Figure 8.– Continued.





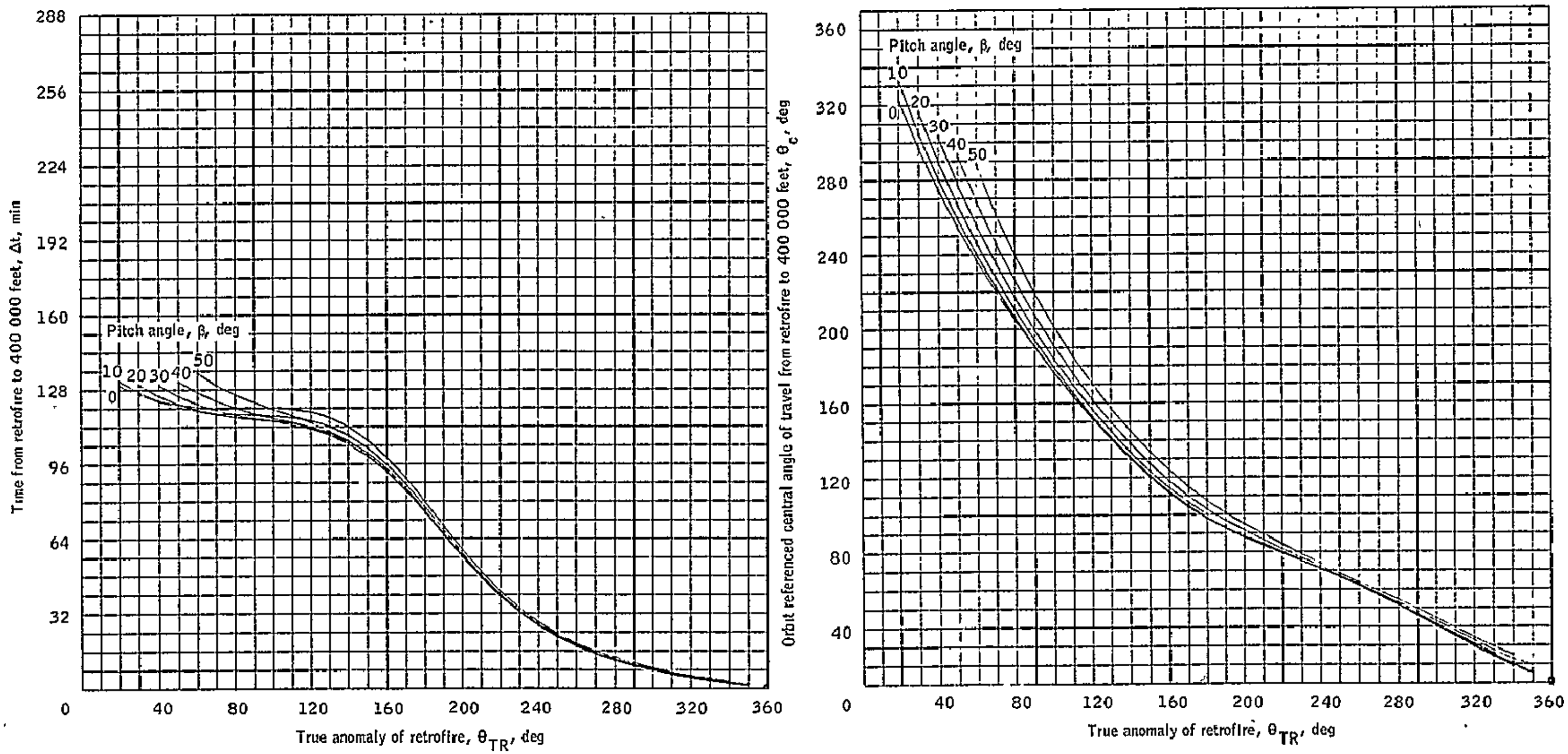
(j) Time from retrofire and central angle for retrograde ΔV = 1700 feet per second.

Figure 8.- Continued.



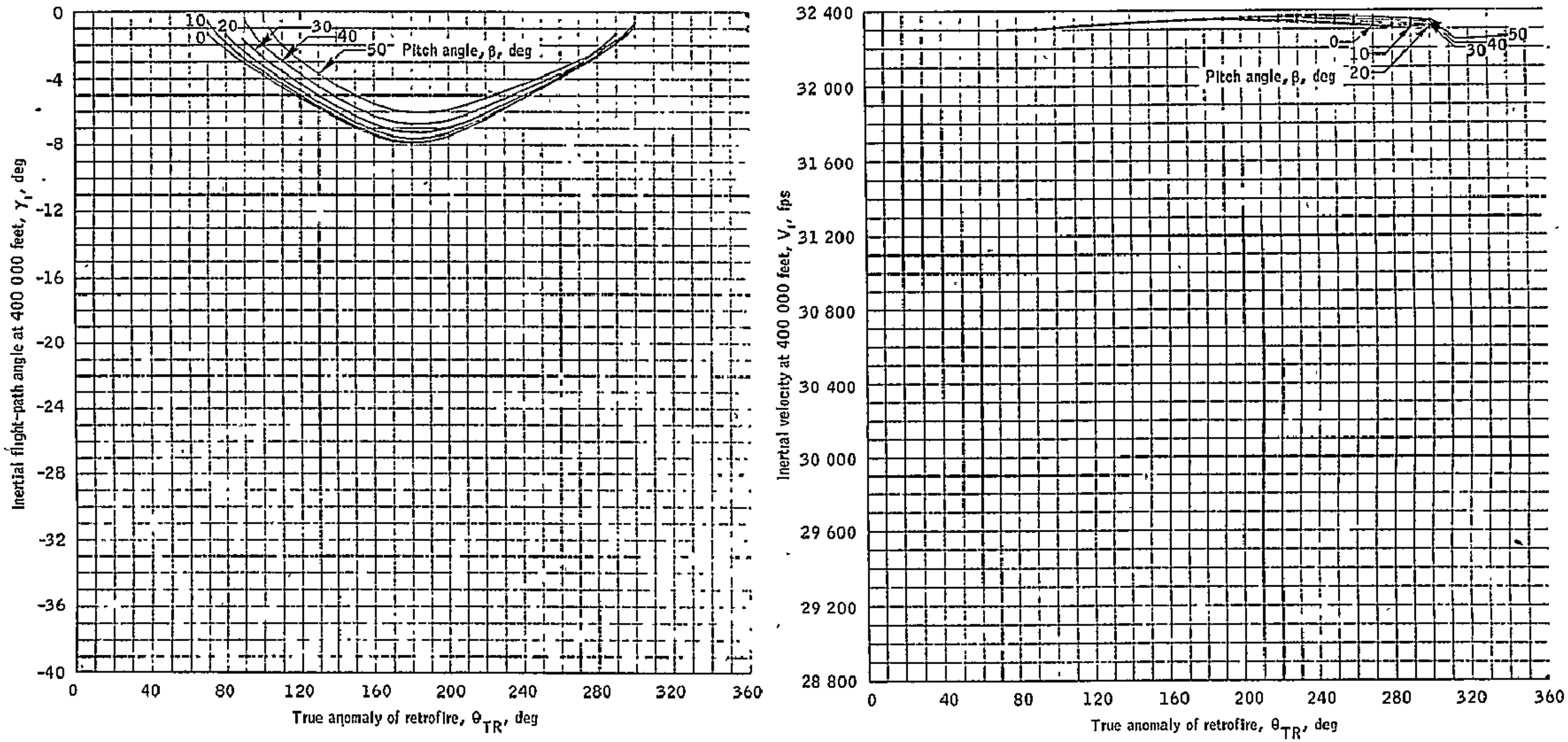
(k) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

Figure 8.- Continued.



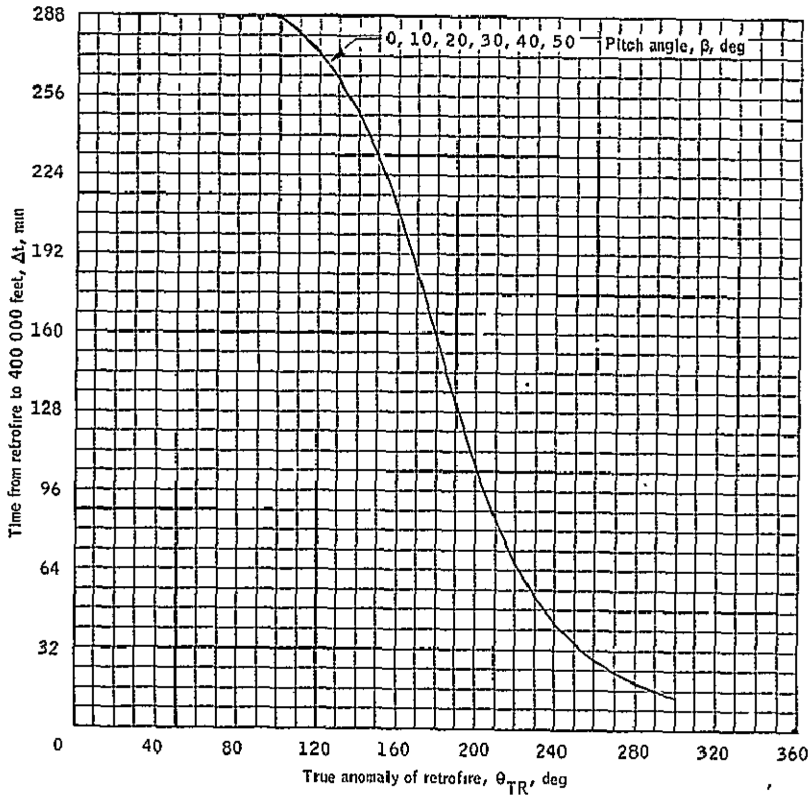
(l) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

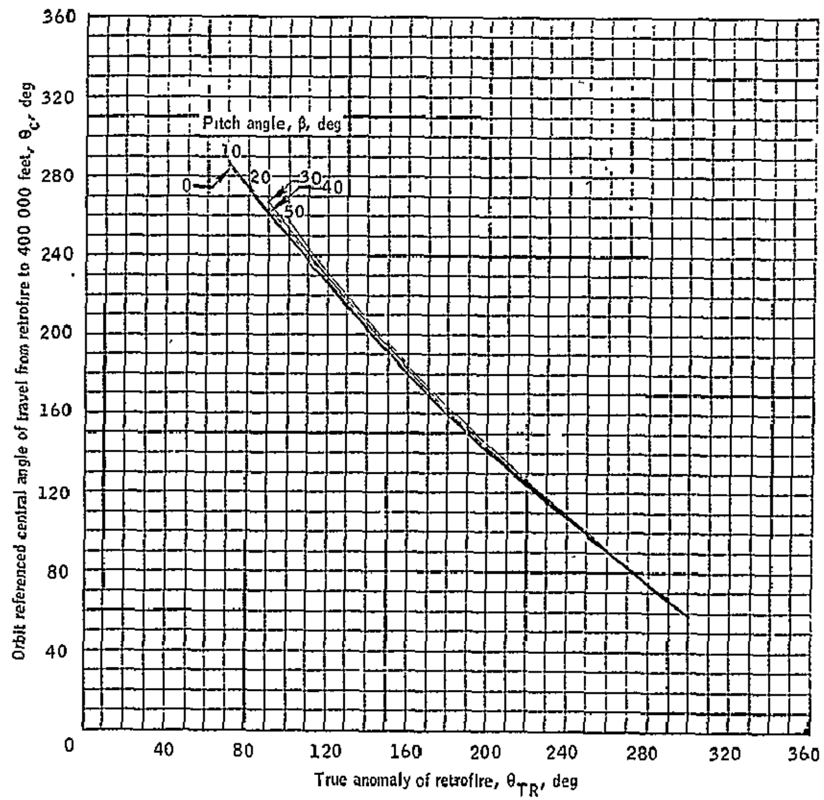
Figure 8.- Concluded.



(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

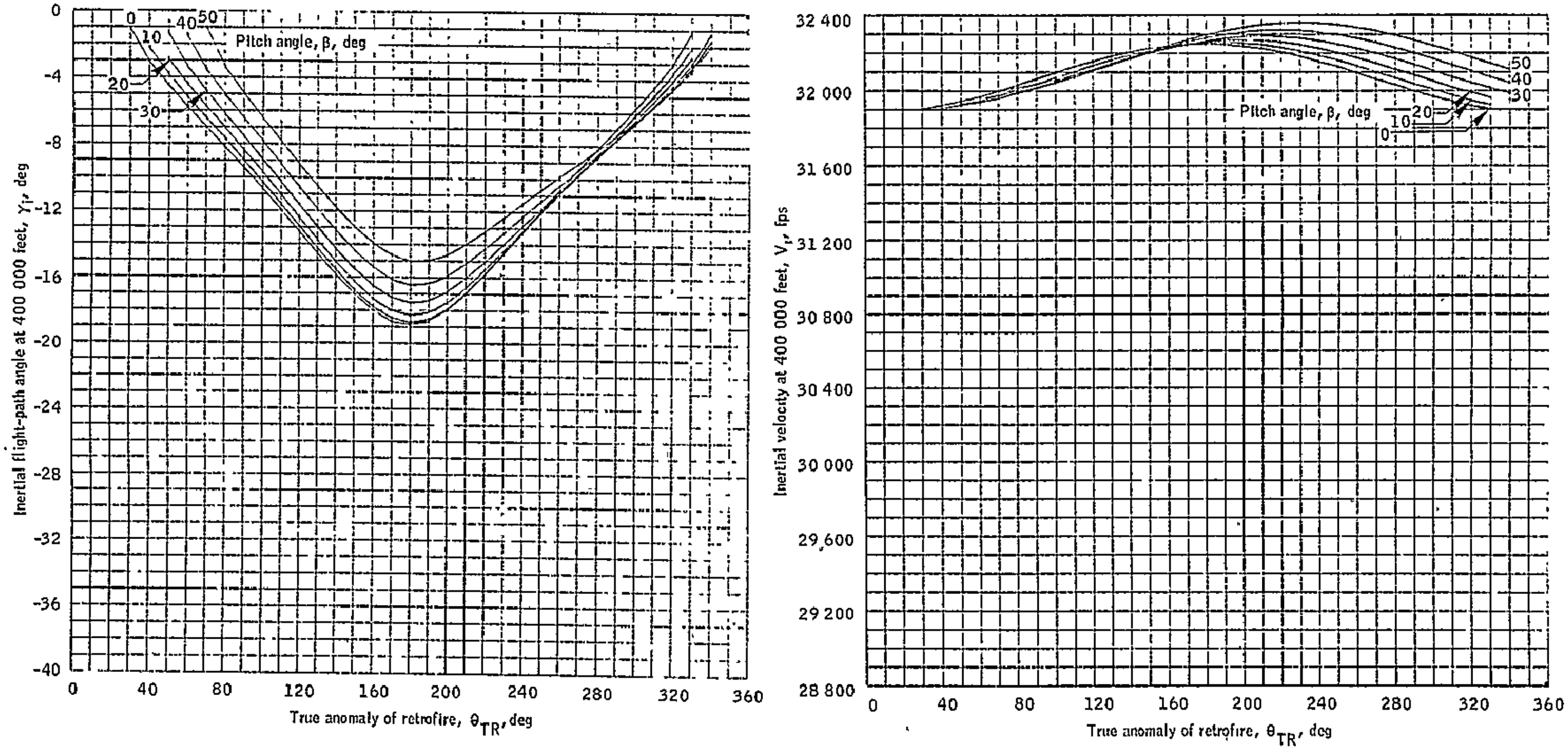
Figure 9.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 80/10 000 nautical mile orbit.





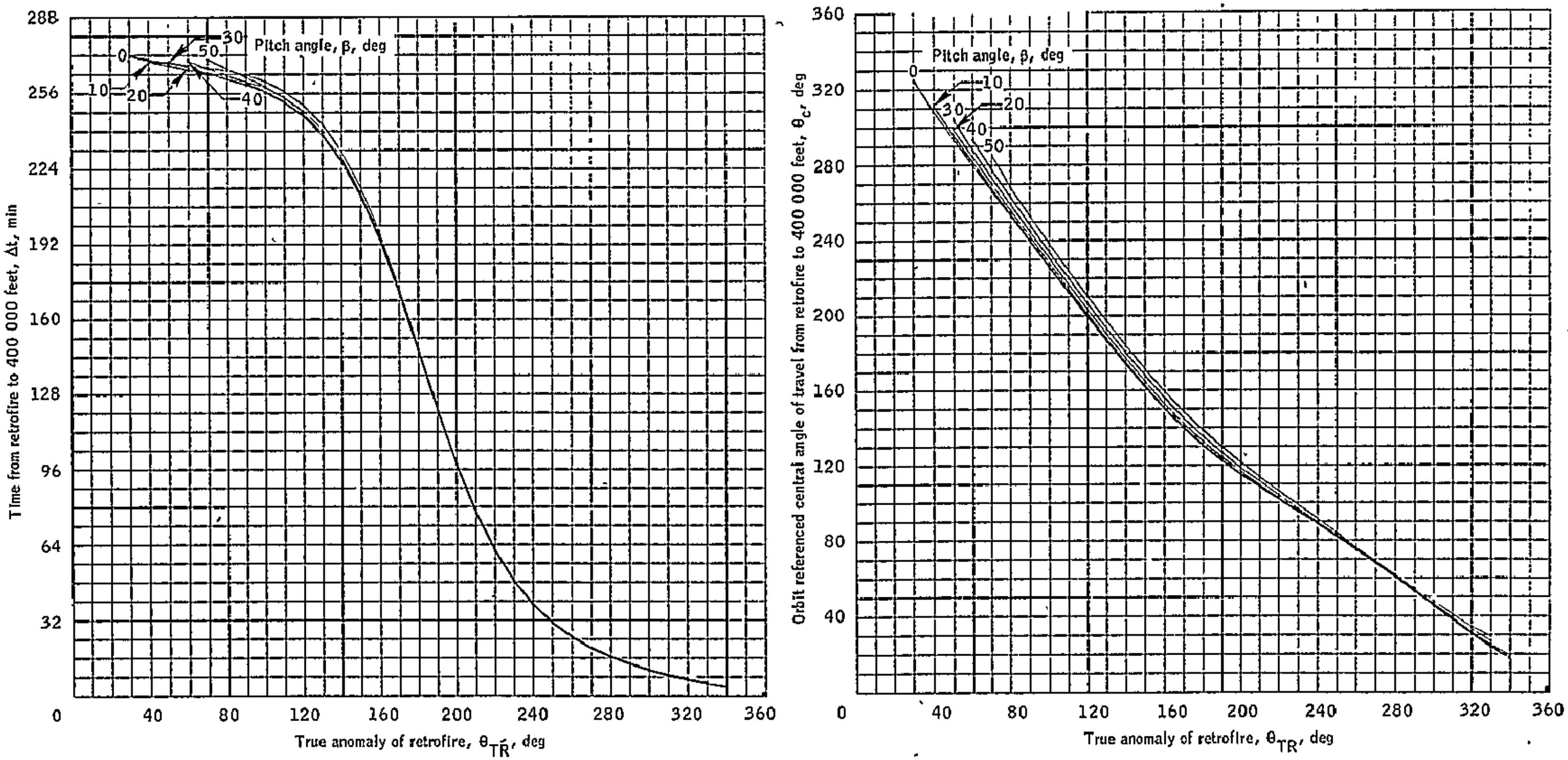
(b) Time from retrofire and central angle for retrograde ΔV = 100 feet per second.

Figure .- Continued.



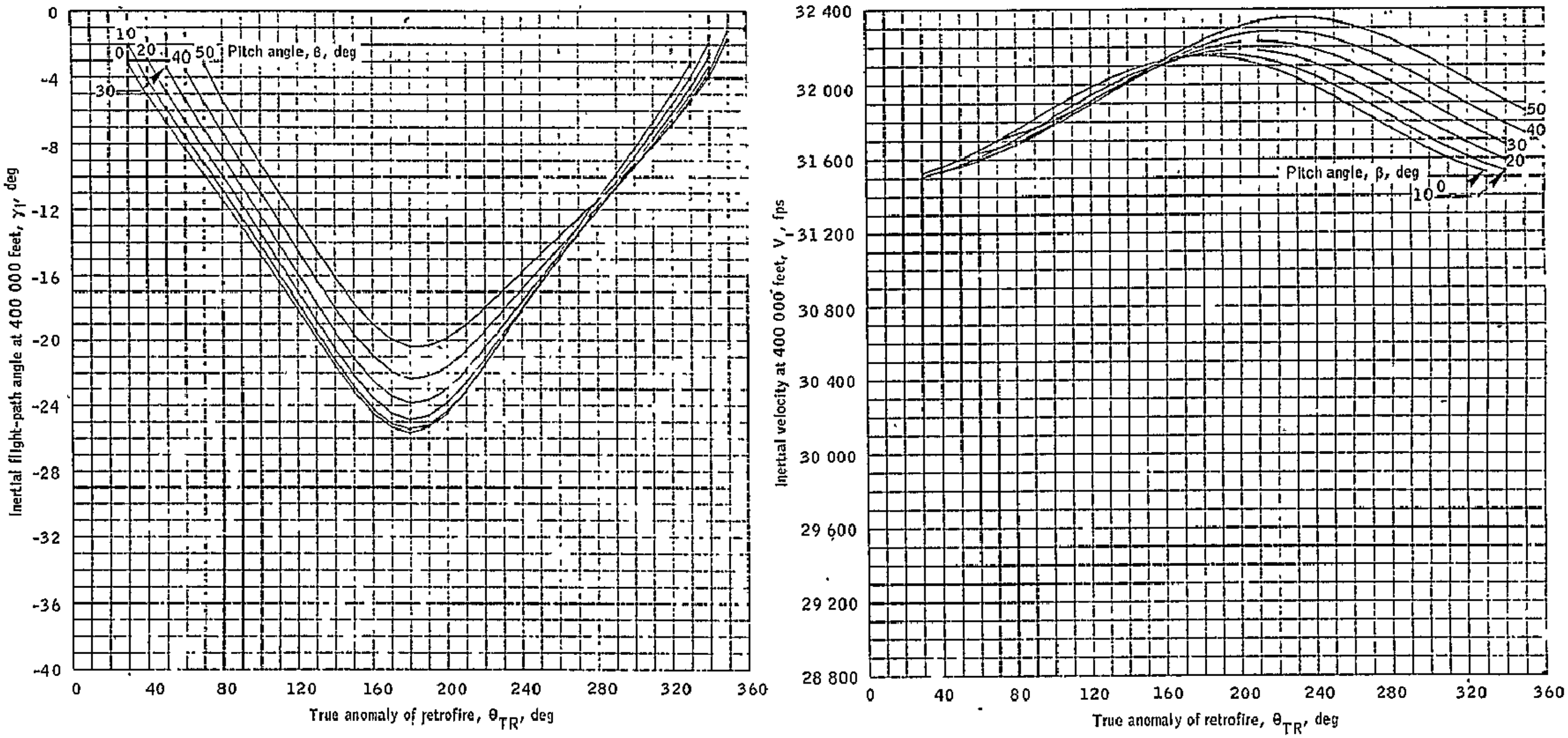
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 9.- Continued.



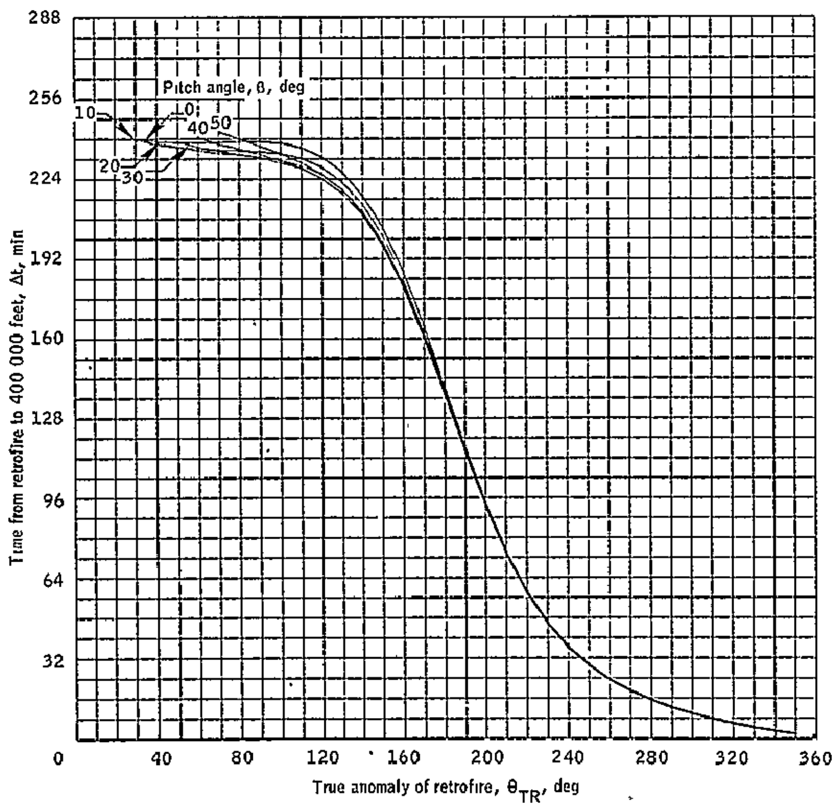
(d) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

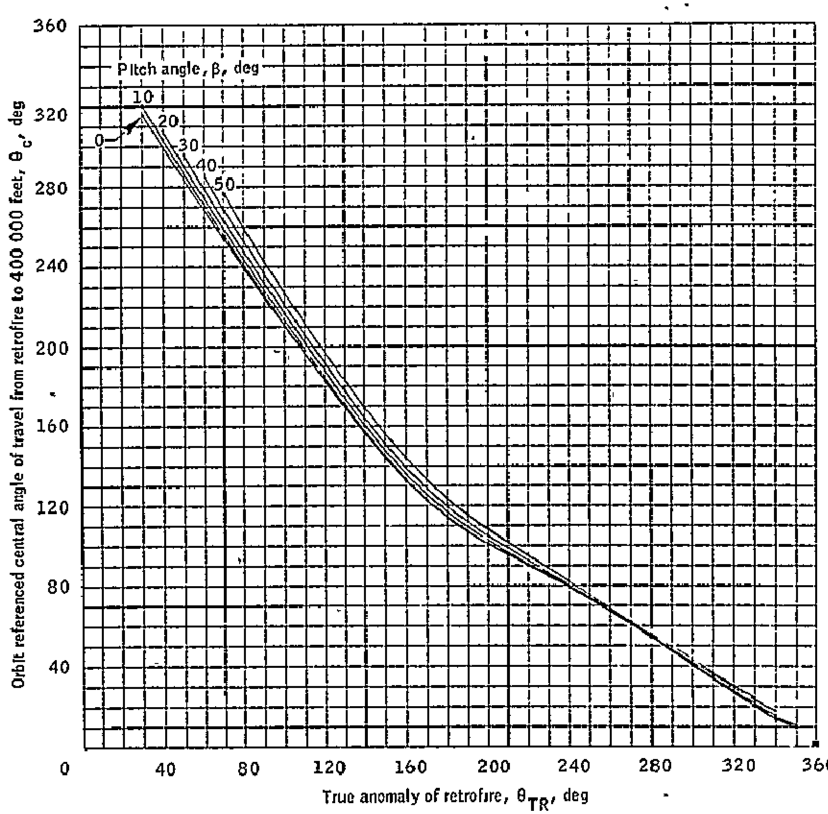
Figure 9.- Continued.



(e) Flight-path angle and velocity for retrograde $\Delta V = 900$ feet per second.

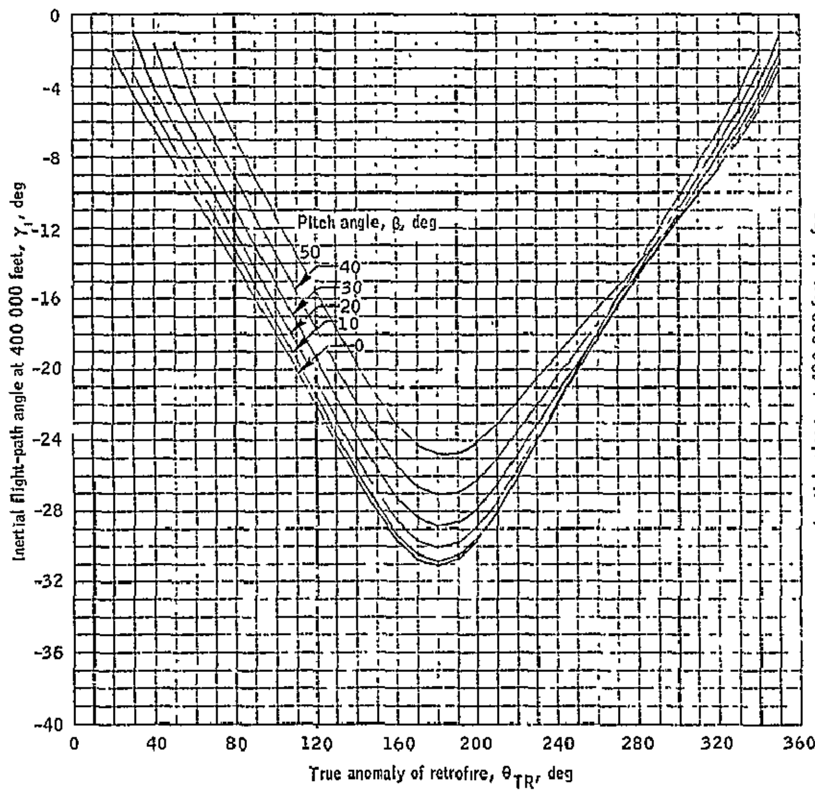
Figure 9.- Continued.

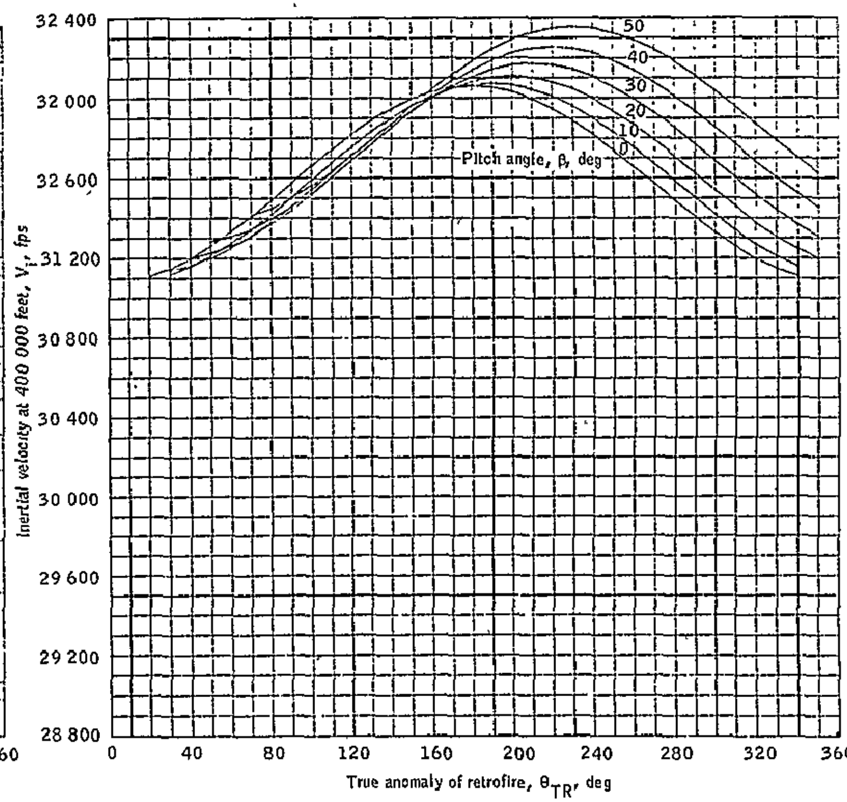




(f) Time from retrofire and central angle for retrograde ΔV = 900 feet per second.

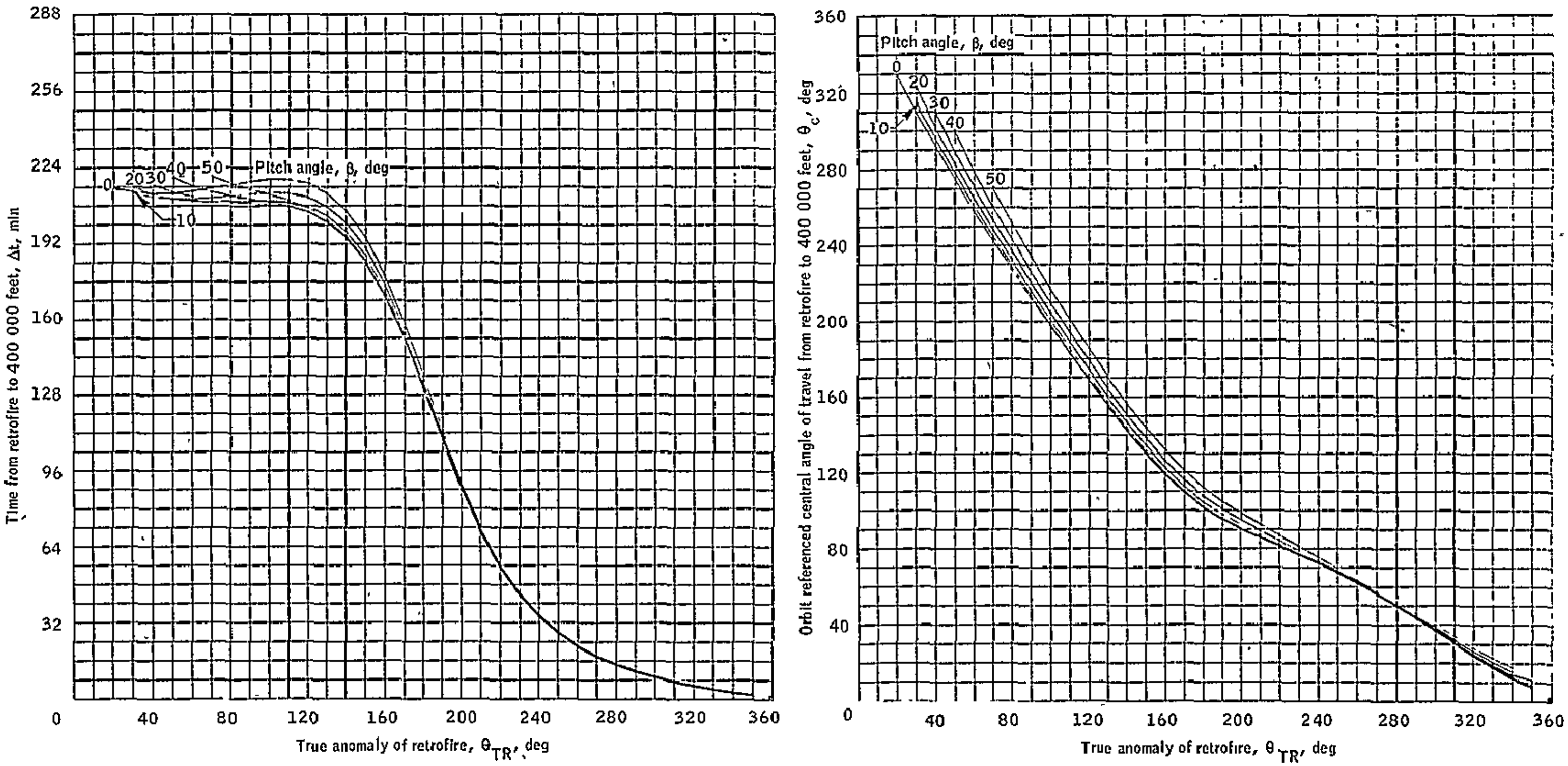
Figure 9.- Continued.





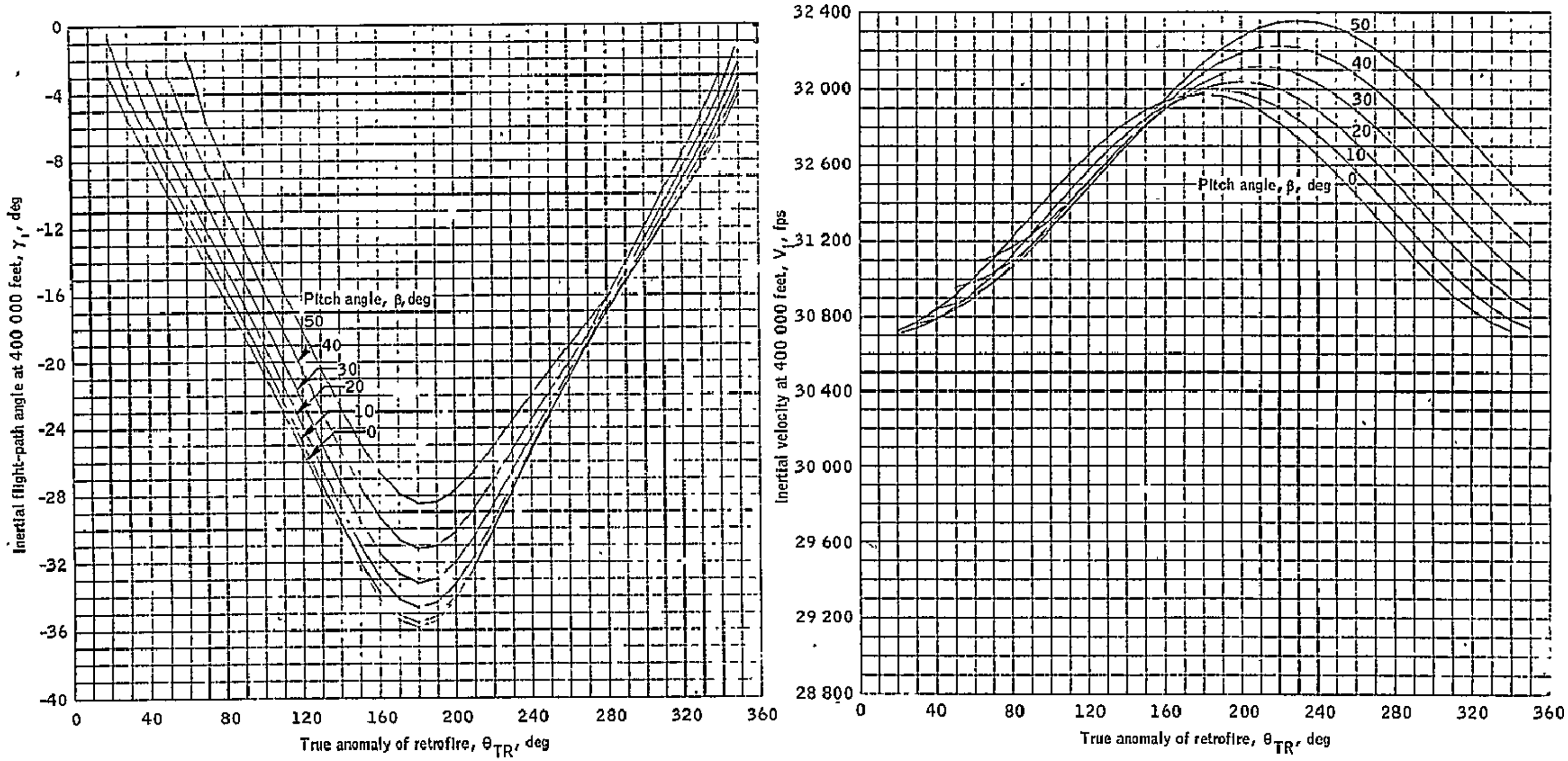
(g) Flight-path angle and velocity for retrograde ΔV = 1300 feet per second.

Figure 9.- Continued.



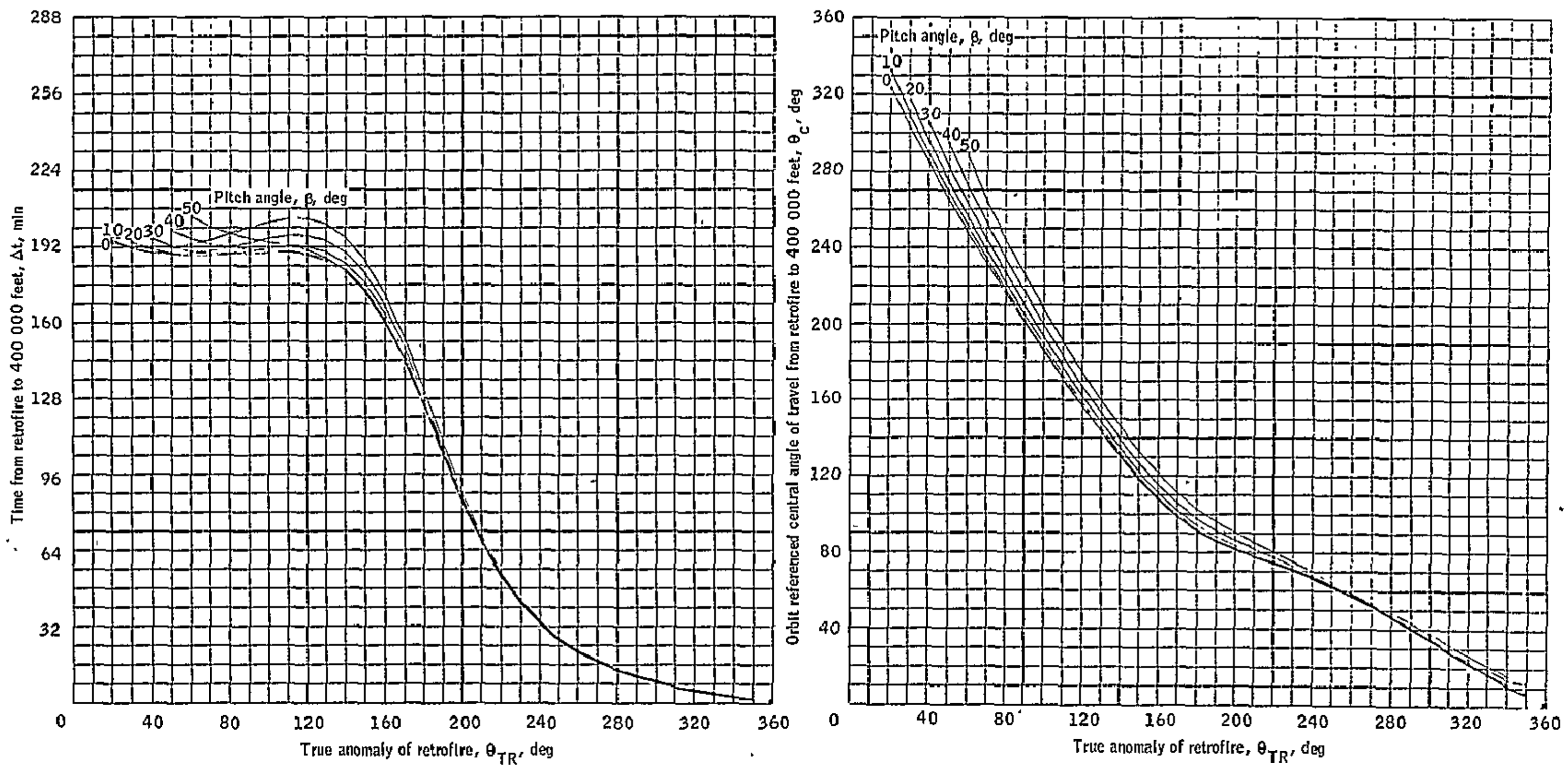
(h) Time from retrofire and central angle for retrograde ΔV = 1300 feet per second.

Figure 9.- Continued.



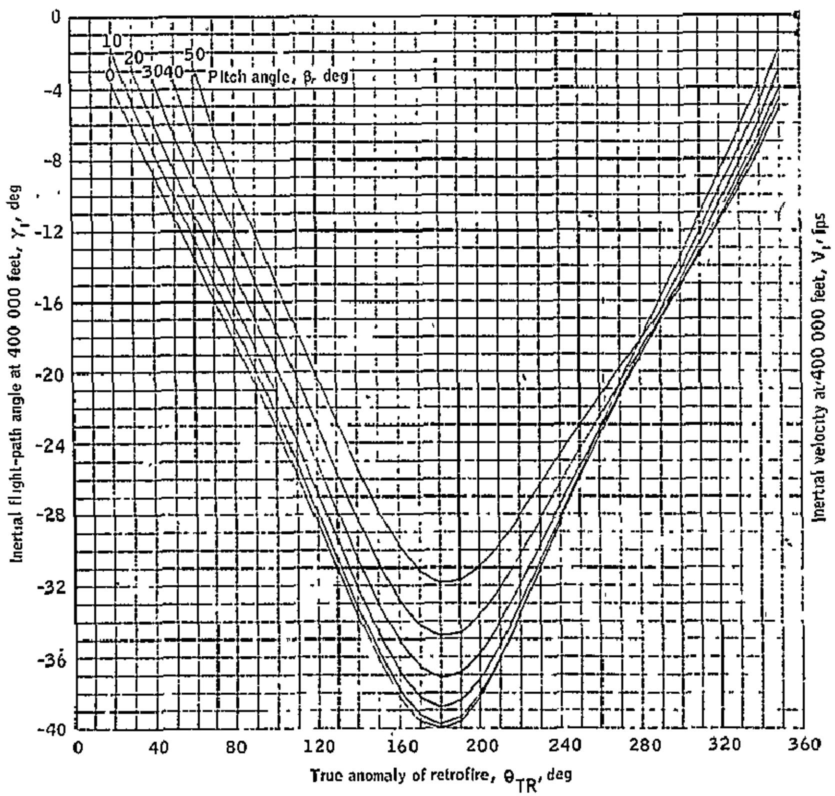
(l) Flight-path angle and velocity for retrograde ΔV = 1700 feet per second.

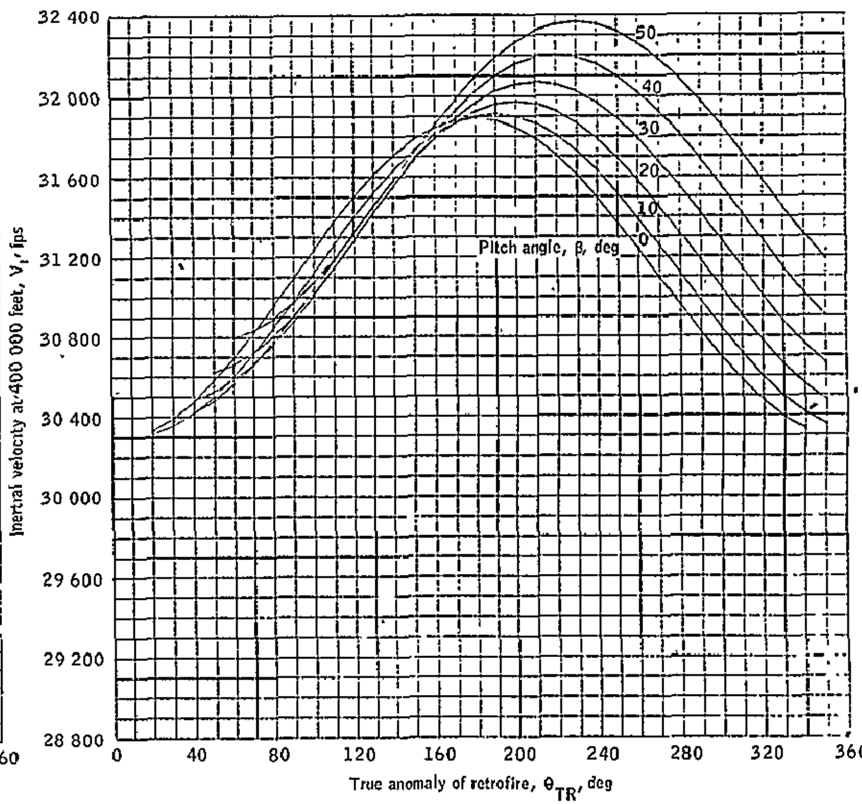
Figure 9.- Continued.



(j) Time from retrofire and central angle for retrograde $\Delta V = 1700$ feet per second.

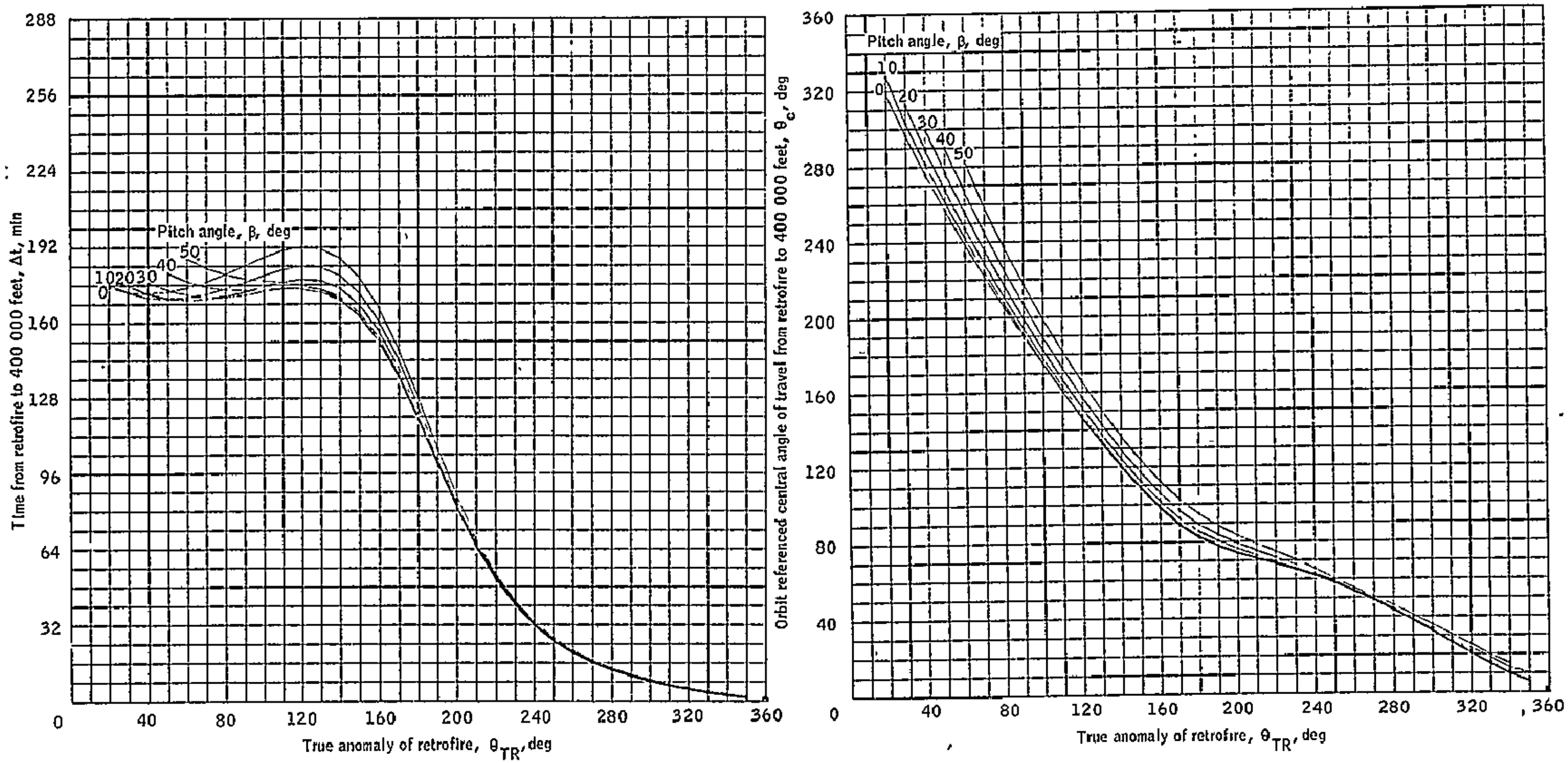
Figure 9.- Continued.





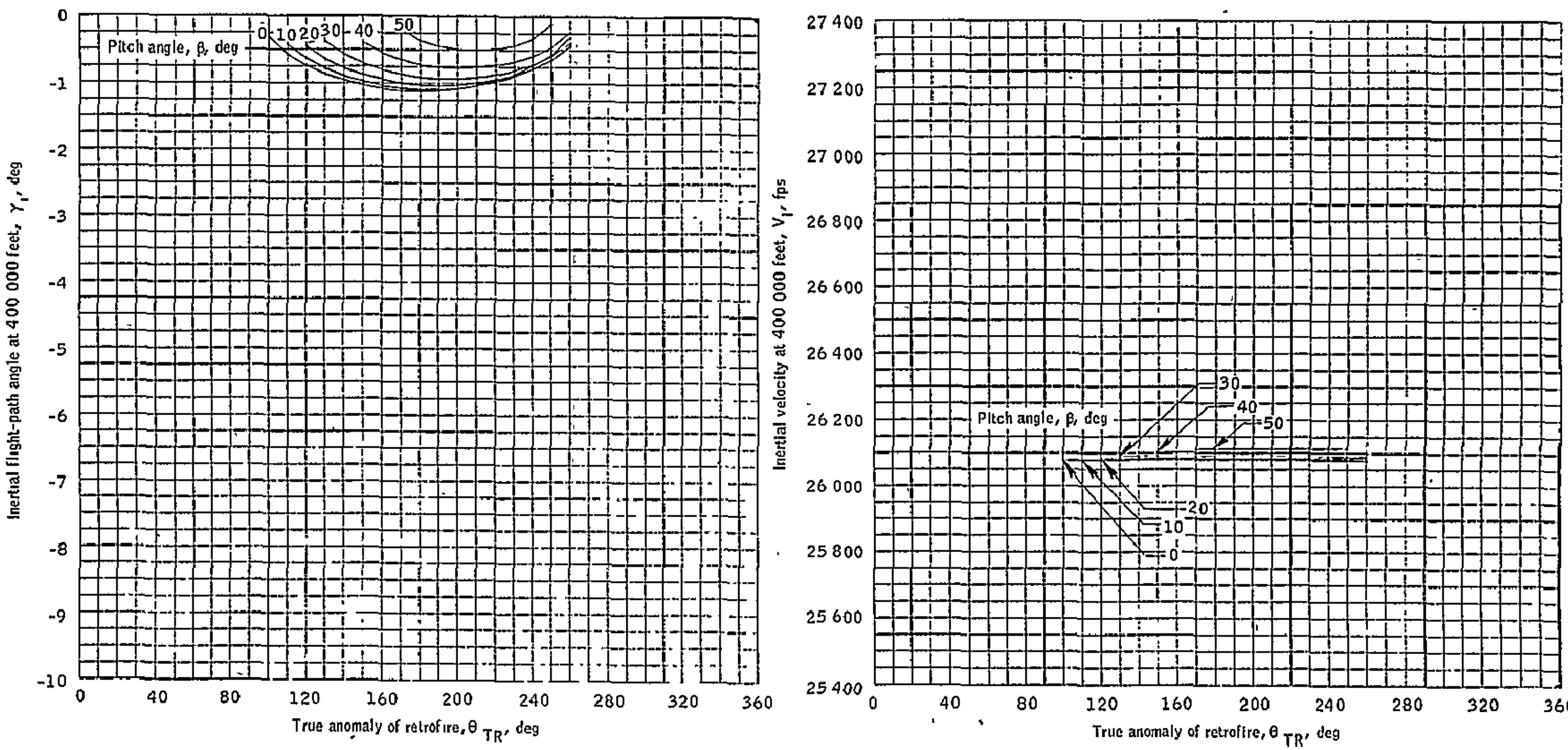
(k) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

Figure 9.- Continued.



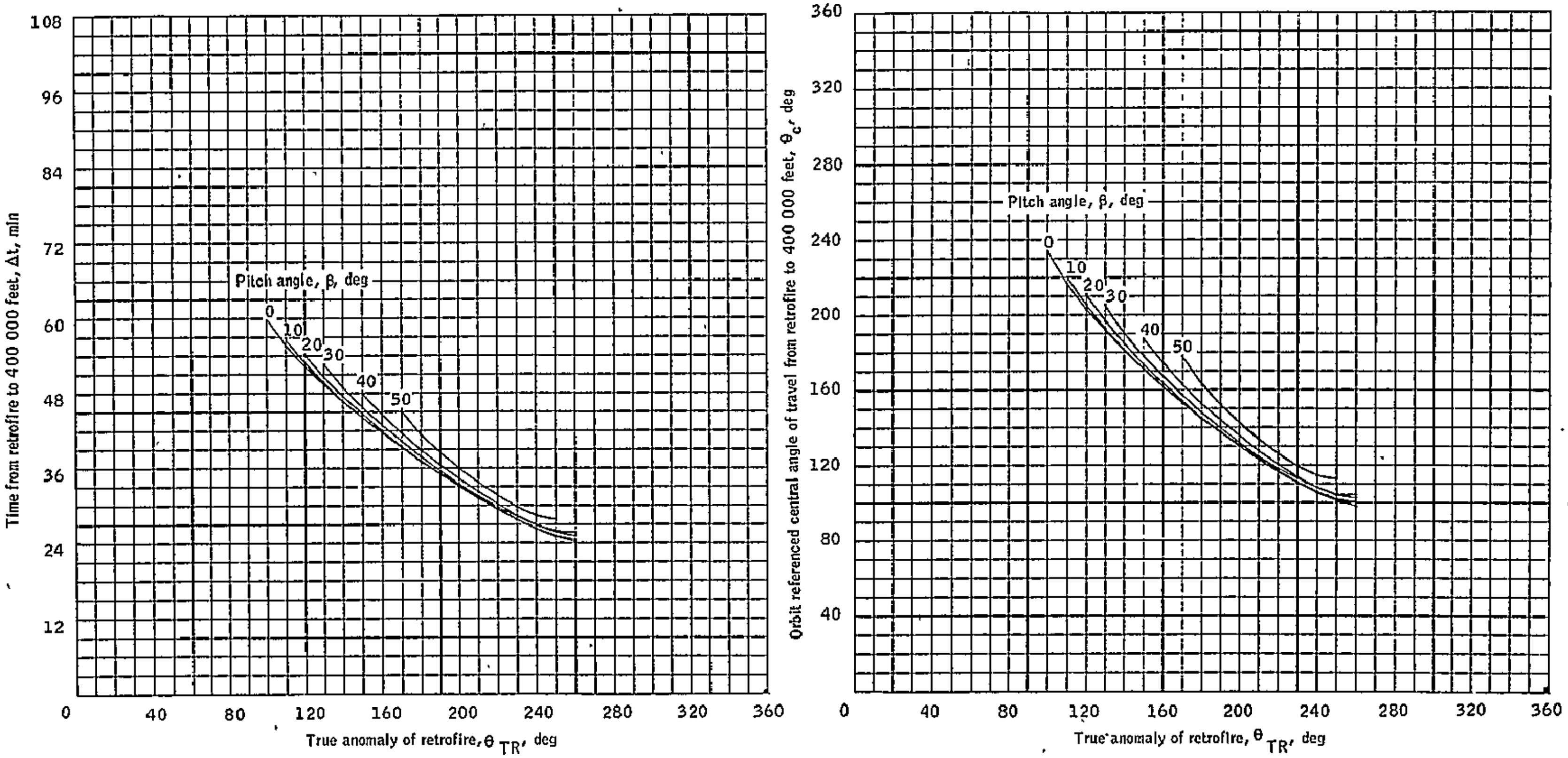
(l) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

Figure 9.- Concluded.



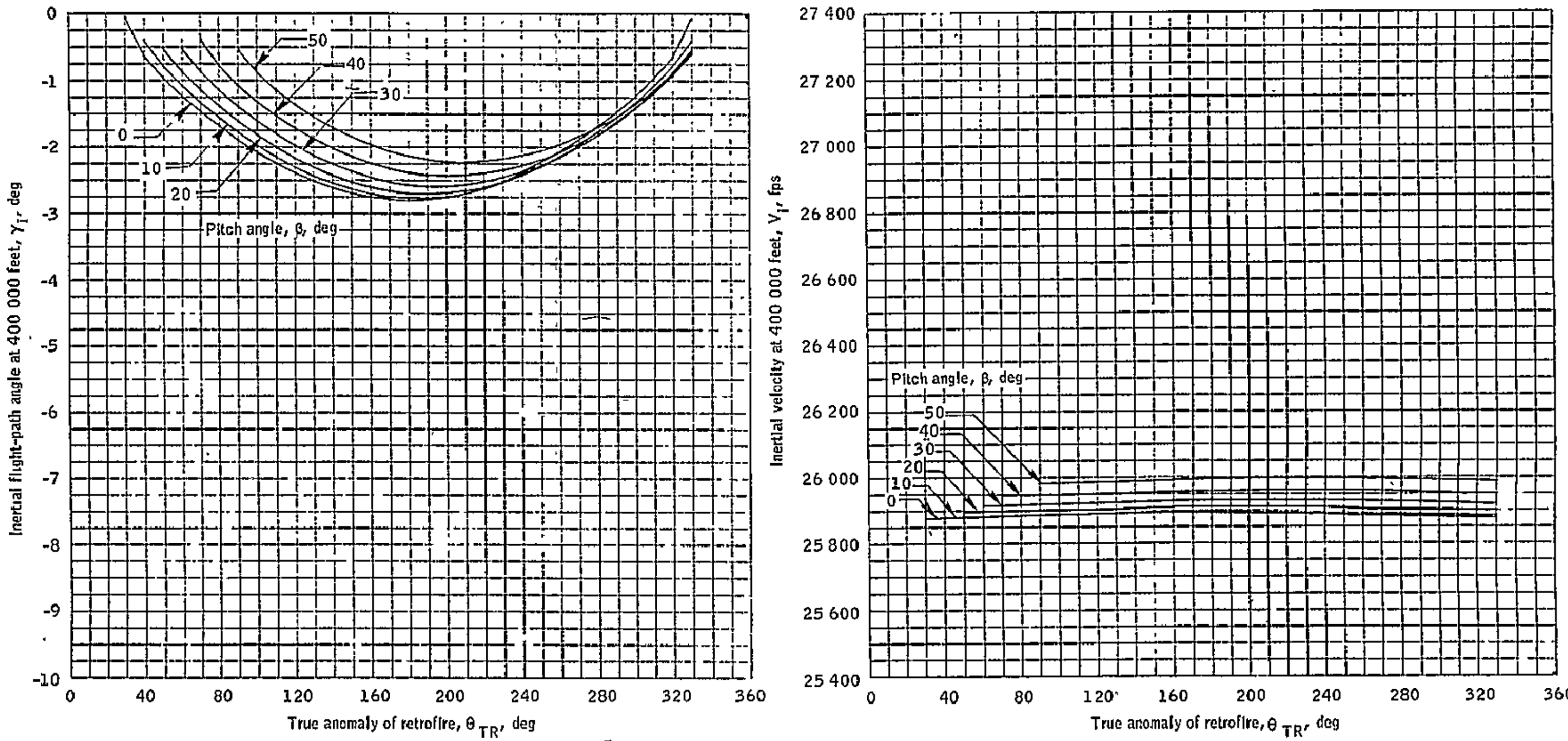
(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

Figure 10.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for a 100/300 nautical mile orbit.



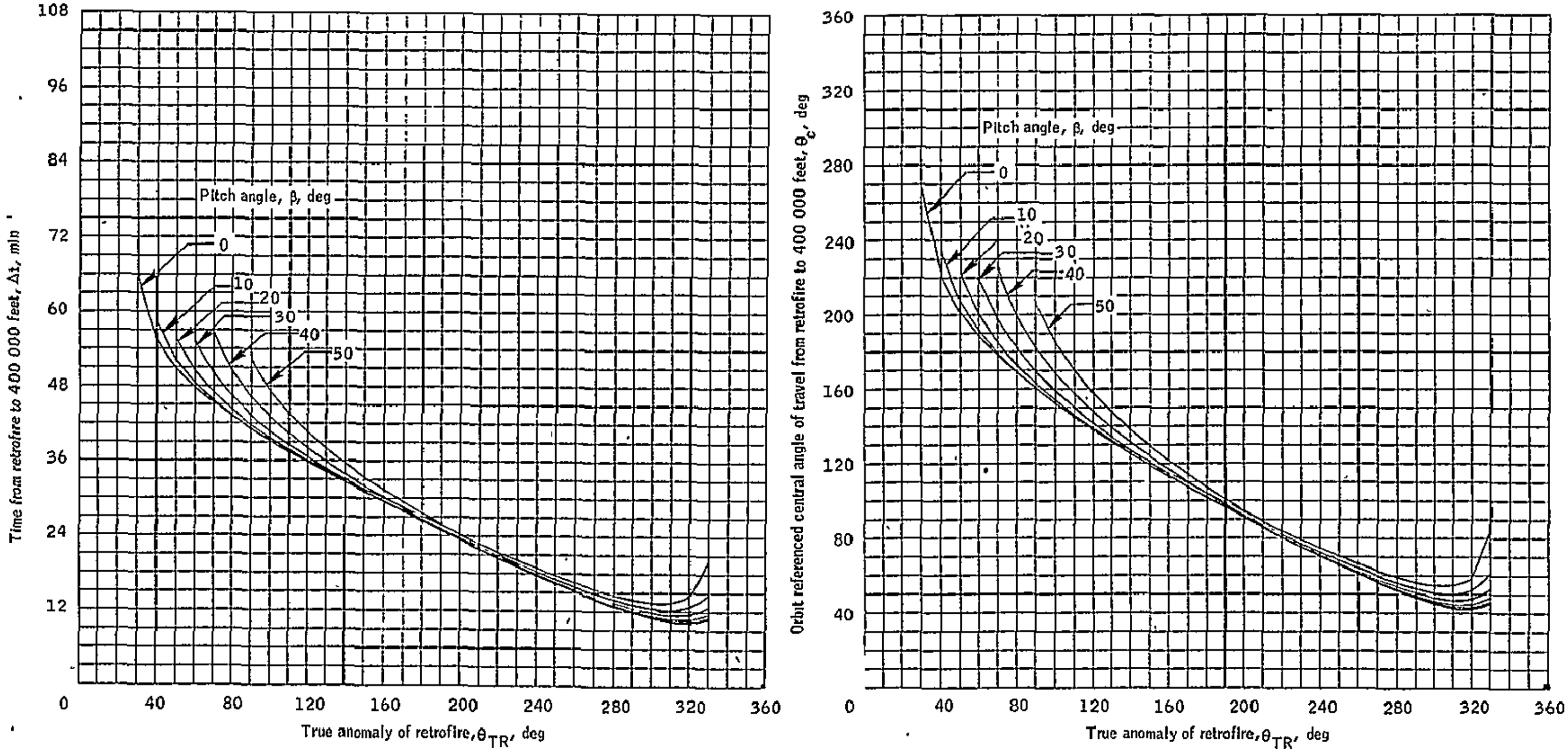
(b) Time from retrofire and central angle for retrograde ΔV = 100 feet per second.

Figure 10.- Continued.



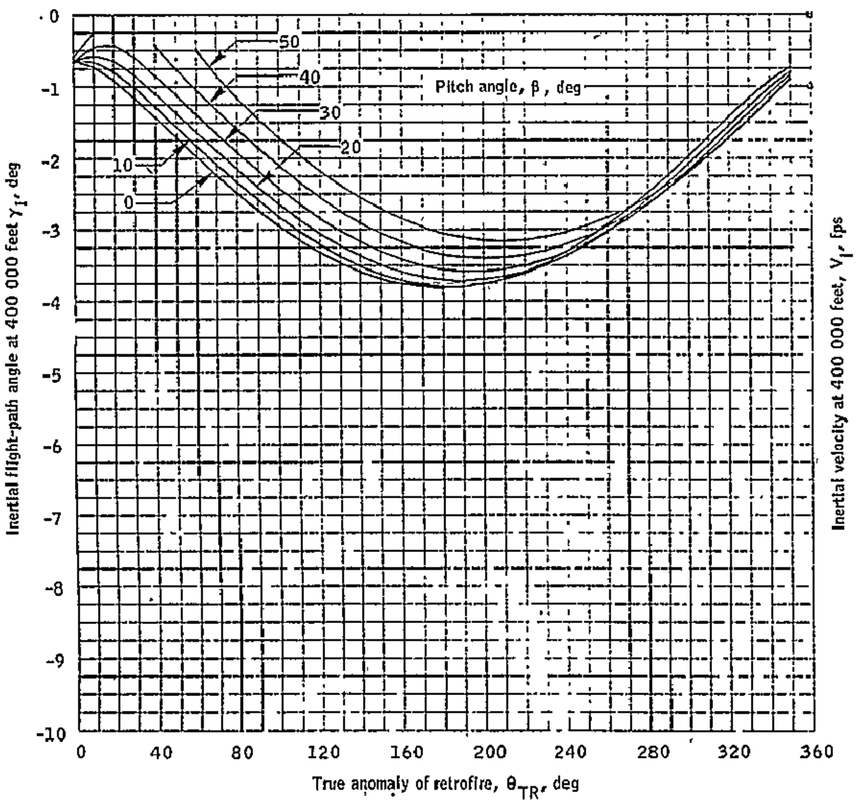
(c) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

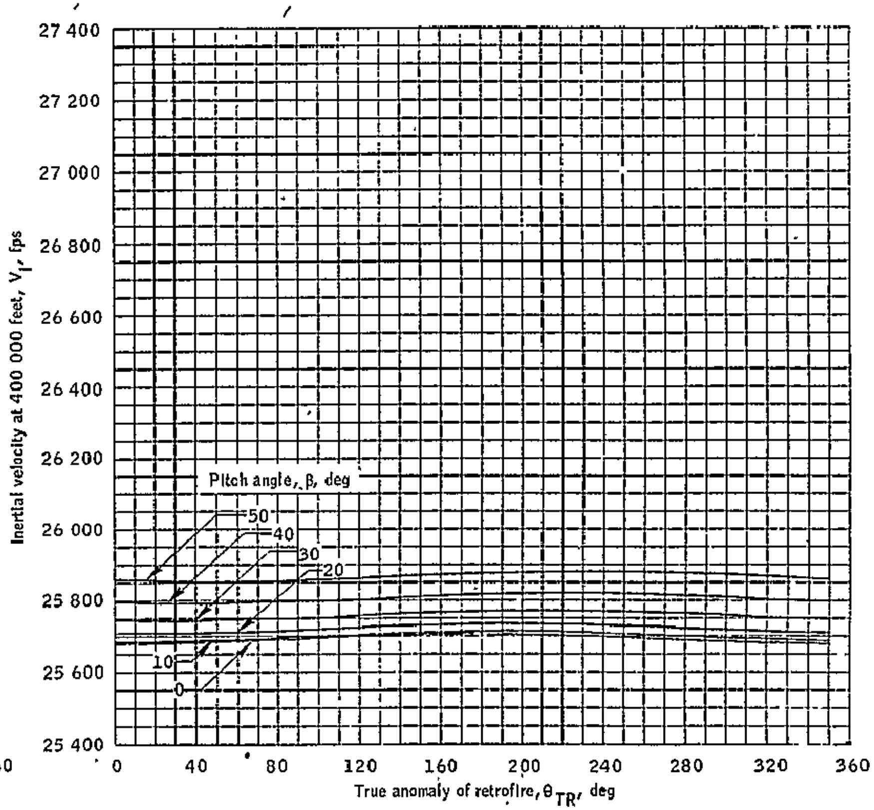
Figure 10.- Continued.



(d) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

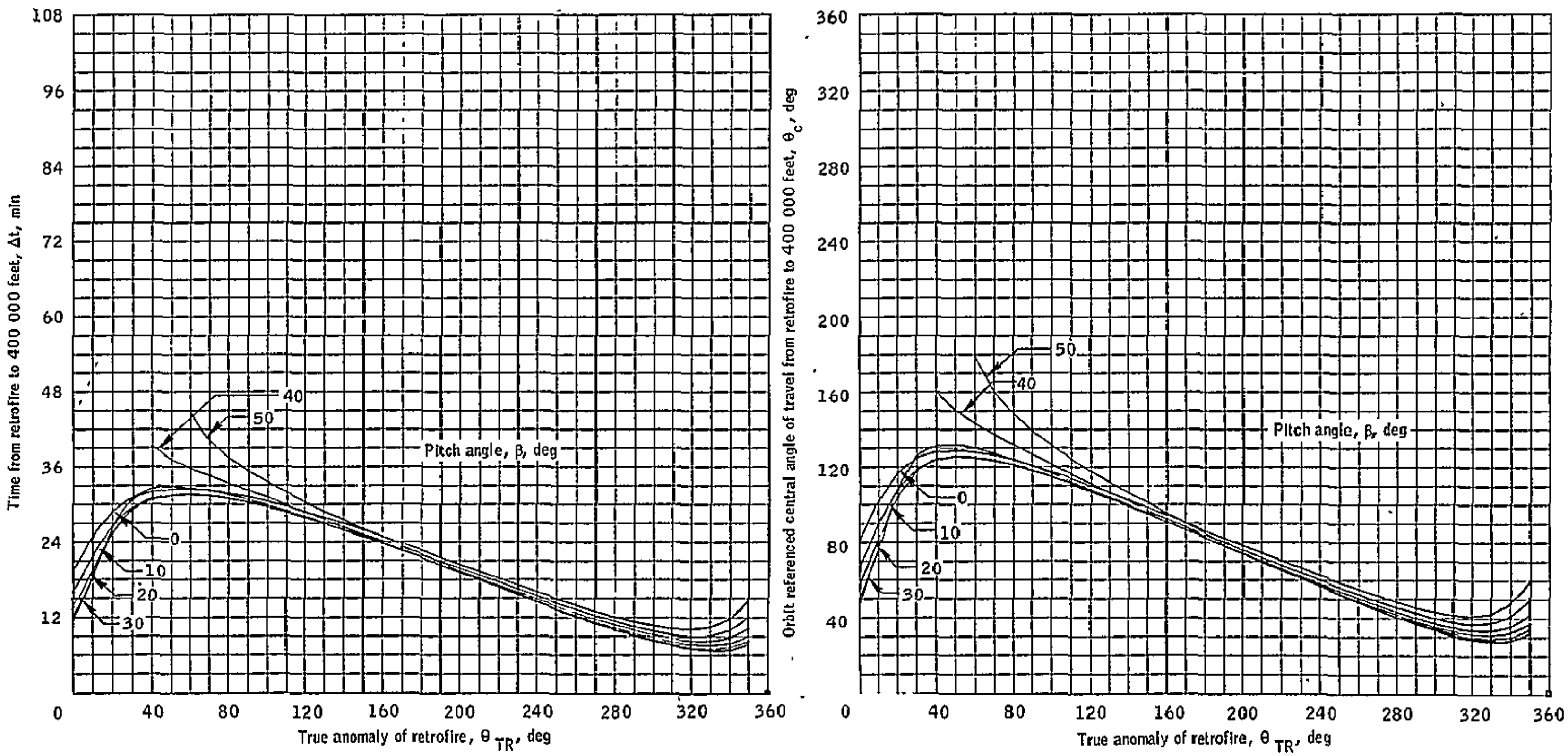
Figure 10.- Continued.





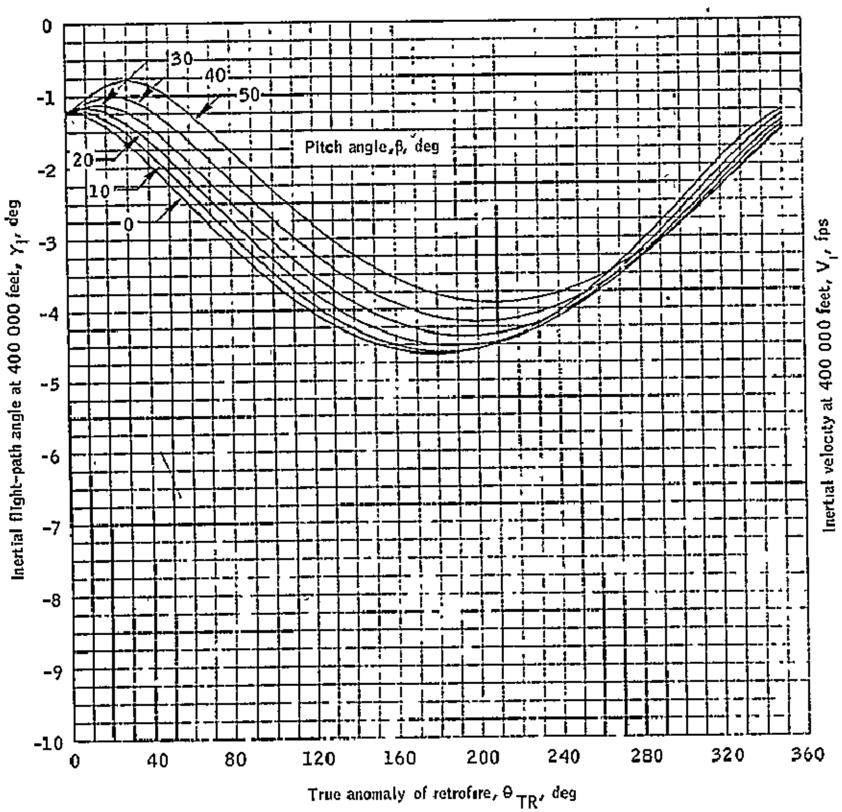
(e) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

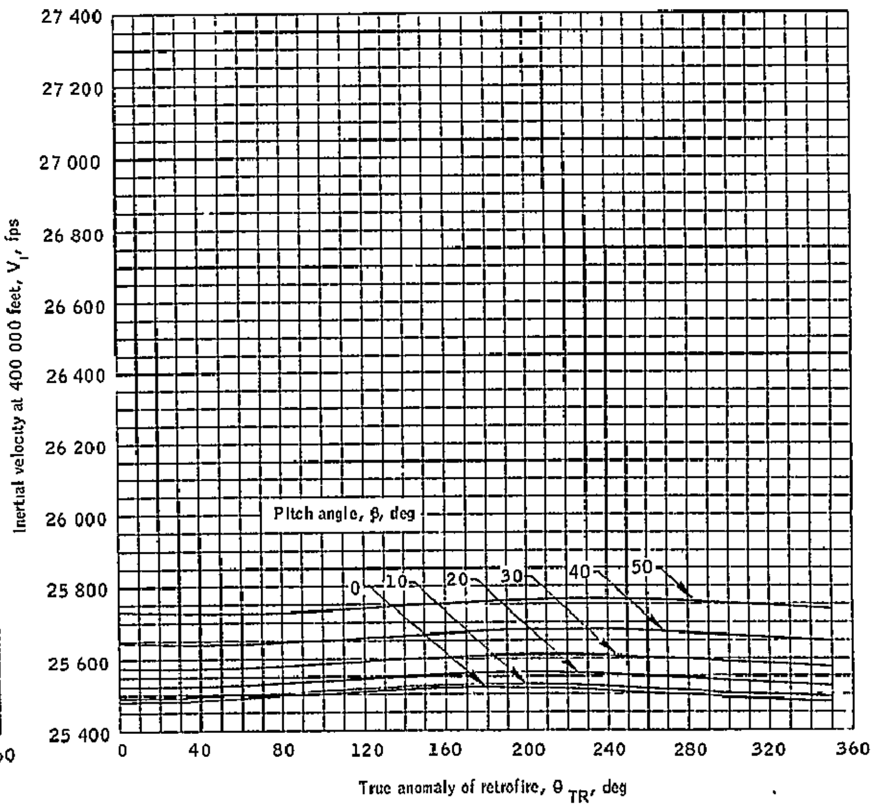
Figure 10.- Continued.



(f) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

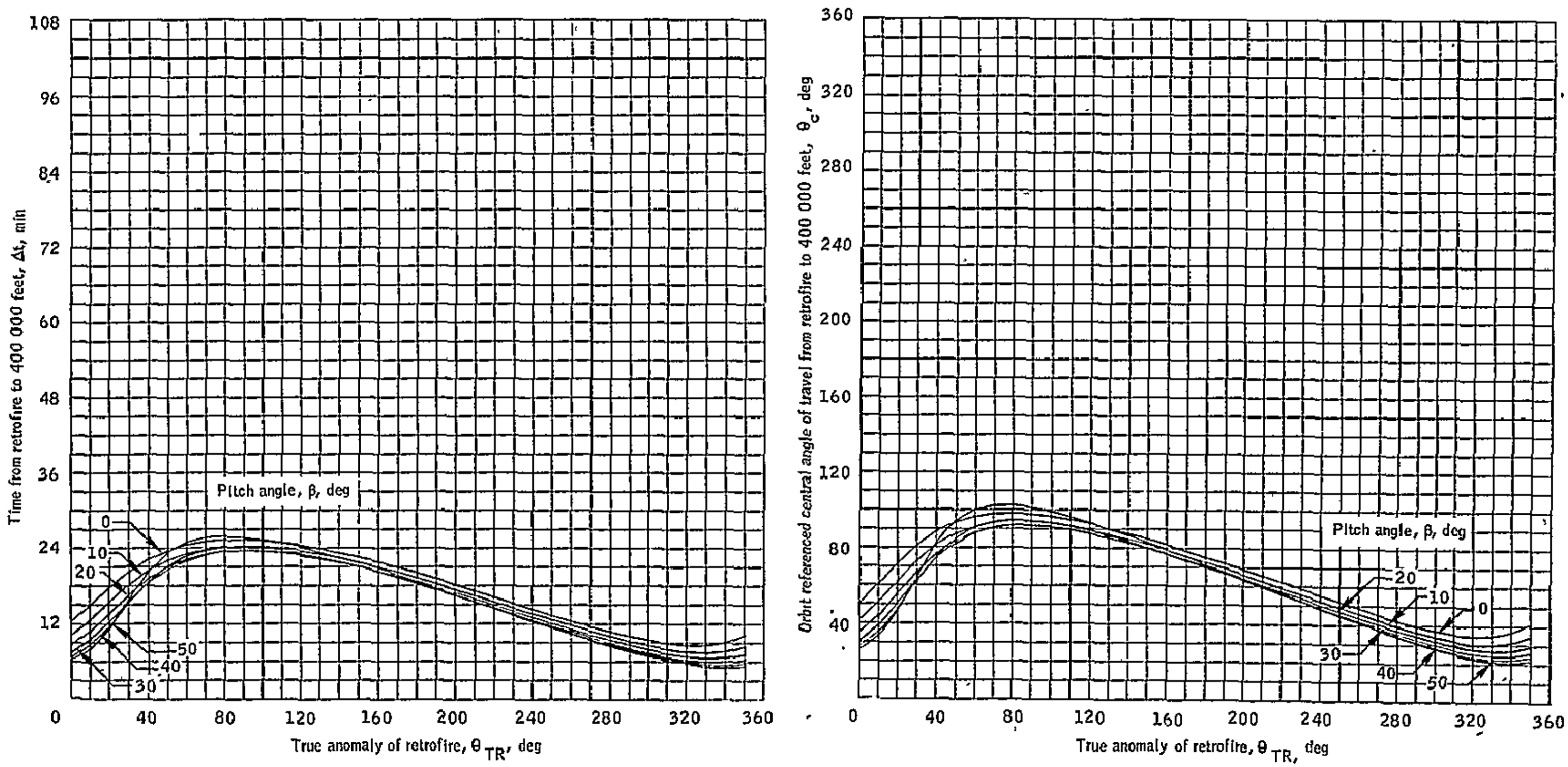
Figure 10.- Continued.





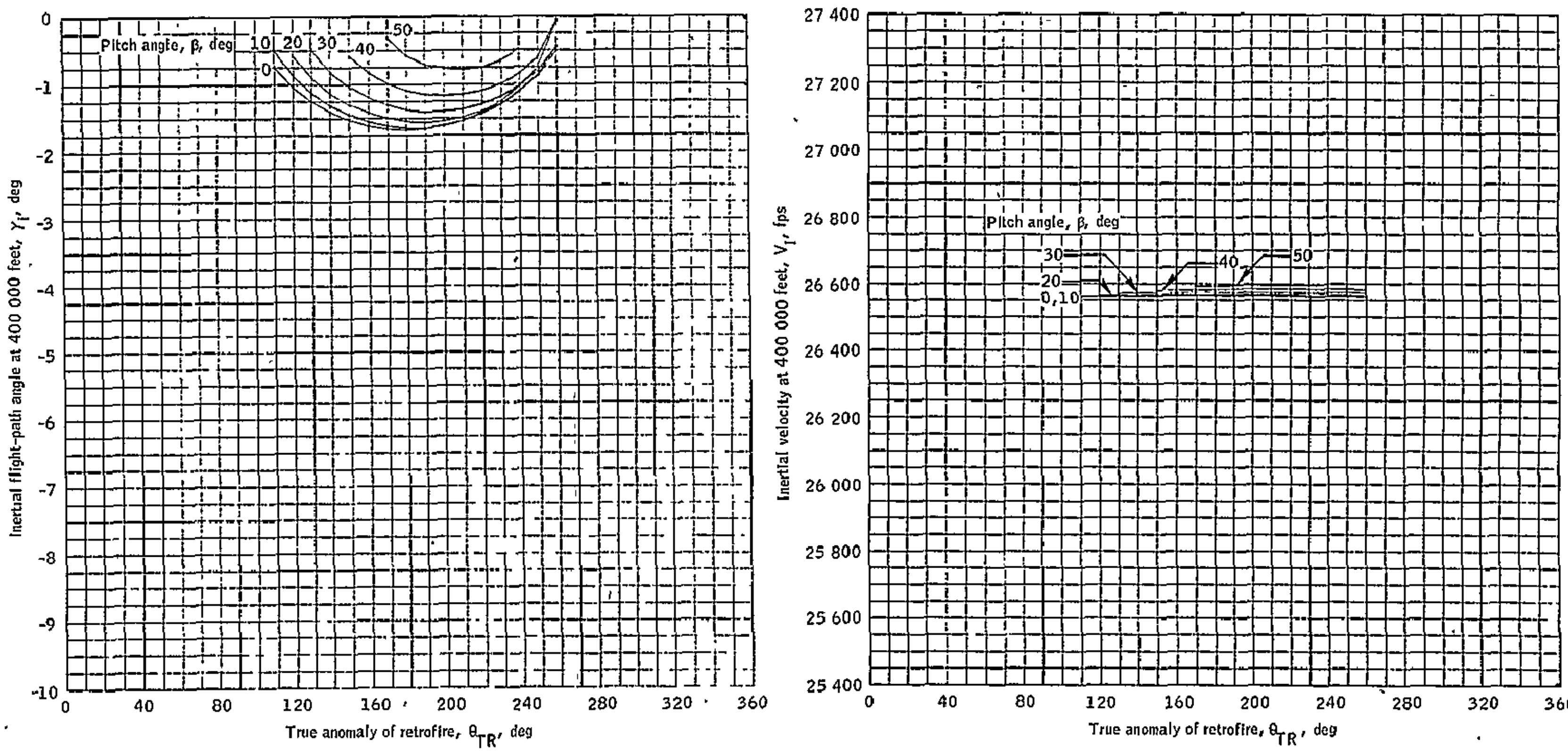
(g) Flight-path angle and velocity for retrograde ΔV = 700 feet per second.

Figure 10.- Continued.



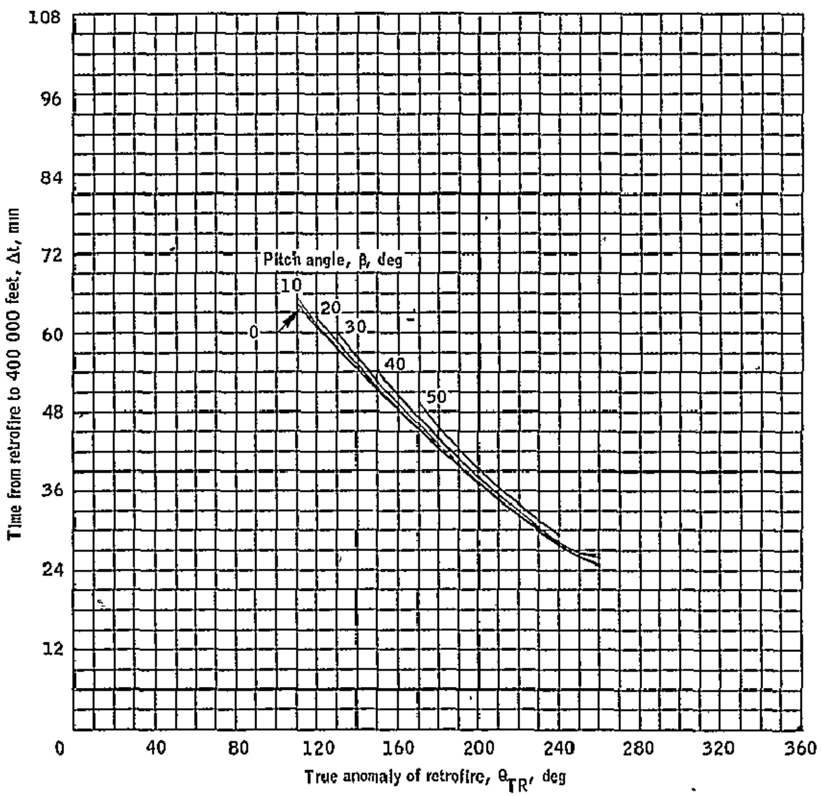
(h) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

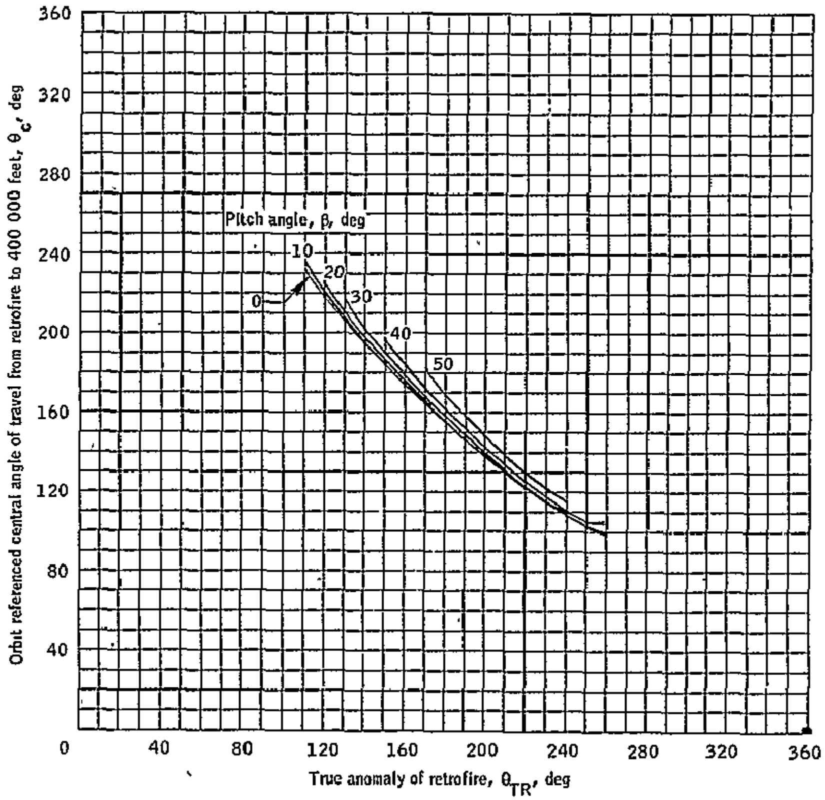
Figure 10.- Concluded.



(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

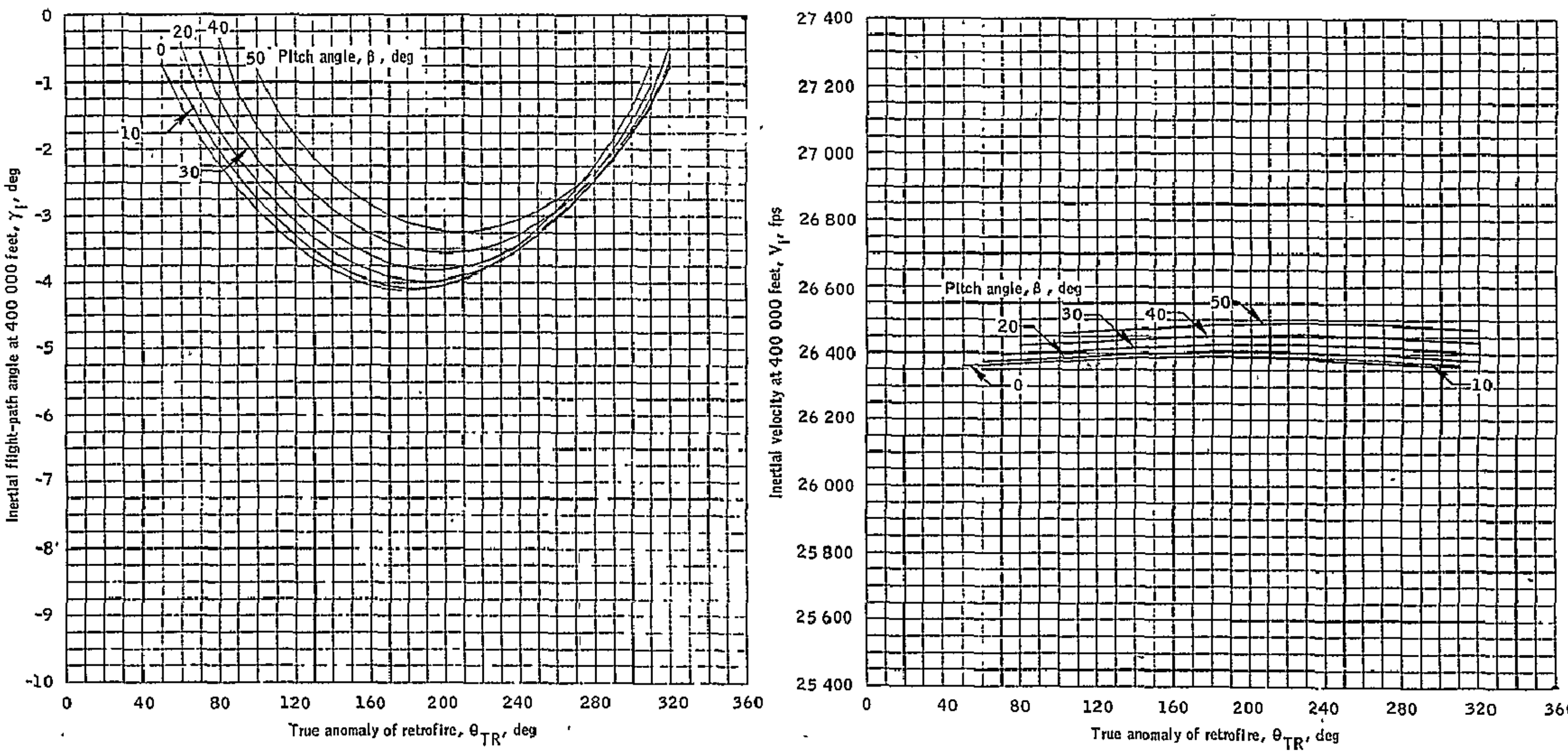
Figure 11.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 100/600 nautical mile orbit.





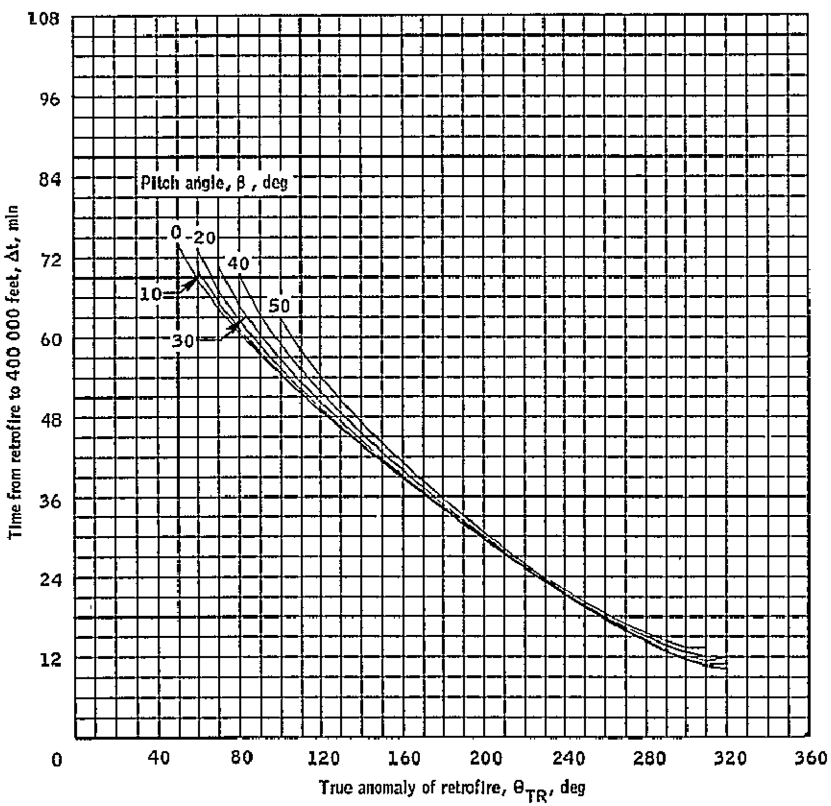
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

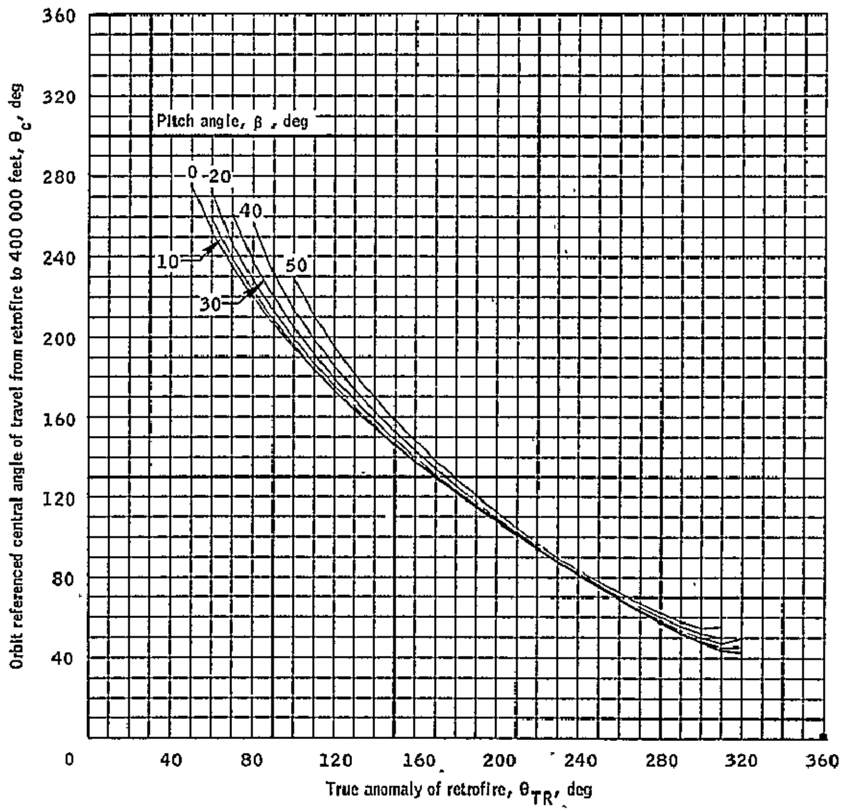
Figure 11.- Continued.



(c) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

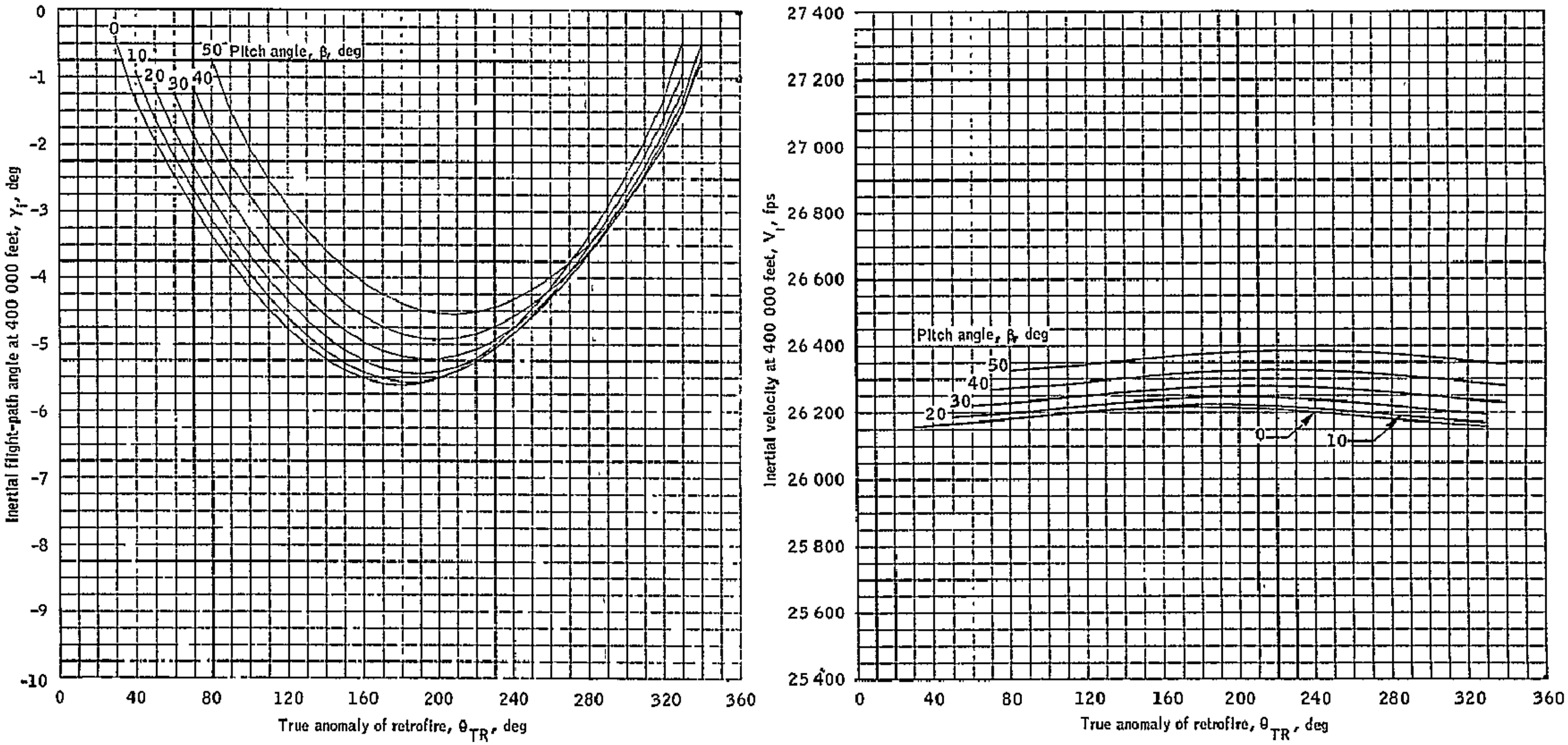
Figure 11.- Continued.





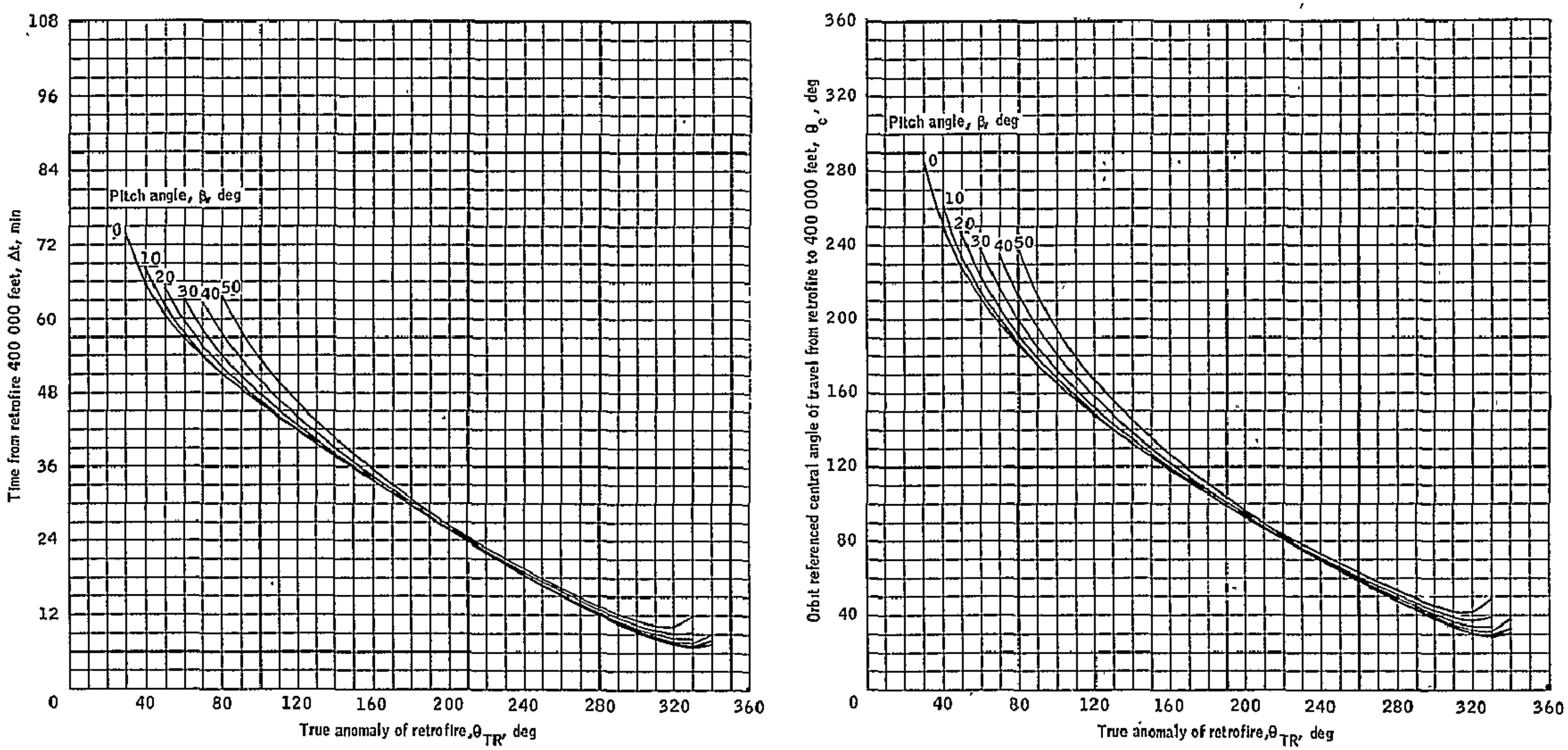
(d) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

Figure 11.- Continued.



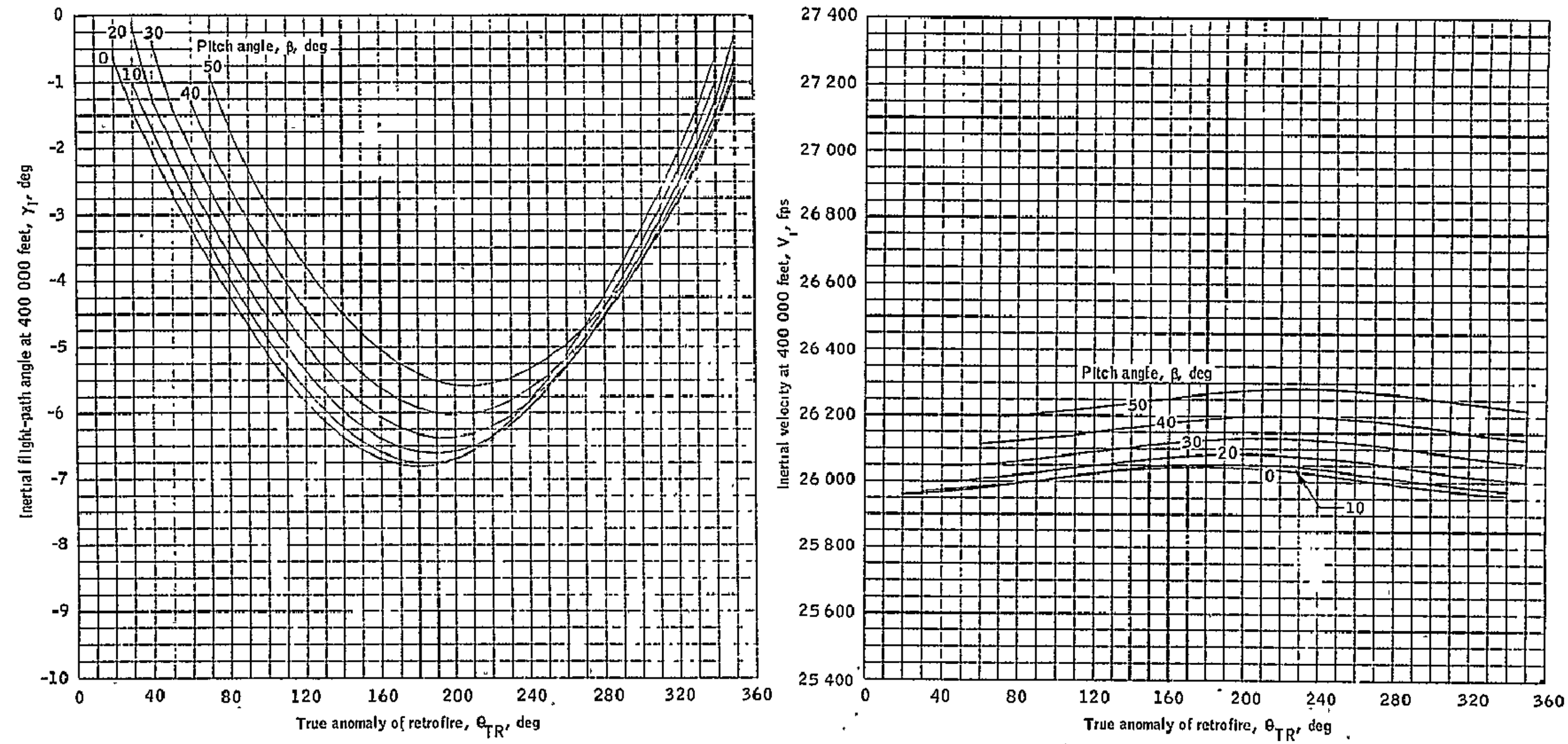
(e) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 11.- Continued.



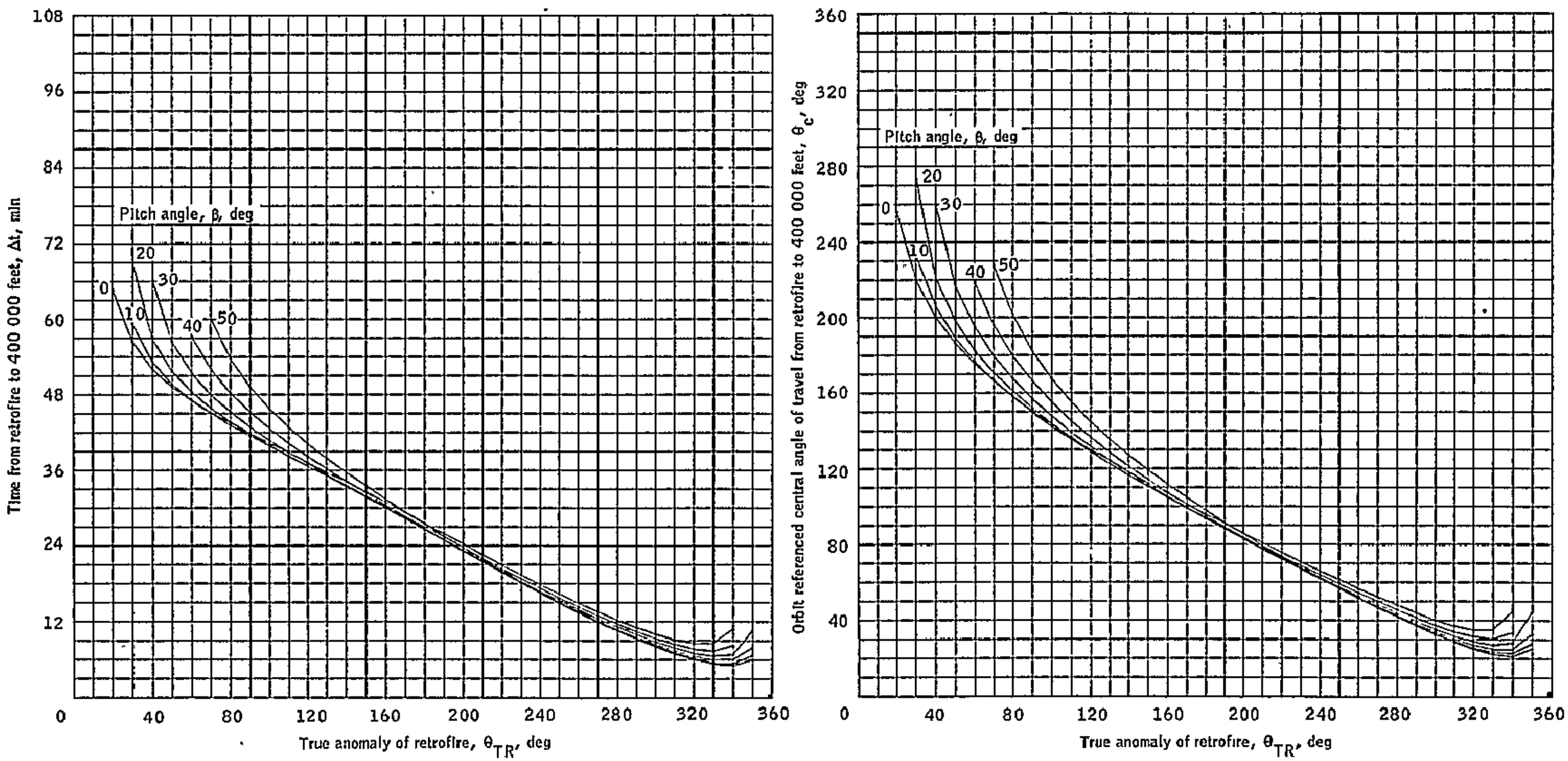
(f) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 11.- Continued.



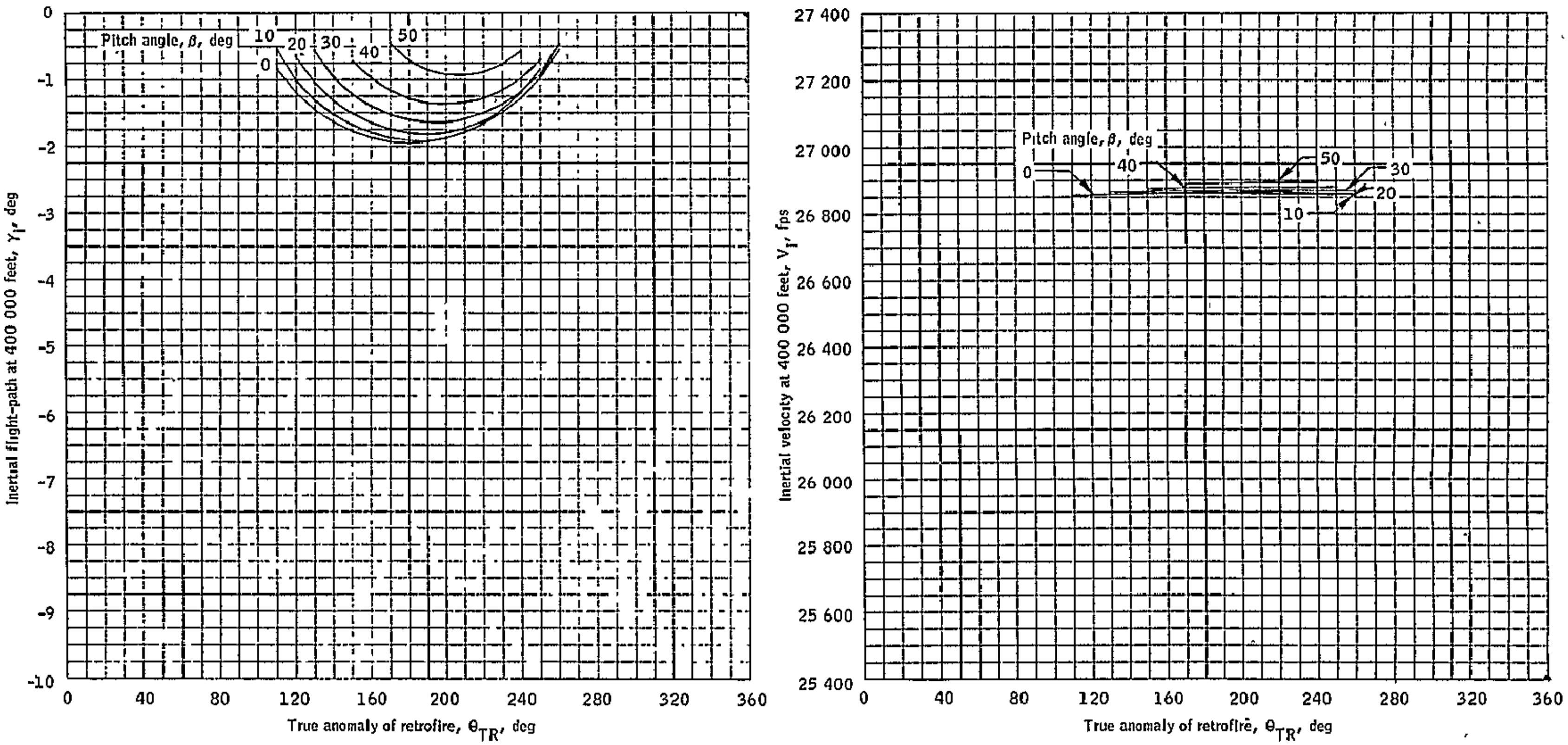
(g) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 11.- Continued.



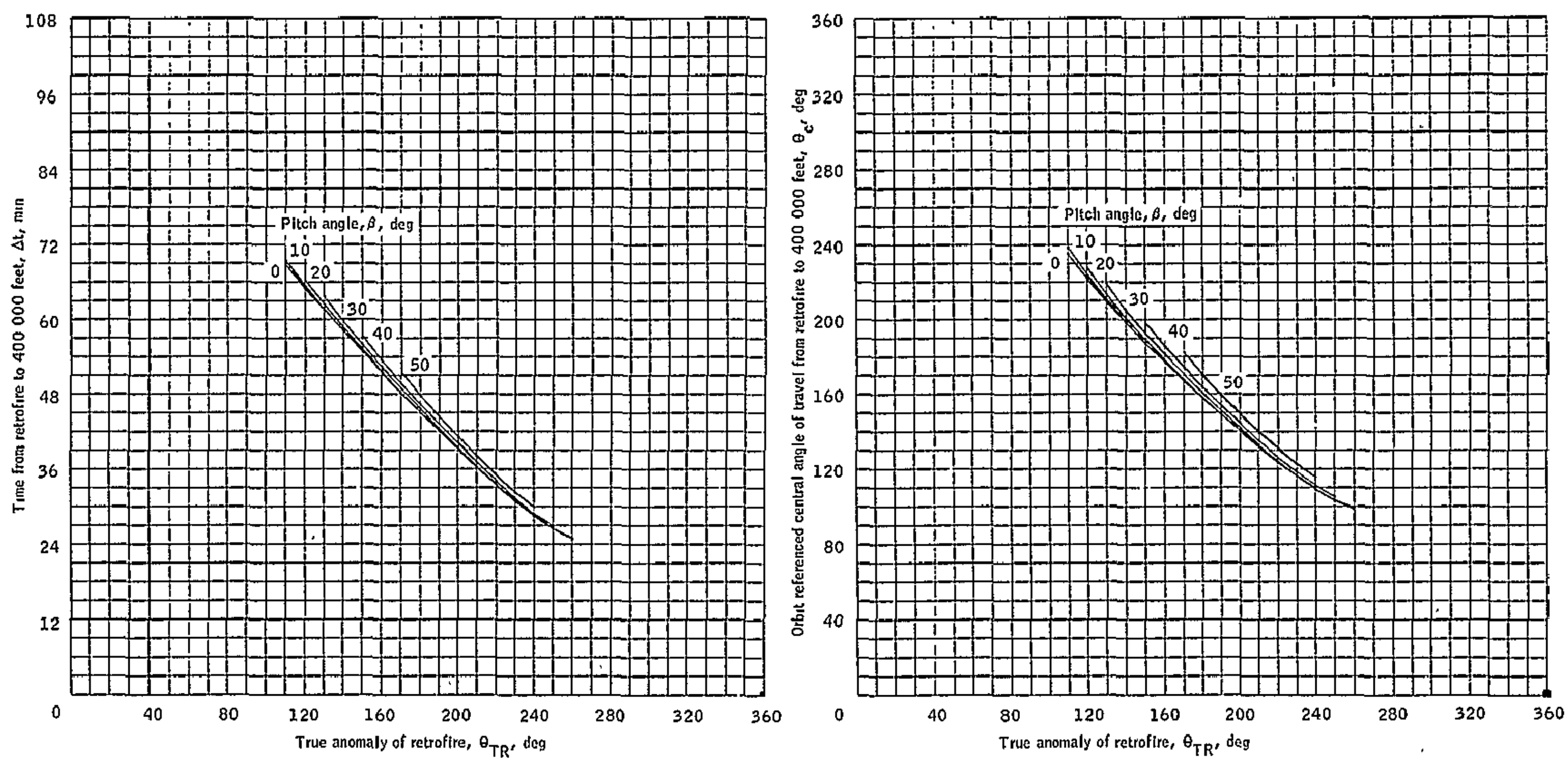
(h) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

Figure 11.- Concluded.



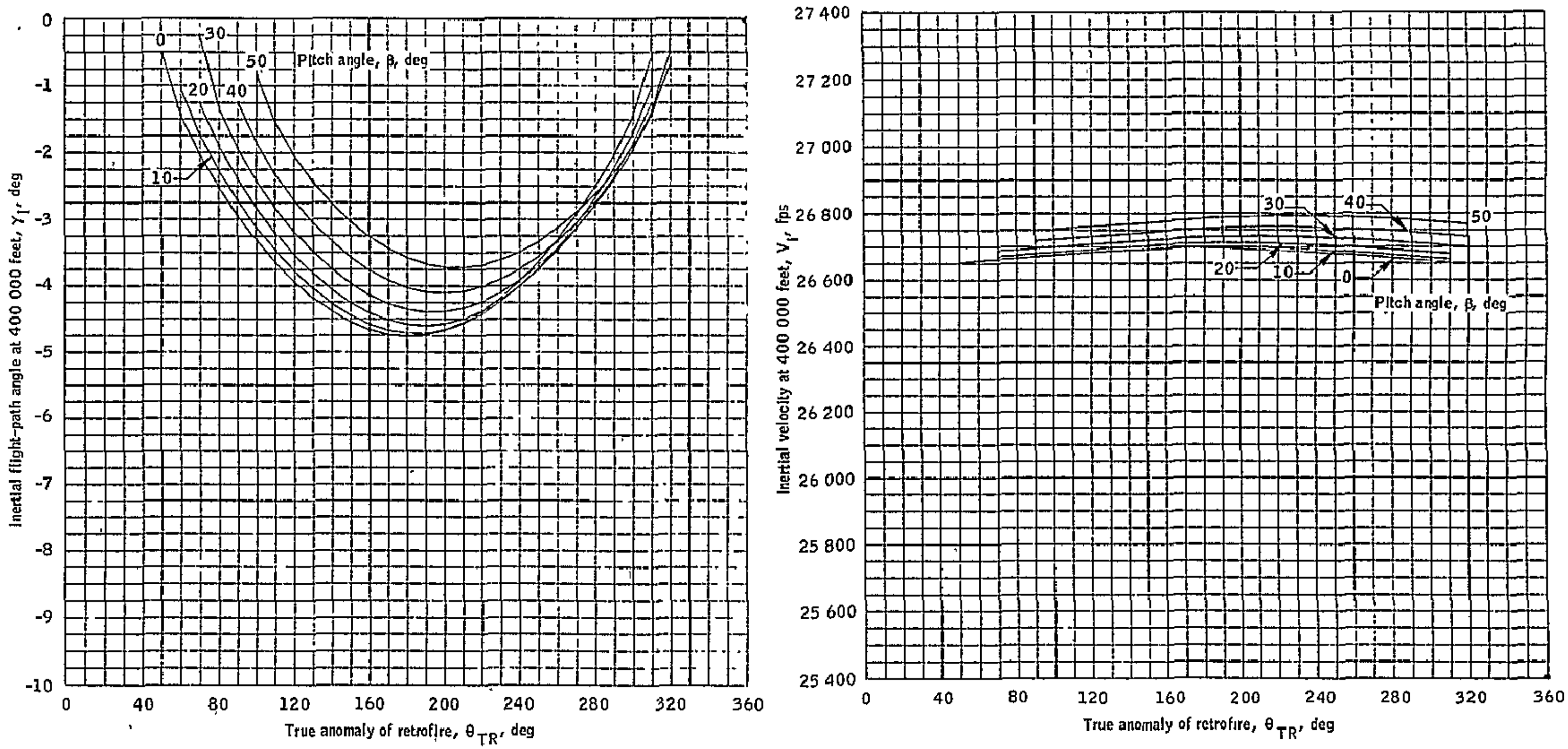
(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

Figure 12.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 100/800 nautical mile orbit.



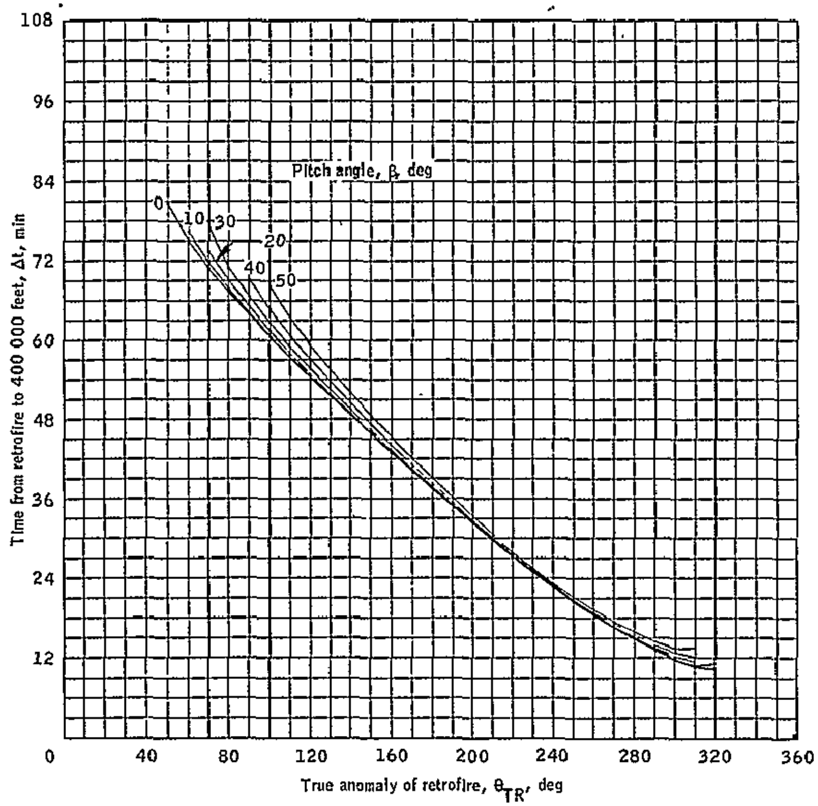
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

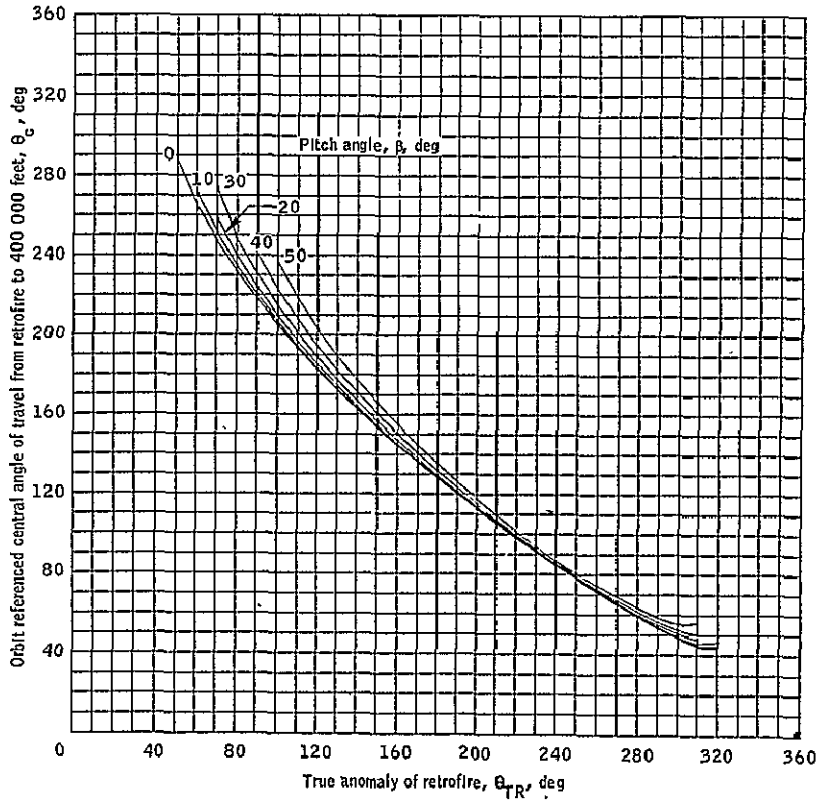
Figure 12.- Continued.



(c) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

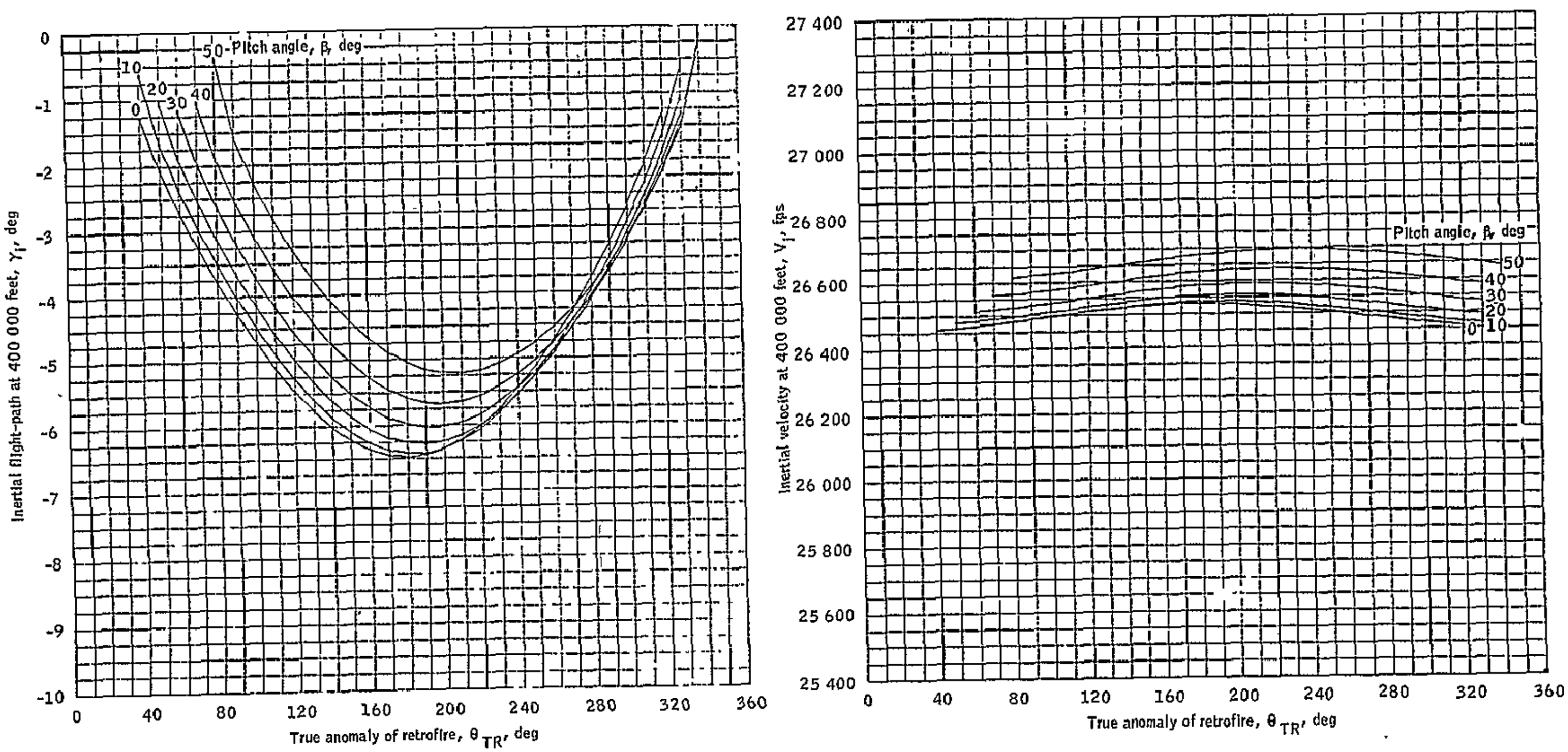
Figure 12.- Continued.





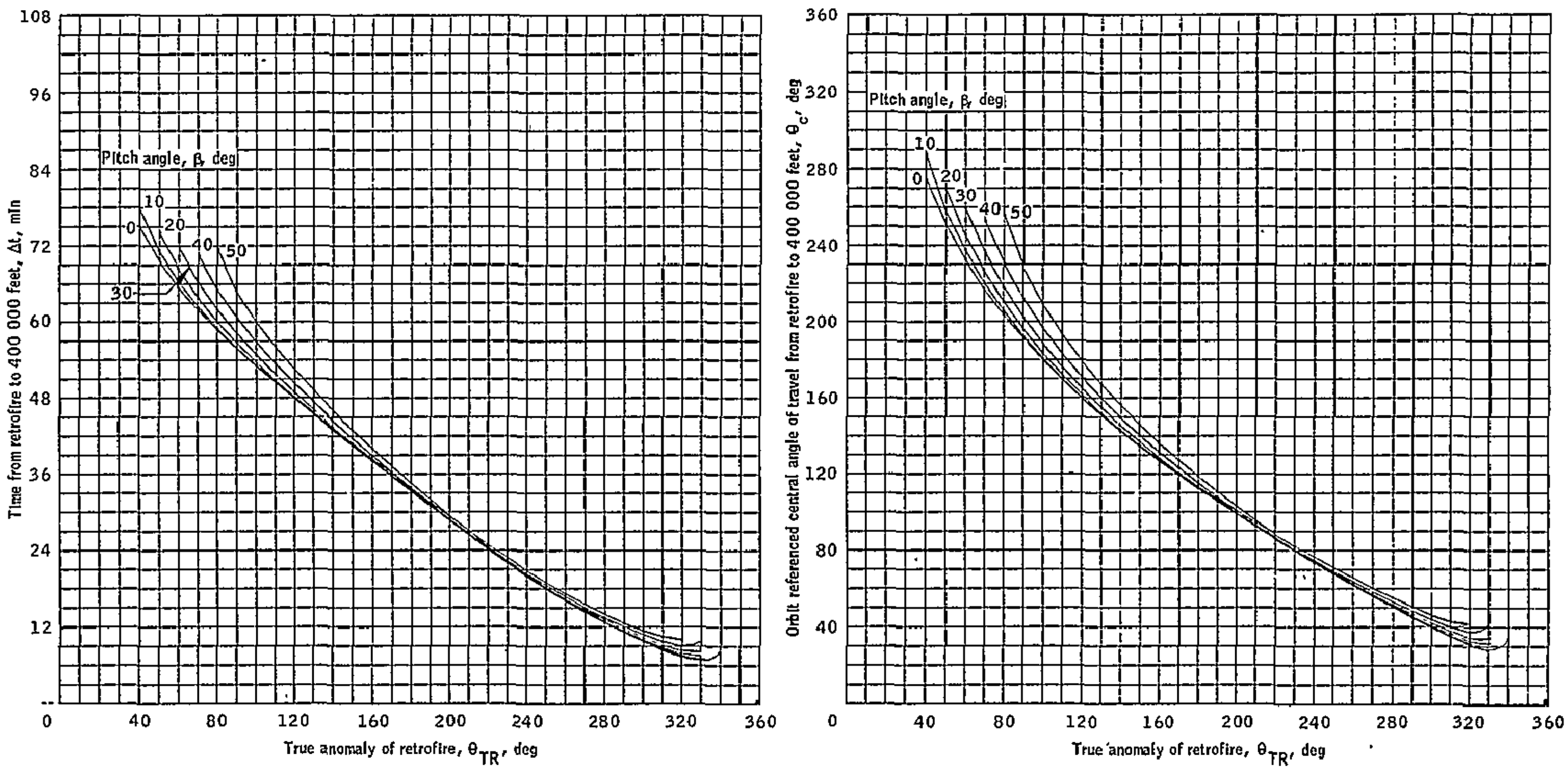
(d) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

Figure 12- Continued.



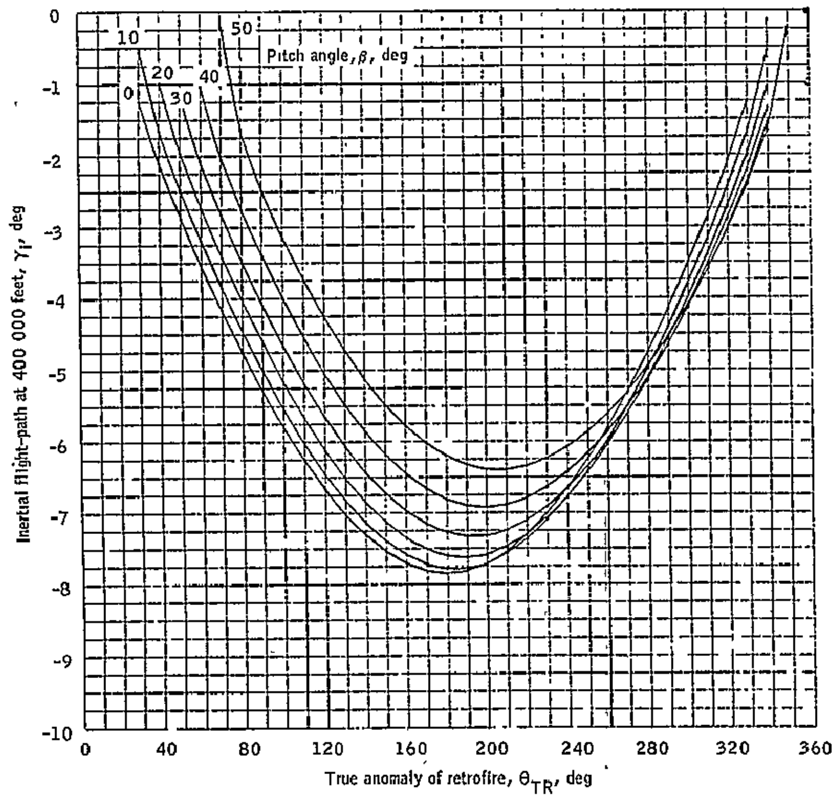
(e) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

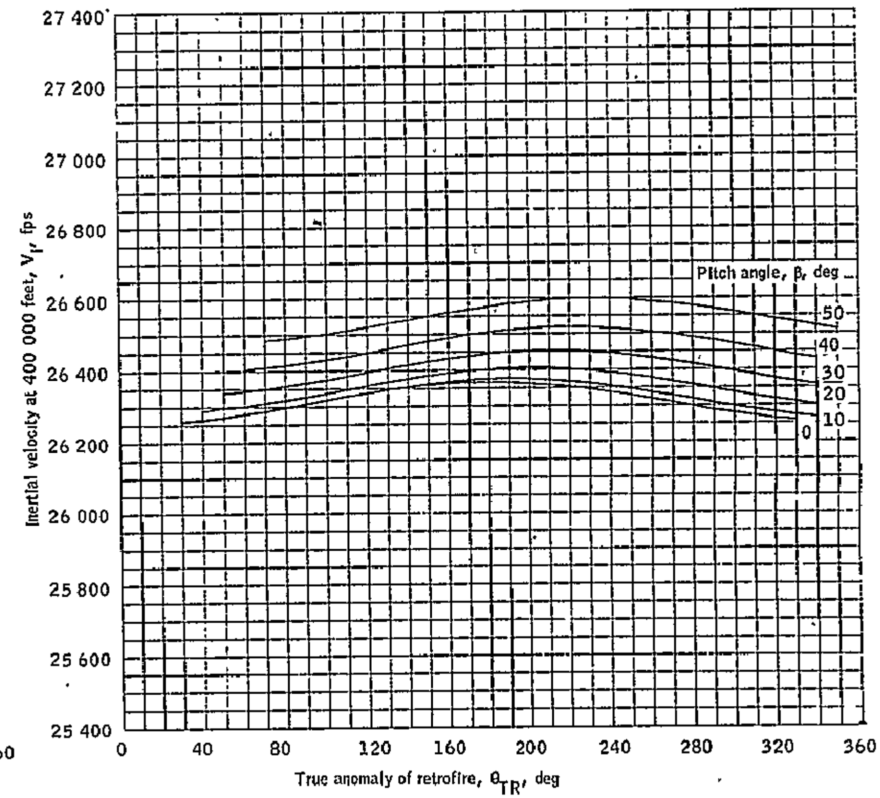
Figure 12.- Continued.



(f) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

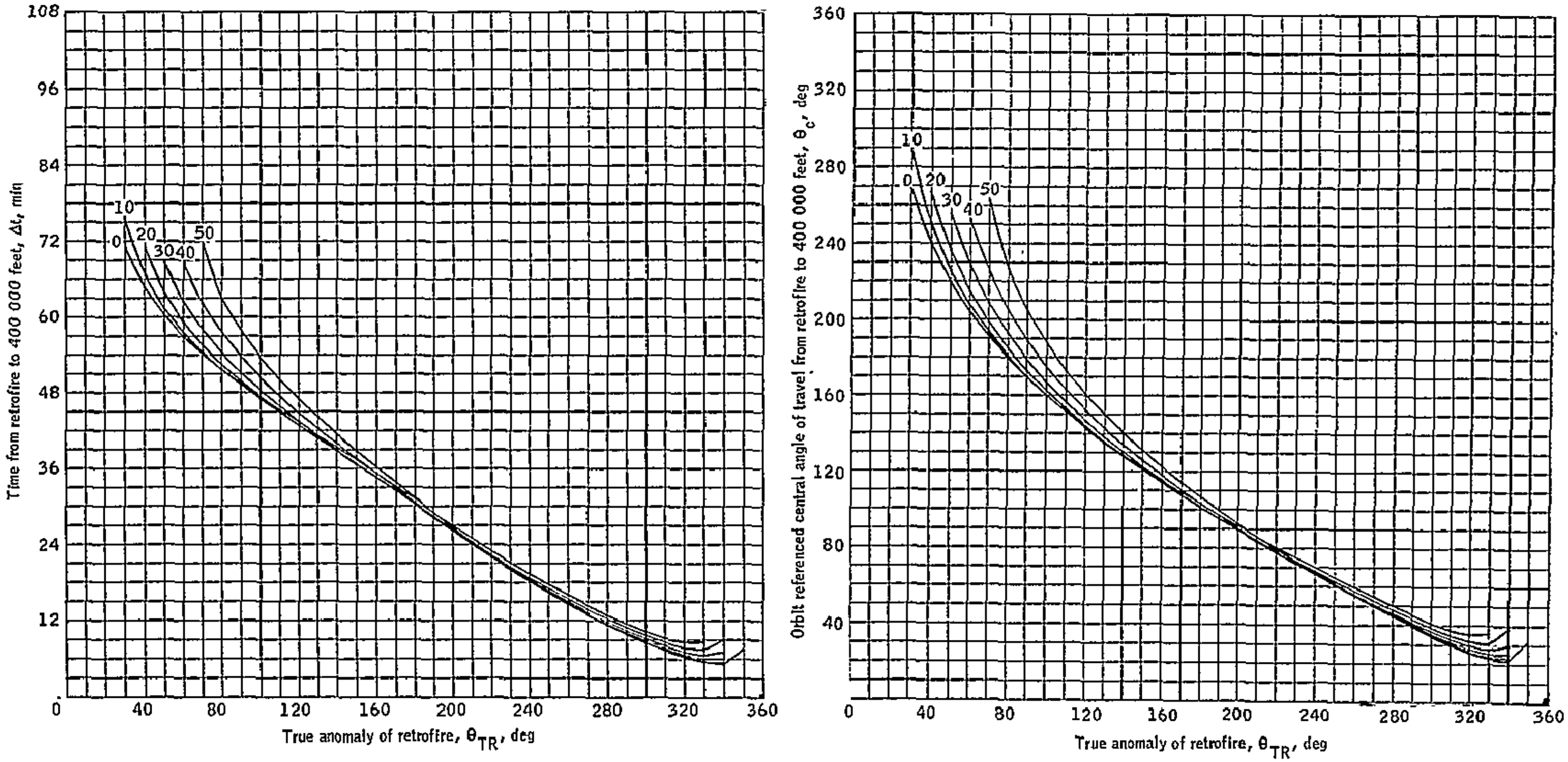
Figure 12.- Continued.





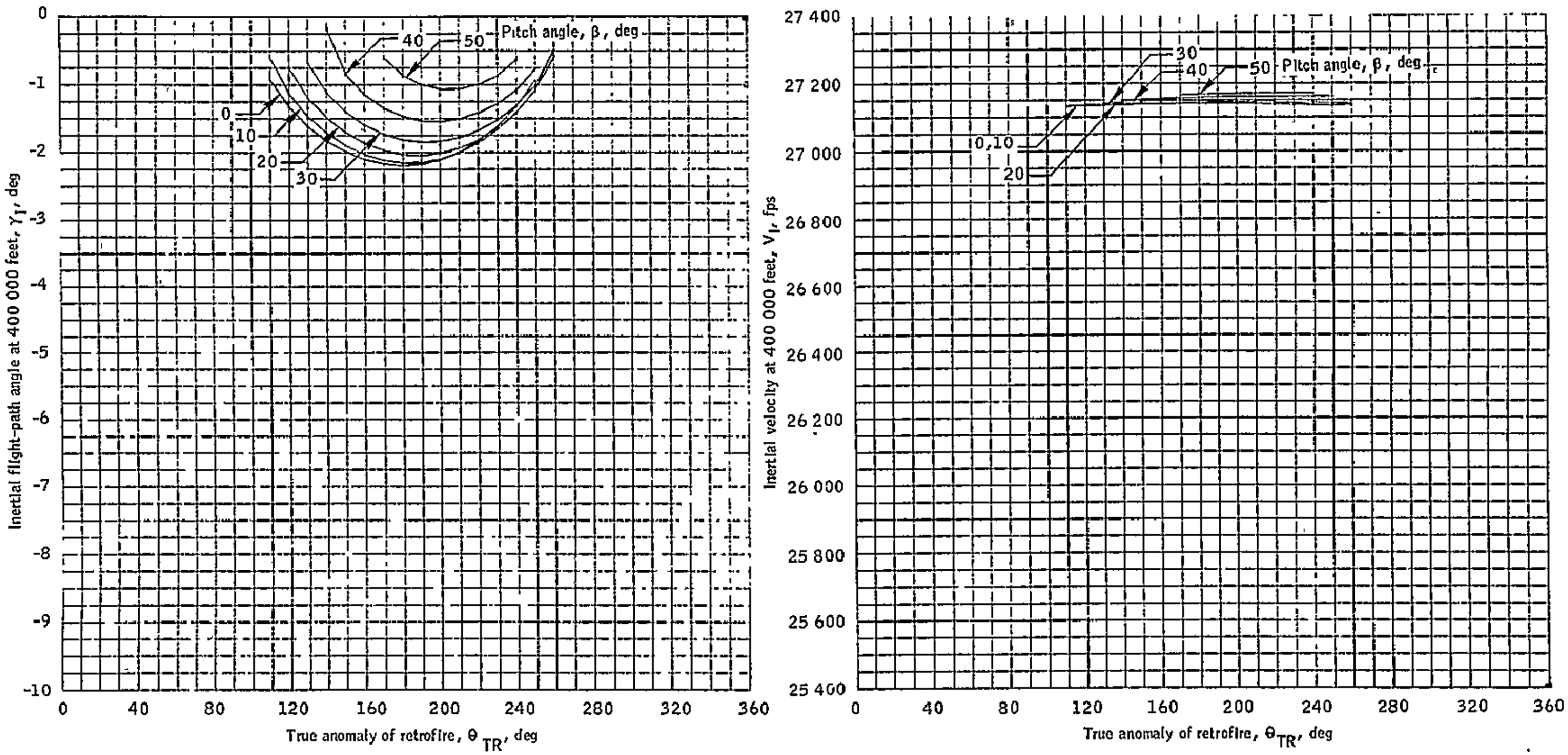
(g) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 12.- Continued.



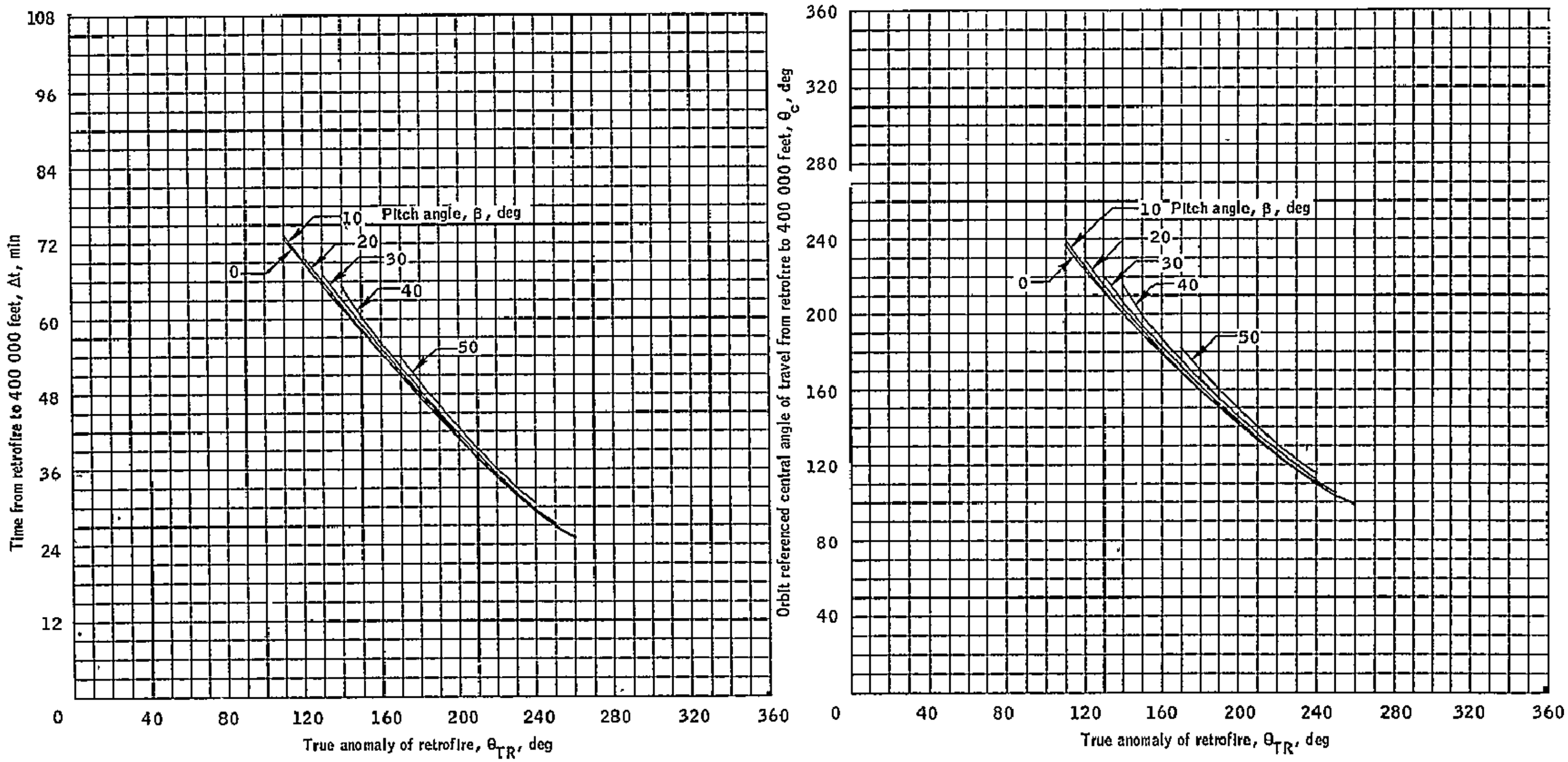
(h) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

Figure 12.- Concluded.



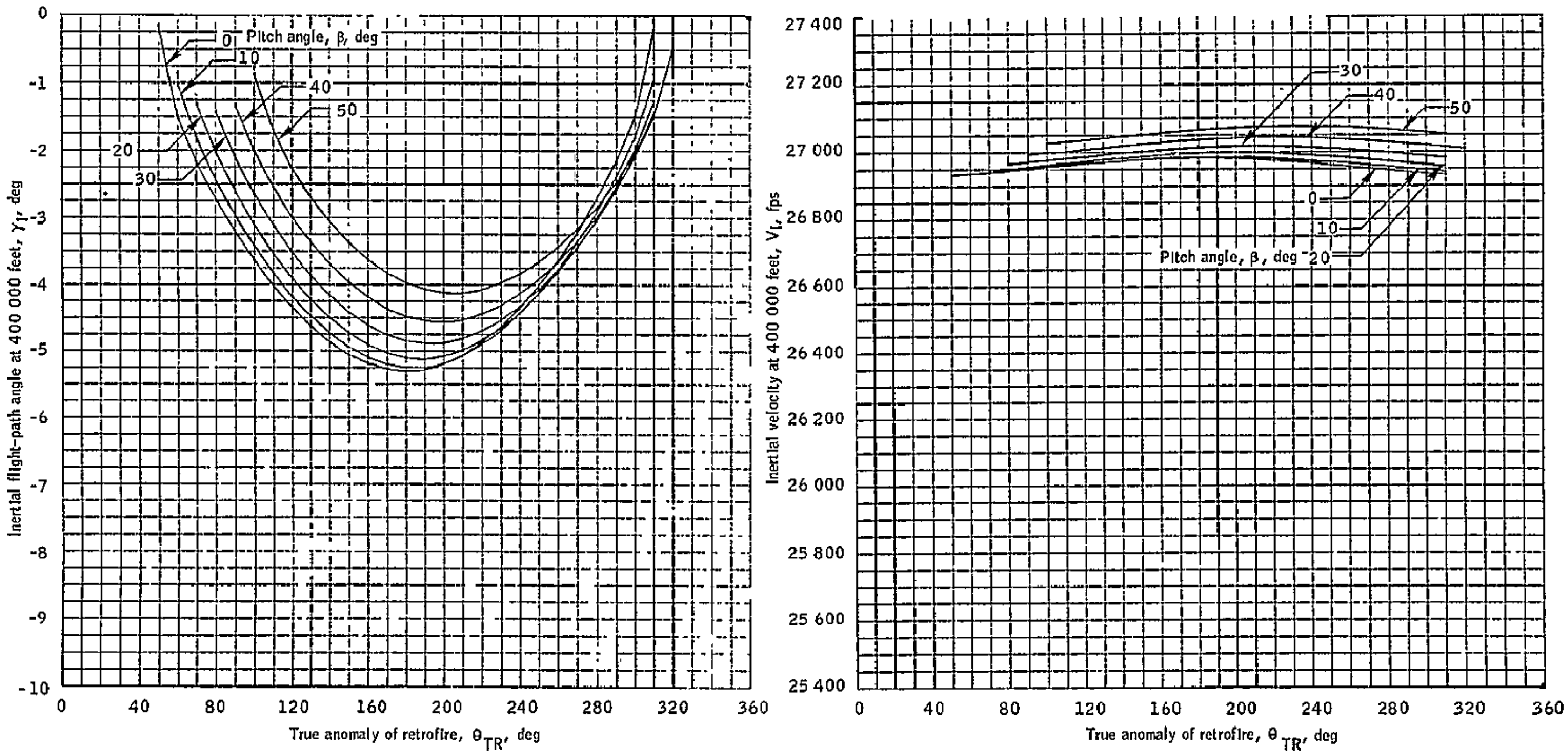
(a) Flight-path angle and velocity for retrograde ΔV = 100 feet per second.

Figure 13.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 100/1000 nautical mile orbit.



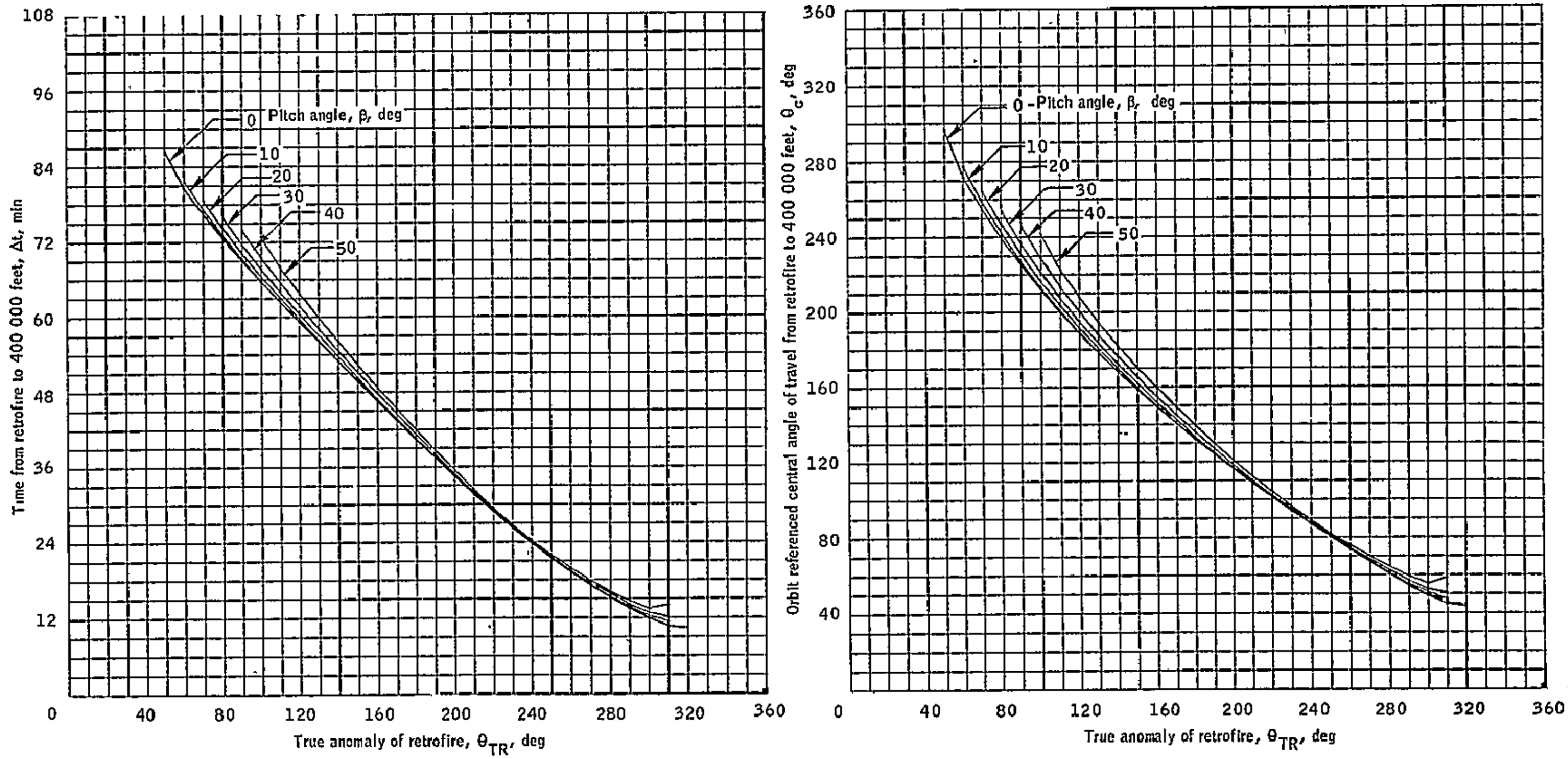
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

Figure 13.- Continued.



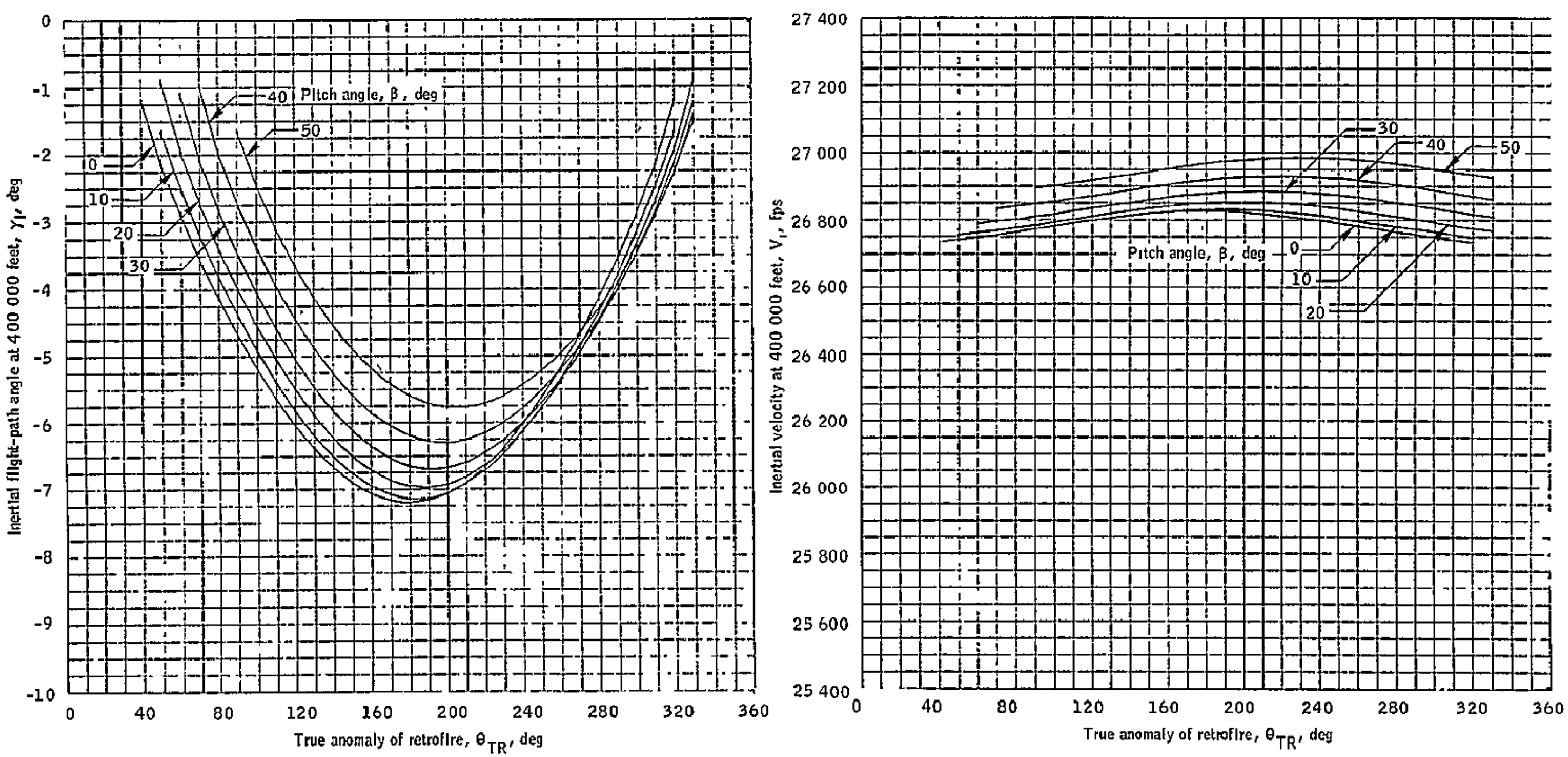
(c) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

Figure 13.- Continued.



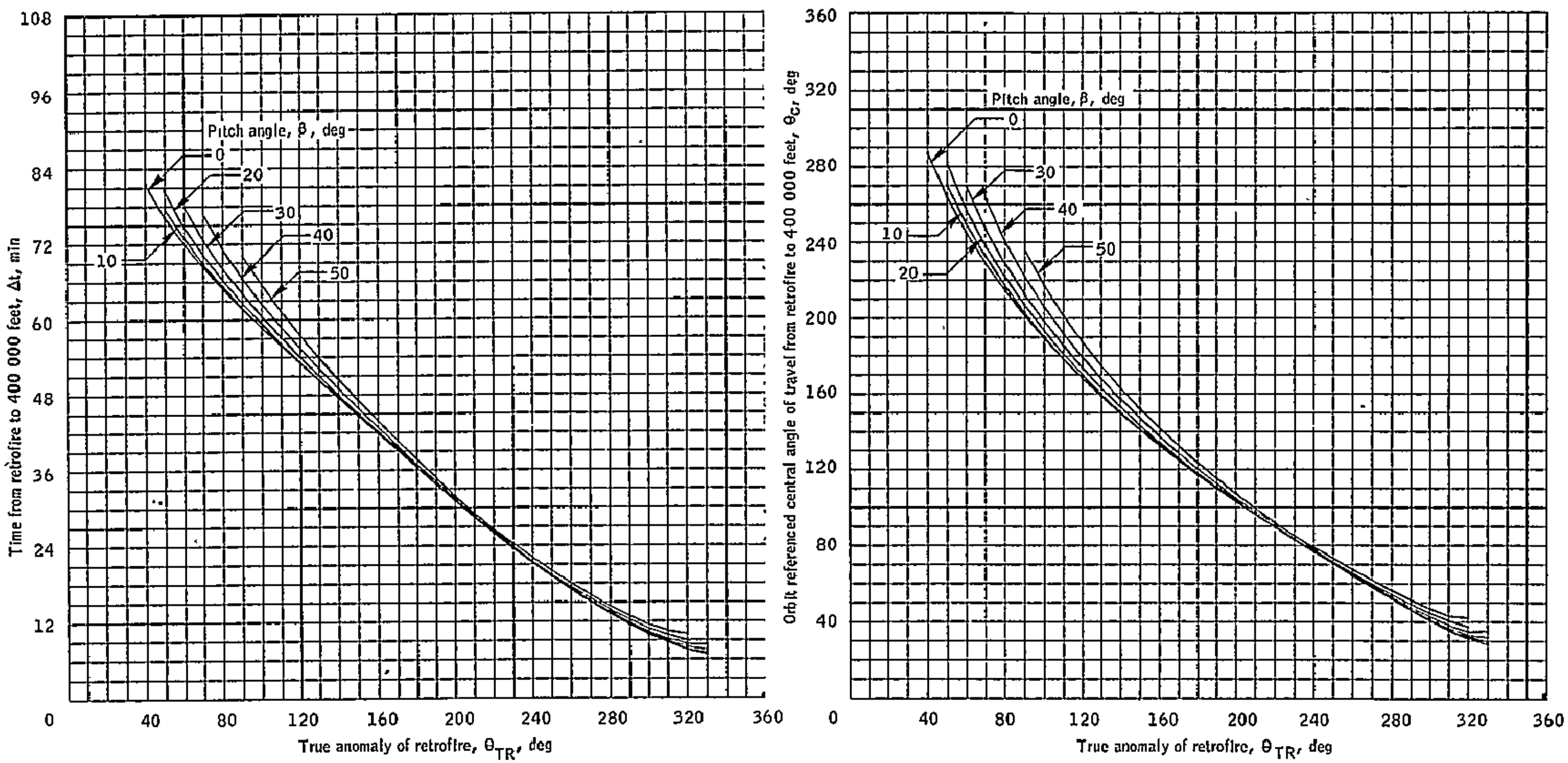
(d) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

Figure 13.- Continued.



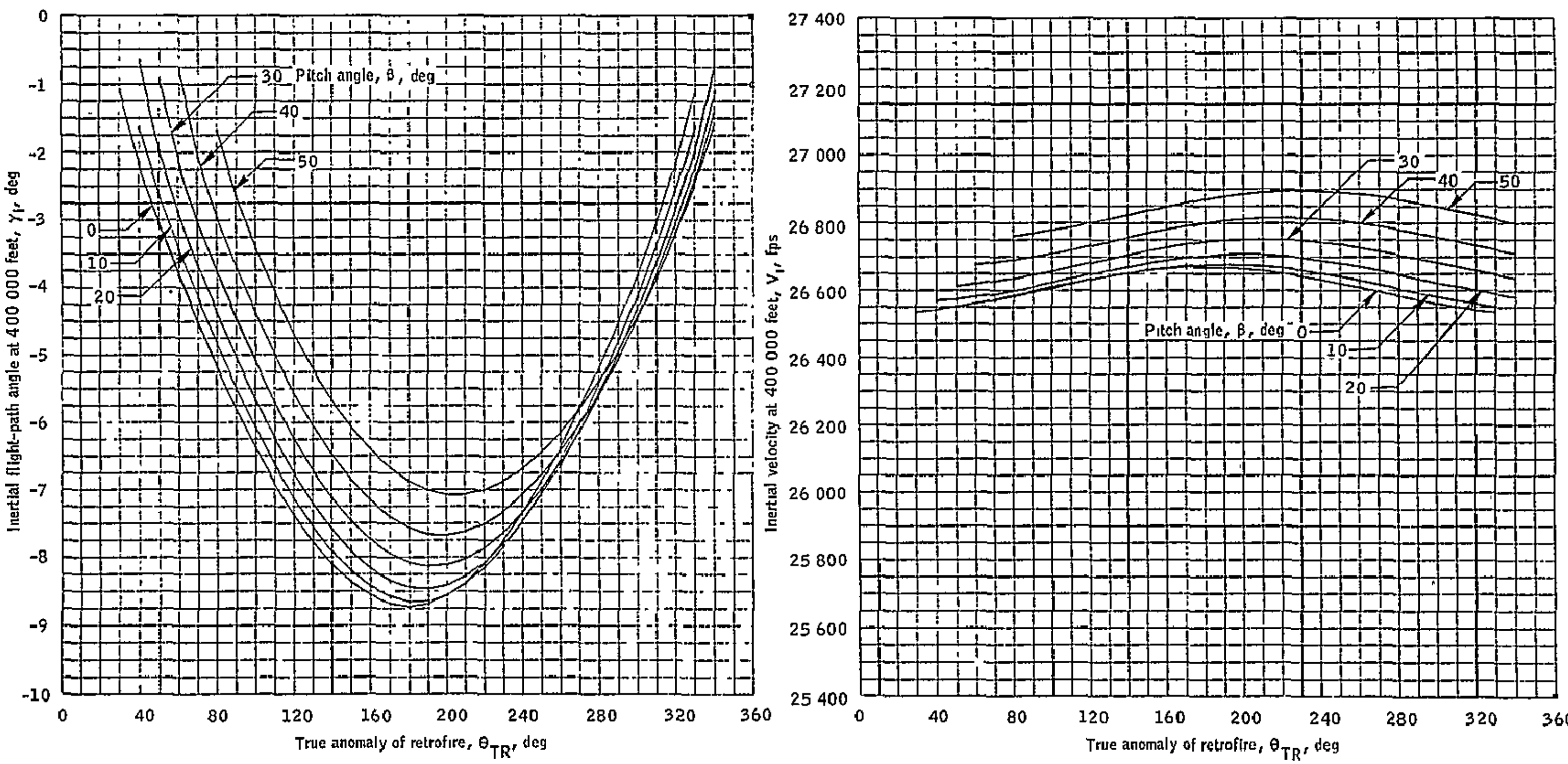
(e) Flight-path angle and velocity for retrograde ΔV = 500 feet per second

Figure 13.- Continued



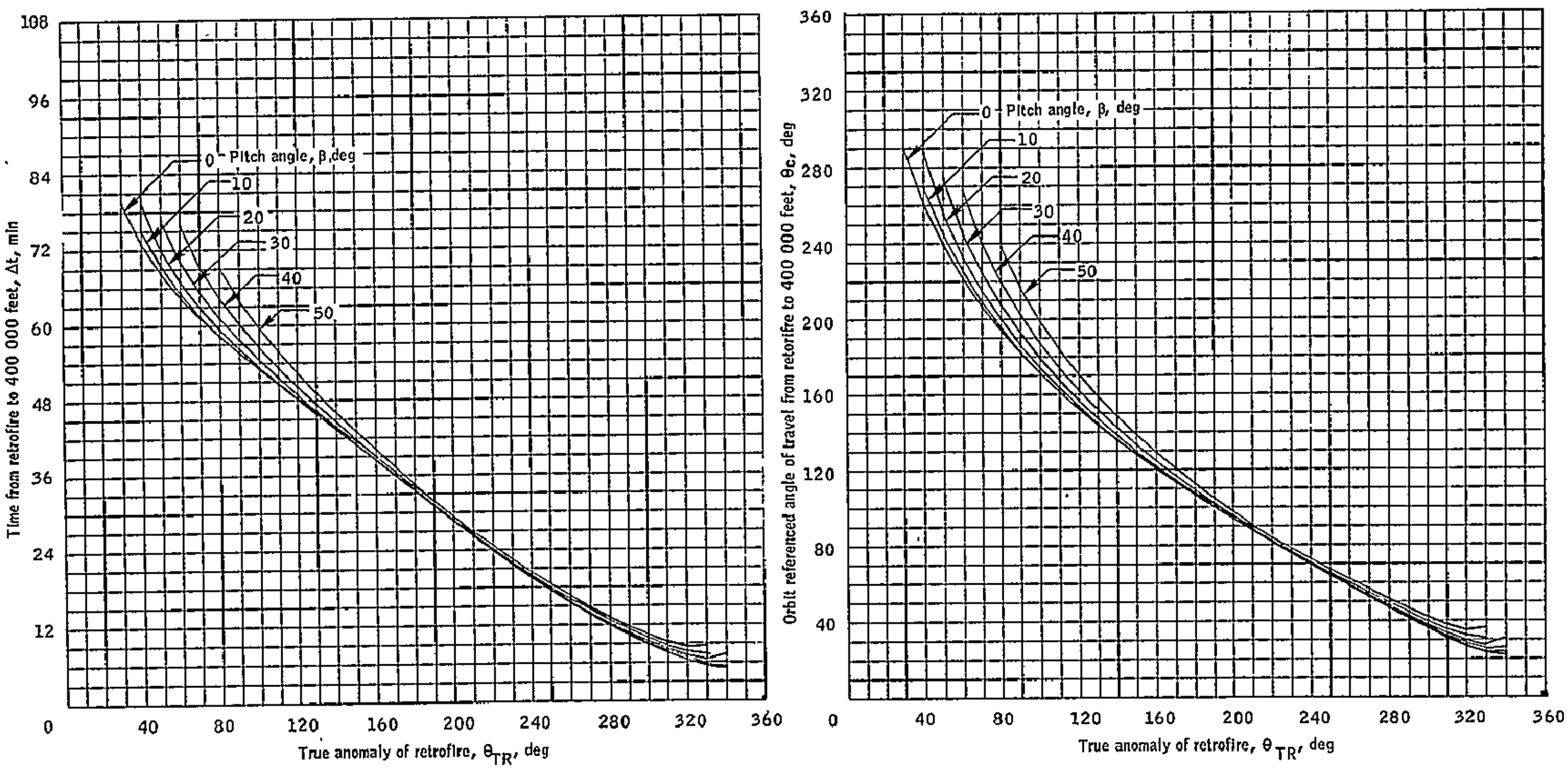
(f) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 13.- Continued.



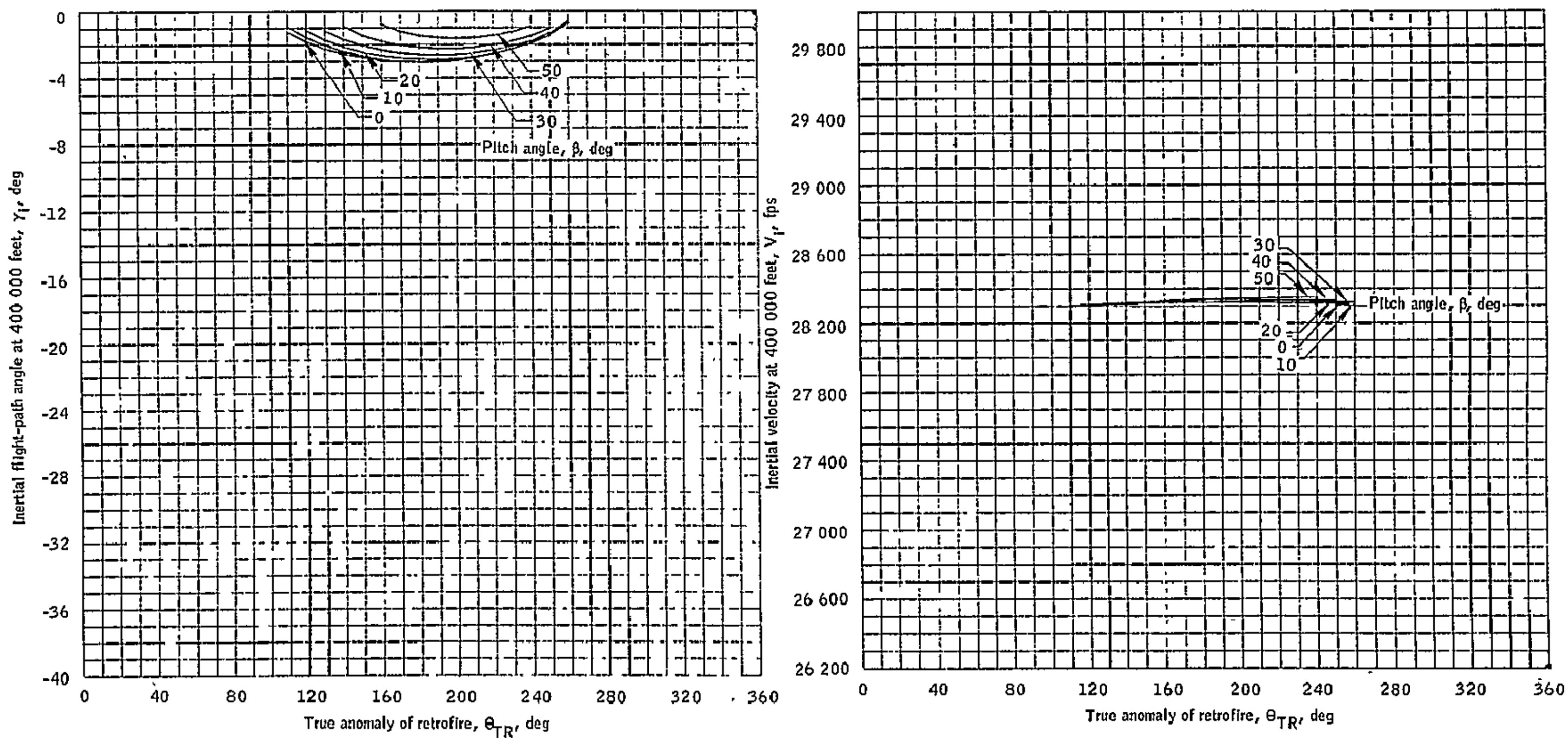
(g) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 13.- Continued.



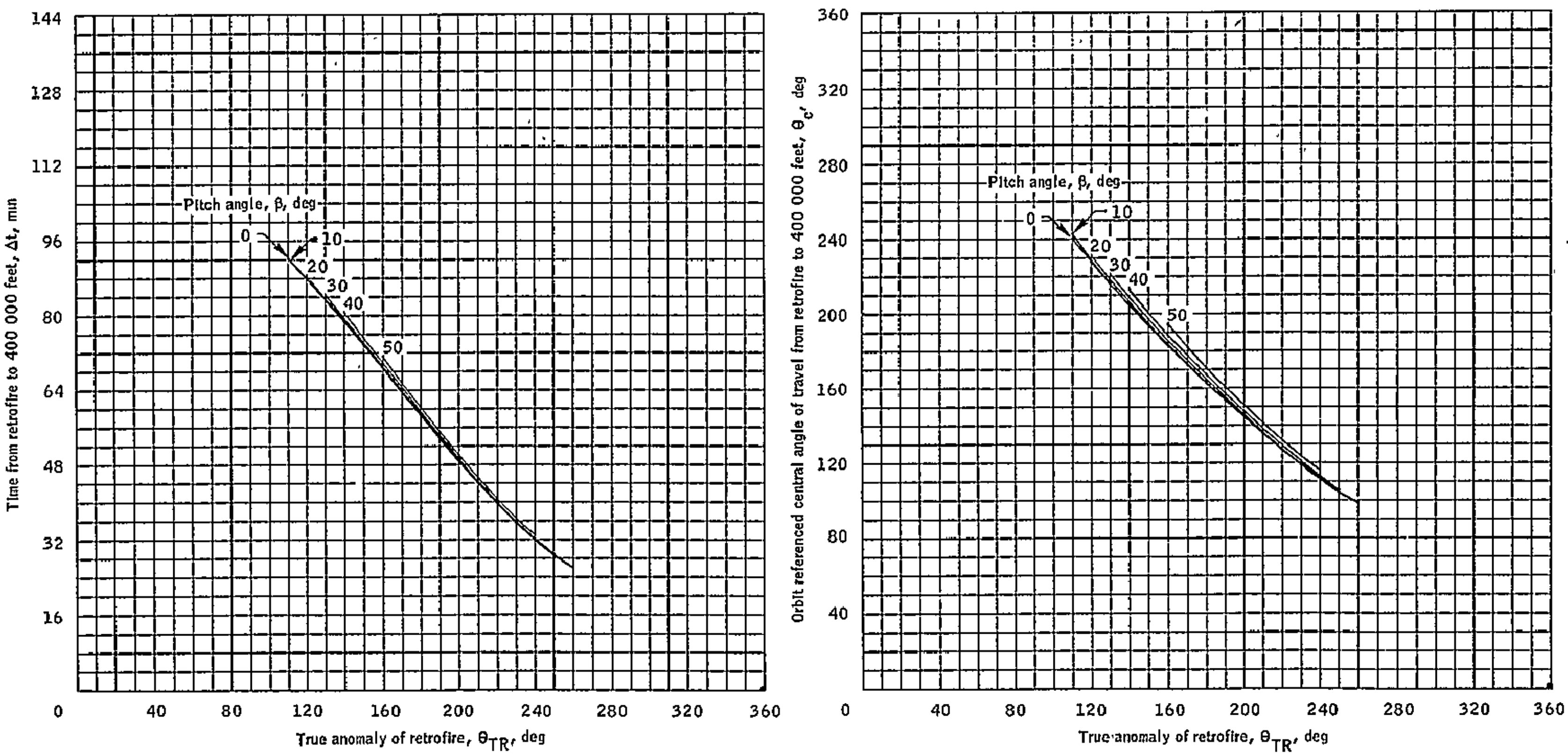
(h) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

Figure 13.- Concluded.



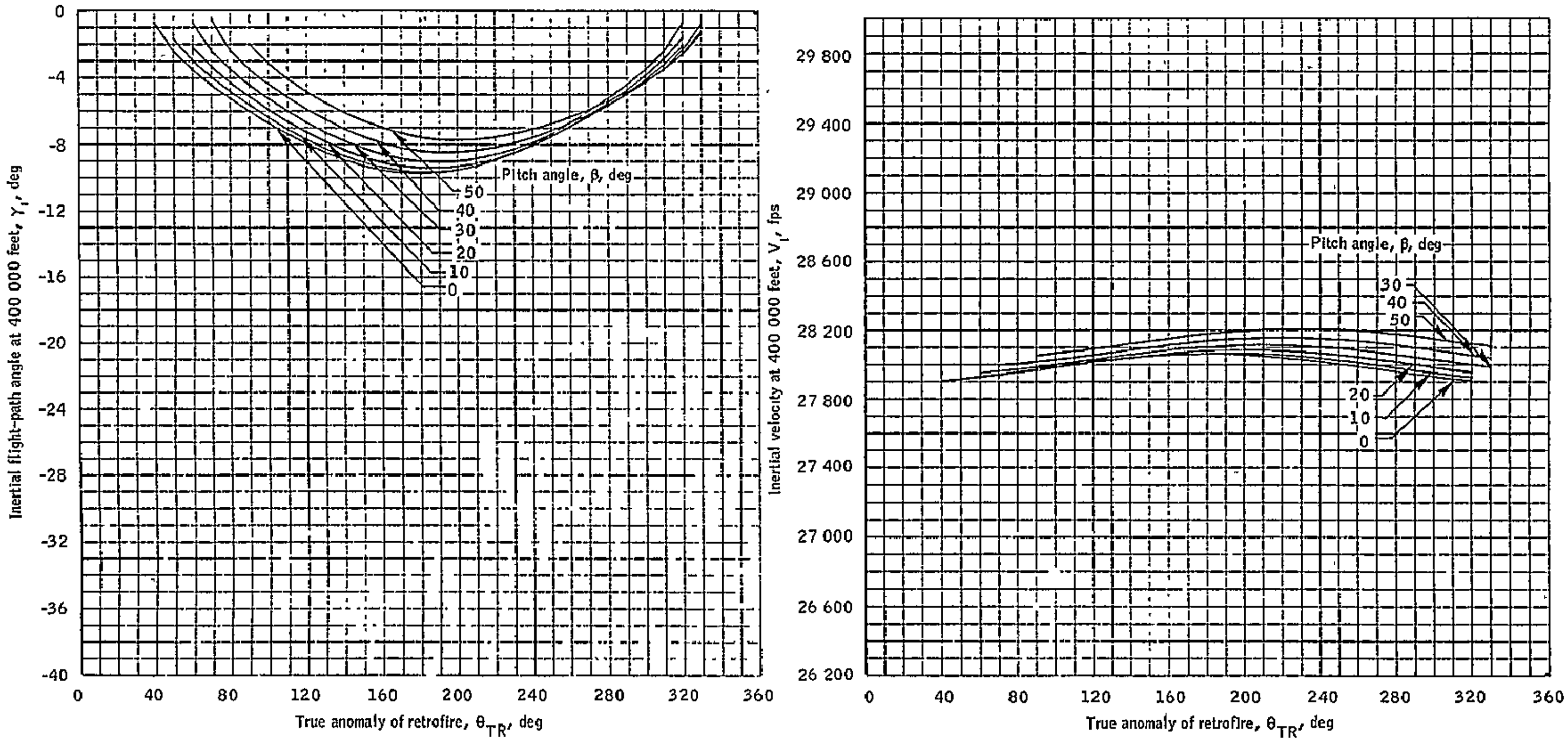
(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

Figure 14.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 100/2000 nautical mile orbit.



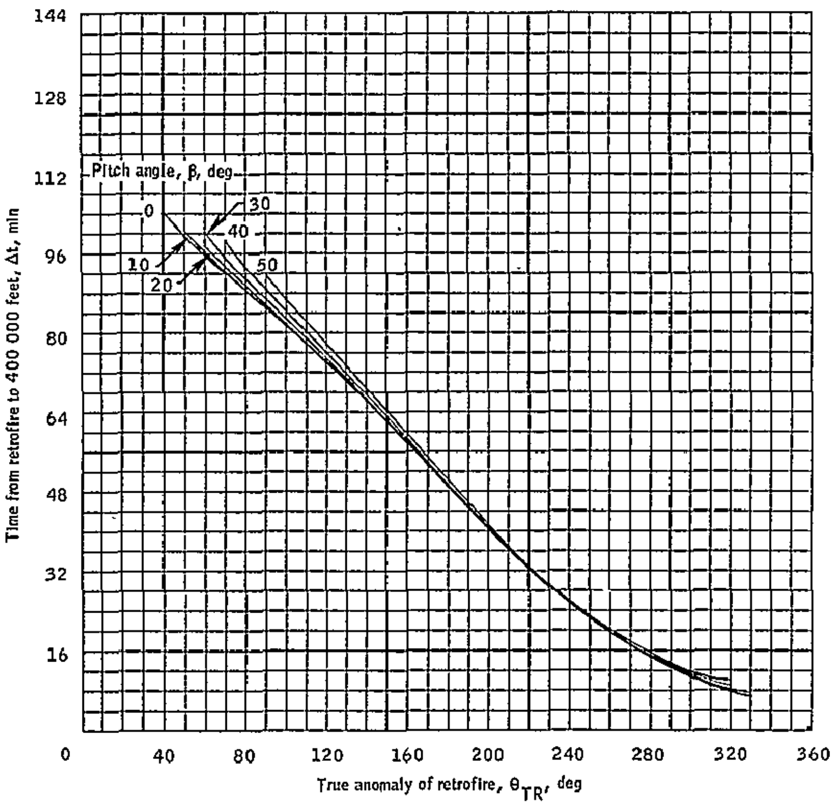
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

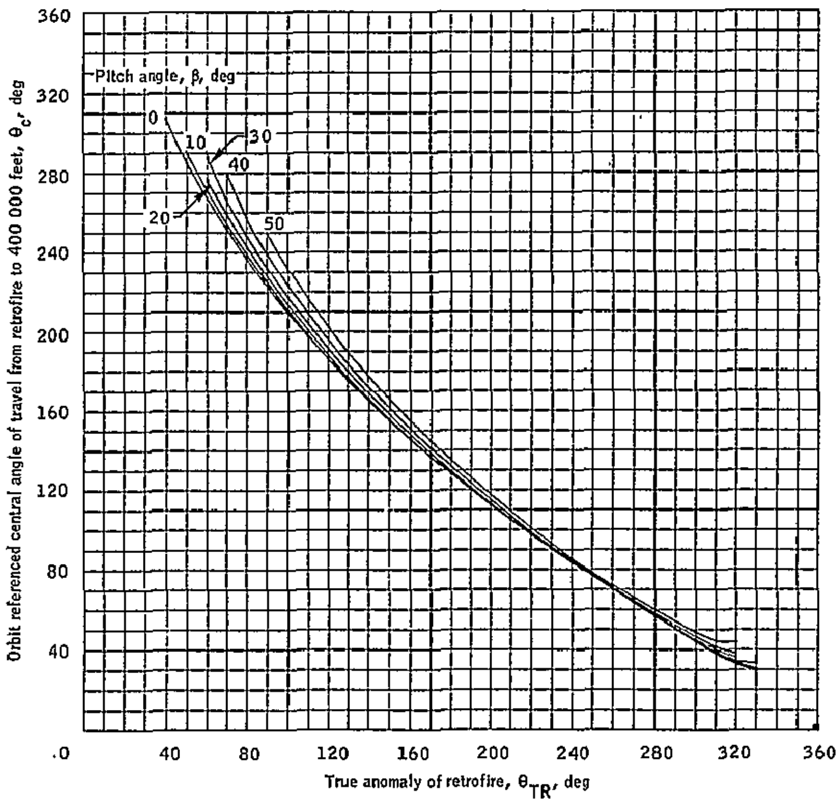
Figure 14.- Continued.



(c) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

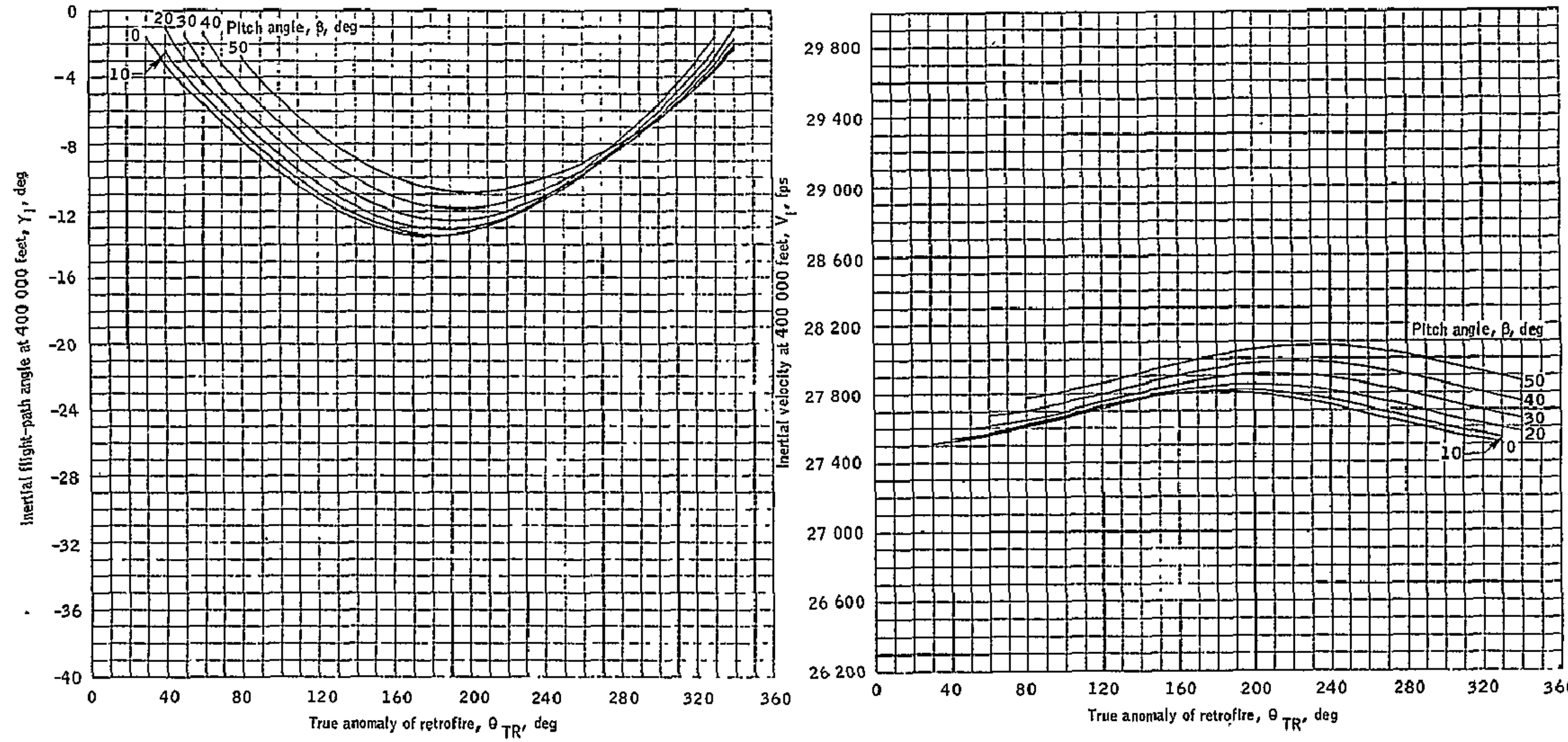
Figure 14.- Continued.





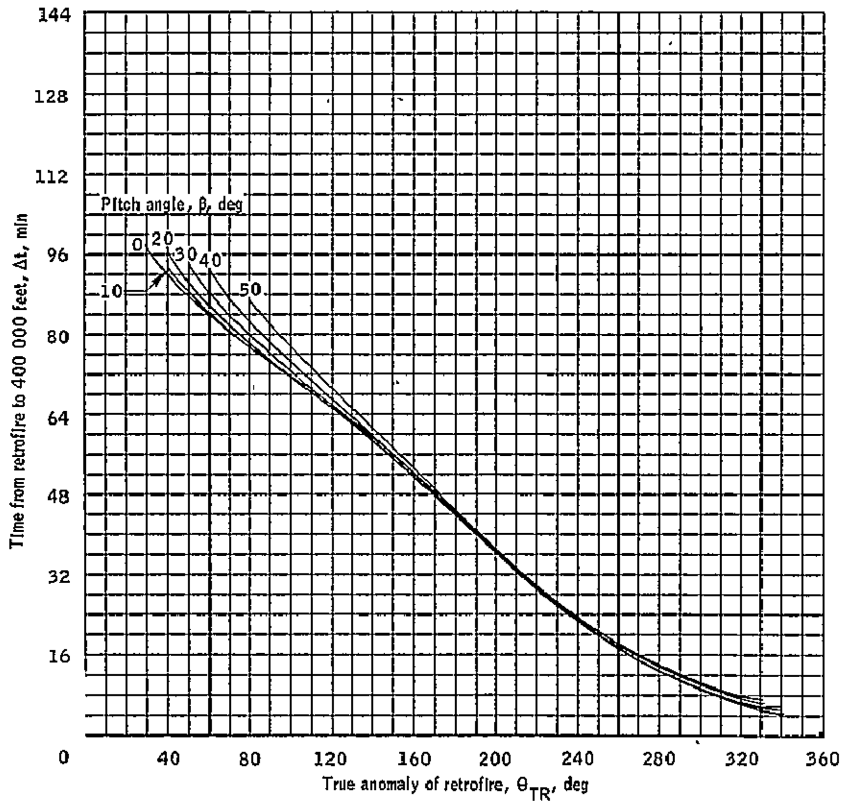
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

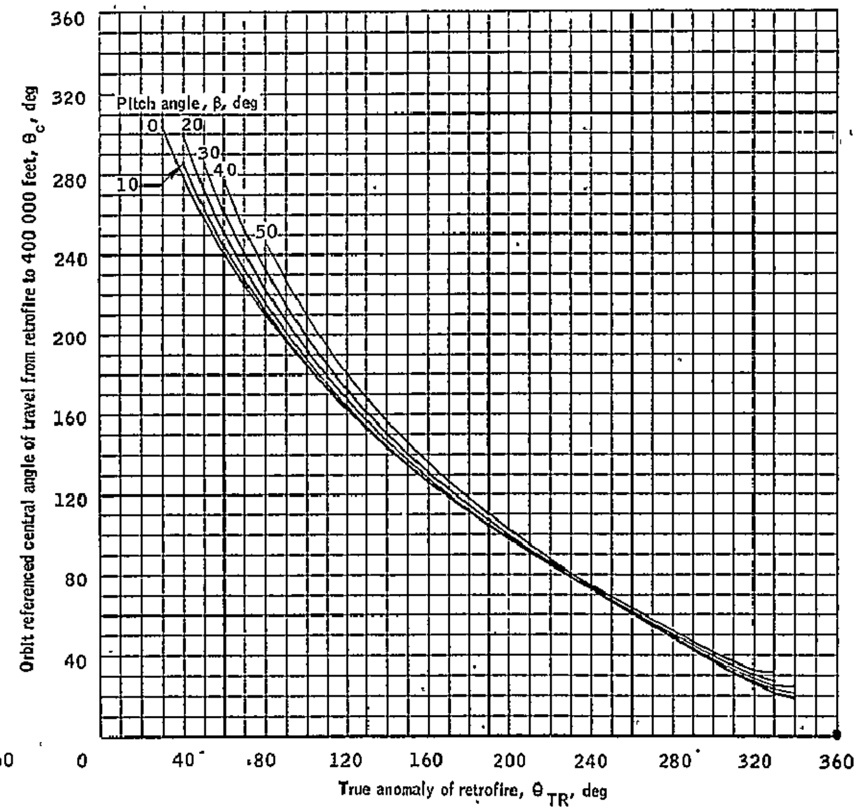
Figure 14.- Continued.



(e) Flight-path angle and velocity for retrograde ΔV = 900 feet per second.

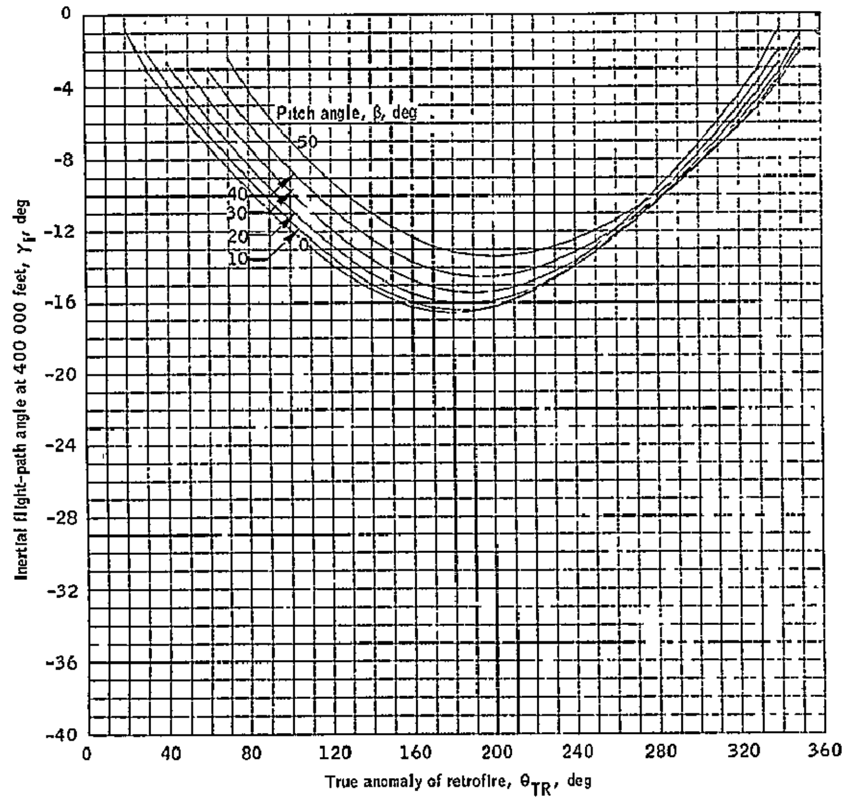
Figure 14.- Continued.

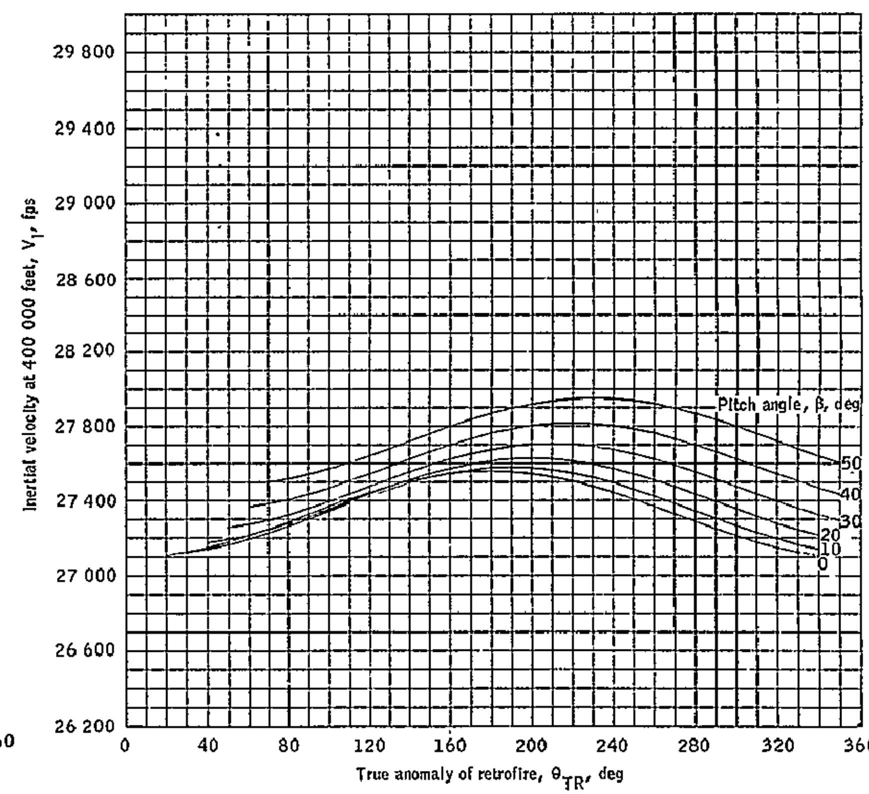




(f) Time from retrofire and central angle for retrograde ΔV = 900 feet per second.

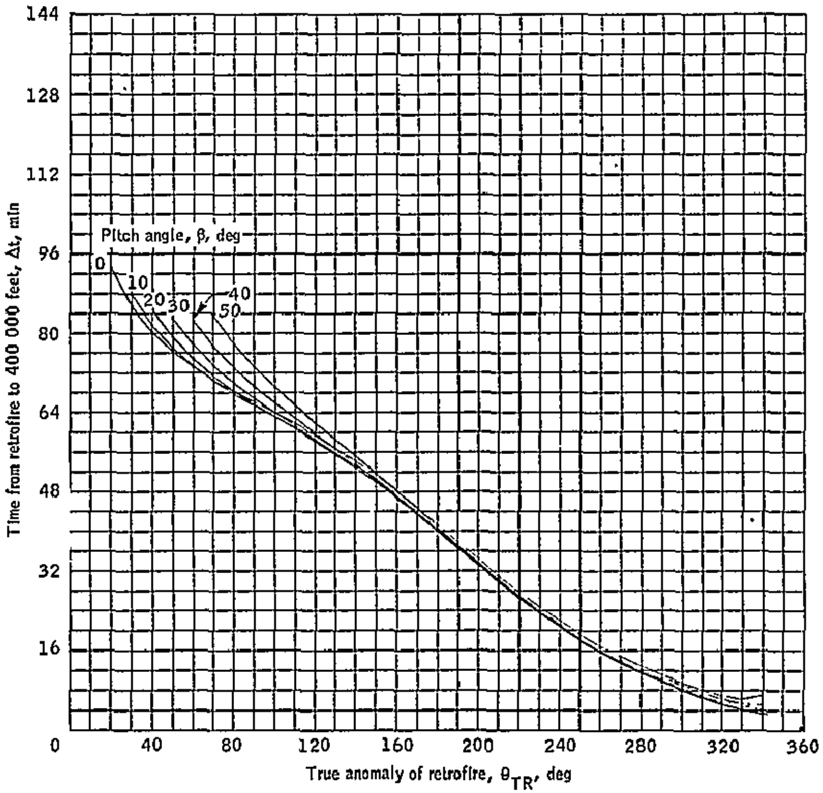
Figure 14.- Continued.

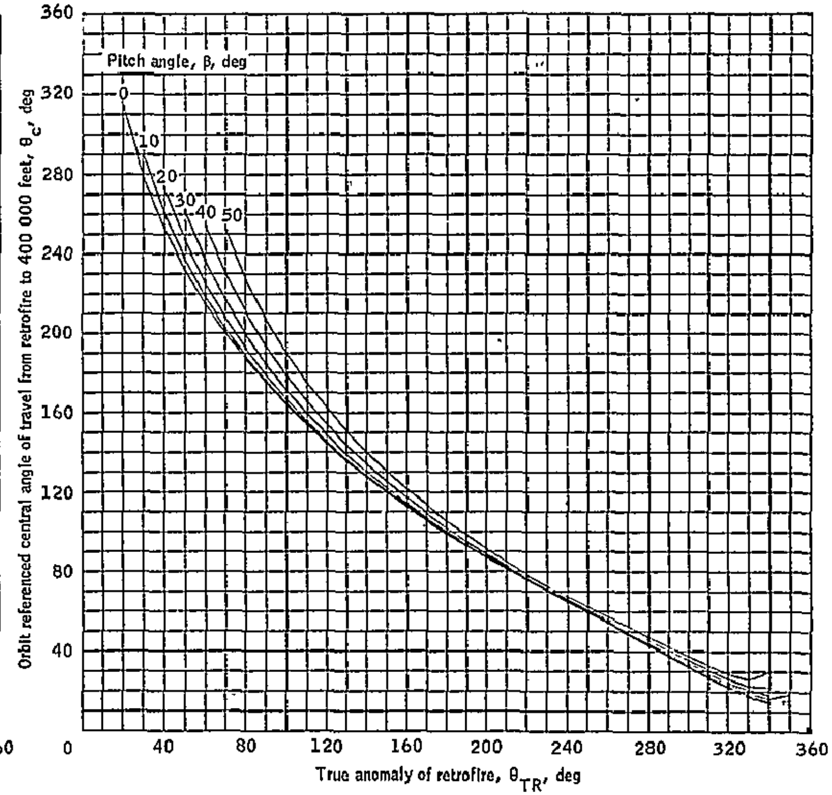




(g) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

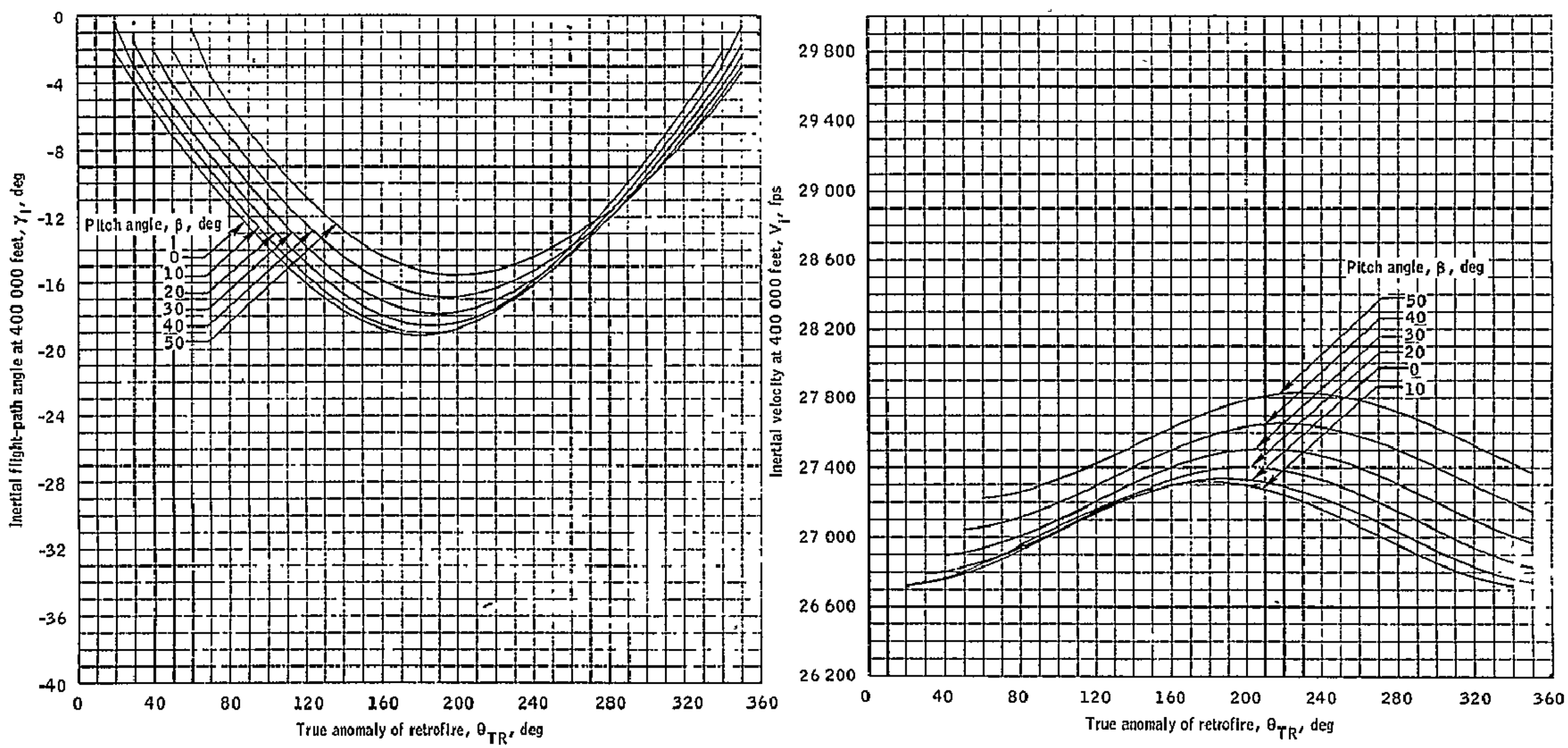
Figure 14.- Continued.





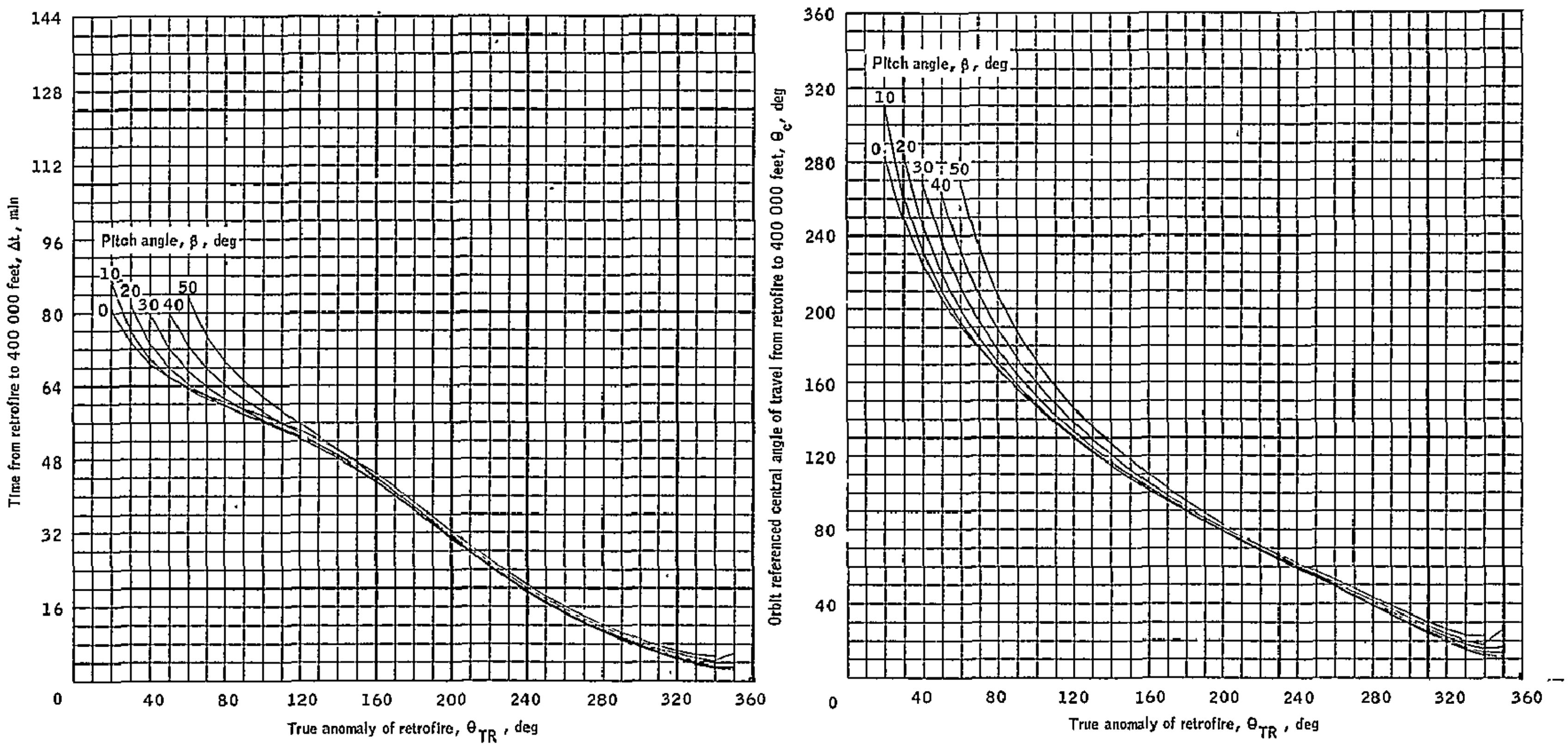
(h) Time from retrofire and central angle for retrograde $\Delta V \doteq 1300$ feet per second.

Figure 14.- Continued.



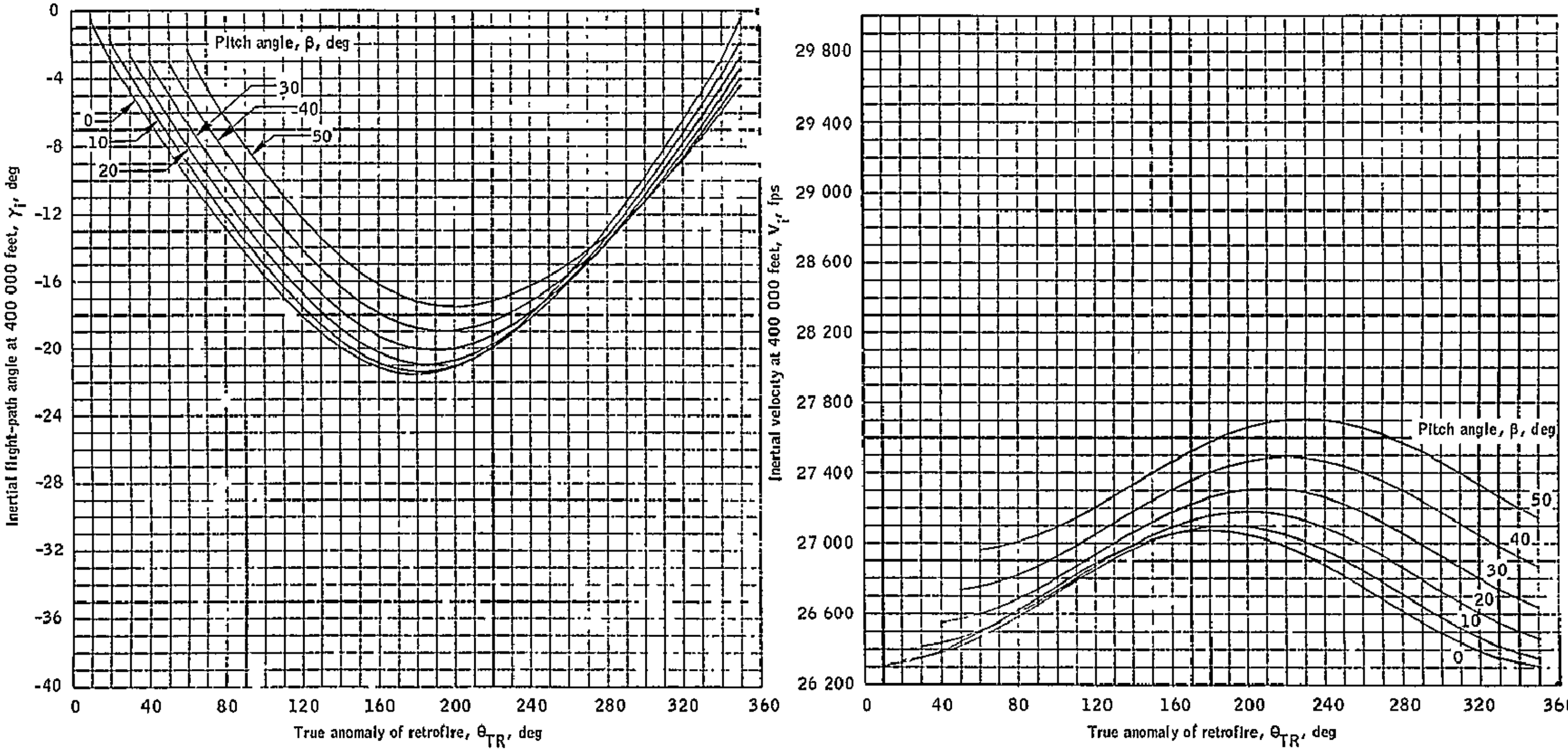
(i) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

Figure 14.- Continued.



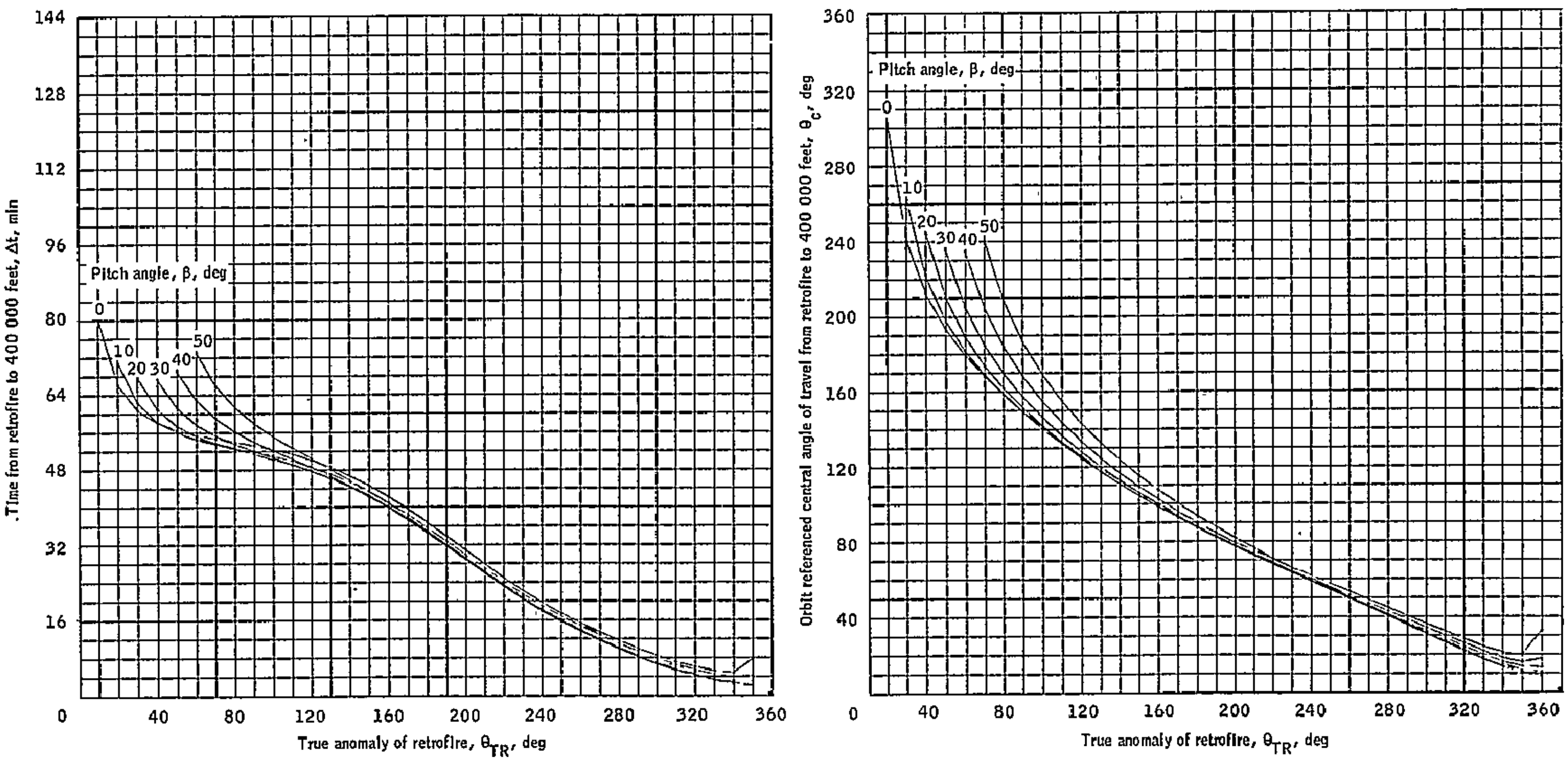
(j) Time from retrofire and central angle for retrograde $\Delta V = 1700$ feet per second.

Figure 14.- Continued.



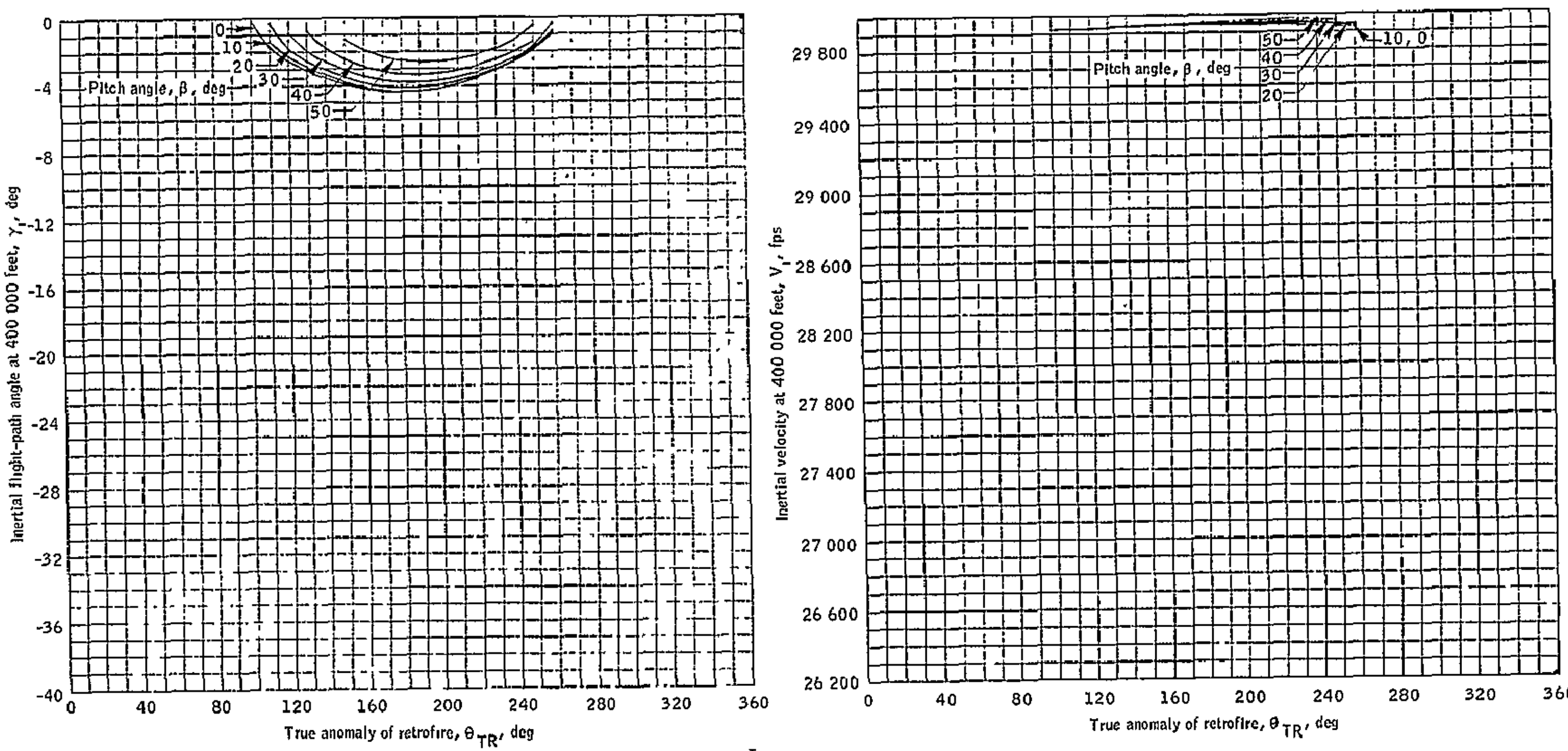
(k) Flight-path angle and velocity for retrograde ΔV = 2100 feet per second

Figure 14.- Continued.



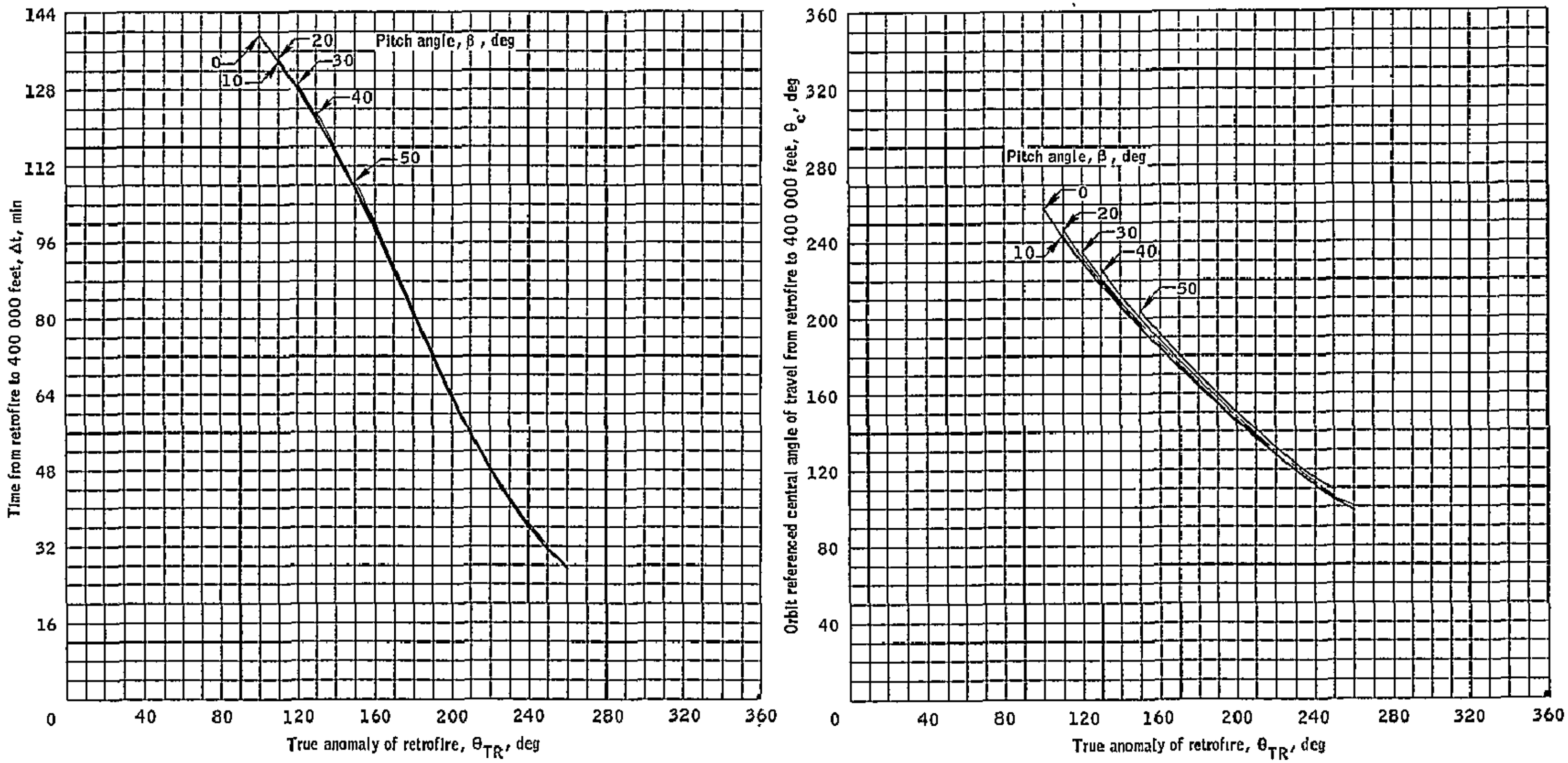
(l) Time from retrofire and central angle for retrograde ΔV = 2100 feet per second.

Figure 14.- Concluded.



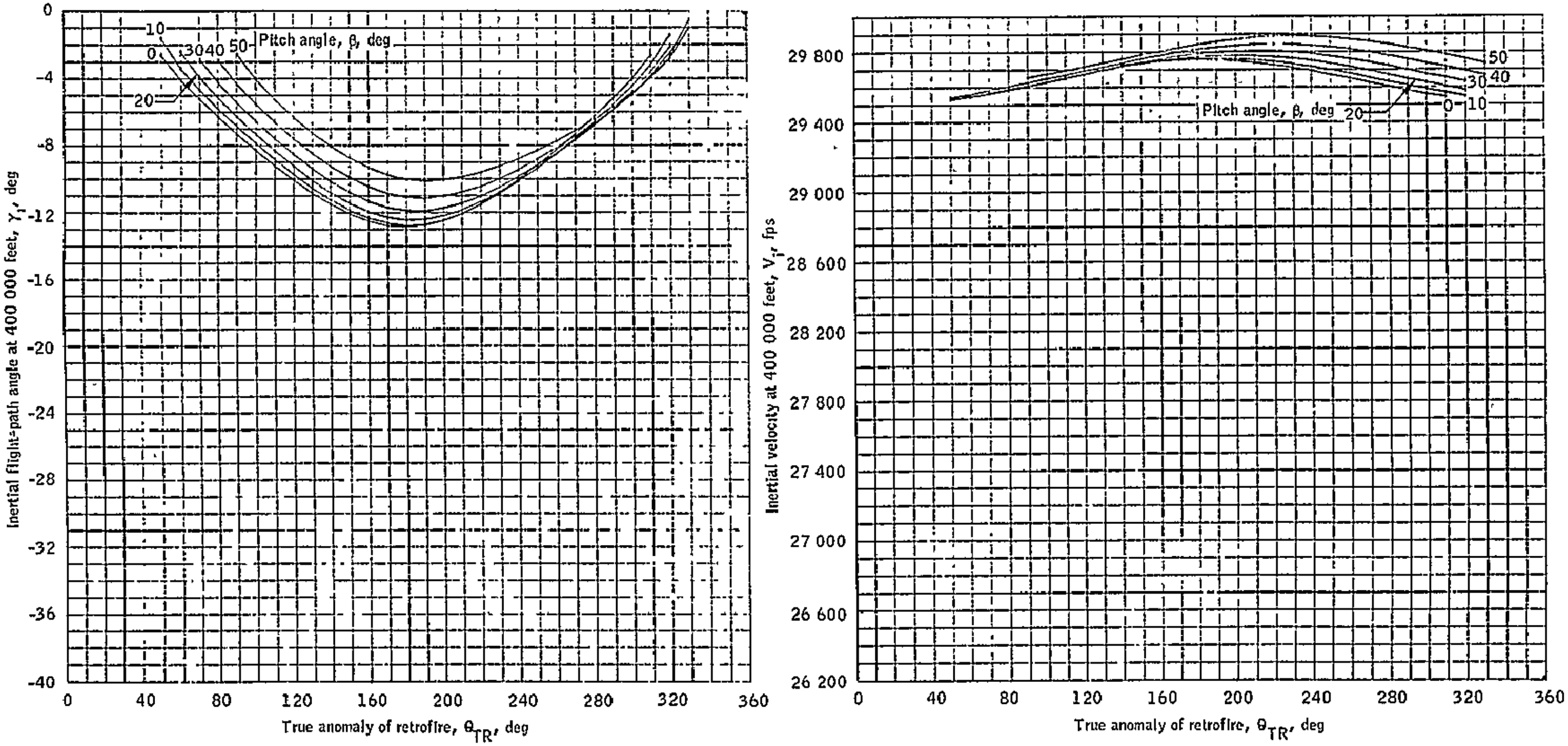
(a) Flight-path angle and velocity for retrograde ΔV = 100 feet per second.

Figure 15.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 100/4000 nautical mile orbit.



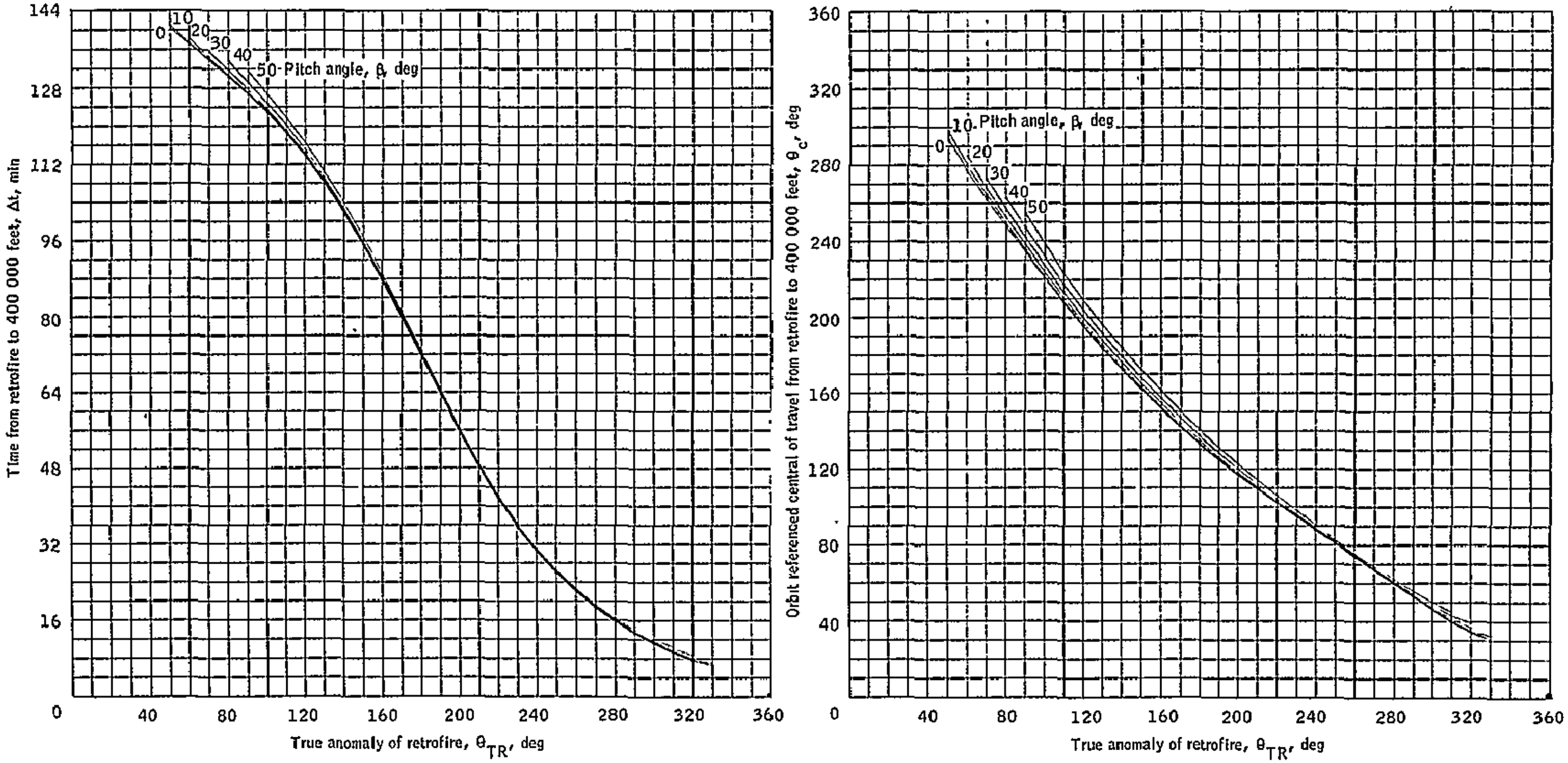
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

Figure 15.- Continued.



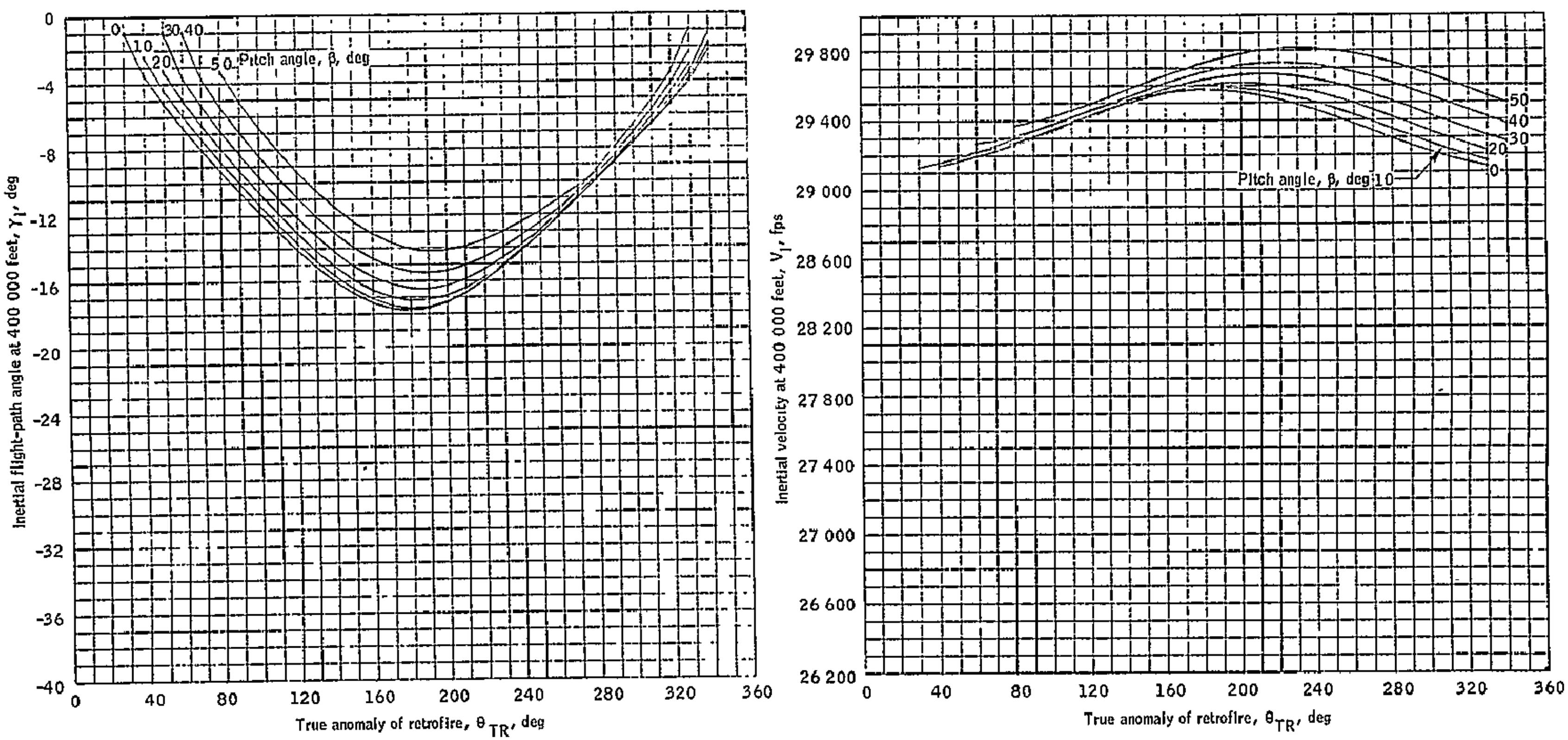
(c) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

Figure 15.- Continued.



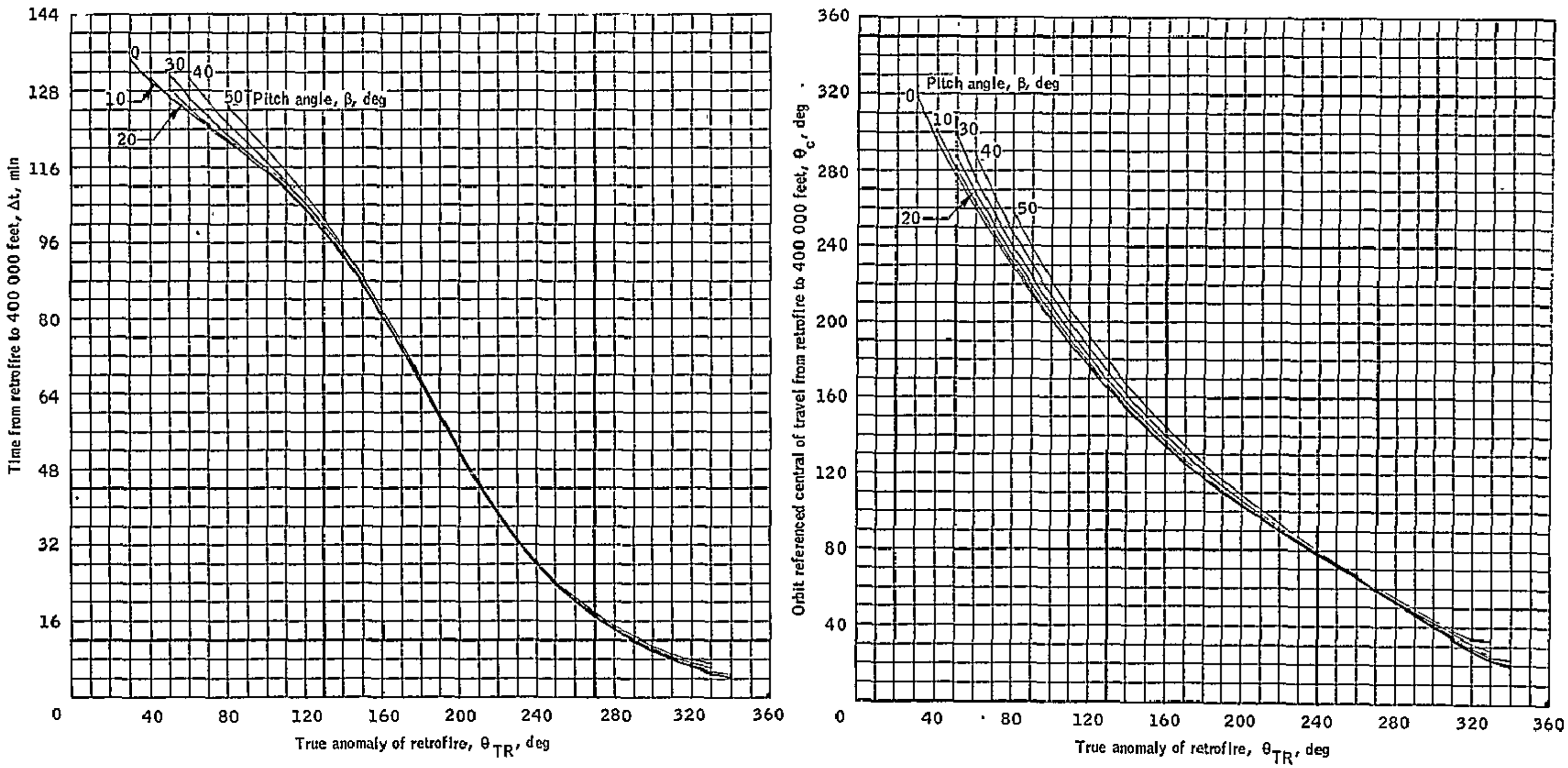
(d) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

Figure 15.- Continued.



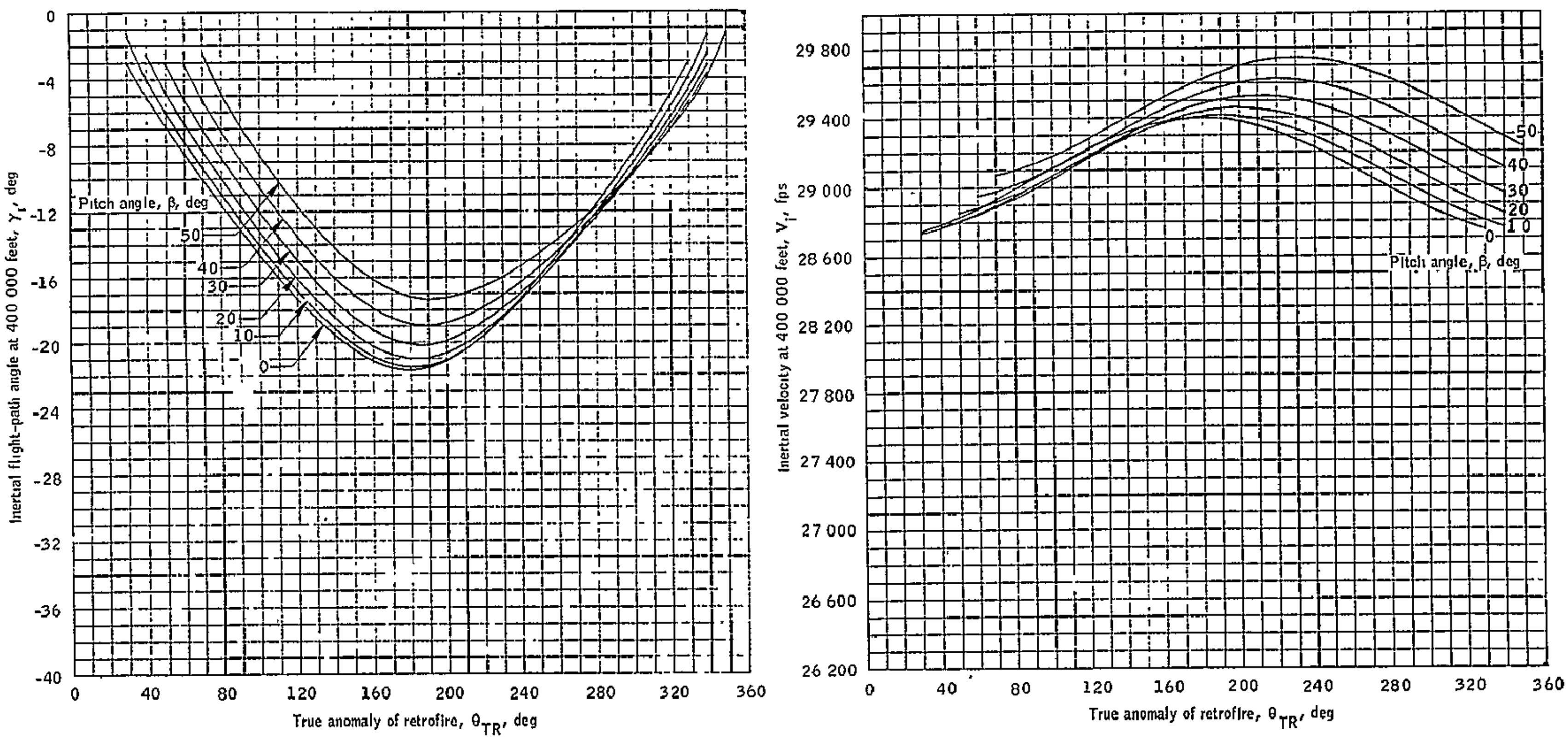
(e) Flight-path angle and velocity for retrograde ΔV = 900 feet per second.

Figure 15.- Continued



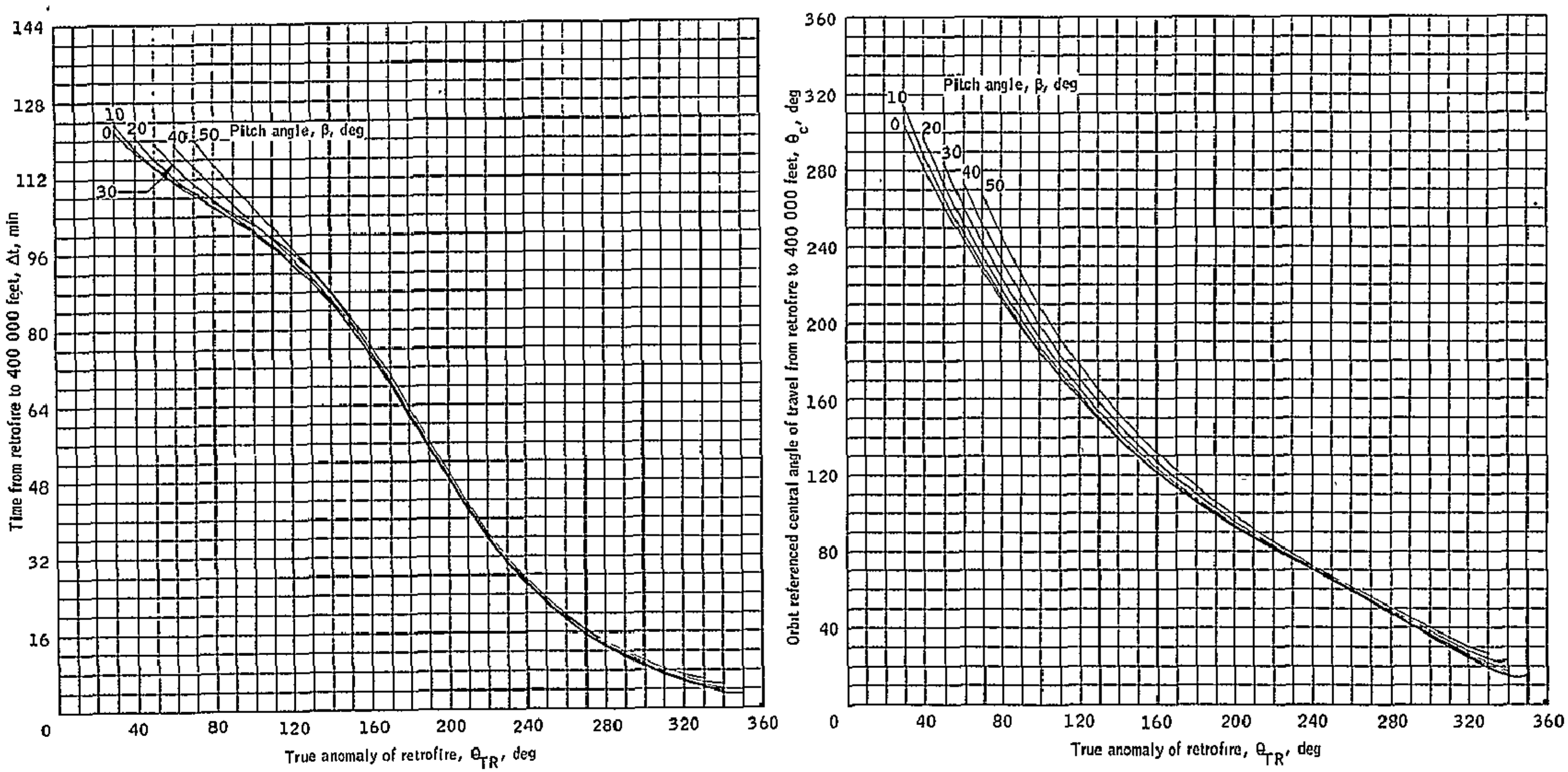
(f) Time from retrofire and central angle for retrograde ΔV = 900 feet per second.

Figure 15.- Continued.



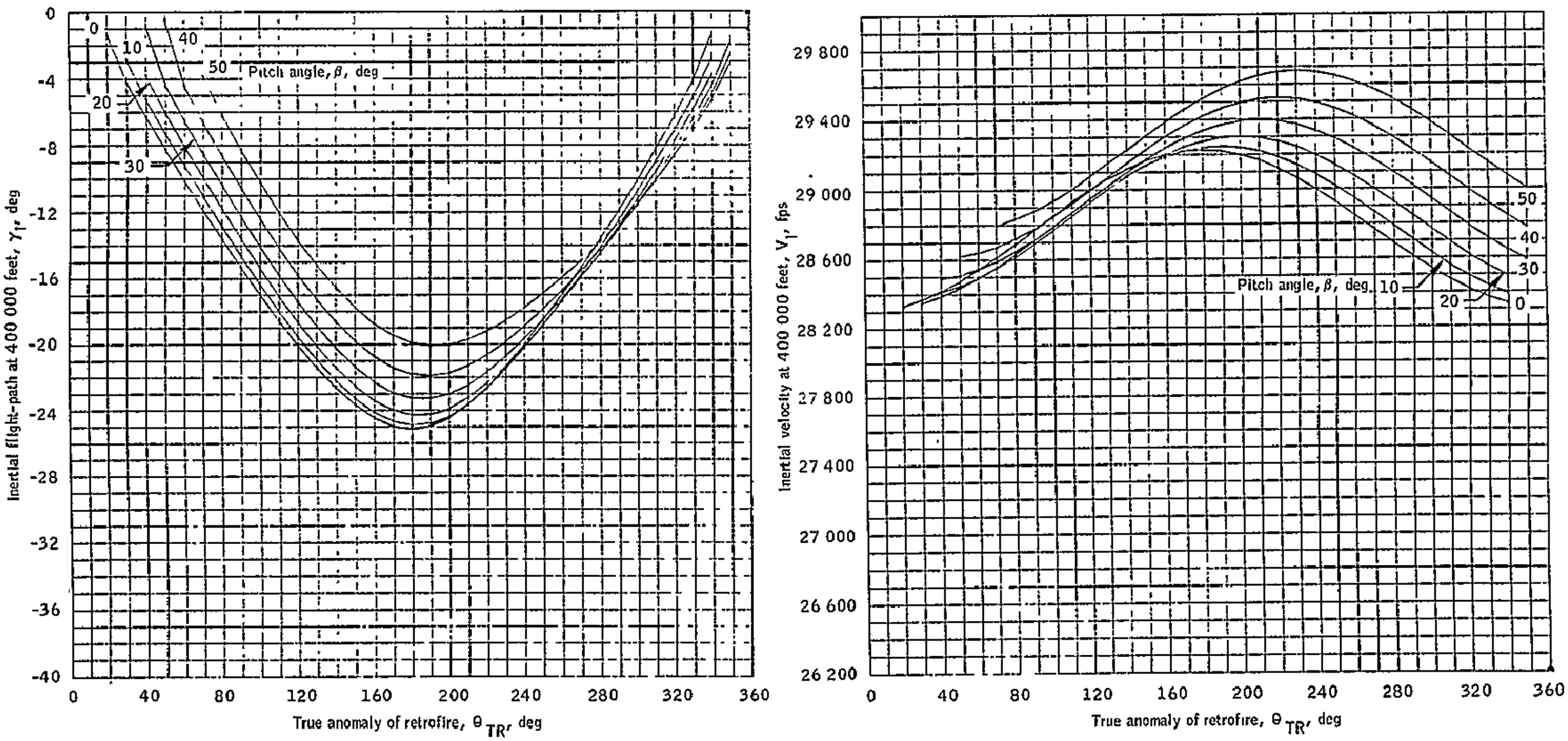
(g) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

Figure 15.- Continued.



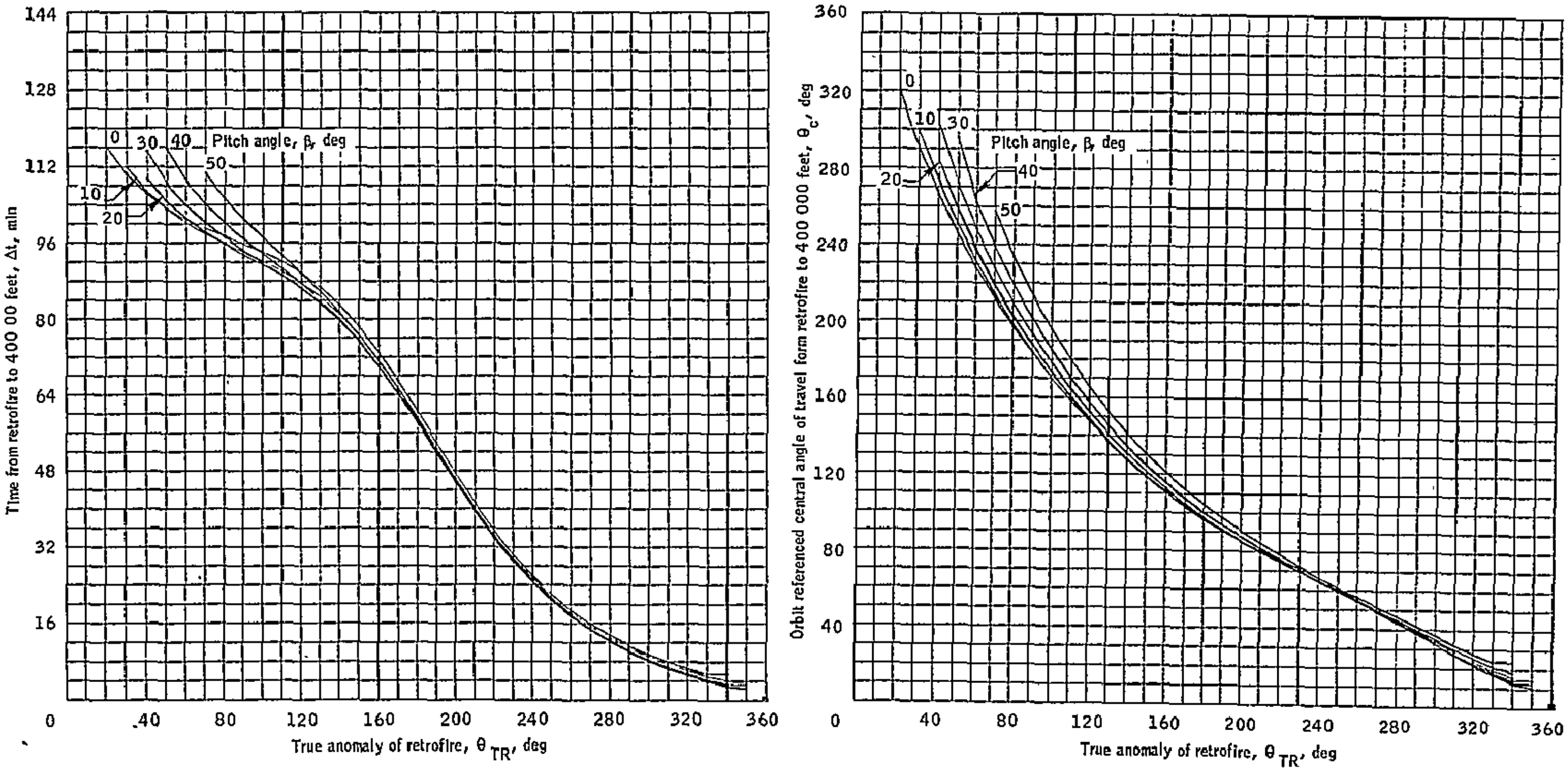
(h) Time from retrofire and central angle for retrograde ΔV = 1300 feet per second.

Figure 15.- Continued.



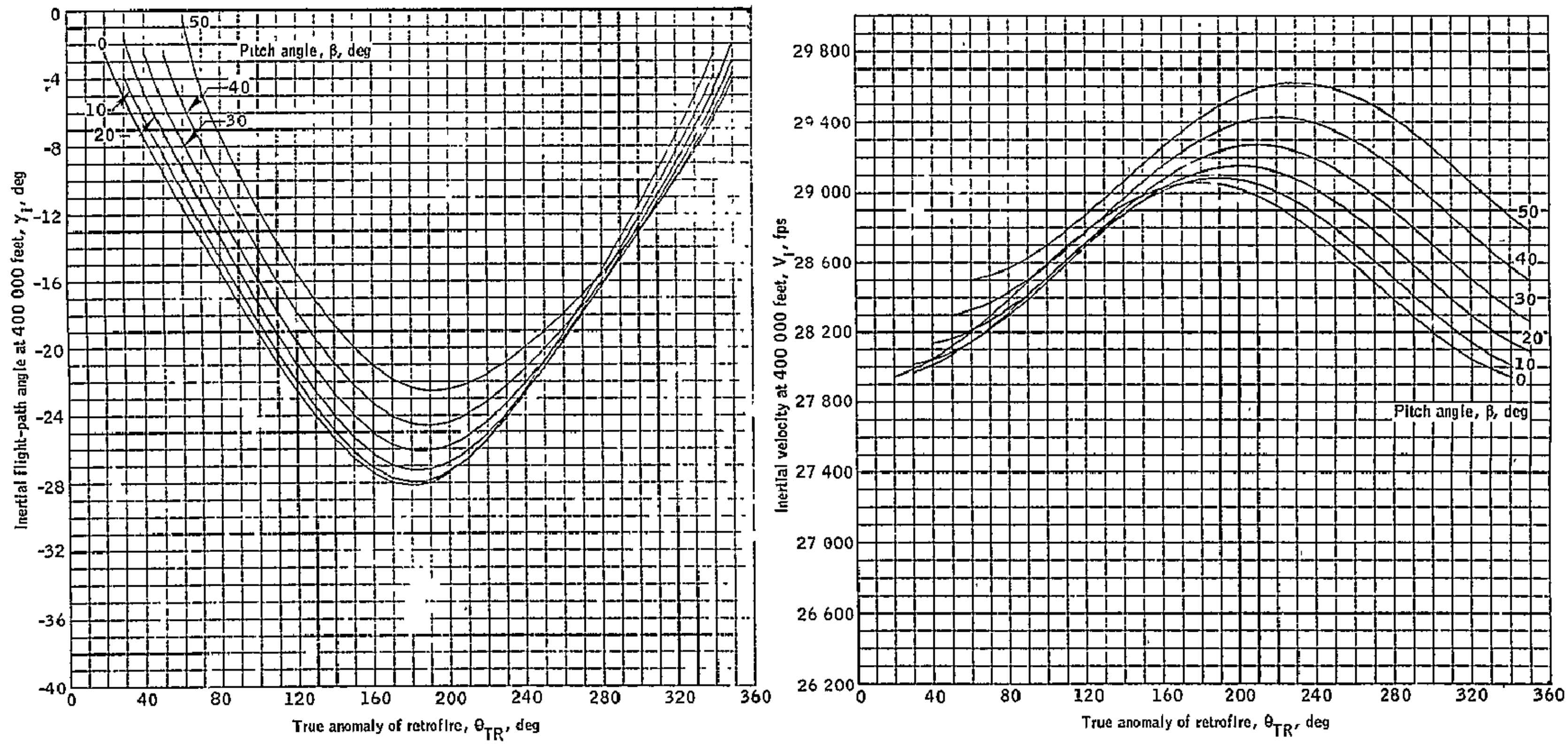
(i) Flight-path angle and velocity for retrograde ΔV = 1700 feet per second.

Figure 15.- Continued.



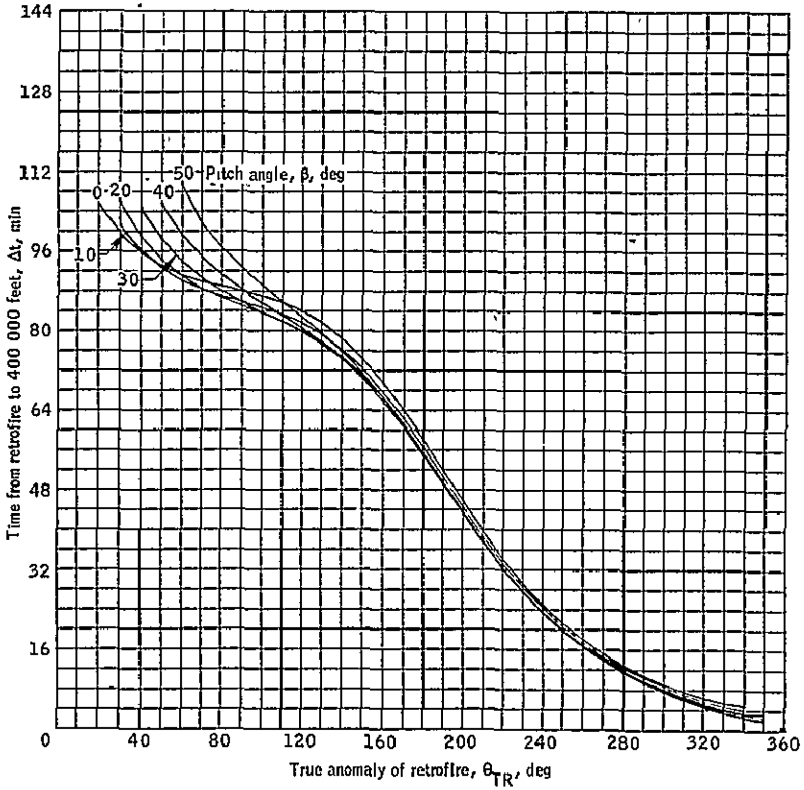
(j) Time from retrofire and central angle for retrograde $\Delta V = 1700$ feet per second.

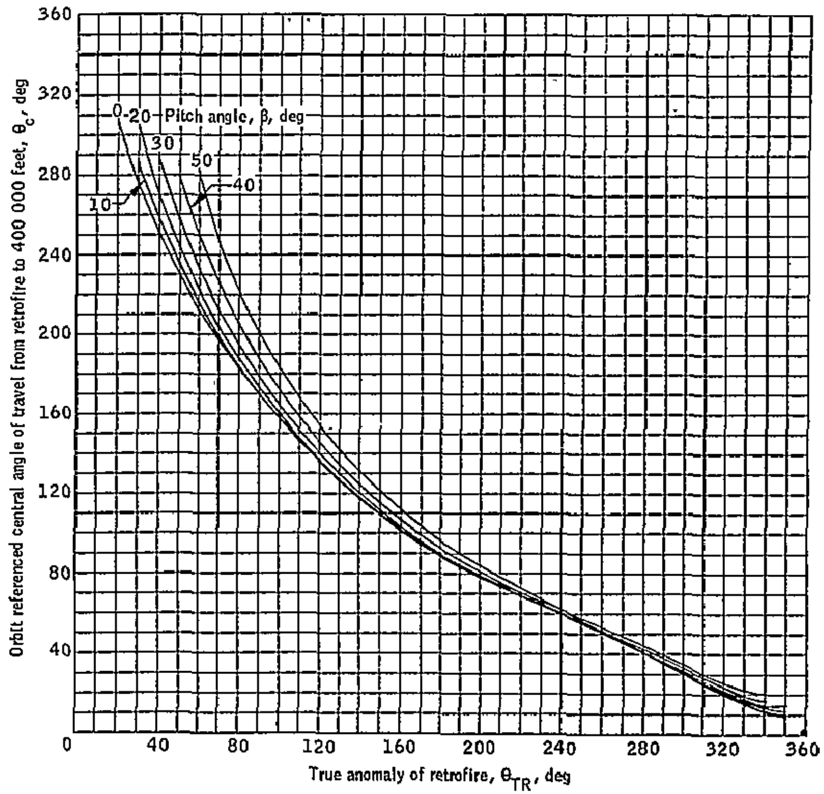
Figure 15.- Continued.



(k) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

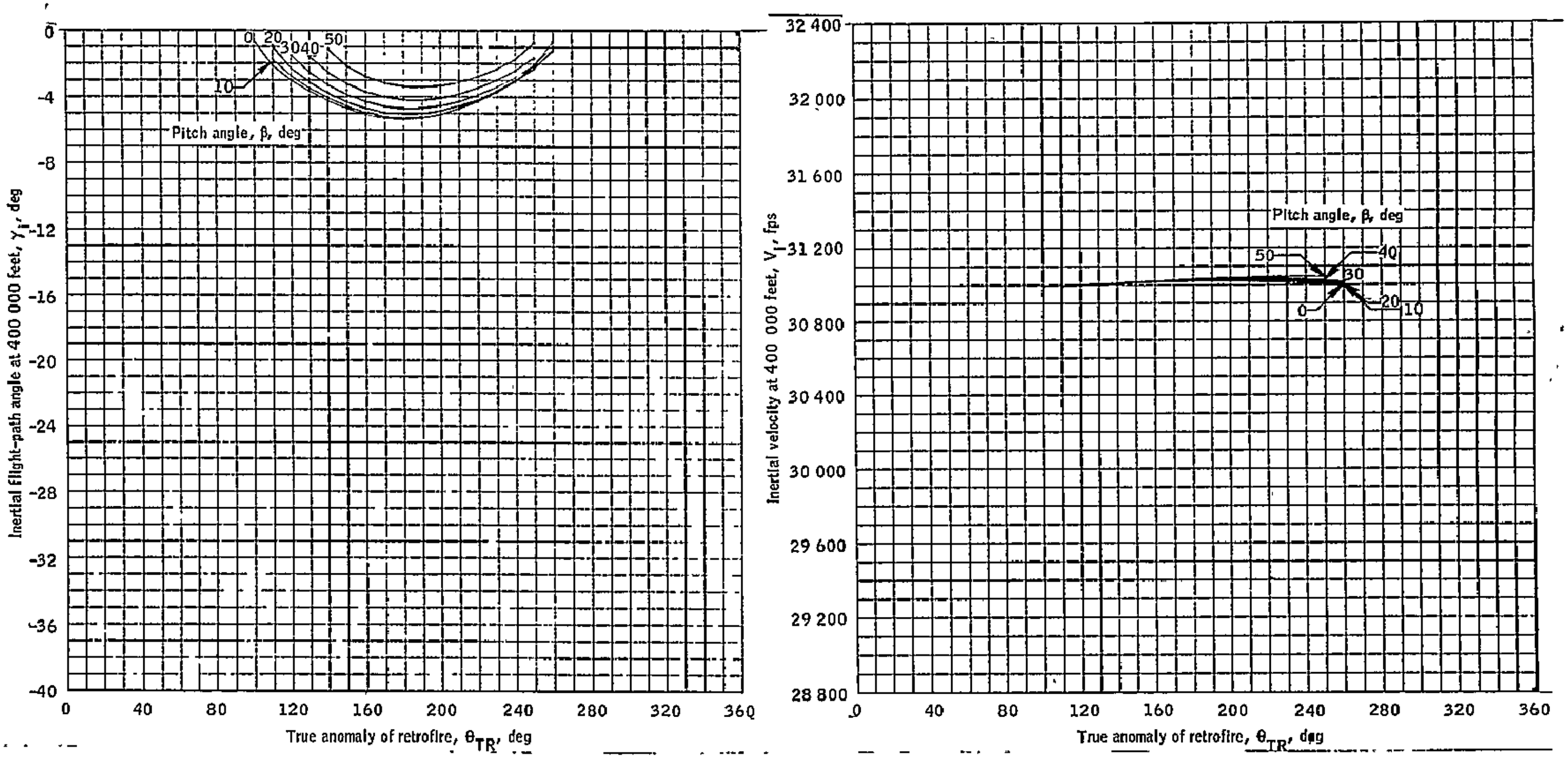
Figure 15.- Continued.





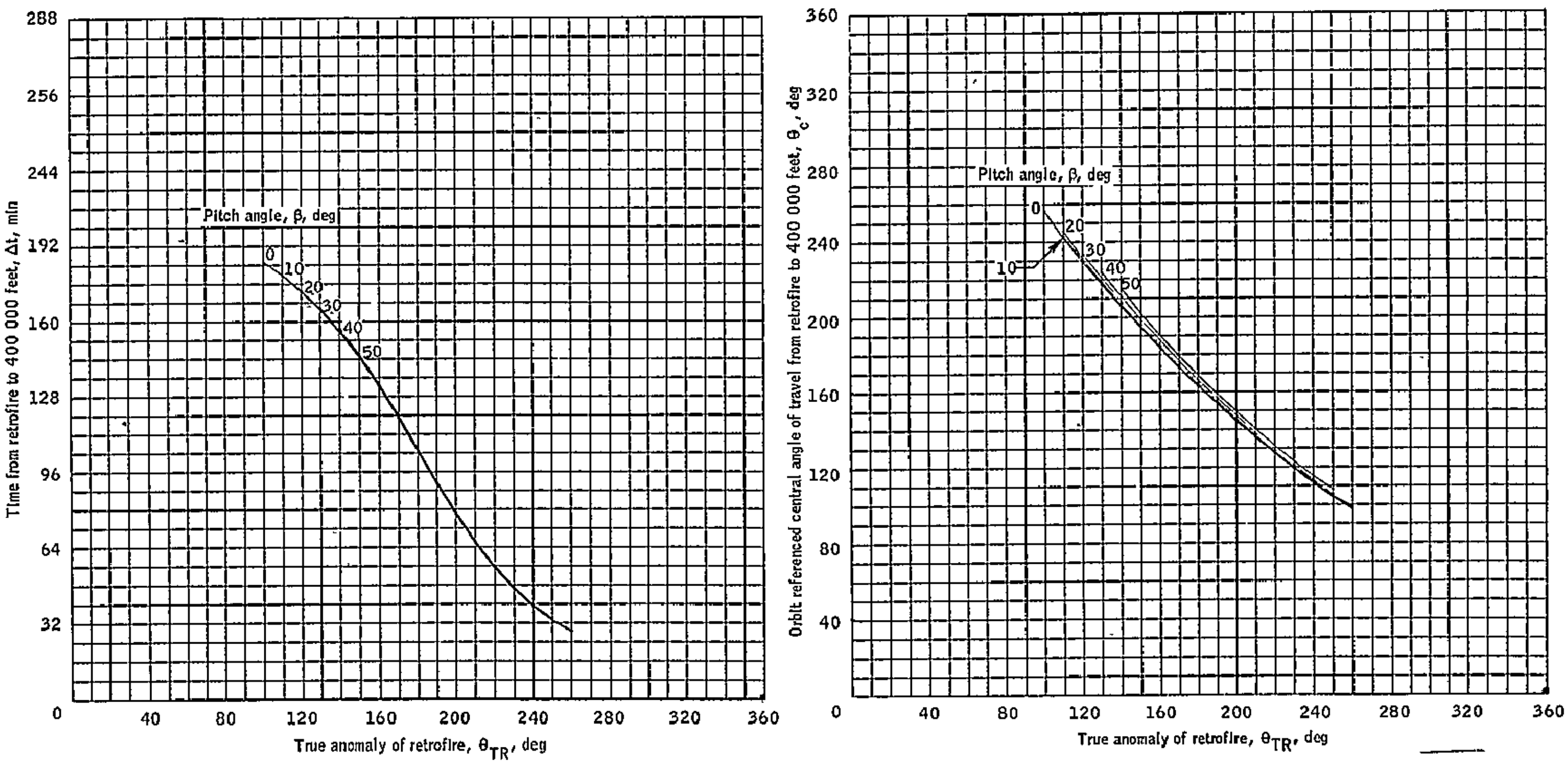
(l) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

Figure 15.- Concluded.



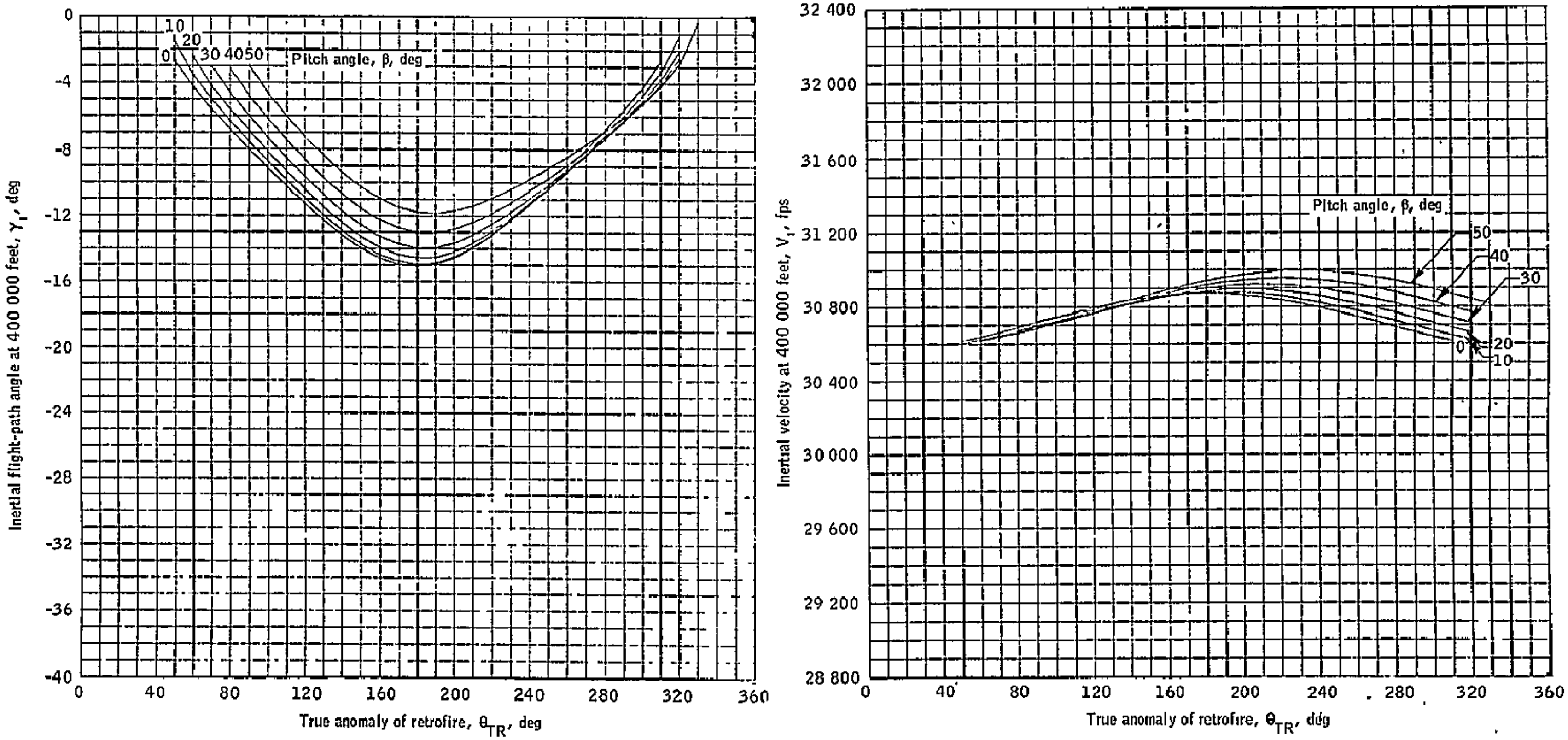
(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

Figure 16.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 100/6000 nautical mile orbit.



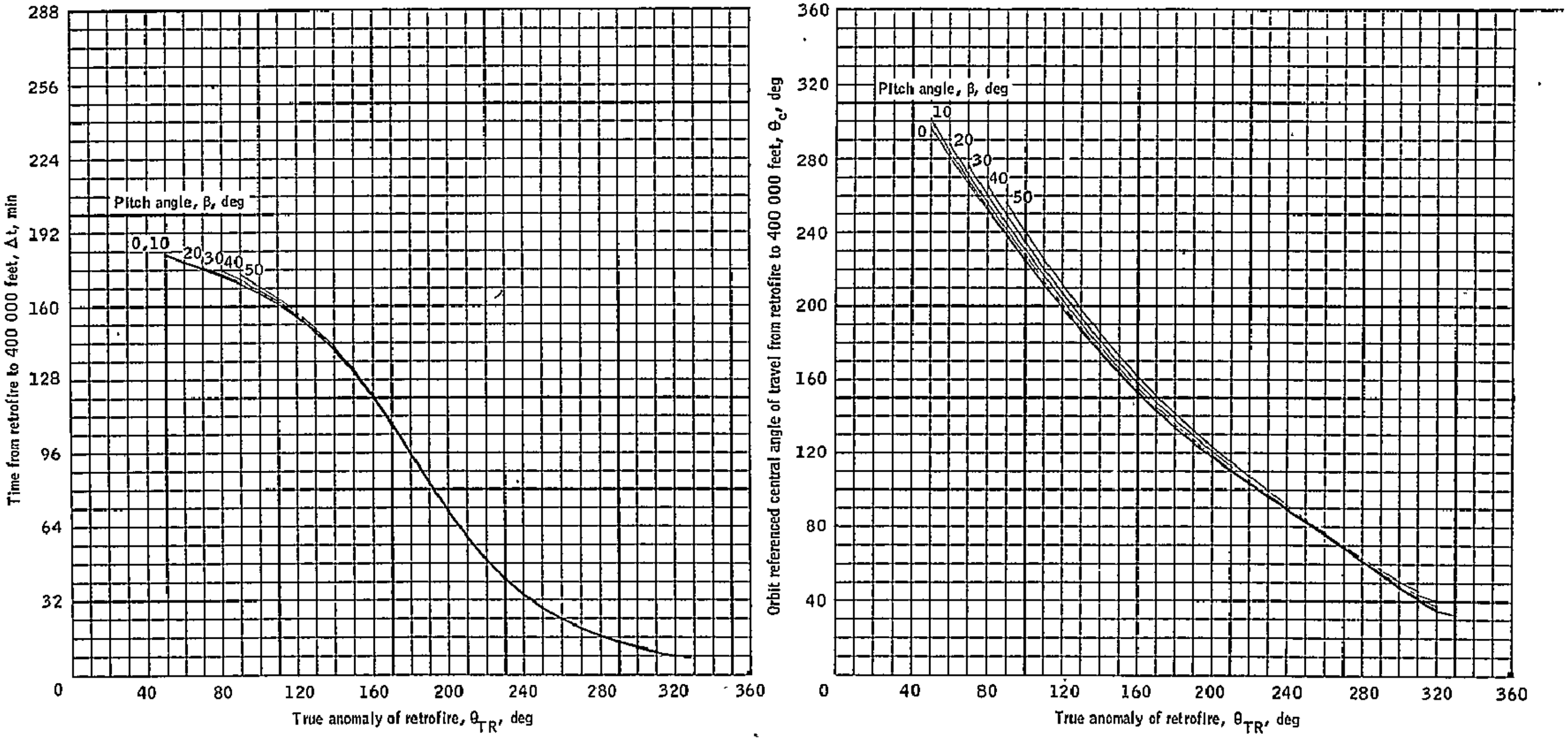
(b) Time from retrofire and central angle for retrograde ΔV=100 feet per second.

Figure 16.- Continued.



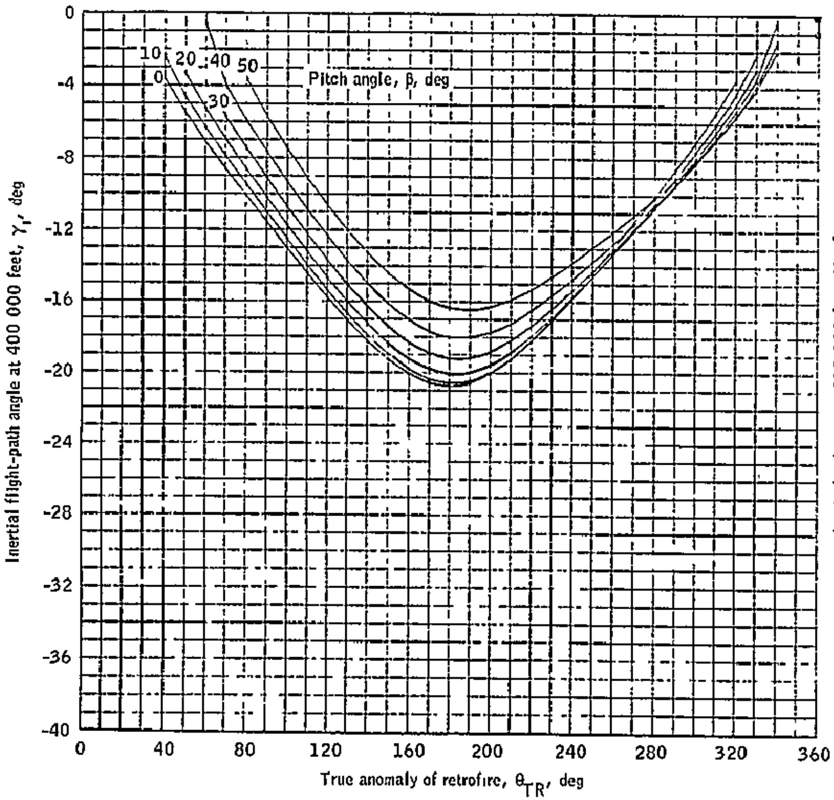
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

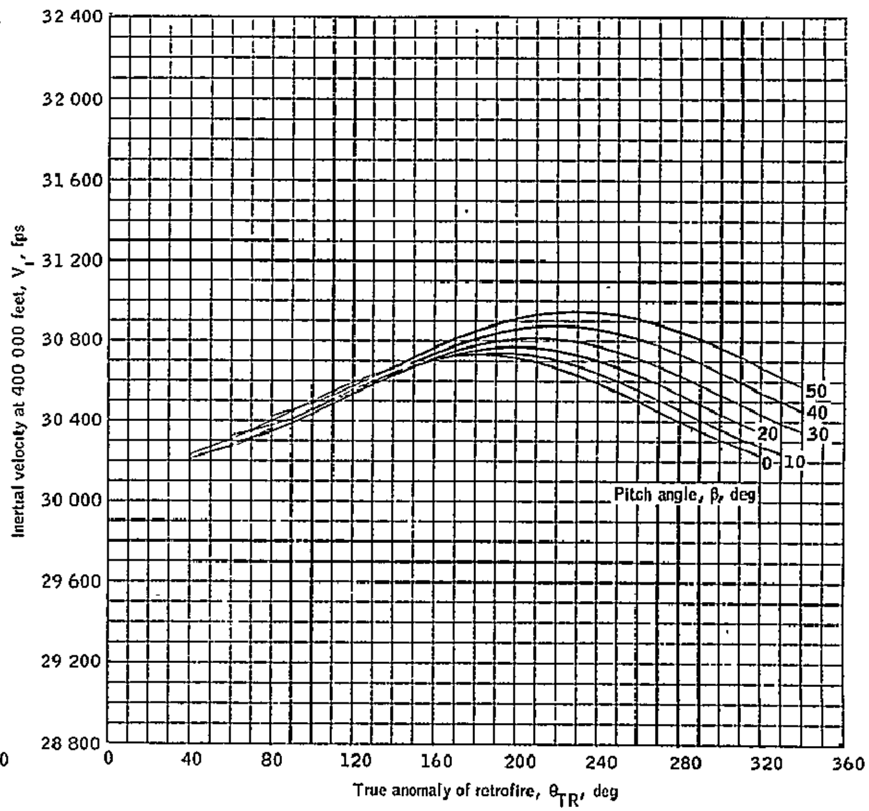
Figure 16.- Continued.



(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

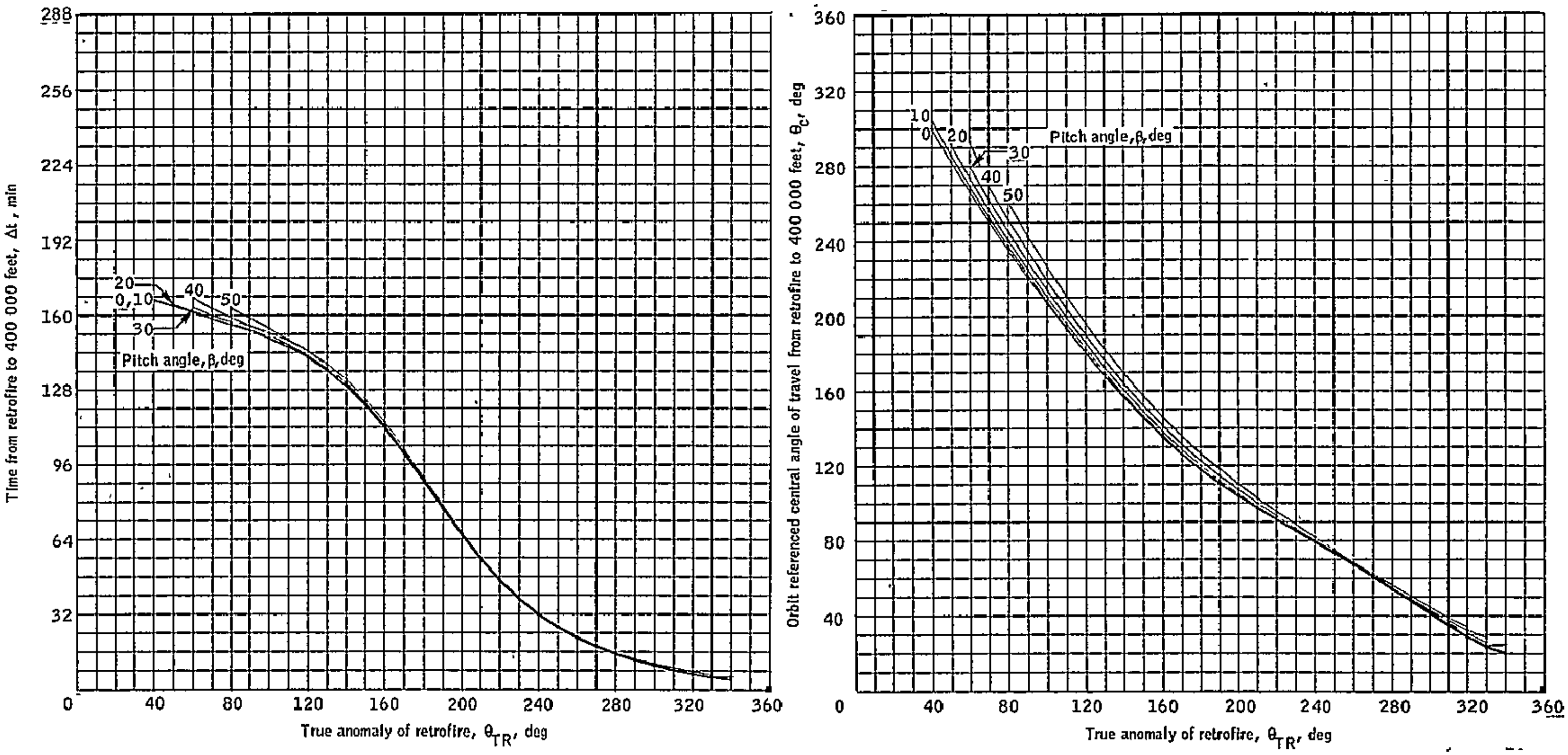
Figure 16.- Continued.





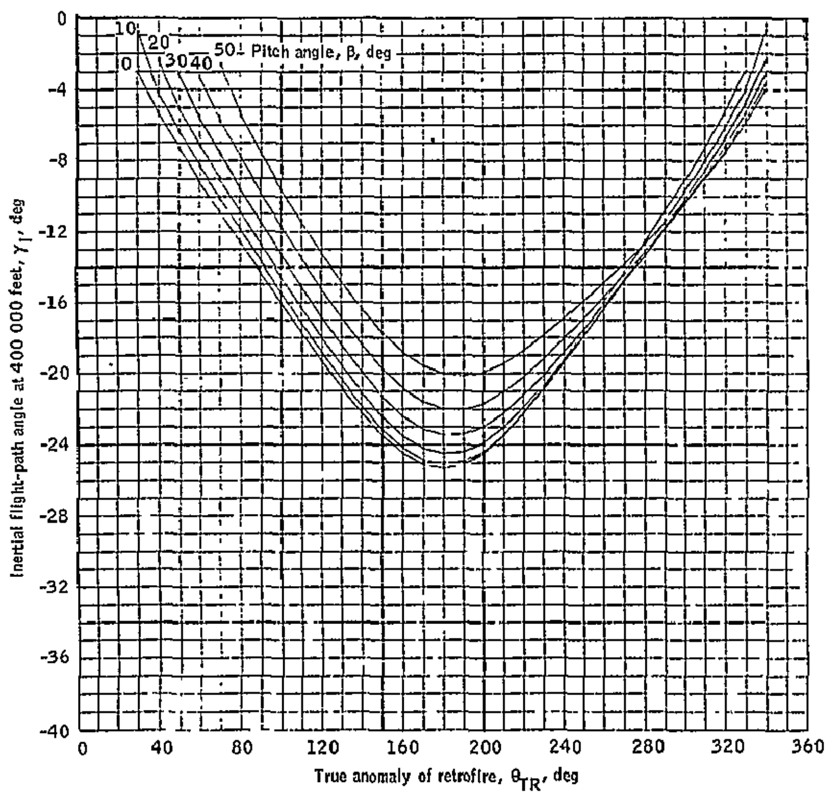
(e) Flight-path angle and velocity for retrograde ΔV=900 feet per second.

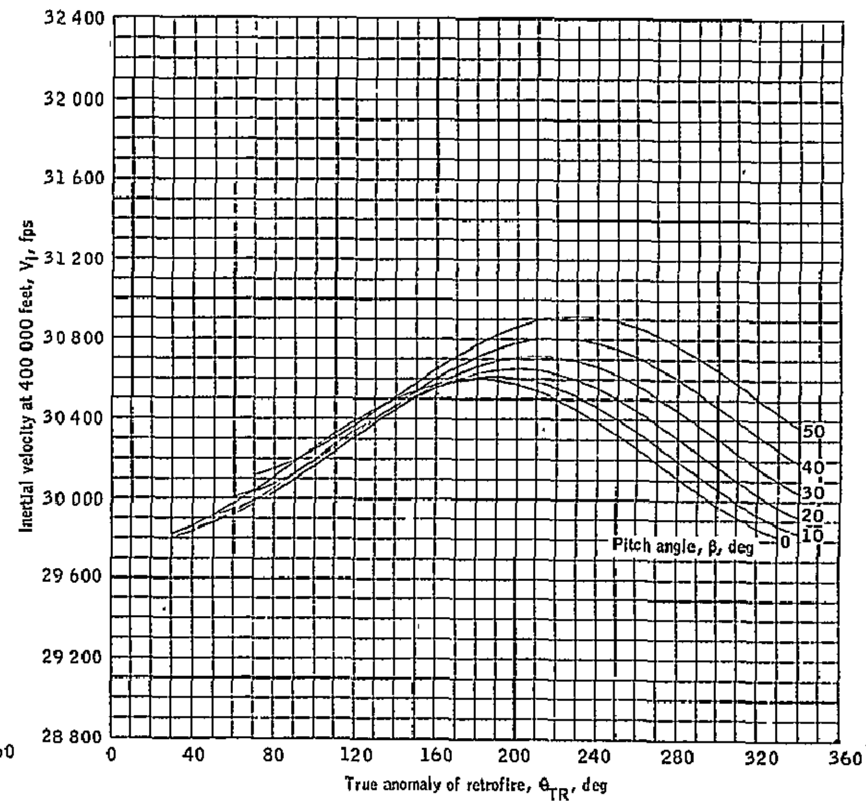
Figure 16.- Continued.



(f) Time from retrofire and central angle for retrograde ΔV=900 feet per second.

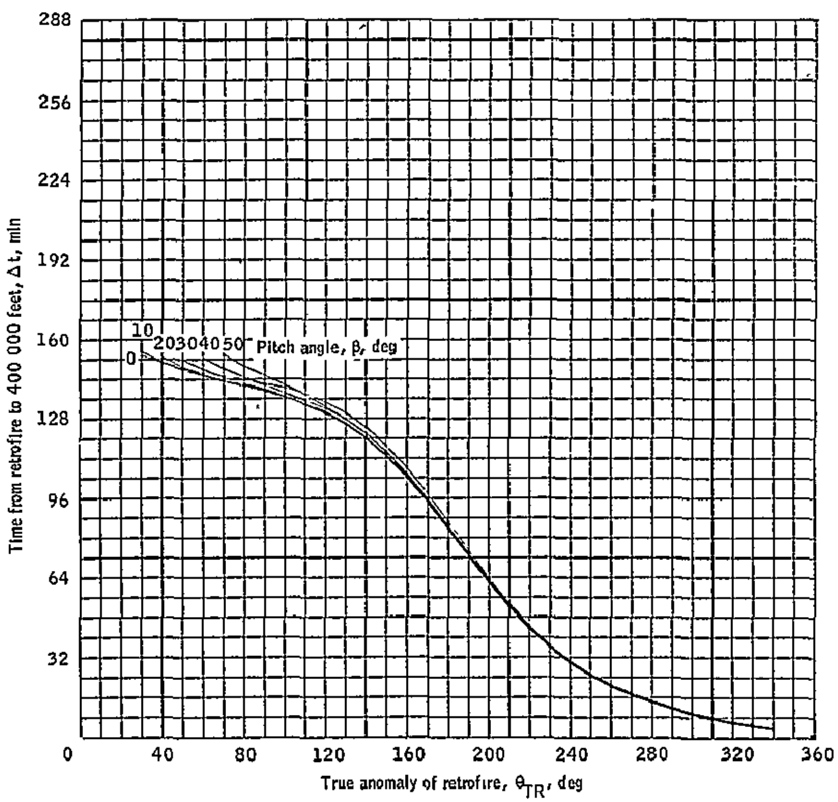
Figure 16.- Continued.

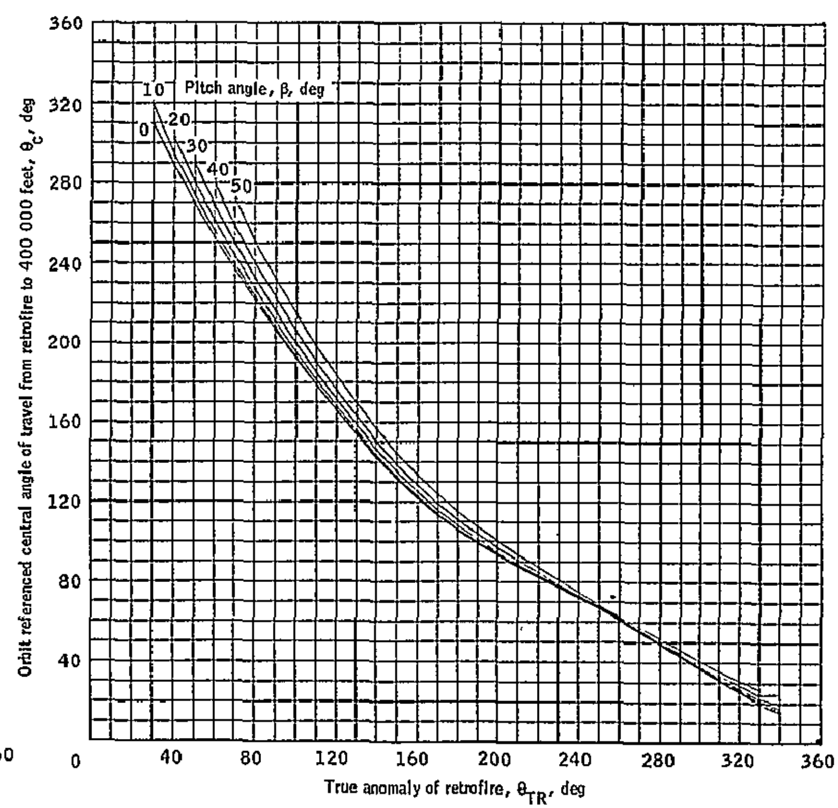




(g) Flight-path angle and velocity for retrograde ΔV = 1300 feet per second.

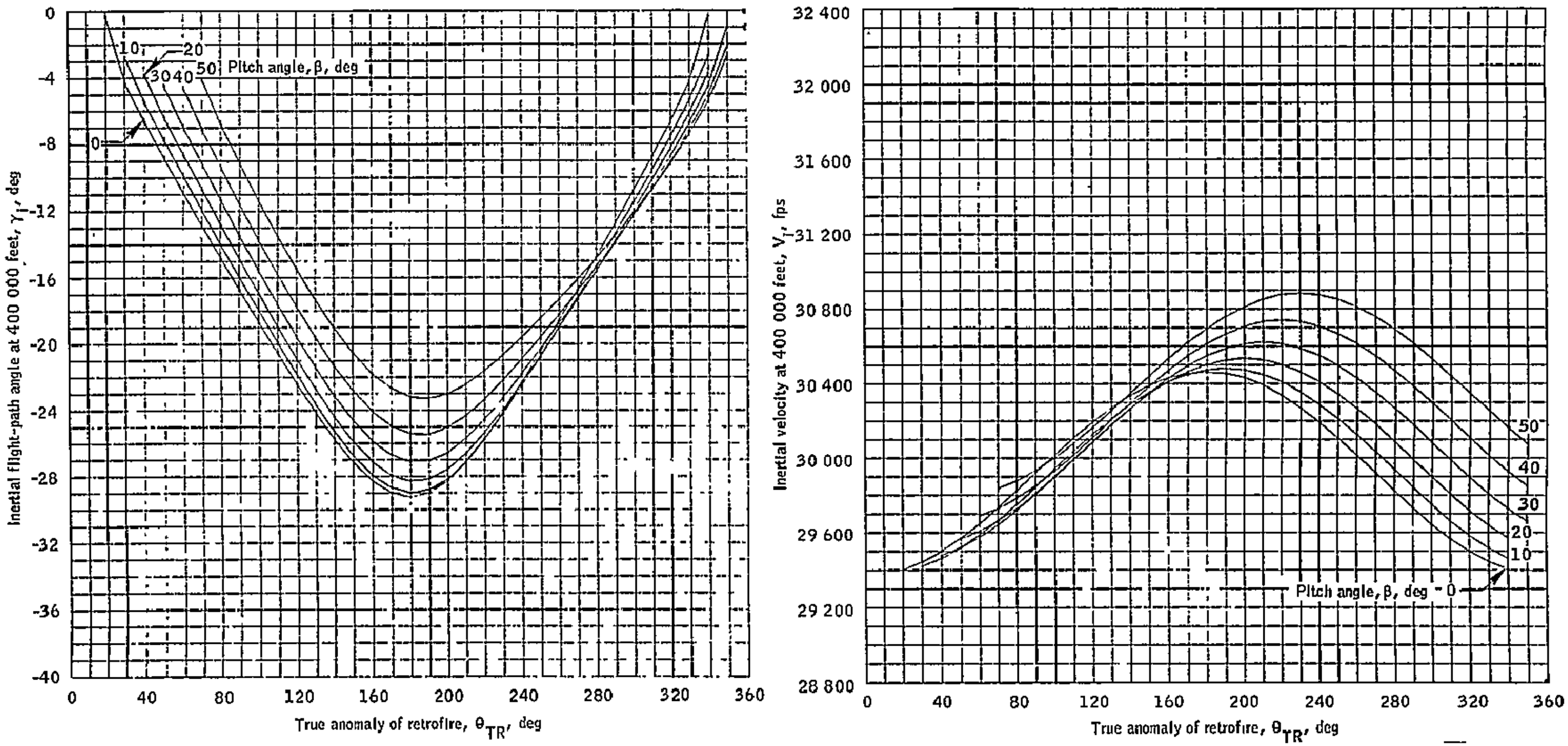
Figure 16.- Continued.





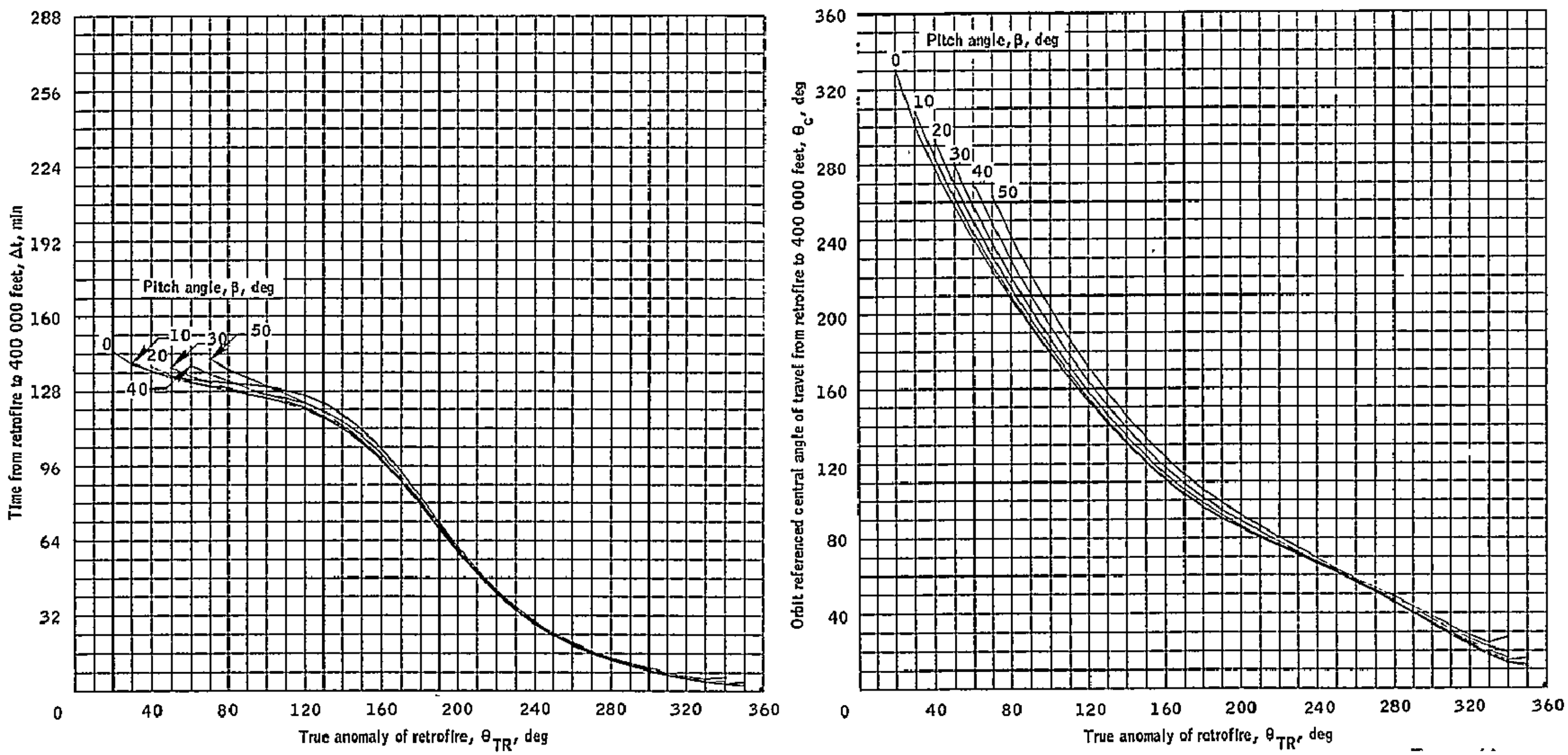
(h) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

Figure 16.- Continued.



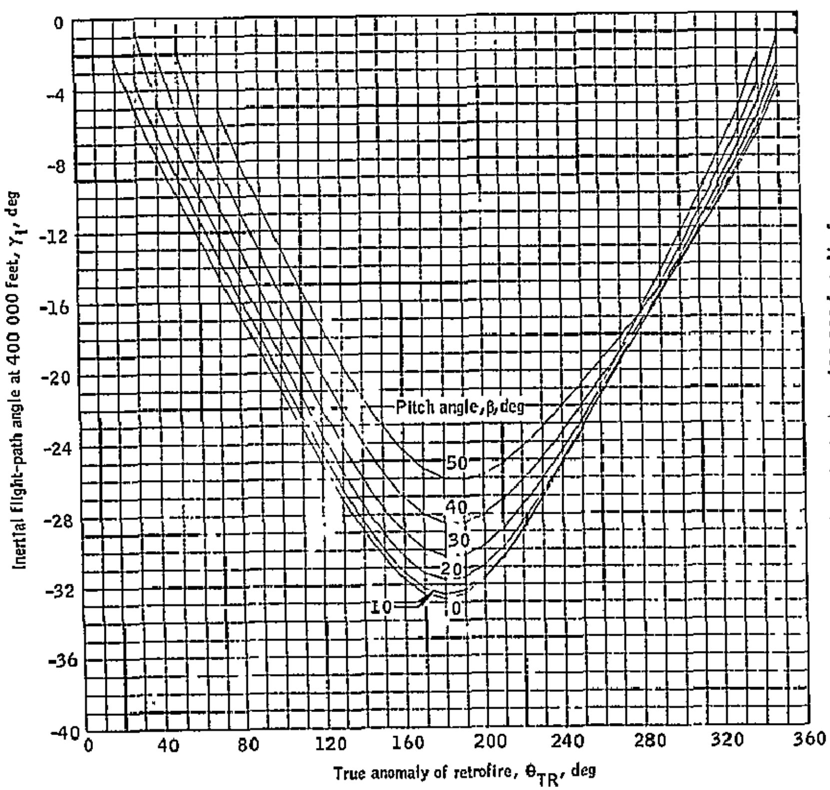
(l) Flight-path angle and velocity for retrograde ΔV=1700 feet per second.

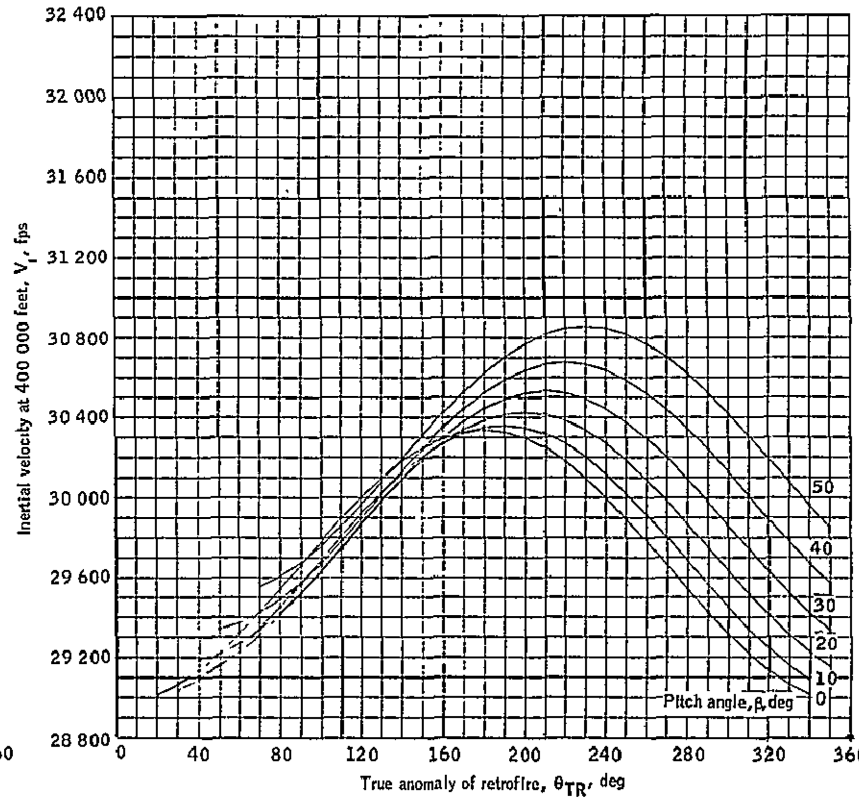
Figure 16.- Continued.



(j) Time from retrofire and central angle for retrograde ΔV=1700 feet per second.

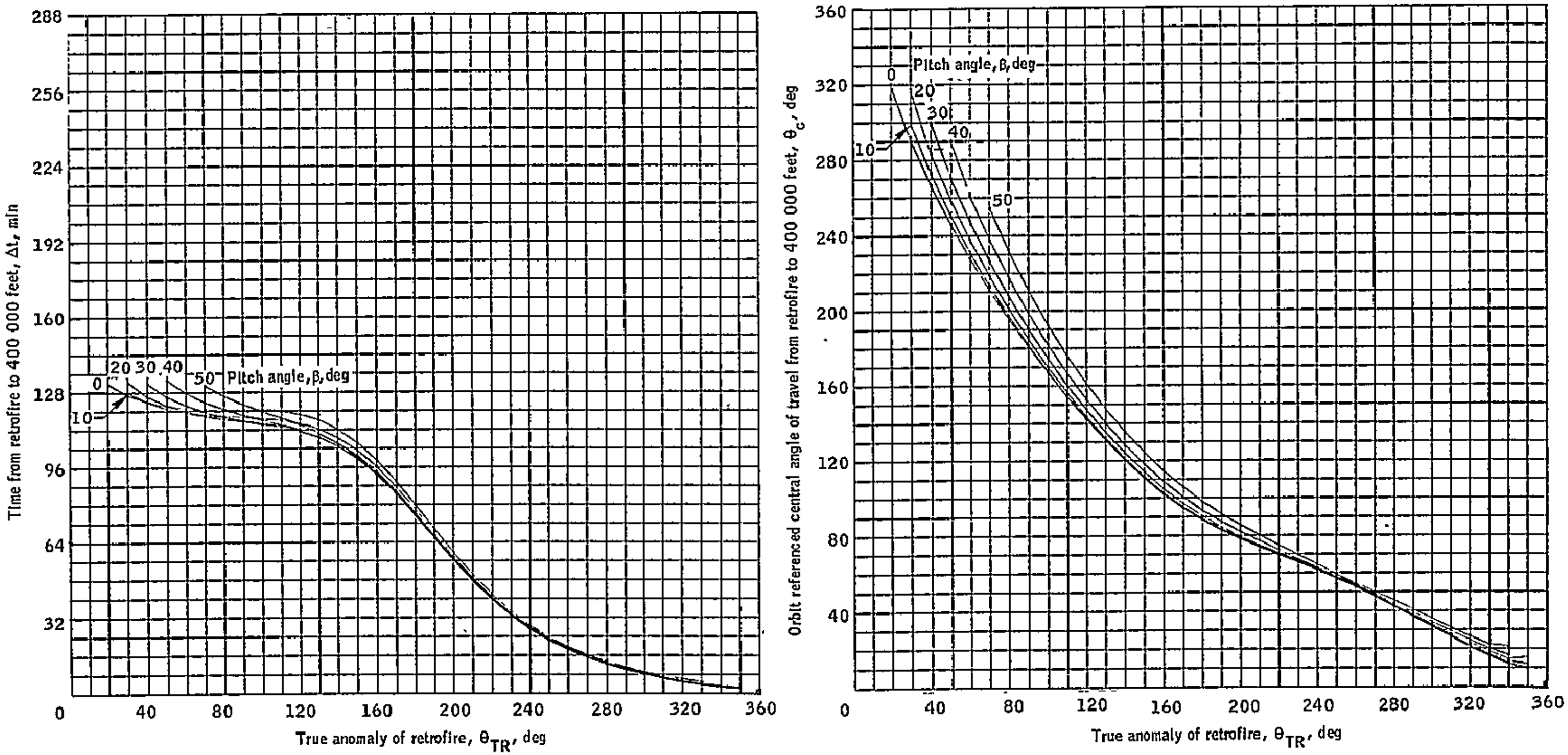
Figure 16.- Continued.





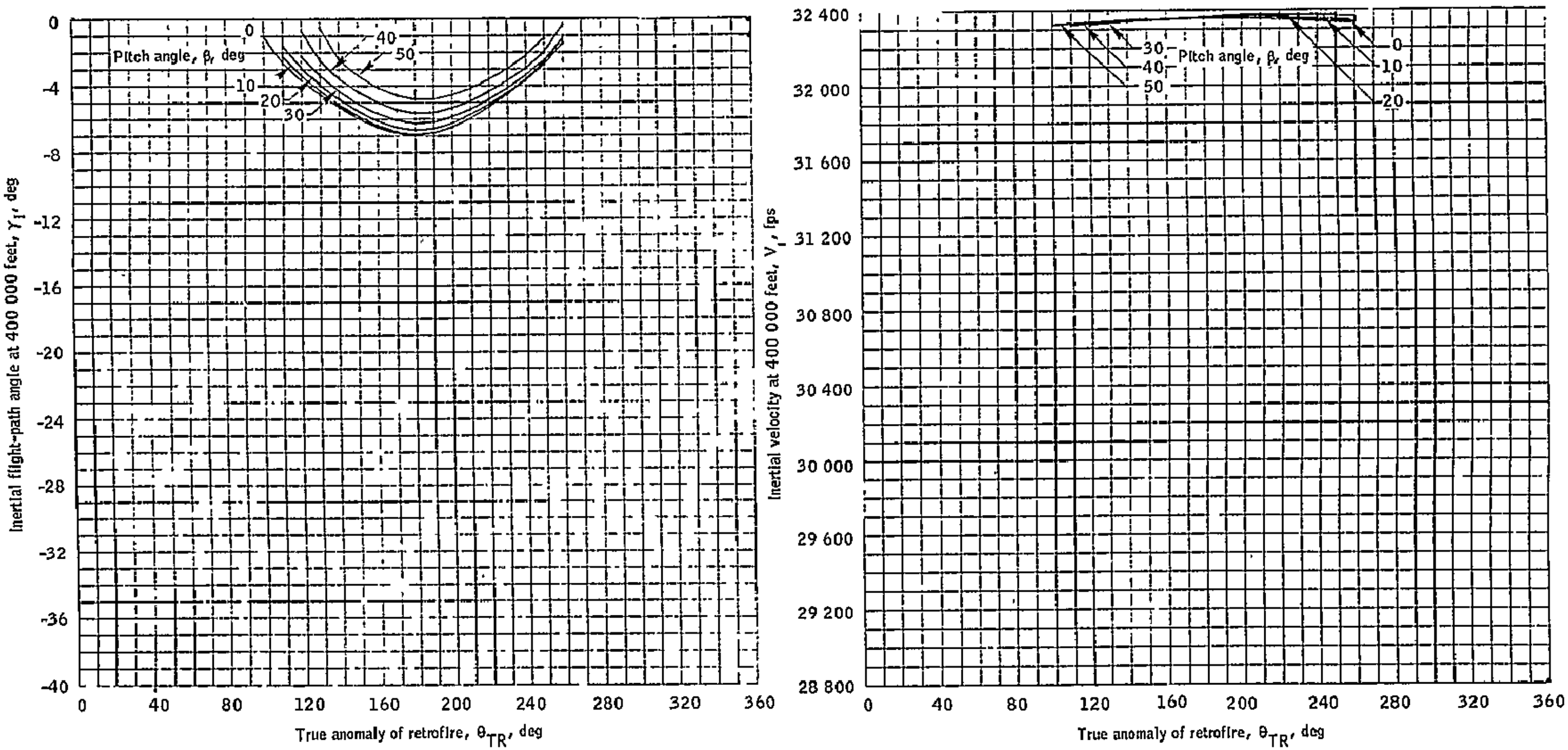
(k) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

Figure 16.- Continued.



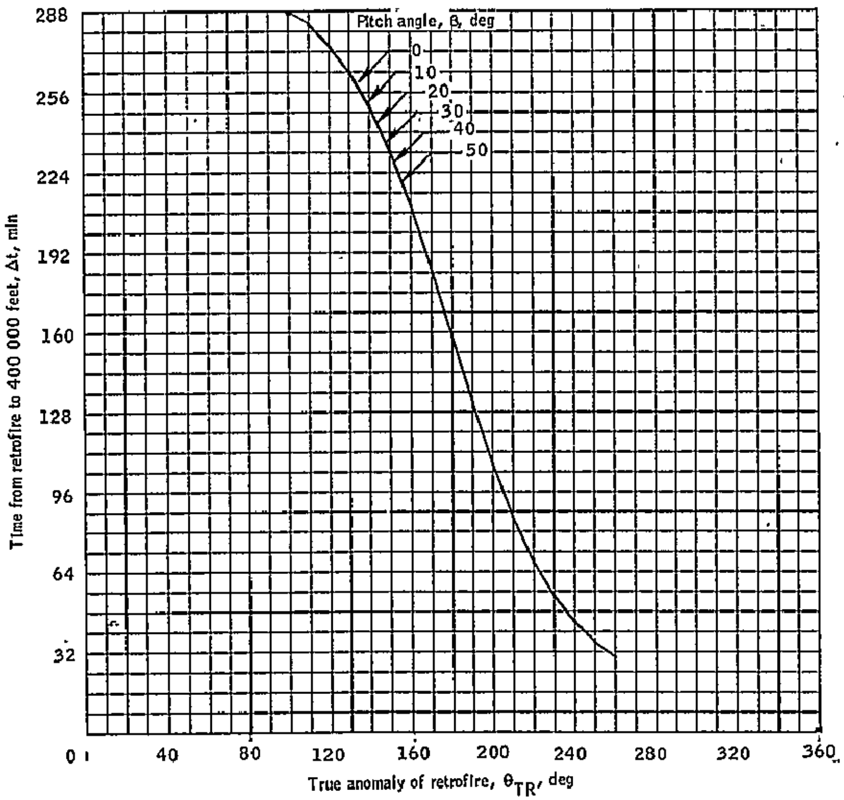
(l) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

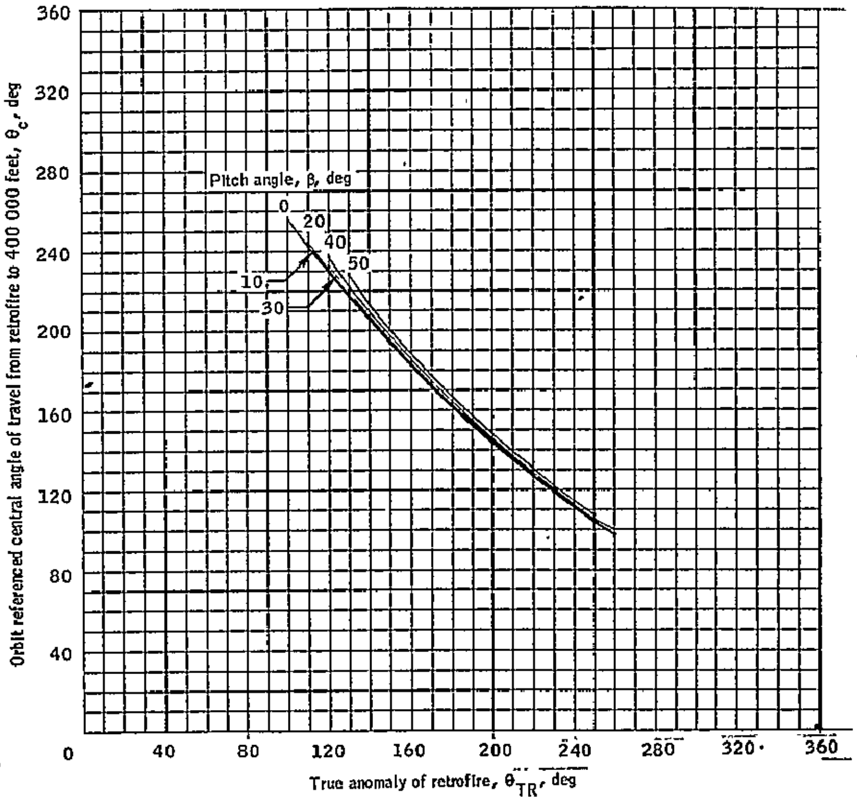
Figure 16.- Concluded.



(a) Flight-path angle and velocity for retrograde ΔV= 100 feet per second.

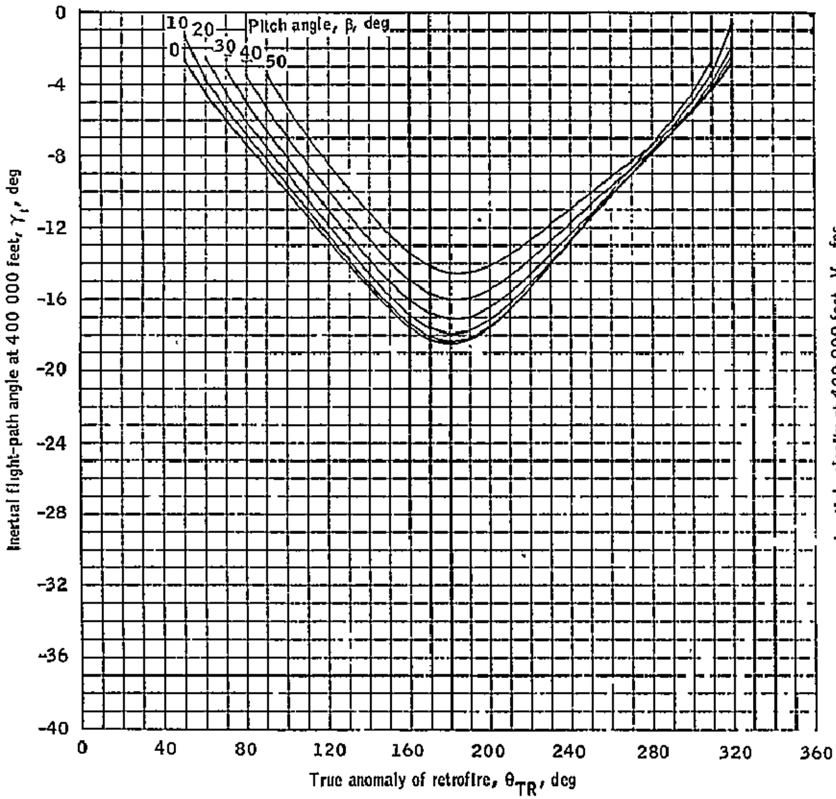
Figure 17.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for a 100/1000 nautical mile orbit.

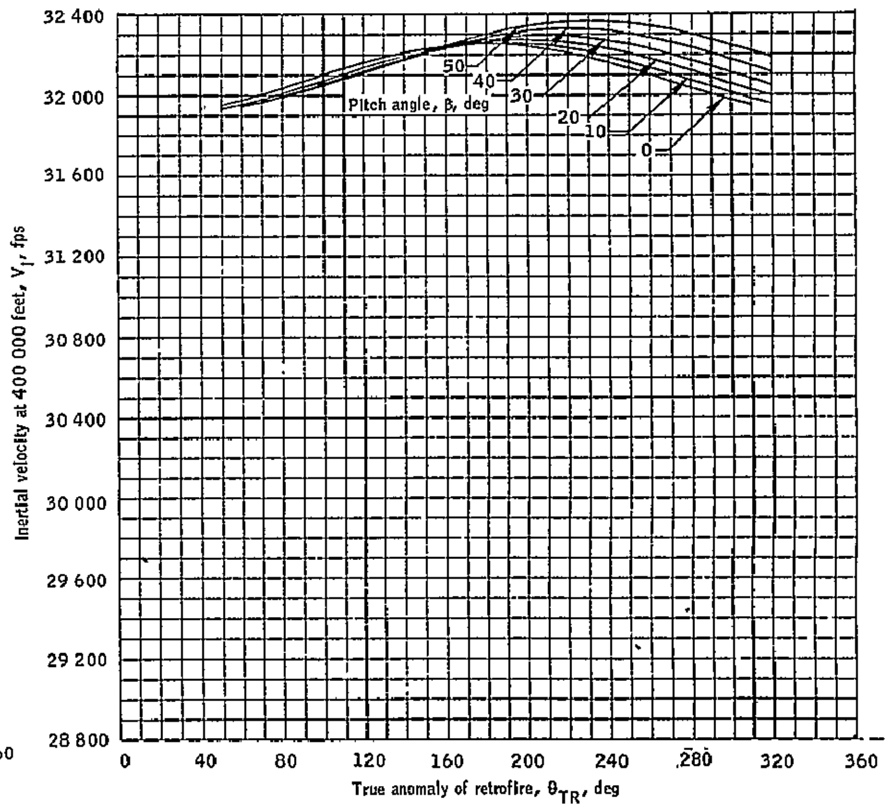




(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

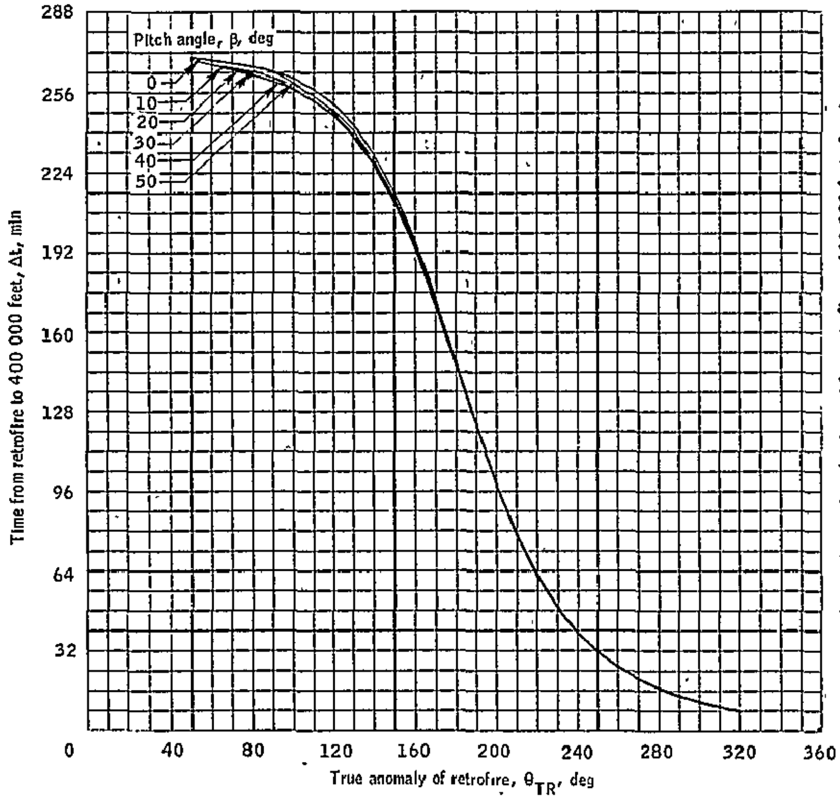
Figure 17.- Continued.

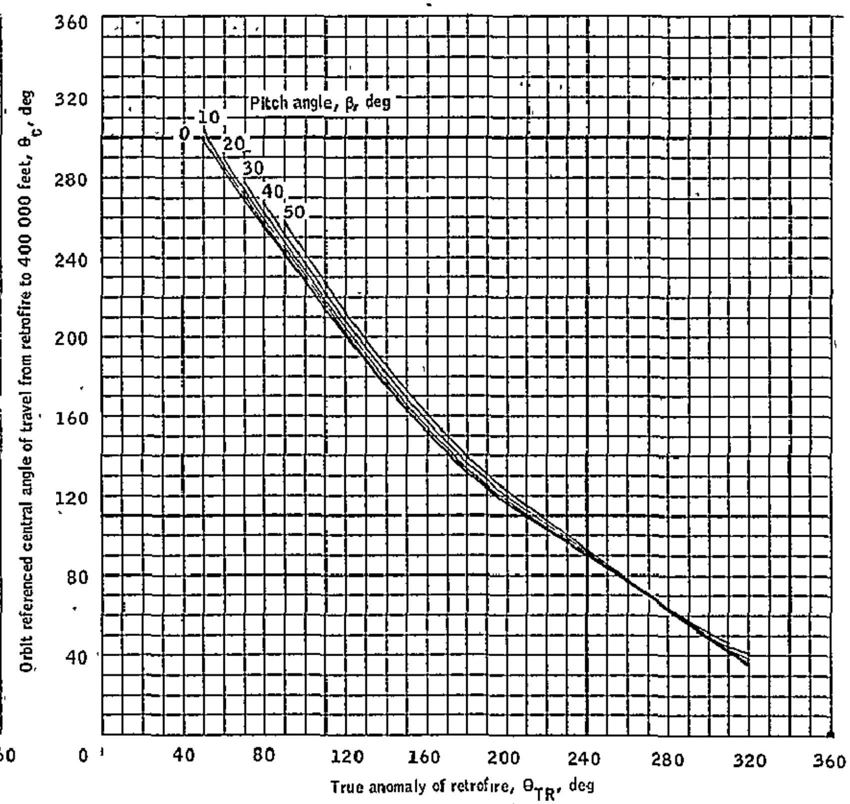




(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

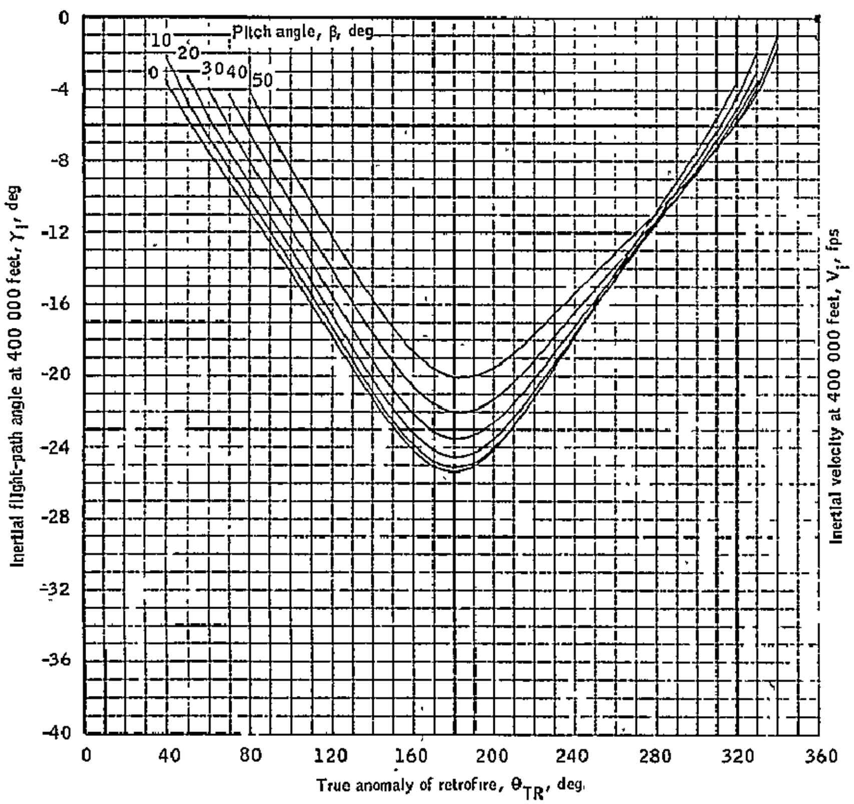
Figure 17.- Continued.

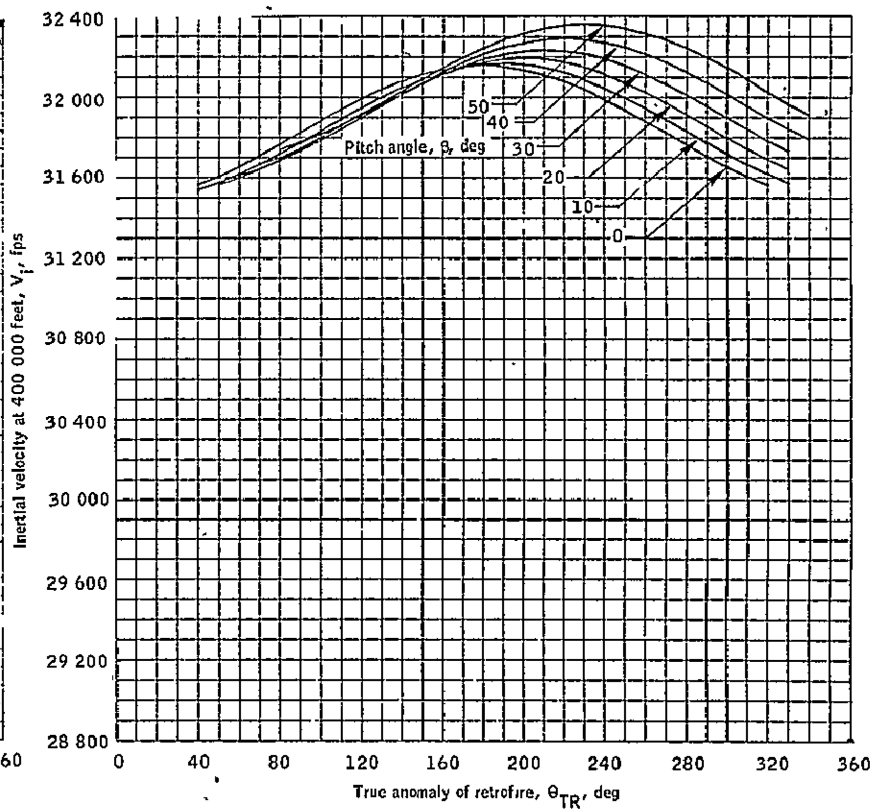




(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

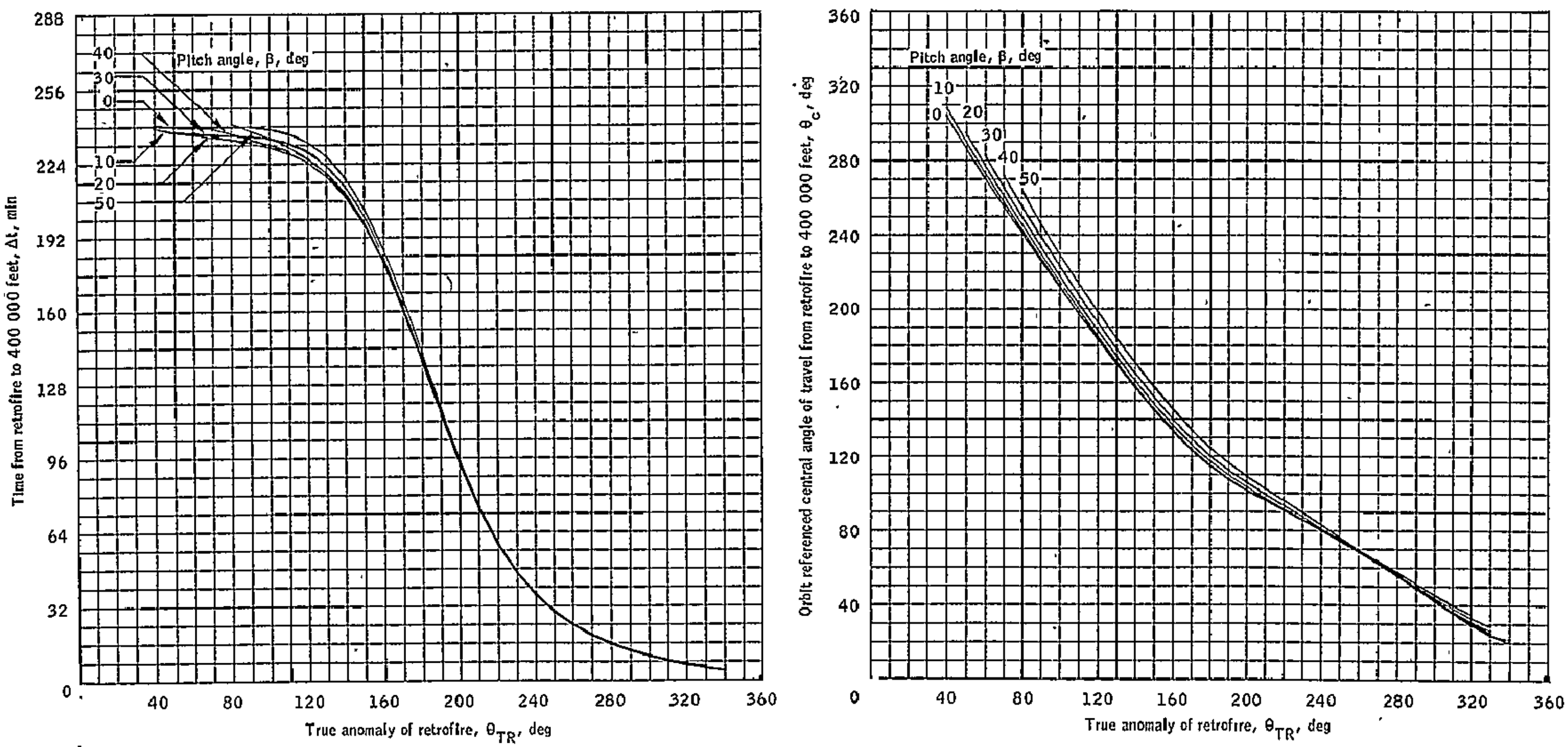
Figure 17.- Continued.





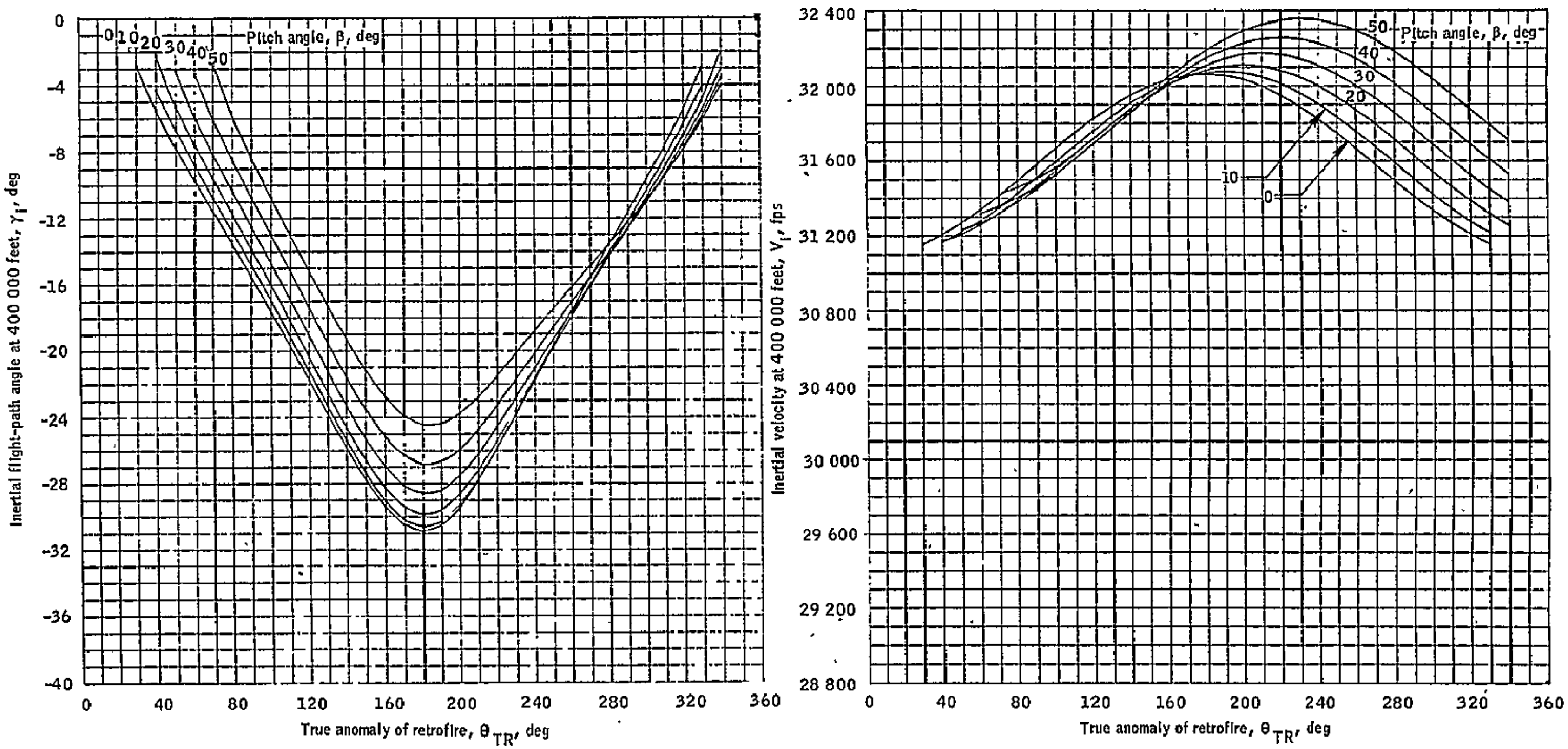
(e) Flight-path angle and velocity for retrograde ΔV = 900 feet per second.

Figure 17.- Continued.



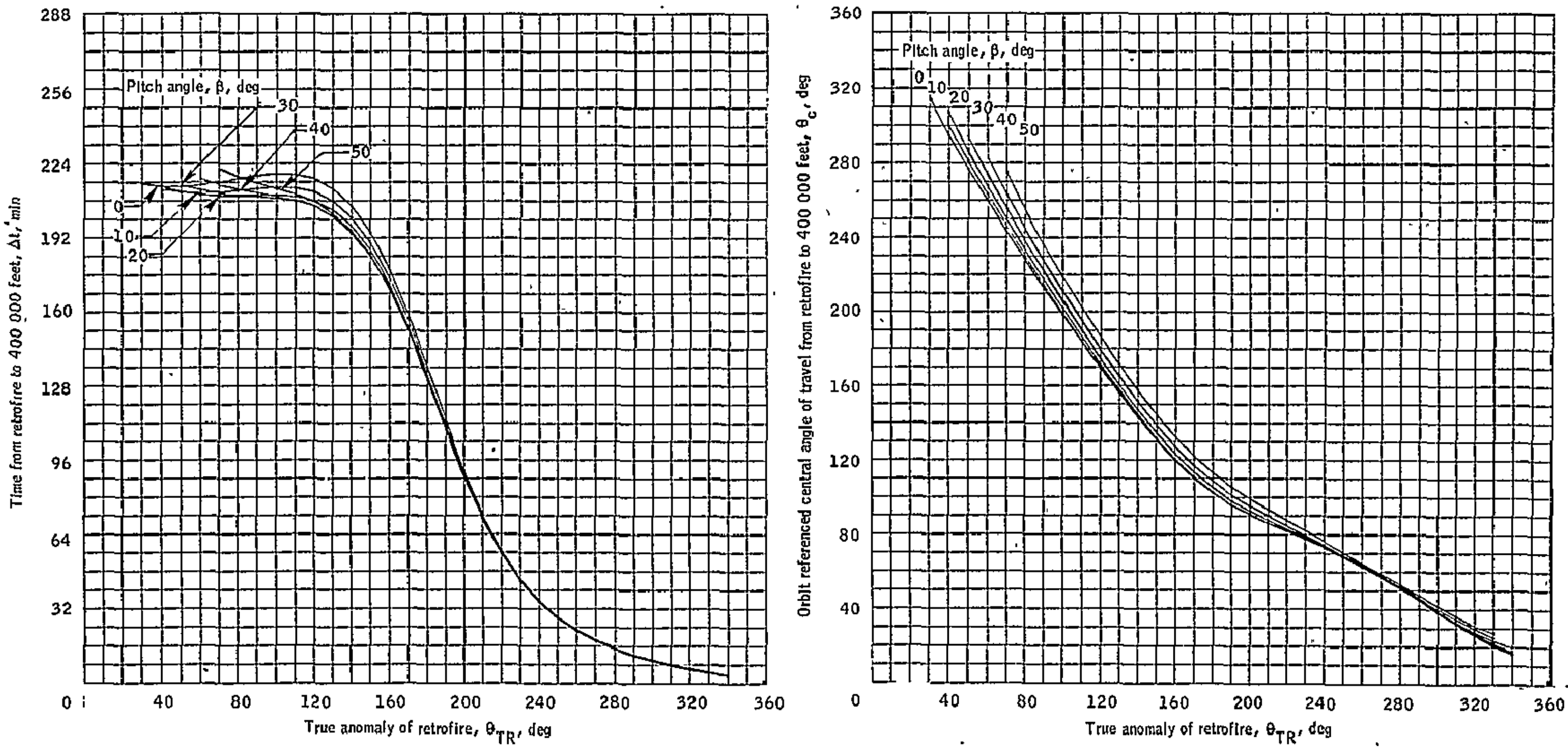
(f) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

Figure 17.- Continued.



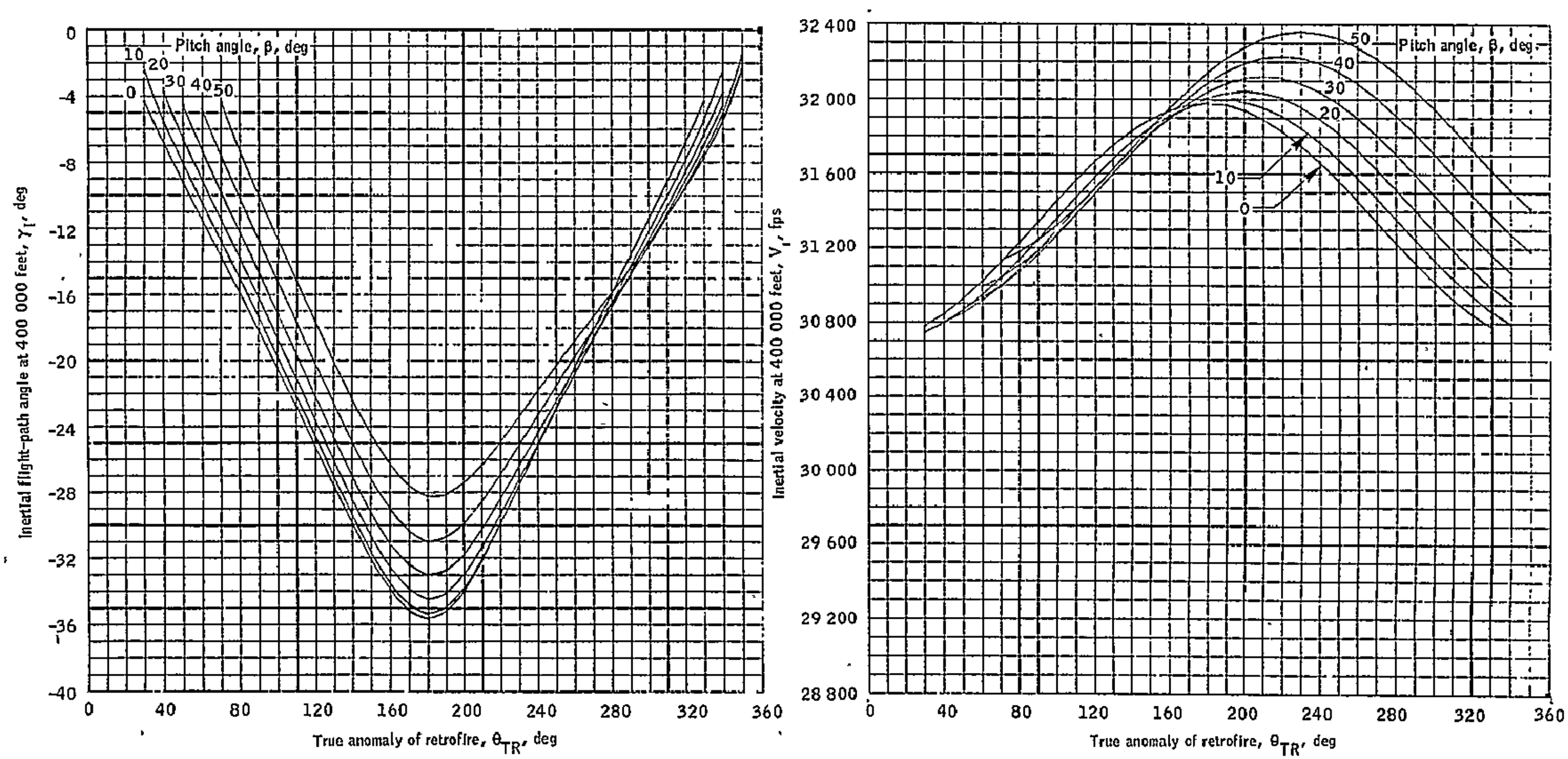
(g) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

Figure 17.- Continued.



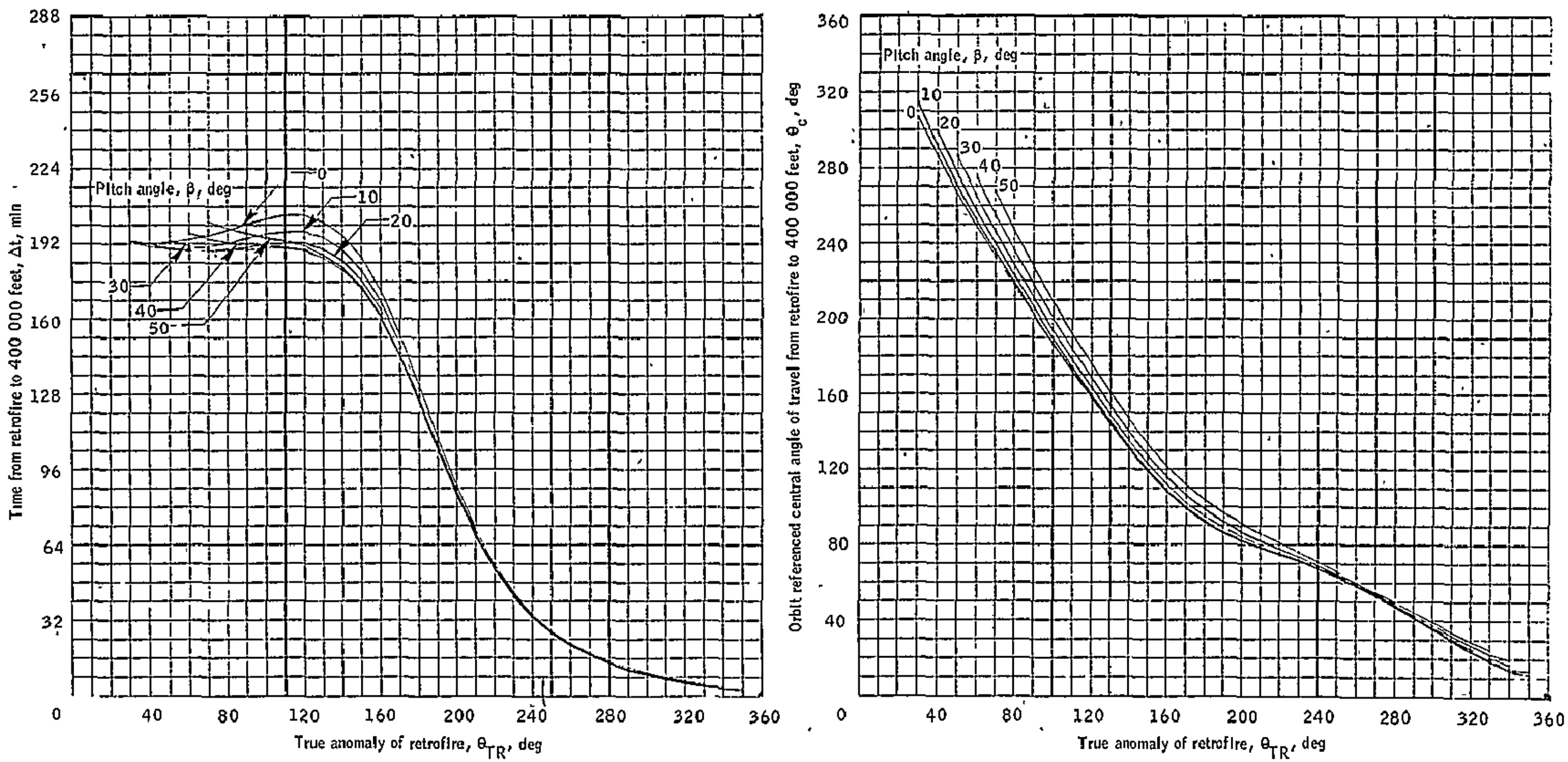
(h) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

Figure 17.- Continued.



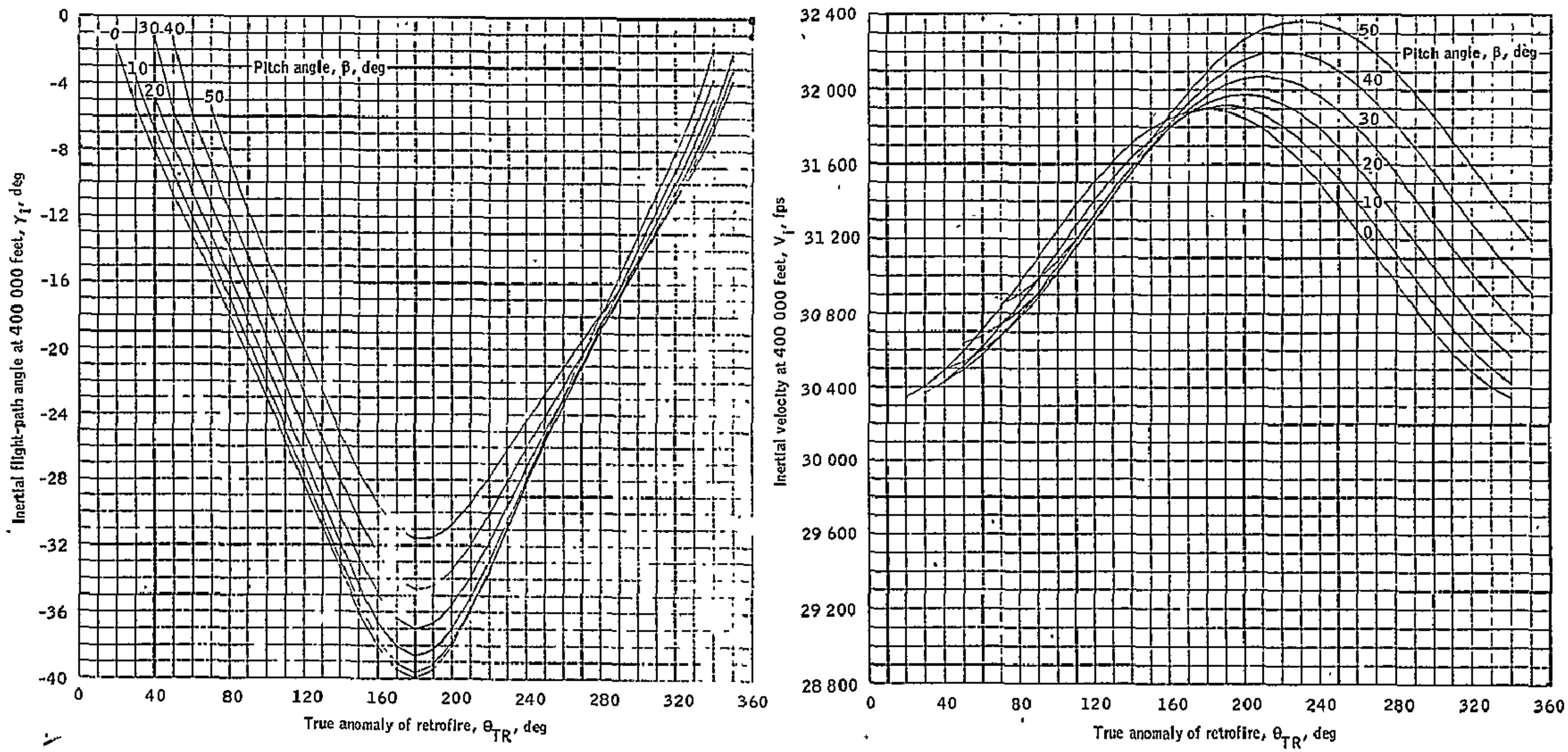
(i) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

Figure 17.- Continued.



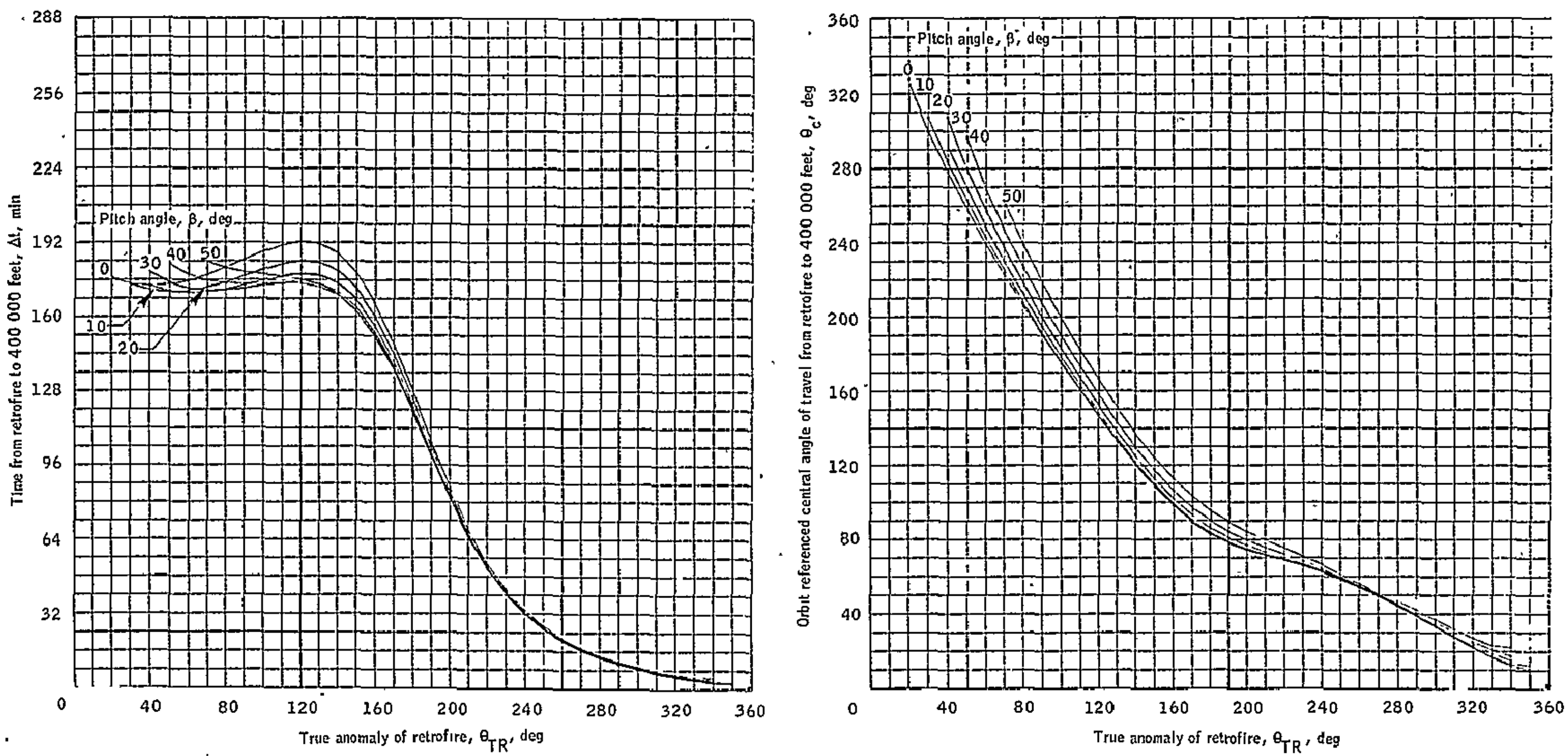
(j) Time from retrofire and central angle for retrograde $\Delta V = 1700$ feet per second.

Figure 17.- Continued.



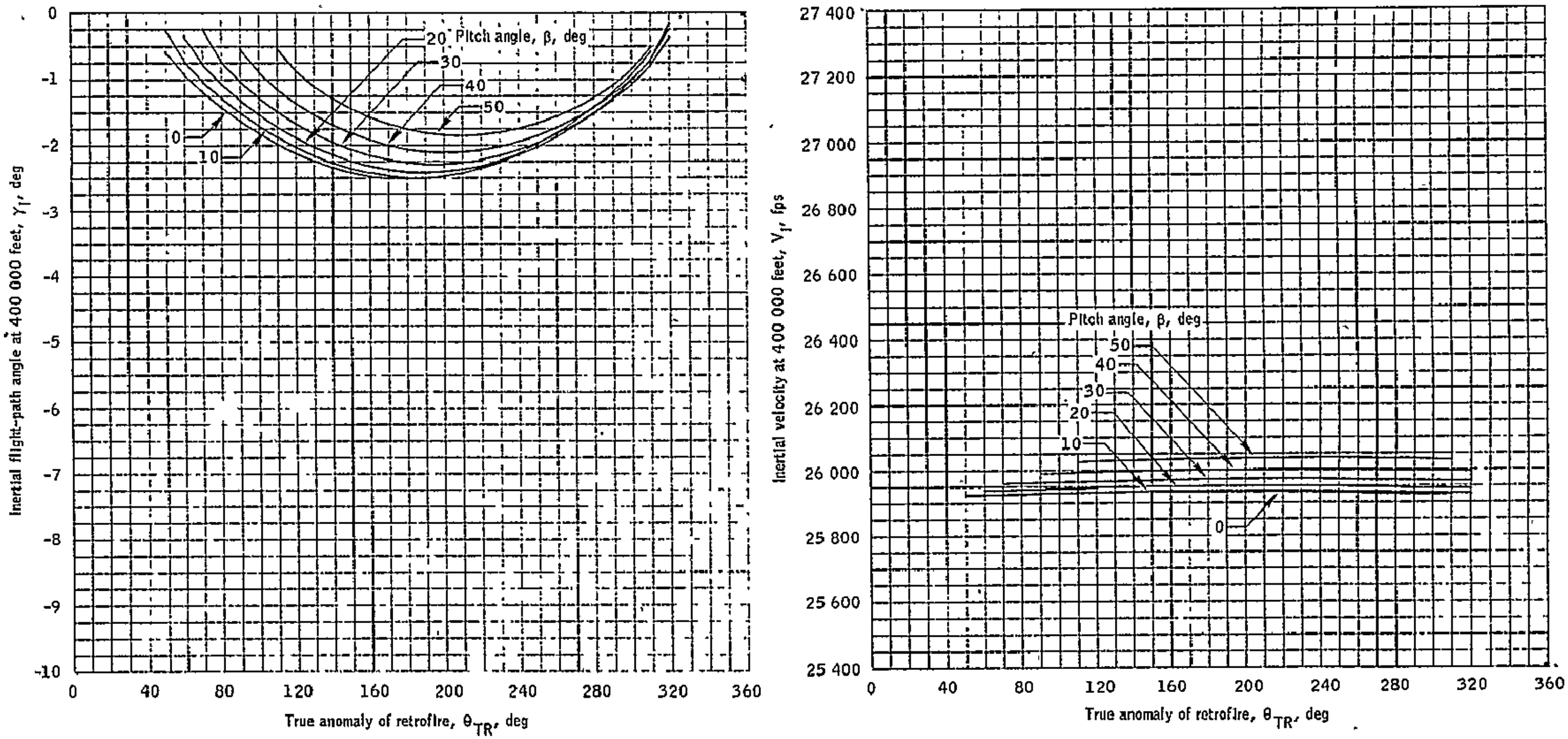
(k) Flight-path angle and velocity for retrograde ΔV = 2100 feet per second.

Figure 17.- Continued.



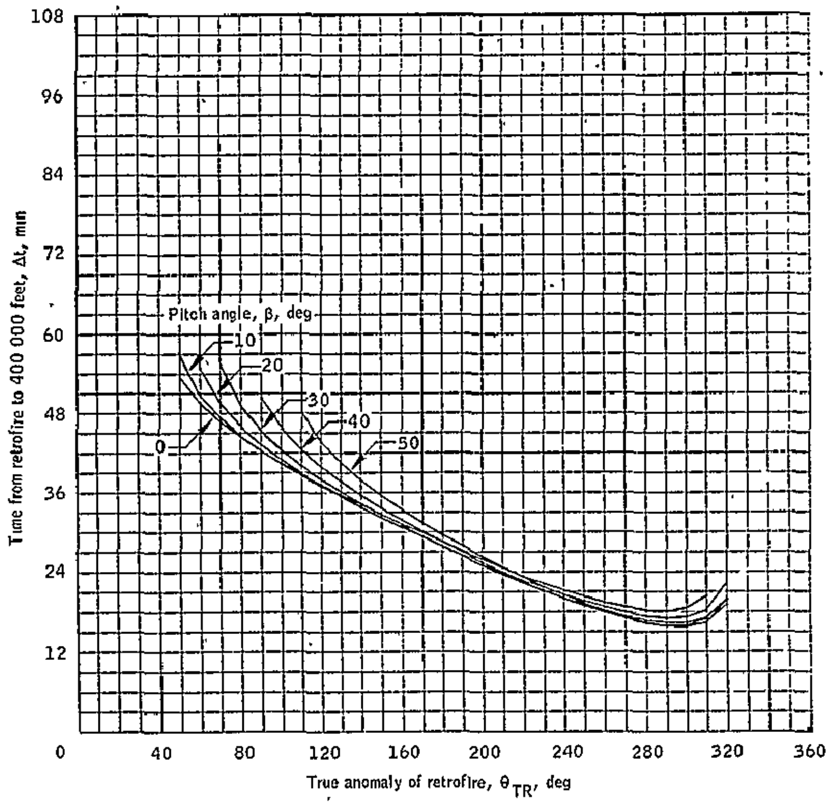
(l) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

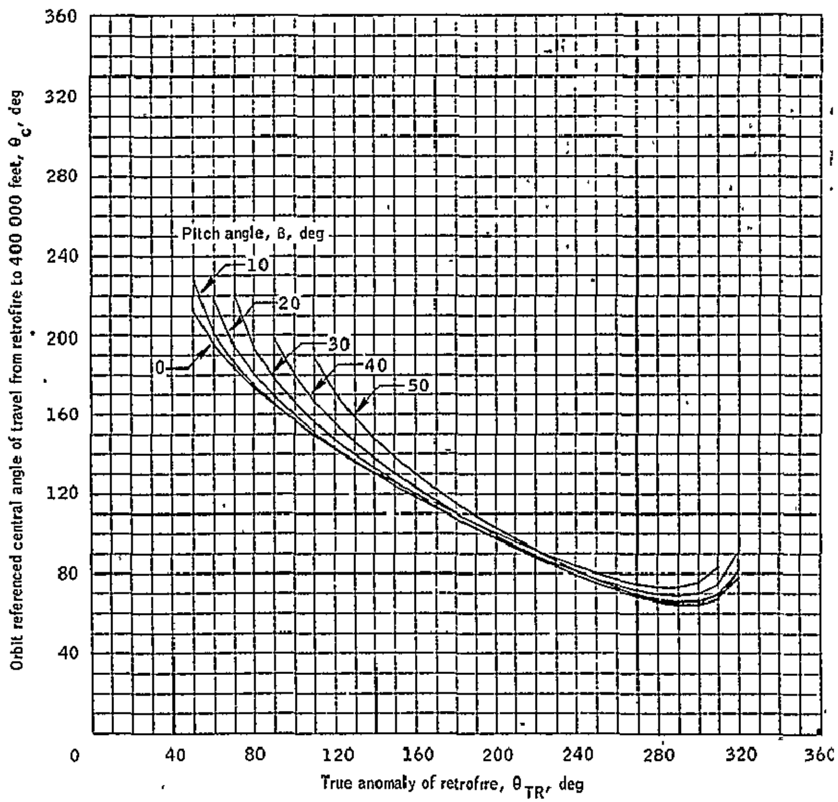
Figure 17.- Concluded.



(a) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

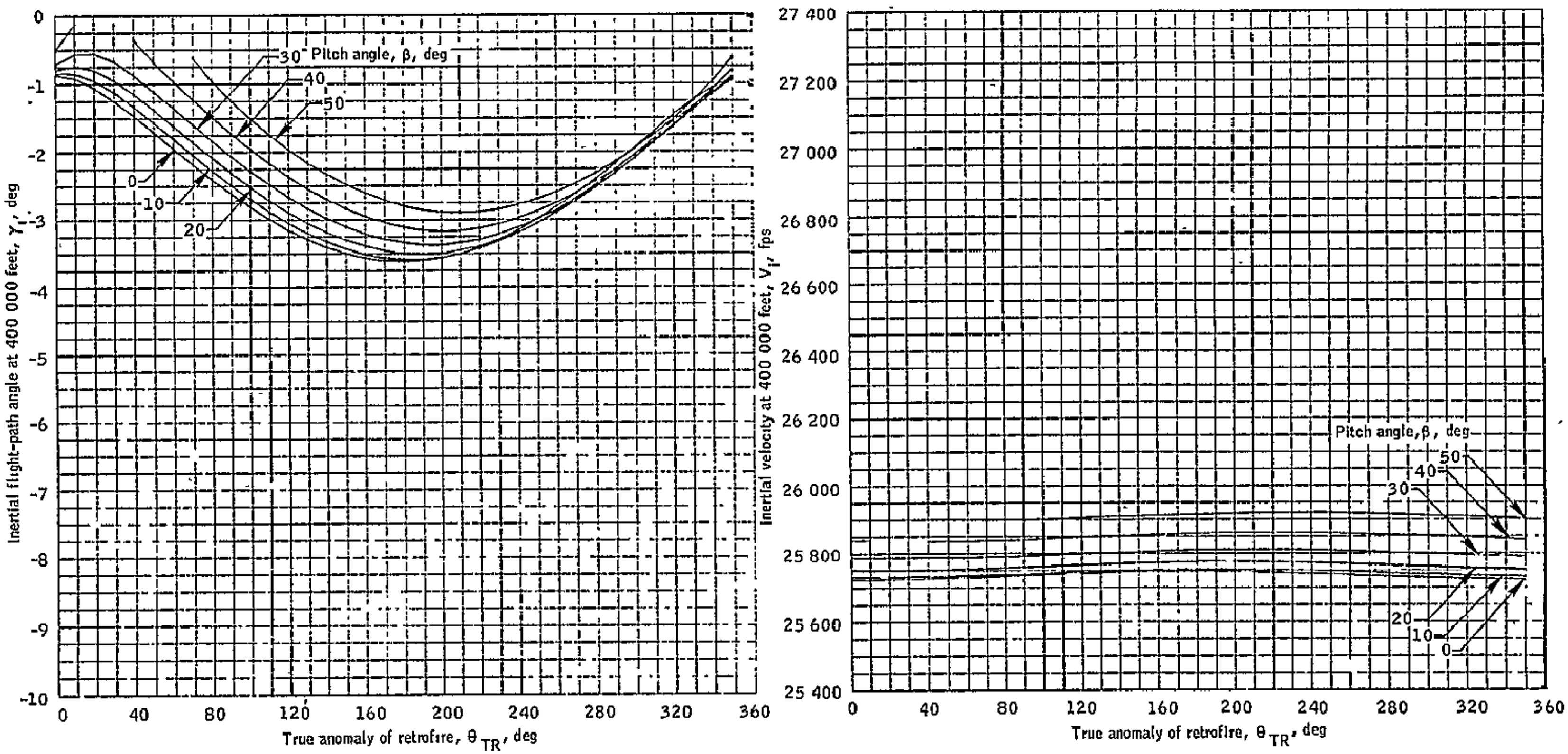
Figure 18.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for a 125/300 nautical mile orbit.





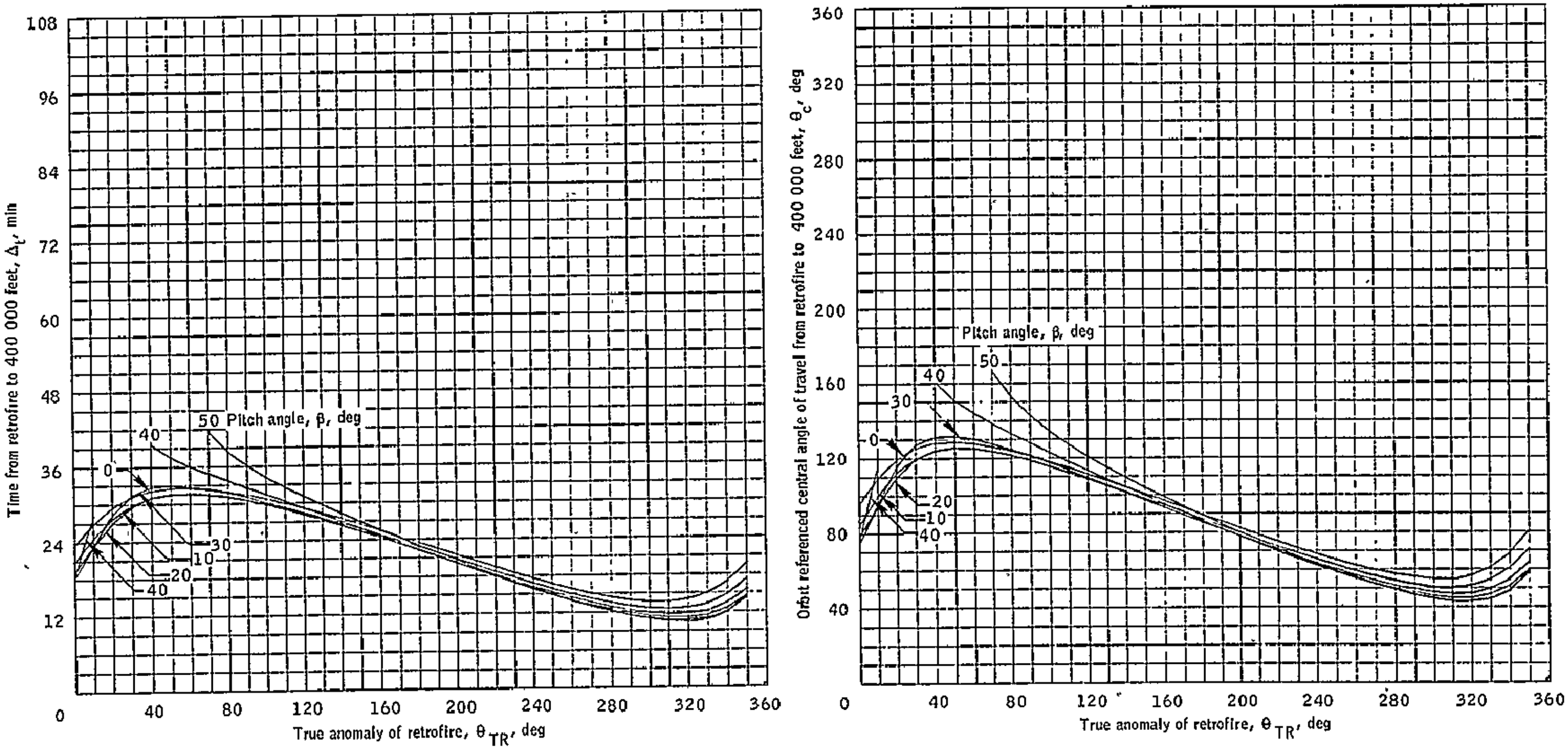
(b) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

Figure 18.- Continued.



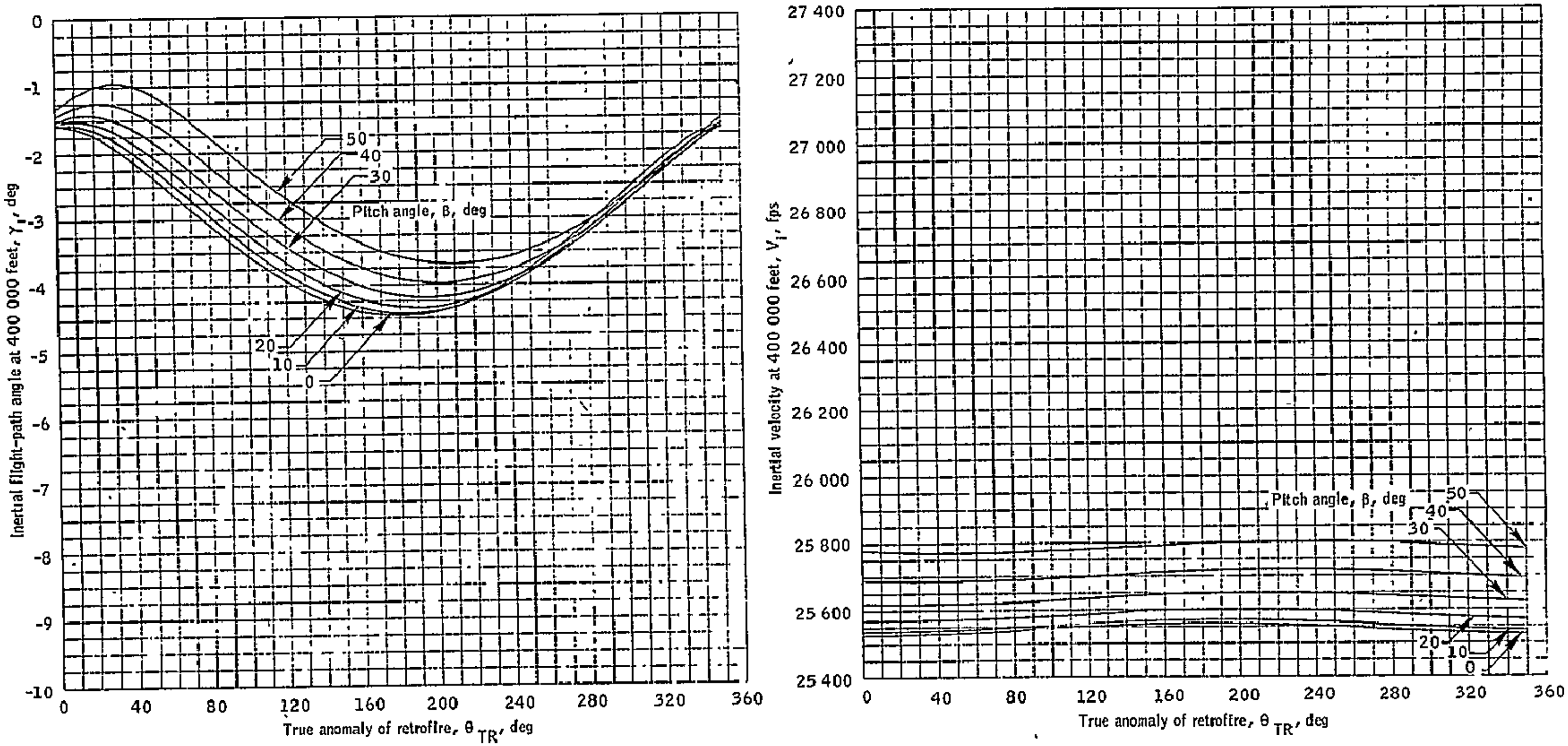
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 18.- Continued.



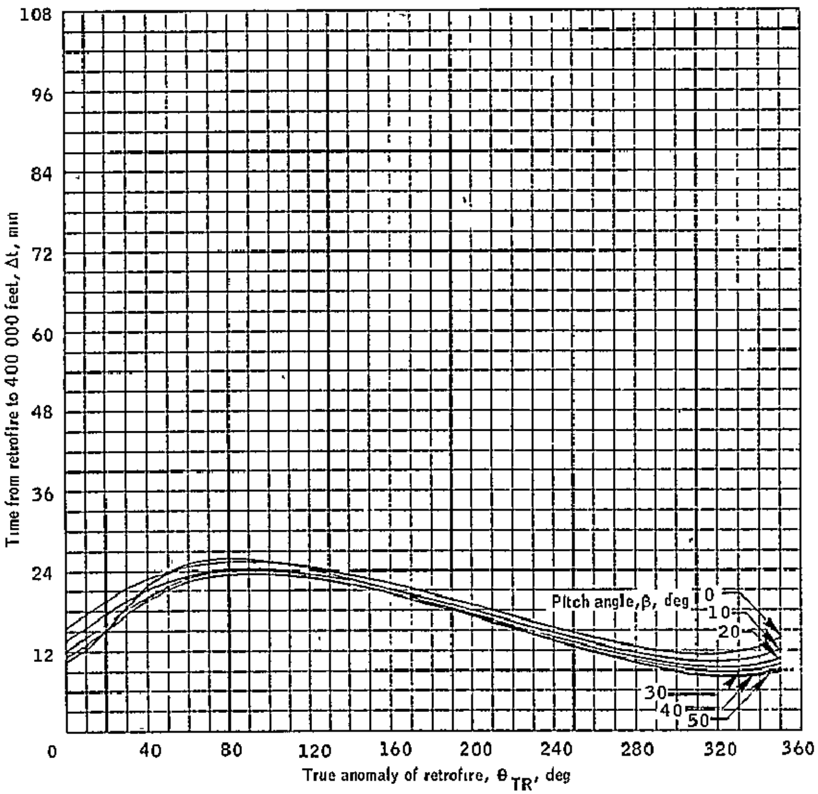
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

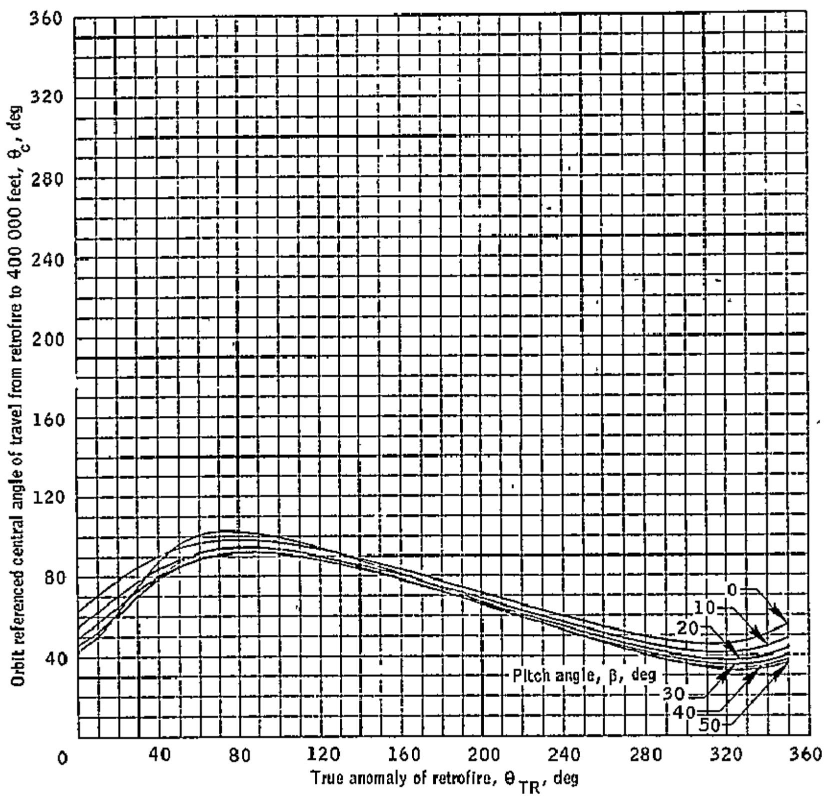
Figure 18.- Continued.



(e) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

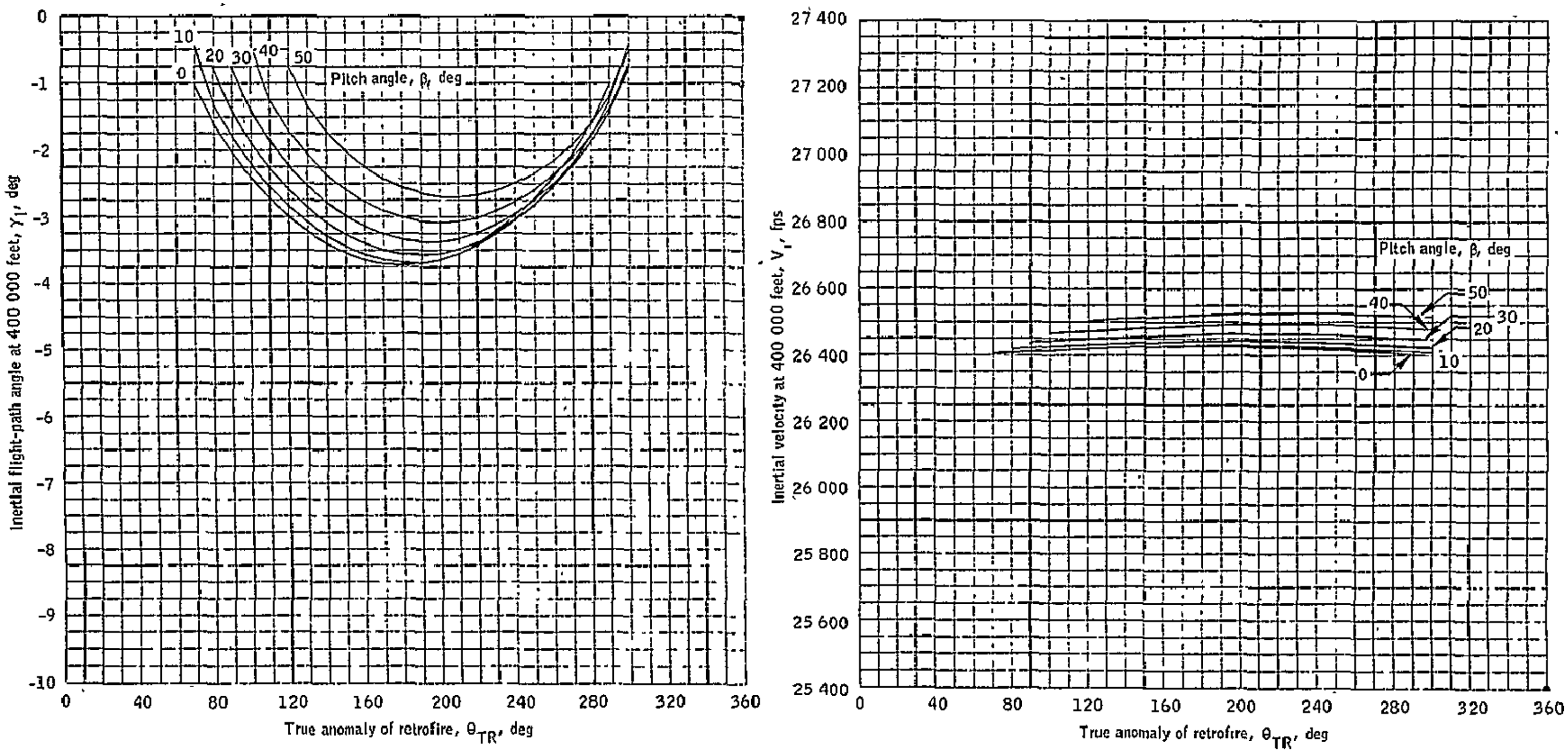
Figure 18.- Continued.





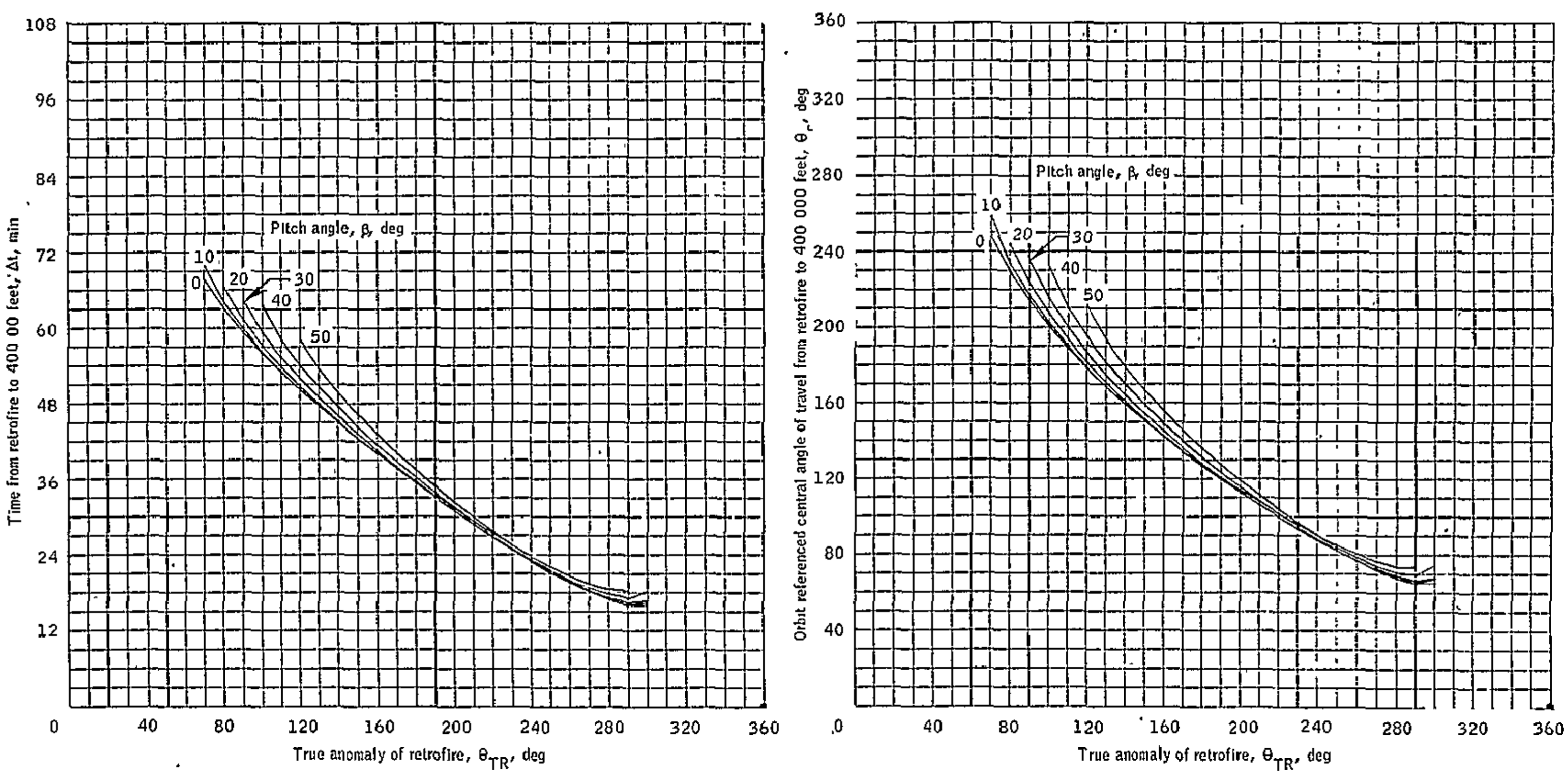
(f) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

Figure 18.- Concluded.



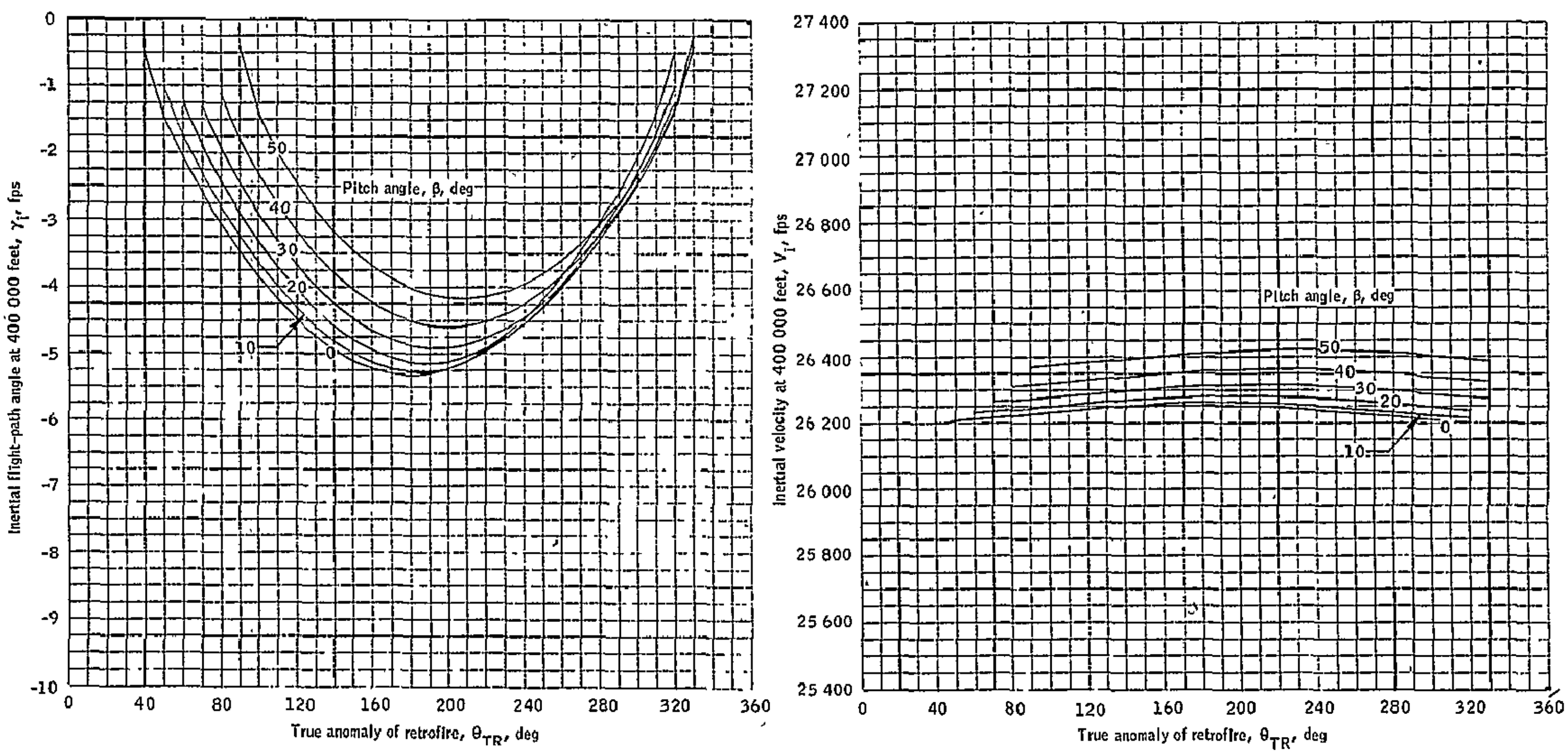
(a) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

Figure 19.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 125/600 nautical mile orbit.



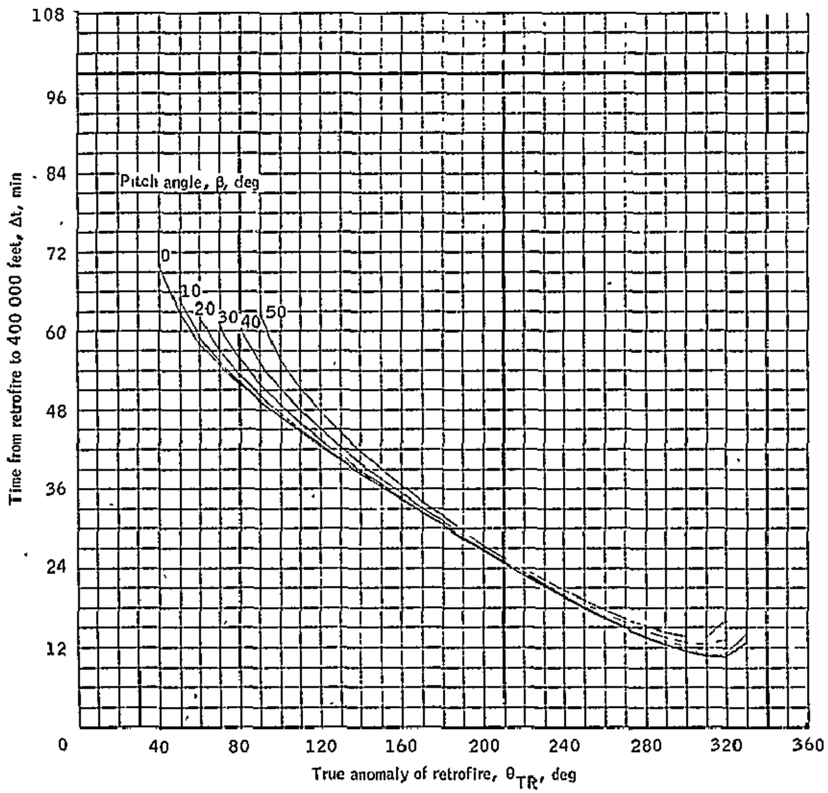
(b) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

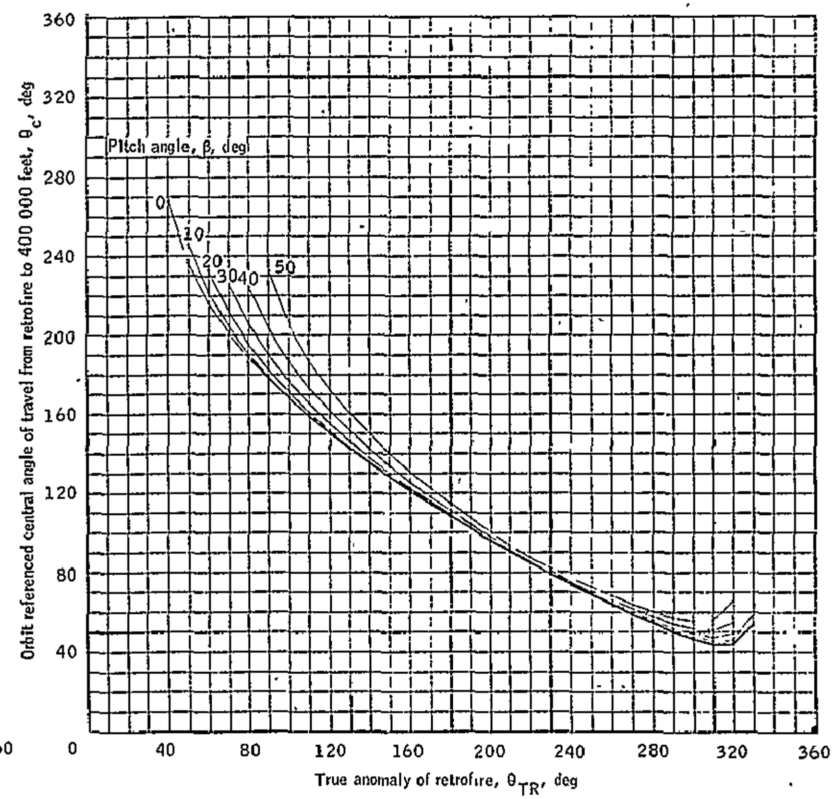
Figure 19.- Continued.



(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

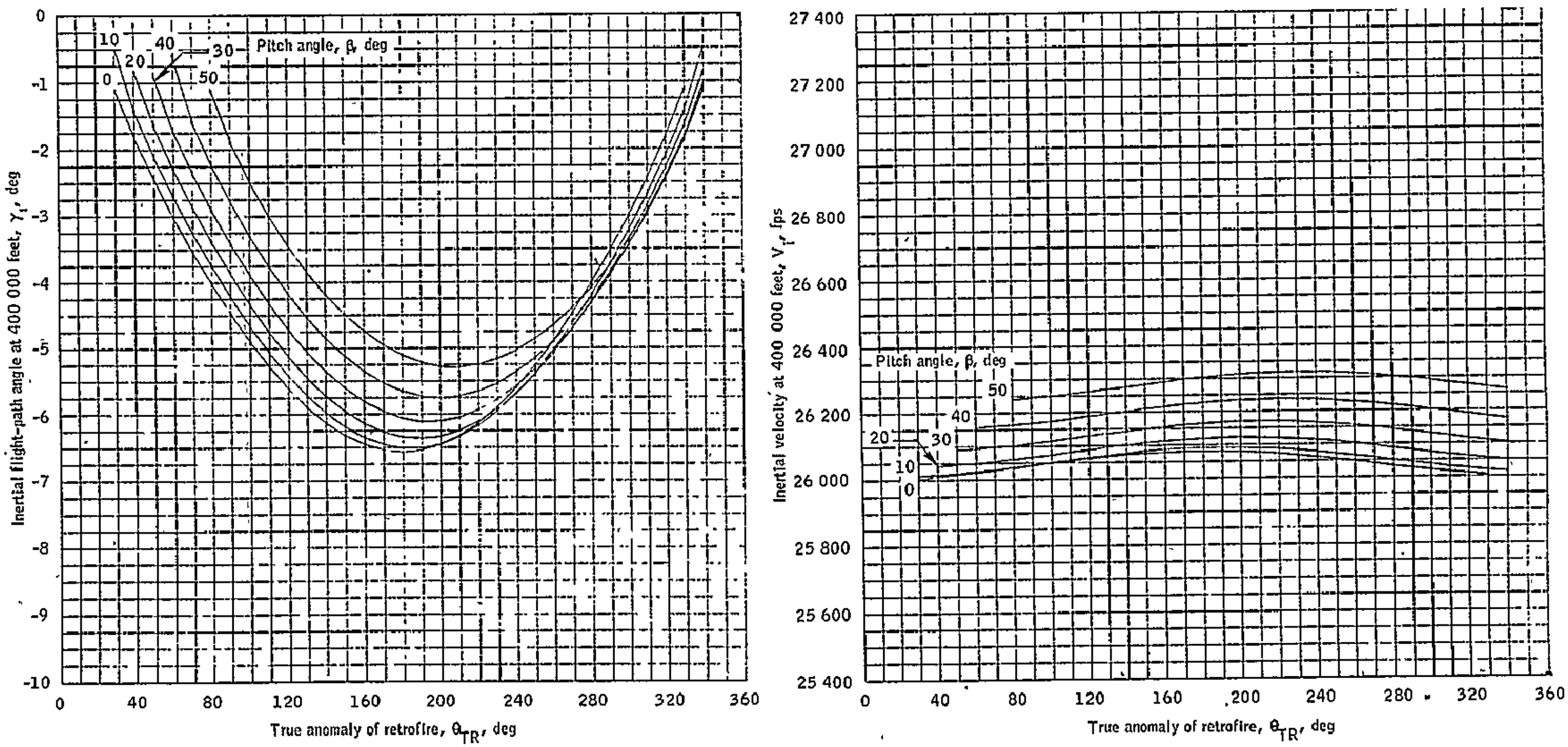
Figure 19.- Continued.





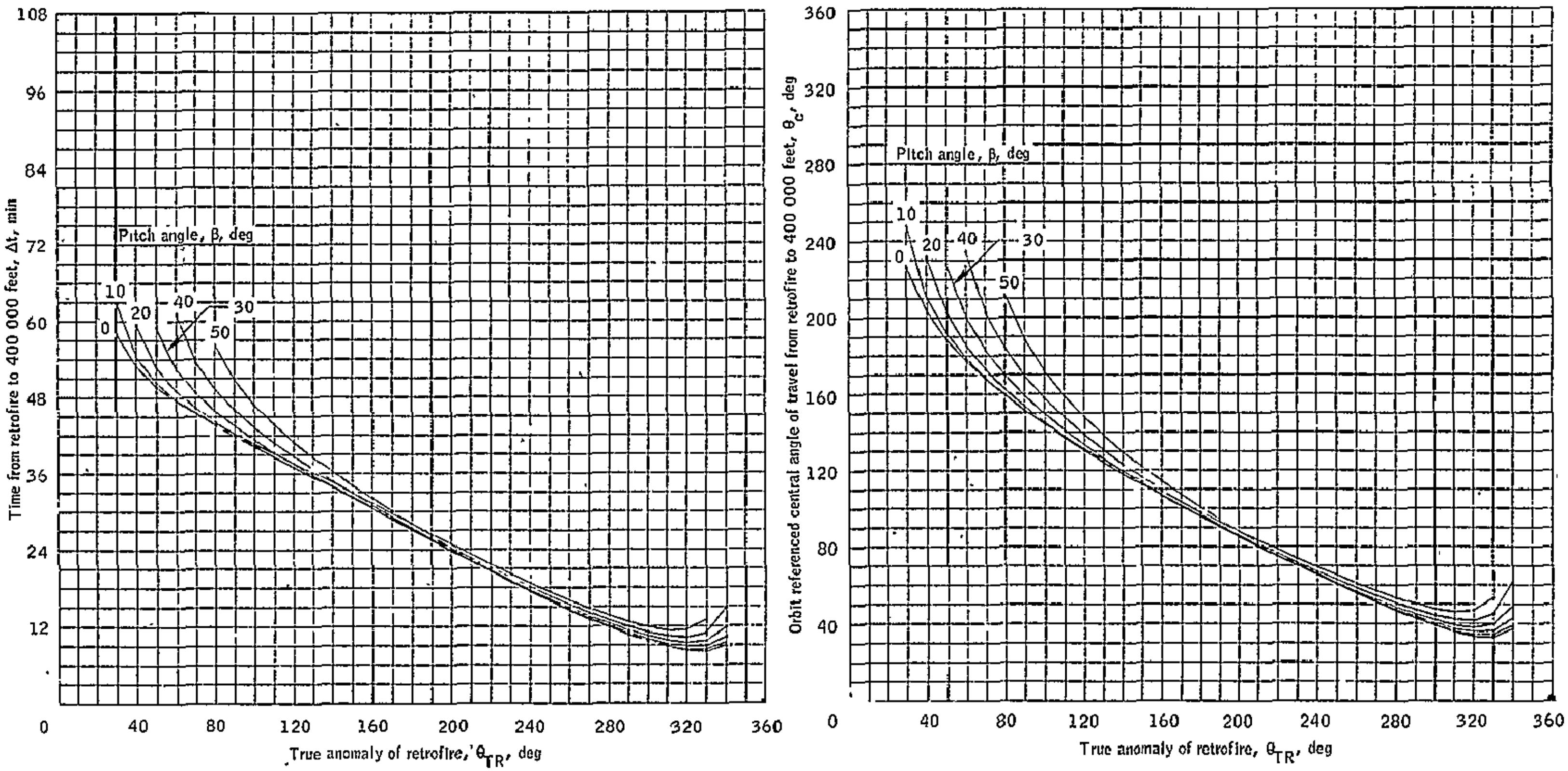
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 19.- Continued.



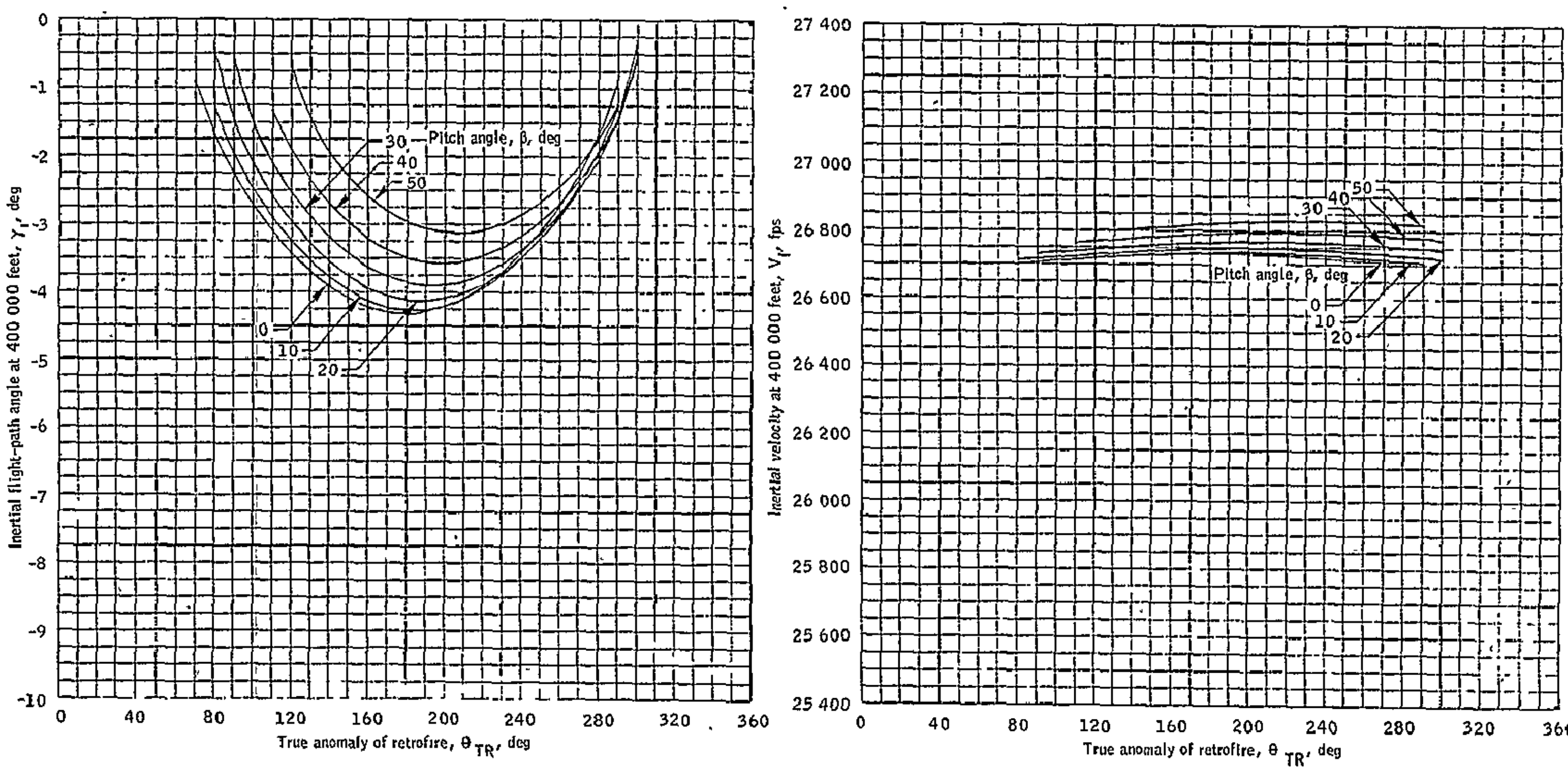
(e) Flight-path angle and velocity for retrograde ΔV=700 feet per second.

Figure 19.- Continued.



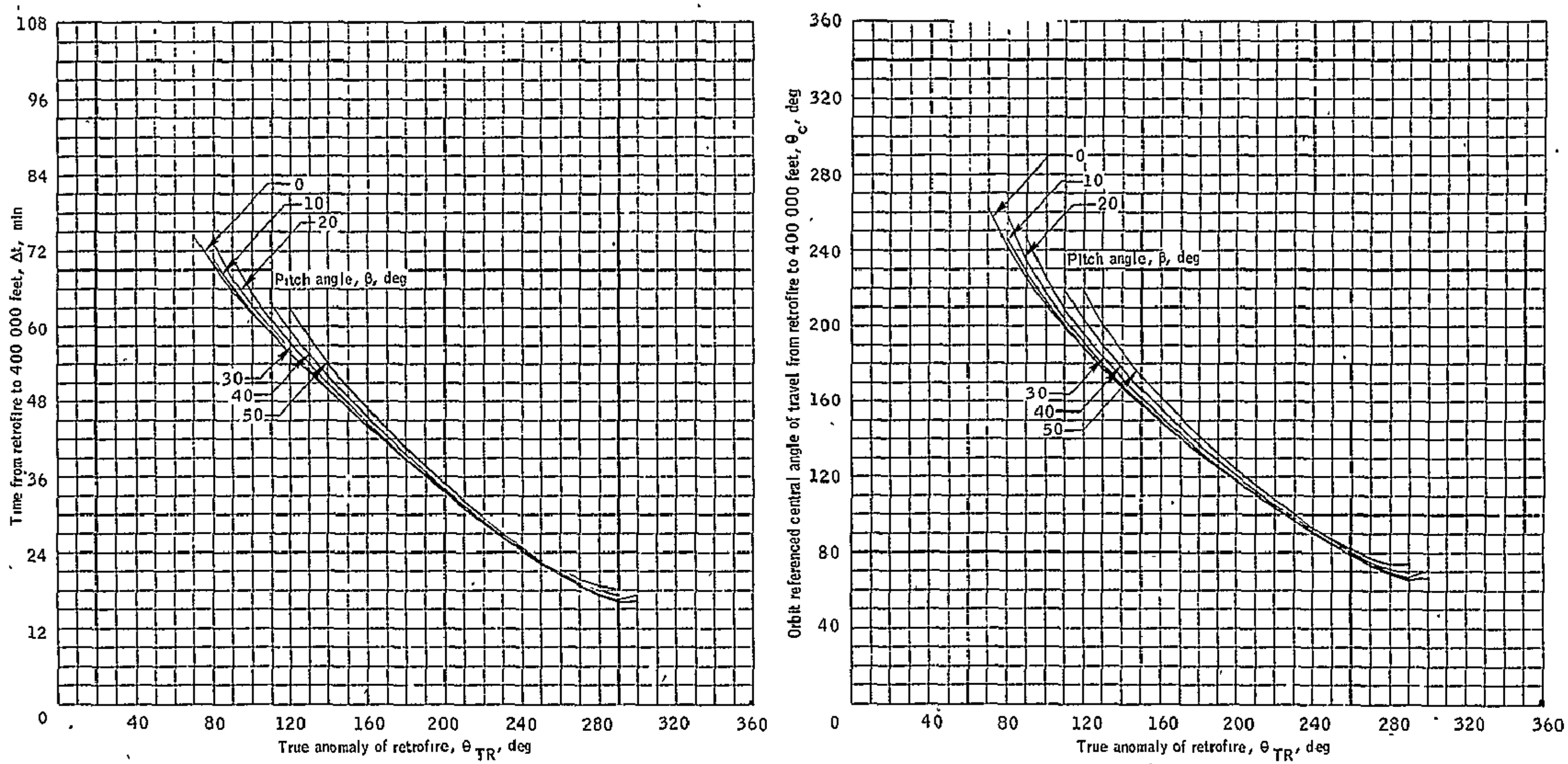
(f) Time from retrofire and central angle for retrograde ΔV=700 feet per second.

Figure 19.- Concluded.



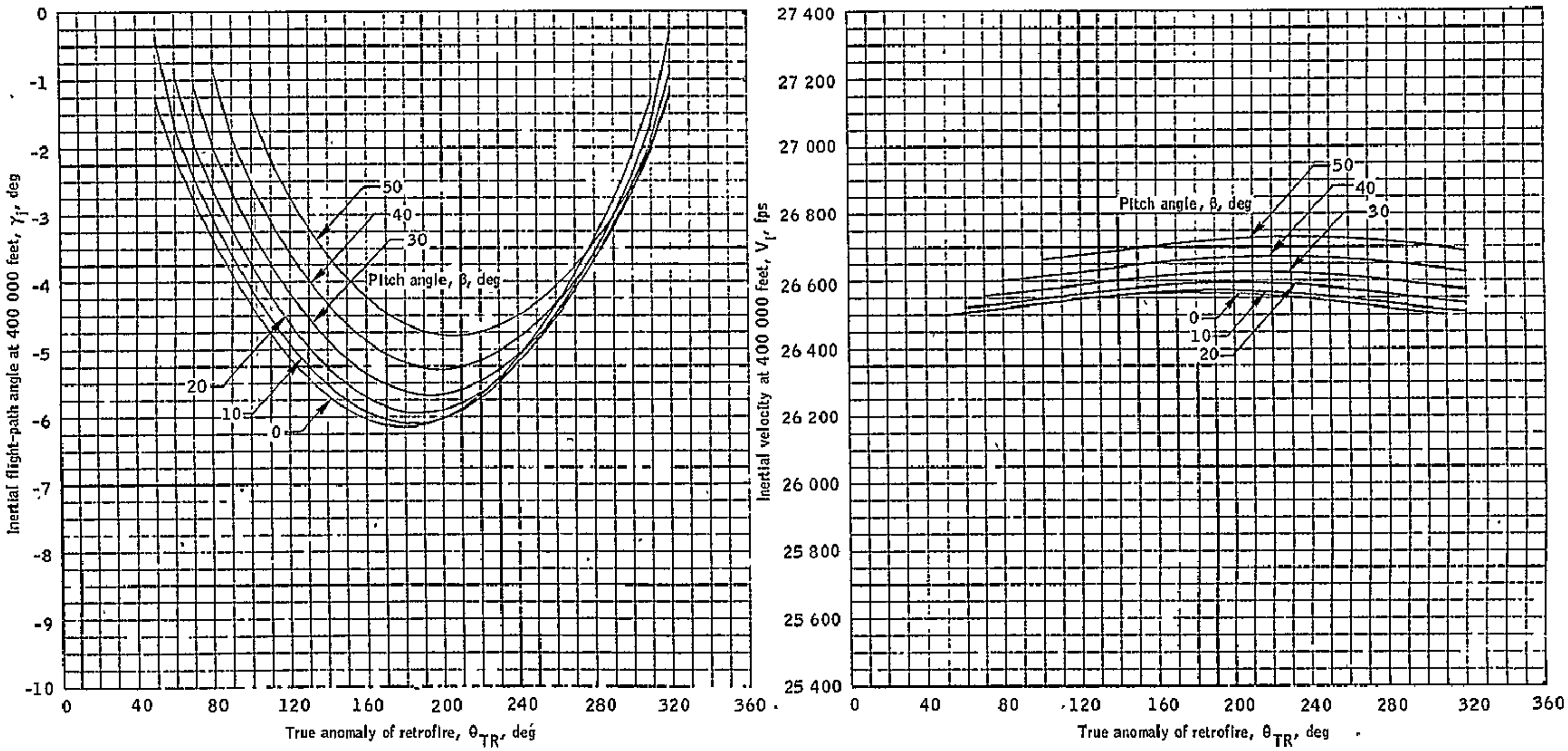
(a) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

Figure 20.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for a 125/800 nautical mile orbit.



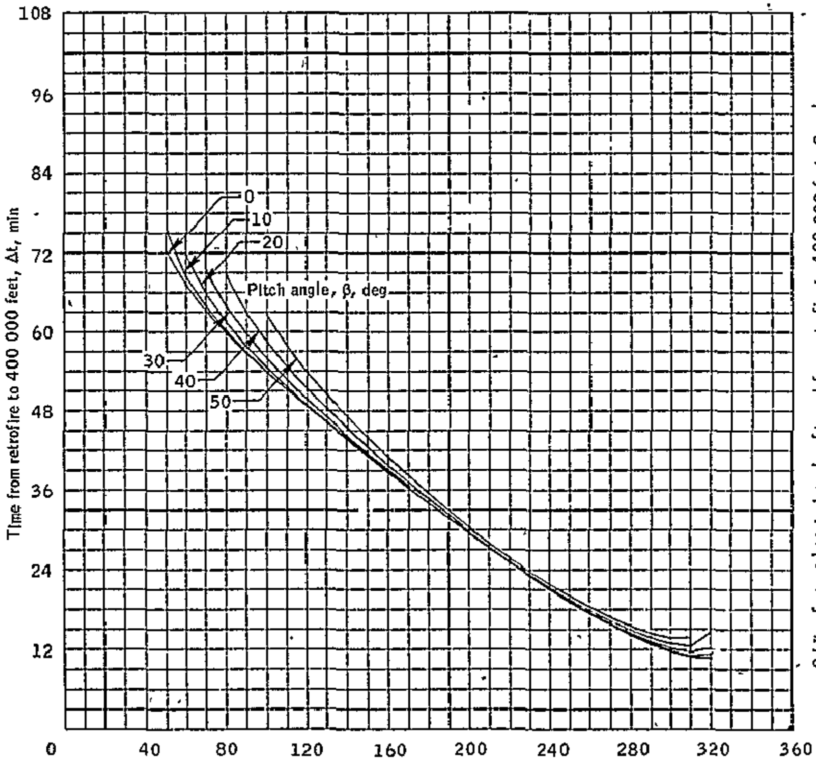
(b) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

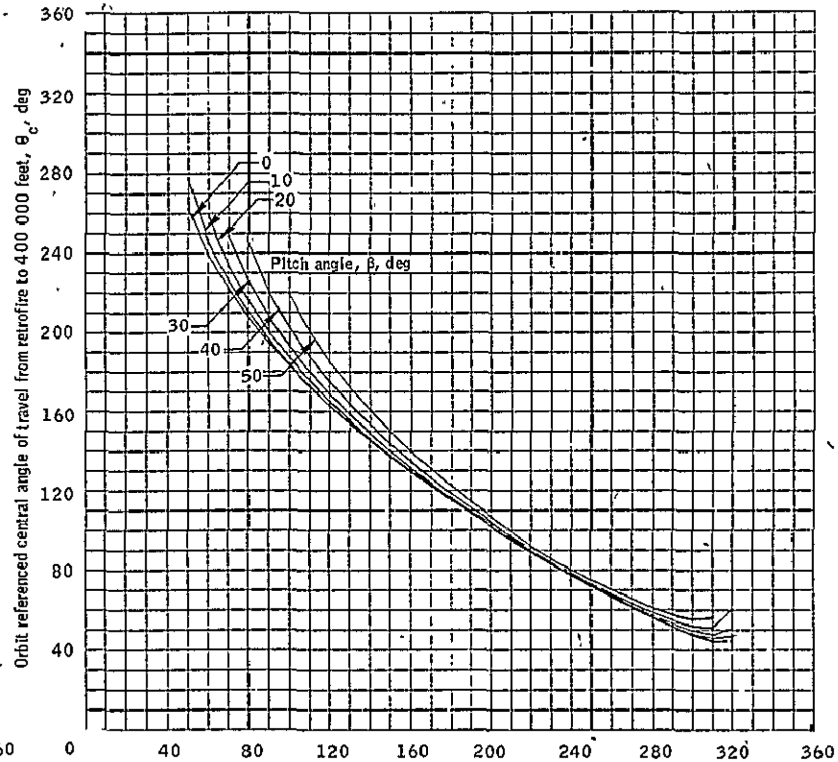
Figure 20.- Continued.



(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

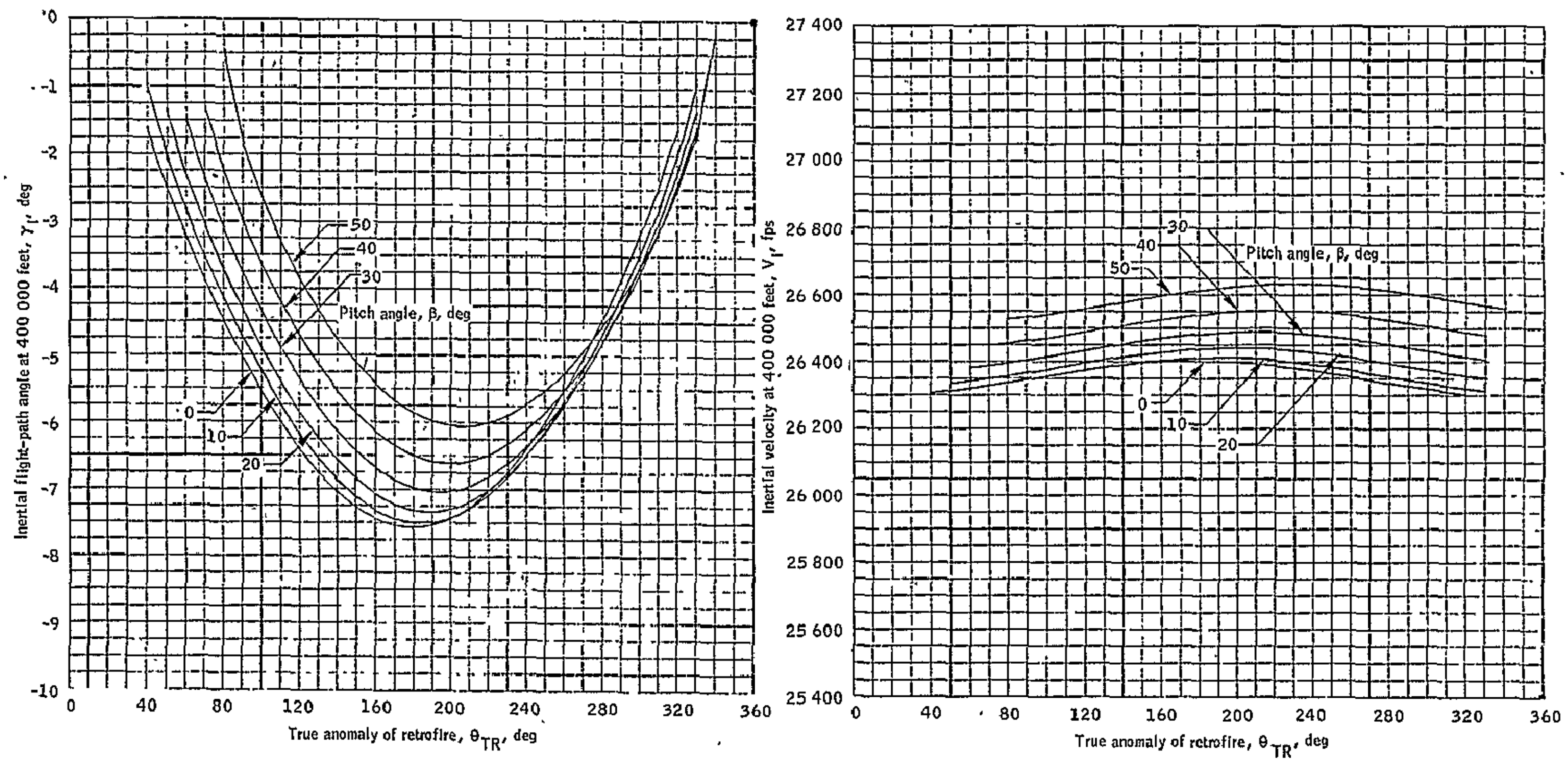
Figure 20.- Continued.





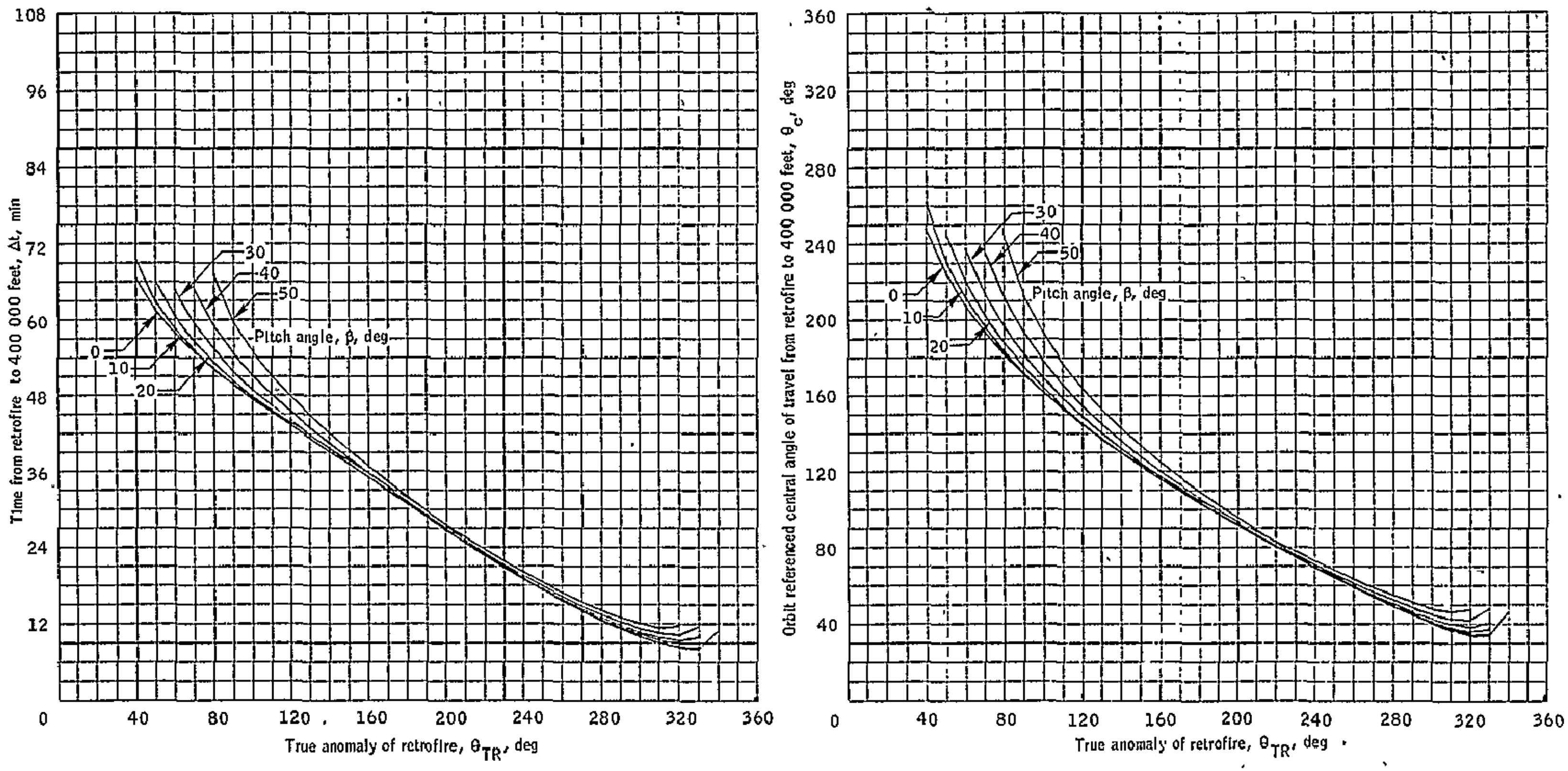
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 20.- Continued.



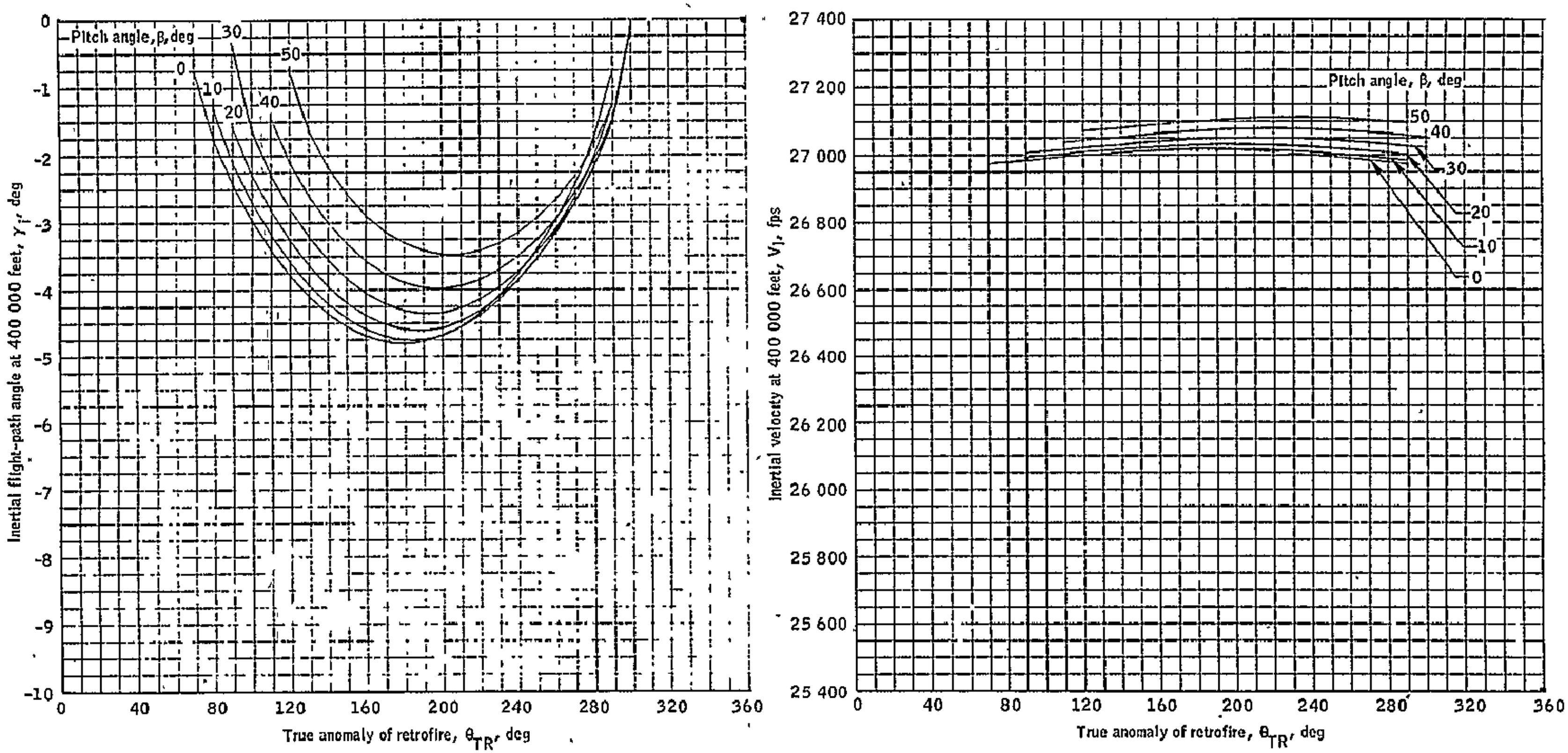
(e) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 20.- Continued.



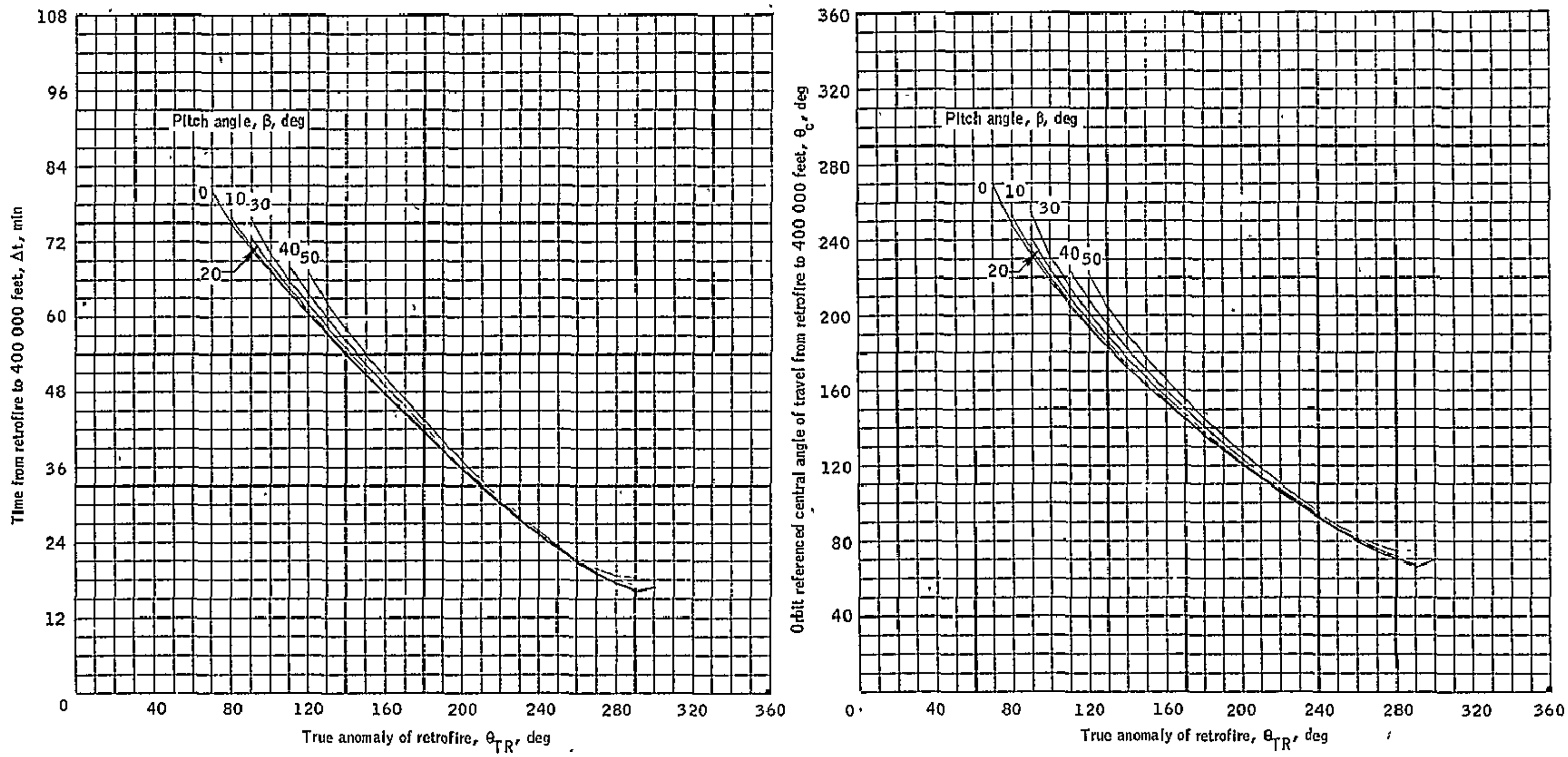
(f) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

Figure 20.- Concluded.



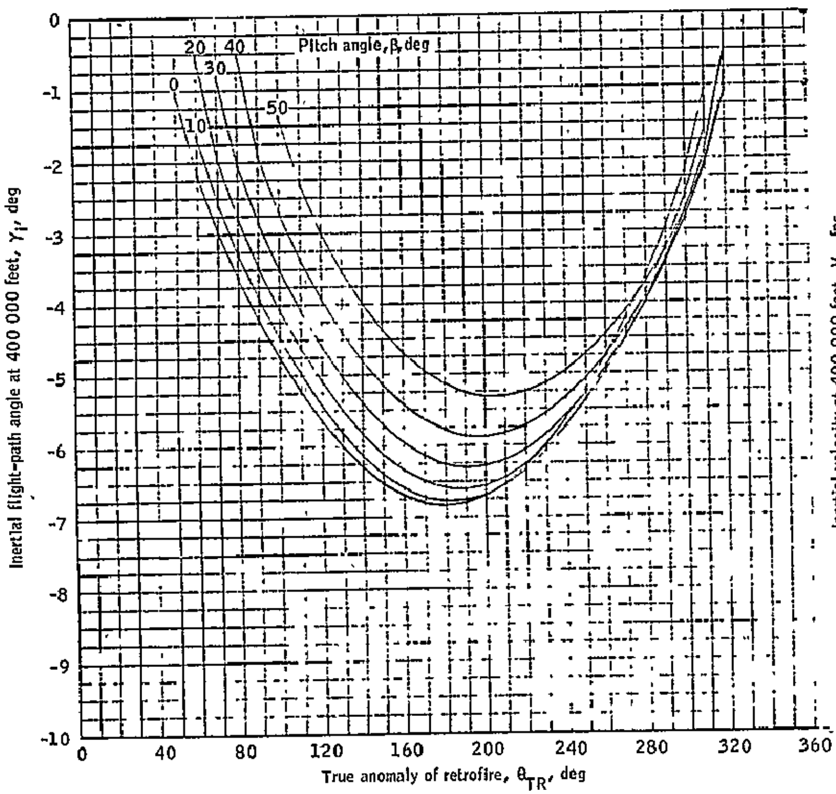
(a) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

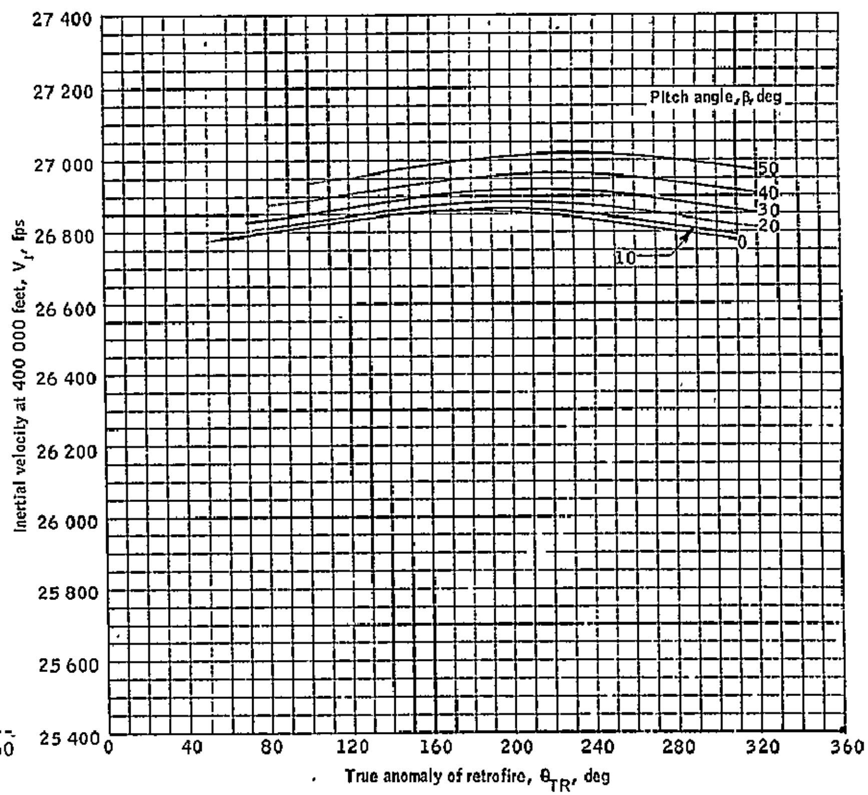
Figure 21.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 125/1000 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

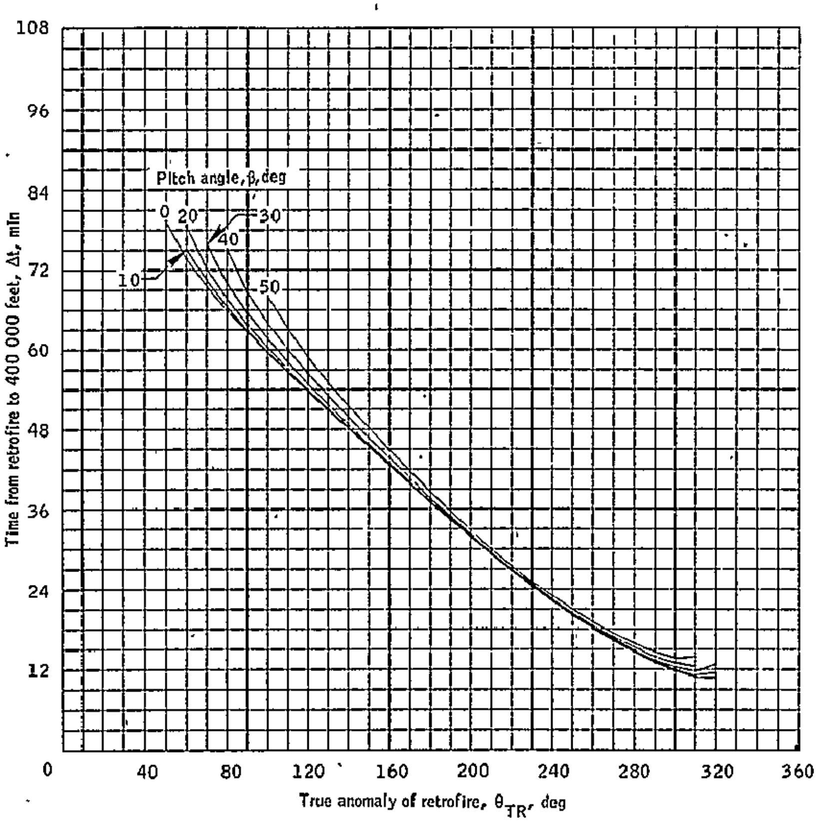
Figure 21.- Continued.

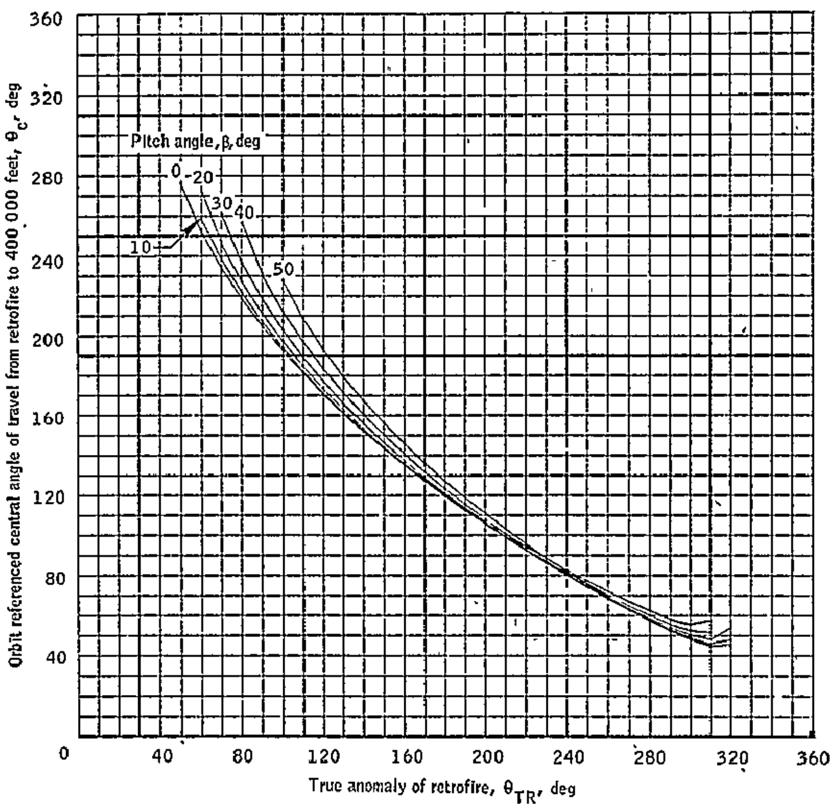




(c) Flight-path angle and velocity for retrograde ΔV=500 feet per second.

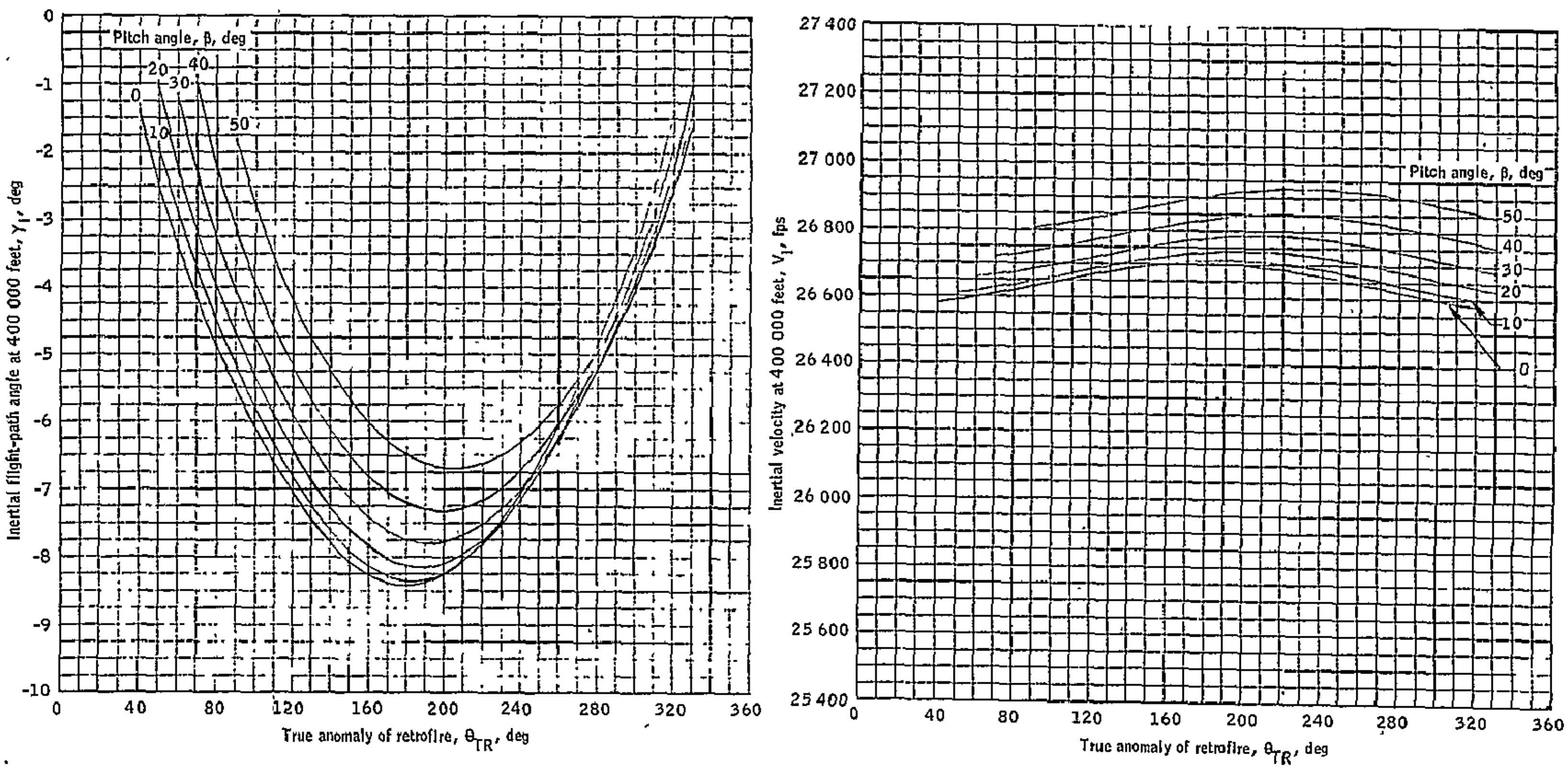
Figure 21.- Continued.





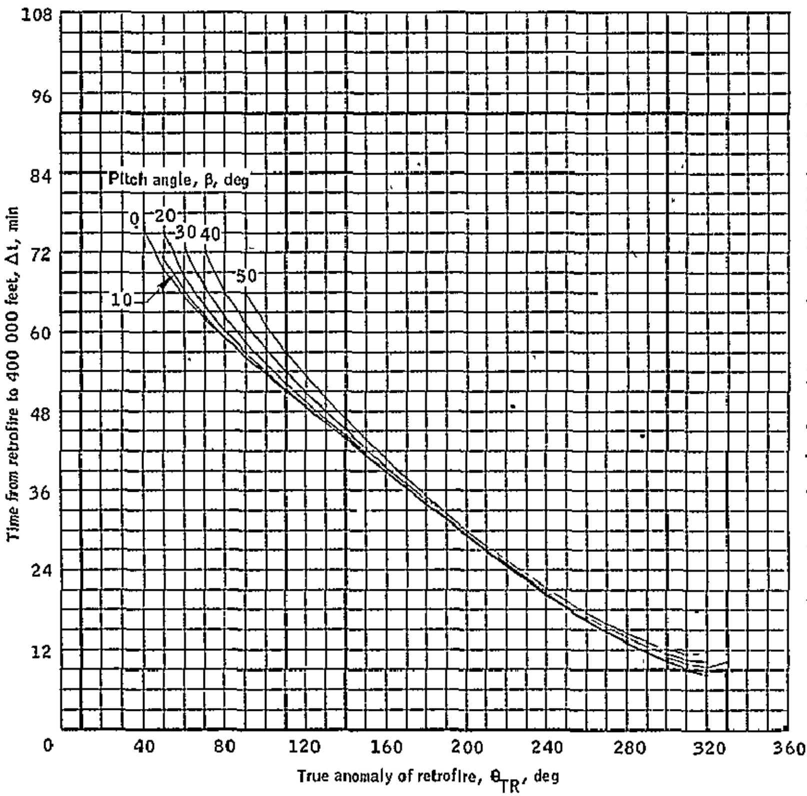
(d) Time from retrofire and central angle for retrograde ΔV=500 feet per second.

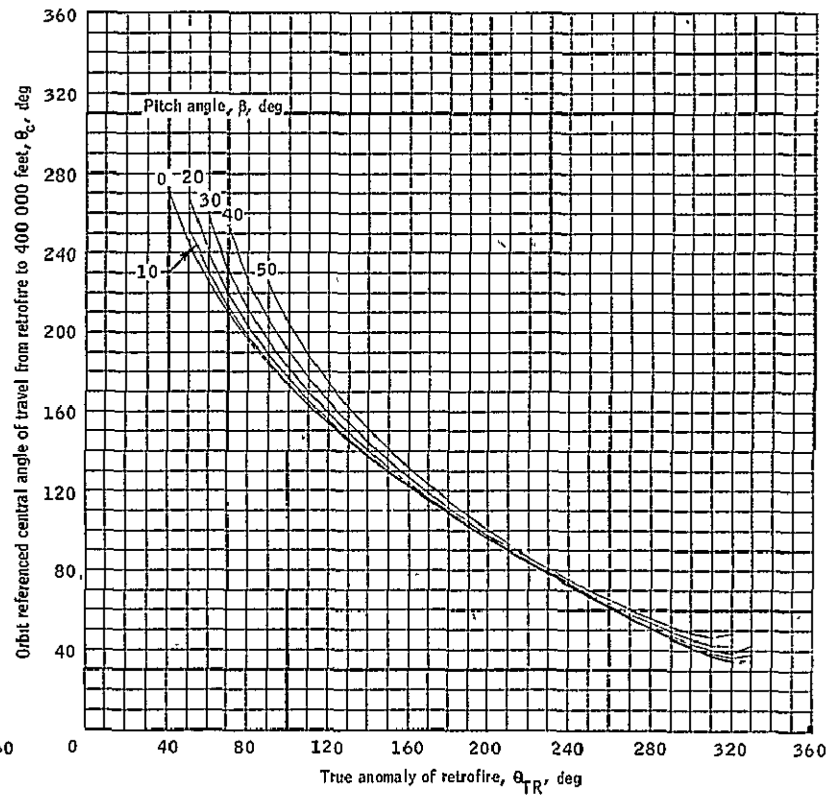
Figure 21.- Continued.



(c) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

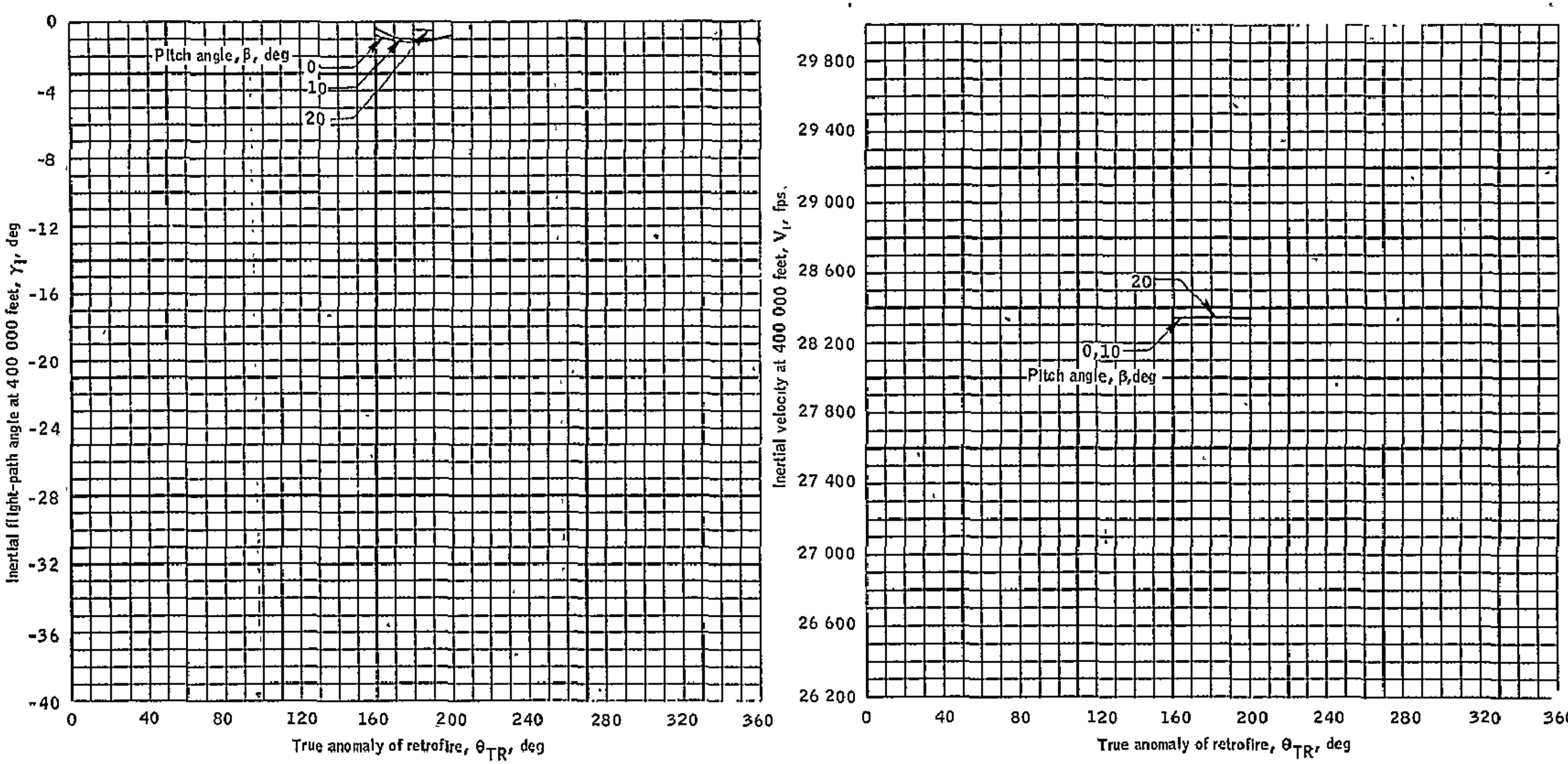
Figure 21.- Continued.





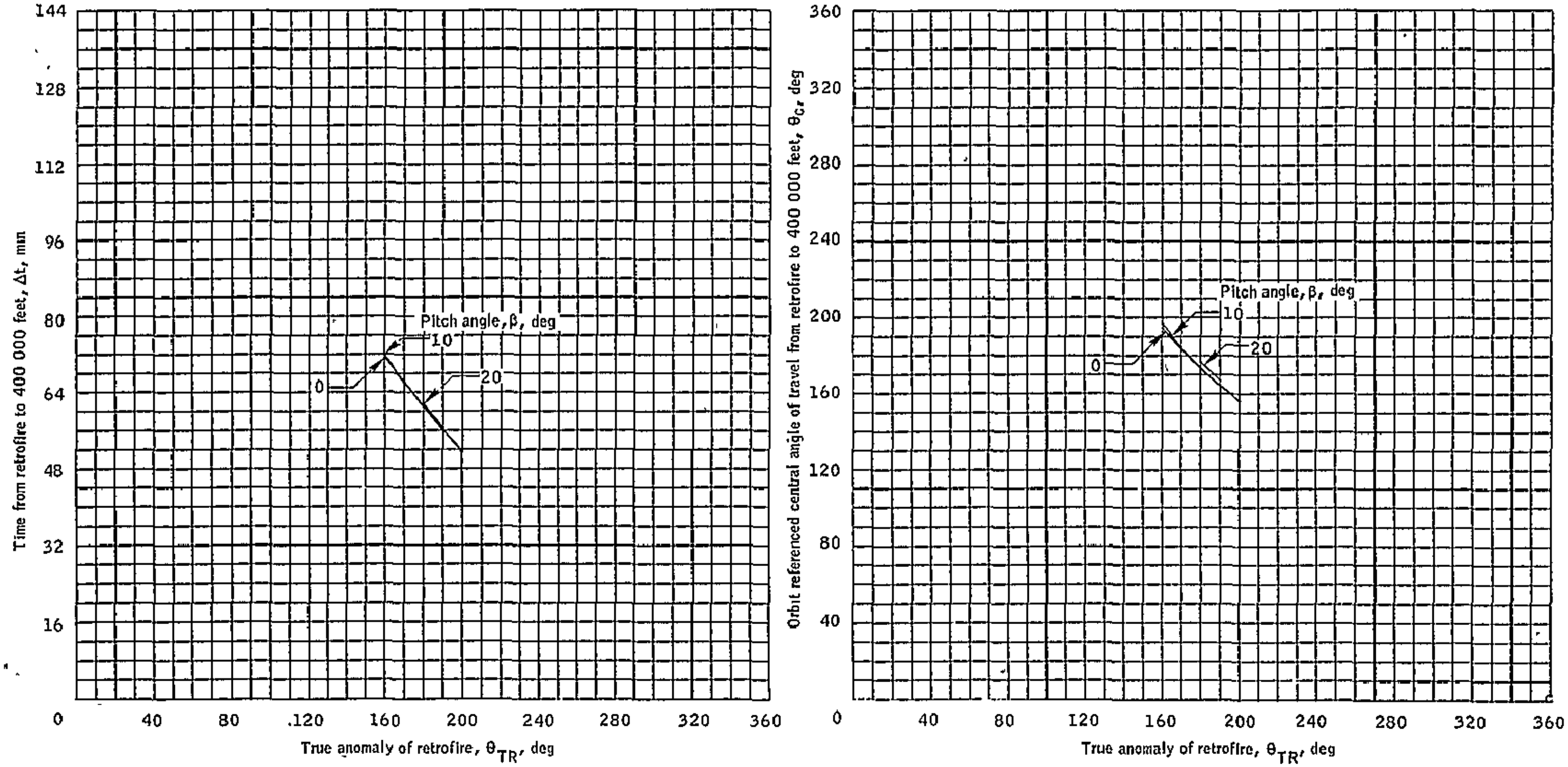
(f) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

Figure 21.- Concluded.



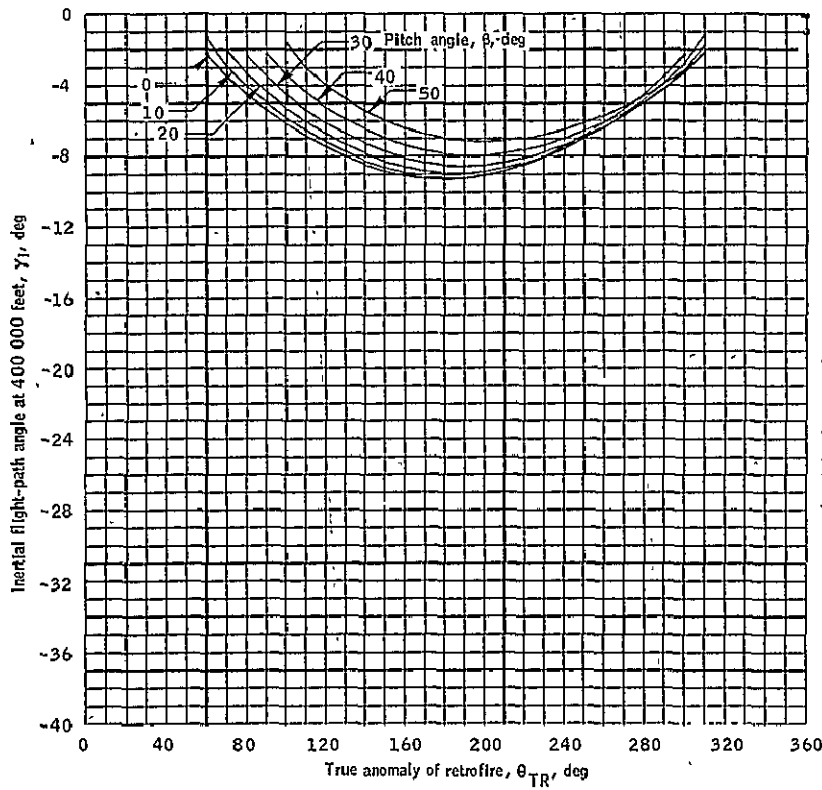
(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

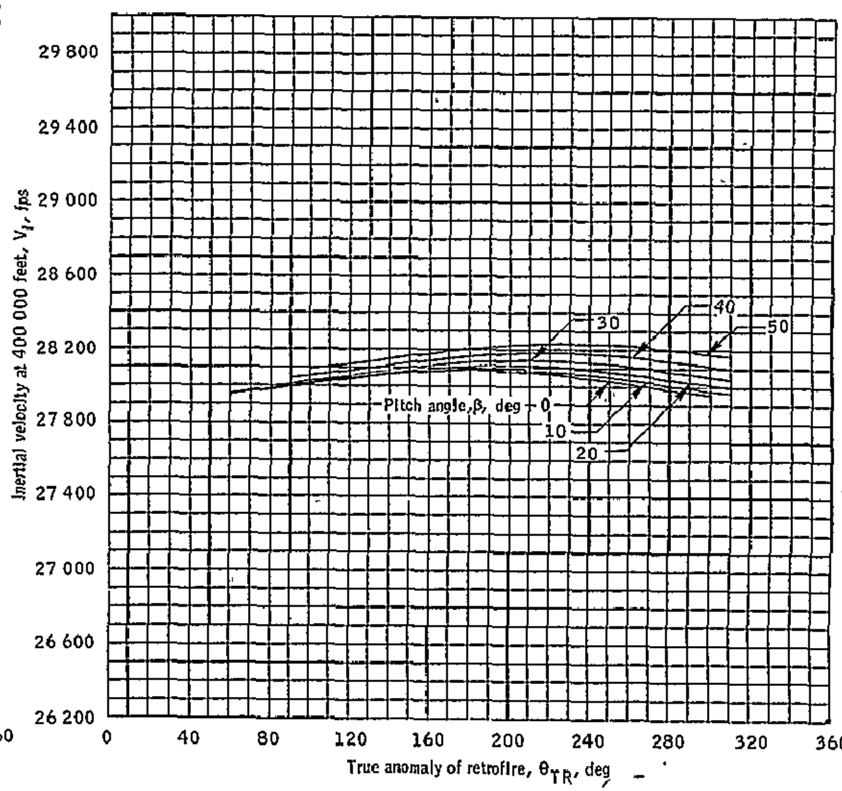
Figure 22.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for a 125/2000 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

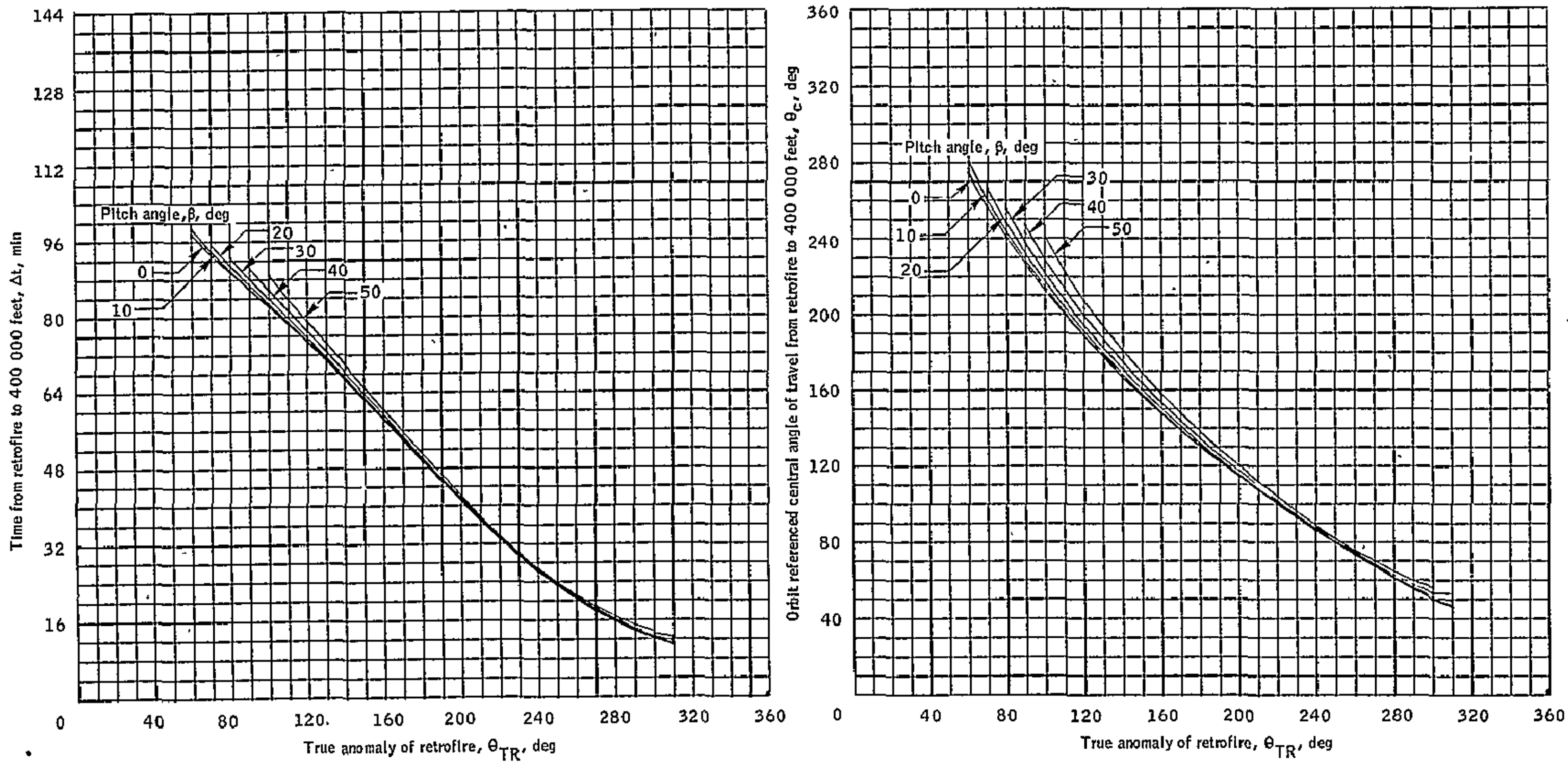
Figure 22.- Continued.





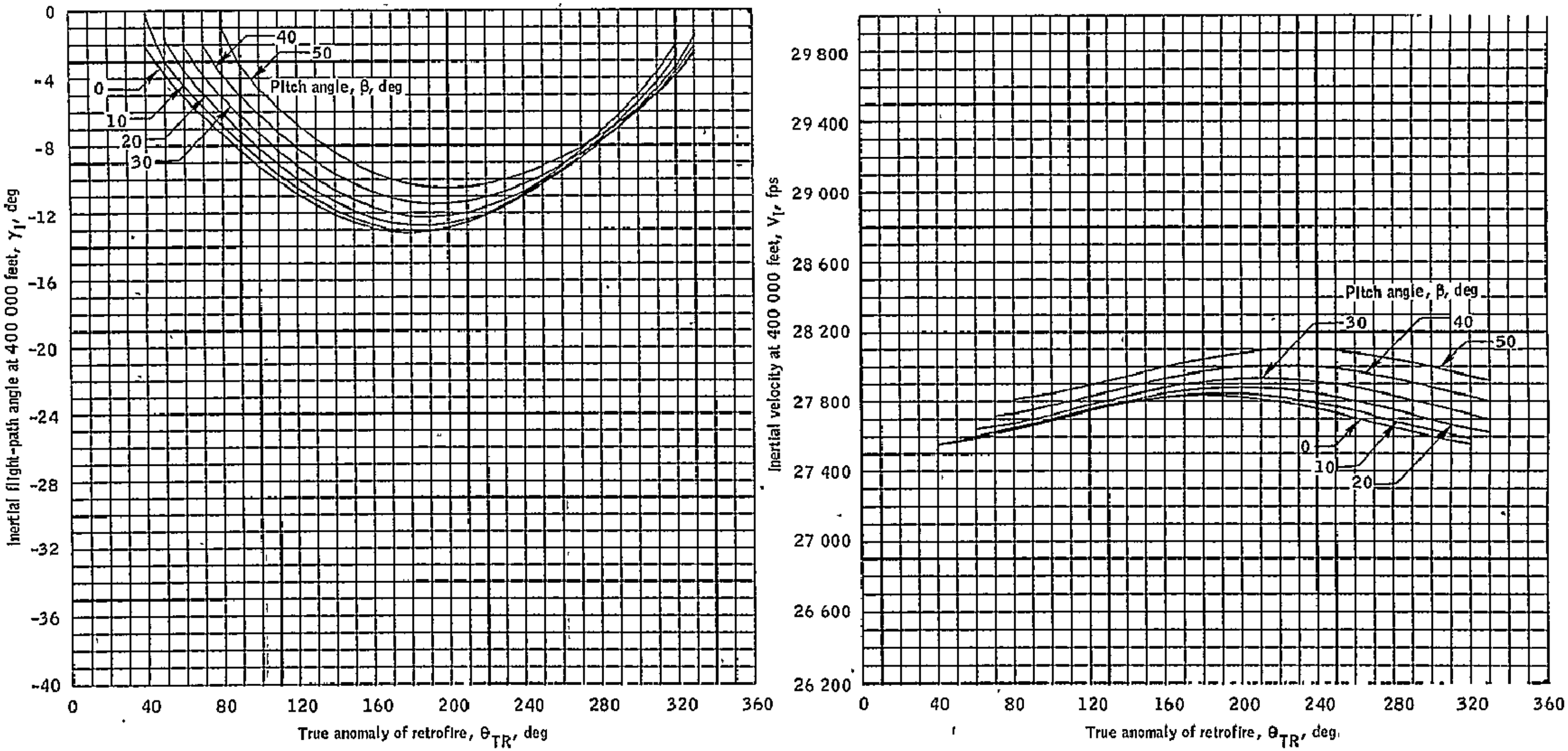
(c) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

Figure 22.- Continued.



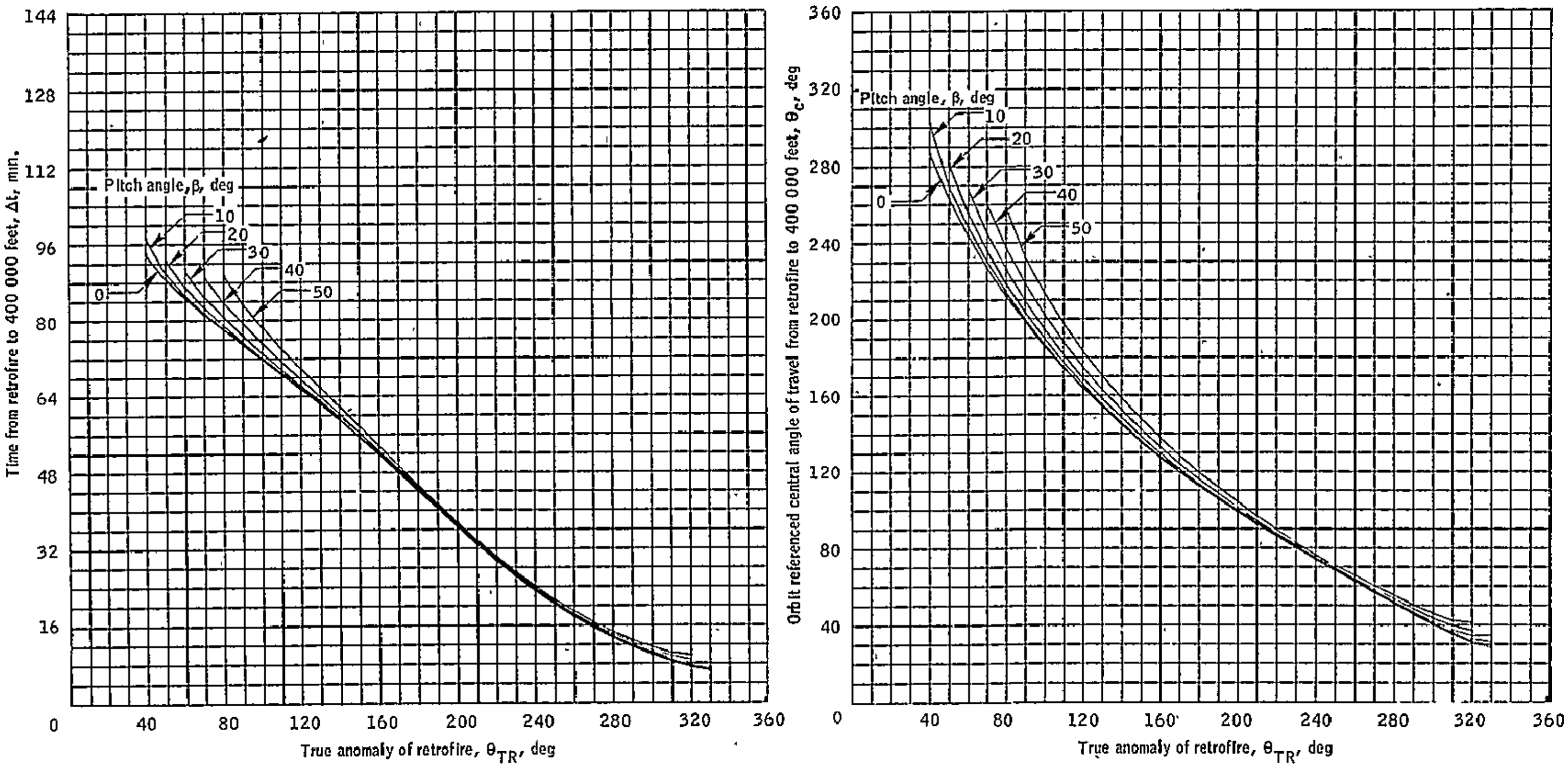
(d) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

Figure 22.- Continued.



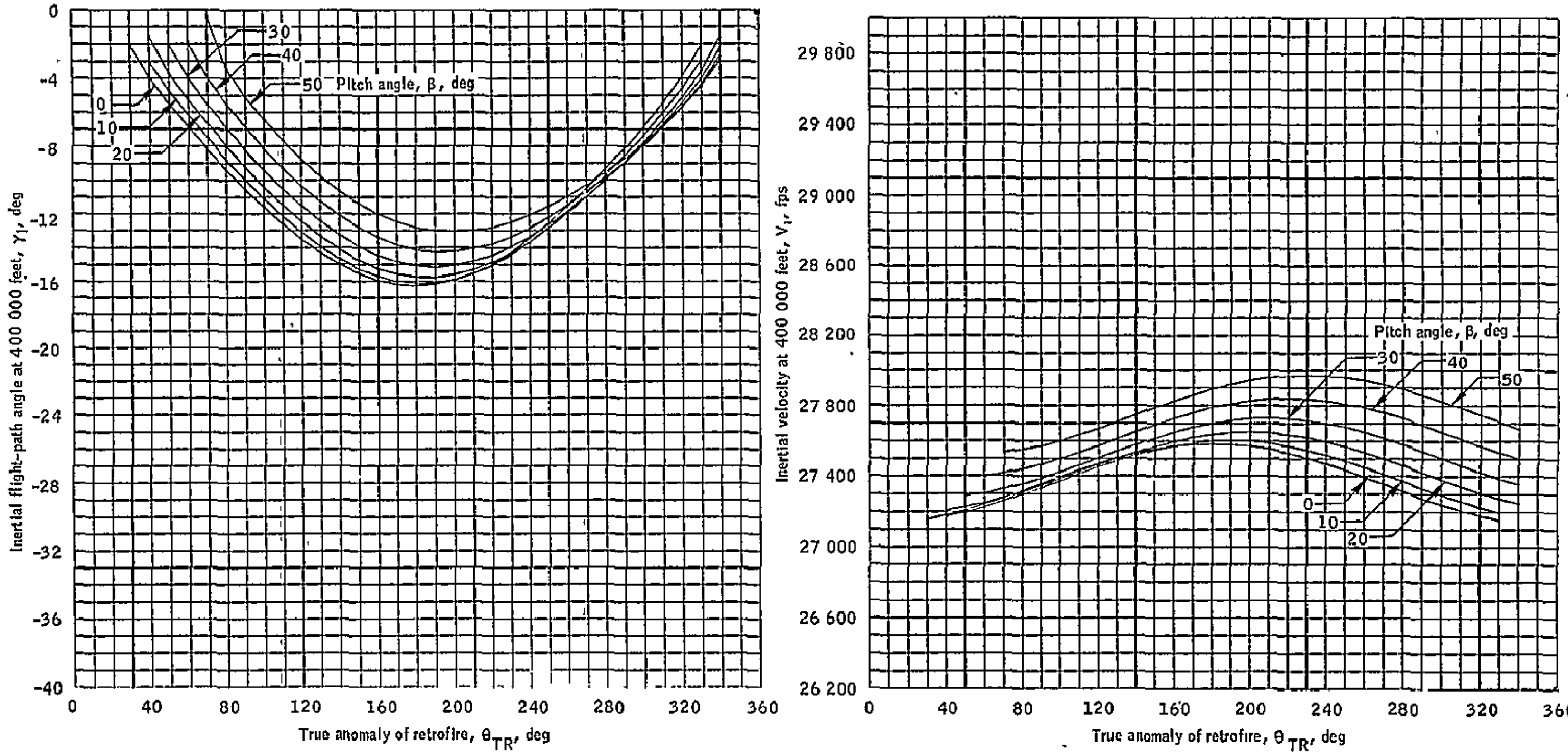
(e) Flight-path angle and velocity for retrograde $\Delta V = 900$ feet per second.

Figure 22.- Continued.



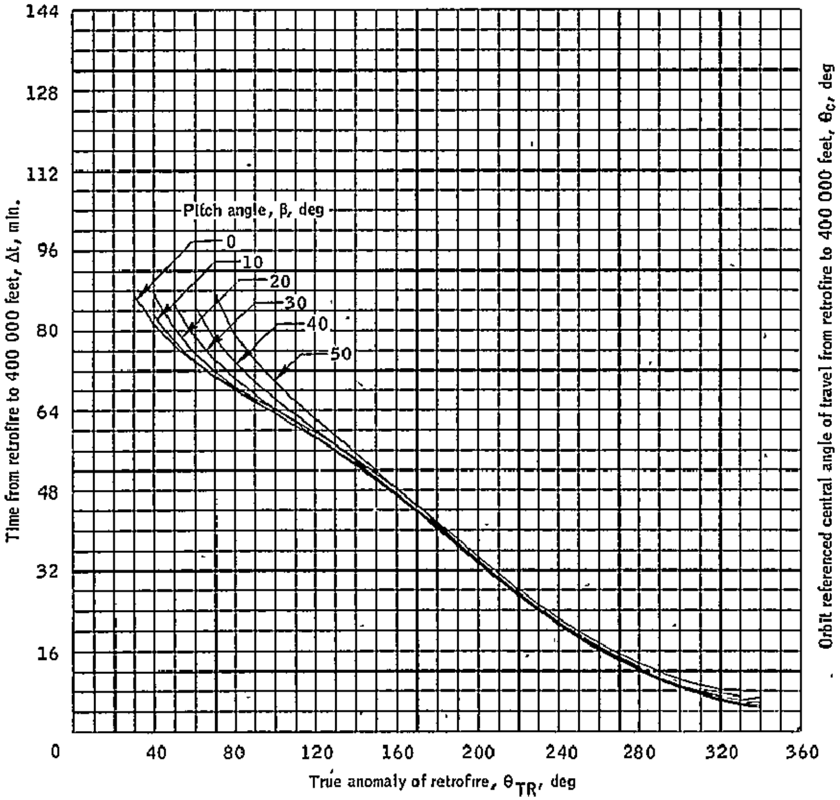
(f) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

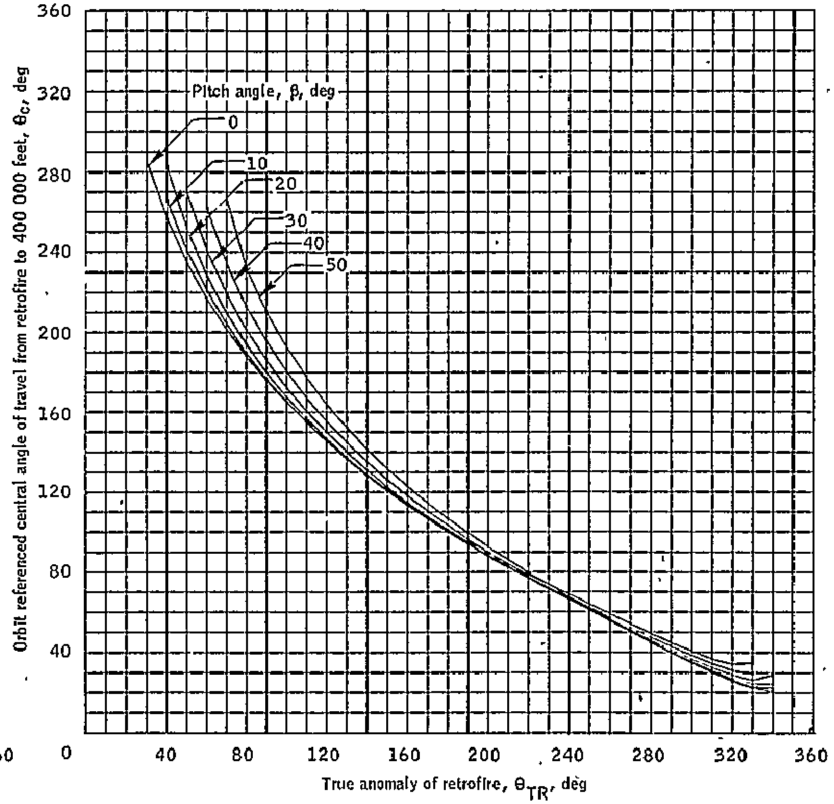
Figure 22.- Continued.



(g) Flight-path angle and velocity for retrograde ΔV = 1300 feet per second.

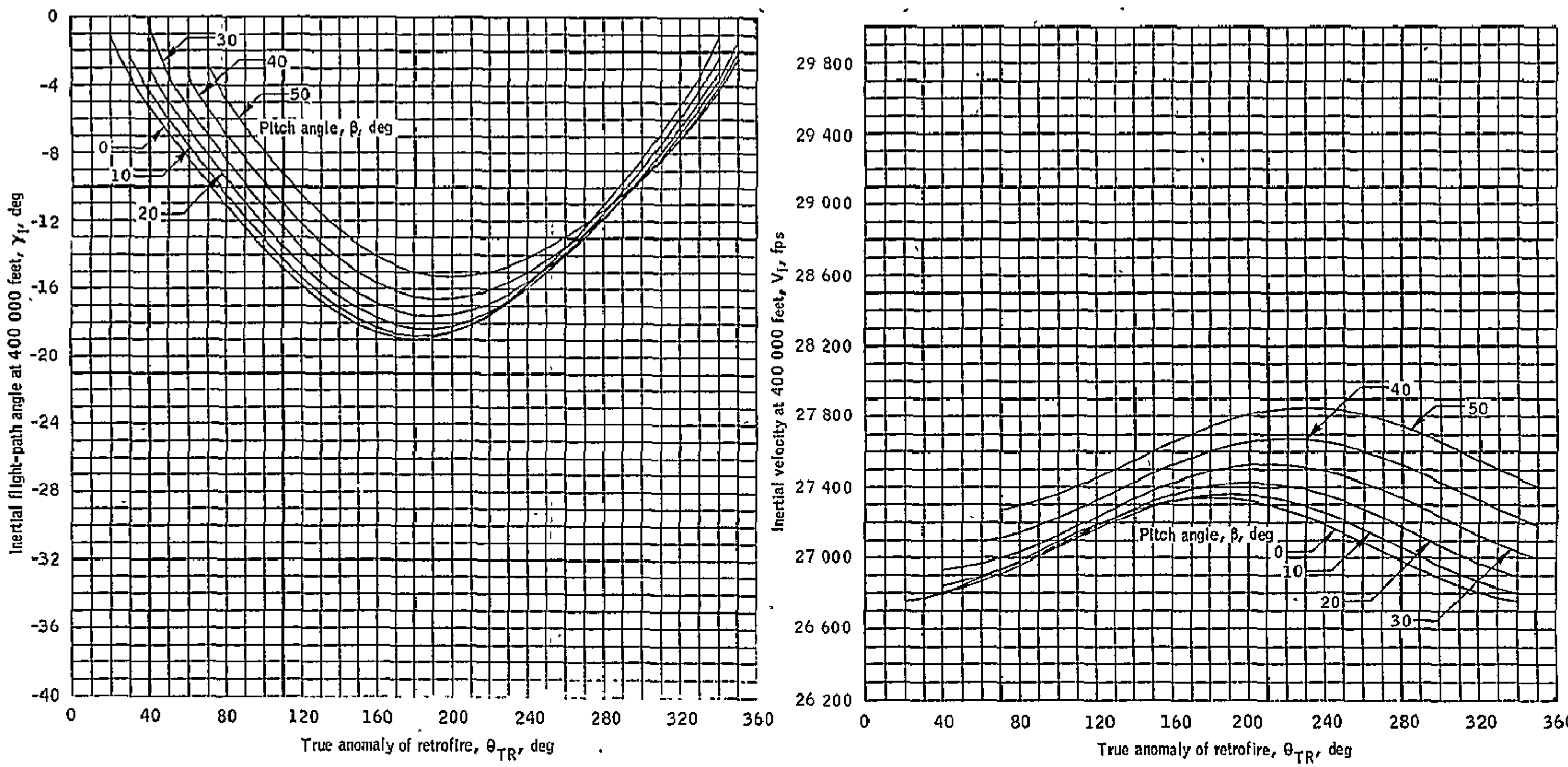
Figure 22.- Continued.





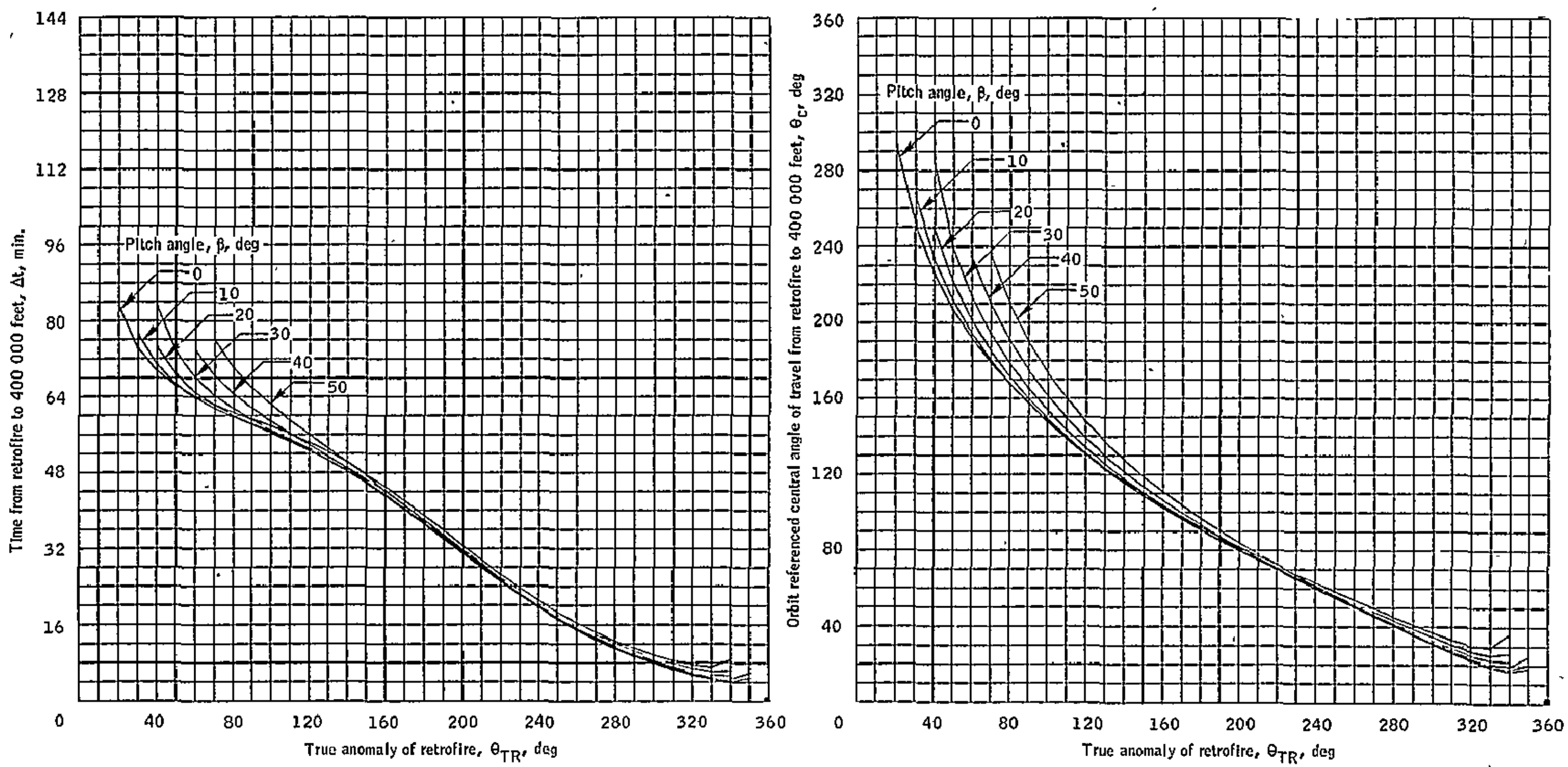
(h) Time from retrofire and central angle for retrograde ΔV = 1300 feet per second.

Figure 22.- Continued.



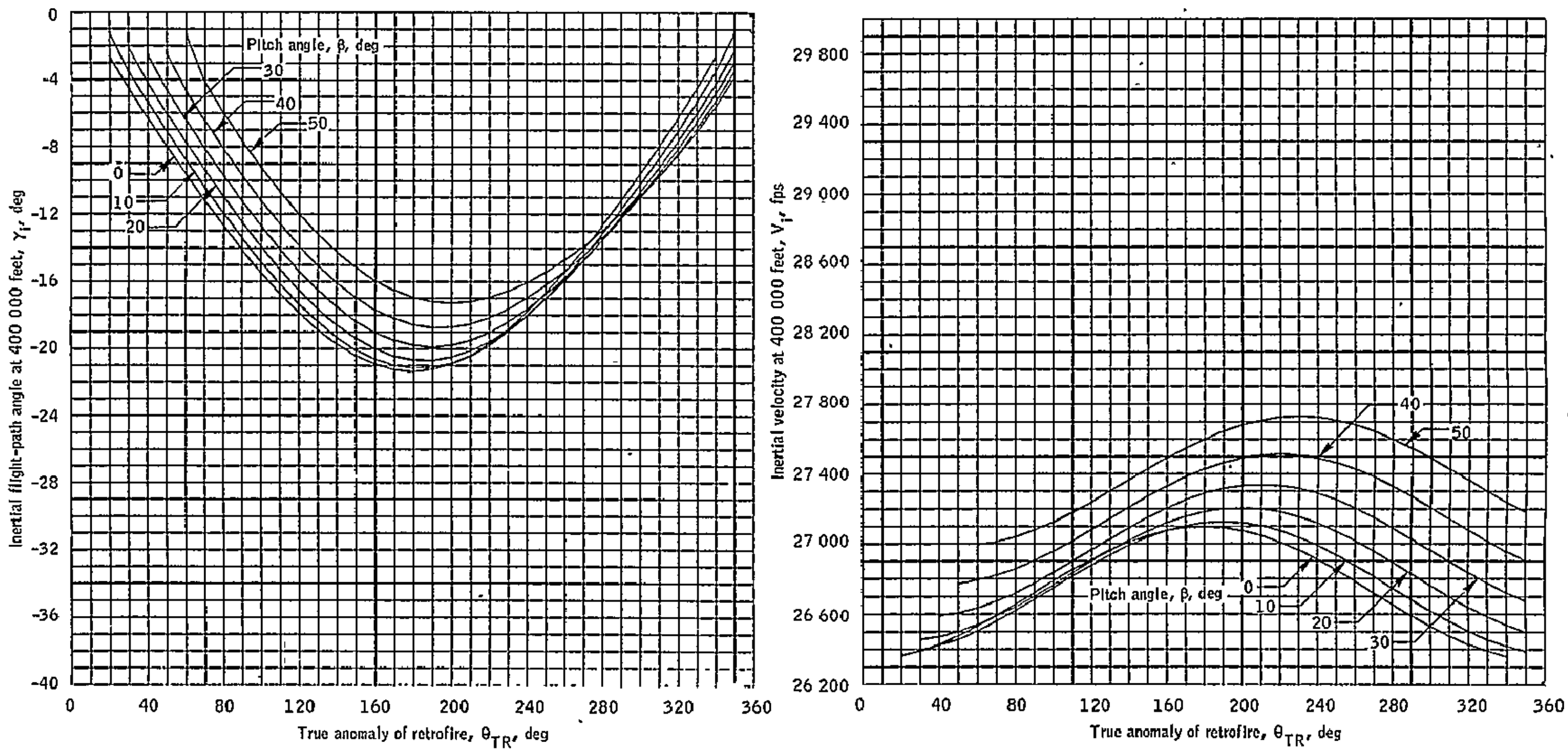
(l) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

Figure 22.- Continued.



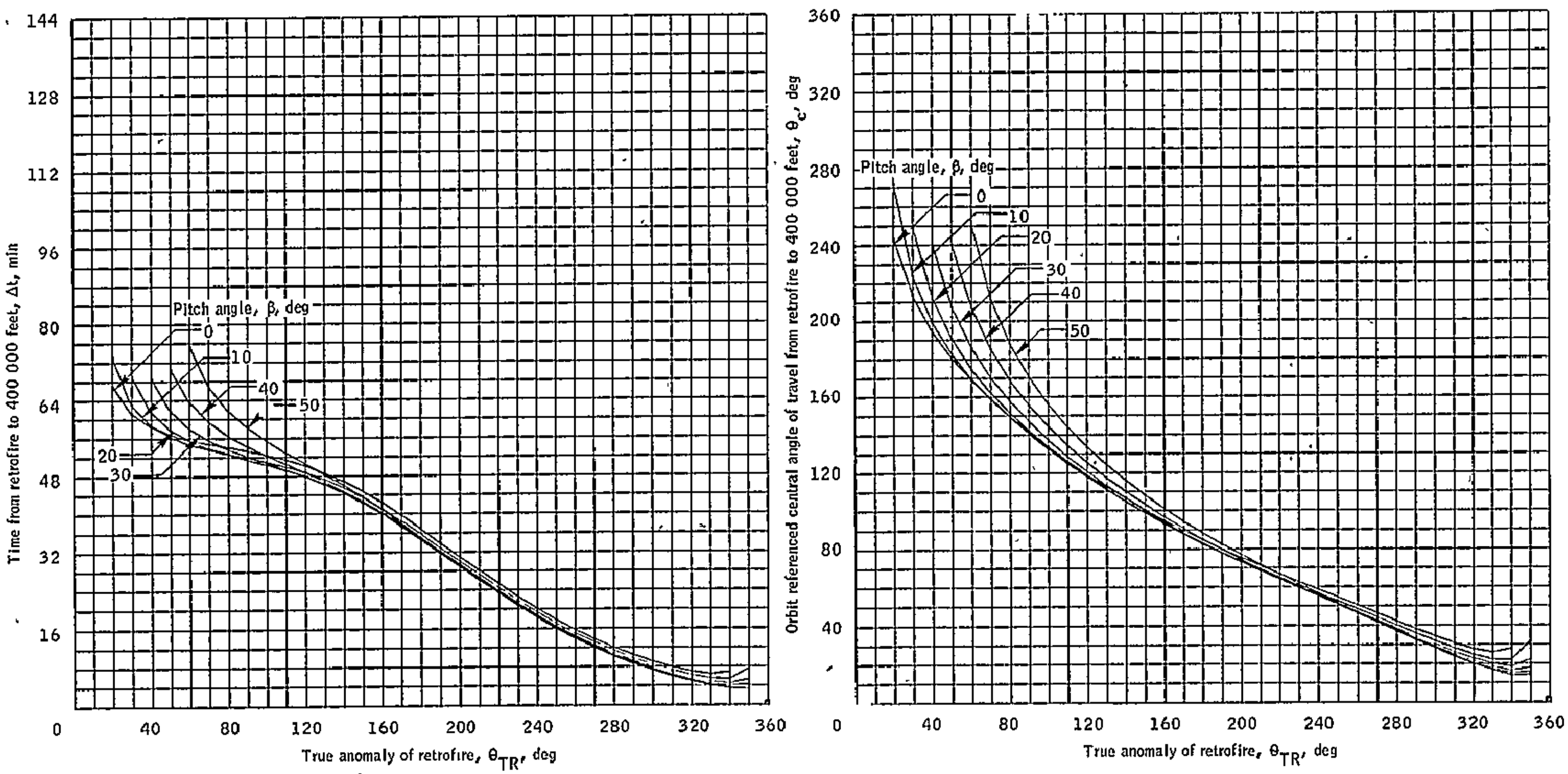
(j) Time from retrofire and central angle for retrograde ΔV = 1700 feet per second.

Figure 22.- Continued.



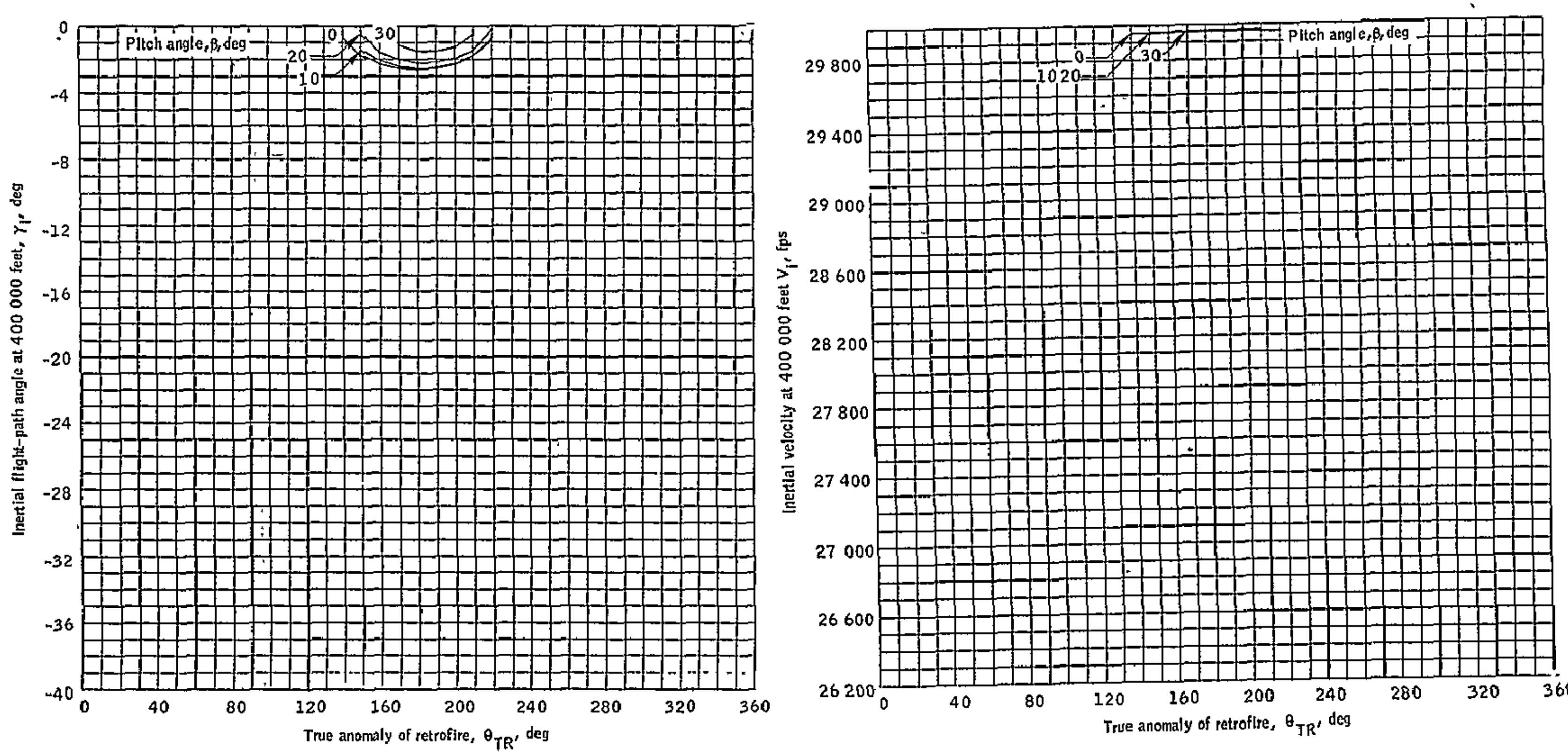
(k) Flight-path angle and velocity for retrograde ΔV = 2100 feet per second.

Figure 22.- Continued.



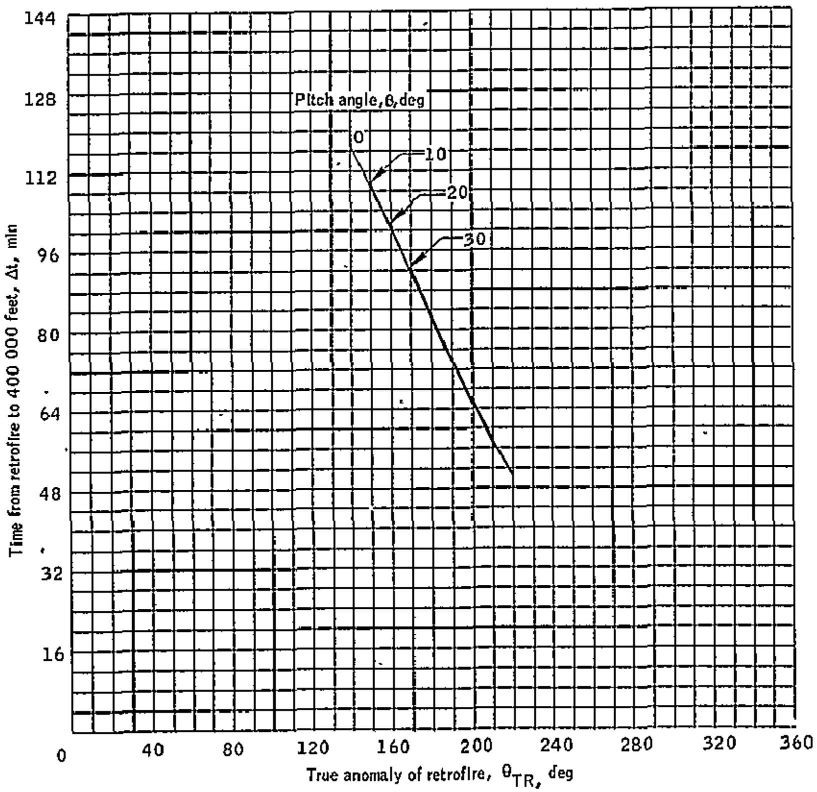
(l) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

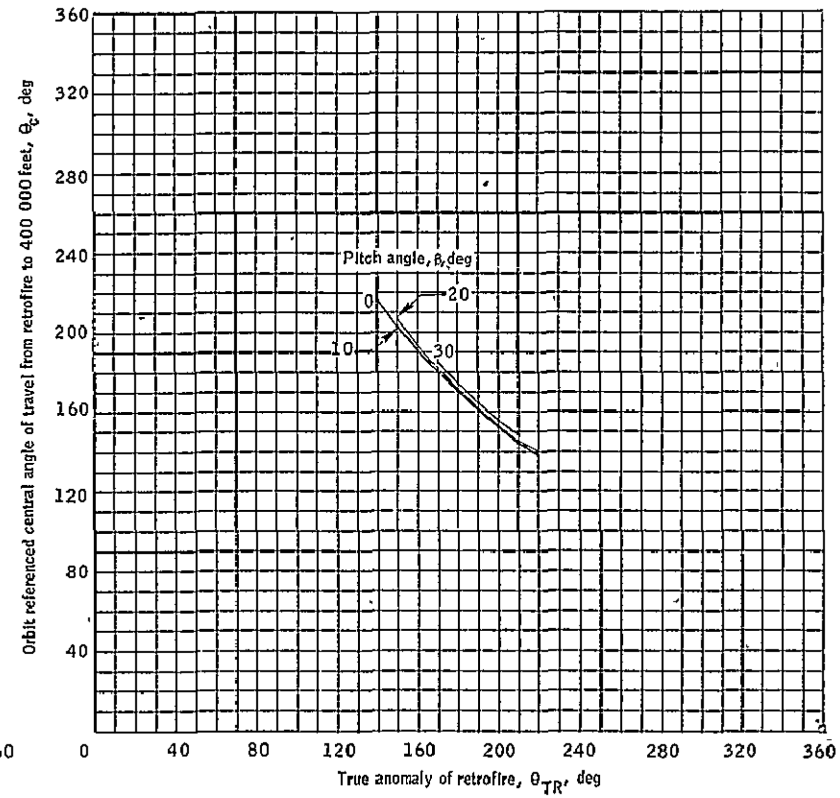
Figure 22.- Concluded.



(a) Flight-path angle and velocity for retrograde ΔV = 100 feet per second.

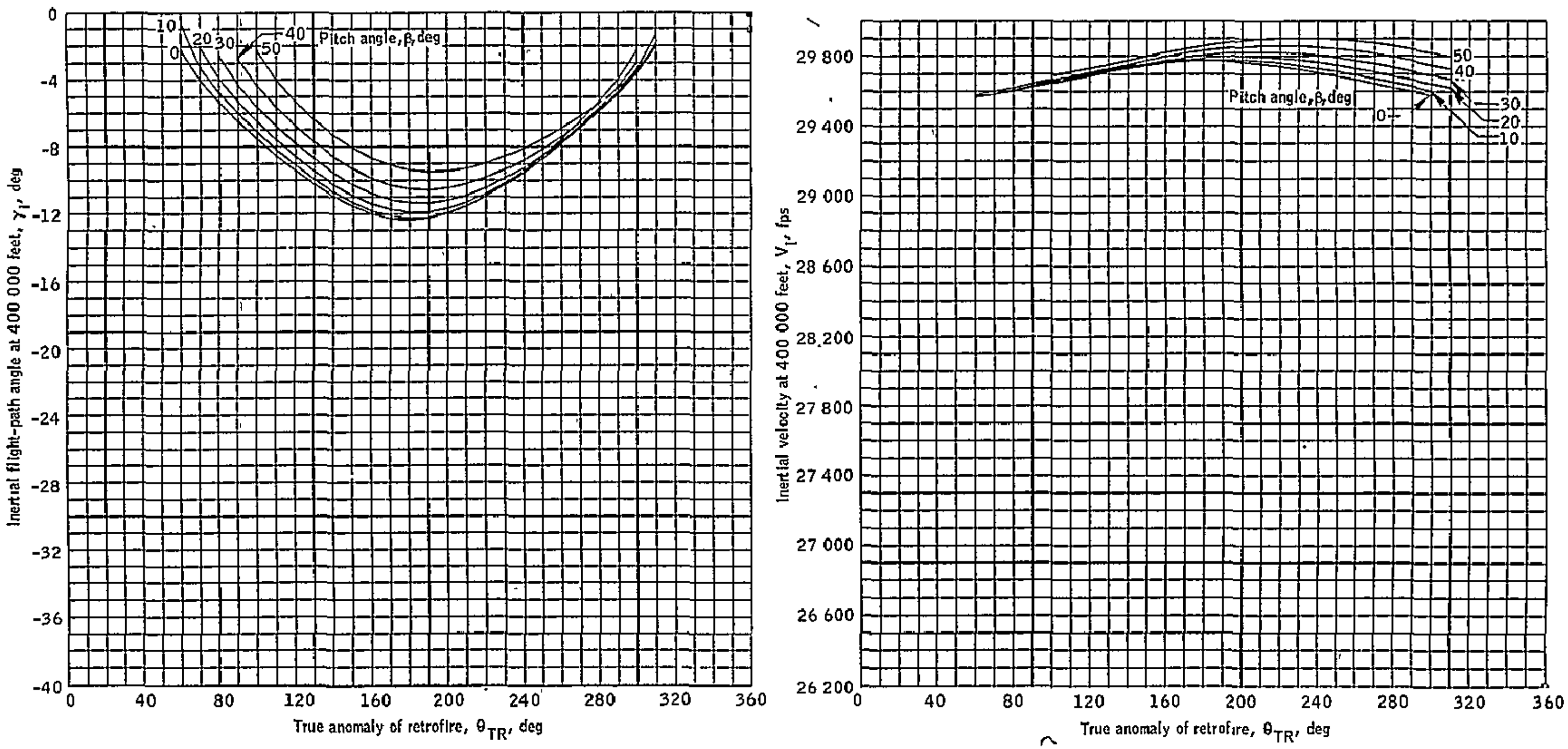
Figure 23.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 125/4000 nautical mile orbit.





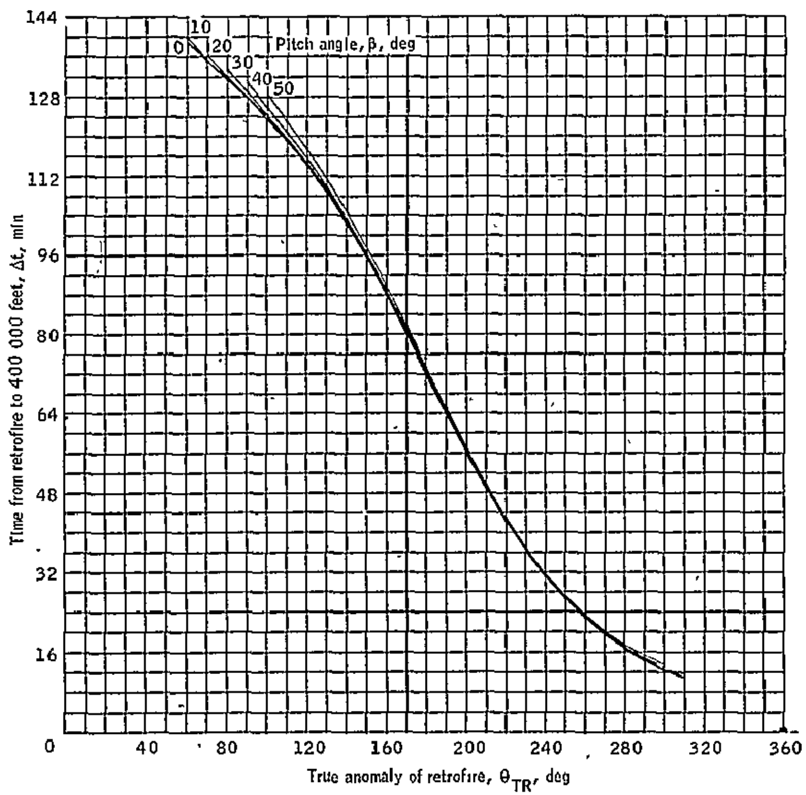
(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

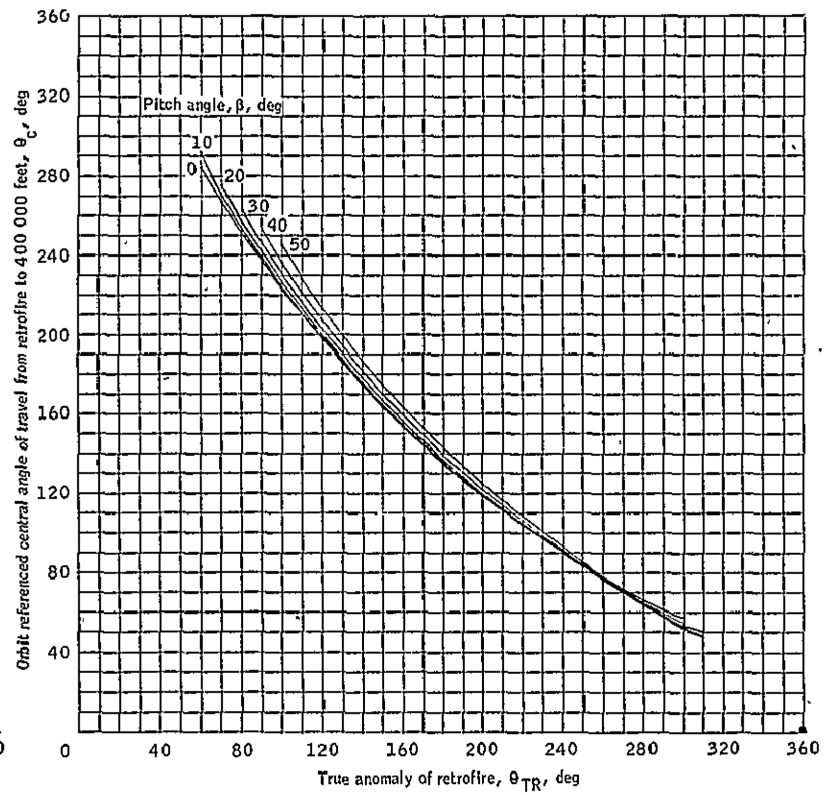
Figure 23.- Continued.



(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

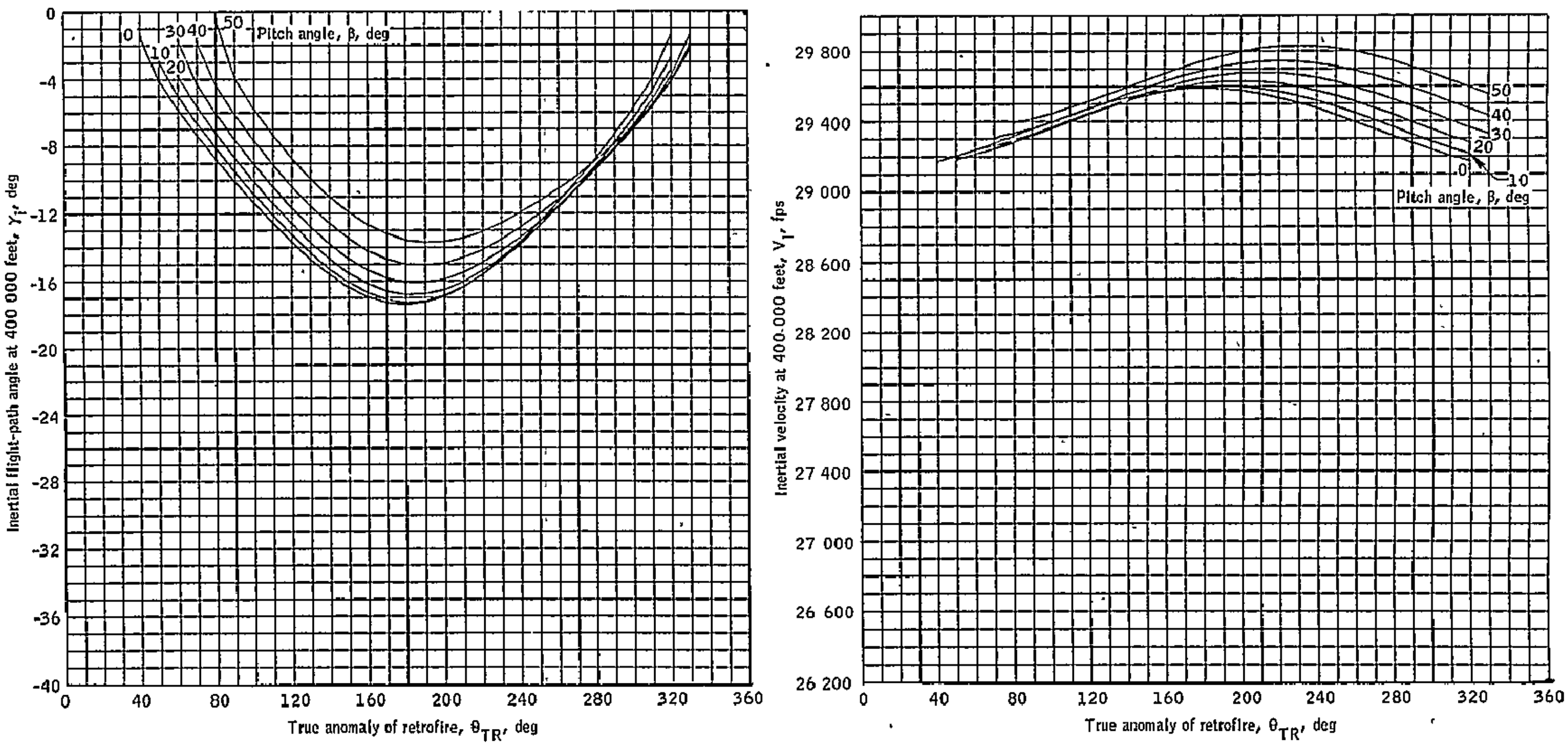
Figure 23.- Continued.





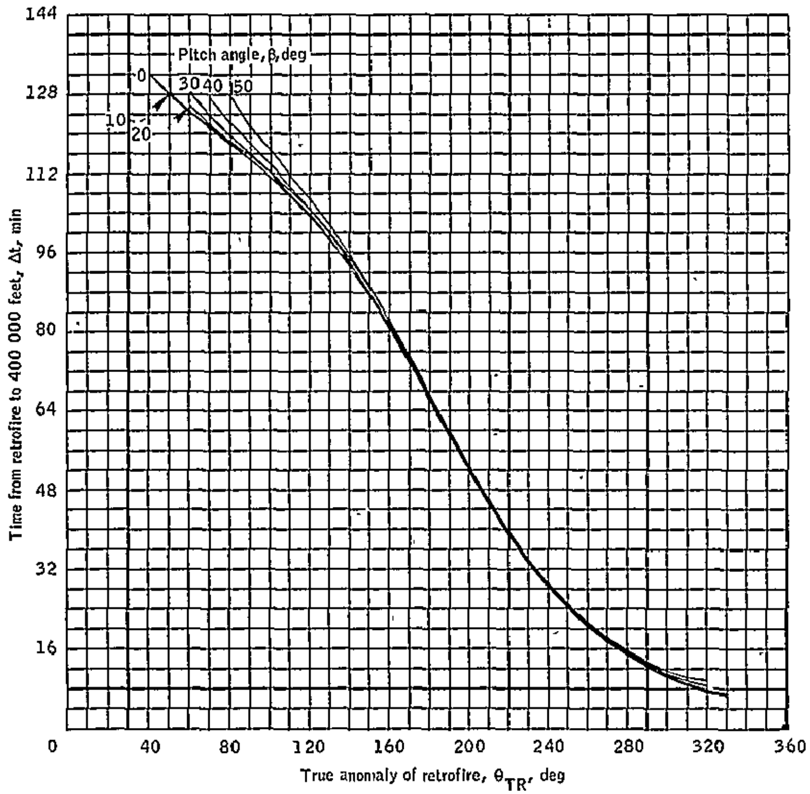
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

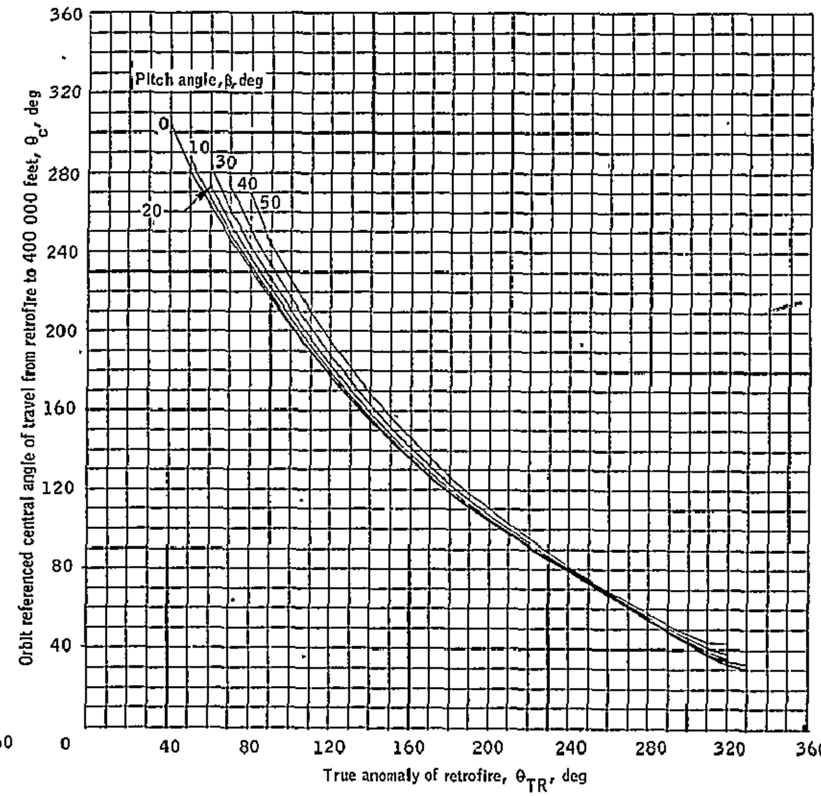
Figure 23.- Continued.



(e) Flight-path angle and velocity for retrograde $\Delta V = 900$ feet per second.

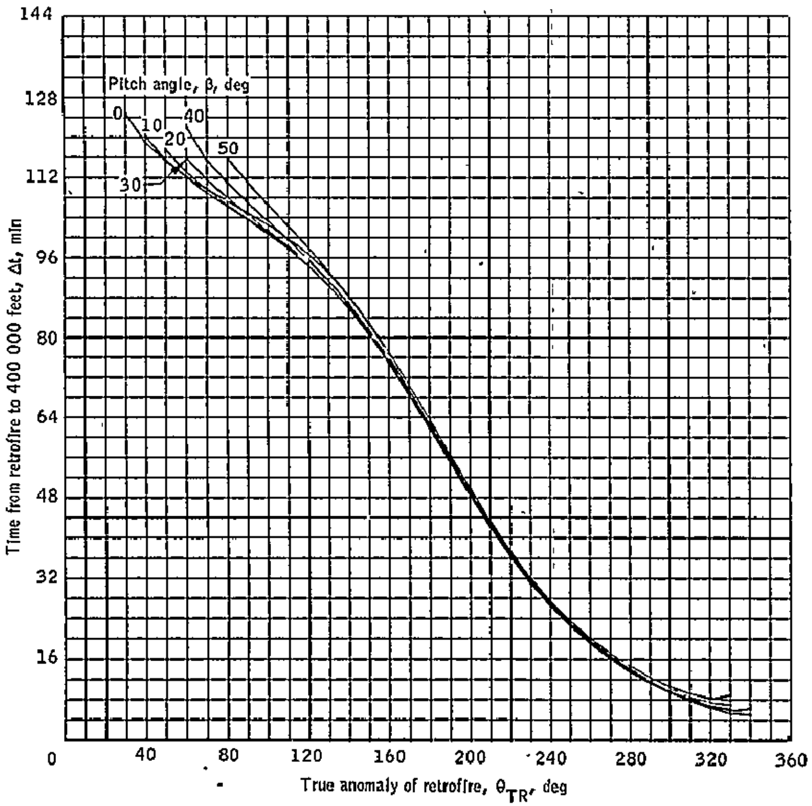
Figure 23.- Continued.

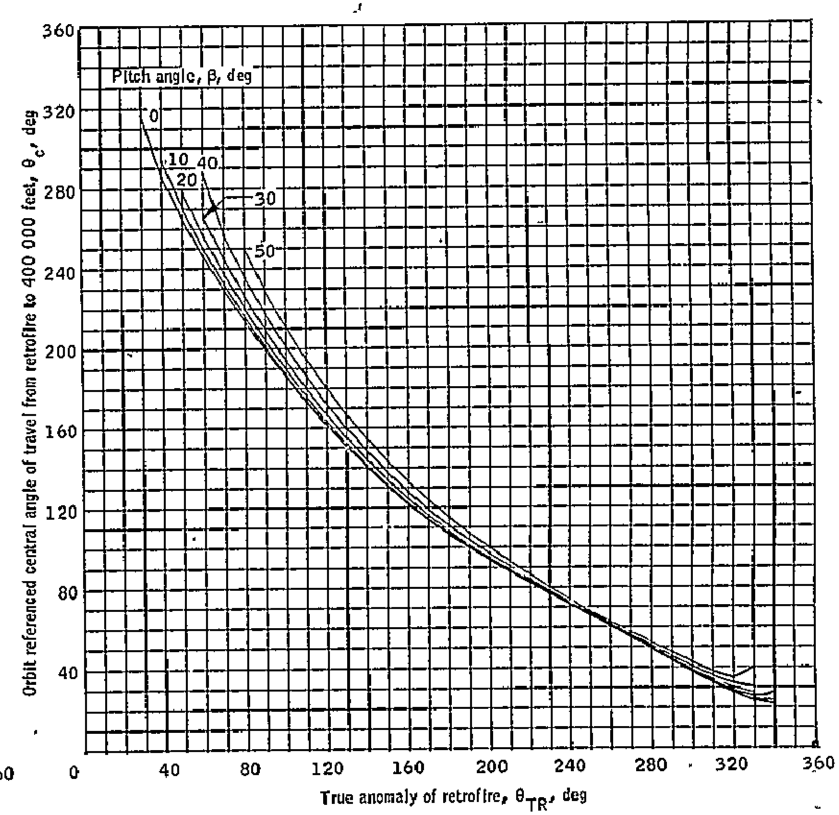




(f) Time from retrofire and central angle for retrograde ΔV = 900 feet per second.

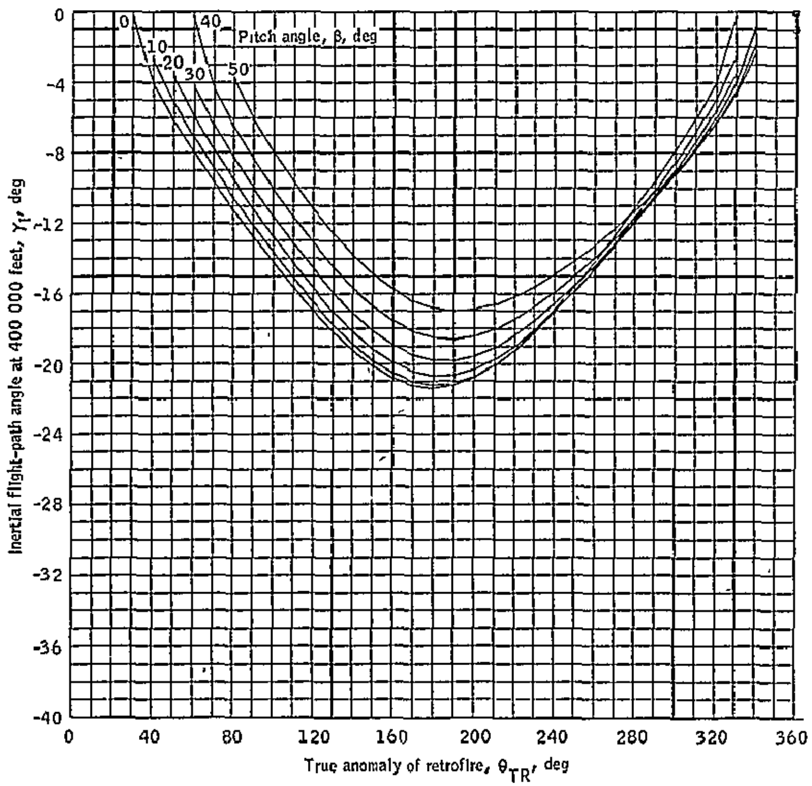
Figure 23.- Continued.

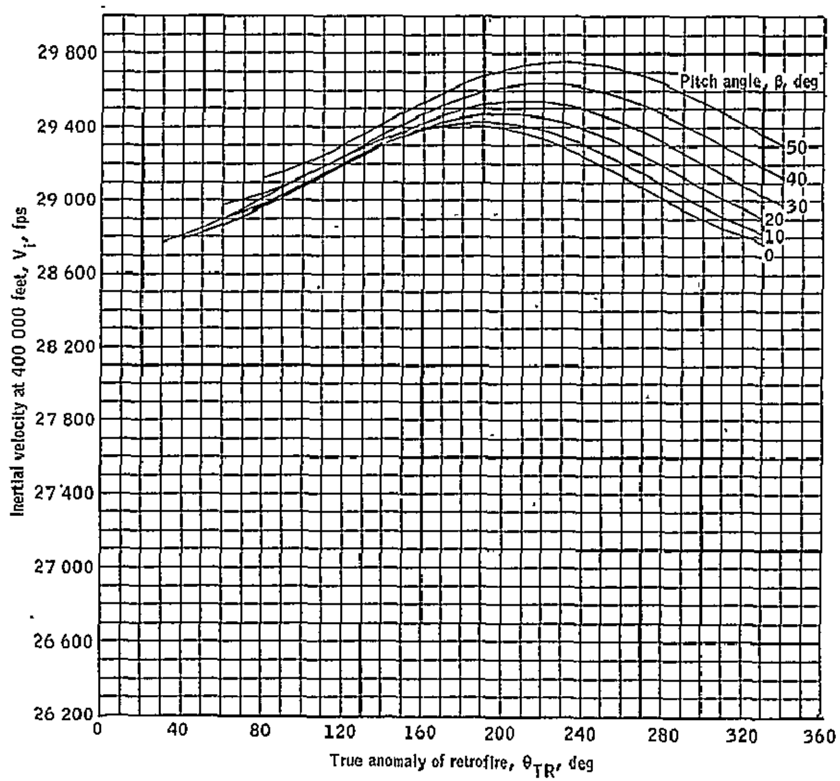




(g) Flight-path angle and velocity for retrograde ΔV = 1300 feet per second.

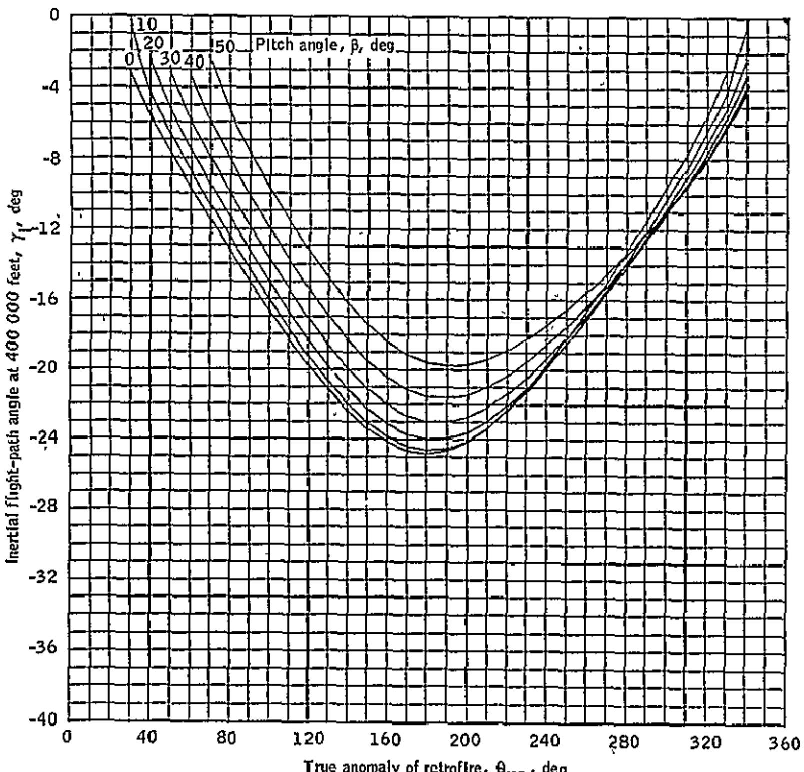
Figure 23.- Continued.

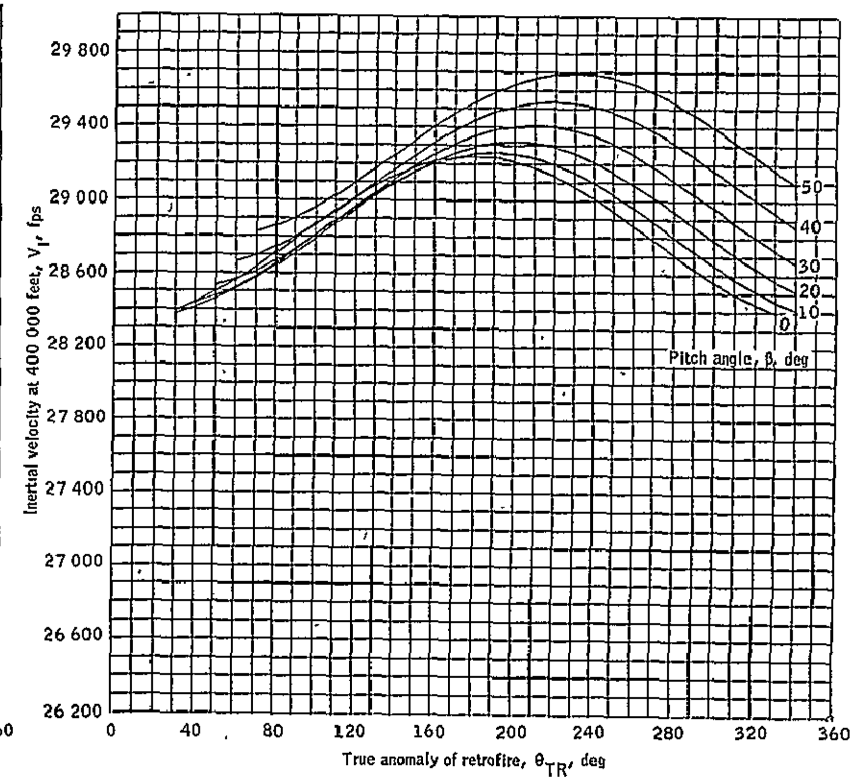




(h) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

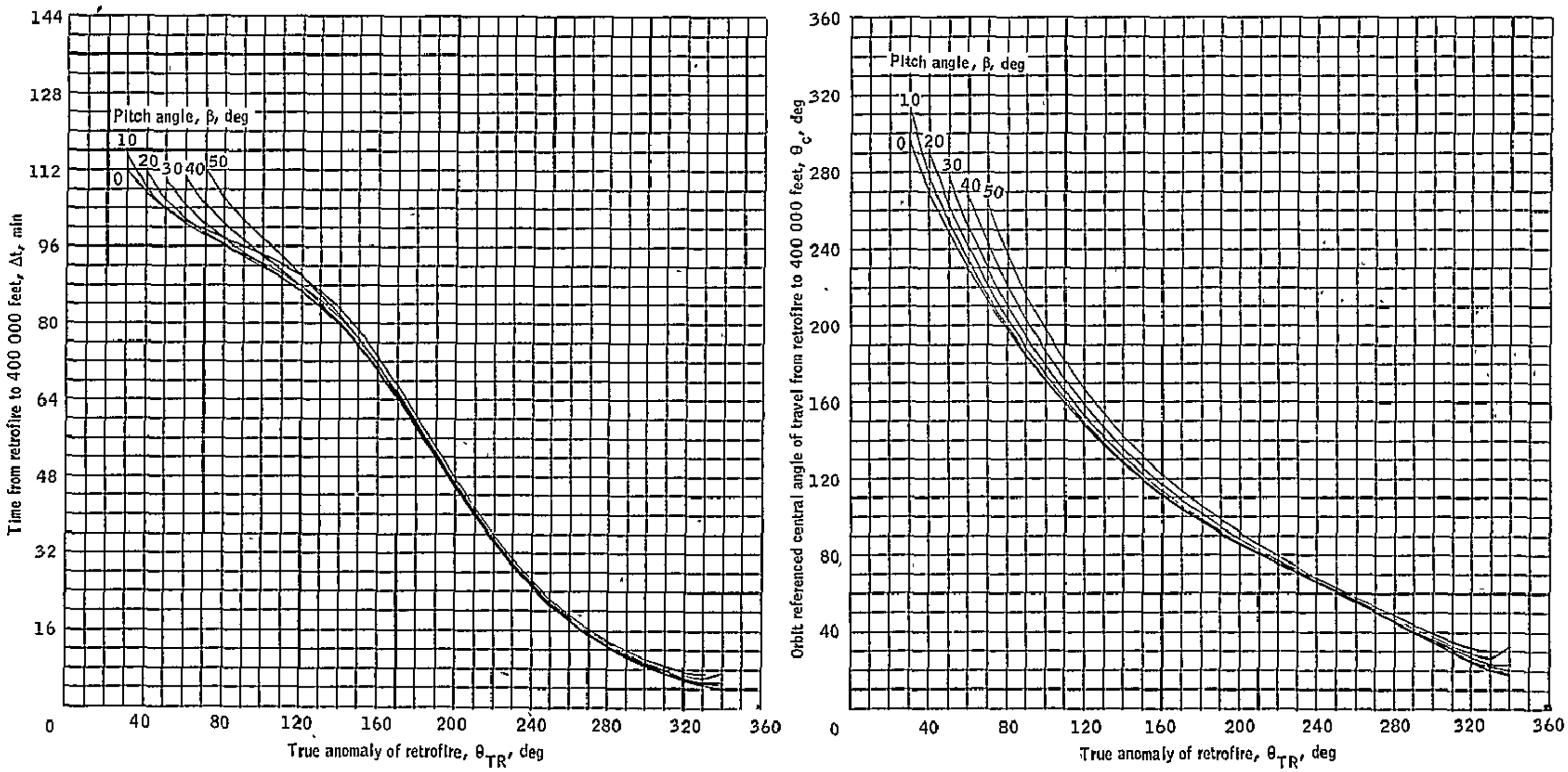
Figure 23.- Continued.





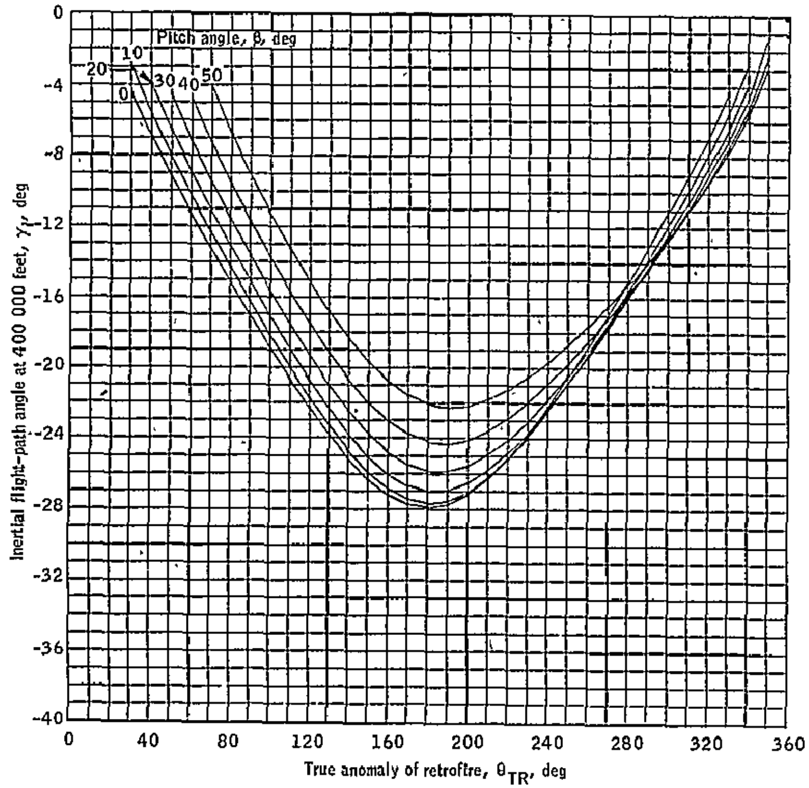
(l) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

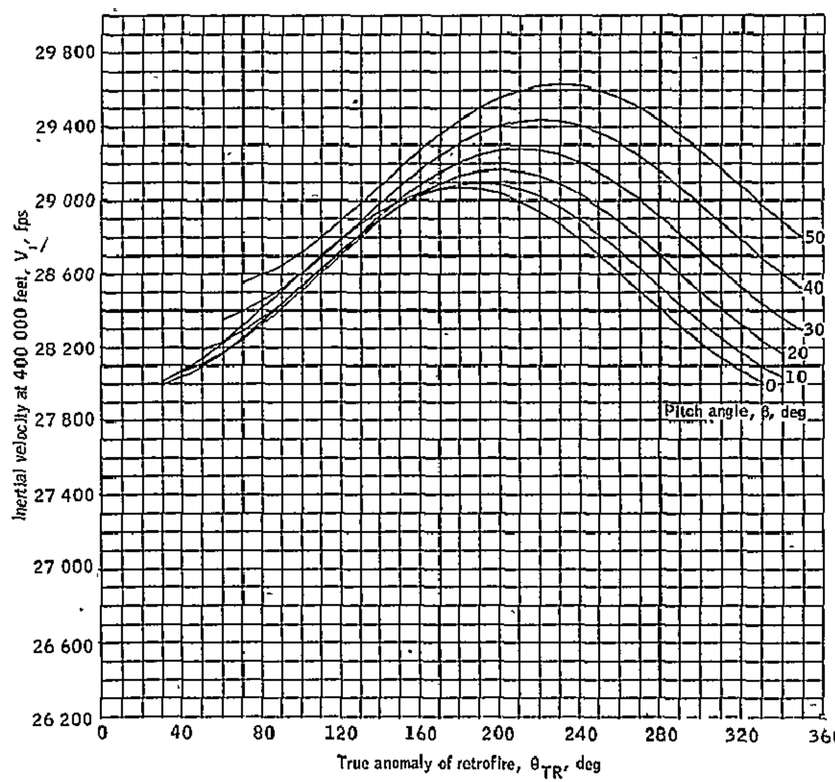
Figure 23.- Continued.



(j) Time from retrofire and central angle for retrograde ΔV = 1700 feet per second.

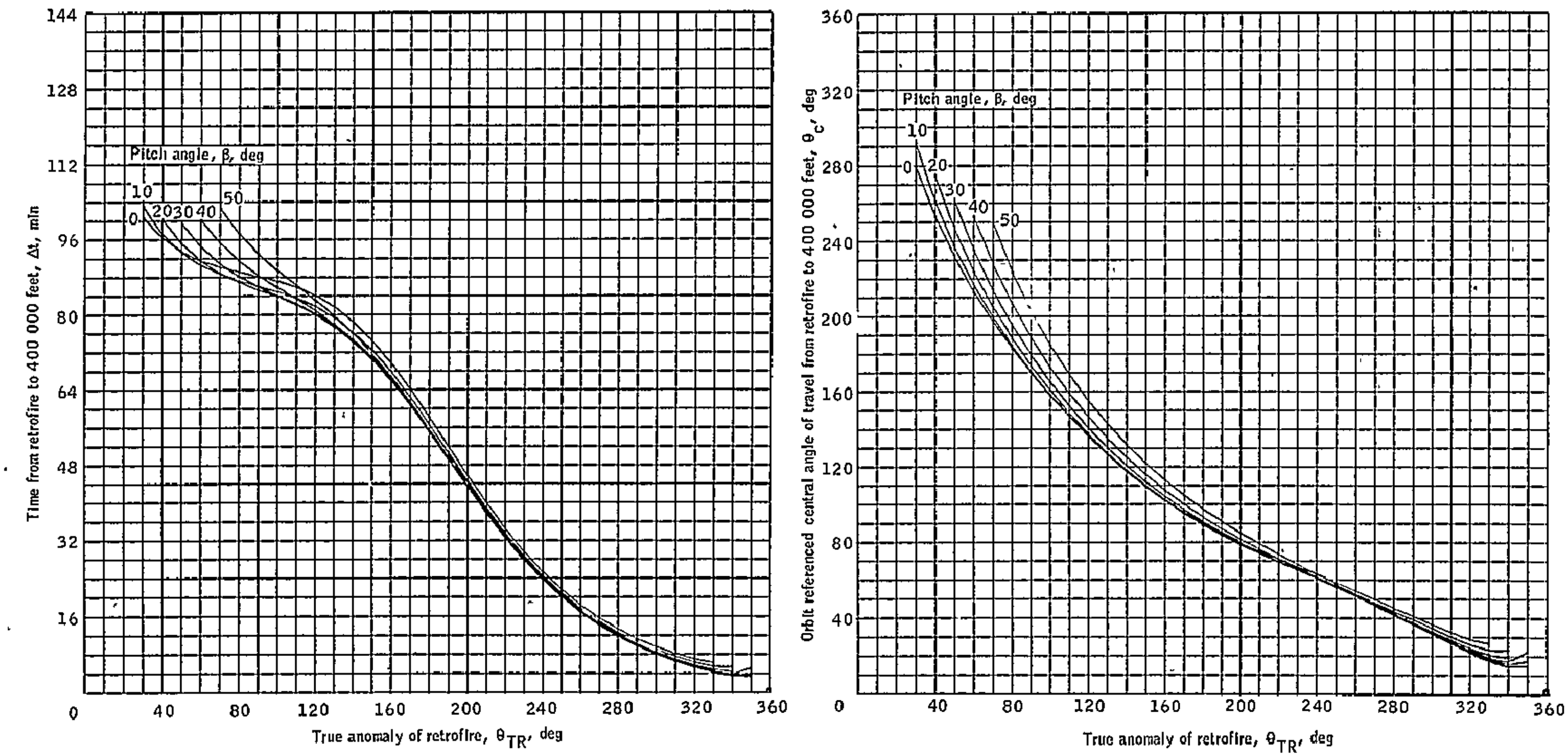
Figure 23.- Continued.





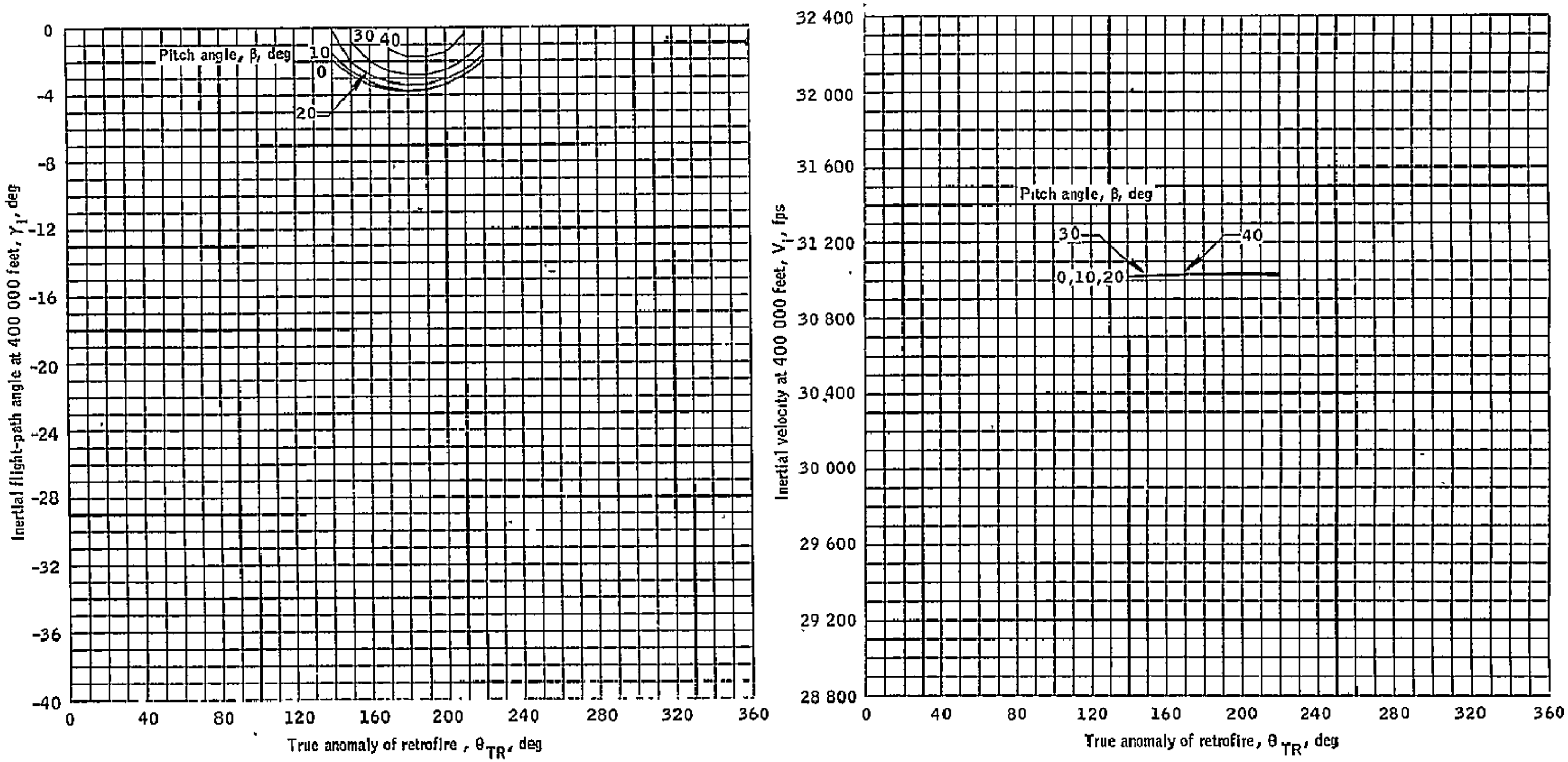
(k) Flight-path angle and velocity for retrograde ΔV = 2100 feet per second.

Figure 23.- Continued.



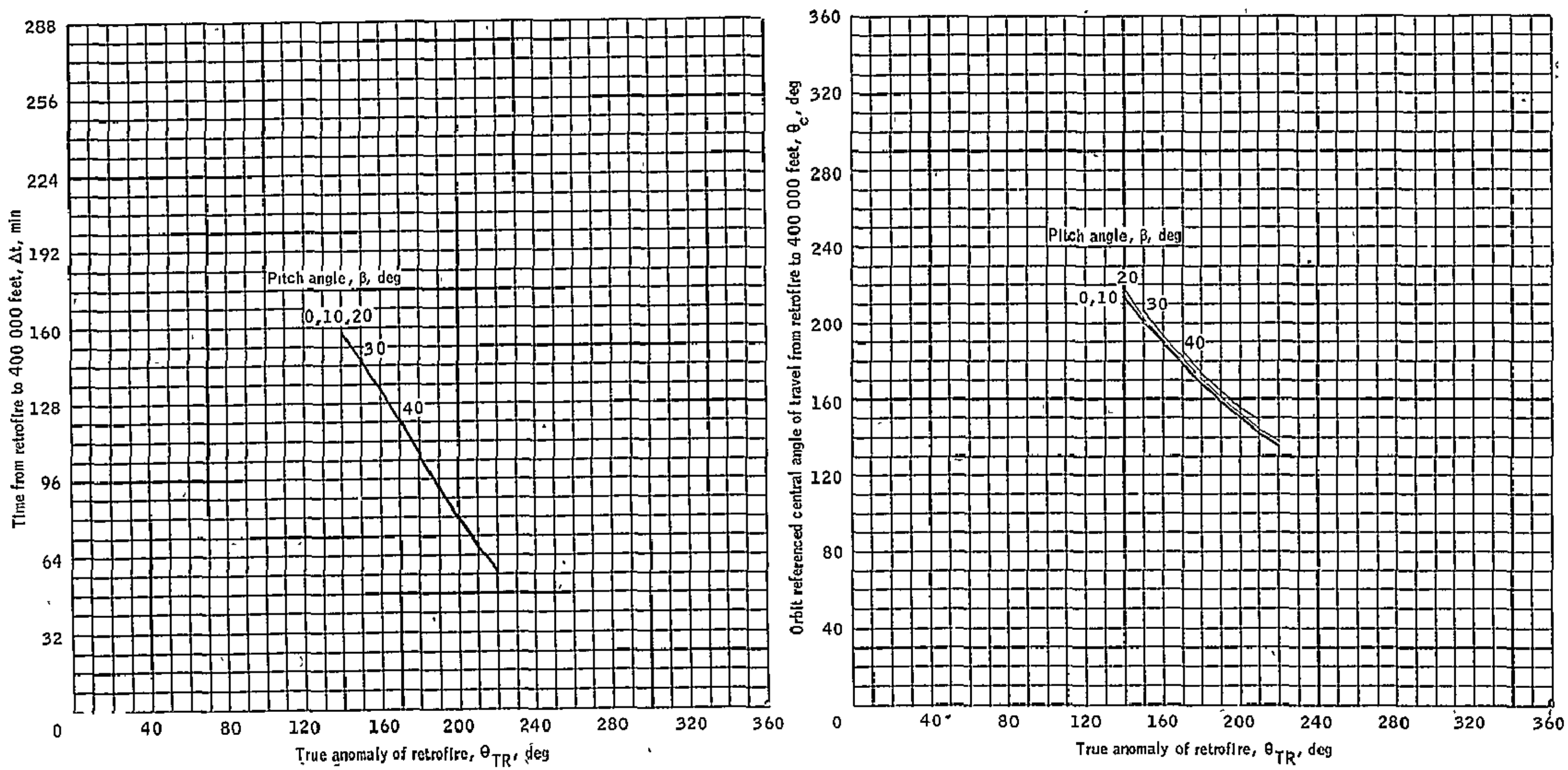
(l) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

Figure 23.- Concluded.



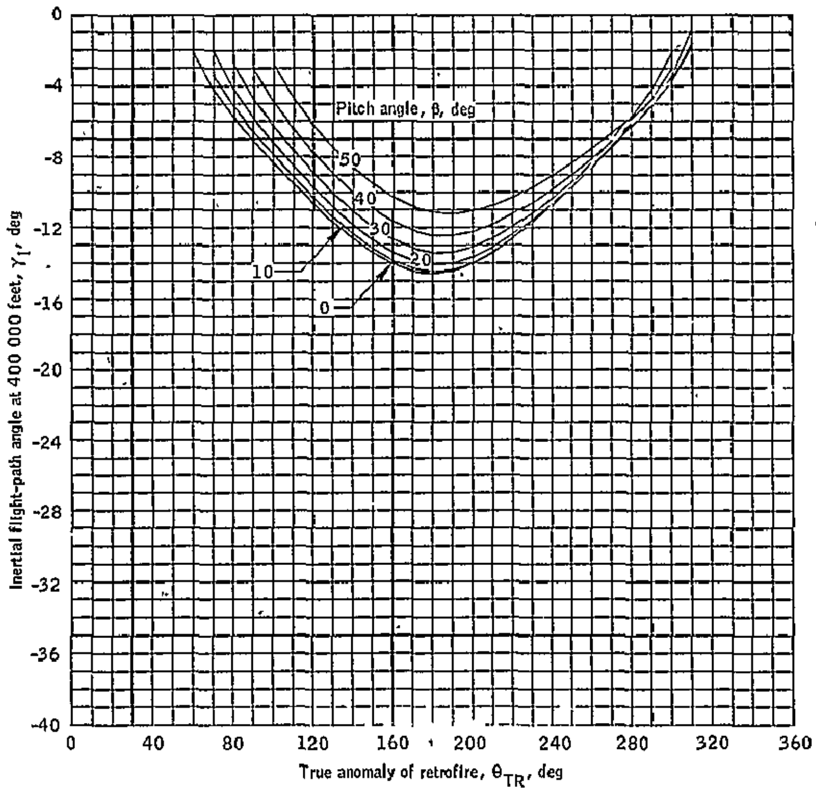
(a) Flight-path angle and velocity for retrograde $\Delta V = 100$ feet per second.

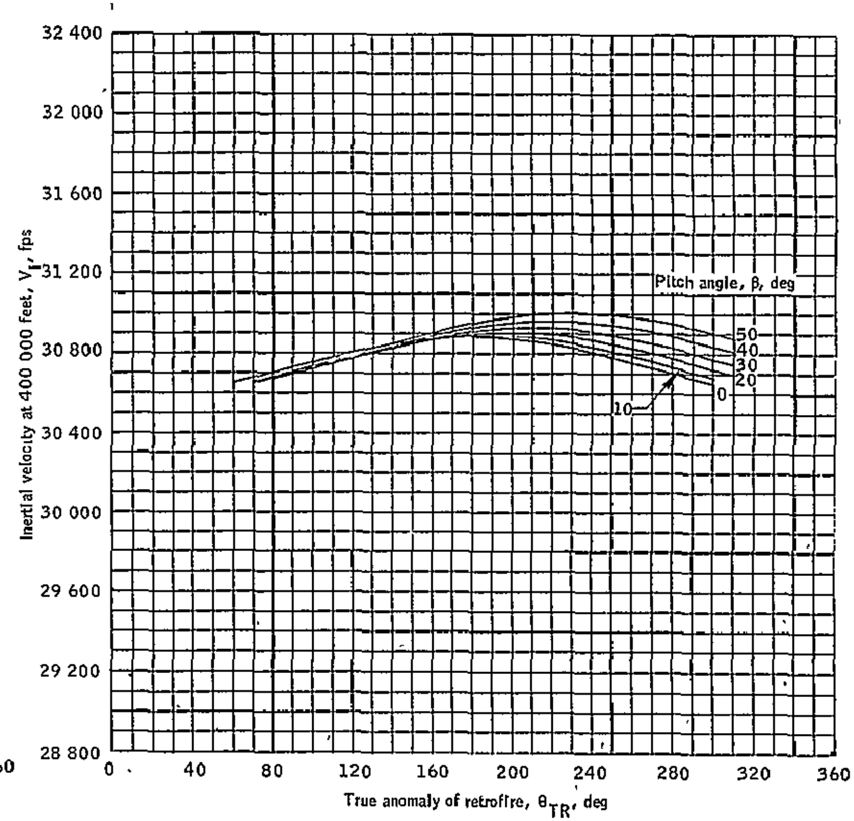
Figure 24.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 125/6000 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

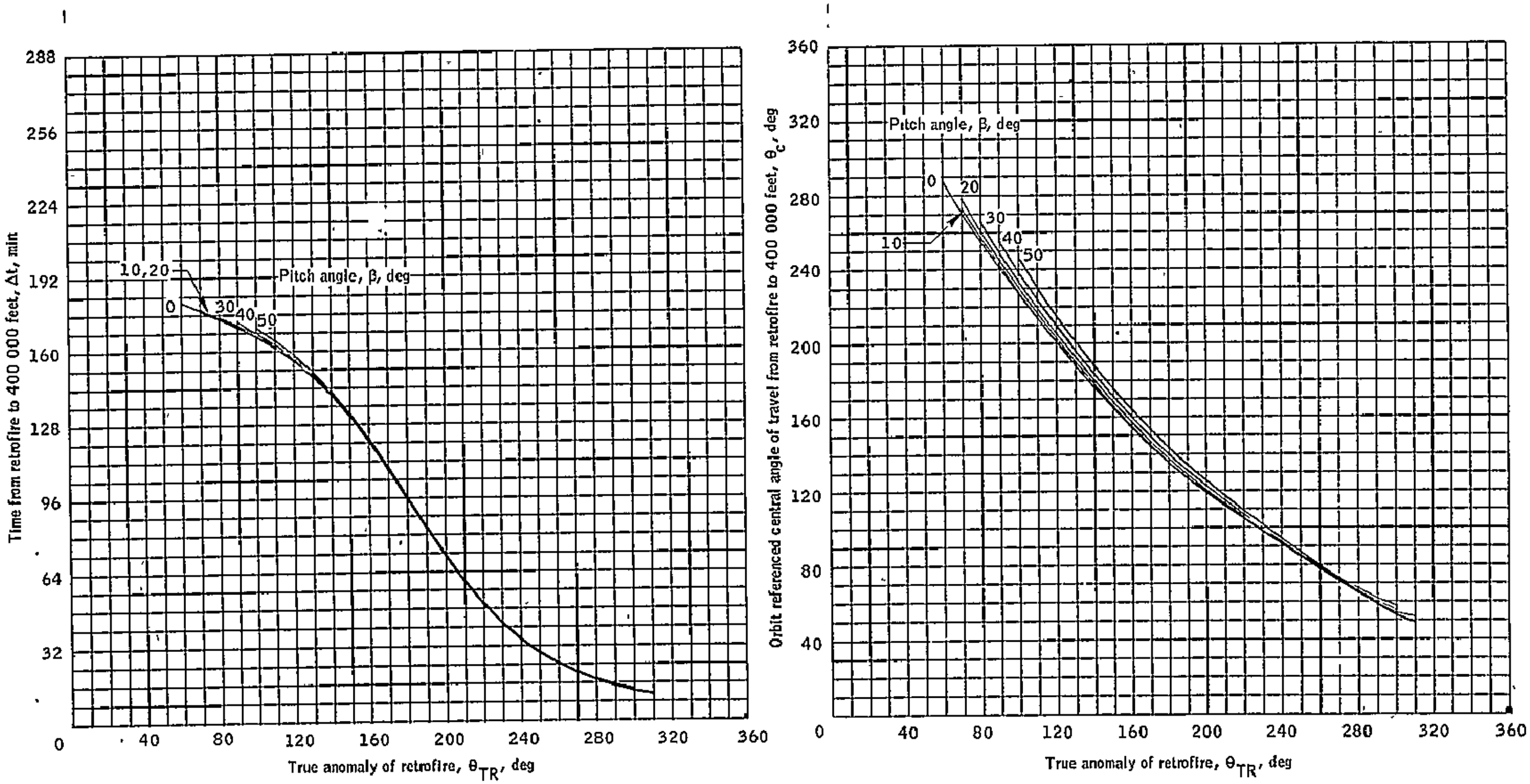
Figure 24.- Continued.





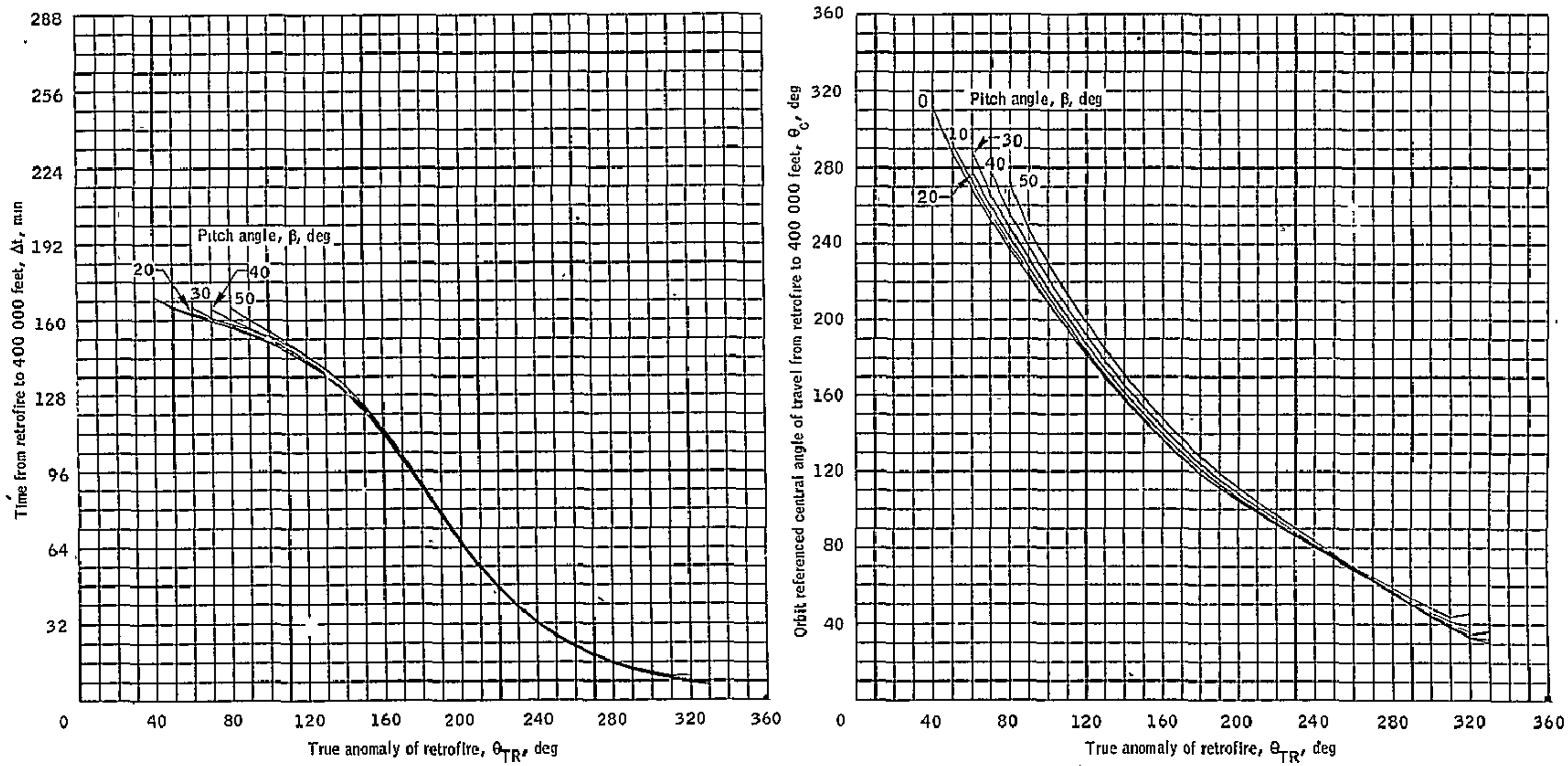
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 24.- Continued.



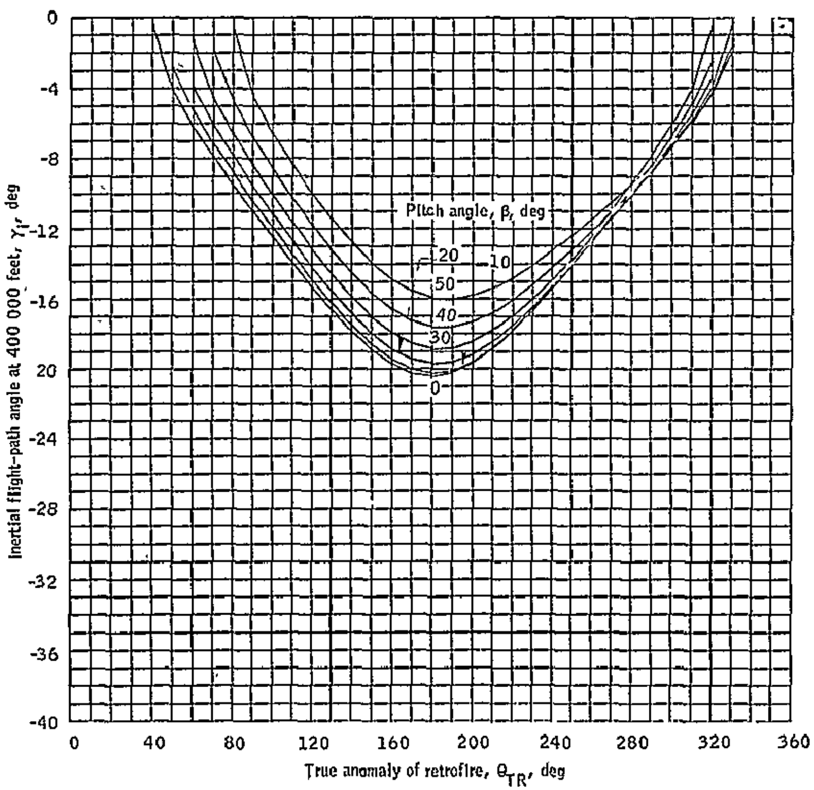
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

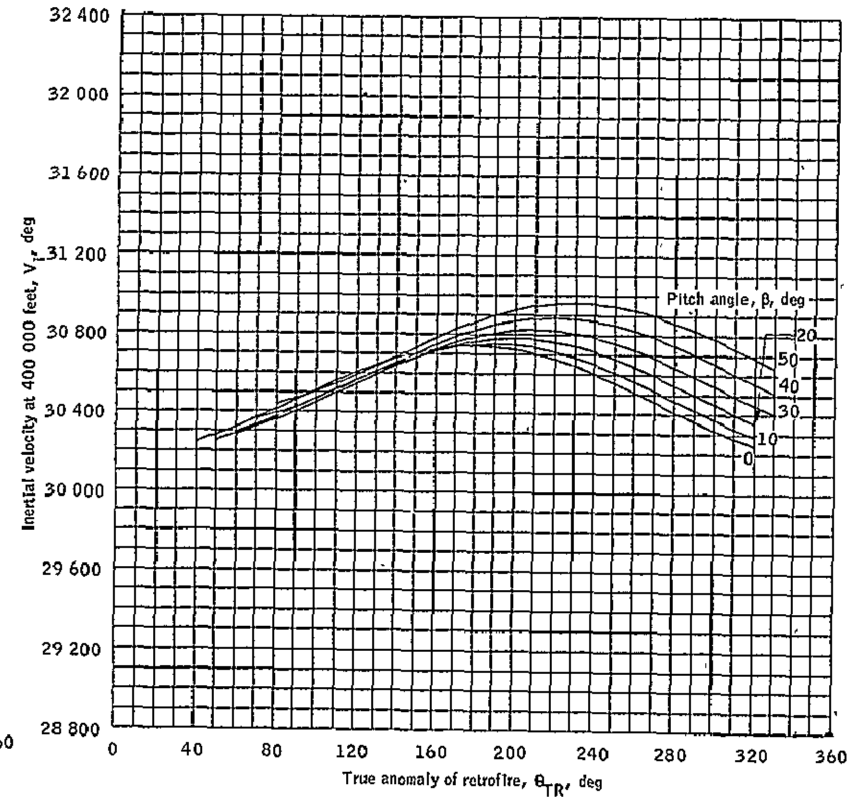
Figure 24.- Continued.



(e) Flight-path angle and velocity for retrograde ΔV= 900 feet per second.

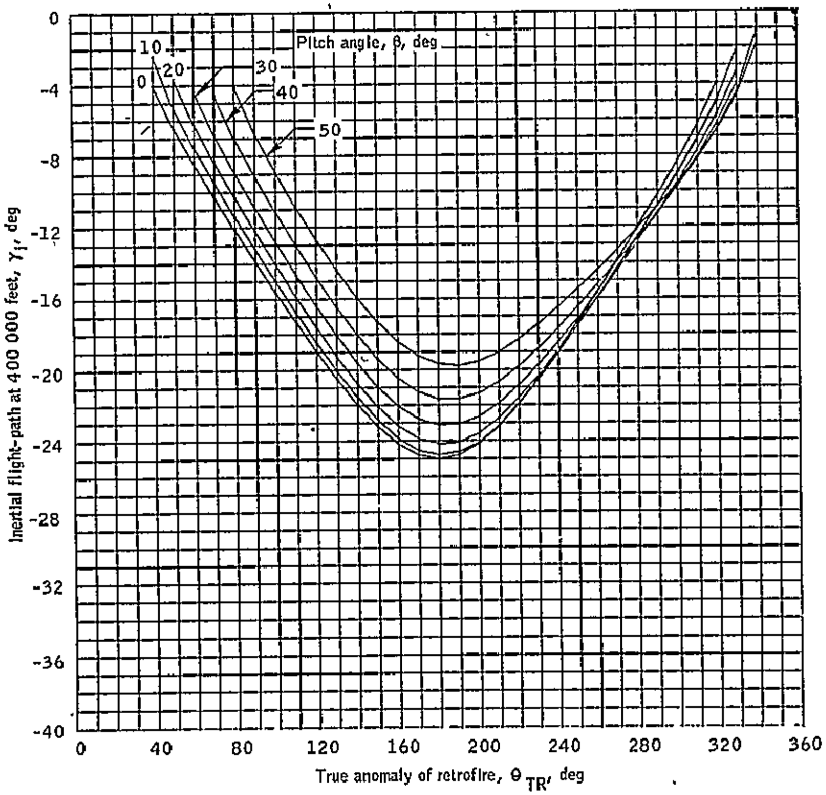
Figure 24.- Continued.

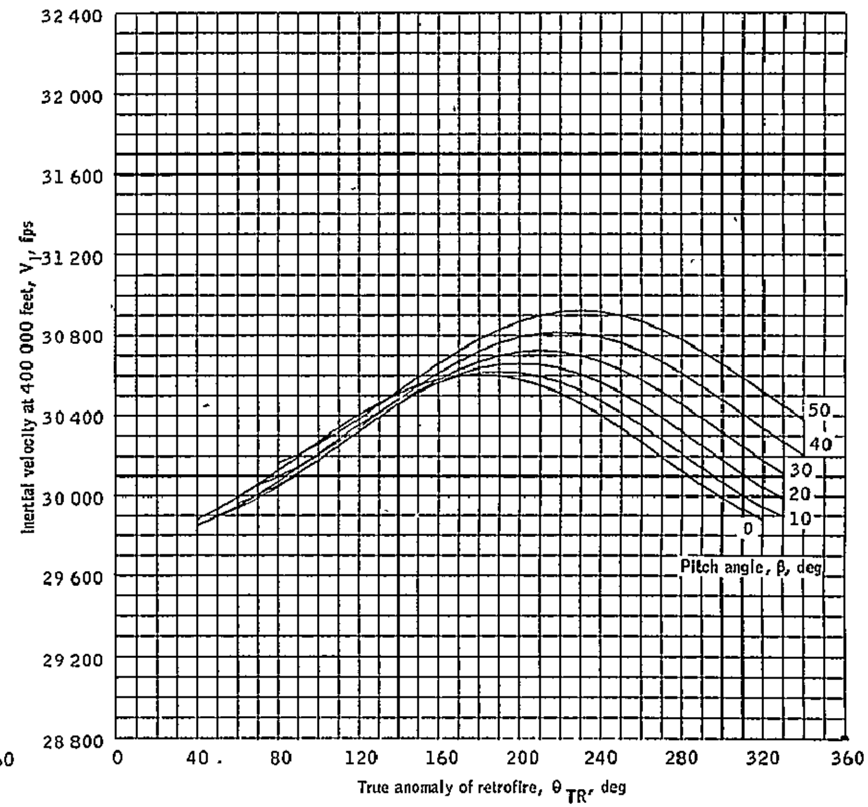




(f) Time from retrofire and central angle for retrograde ΔV= 900 feet per second.

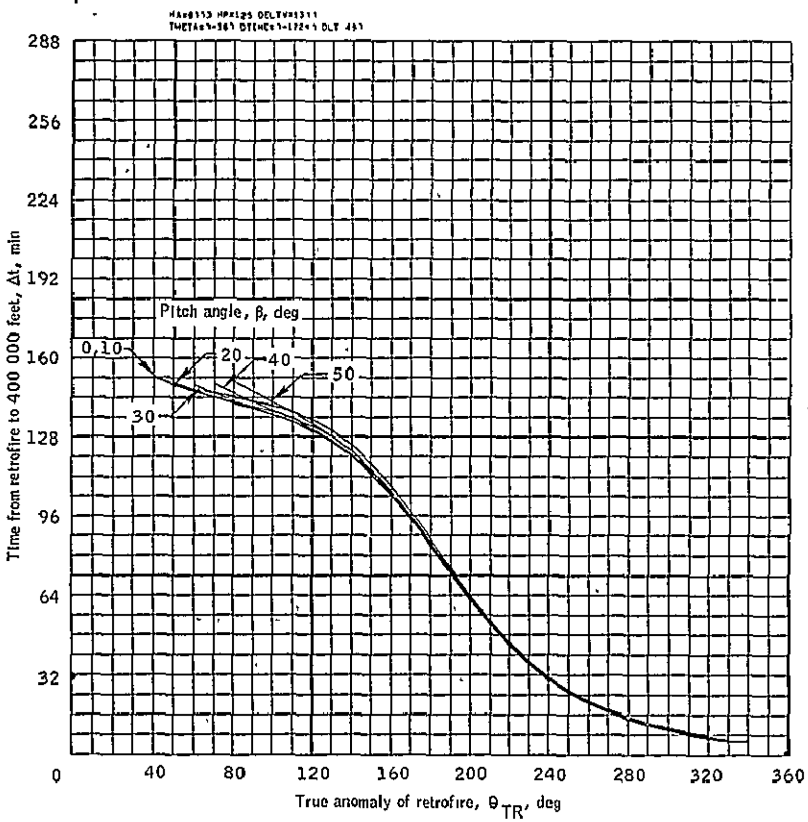
Figure 24.- Continued.

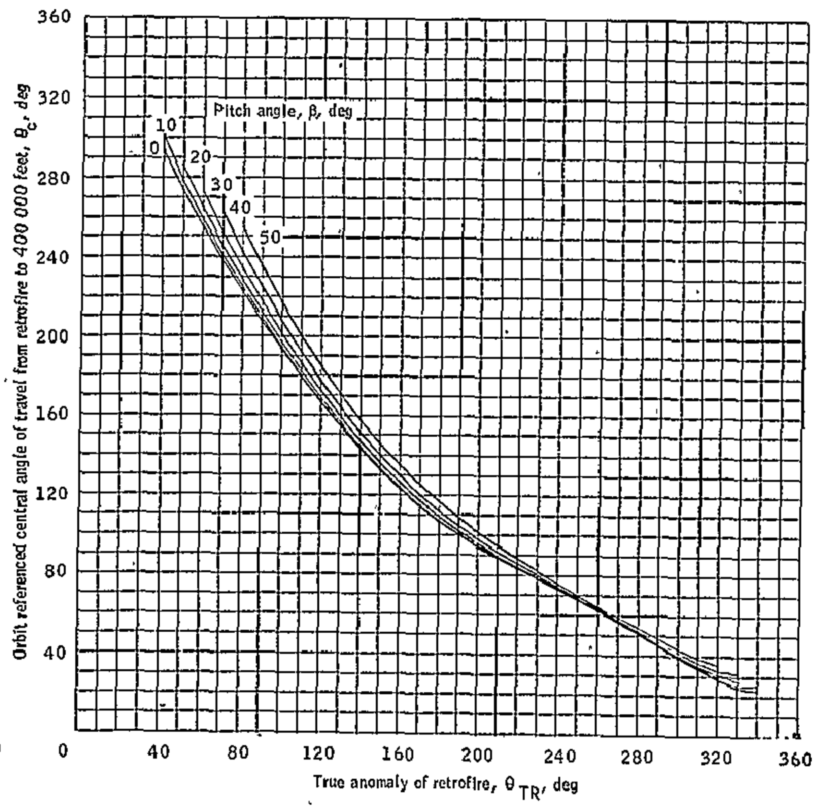




(g) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

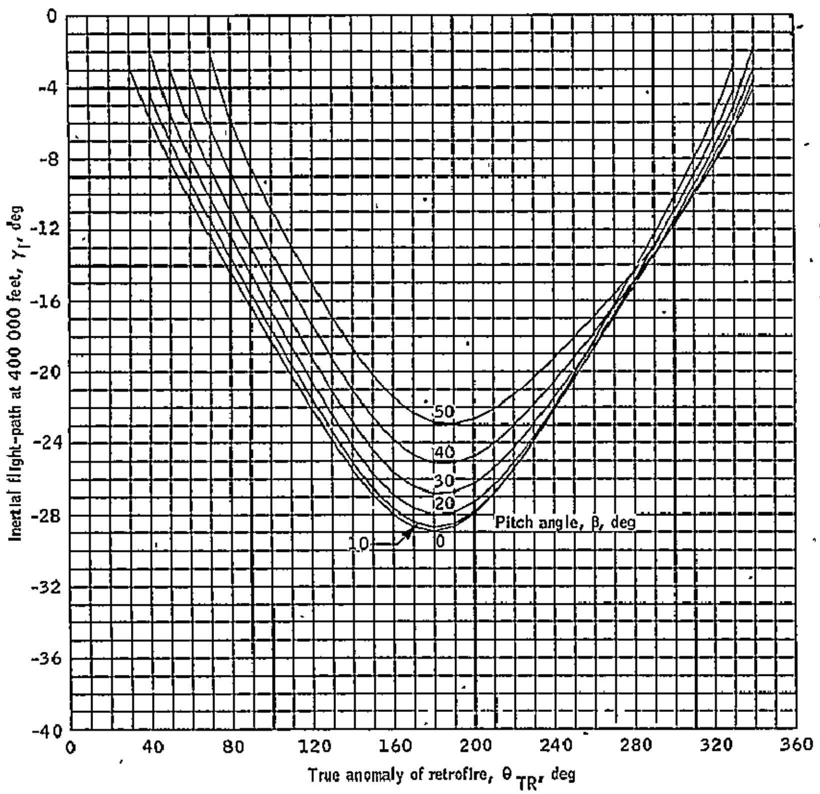
Figure 24.- Continued.

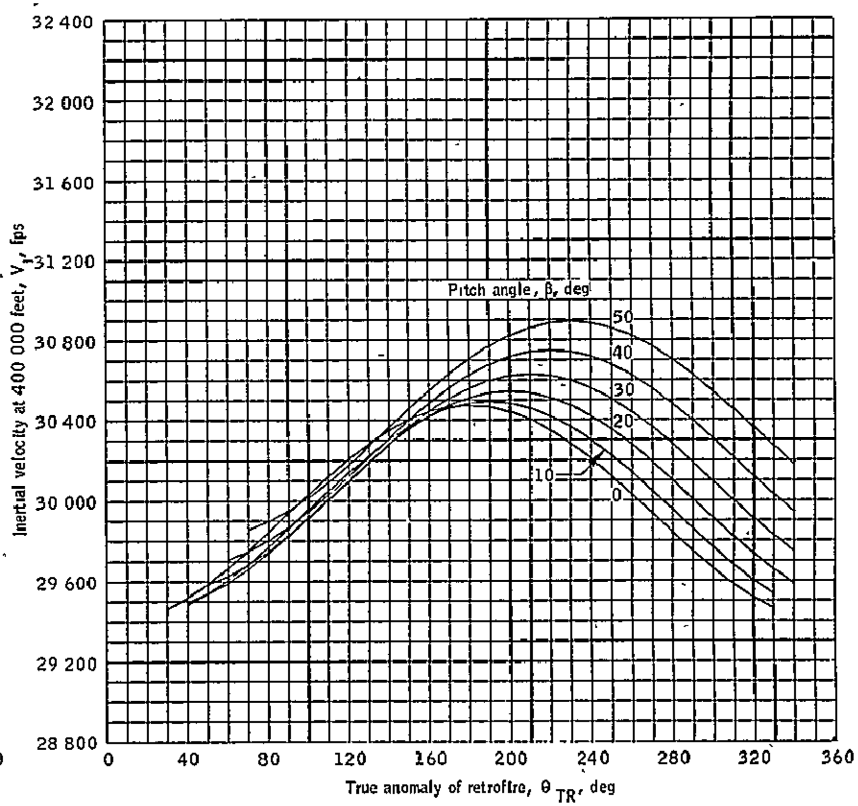




(h) Time from retrofire and central angle for retrograde ΔV = 1300 feet per second.

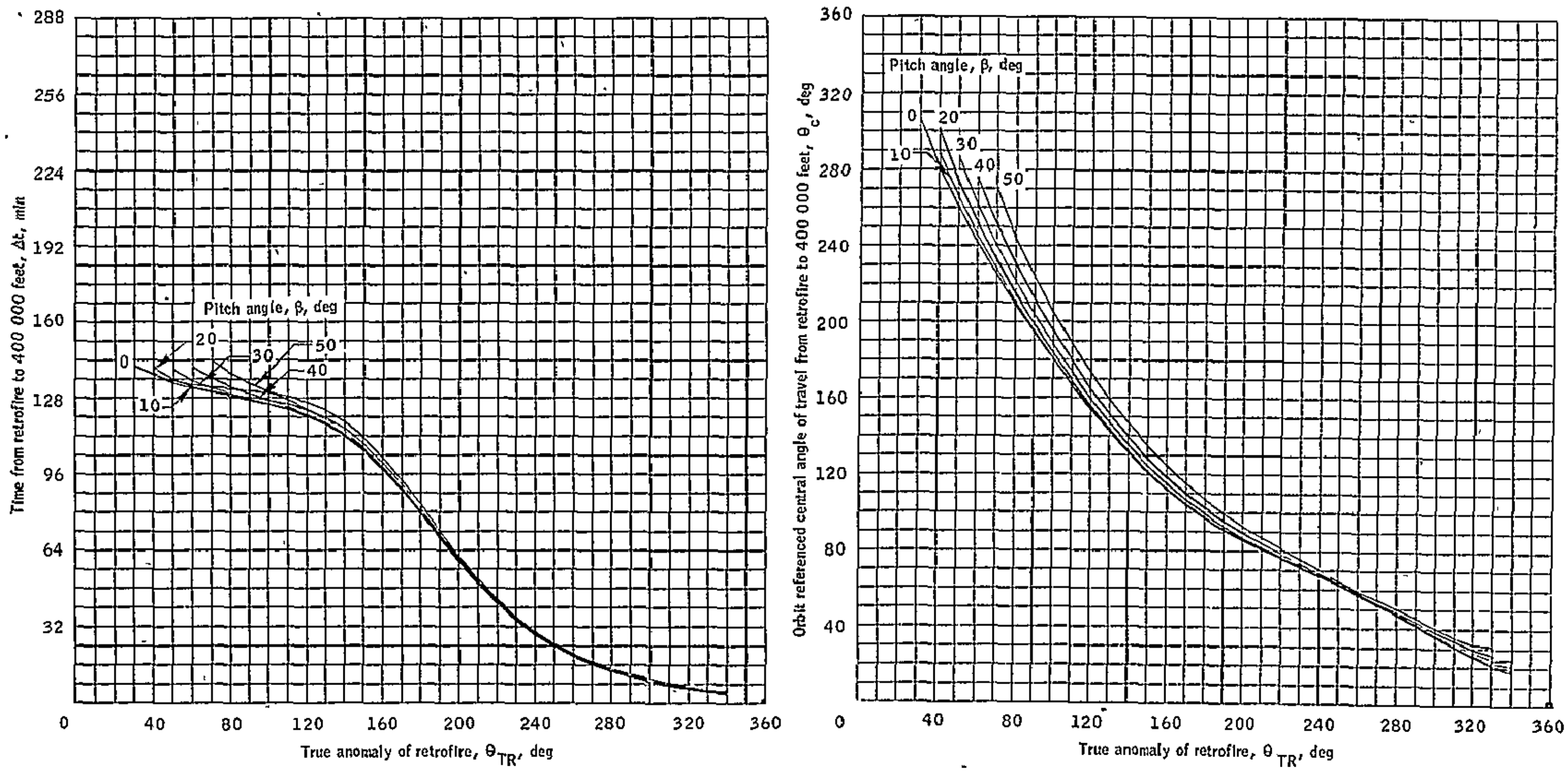
Figure 24.- Continued.





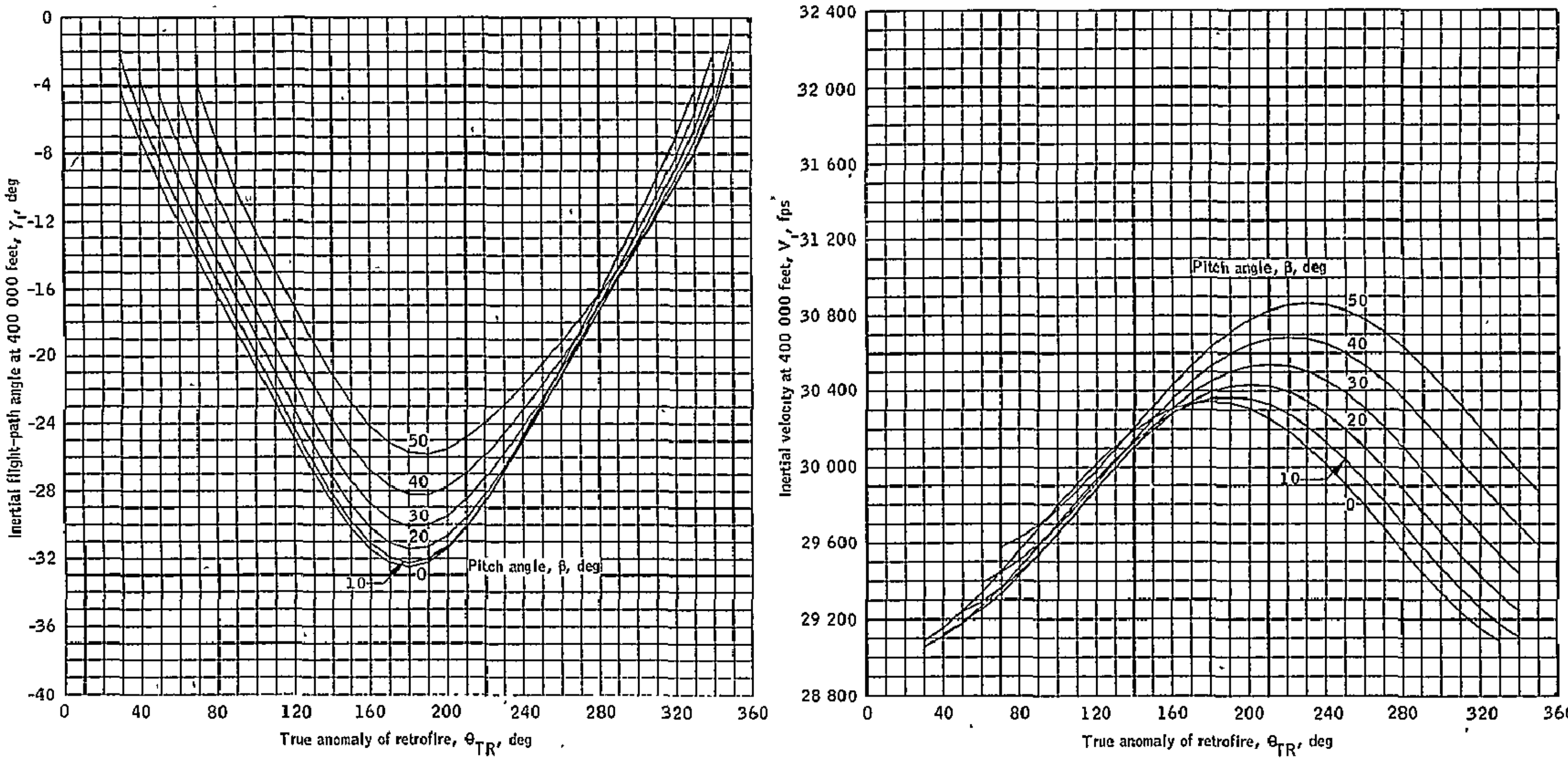
(l) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

Figure 24.- Continued.



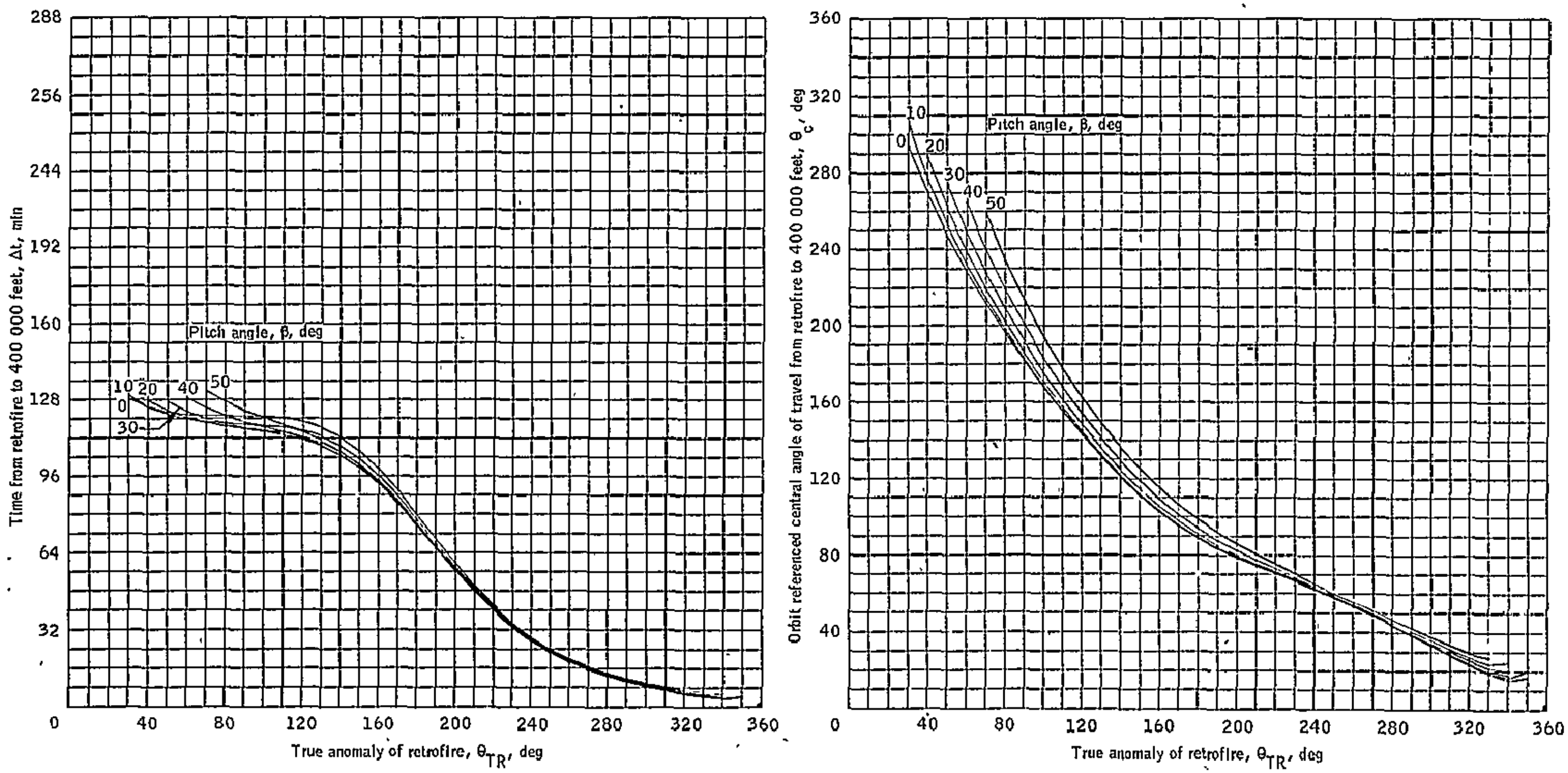
(j) Time from retrofire and central angle for retrograde ΔV = 1700 feet per second.

Figure 24.- Continued.



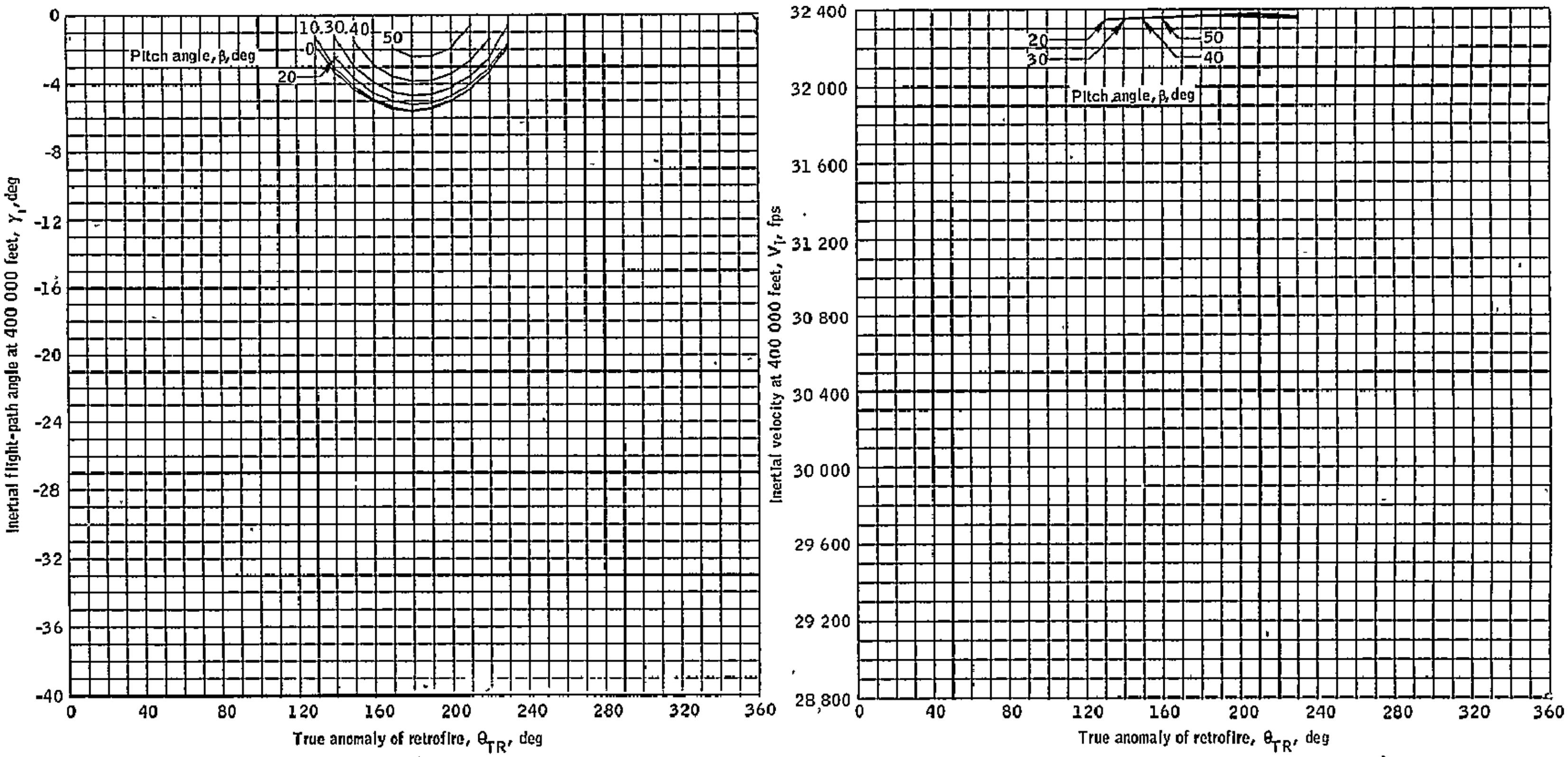
(k) Flight-path angle and velocity for retrograde ΔV = 2100 feet per second.

Figure 24.- Continued.



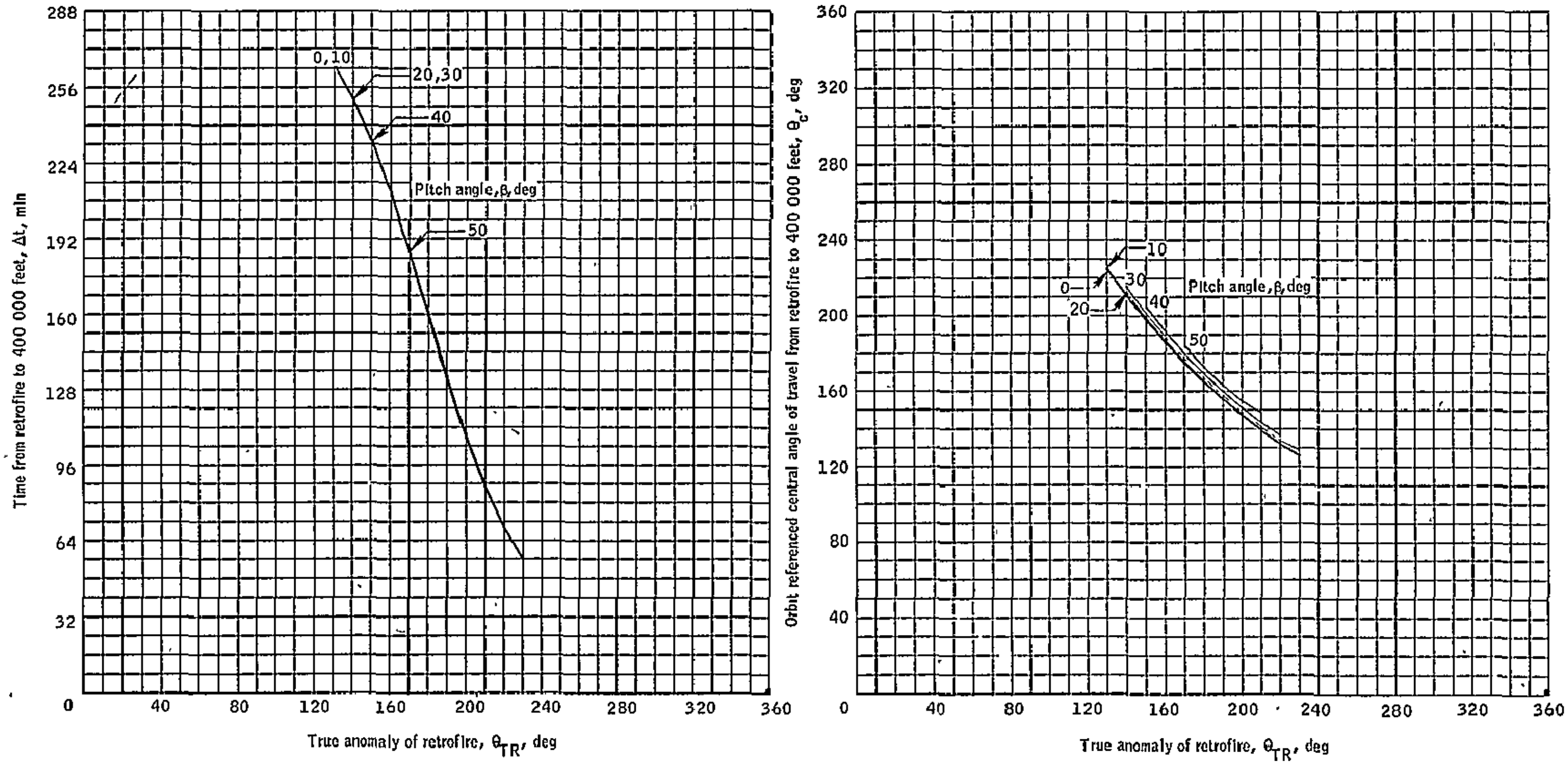
(l) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

Figure 24.- Concluded.



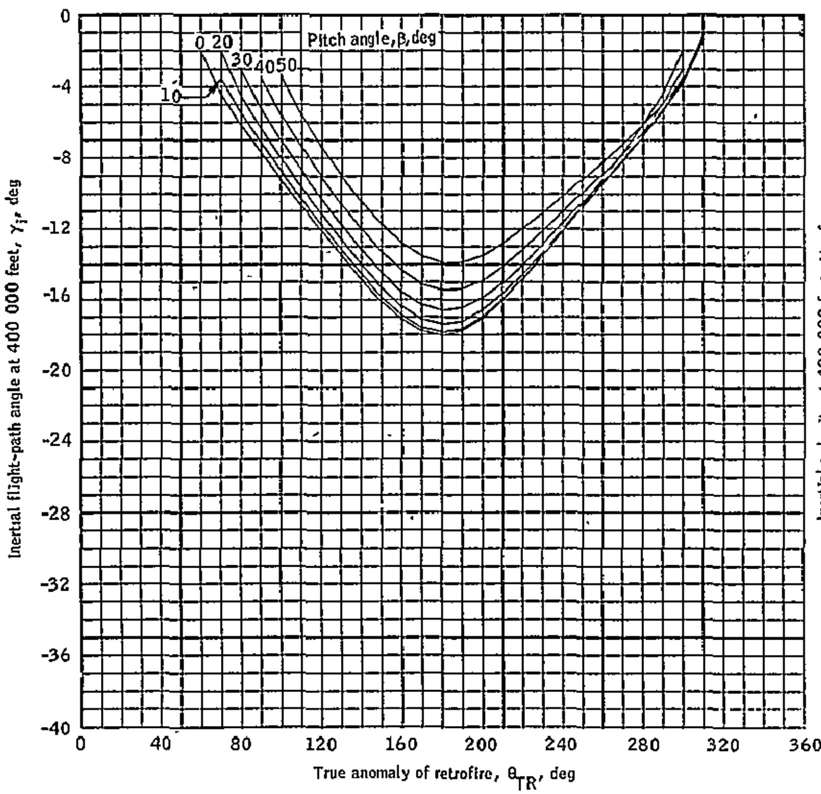
(a) Flight-path angle and velocity for retrograde ΔV=100 feet per second.

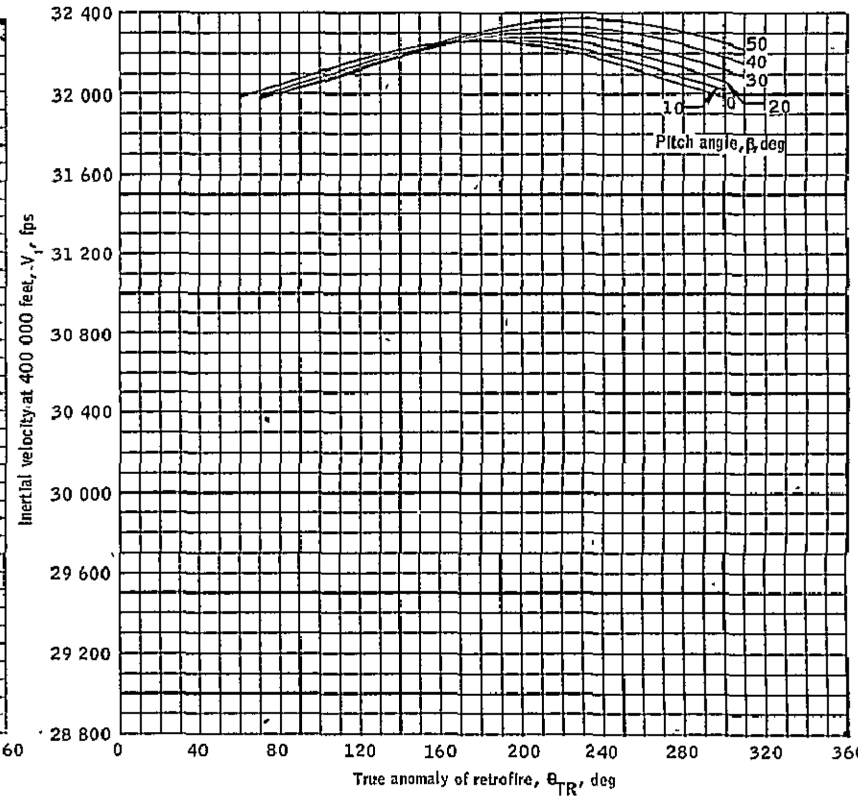
Figure 25.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 125/10 000 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde ΔV=100 feet per second.

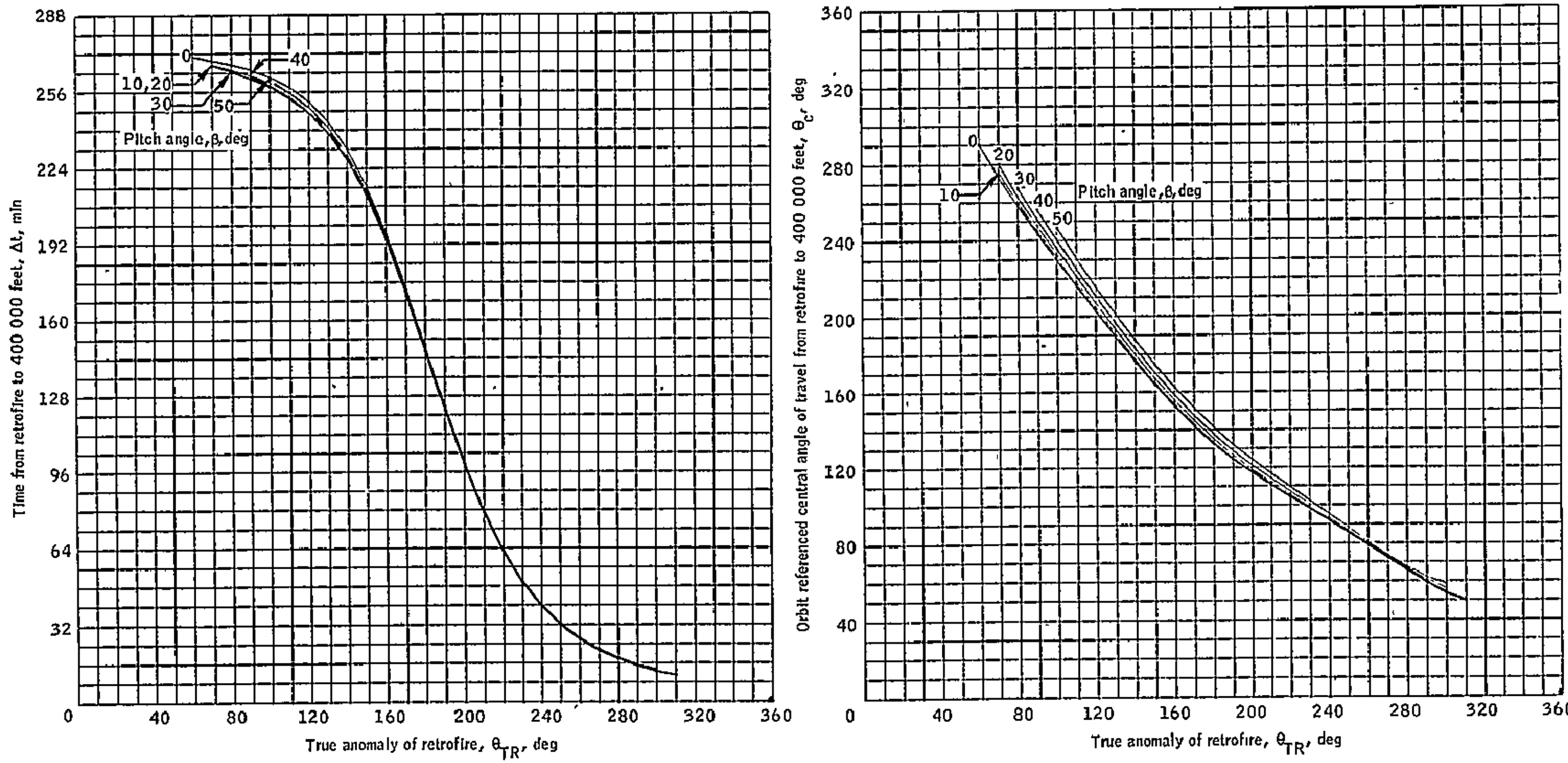
Figure 25.- Continued.





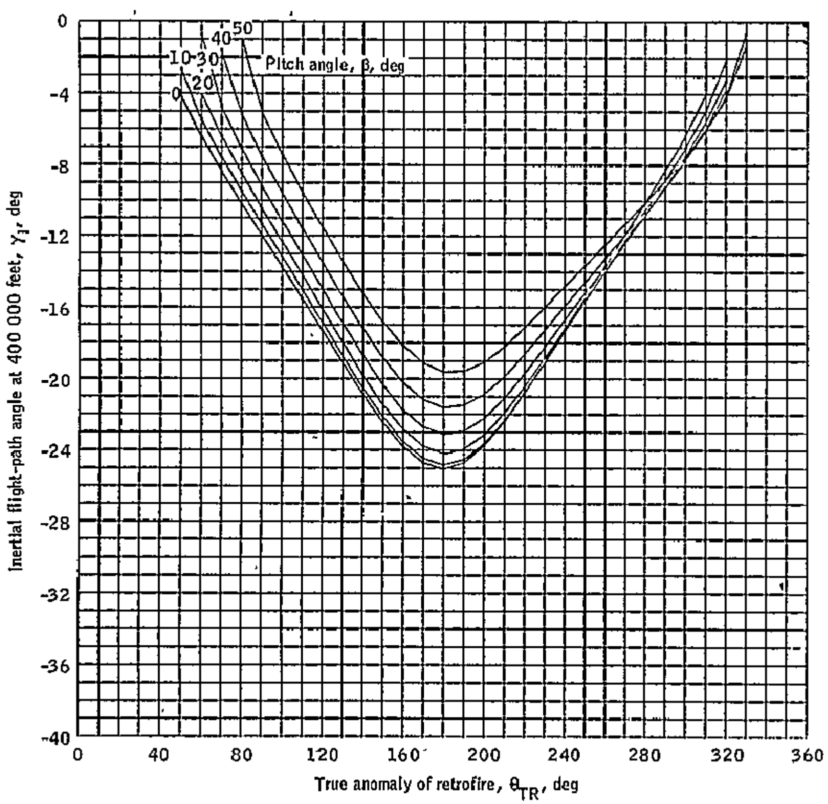
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

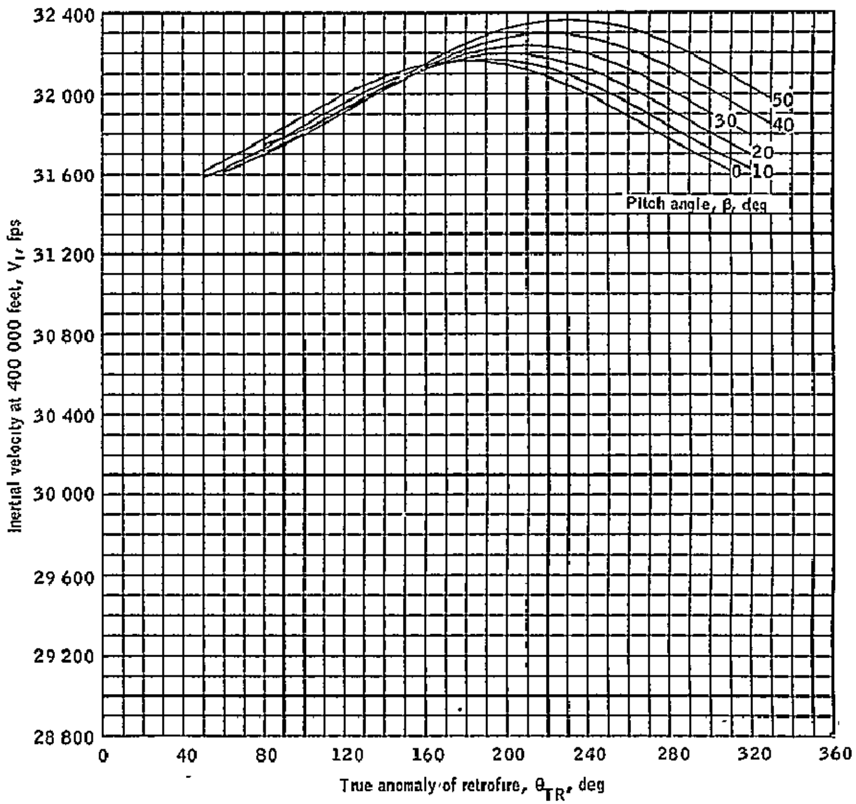
Figure 25.- Continued.



(d) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

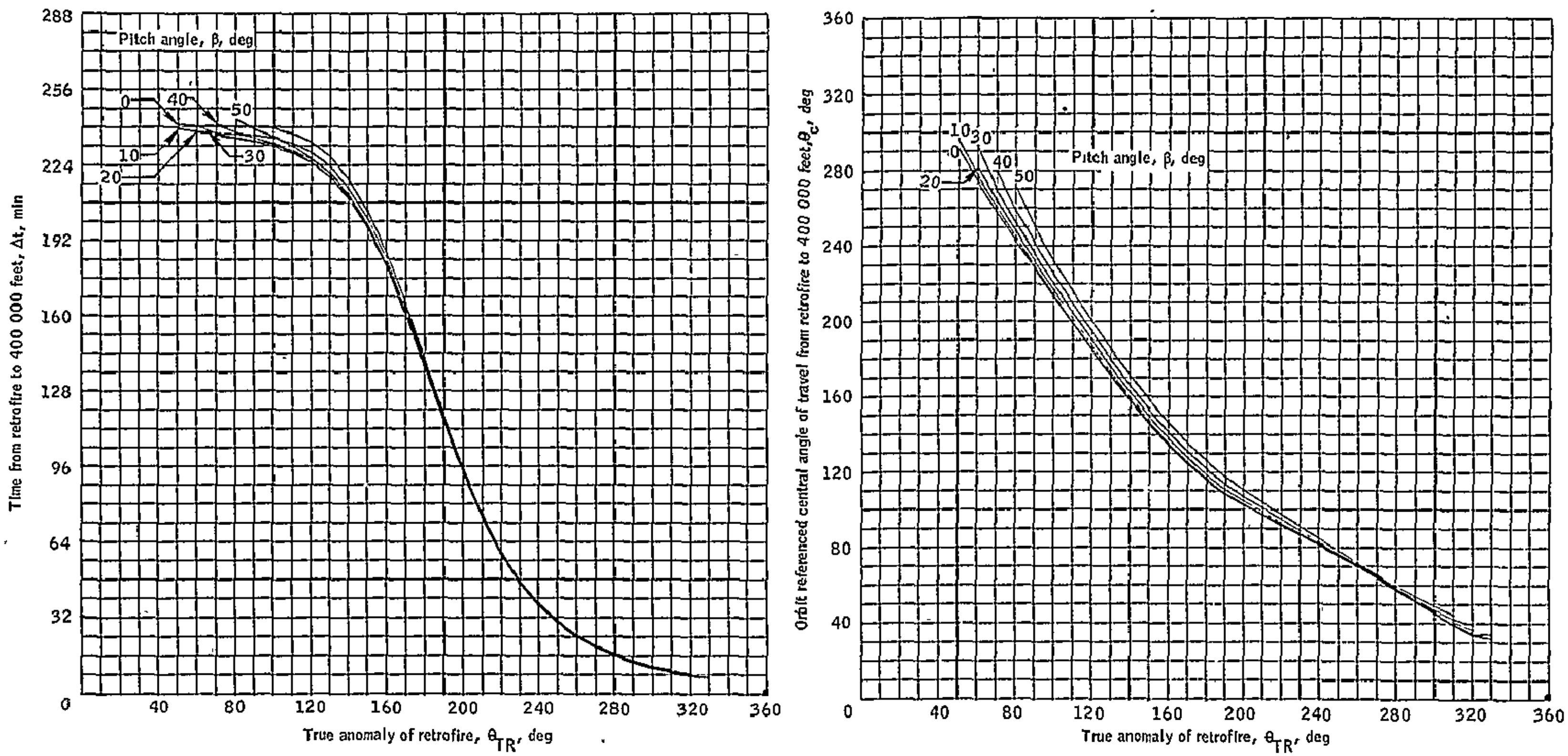
Figure 25.- Continued.





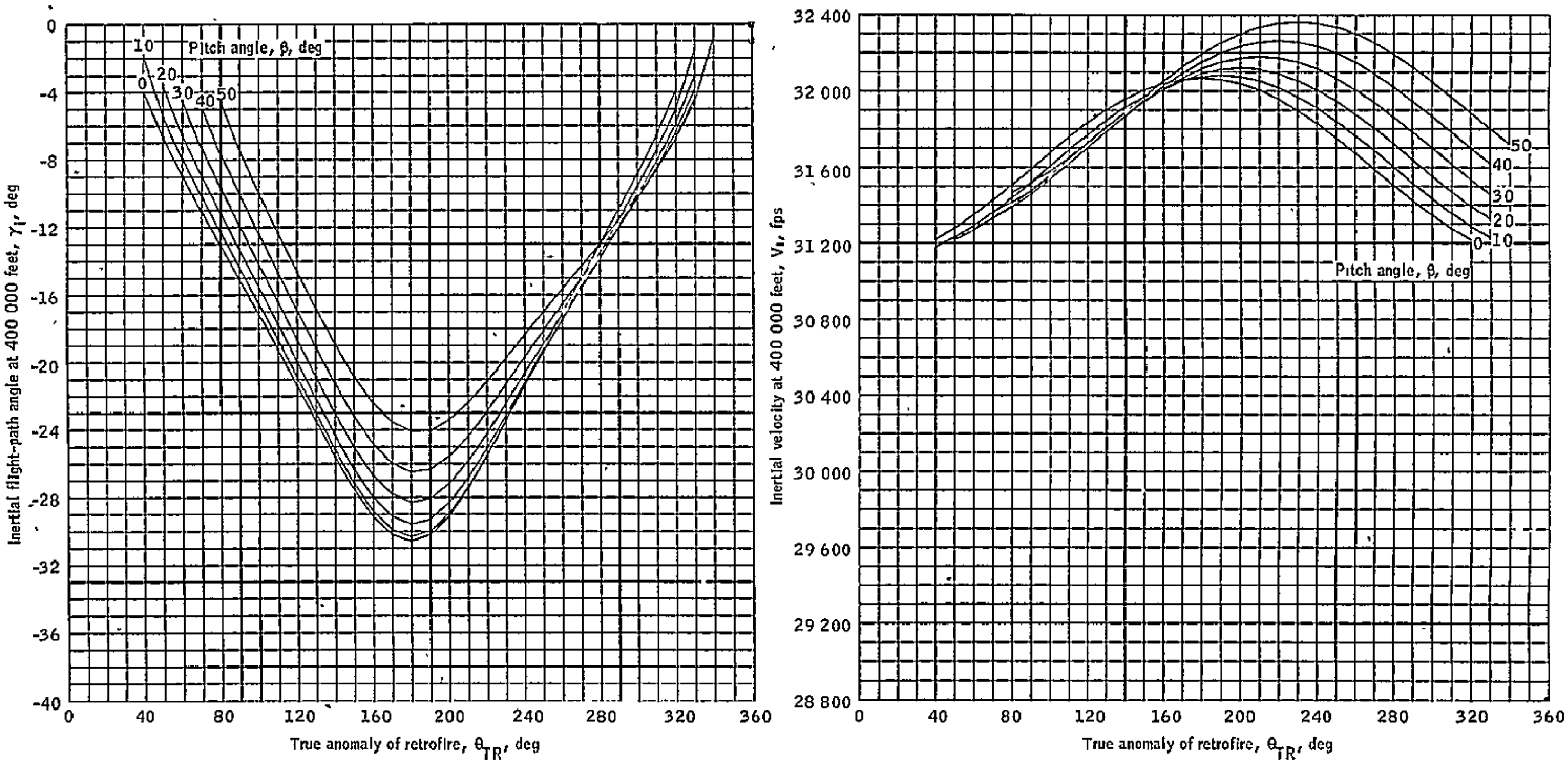
(e) Flight-path angle and velocity for retrograde ΔV=900 feet per second.

Figure 25.- Continued.



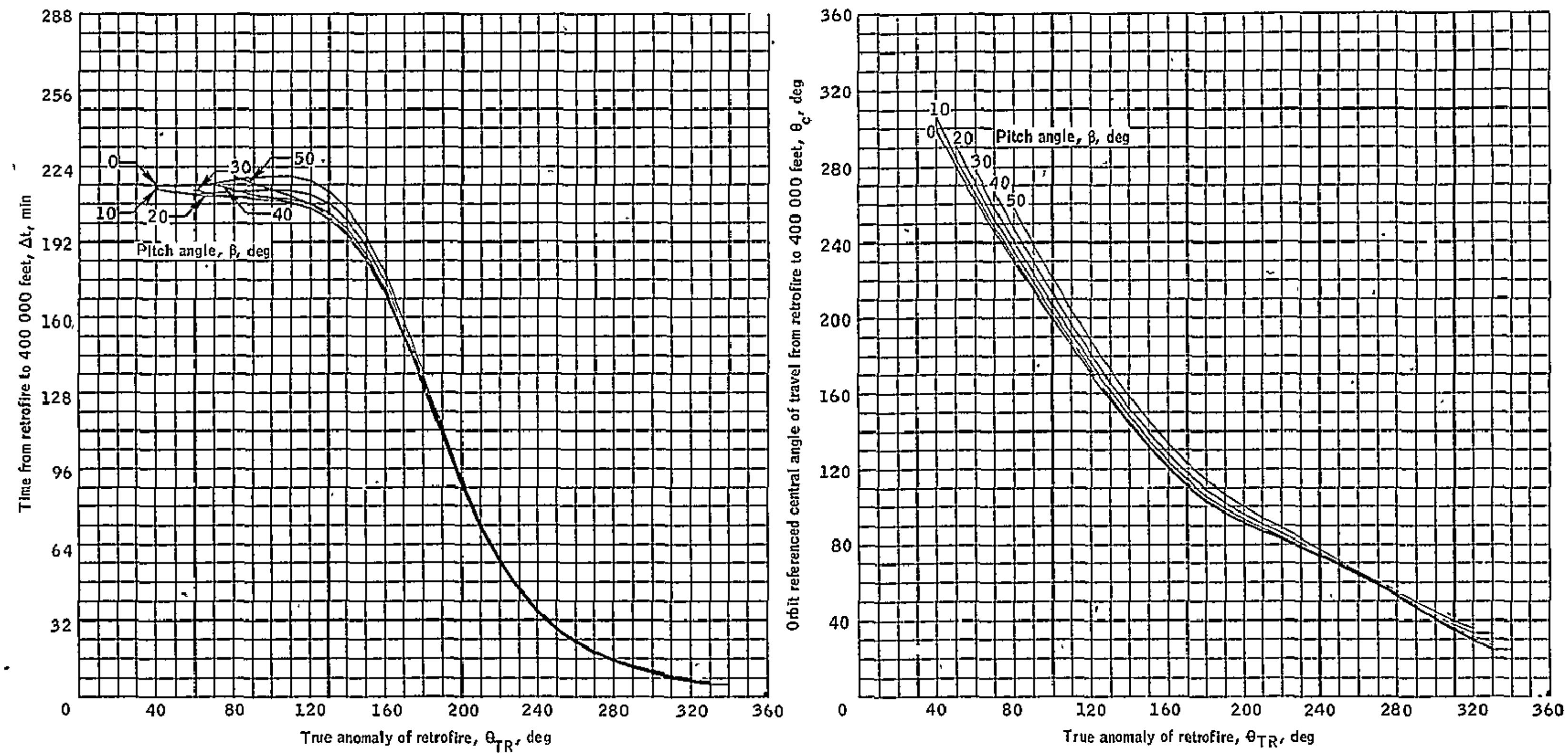
(f) Time from retrofire and central angle for retrograde ΔV=900 feet per second.

Figure 25.- Continued.



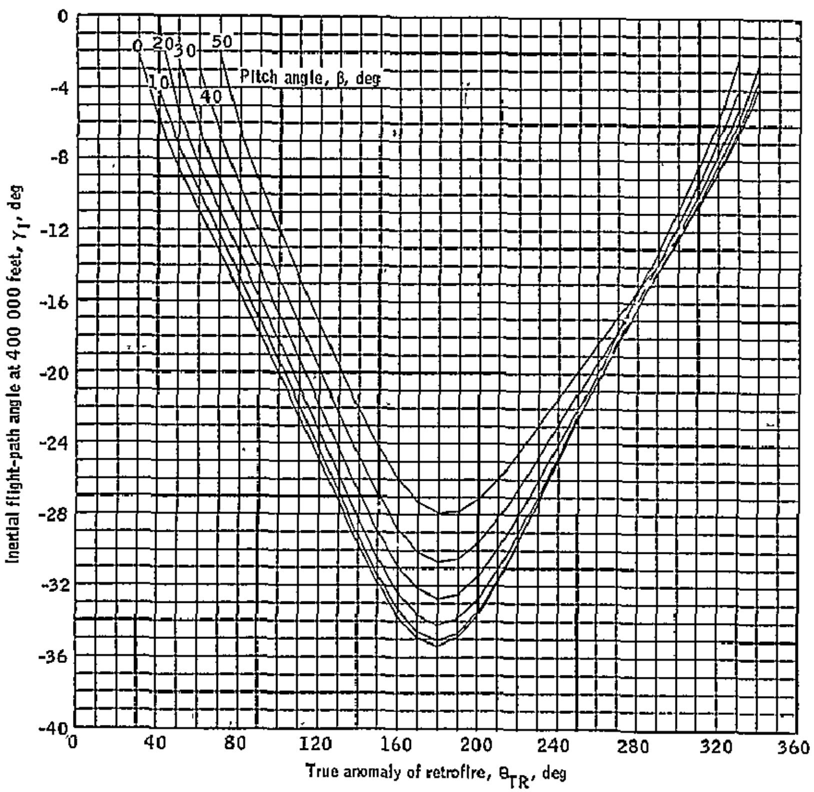
(g) Flight-path and velocity for retrograde ΔV=1300 feet per second.

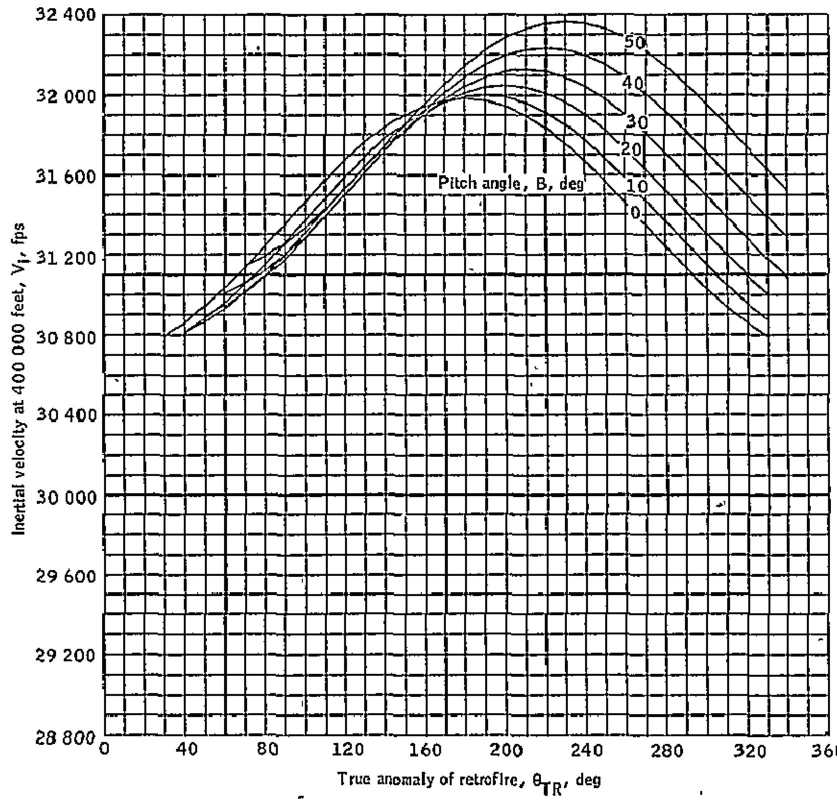
Figure 25.- Continued.



(h) Time from retrofire and central angle for retrograde ΔV=1300 feet per second.

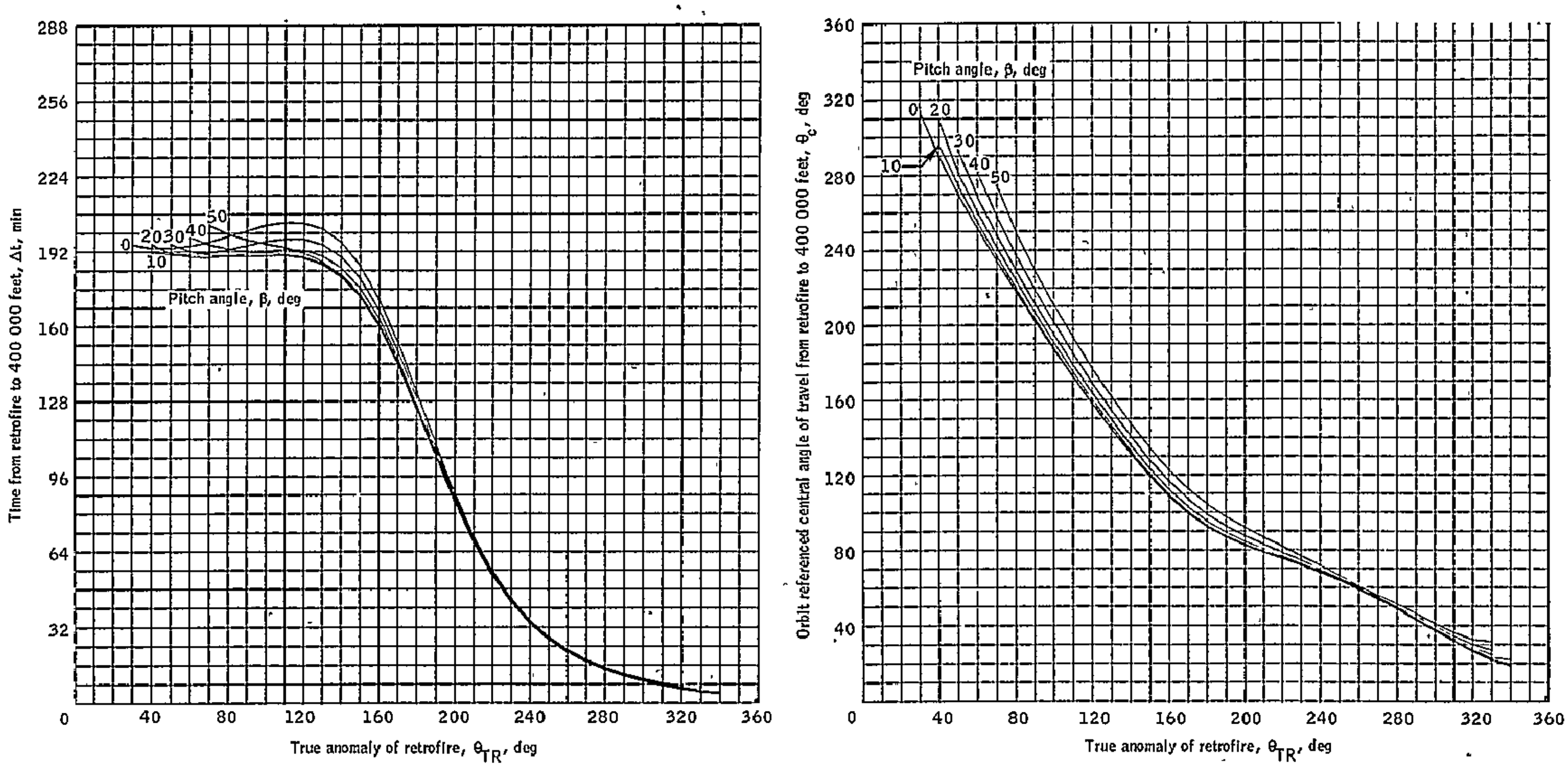
Figure 25.- Continued.





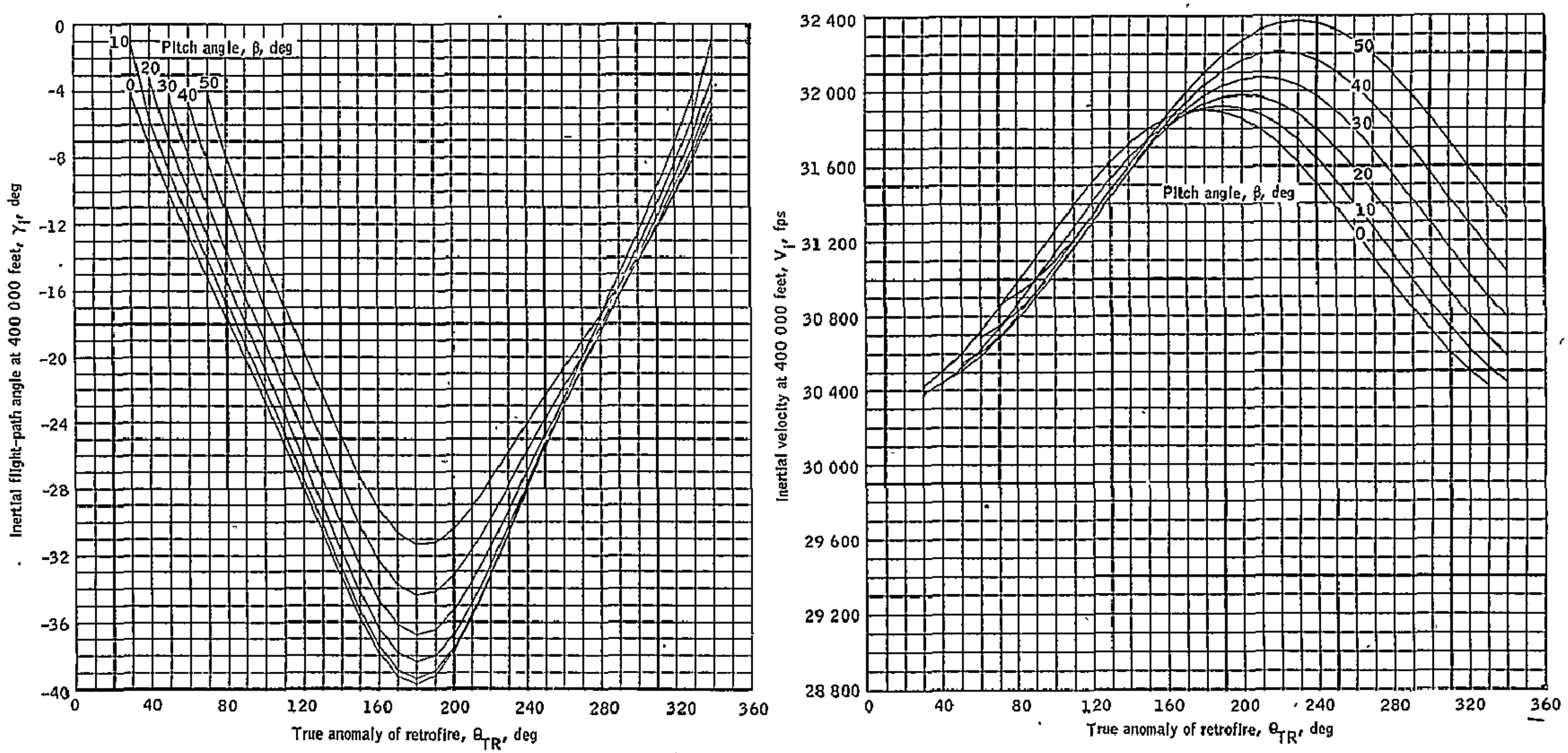
(l) Flight-path angle and velocity for retrograde ΔV=1700 feet per second.

Figure 25.- Continued.



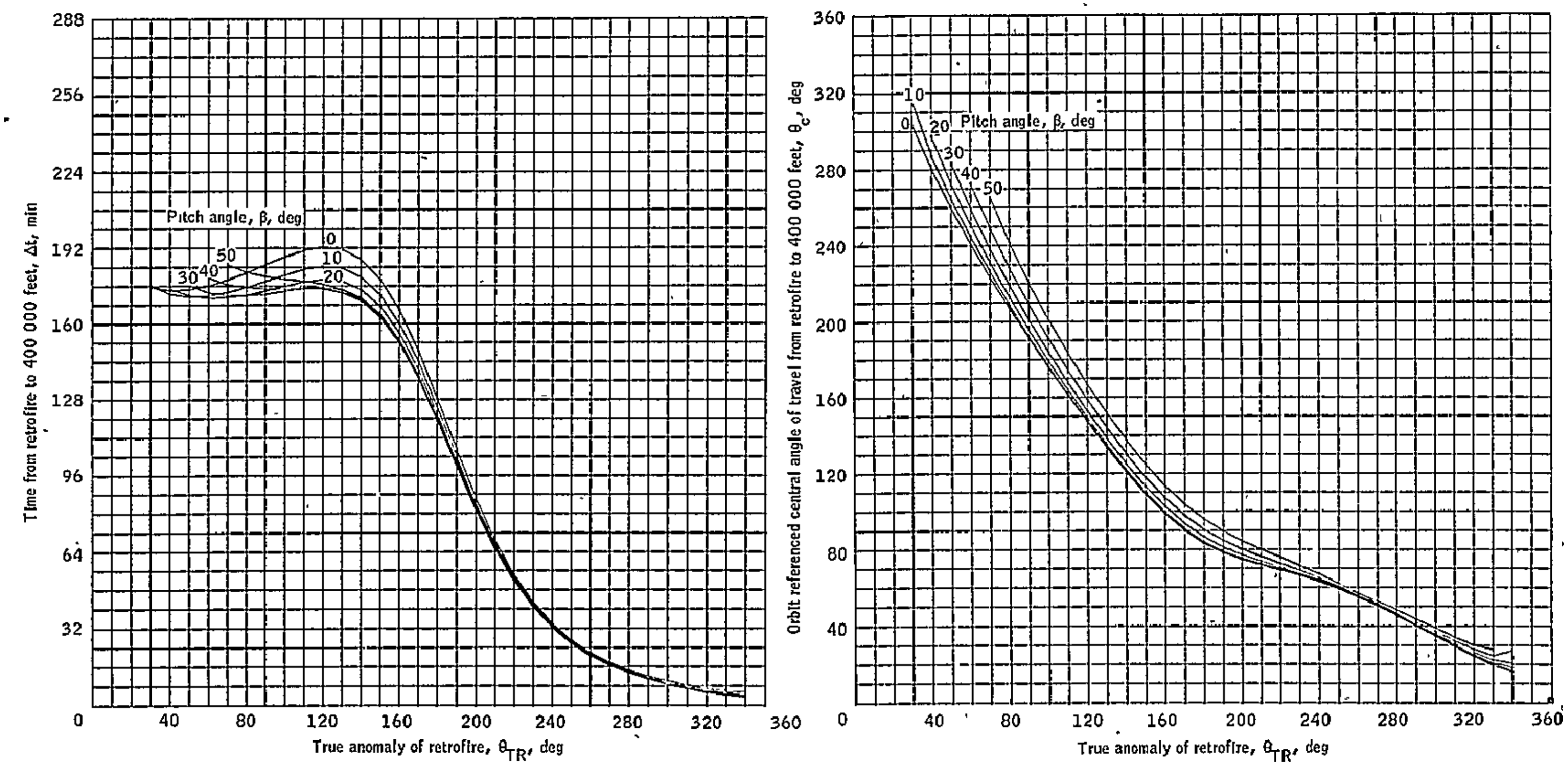
(j) Time from retrofire and central angle for retrograde ΔV=1700 feet per second.

Figure 25.- Continued.



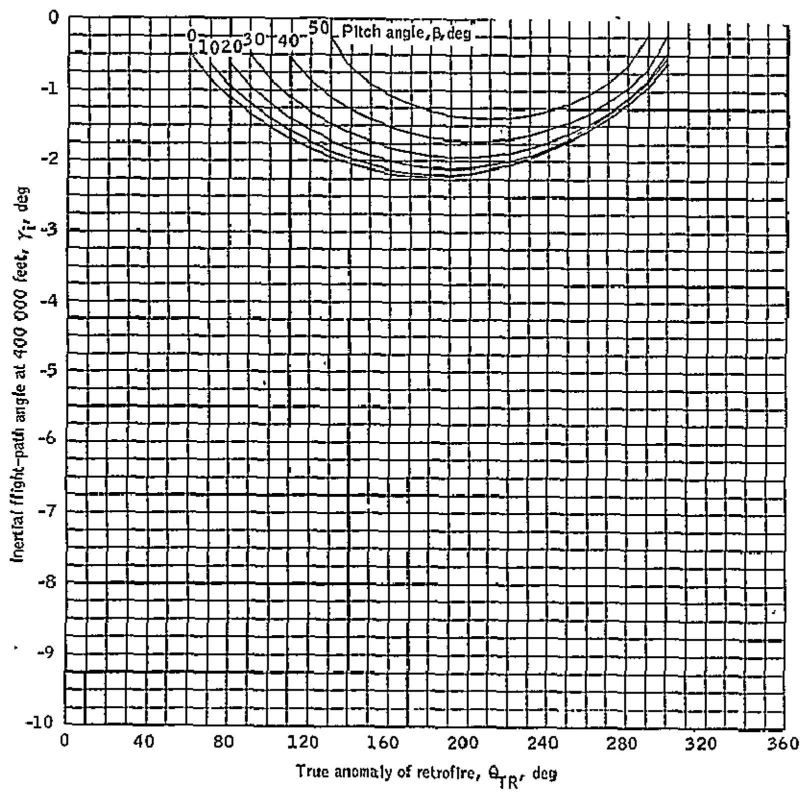
(k) Flight-path angle and velocity for retrograde ΔV=2100 feet per second.

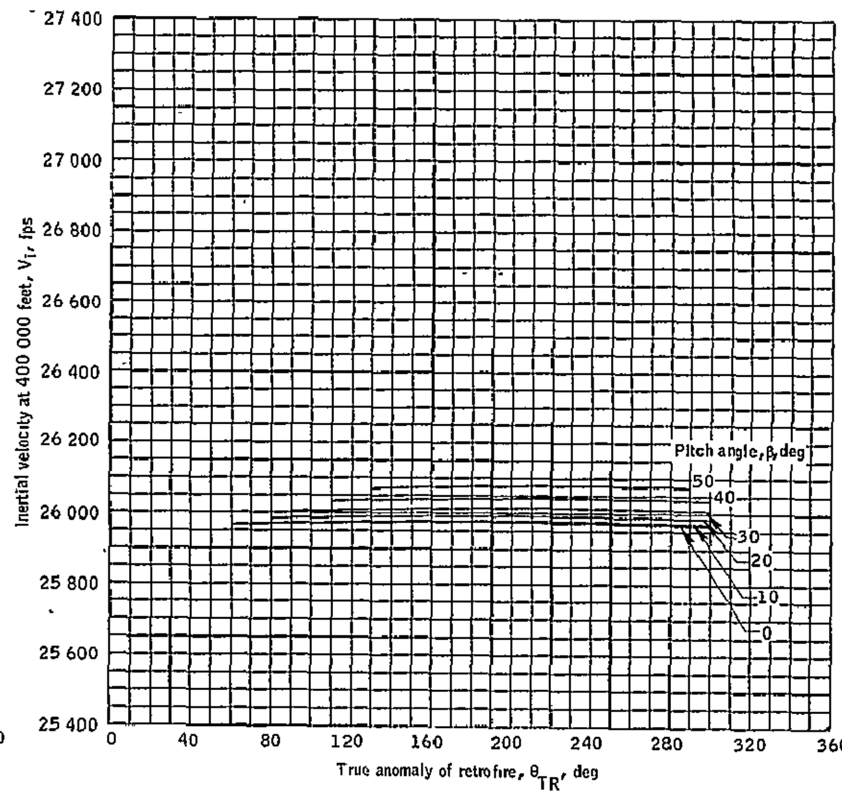
Figure 25.- Continued.



(l) Time from retrofire and central angle for retrograde ΔV=2100 feet per second.

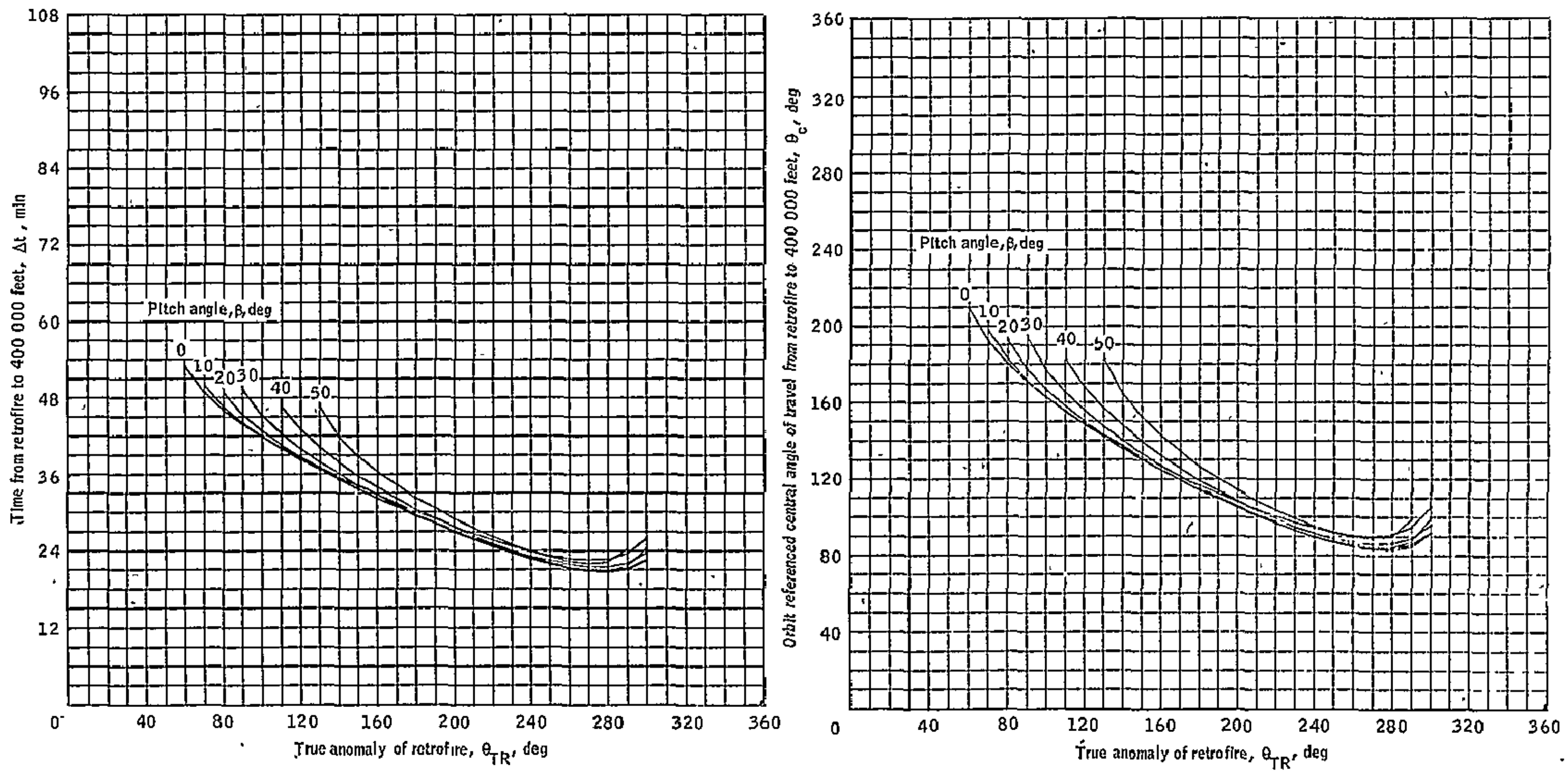
Figure 25.- Concluded.





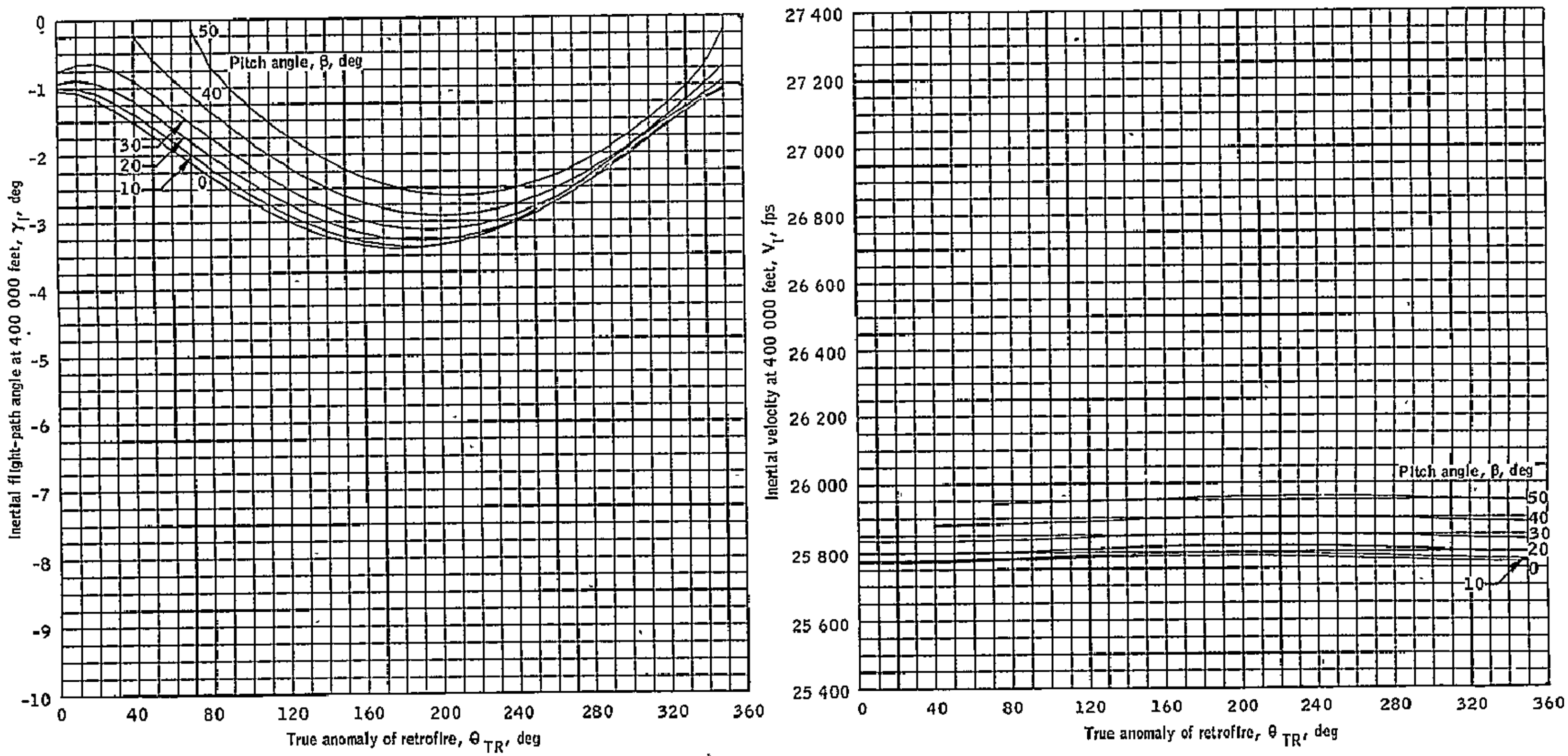
(a) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

Figure 26.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 150/300 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

Figure 26.- Continued.



(c) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

Figure 26.- Continued.

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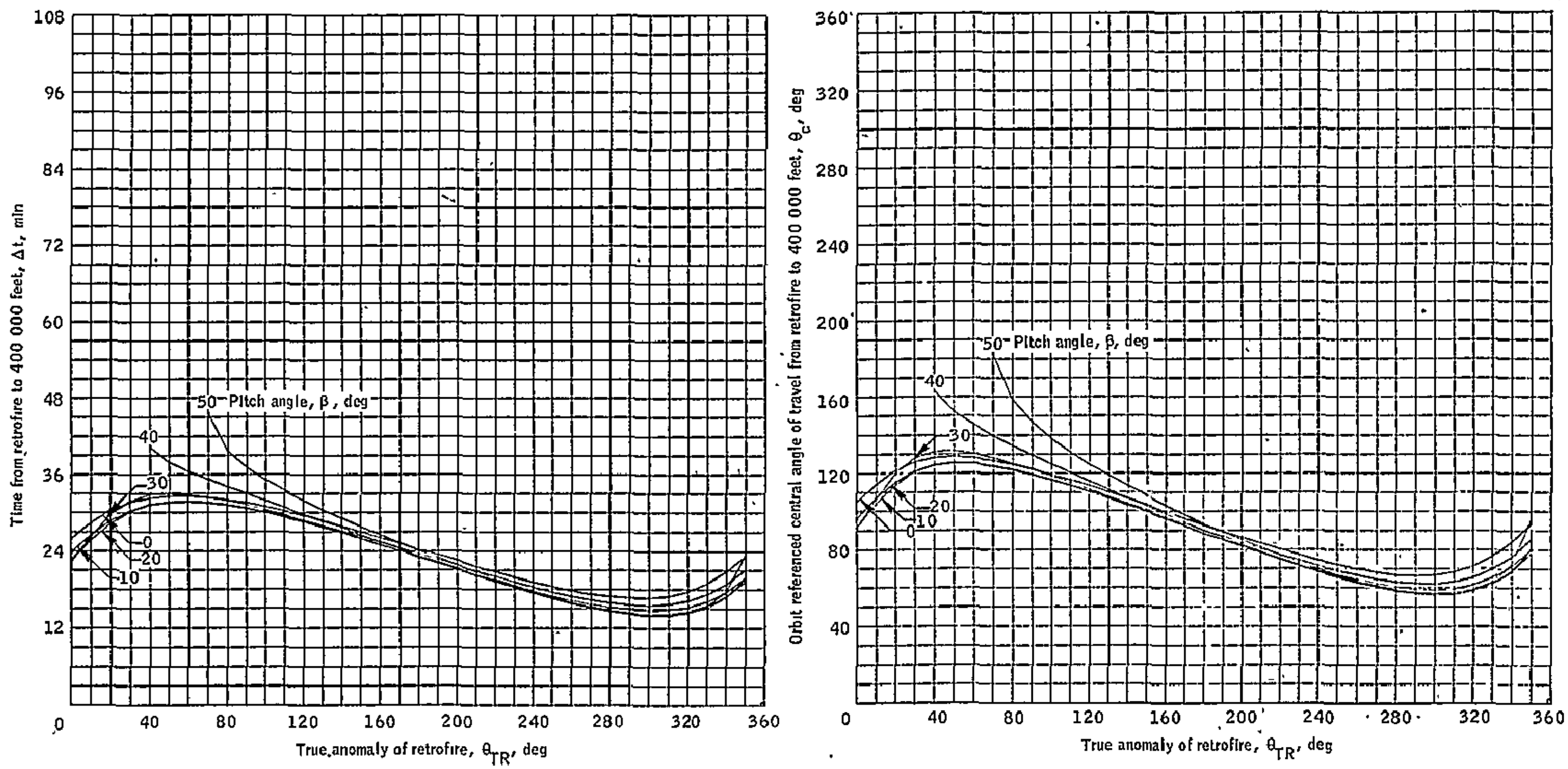
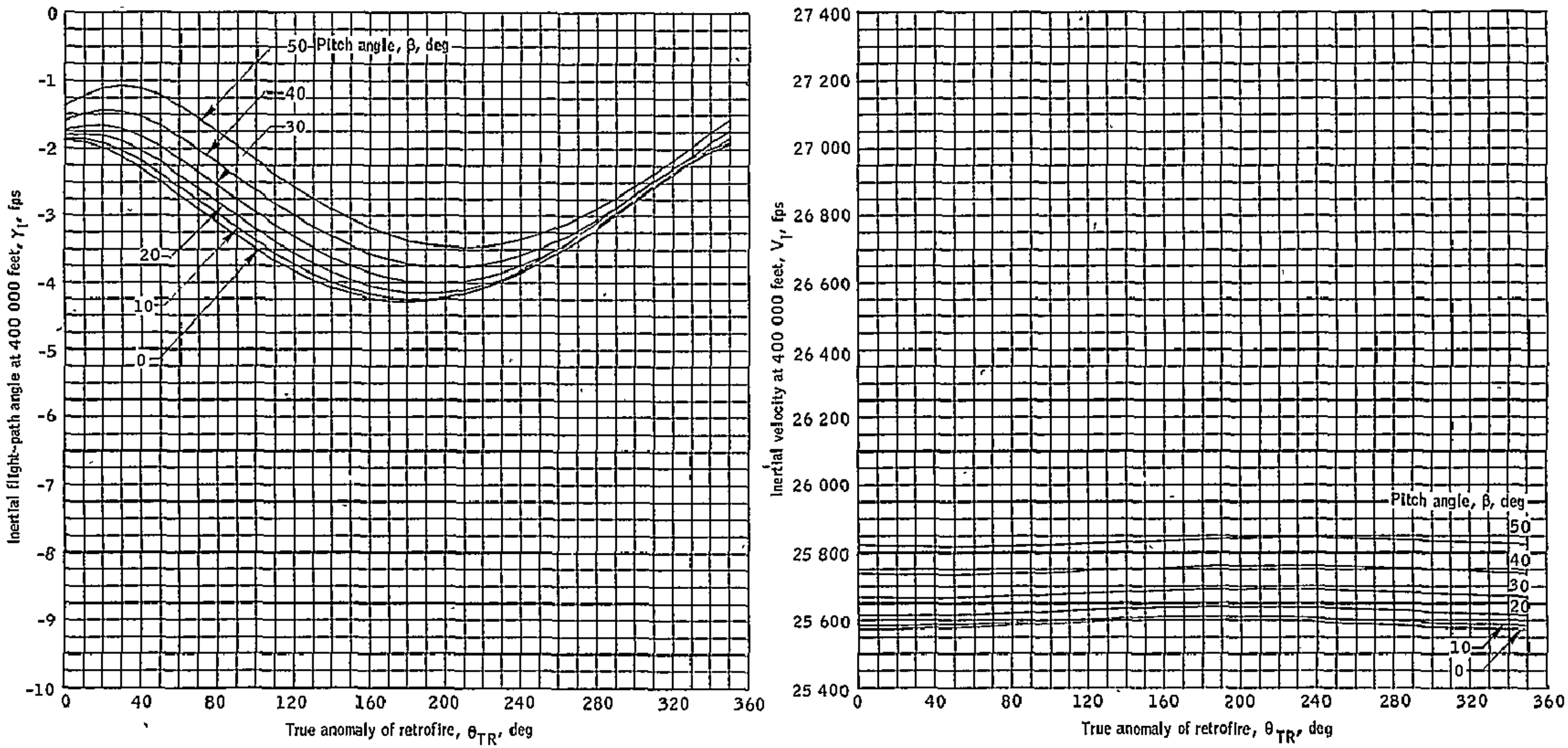


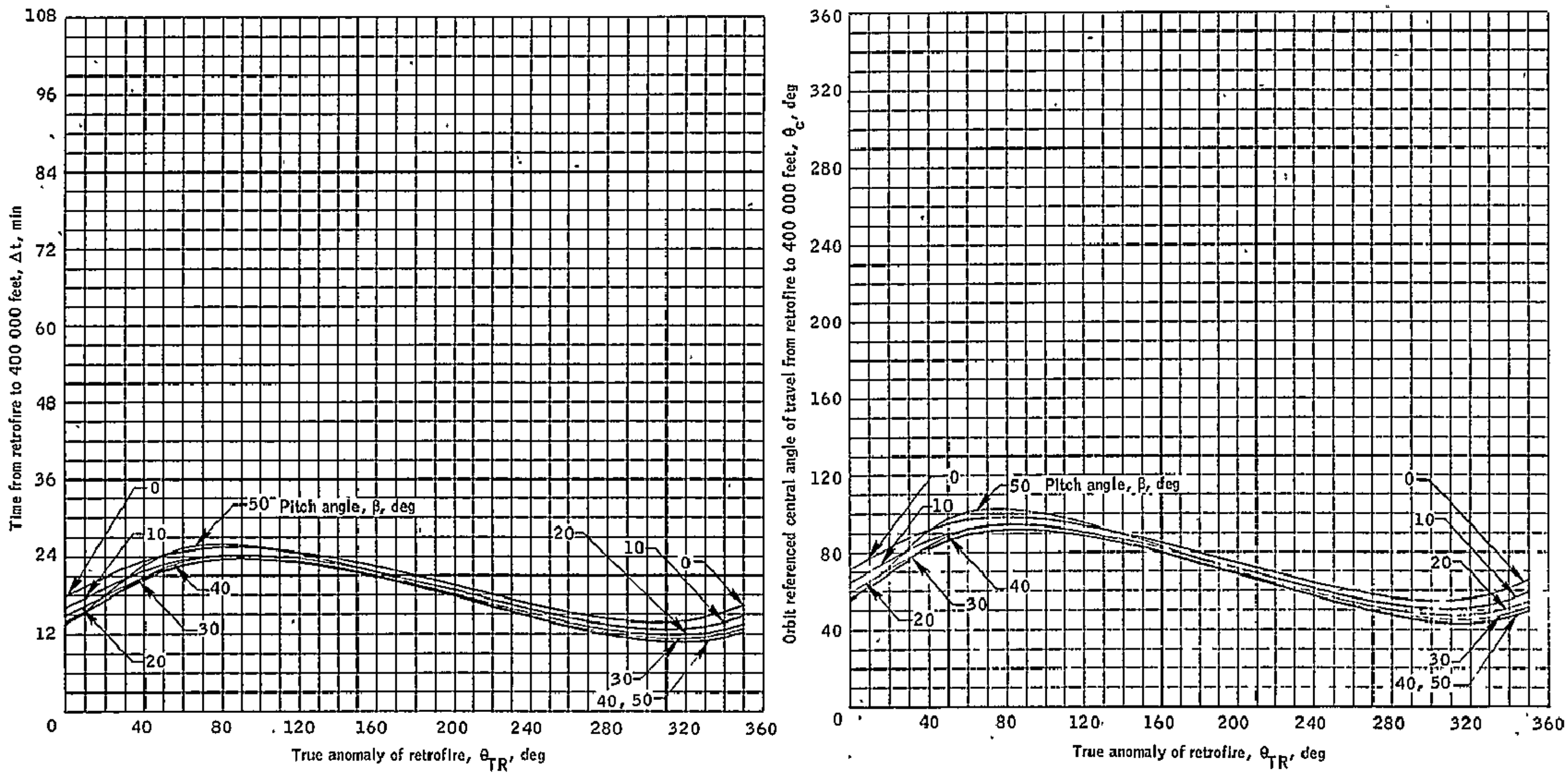
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 26.- Continued.



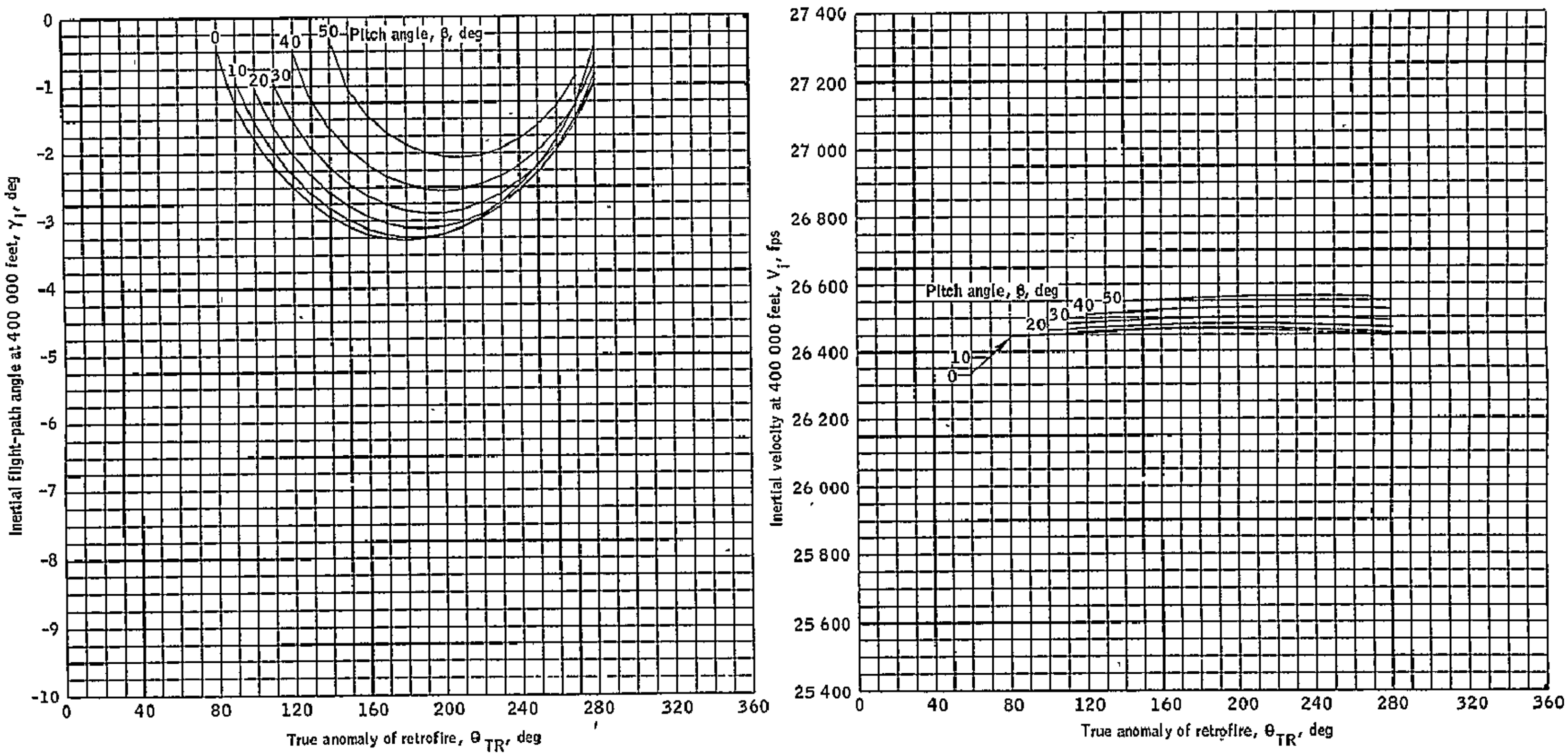
(e) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 26.- Continued.



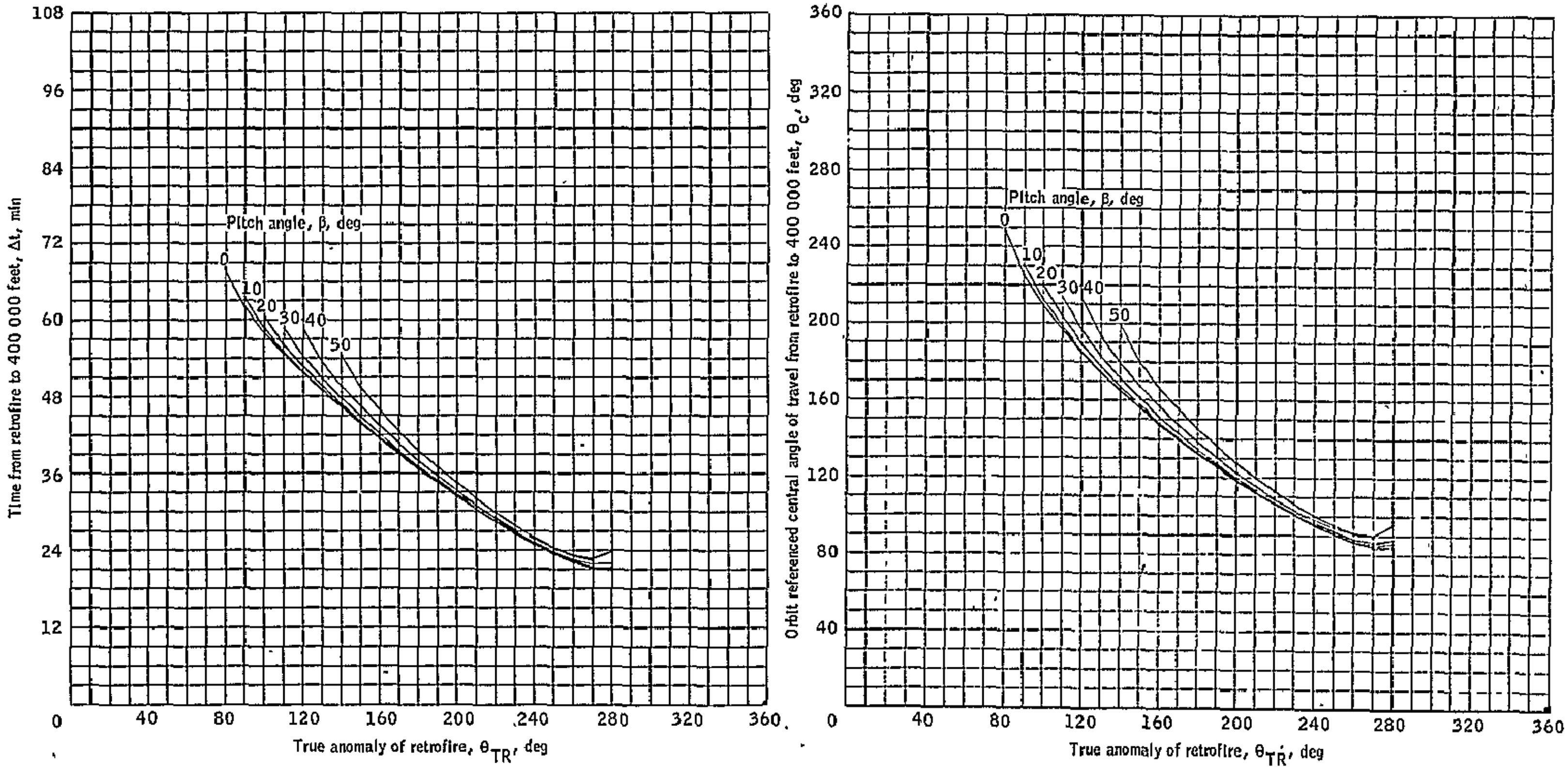
(f) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

Figure 26.- Concluded.



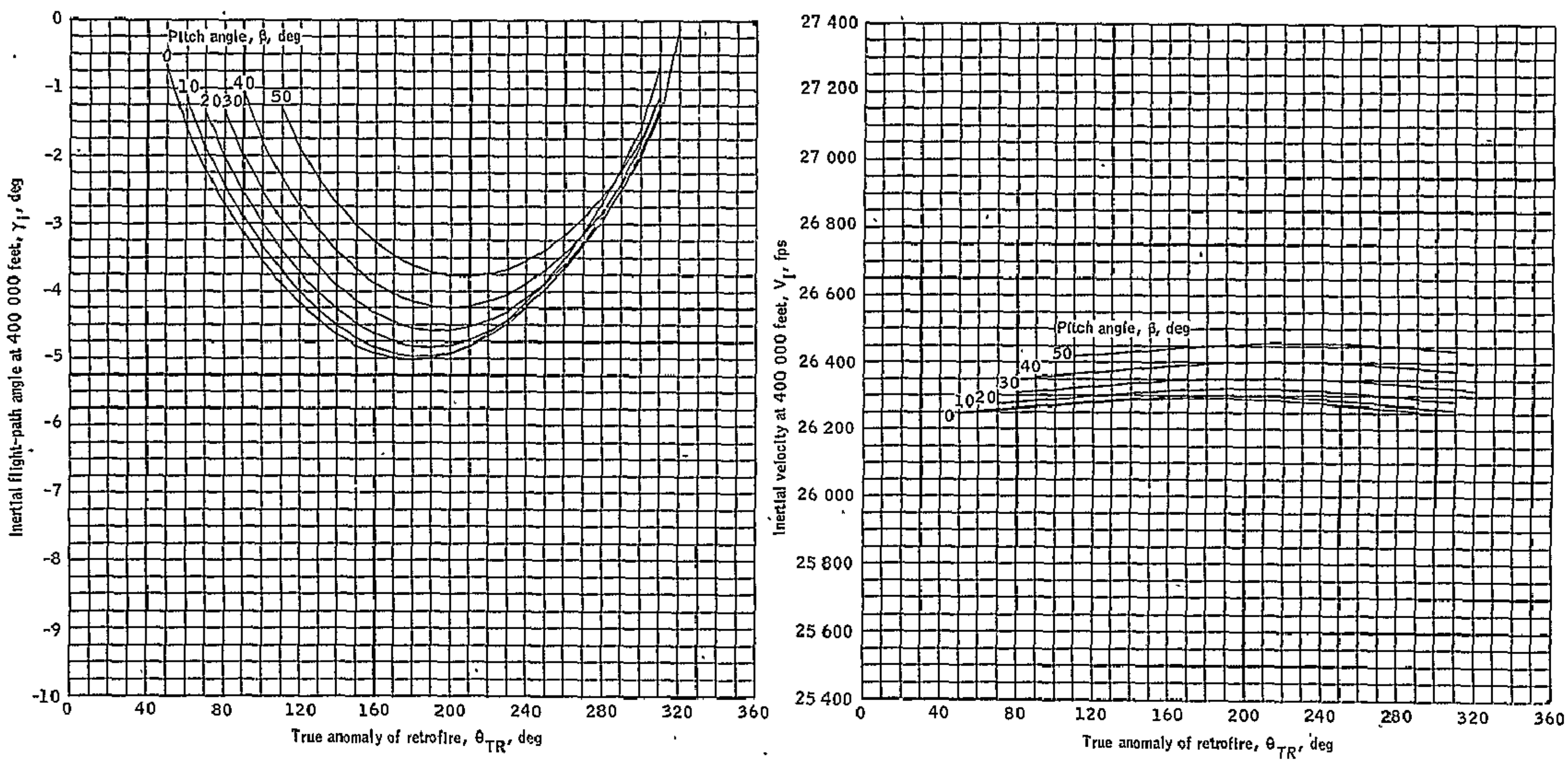
(a) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

Figure 27.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 150/600 nautical mile orbit.



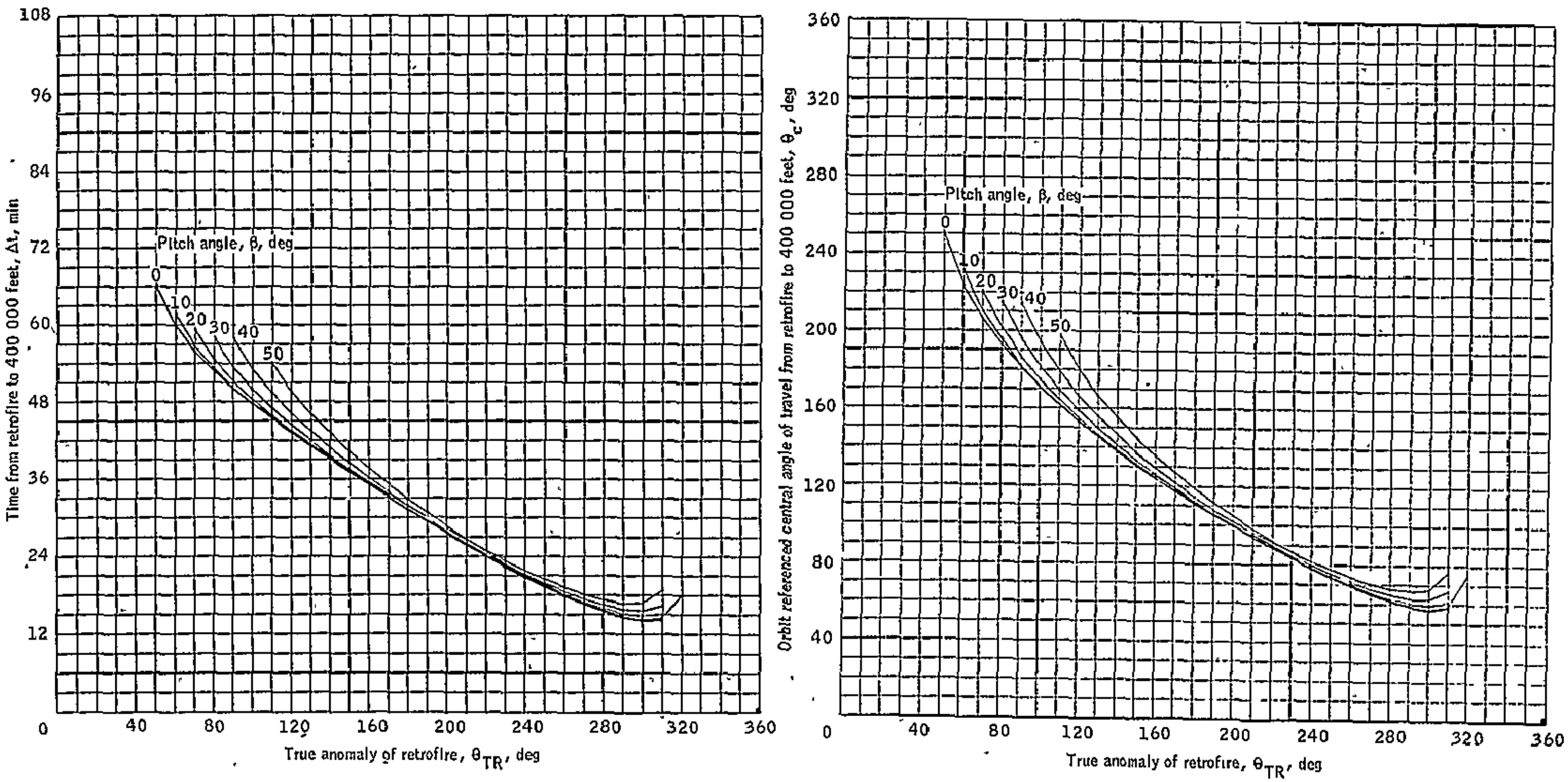
(b) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

Figure 27.- Continued.



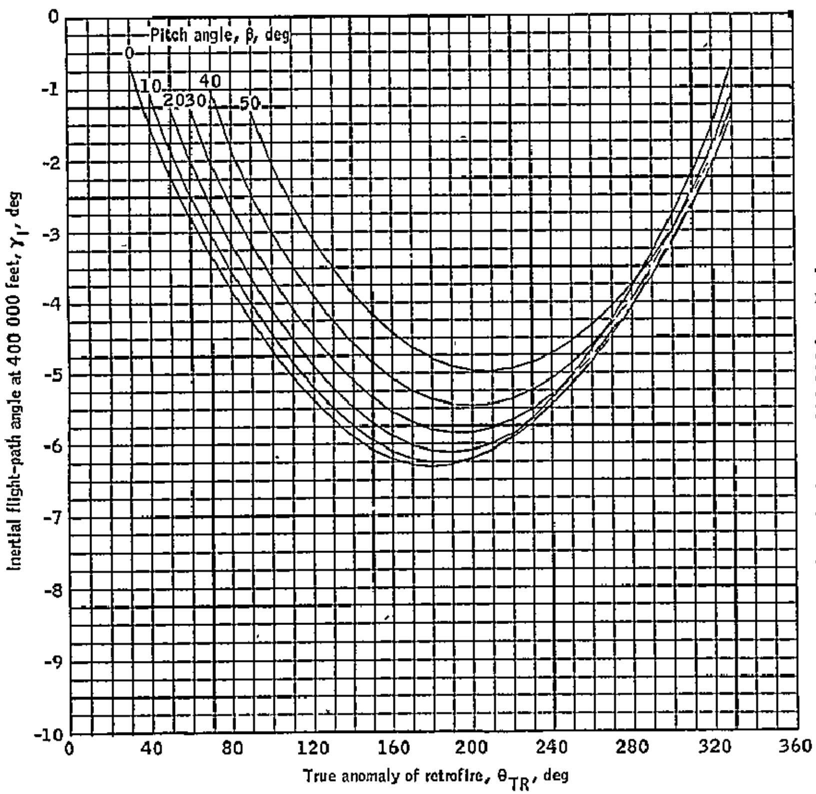
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

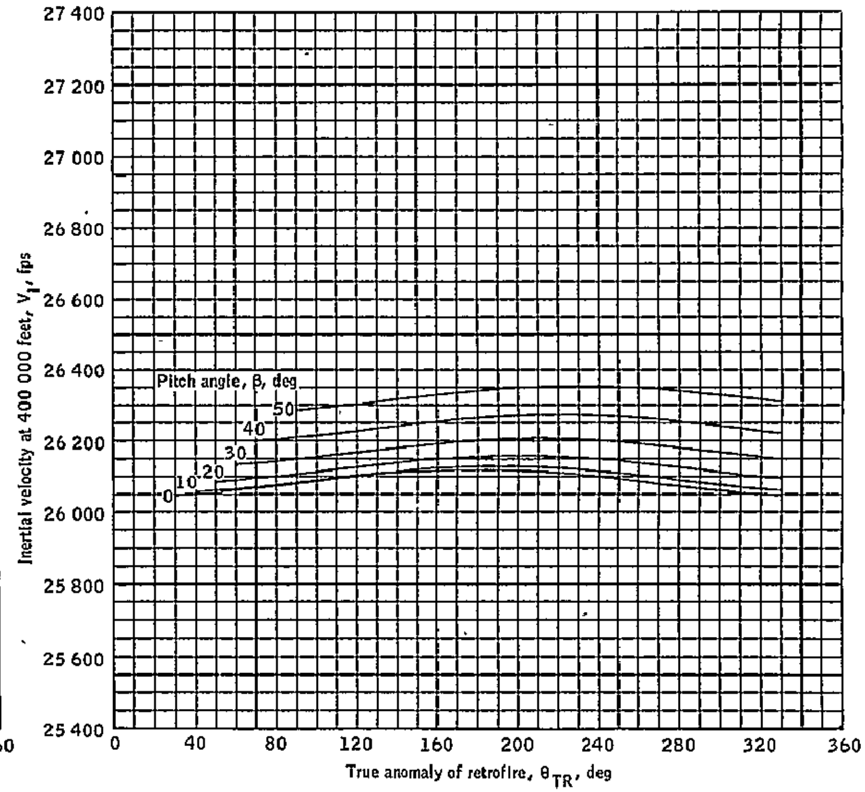
Figure 27.- Continued.



(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

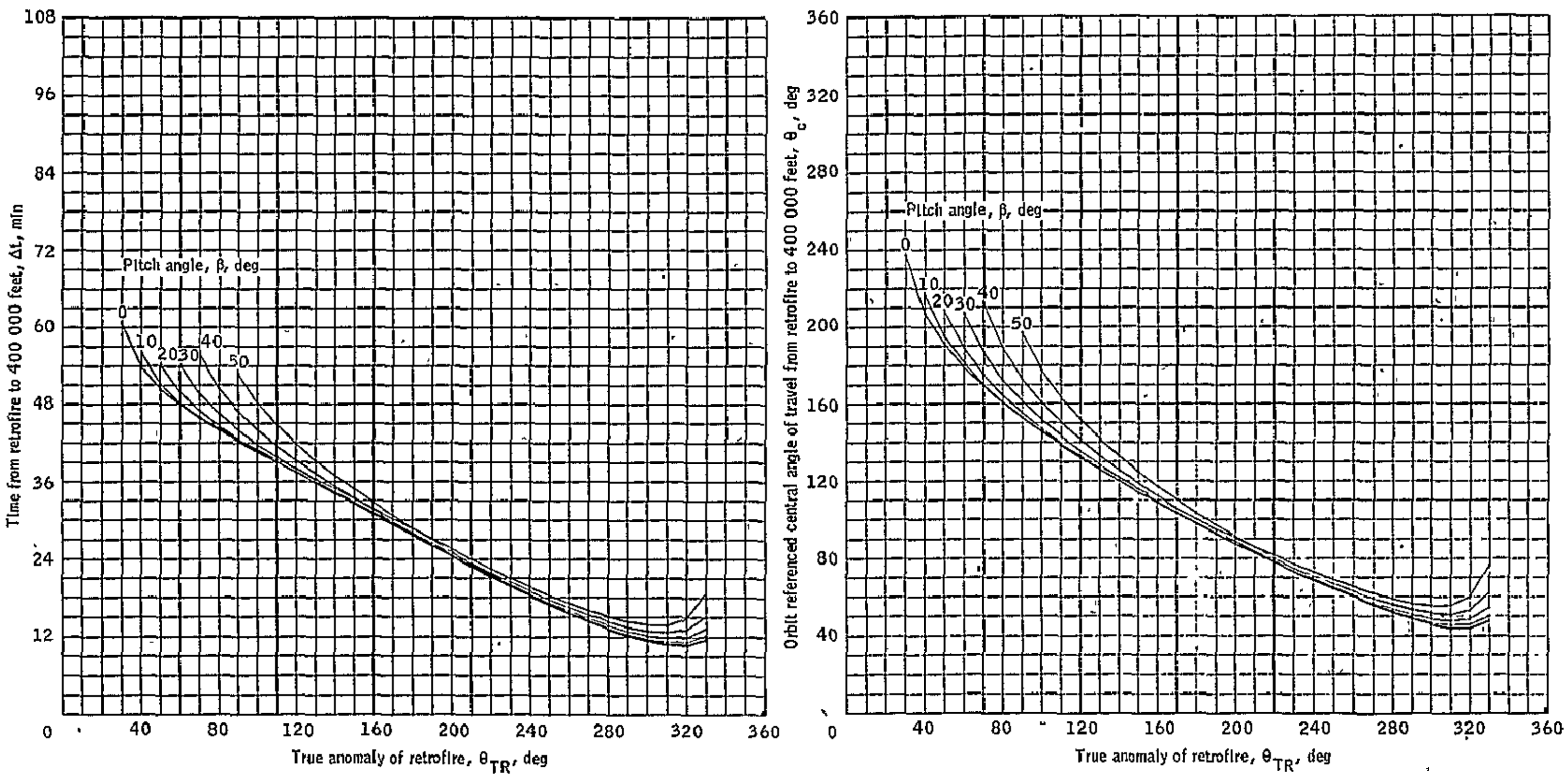
Figure 27.- Continued.





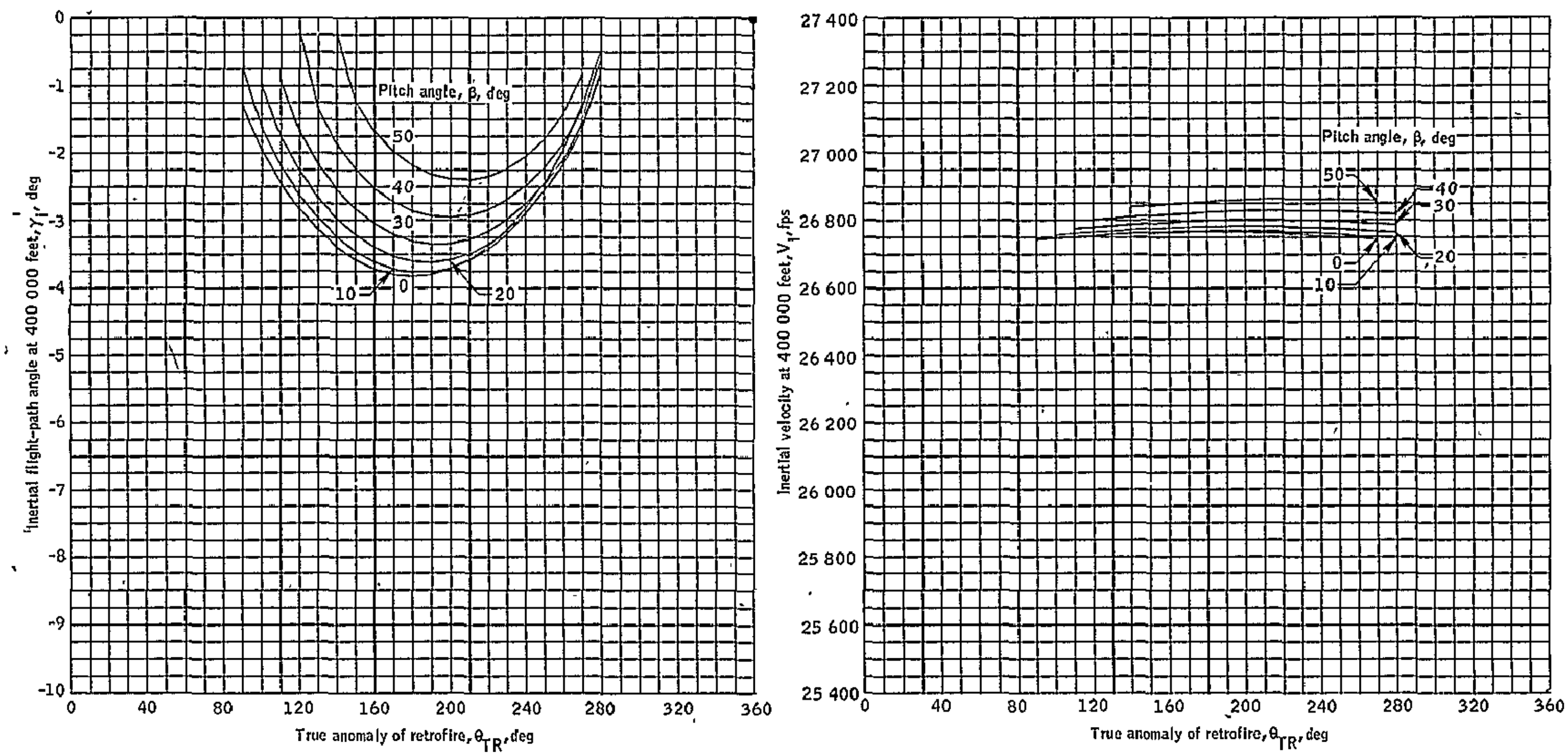
(e) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 27.- Continued.



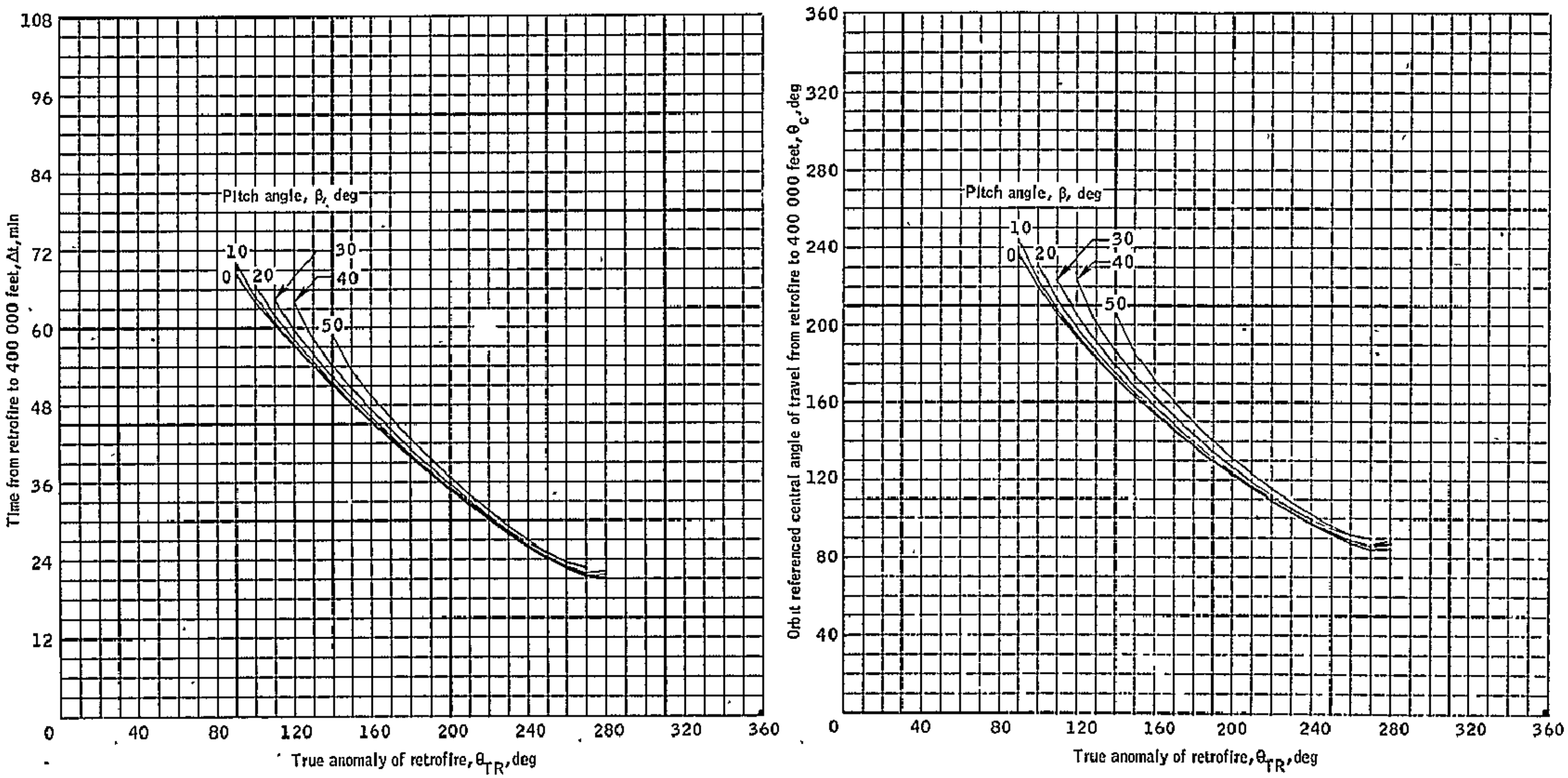
(f) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

Figure 27.- Concluded.



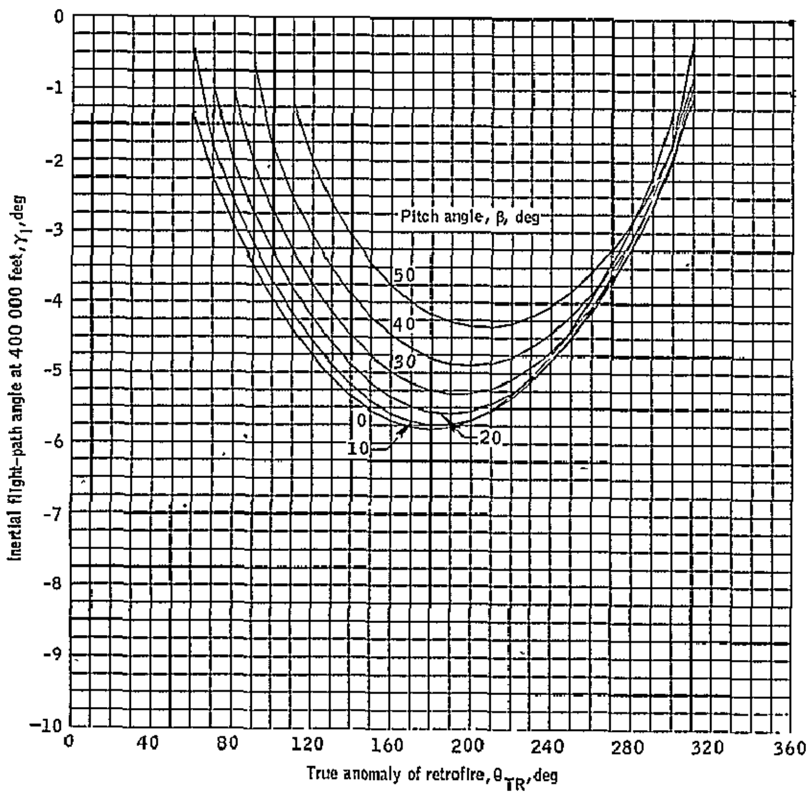
(a) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

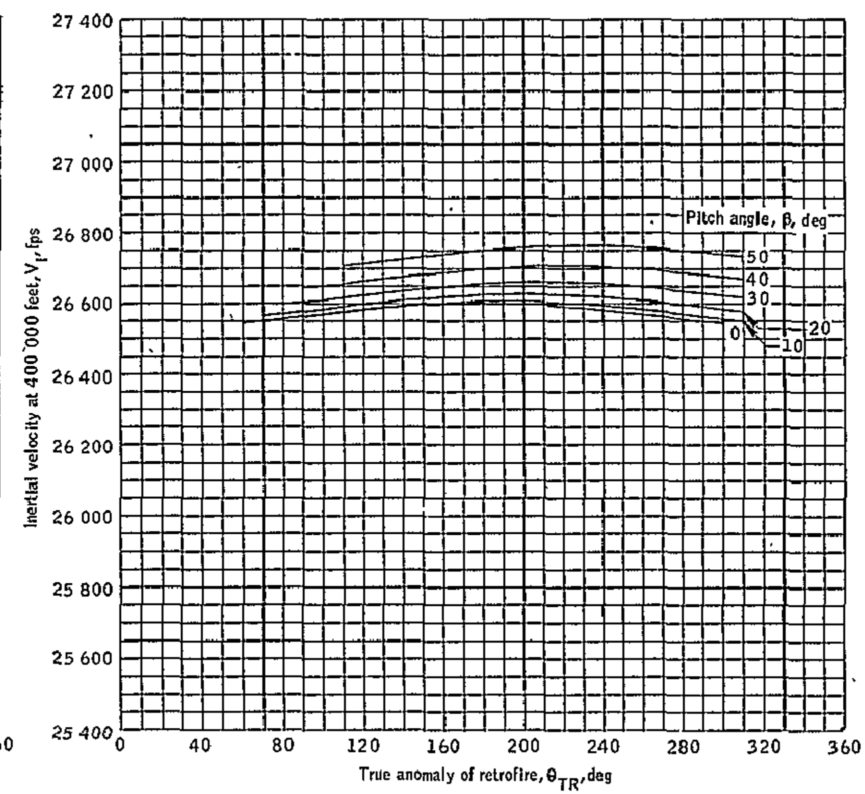
Figure 28.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 150/800 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

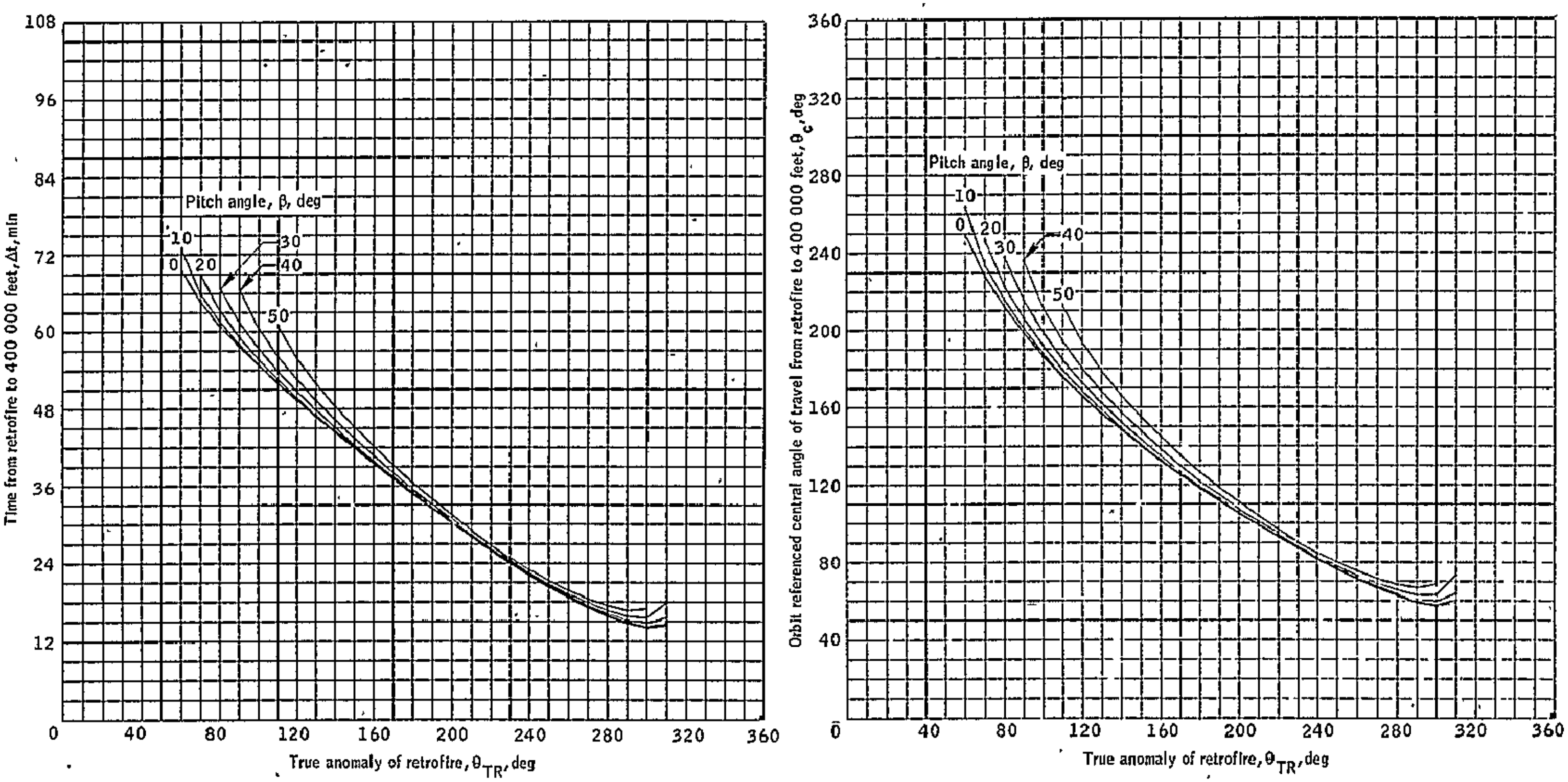
Figure 28.- Continued





(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 28.- Continued



(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 28.- Continued

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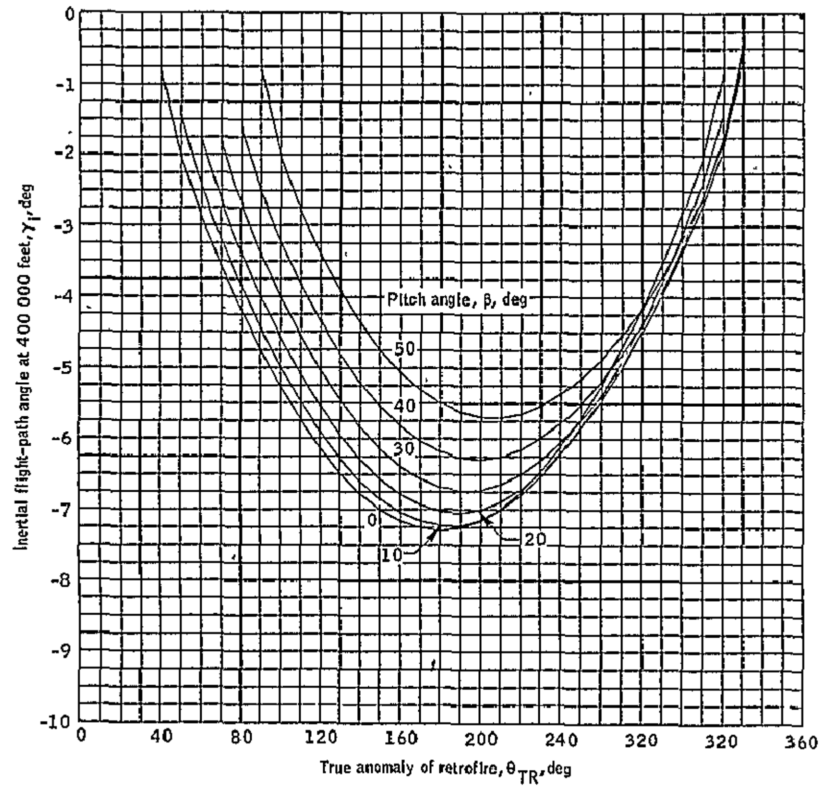
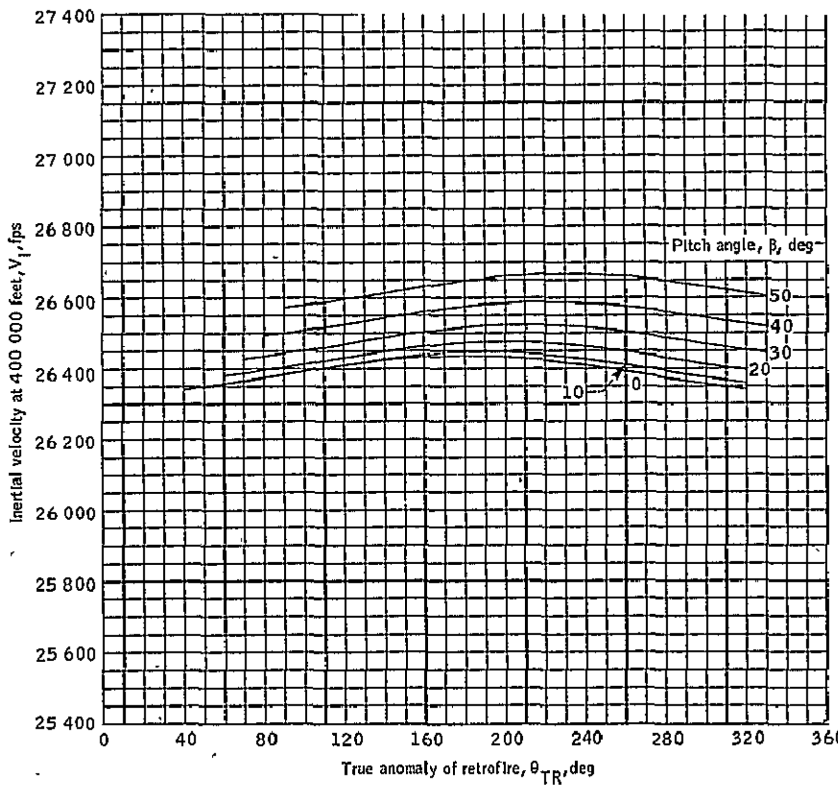
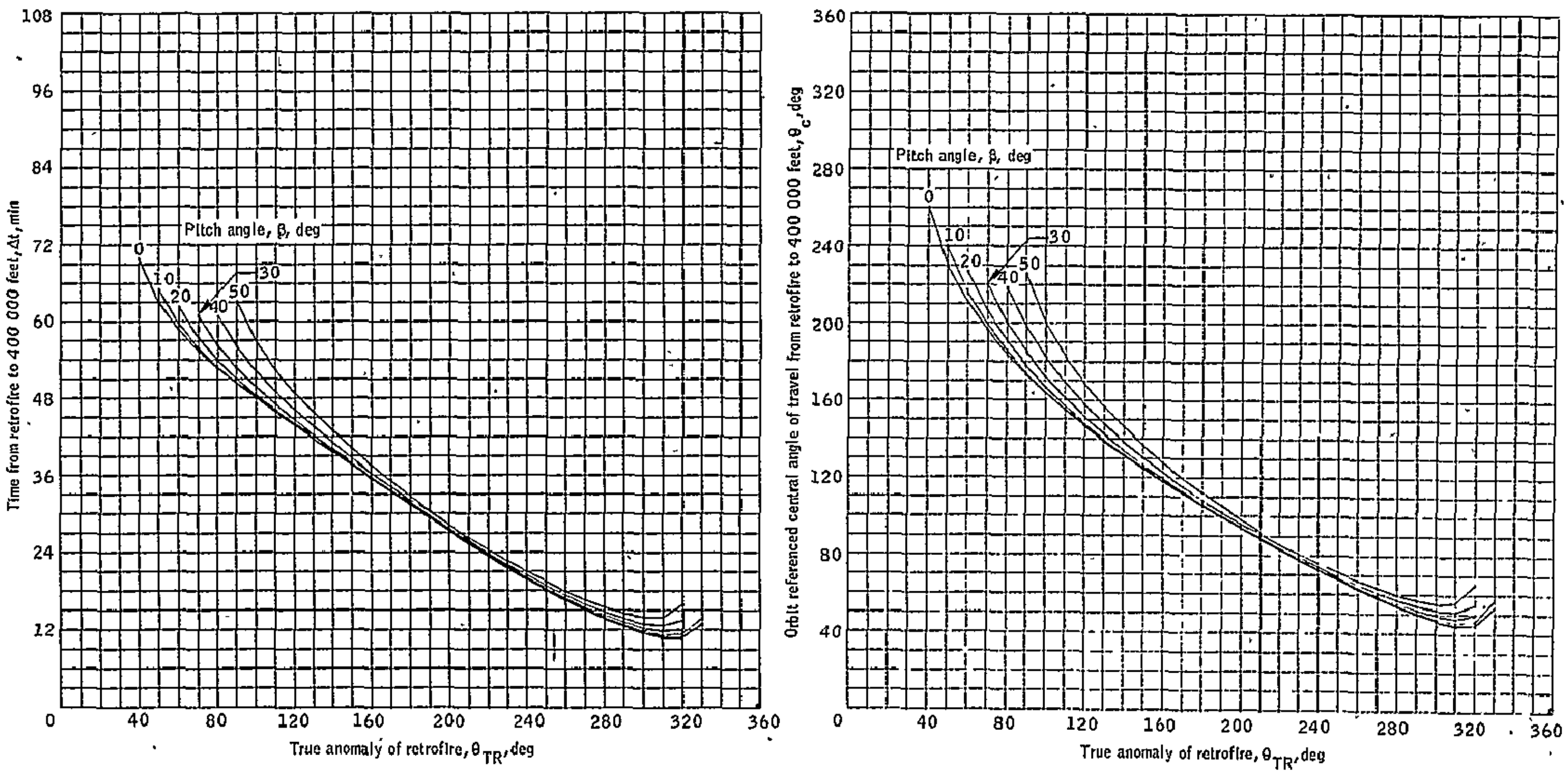




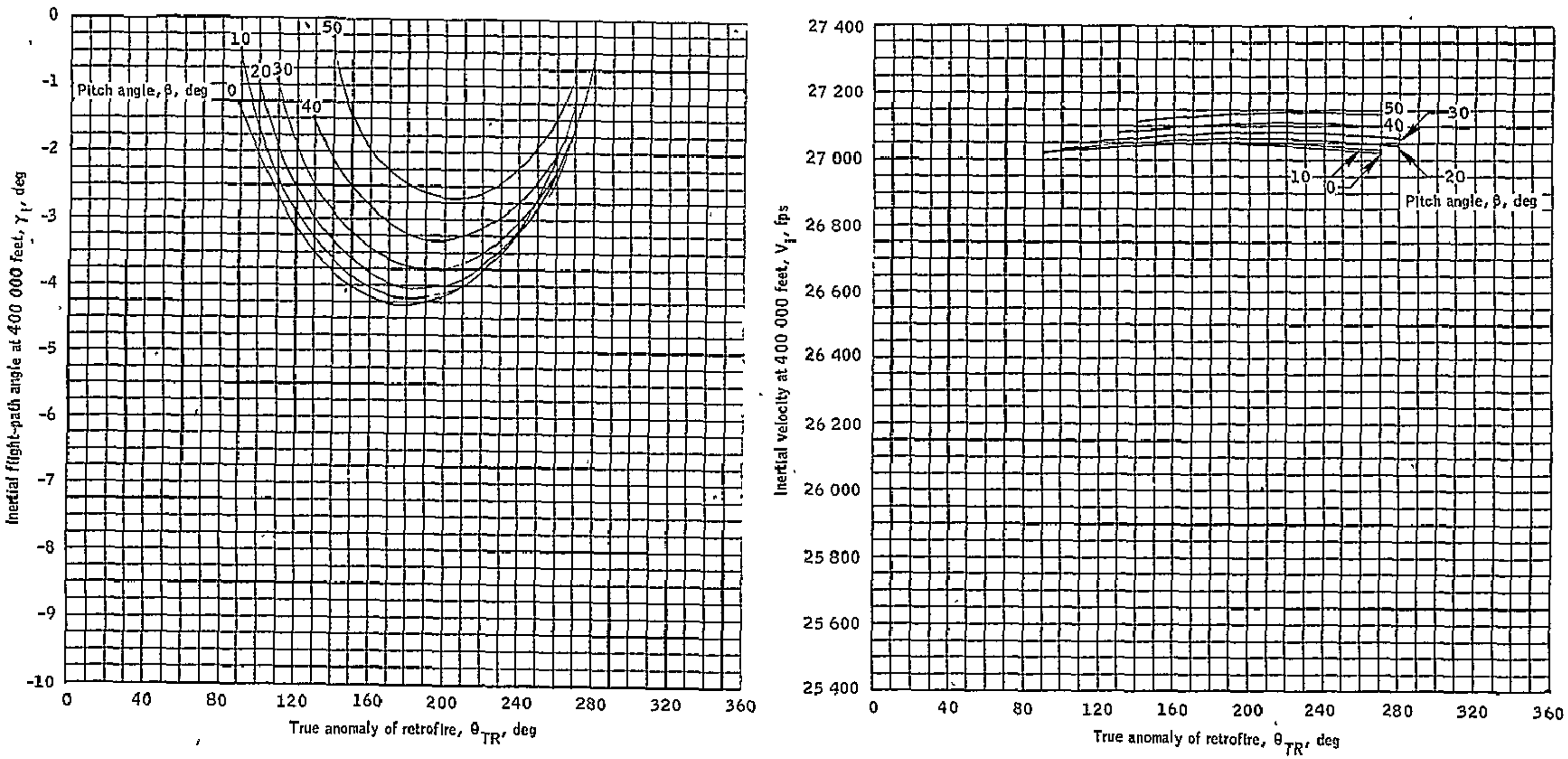
(e) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 28.- Continued



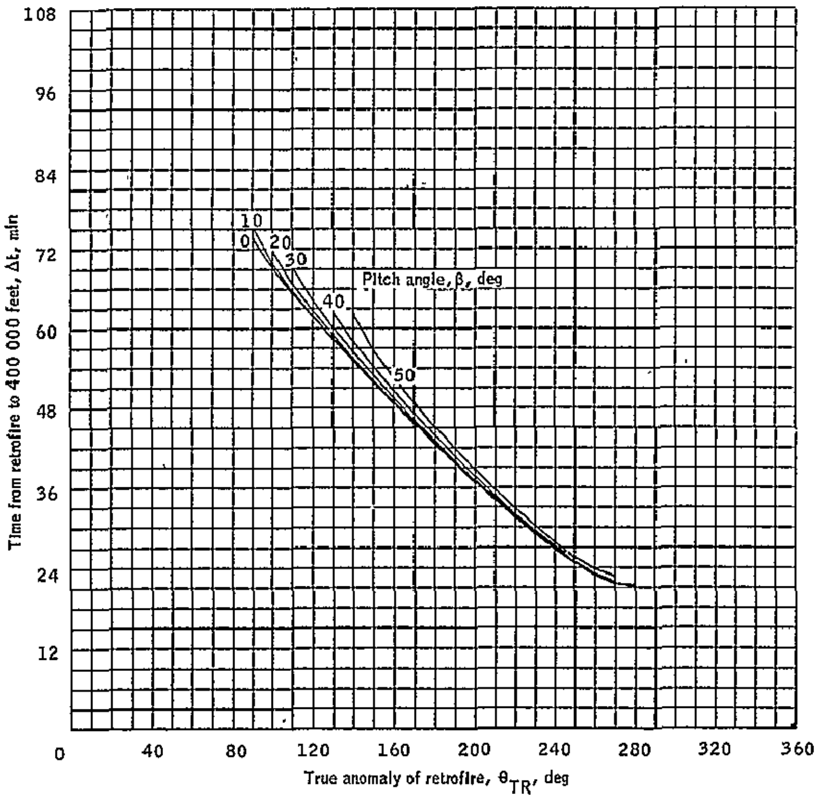
(f) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

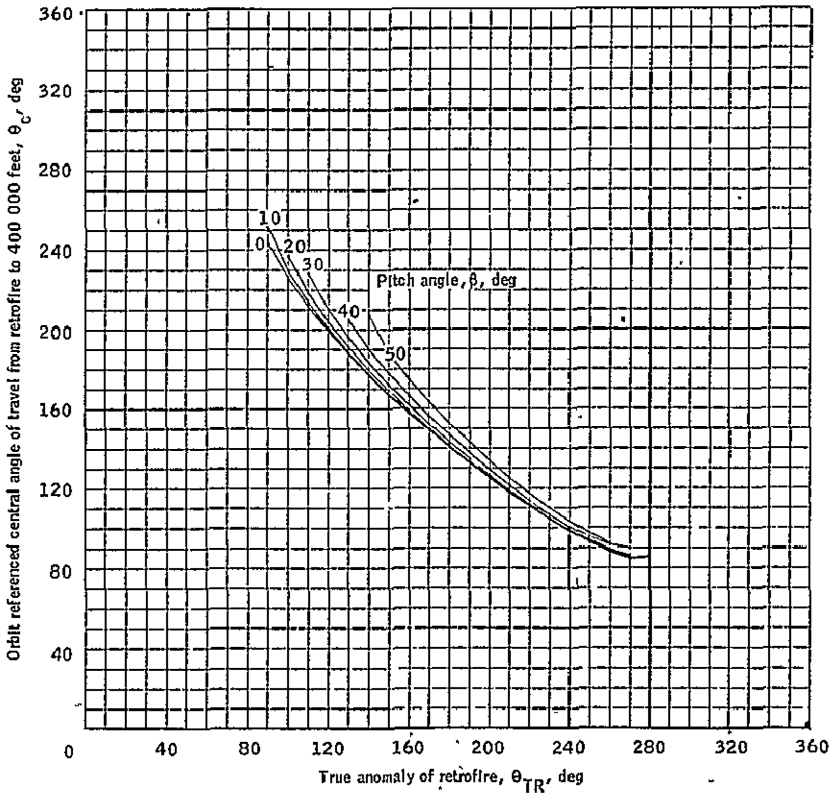
Figure 28.- Concluded



(a) Flight-path angle and velocity for retrograde ΔV=300 feet per second.

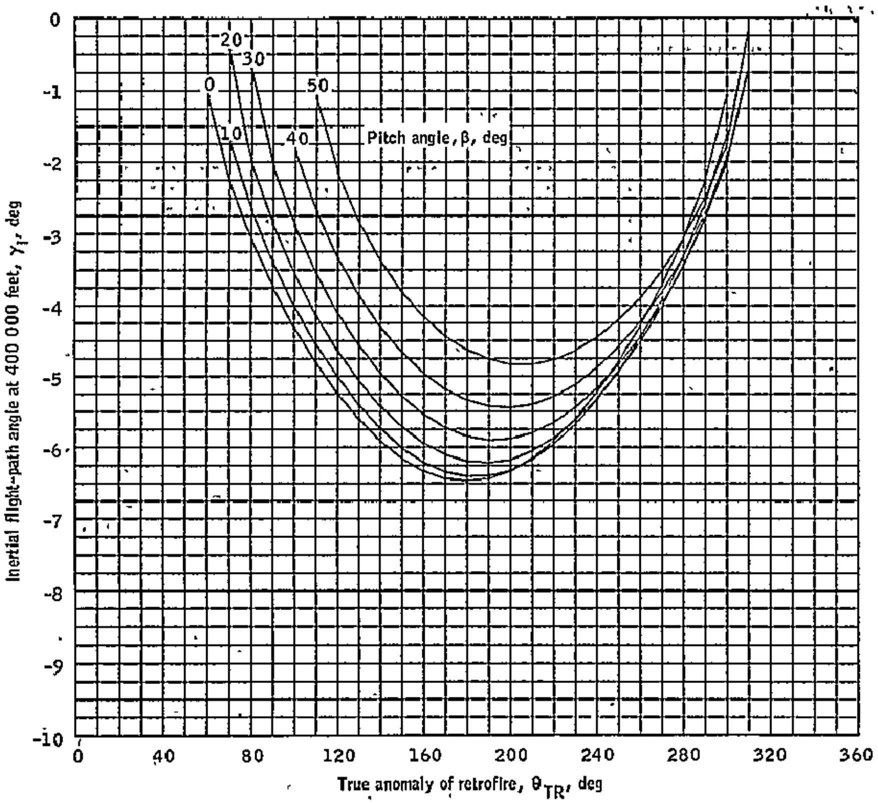
Figure 29.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 150/1000 nautical mile orbit.

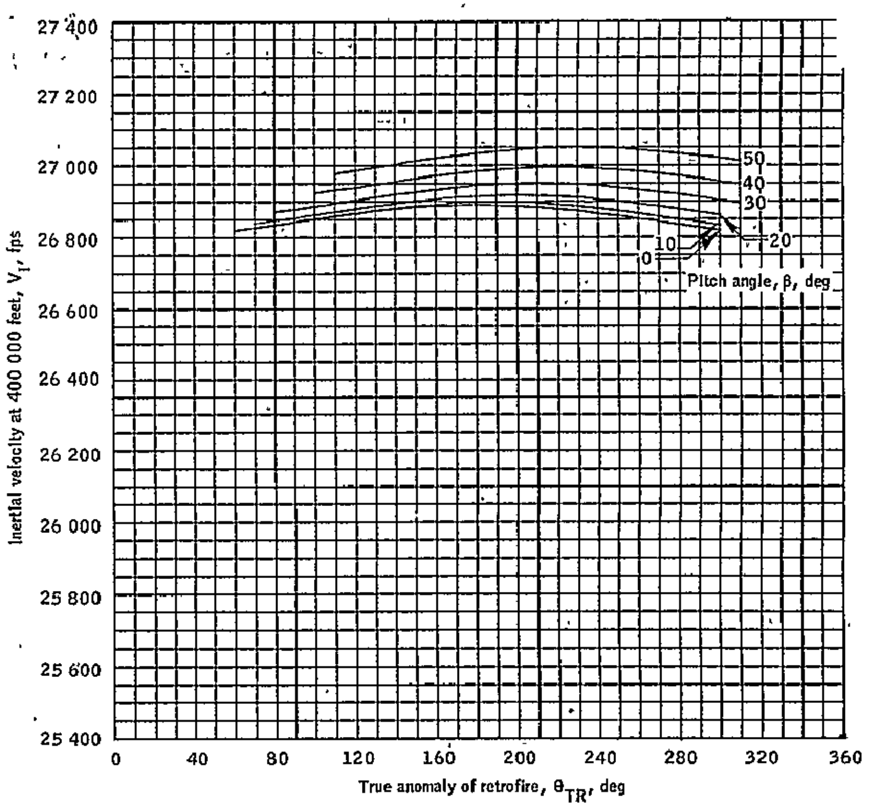




(b) Time from retrofire and central angle for retrograde ΔV=300 feet per second.

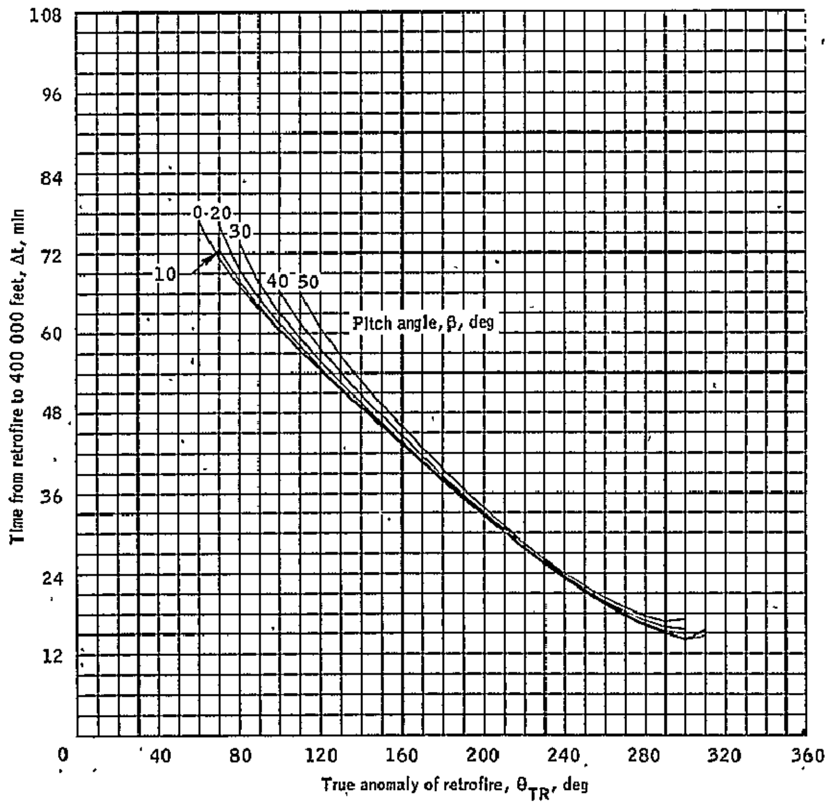
Figure 29.- Continued.

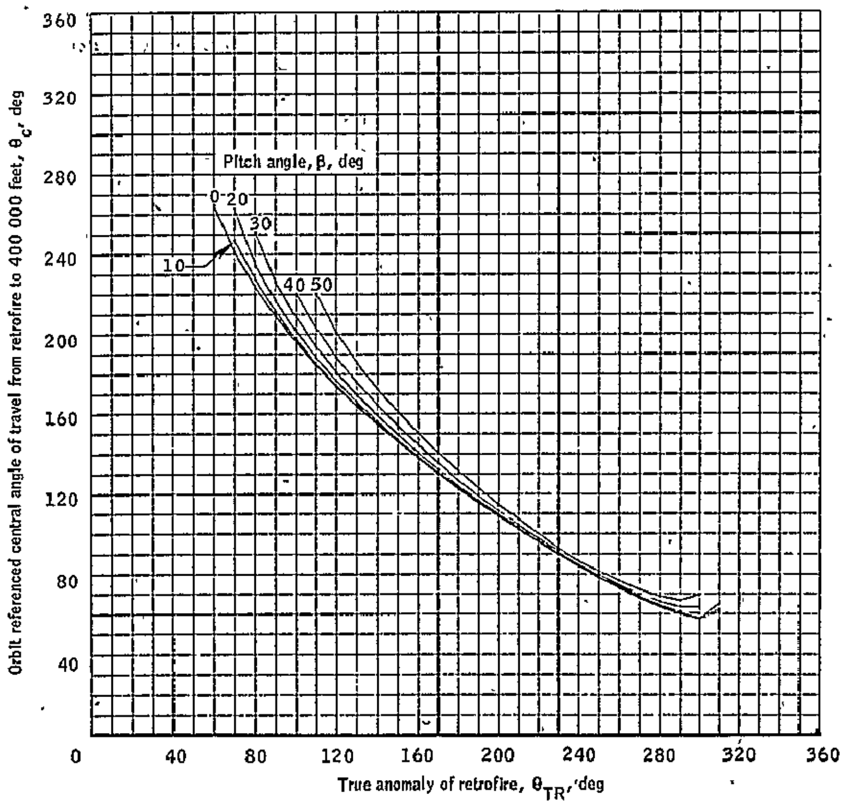




(c) Flight-path angle and velocity for retrograde ΔV=500 feet per second.

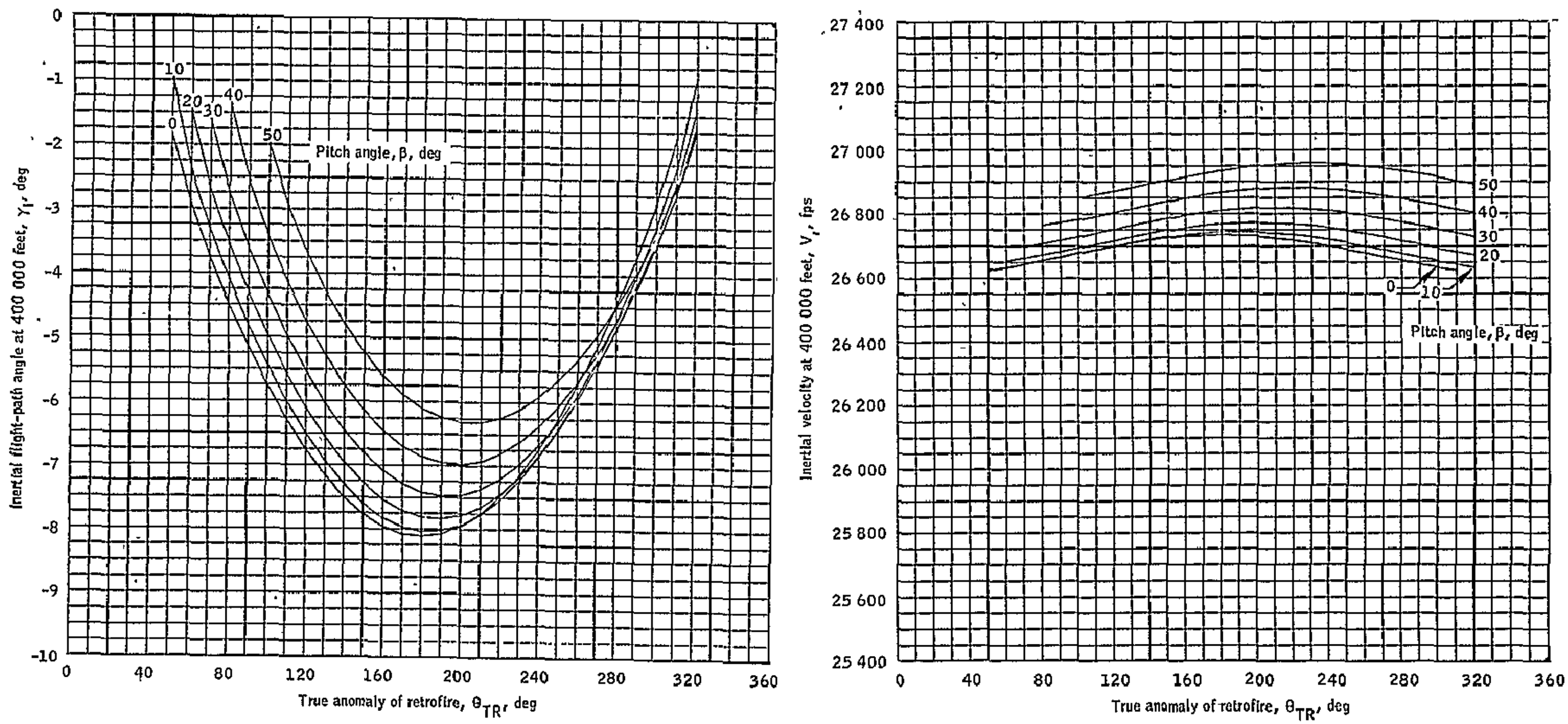
Figure 29.- Continued.





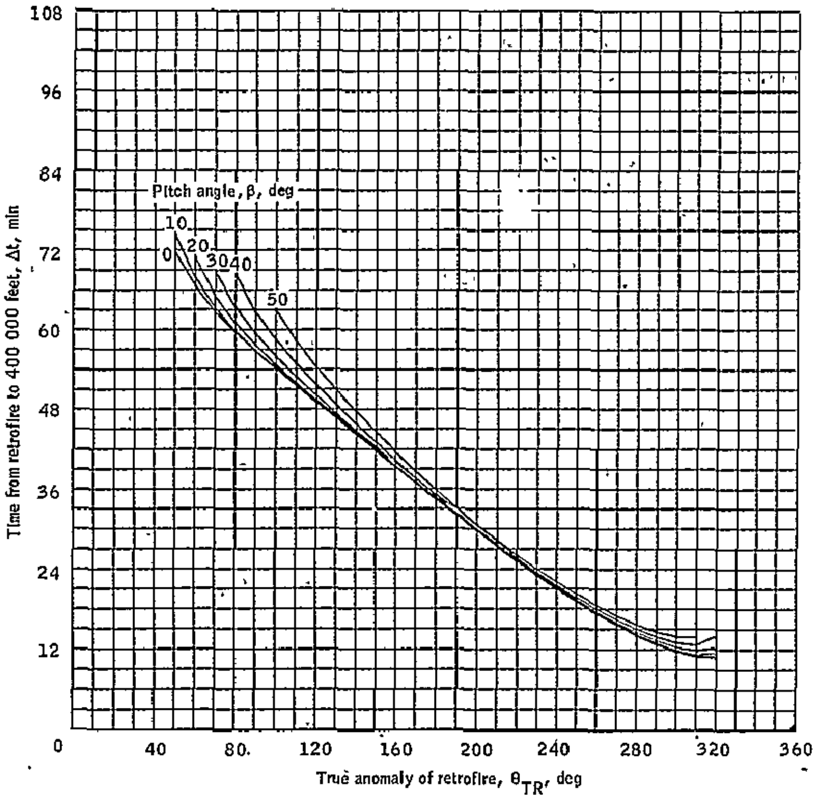
(d) Time from retrofire and central angle for retrograde ΔV=500 feet per second.

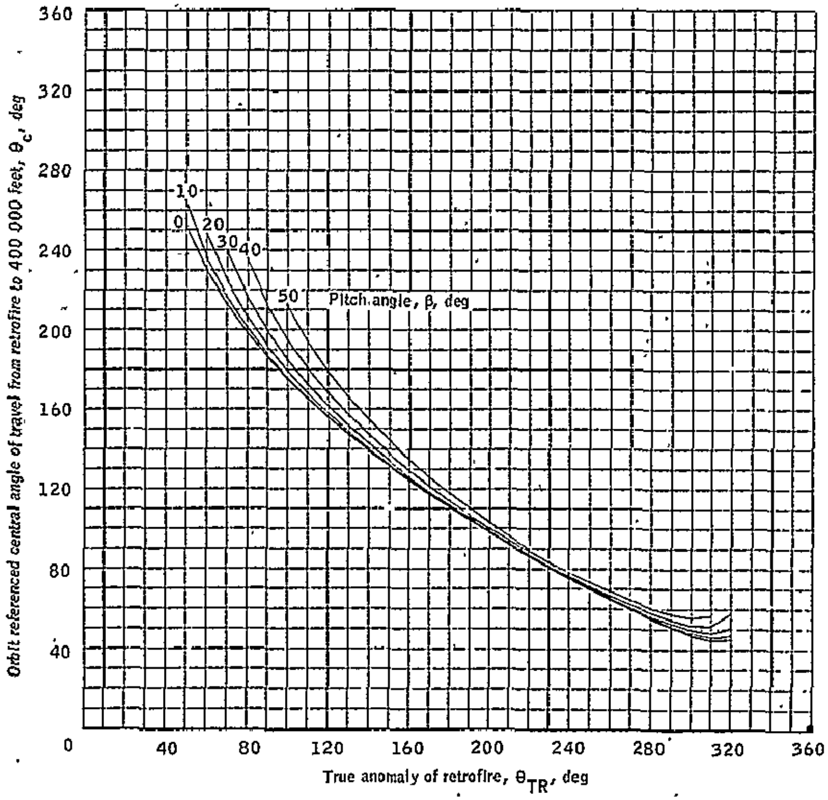
Figure 29.- Continued.



(e) Flight-path angle and velocity for retrograde ΔV=700 feet per second.

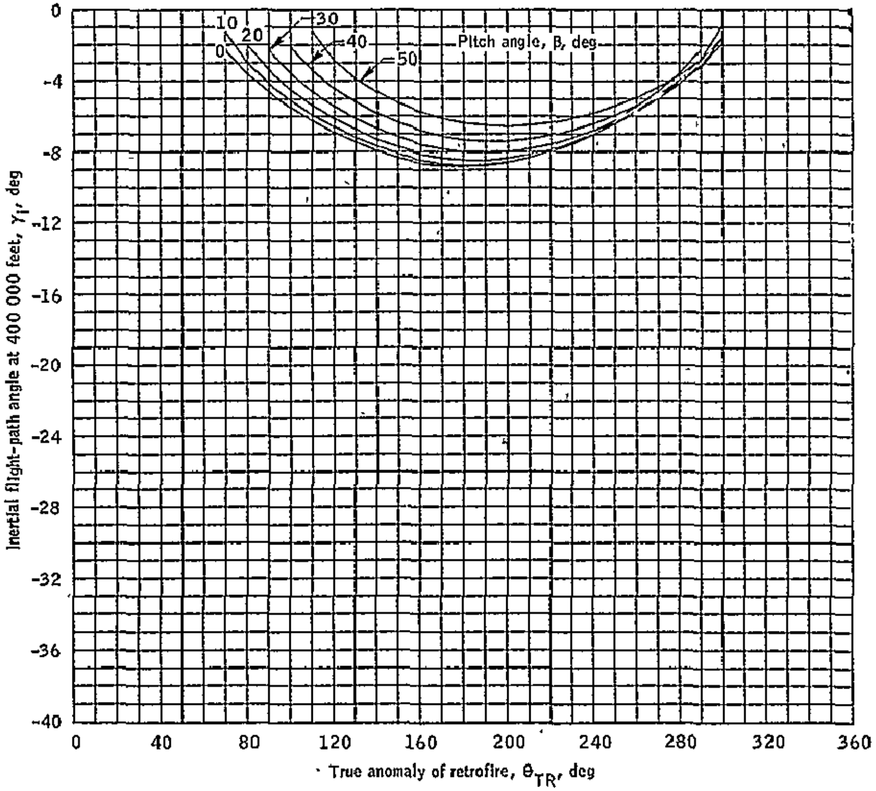
Figure 29.- Continued.

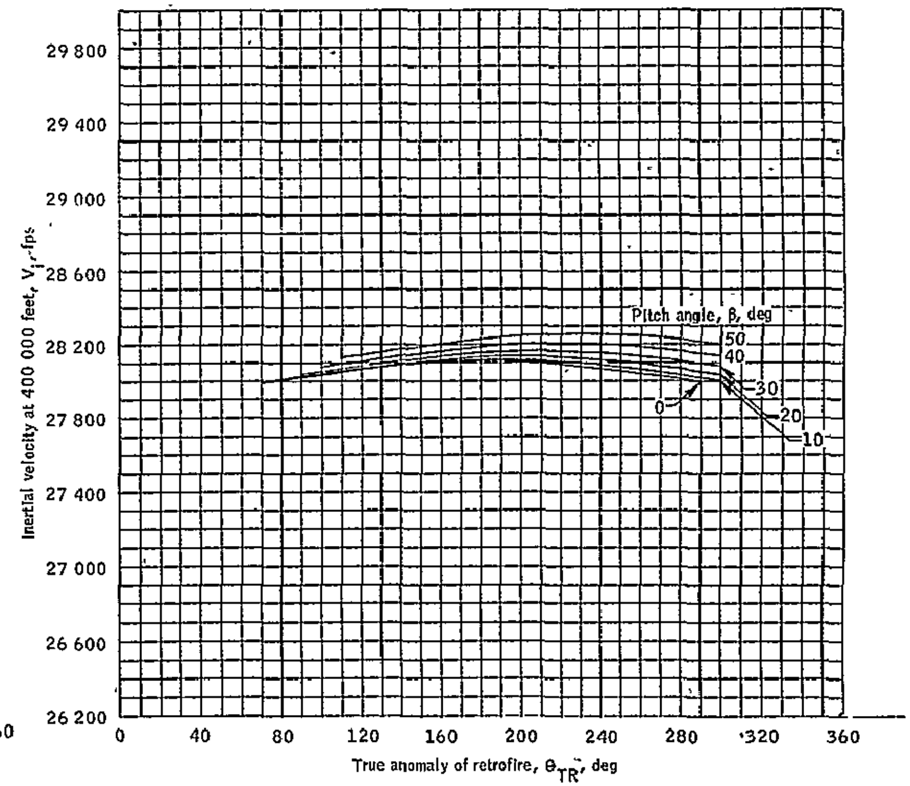




(f) Time from retrofire and central angle for retrograde ΔV=700 feet per second.

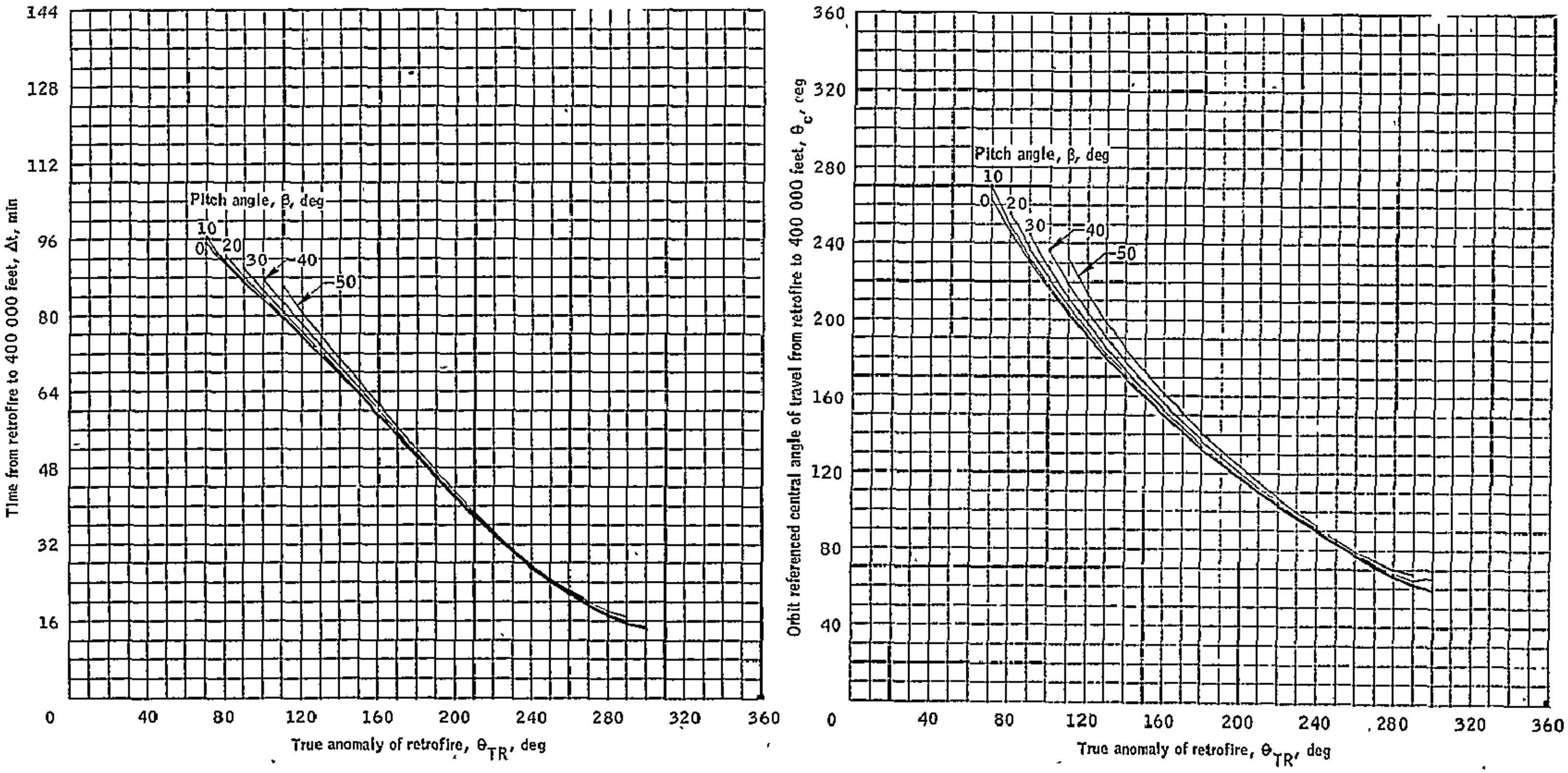
Figure 29.- Concluded.





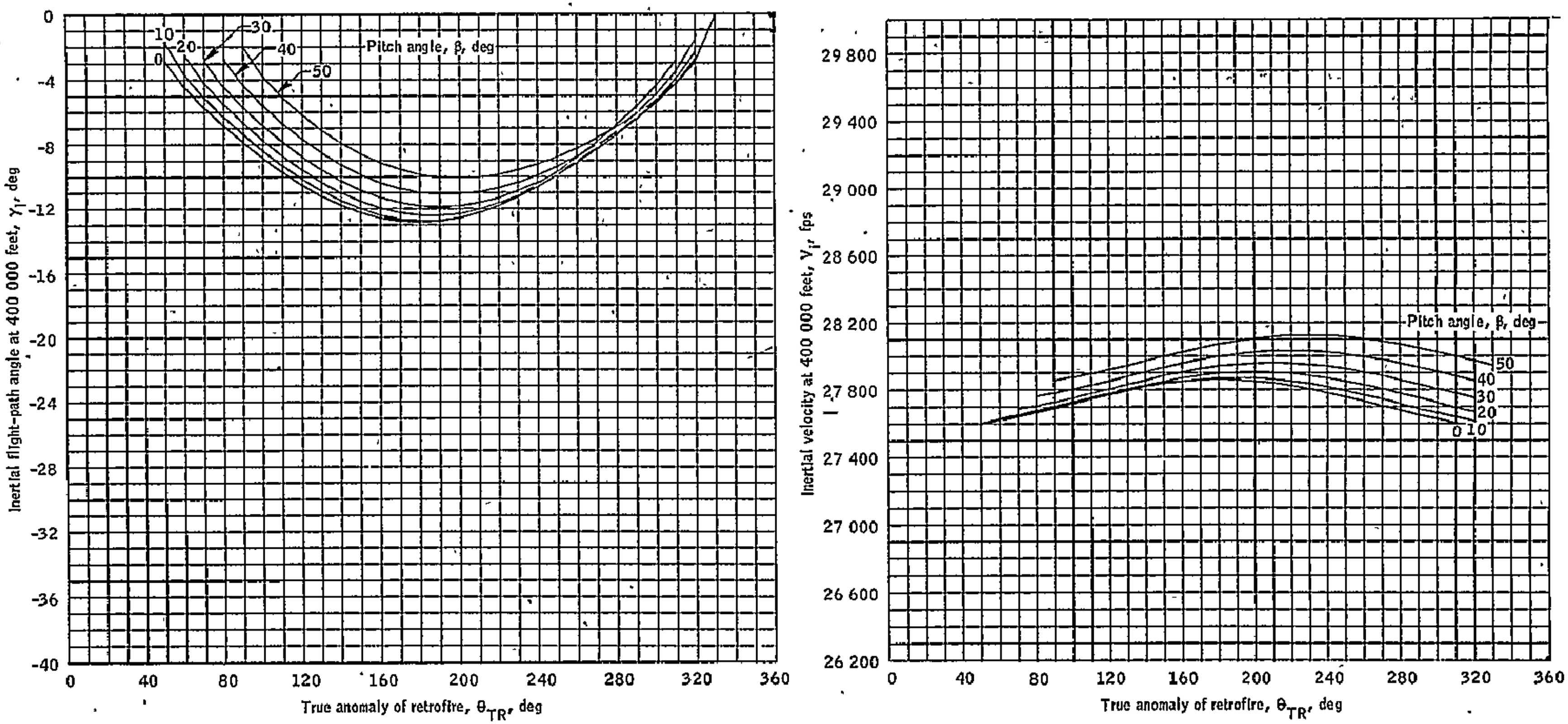
(a) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 30.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 150/2000 nautical mile orbit.



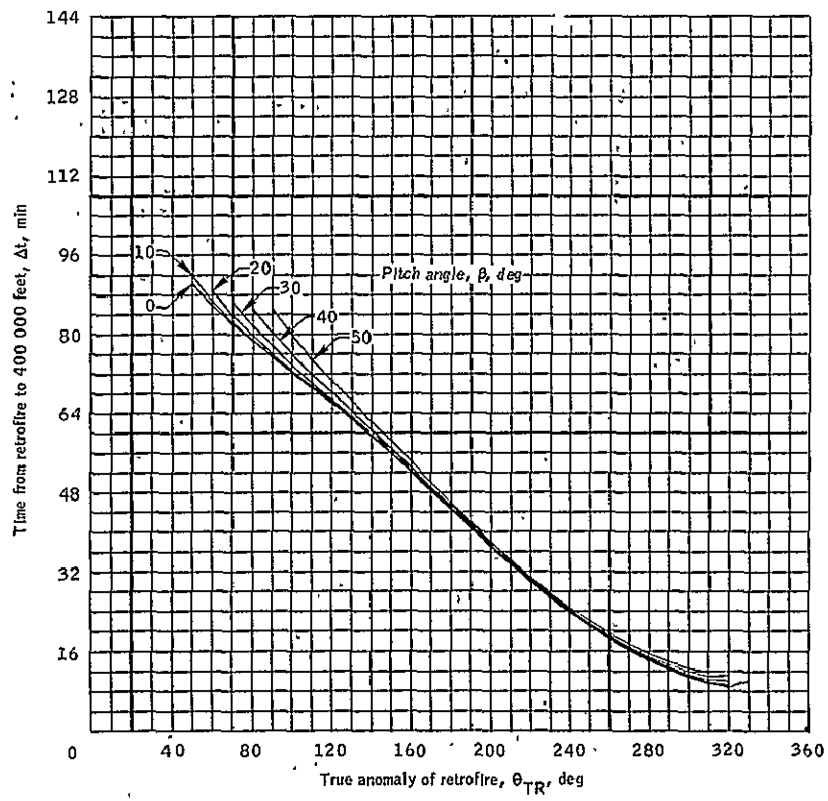
(b) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

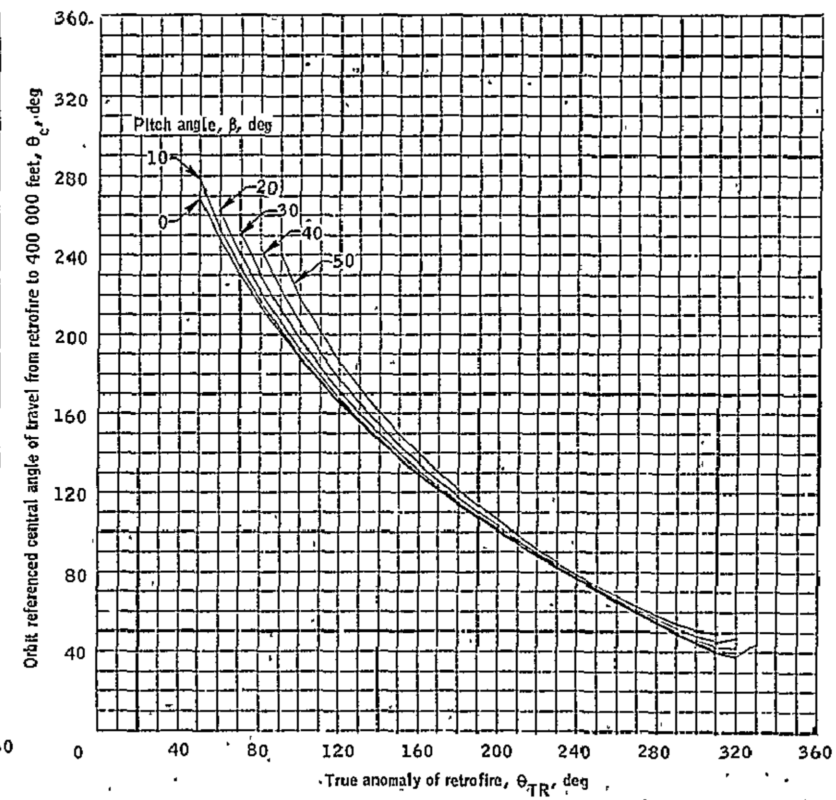
Figure 30.- Continued.



(c) Flight-path angle and velocity for retrograde ΔV = 900 feet per second.

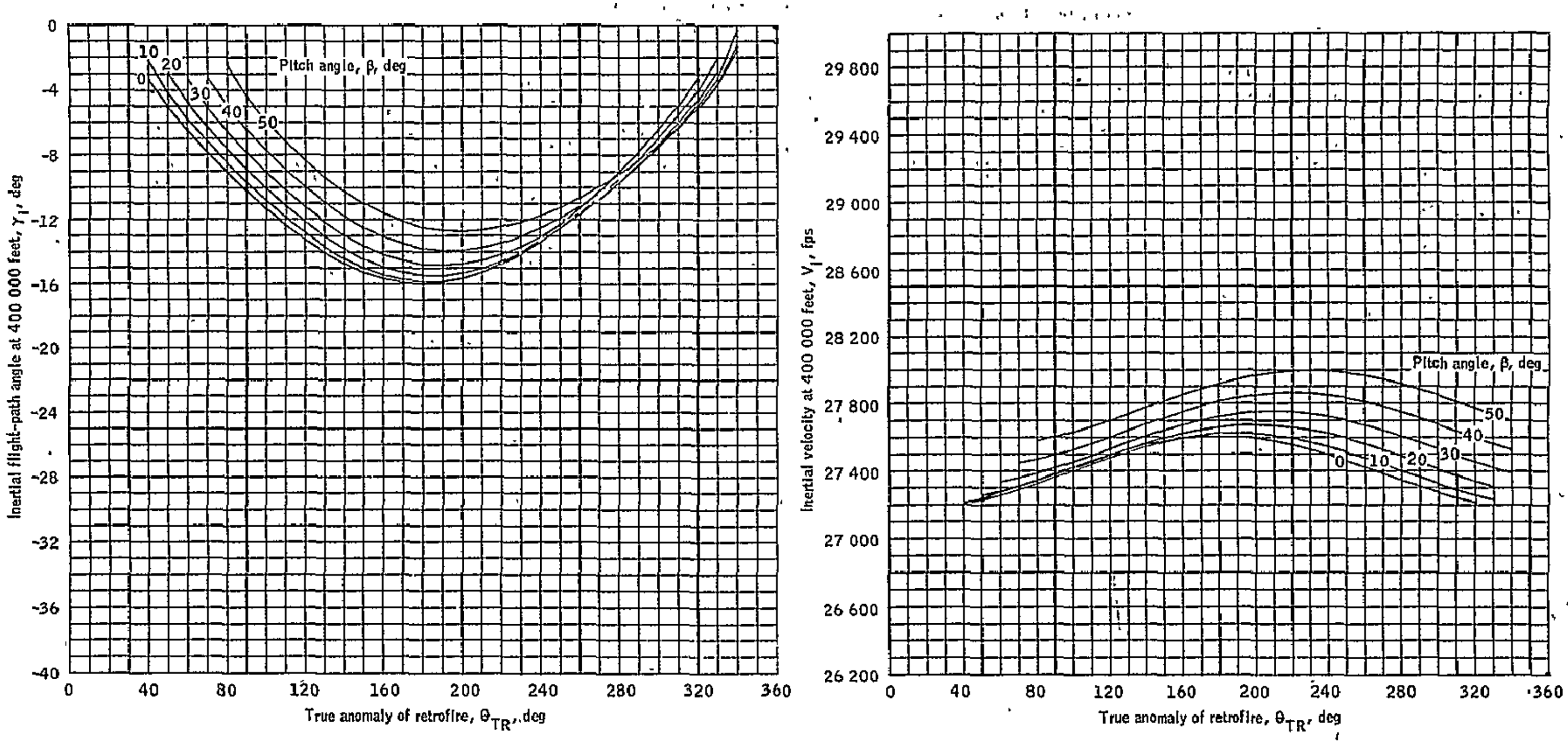
Figure 30.- Continued.





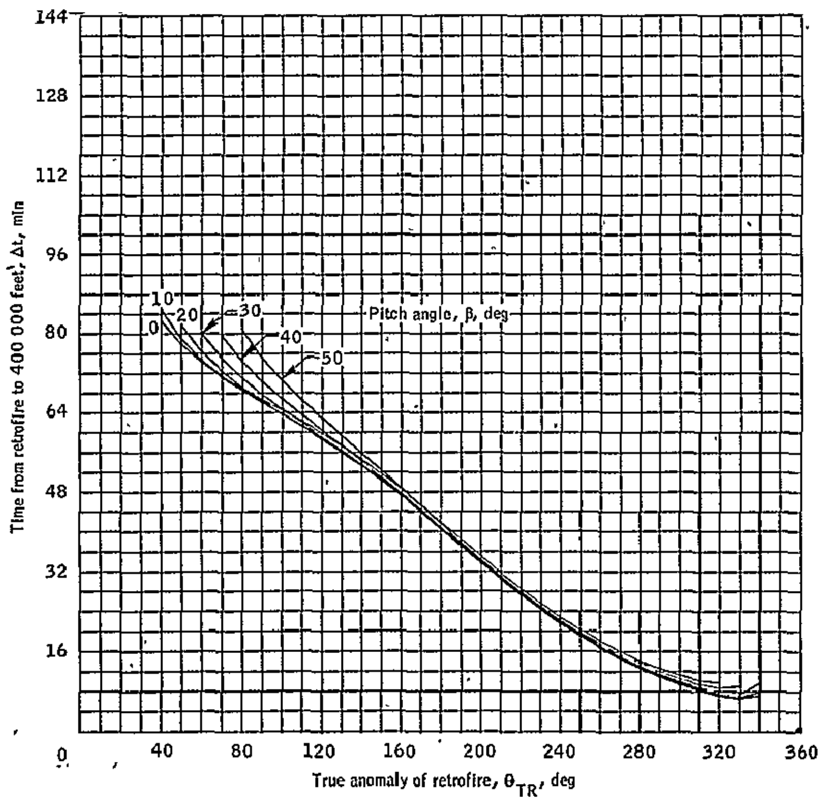
(d) Time from retrofire and central angle for retrograde ΔV = 900 feet per second.

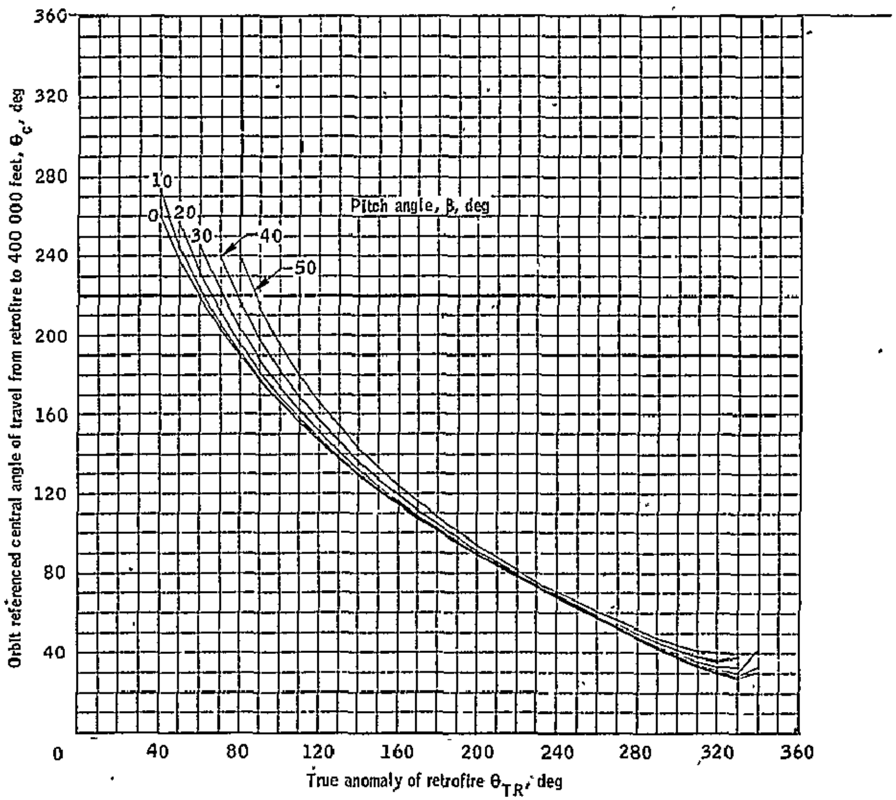
Figure 30.- Continued.



(e) Flight-path angle and velocity for retrograde ΔV = 1300 feet per second.

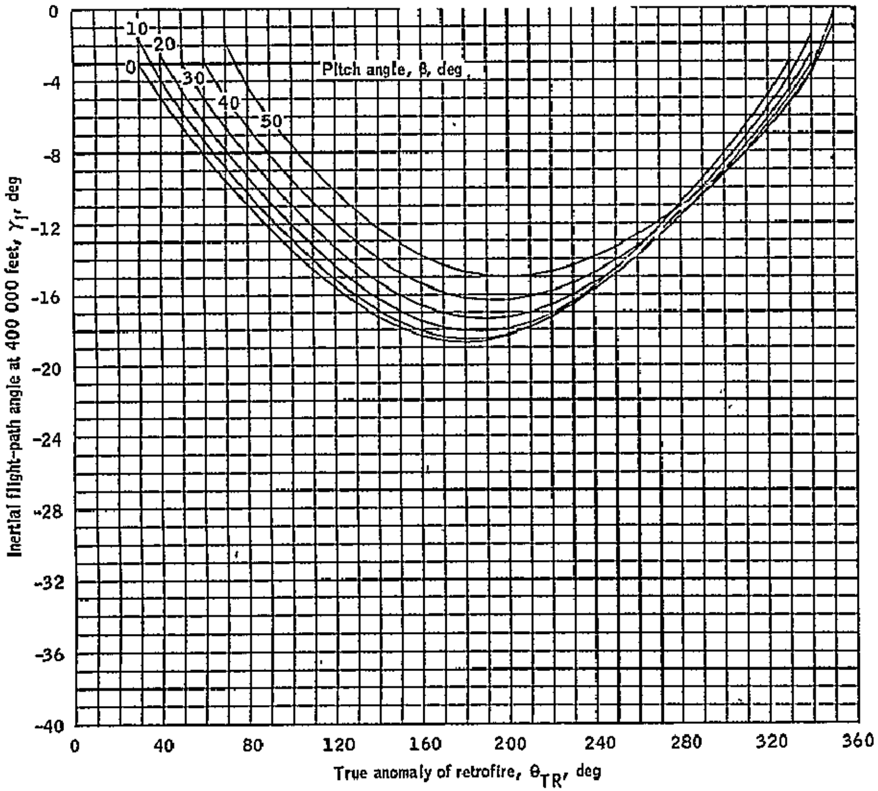
Figure 30.- Continued.

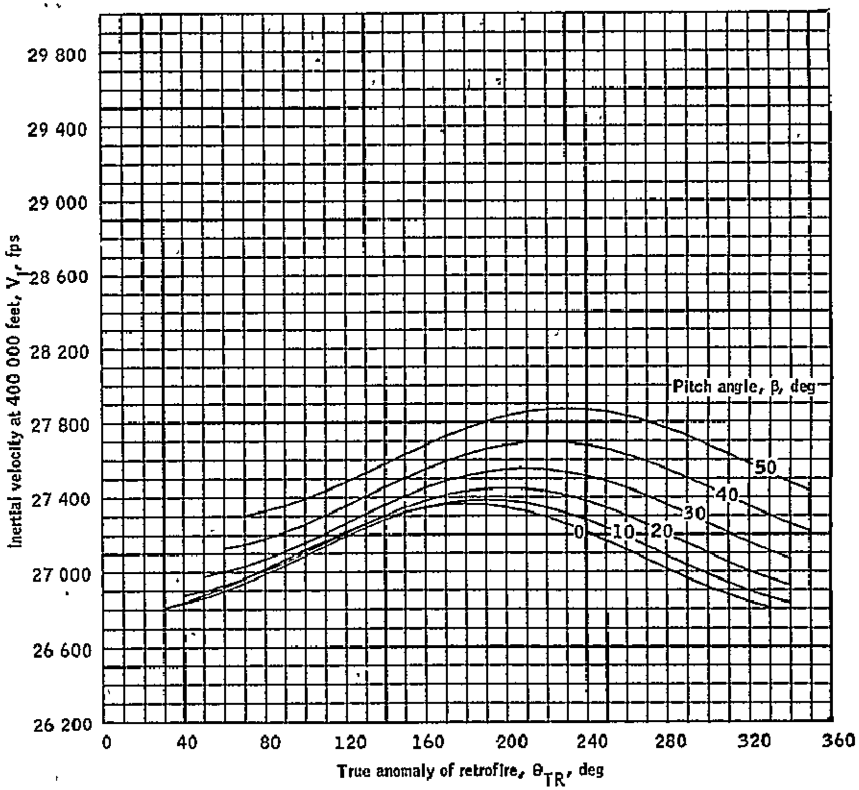




(f) Time from retrofire and central angle for retrograde ΔV = 1300 feet per second.

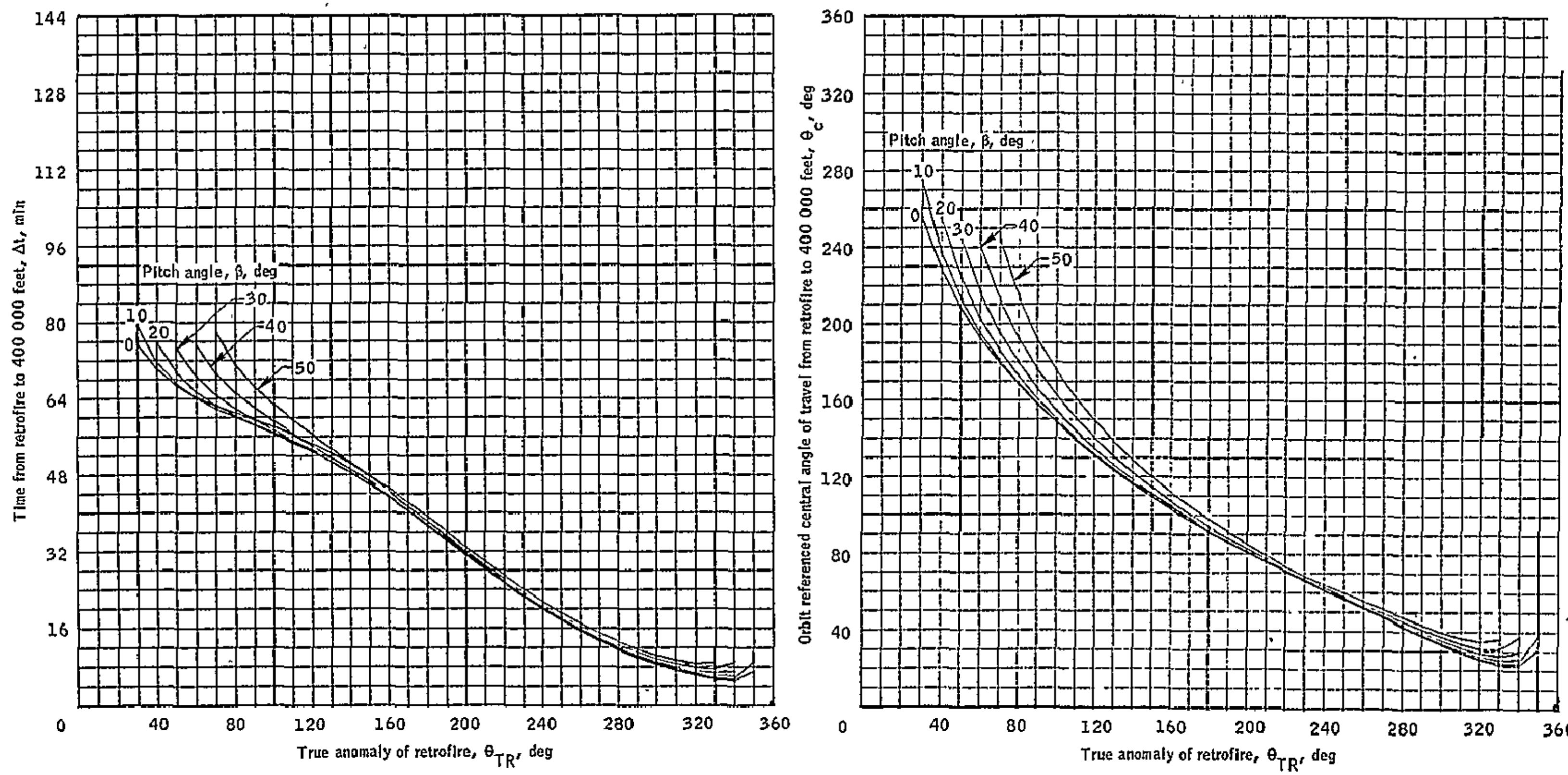
Figure 30.- Continued.





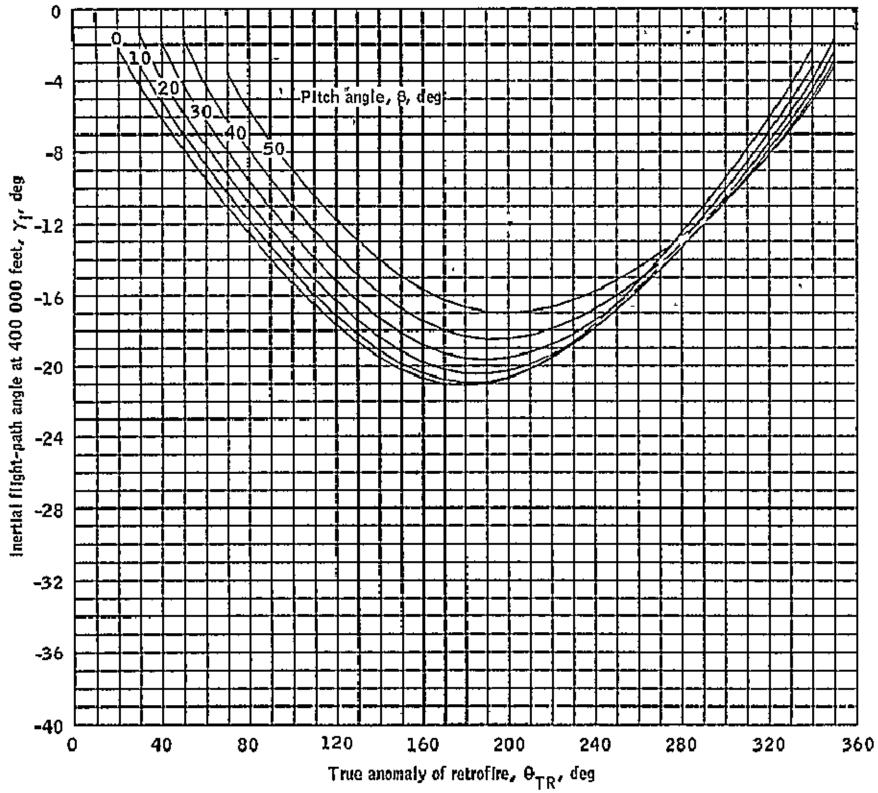
(g) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

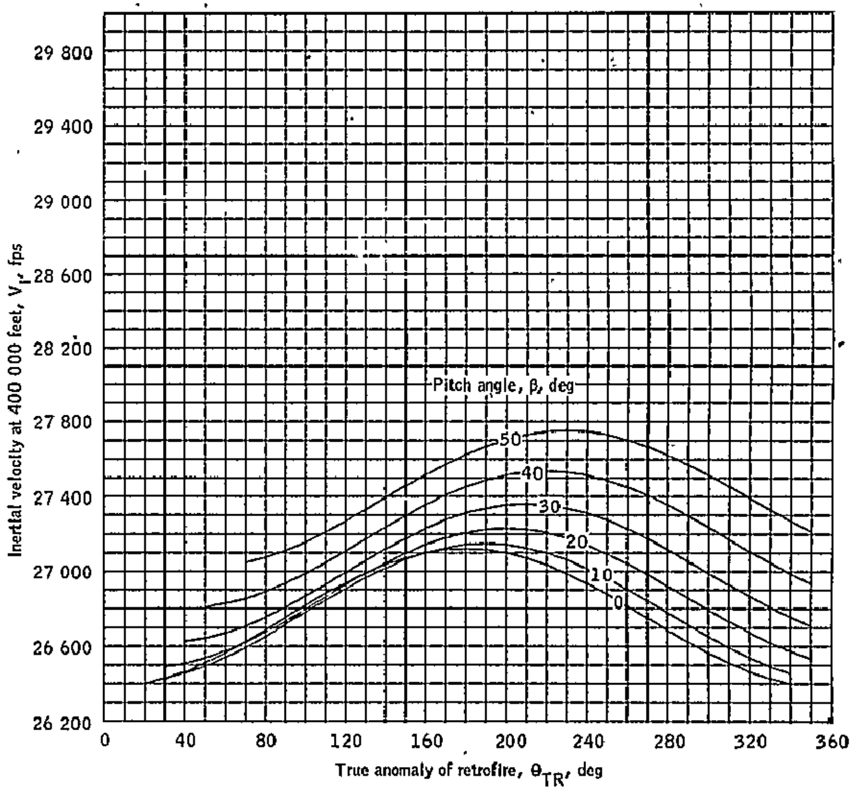
Figure 30.- Continued.



(h) Time from retrofire and central angle for retrograde $\Delta V = 1700$ feet per second.

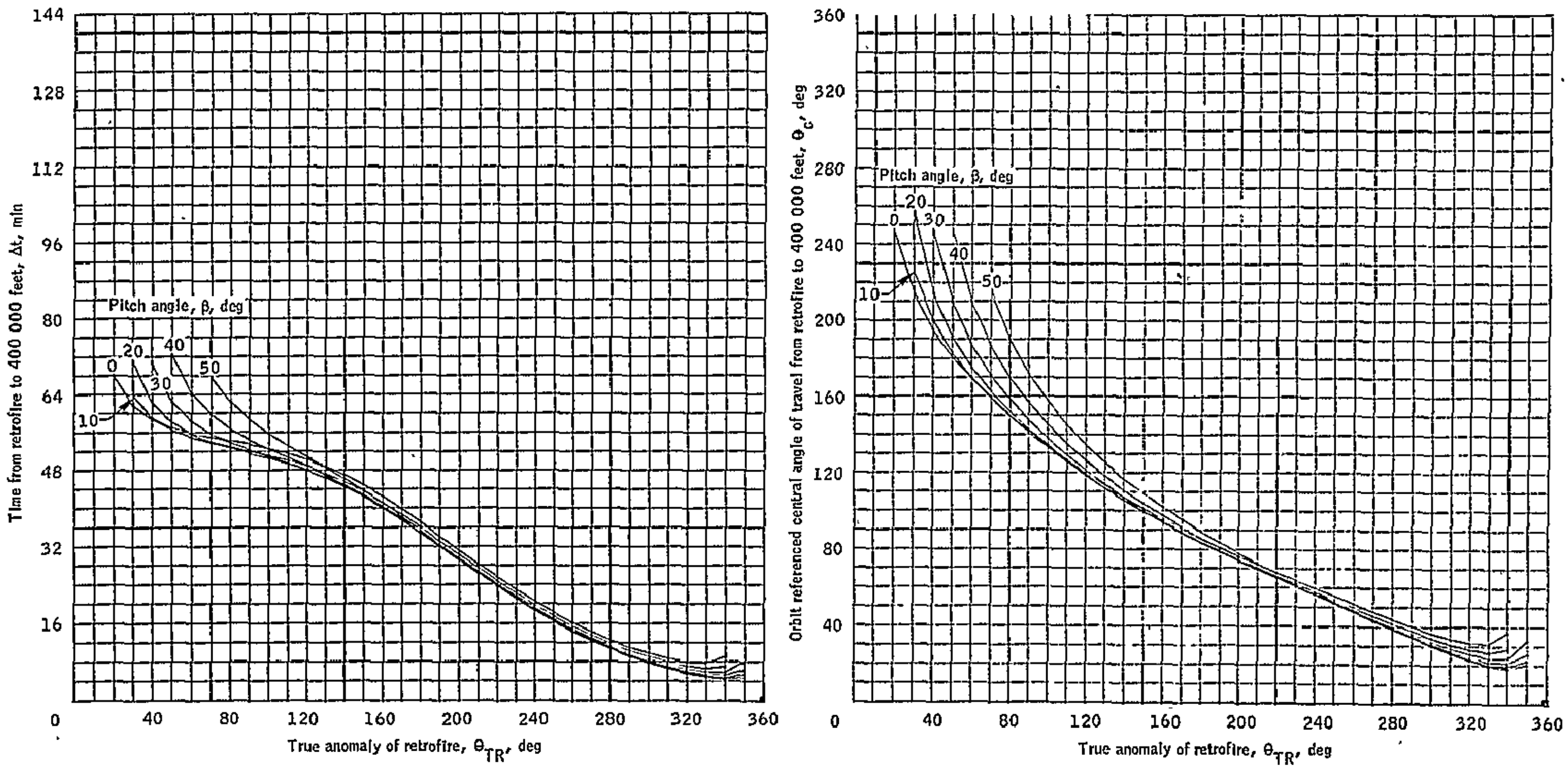
Figure 30.- Continued.





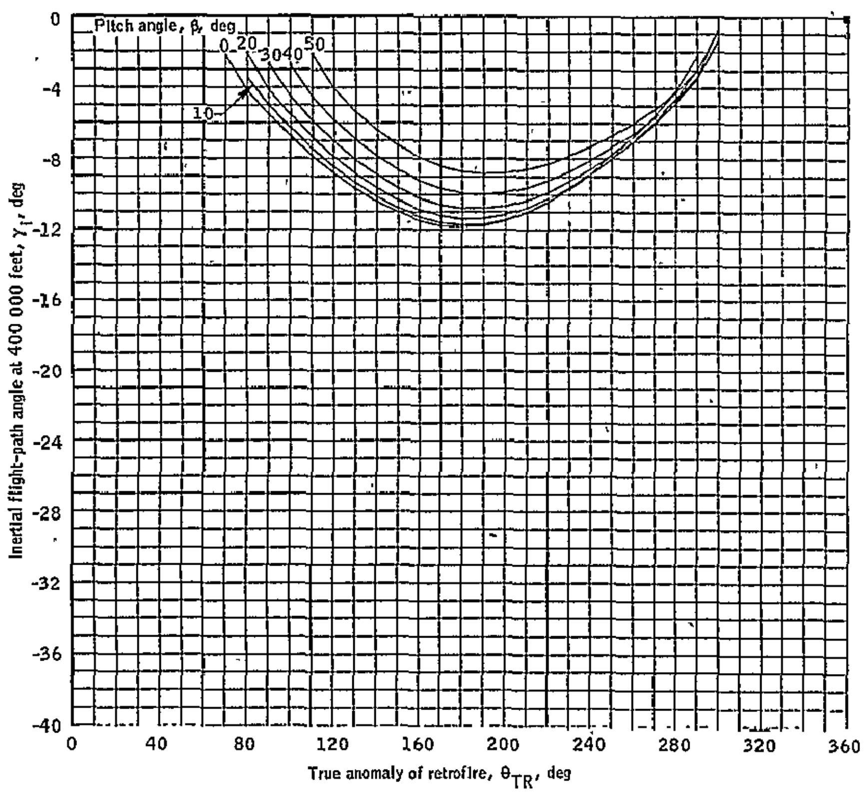
(l) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

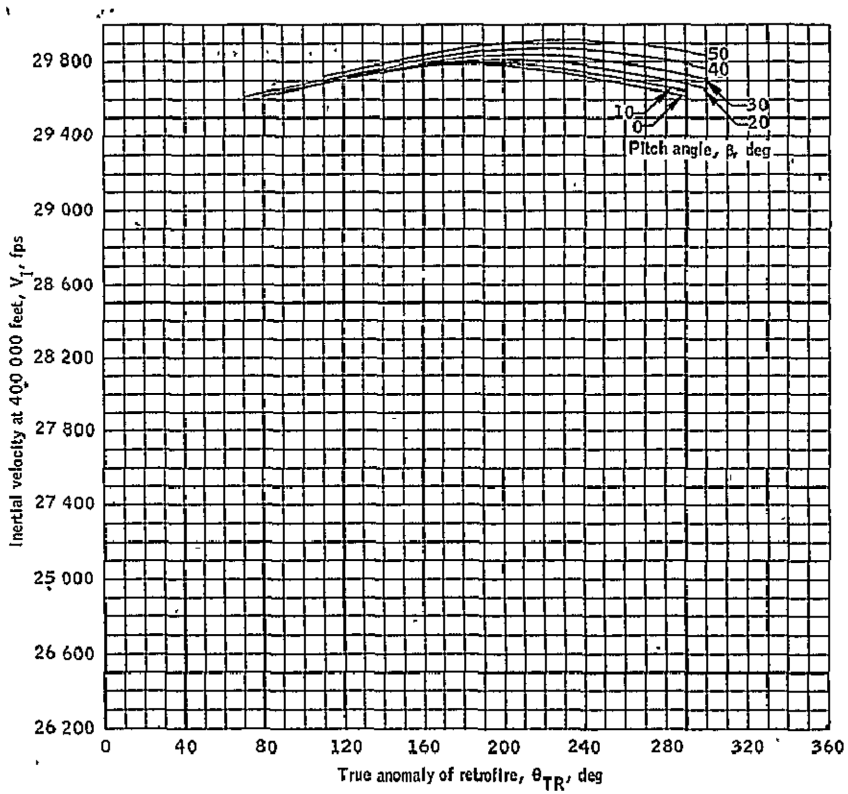
Figure 30.- Continued.



(j) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

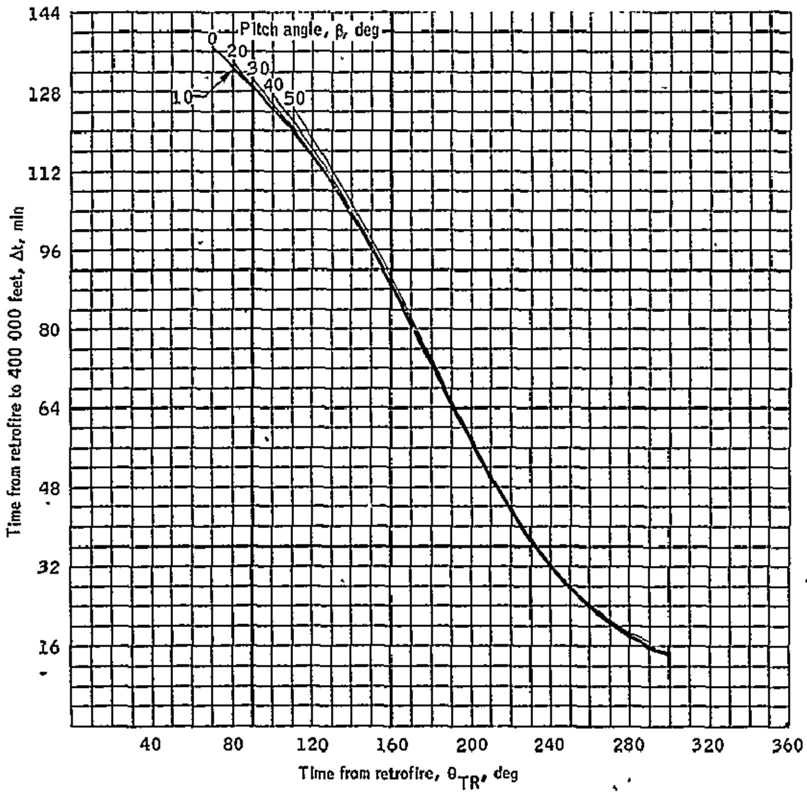
Figure 30.- Concluded.

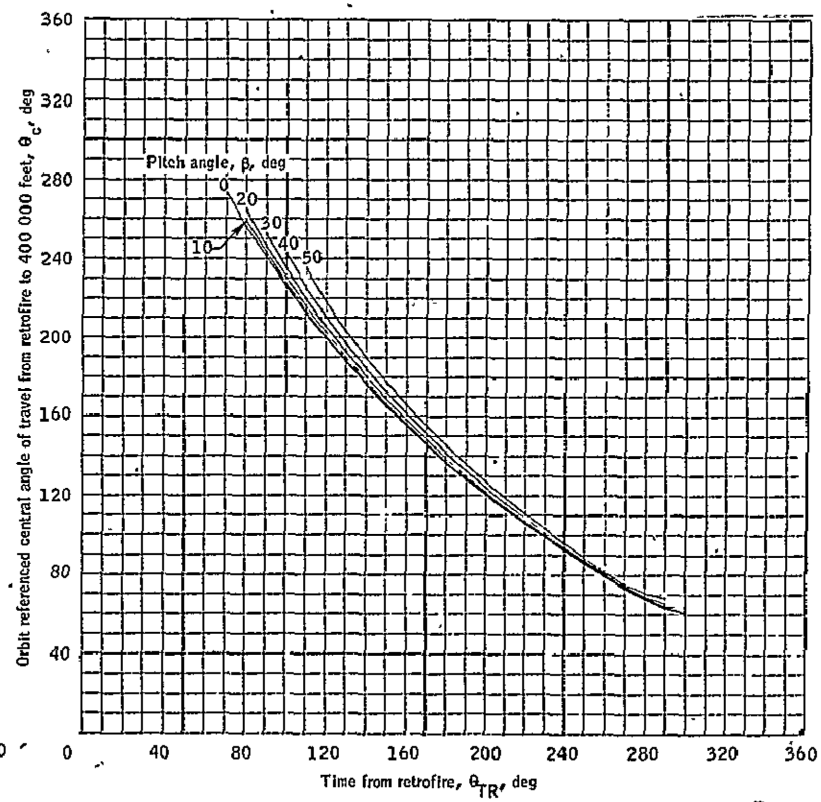




(a) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

Figure 31.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 150/4000 nautical mile orbit.

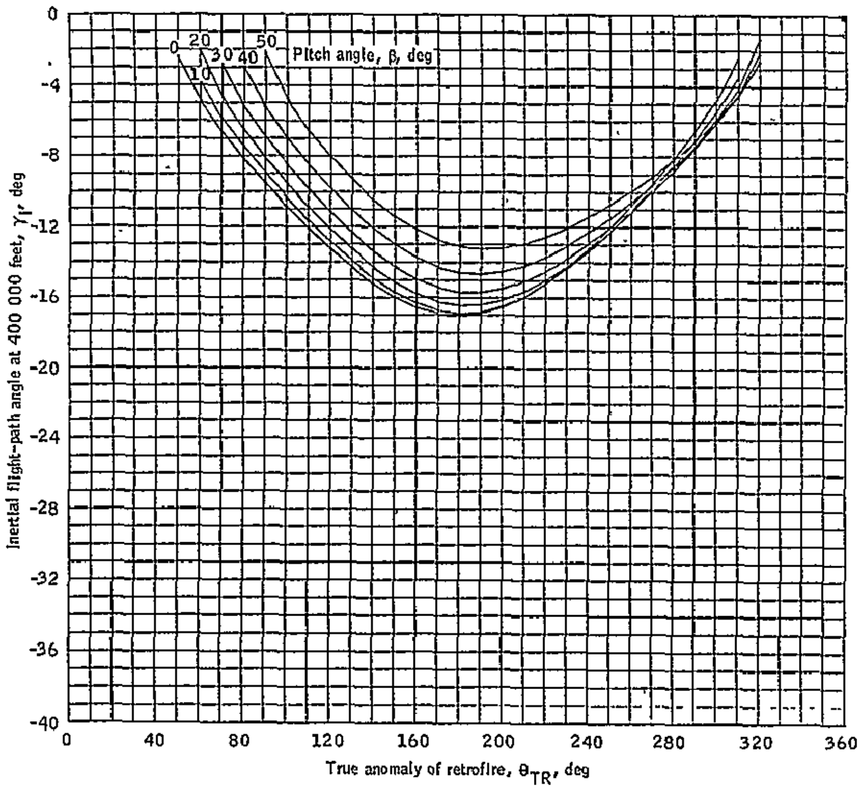


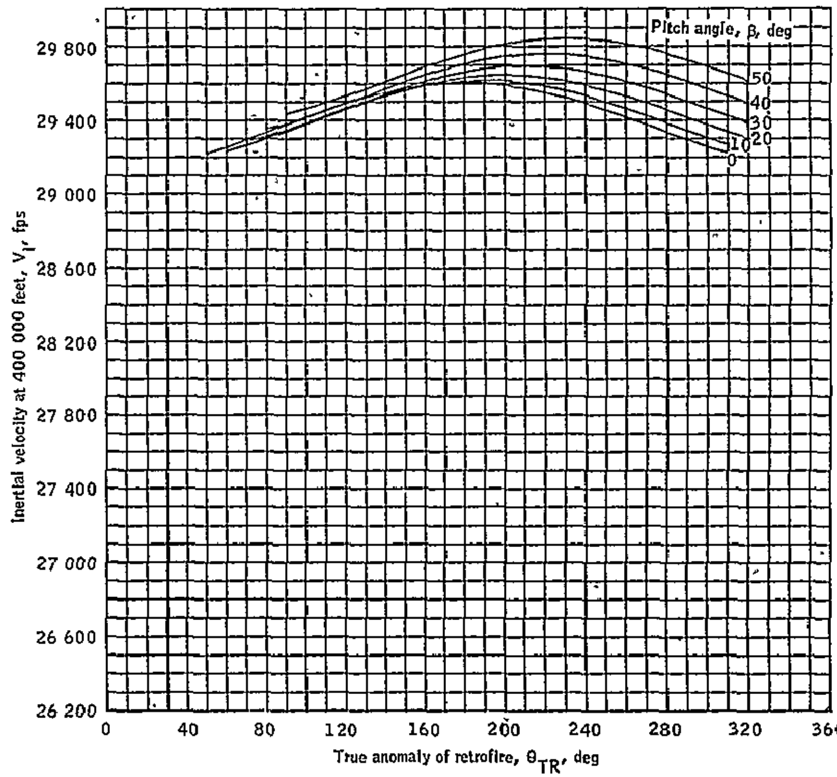


(b) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 31.- Continued.

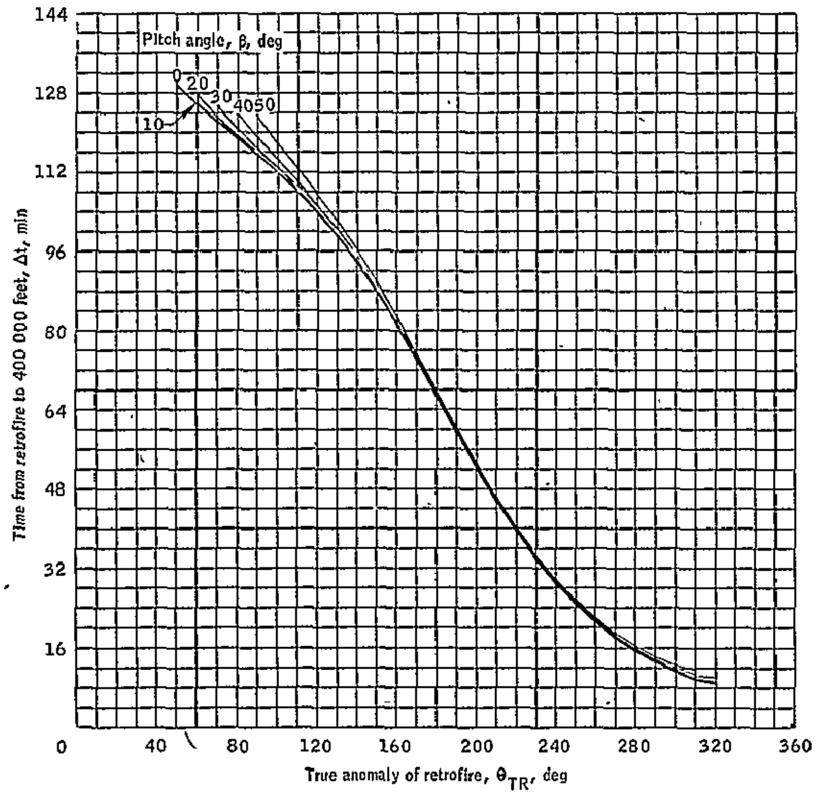
280'i

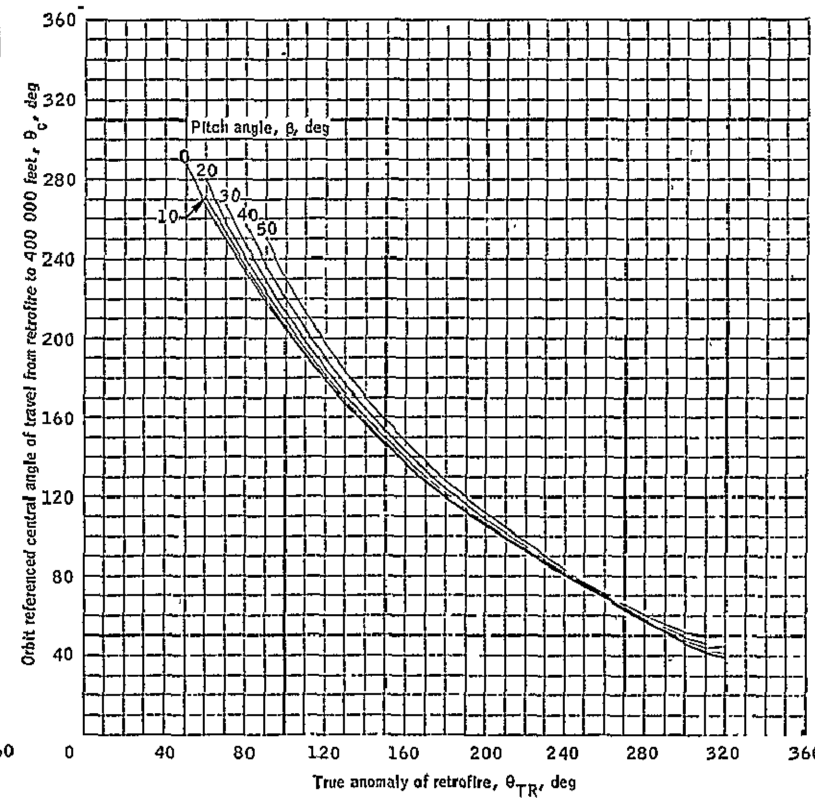




(c) Flight-path angle and velocity for retrograde $\Delta V = 900$ feet per second.

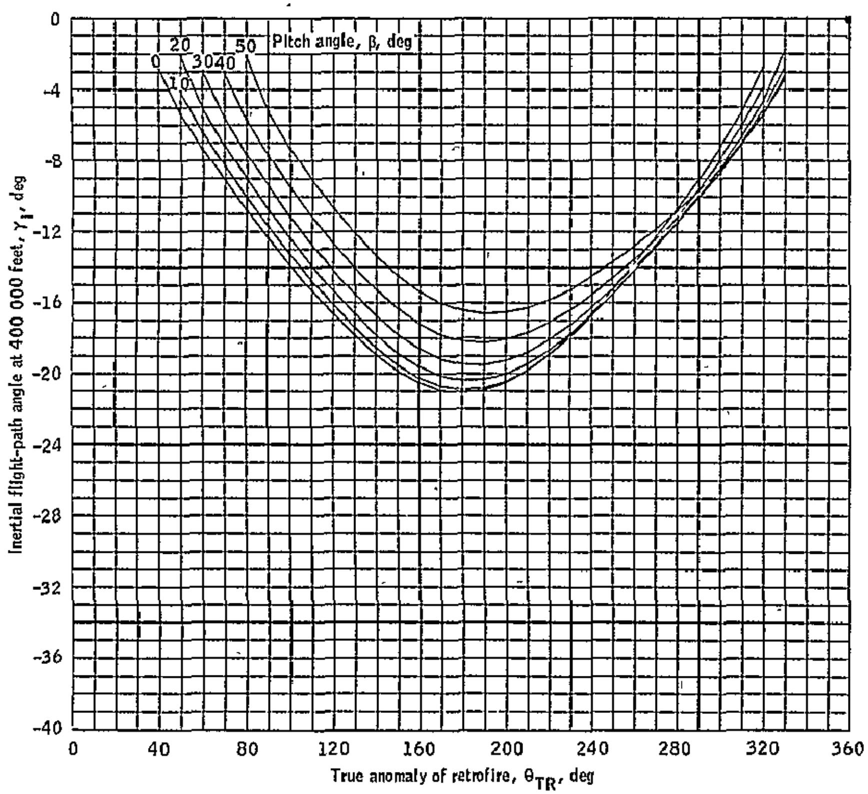
Figure 31.- Continued.

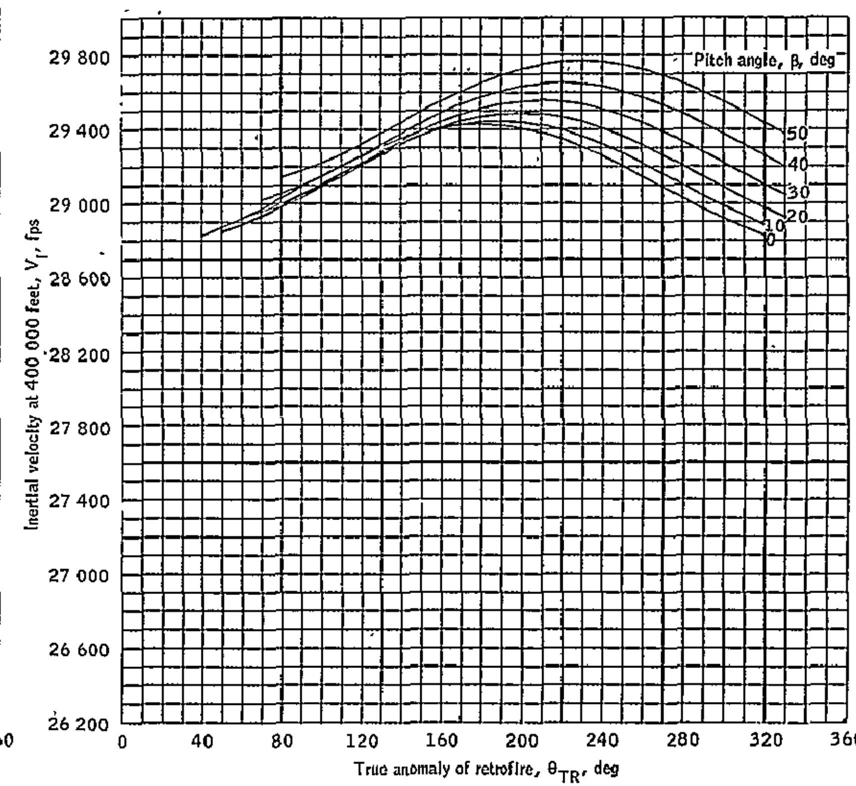




(d) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

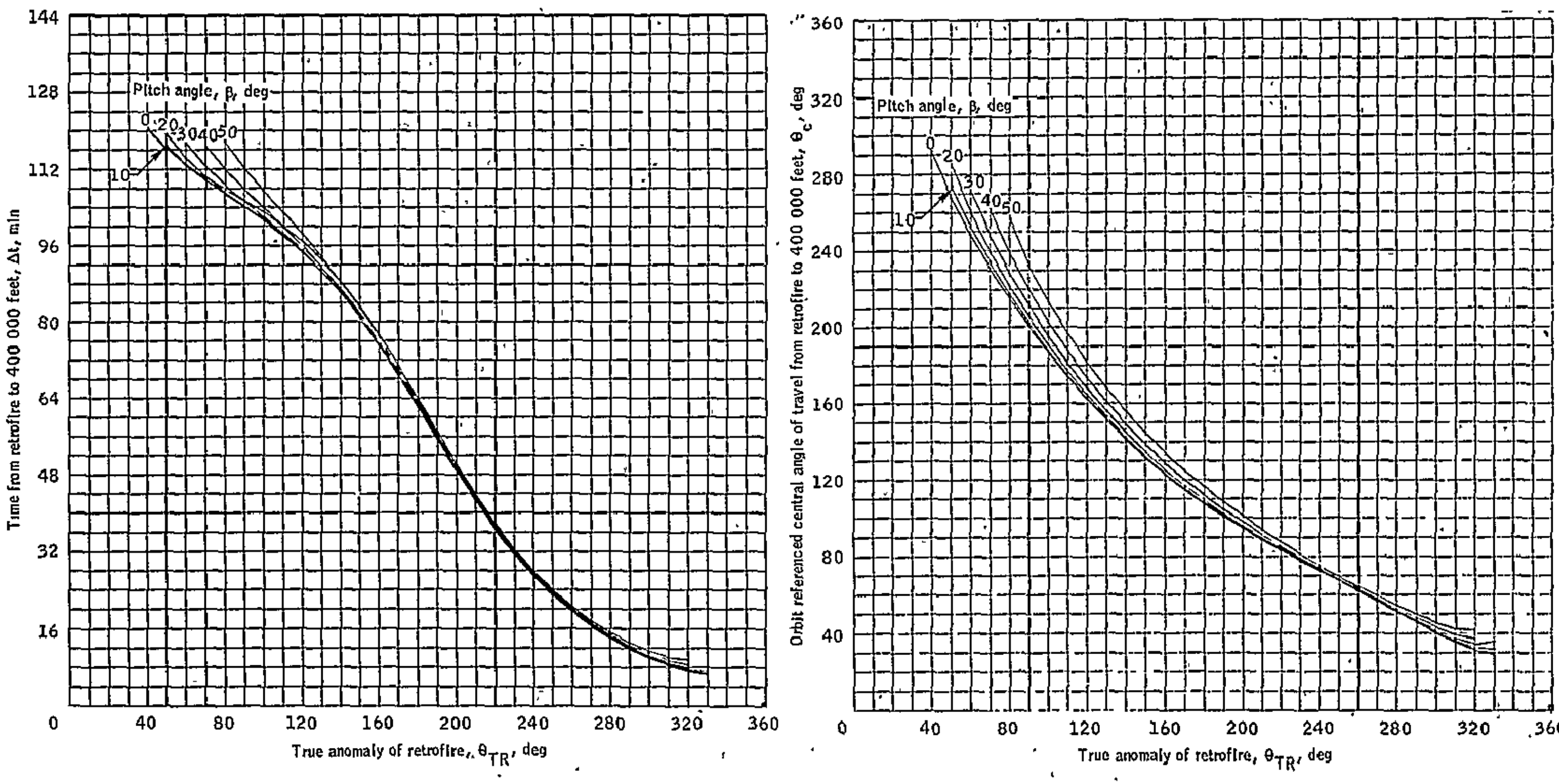
Figure 31.- Continued.





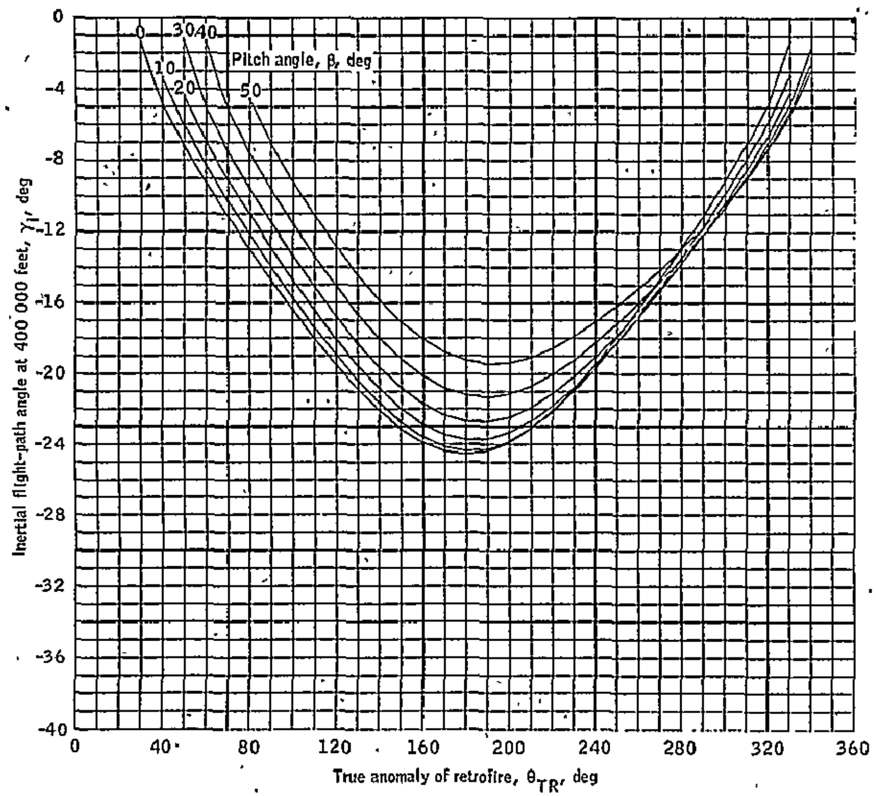
(e) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

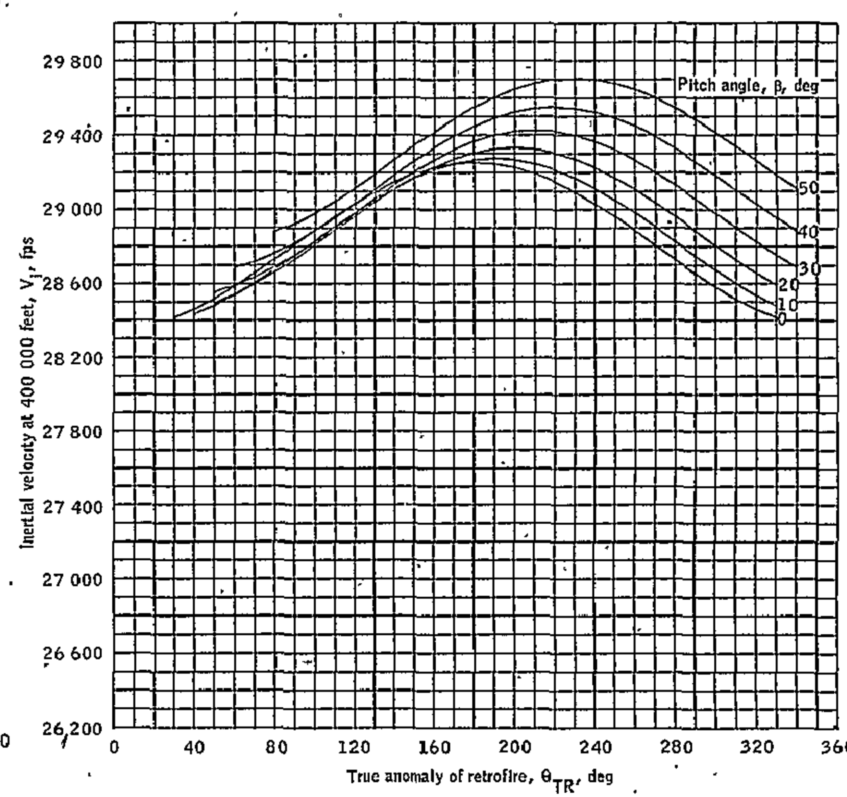
Figure 31.- Continued.



(f) Time from retrofire and central angle for retrograde $\Delta V \approx 1300$ feet per second.

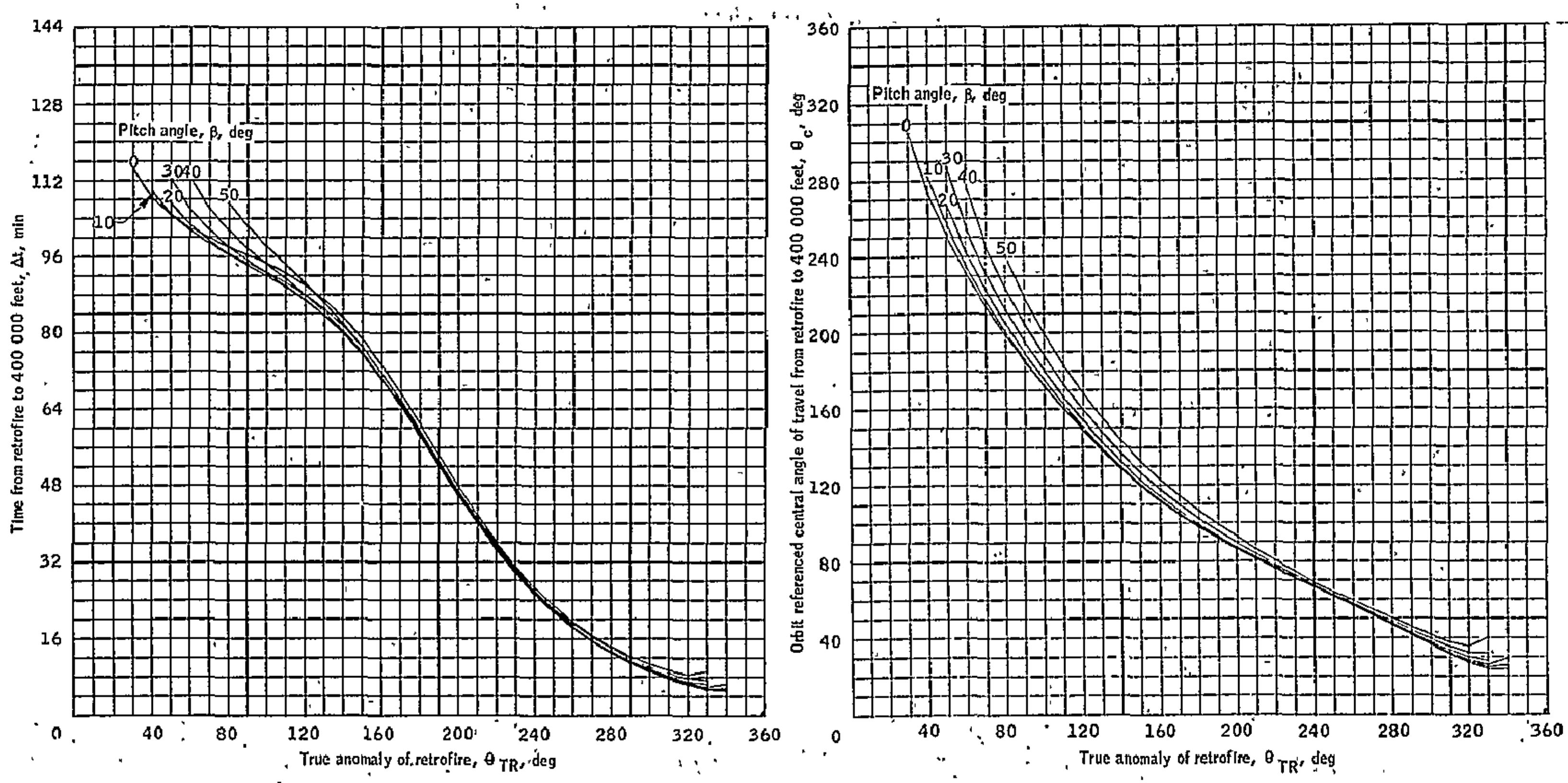
Figure 31.- Continued.





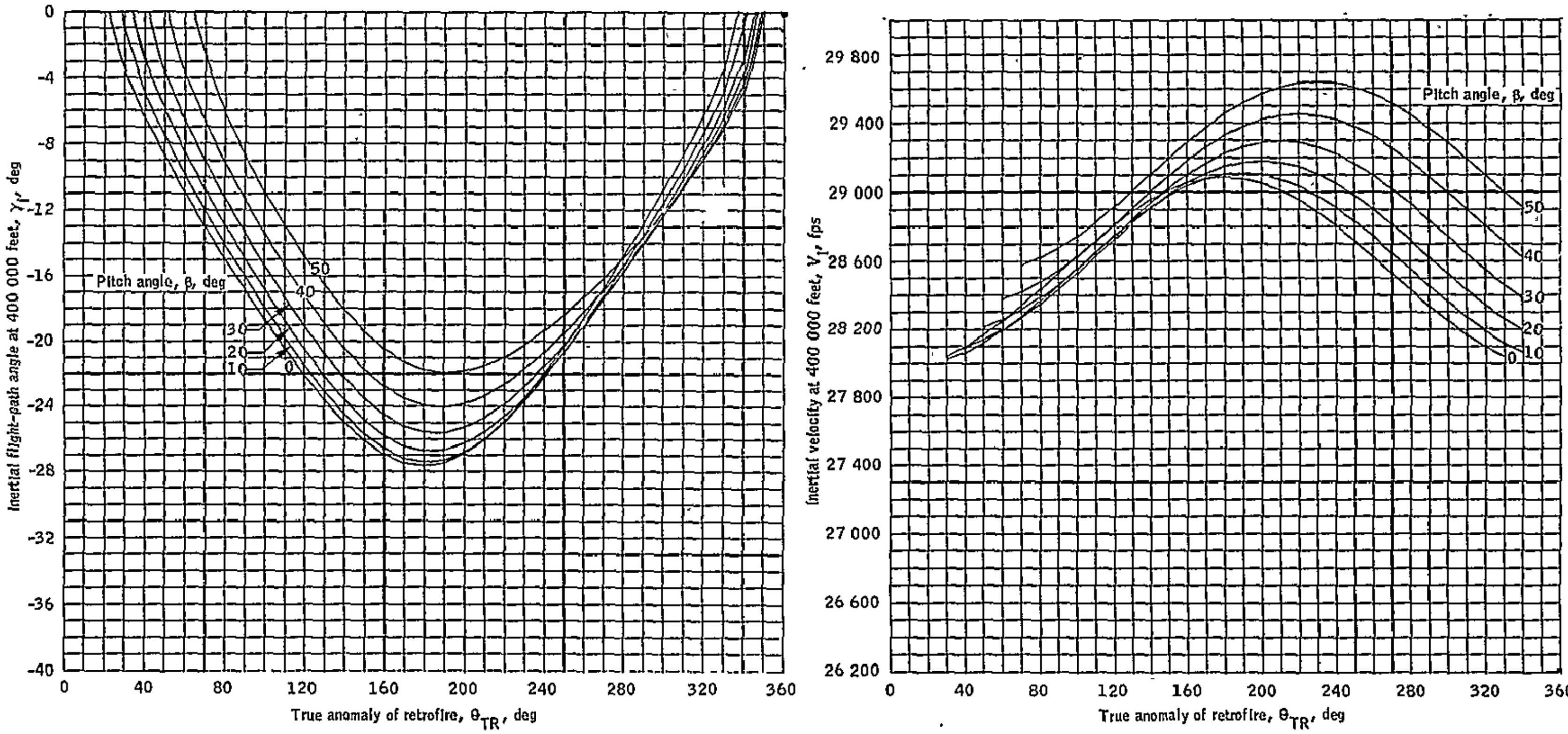
(g) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

Figure 31.- Continued.



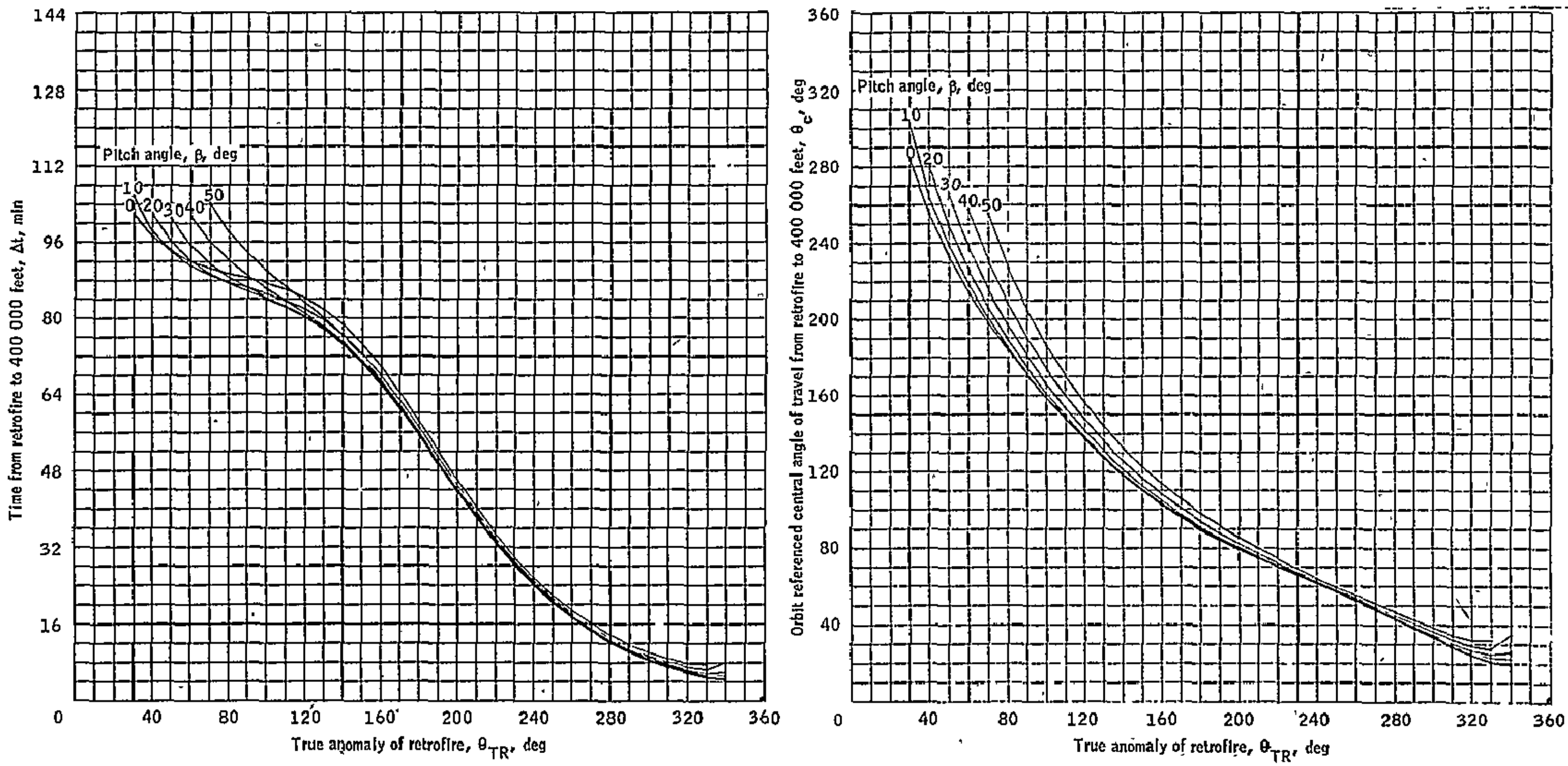
(h) Time from retrofire and central angle for retrograde ΔV = 1 700 feet per second.

Figure 31.- Continued.



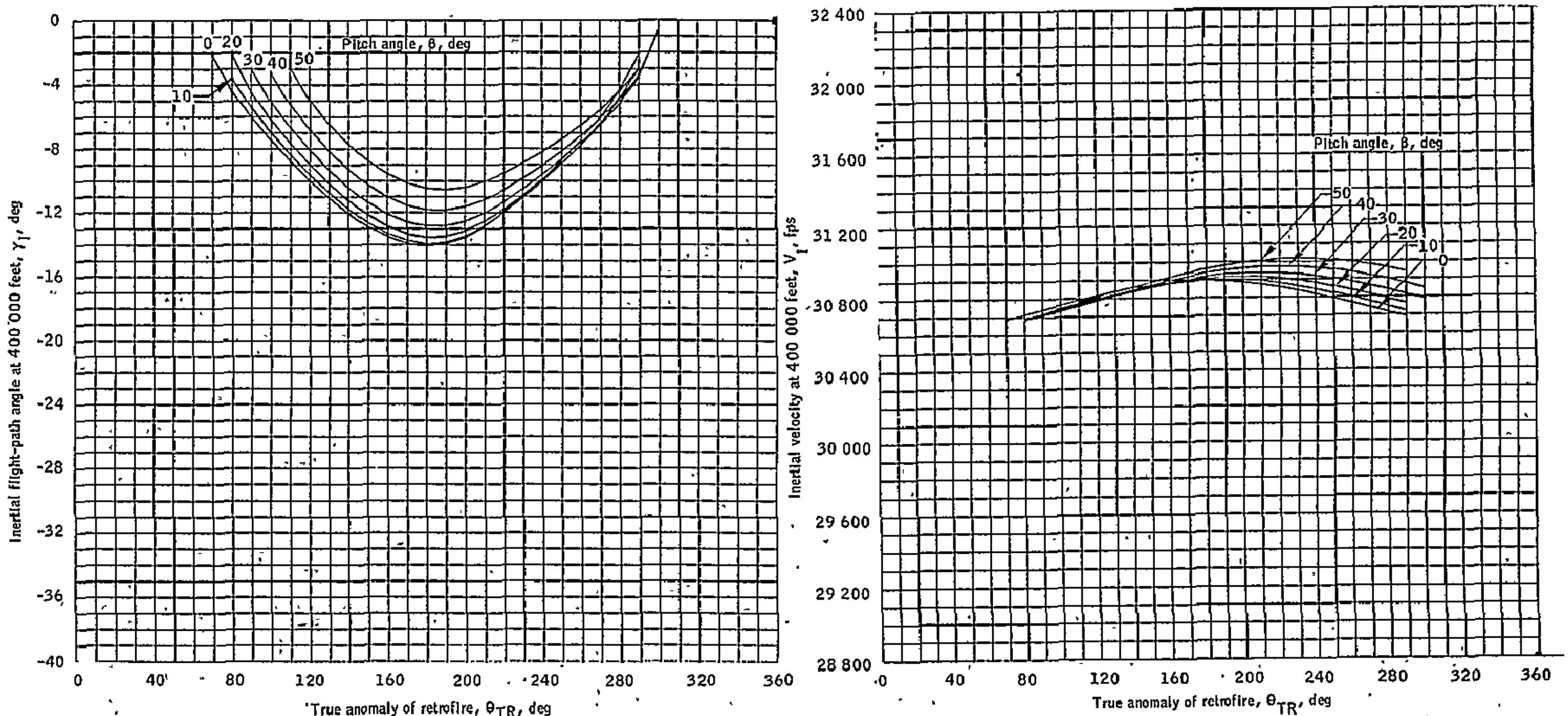
(l) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

Figure 31.- Continued.



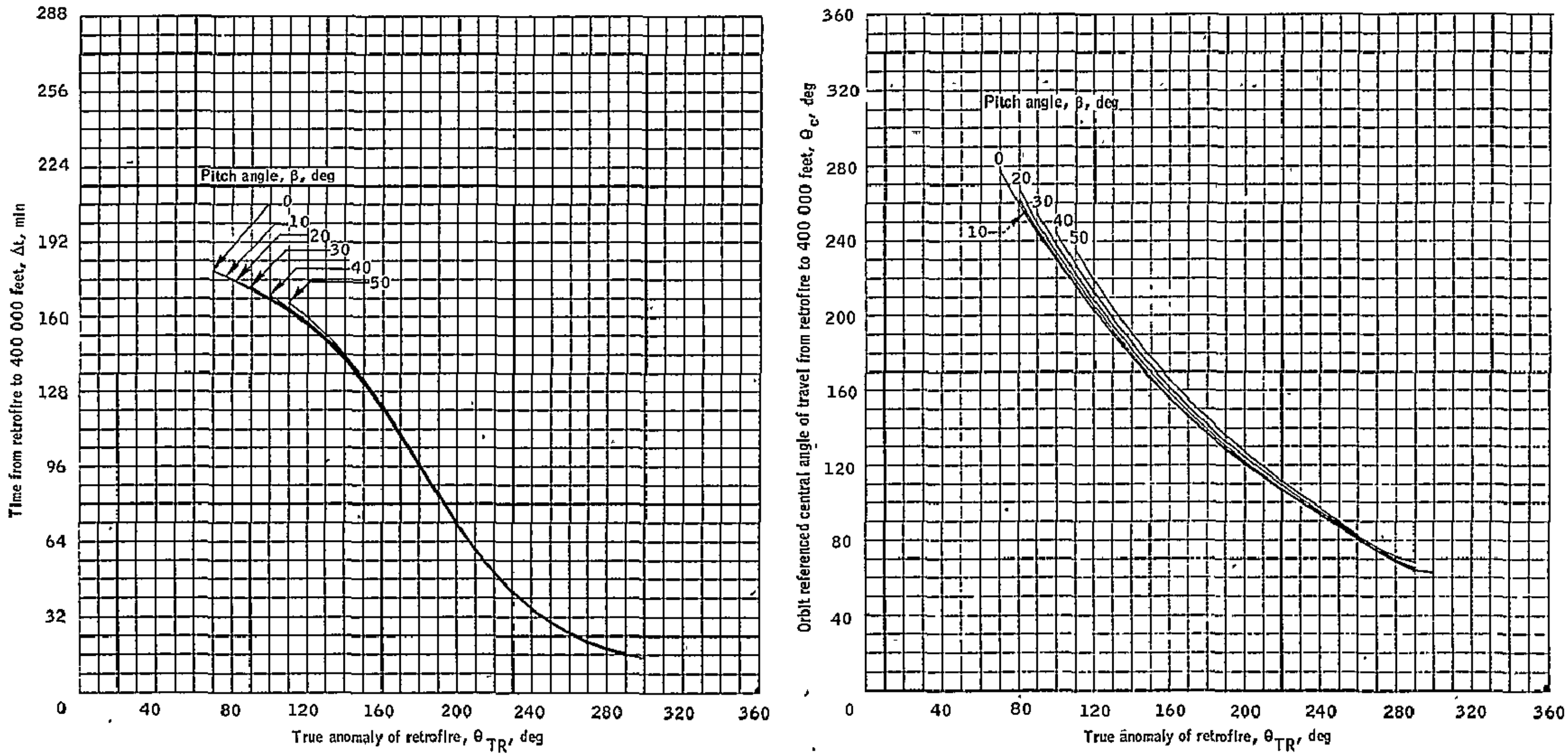
(j) Time from retrofire and central angle for retrograde ΔV = 2100 feet per second.

Figure 31.- Concluded.



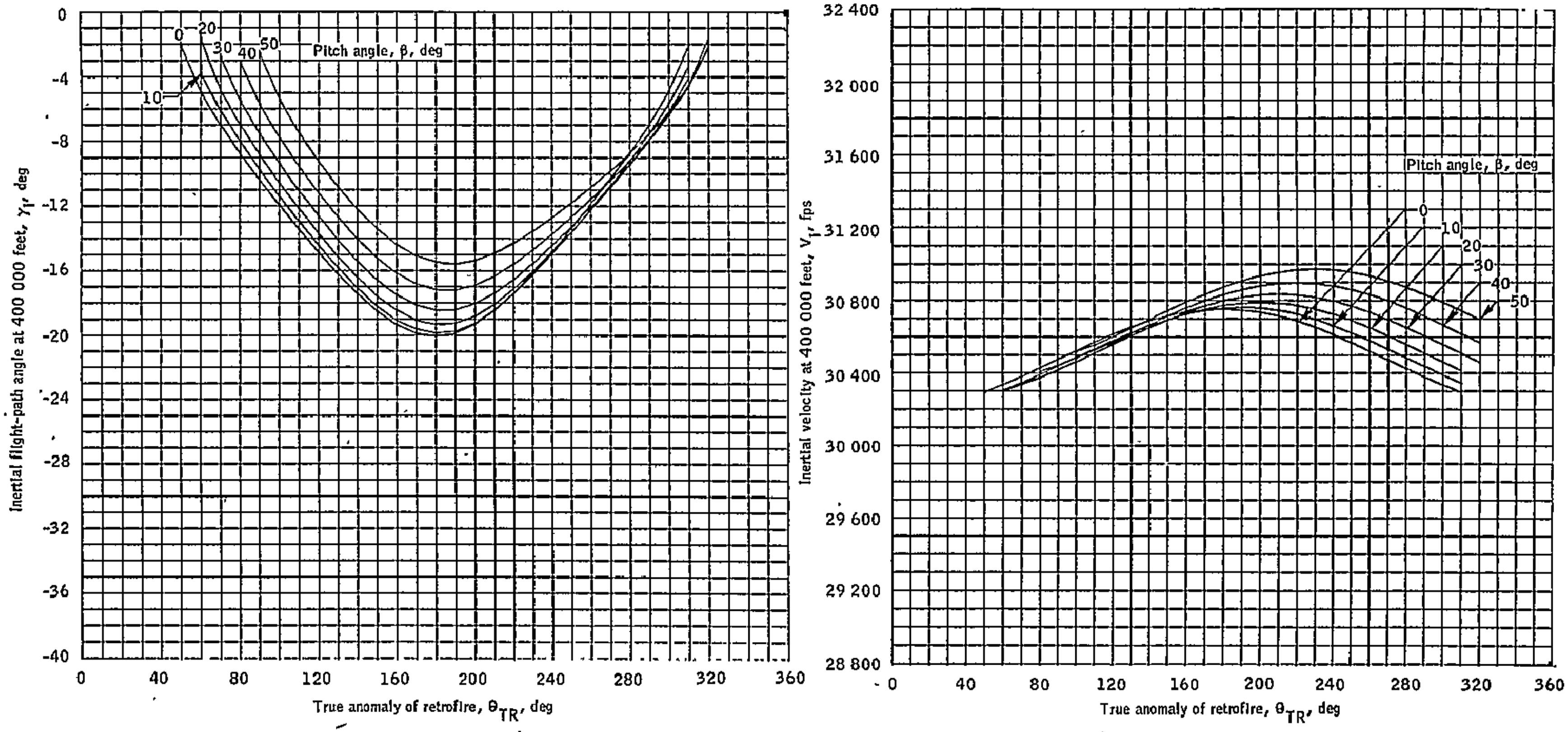
(a) Flight path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 32.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 150/6000 nautical mile orbit.



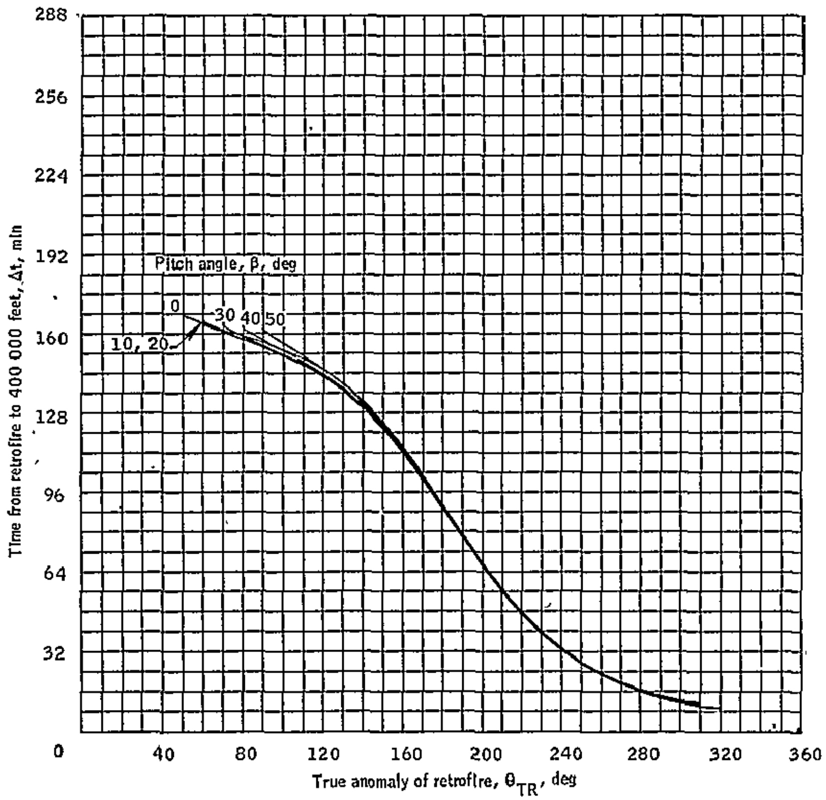
(b) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

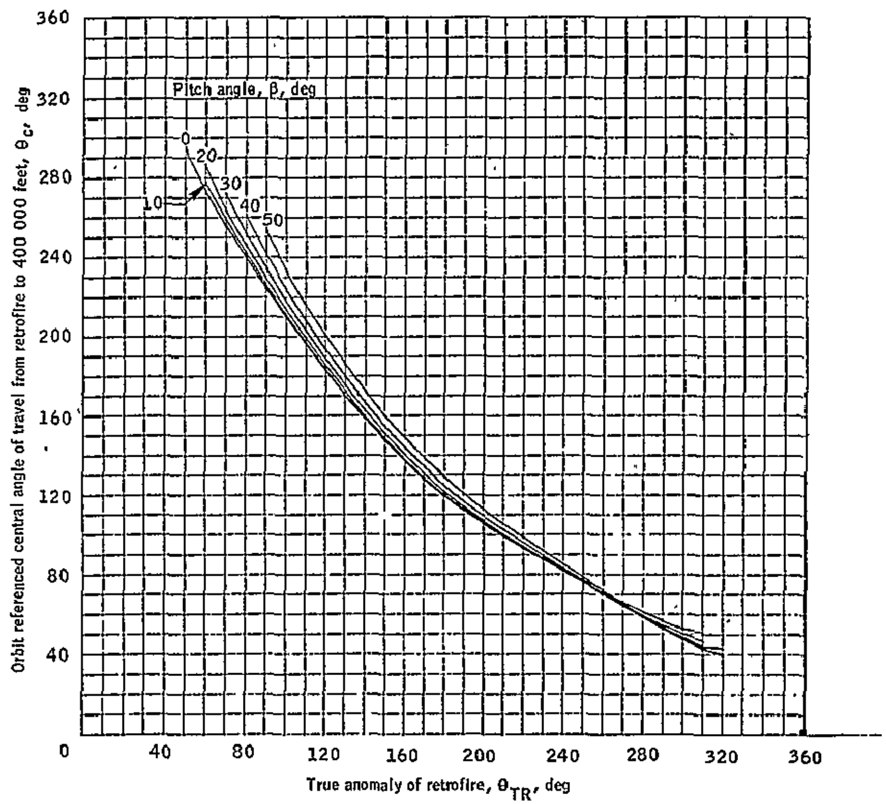
Figure 32.- Continued.



(c) Flight-path angle and velocity for retrograde ΔV = 900 feet per second.

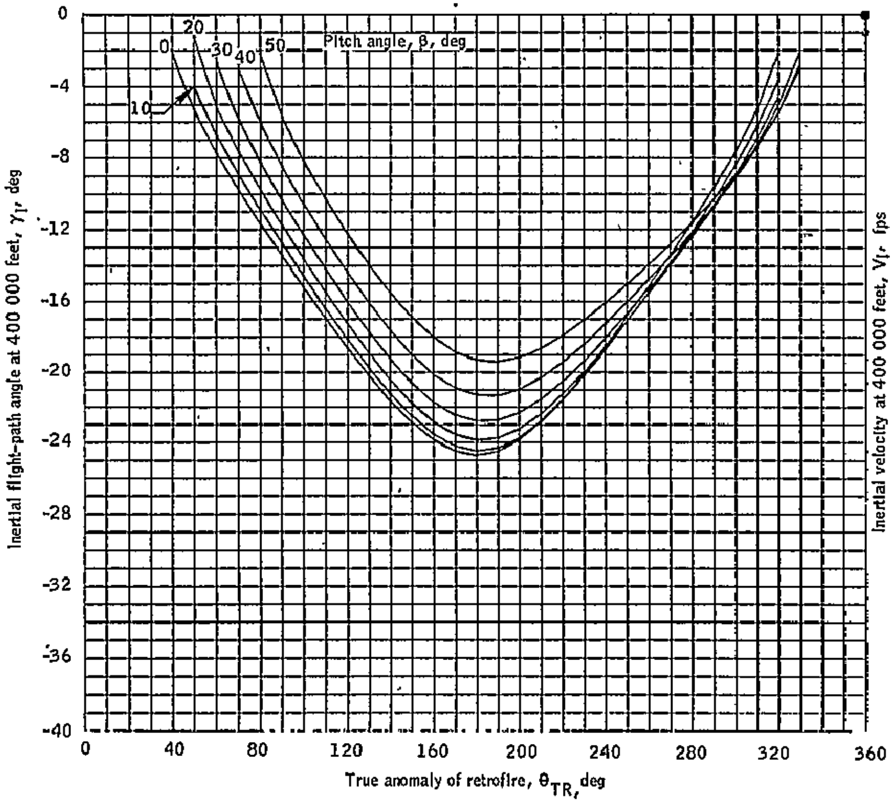
Figure 32.- Continued.

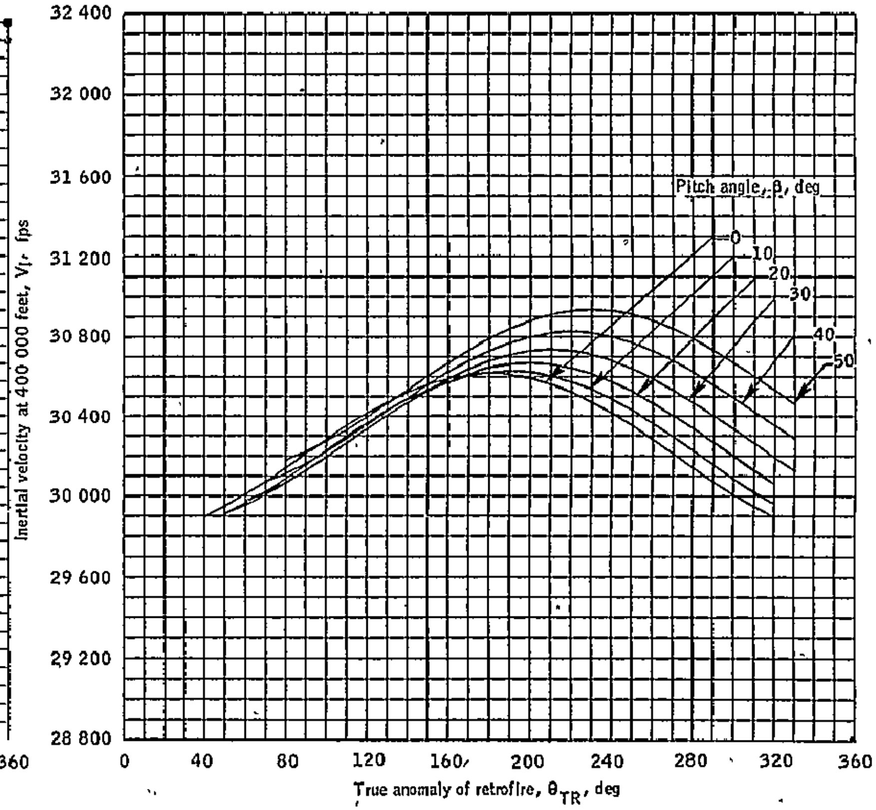




(d) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

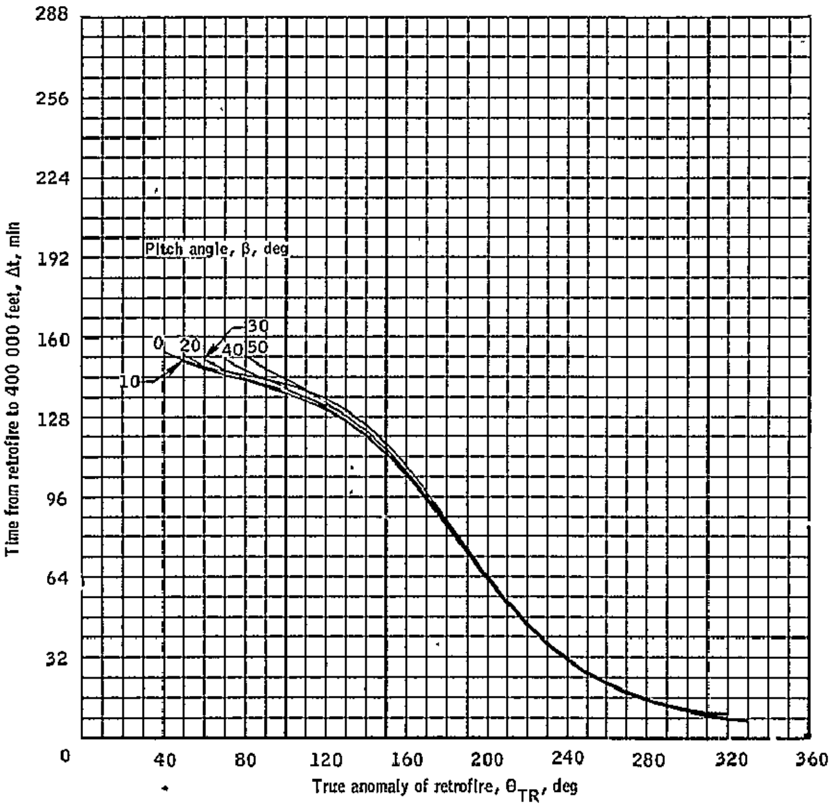
Figure 32.- Continued.

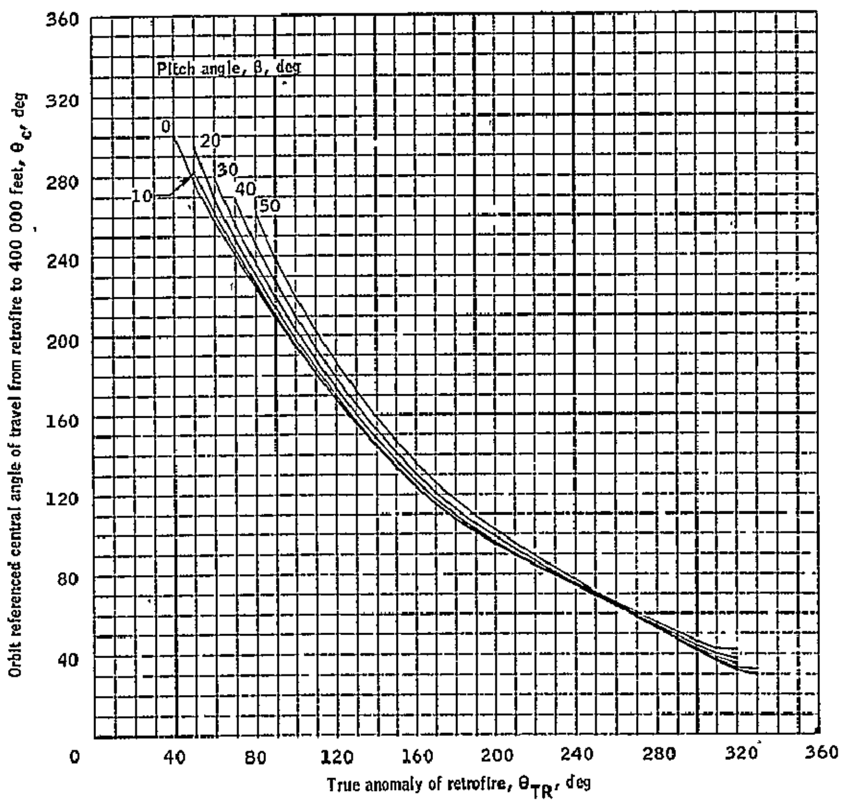




(e) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

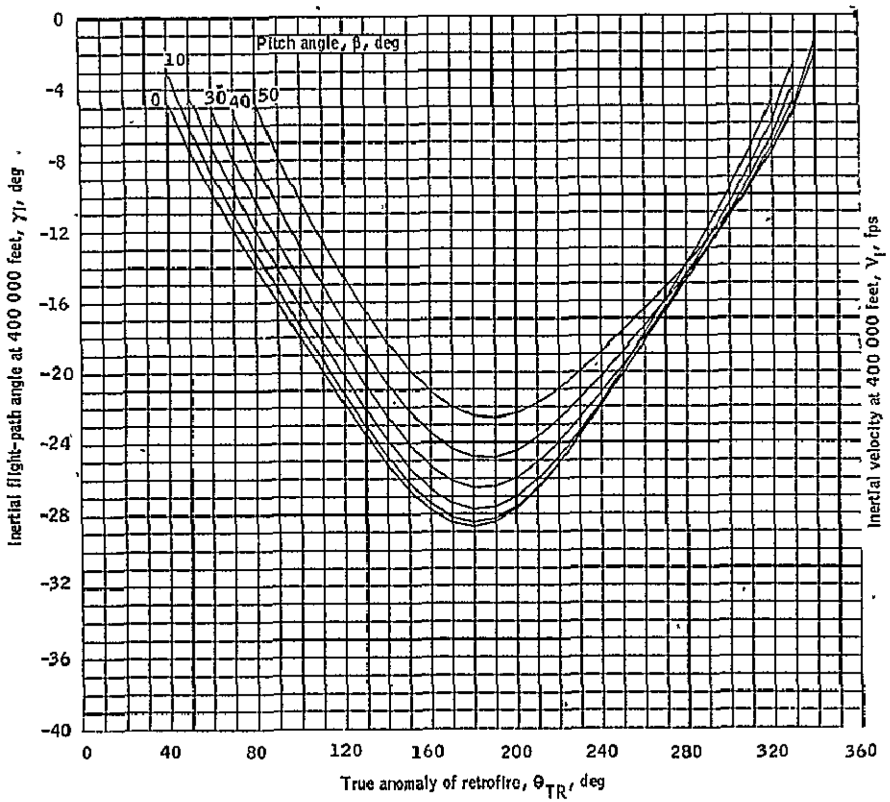
Figure 32.- Continued.

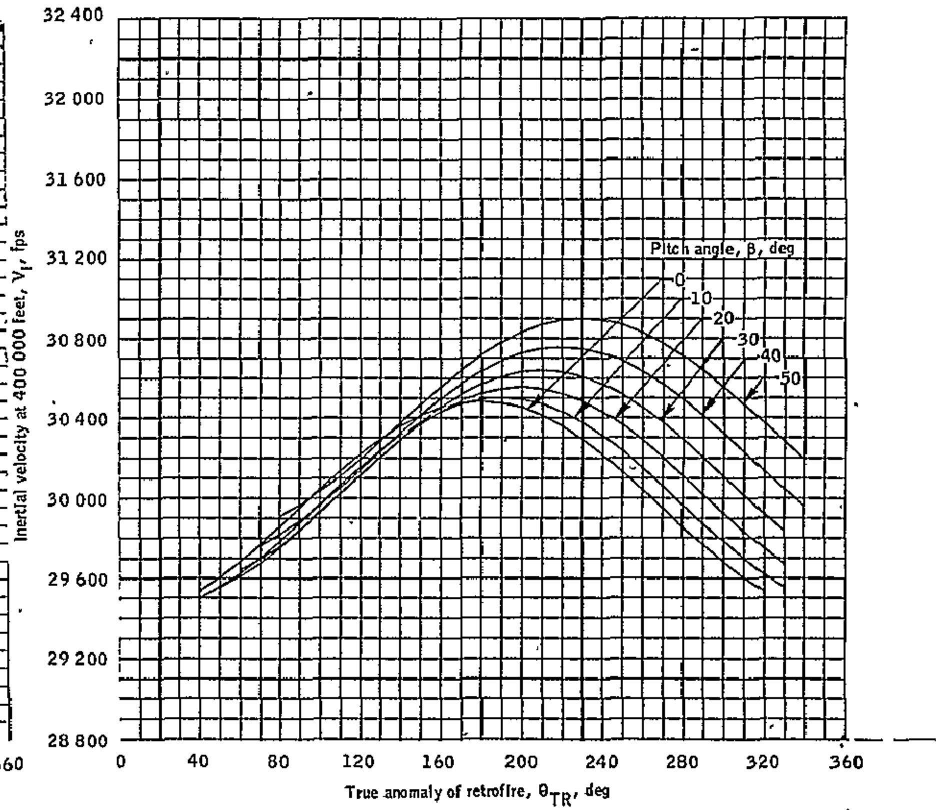




(f) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

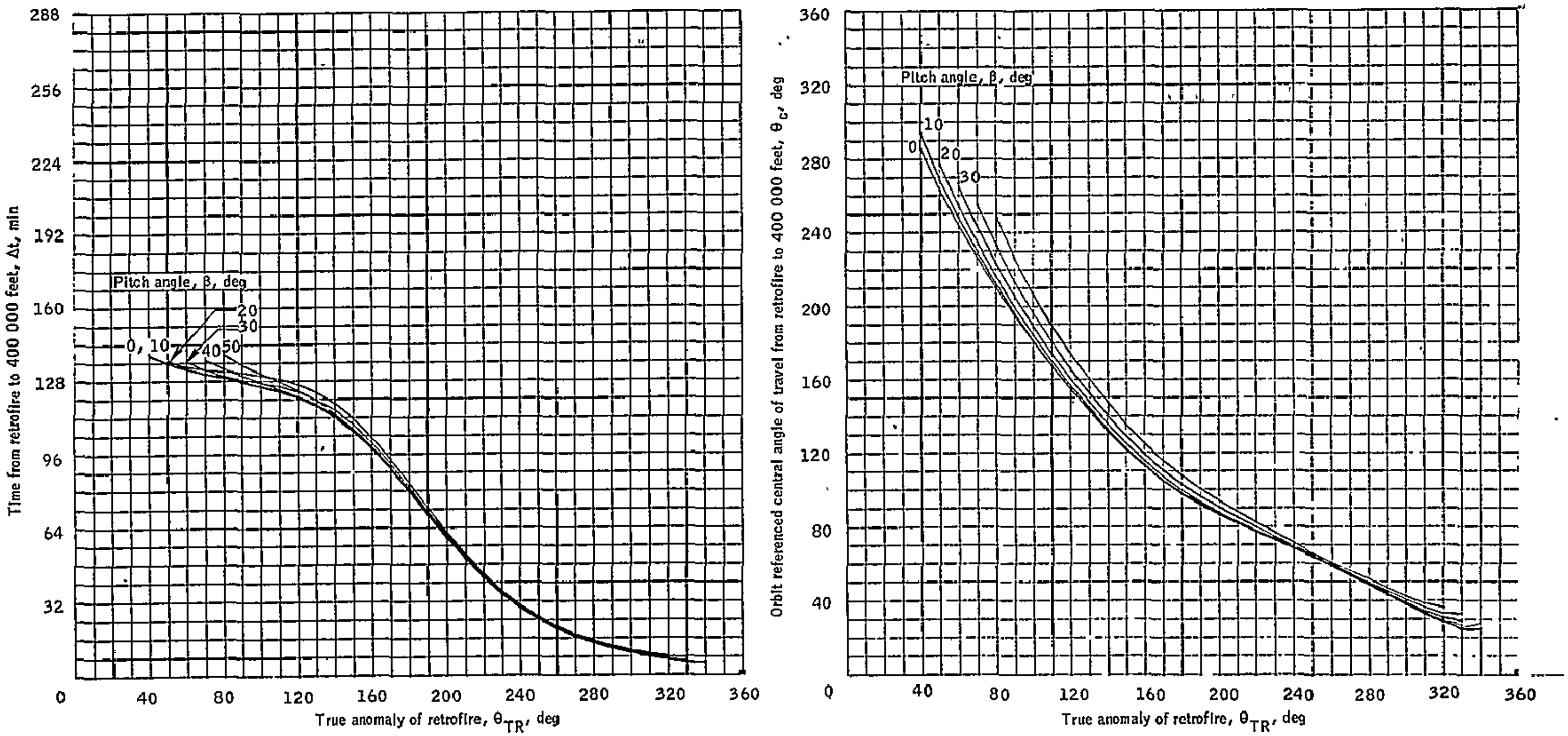
Figure 32.- Continued.





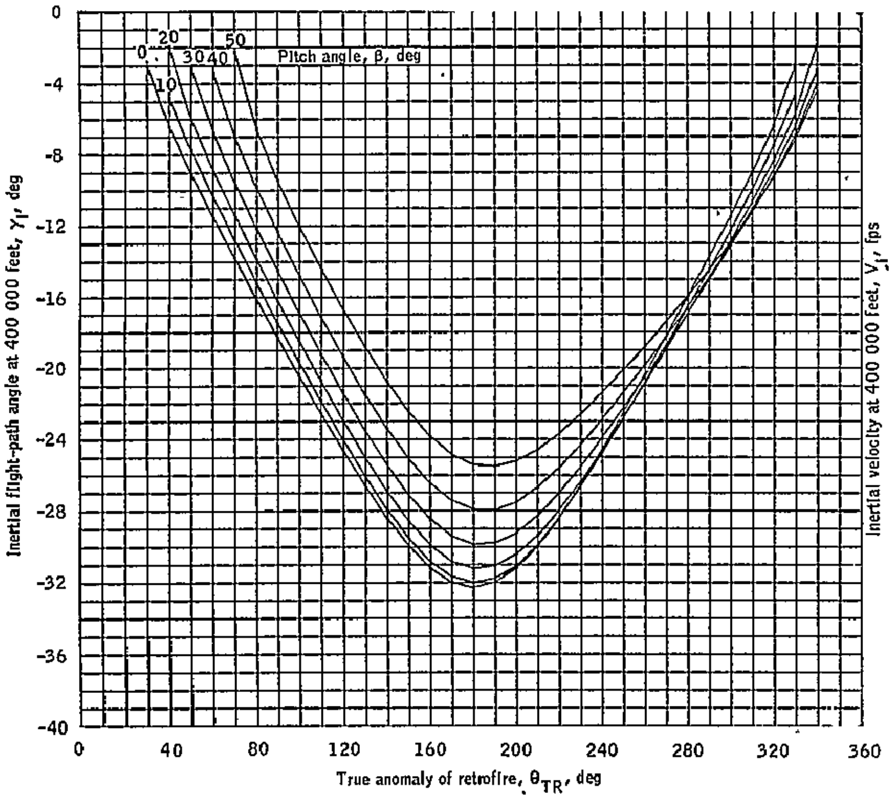
(g) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

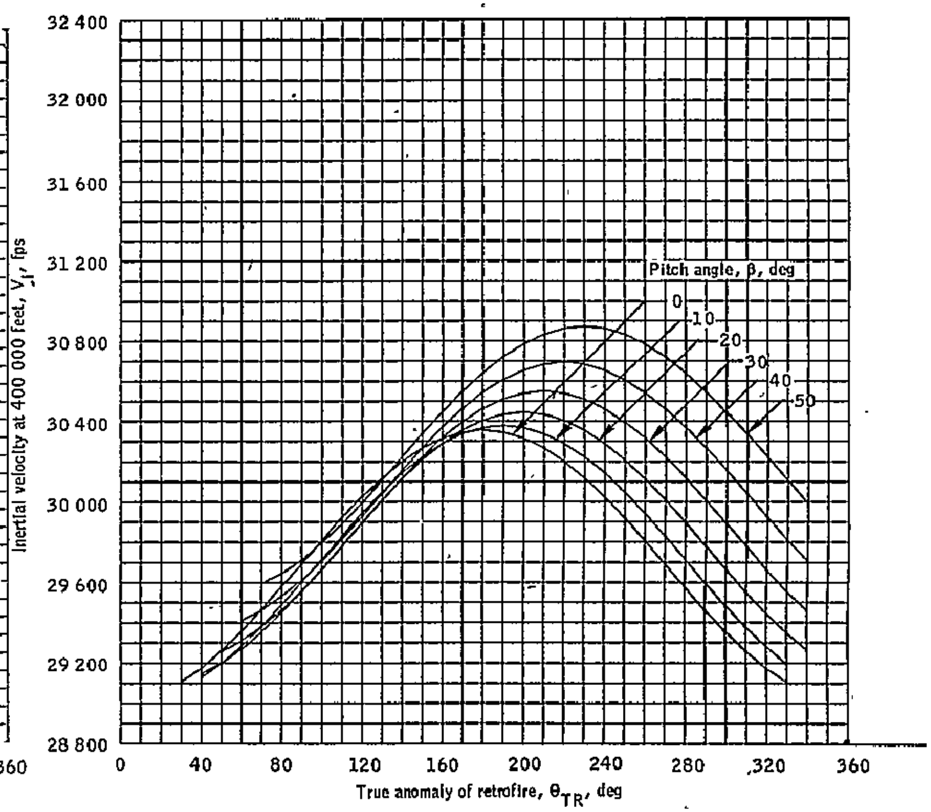
Figure 32.- Continued.



(h) Time from retrofire and central angle for retrograde $\Delta V = 1700$ feet per second.

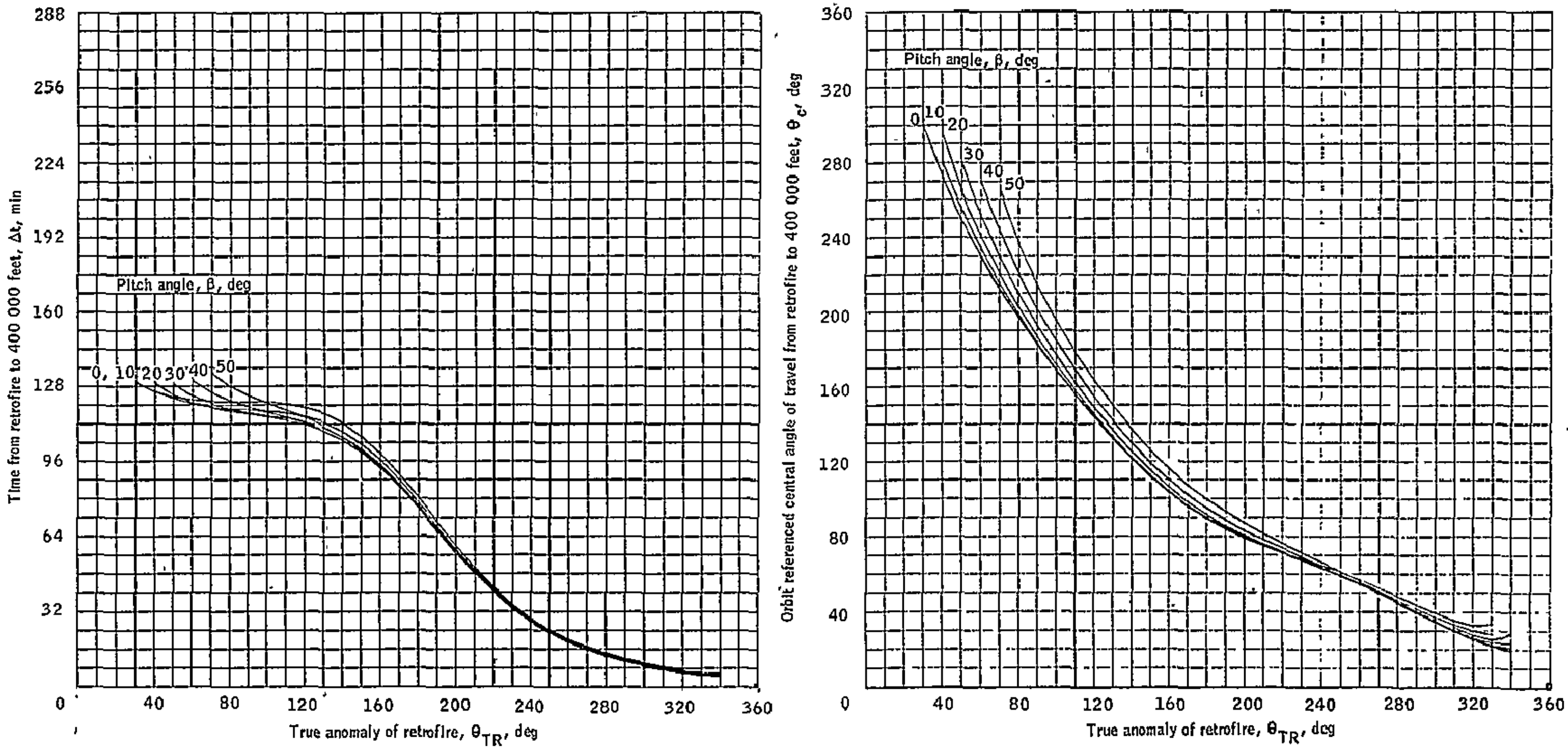
Figure 32.- Continued.





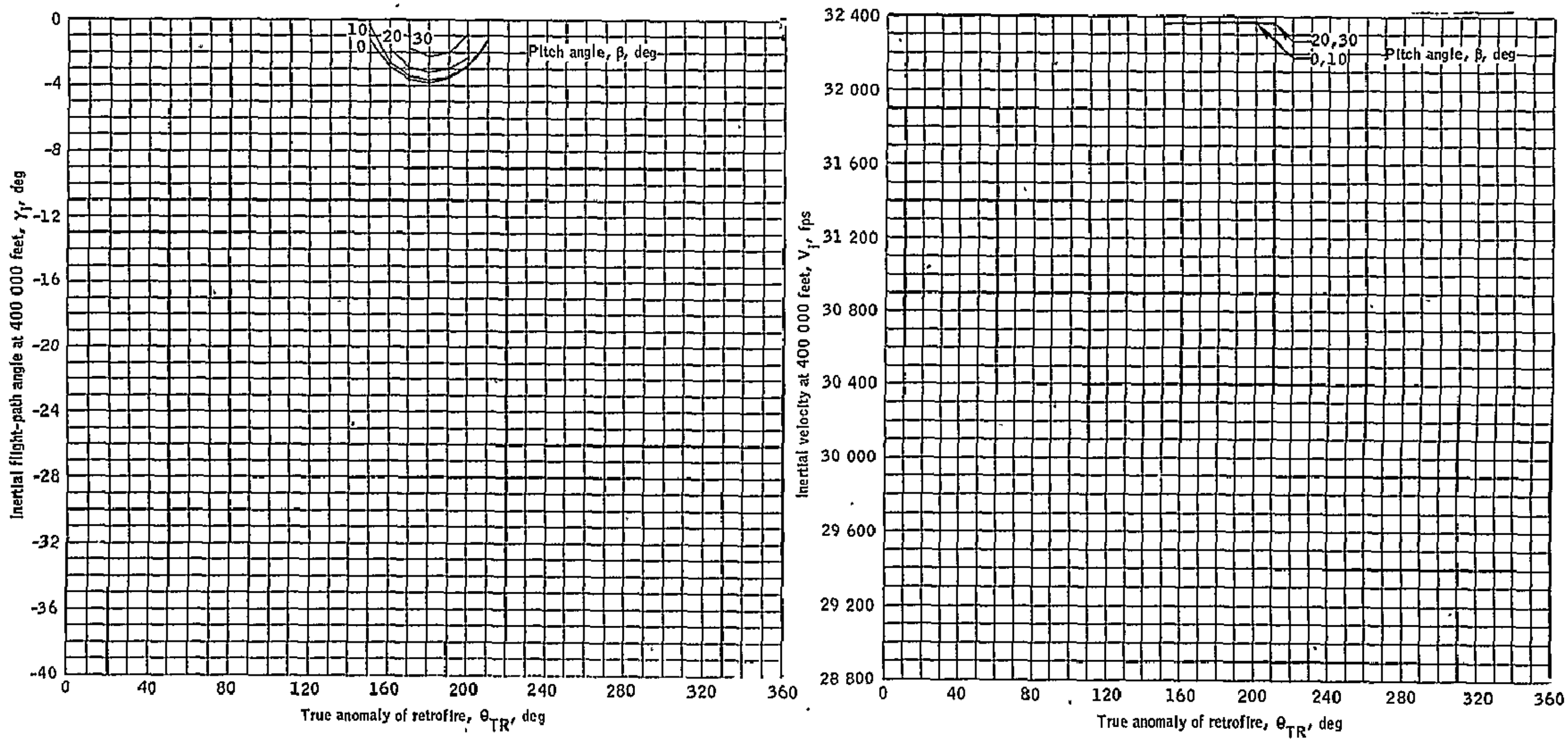
(l) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

Figure 32.- Continued.



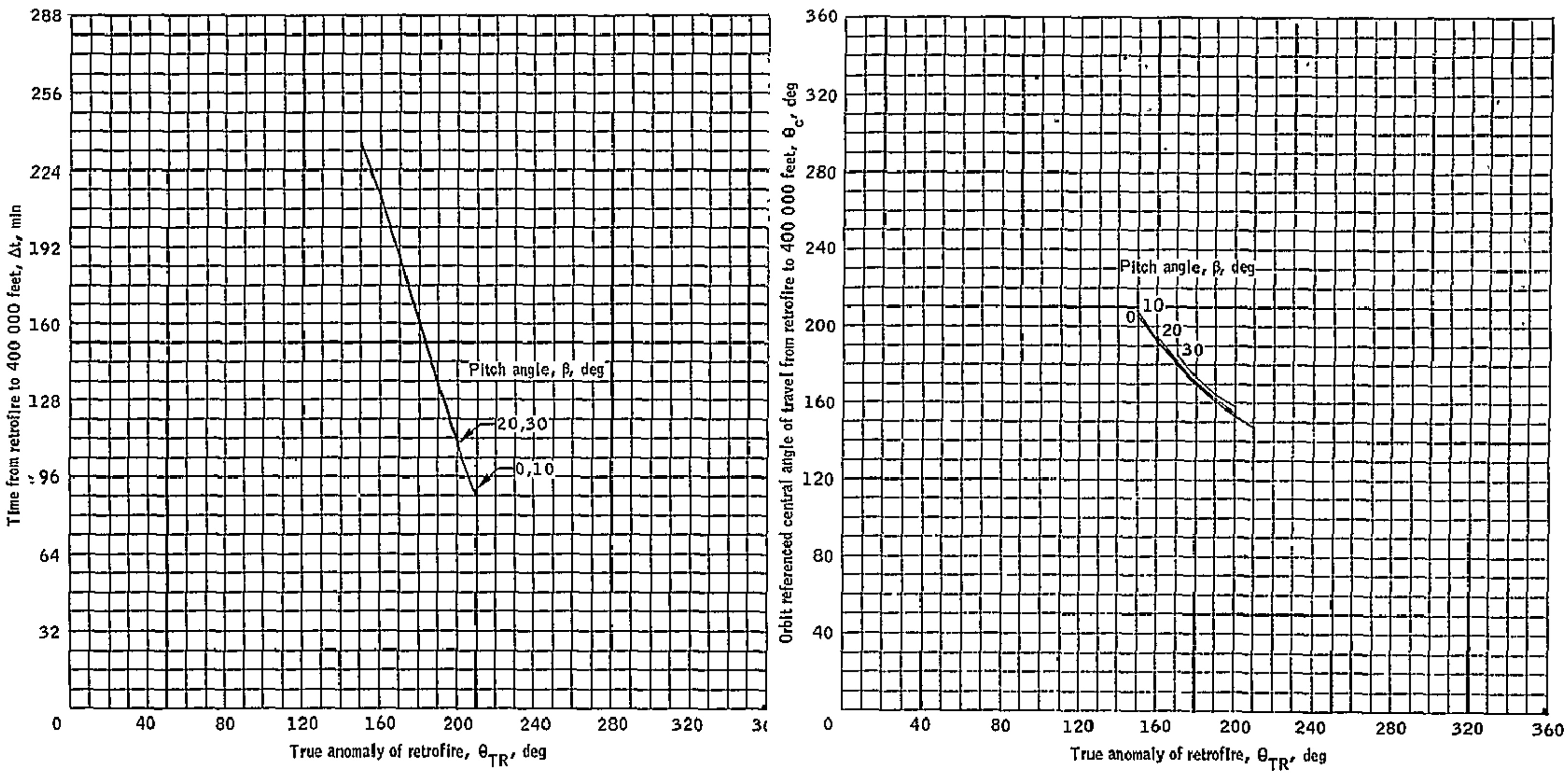
(j) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

Figure 32.- Concluded.



(a) Flight-path angle and velocity for retrograde ΔV = 100 feet per second.

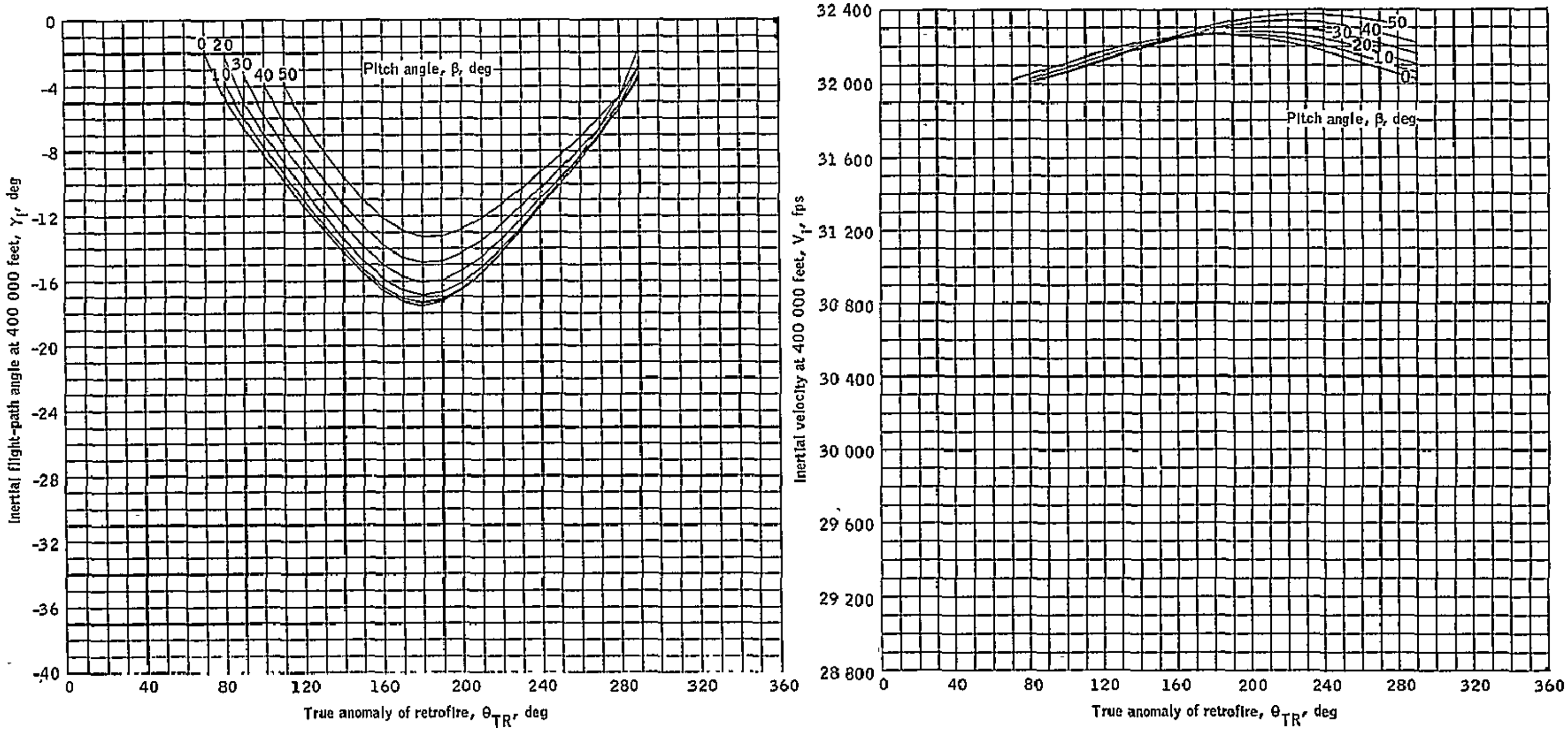
Figure 33.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 100/10 000 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde $\Delta V = 100$ feet per second.

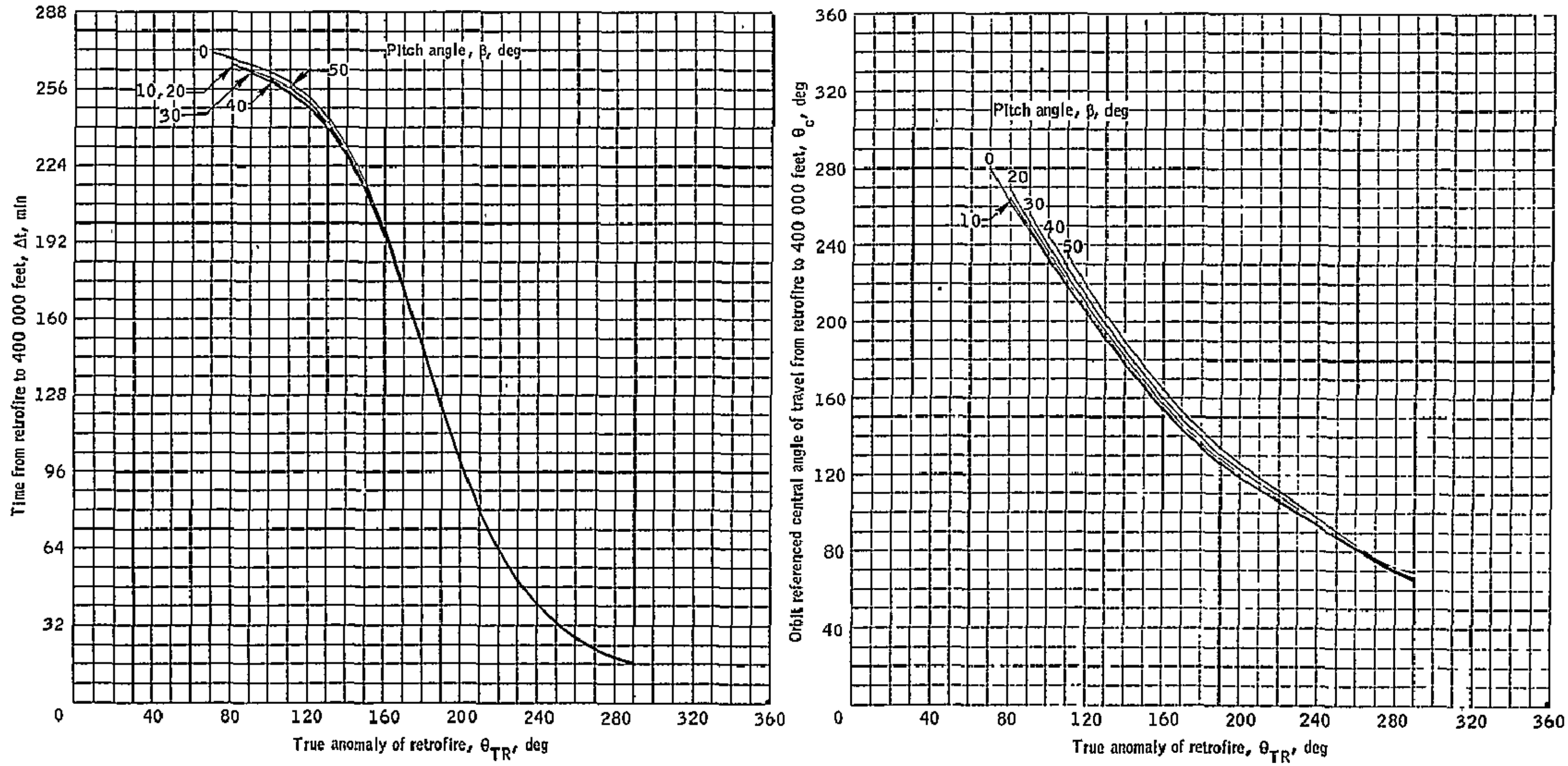
Figure 33.- Continued.

1299



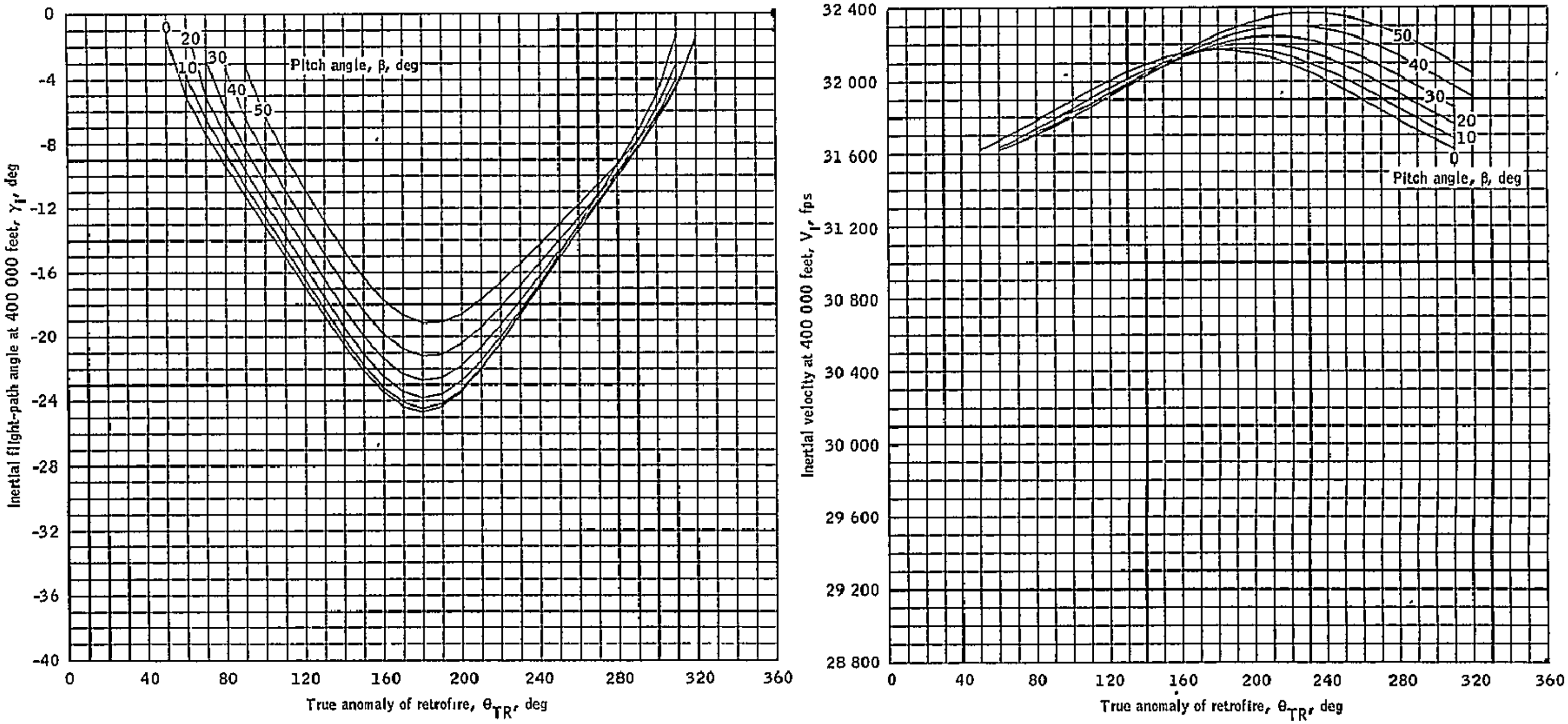
(c) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

Figure 33.- Continued.



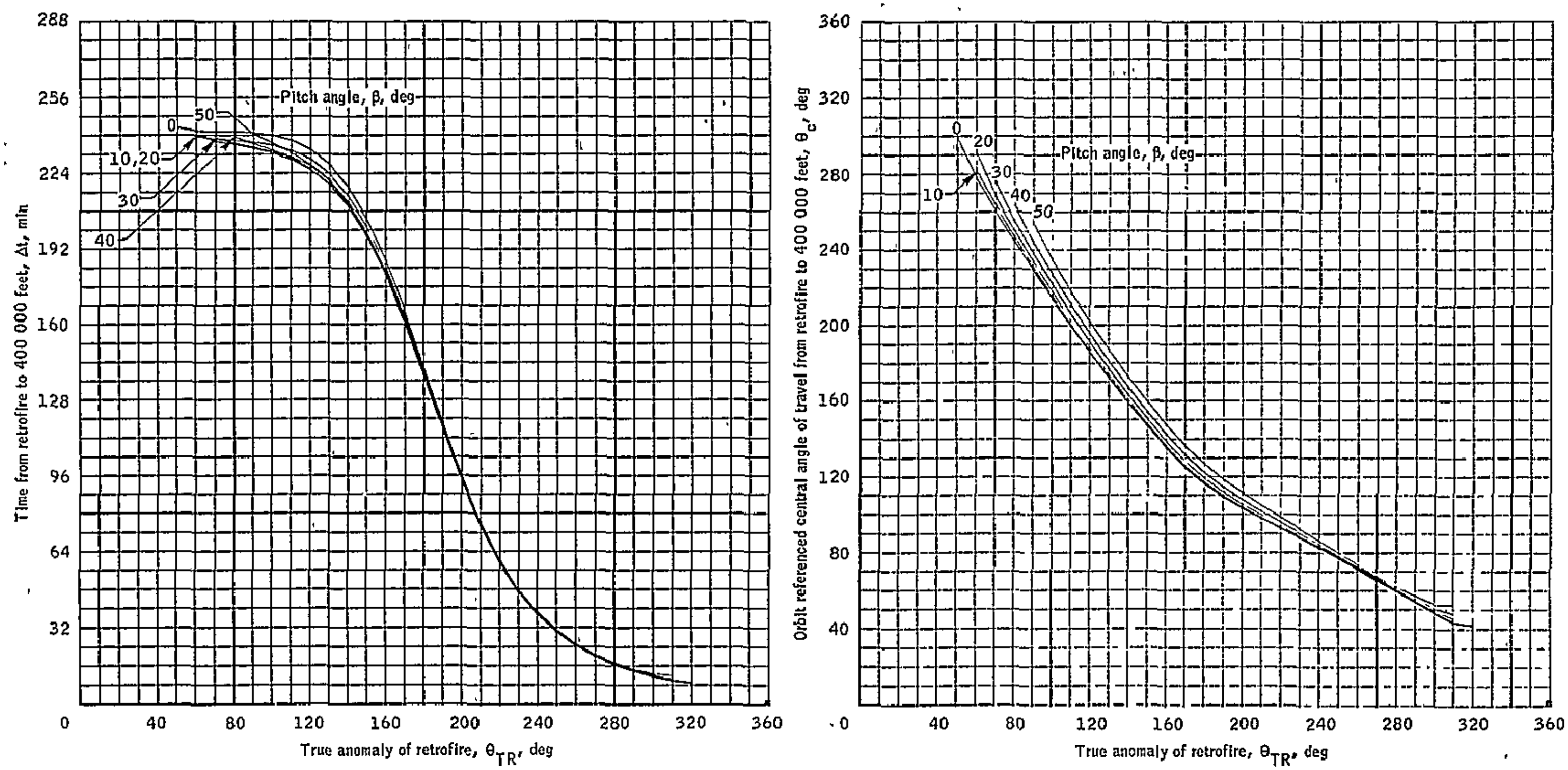
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 33.- Continued.



(e) Flight-path angle and velocity for retrograde ΔV = 900 feet per second.

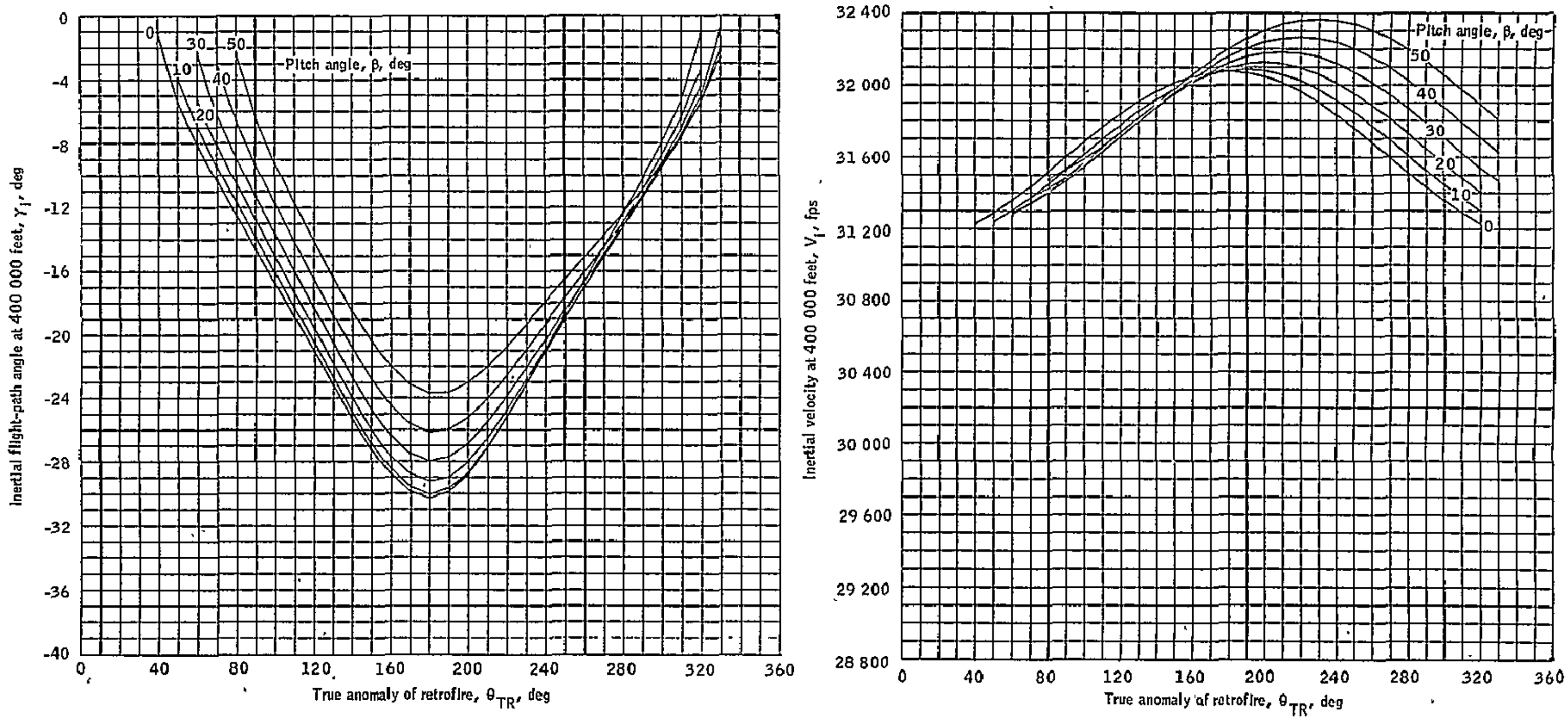
Figure 33.- Continued.



(f) Time from retrofire and central angle for retrograde ΔV = 900 feet per second.

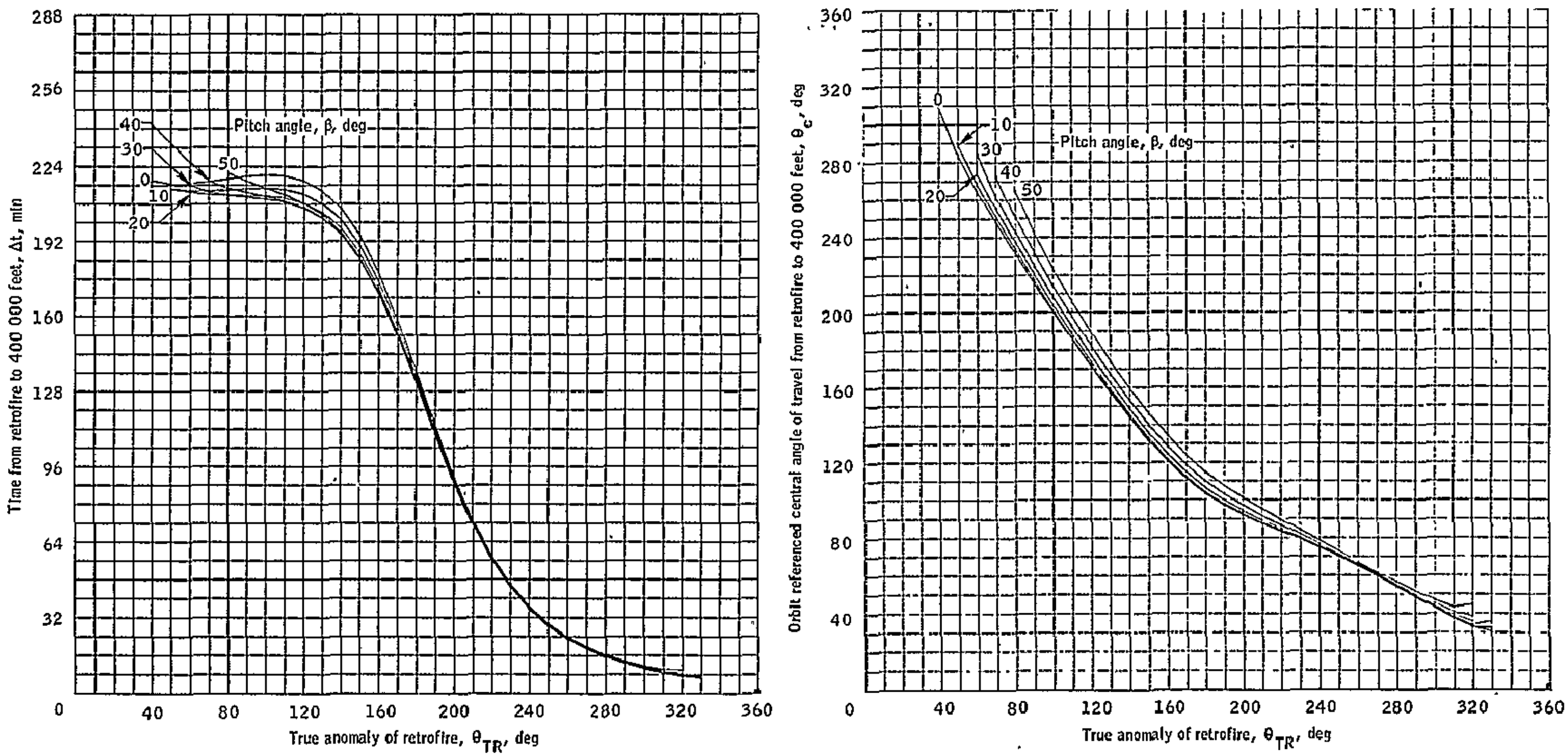
Figure 33.- Continued.

3041



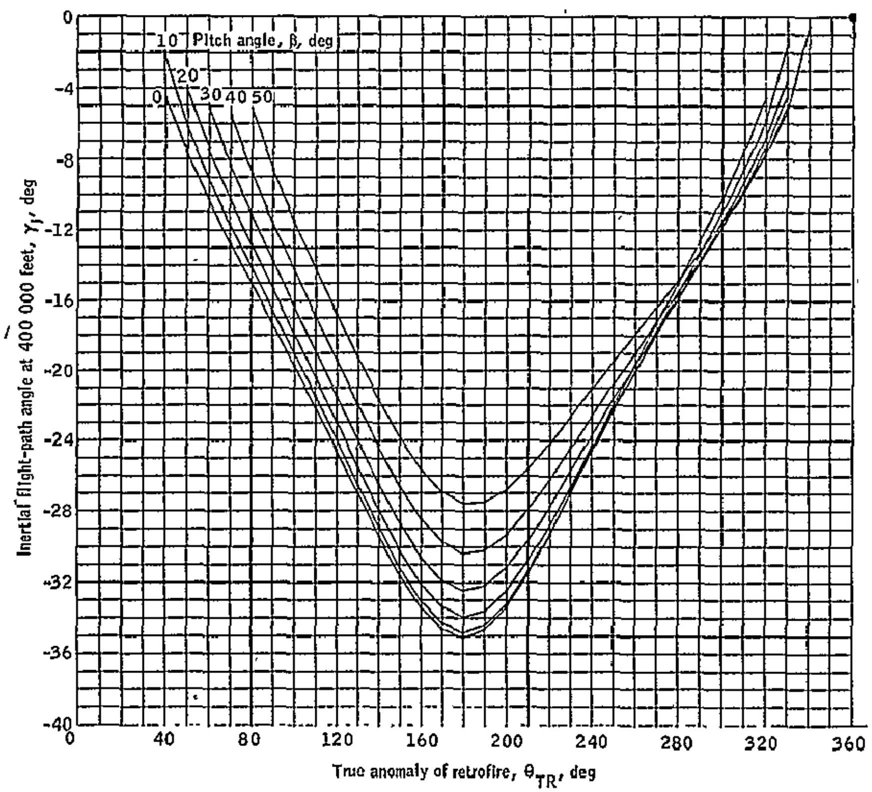
(g) Flight-path angle and velocity for retrograde ΔV = 1300 feet per second.

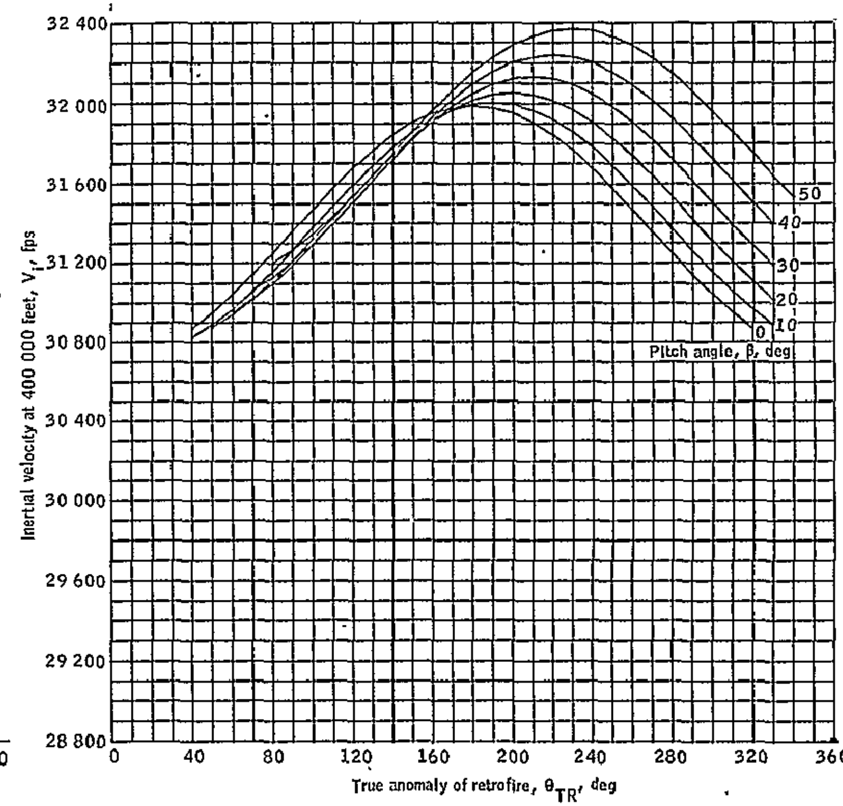
Figure 33.- Continued.



(h) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

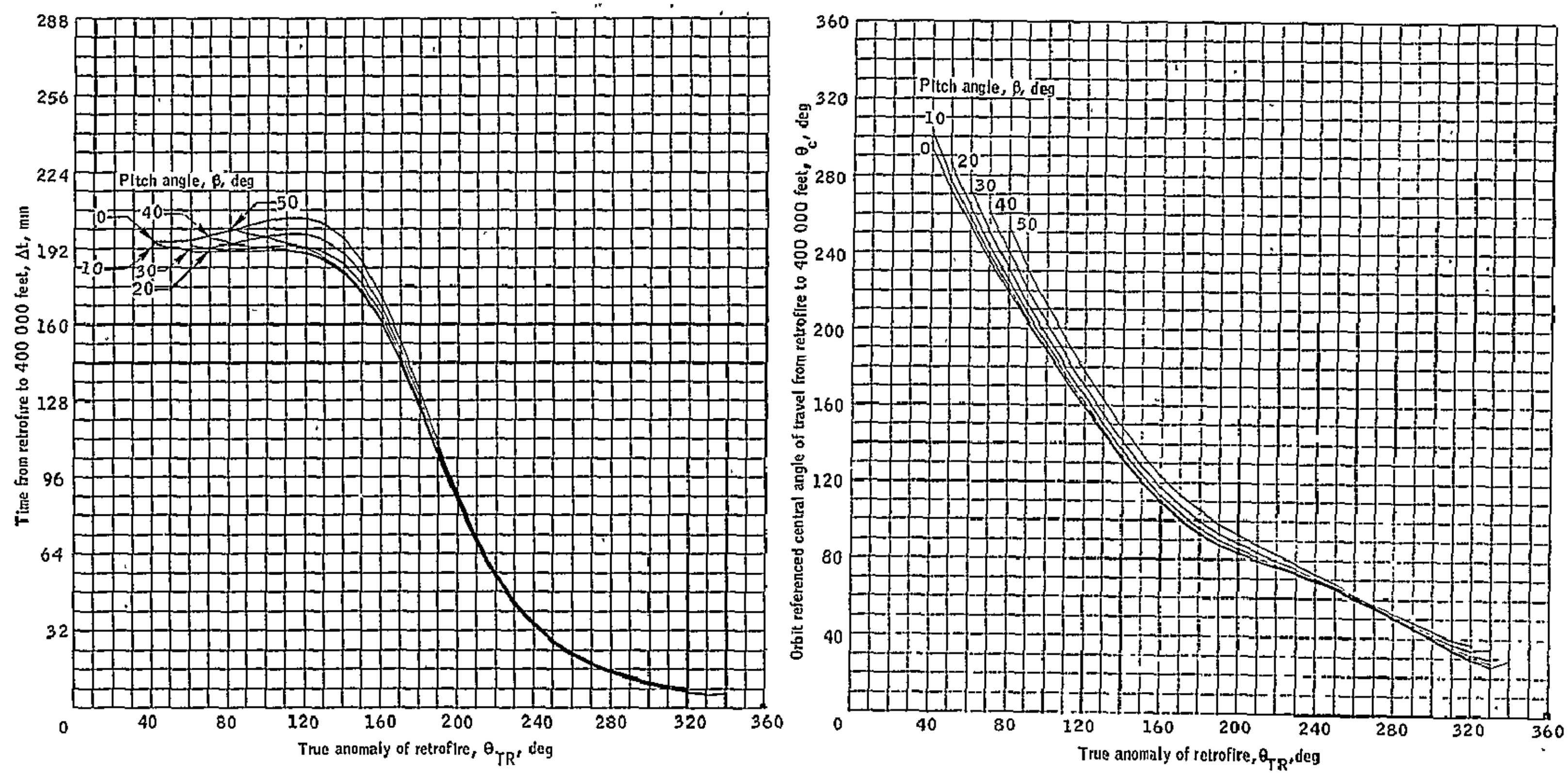
Figure 33.- Continued.





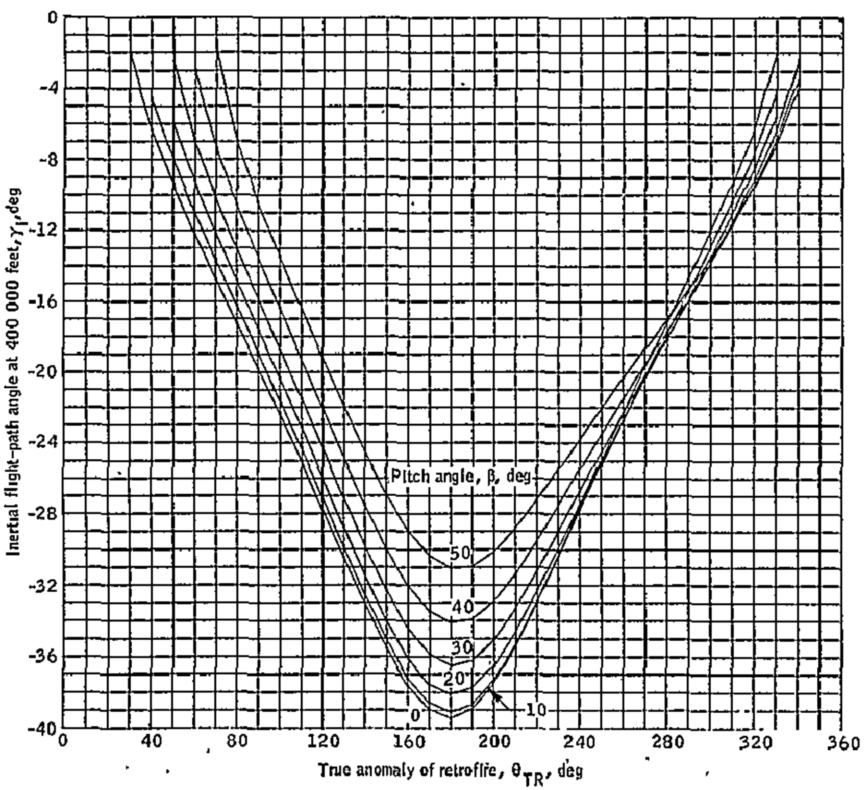
(i) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

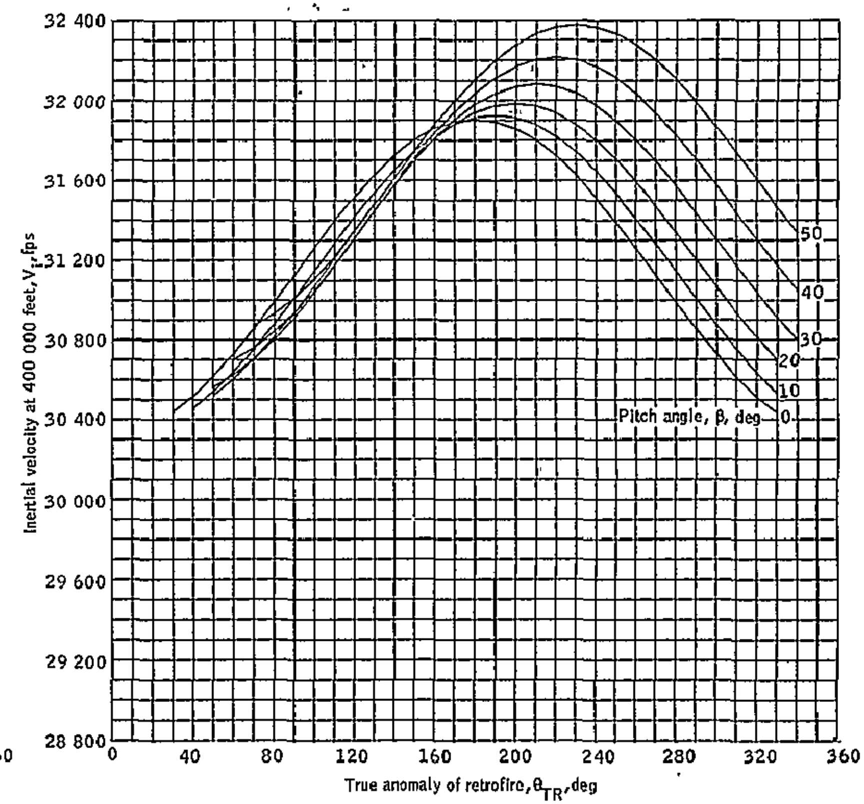
Figure 33.- Continued.



(j) Time from retrofire and central angle for retrograde $\Delta V = 1700$ feet per second.

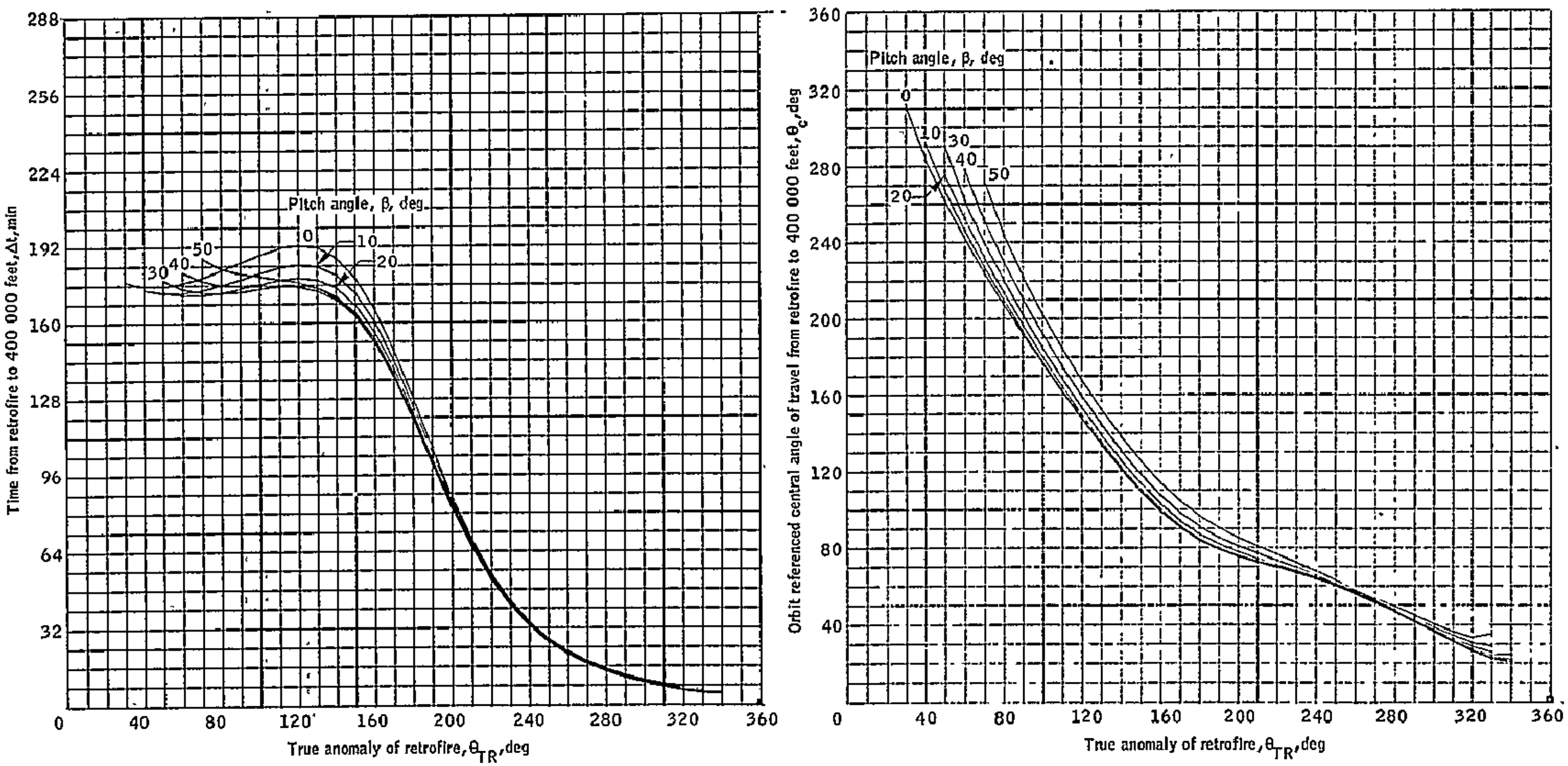
Figure 33.- Continued.





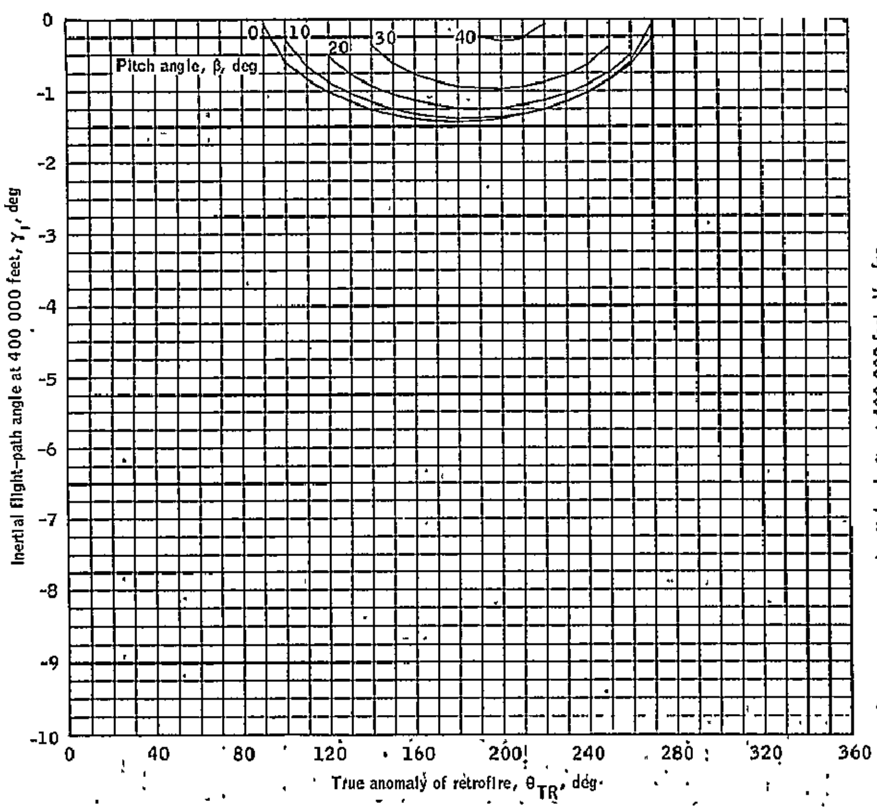
(k) Flight-path angle and velocity for retrograde ΔV = 2100 feet per second.

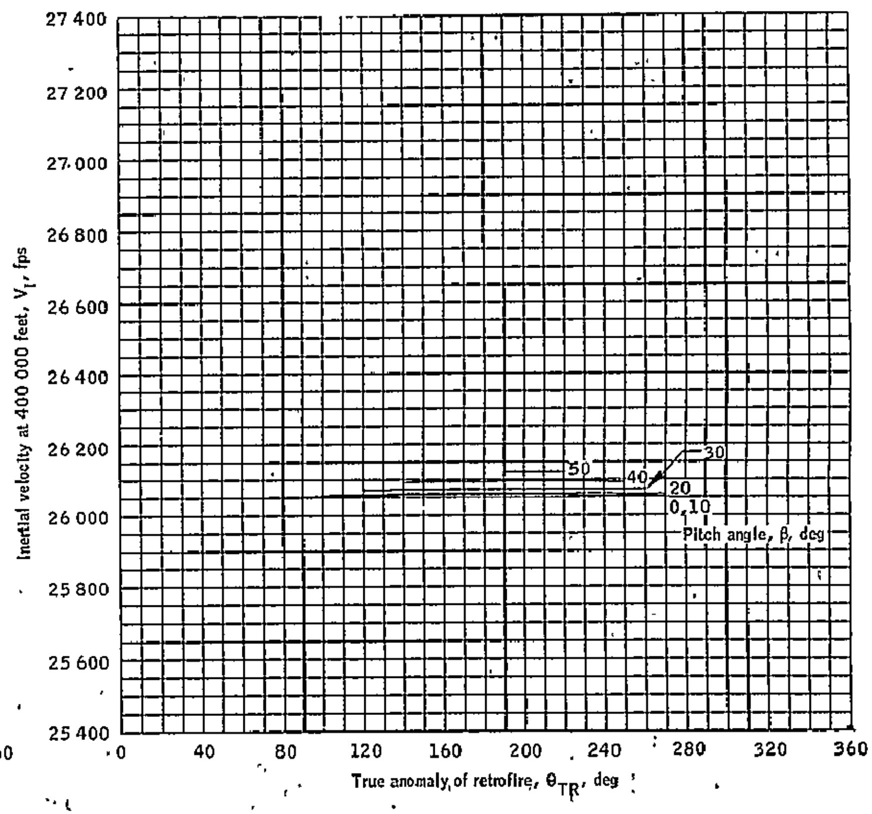
Figure 33.- Continued.



(l) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

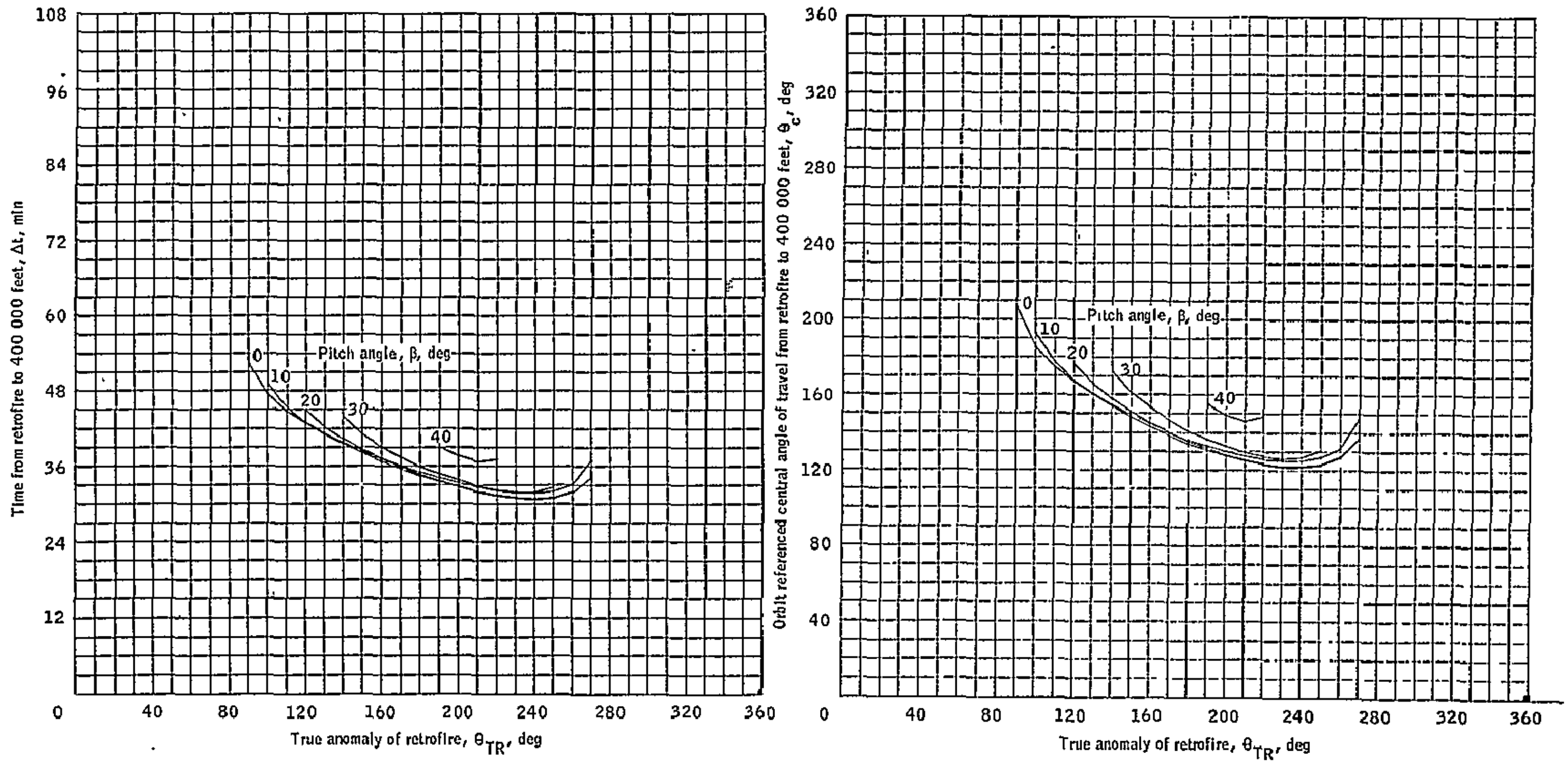
Figure 33.- Concluded.





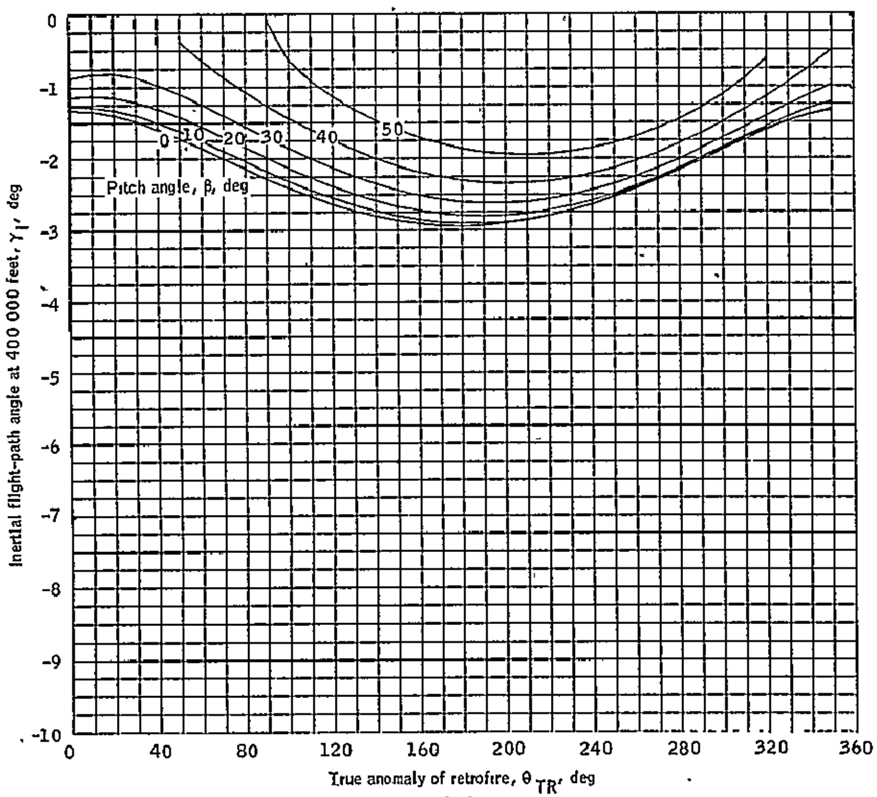
(a) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

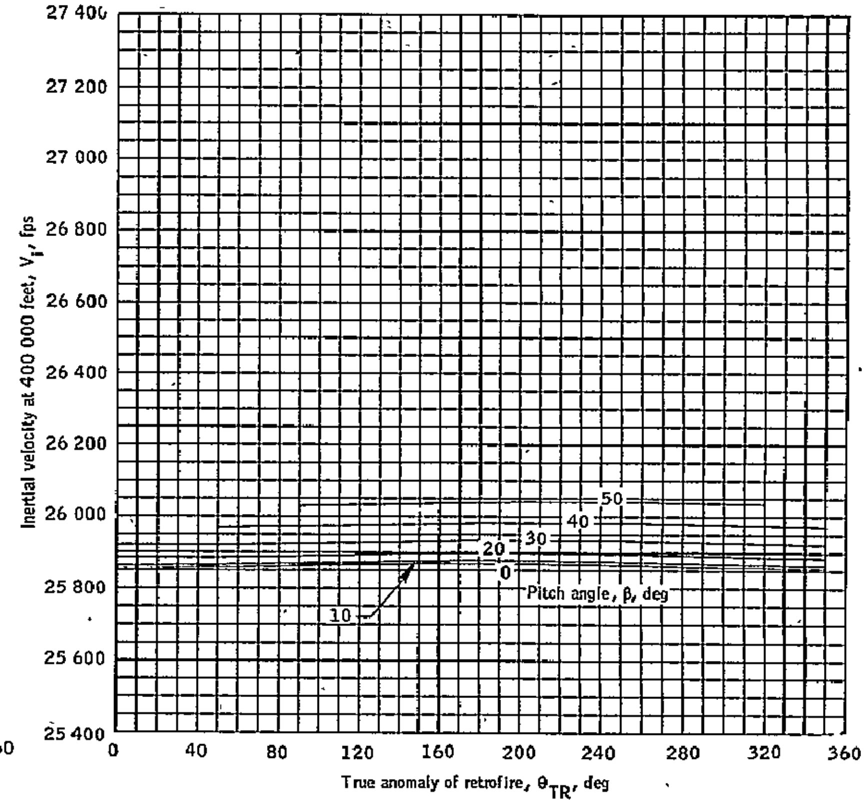
Figure 34.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 200/300 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde $\Delta V=300$ feet per second.

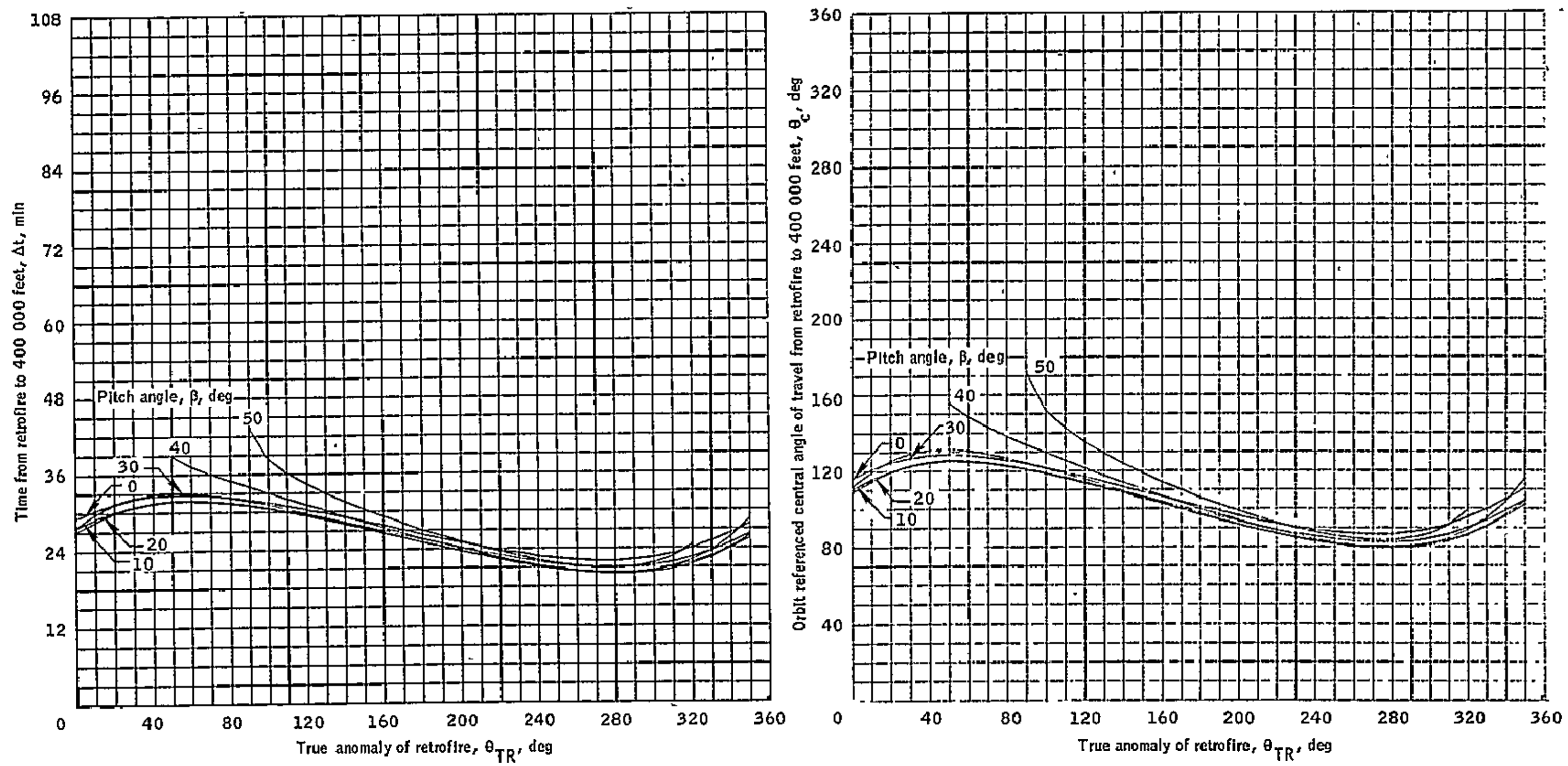
Figure 34.- Continued.





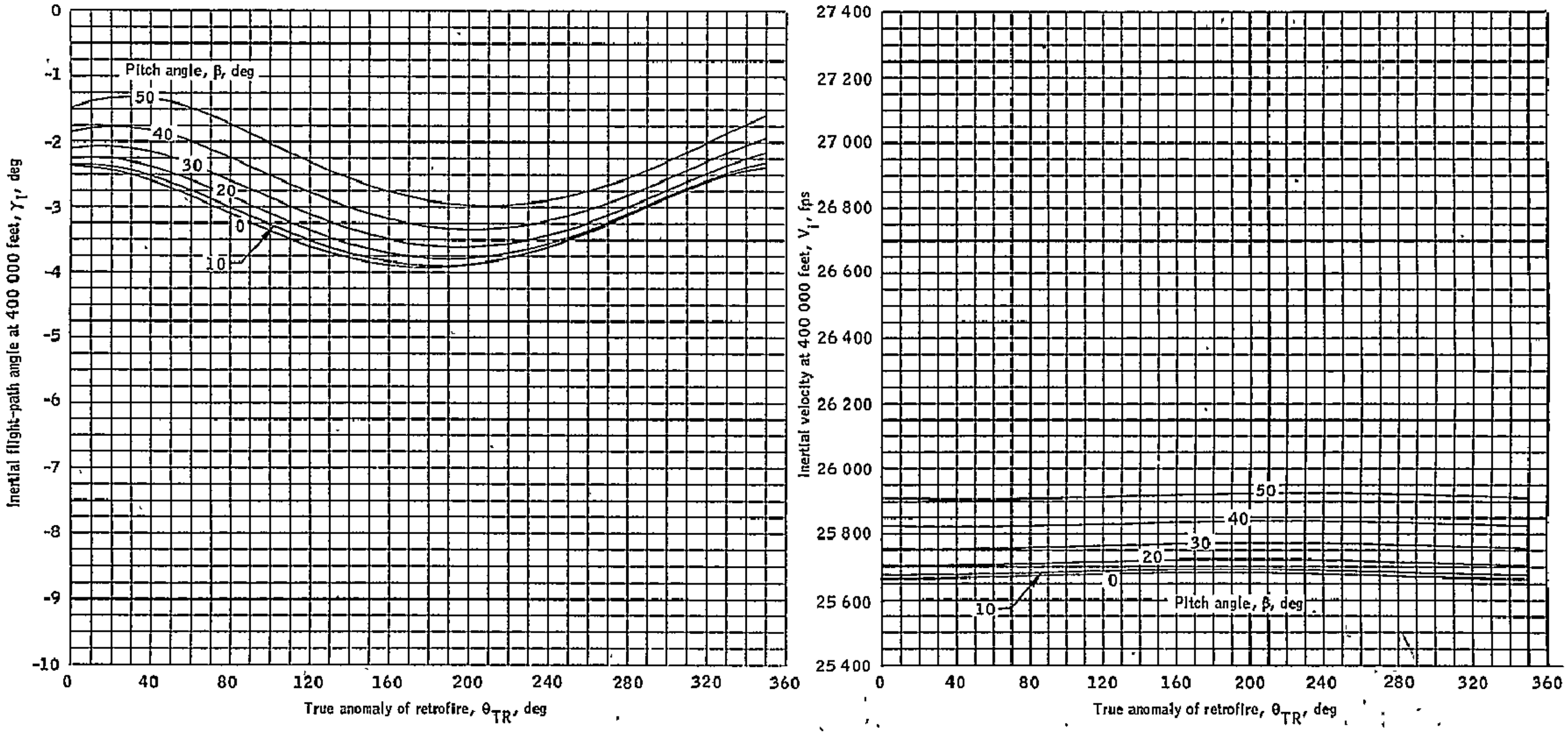
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

Figure 34.- Continued.



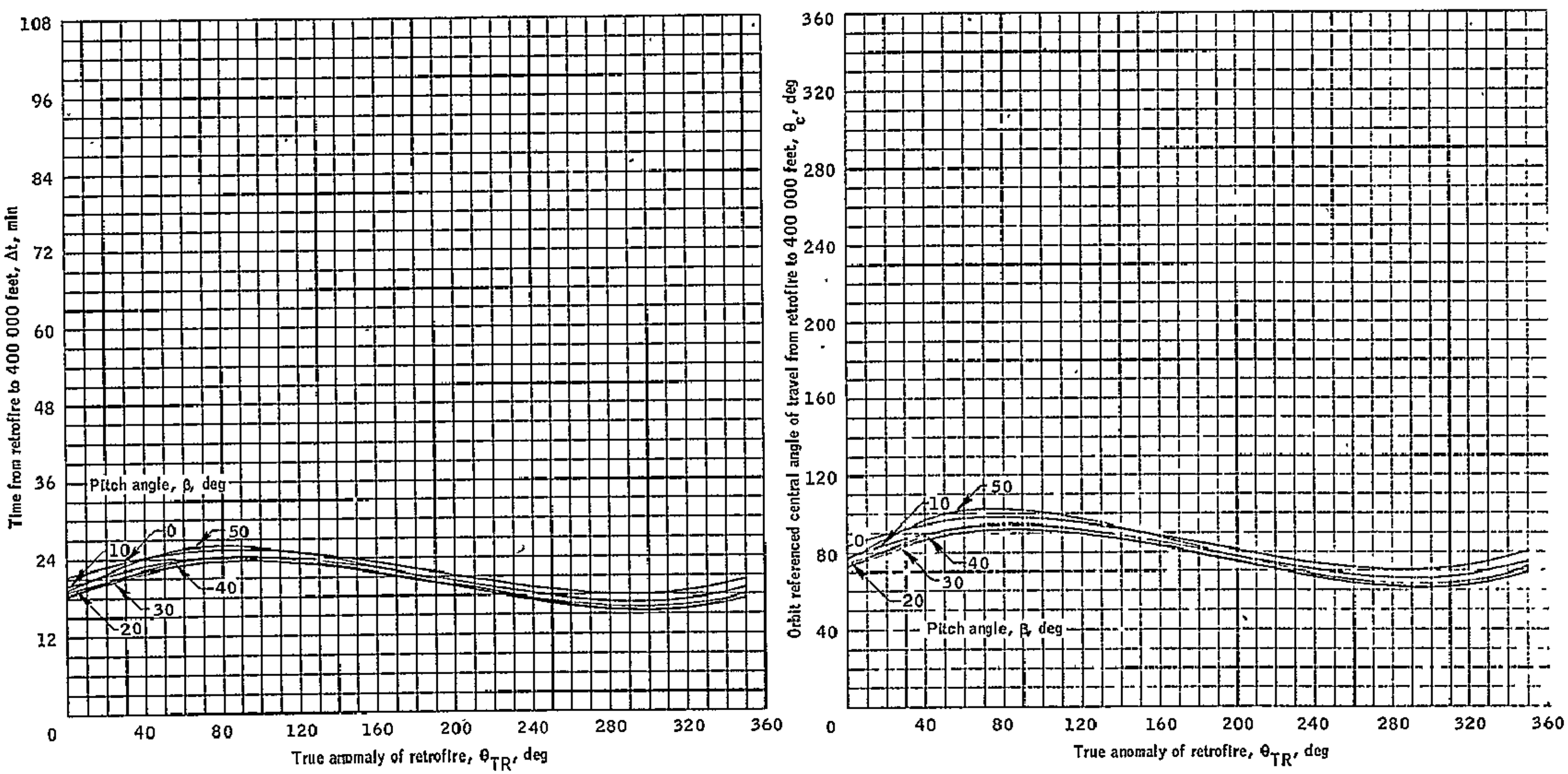
(d) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

Figure 34.- Continued.



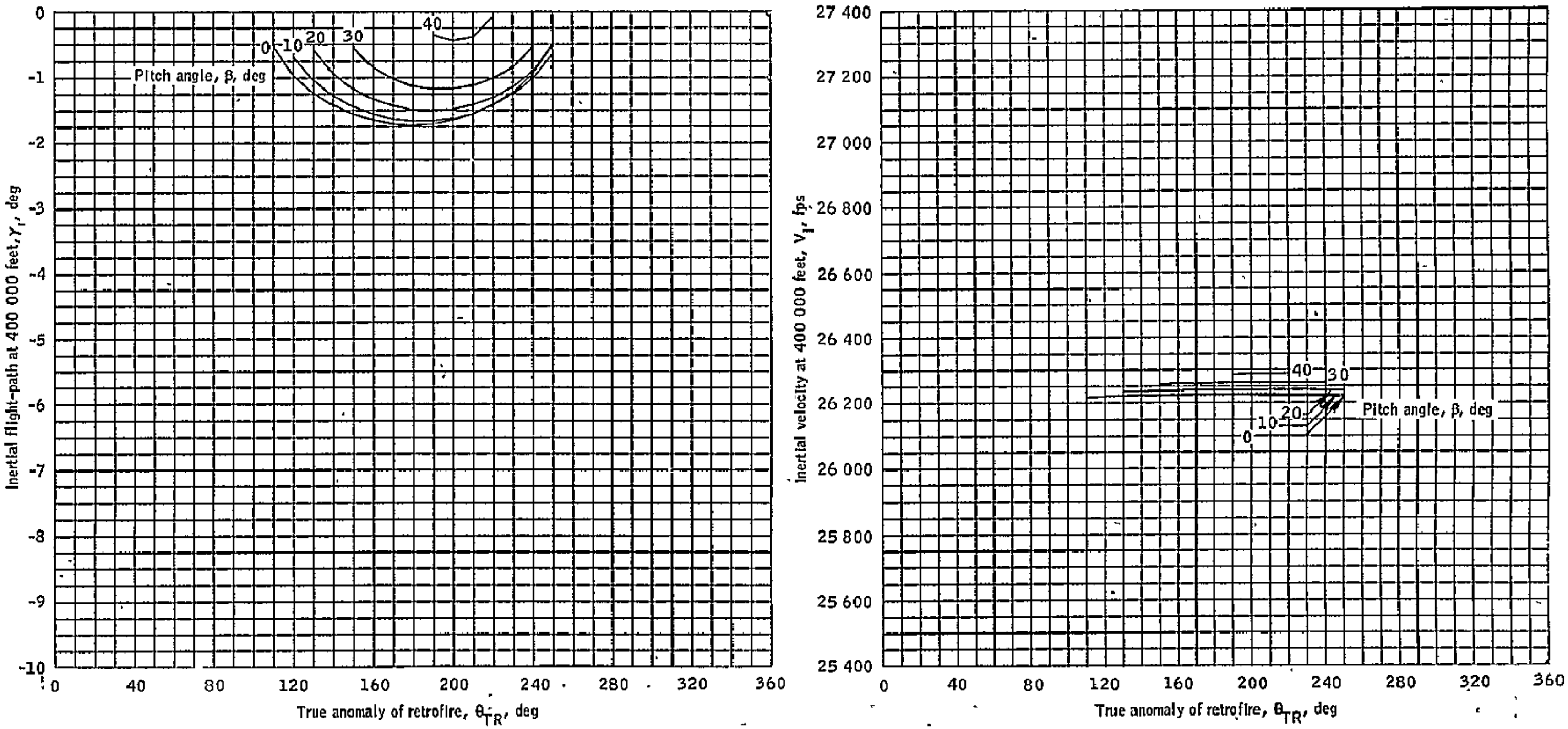
(e) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

Figure 34.- Continued.



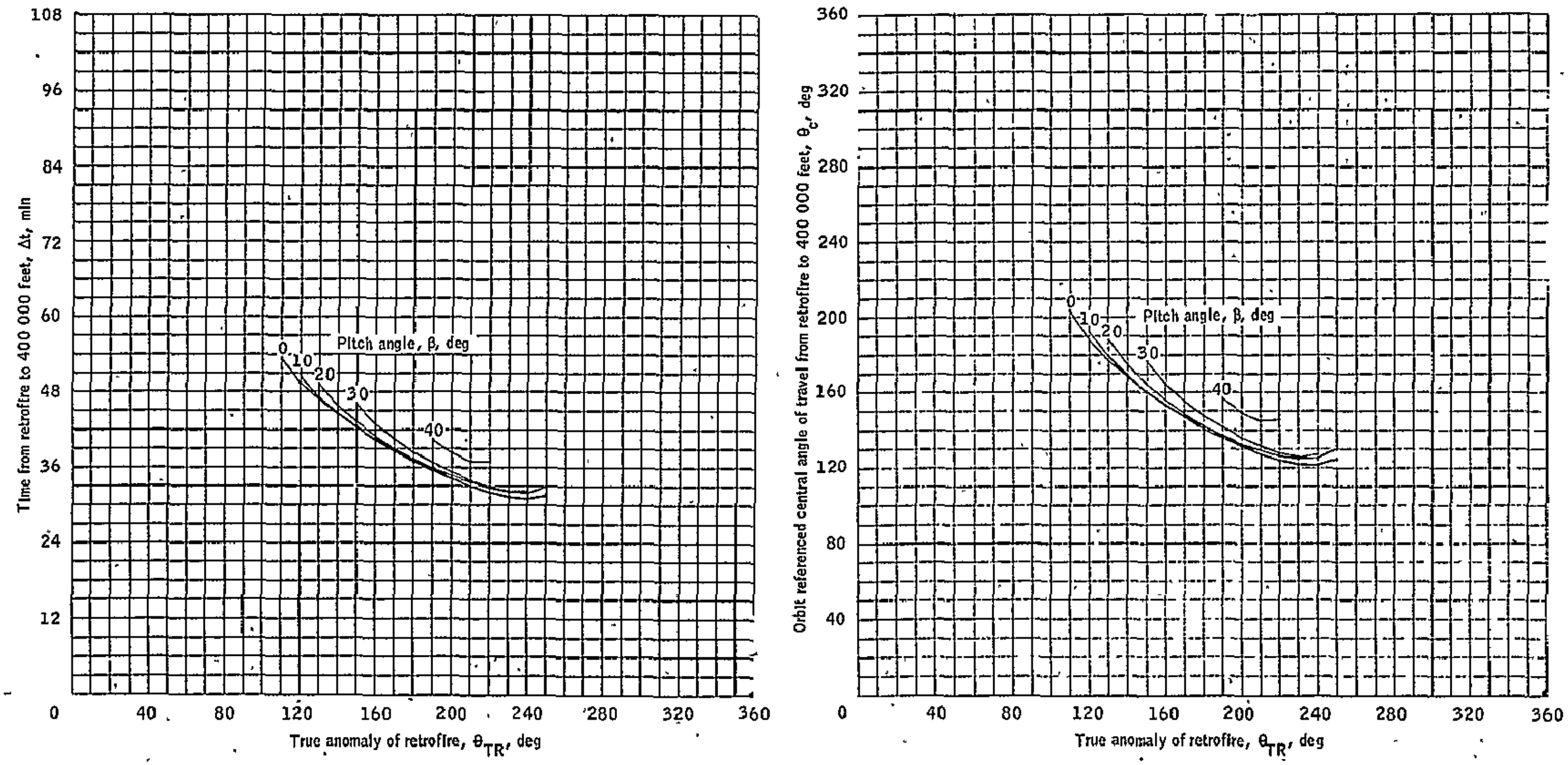
(f) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

Figure 34.- Concluded.



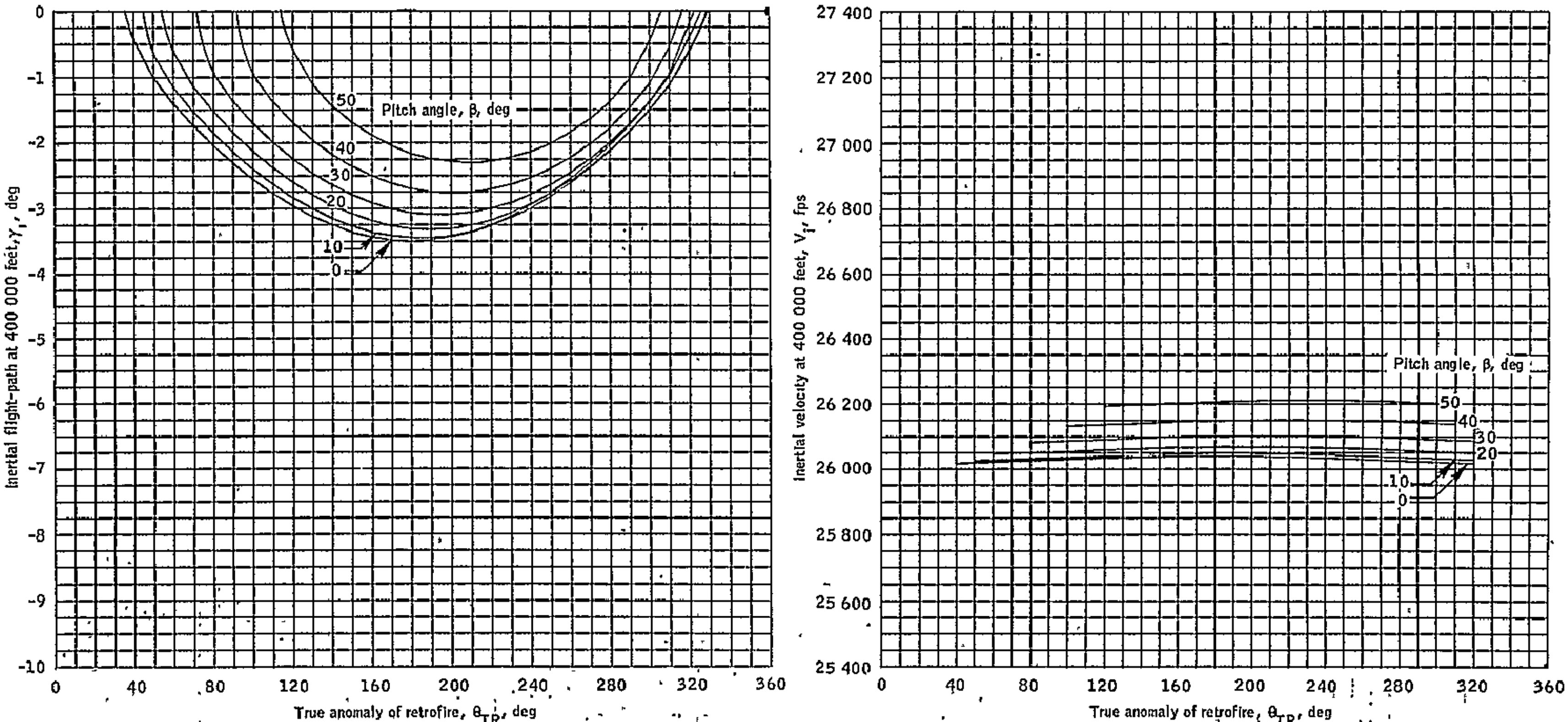
(a) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

Figure 35.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 200/400 nautical mile orbit.



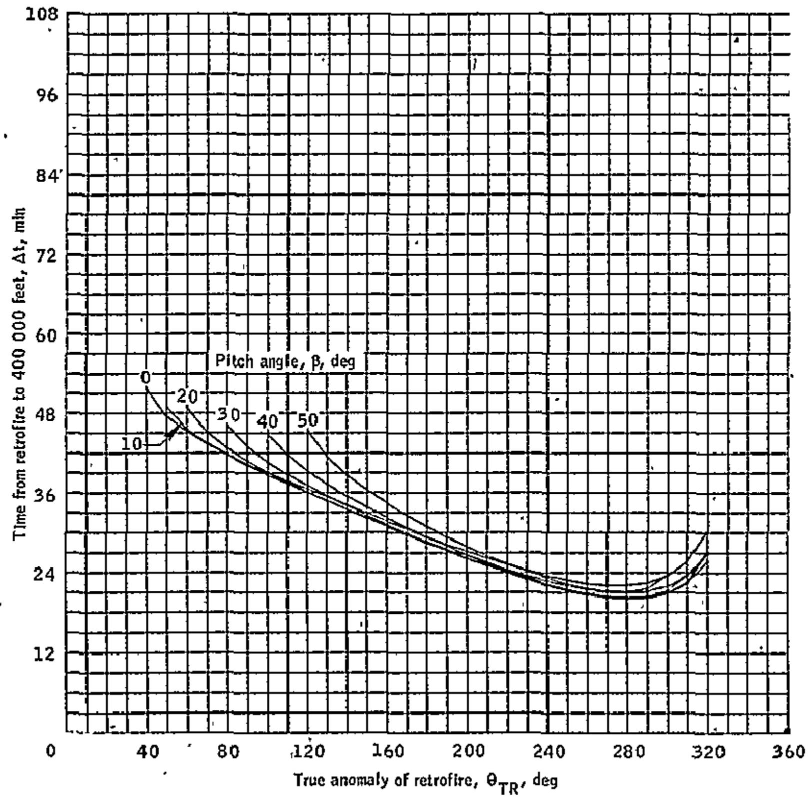
(b) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

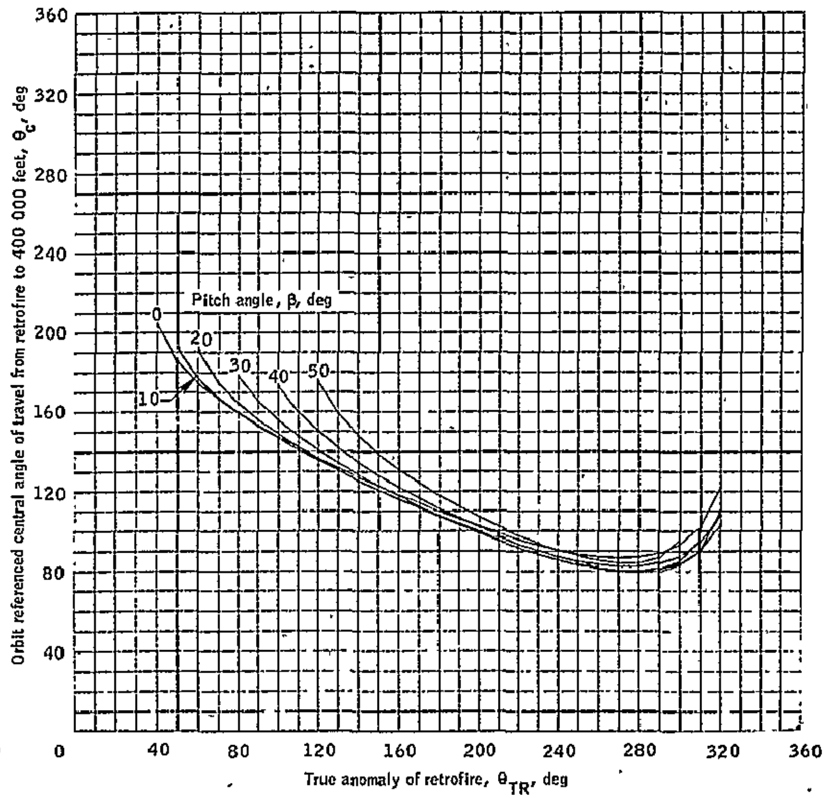
Figure 35.- Continued.



(c) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

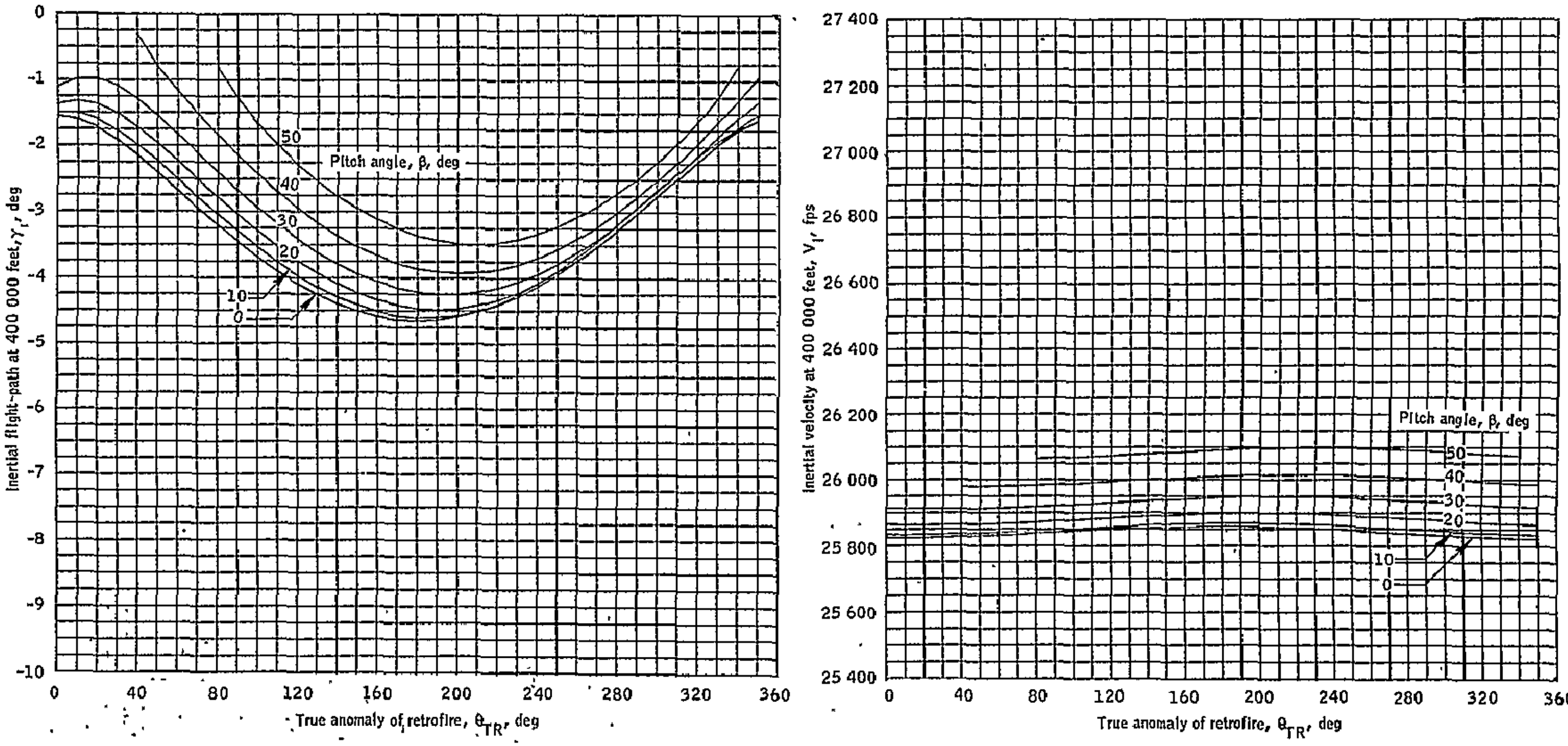
Figure 35.- Continued.





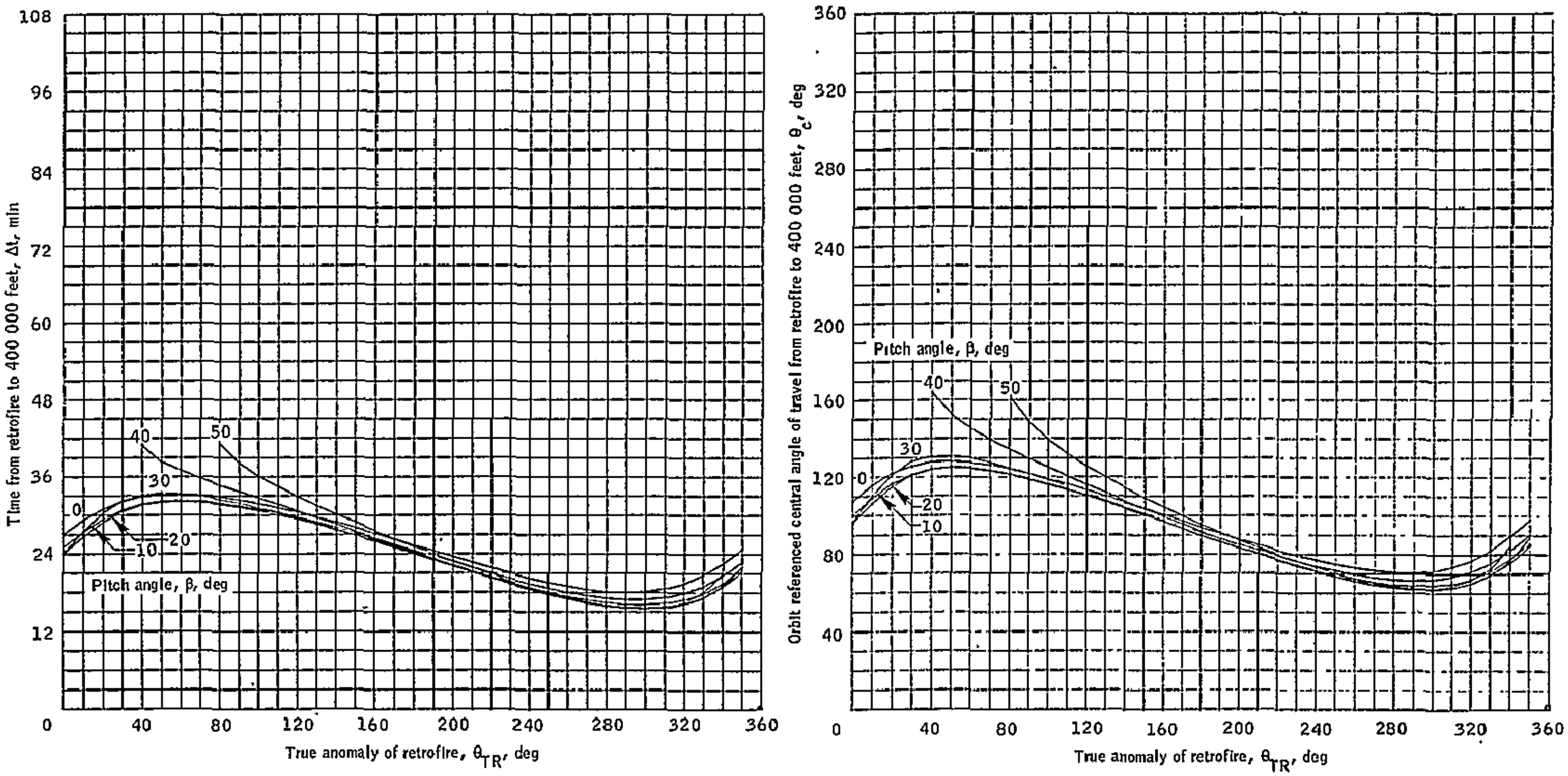
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 35.- Continued.



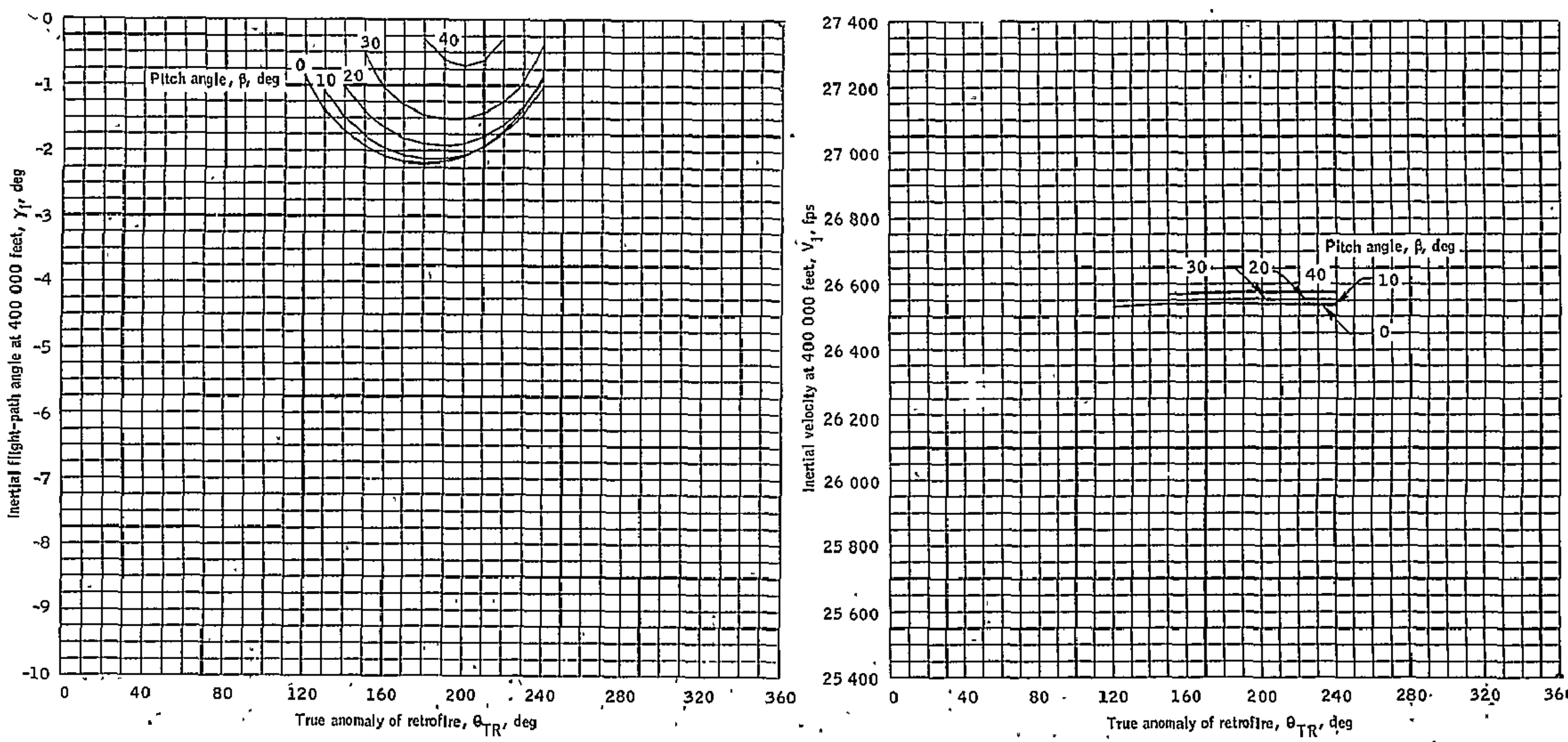
(e) Flight-path angle and velocity for retrograde ΔV = 700 feet per second.

Figure 35.- Continued.



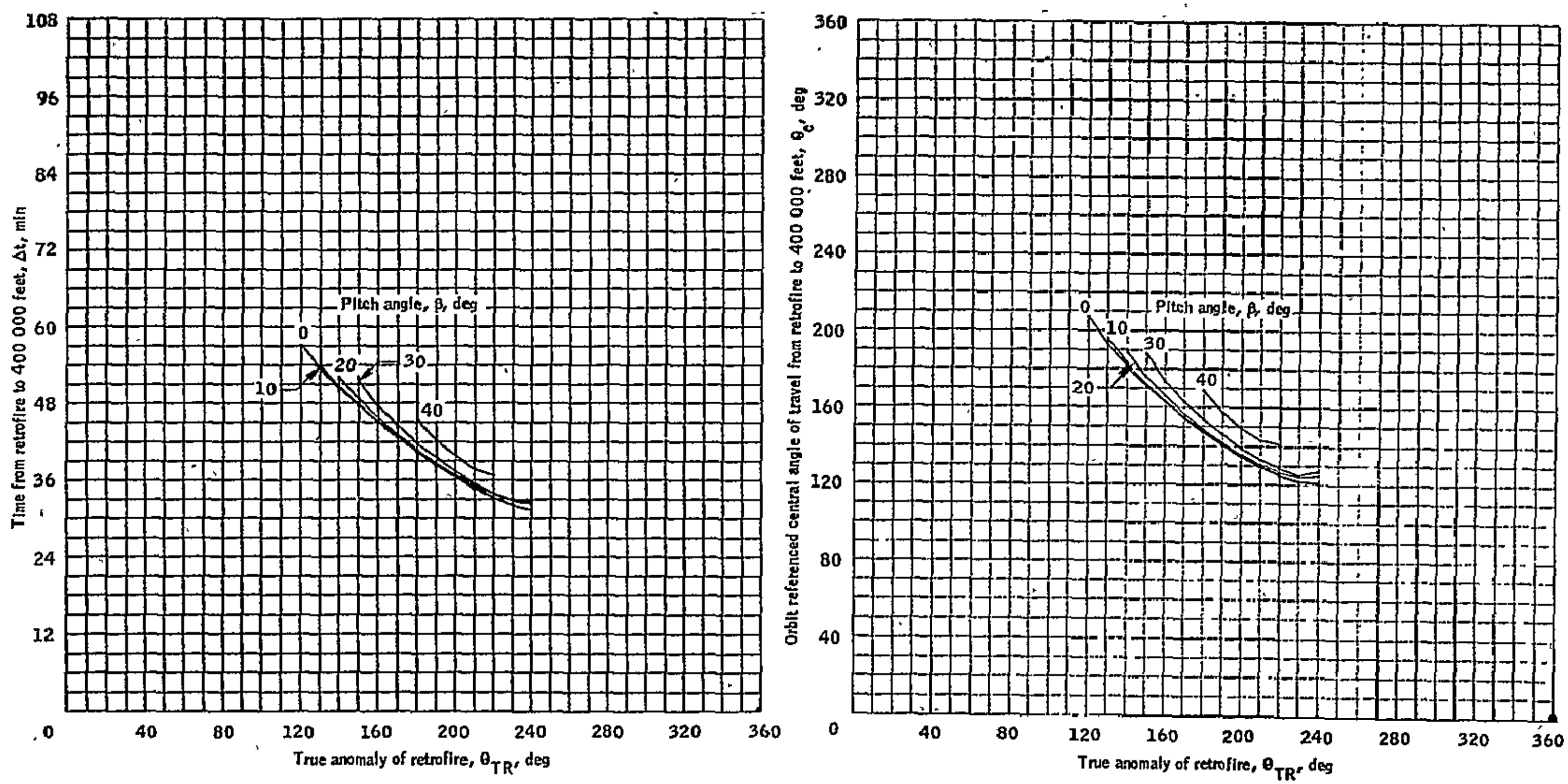
(f) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

Figure 35.– Concluded.



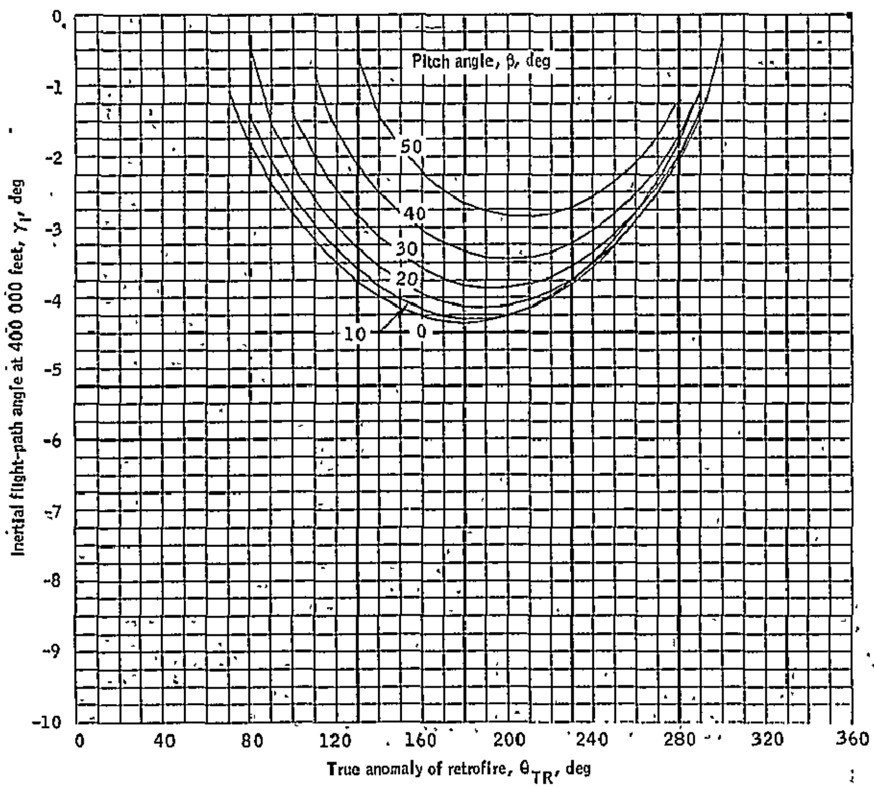
(a) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

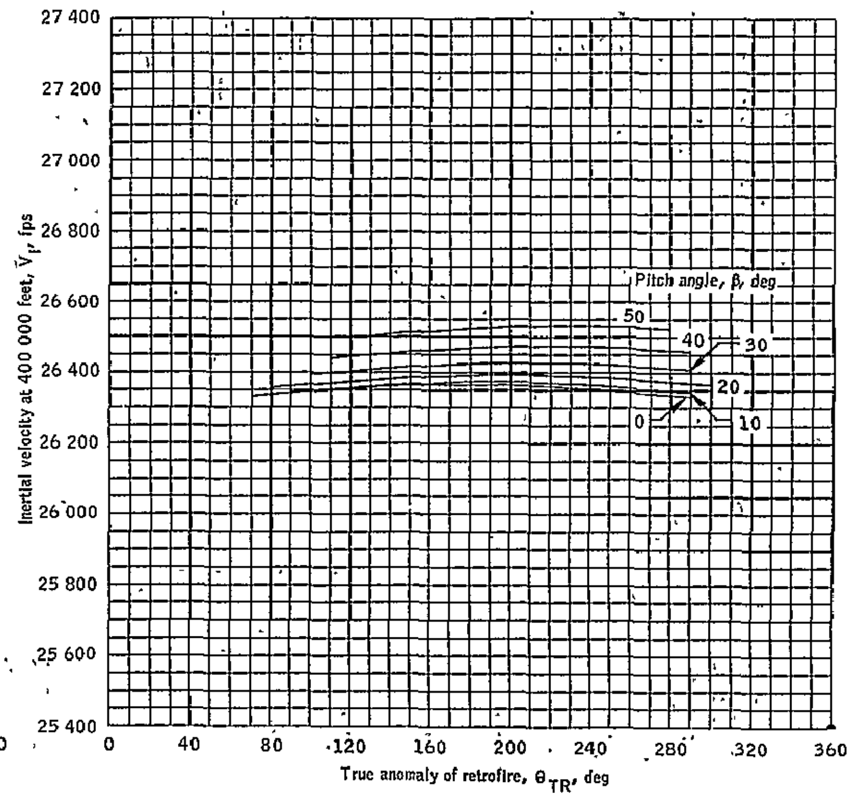
Figure 36.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 200/600 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde $\Delta V = 300$ feet per second.

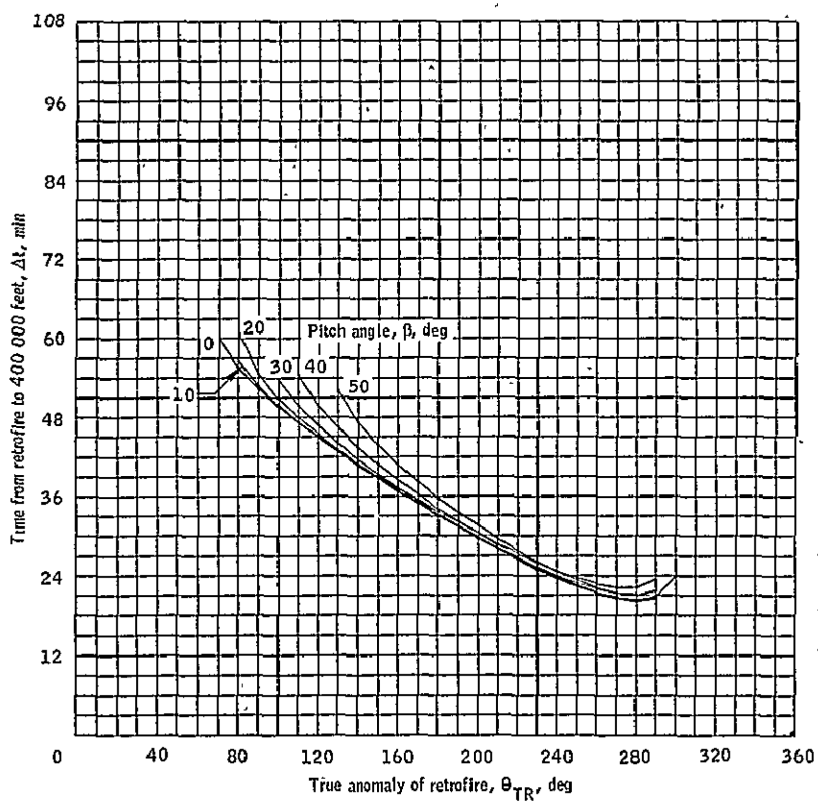
Figure 36.- Continued.

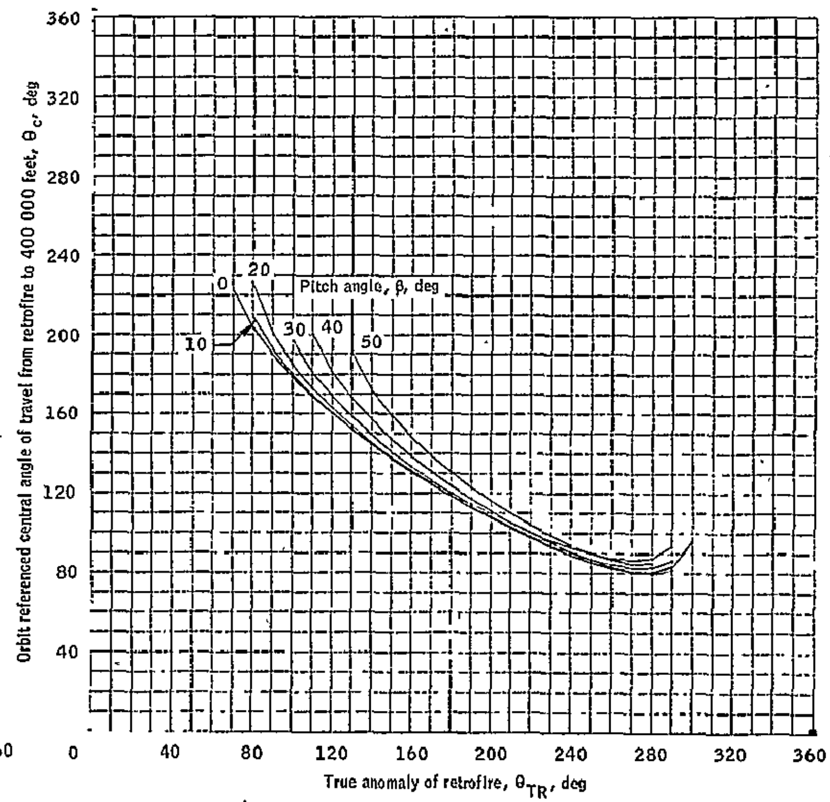




(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

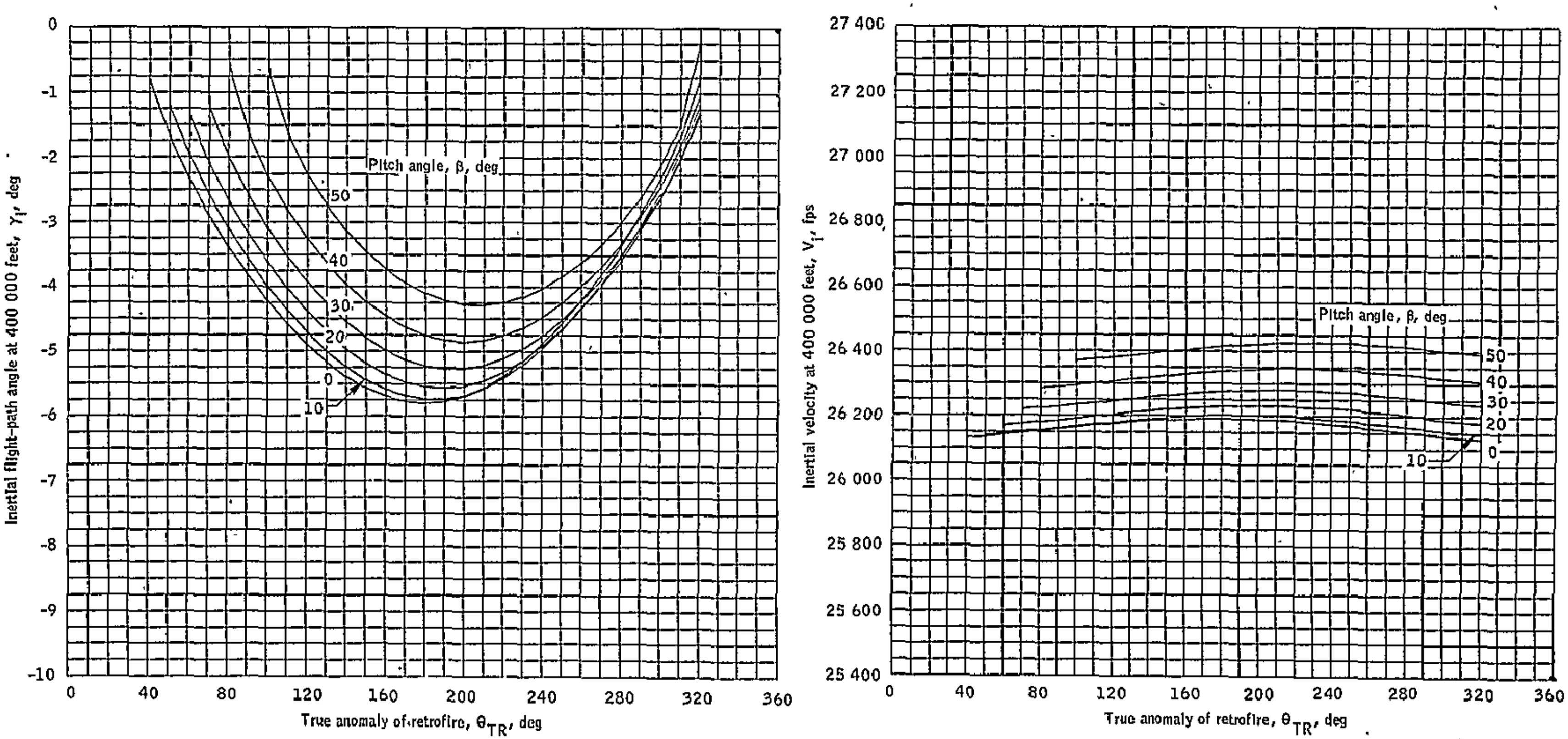
Figure 36.- Continued.





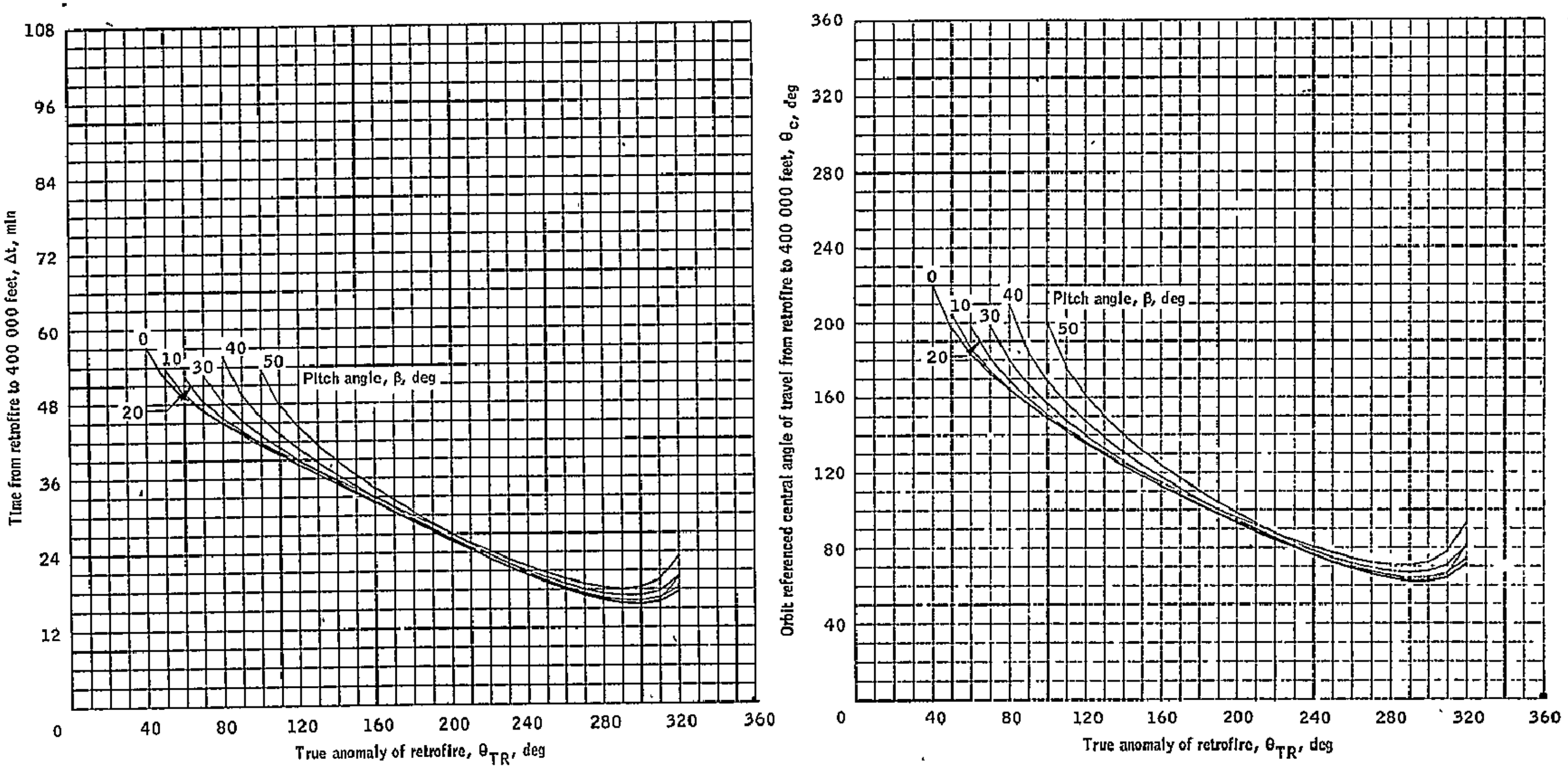
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 36.- Continued.



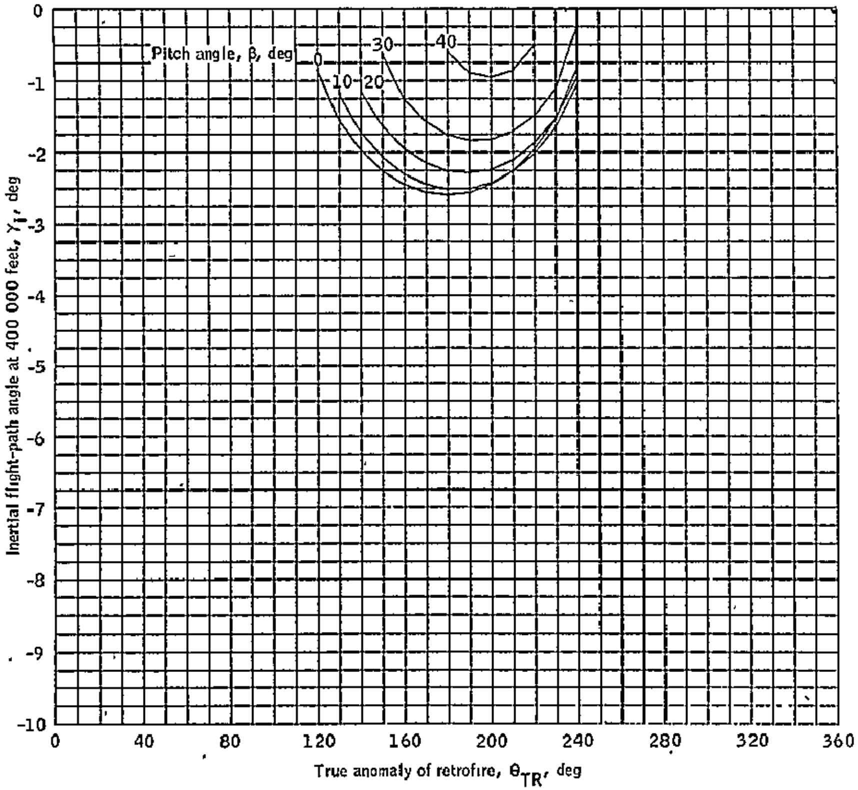
(e) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

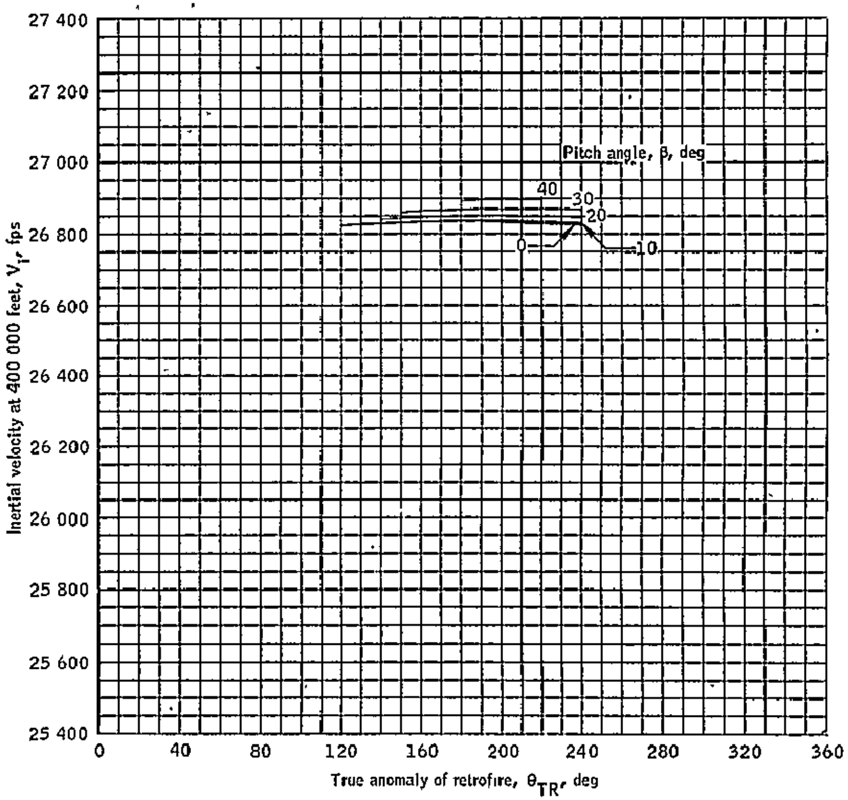
Figure 36.- Continued.



(f) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

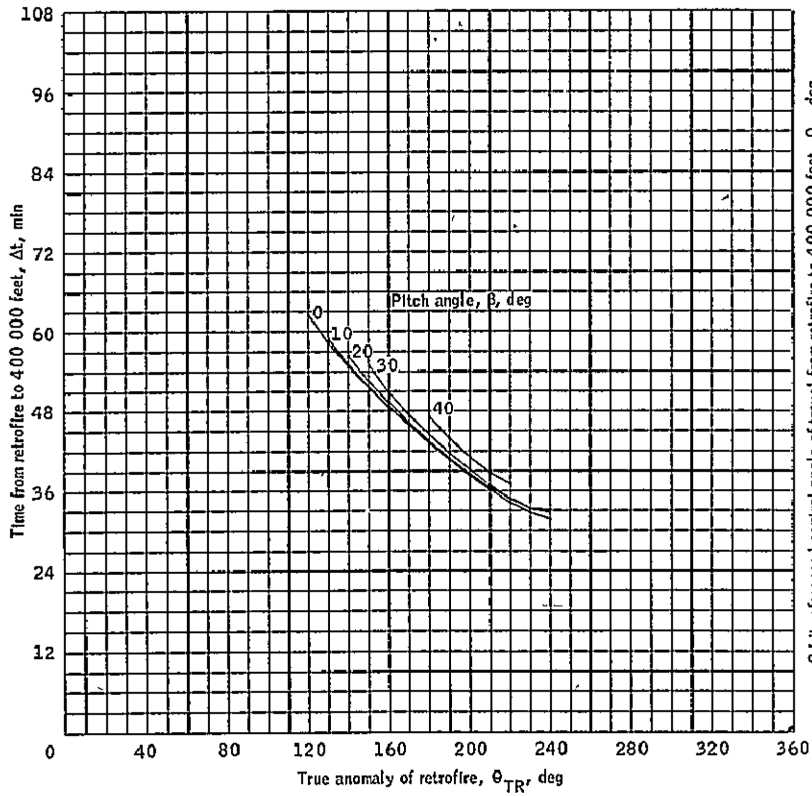
Figure 36.- Concluded.

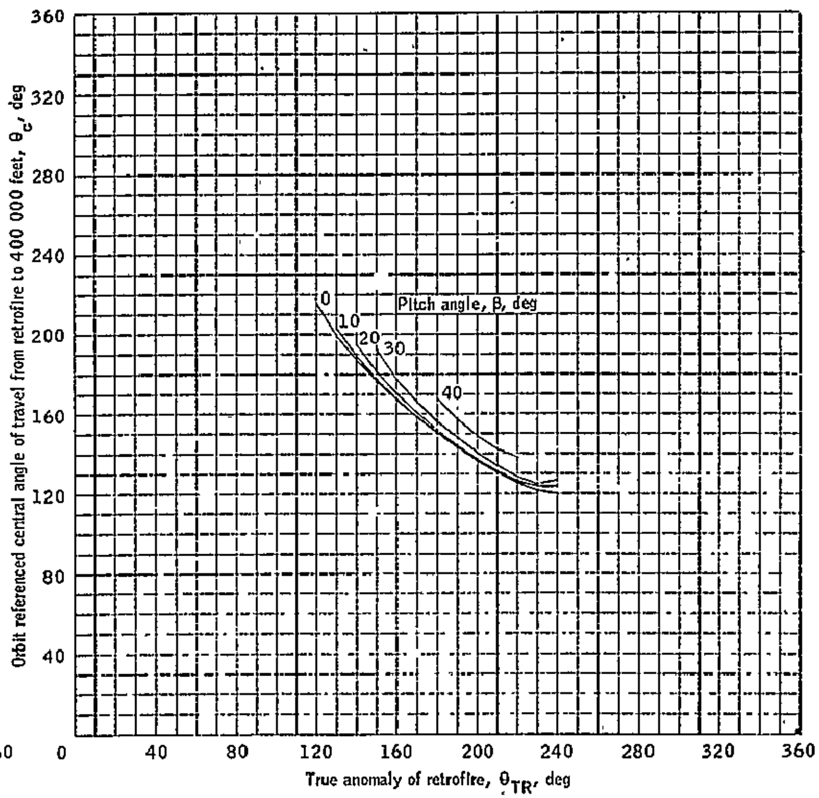




(a) Flight-path angle and velocity for retrograde $\Delta V = 300$ feet per second.

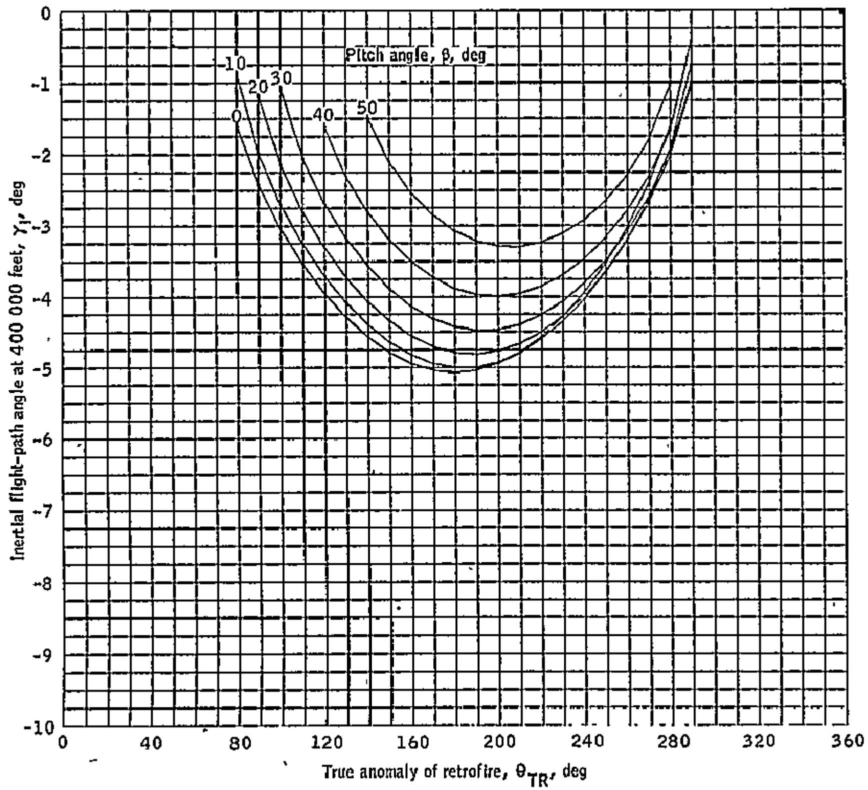
Figure 37.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 200/800 nautical mile orbit.

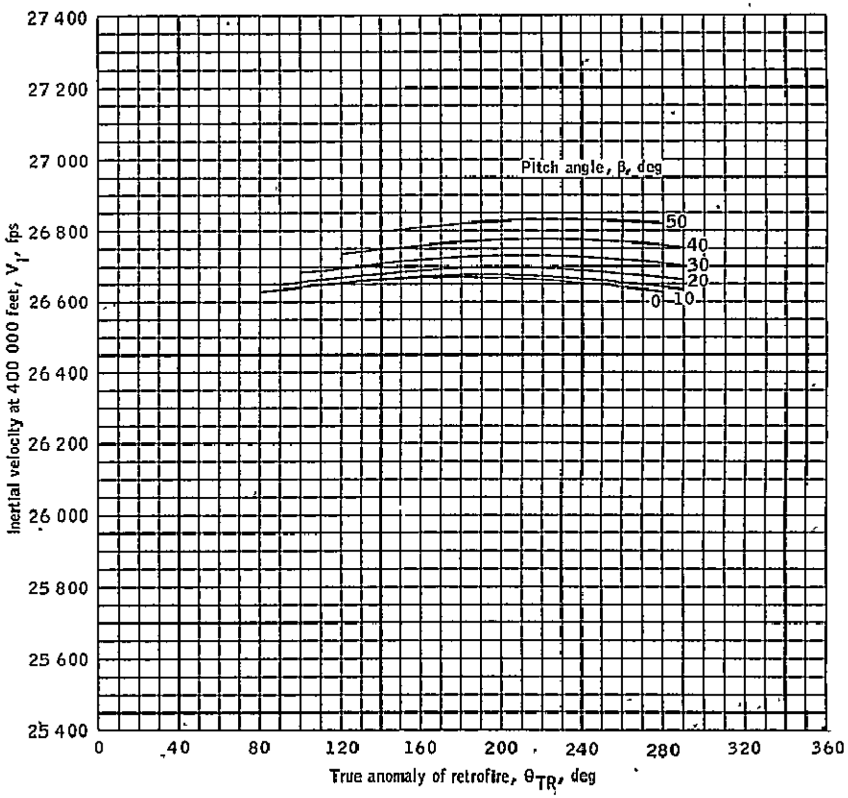




(b) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

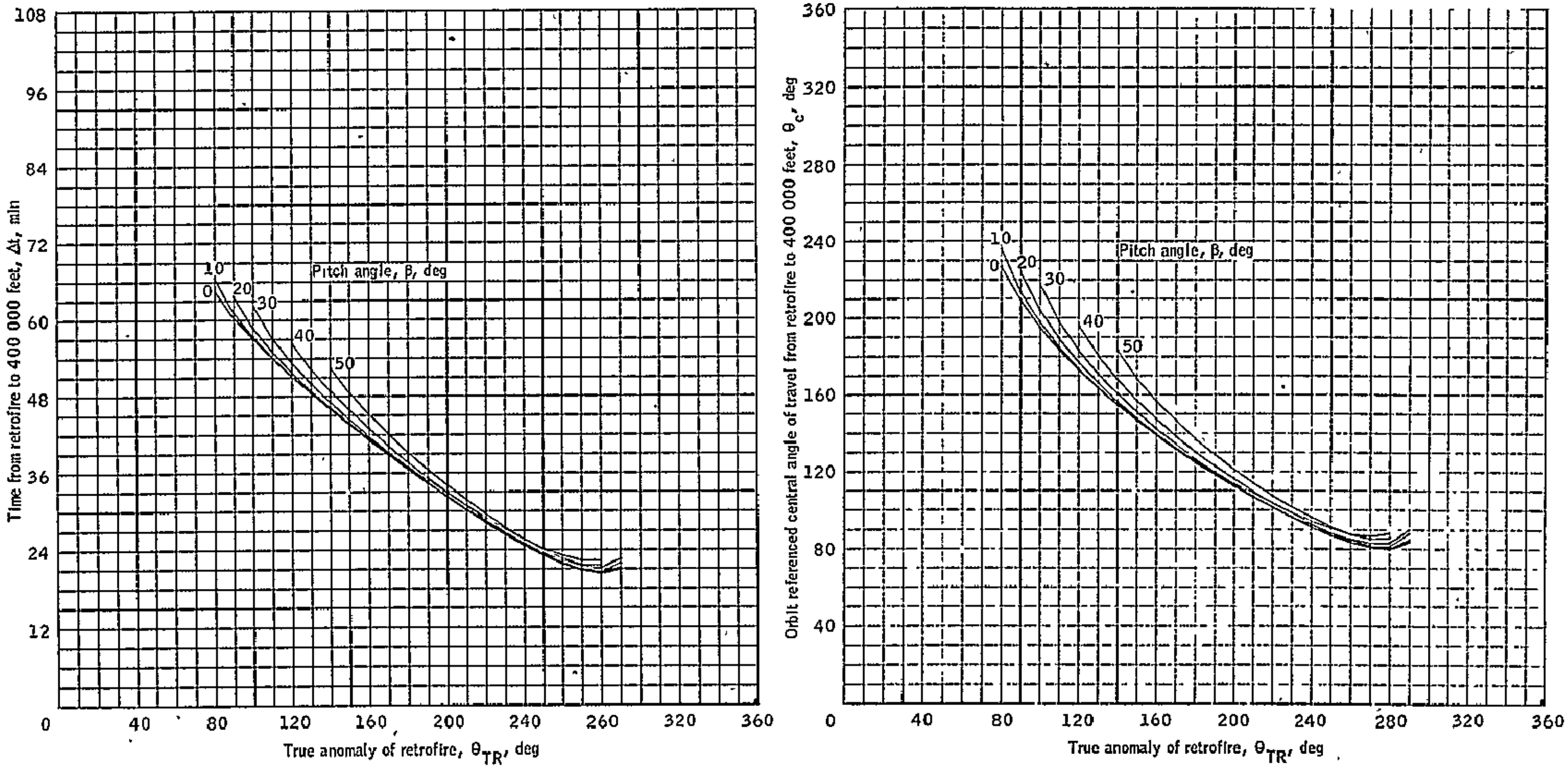
Figure 37.- Continued.





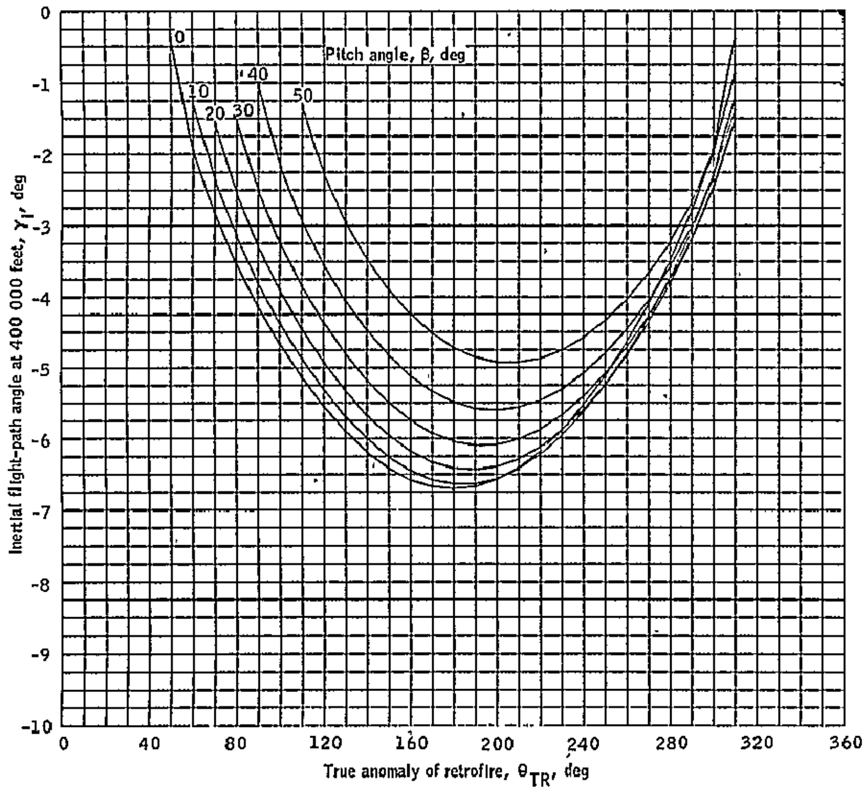
(c) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

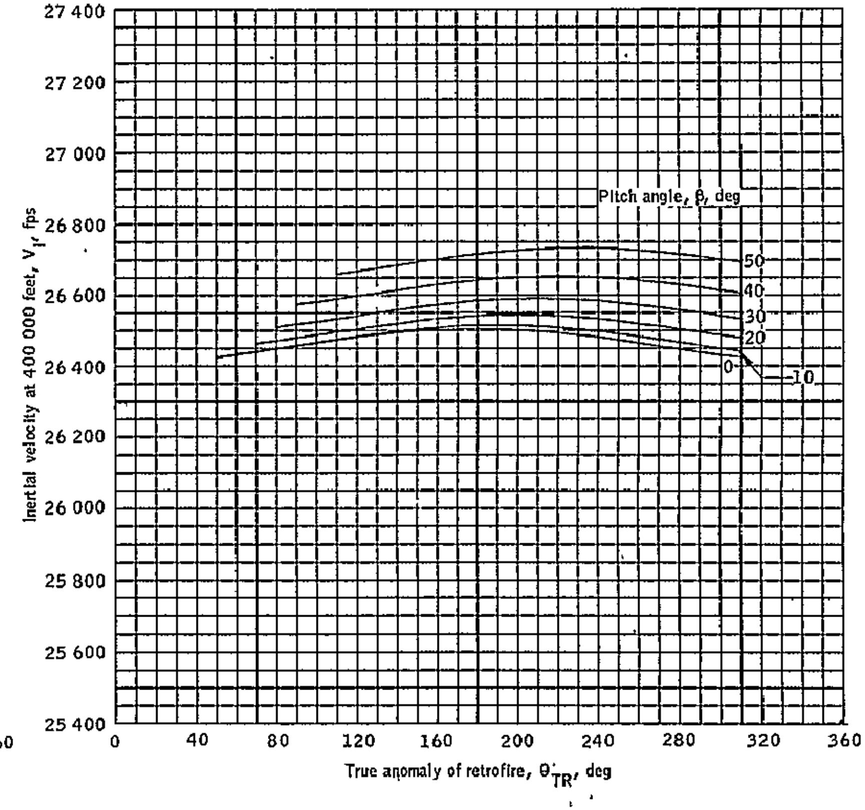
Figure 37.- Continued.



(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

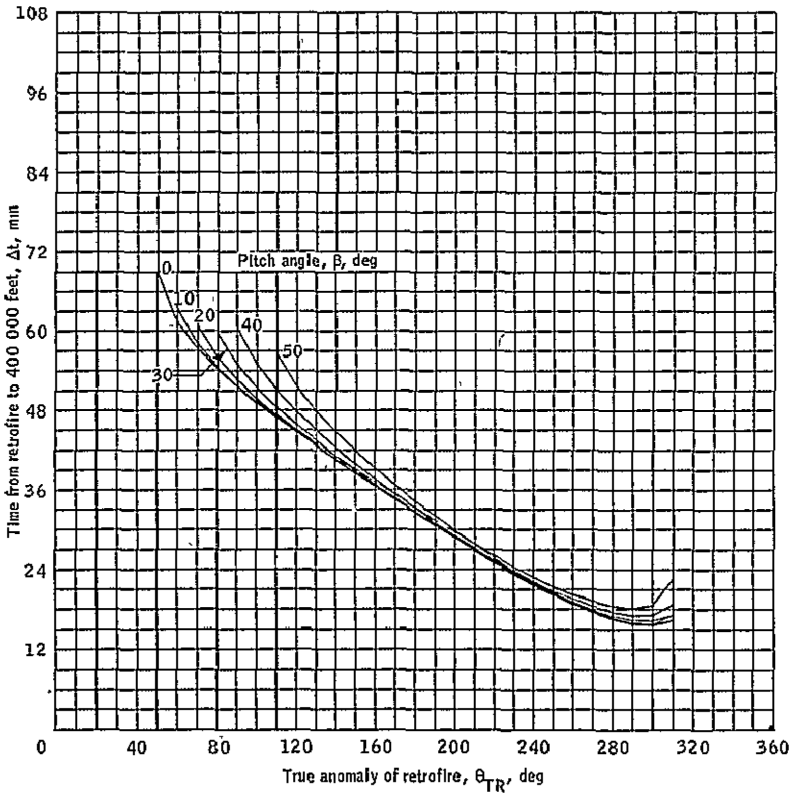
Figure 37.- Continued.

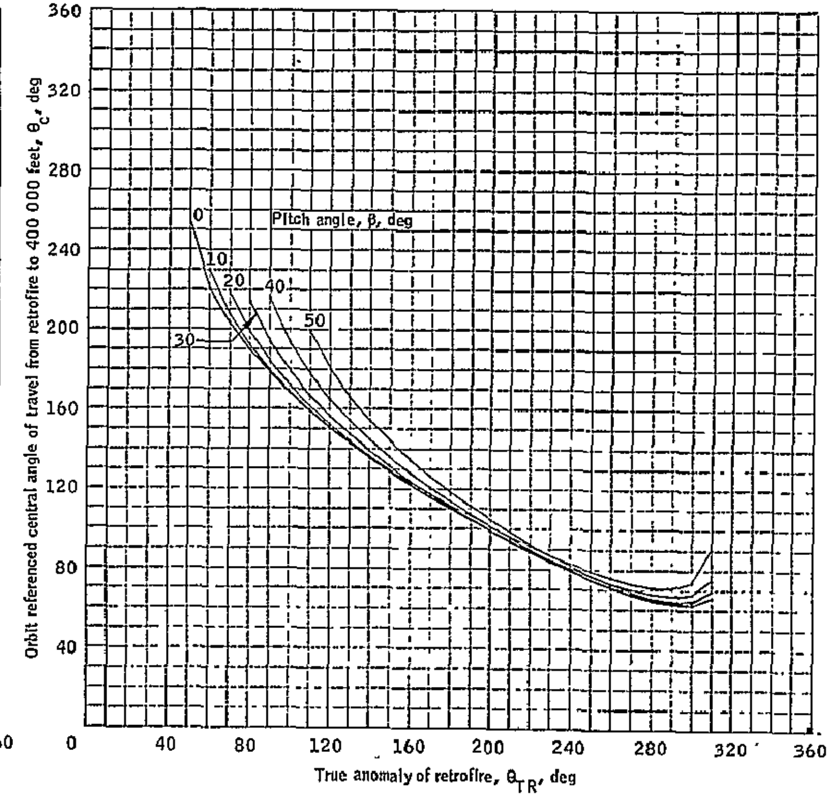




(e) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

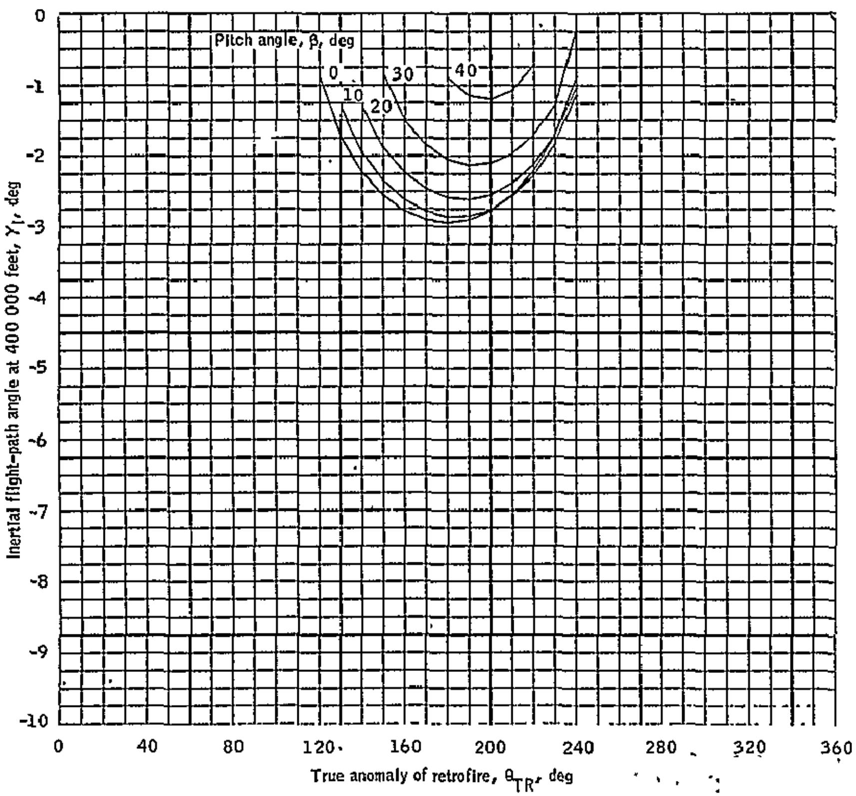
Figure 37.- Continued.

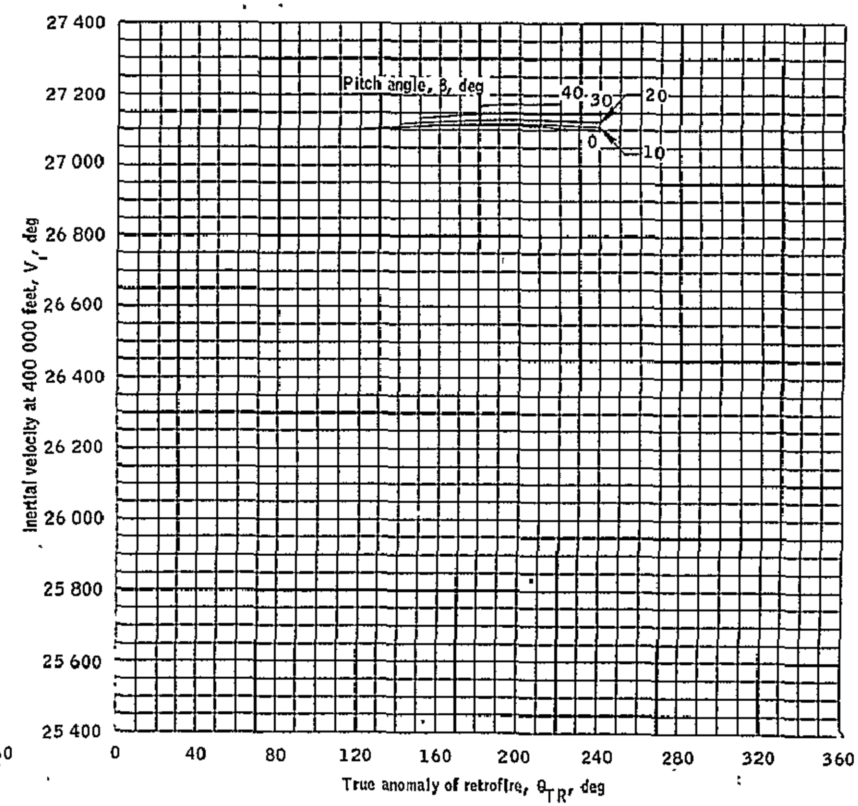




(f) Time from retrofire and central angle for retrograde ΔV = 700 feet per second.

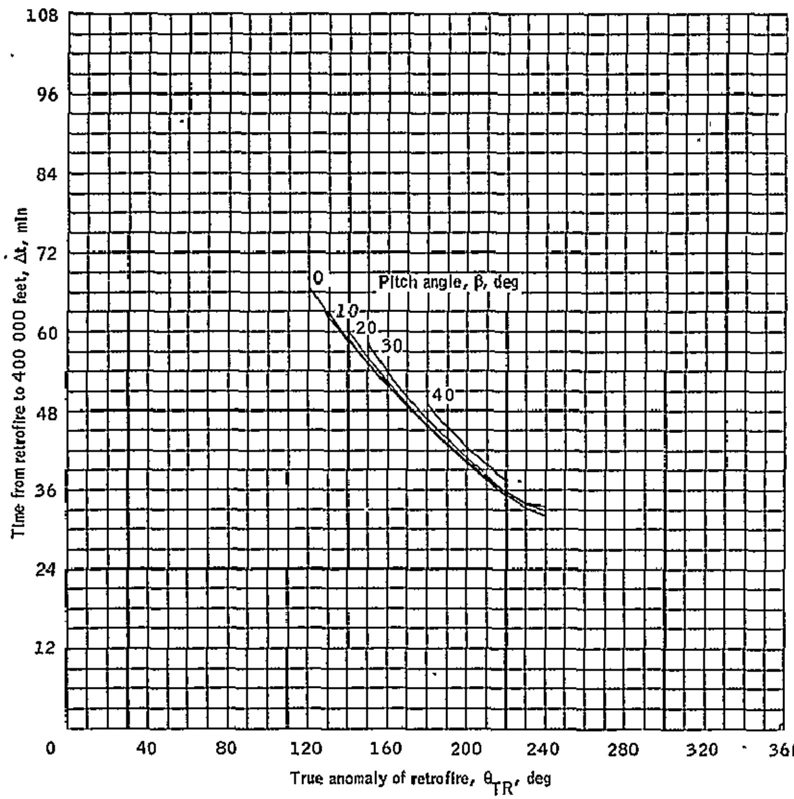
Figure 37.- Concluded.

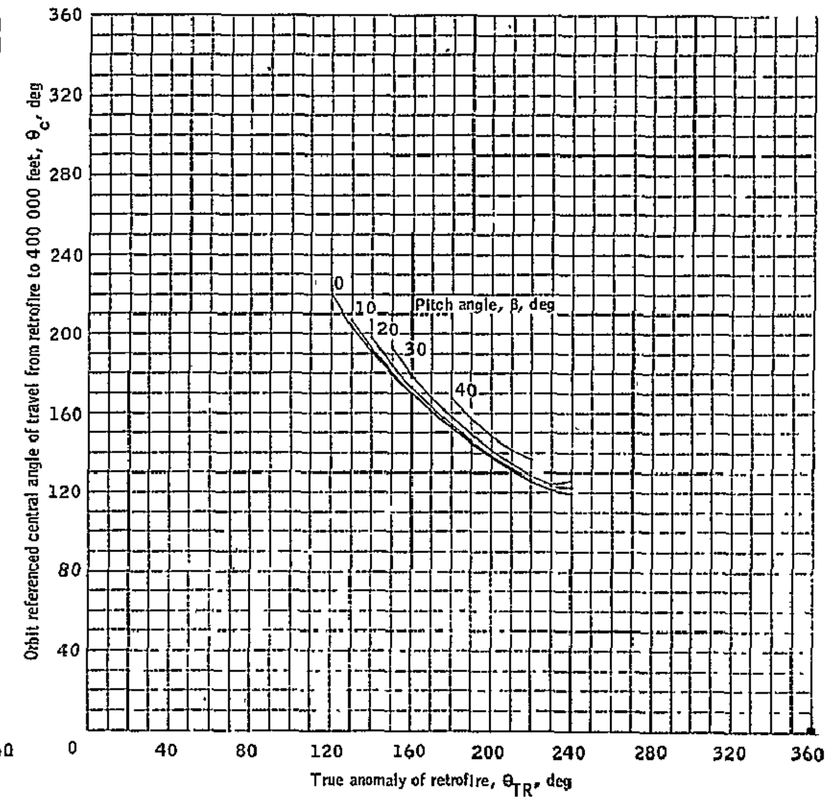




(a) Flight-path angle and velocity for retrograde ΔV = 300 feet per second.

Figure 38.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 200/1000 nautical mile orbit.

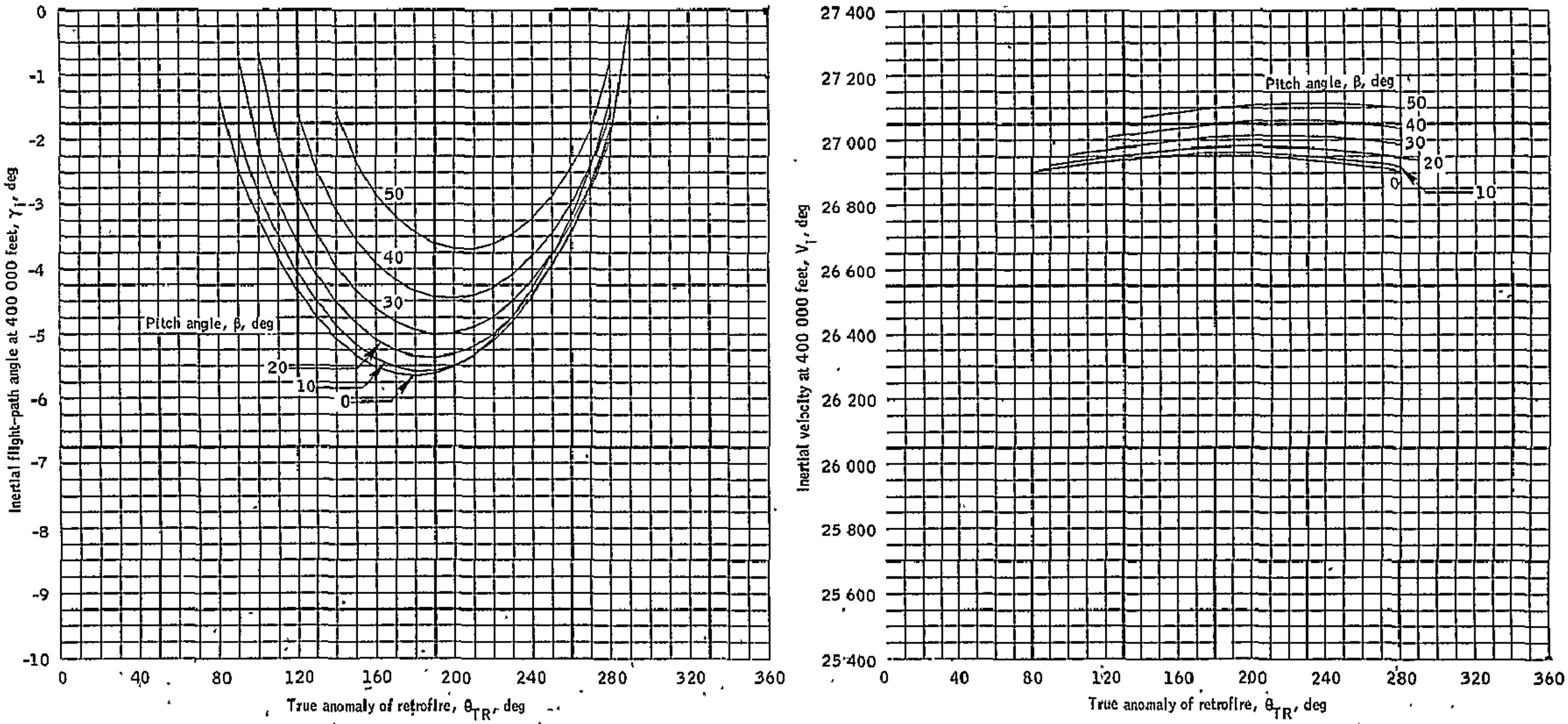




(b) Time from retrofire and central angle for retrograde ΔV = 300 feet per second.

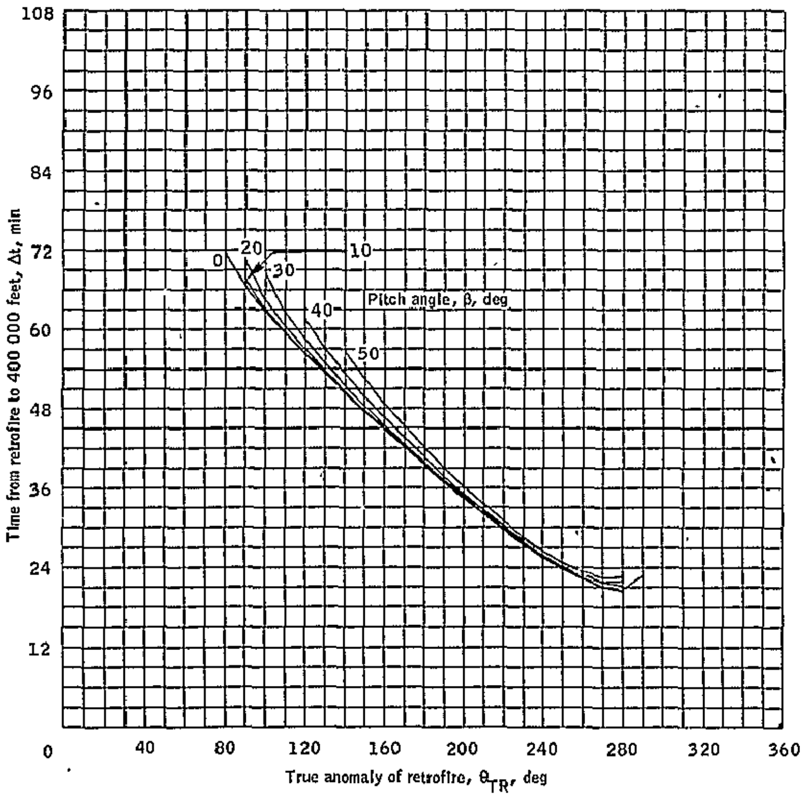
Figure 38.- Continued.

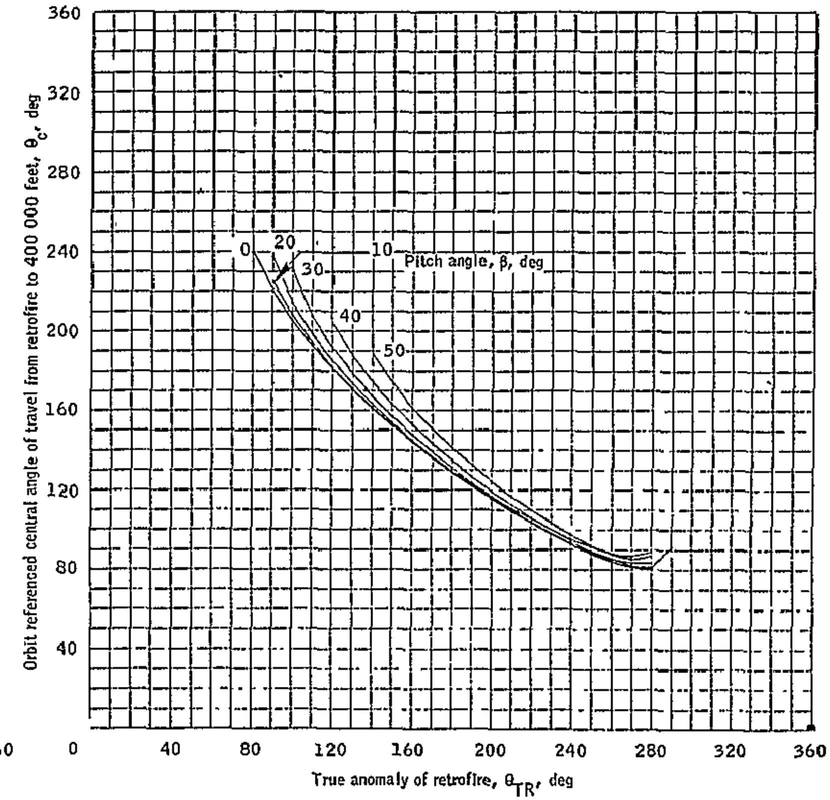
1335



(c) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

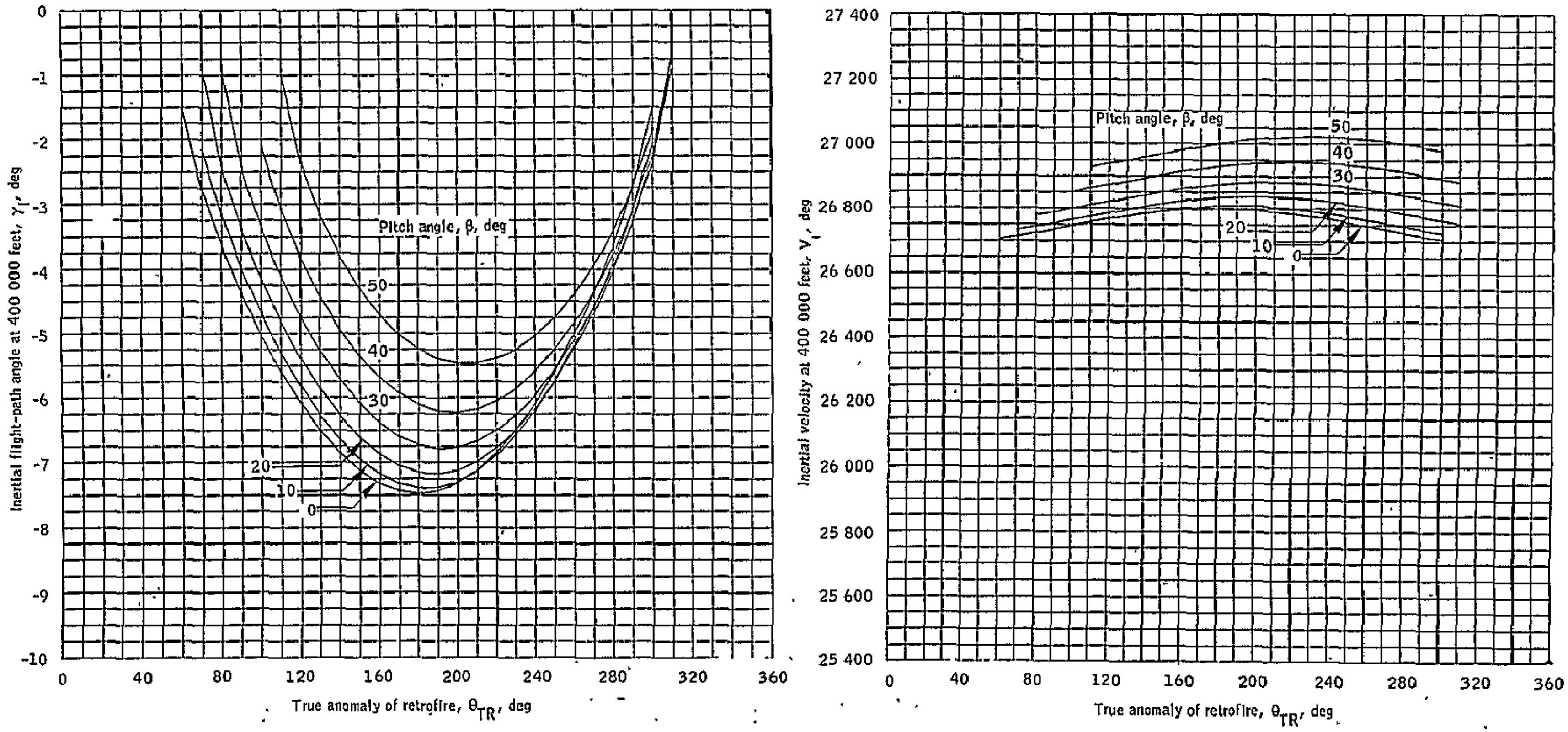
Figure 38.- Continued.





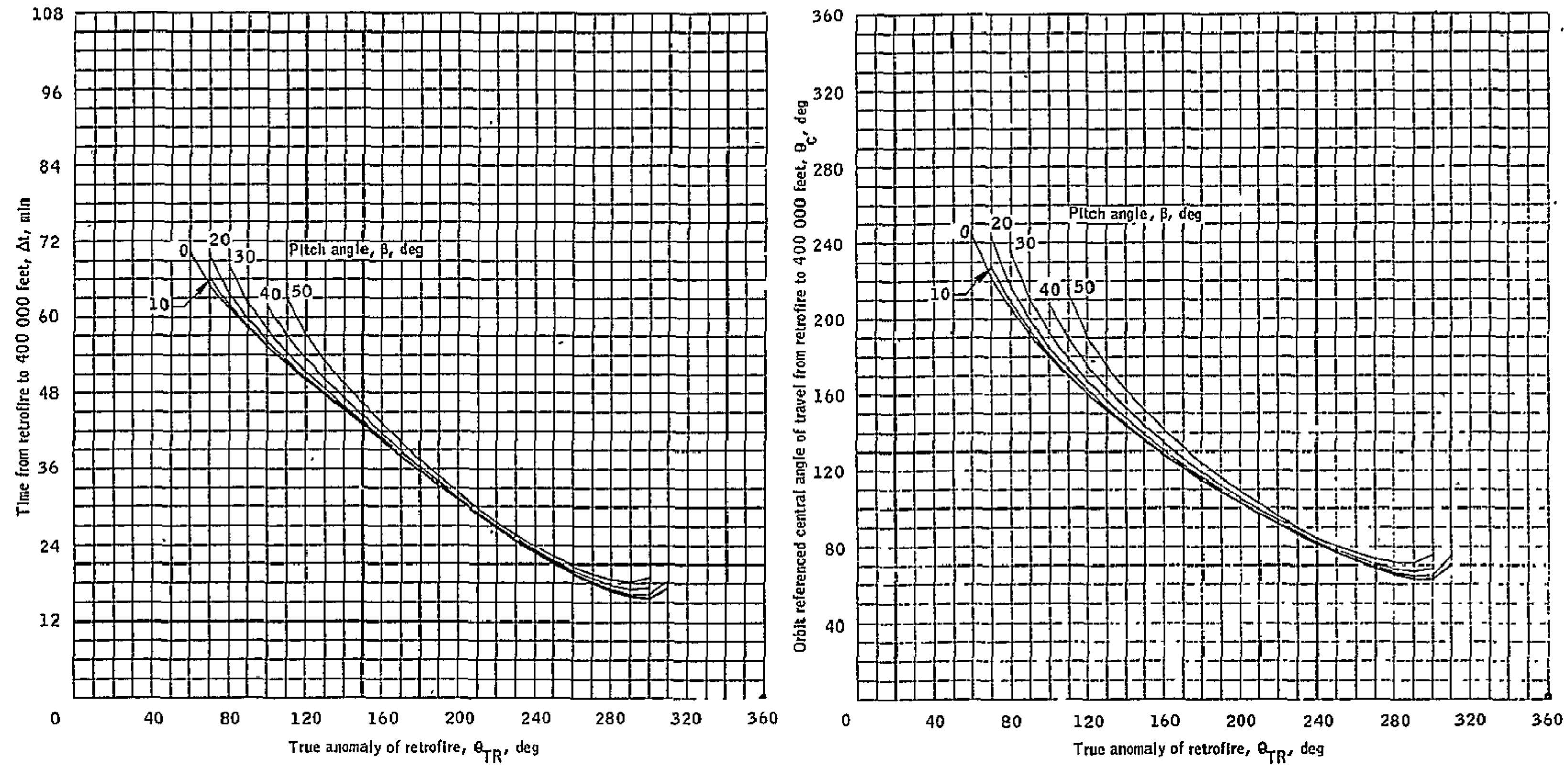
(d) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 38.- Continued.



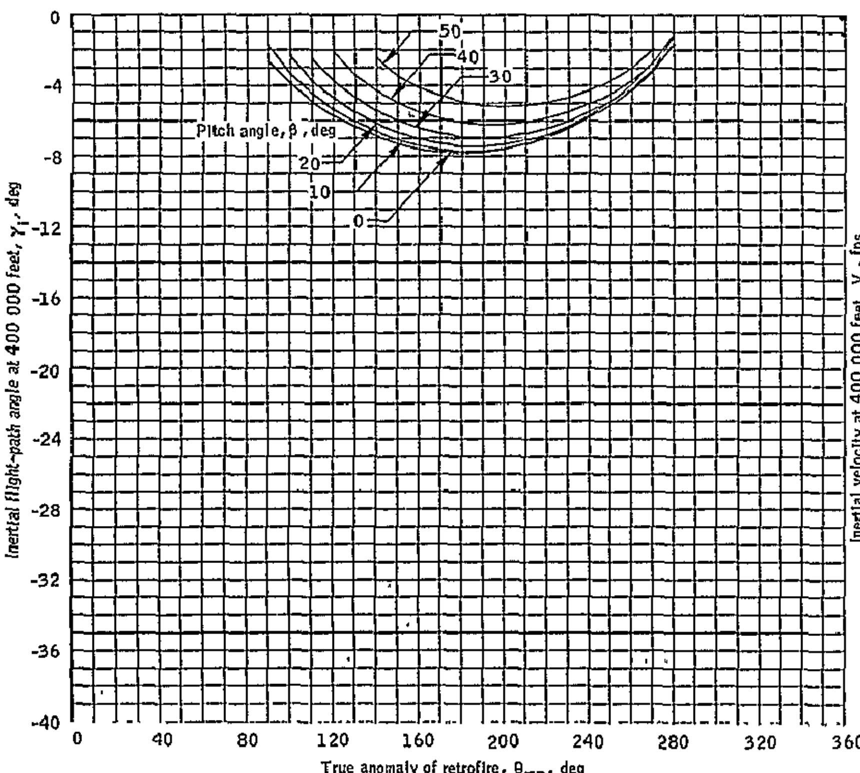
(e) Flight-path angle and velocity for retrograde $\Delta V = 700$ feet per second.

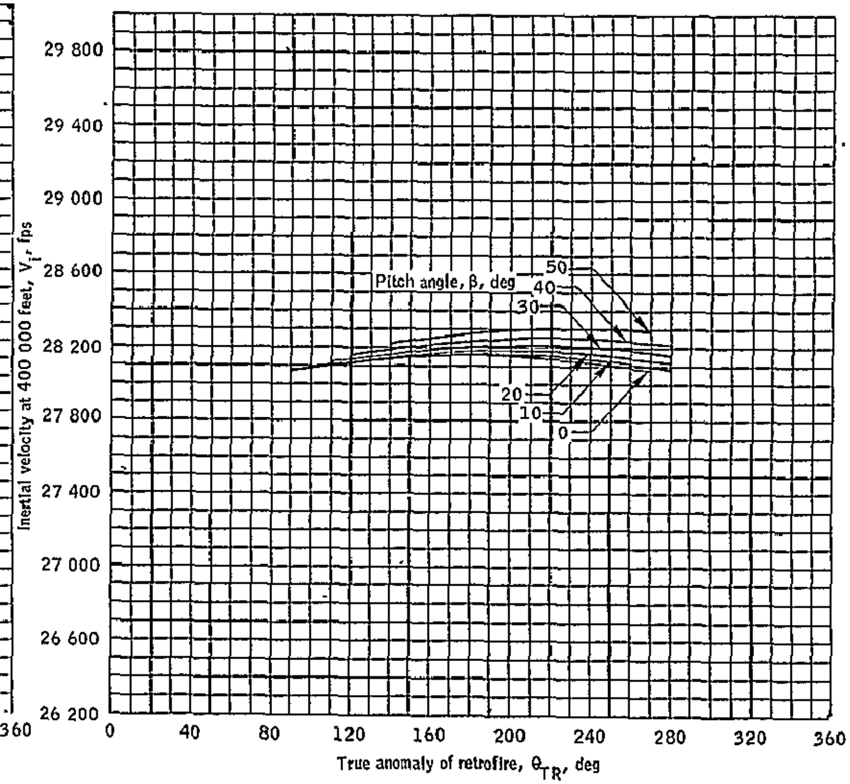
Figure 38.- Continued.



(f) Time from retrofire and central angle for retrograde $\Delta V = 700$ feet per second.

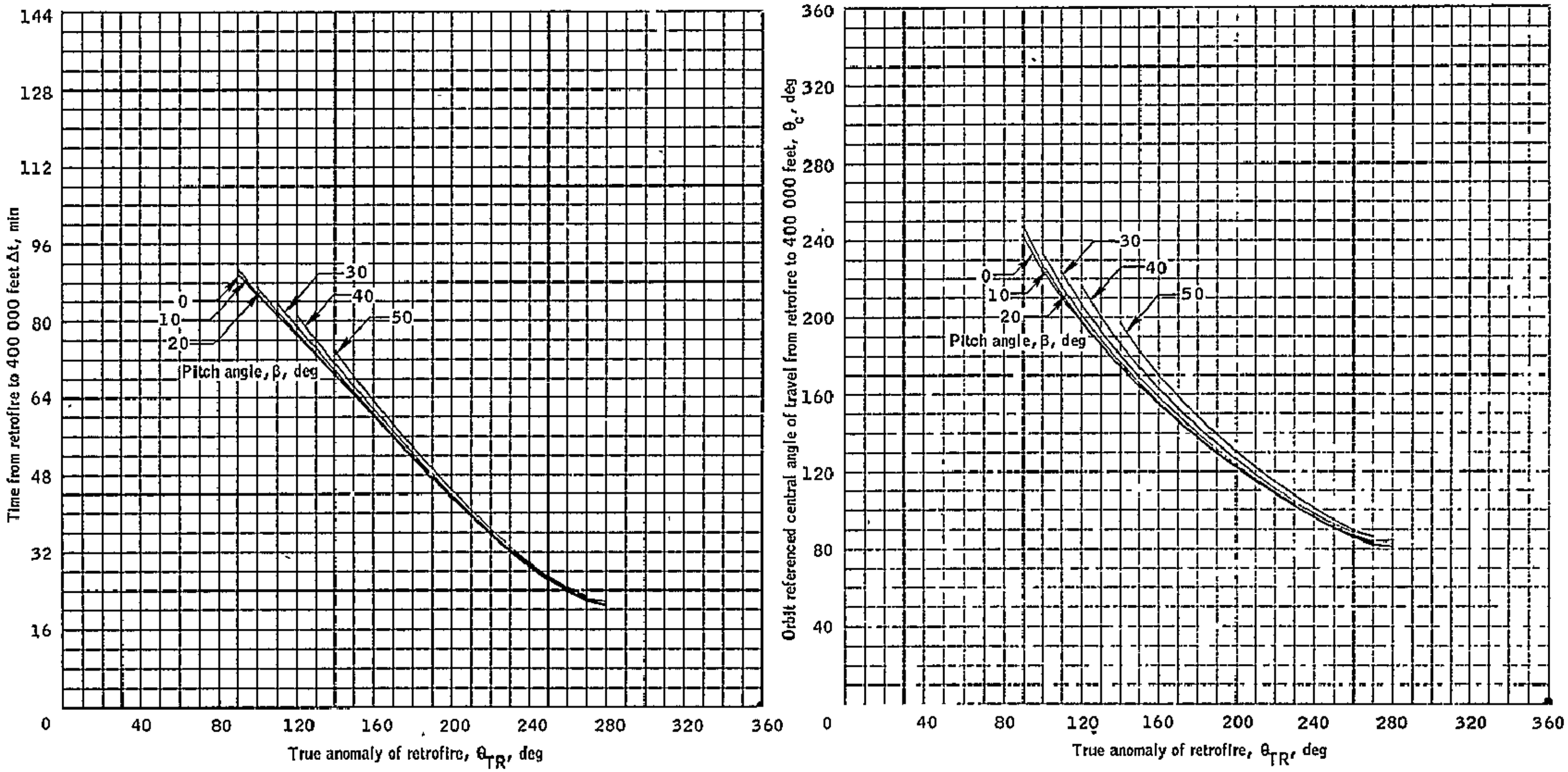
Figure 38.- Concluded.





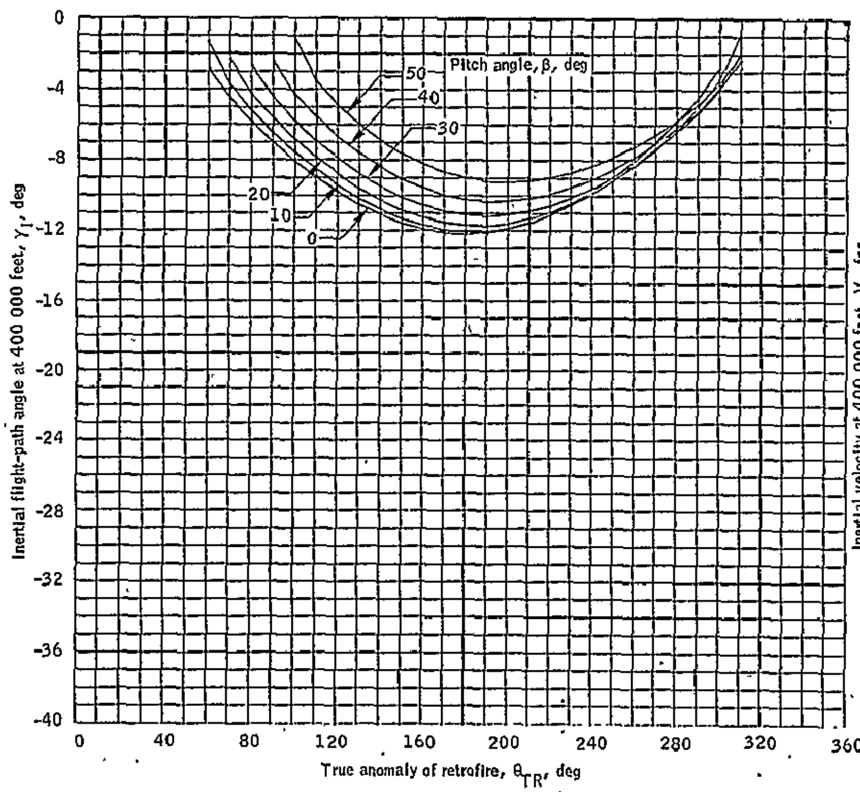
(a) Flight-path angle and velocity for retrograde ΔV= 500 feet per second.

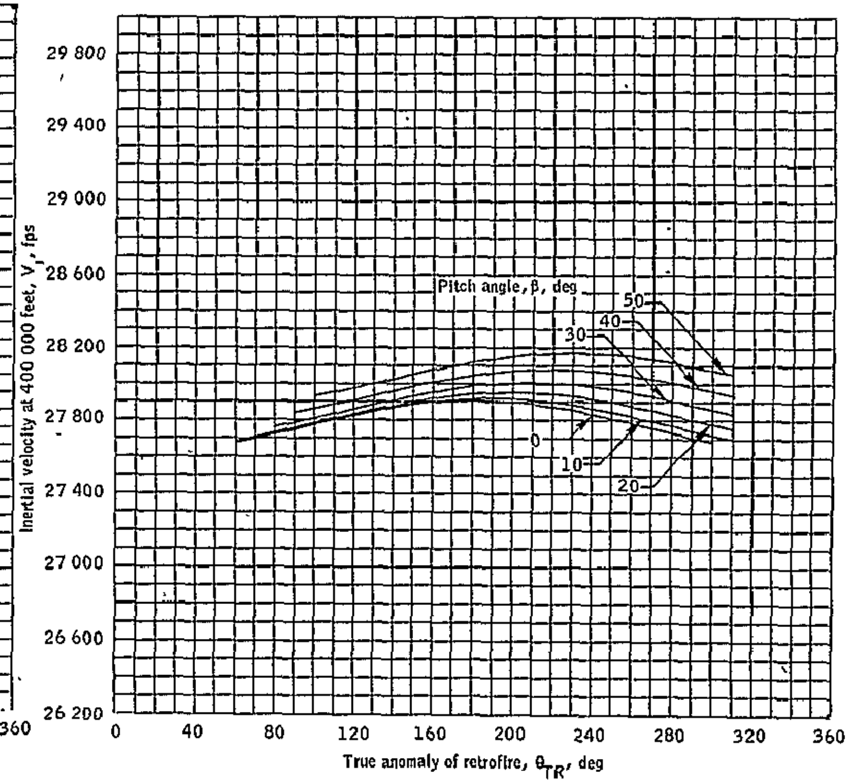
Figure 39.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for a 200/2000 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

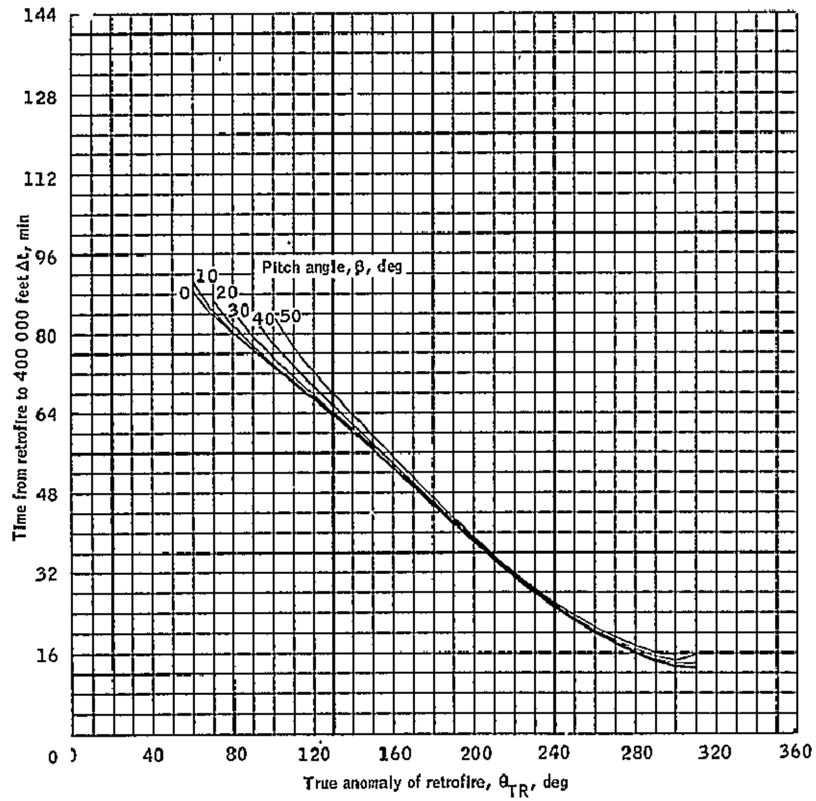
Figure 39.- Continued.

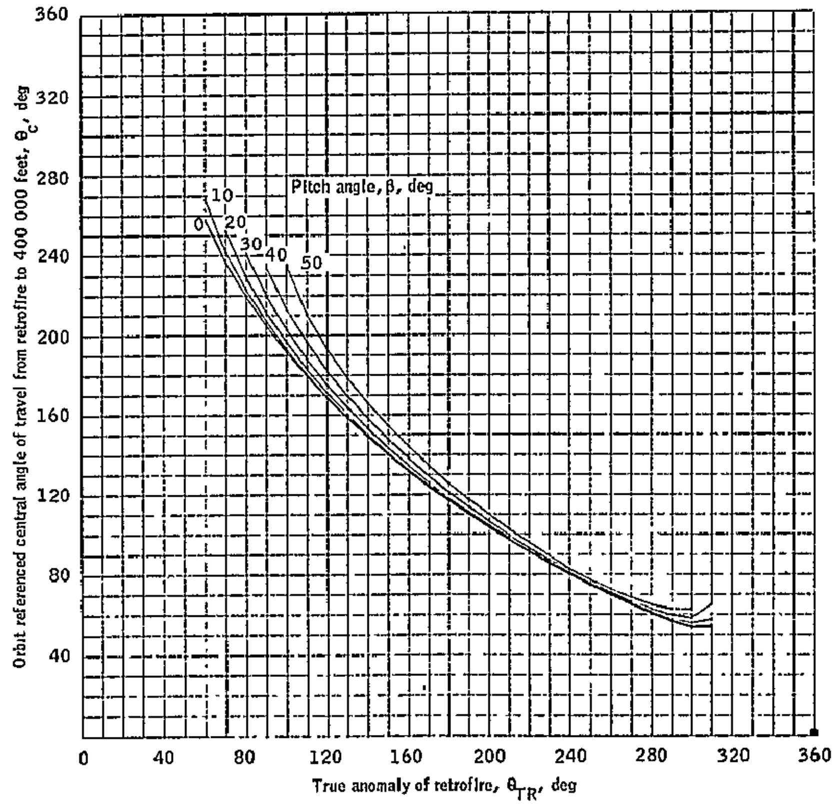




(c) Flight-path angle and velocity for retrograde ΔV = 900 feet per second.

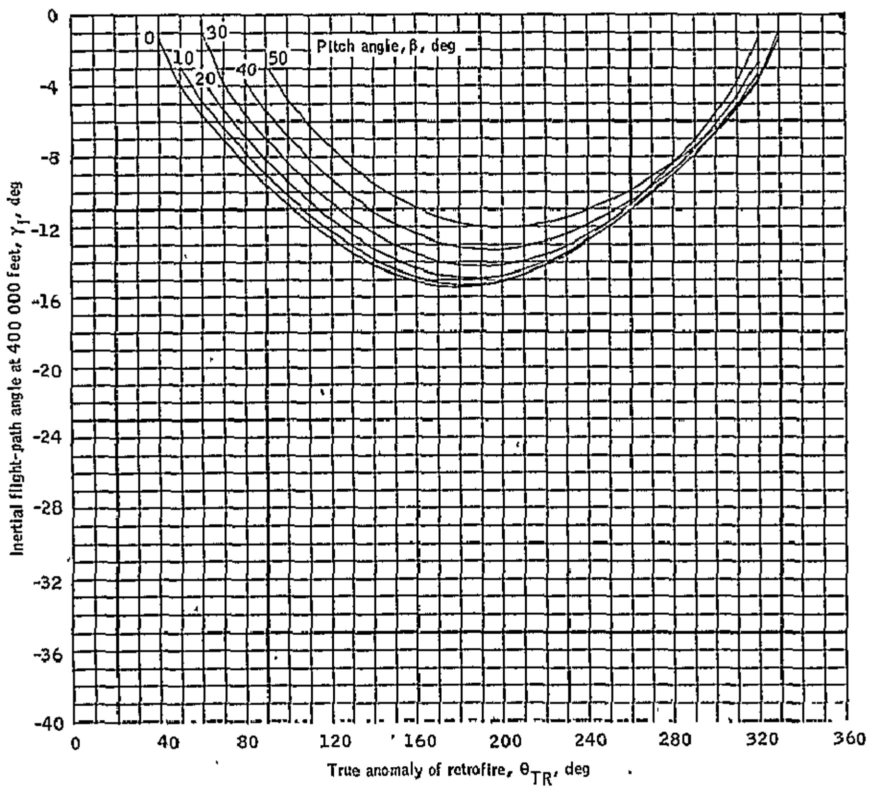
Figure 39.- Continued.

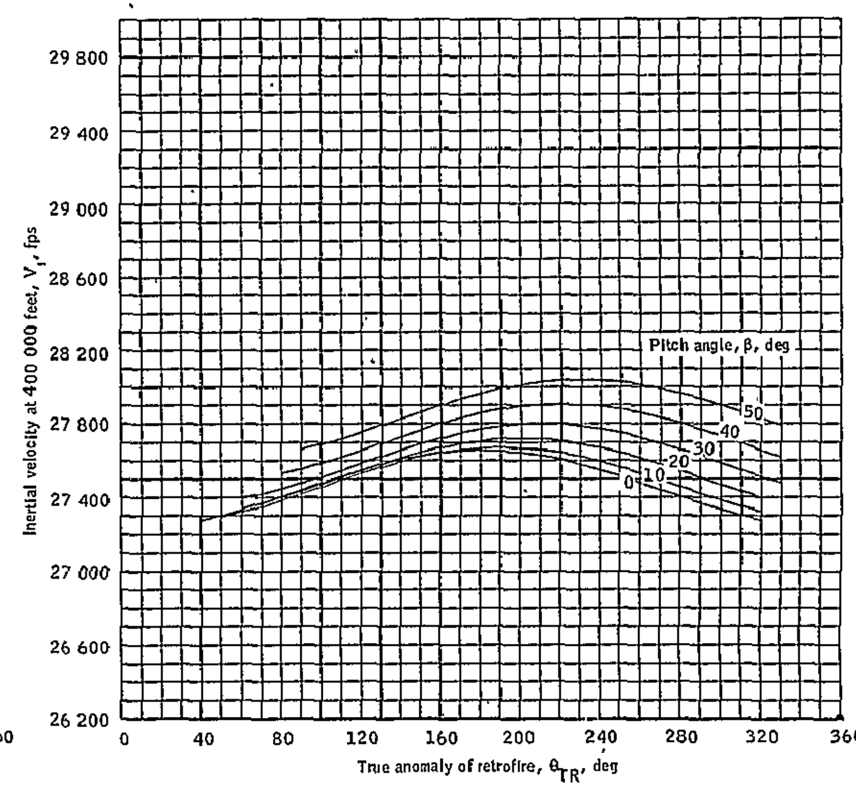




(d) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

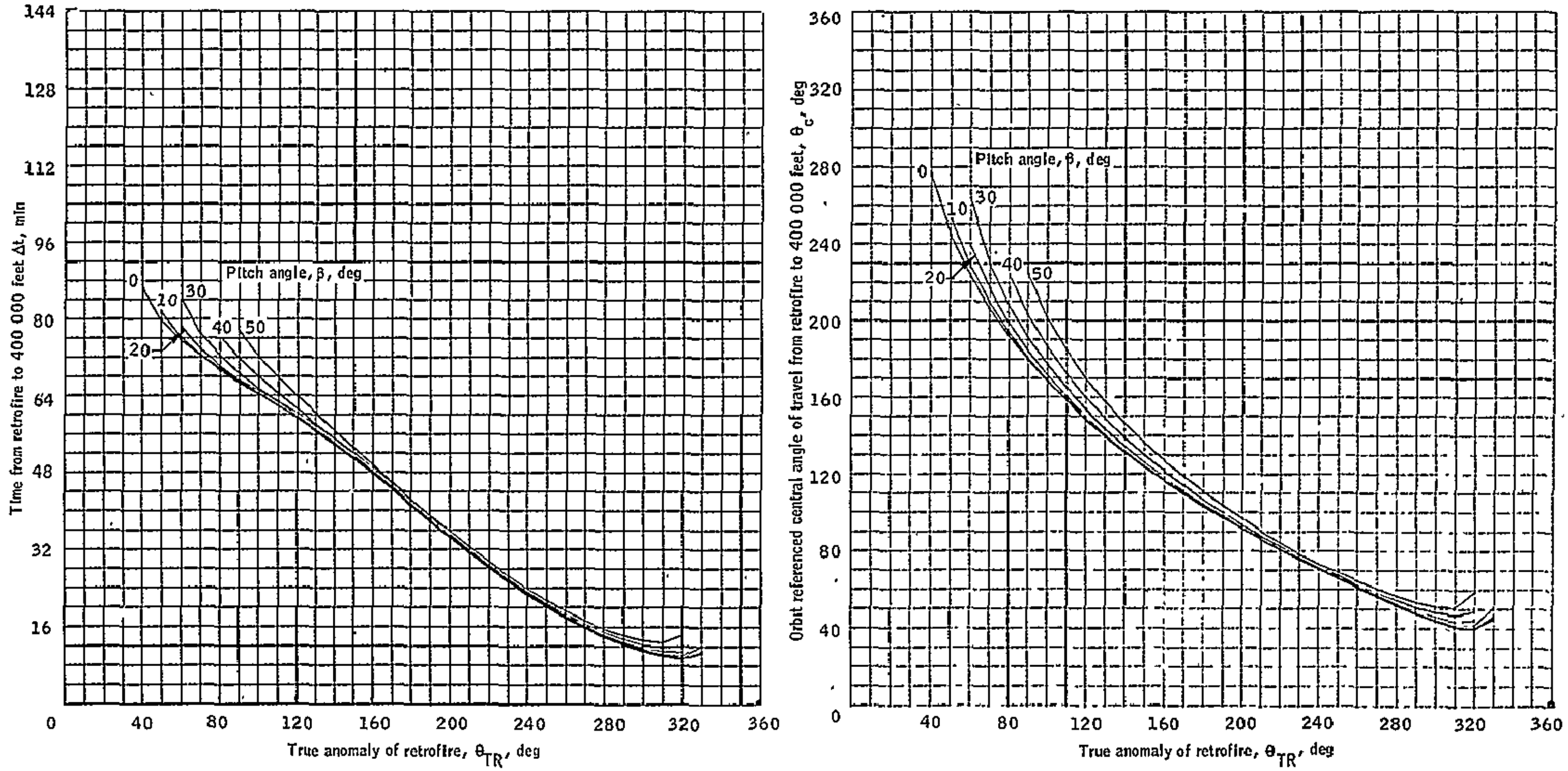
Figure 39.- Continued.





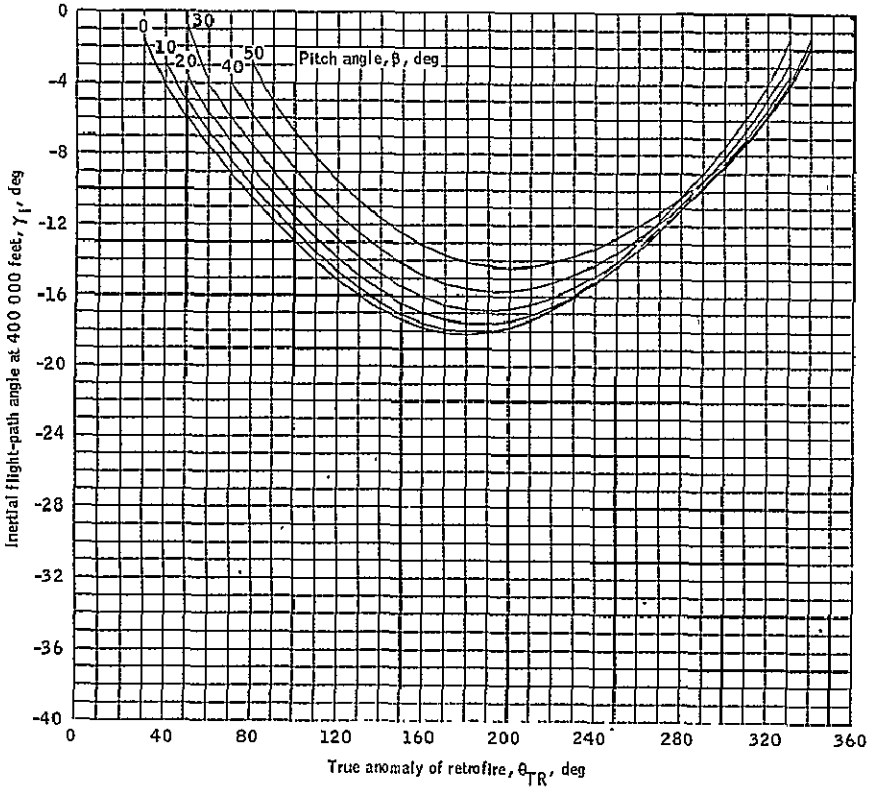
(e) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

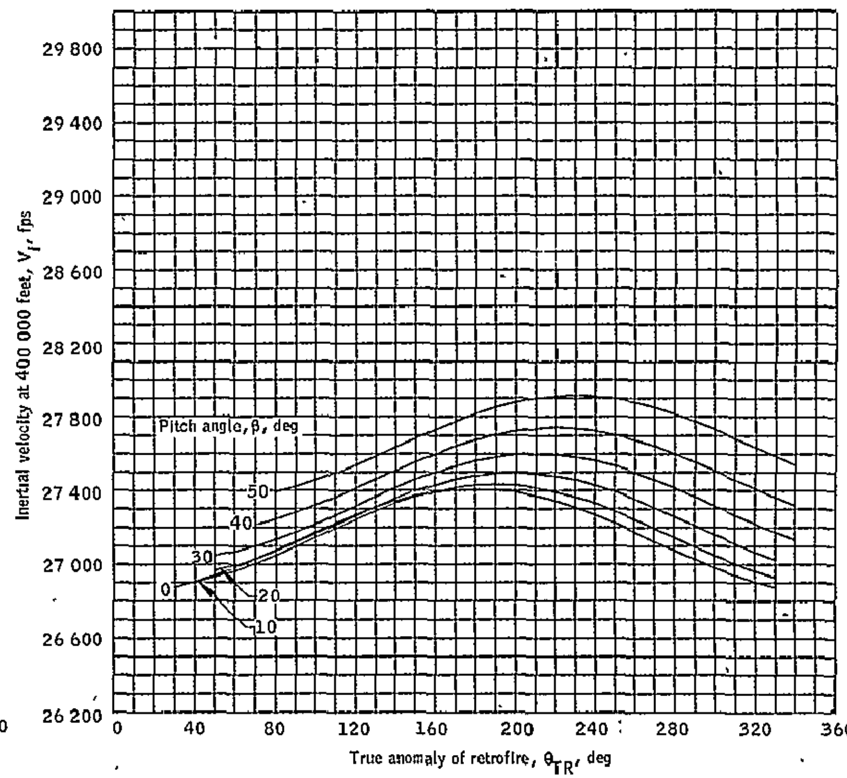
Figure 39.- Continued.



(f) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

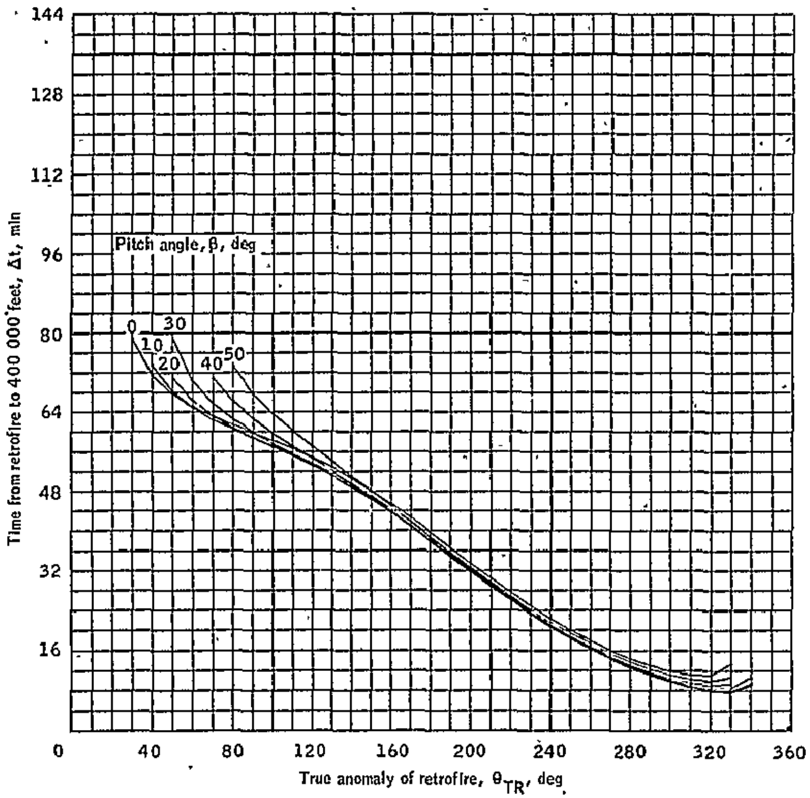
Figure 39.- Continued.

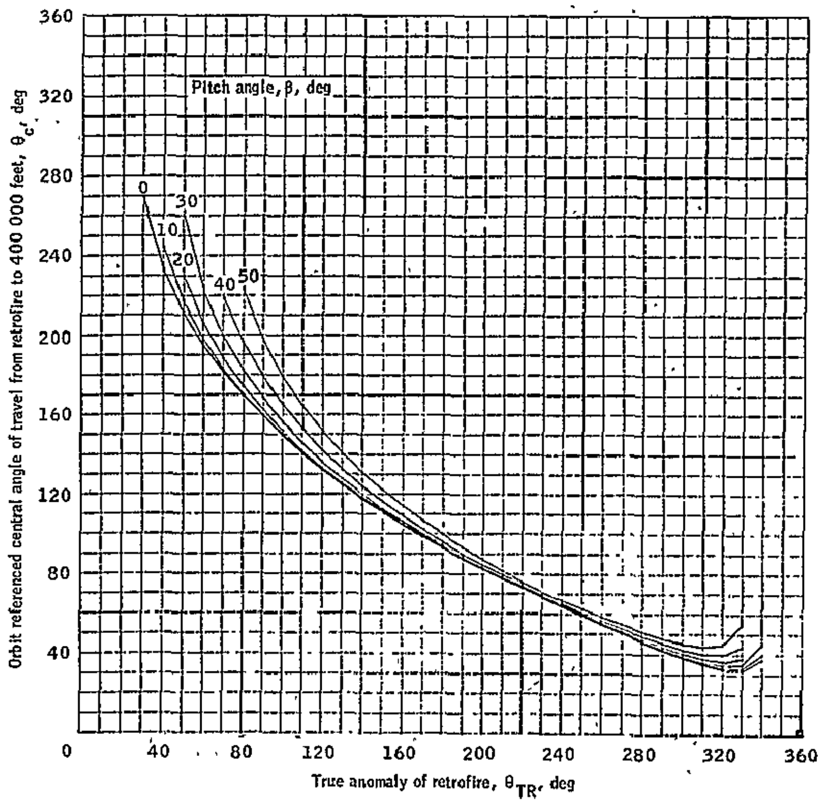




(g) Flight-path angle and velocity for retrograde ΔV = 1700 feet per second.

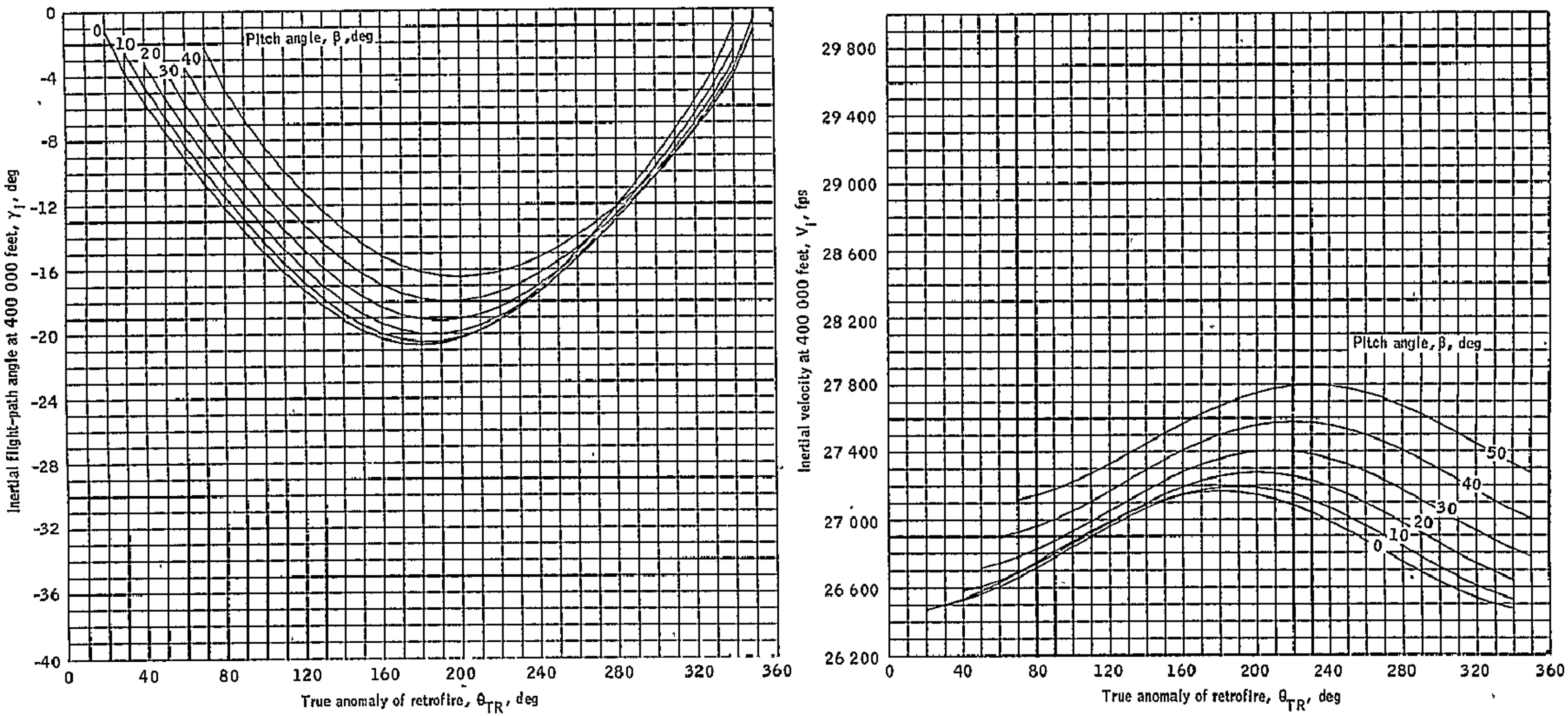
Figure 39.- Continued.





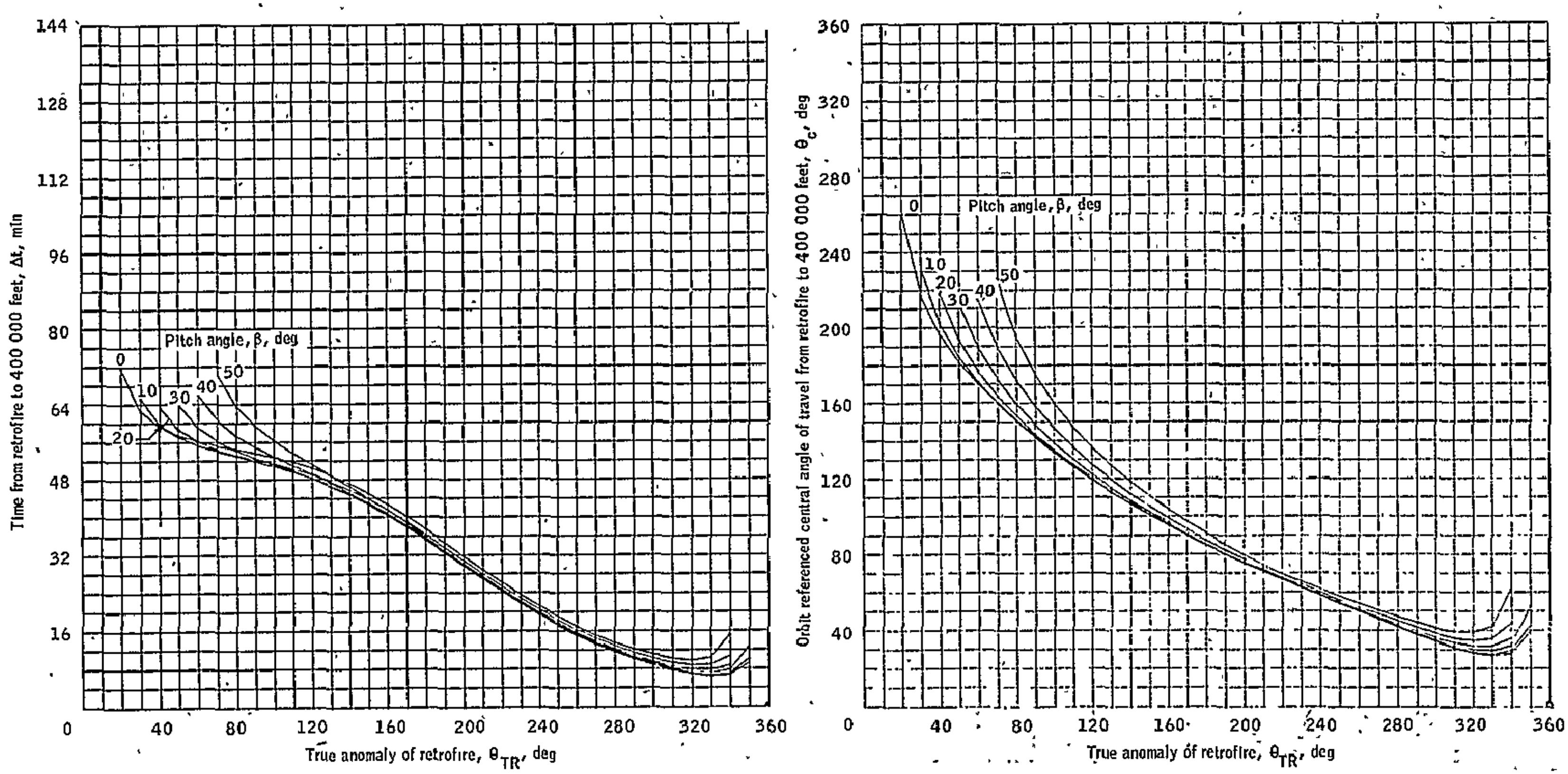
(h) Time from retrofire and central angle for retrograde ΔV = 1700 feet per second.

Figure 39.- Continued.



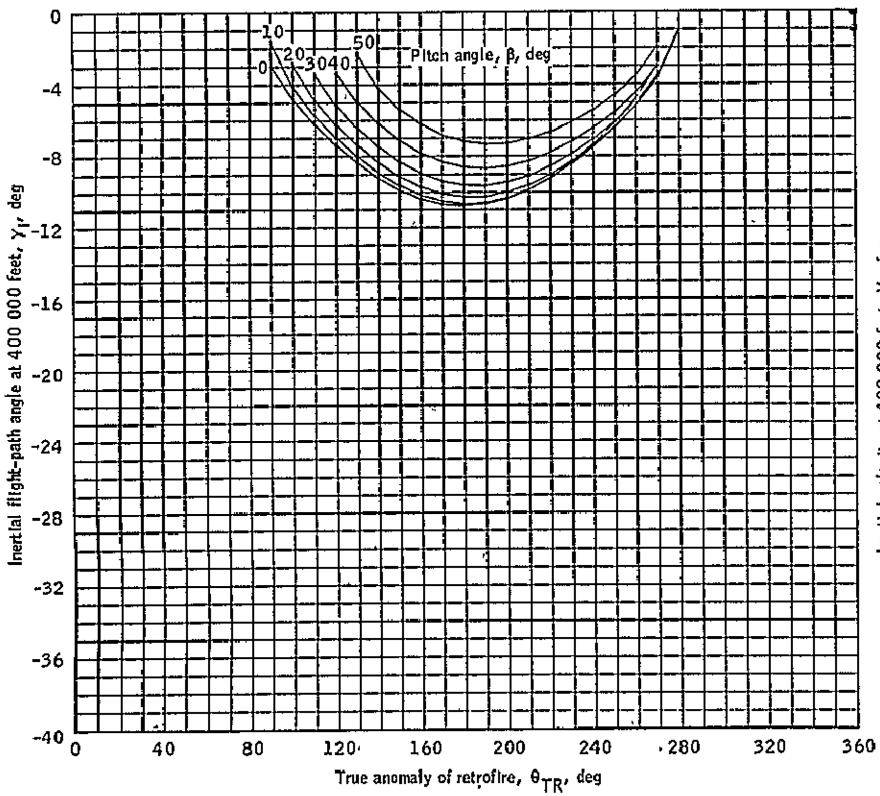
(i) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

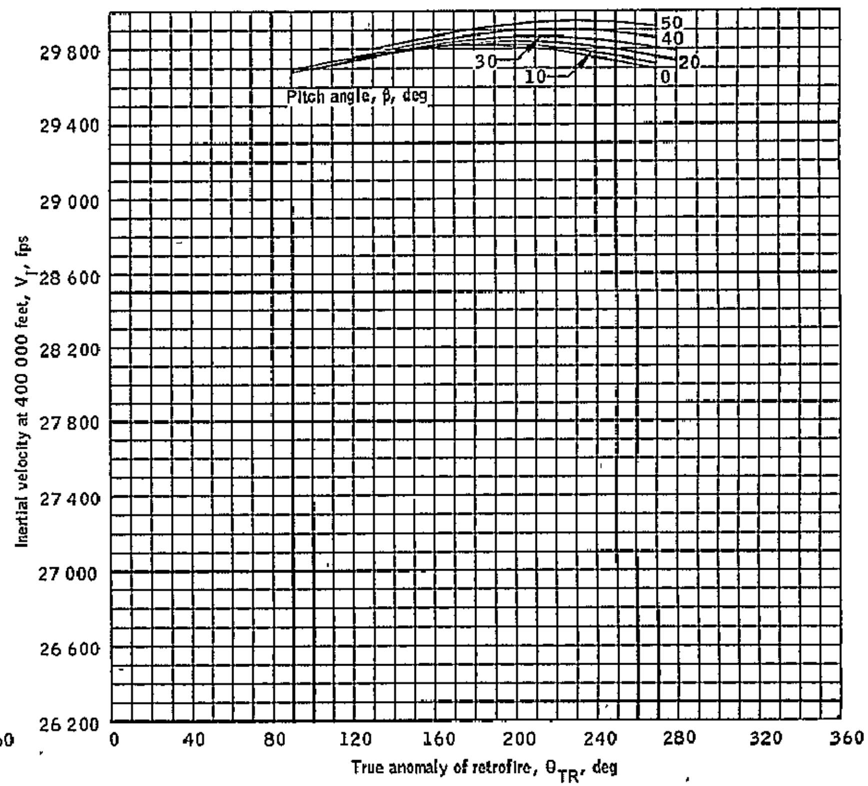
Figure 39.- Continued.



(j) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

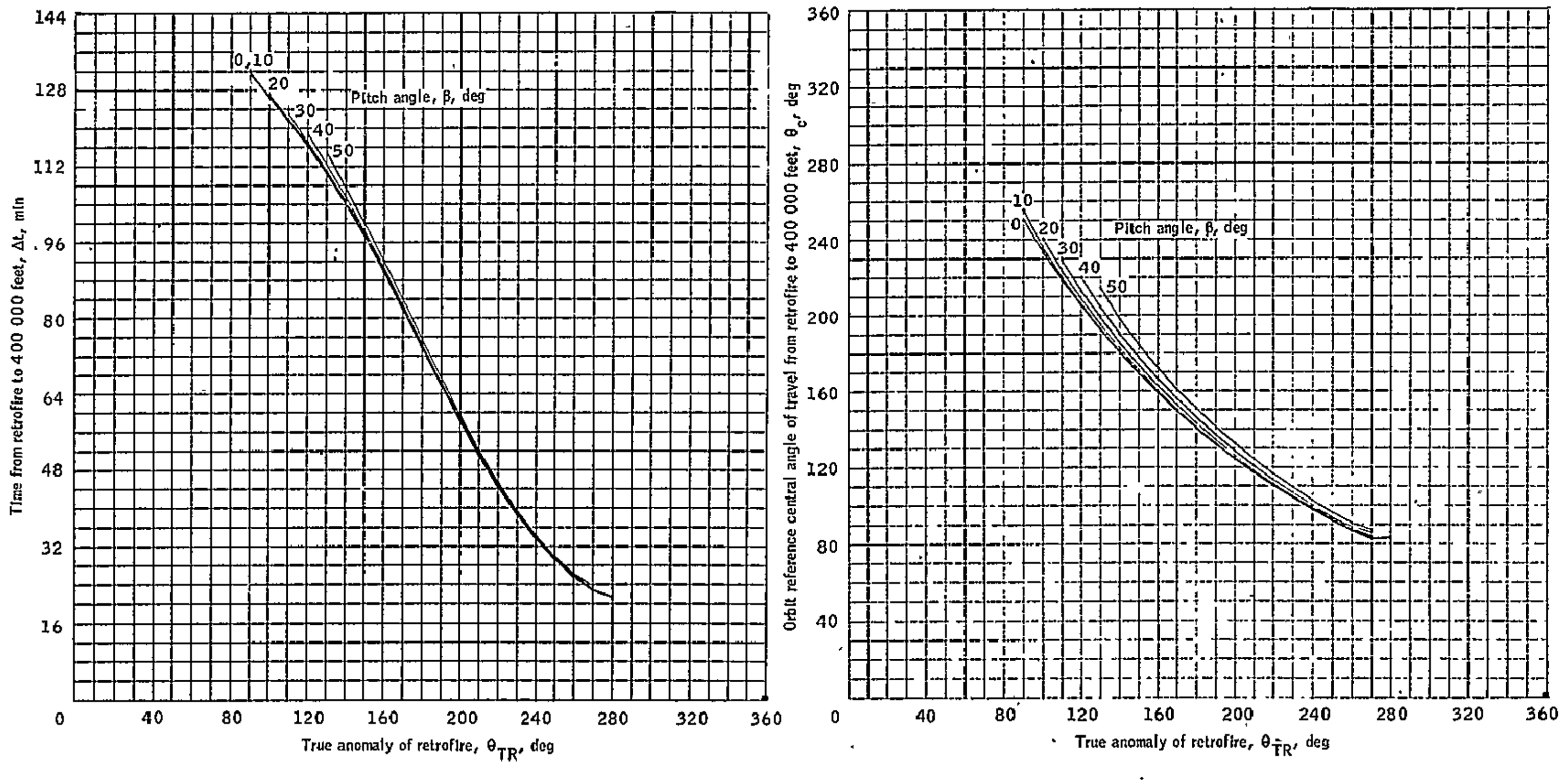
Figure 39.- Concluded.





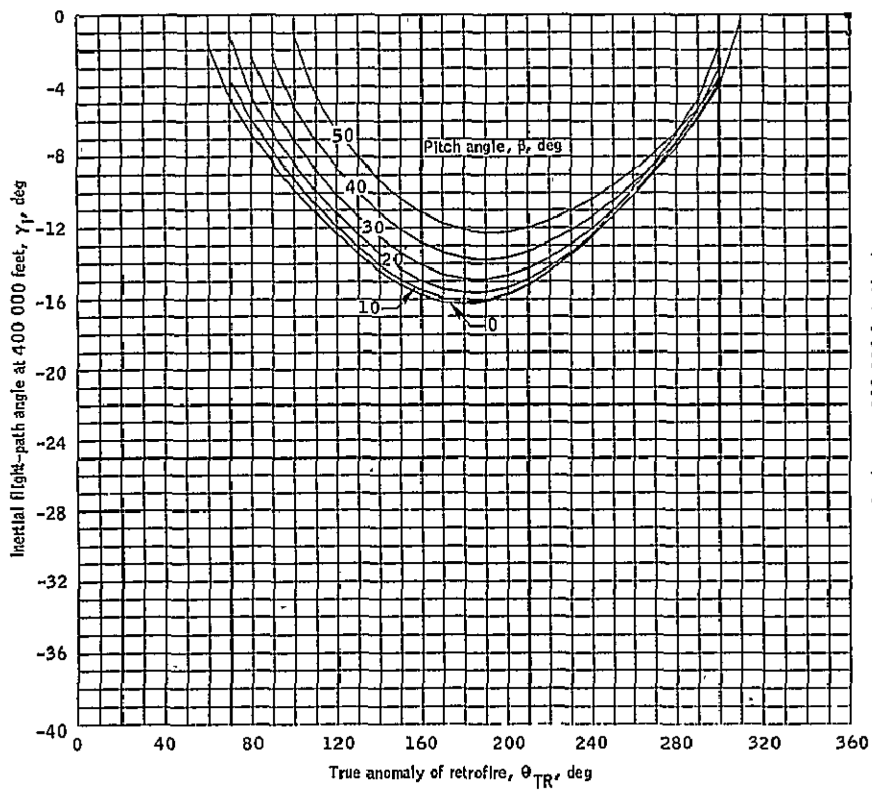
(a) Flight-path angle and velocity for retrograde $\Delta V = 500$ feet per second.

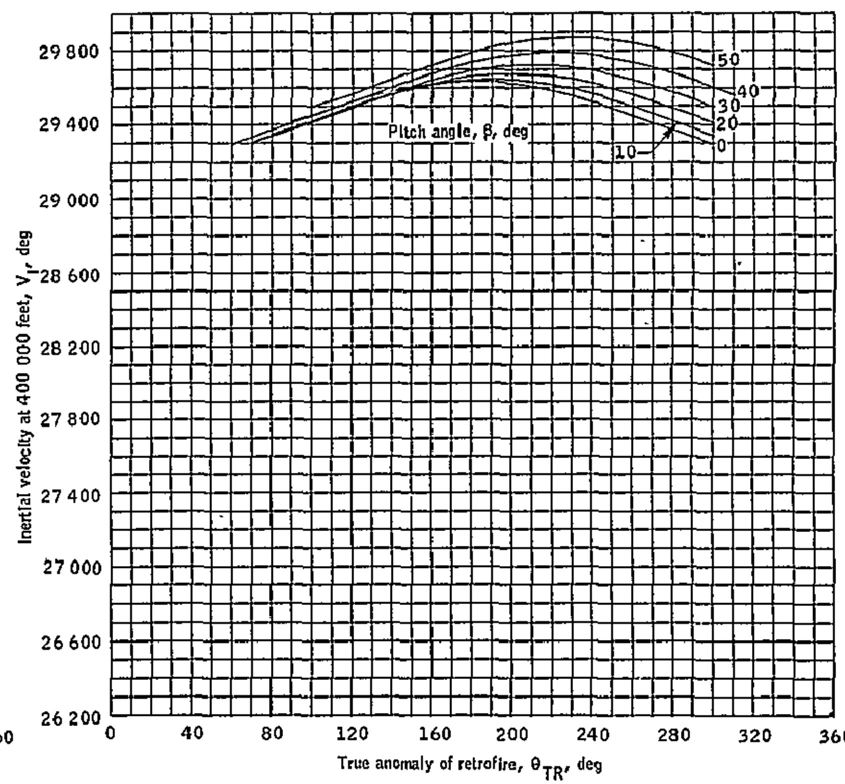
Figure 40.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 200/4 000 nautical mile orbit.



(b) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

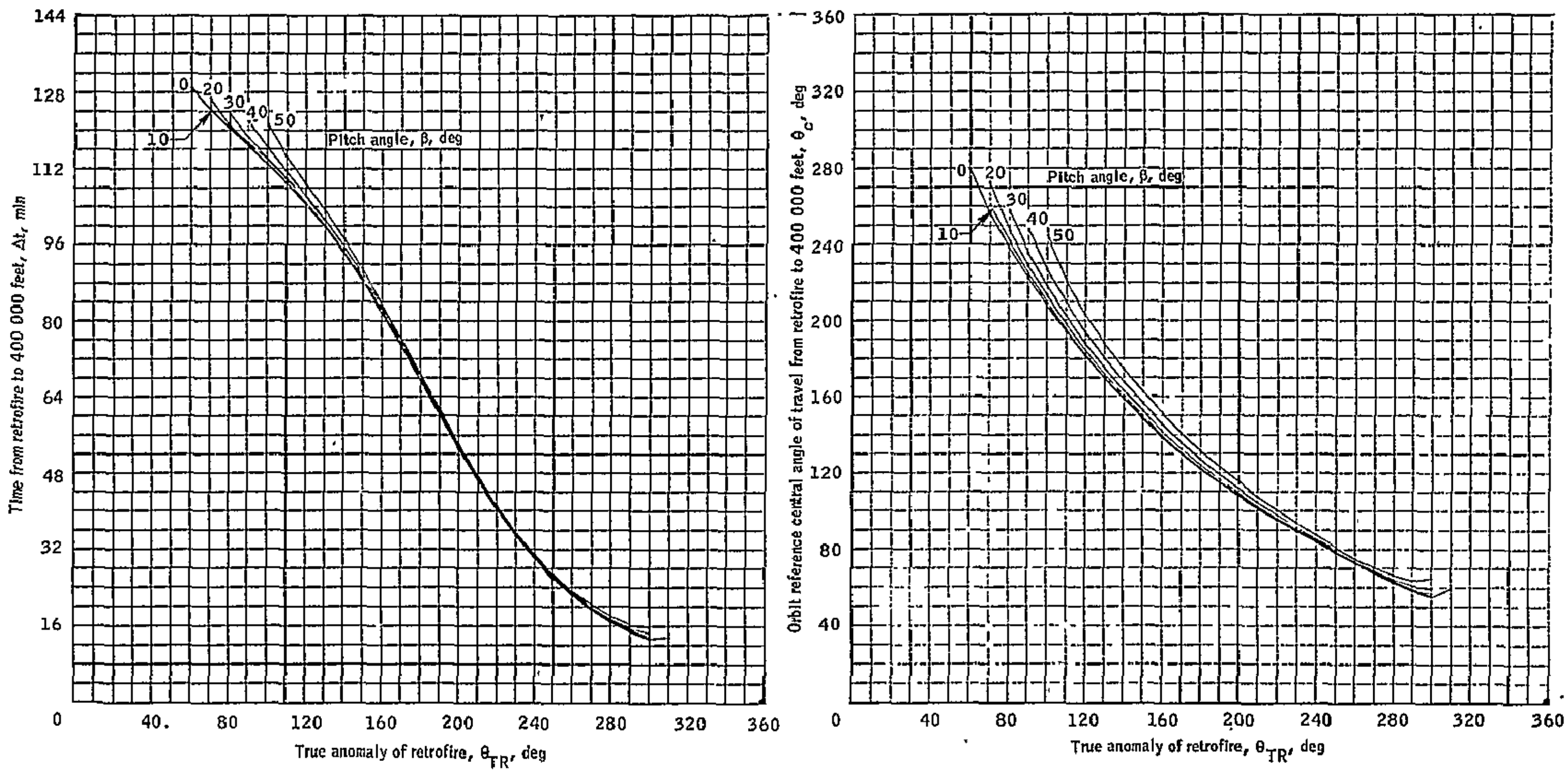
Figure 40.- Continued.





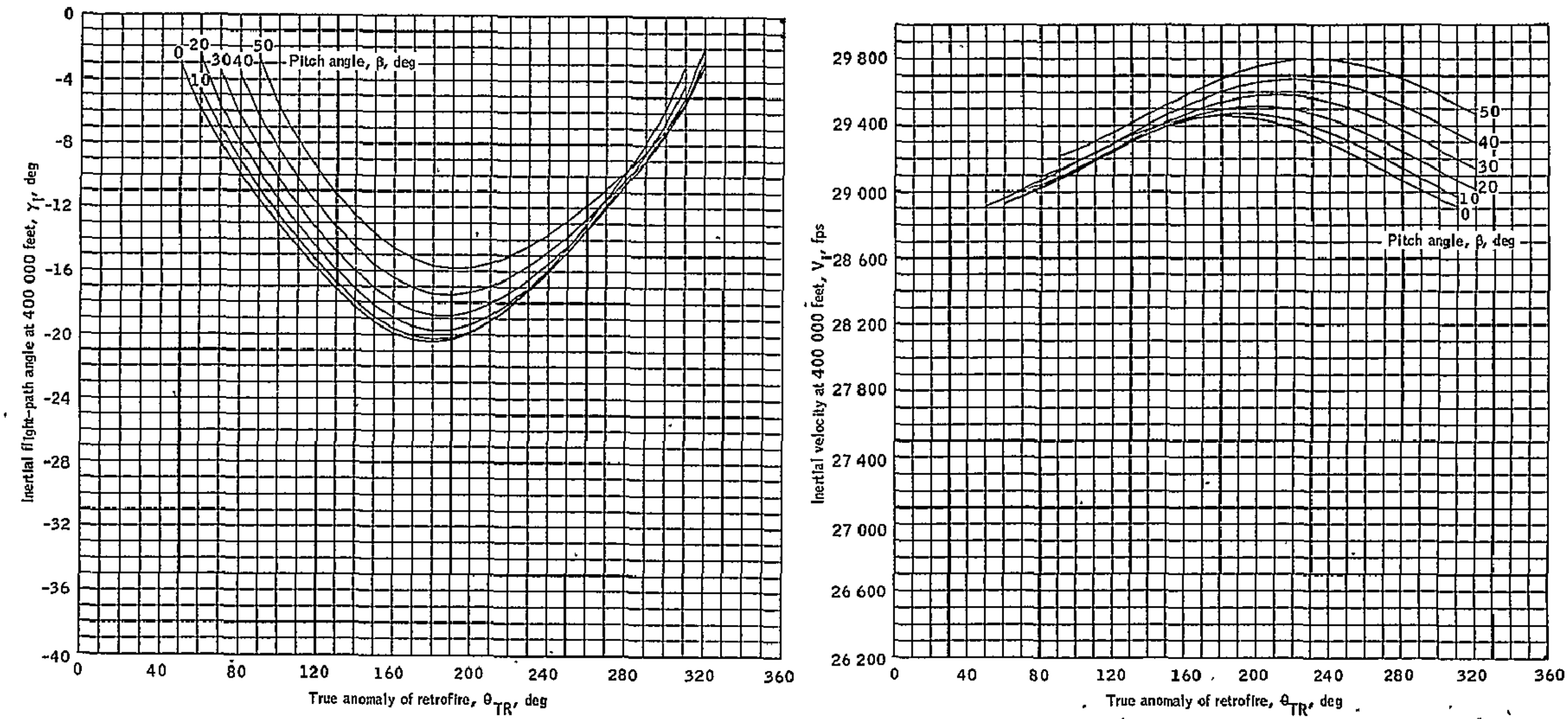
(c) Flight-path angle and velocity for retrograde $\Delta V = 900$ feet per second.

Figure 40.- Continued.



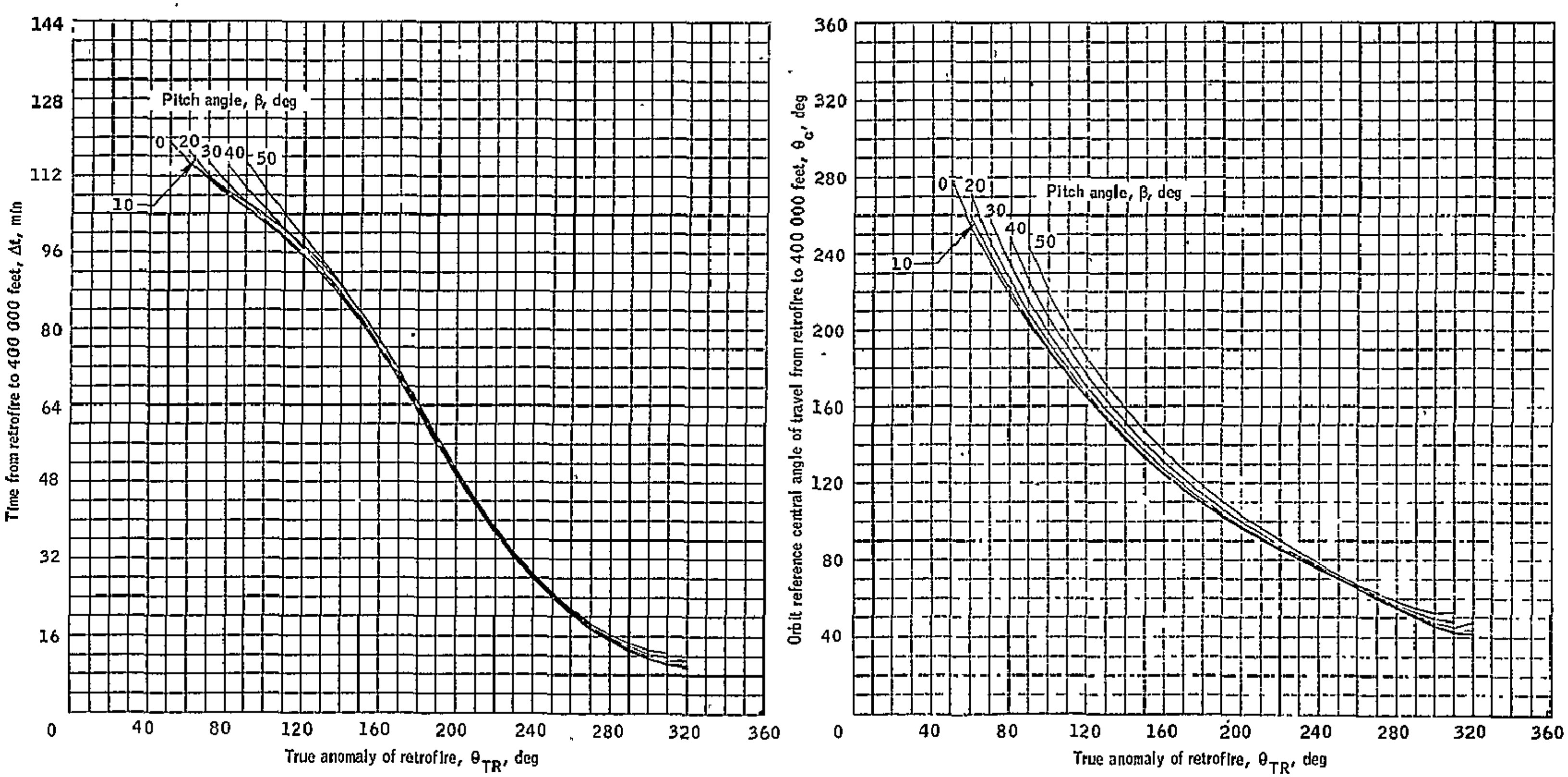
(d) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

Figure 40.- Continued.



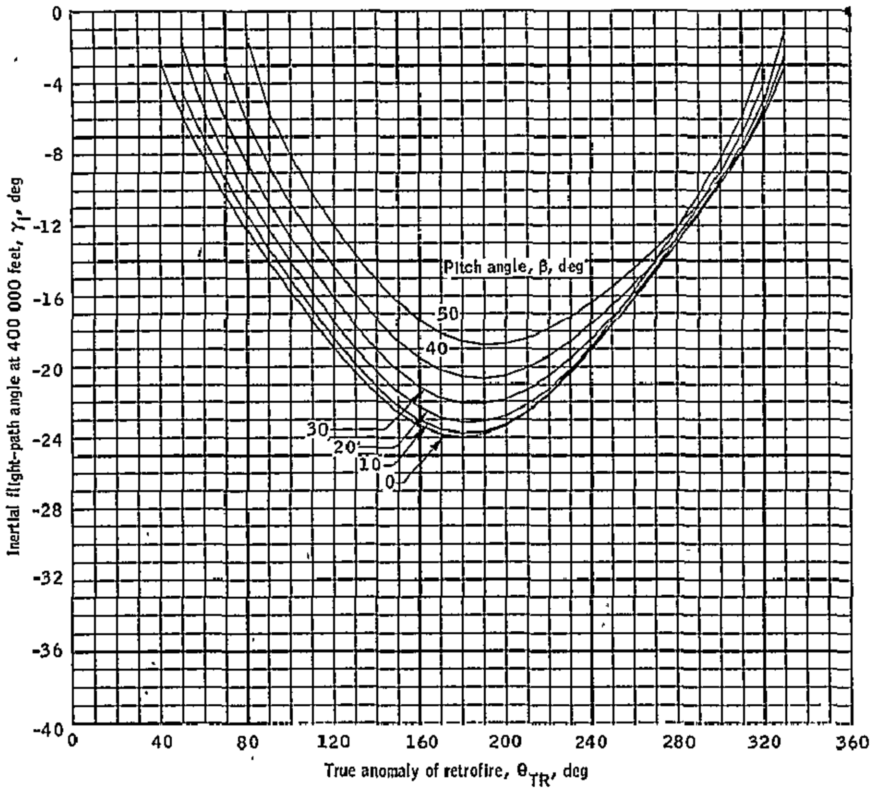
(e) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

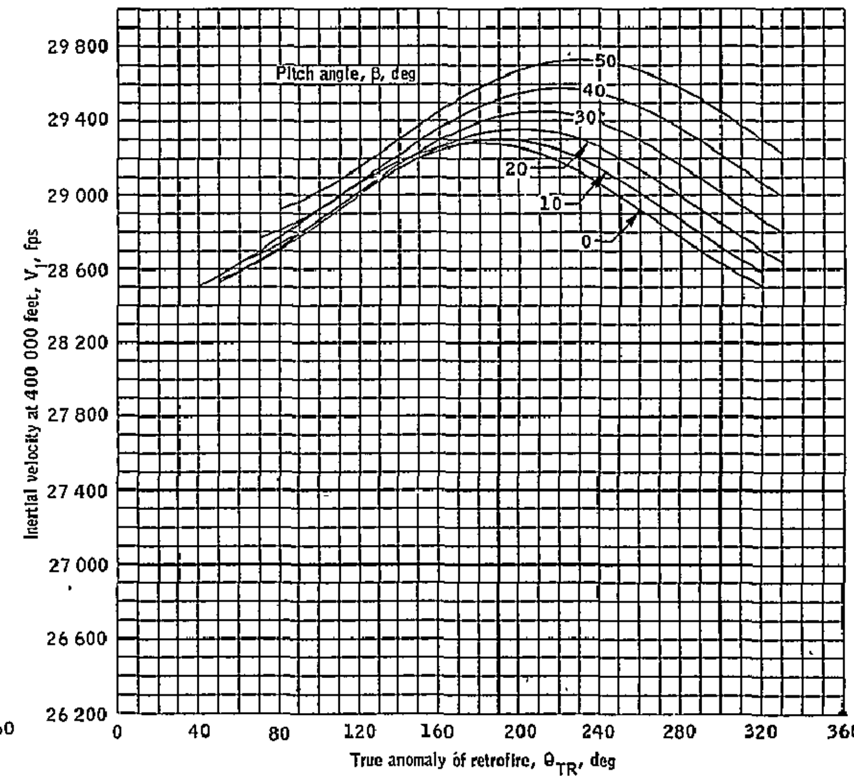
Figure 40.- Continued.



(f) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

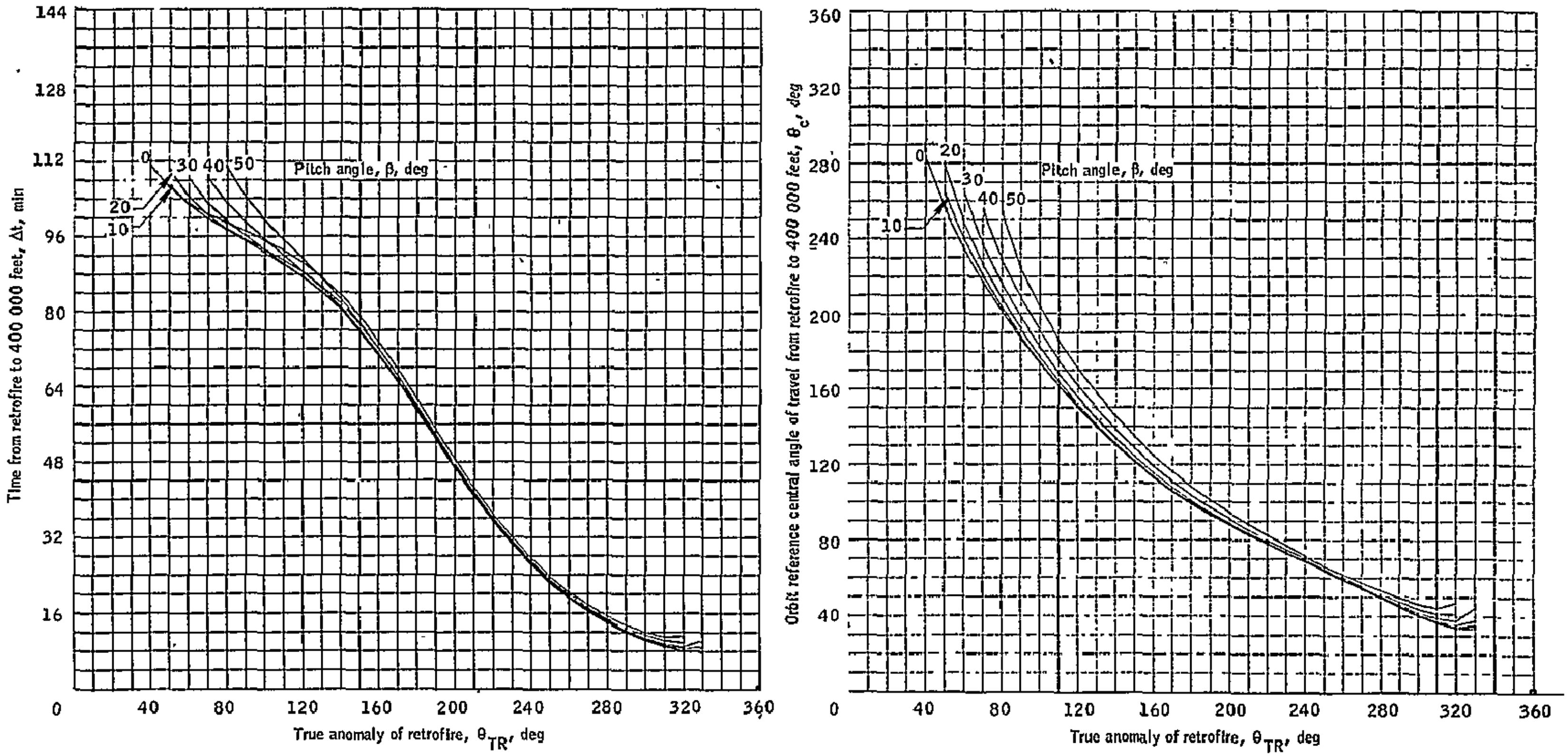
Figure 40.- Continued.





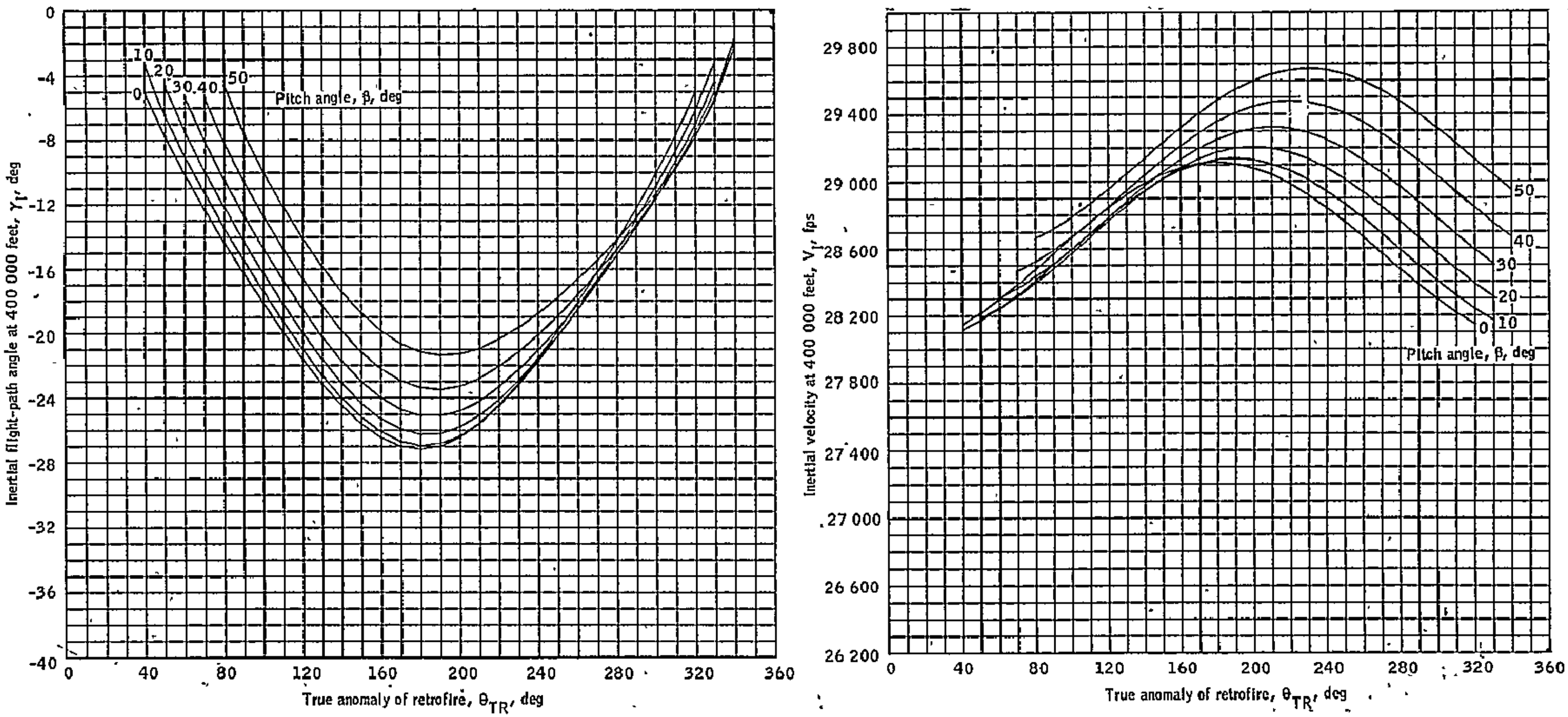
(g) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

Figure 40.- Continued.



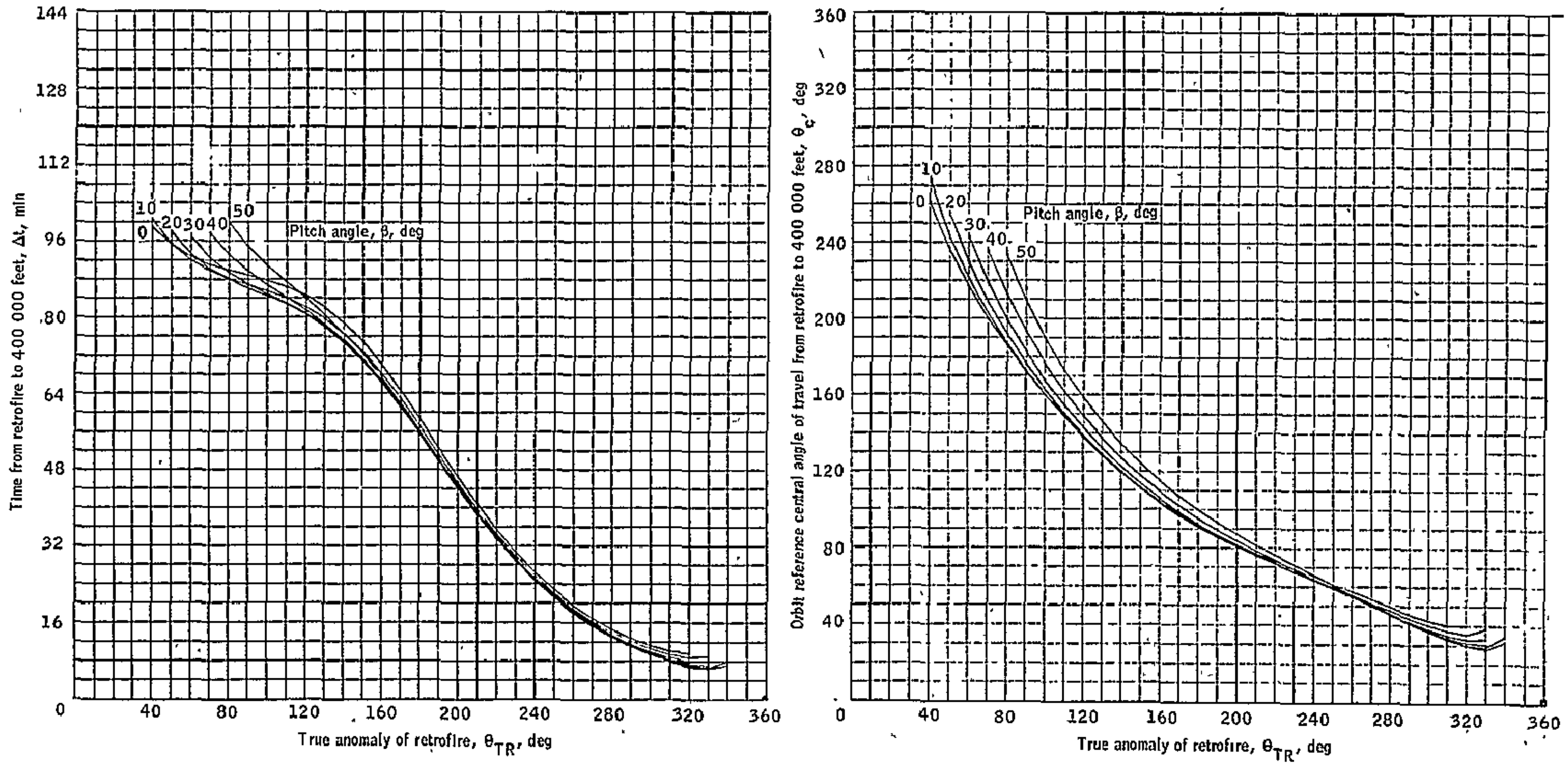
(h) Time from retrofire and central angle for retrograde ΔV = 1700 feet per second.

Figure 40.- Continued.



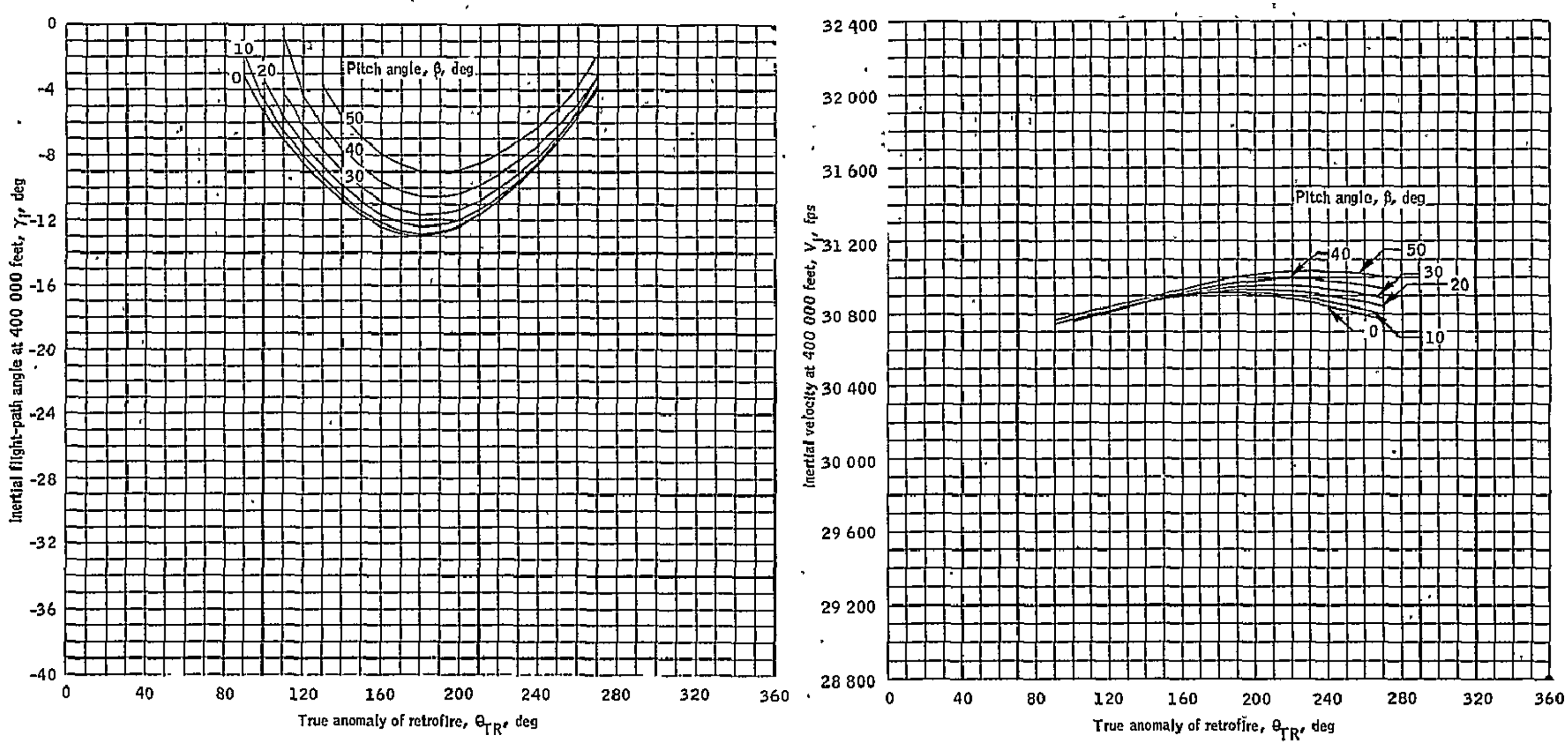
(l) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

Figure 40.- Continued.



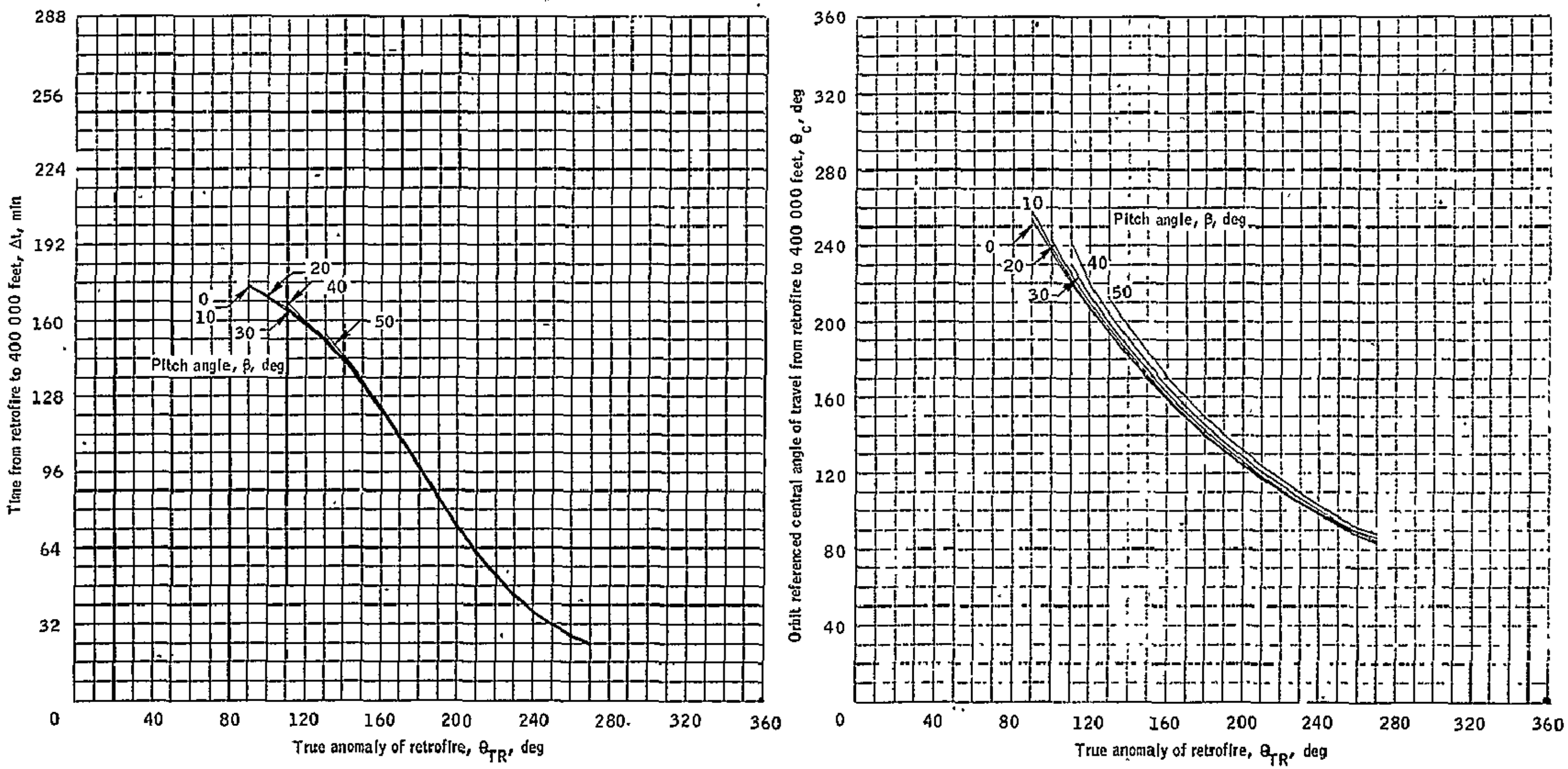
(j) Time from retrofire and central angle for retrograde $\Delta V = 2100$ feet per second.

Figure 40.- Concluded.



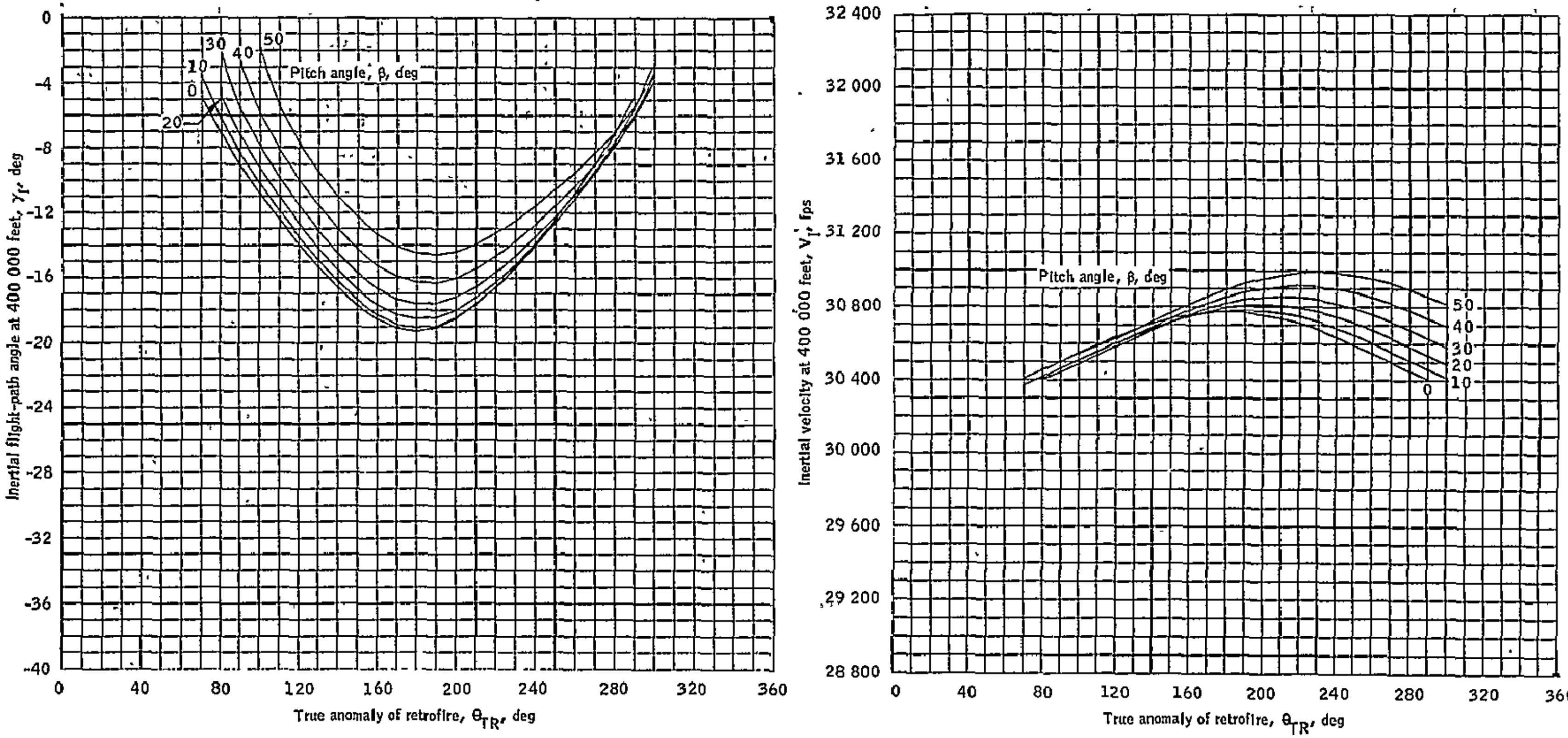
(a) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

Figure 41.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for 200/6000 nautical mile orbit.



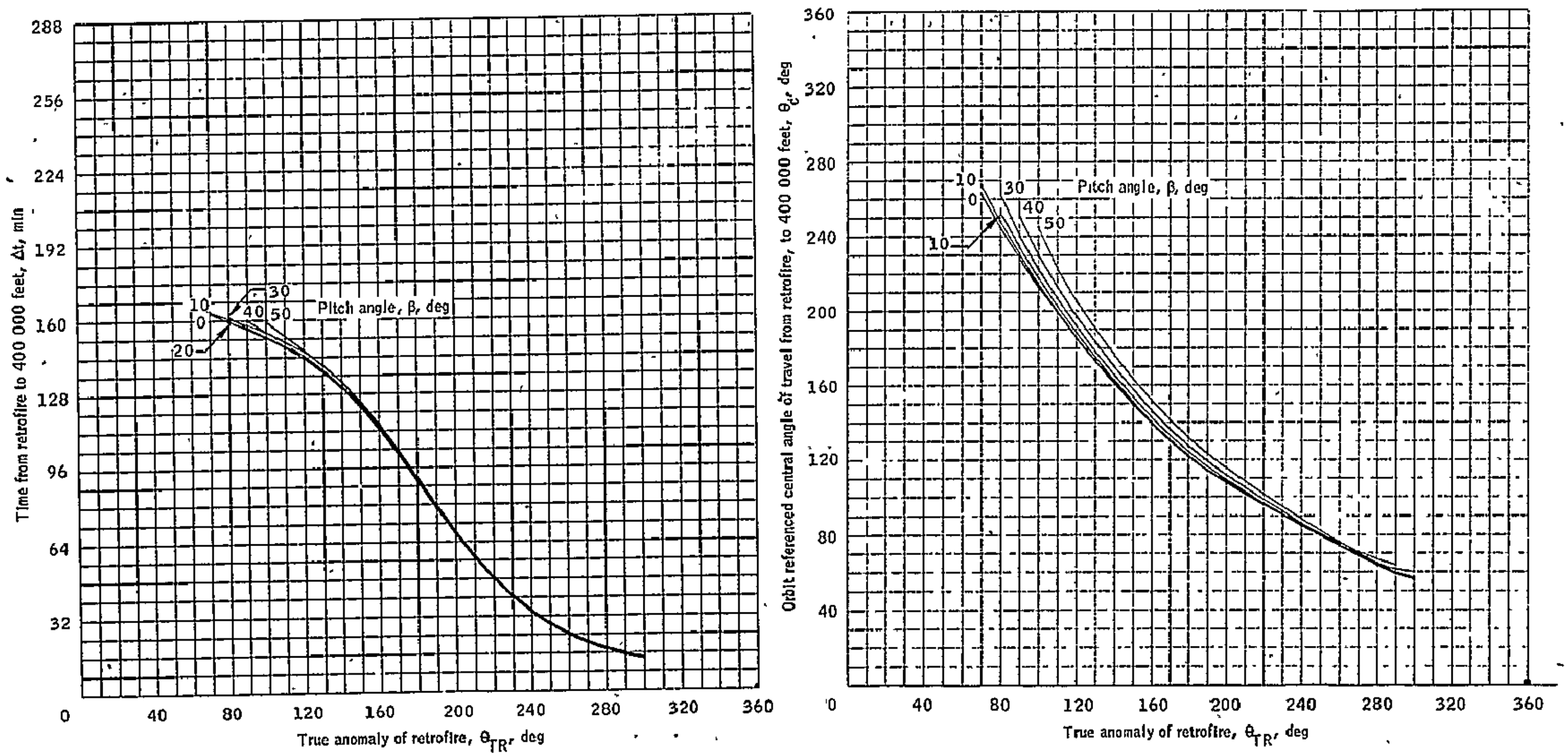
(b) Time from retrofire and central angle for retrograde $\Delta V = 500$ feet per second.

Figure 41.– Continued.



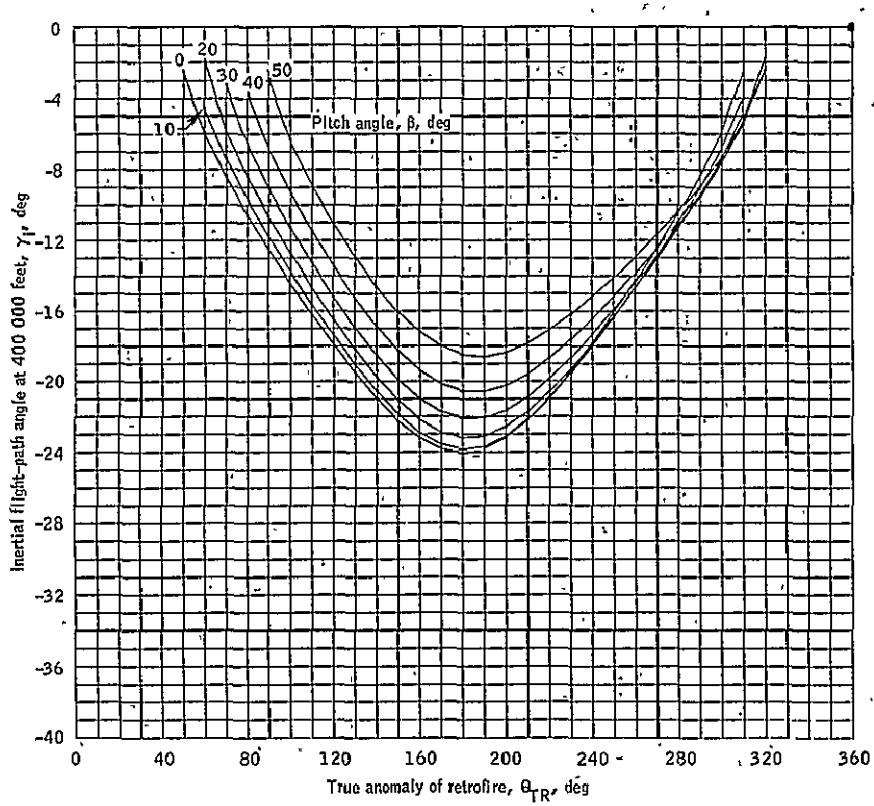
(c) Flight-path angle and velocity for retrograde ΔV = 900 feet per second.

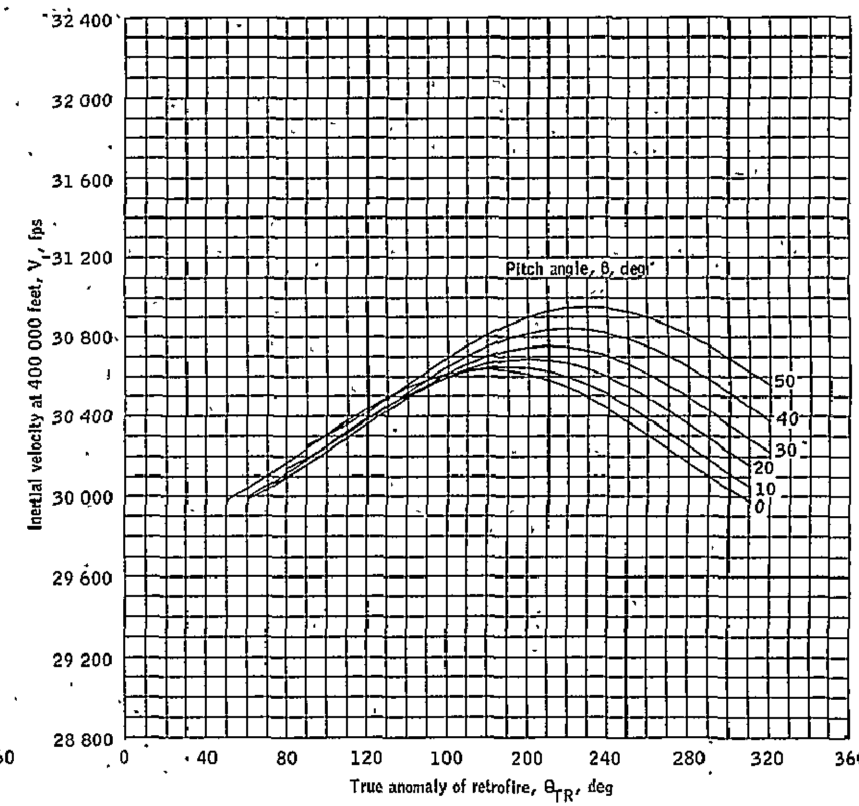
Figure 41.- Continued.



(d) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

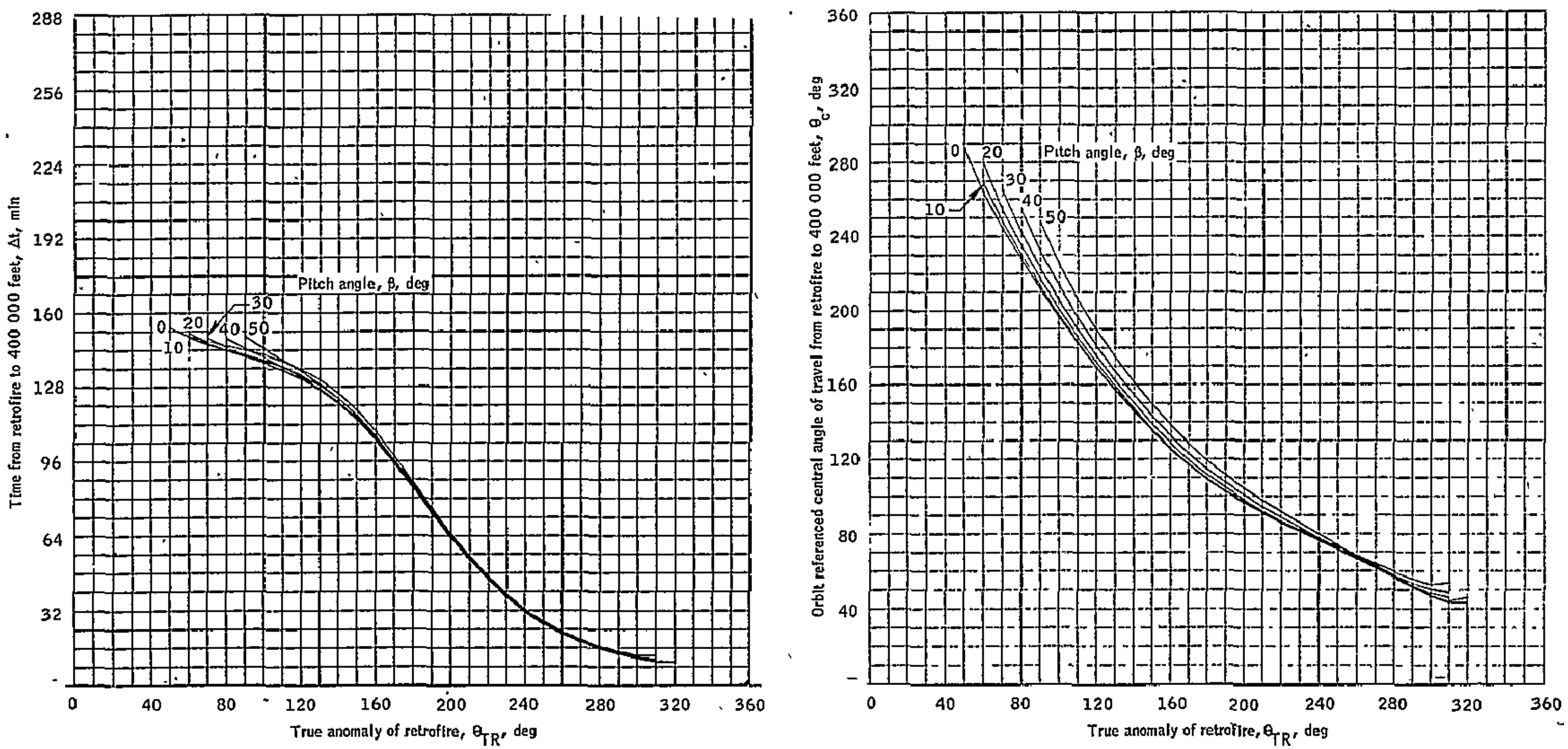
Figure 41.- Continued.





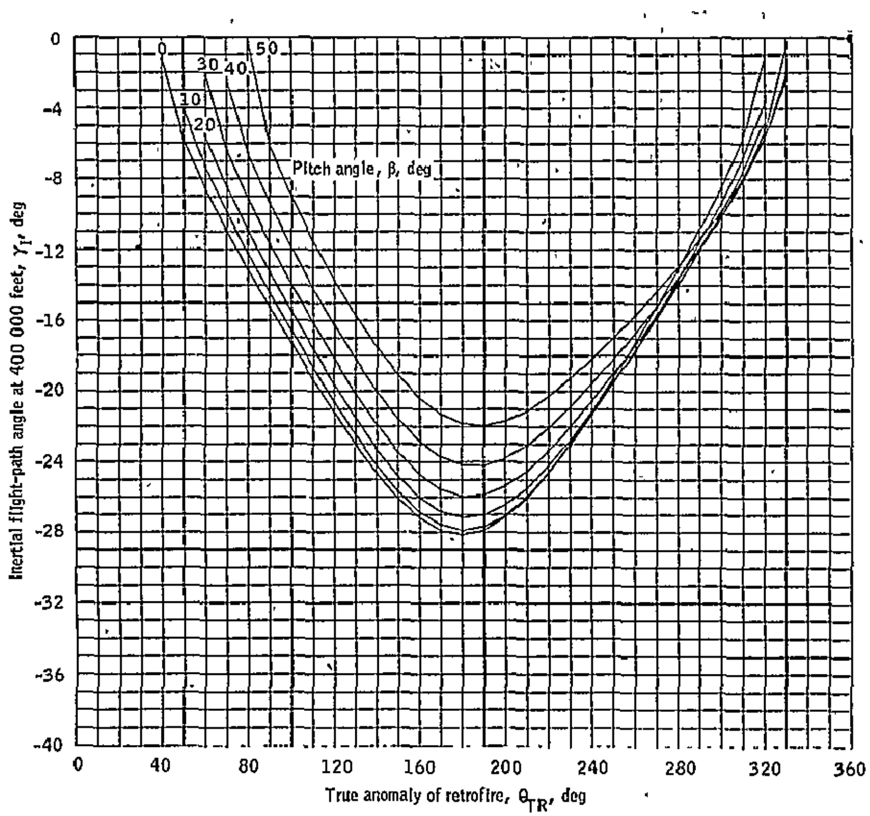
(e) Flight-path angle and velocity for retrograde ΔV = 1300 feet per second.

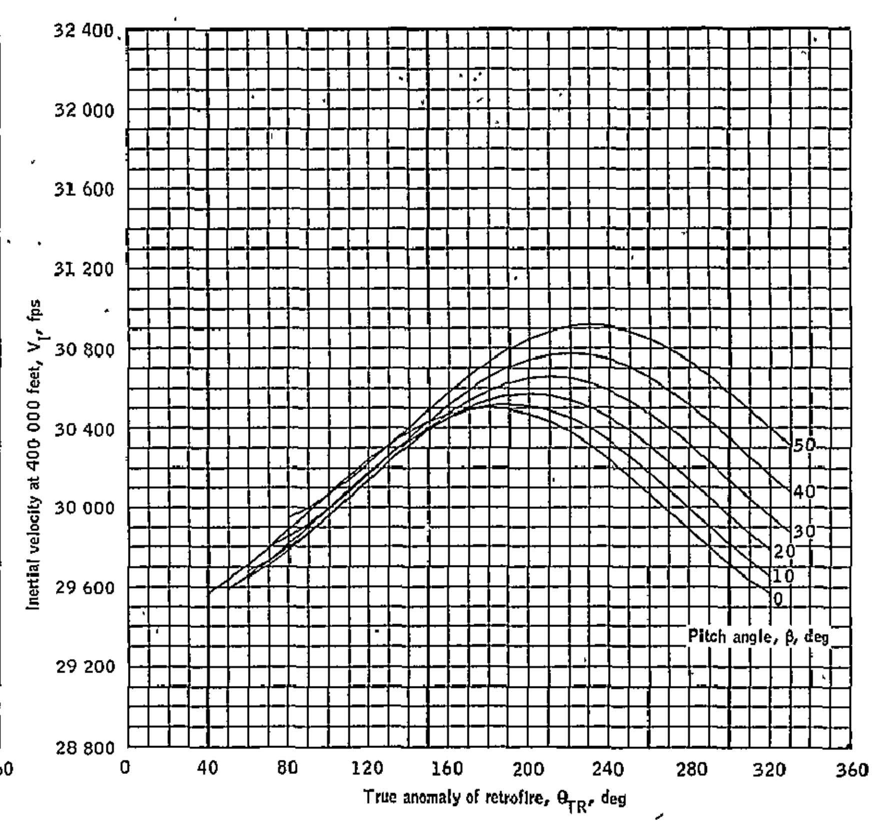
Figure 41.- Continued.



(f) Time from retrofire and central angle for retrograde $\Delta V = 1300$ feet per second.

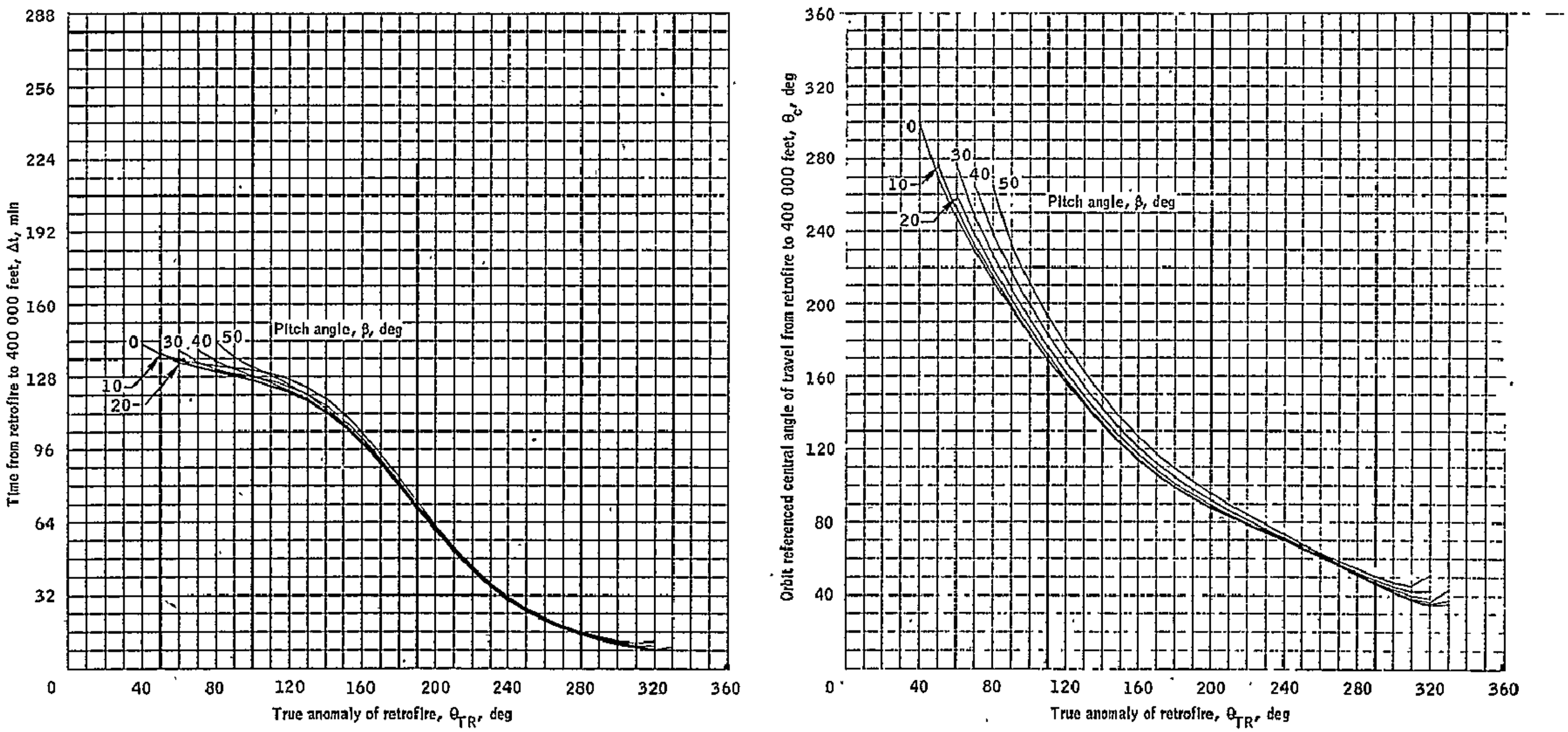
Figure 41.- Continued.





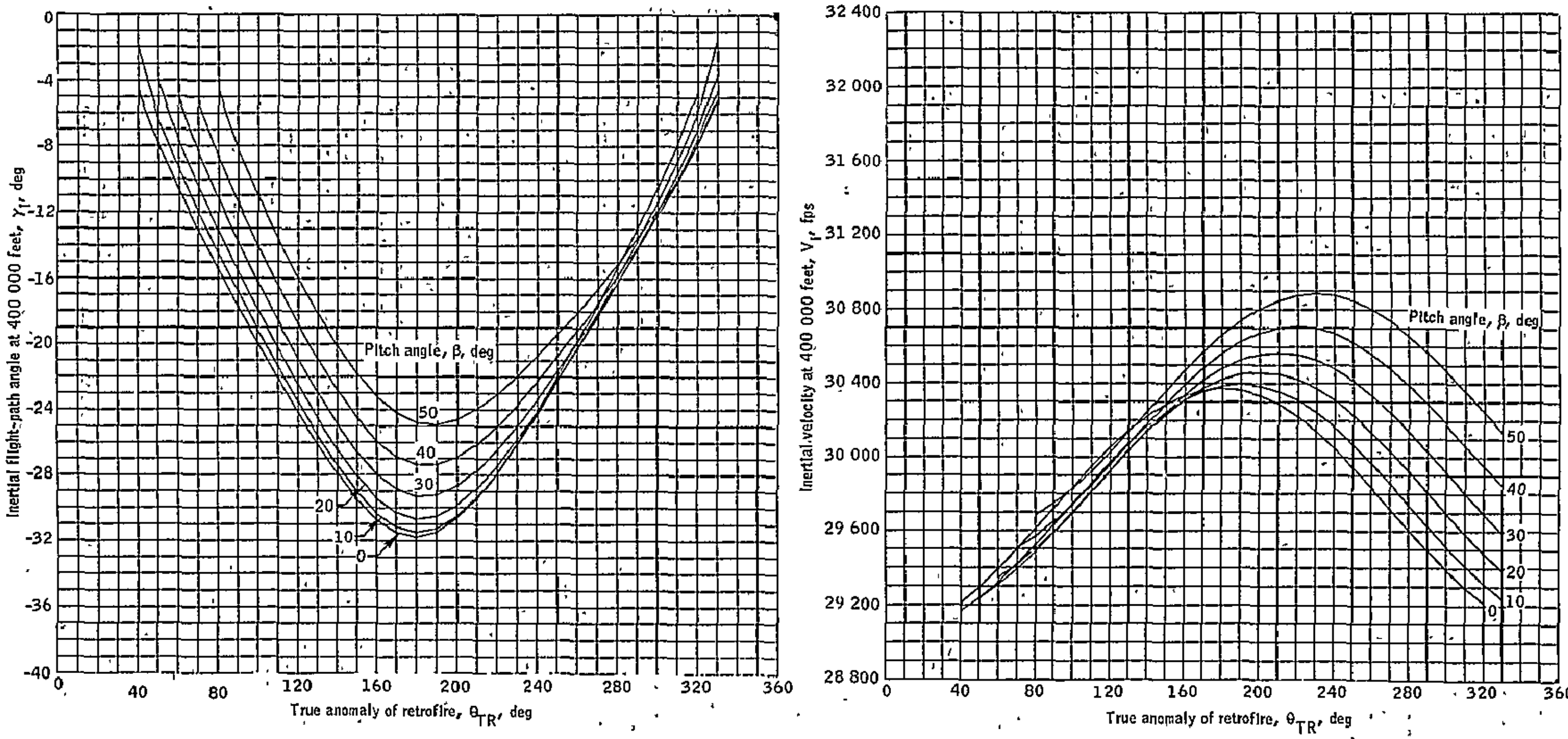
(g) Flight-path angle and velocity for retrograde ΔV = 1700 feet per second.

Figure 41.- Continued.



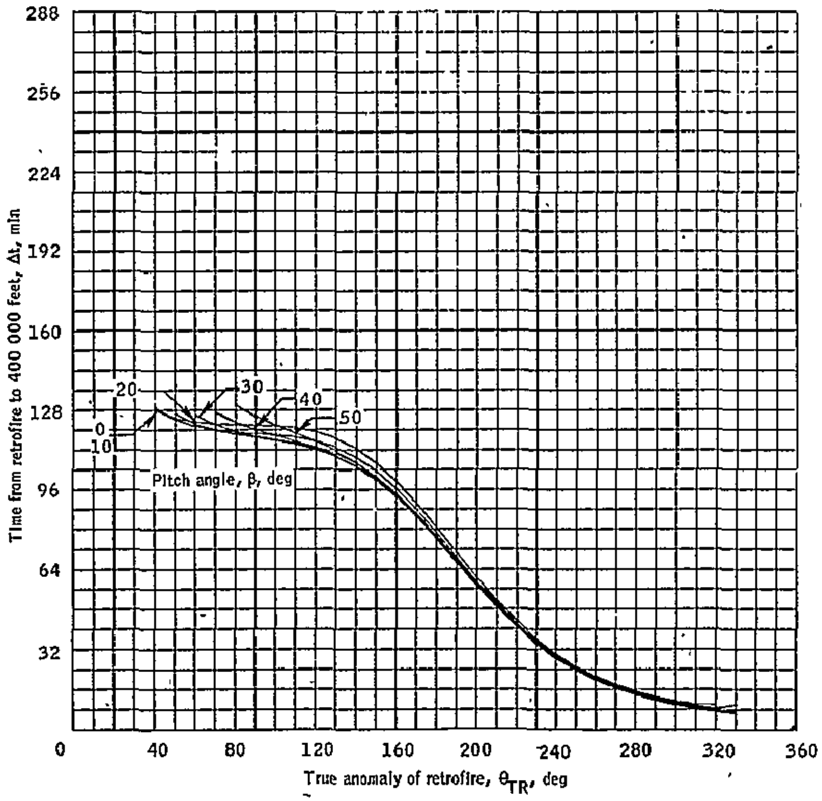
(h) Time from retrofire and central angle for retrograde $\Delta V = 1700$ feet per second.

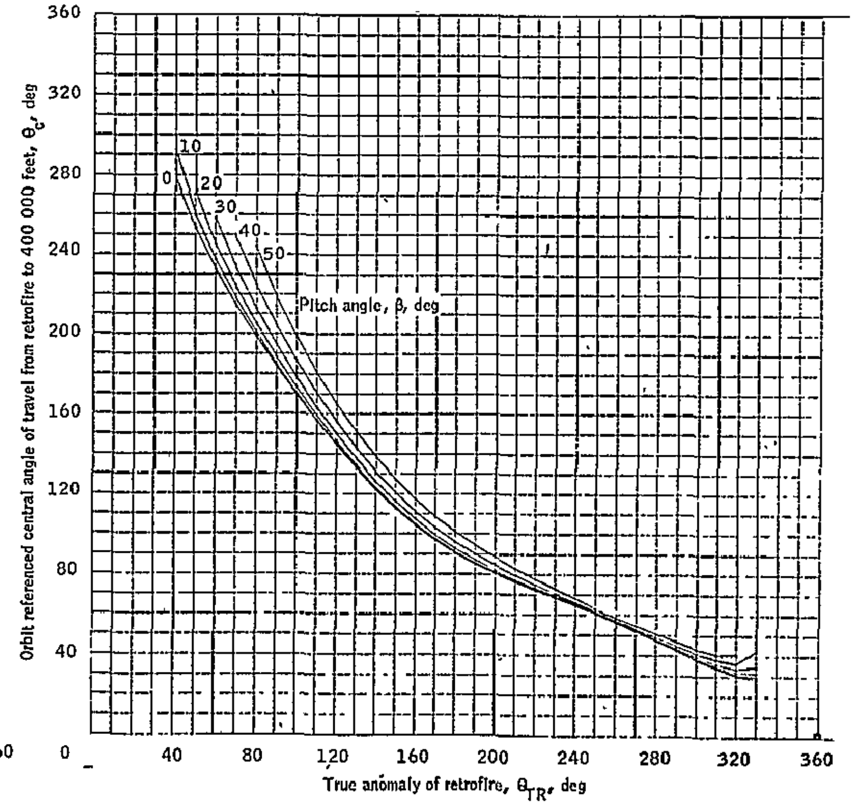
Figure 41.- Continued.



(l) Flight-path angle and velocity for retrograde ΔV = 2100 feet per second.

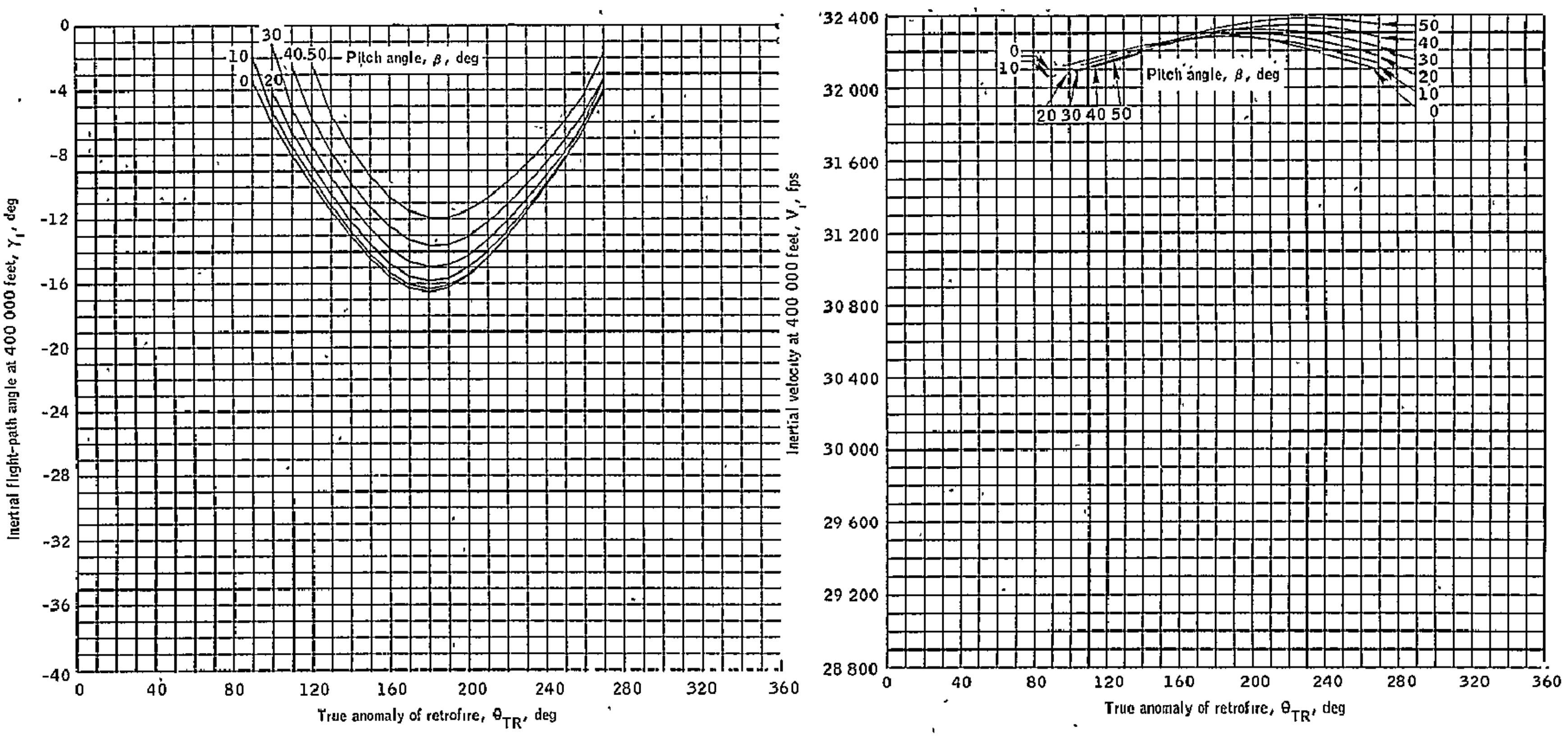
Figure 41.- Continued.





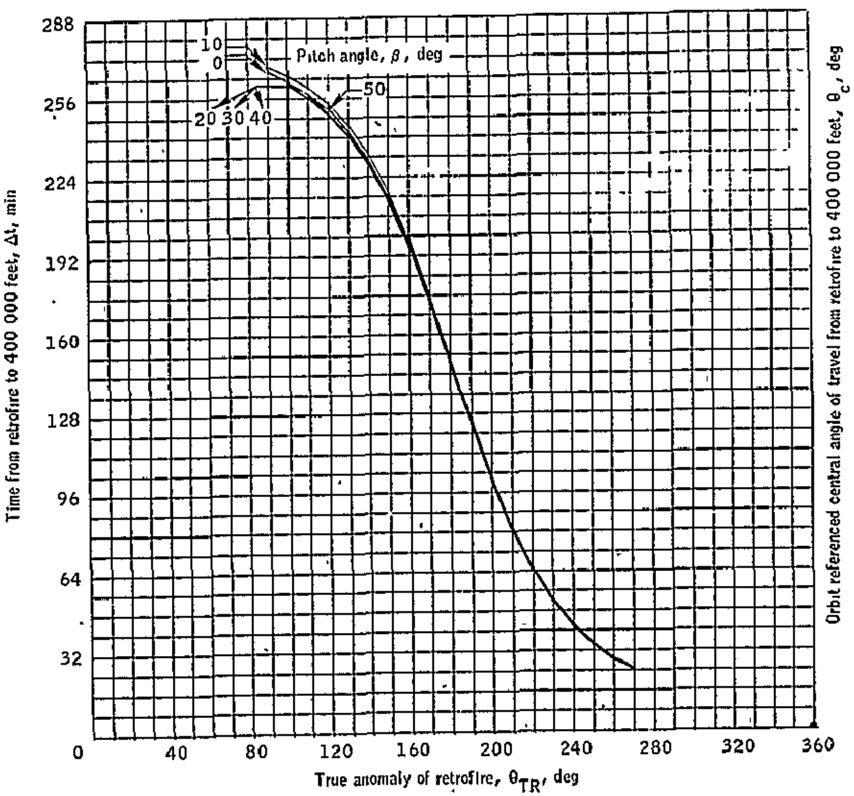
(j) Time from retrofire and central angle for retrograde ΔV = 2100 feet per second.

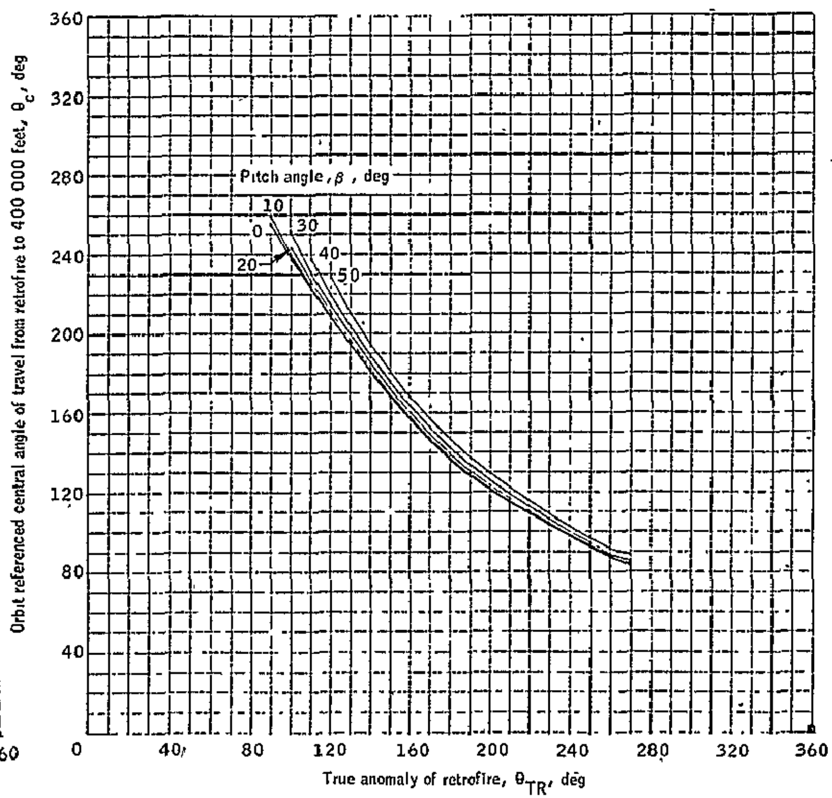
Figure 41.- Concluded.



(a) Flight-path angle and velocity for retrograde ΔV = 500 feet per second.

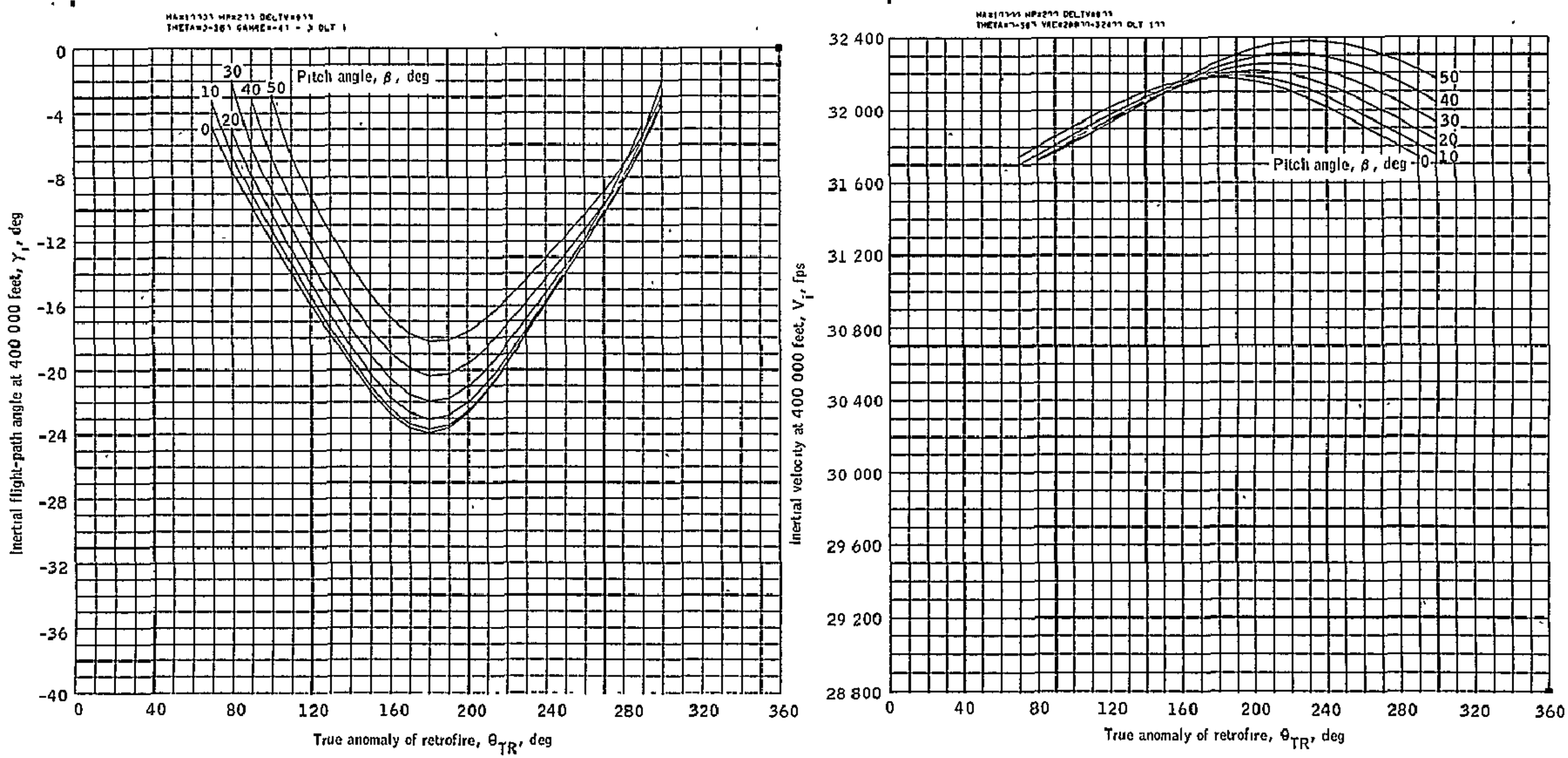
Figure 42.- Reentry parameters as a function of true anomaly of retrofire from various pitch angles for a 200/10 000 nautical mile orbit.





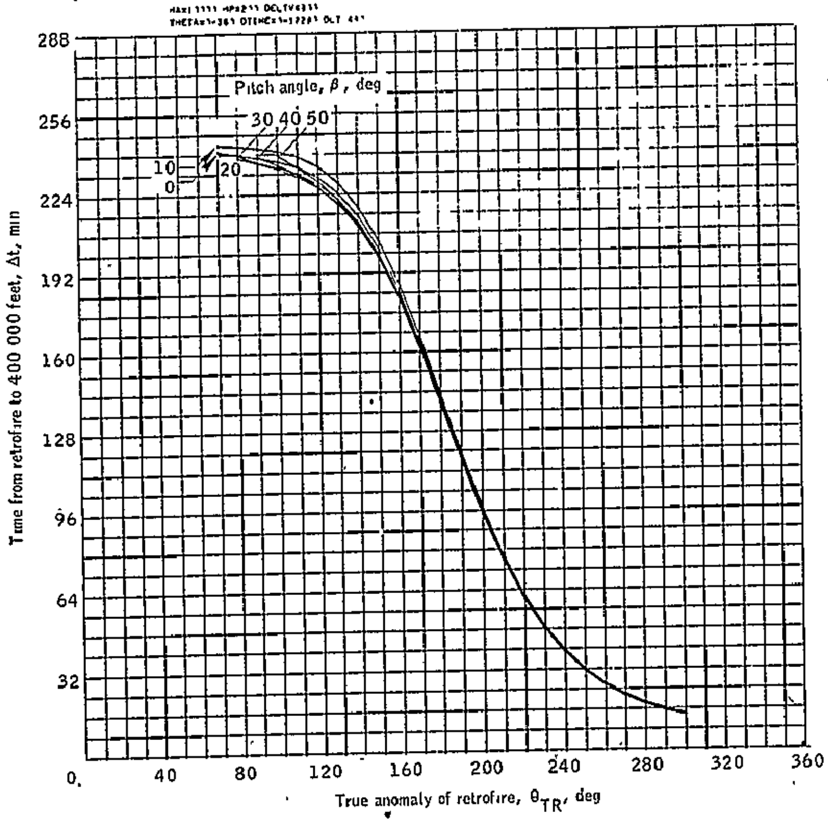
(b) Time from retrofire and central angle for retrograde ΔV = 500 feet per second.

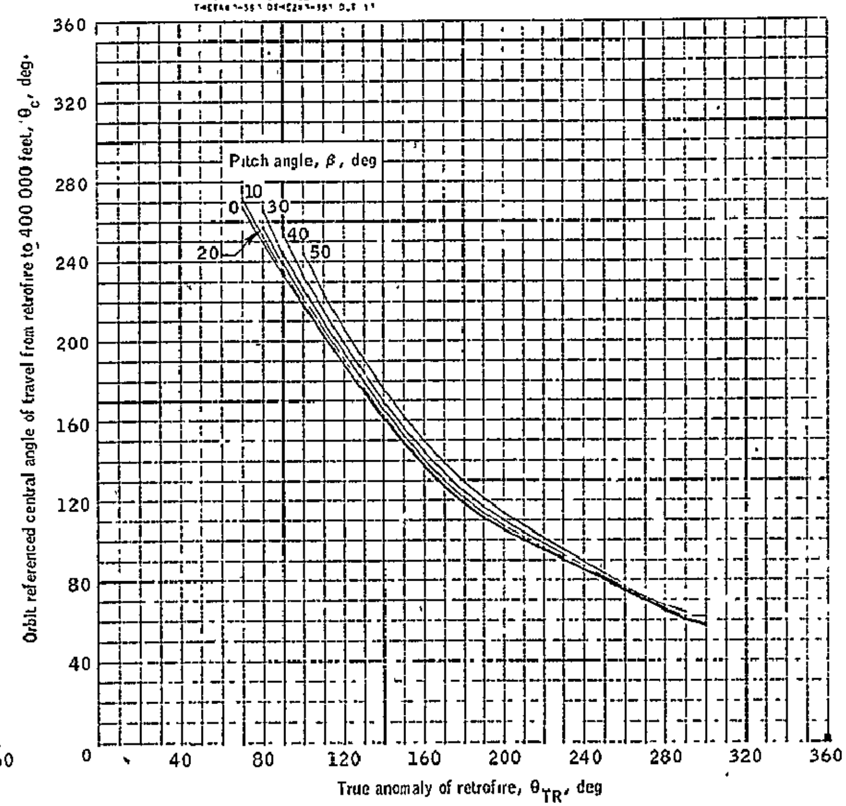
Figure 42.- Continued.



(c) Flight-path angle and velocity for retrograde $\Delta V = 900$ feet per second.

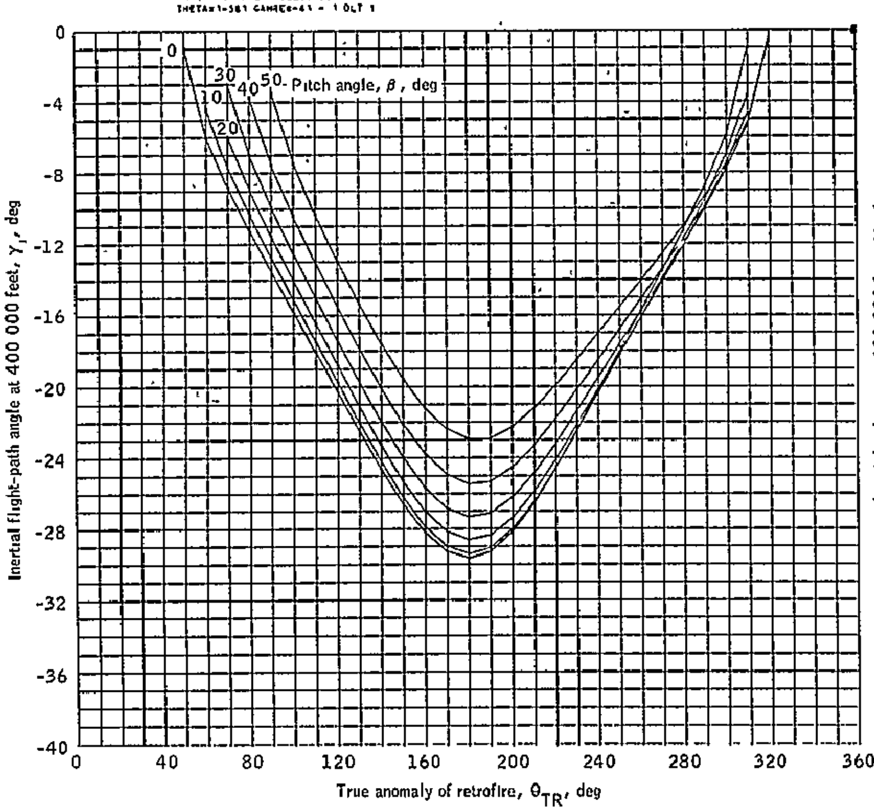
Figure 42.- Continued.

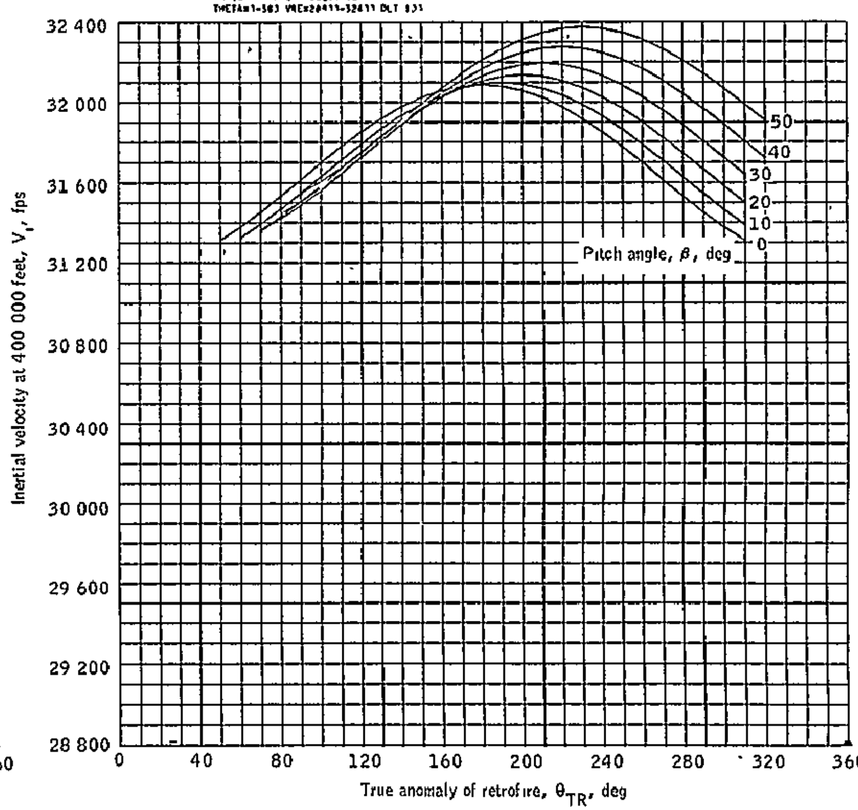




(d) Time from retrofire and central angle for retrograde $\Delta V = 900$ feet per second.

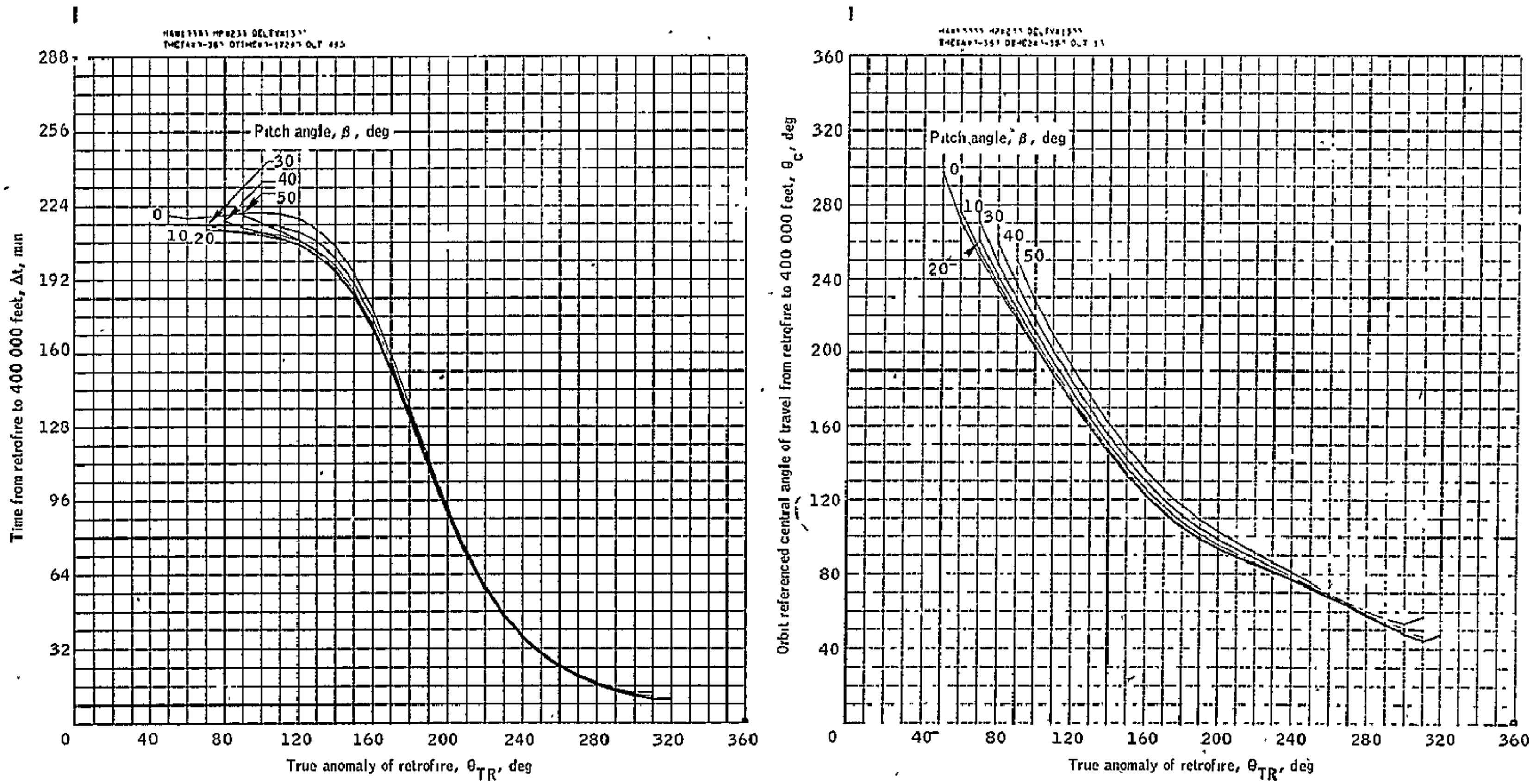
Figure 42.- Continued.





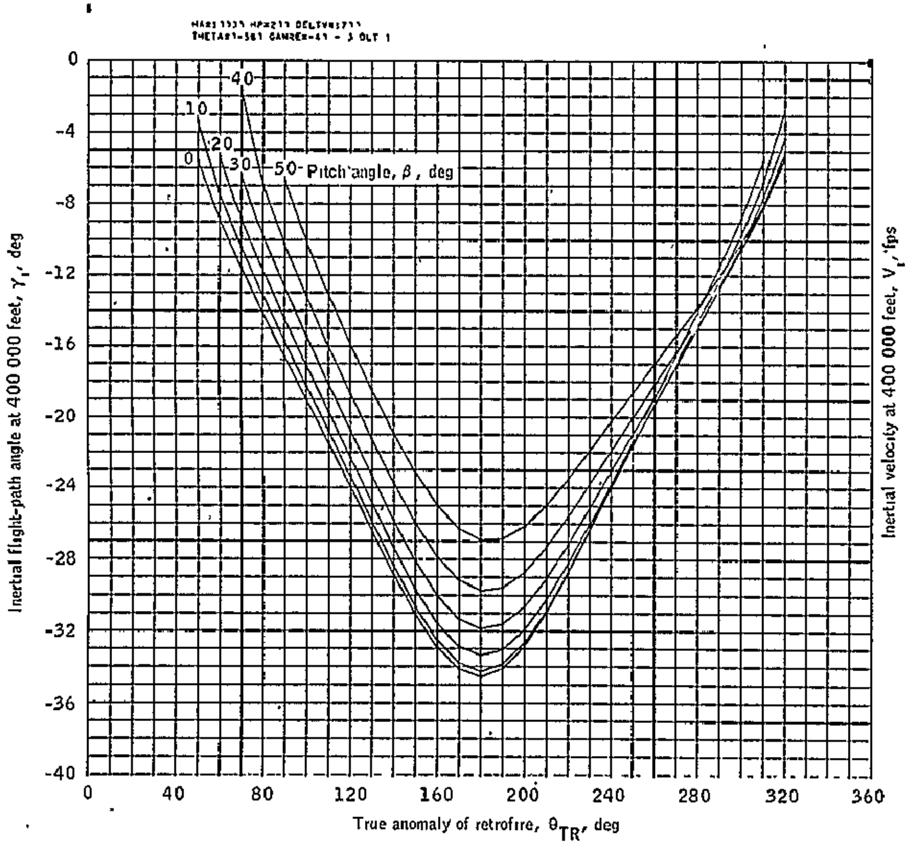
(e) Flight-path angle and velocity for retrograde $\Delta V = 1300$ feet per second.

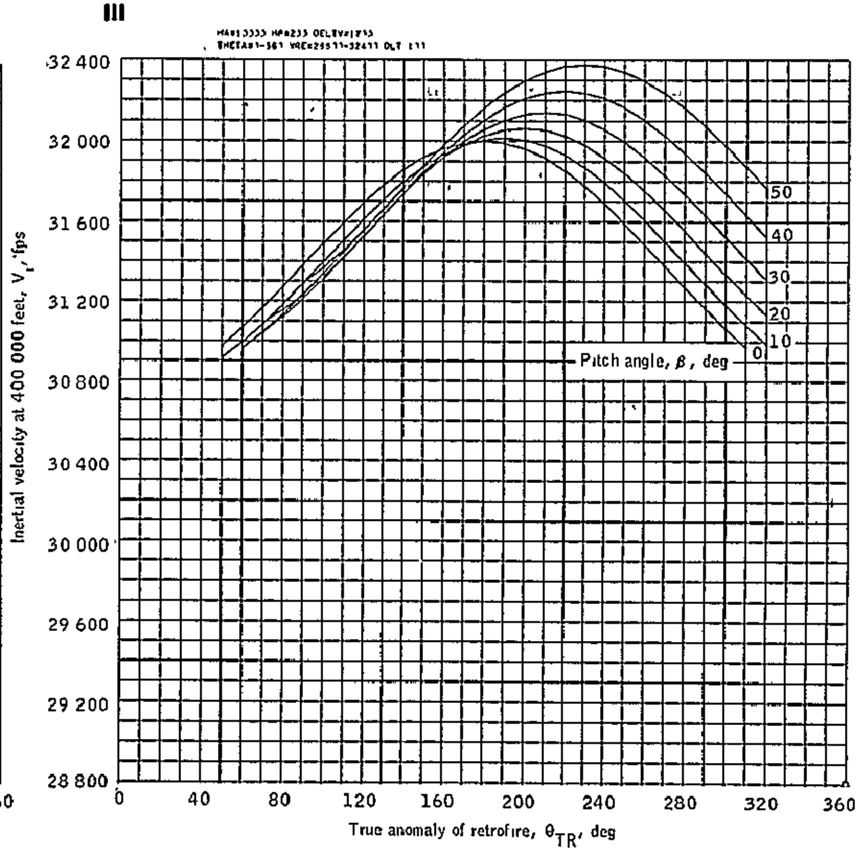
Figure 42.- Continued.



(f) Time from retrofire and central angle for retrograde ΔV = 1300 feet per second.

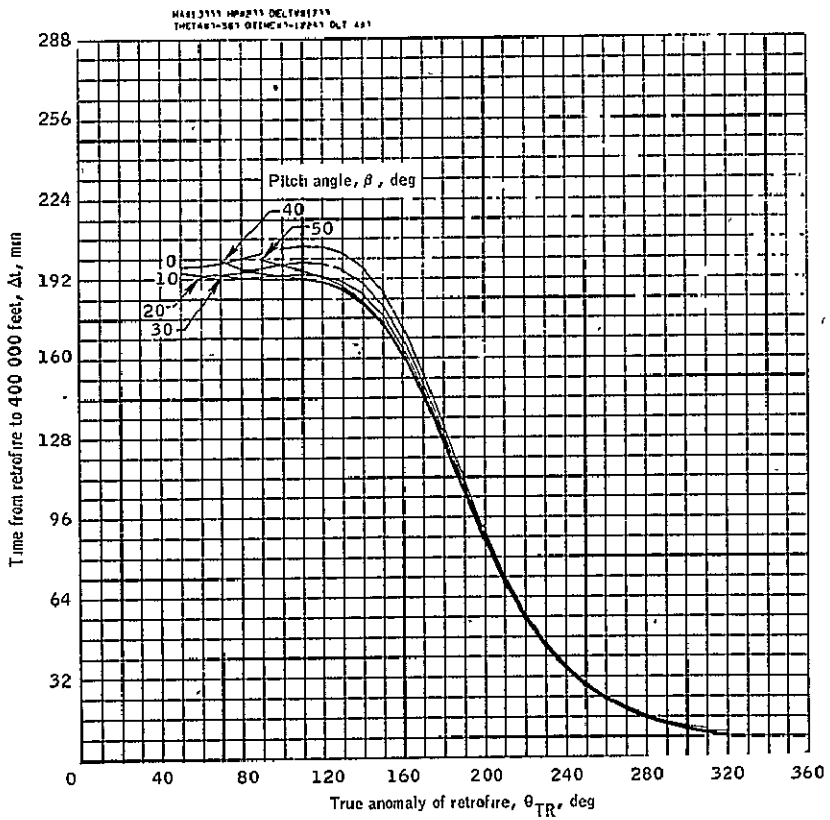
Figure 42.- Continued.

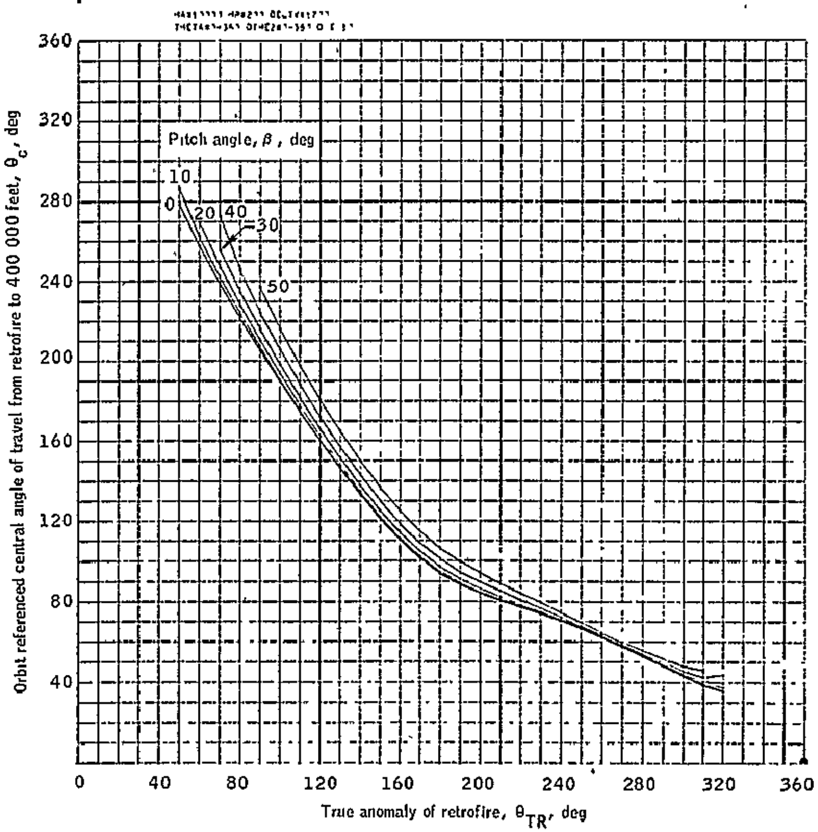




(g) Flight-path angle and velocity for retrograde $\Delta V = 1700$ feet per second.

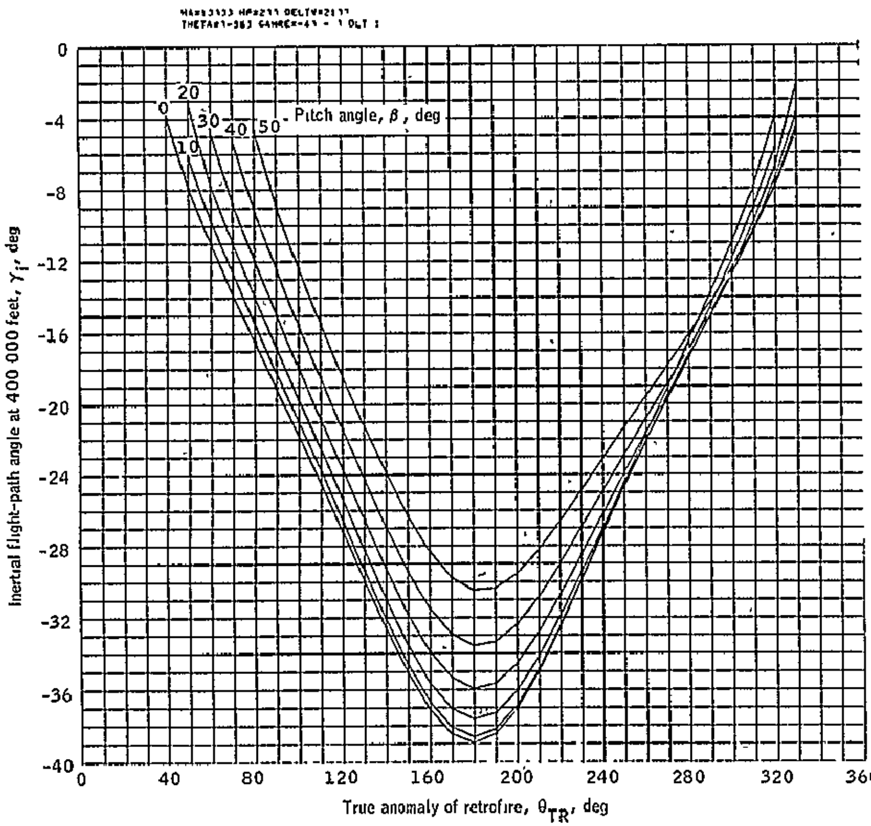
Figure 42.- Continued.

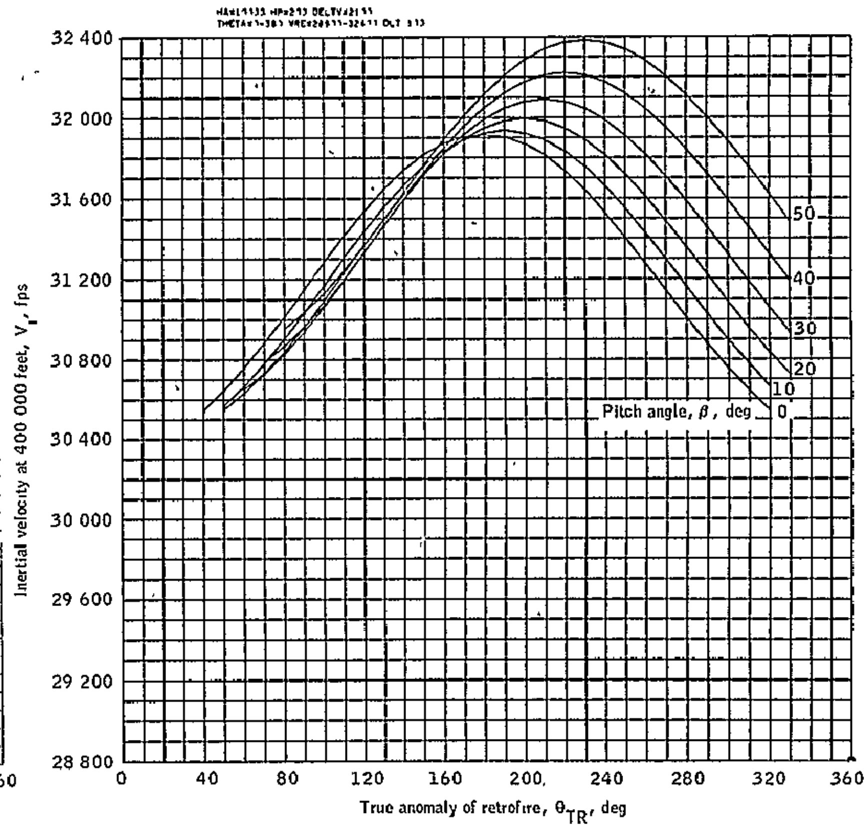




(h) Time from retrograde and central angle for retrograde ΔV = 1700 feet per second.

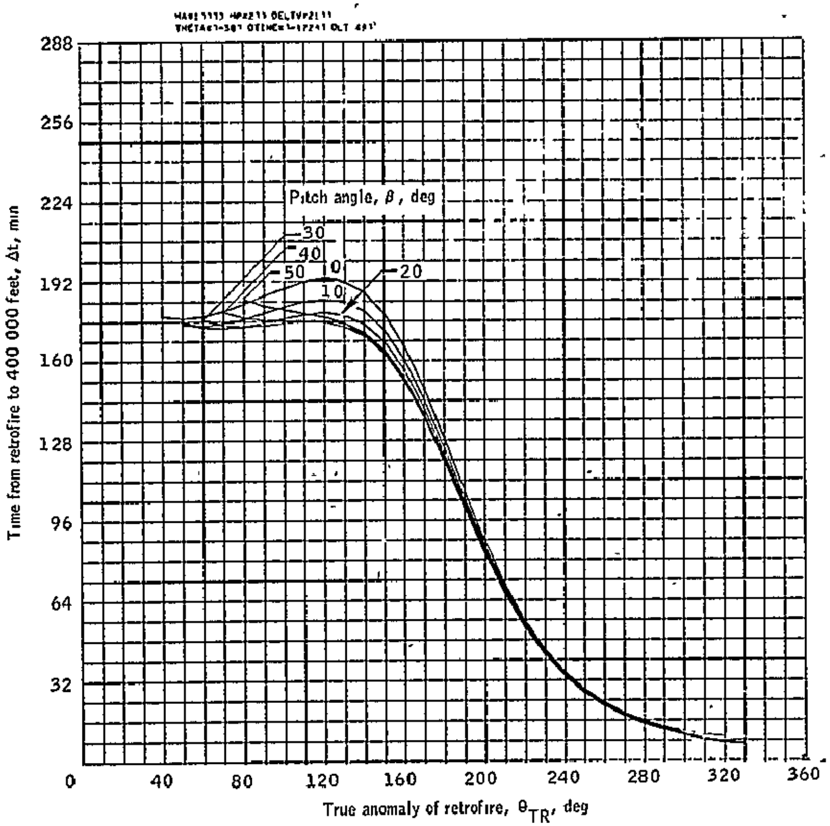
Figure 42.- Continued.

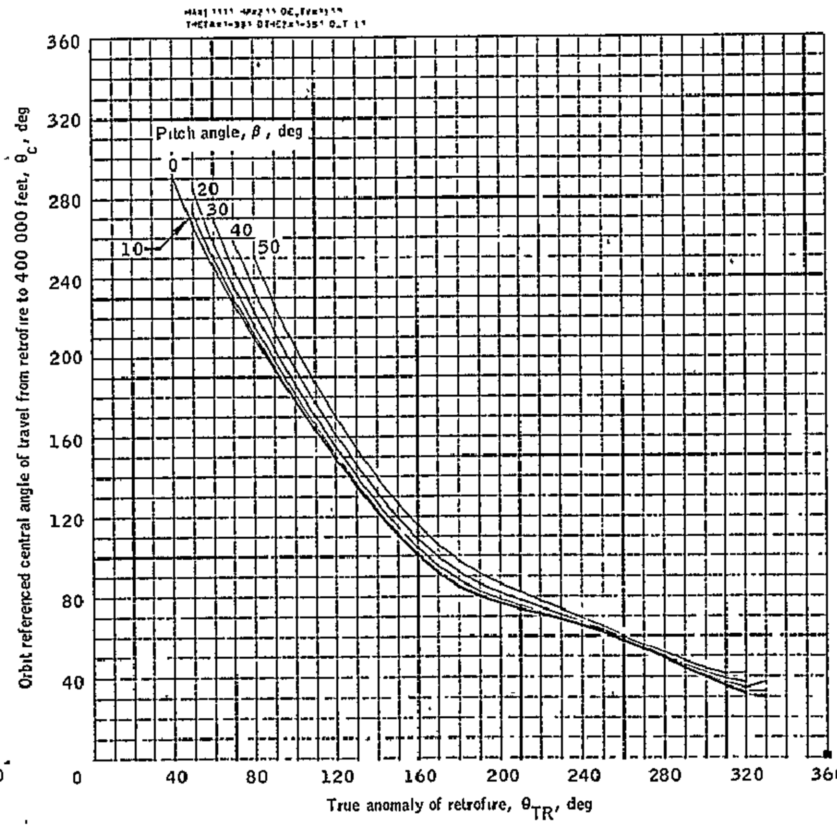




(i) Flight-path angle and velocity for retrograde $\Delta V = 2100$ feet per second.

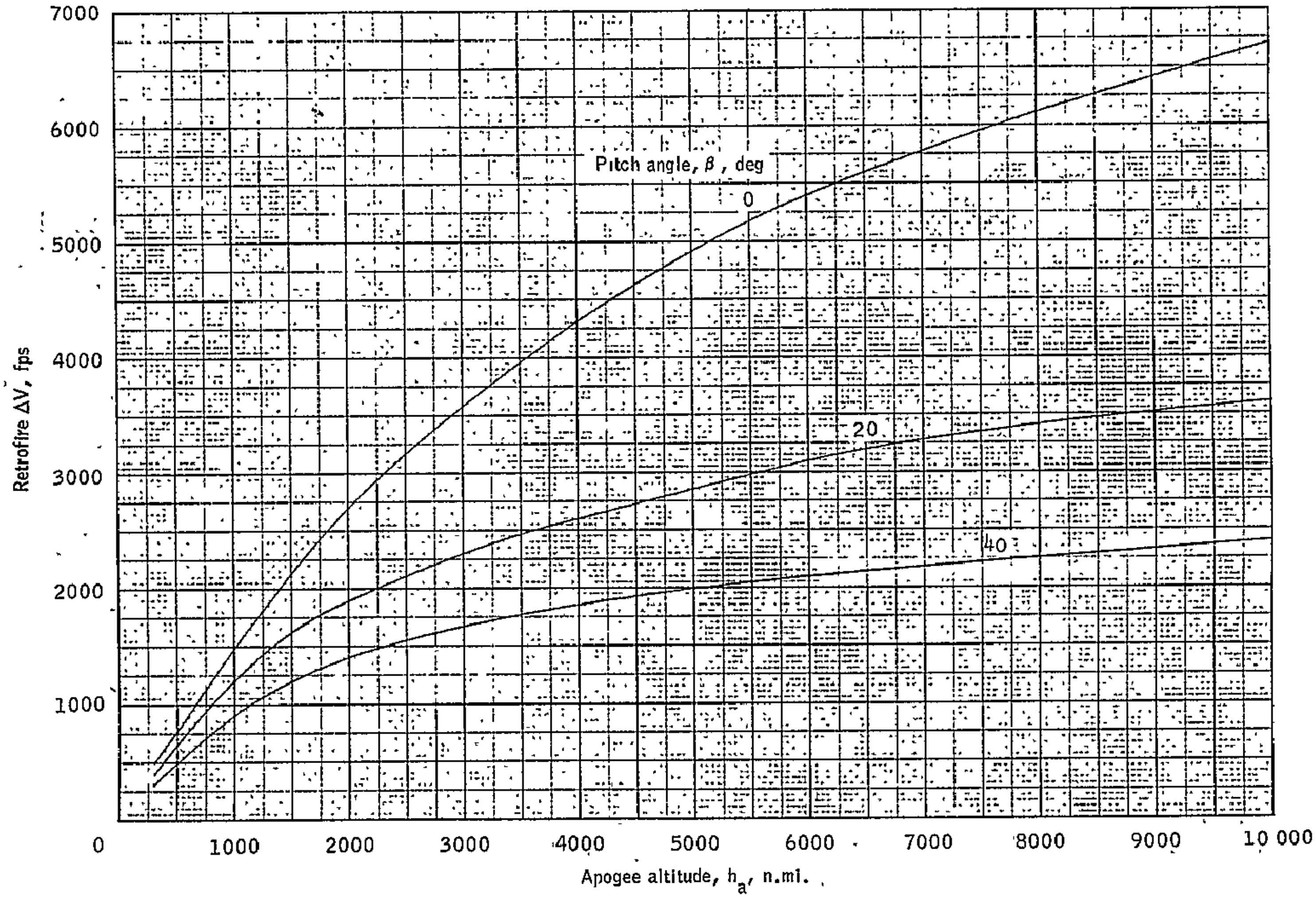
Figure 42.- Continued.





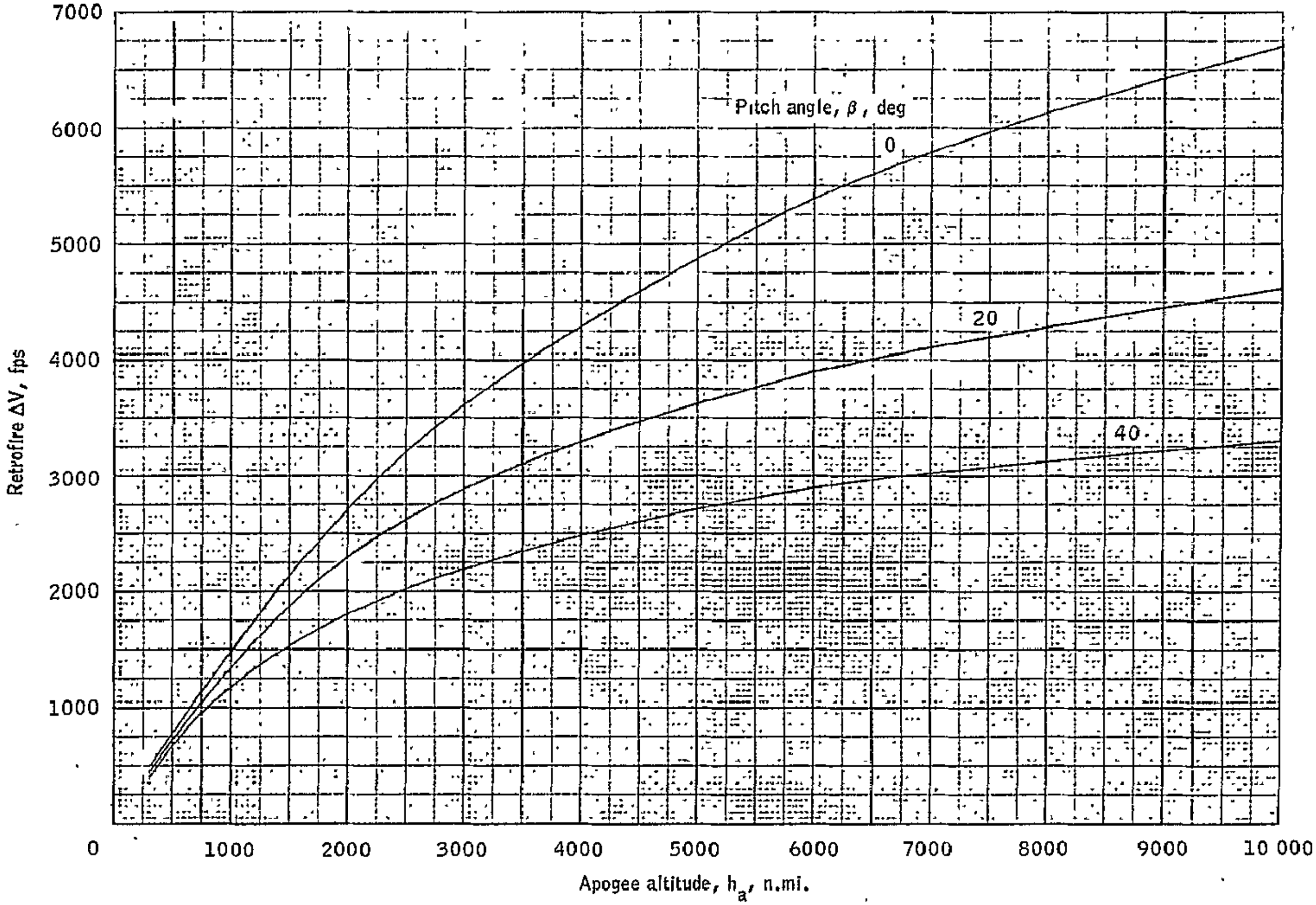
(j) Time from retrograde and central angle for retrograde $\Delta V = 2100$ feet per second.

Figure 42.- Concluded.



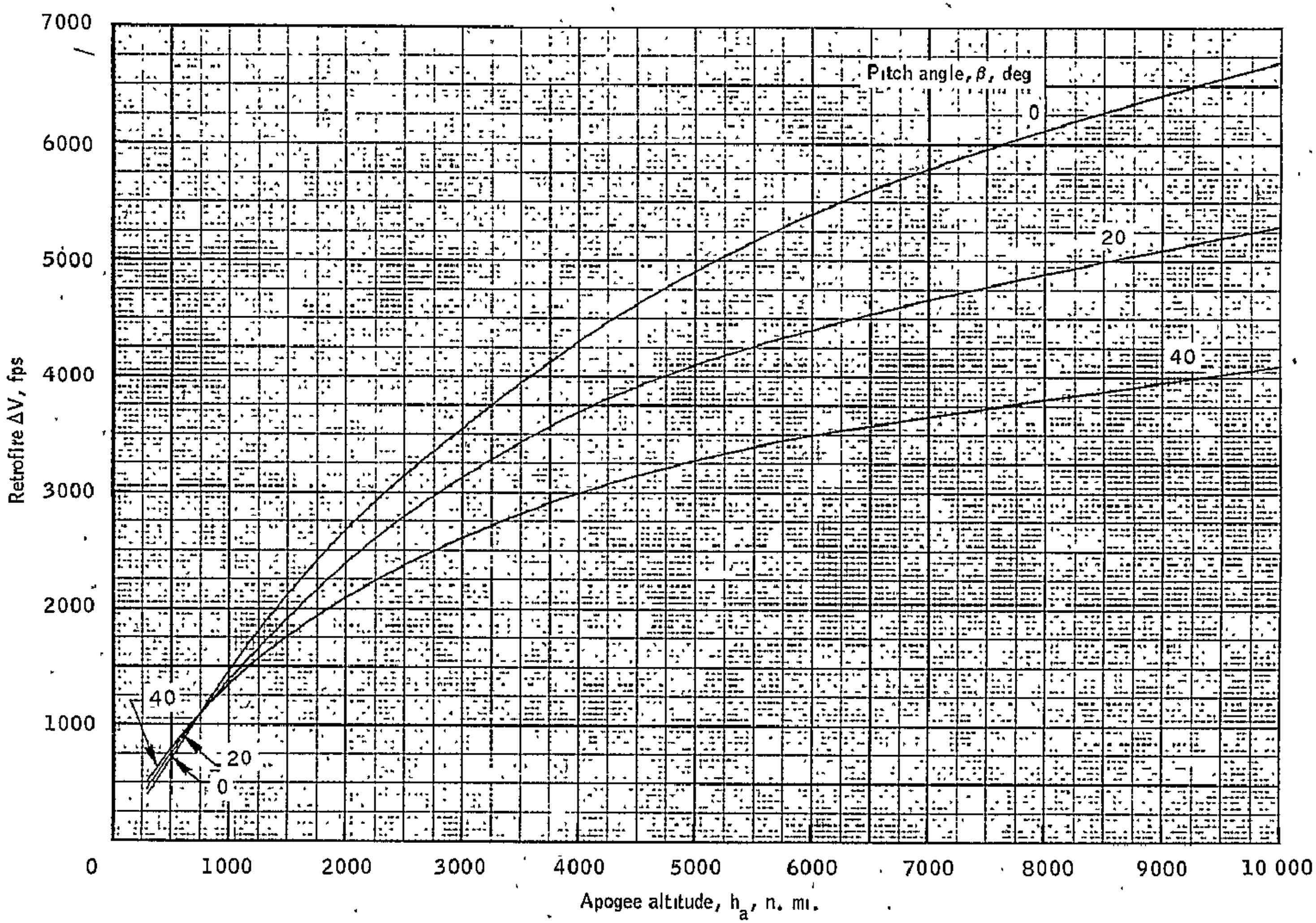
(a) Perigee altitude = 80 nautical miles.

Figure 43.- Minimum ΔV necessary to reenter from perigee as a function of apogee altitude.



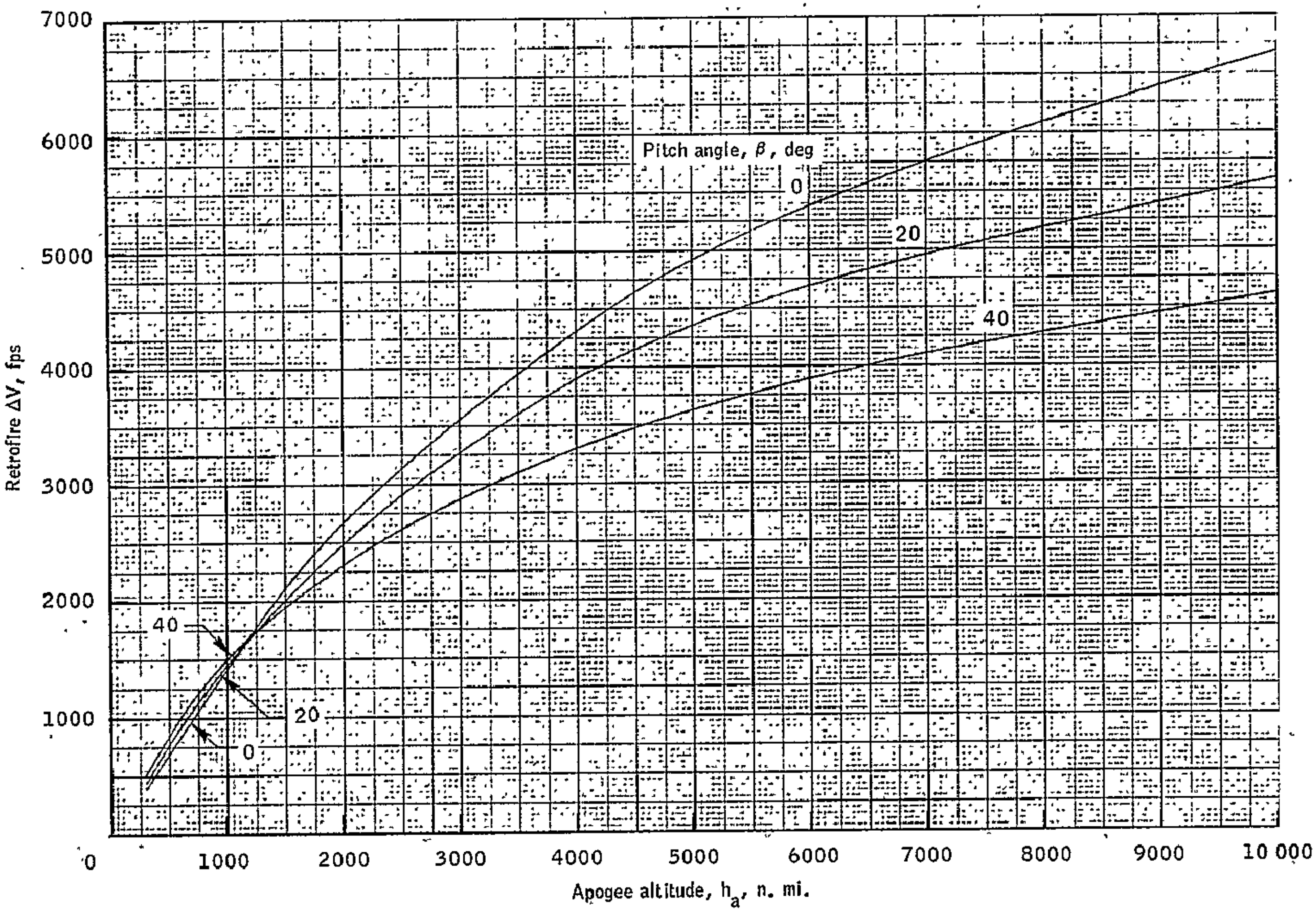
(b) Perigee altitude = 100 nautical miles.

Figure 43.- Continued.



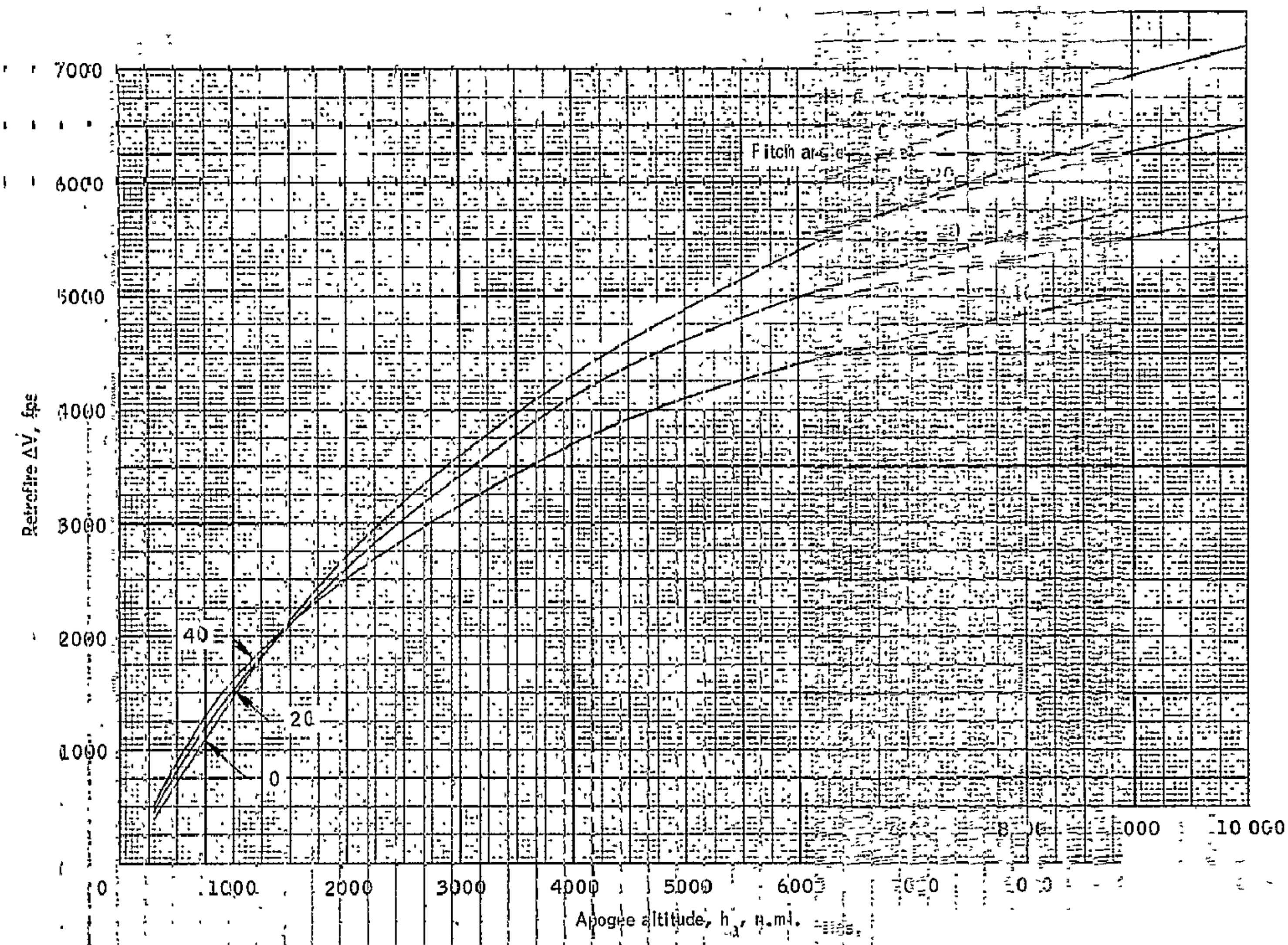
(c) Perigee altitude = 125 nautical miles.

Figure 43.- Continued.



(d) Perigee altitude = 150 nautical miles.

Figure 43.- Continued.



(e) Perigee altitude = 200 nautical miles.

Figure 43.- Concluded.

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