UNCLASSIFIED

AD NUMBER

AD486328

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; Mayy 1966. Other requests shall be referred to Naval Ordnance Laboratory, White Oak, MD.

AUTHORITY

USNSWC ltr., 4 Dec 1974

THIS PAGE IS UNCLASSIFIED

AD-486328

NOL TR-65-230 C.1

NOLTR 65-230

MK 81 & MK 82 BOMB RELEASE CURVES

Do not [illegible] to other activities without [illegible]

RETURN TO
TECHNICAL LIBRARY BRANCH
NAVAL ORDNANCE SYSTEMS COMMAND
Dept. of Navy
Washington 25, D. C., 20360

18 MAY 1966

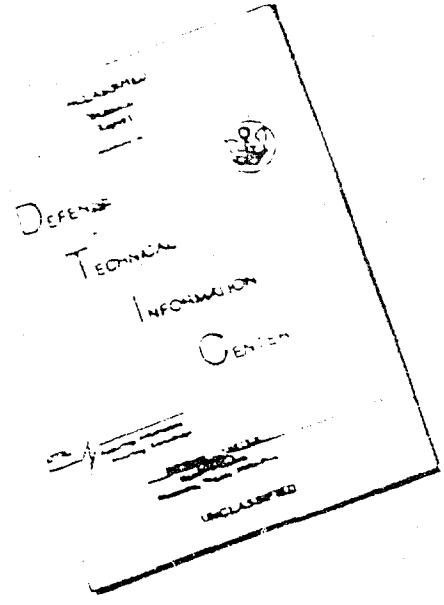
NOL
UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

NOLTR 65-230

Each transmittal of this document outside the agencies of the U. S. Government must have prior approval of NOL.

37

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

REPRODUCED FROM
BEST AVAILABLE COPY

NOLTR 65-230

Mk 81 AND Mk 82 BOMB RELEASE CURVES

Prepared by:
Marvin Kasper
Arthur Wrenn

ABSTRACT: A study was conducted to determine the release envelopes for the Mark 81 and Mark 82 bombs in the retarded and unretarded modes. Release curves are presented for release velocities between 200 and 600 knots. Aircraft pullout limits and line of sight between pilot and target limits are indicated on the release curves. The time of fall of the bomb is also indicated on the curves. The curves presented are not intended to replace the ballistic table but rather to present them in a more usable form for the fuze designer and analyst.

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND 20910

NOLTR 65-230 18 May 1966

Mk 81 and Mk 82 Bomb Release Curves

This report contains the release envelopes for the Mark 81 and Mark 82 bombs in both the retarded and unretarded modes. This work was performed under Bureau of Naval Weapons WEPTASK RM37 73002/212 1/S470 BC 02, Problem Assignment 1, Bomb and Air Rocket Fuze Fleet Support.

J. A. DARE
Commander

R. E. Grantham

R. E. GRANTHAM
By direction

CONTENTS

	Page
INTRODUCTION	1
MATHEMATICAL METHOD	1
EXPLANATION OF GRAPHS	4
REMARKS	9

ILLUSTRATIONS

Figure	Title	Page
1-36	Mark 81 Retarded Release Envelopes	12
37-72	Mark 82 Retarded Release Envelopes	48
73-90	Mark 81 Unretarded Release Envelopes	84
91-108	Mark 82 Unretarded Release Envelopes	102

TABLES

Table	Title	Page
1	Range Correction Table	11

REFERENCES

(a) NWL ltr KEB:PES:jes 8150/B of 2 Jan 1965 to Eglin AFB, Subj: Exterior Ballistic Data for Bomb Mark 81/ Snakeye/ Mech Nose Fuse/ FF, Bomb Mark 82/ Snakeye I/ Mech Nose Fuse/ FF, Chemical Bomb Mark 116 Mod 0

(b) NWL rpt NWL Table No 05-64-011 of May 1964, Ballistic Tables (Interim) for Bomb Mark 81 Mod 1 with Bomb Fin Mark 14 Mod 1/ Retarded (Snakeye 1) Range and Time of Fall Level and Dive

(c) NWL rpt Ballistic Table No 010 of Oct 1964, Bomb Mark 82 Mods 0 & 1 with Bomb Fin Mark 15 Mod 0/ Retarded (Snakeye I), Range and Time of Fall Level and Dive Zero Ejection Velocity

INTRODUCTION

1. The purpose of this study is to aid in the determination of what delivery conditions can be used to hit a target with the Mark 81 and Mark 82 bombs in either the retarded or unretarded modes. The study is also concerned with the tactics that the delivery aircraft uses after releasing the bomb, in that the recovery altitude of the aircraft under a given set of release conditions is also investigated. Several questions which this report attempts to answer are:

a. For a given release velocity, release (dive) angle, and altitude:

(1) At what horizontal distance from the target should the bomb be dropped in order to hit the target?

(2) At what altitude will the aircraft be able to recover from its dive?

(3) What is the time of fall of the bomb?

b. For a given velocity, angle, and pullout recovery altitude:

(1) At what altitude should the bomb be released?

(2) At what horizontal distance from the target should the bomb be dropped?

(3) What is the time of fall of the bomb?

MATHEMATICAL METHOD

2. To determine the release envelopes of a given bomb a set of release conditions, such as release velocity, bomb ejection velocity, and release angle, must first be chosen. An arbitrary set of release altitudes is now selected and under the given release conditions the corresponding time of fall and horizontal distance of bomb travel during fall is determined. To hit a given target, a bomb that is released at one of the arbitrary altitudes must also be at the determined horizontal distance from the target. For a given set of release conditions, the set of release altitudes is plotted against their corresponding horizontal distance from the target. On each graph (Figures 1 through 108) a series of these altitude vs. horizontal distance curves is plotted; one curve for each release (dive) angle.

Time is regarded as a parameter on these release curves. In addition to determining the horizontal distance of bomb travel, the time of fall of the bomb is also determined for each member of the set of release altitudes. By interpolation between these determined values of the time of fall, a point on each release curve for which the bomb will have a given time of fall can be located. In this way constant time of fall curves can be drawn of each graph.

3. For a given altitude the horizontal distance the bomb travels is determined by solving a set of simultaneous differential equations. The equations of motion:

$$\ddot{X} = D\dot{X}$$

$$\ddot{Y} = D\dot{Y} - g$$

where

$\dot{X}$ = the horizontal velocity of the bomb

$\ddot{X}$ = the horizontal acceleration of the bomb

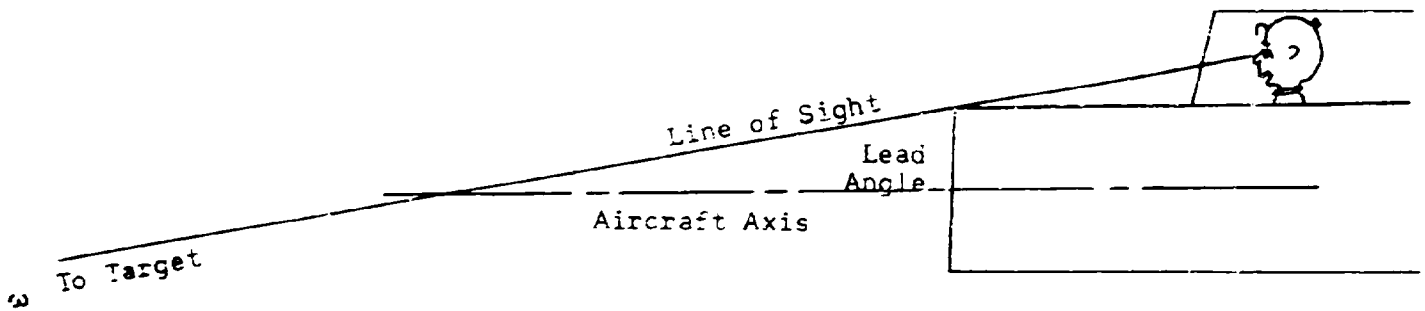
$\dot{Y}$ = the vertical velocity of the bomb

$\ddot{Y}$ = the vertical acceleration of the bomb

are written with the assumption that the only forces acting on the bomb are due to drag (D) and gravity (g). Drag is assumed to be acting in the opposite direction of the velocity vector, and gravity is assumed to be varying with altitude.

4. The drag coefficient of the Mk 81 and Mk 82 bombs in the unretarded mode was obtained from reference (a). The drag coefficient of the Mk 81 and Mk 82 bombs in the retarded mode was obtained from equations in reference (b) and reference (c) respectively. Atmospheric properties are determined by using the 1959 ARDC model atmosphere.

5. Each set of release conditions yields a release curve, and a given release altitude determines a release point on this curve. There exist certain conditions which limit the release altitudes and as a result restrict the possible release points to a segment of the release curve. One of these conditions is the lead angle which is the limiting angle between the line of sight from the pilot to the target and the aircraft axis. (See following illustration.) Each release curve may have at most one limit point induced by the lead angle. By joining the lead angle limit points we can obtain a curve of


Line of Sight
Lead
Angle
Aircraft Axis
To Target

limit points corresponding to this lead angle. If the release angle is sufficiently large, the release curve corresponding to this release angle and all release curves for larger release angles will not have lead angle limit points.

6. Another limiting conditions on each release curve is the recovery altitude of the aircraft for a given pullout. The release altitude A corresponding to pullout at altitude H is calculated by the following equations: (See following illustration.)

$$A = V \cdot T \cdot \sin \Phi + D + H$$

where

V = release velocity of the bomb, i.e., aircraft velocity

T = the delay in time when the pilot initiates pullout and when pullout actually begins

Φ = release angle

D = the loss in altitude during pullout which is given by the following equation:

$$D = \frac{V^2}{32.0} \left(\frac{1}{G-1} - \frac{\cos \Phi}{G - \cos \Phi} \right)$$

where

G = number of g's experienced by the pilot during pullout.

The range corresponding to release at altitude A is determined by interpolation on the release curve. By joining the limit points on each release curve corresponding to a recovery altitude H a pullout curve can be determined for a given set of release velocity, ejection velocity, and number of g's during pullout. By using different values of H, a series of pullout curves can be plotted on each graph.

EXPLANATION OF GRAPHS

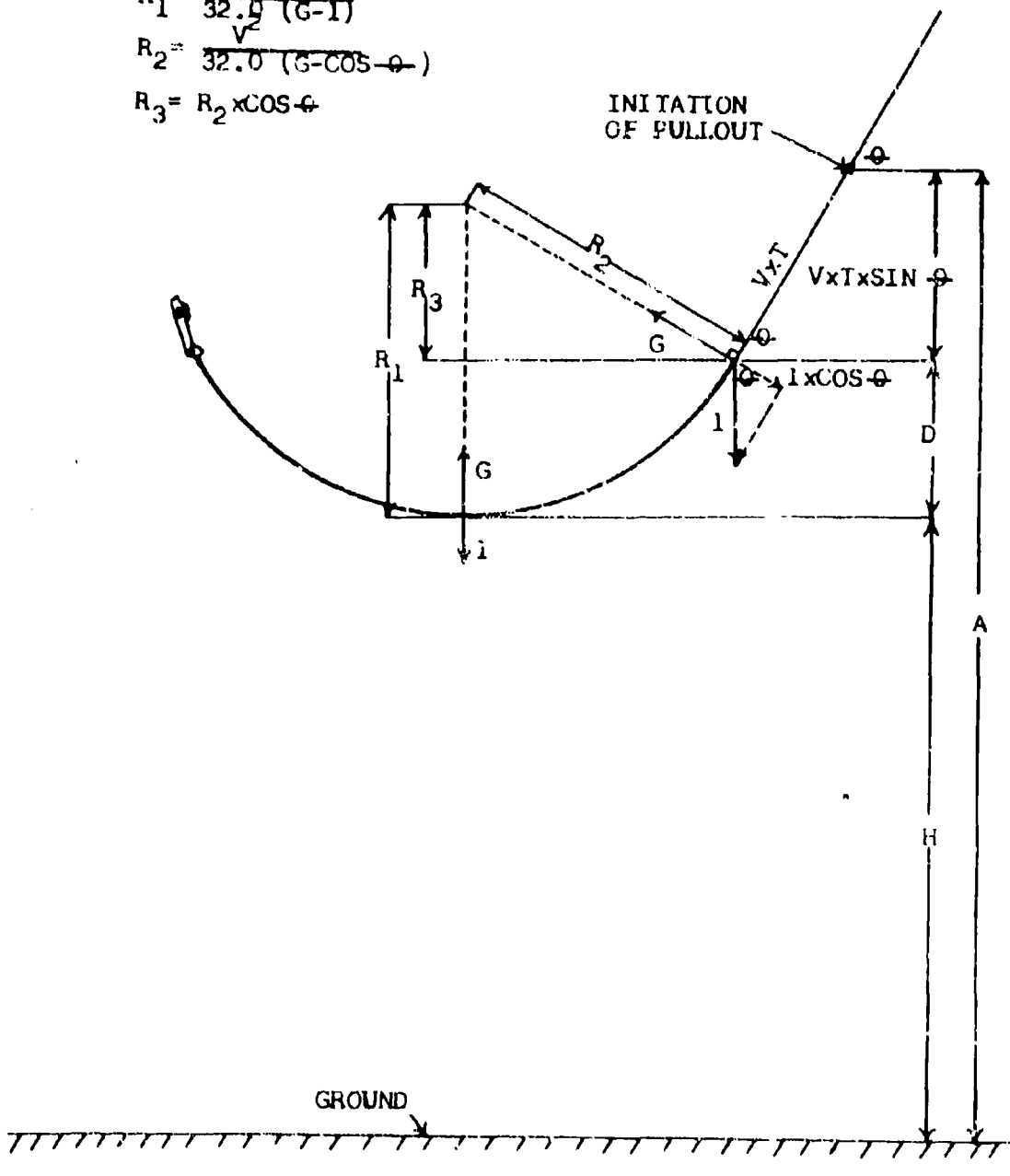
7. The release curves for the Mk 81 and Mk 82 bombs are given for release velocities (speeds) varying from 200 to 600 knots in 50-knot increments and for 2.0g and 4.0g pullout. Release curves are given for ejection velocities of 0 and 10 fps in the retarded mode and for 10 fps only in the free fall (unretarded) mode. Figures 1-36 are the Mk 81 retarded release curves, Figures 37-72 are the Mk 82 retarded release curves, Figures 73-90 are the Mk 81 unretarded release curves, and Figures 91-108 are the Mk 82 unretarded release curves.

$D = R_1 - R_2 \times \cos\theta$

$R_1 = \frac{V^2}{32.0\,(G-1)}$

$R_2 = \frac{V^2}{32.0\,(G-\cos\theta)}$

$R_3 = R_2 \times \cos\theta$



8. There is an error in Figures 1-72. On these curves the point corresponding to a release angle of 0 degree and a release altitude of 50 feet is incorrect. Table 1 is a table of corrections for these graphs. The values of horizontal range in this table should be used instead of the points indicated on the graphs for 50-foot altitude and 0-degree angle and the segment of the 0-degree release curve between 0 and 100-foot altitude should be adjusted to account for the corrected value.

9. On a given graph there are 5 variables that are considered: release angle, release altitude, horizontal distance of bomb travel, time of fall, and pullout altitude. If 2 of these variables are known the other 3 can be determined. On the graphs it is assumed that pullout is initiated as soon as the bomb is released and that there is a 2.25-second delay between the time when the pilot initiates pullout and when pullout actually begins. The best way to explain how the curves are to be used is through several illustrative examples.

a. Example 1:

Given:

(1) Bomb - Mk 82

(2) Mode - retarded

(3) Ejection velocity - 10 fps

(4) Release velocity (speed) - 450 knots

(5) Release angle - 20 degrees

(6) Release altitude - 1200 feet

Find:

(1) Horizontal distance of bomb travel

(2) Time of fall of the bomb

(3) Minimum recovery altitude for a 2.0g and 4.0g pullout.

Given quantities (1) through (4) indicate that Figure 60 or 69 should be used. Figure 60 corresponds to 2.0g pullout, Figure 69 to 4.0g pullout. We locate the point on the 20-degree dive angle curve which corresponds to a 1200-foot

release altitude. The horizontal distance (range) the bomb will trabel is 2235 feet. The time of fall is between the big dash lines representing 5 and 6 seconds or approximately 5.7 seconds. Using Figure 60 it can be seen that the recovery altitude during a 2.0g pullout is less than zero, for no pull-out recovery altitude curves intersect the 20-degree curve; therefore, for a 2.0g pullout this run cannot be made. For a 4.0g pullout Figure 69 is used and the minimum altitude during pullout; i.e., the pullout recovery altitude, is approximately 145 feet. If one desired to pullout at a greater altitude, i.e., 200 feet, this drop could not be made at 1200 feet.

b. Example 2:

Given:

(1) Bomb Mk 81

(2) Mode - retarded

(3) Ejection velocity - 0 fps

(4) Release velocity (speed) - 300 knots

(5) Release angle - 10 degrees

(6) Safe arming time of the fuze - 5 seconds

Find:

(1) Minimum release altitude so that the bomb will hit the target and be armed before impact

(2) Recovery altitude for the aircraft using 2.0g and 4.0g pullout.

Given quantities (1) through (4) indicate that Figure 3 or Figure 12 should be used. Using Figure 3 the intersection of the 5-second time-of-fall curve and the 10-degree dive angle release curve is located. The bomb can be dropped from any altitude above 560 feet; i.e., 560 feet is the minimum release altitude that can be used to hit the target and have the bomb fuze armed before impact. Using Figure 3 the recovery altitude corresponding to this minimum release altitude of 560 feet is determined to be 125 feet for a 2.0g pullout and using Figure 12 determined to be 310 feet for a 4.0g pullout.

c. Example 3:

Given:

(1) Bomb - Mk 82

(2) Mode - unretarded, free fall

(3) Ejection velocity - 10 fps

(4) Aircraft speed (release velocity) - 450 knots

(5) Release (dive) angle - 50 degrees

(6) Safe-arming time - 6 seconds

Find:

(1) Minimum release altitude so that the bomb will hit the target and be armed before impact

(2) Recovery altitude for the aircraft using 2.0g and 4.0g pullout.

Using Figure 96 the release altitude is approximately 4000 feet. The pullout recovery altitude corresponding to this altitude for a 2.0g pullout is non-existent, for the 50-degree release curve does not intersect any 2.0g pullout curve at a time below 6 seconds; therefore, the aircraft will not be able to pullout from this dive. Using Figure 105, again there is no intersection of the 50-degree release curve and the pullout recovery curves below the intersection of the 6-second curve and the 50-degree release curve. It can be seen from Figure 105 that the 200-foot pullout recovery altitude intersects the 50-degree release curve at 4100-foot altitude; therefore, if the bomb is dropped at this altitude or higher and 4.0g pullout initiated immediately on bomb release the aircraft will have a pullout recovery altitude of at least 200 feet and this drop can be made. For a 2.0 g pullout since no minimum pullout curve intersects the 50-degree curve in Figure 96 all that can be said is that the drop will have to be made above 10,000 feet with no indication given as to how far above 10,000 feet.

d. Example 4:

Given:

(1) Bomb - Mk 81

(2) Mode - unretarded

(3) Ejection velocity - 10 fps

(4) Release velocity - 200 knots

(5) Release angle - 30 degrees

(6) Safe arming time of fuze - 5 seconds

Find:

(1) Minimum release altitude so that the bomb will hit the target and be armed before impact

(2) The recovery altitude of the aircraft corresponding to the minimum release altitude using 2.0g and 4.0g pullout

(3) The maximum altitude at which the bomb can be dropped and hit the target and the pilot see the target at release if the line of sight to target is limited by a lead angle of 16 degrees

Using Figure 73 to locate the intersection of the 5-second time of fall curve and the 30-degree release curve, the minimum altitude at which the bomb can be dropped, hit the target, and arm is determined to be 1250 feet. The recovery altitude using 2.0g pullout is below 200 feet so this may be an unsafe drop. Using Figure 82 the recovery altitude for 4.0g pullout is approximately 650 feet. Using either Figure 73 or Figure 82 the intersection of the 16-degree sight curve, which is indicated by long and short dashes, and the 30-degree release angle curve is located at 2050-foot altitude. For release altitudes greater than 2050 feet the pilot would not be able to see the target at the time of release. Assume the dive had been made at 60 degrees, the 16-degree sight limit curve and the 60-degree release curve do not intersect; therefore, at any point on the 60-degree release curve up to an altitude of 10,000 feet the pilot can see the target.

REMARKS

10. The release curves presented in this report are based on a mathematical model which was programmed for the IBM 7090 computer. The matematical model presented here is similar to one used at the Naval Weapons Laboratory (NWL), Dahlgren, Va. The program uses data processed by the NWL from drop tests conducted at the Naval Ordnance Test Station, China Lake, California.

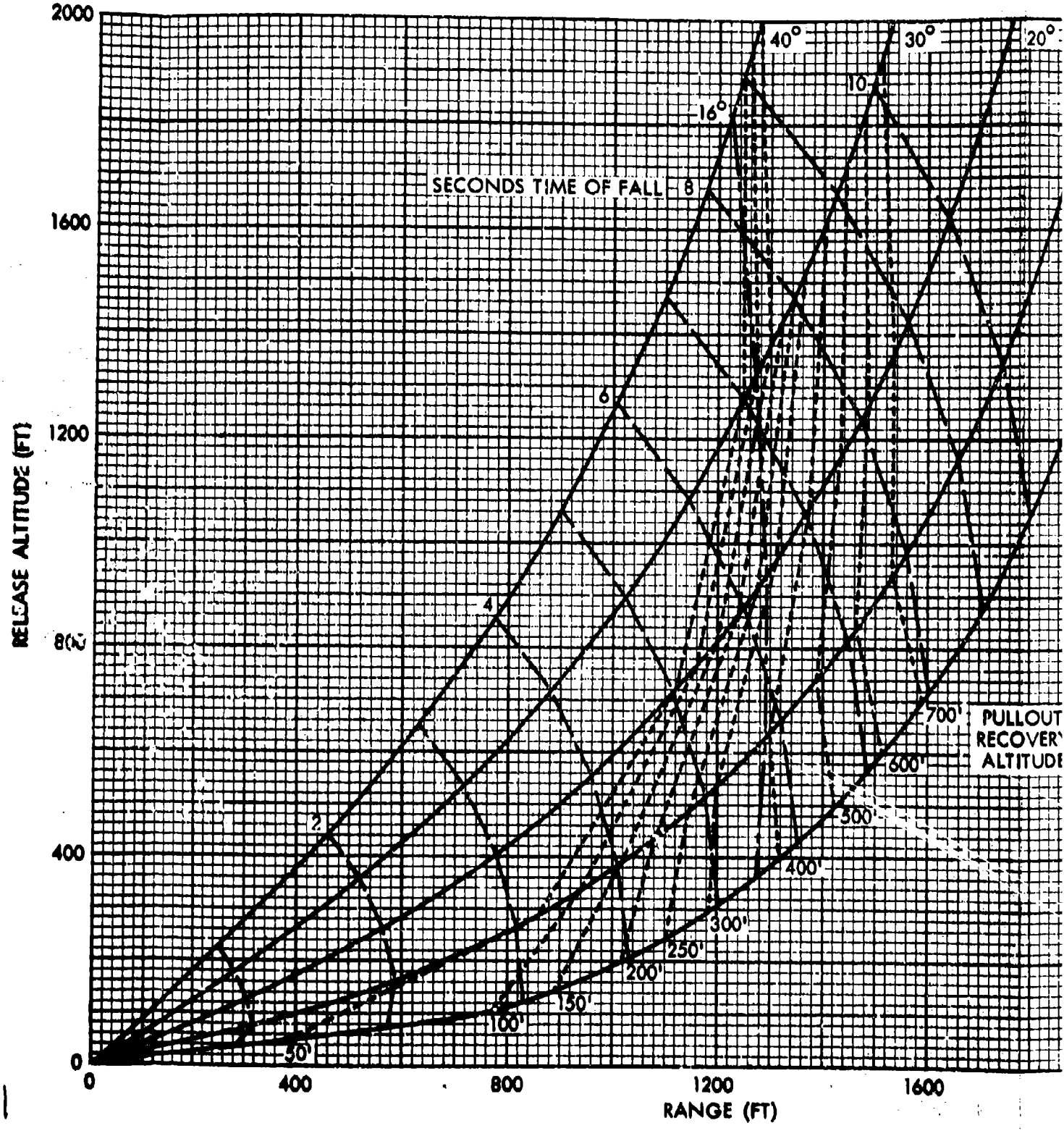
11. The curves presented here are not intended to replace the ballistic tables but rather to present them in a more usable

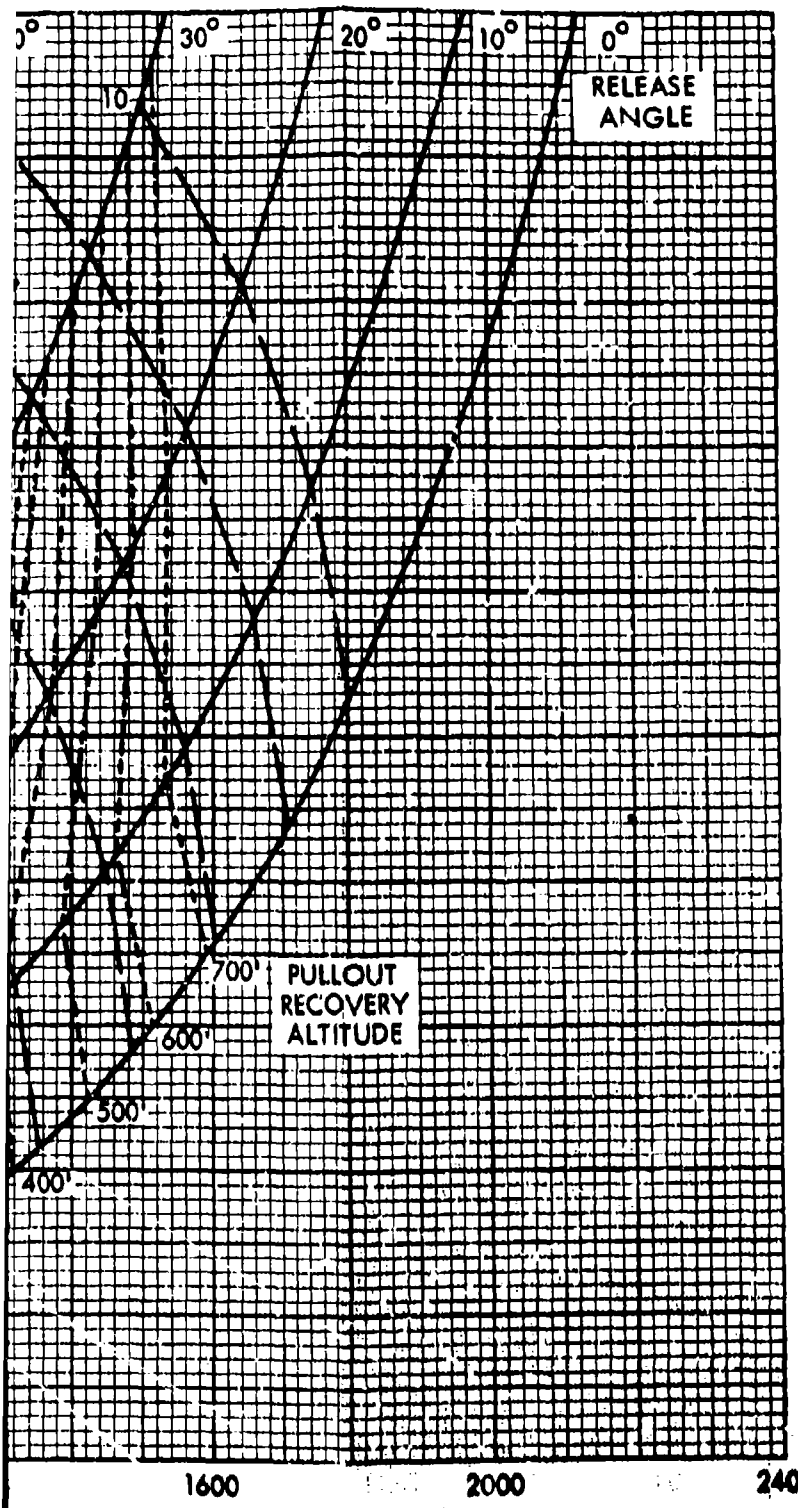
form. Changes in drag of the weapon, pilot reaction time and aircraft pullout characteristics are the major areas where inaccuracies could be introduced, but unless there are radical changes, the curves will still be usable.

TABLE 1

RANGE CORRECTION TABLE
(50-FOOT ALTITUDE, 0-DEGREE RELEASE ANGLE, RETARDED MODE)

Release Velocity (knots)	Mk 81 Range Ejection Velocity 0 fps (feet)	Mk 81 Range Ejection Velocity 10 fps (feet)	Mk 82 Range Ejection Velocity 0 fps (feet)	Mk 82 Range Ejection Velocity 10 fps (feet)
200	568	480	574	486
250	700	591	710	602
300	827	700	892	716
350	949	805	969	826
400	1064	900	1091	933
450	1173	1003	1206	1034
500	1273	1095	1316	1134
550	1365	1182	1445	1255
600	1450	1266	1512	1316


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
40°
30°
20°
16°
10
SECONDS TIME OF FALL
8
6
4
2
700'
600'
500'
400'
300'
250'
200'
150'
100'
50'
PULLOUT
RECOVERY
ALTITUDE



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

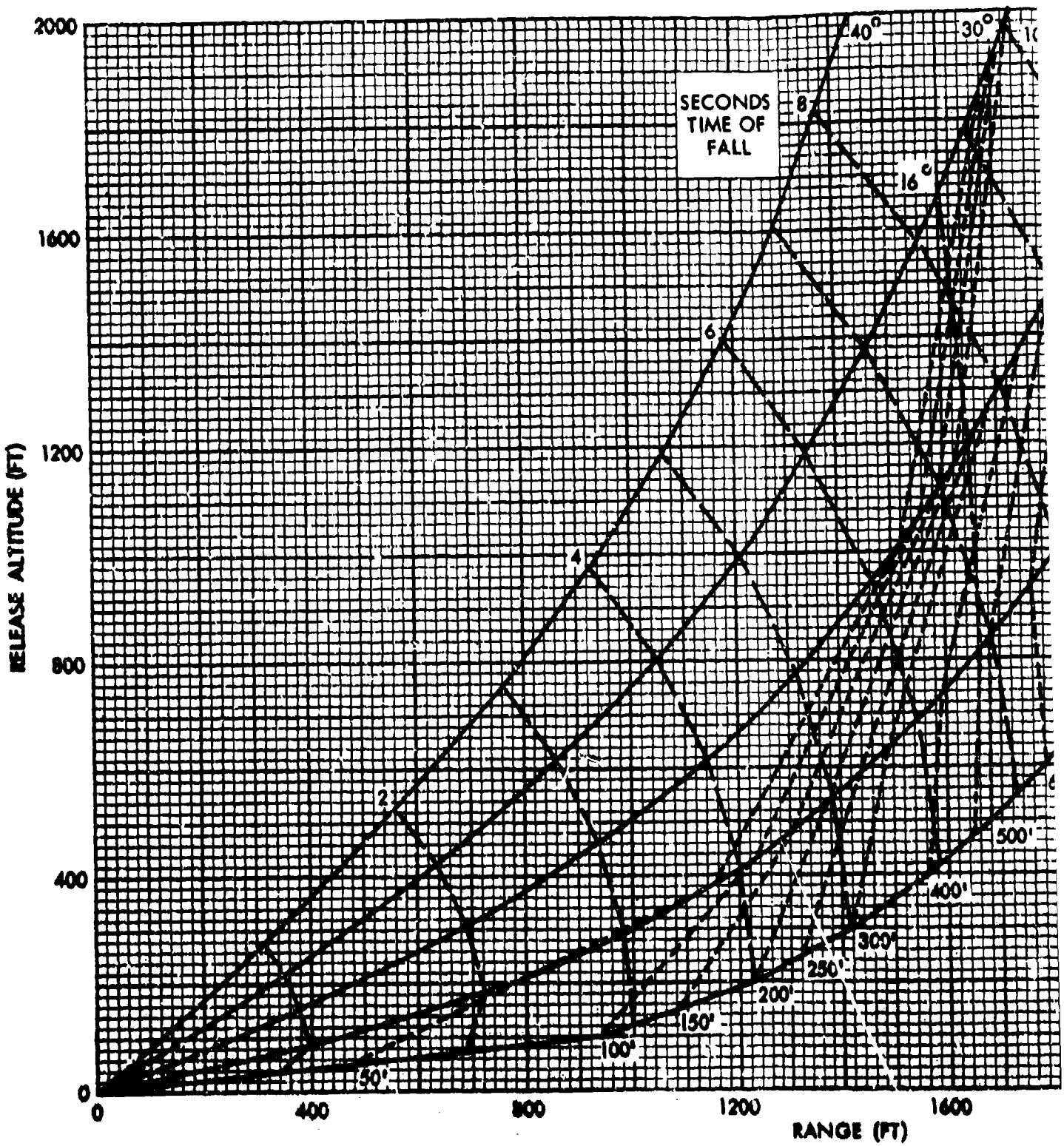
— — — CONSTANT TIME OF FALL CURVE

———— 16° SIGHT ANGLE LIMIT CURVE

200 KNOTS RELEASE VELOCITY

2.0g PULLOUT

FIG. 1 MK 81/RETARDED EJ VEL O FPS


SECONDS TIME OF FALL
40°
30°
16°
8
6
4
2
500'
400'
300'
250'
200'
150'
100'
50'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)

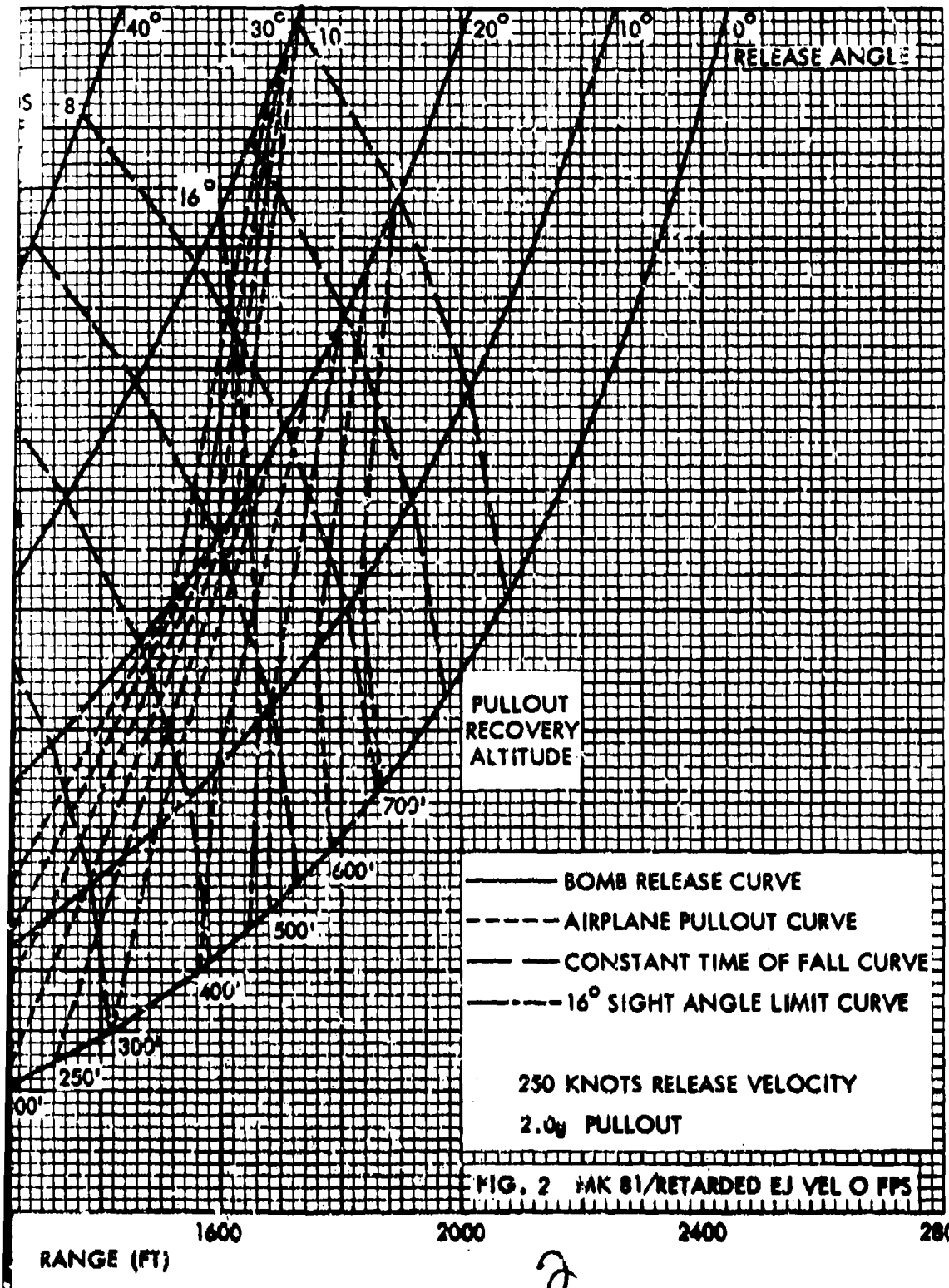
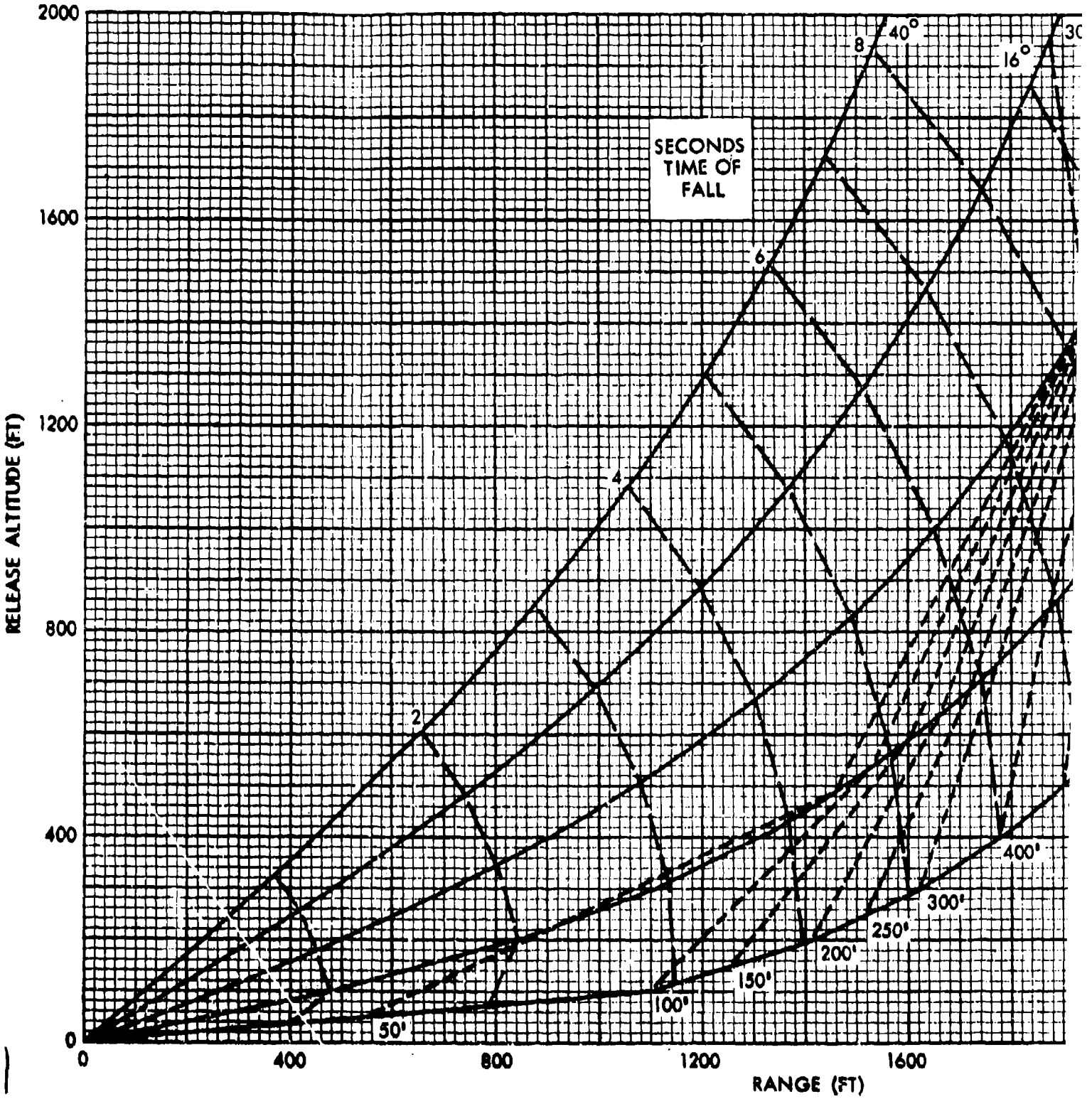
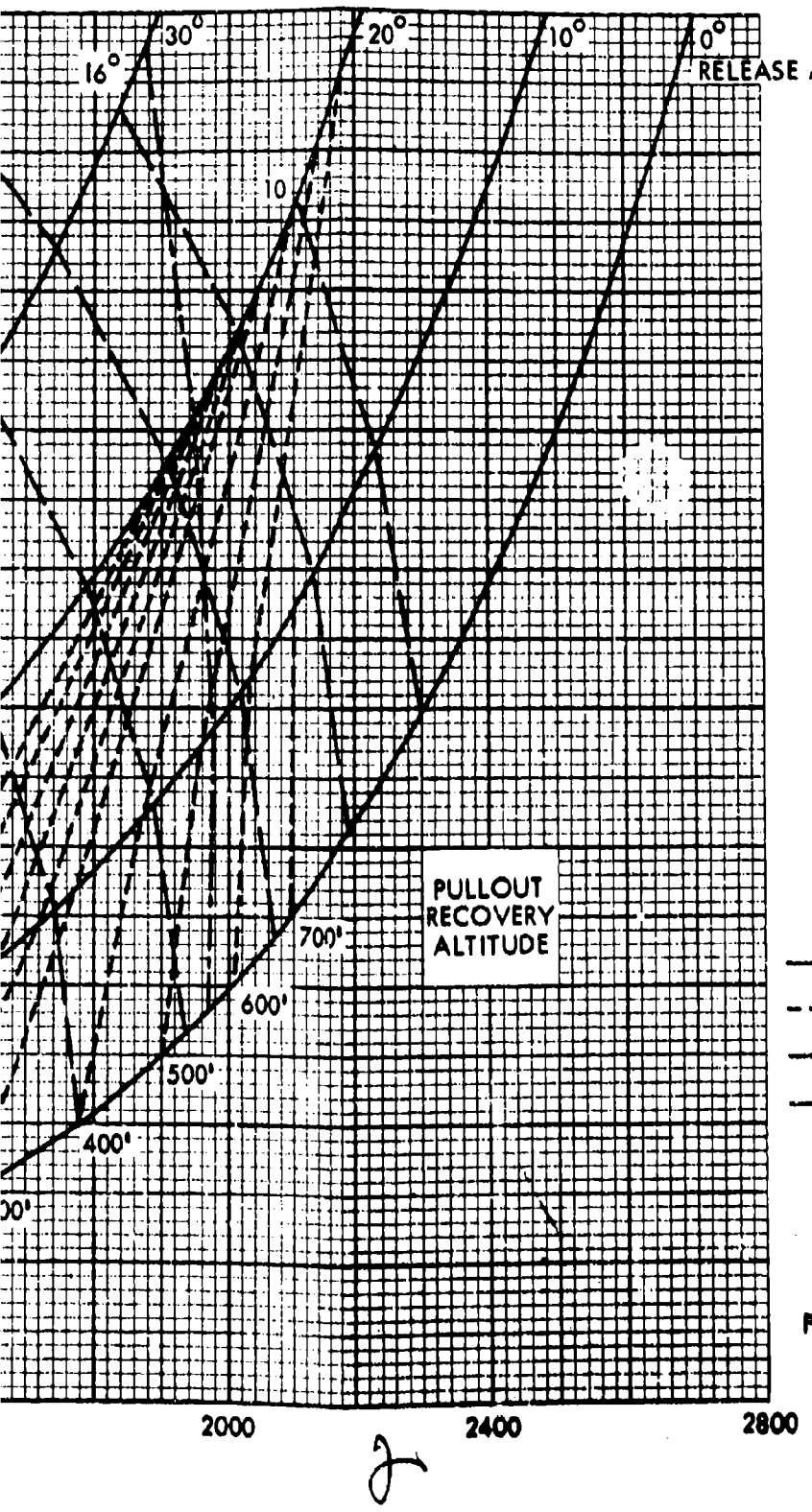


FIG. 2 MK 81/RETARDED EJ VEL O FPS

2


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
8
40°
16°
50'
100'
150'
200'
250'
300'
400'



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

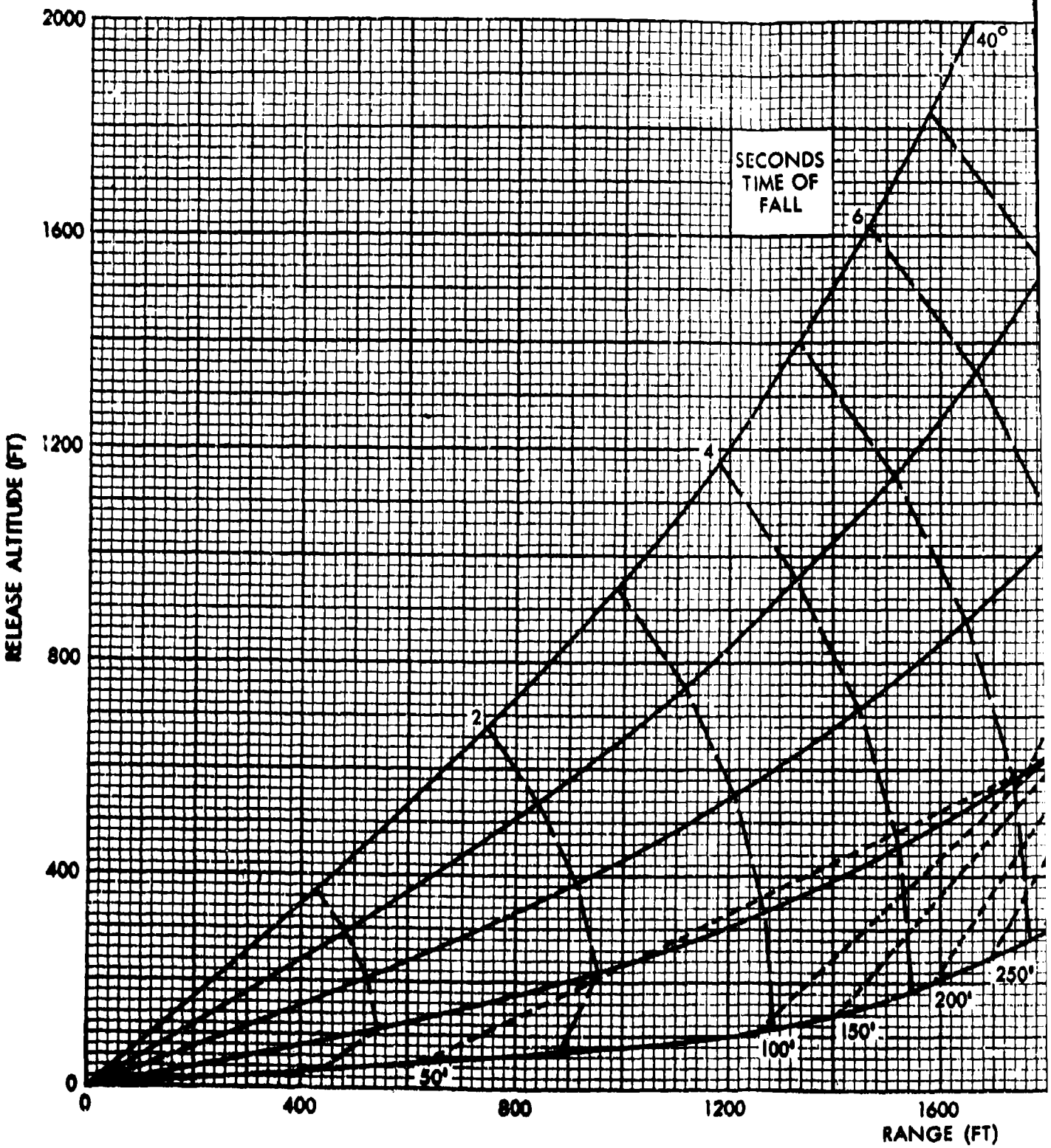
—— —— CONSTANT TIME OF FALL CURVE

——·—— 16° SIGHT ANGLE LIMIT CURVE

300 KNOTS RELEASE VELOCITY

2.0g PULLOUT

FIG. 3 MK 81/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS
TIME OF
FALL
6
4
2
40°
250'
200'
150'
100'
50'

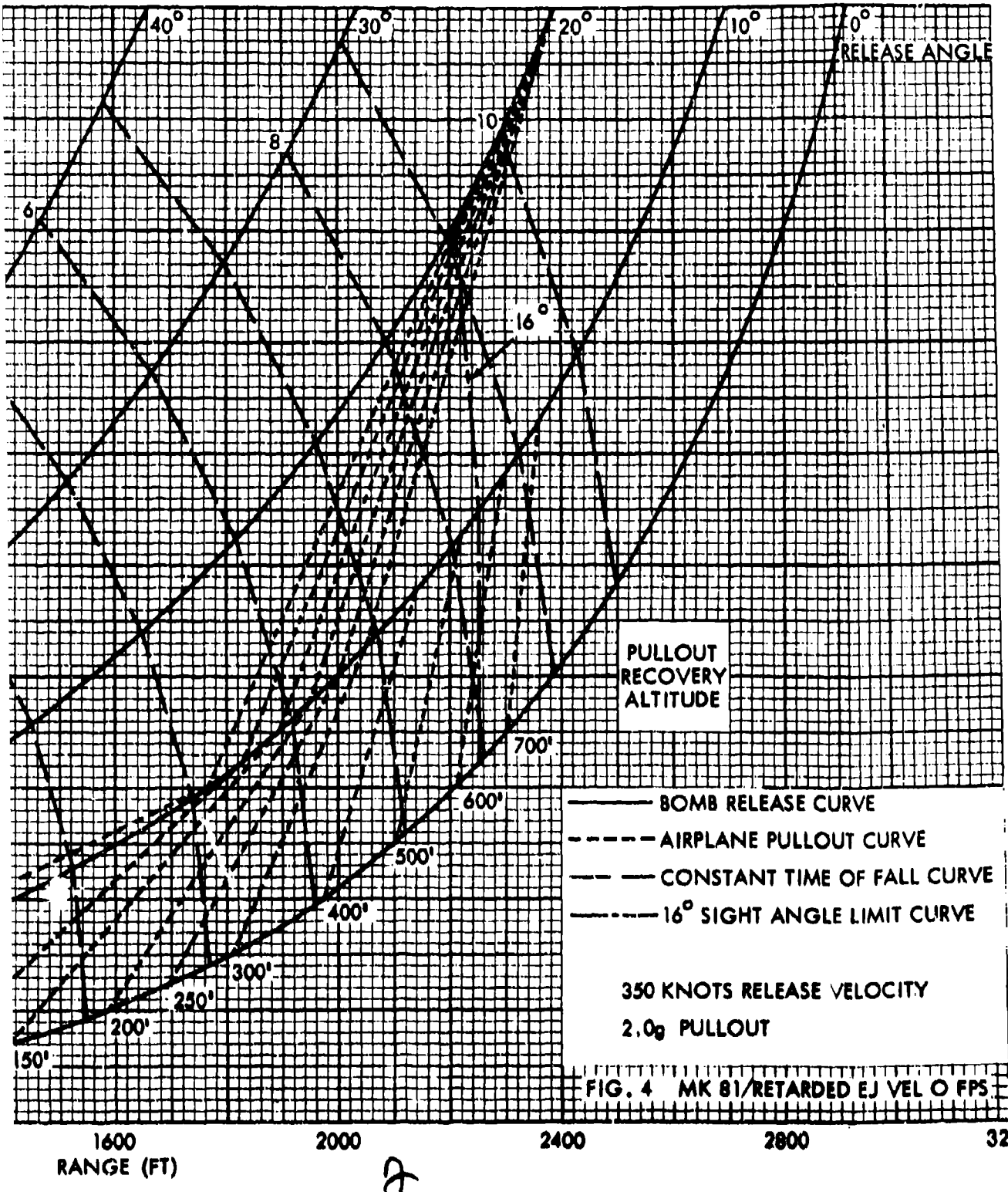
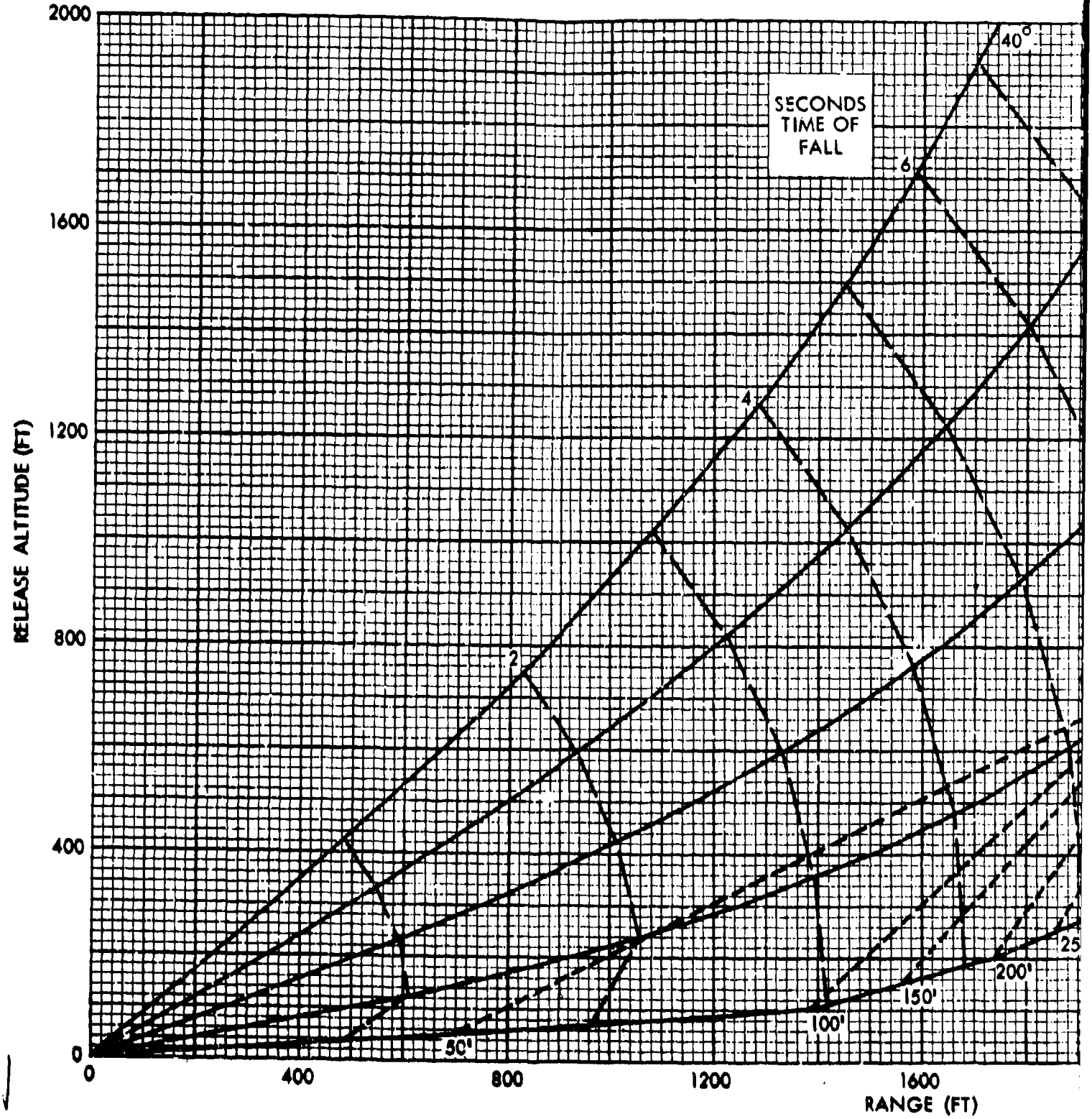
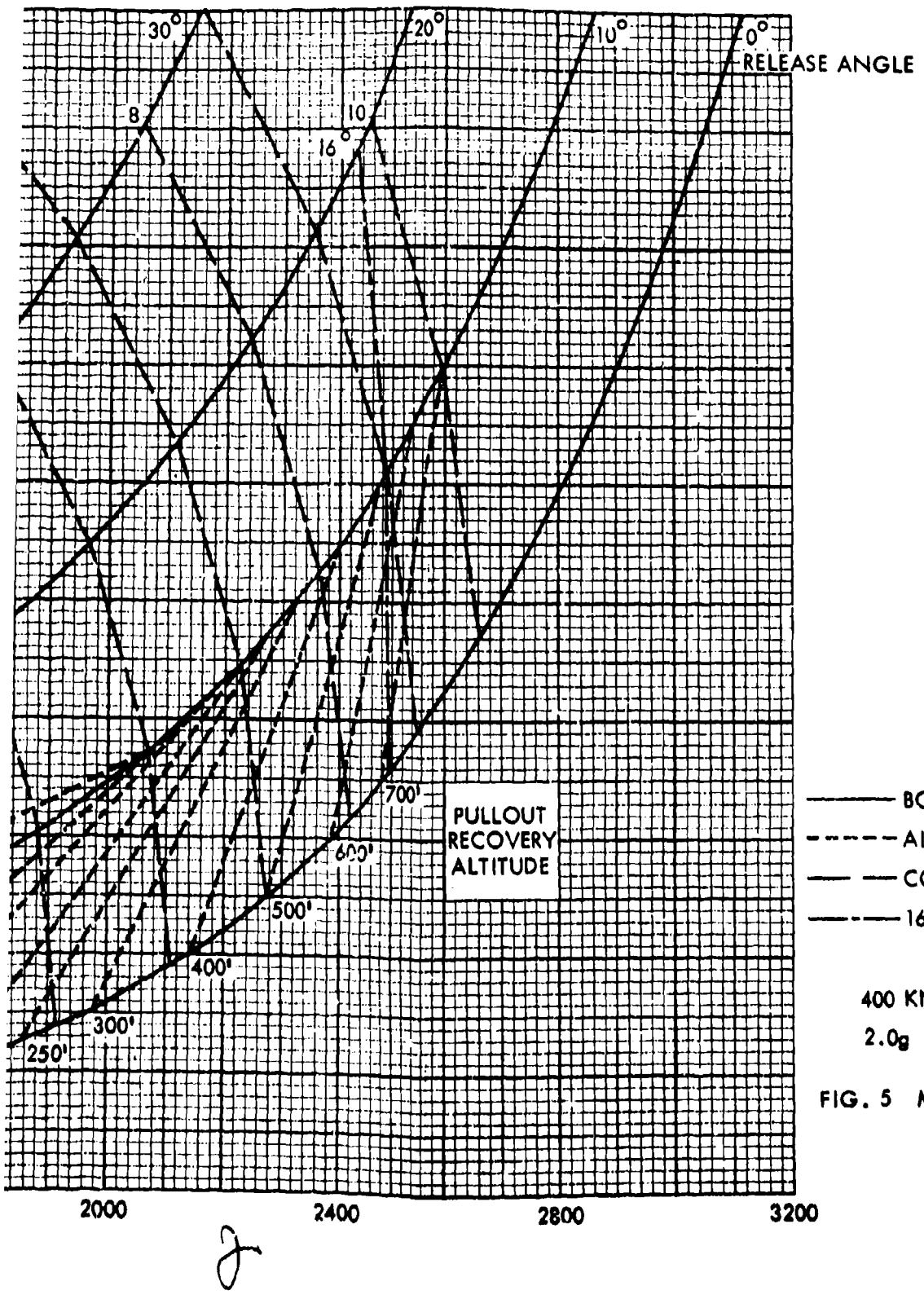


FIG. 4 MK 81/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS
TIME OF
FALL
40°
6
4
2
25
200'
150'
100'
50'



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

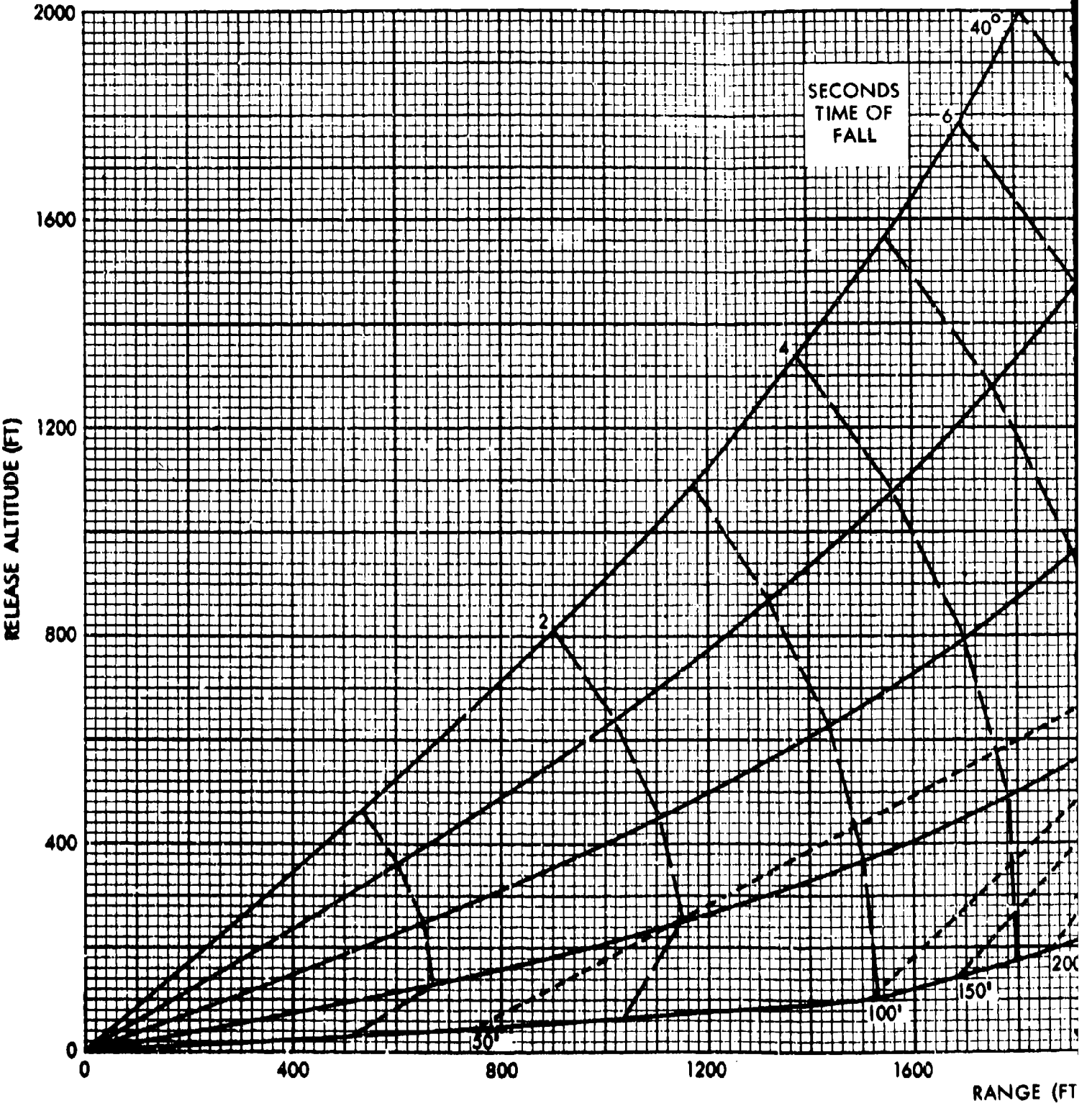
— — CONSTANT TIME OF FALL CURVE

——·—— 16° SIGHT ANGLE LIMIT CURVE

400 KNOTS RELEASE VELOCITY

2.0g PULLOUT

FIG. 5 MK 81/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT
SECONDS
TIME OF
FALL
40°
6
4
2
50'
100'
150'
200

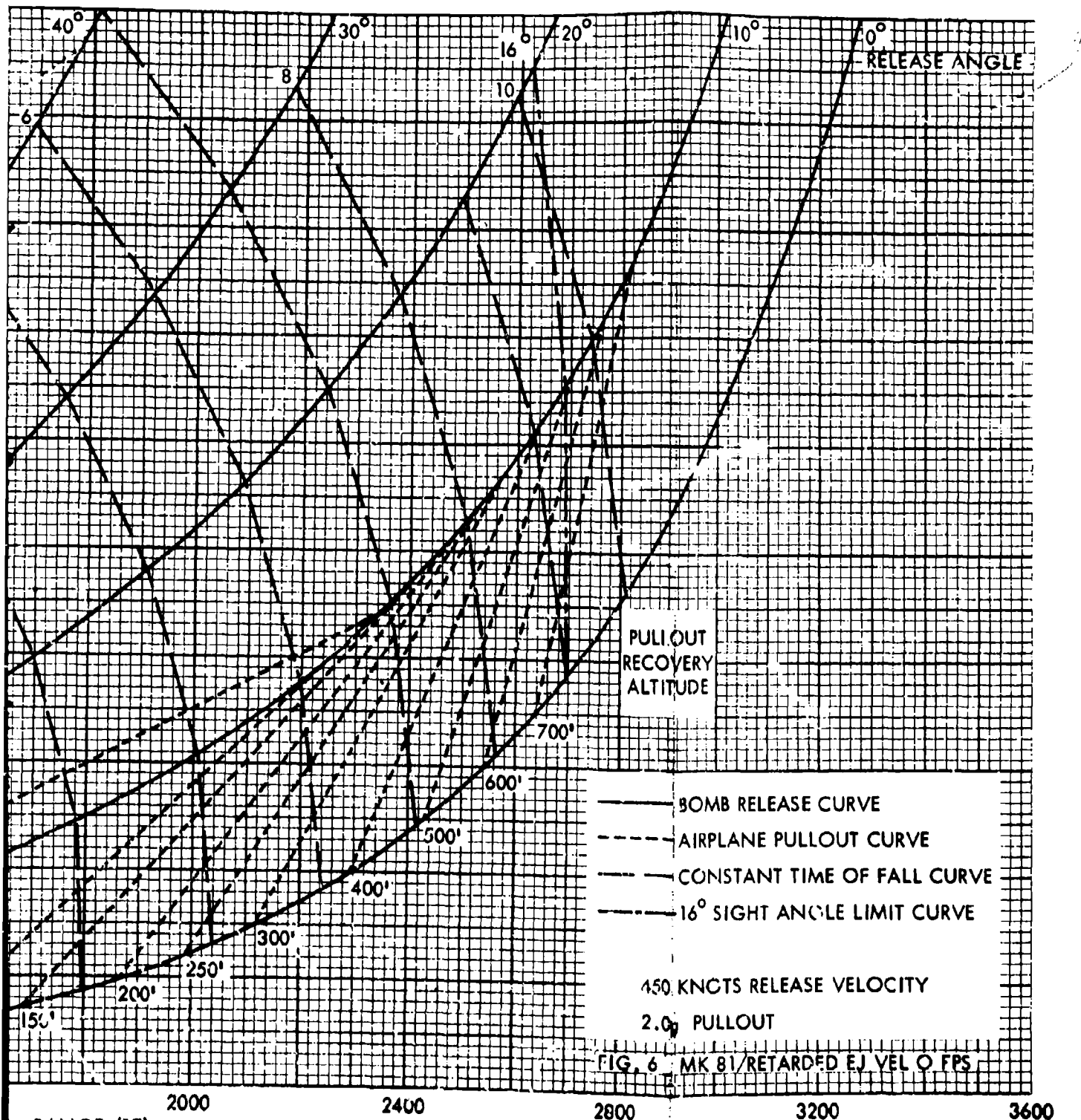
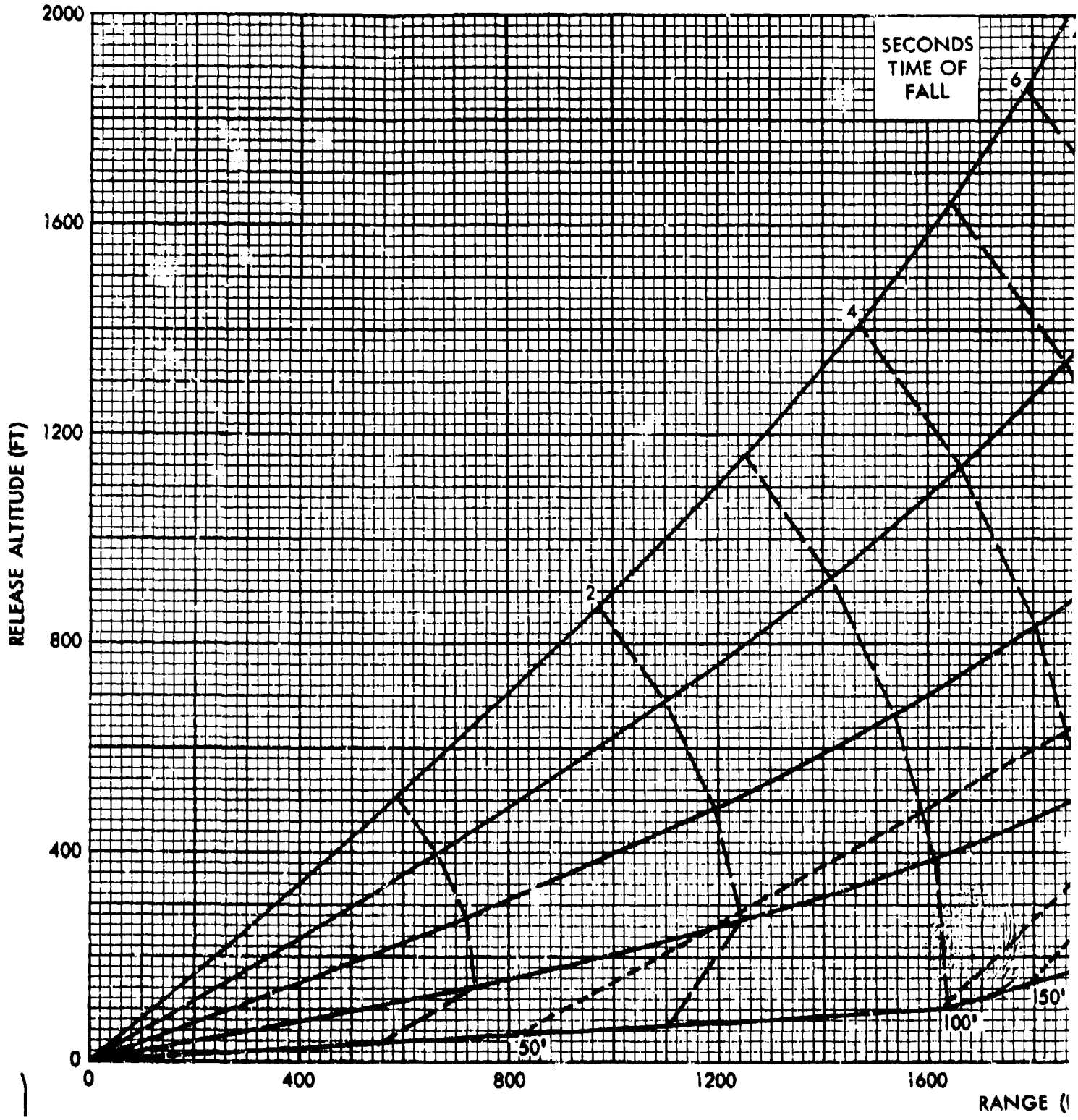


FIG. 6 MK 81/RETARDED EJ VEL 0 FPS


SECONDS
TIME OF
FALL
6
4
2
50'
100'
150'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (

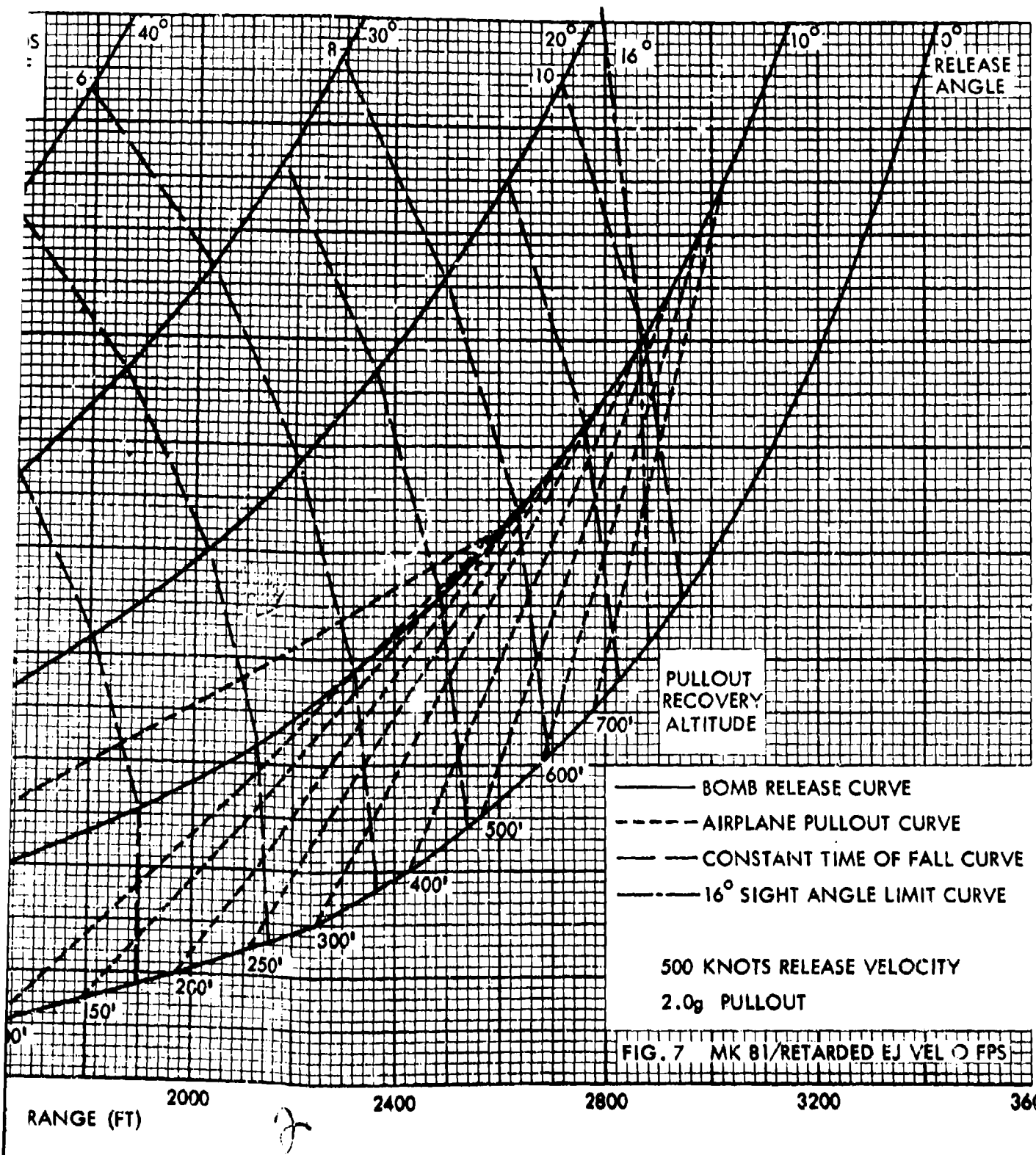
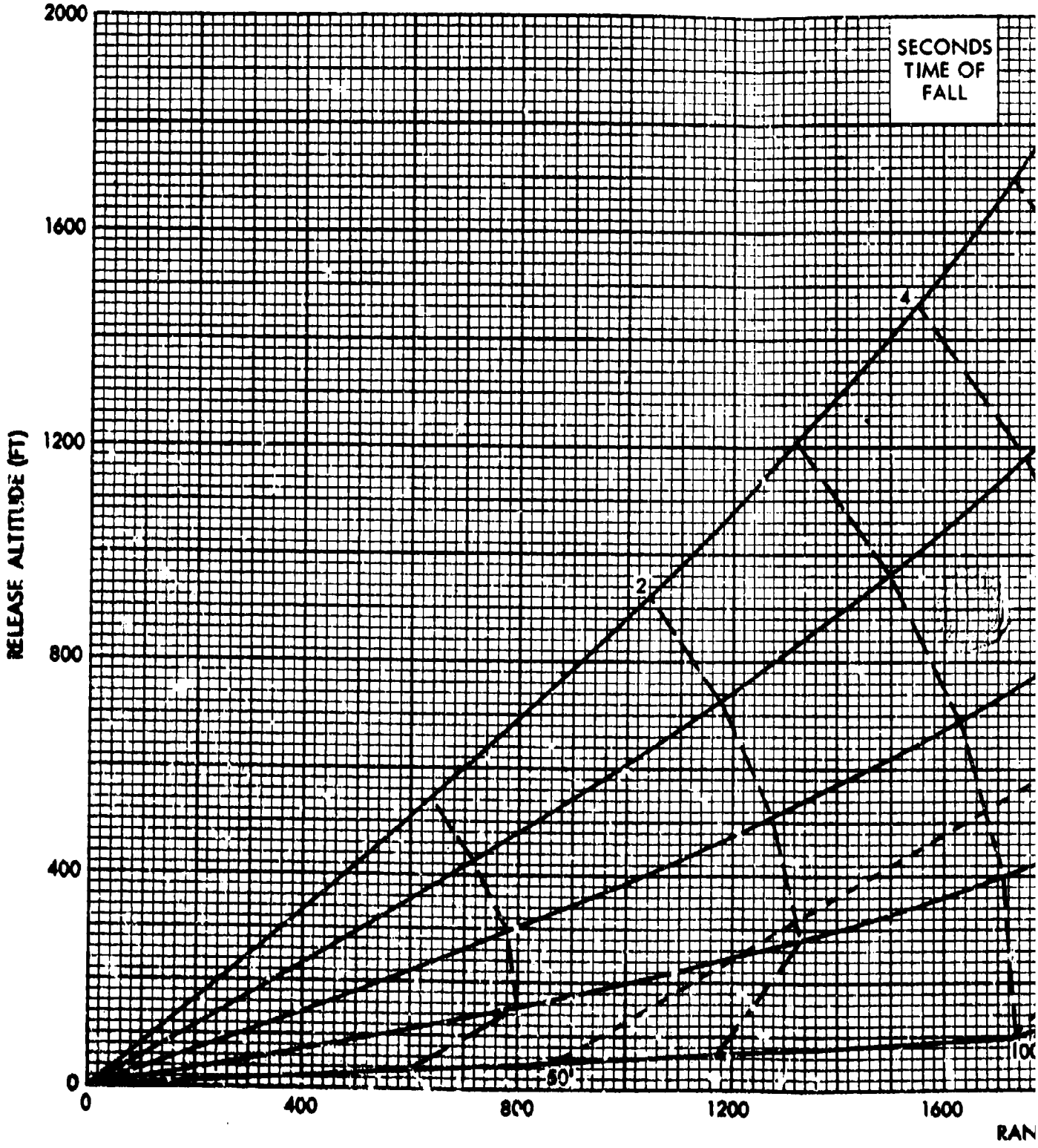


FIG. 7 MK 81/RETARDED EJ VEL 0 FPS


SECONDS
TIME OF
FALL
2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
4
2
50
0
400
800
1200
1600
RAN

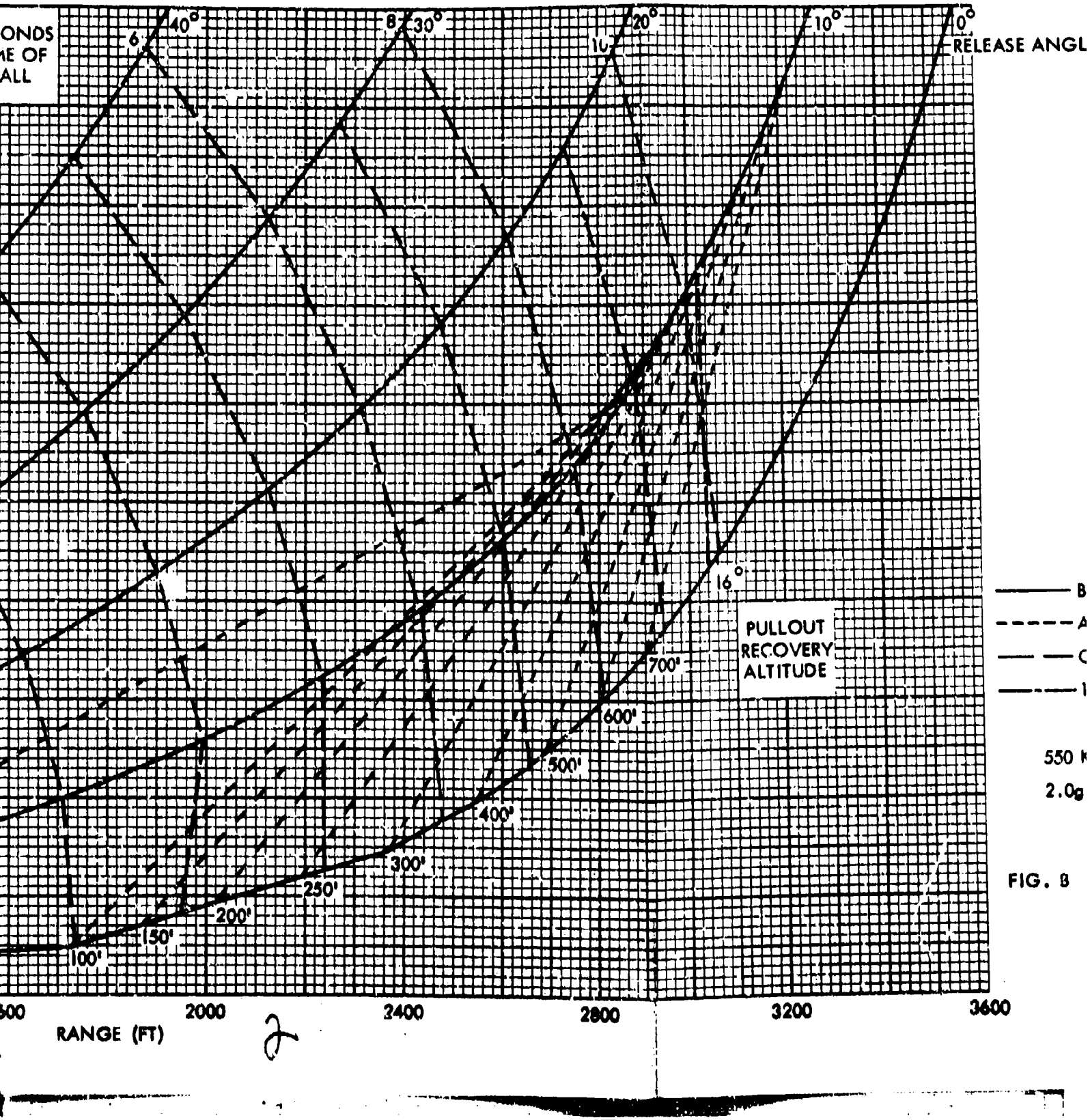
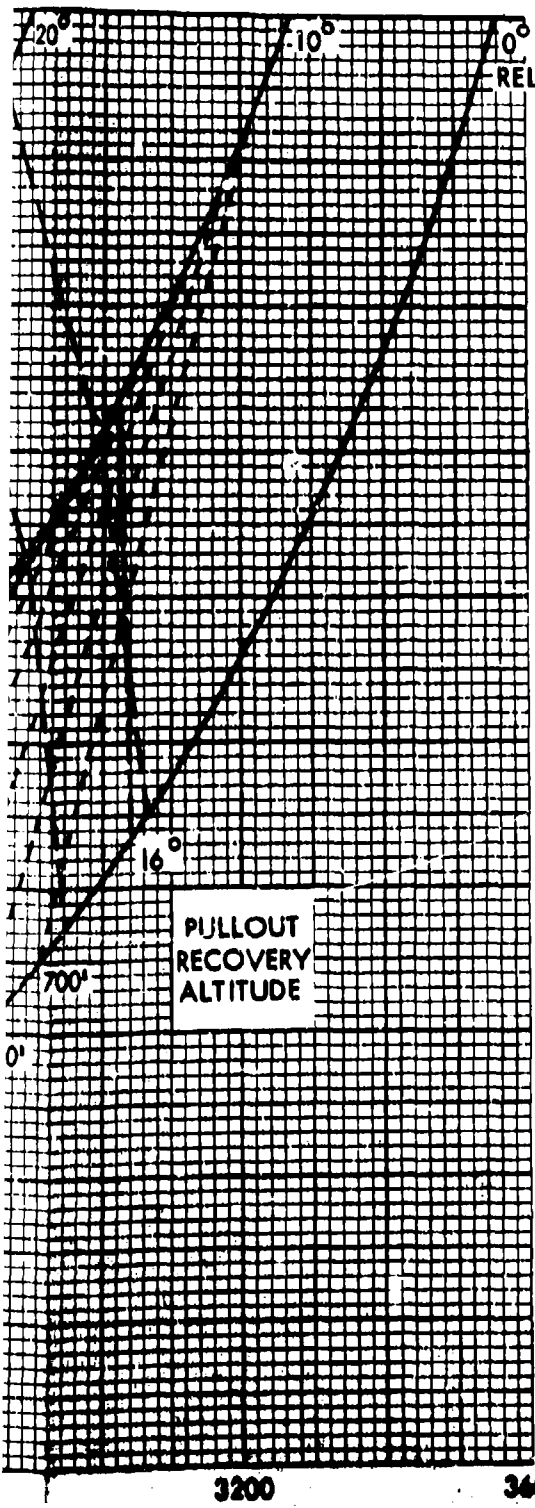

ONDS
ME OF
ALL
40°
30°
20°
10°
0°
RELEASE ANGL
6
8
10
16°
PULLOUT
RECOVERY
ALTITUDE
700'
600'
500'
400'
300'
250'
200'
150'
100'
2000
2400
2800
3200
3600
RANGE (FT)
550 K
2.0g

FIG. 8



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

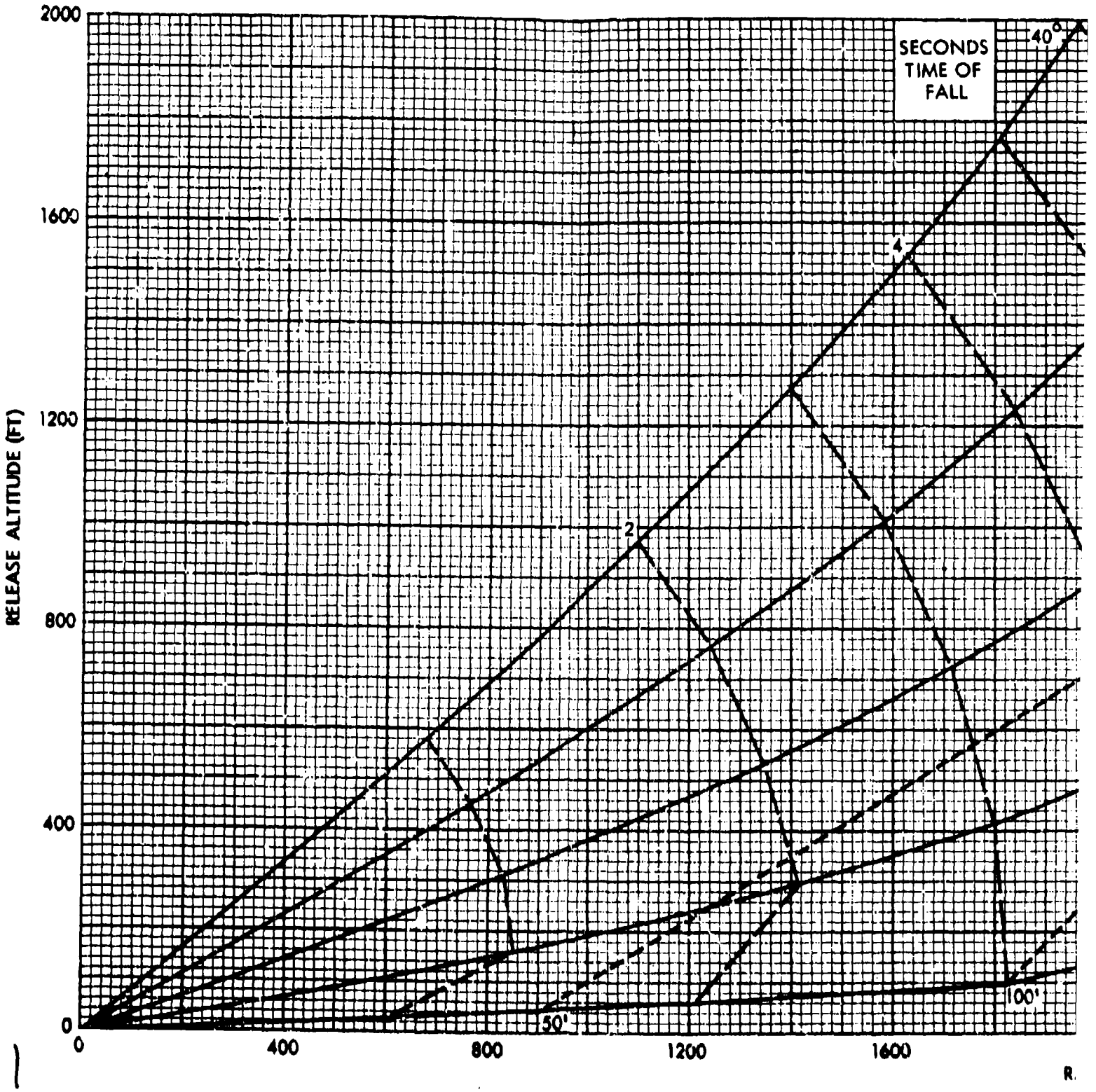
— — CONSTANT TIME OF FALL CURVE

——·—— 16° SIGHT ANGLE LIMIT CURVE

550 KNOTS RELEASE VELOCITY

2.0_g PULLOUT

FIG. 8 MK 81/RETARDED EJ VEL O FPS


SECONDS
TIME OF
FALL
40°
4
2
50'
100'
RELEASE ALTITUDE (FT)
2000
1600
1200
800
400
0
0
400
800
1200
1600

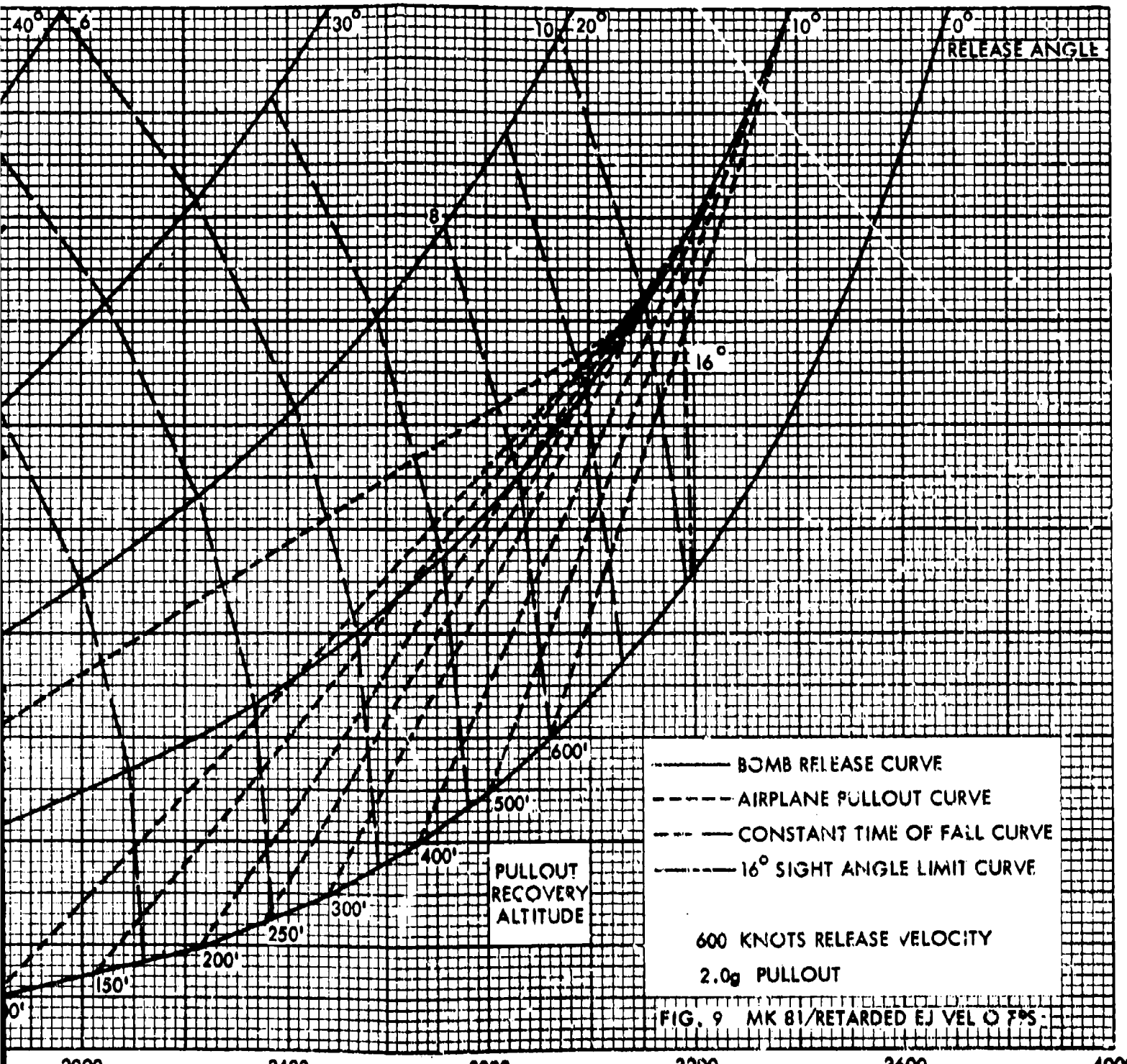
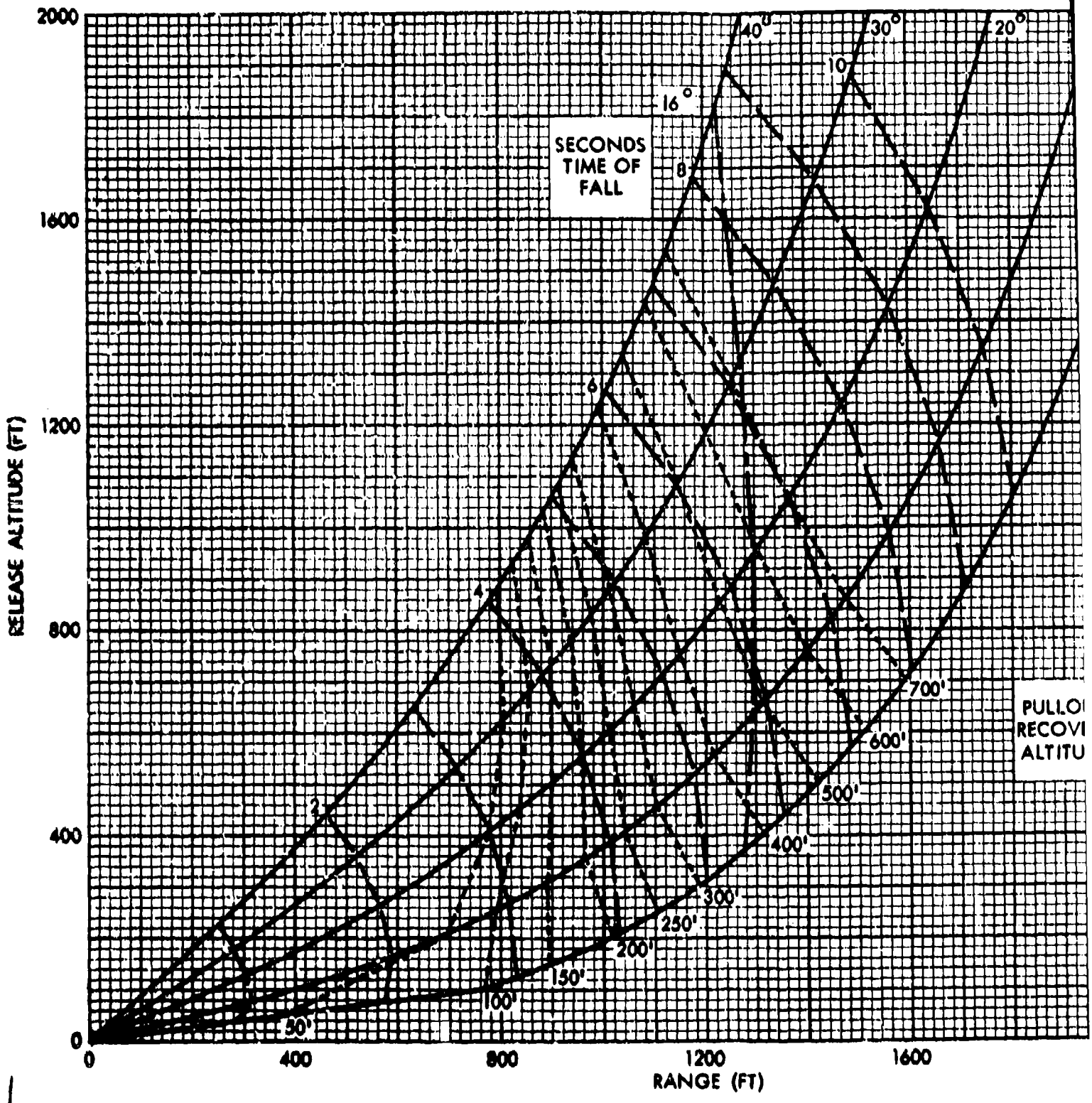
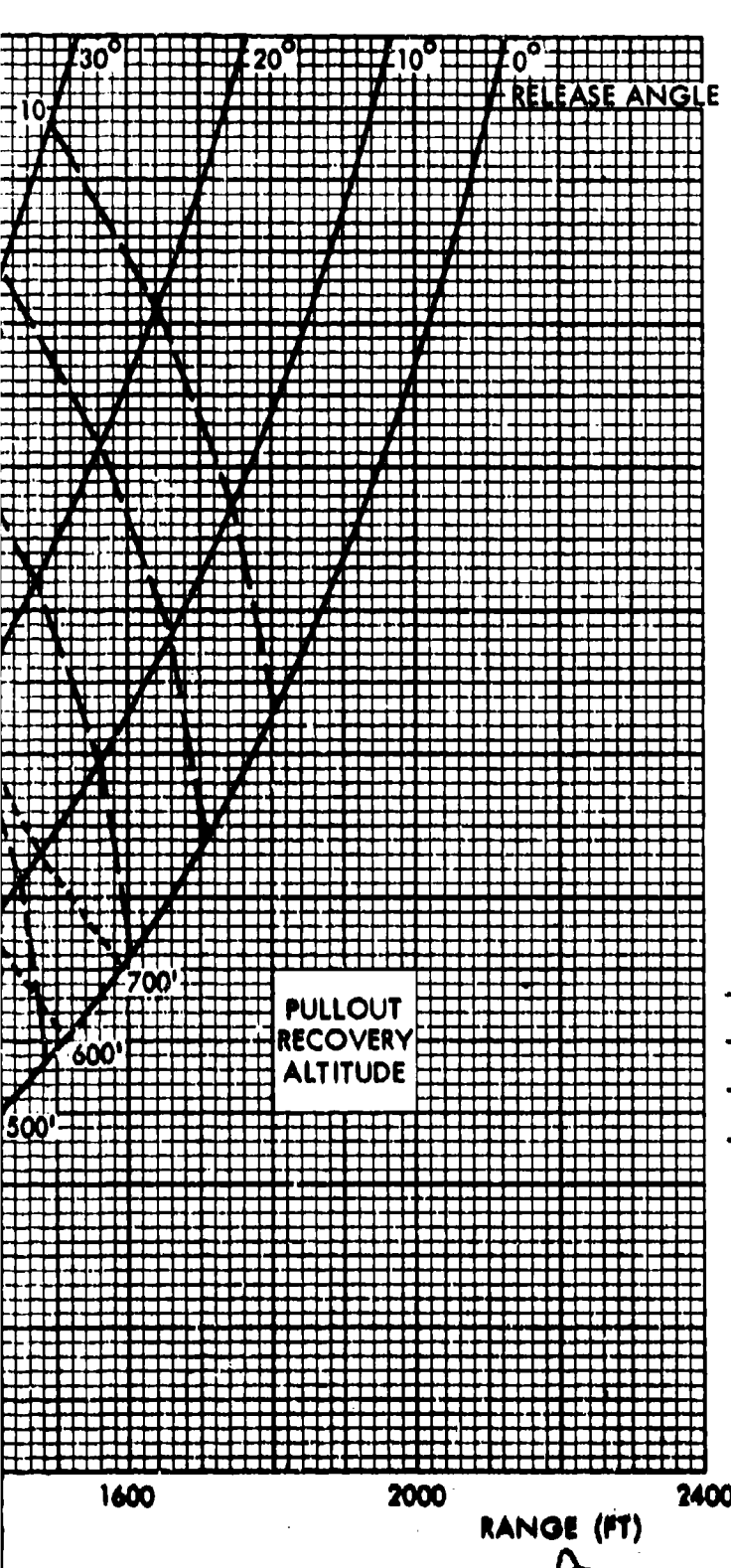


FIG. 9 MK 81/RETARDED EJ VEL 0 FPS


SECONDS TIME OF FALL
40°
30°
20°
16°
10
8
6
4
2
700'
600'
500'
400'
300'
250'
200'
150'
100'
50'
PULLO
RECOVI
ALTITU
RELEASE ALTITUDE (FT)
2000
1600
1200
800
400
0
0
400
800
1200
1600
RANGE (FT)



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

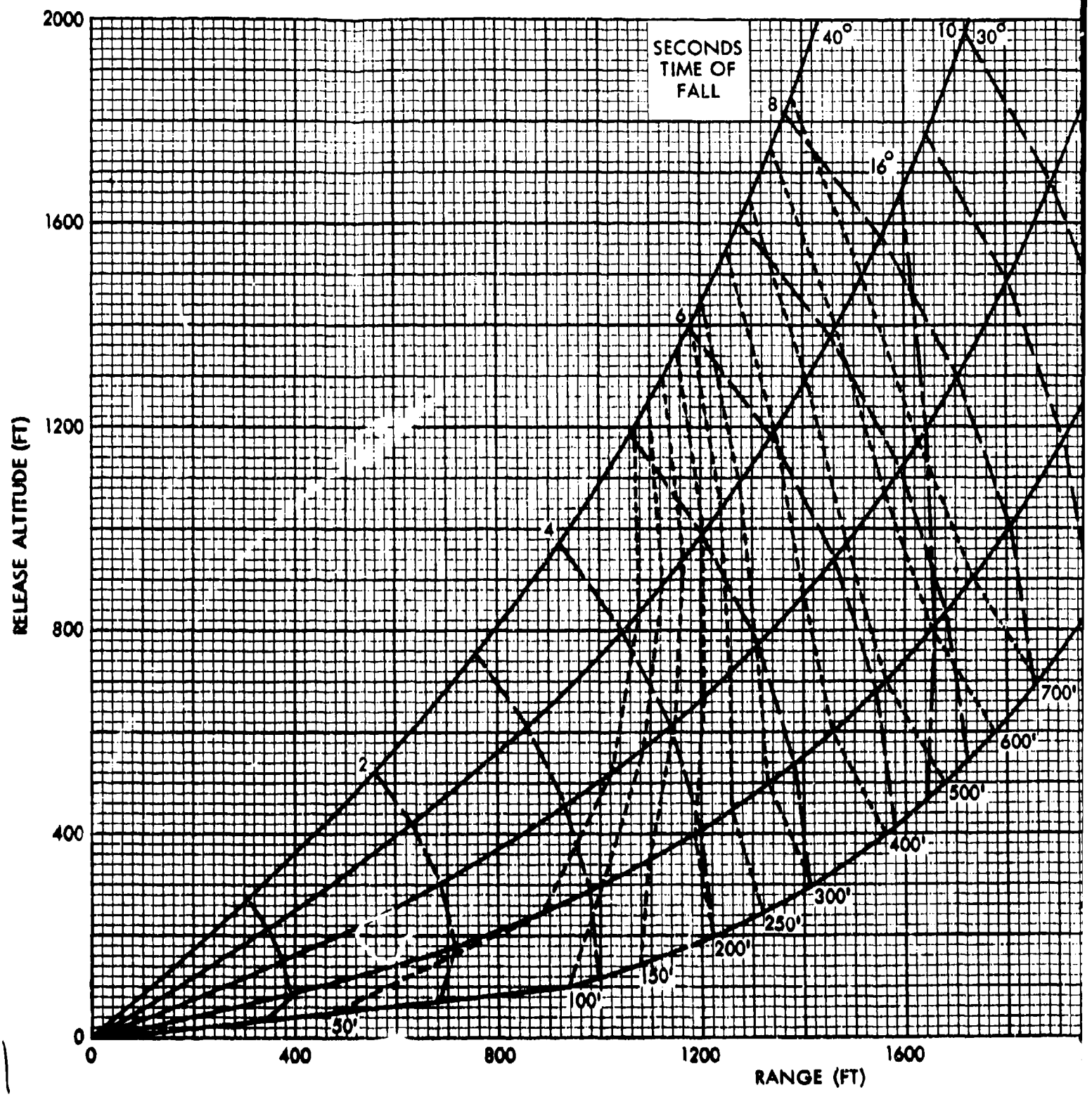
— — CONSTANT TIME OF FALL CURVE

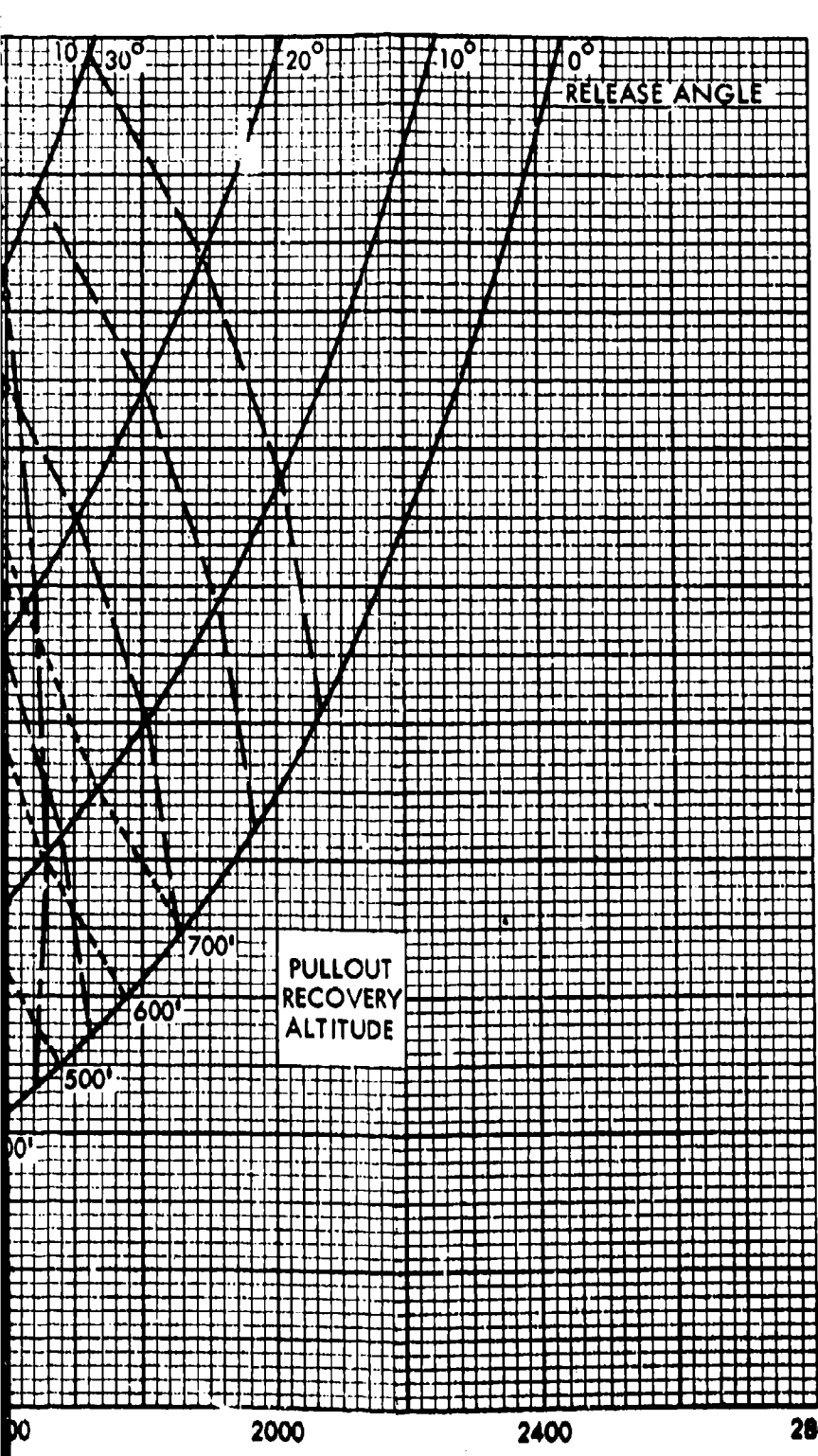
——·—— 16° SIGHT ANGLE LIMIT CURVE

200 KNOTS RELEASE VELOCITY

4.0g PULLOUT

FIG. 10 MK 81/RETARDED EJ VEL O FPS


SECONDS
TIME OF
FALL
40°
30°
16°
10
8
6
4
2
700'
600'
500'
400'
300'
250'
200'
150'
100'
50'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

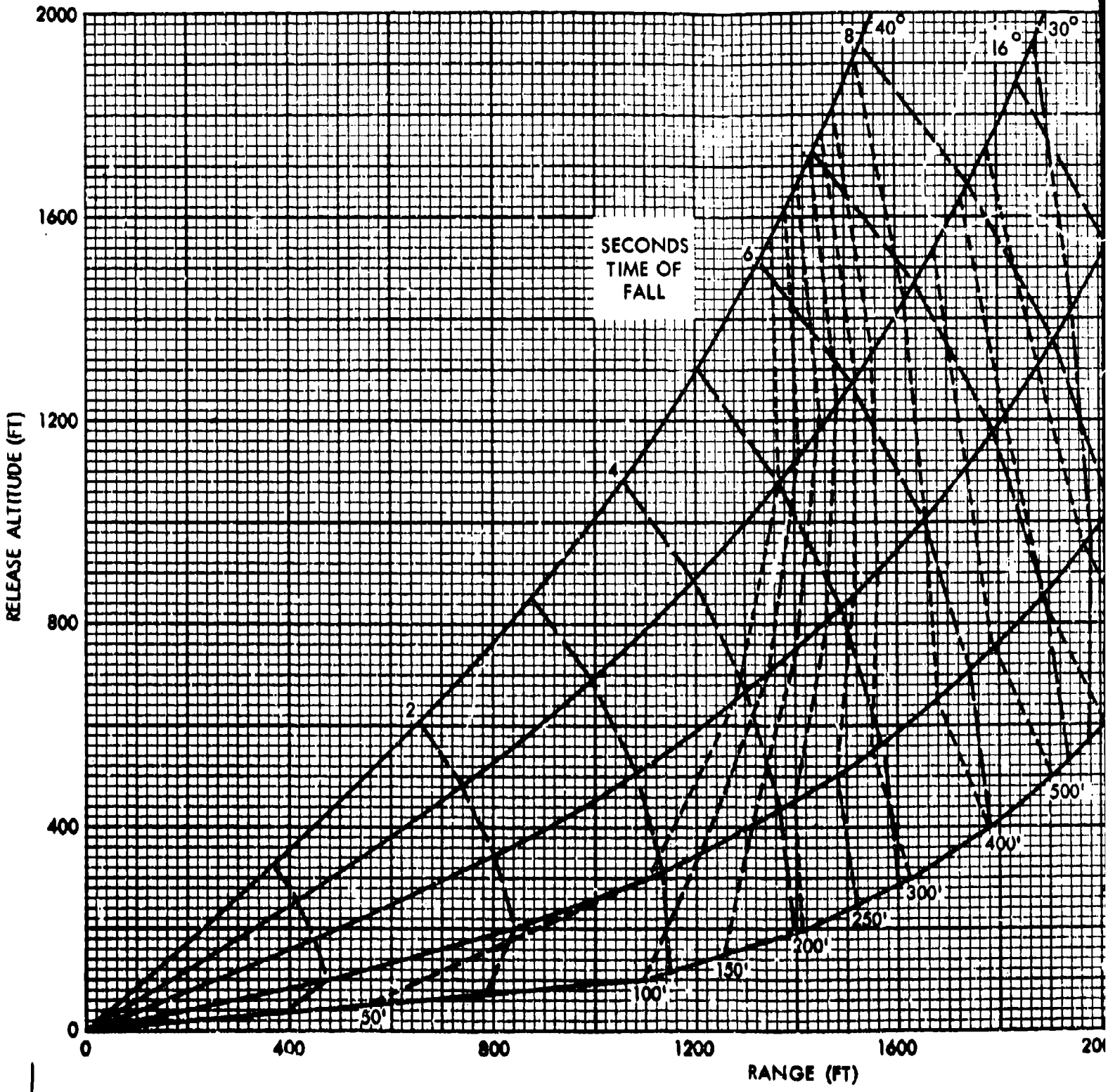
— — CONSTANT TIME OF FALL CURVE

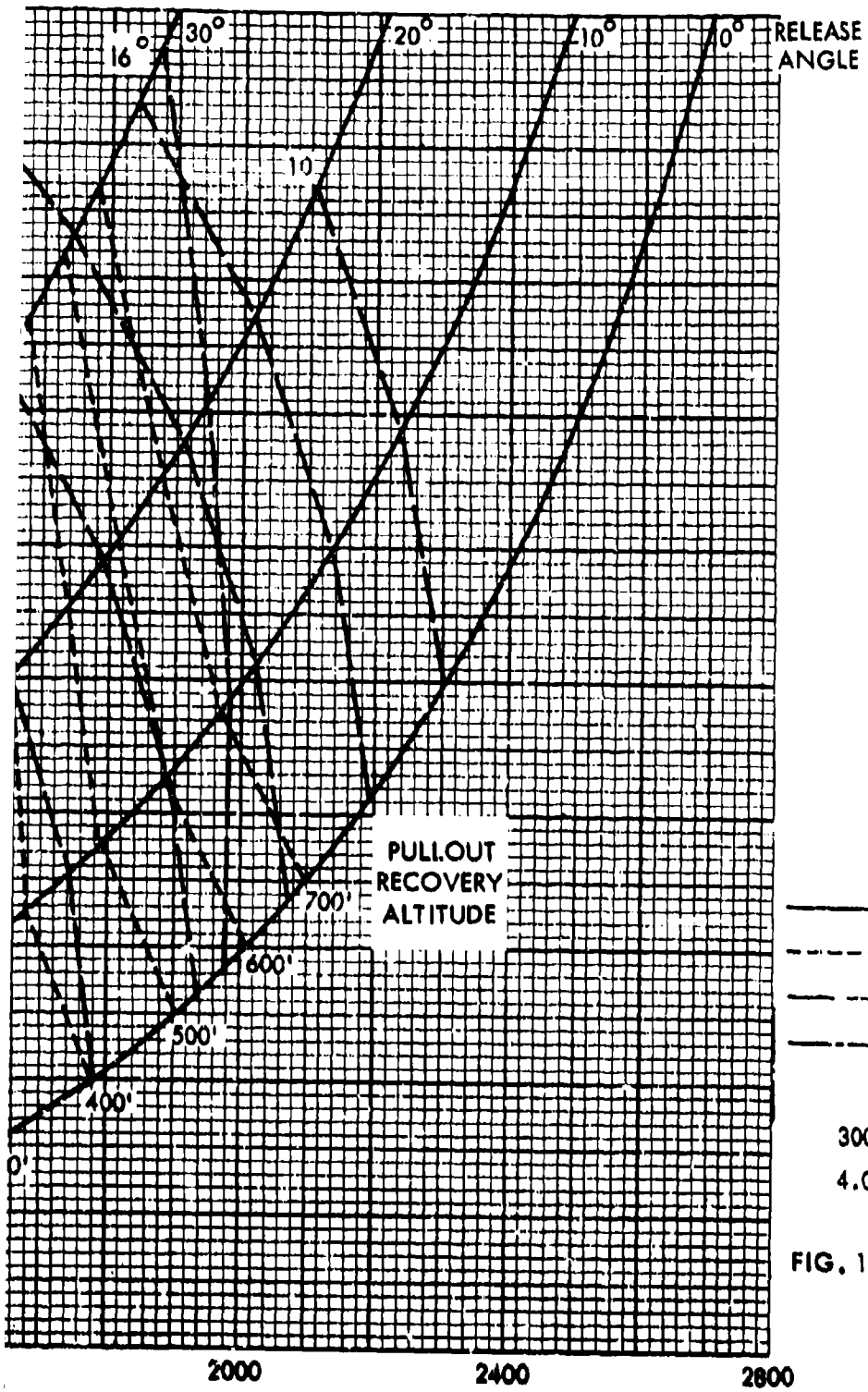
——·—— 16° SIGHT ANGLE LIMIT CURVE

250 KNOTS RELEASE VELOCITY

4.0g PULLOUT

FIG.11 MK 81/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
8
40°
30°
16°
50'
100'
150'
200'
250'
300'
400'
500'



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

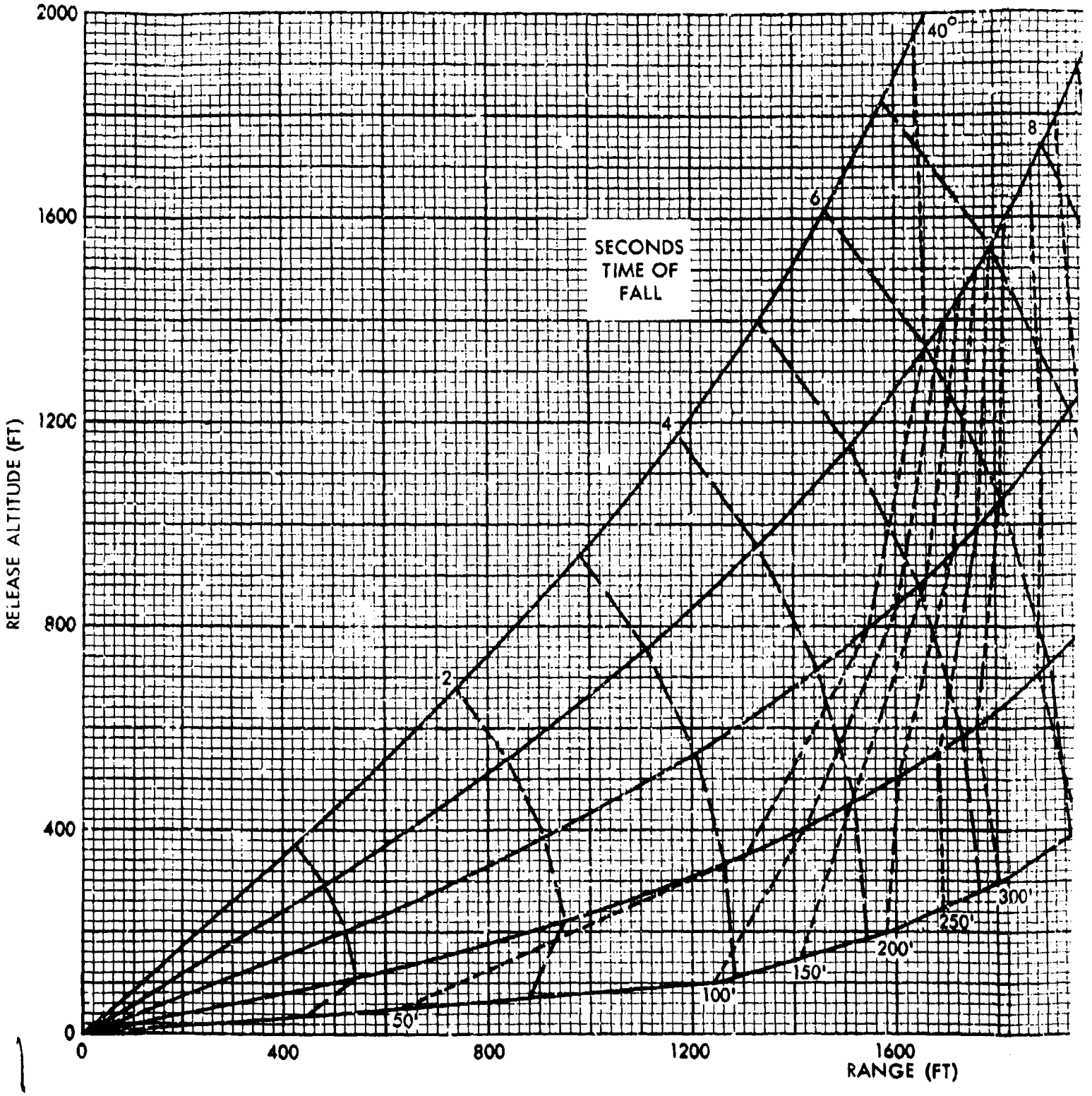
— — CONSTANT TIME OF FALL CURVE

———— 16° SIGHT ANGLE LIMIT CURVE

300 KNOTS RELEASE VELOCITY

4.0 g PULLOUT

FIG. 12 MK 81/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS
TIME OF
FALL
40°
8
6
4
2
300'
250'
200'
150'
100'
50'

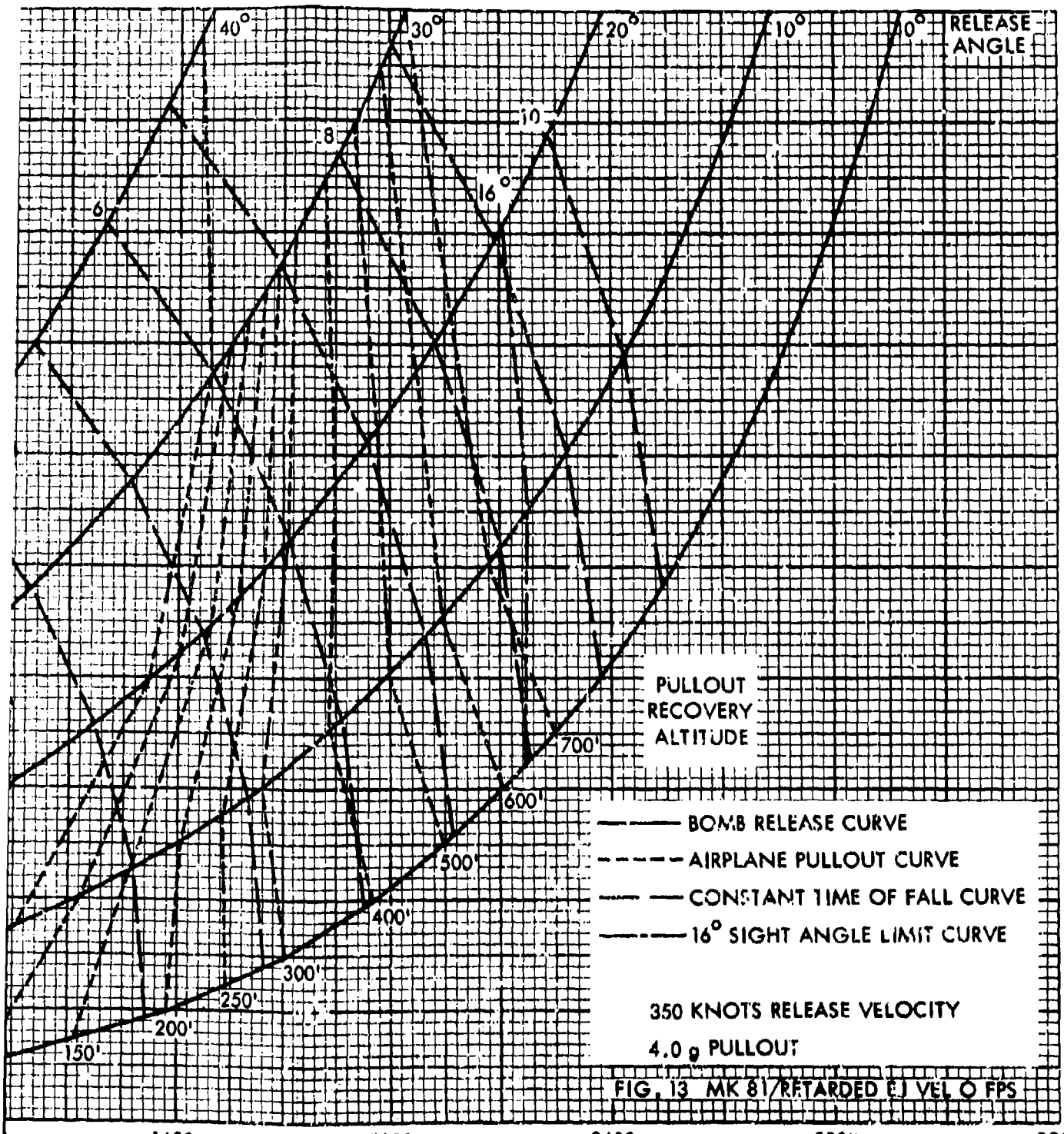
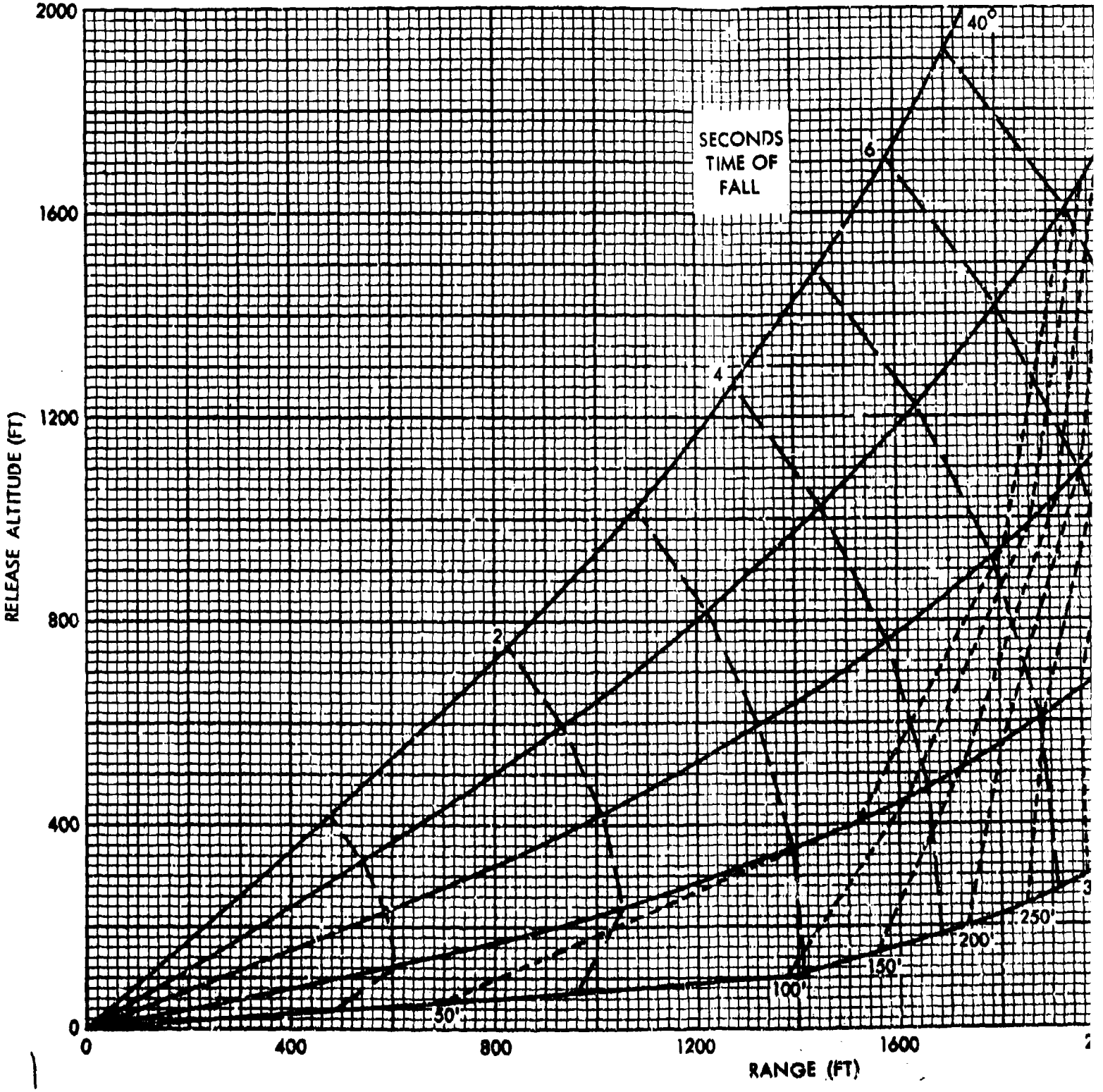
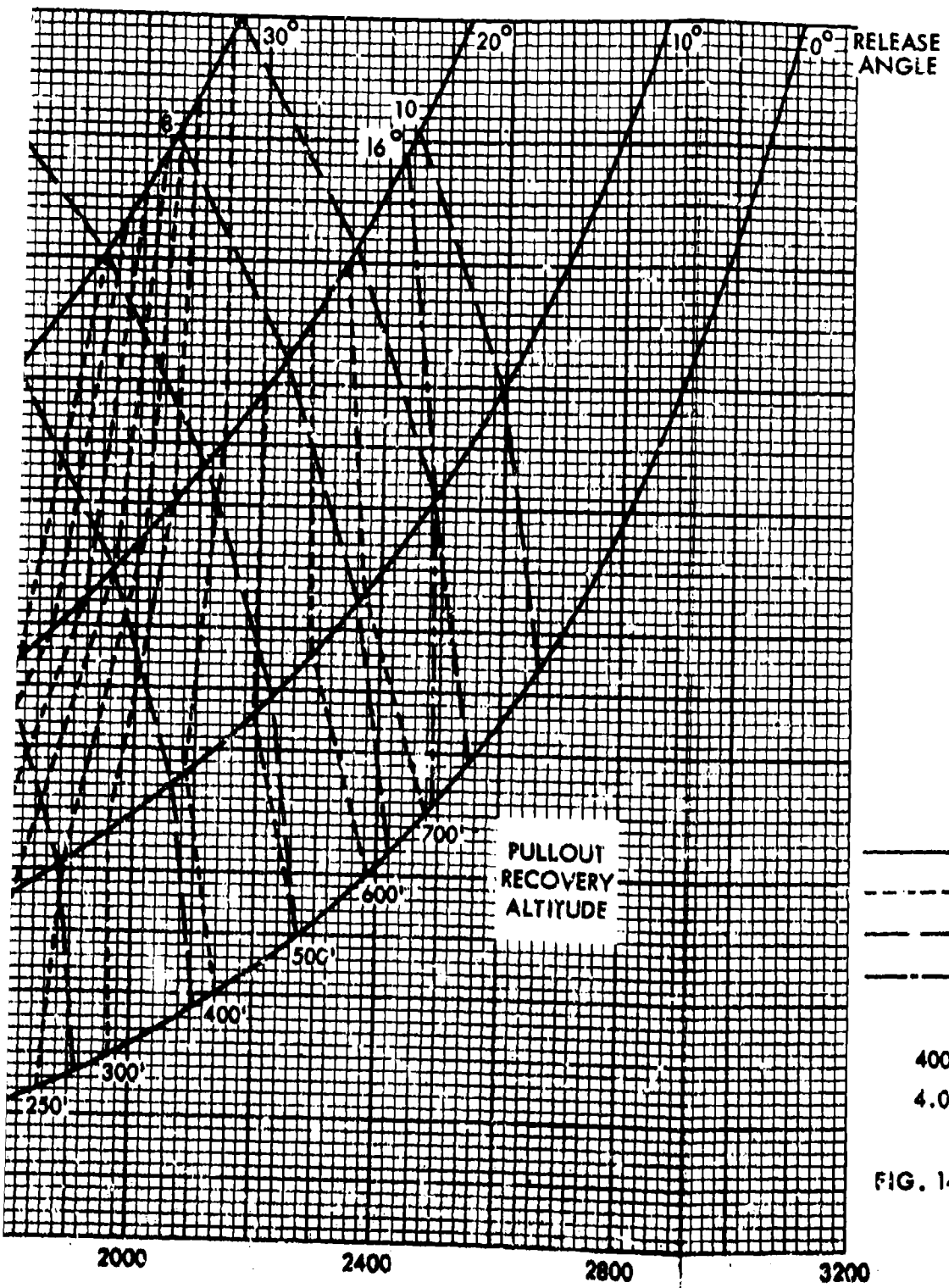


FIG. 13 MK 81/RETARDED EJ VEL 0 FPS


SECONDS
TIME OF
FALL
40°
6
4
2
1
3
250'
200'
150'
100'
50'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)



BOMB RELEASE CURVE

AIRPLANE PULLOUT CURVE

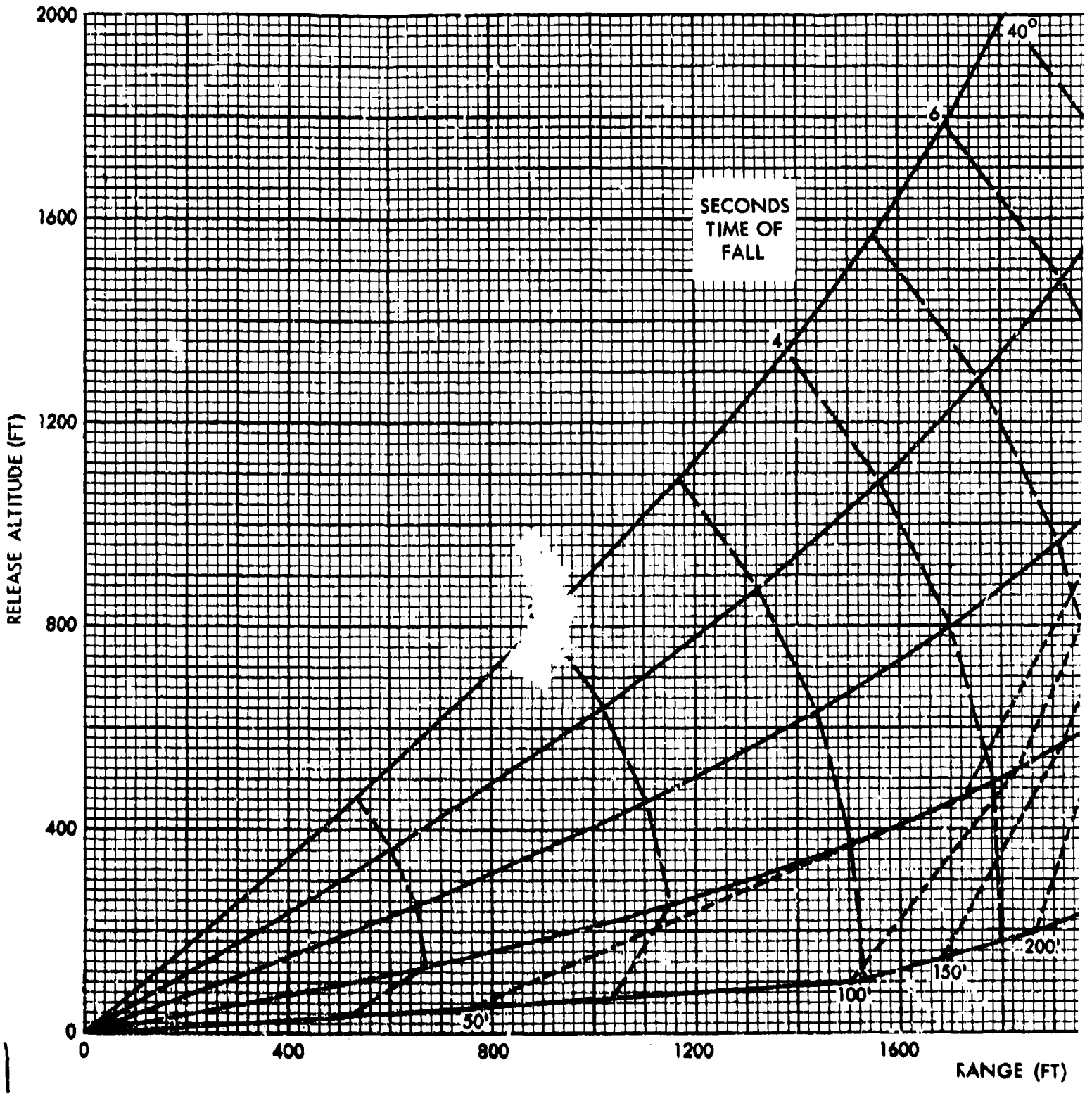
CONSTANT TIME OF FALL CURVE

16° SIGHT ANGLE LIMIT CURVE

400 KNOTS RELEASE VELOCITY

4.0 g PULLOUT

FIG. 14 MK 81/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS
TIME OF
FALL
40°
6
4
50'
100'
150'
200'

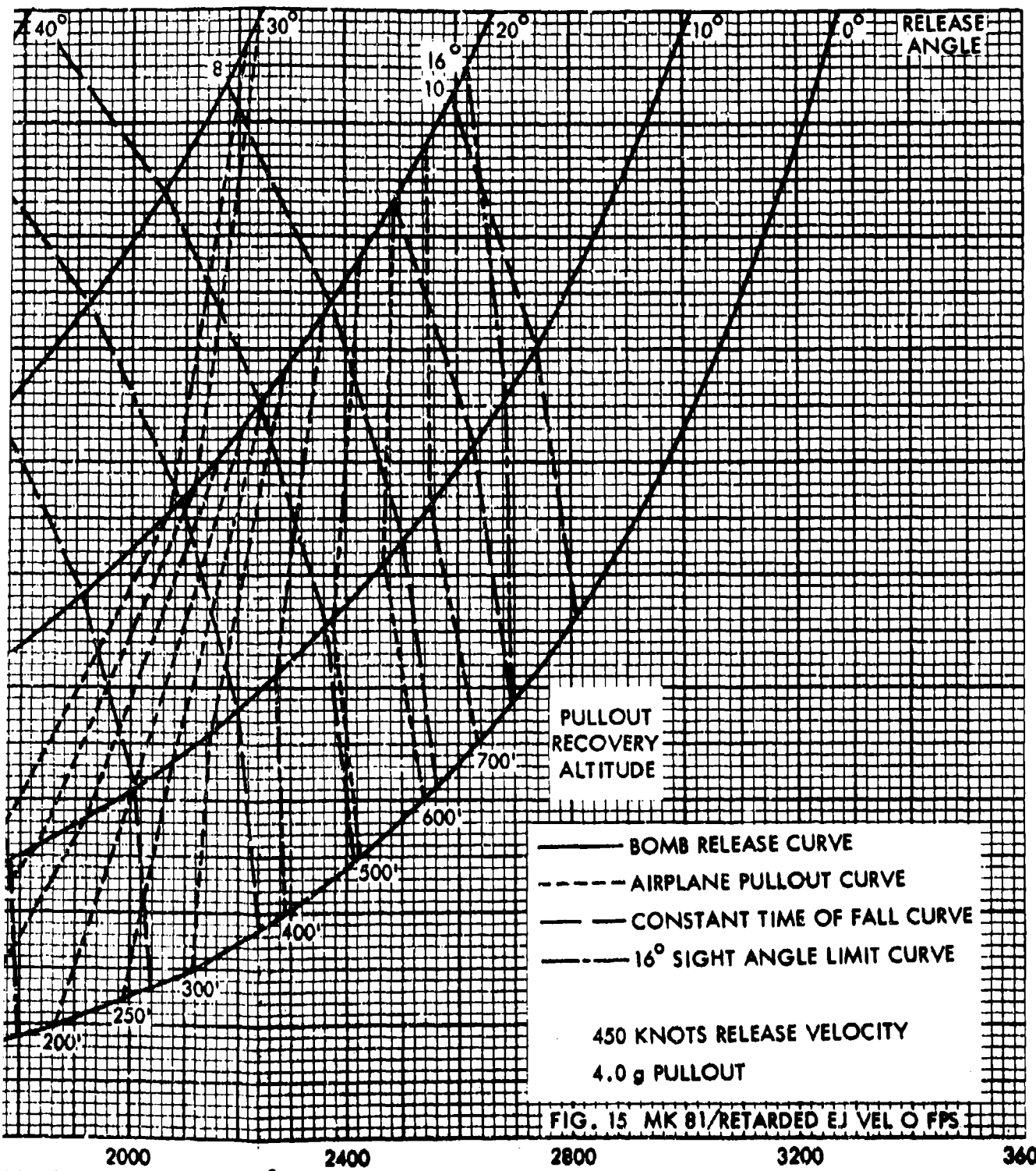
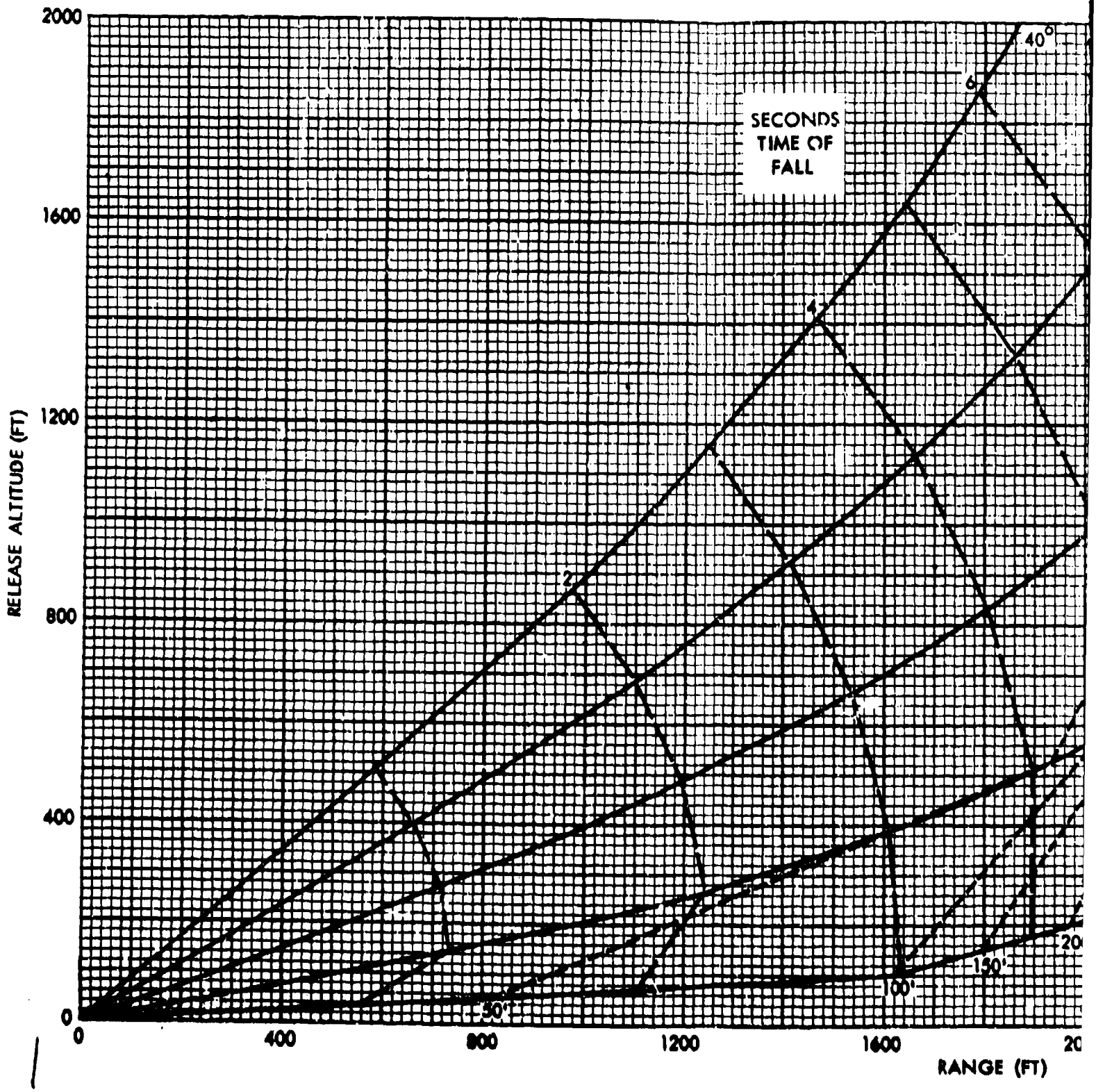


FIG. 15 MK 81/RETARDED EJ VEL O FPS


SECONDS
TIME OF
FALL
40°
6
4
2
50'
100'
150'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)

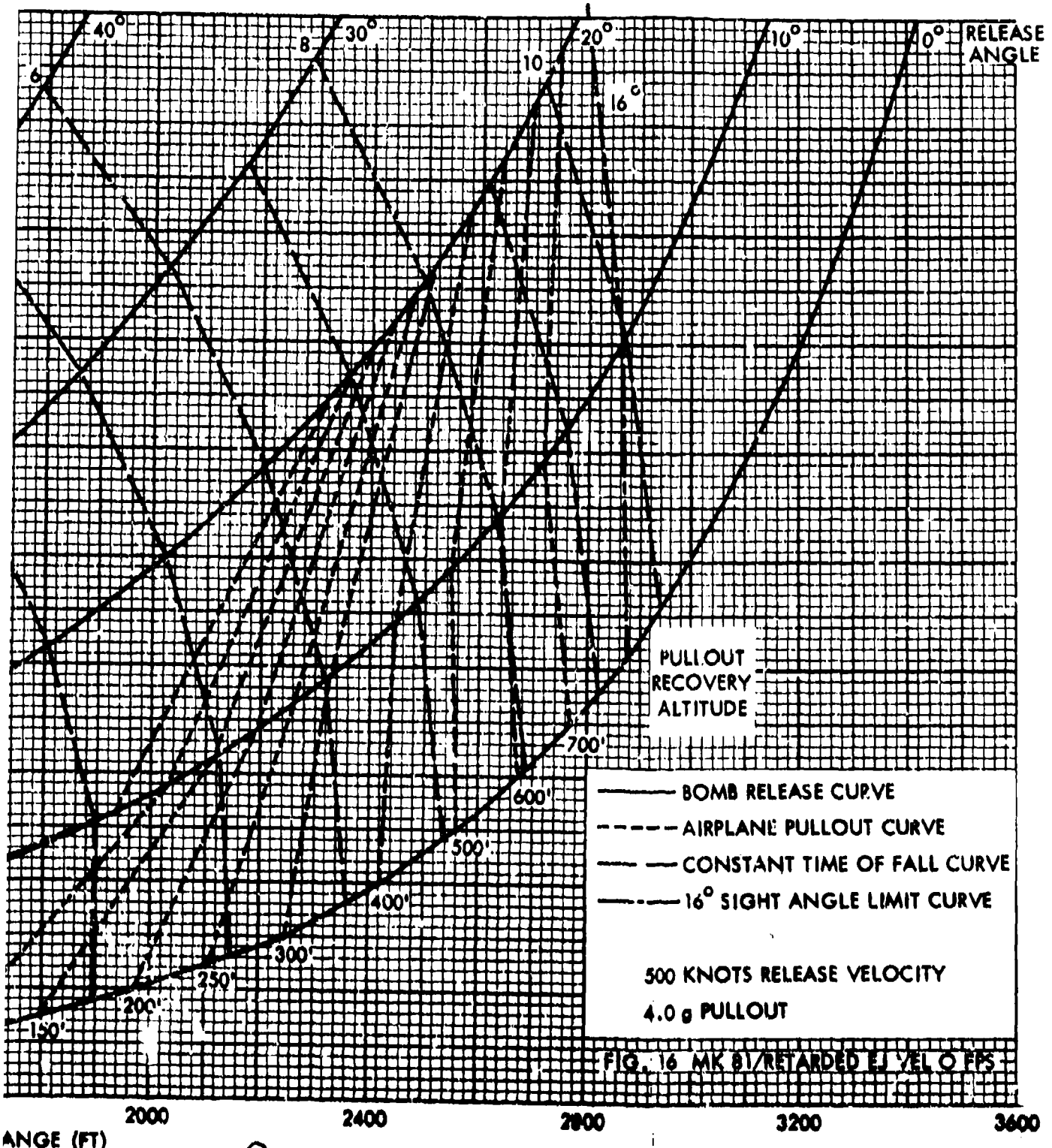
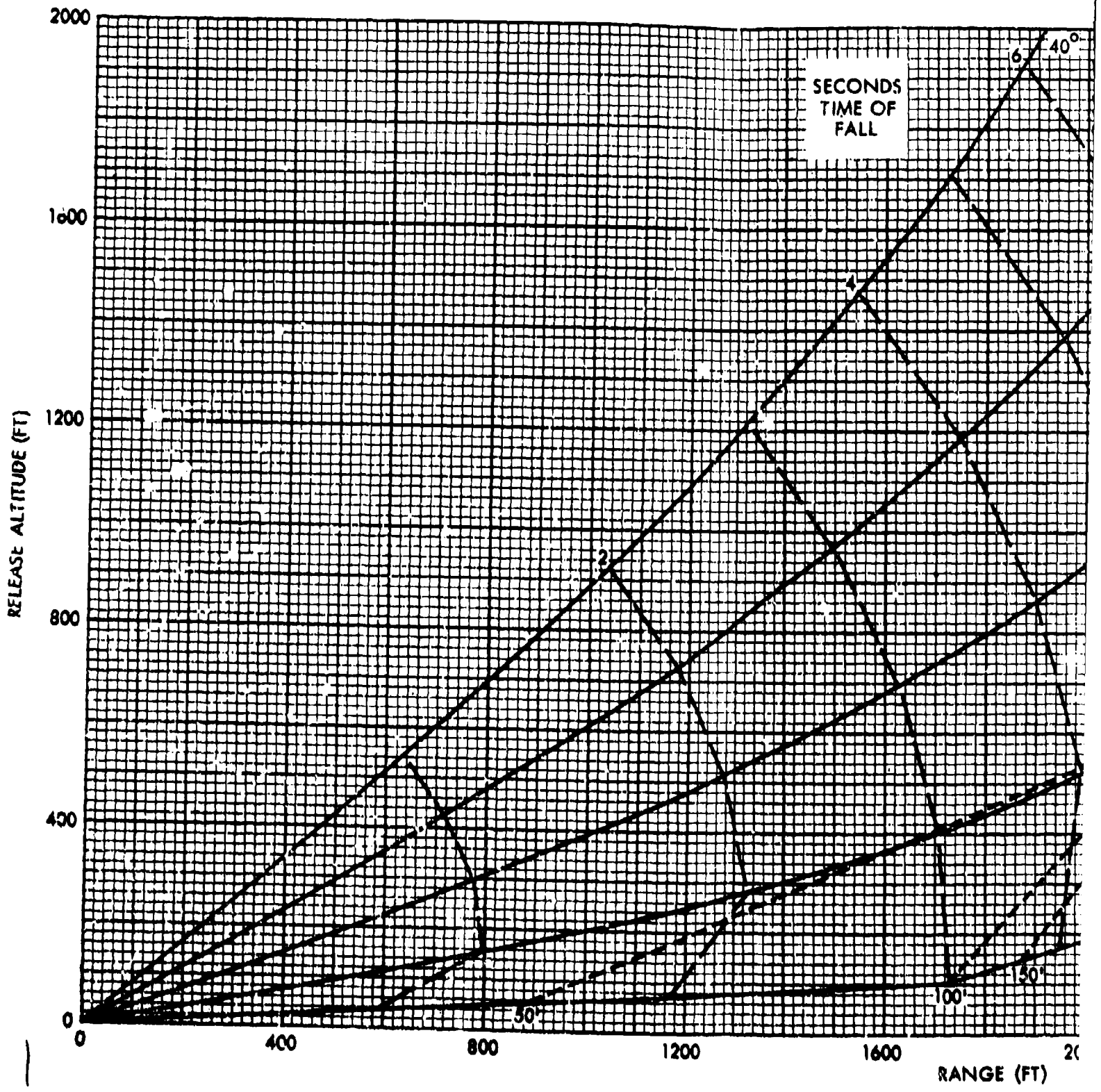


FIG. 16 MK 81/RETARDED EJ VEL 0 FPS

2


SECONDS TIME OF FALL
6
4
2
40°
30°
100°
150°
2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)

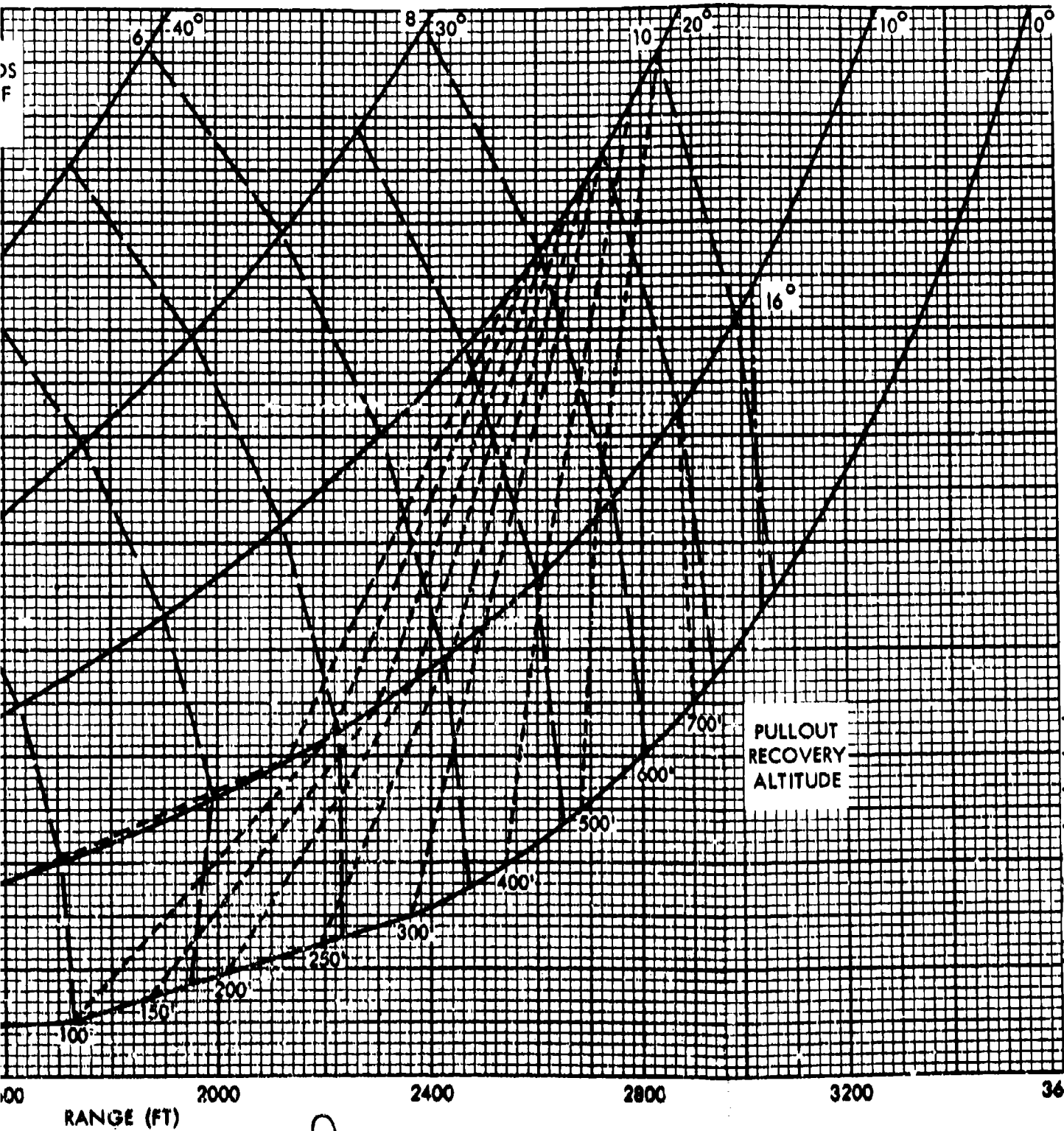
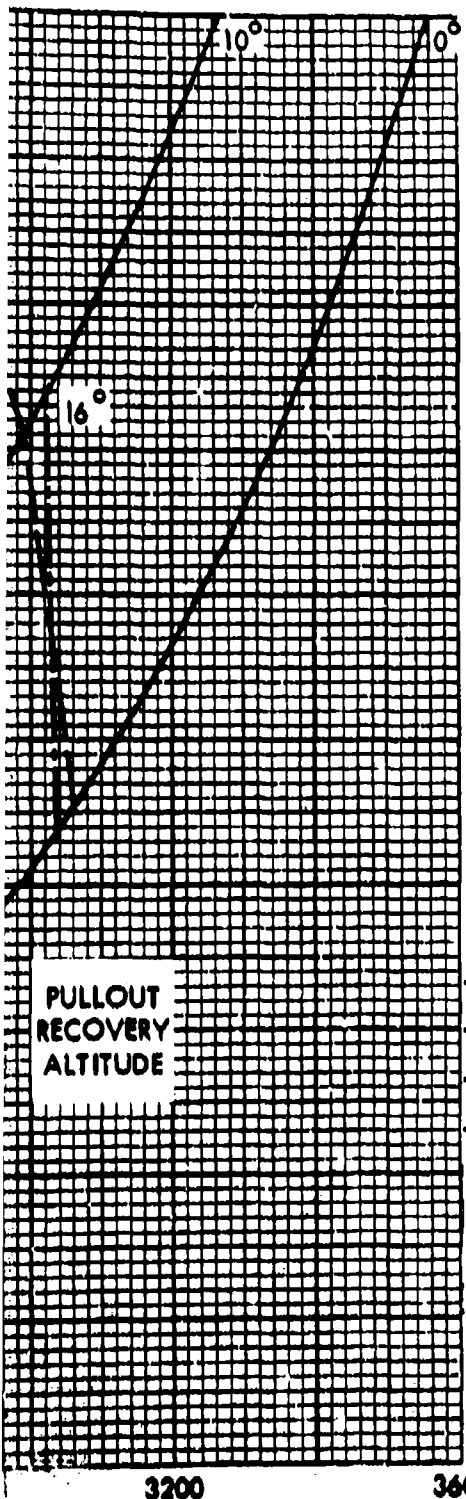

6
-40°
8
30°
10
20°
10°
0°
16°
PULLOUT
RECOVERY
ALTITUDE
700'
600'
500'
400'
300'
250'
200'
150'
100'
2000
2400
2800
3200
3600
RANGE (FT)

FIG. 17



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

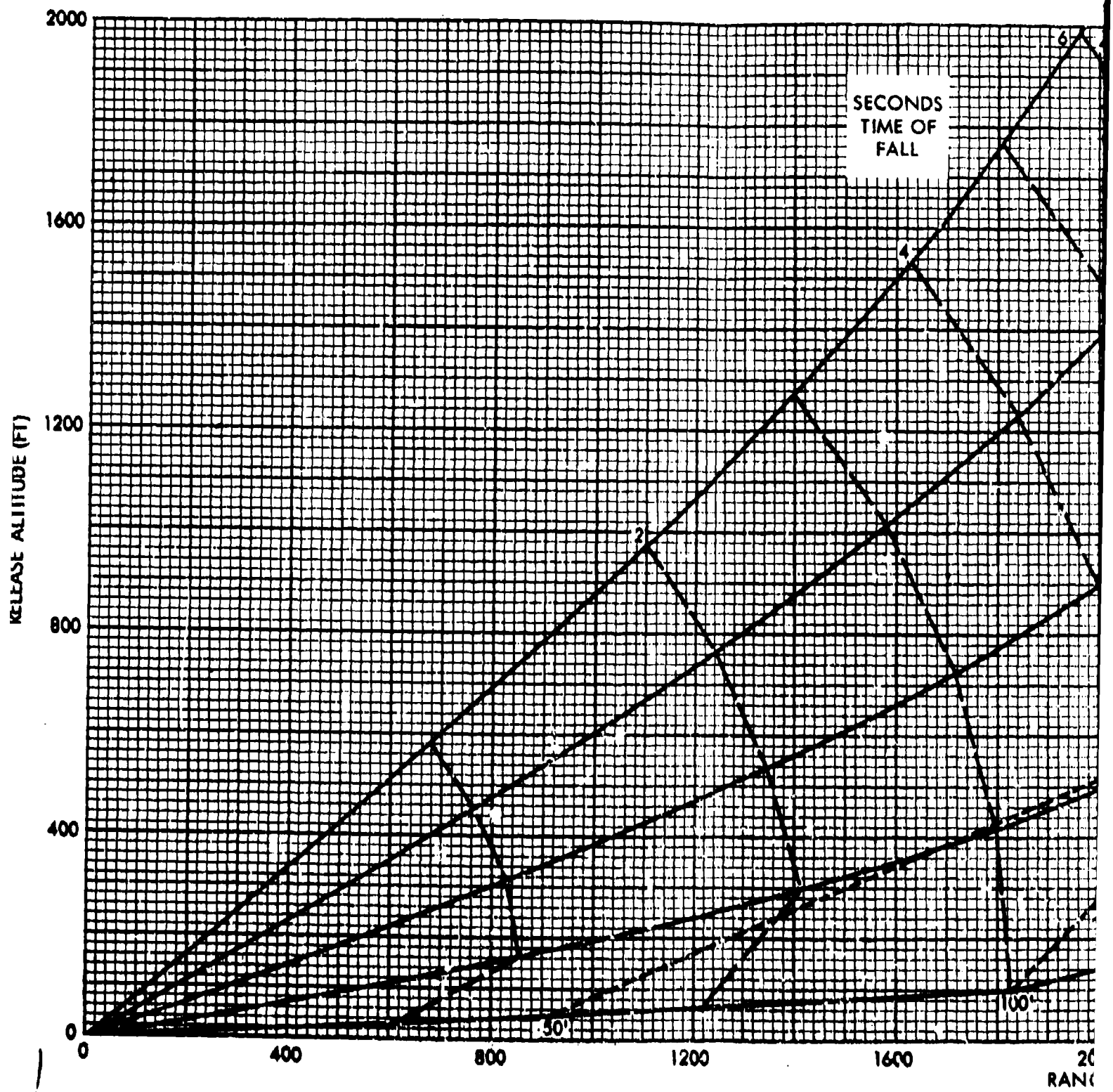
— — CONSTANT TIME OF FALL CURVE

——·—— 16° SIGHT ANGLE LIMIT CURVE

550 KNOTS RELEASE VELOCITY

4.0 g PULLOUT

FIG. 17 MK 81/RETARDED EJ VEL O FPS


SECONDS
TIME OF
FALL
6
4
2
100'
50'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)

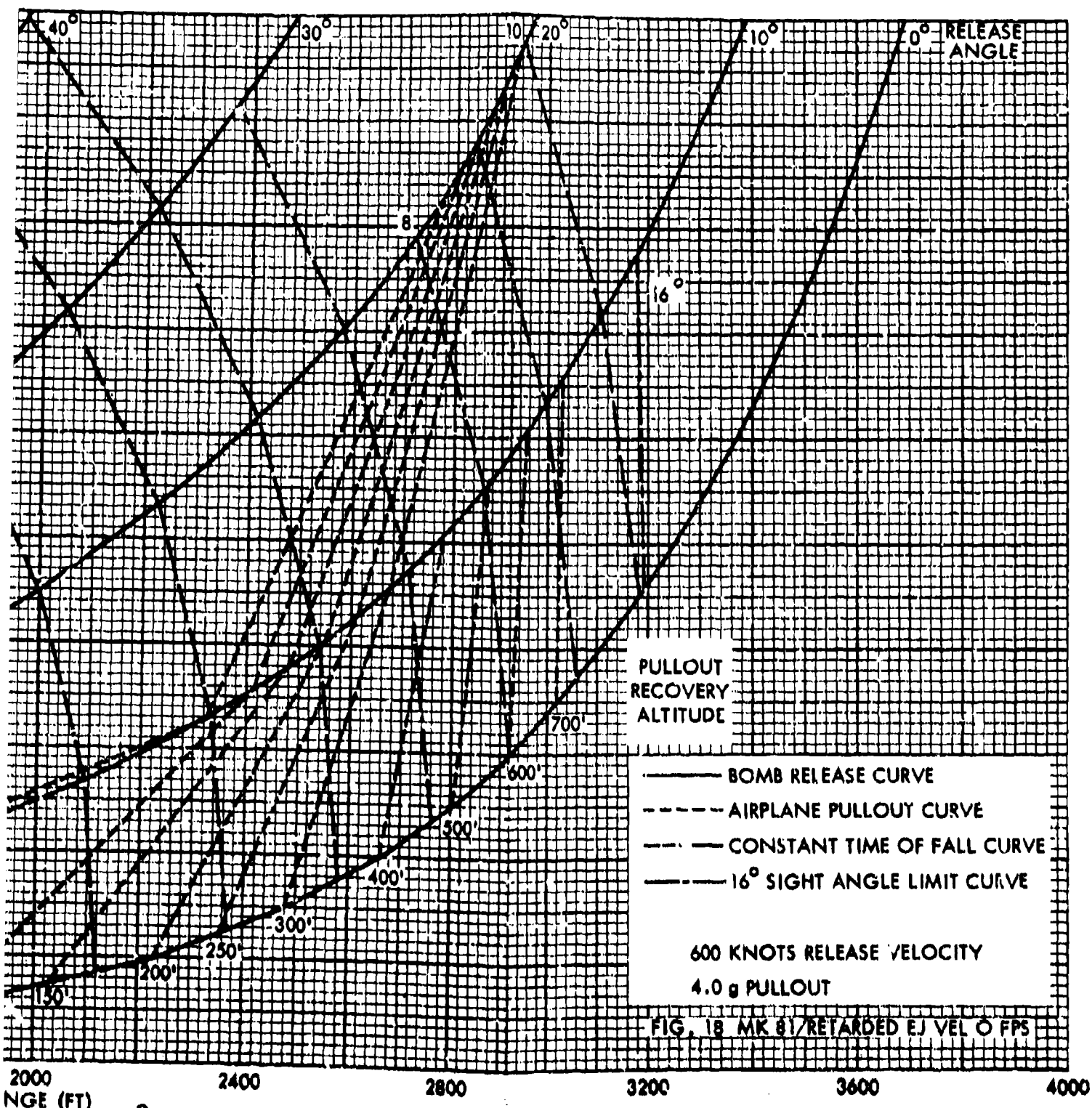


FIG. 18 MK 81/RETARDED EJ VEL 0 FPS

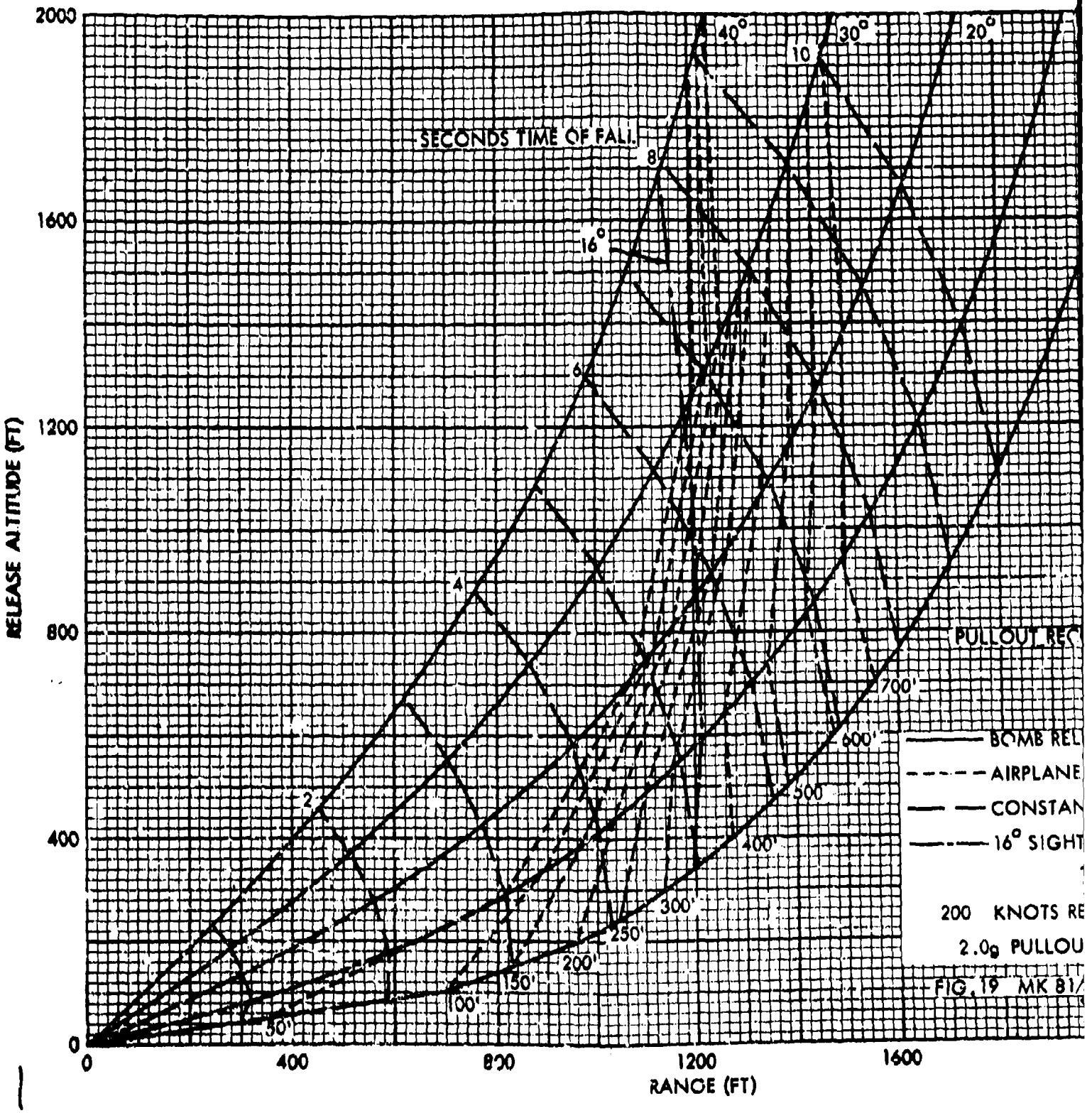

2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
40°
30°
20°
10
8
16°
6
4
2
SECONDS TIME OF FALL
PULLOUT REC
700'
600'
500
400'
300'
250'
200'
150'
100'
50'
BOMB REL
AIRPLANE
CONSTAN
16° SIGHT
200 KNOTS RE
2.0g PULLOU

FIG. 19 MK 81/

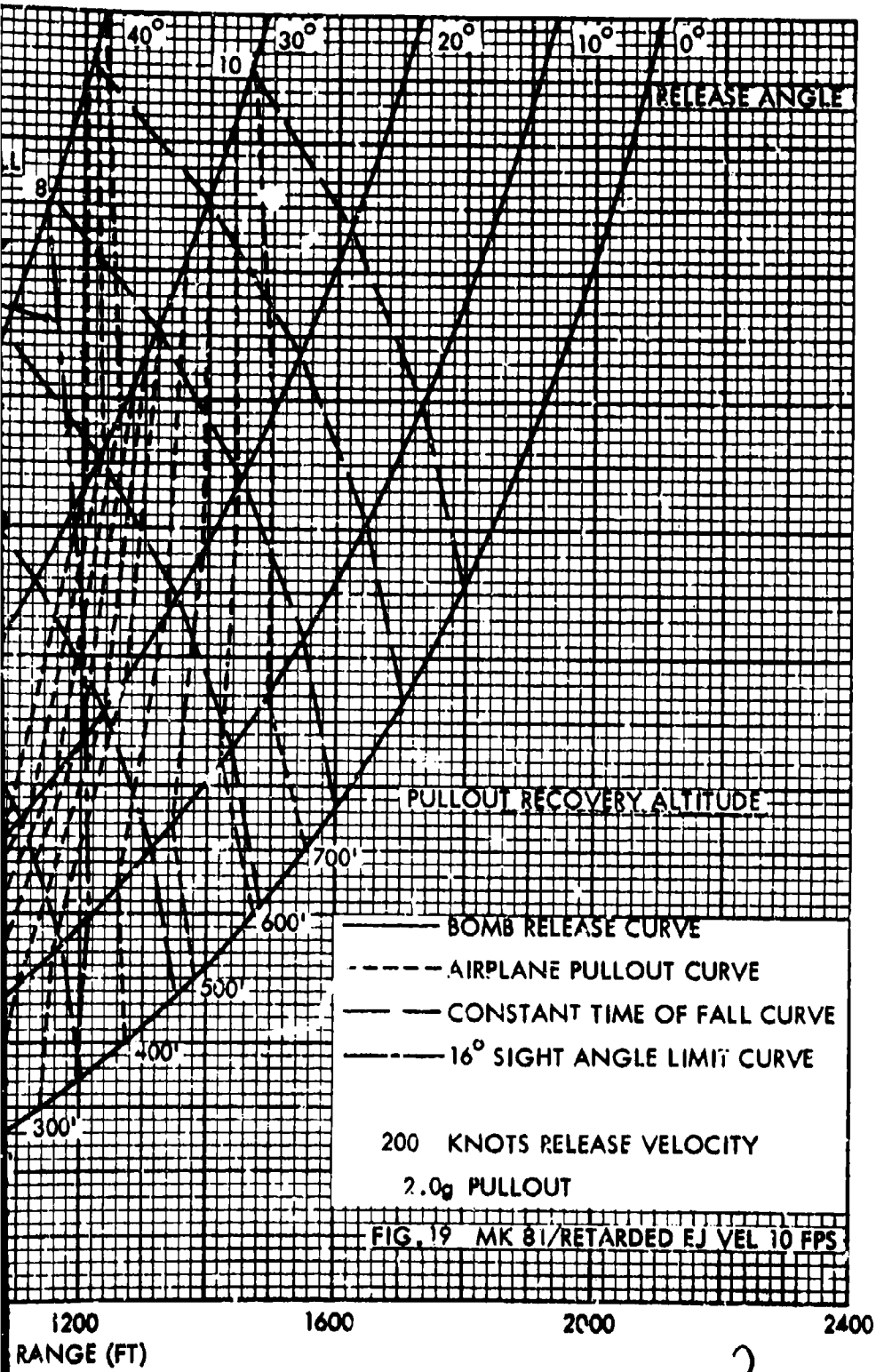
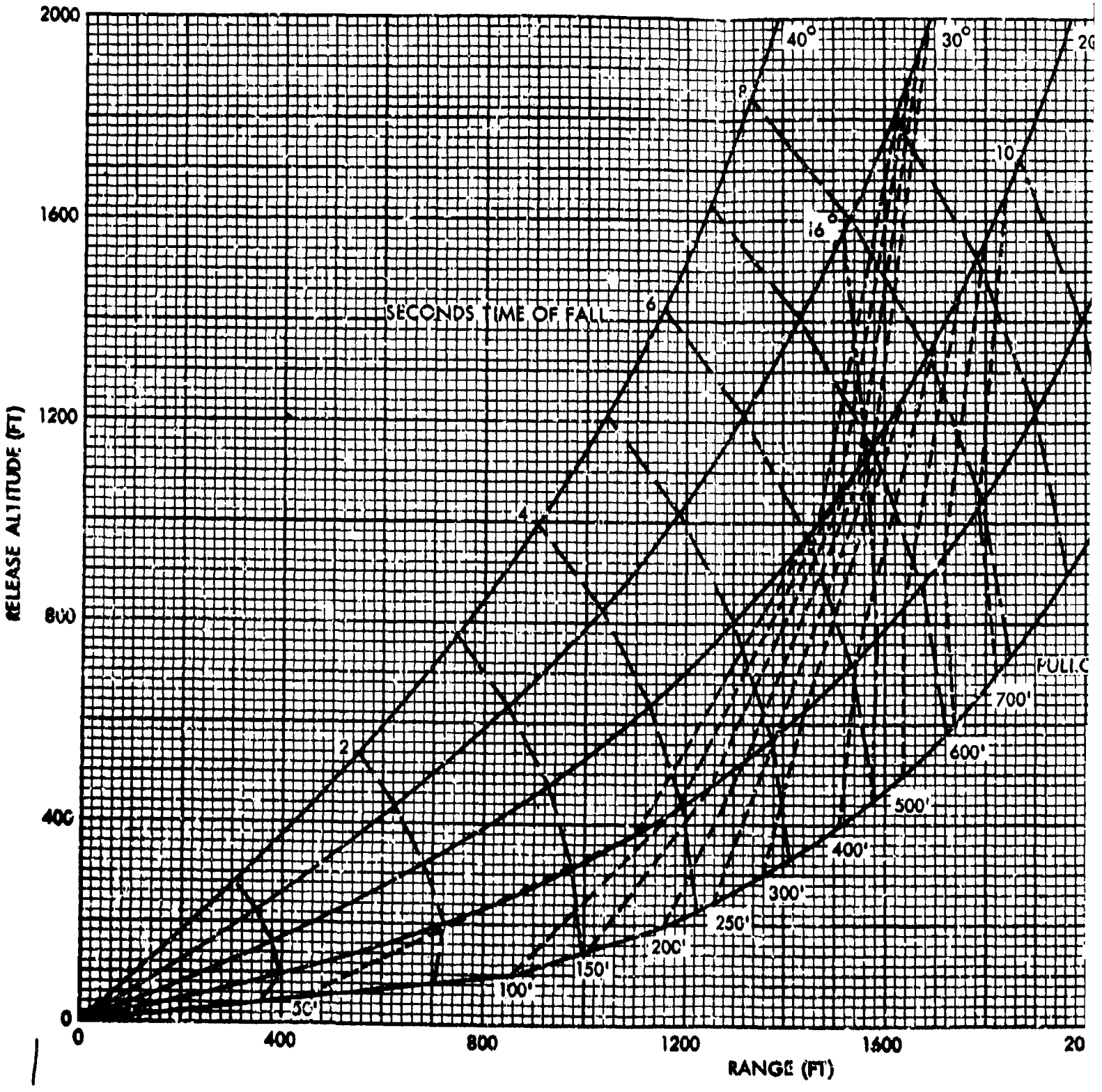


FIG. 19 MK 81/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
20
RANGE (FT)
40°
30°
20
16°
10
SECONDS TIME OF FALL
6
4
2
700'
600'
500'
400'
300'
250'
200'
150'
100'
50'

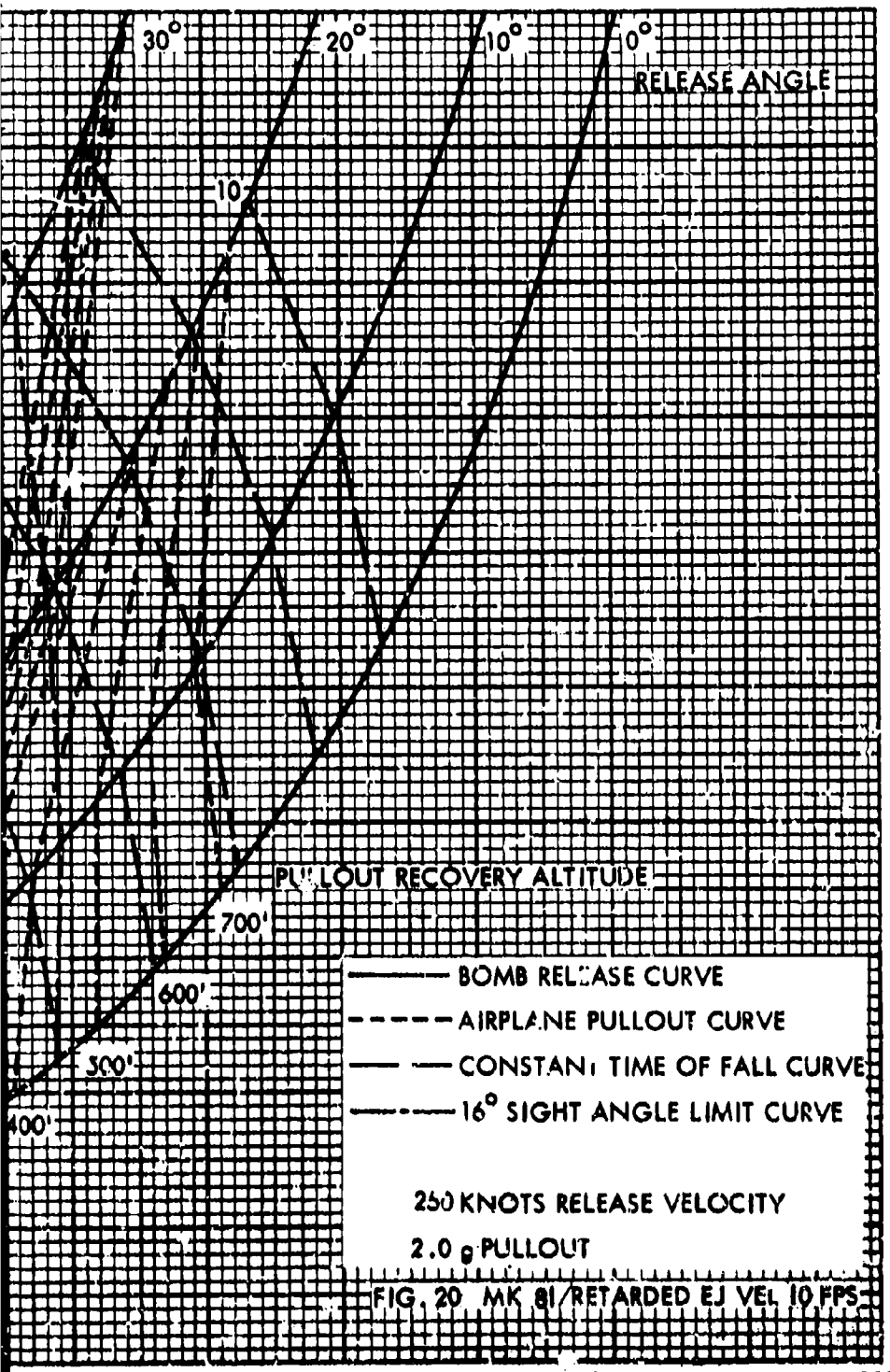
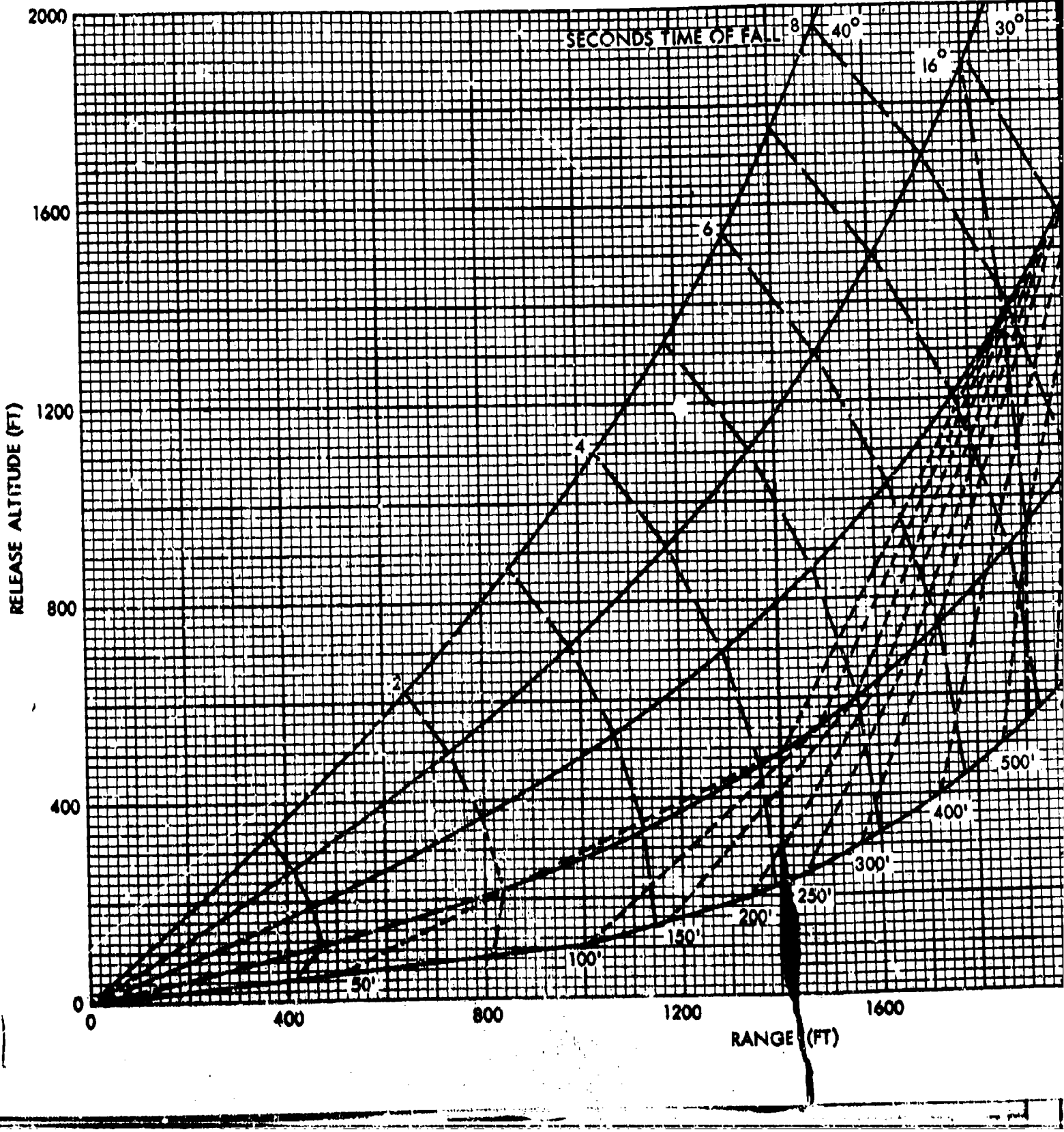


FIG. 20 MK 81/RETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
8
6
4
2
40°
30°
16°
RELEASE ALTITUDE (FT)
2000
1600
1200
800
400
0
0
400
800
1200
1600
RANGE (FT)
500'
400'
300'
250'
200'
150'
100'
50'

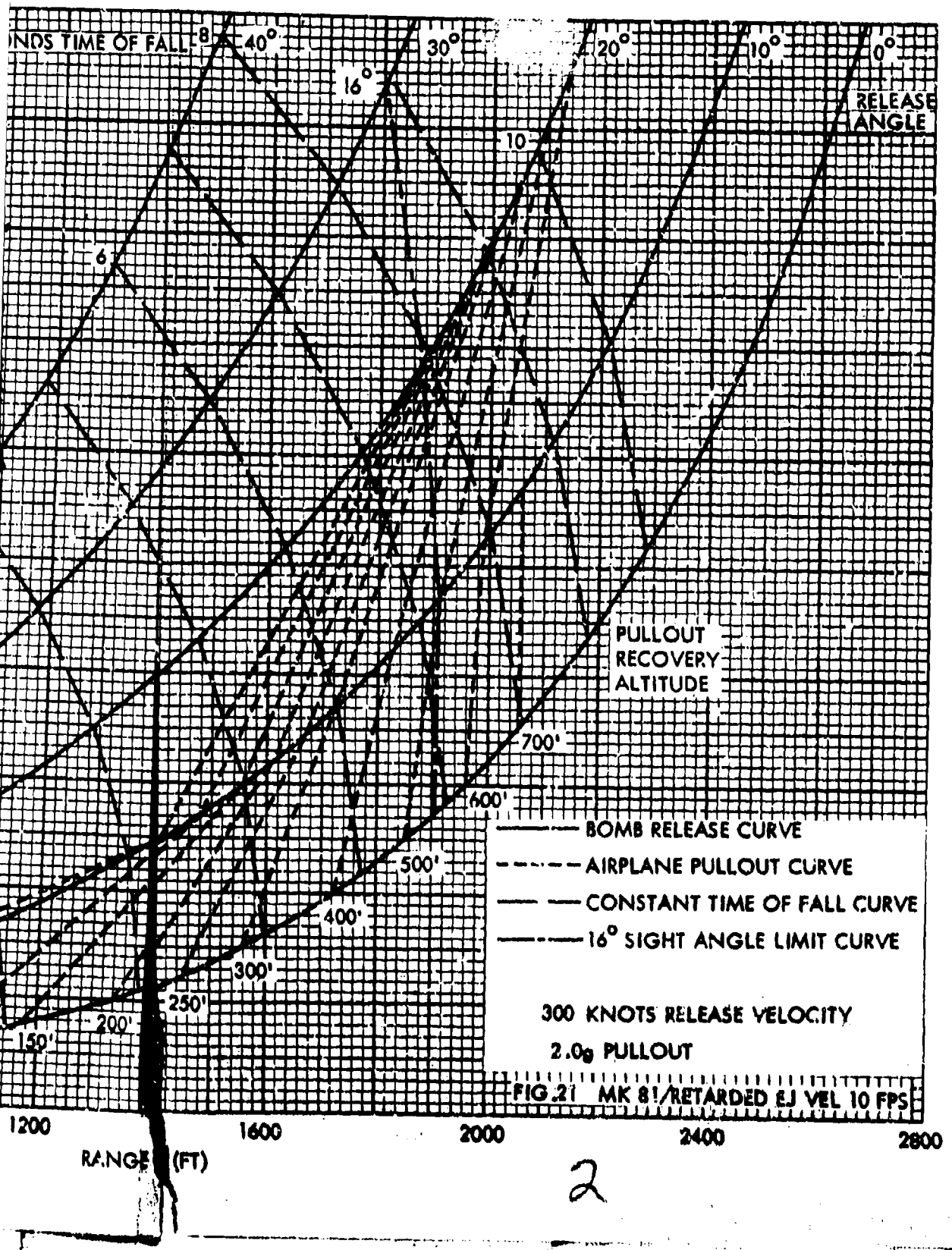
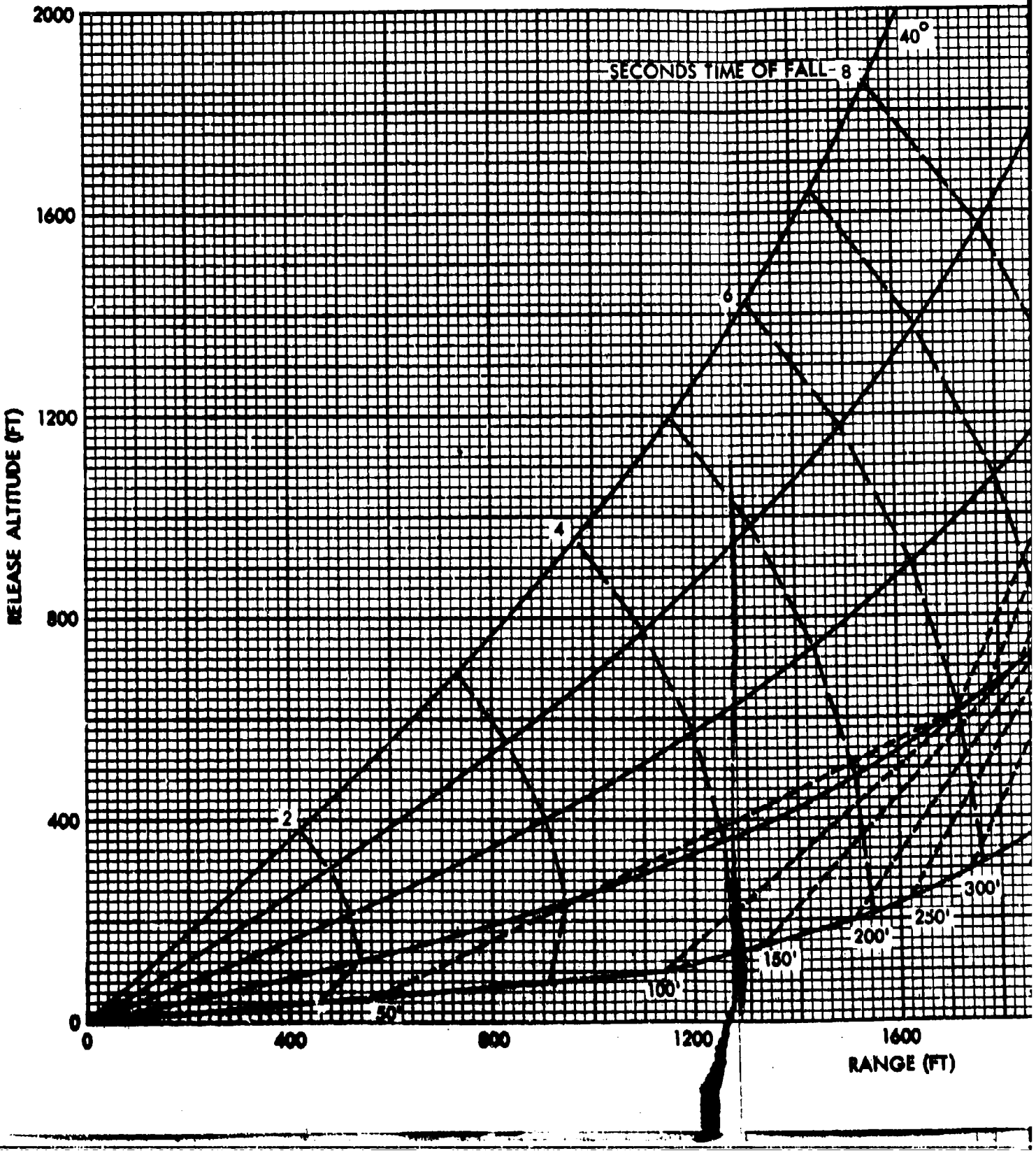


FIG.21 MK 81/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
40°
SECONDS TIME OF FALL - 8
6
4
2
300'
250'
200'
150'
100'
50'

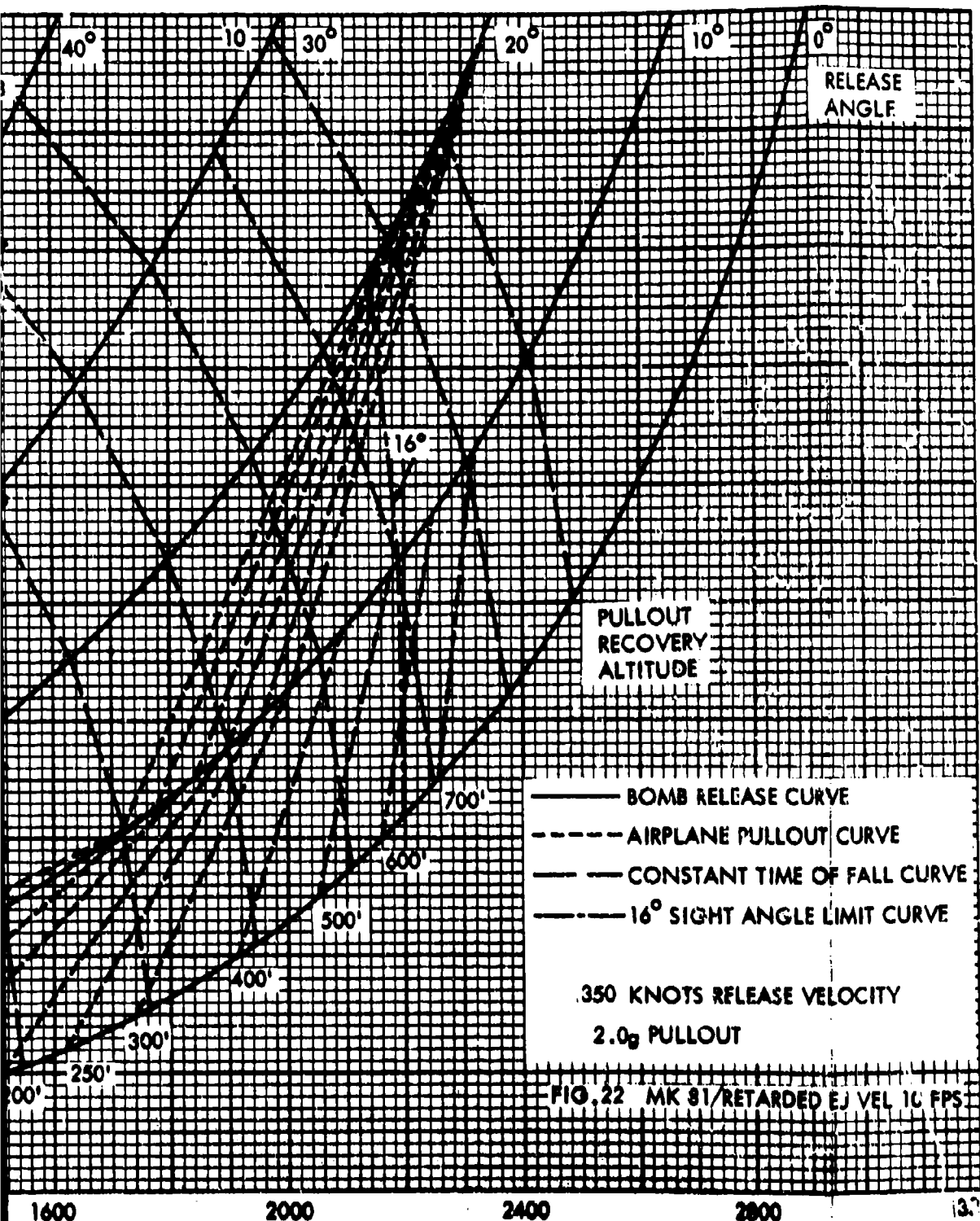
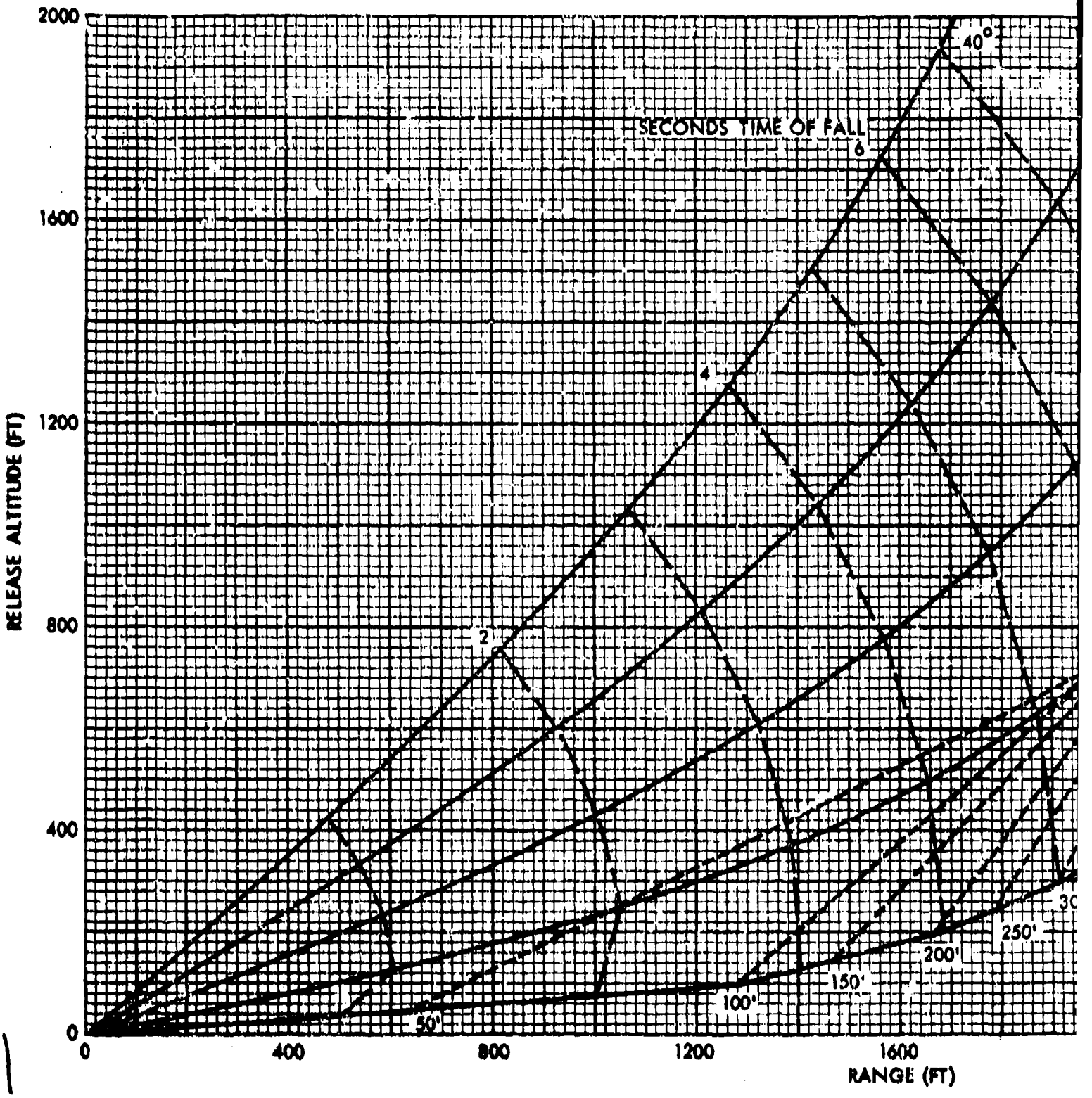


FIG. 22 MK 81/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
40°
50'
100'
150'
200'
250'

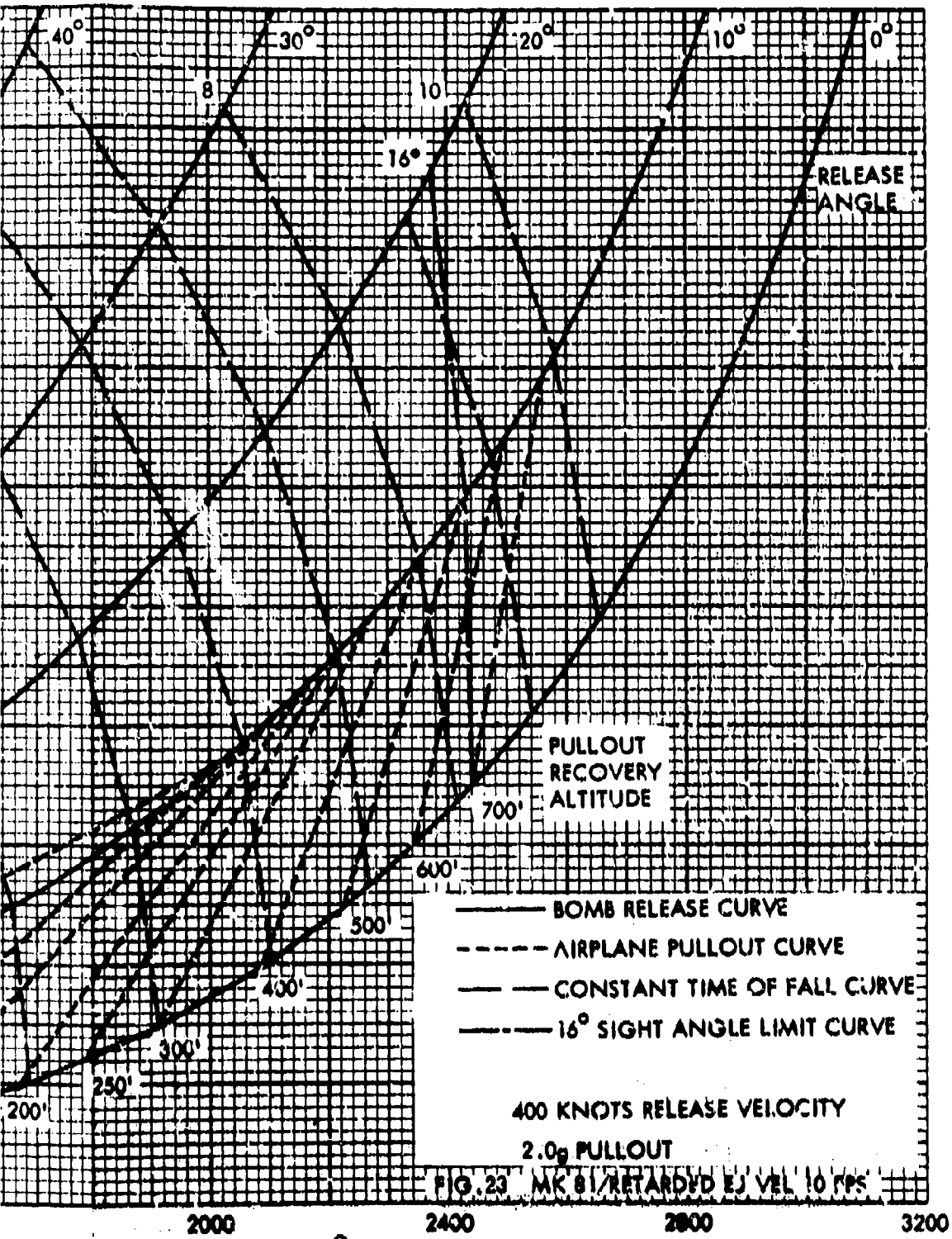
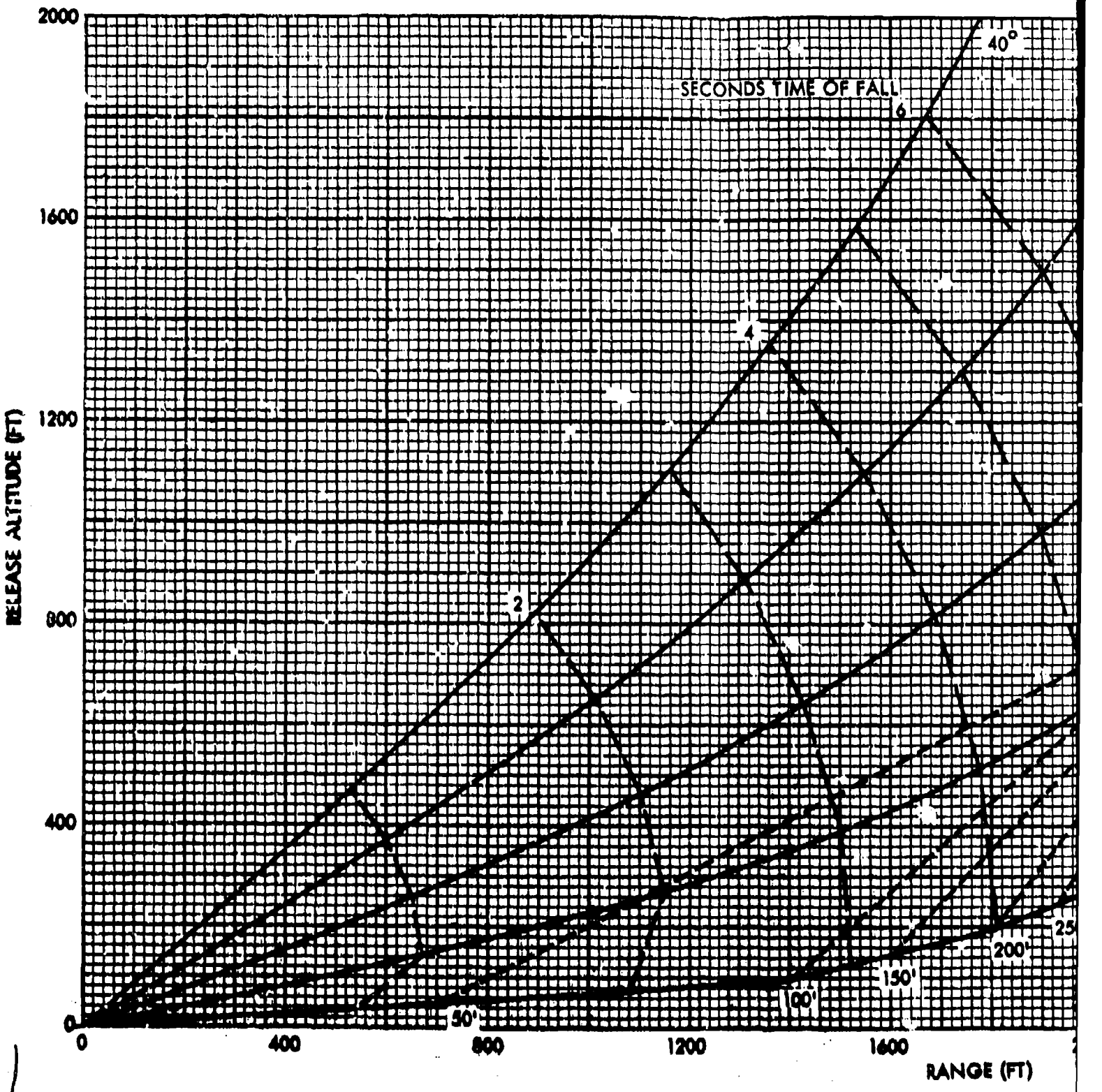


FIG.23 MK 81/RETARDED EJ VEL 10 FPS

2


SECONDS TIME OF FALL
40°
6
4
2
2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
50'
100'
150'
200'
25

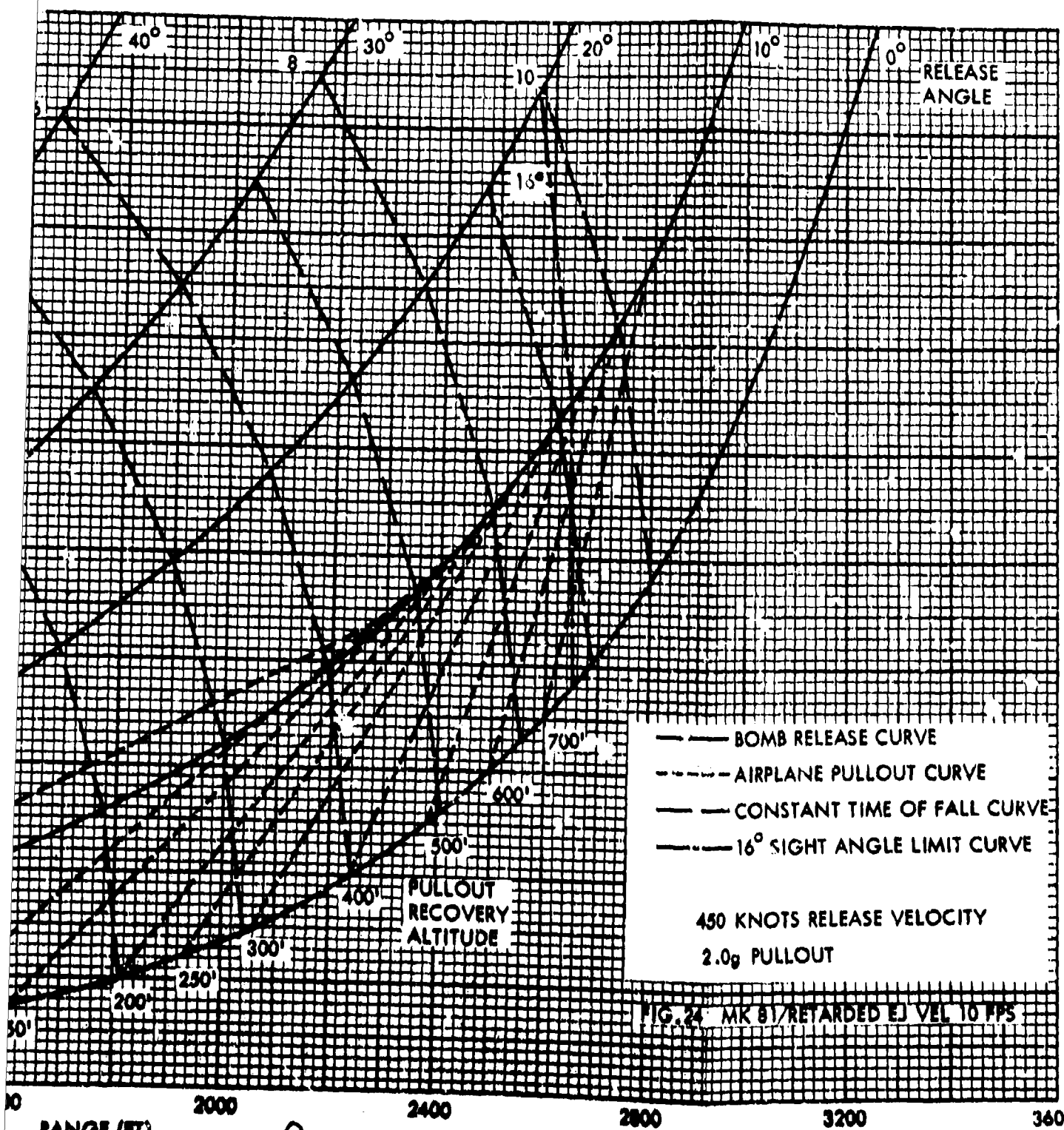
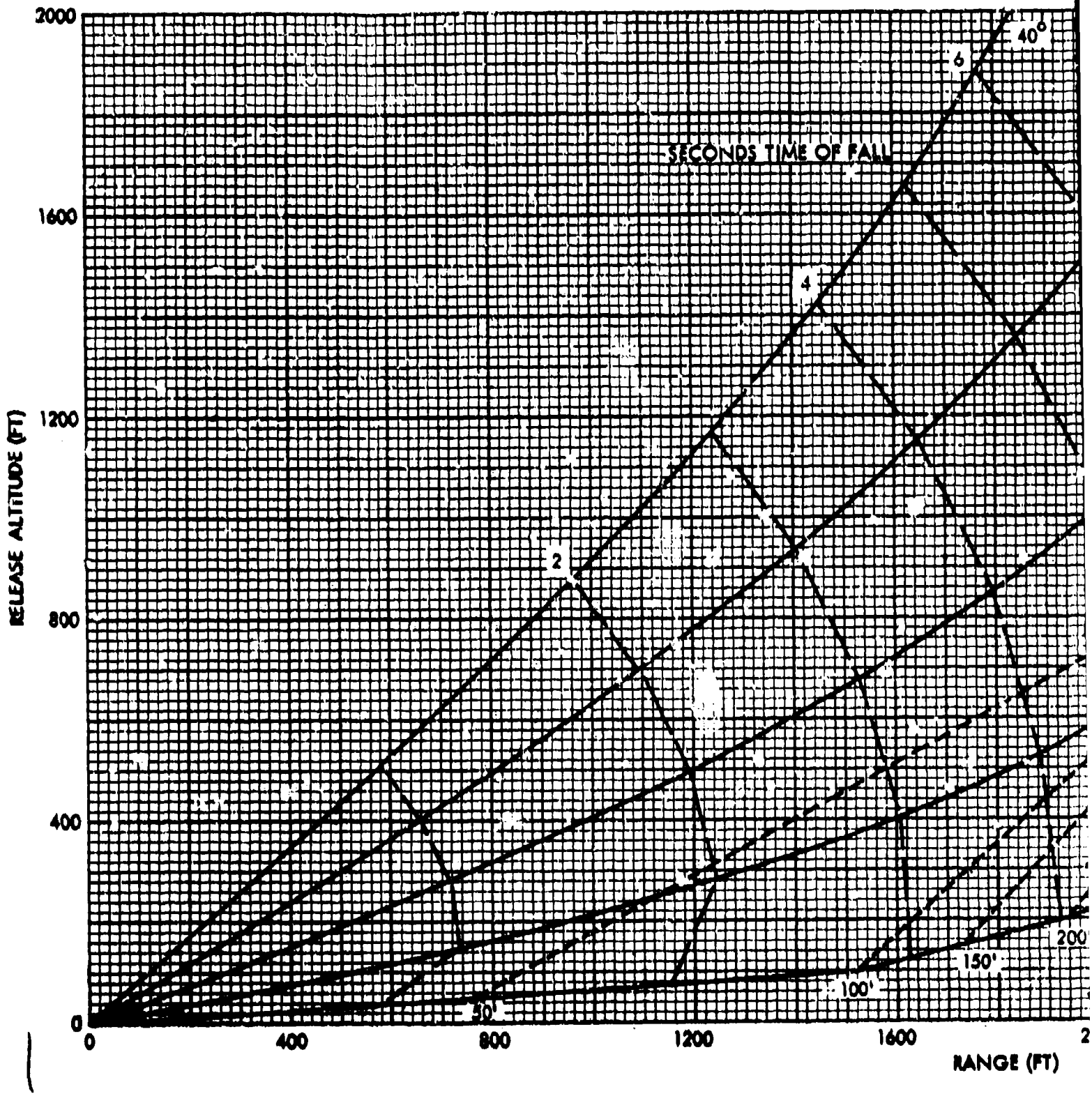


FIG. 24 MK 81/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
2
RANGE (FT)
SECONDS TIME OF FALL
40°
6
4
2
200'
150'
100'
50'

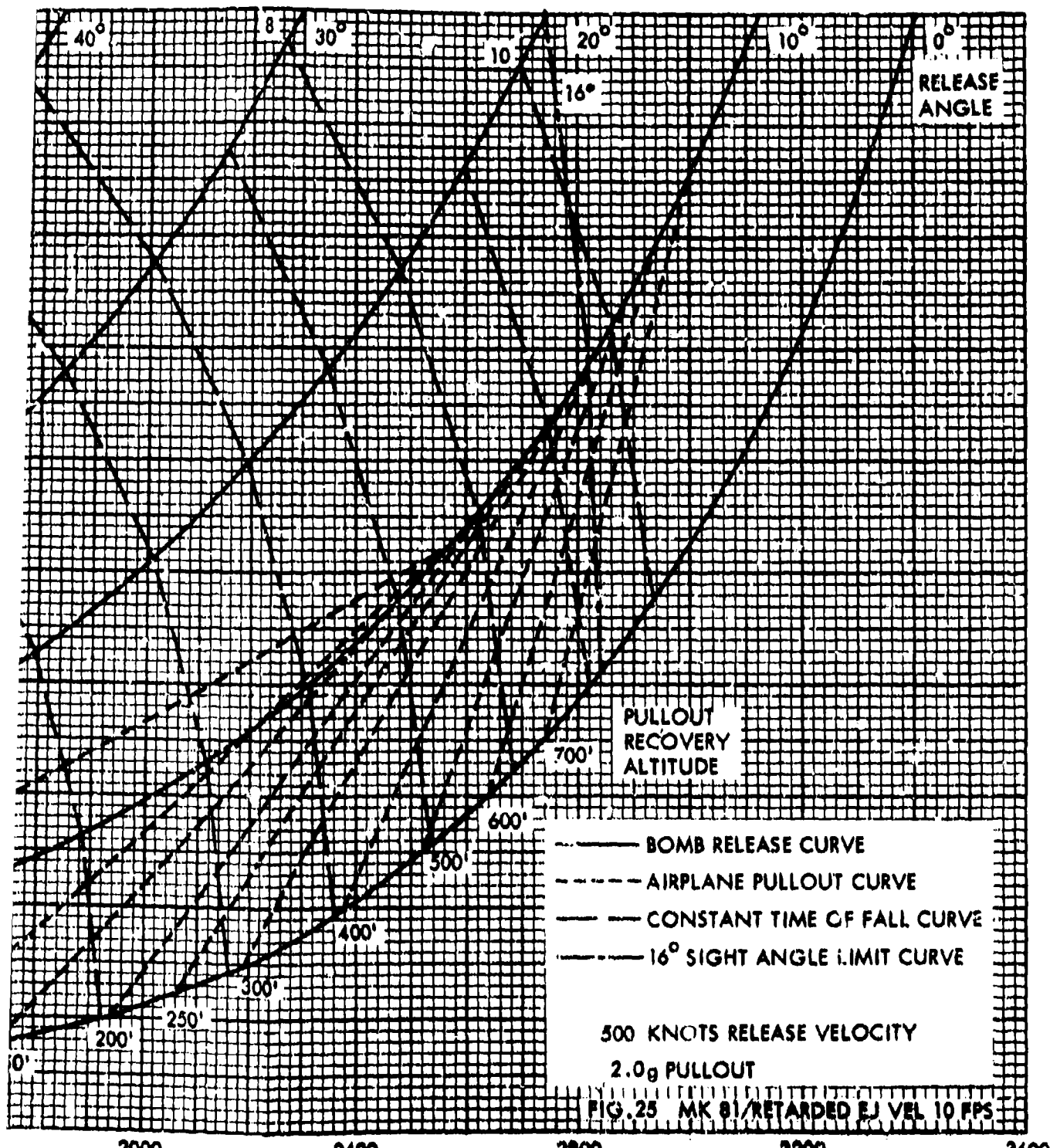
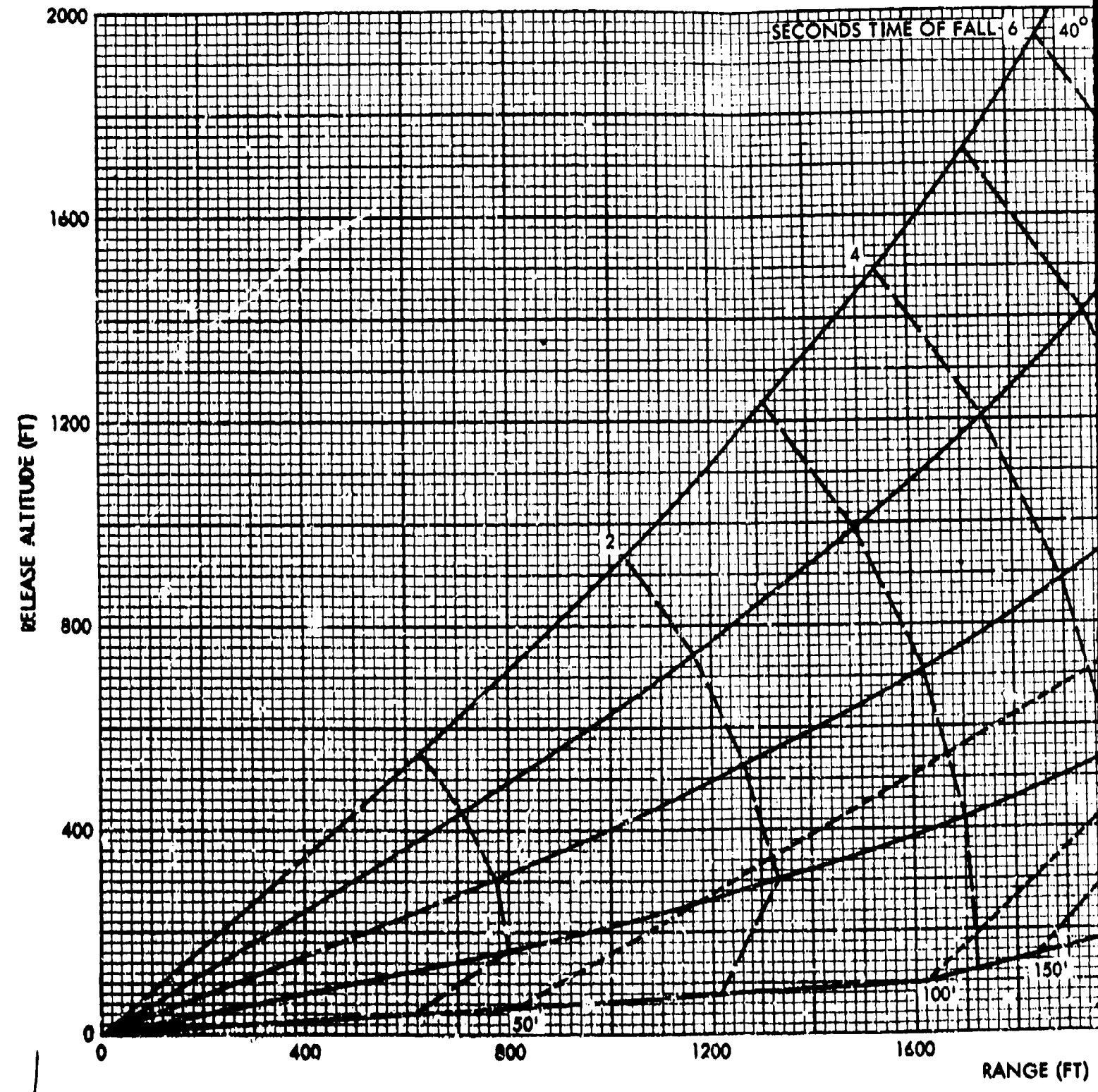


FIG. 25 MK 81/RETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
6
40°
4
2
50'
100'
150'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)

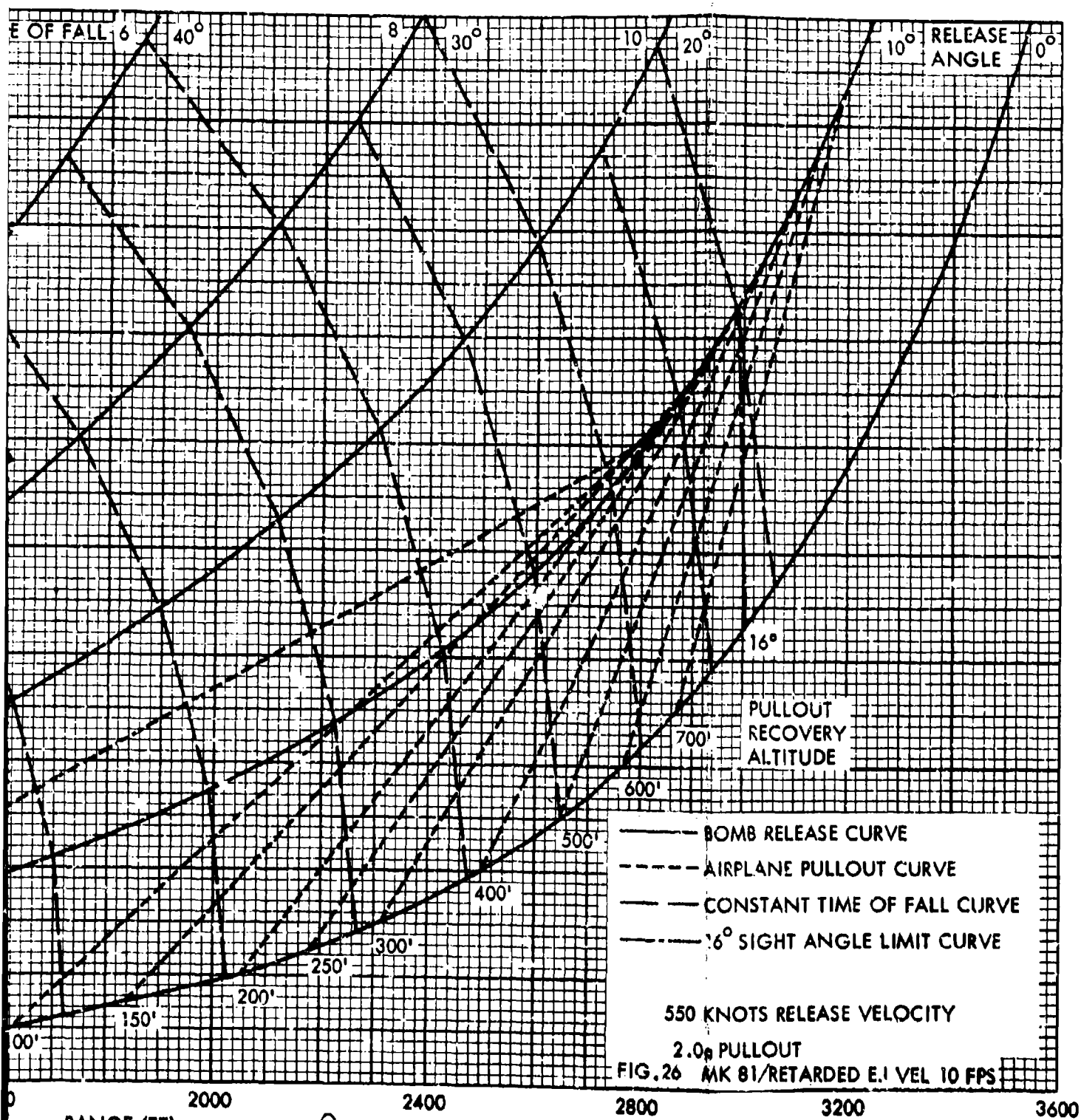
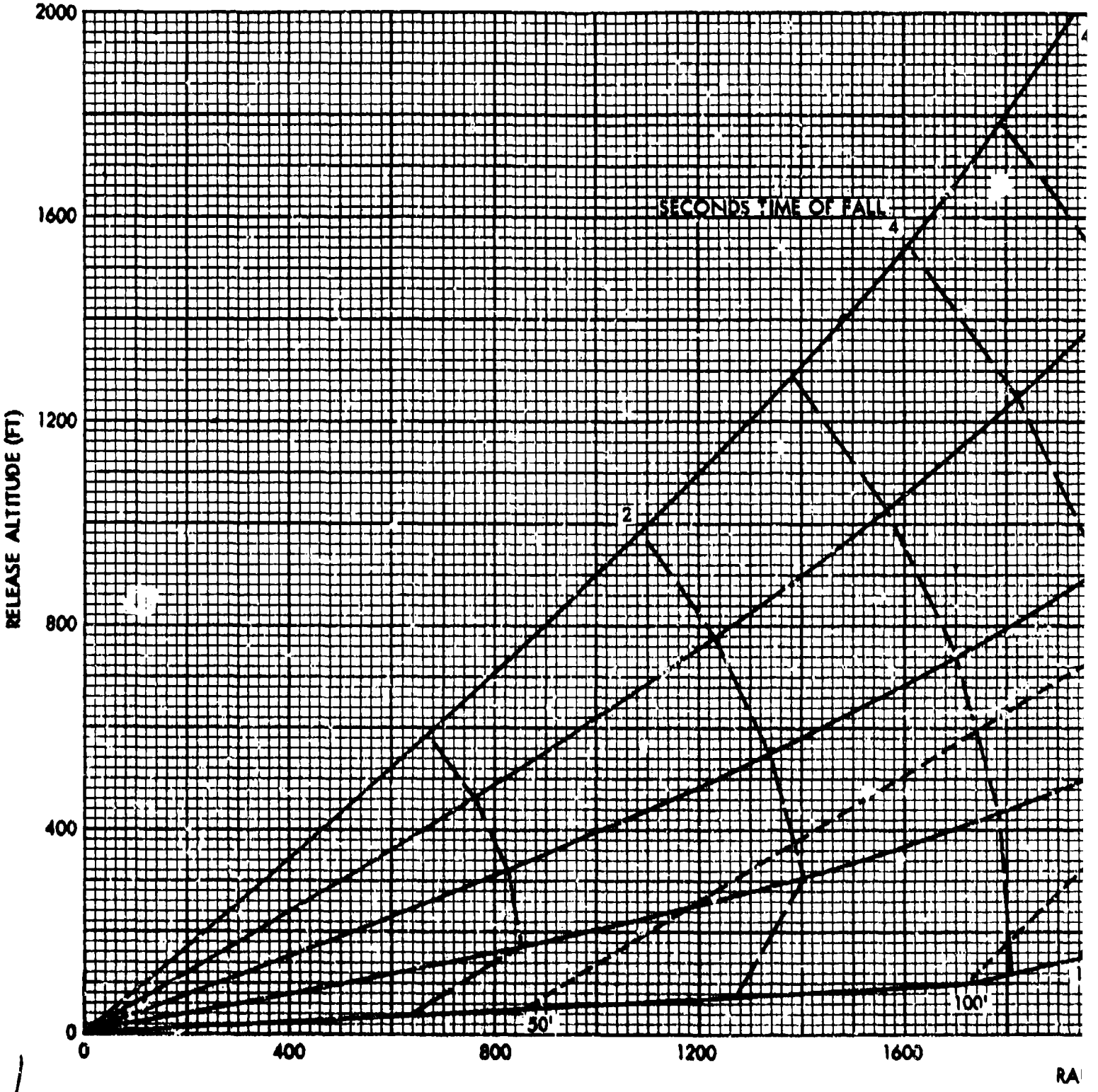


FIG. 26 MK 81/RETARDED E.I VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
SECONDS TIME OF FALL
4
2
1
100'
50'
0
400
800
1200
1600

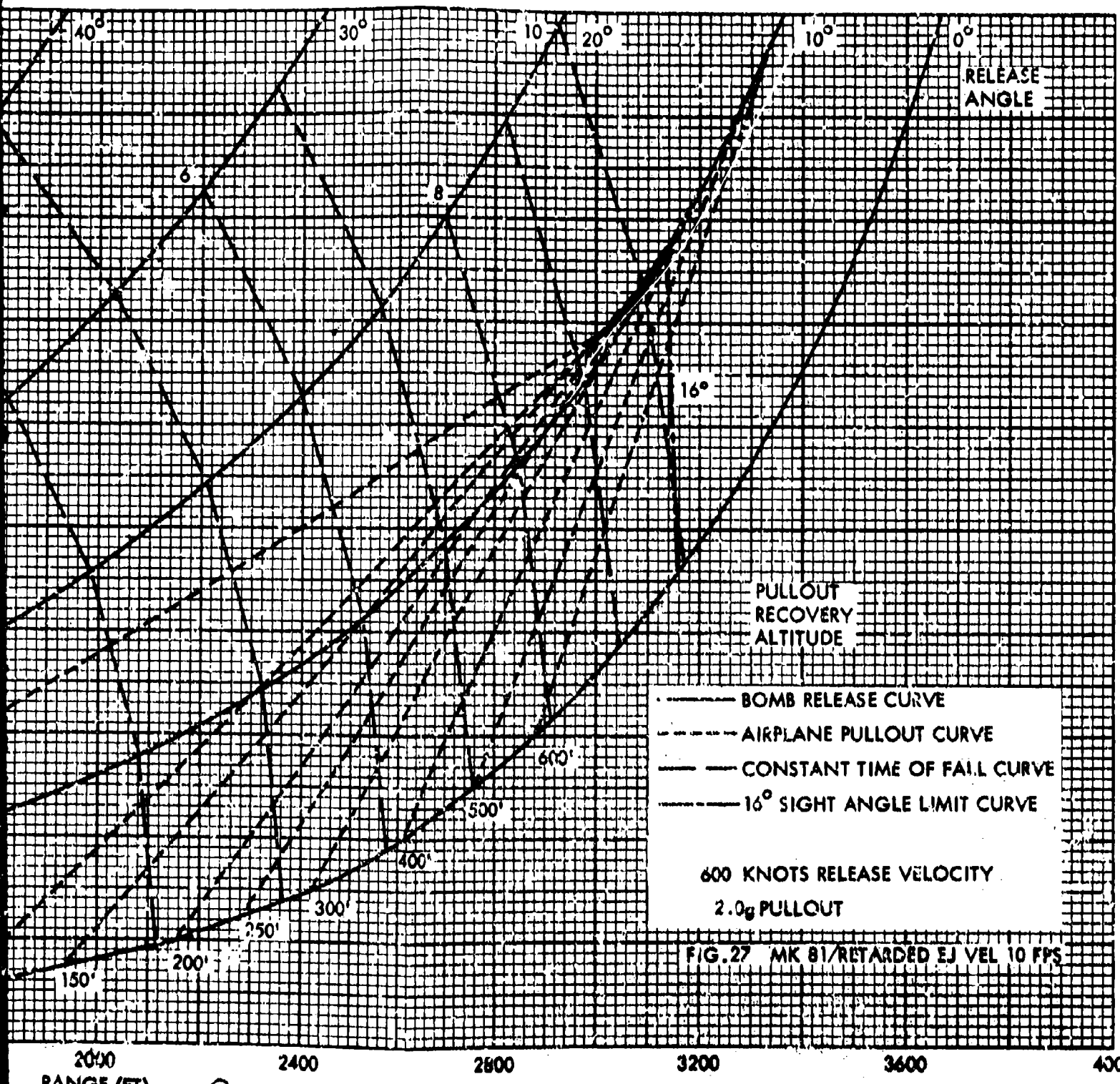


FIG. 27 MK 81/RETARDED EJ VEL 10 FPS

7

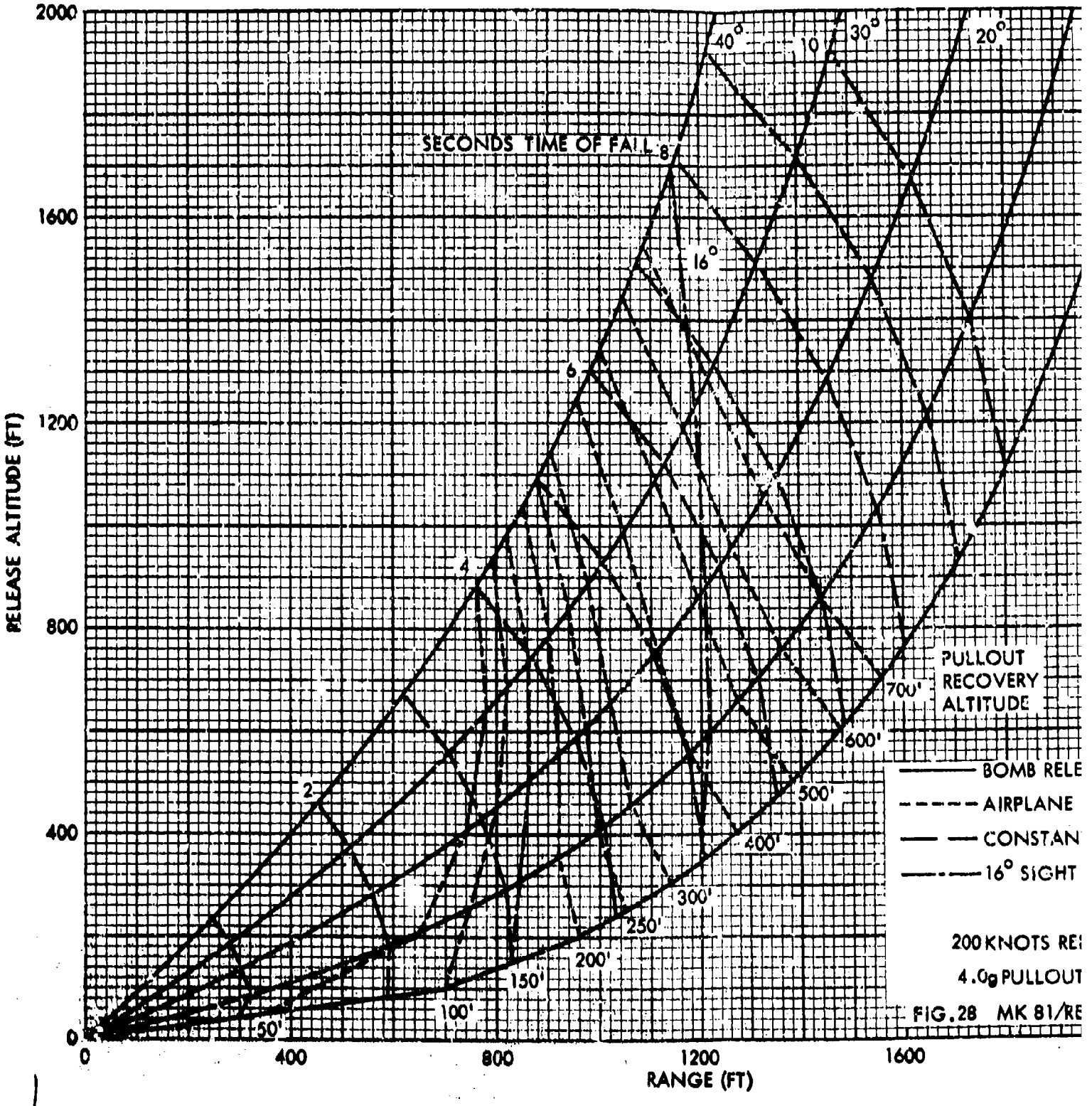


FIG. 28 MK 81/RE

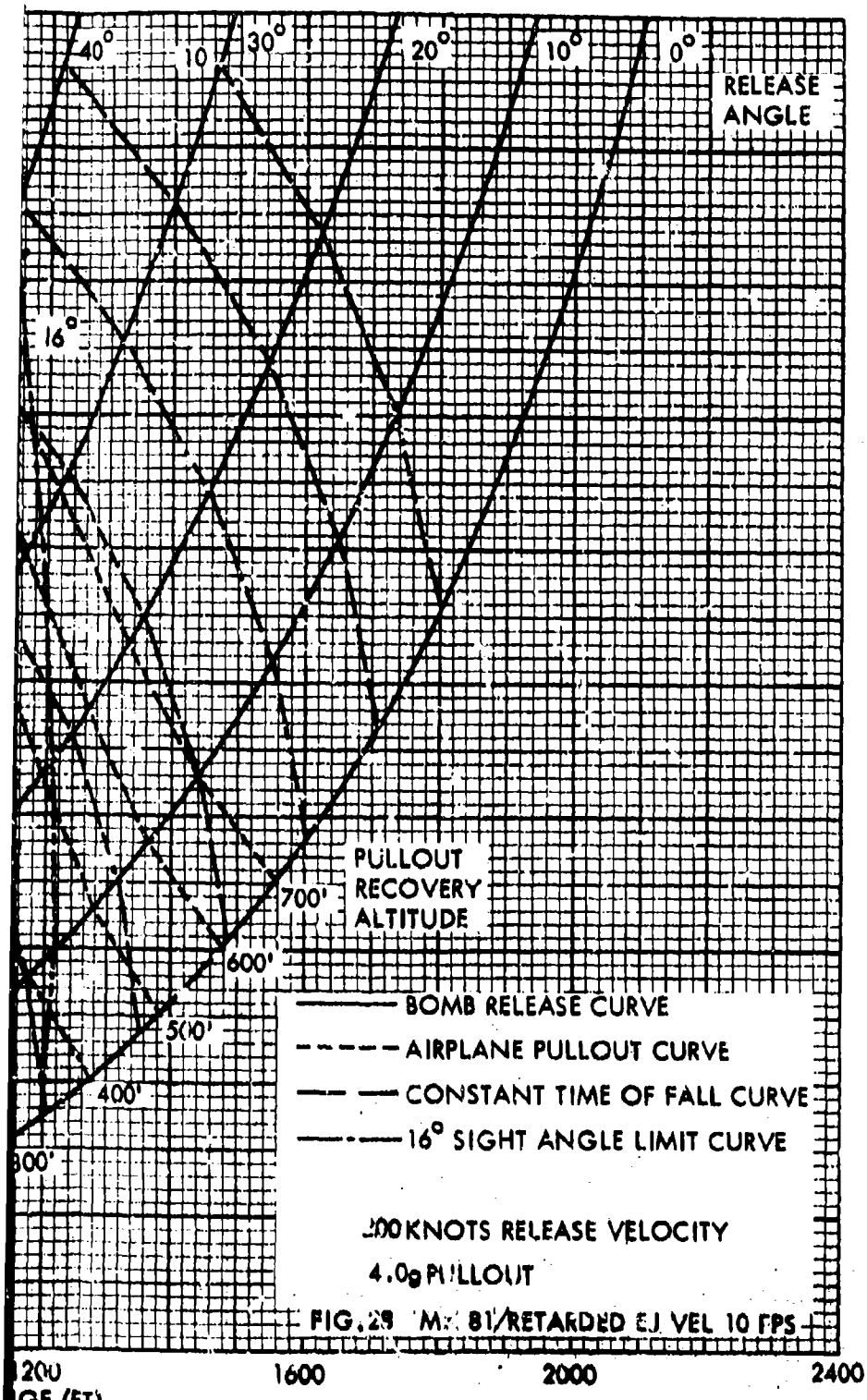
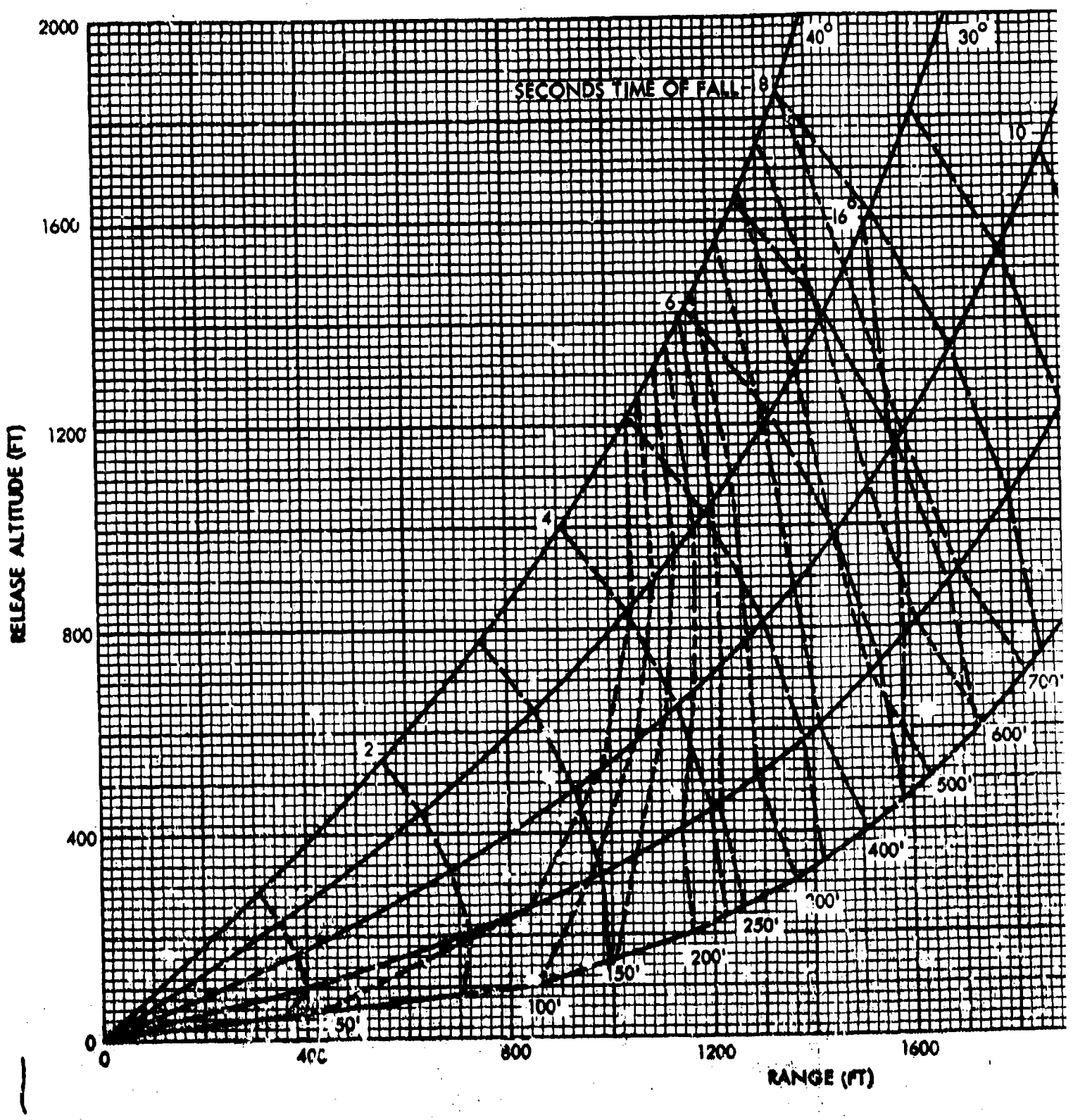
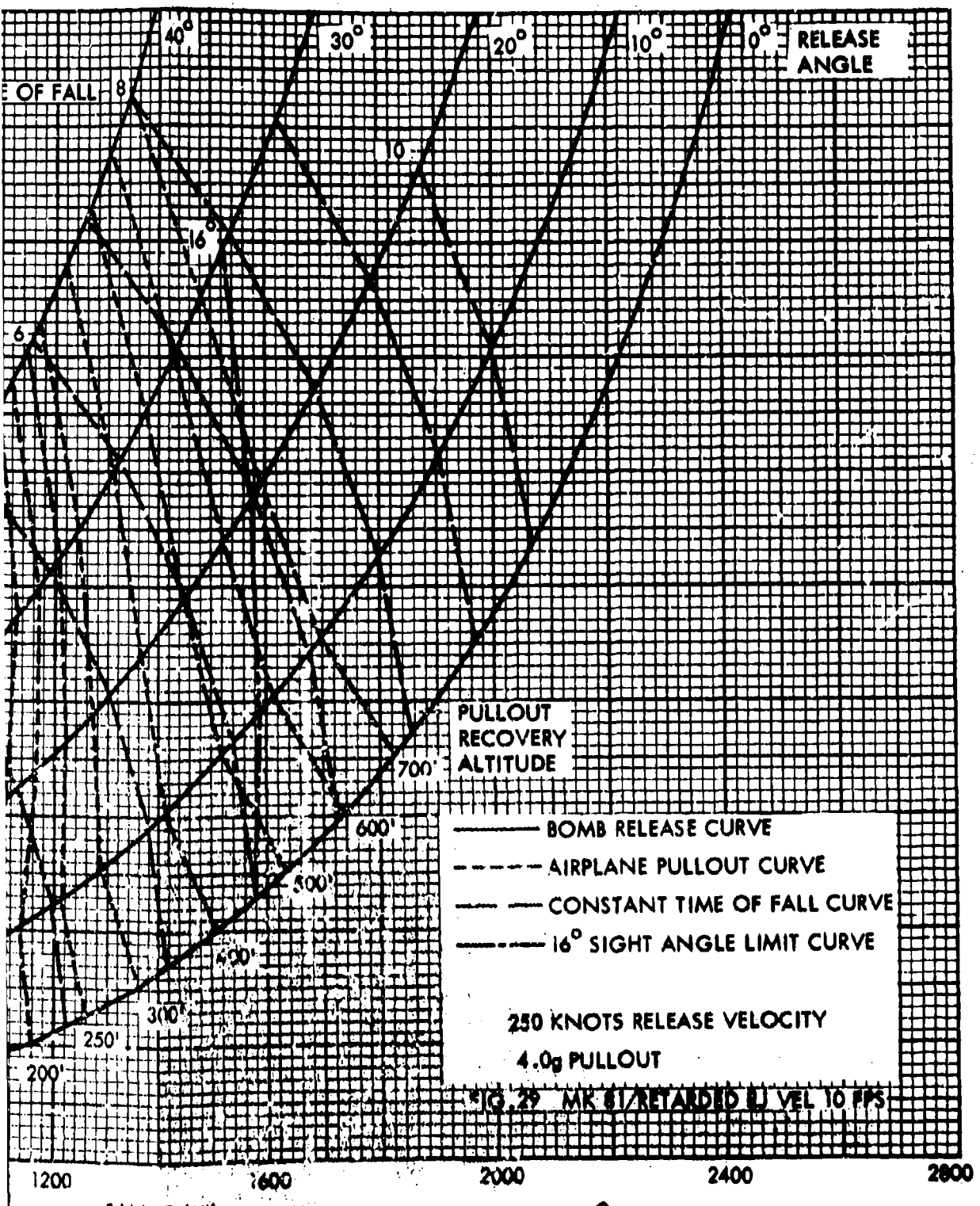
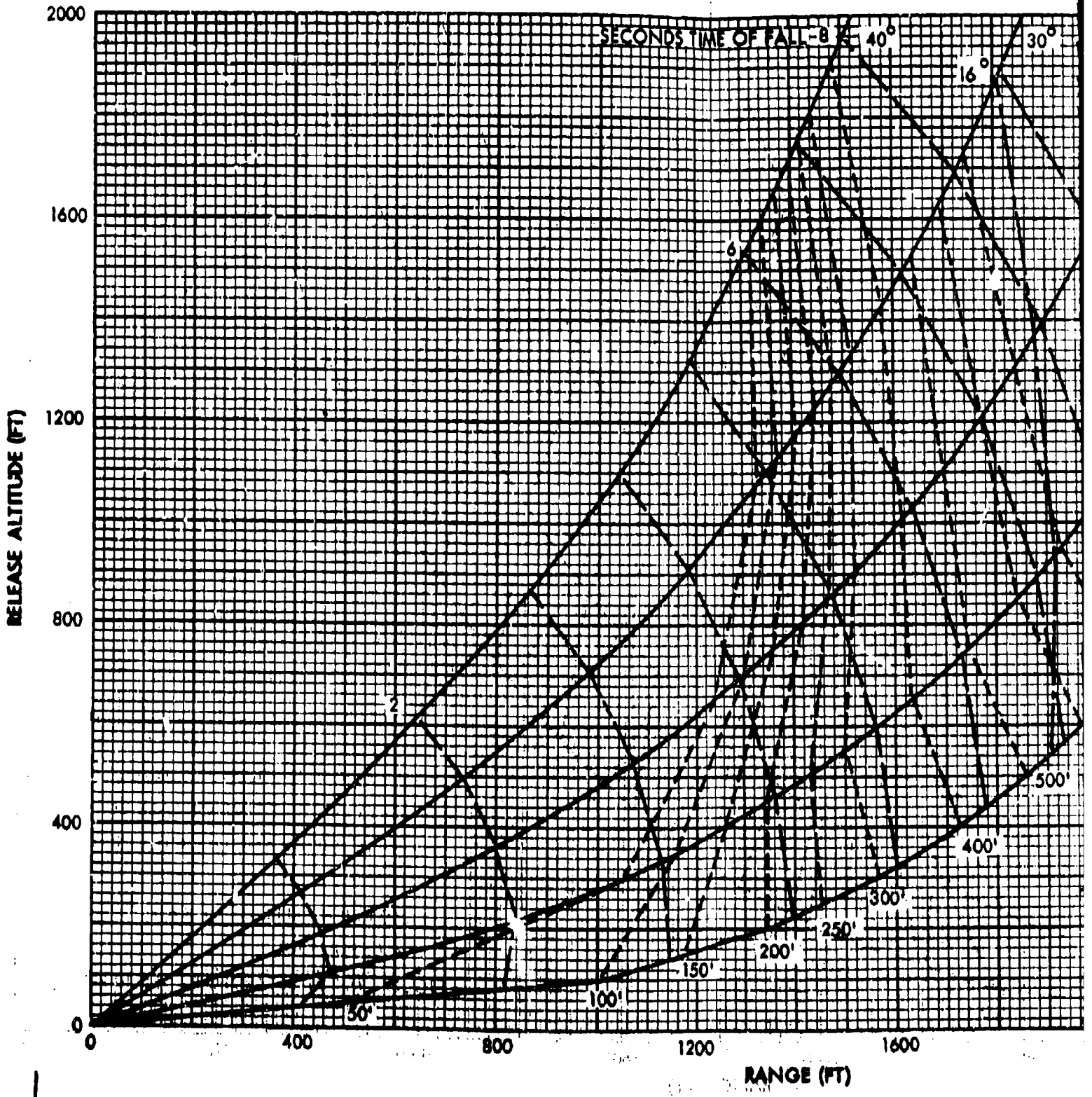


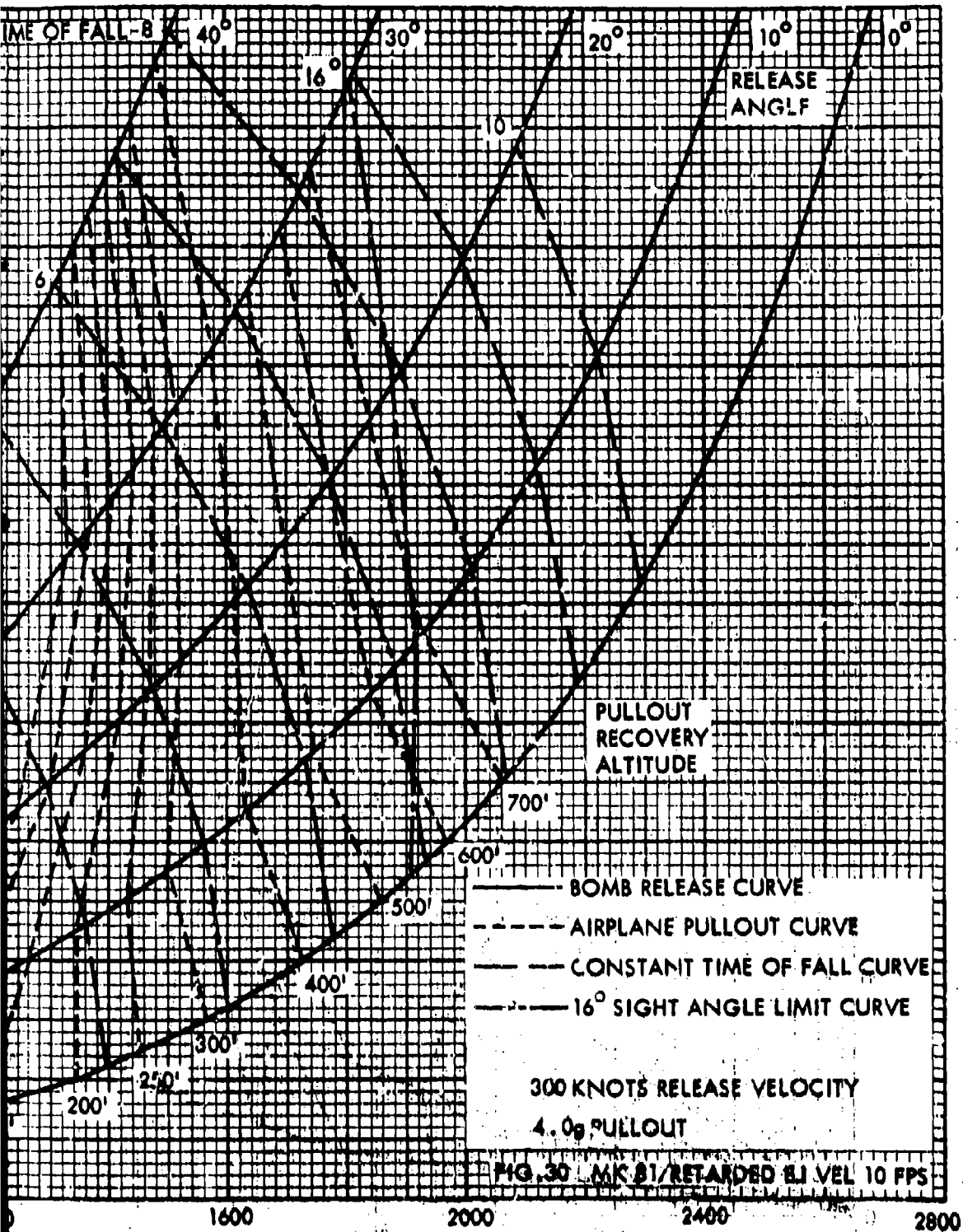
FIG. 29 M[illegible] 81/RETARDED EJ VEL 10 FPS

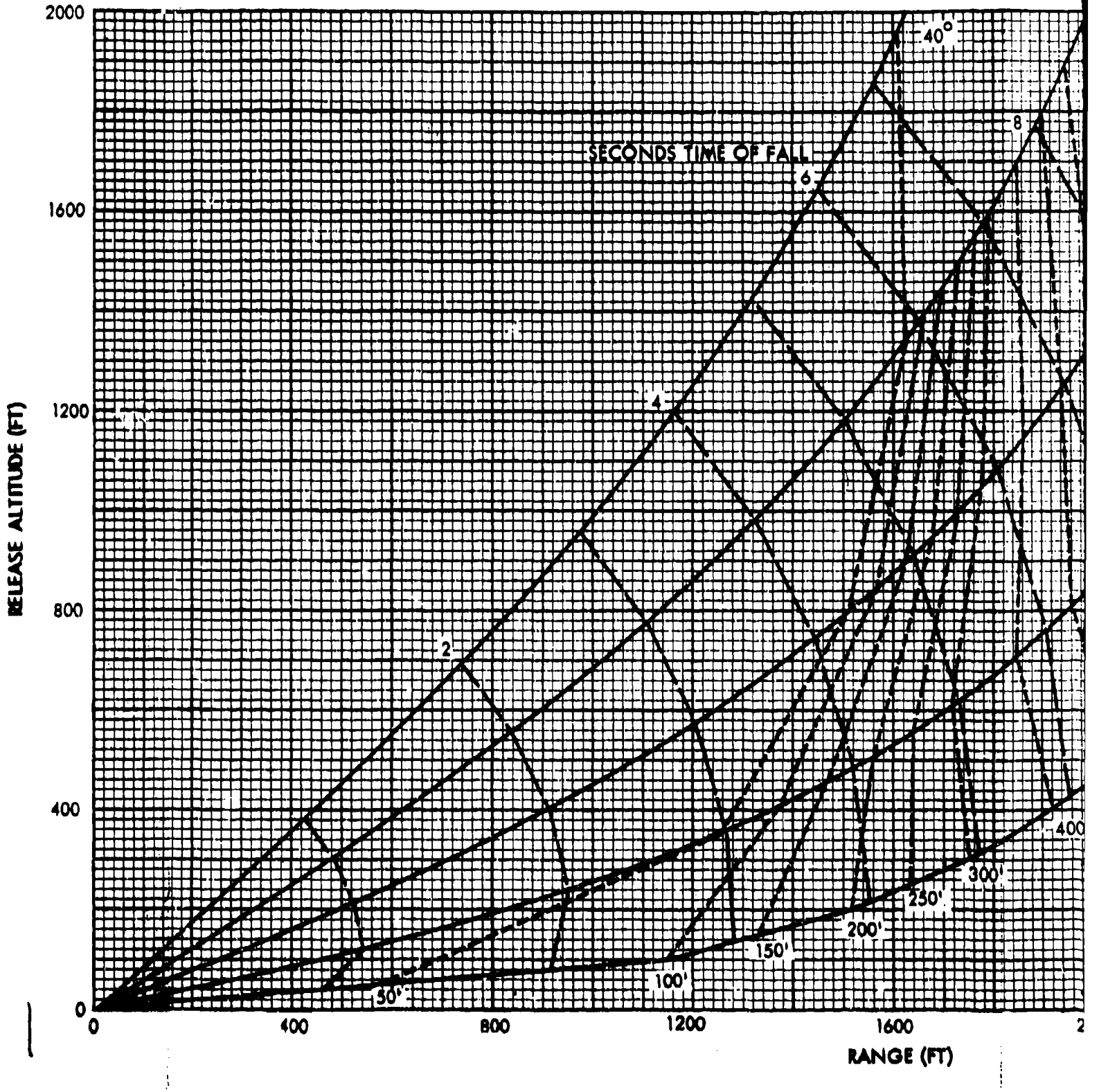
NO


SECONDS TIME OF FALL
40°
30°
2
4
6
8
10
16
50'
100'
150'
200'
250'
300'
400'
500'
600'
700'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)


40°
30°
20°
10°
0°
RELEASE ANGLE
OF FALL
8
10
16°
6
PULLOUT RECOVERY ALTITUDE
700'
600'
500'
400'
300'
250'
200'
BOMB RELEASE CURVE
AIRPLANE PULLOUT CURVE
CONSTANT TIME OF FALL CURVE
16° SIGHT ANGLE LIMIT CURVE
250 KNOTS RELEASE VELOCITY
4.0g PULLOUT
*IG.29 MK 81/RETARDED EJ VEL 10 FPS
1200
1600
2000
2400
2800
RANGE (FT)


SECONDS TIME OF FALL-8 K
40°
30°
16°
6
2
500'
400'
300'
250'
200'
150'
100'
50'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)


IME OF FALL-8 K
40°
30°
20°
10°
0°
16°
RELEASE ANGLE
10
6
PULLOUT RECOVERY ALTITUDE
700'
600'
500'
400'
300'
250'
200'
BOMB RELEASE CURVE
AIRPLANE PULLOUT CURVE
CONSTANT TIME OF FALL CURVE
16° SIGHT ANGLE LIMIT CURVE
300 KNOTS RELEASE VELOCITY
4.0g PULLOUT
FIG. 30 MK 81/RETARDED EJ VEL 10 FPS
1600
2000
2400
2800
RANGE (FT)


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
8
40°
400'
300'
250'
200'
150'
100'
50'

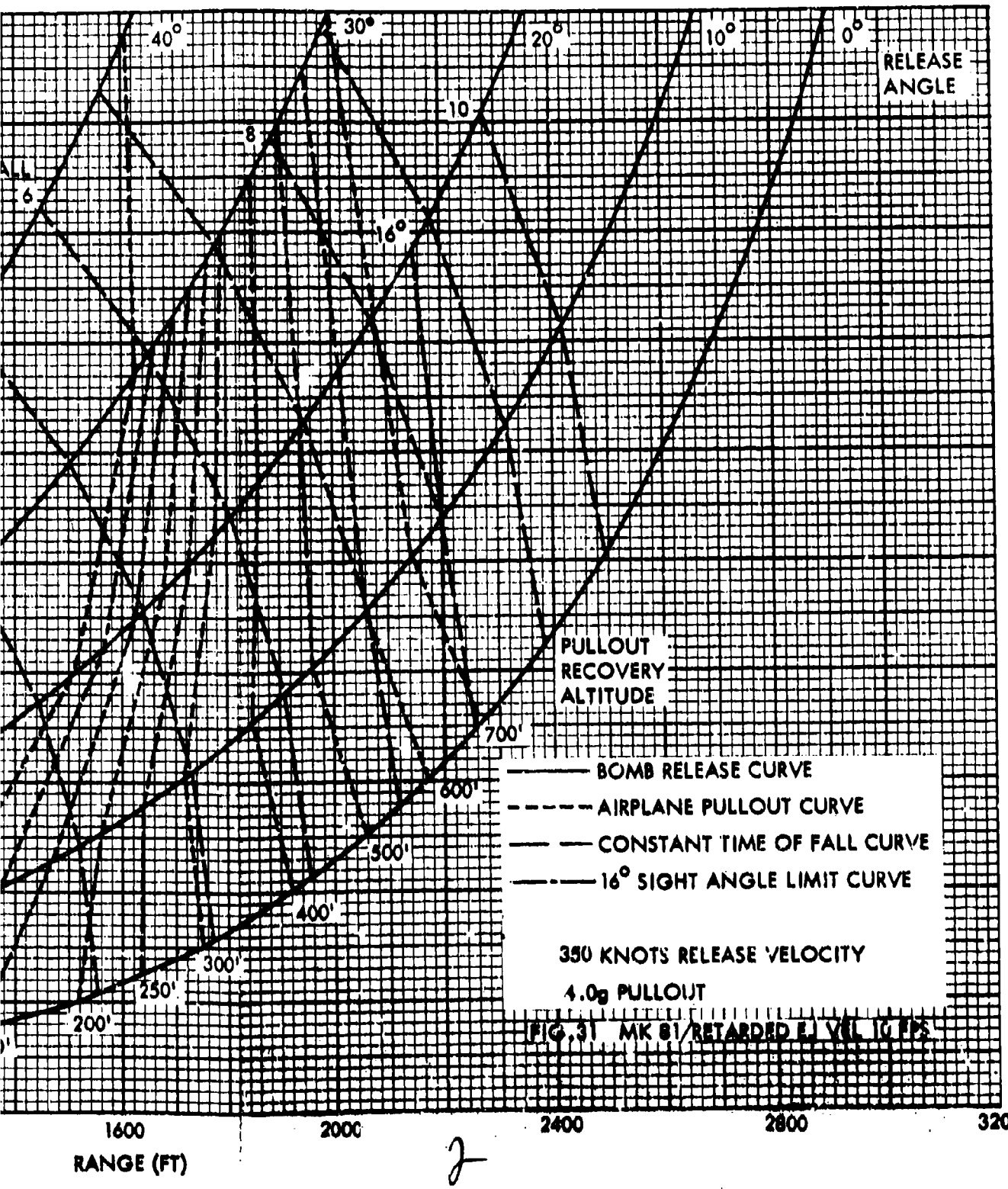
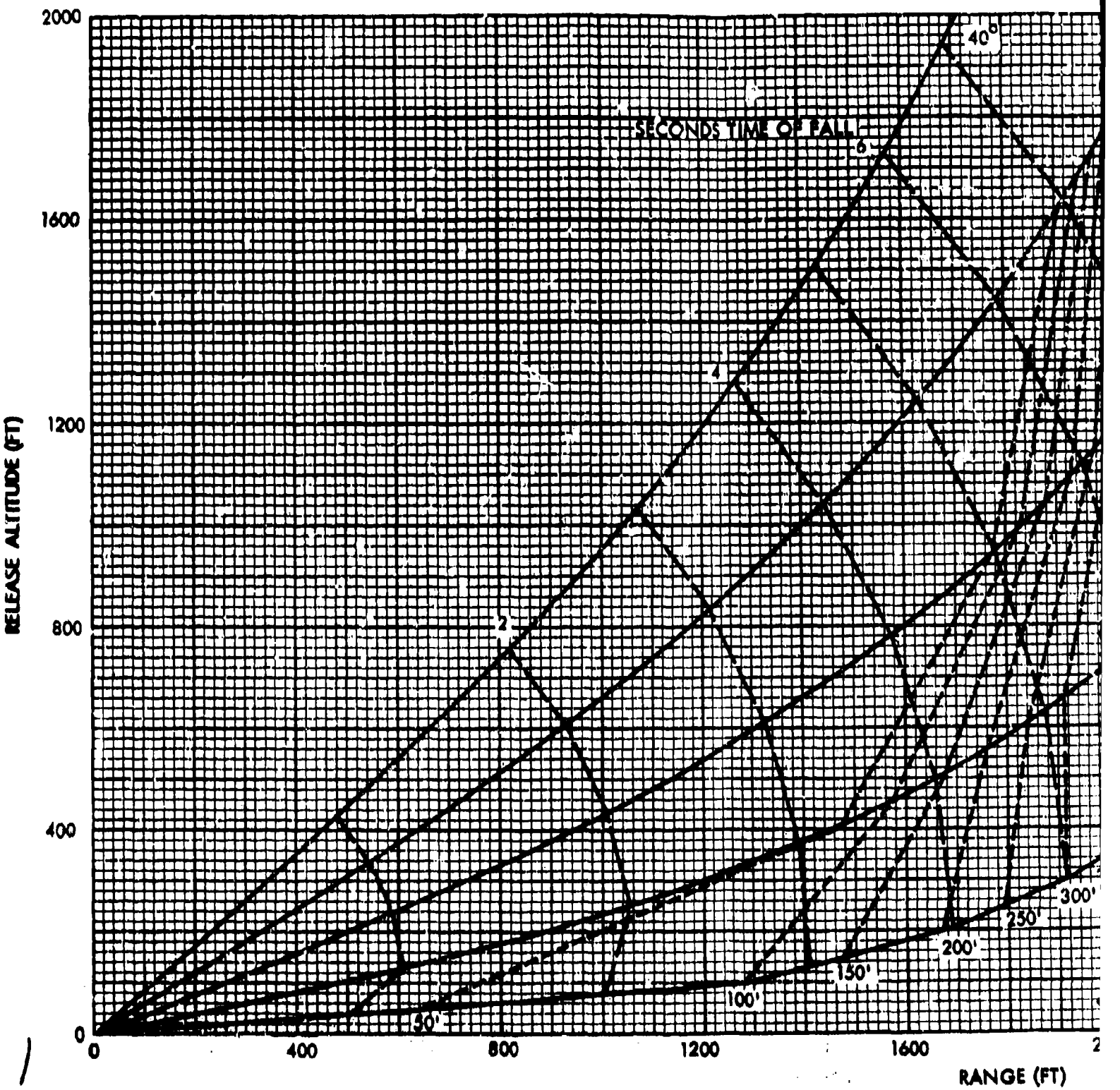


FIG. 31 MK 81/RETARDED EJ VEL 10 FPS

2


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
40°
50'
100'
150'
200'
250'
300'

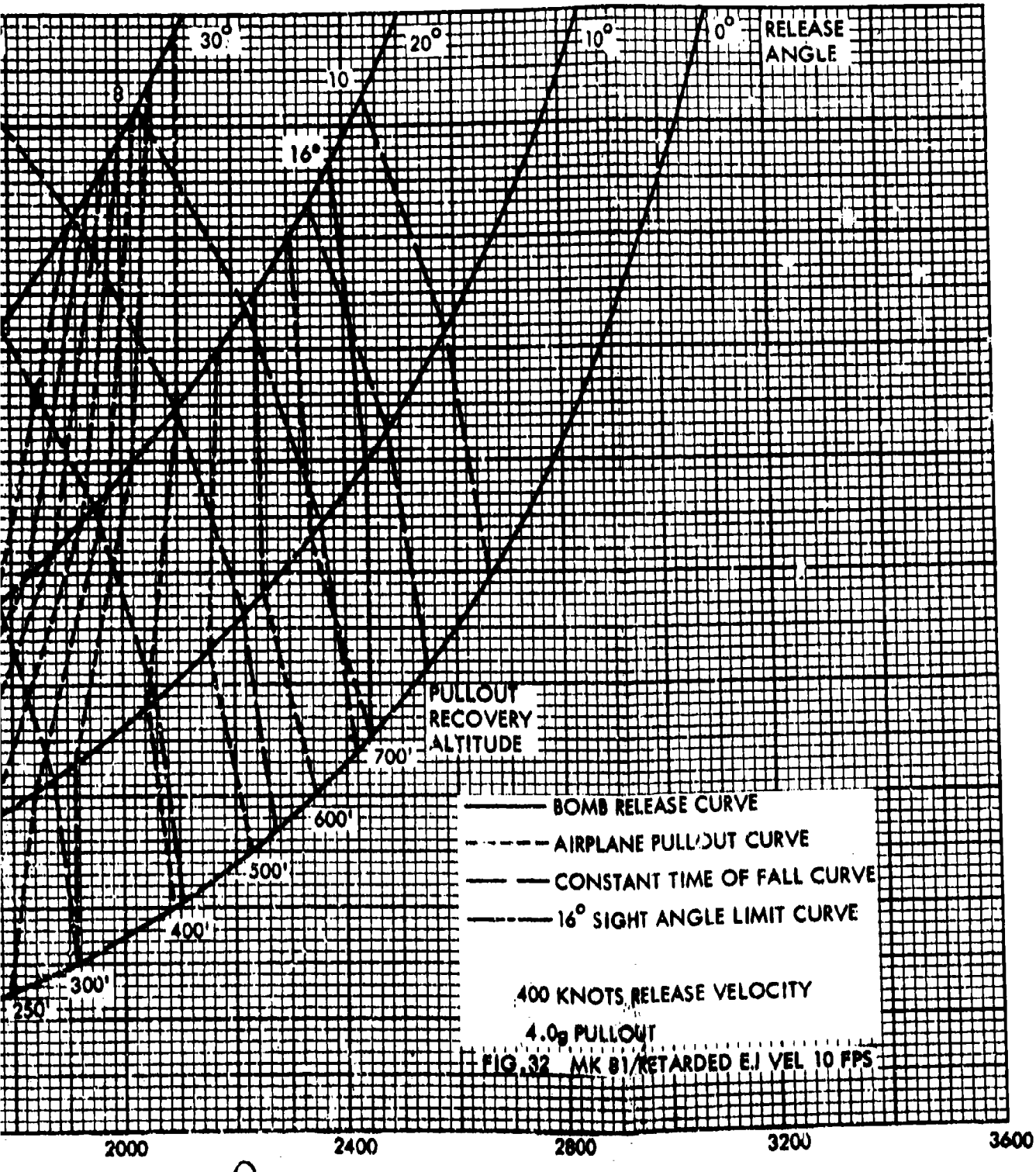
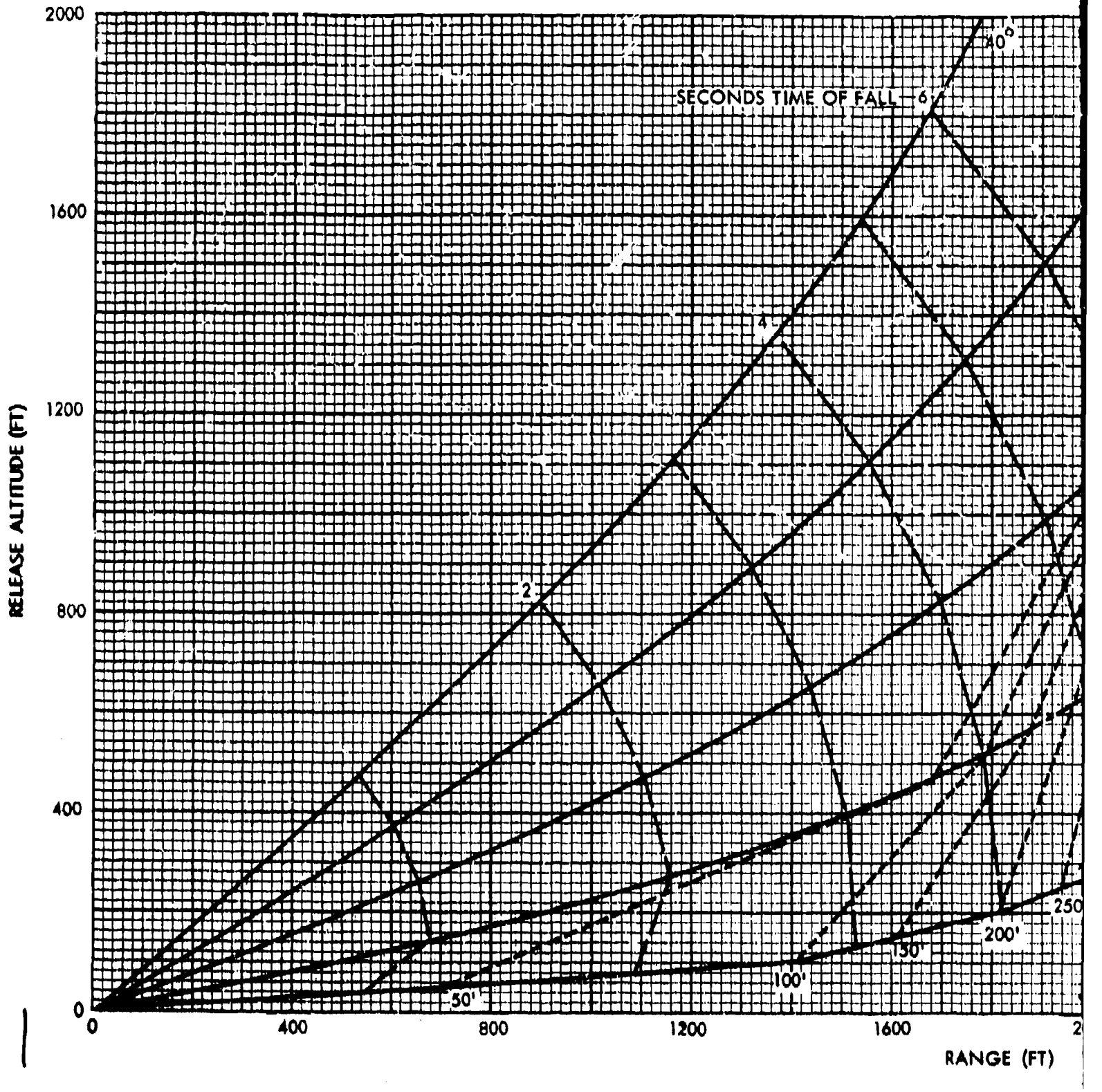


FIG. 32 MK 81/RETARDED E.I VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
40°
50'
100'
150'
200'
250

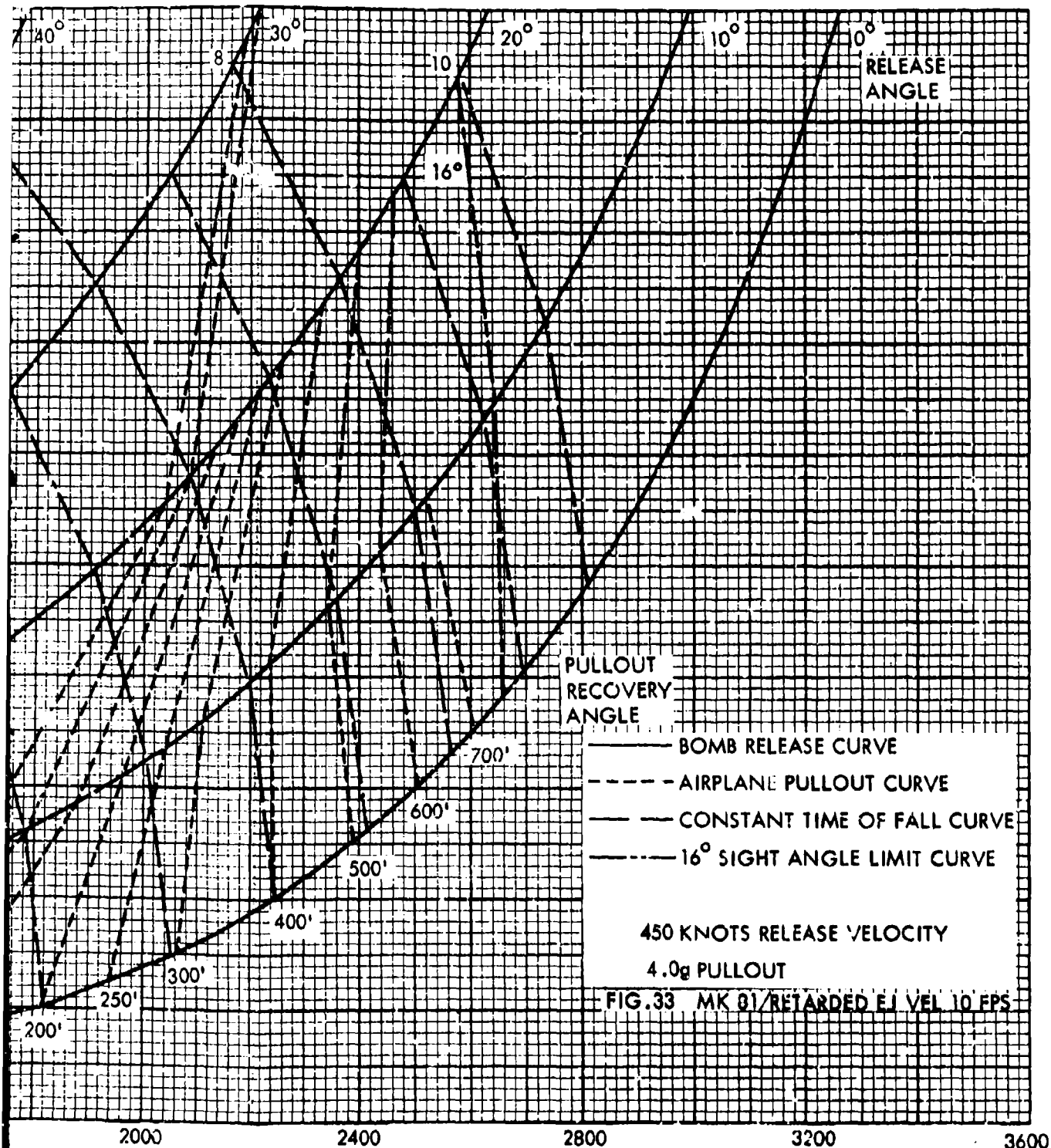
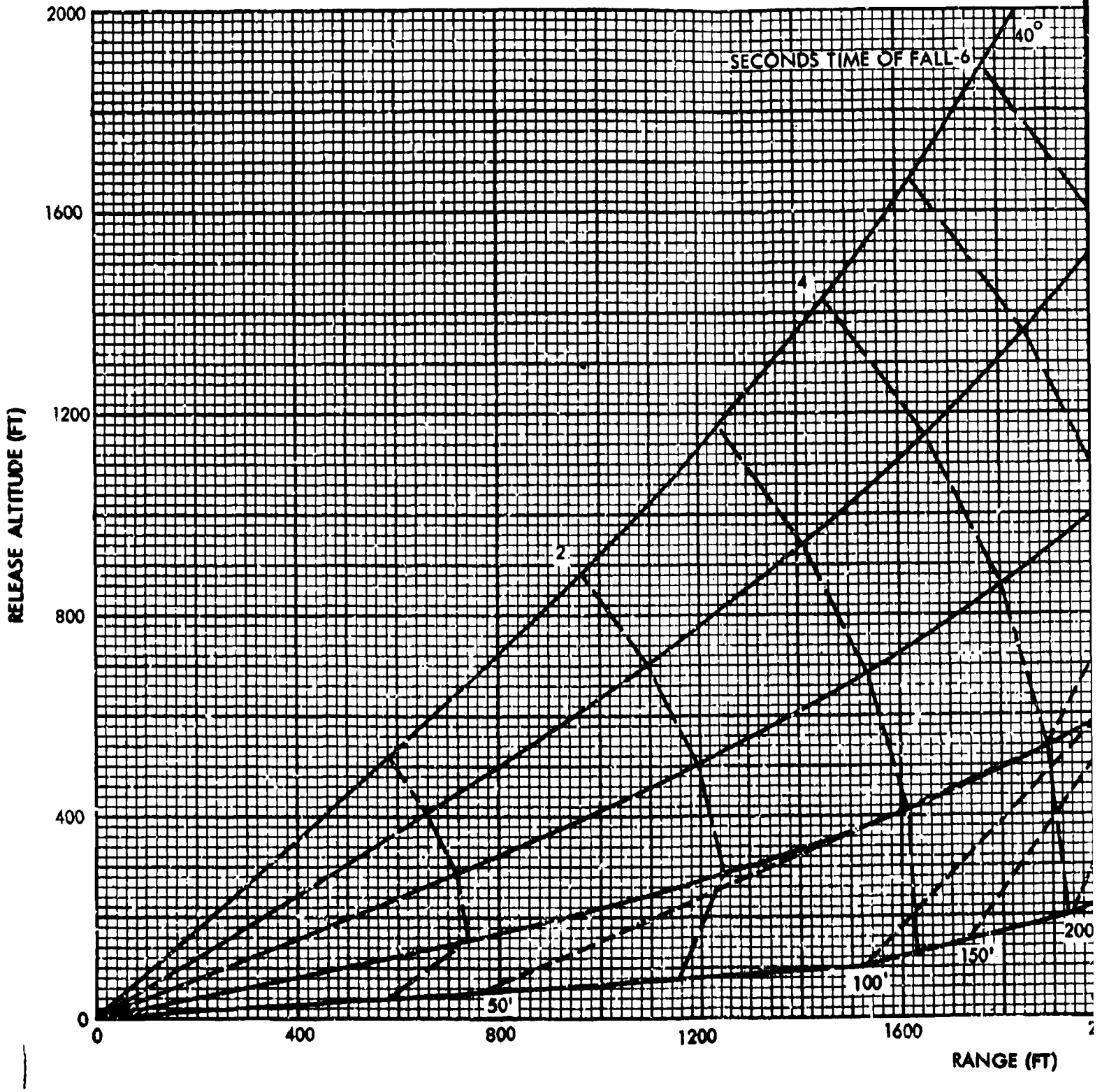


FIG. 33 MK 81/RETARDED EJ VEL 10 FPS

2


SECONDS TIME OF FALL-6
40°
4
2
50'
100'
150'
200
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)

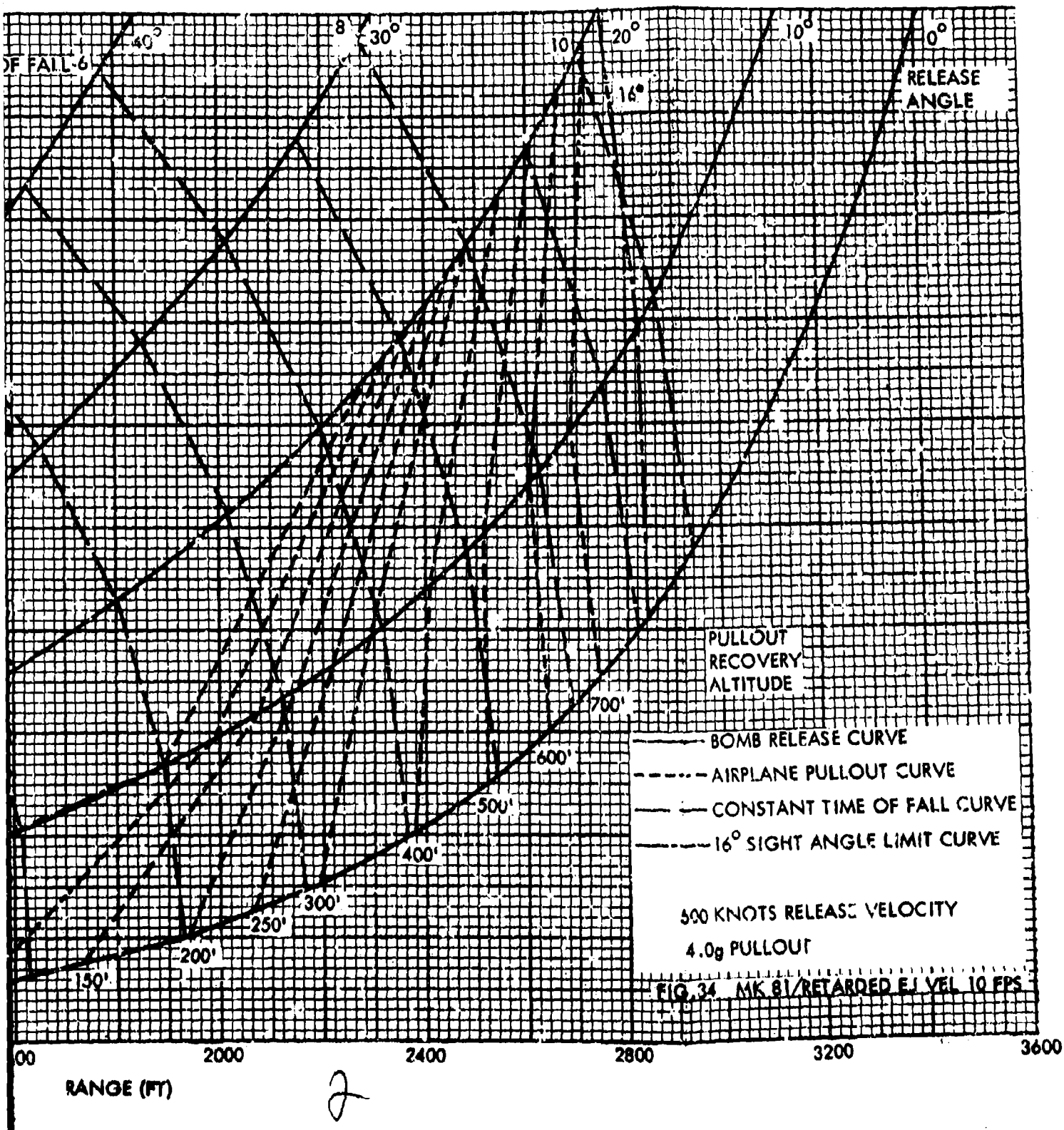
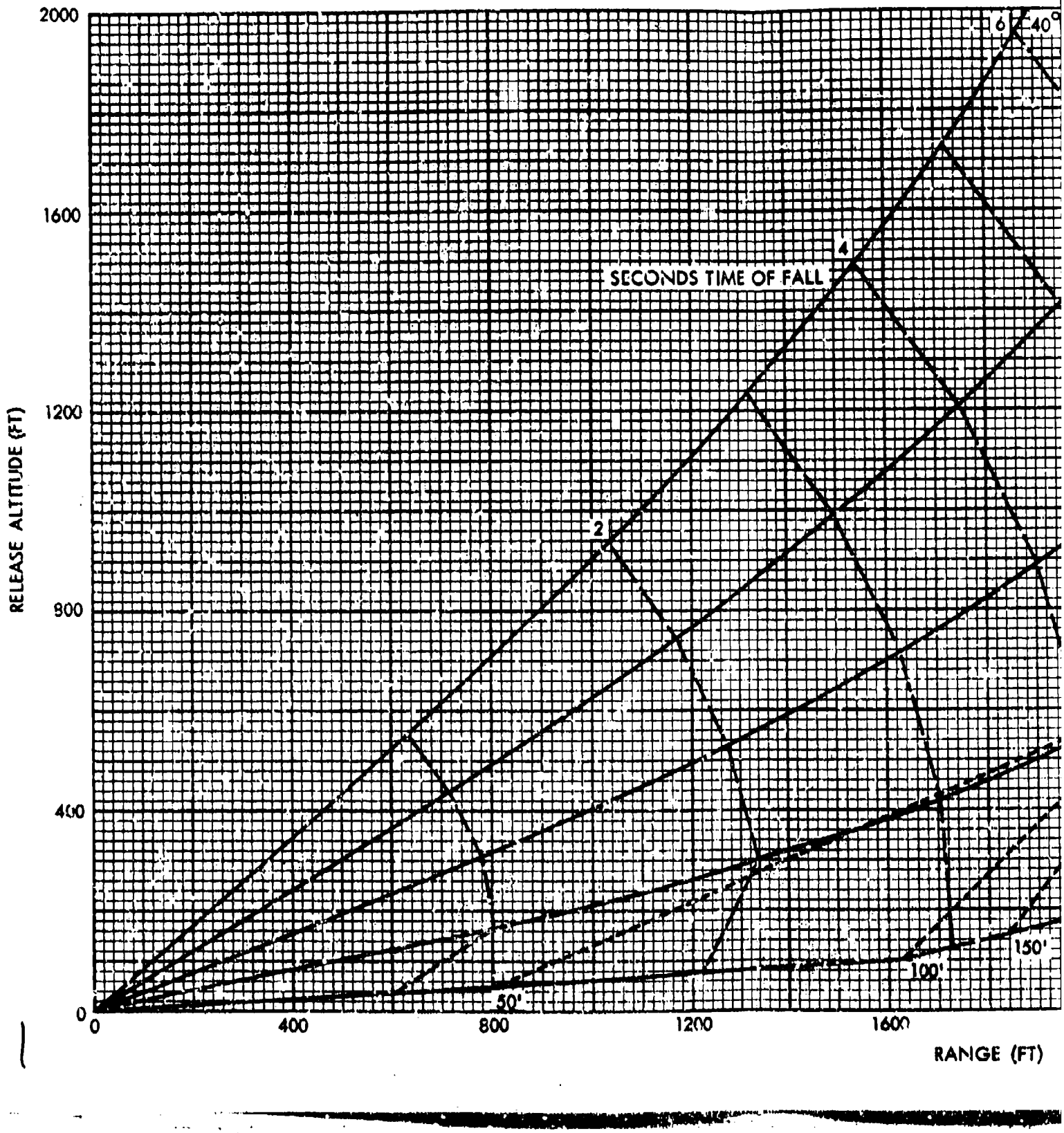


FIG. 34 MK 81/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
40°
50'
100'
150'

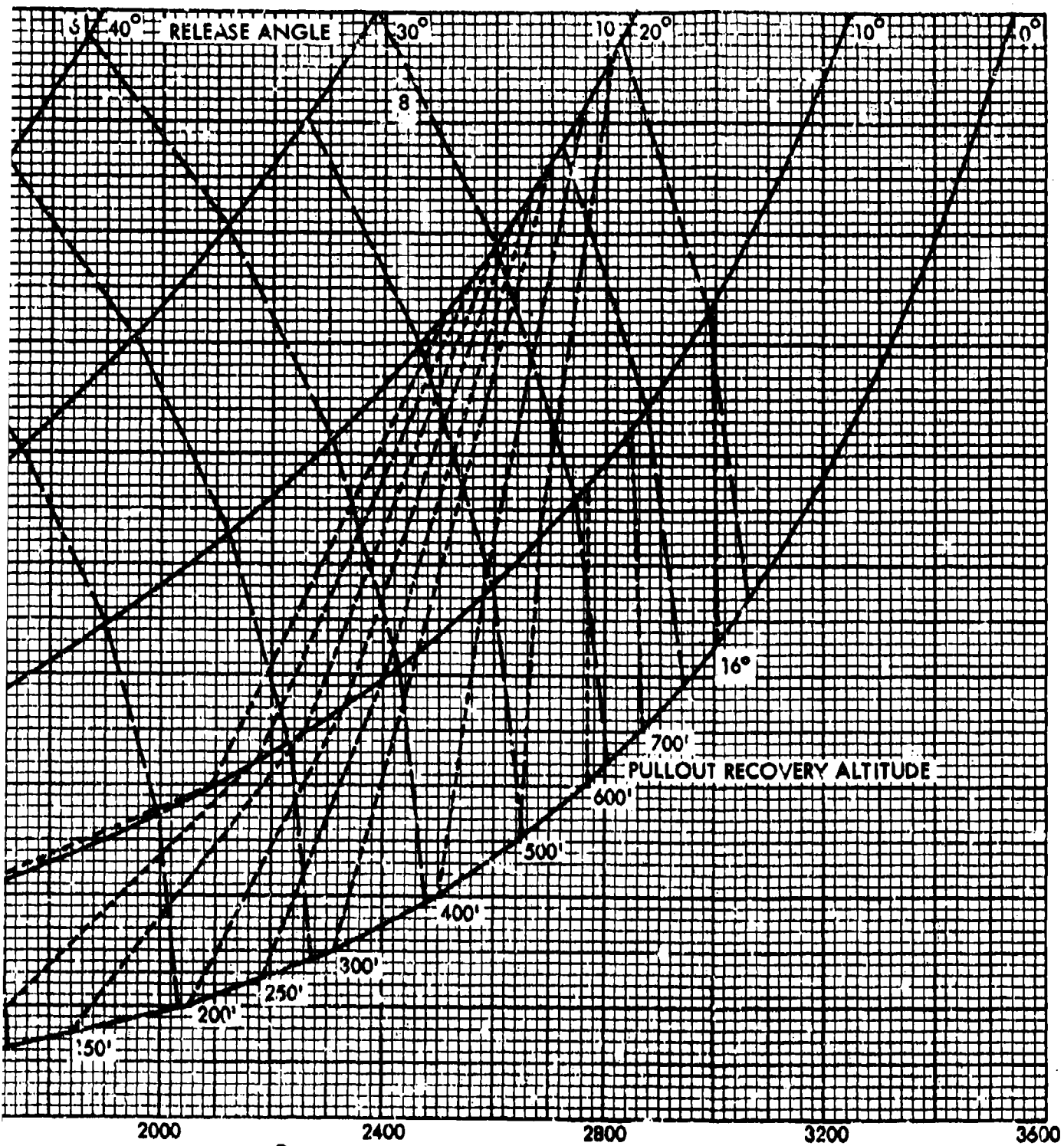
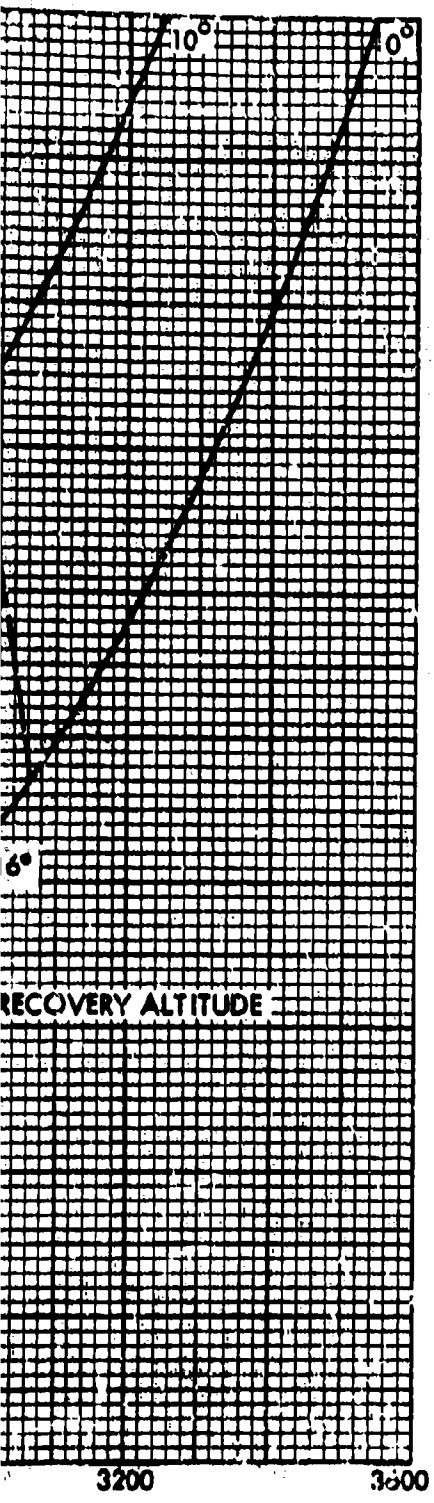

RELEASE ANGLE
40°
30°
20°
10°
0°
8
16°
700'
PULLOUT RECOVERY ALTITUDE
600'
500'
400'
300'
250'
200'
150'
2000
2400
2800
3200
3600
ANGE (FT)
BOMB R
AIRPLA
CONST
16° SIG
550 KNOTS
4.0 g PULL

FIG. 35 MK 81/



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

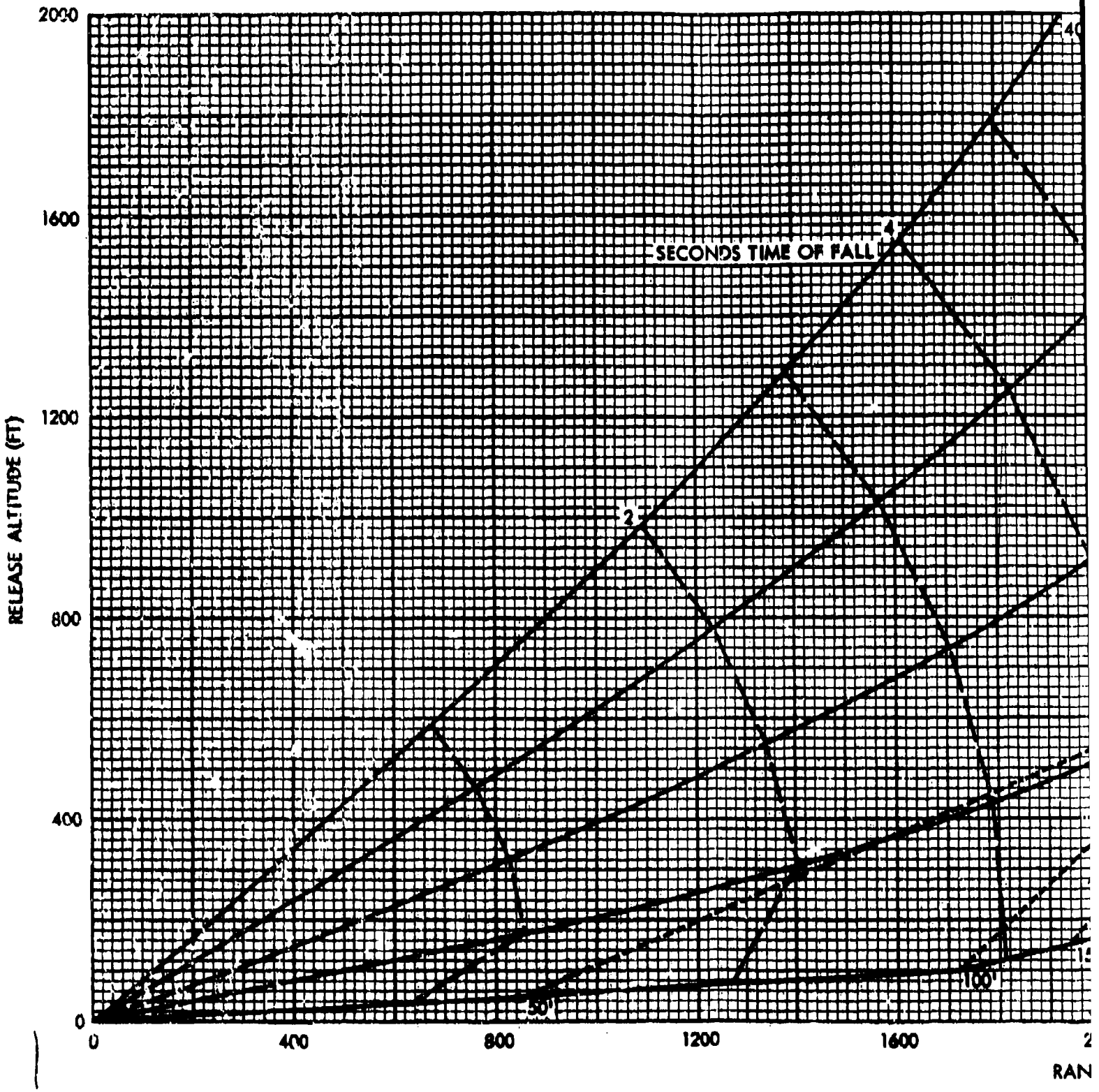
— — CONSTANT TIME OF FALL CURVE

——-—— 16° SIGHT ANGLE LIMIT CURVE

550 KNOTS RELEASE VELOCITY

4.0 g PULLOUT

FIG. 35 MK 81/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
SECONDS TIME OF FALL
4
2
50'
100'
0
400
800
1200
1600
RAN

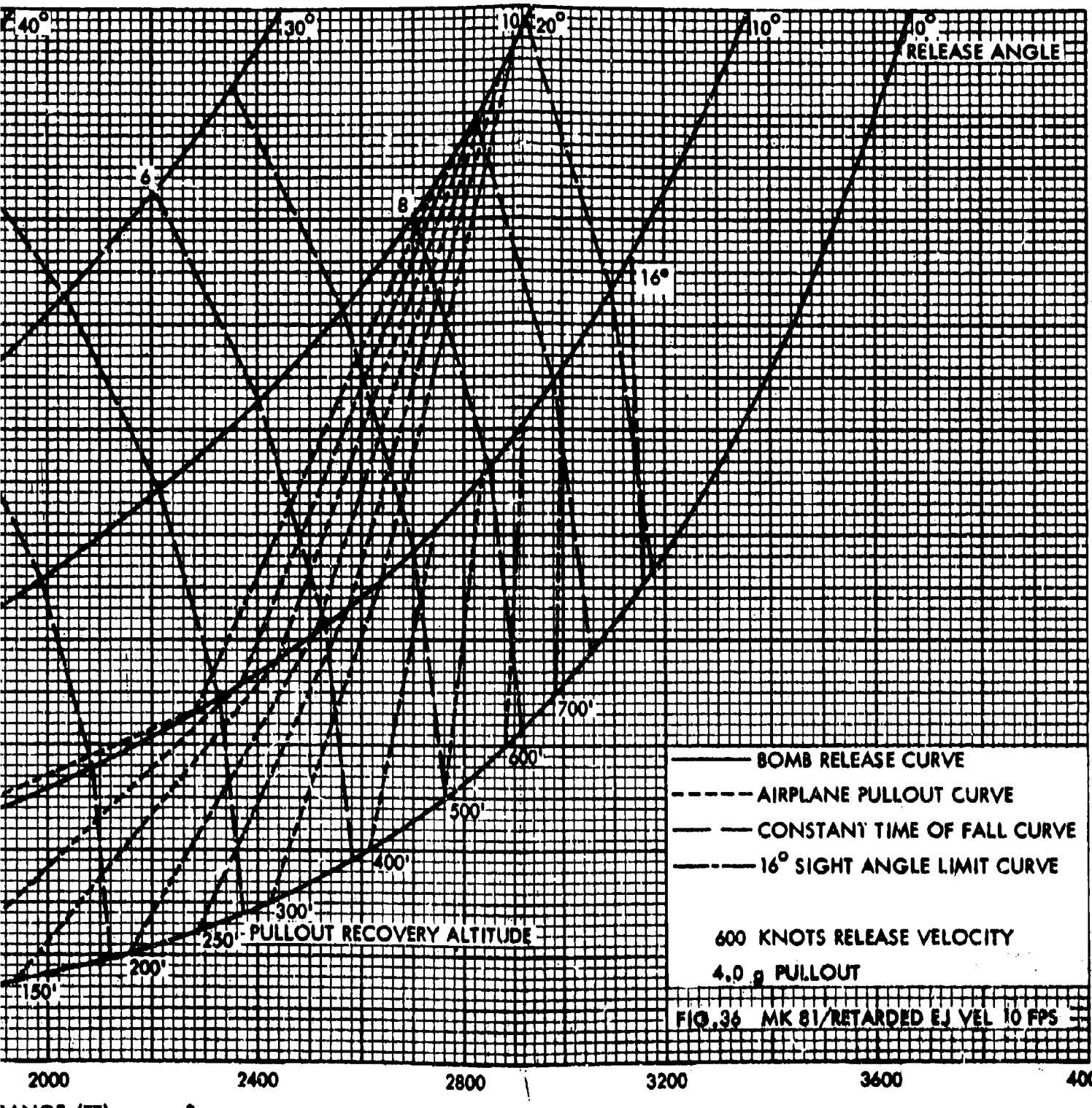


FIG. 36 MK 81/RETARDED EJ VEL 10 FPS

2

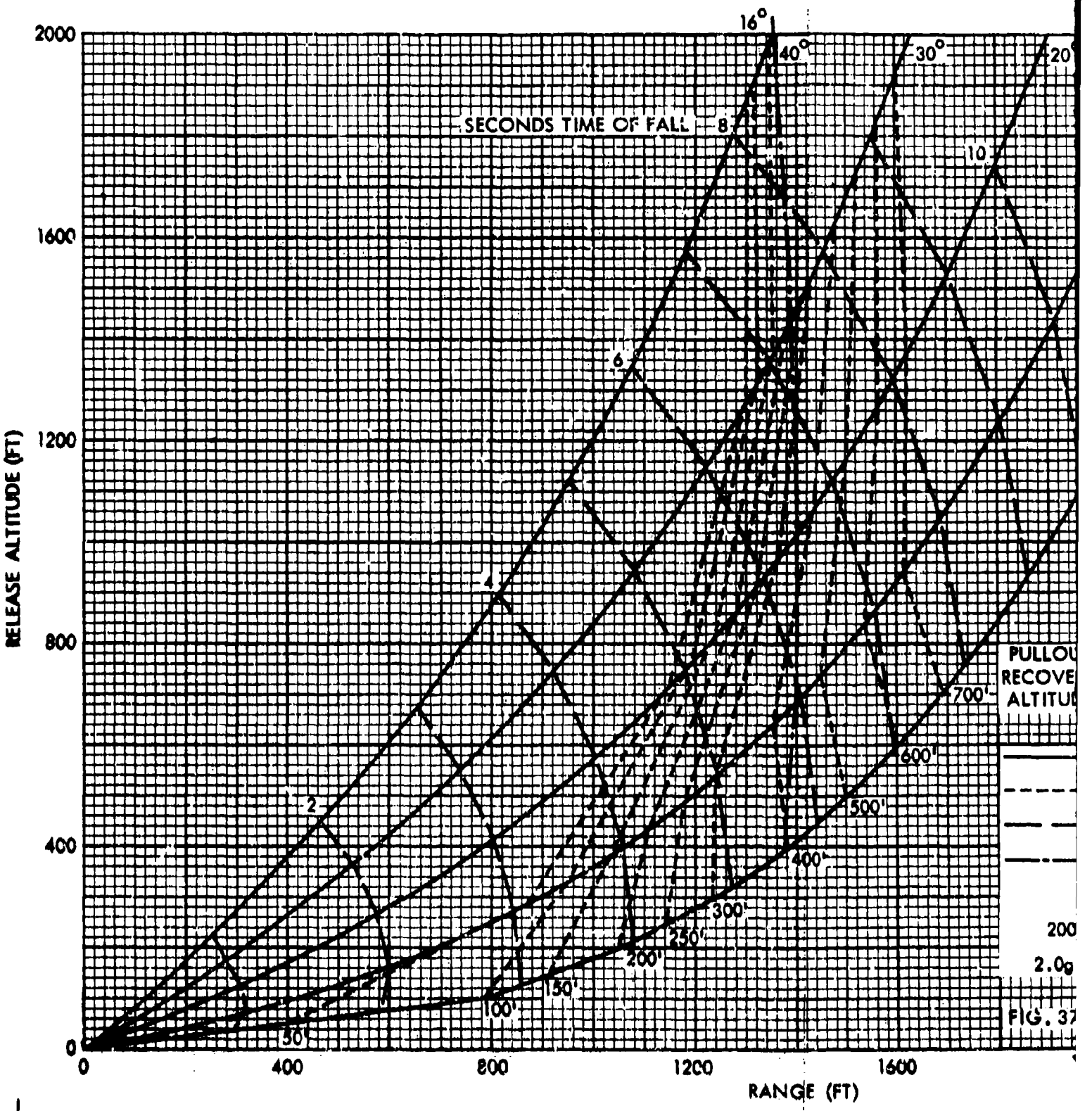

16°
40°
30°
20°
SECONDS TIME OF FALL
8
10
6
4
2
RELEASE ALTITUDE (FT)
2000
1600
1200
800
400
0
0
400
800
1200
1600
RANGE (FT)
700'
600'
500'
400'
300'
250'
200'
150'
100'
50'
PULLOU
RECOVE
ALTITU
200
2.0g

FIG. 37

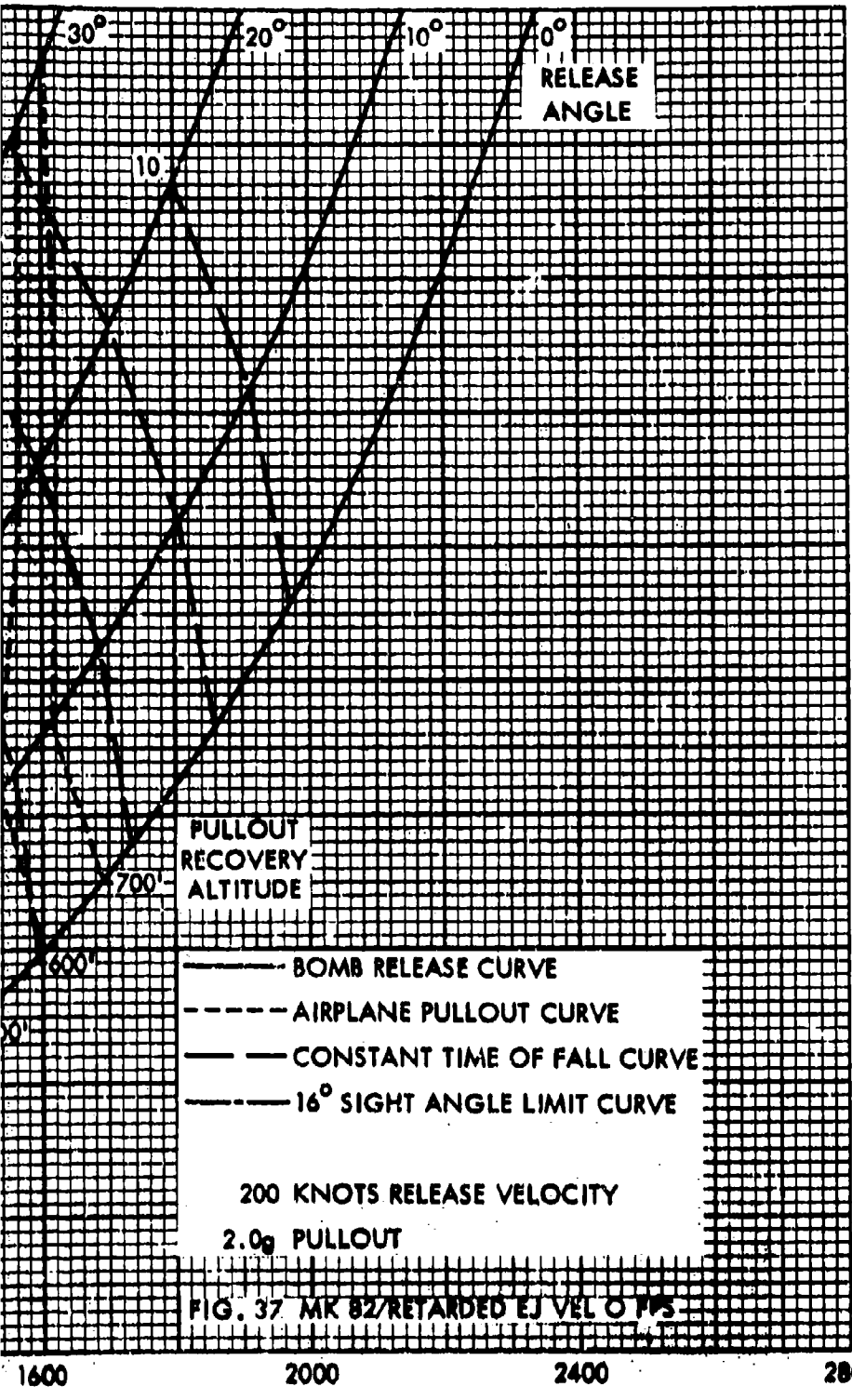
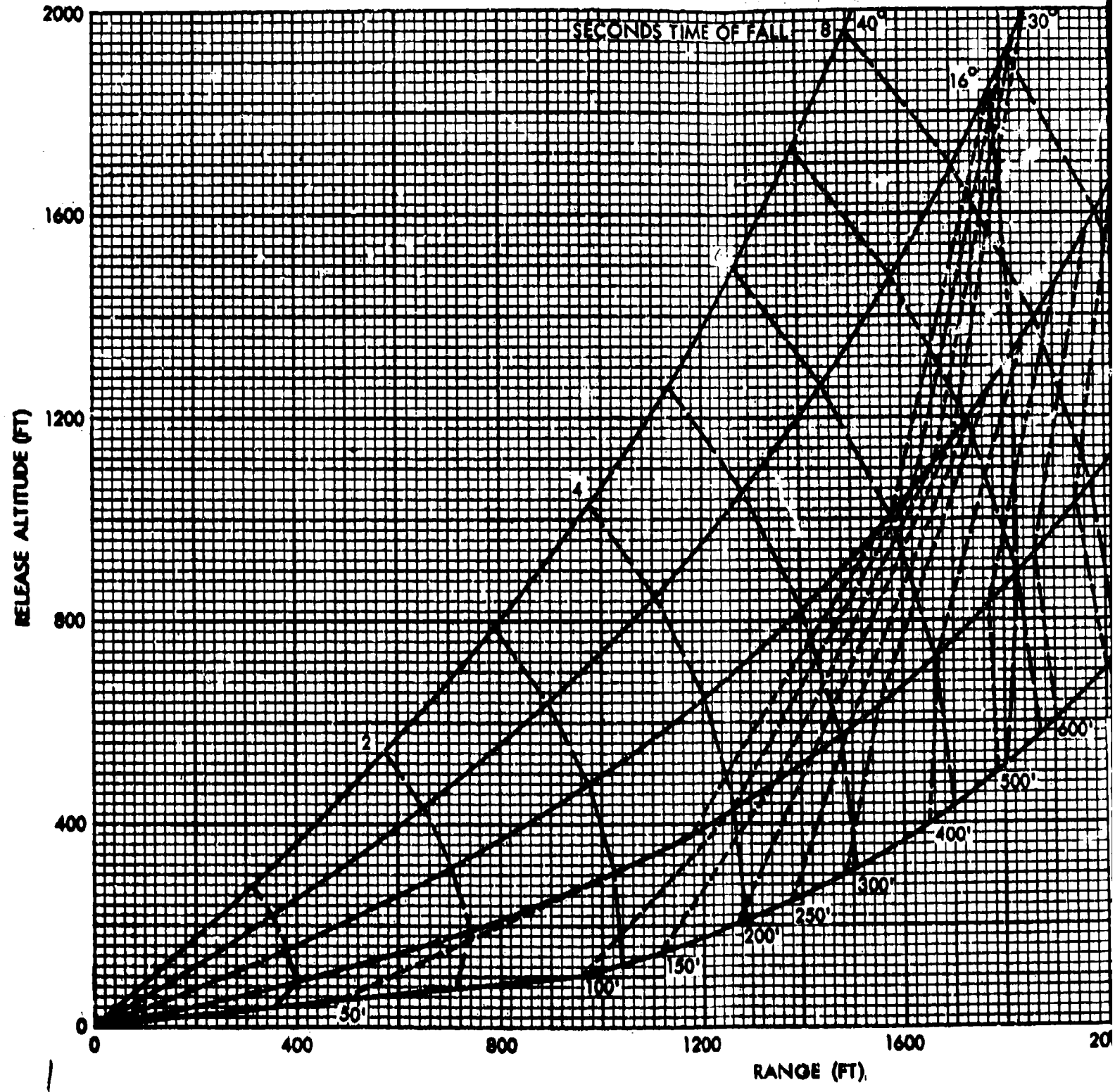


FIG. 37 MK 82/RETARDED EJ VEL 0 FPS


SECONDS TIME OF FALL
8
4
2
40°
30°
16°
600'
500'
400'
300'
250'
200'
150'
100'
50'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)

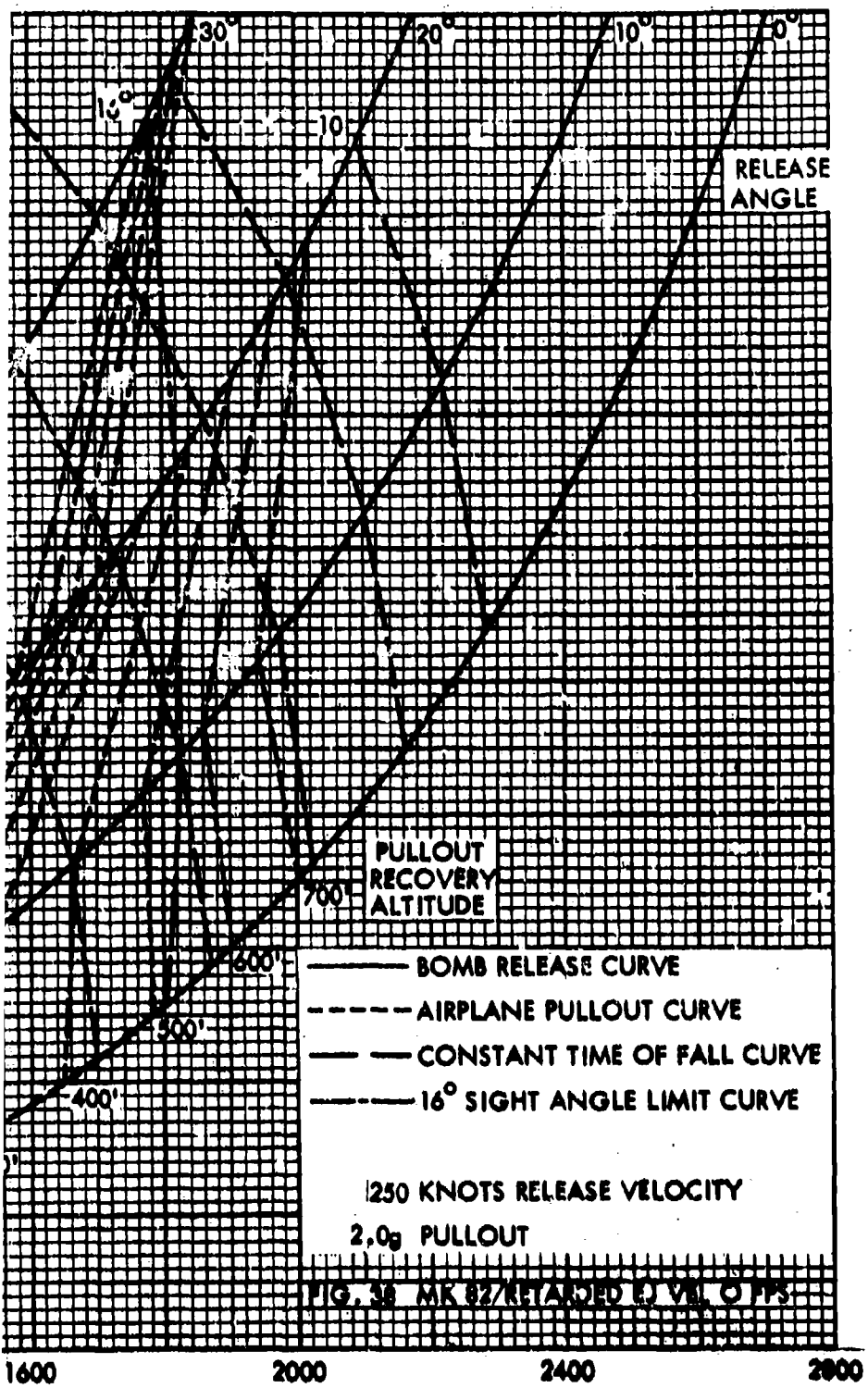
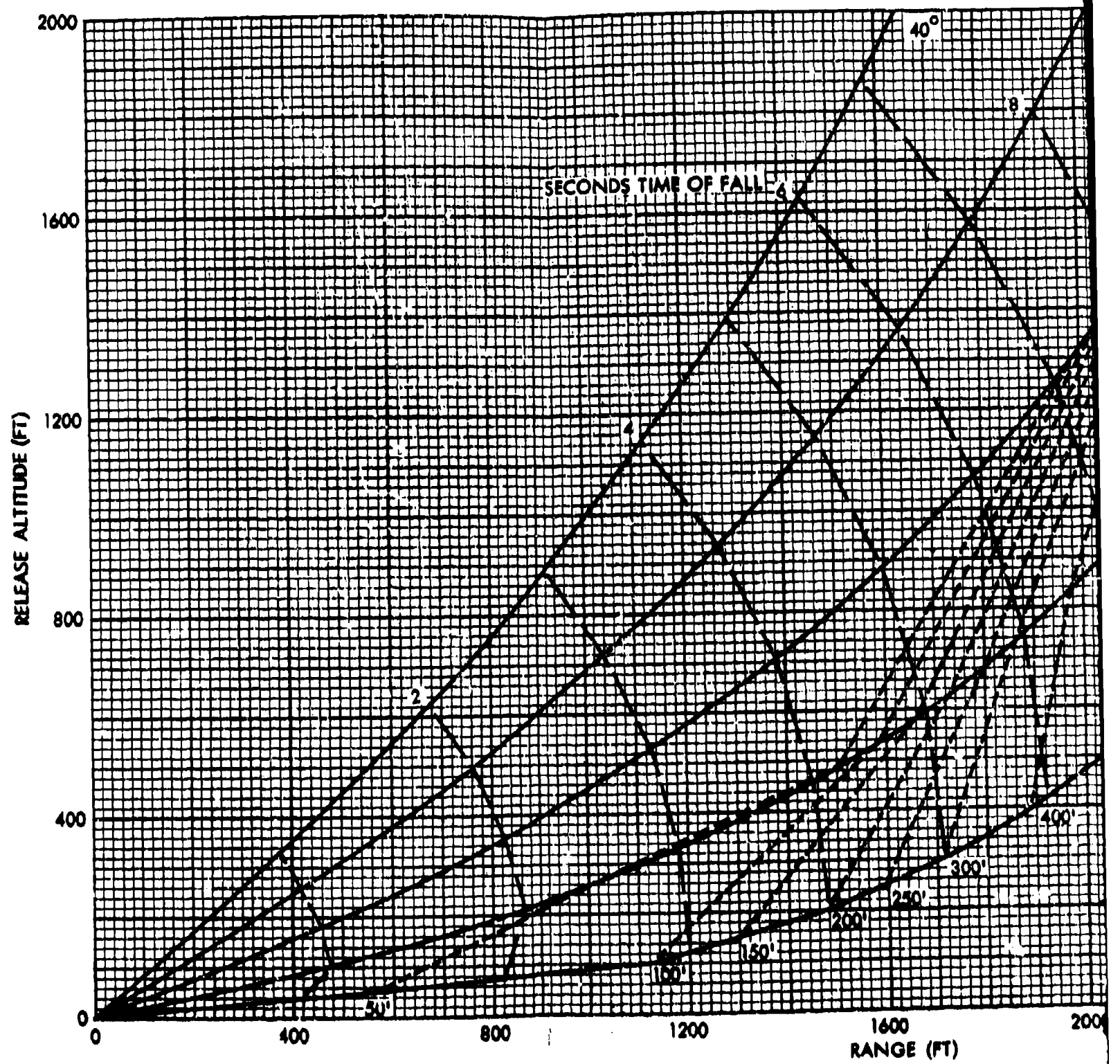
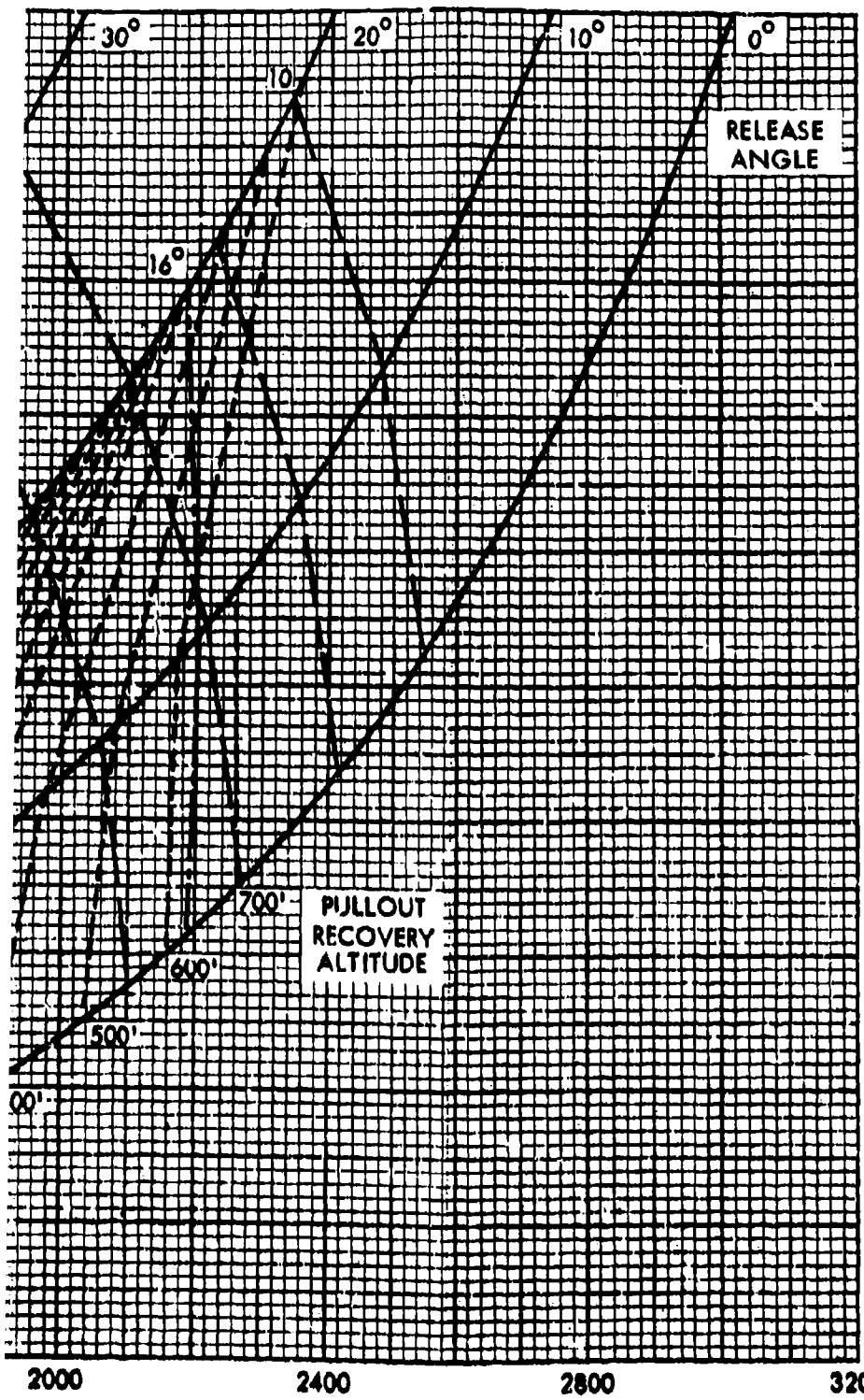


FIG. 38 MK 82/RETARDED 0 VEL. 0 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
40°
8
6
4
2
500'
400'
300'
250'
200'
150'
100'



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

— — CONSTANT TIME OF FALL CURVE

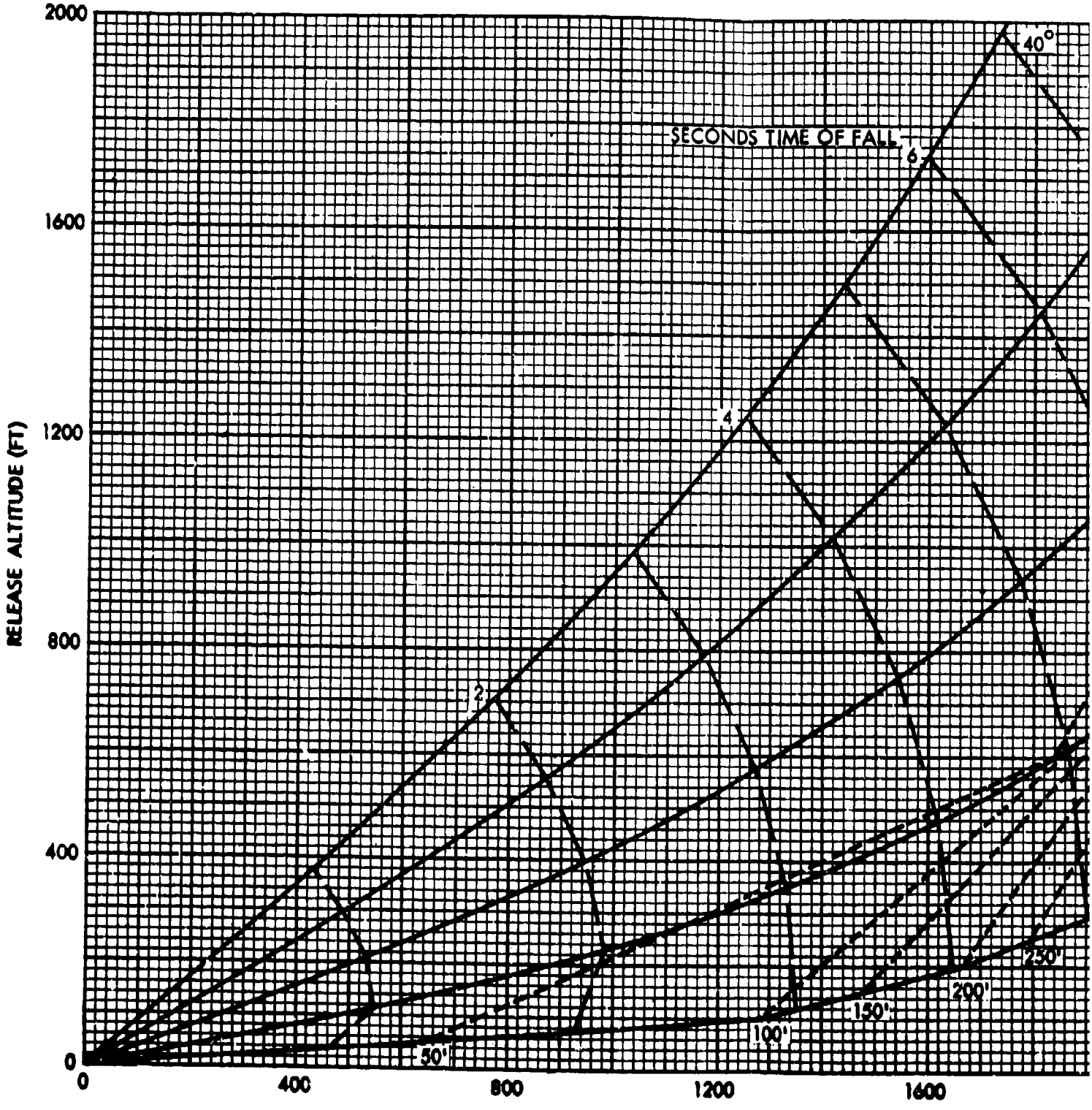
—·— 16° SIGHT ANGLE LIMIT CURVE

300 KNOTS RELEASE VELOCITY

2.0$_g$ PULLOUT

FIG. 39 MK 82/RETARDED EJ VEL O FPS

2


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
SECONDS TIME OF FALL
2
4
6
40°
50'
100'
150'
200'
250'

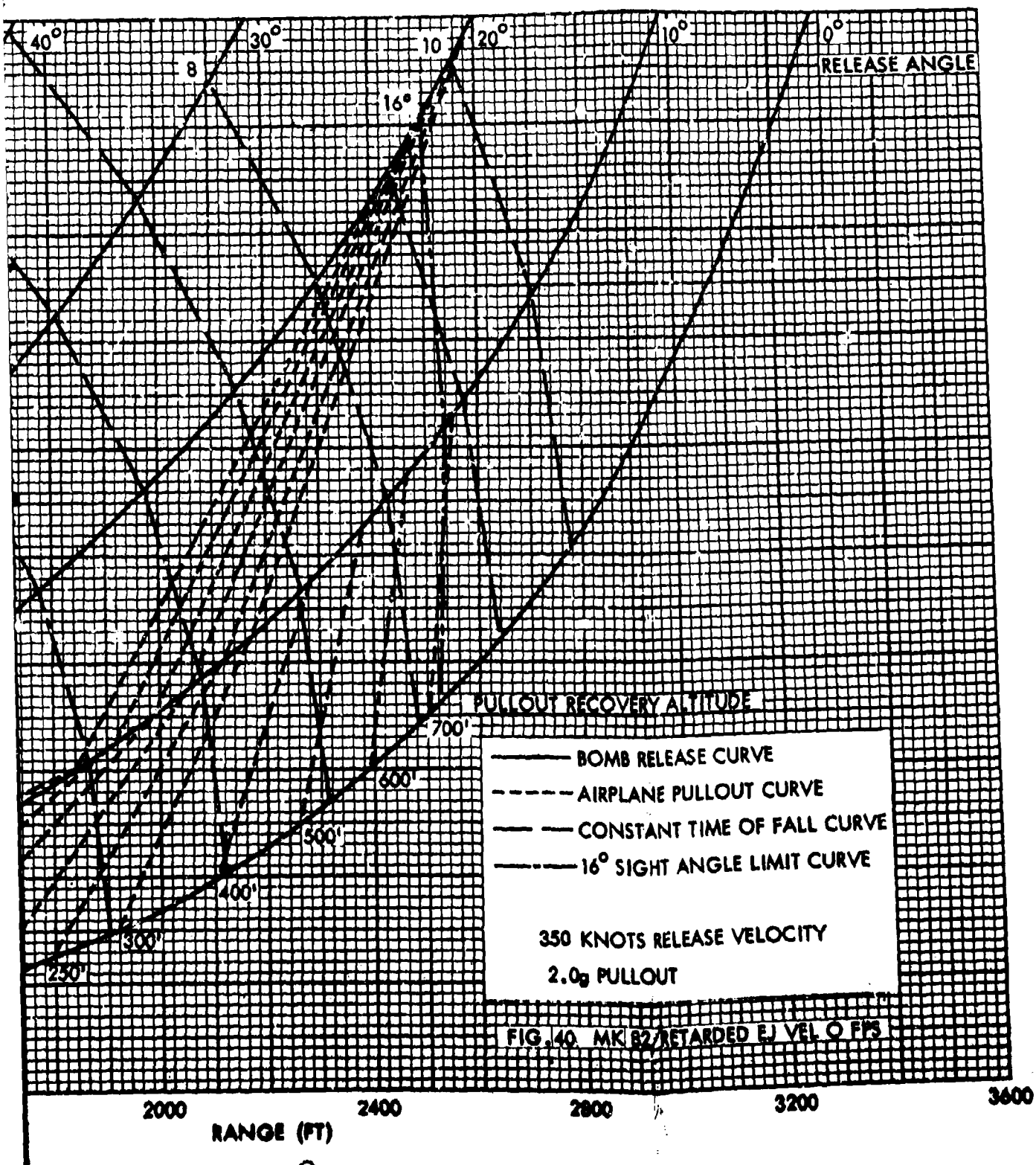
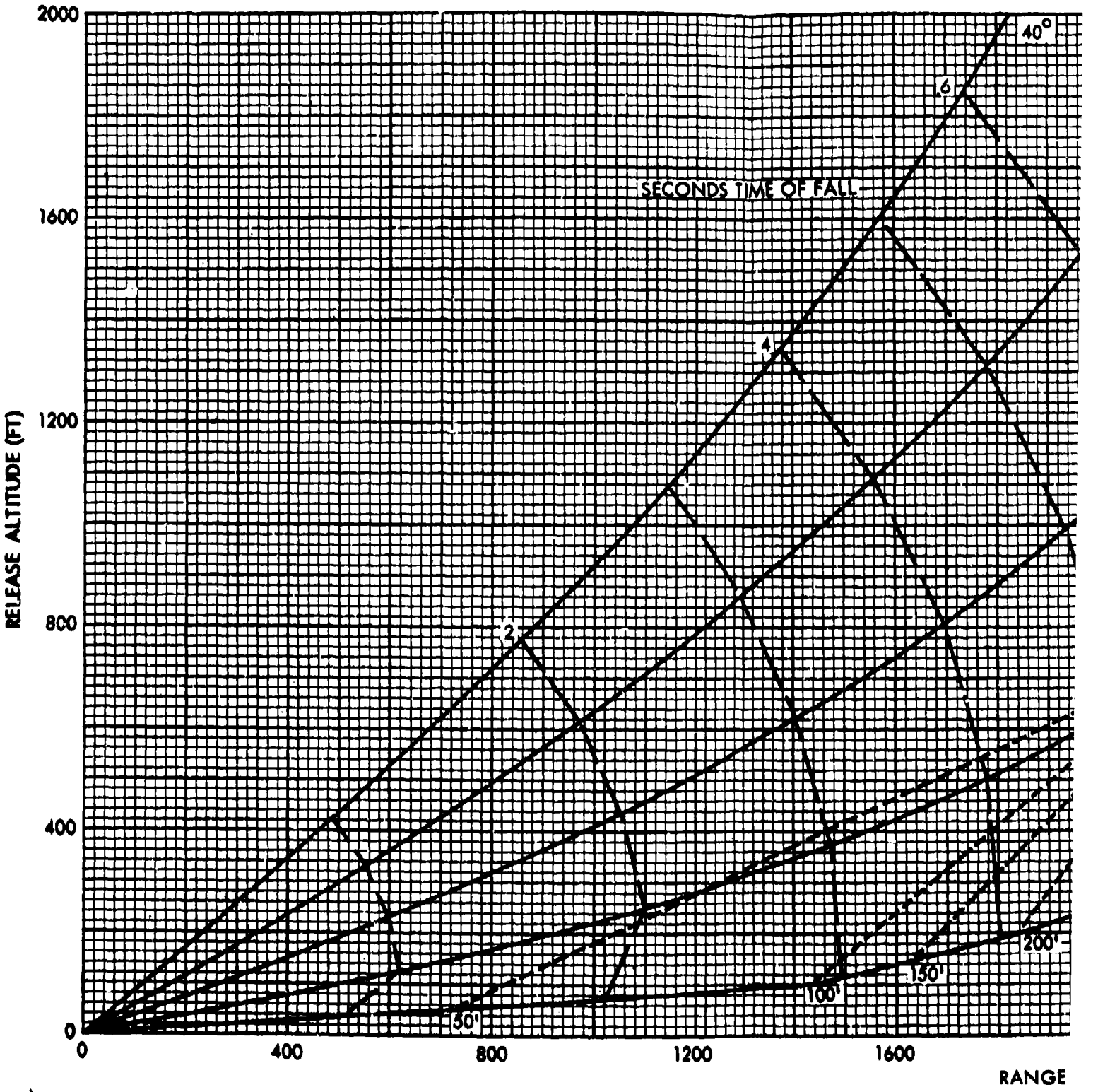


FIG. 40 MK 82/RETARDED EJ VEL 0 FPS

2


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE
SECONDS TIME OF FALL
40°
.6
4
2
50'
100'
150'
200'

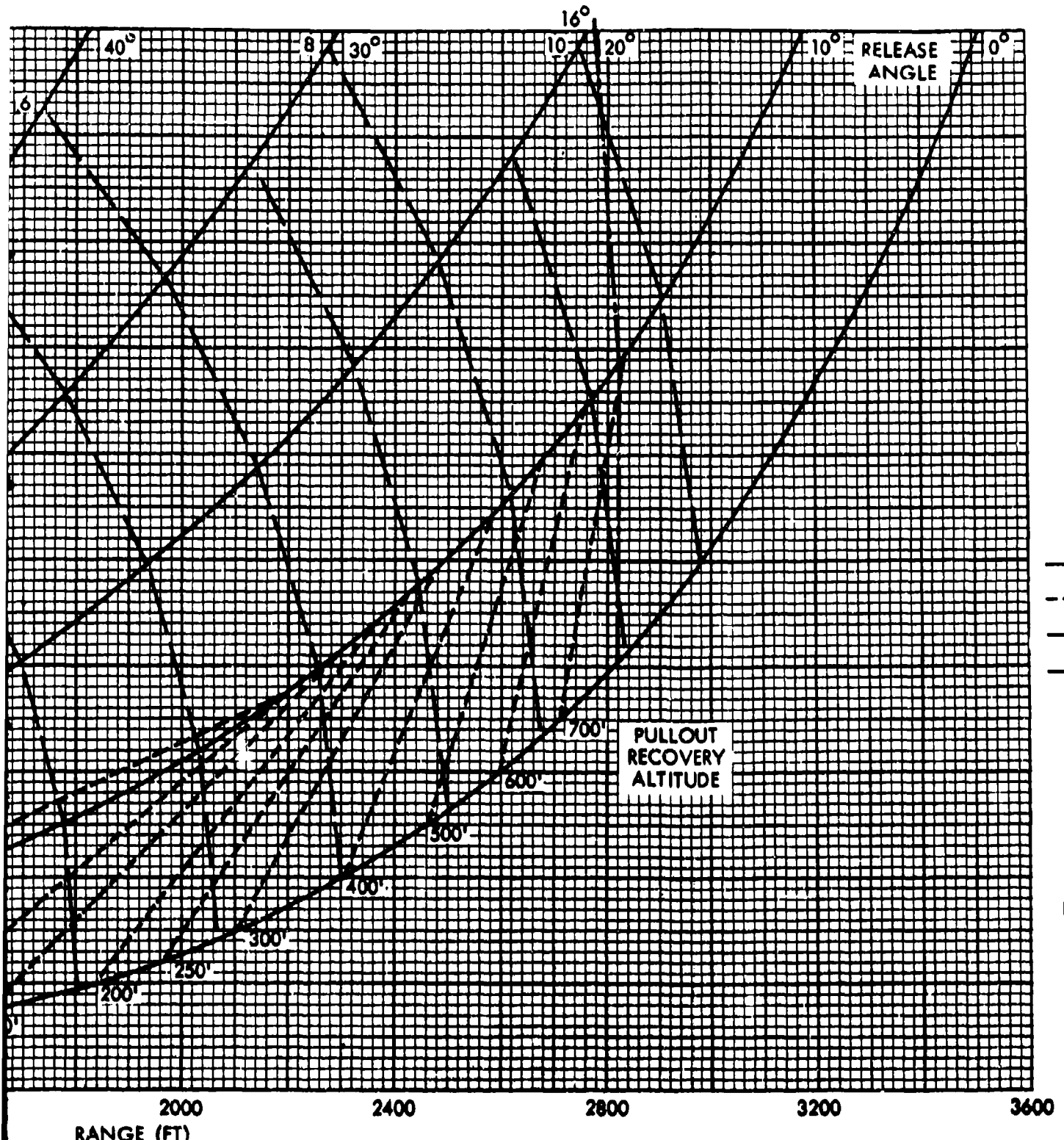
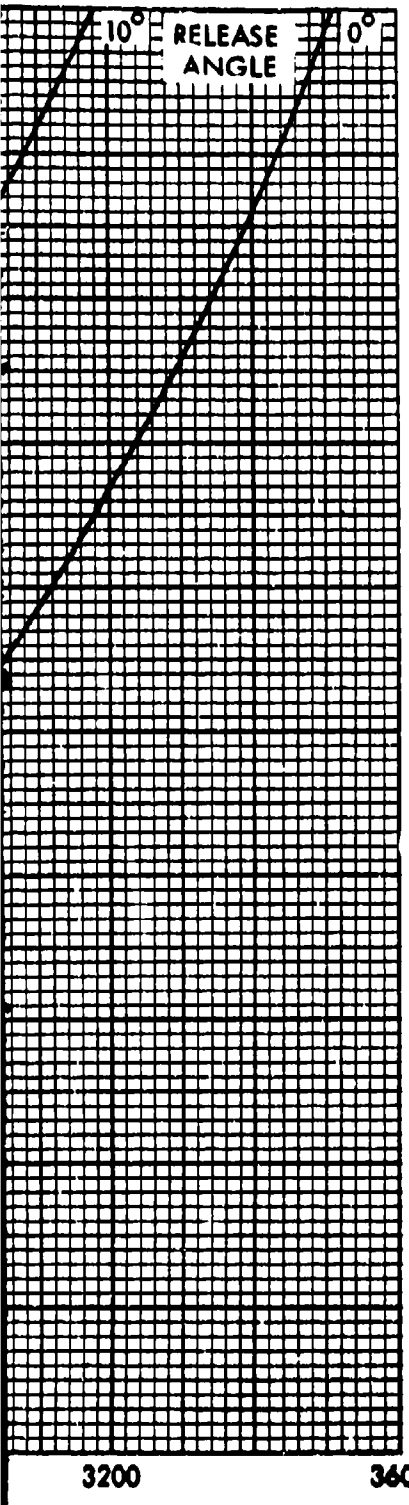

16°
40°
30°
20°
10°
0°
RELEASE ANGLE
16
8
10
700'
600'
500'
400'
300'
250'
200'
PULLOUT RECOVERY ALTITUDE
2000
2400
2800
3200
3600
RANGE (FT)
BOME
AIRPL
CON
16° S
400 KNO
2.0g PUL

FIG. 41 MK



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

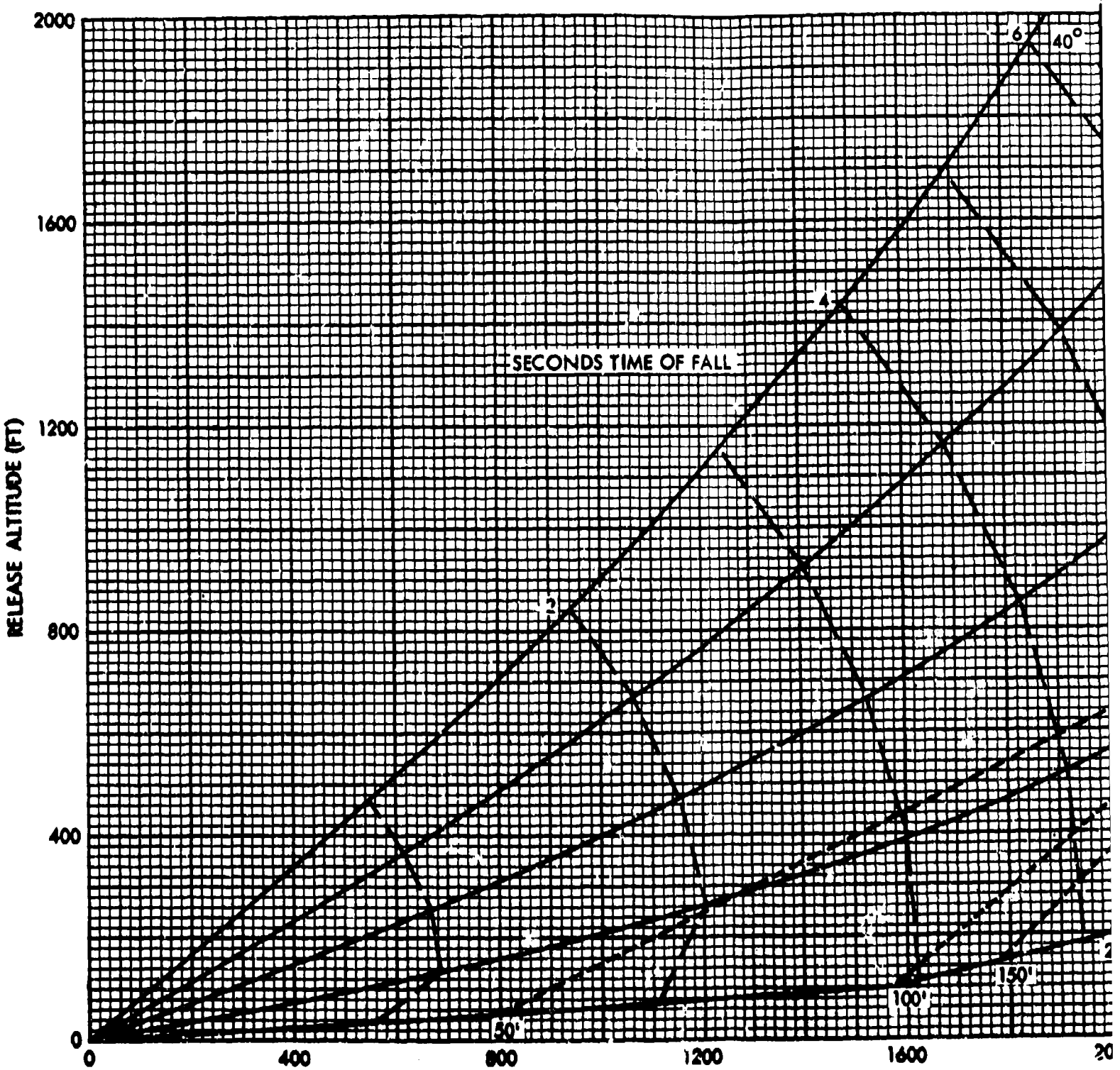
— — CONSTANT TIME OF FALL CURVE

—·— 16° SIGHT ANGLE LIMIT CURVE

400 KNOTS RELEASE VELOCITY

2.0g PULLOUT

FIG. 41 MK 82/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
SECONDS TIME OF FALL
6
40°
4
3
2
50'
100'
150'
0
400
800
1200
1600

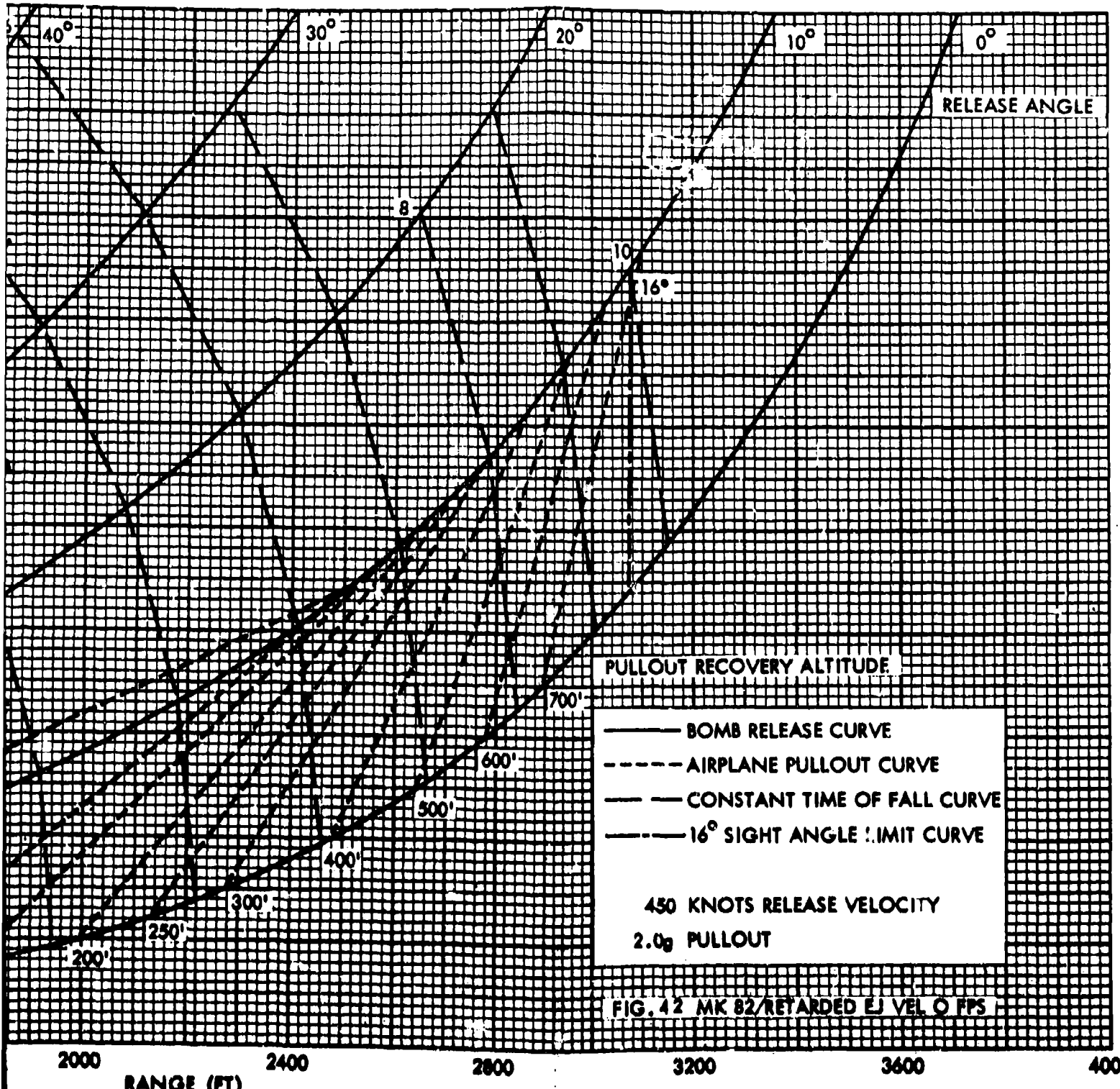
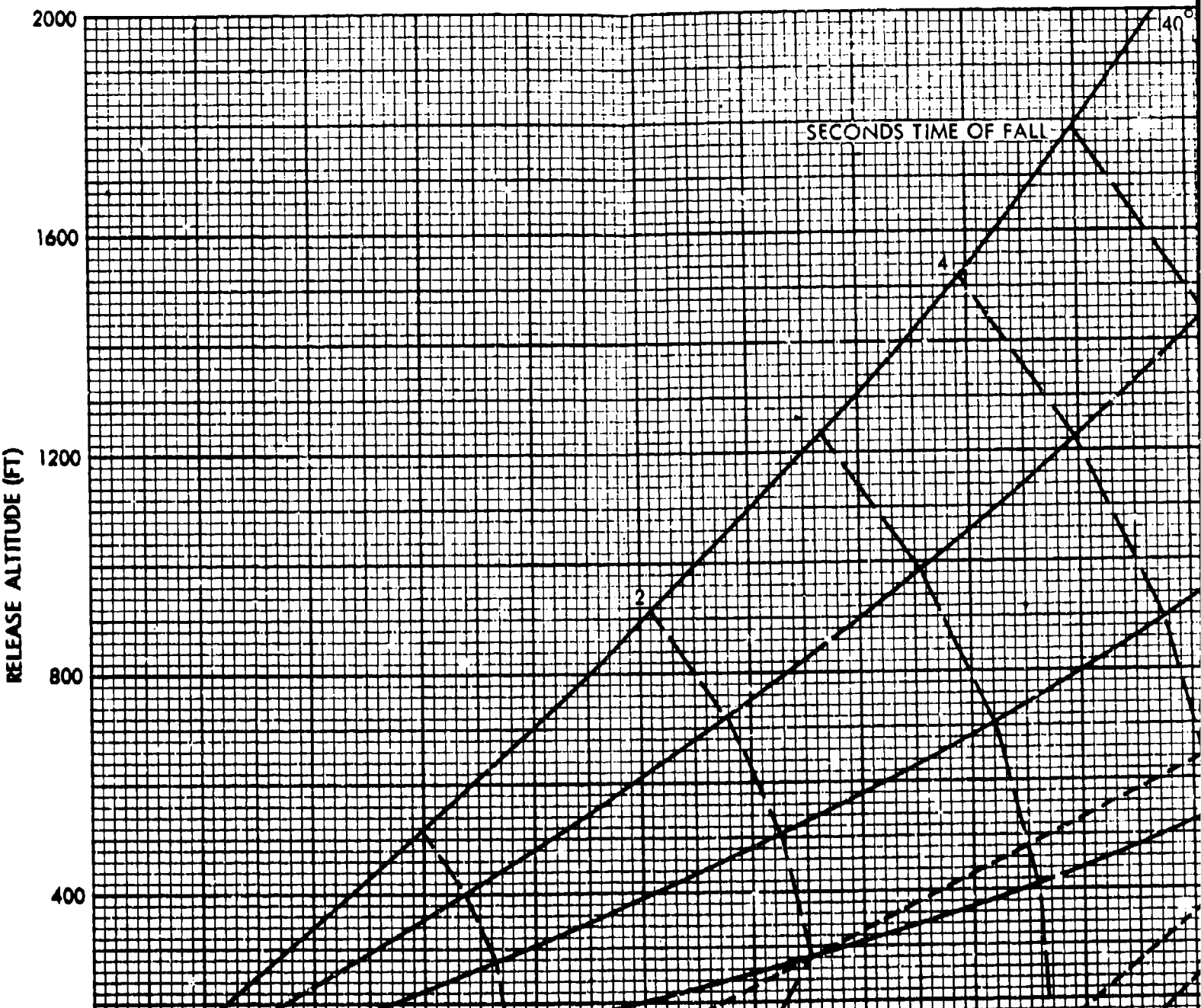


FIG. 42 MK 82/RETARDED EJ VEL 0 FPS

2


SECONDS TIME OF FALL
40
4
2
150'
100'
50'
RELEASE ALTITUDE (FT)
2000
1600
1200
800
400
0
0
400
800
1200
1600

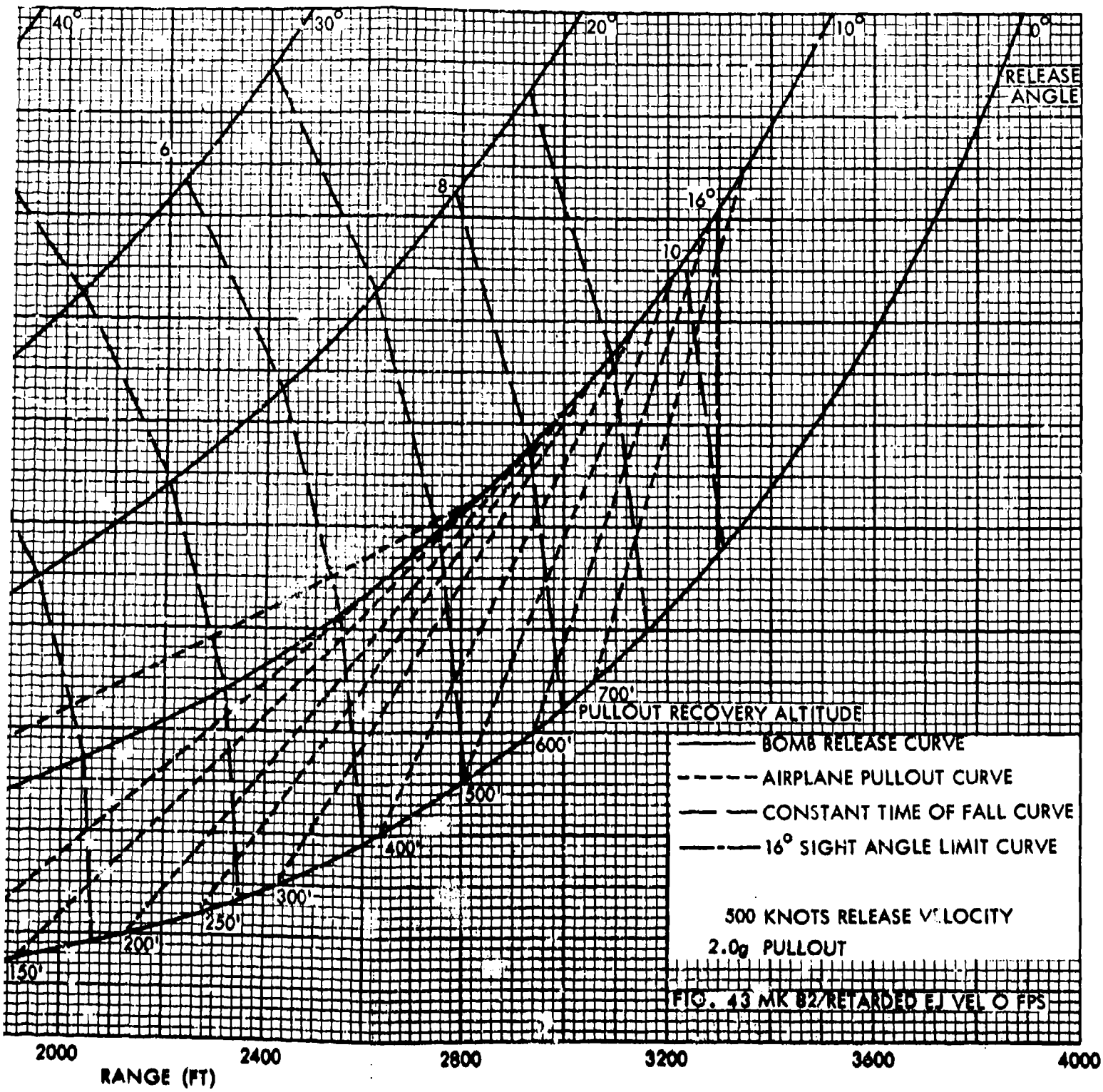
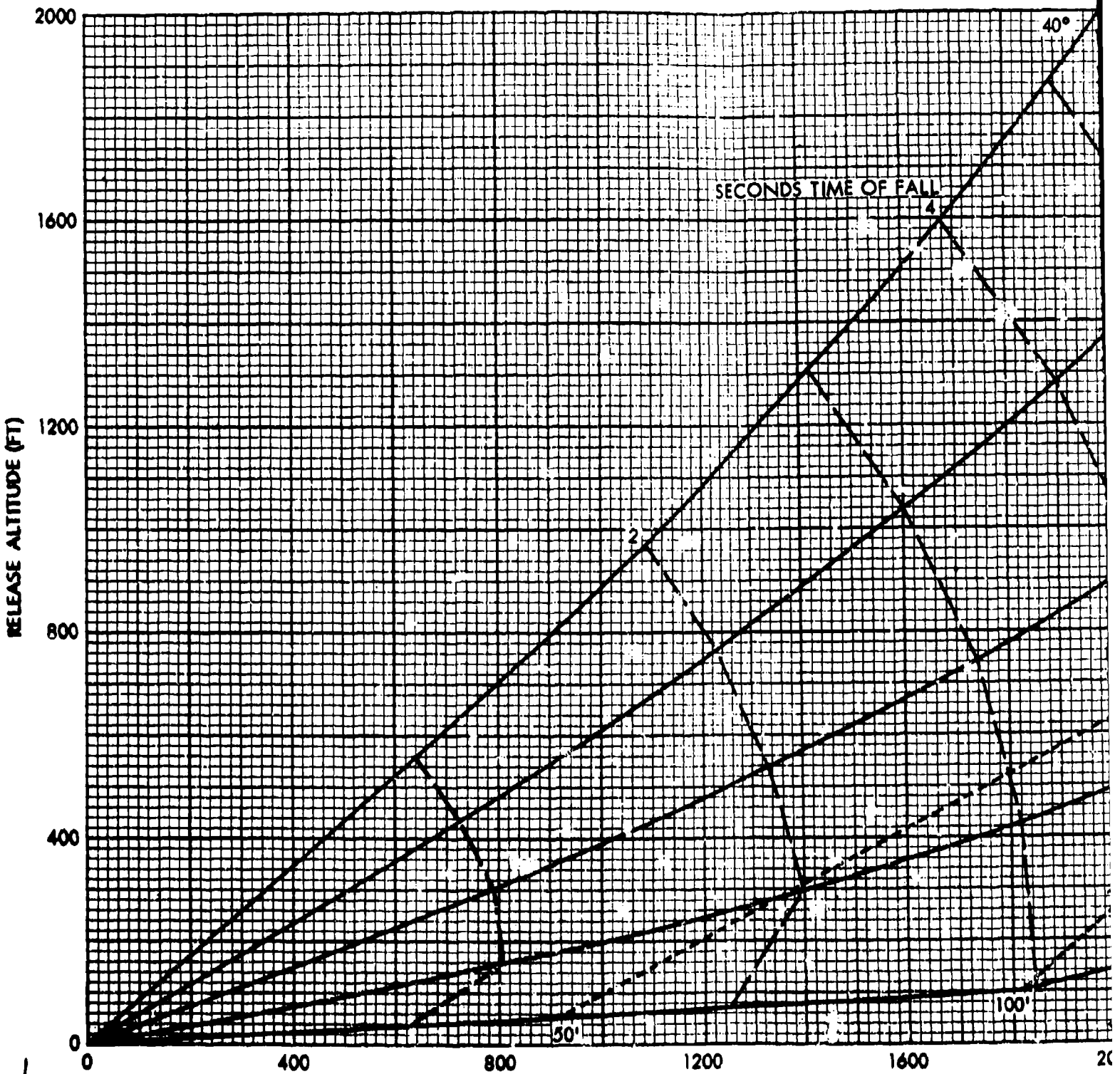


FIG. 43 MK 82/RETARDED EJ VEL 0 FPS

2


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
40°
SECONDS TIME OF FALL
4
2
100'
50'

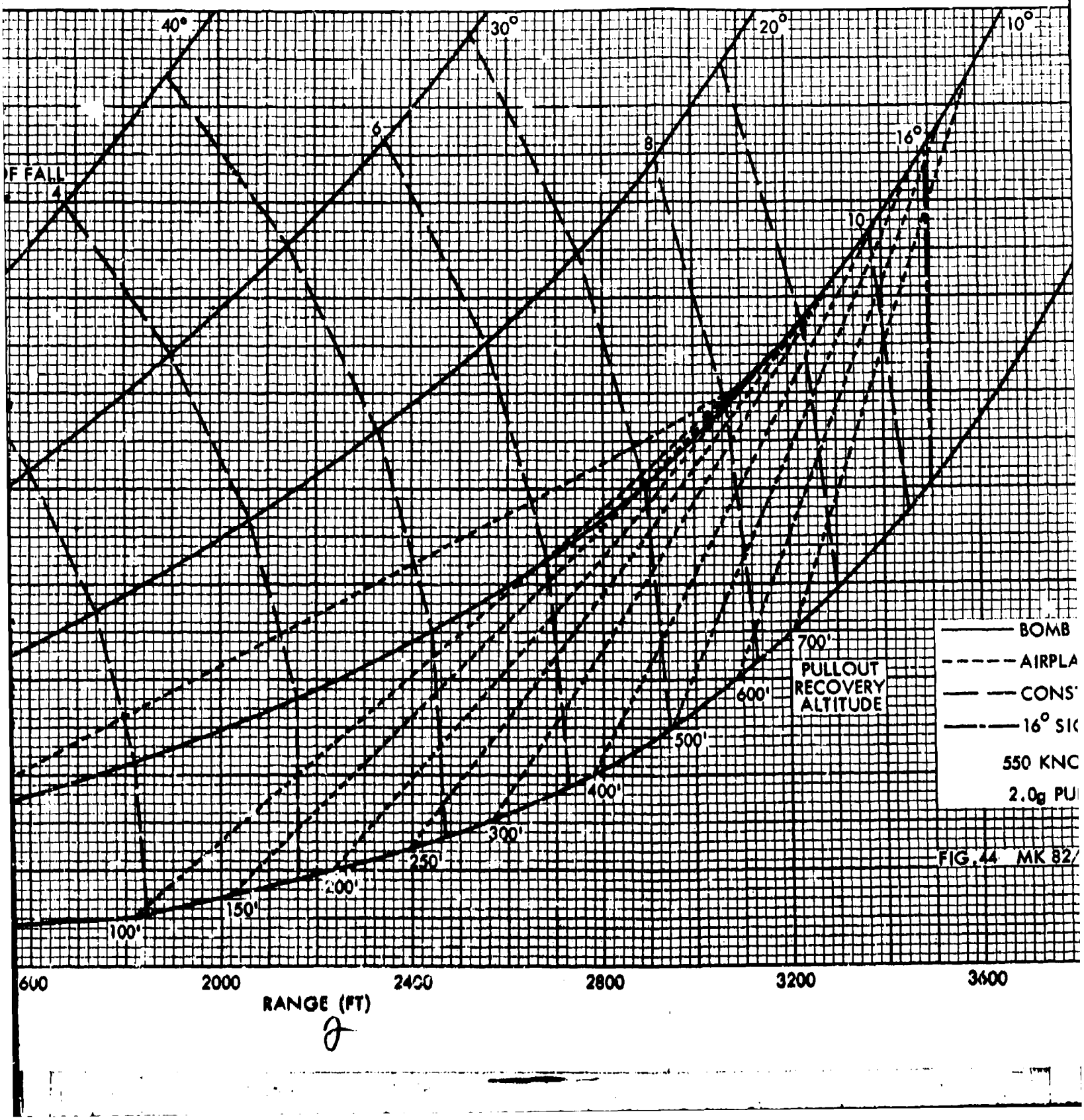

40°
30°
20°
10°
16°
F FALL
4
6
8
10
700'
PULLOUT
RECOVERY
ALTITUDE
600'
500'
400'
300'
250'
200'
150'
100'
BOMB
AIRPLA
CONS
16° SI
550 KNC
2.0g PU
600
2000
2400
2800
3200
3600
RANGE (FT)

FIG. 44 MK 82/

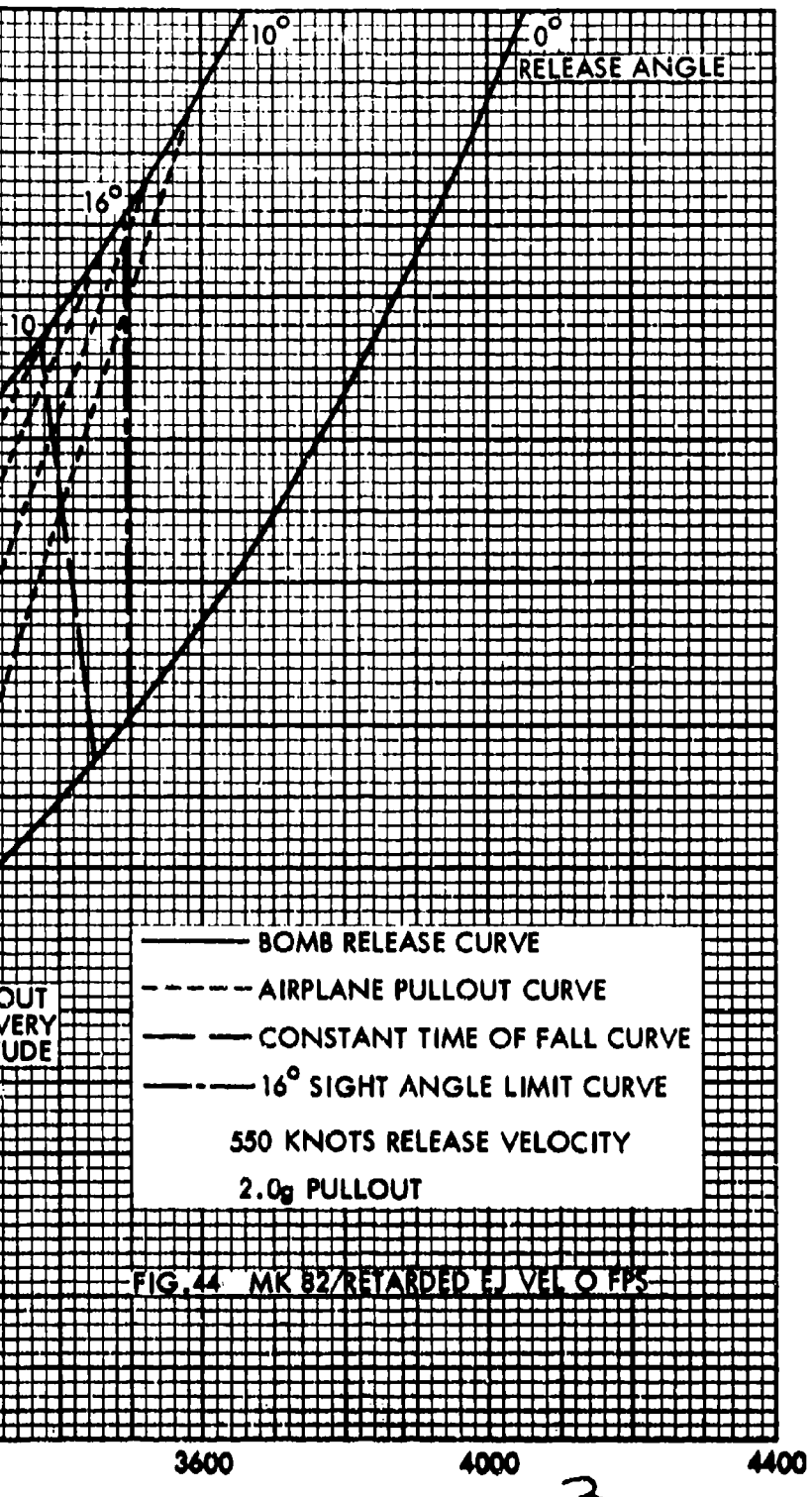
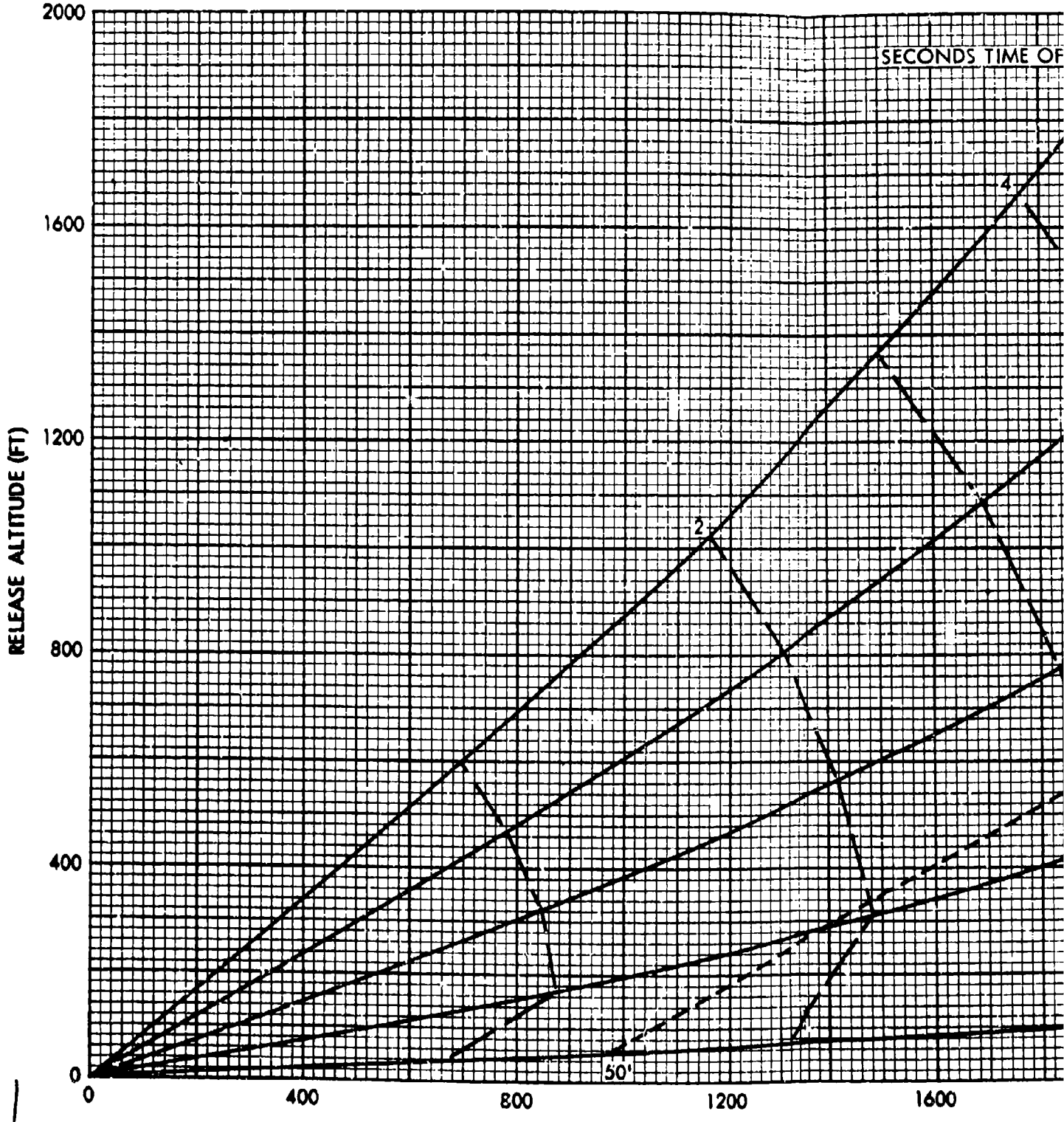


FIG. 44 MK 82/RETARDED EJ VEL 0 FPS


SECONDS TIME OF
4
2
50'
RELEASE ALTITUDE (FT)
2000
1600
1200
800
400
0
0
400
800
1200
1600

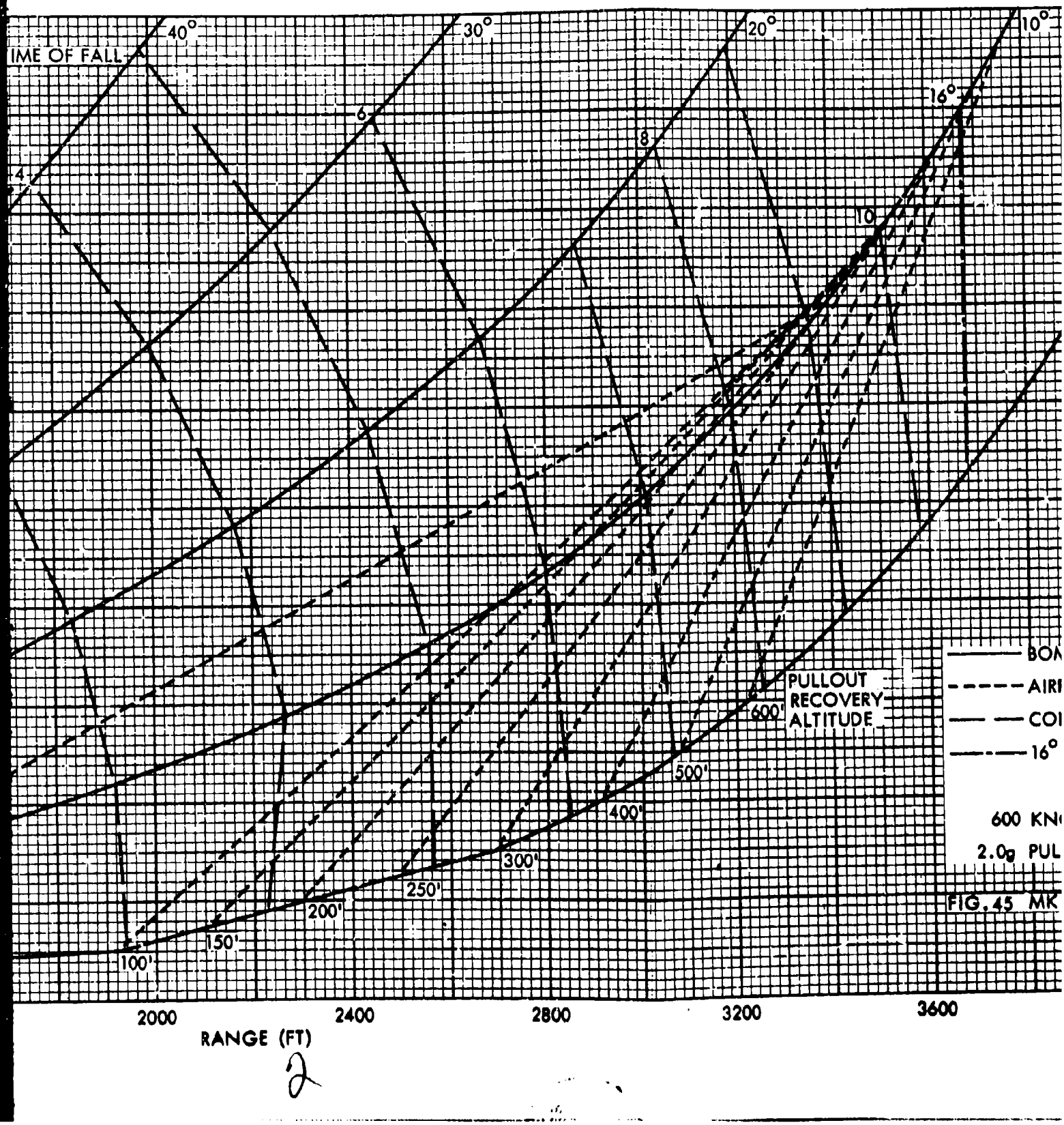

IME OF FALL
40°
30°
20°
10°
16°
4
6
8
10
PULLOUT
RECOVERY
ALTITUDE
600'
500'
400'
300'
250'
200'
150'
100'
BOM
AIRI
COI
16°
600 KN
2.0g PUL
2000
2400
2800
3200
3600
RANGE (FT)

FIG. 45 MK

2

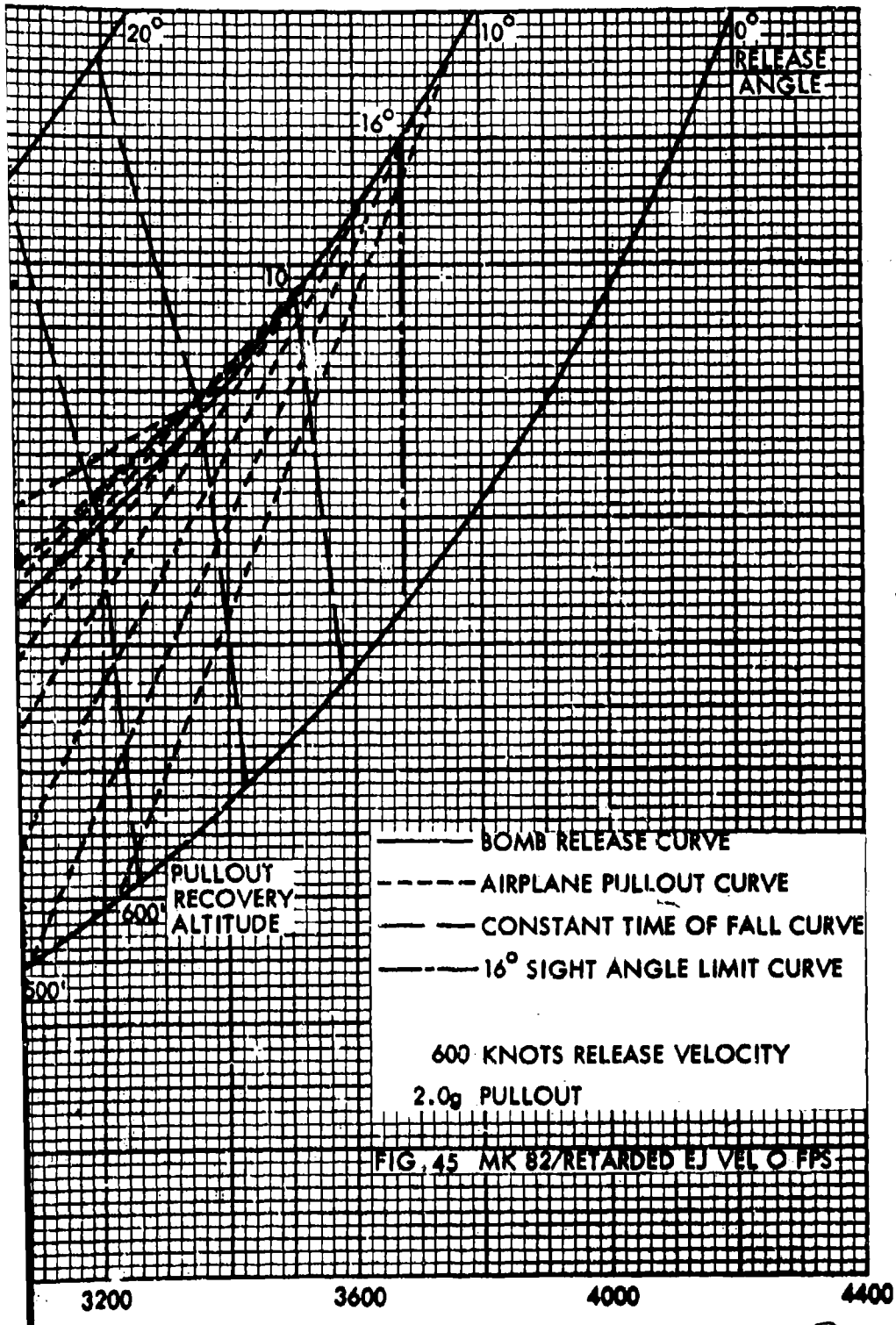
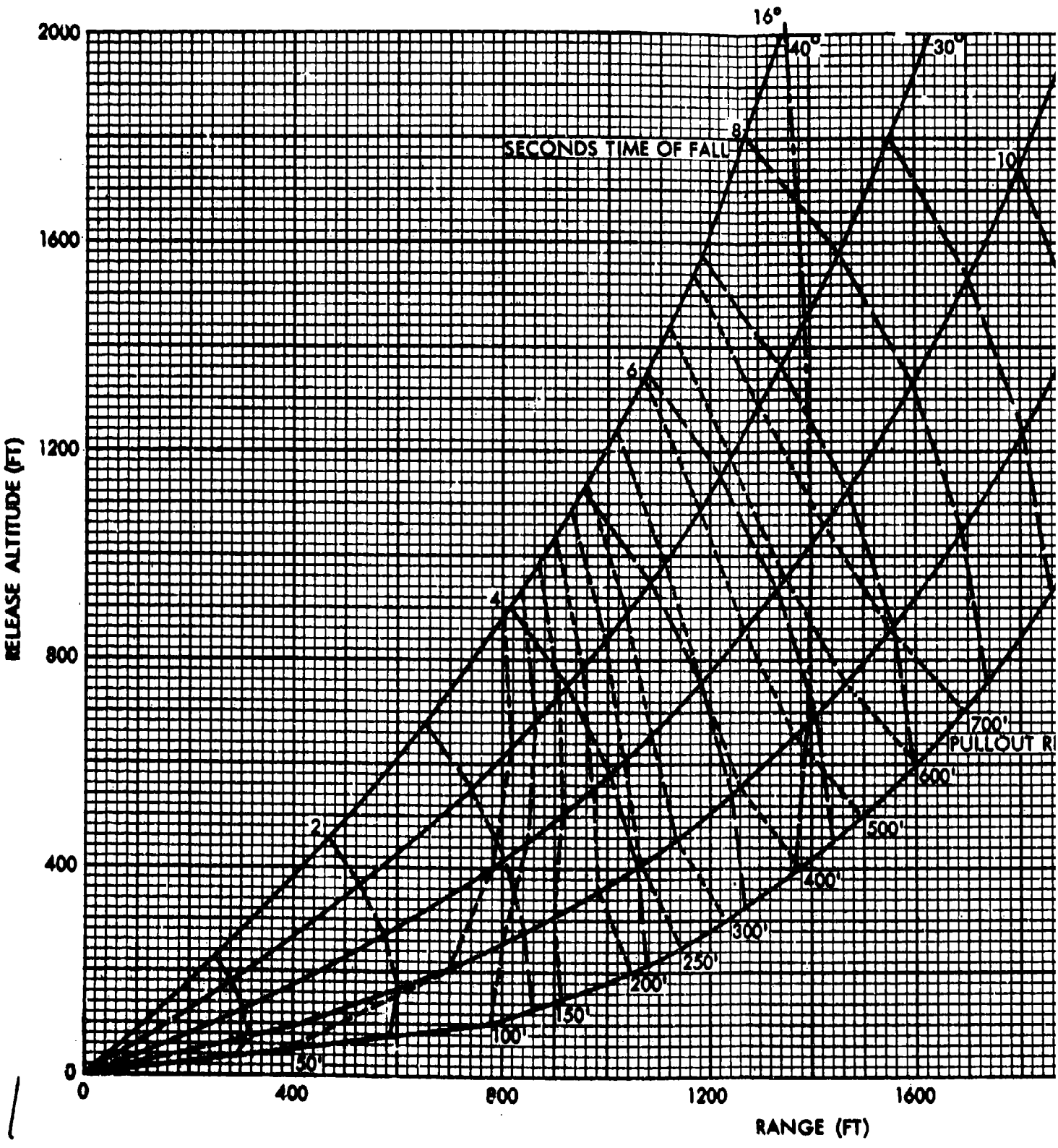


FIG. 45 MK 82/RETARDED EJ VEL 0 FPS


16°
40°
30°
8
SECONDS TIME OF FALL
10
6
4
2
700'
PULLOUT R
600'
500'
400'
300'
250'
200'
150'
100'
50'
2000
1600
1200
800
400
0
0
400
800
1200
1600
RELEASE ALTITUDE (FT)
RANGE (FT)

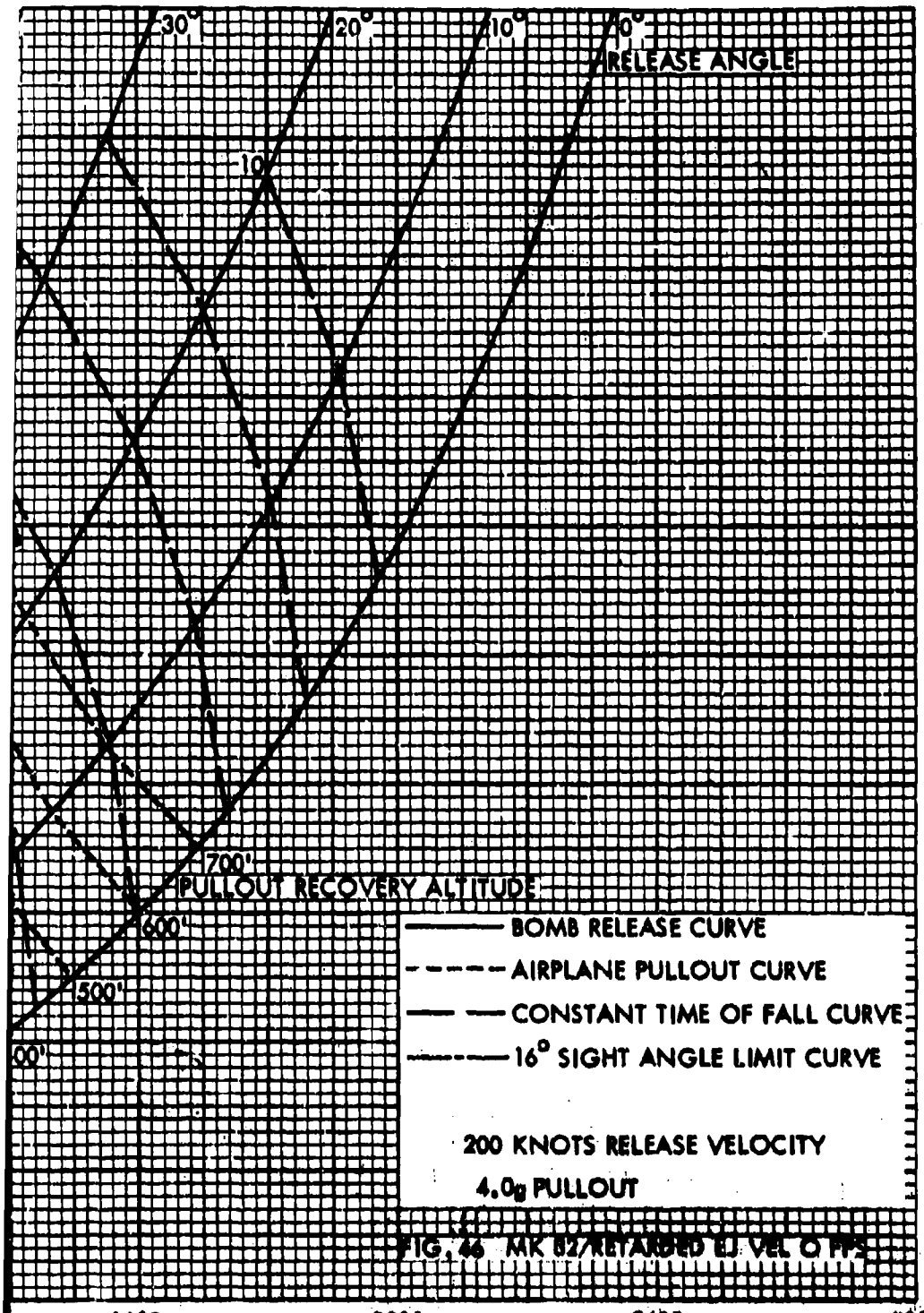
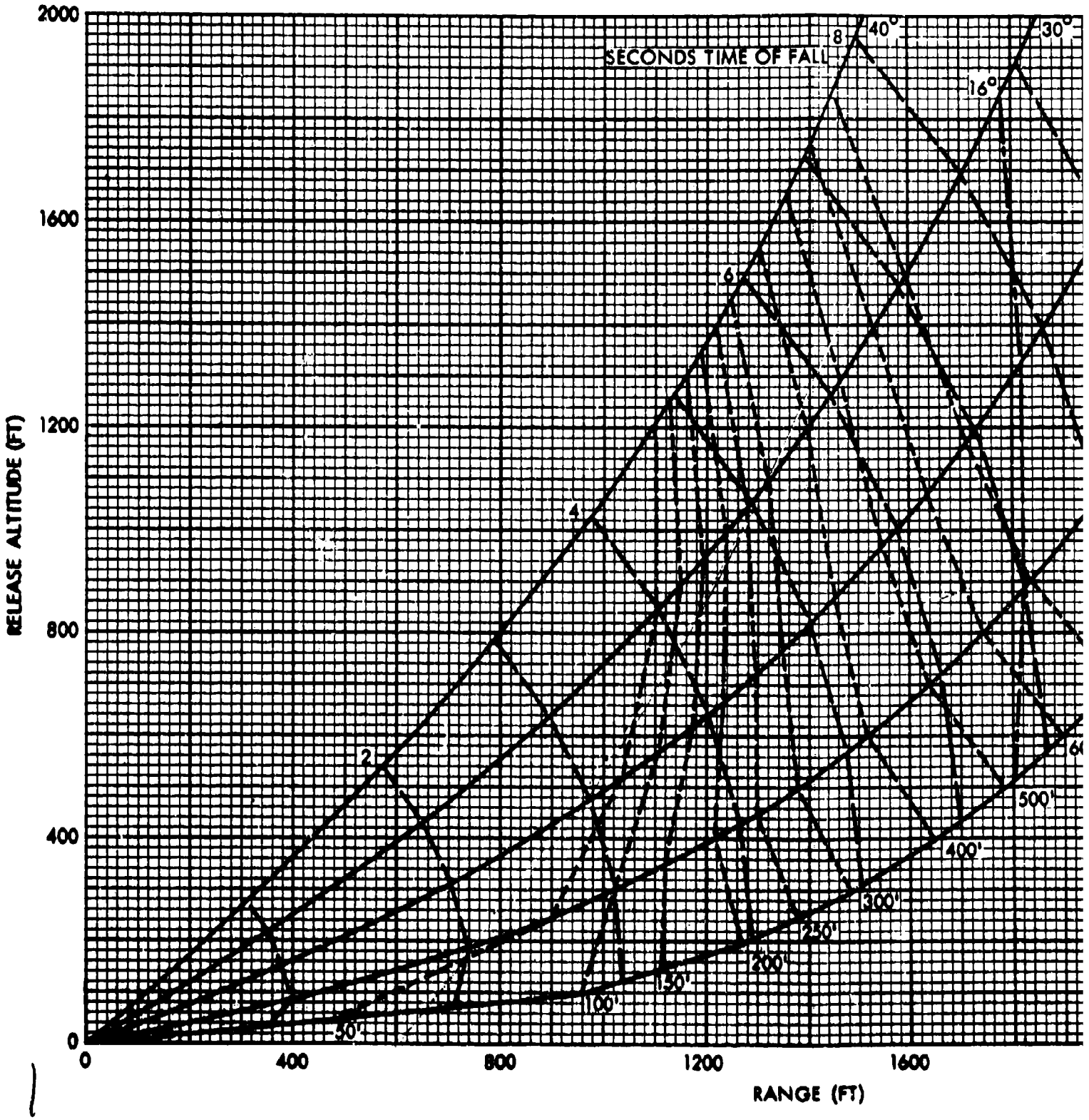


FIG. 46 MK 82/RETARDED EJ VEL 0 FPS


SECONDS TIME OF FALL
8
40°
30°
16°
6
4
2
50'
100'
150'
200'
250'
300'
400'
500'
RELEASE ALTITUDE (FT)
2000
1600
1200
800
400
0
0
400
800
1200
1600
RANGE (FT)

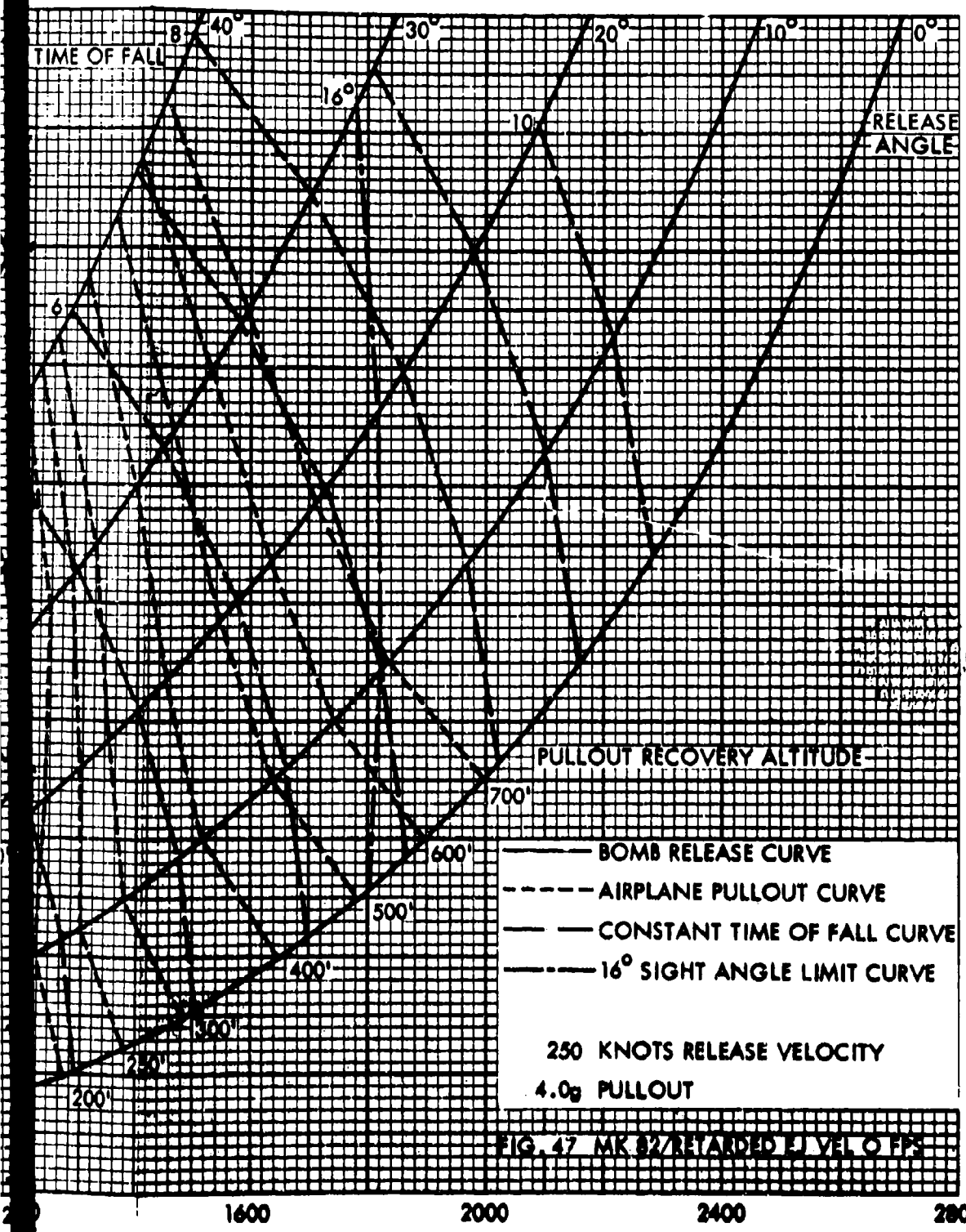
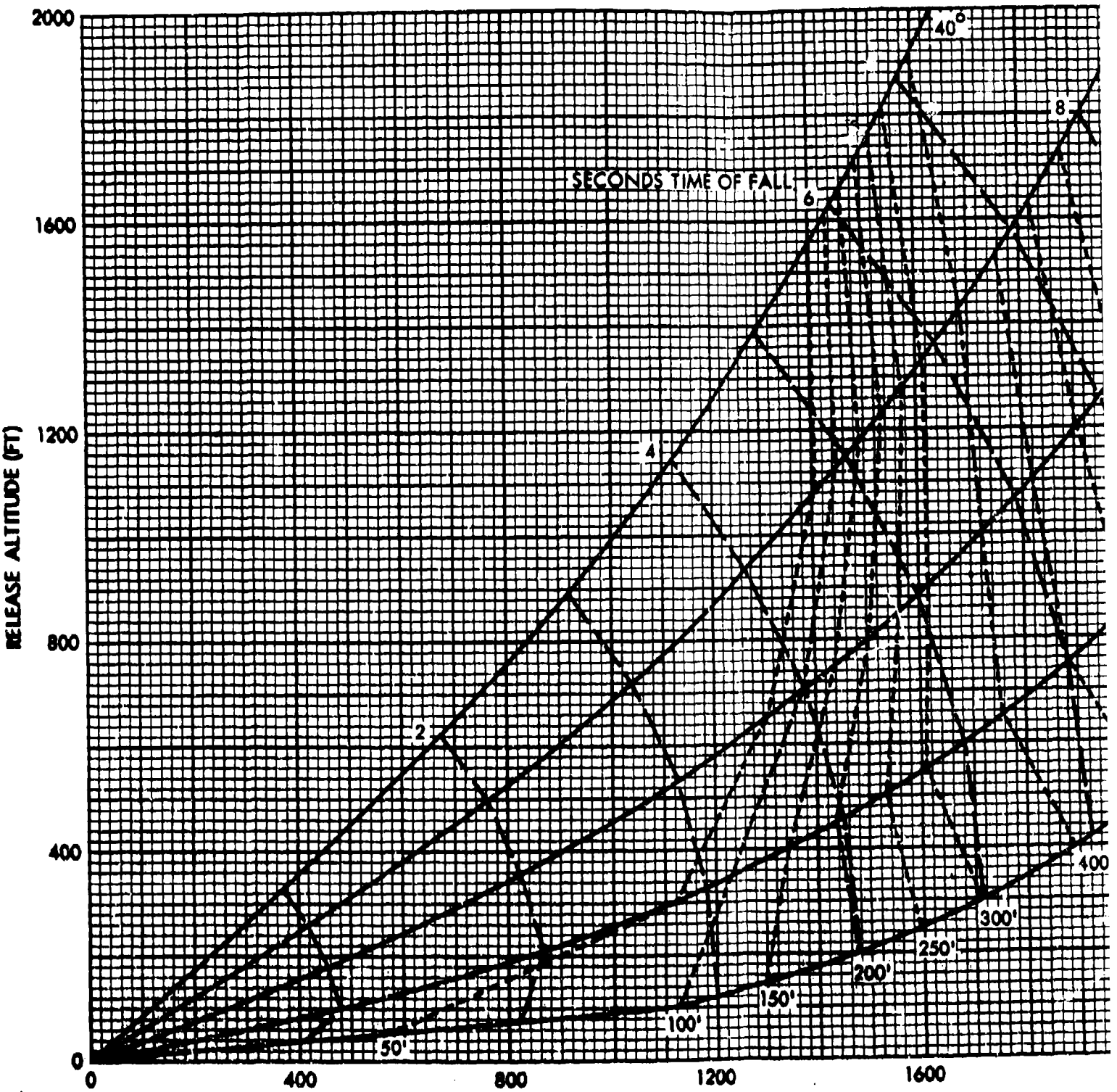


FIG. 47 MK 82/RETARDED FJ VEL 0 FPS


RELEASE ALTITUDE (FT)
2000
1600
1200
800
400
0
0
400
800
1200
1600
SECONDS TIME OF FALL
40°
8
6
4
2
400'
300'
250'
200'
150'
100'
50'

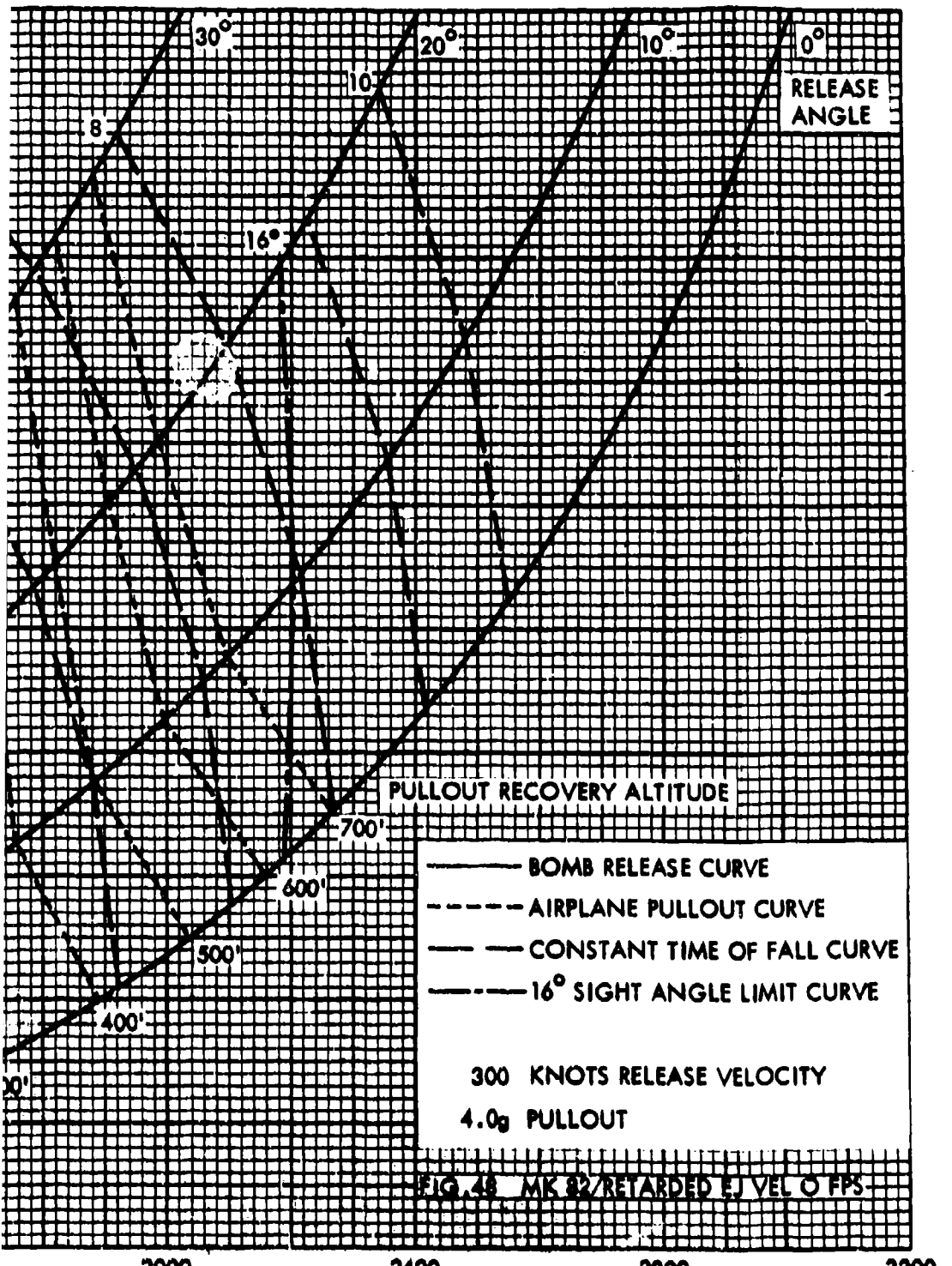
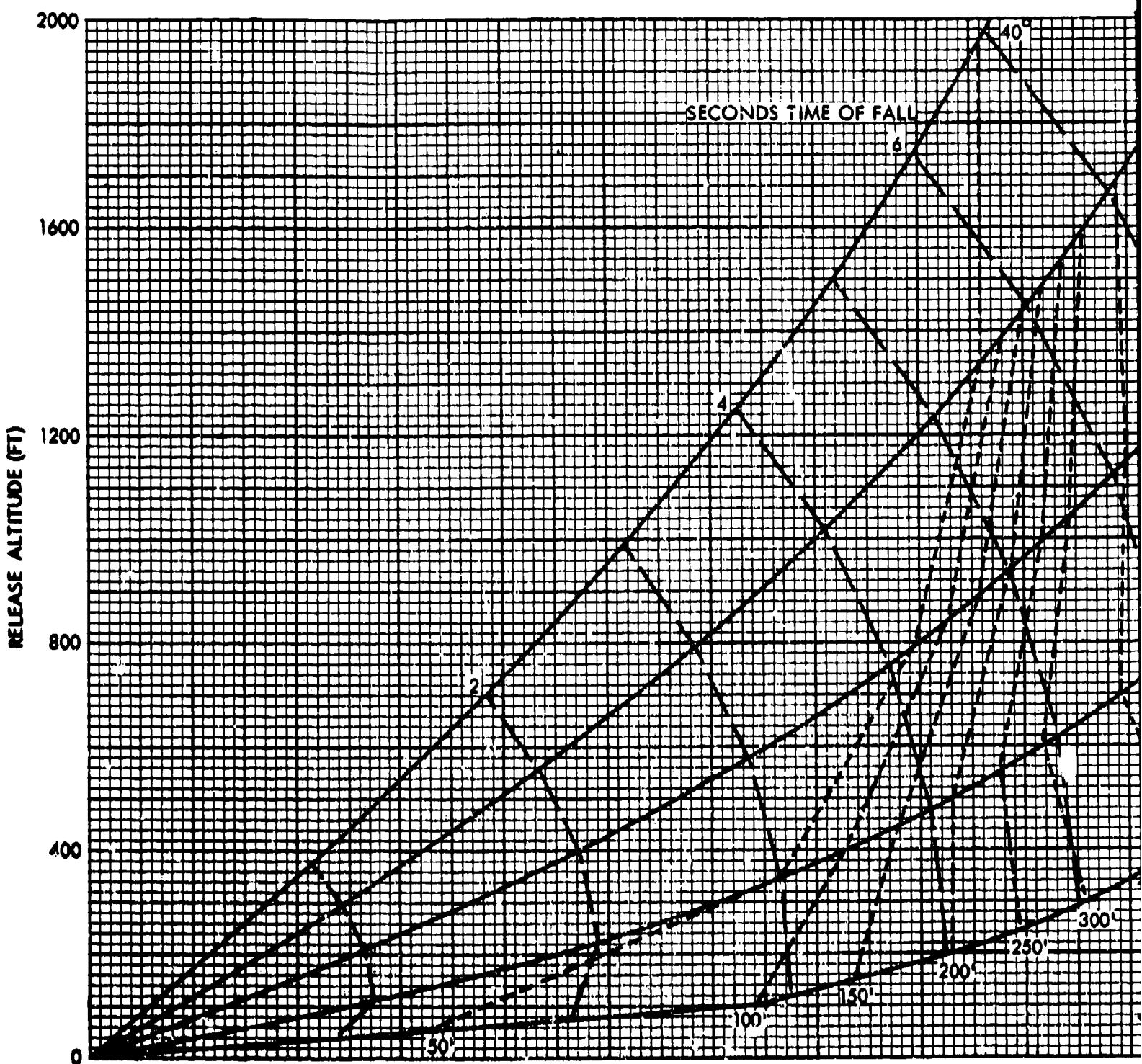


FIG. 48 MK 82/RETARDED EJ VEL 0 FPS

2


SECONDS TIME OF FALL
40"
6
4
2
50'
100'
150'
200'
250'
300'
RELEASE ALTITUDE (FT)
2000
1600
1200
800
400
0
0
400
800
1200
1600
200

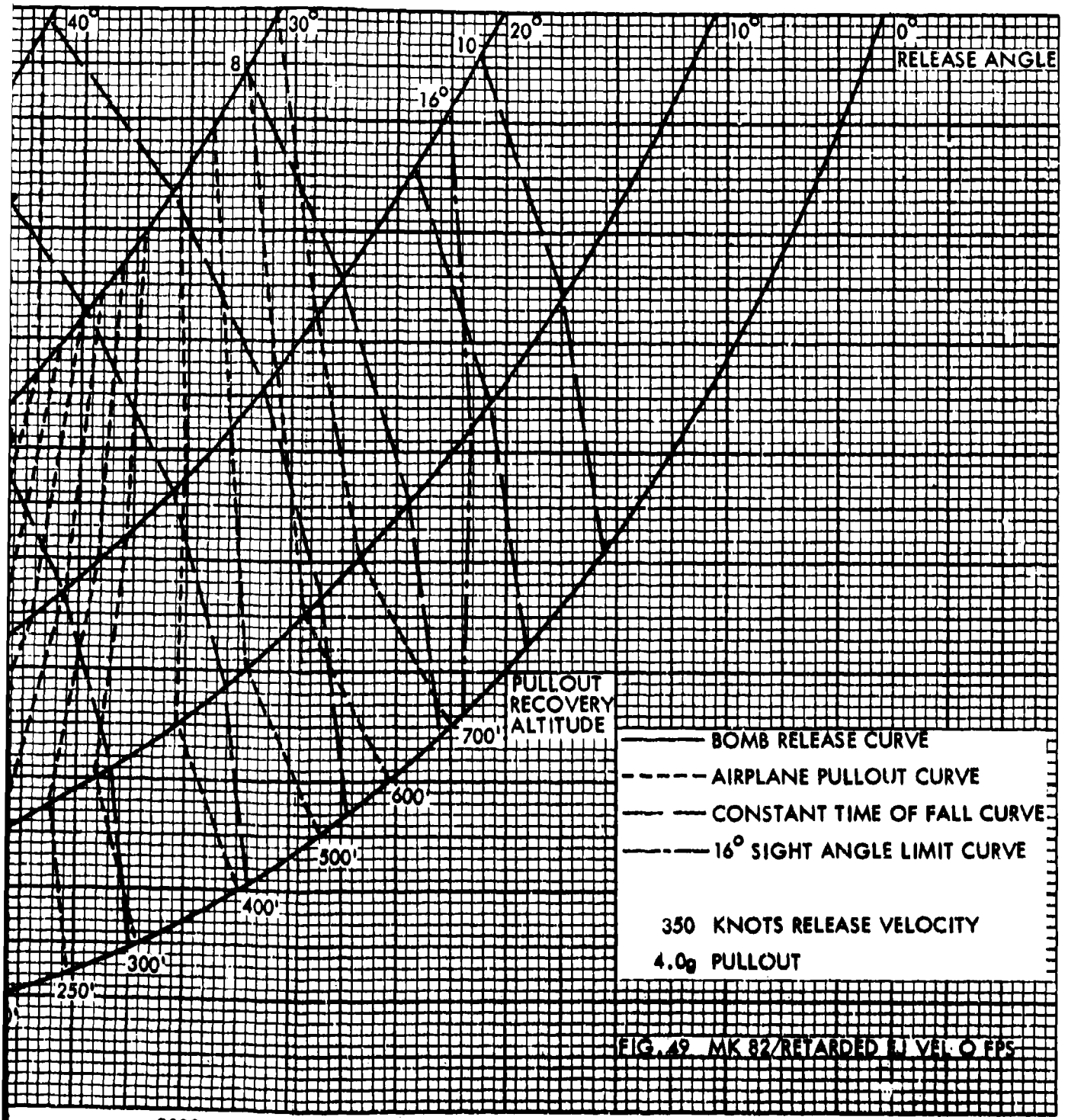
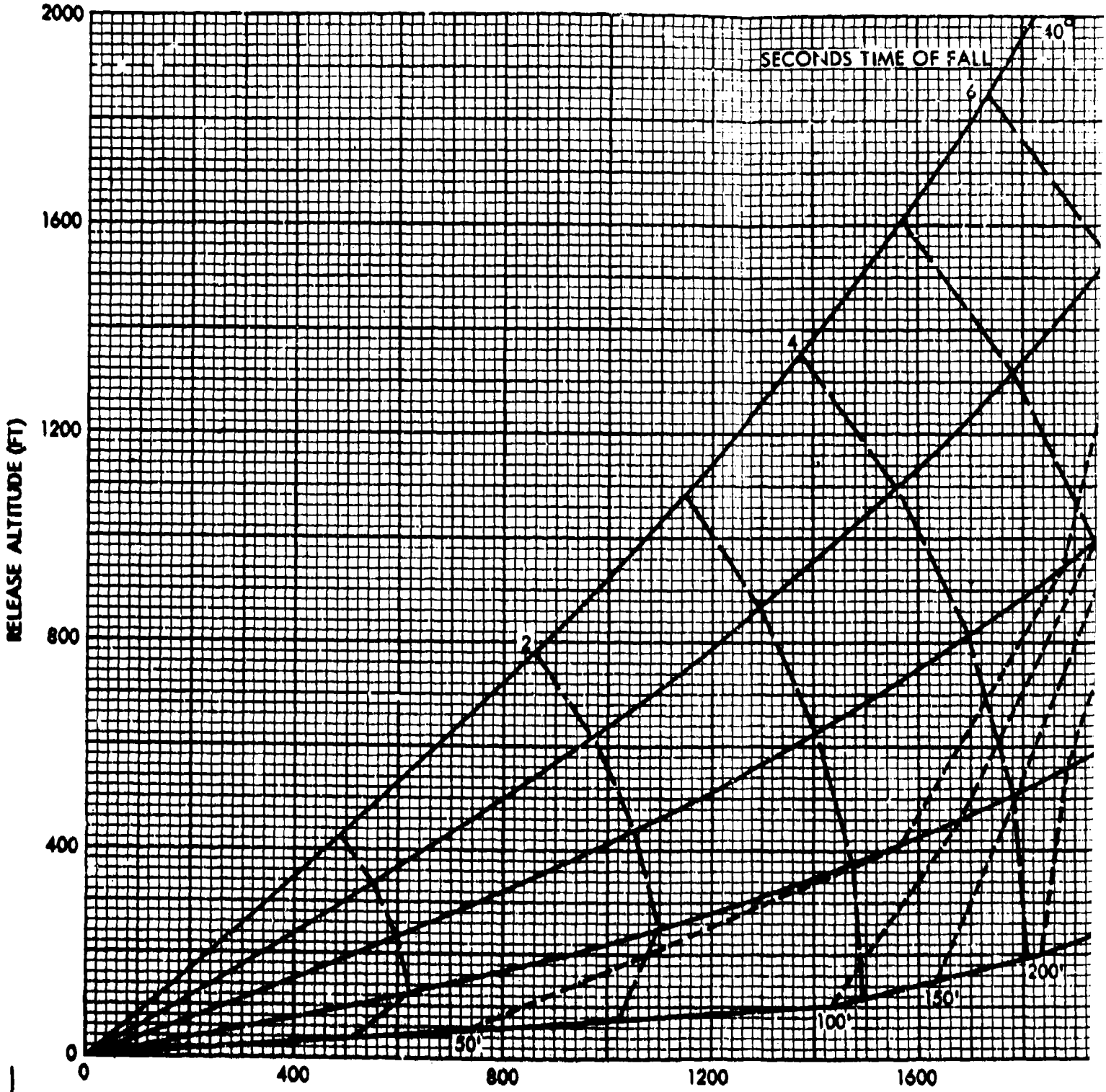


FIG. 49 MK 82/RETARDED BJ VEL 0 FPS


SECONDS TIME OF FALL
2
4
6
40
50'
100'
150'
200'
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
2000

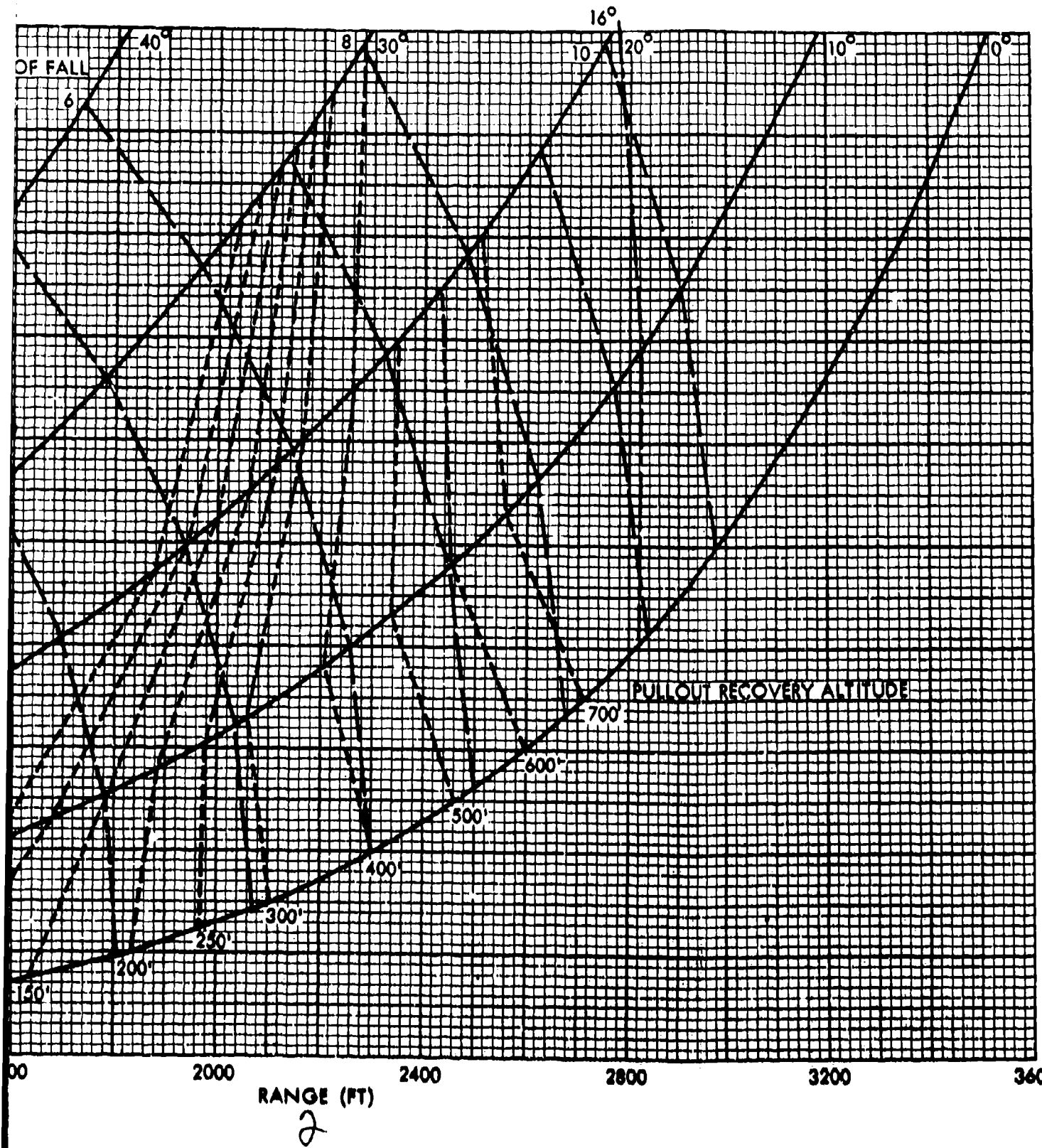
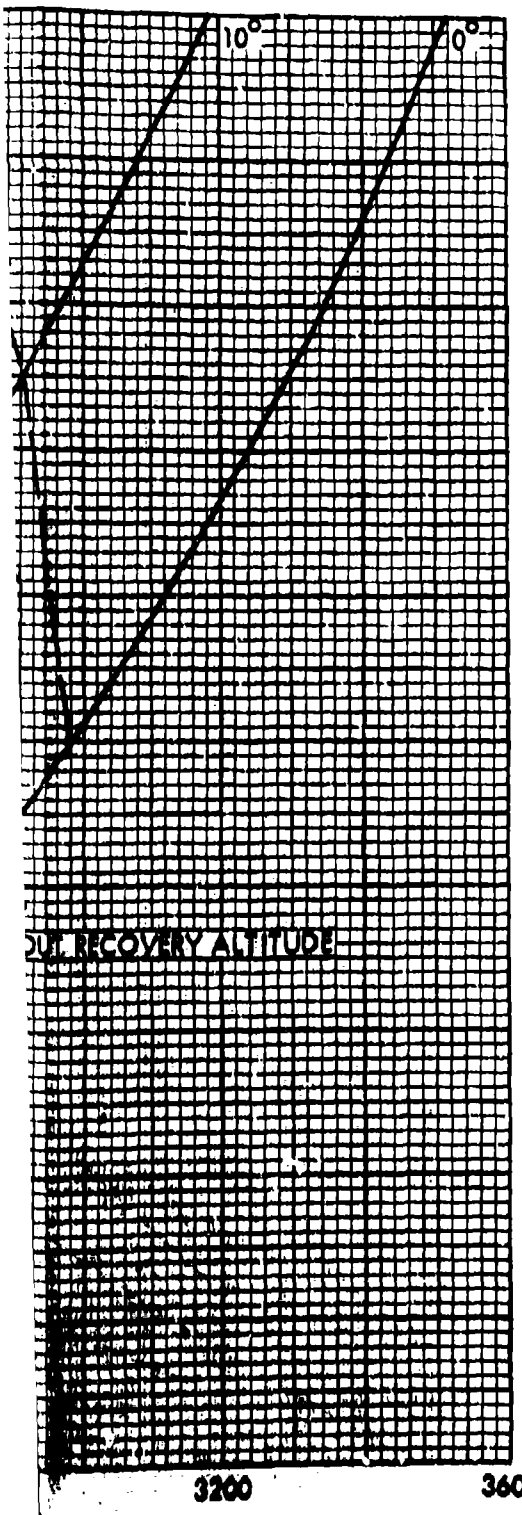

16°
40°
30°
20°
10°
0°
RELEASE ANGLE
OF FALL
6
8
10
PULLOUT RECOVERY ALTITUDE
700'
600'
500'
400'
300'
250'
200'
150'
2000
2400
2800
3200
3600
RANGE (FT)

FIG. 50



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

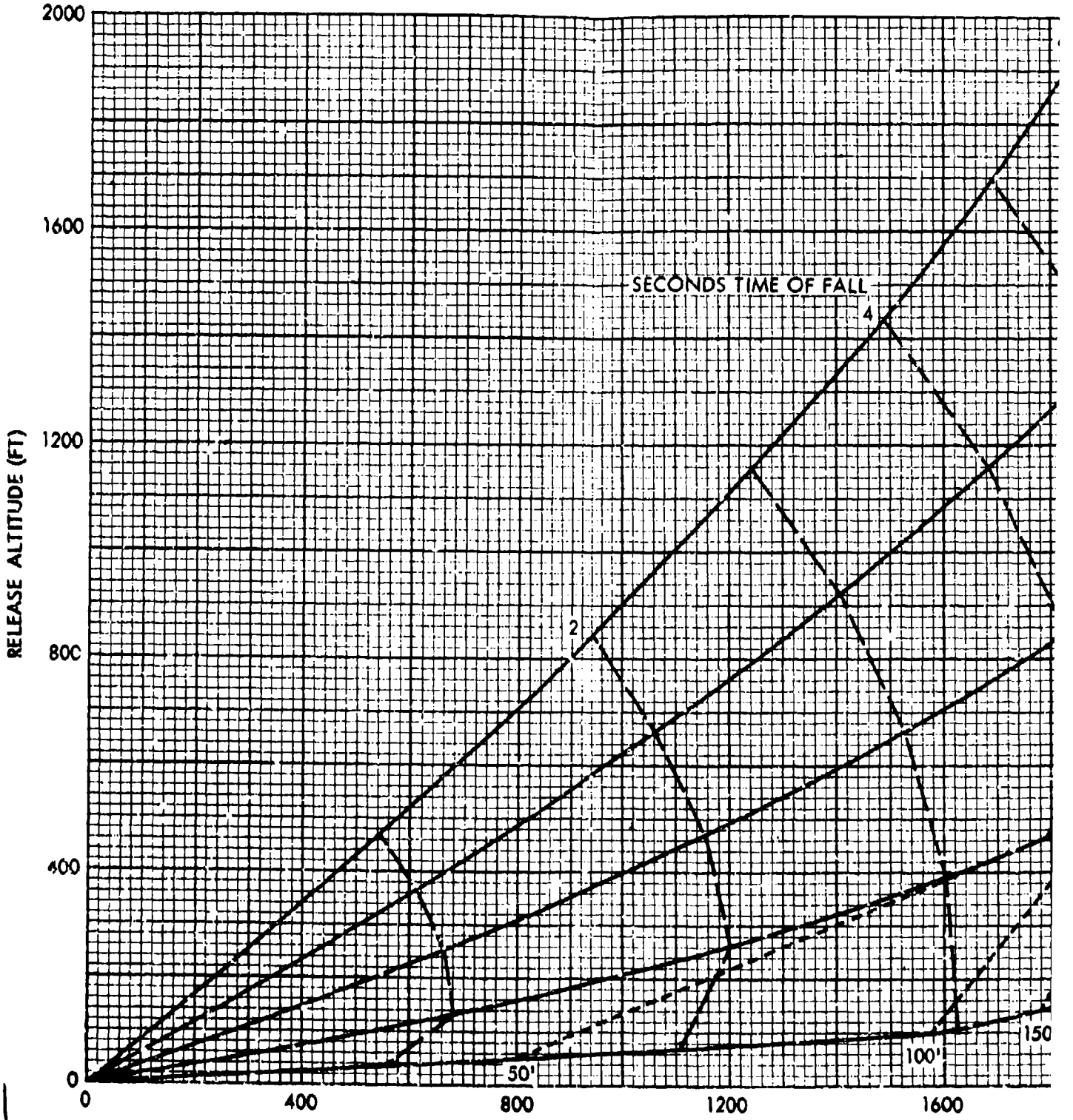
— — CONSTANT TIME OF FALL CURVE

———— 16° SIGHT ANGLE LIMIT CURVE

400 KNOTS RELEASE VELOCITY

4.0g PULLOUT

FIG. 50 MK 82/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
SECONDS TIME OF FALL
4
2
50'
100'
150
0
400
800
1200
1600

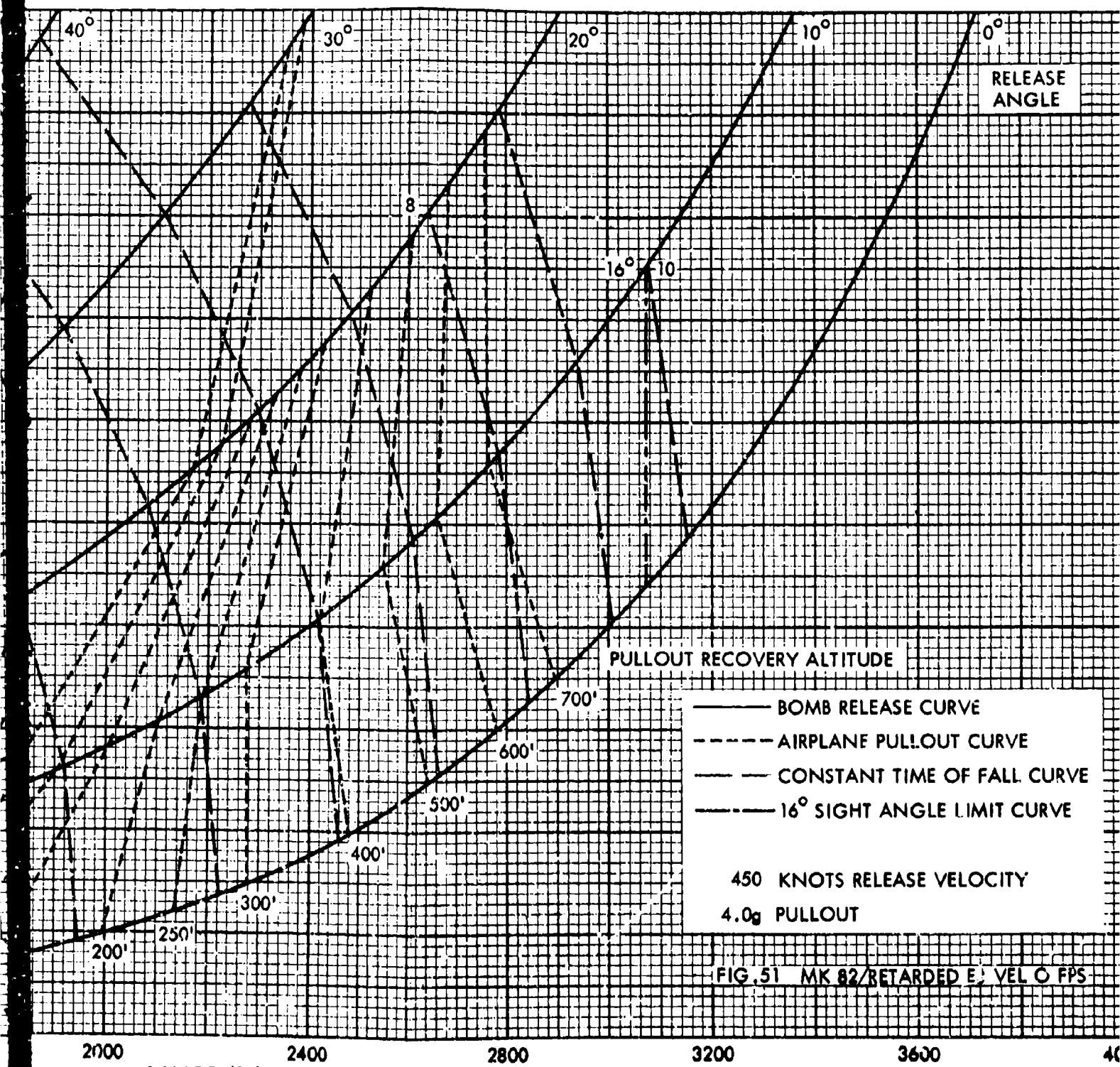
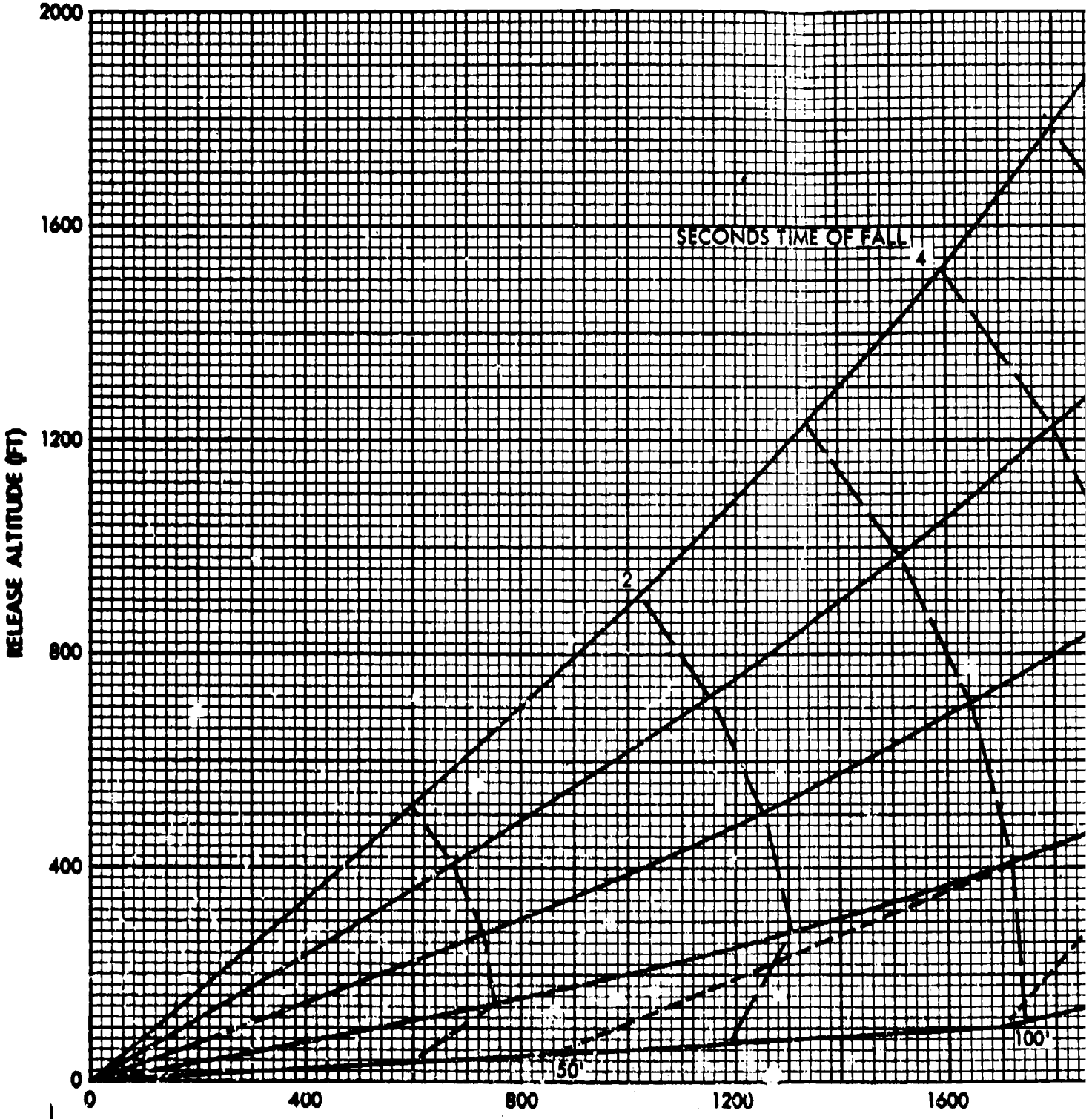
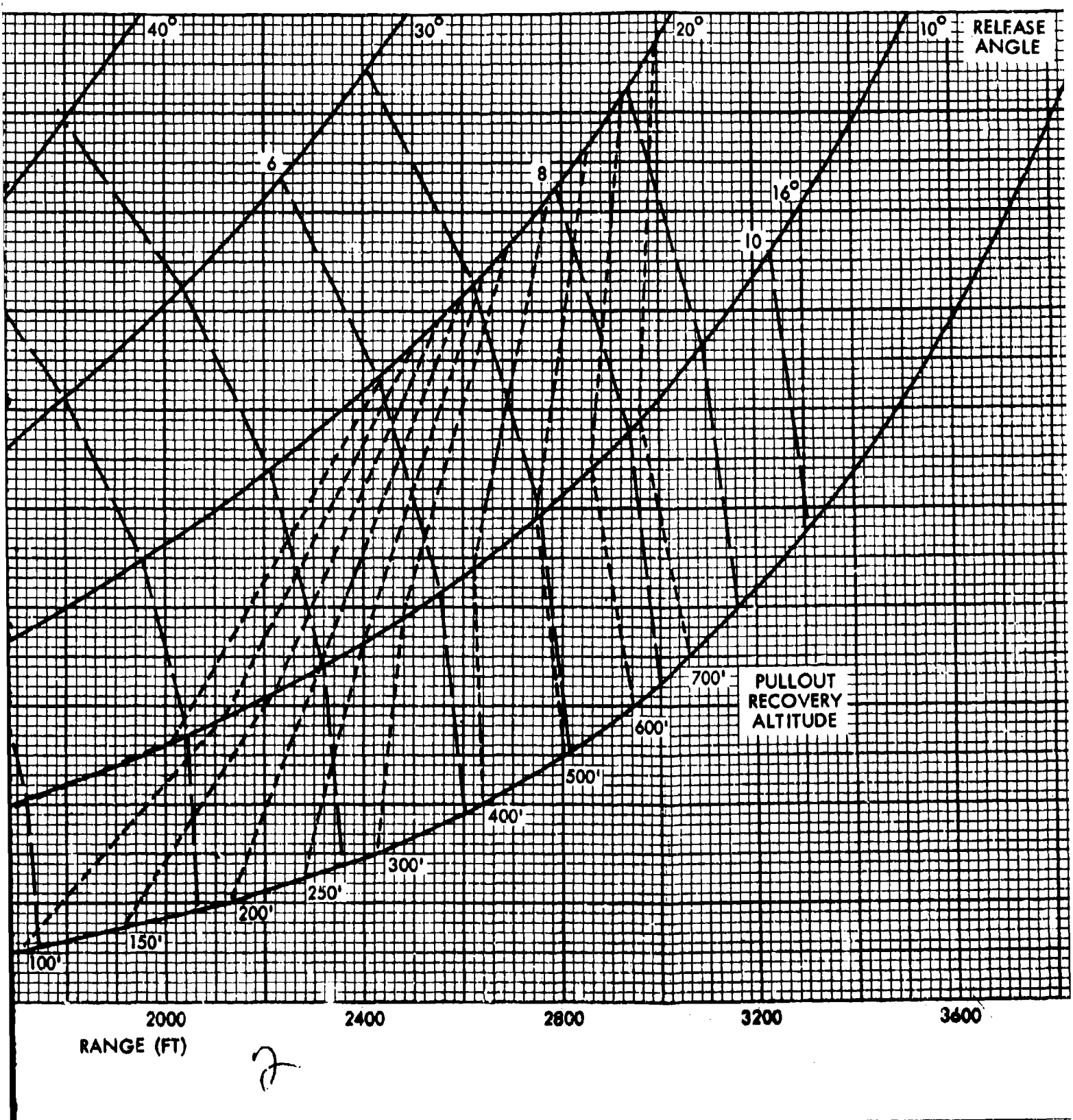
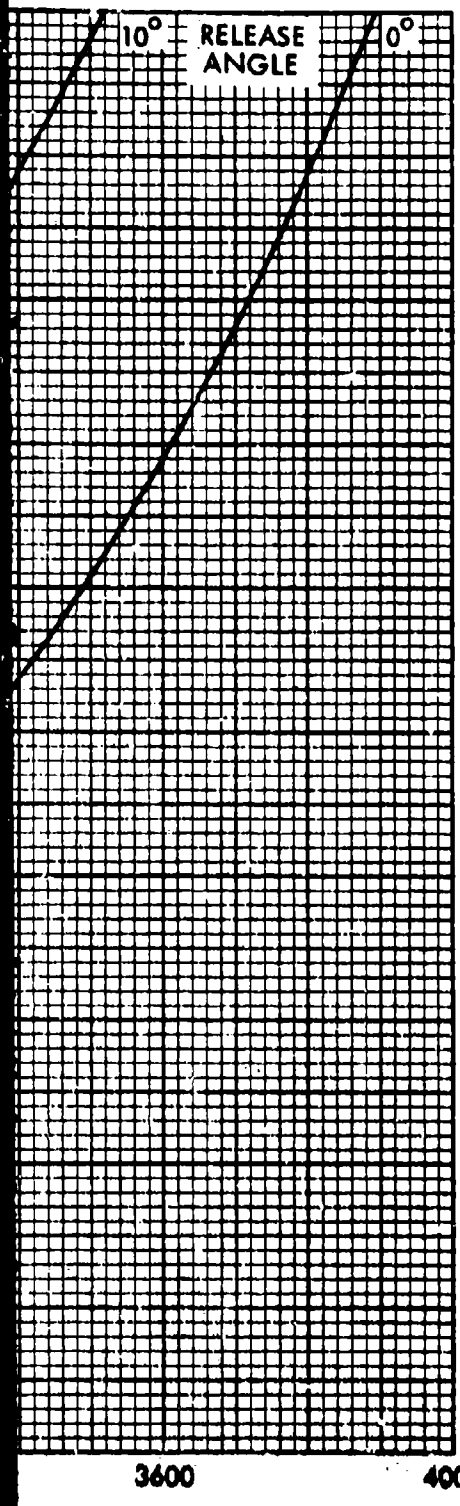


FIG. 51 MK 82/RETARDED E; VEL 0 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
SECONDS TIME OF FALL
4
2
100'
50'
0
400
800
1200
1600


40°
30°
20°
10°
RELEASE ANGLE
6
8
16°
10
700'
600'
500'
400'
300'
250'
200'
150'
100'
PULLOUT RECOVERY ALTITUDE
2000
2400
2800
3200
3600
RANGE (FT)



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

— — CONSTANT TIME OF FALL CURVE

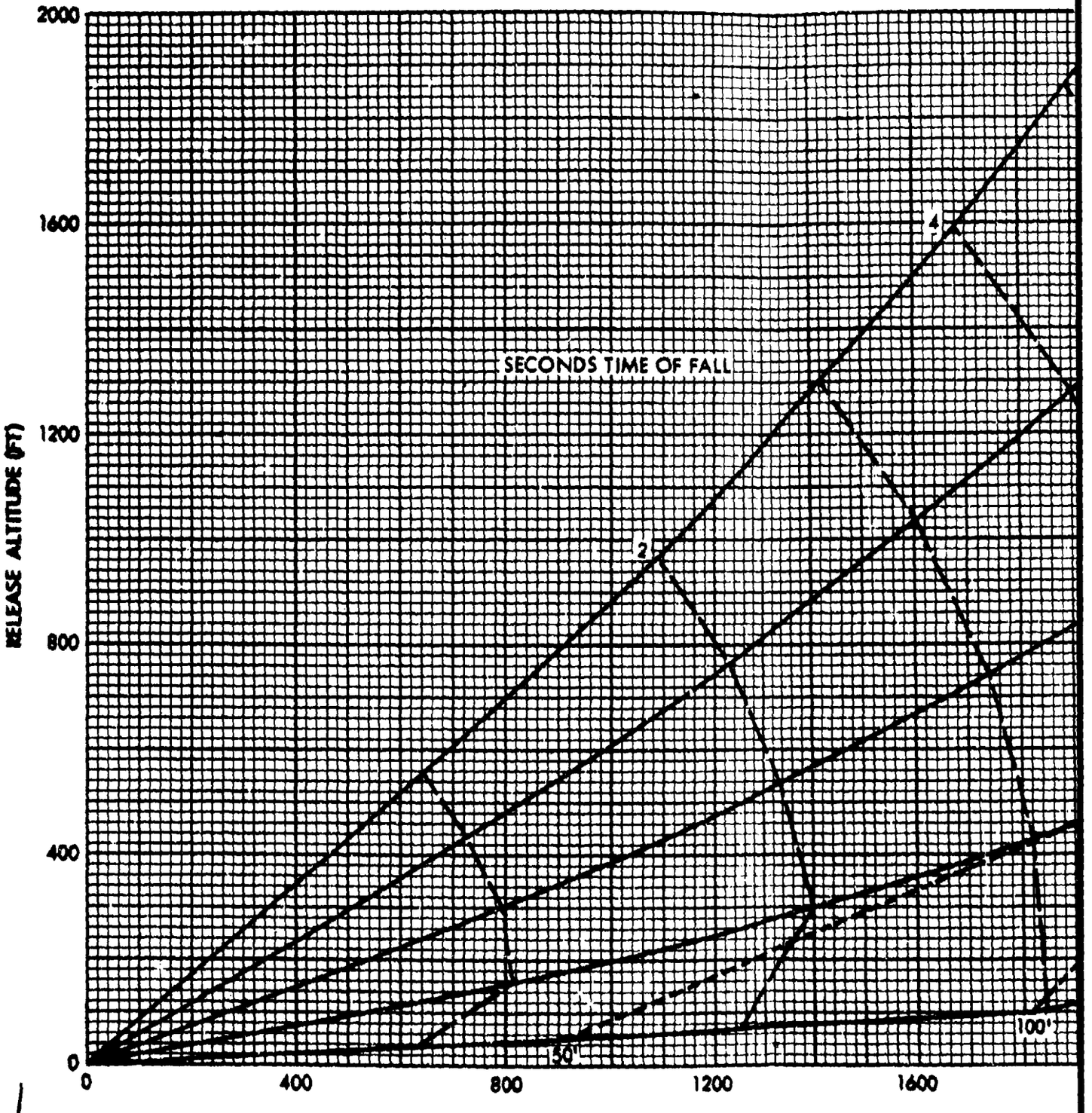
—·— 16° SIGHT ANGLE LIMIT CURVE

500 KNOTS RELEASE VELOCITY

4.0g PULLOUT

FIG. 52 MK 82/RETARDED EJ VEL O FPS

3


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
SECONDS TIME OF FALL
4
2
50'
100'
0
400
800
1200
1600

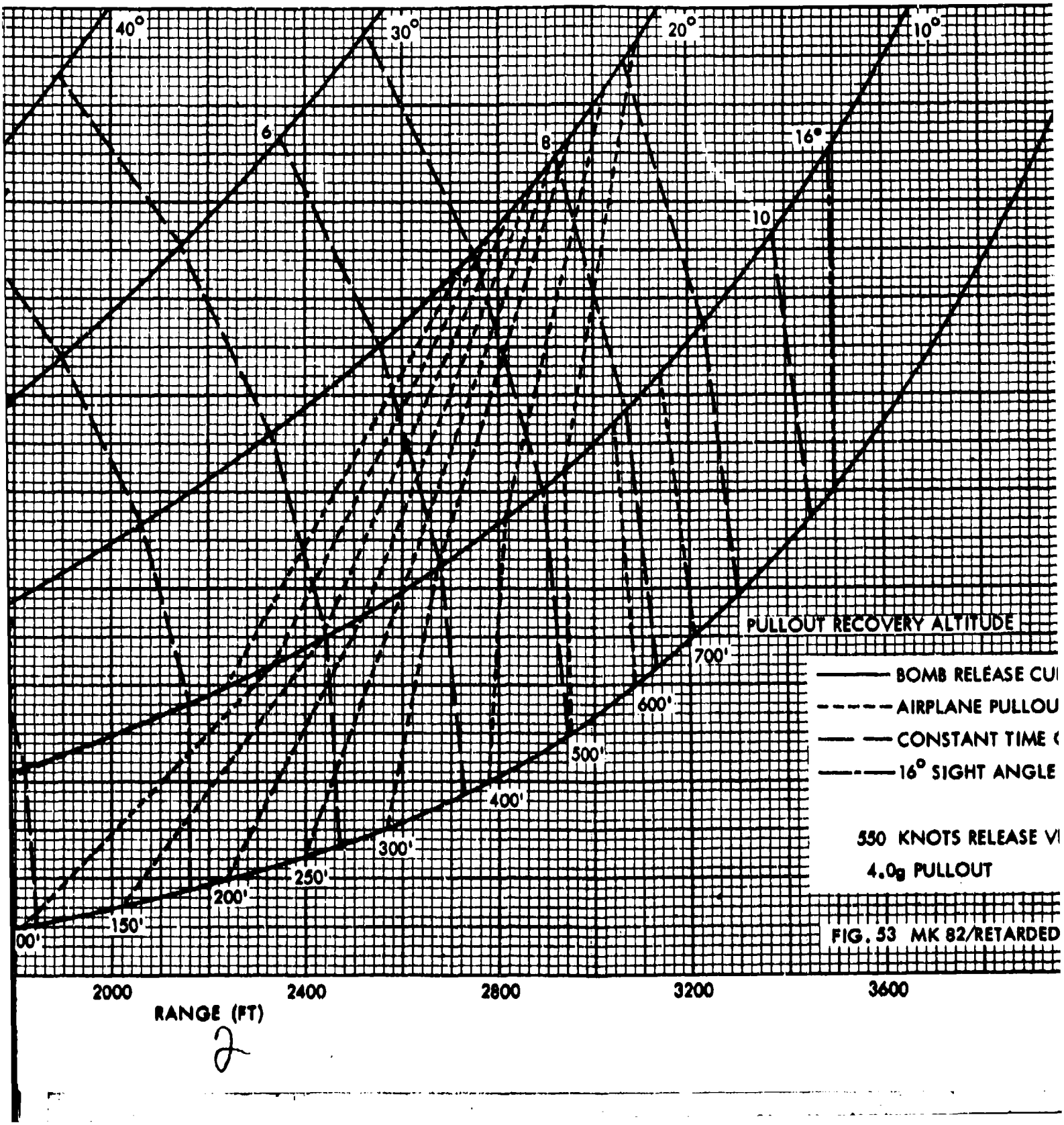


FIG. 53 MK 82/RETARDED

2

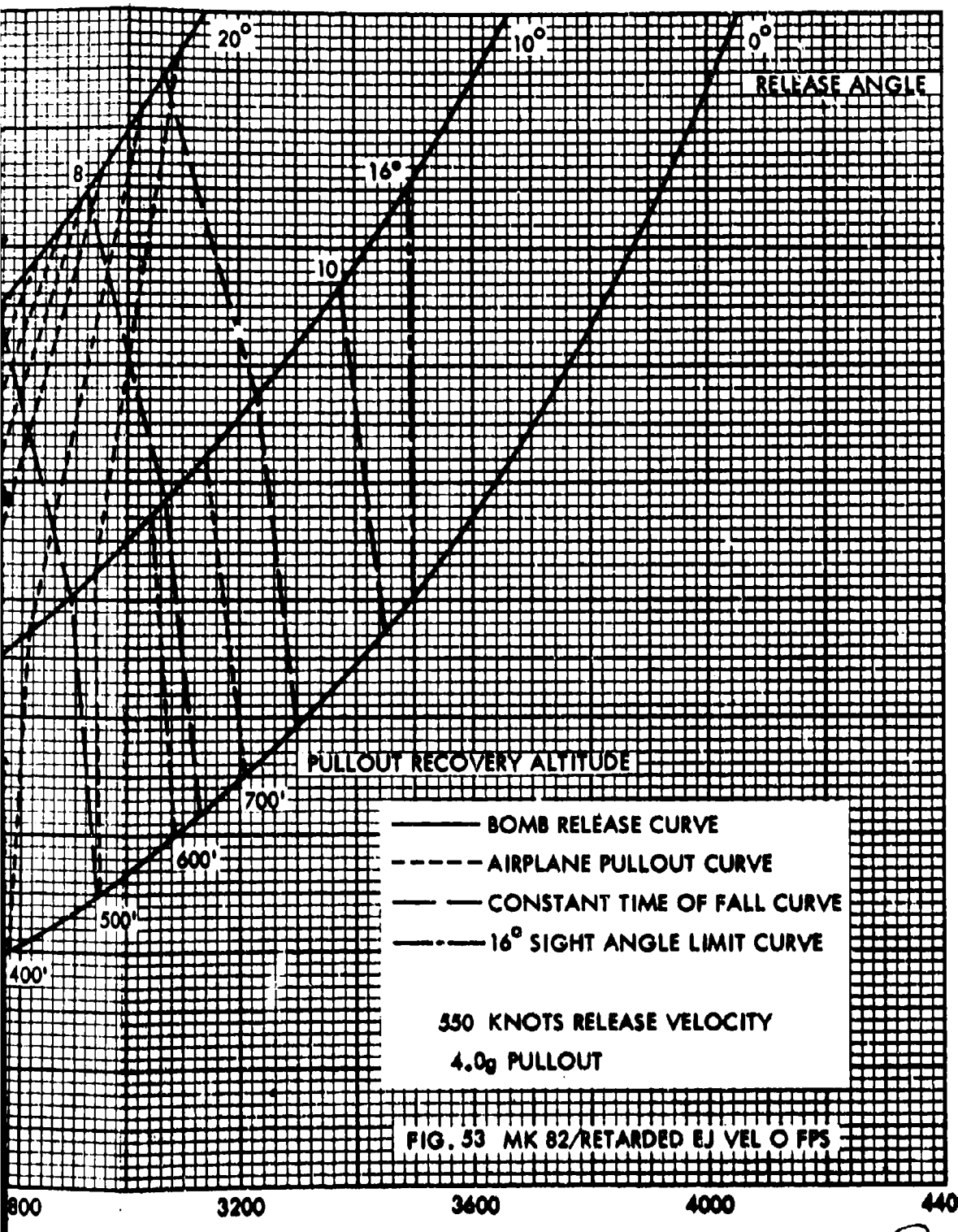
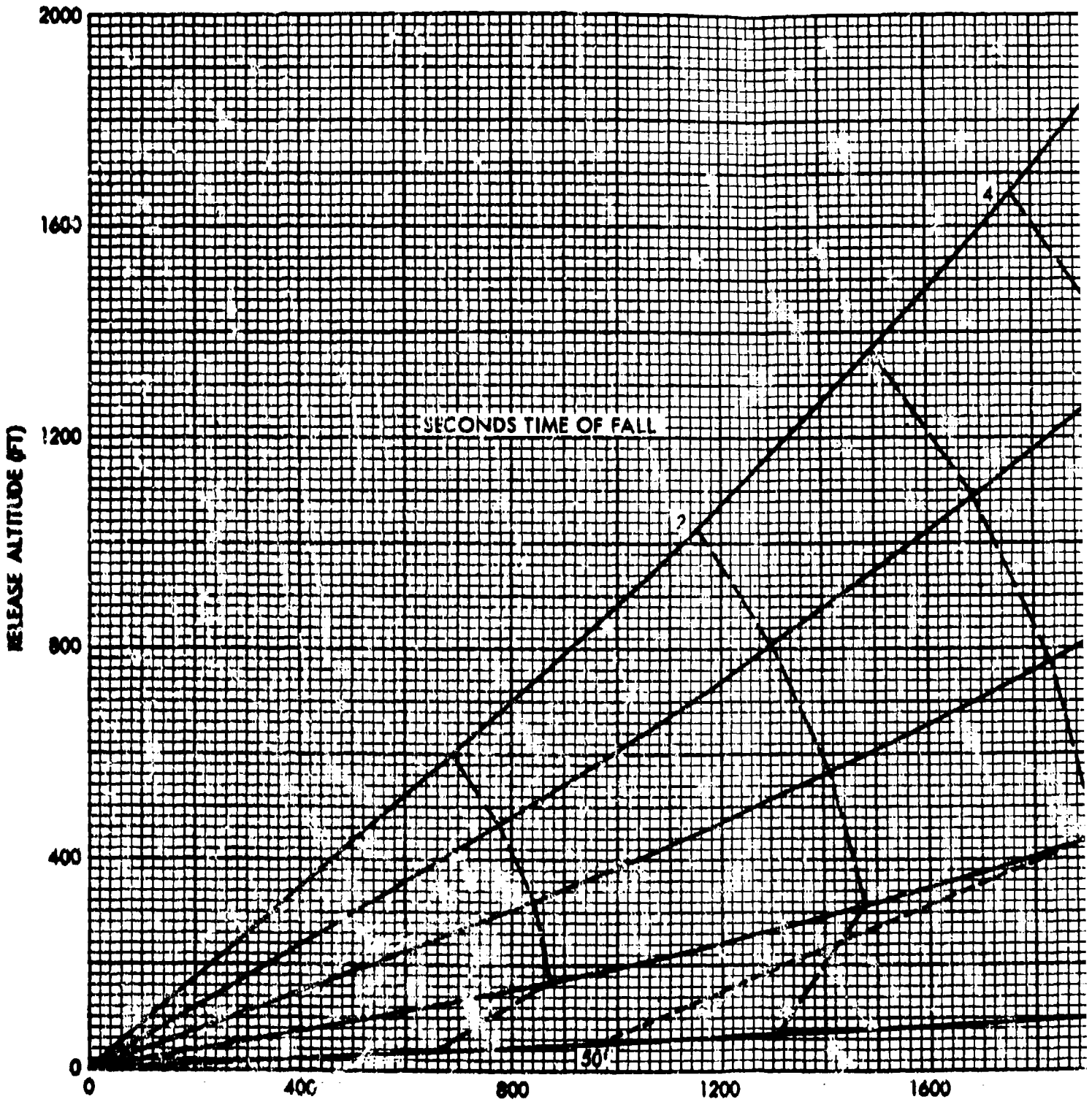


FIG. 53 MK 82/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
SECONDS TIME OF FALL
4
2
30
0
400
800
1200
1600

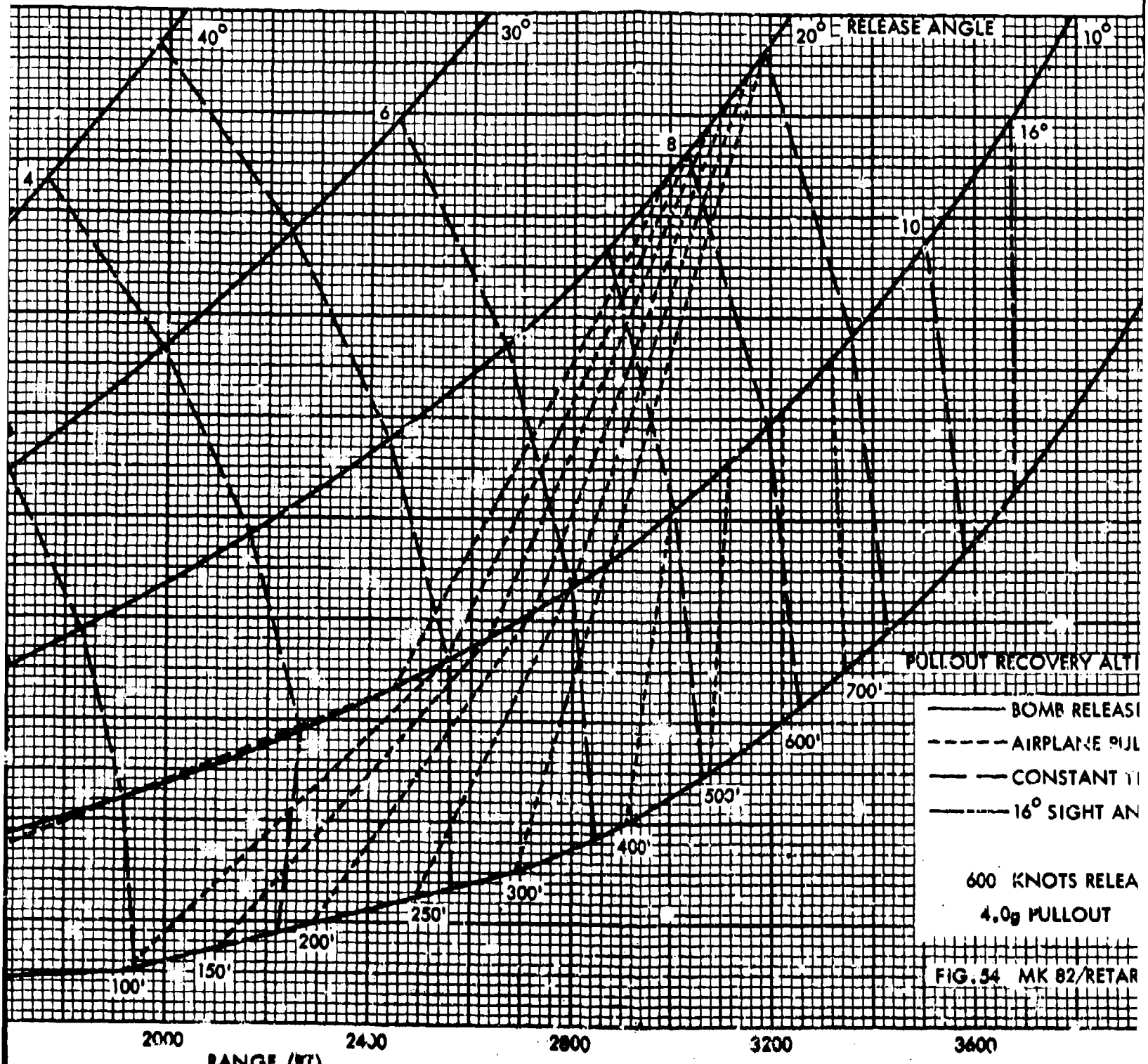


FIG. 54 MK 82/RETAR

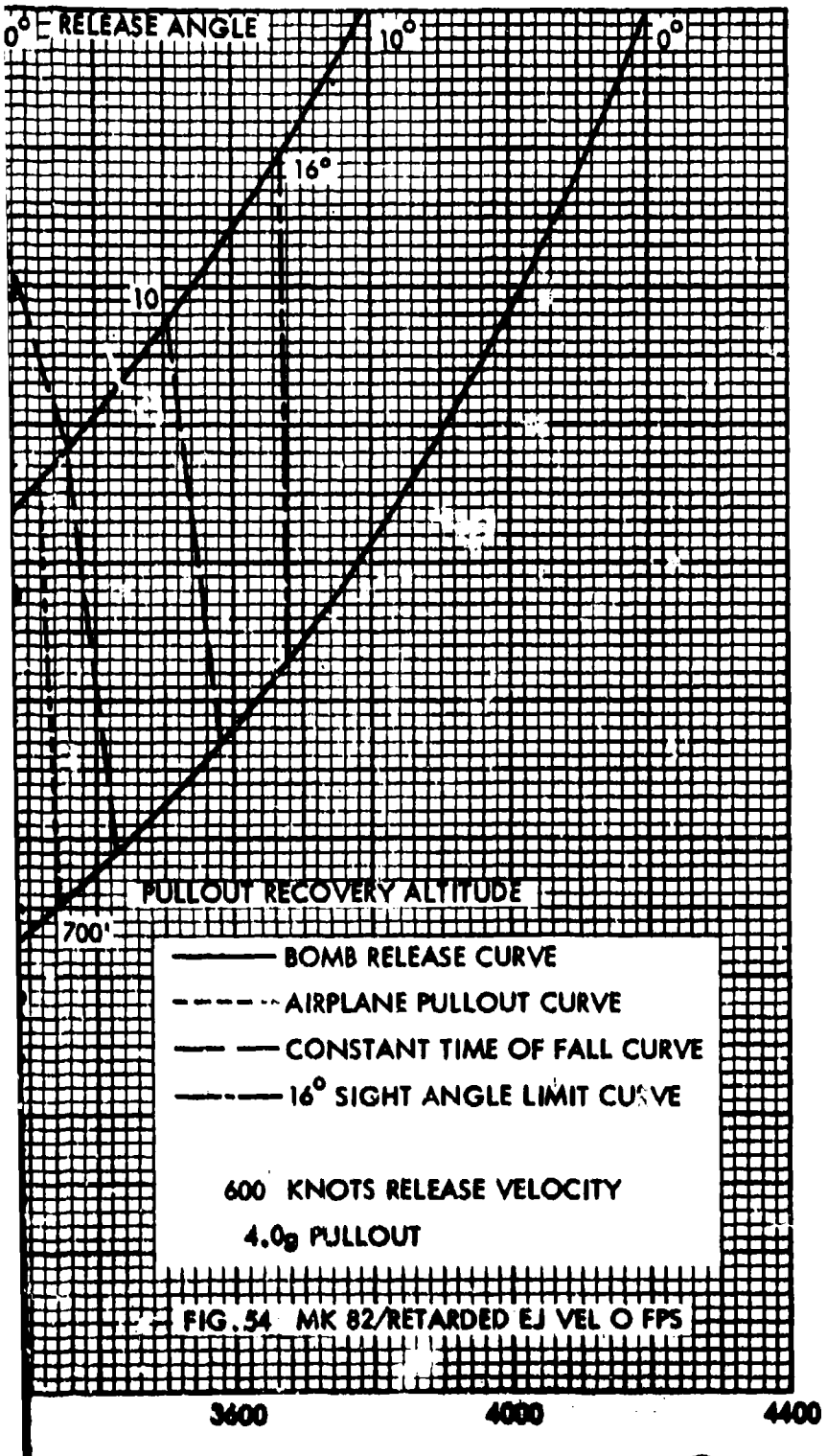
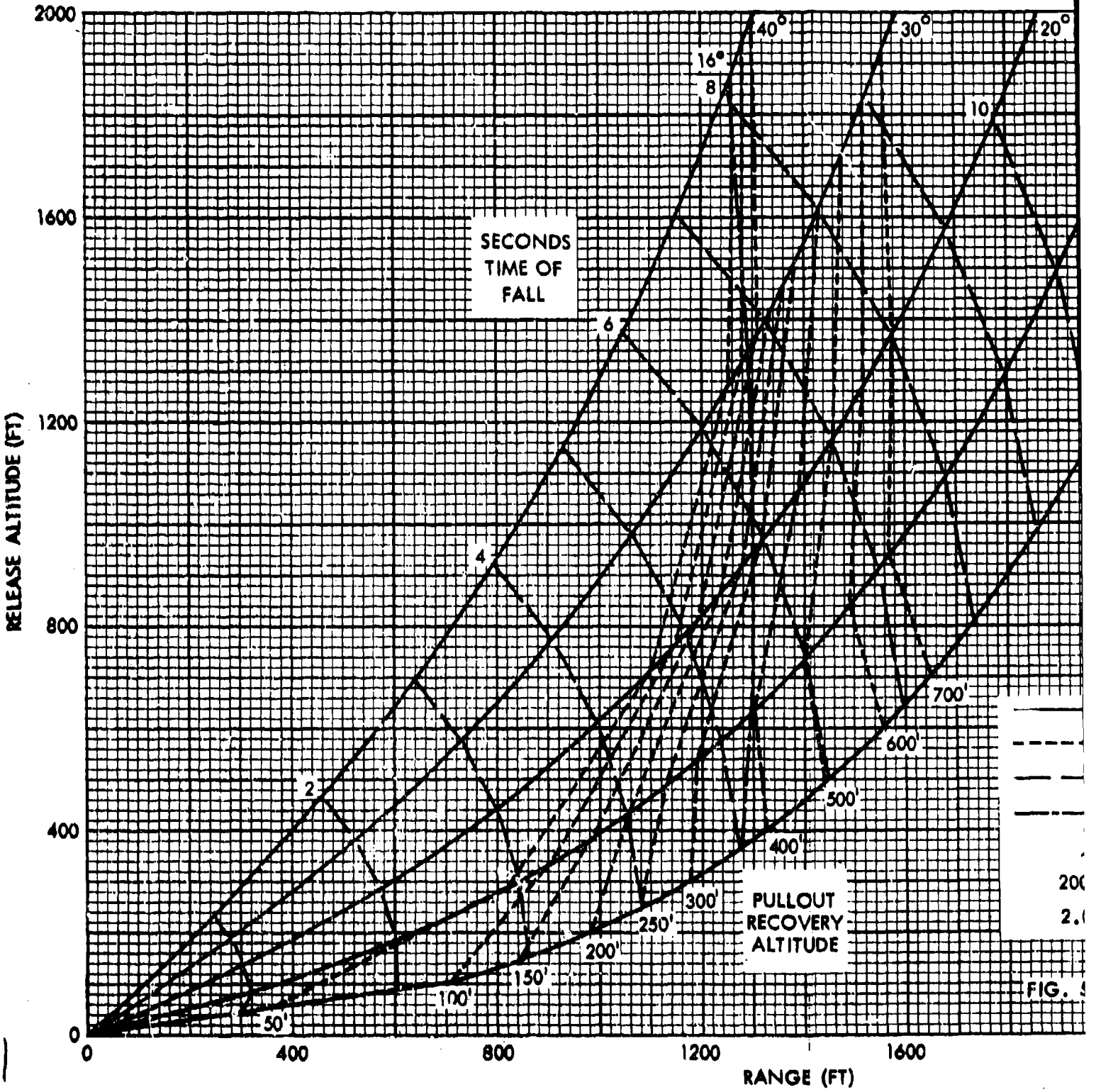


FIG. 54 MK 82/RETARDED EJ VEL O FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
8
10
16°
40°
30°
20°
50'
100'
150'
200'
250'
300'
400'
500'
600'
700'
PULLOUT RECOVERY ALTITUDE

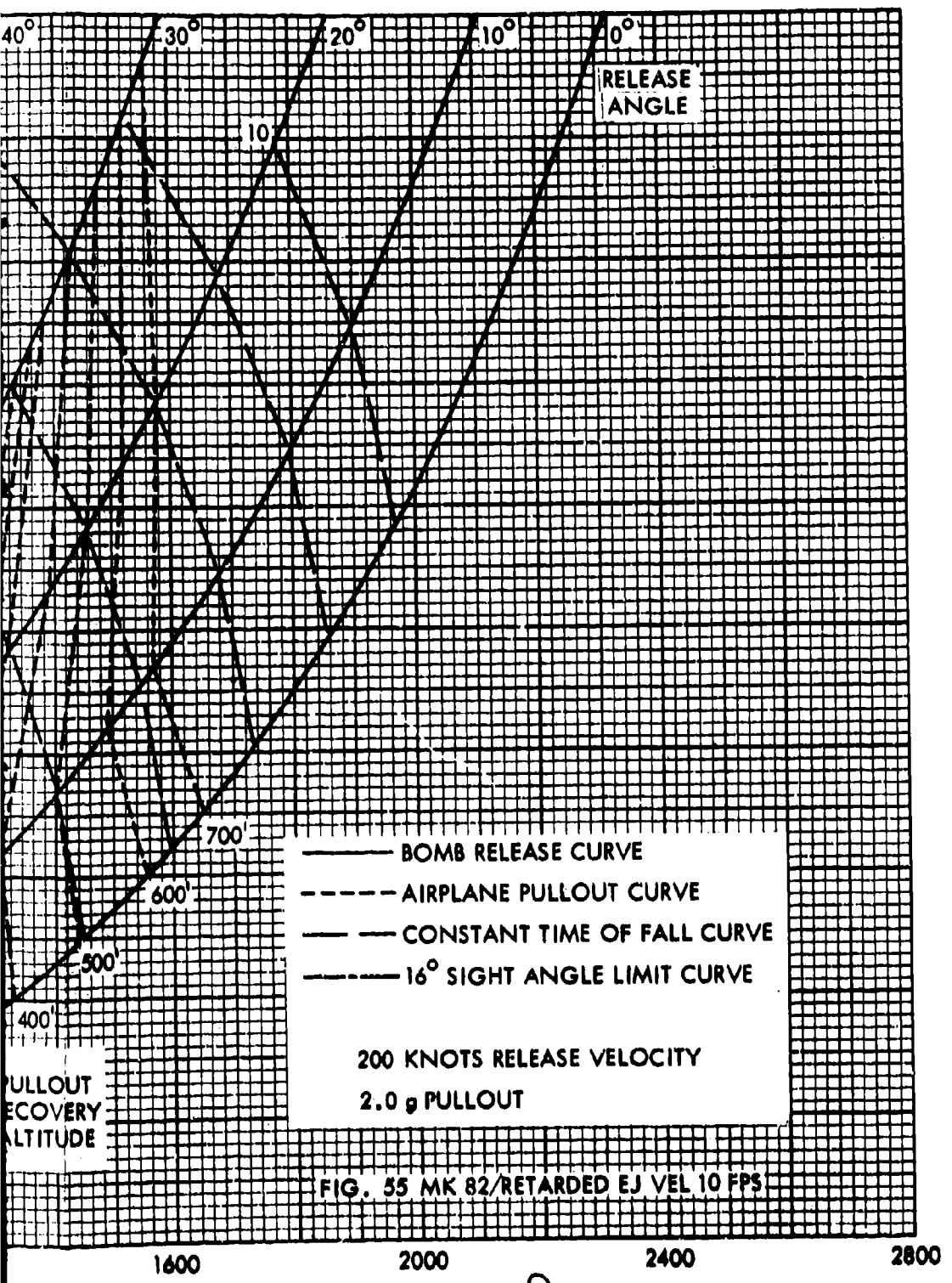
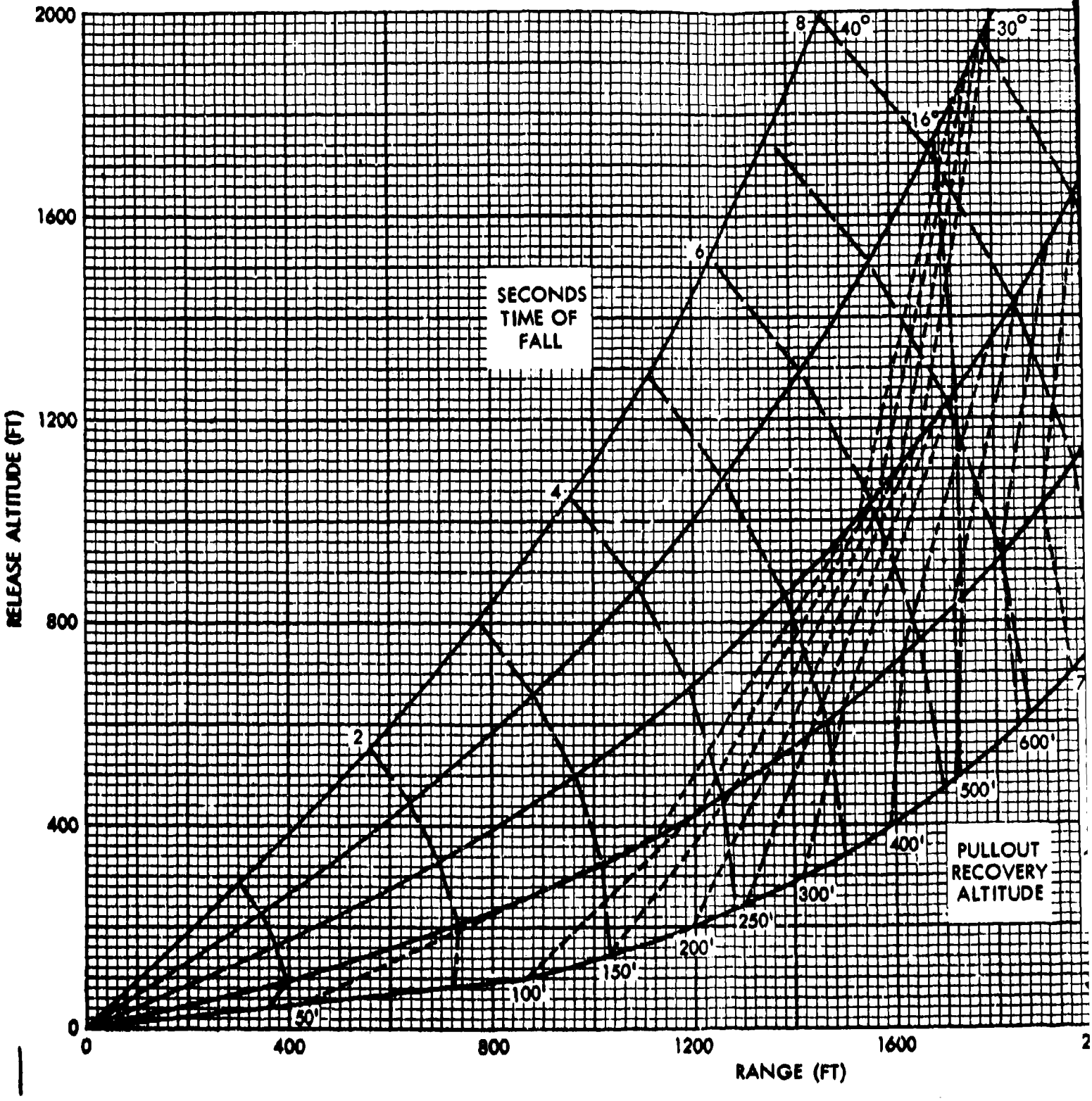


FIG. 55 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
8
40°
30°
16°
50'
100'
150'
200'
250'
300'
400'
500'
600'
PULLOUT RECOVERY ALTITUDE

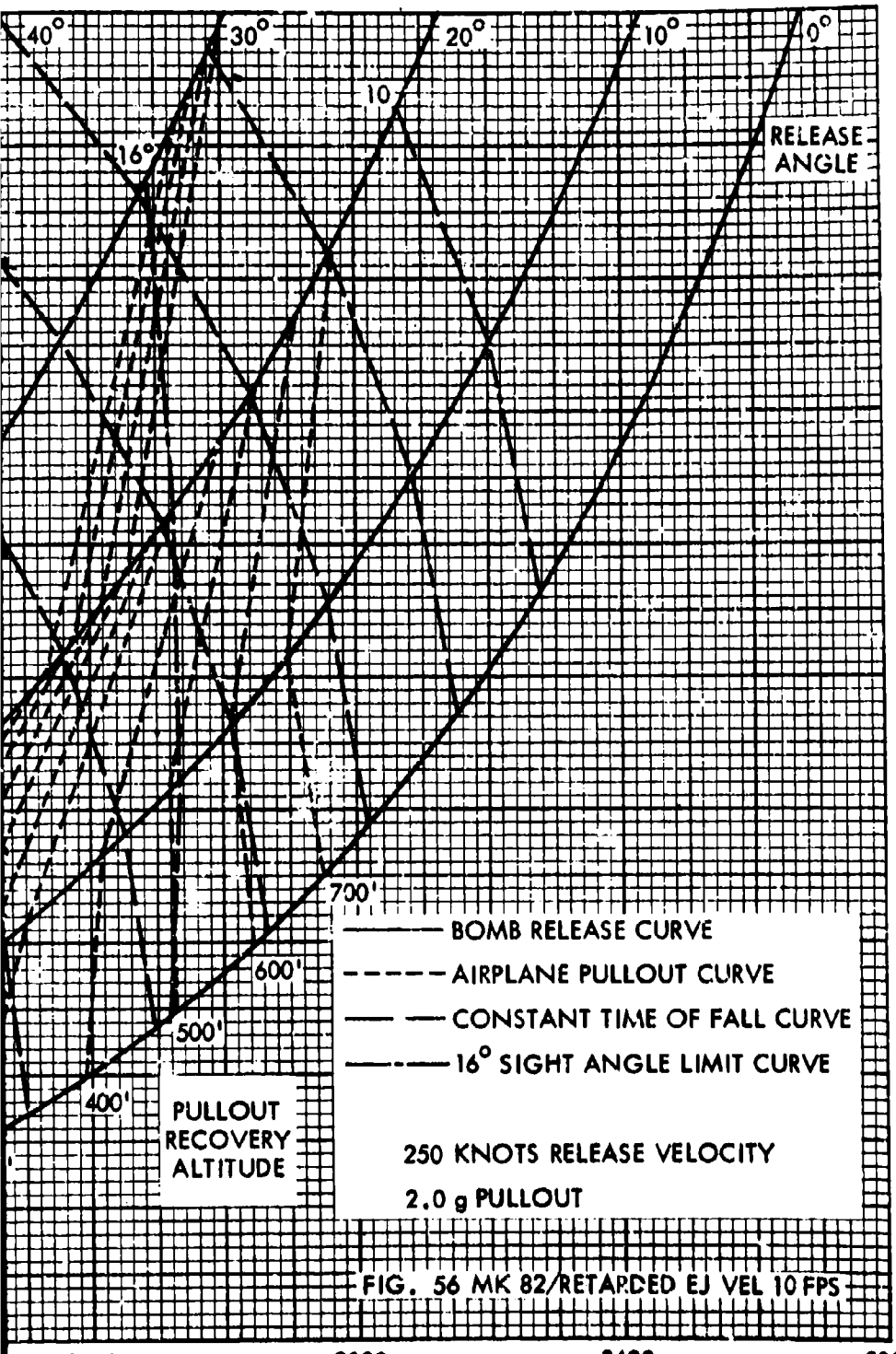
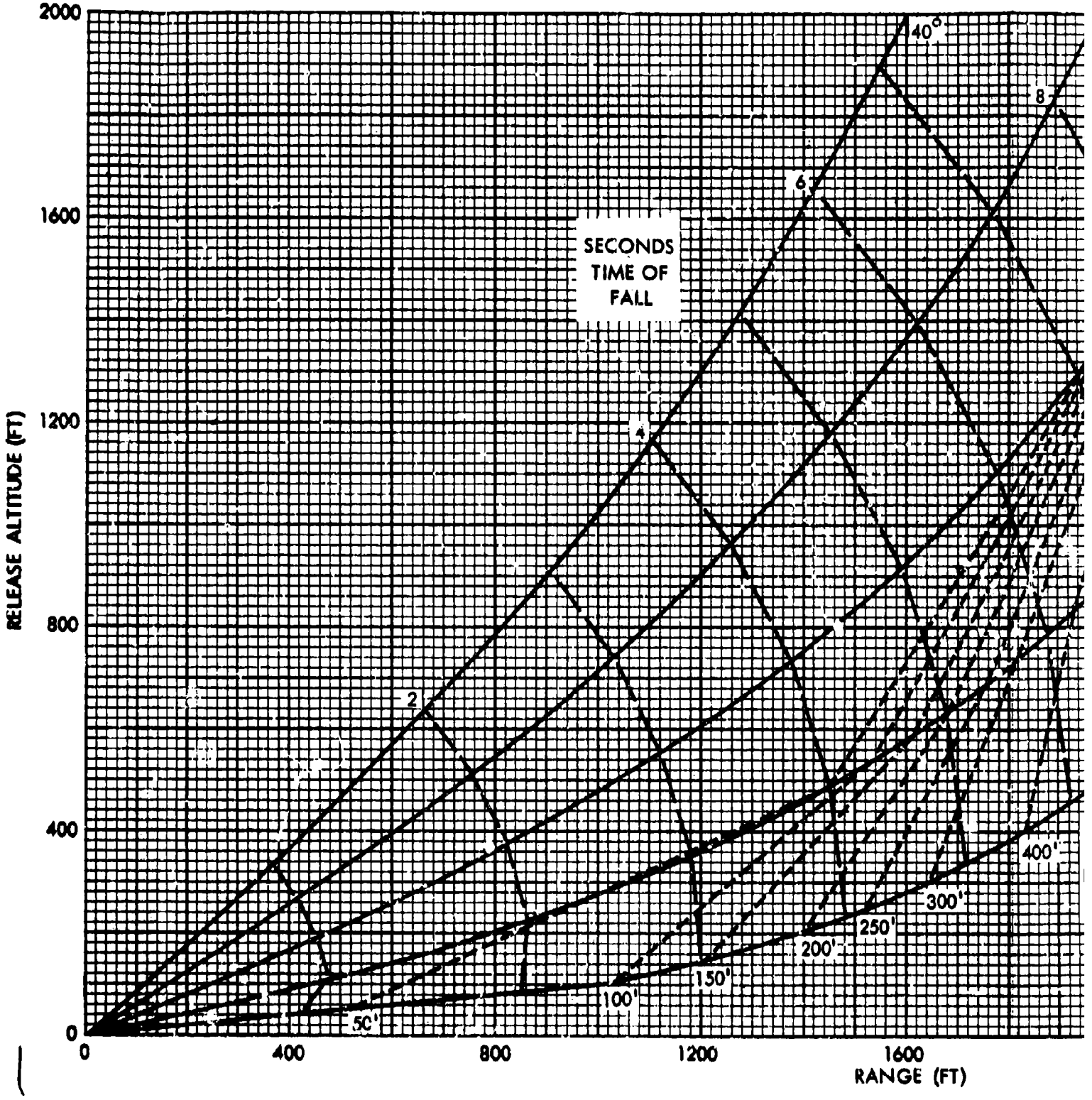


FIG. 56 MK 82/RETARDED EJ VEL 10 FPS

T)

2


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS
TIME OF
FALL
40°
8
6
4
2
400'
300'
250'
200'
150'
100'
50'

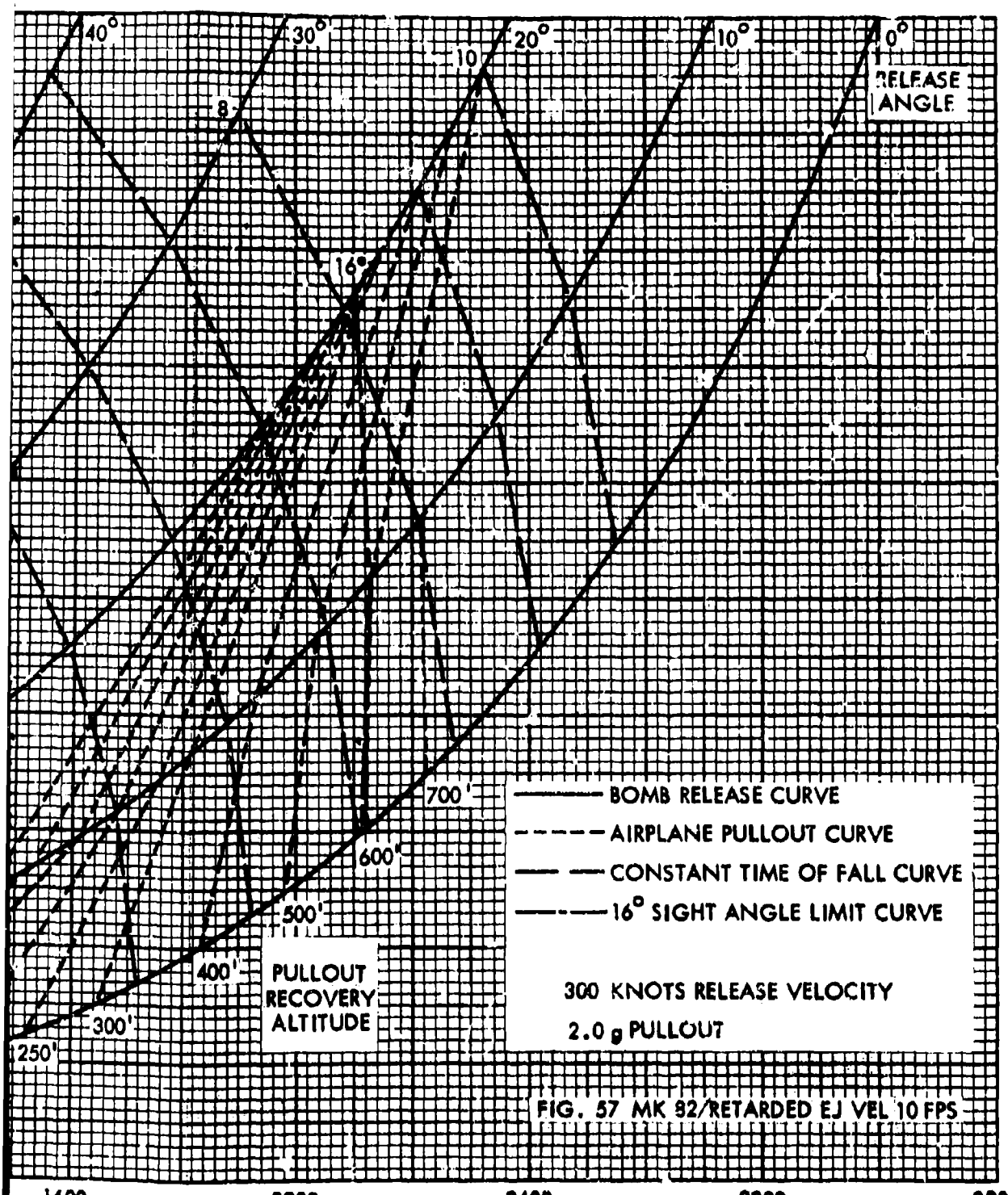
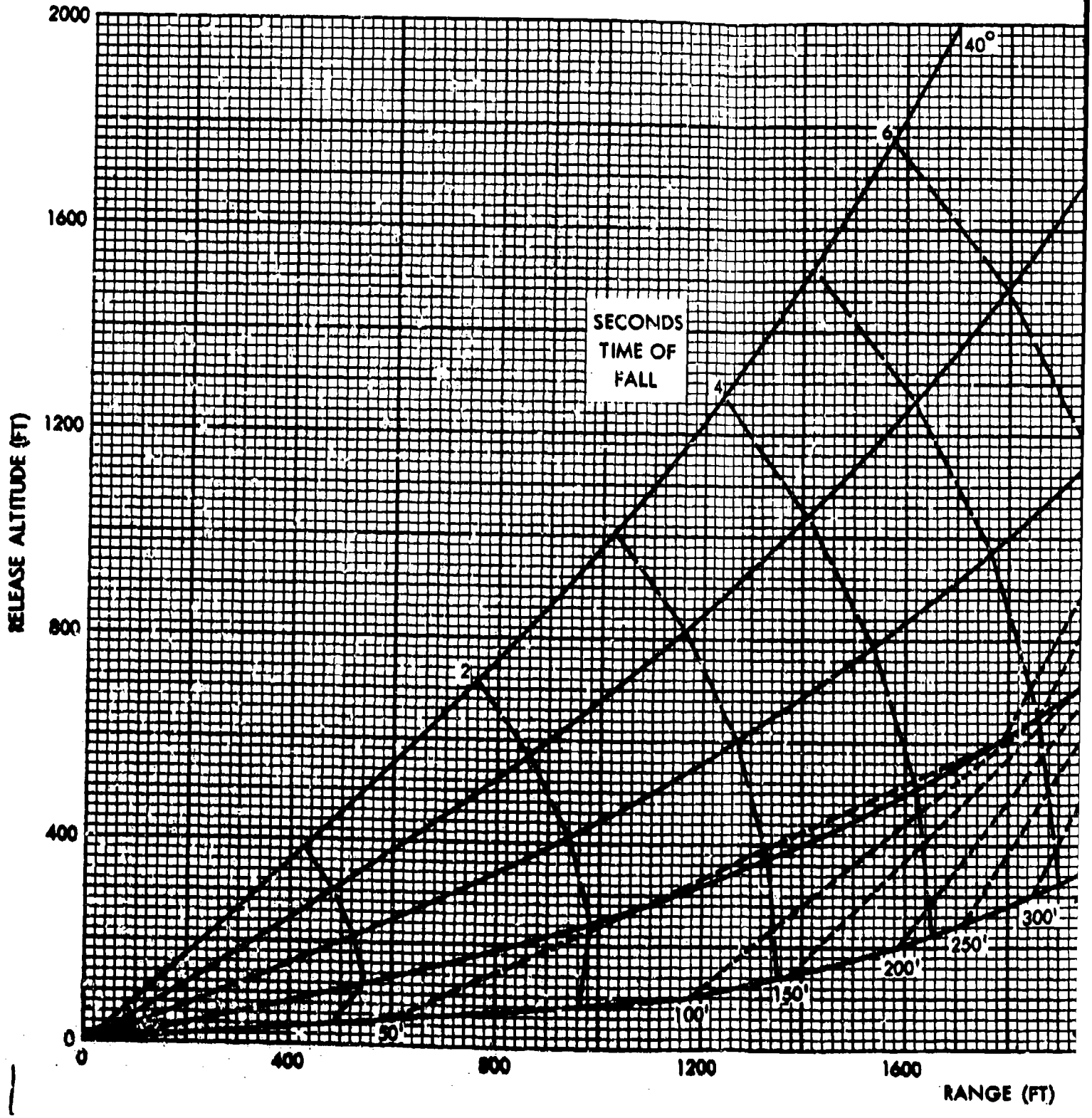


FIG. 57 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS
TIME OF
FALL
2
4
6
40°
50'
100'
150'
200'
250'
300'

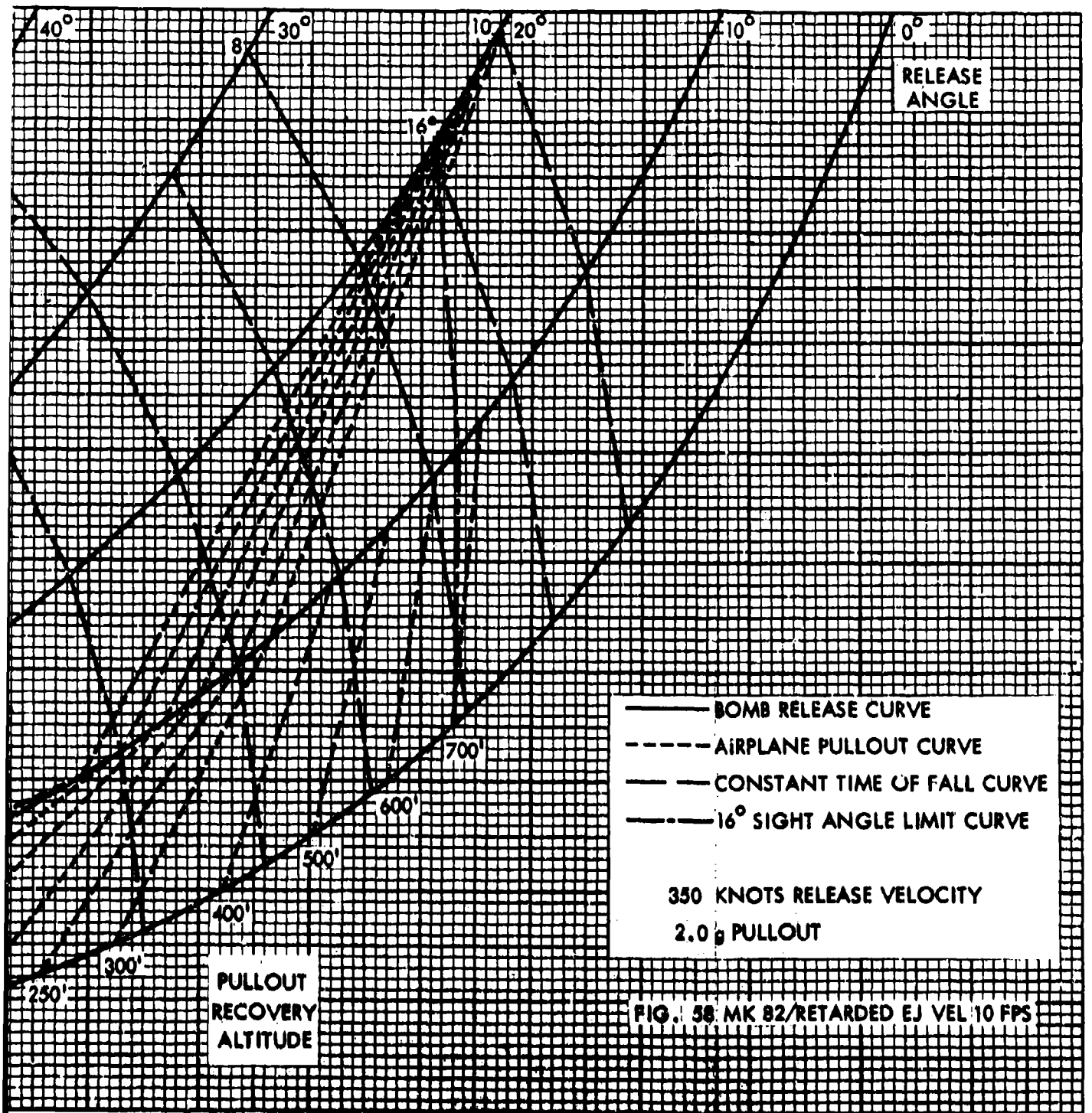
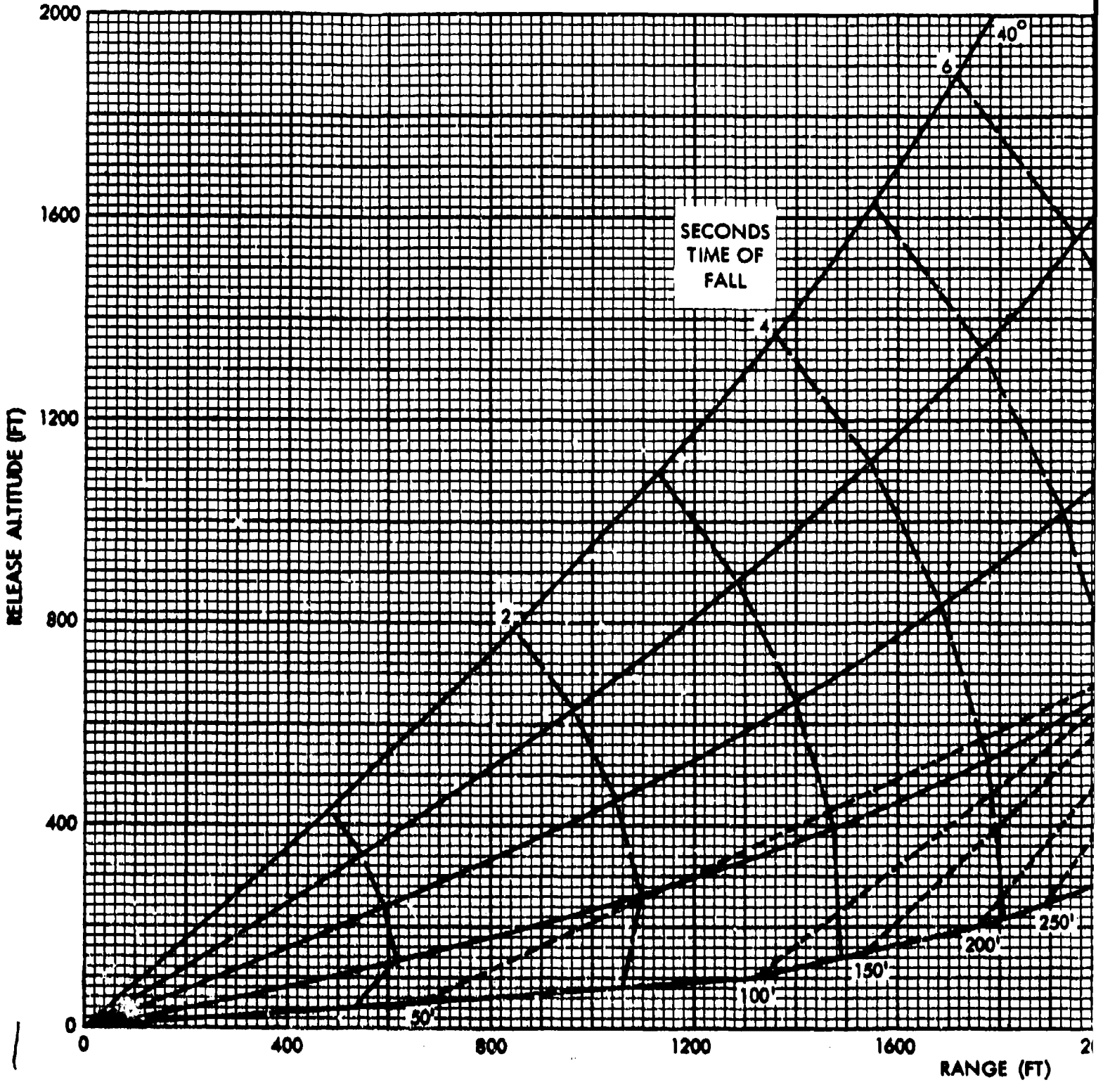


FIG. 58 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
40°
50'
100'
150'
200'
250'

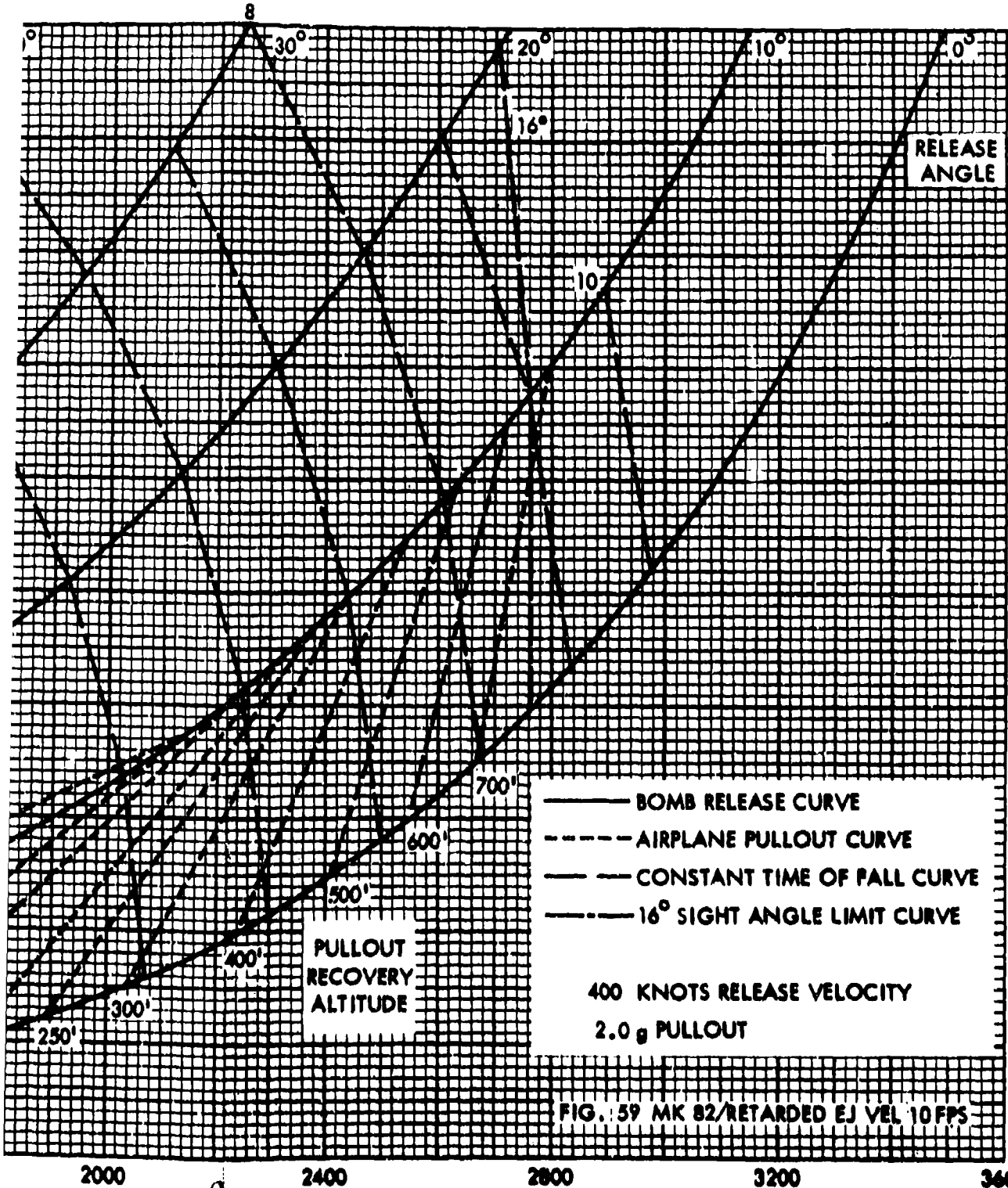
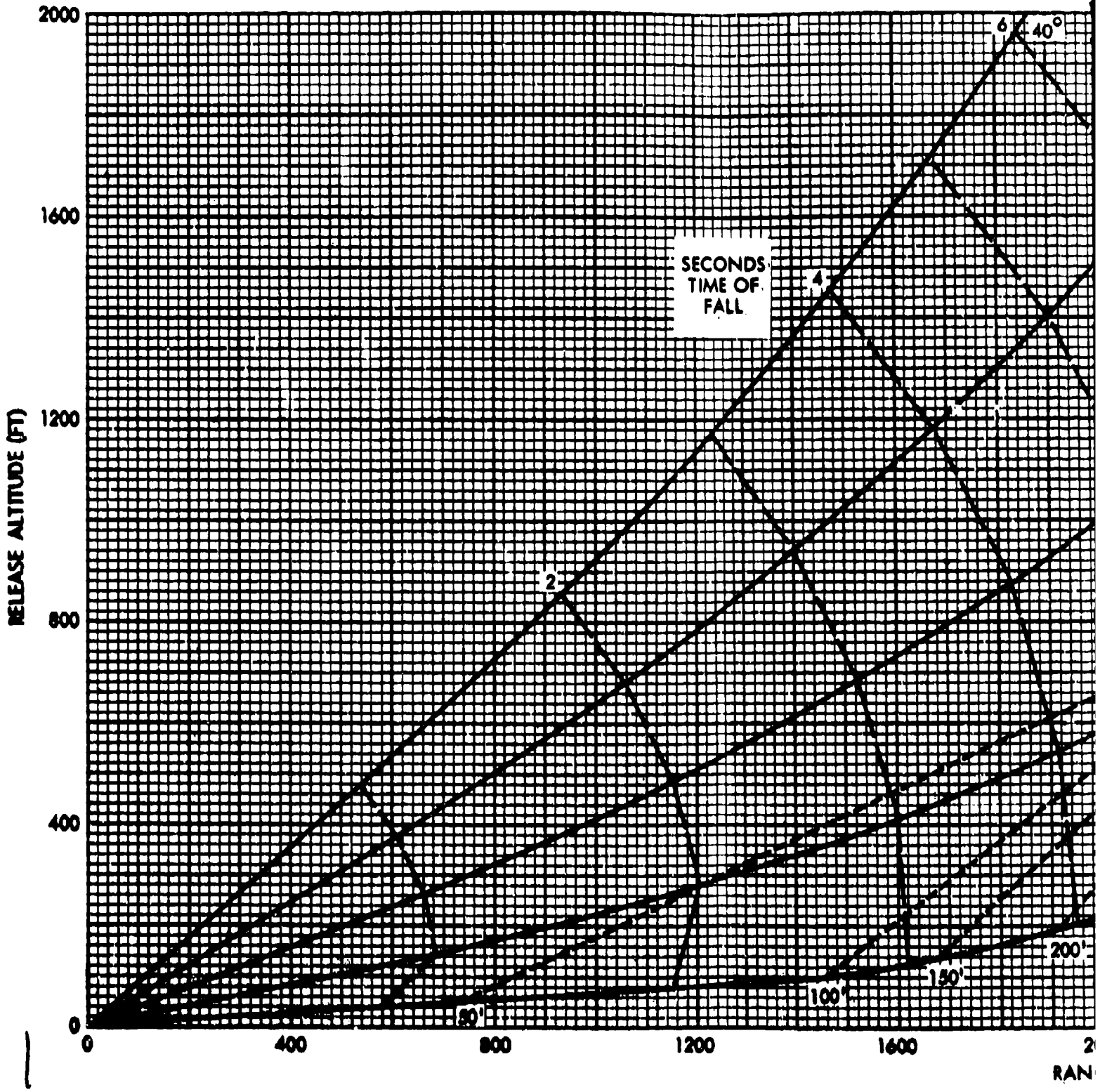


FIG. 59 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RAN
SECONDS TIME OF FALL
2
4
6
40°
80'
100'
150'
200'

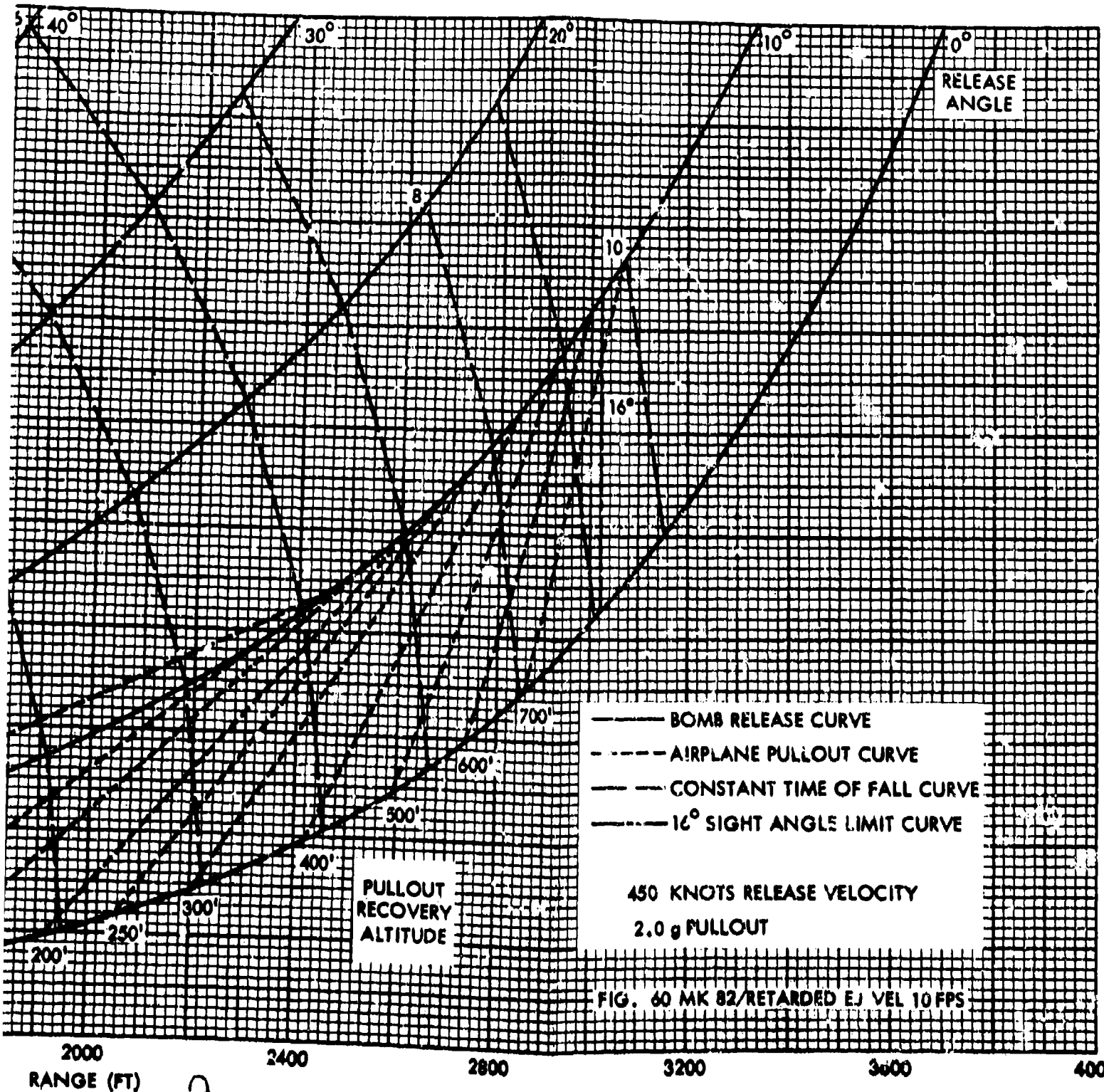
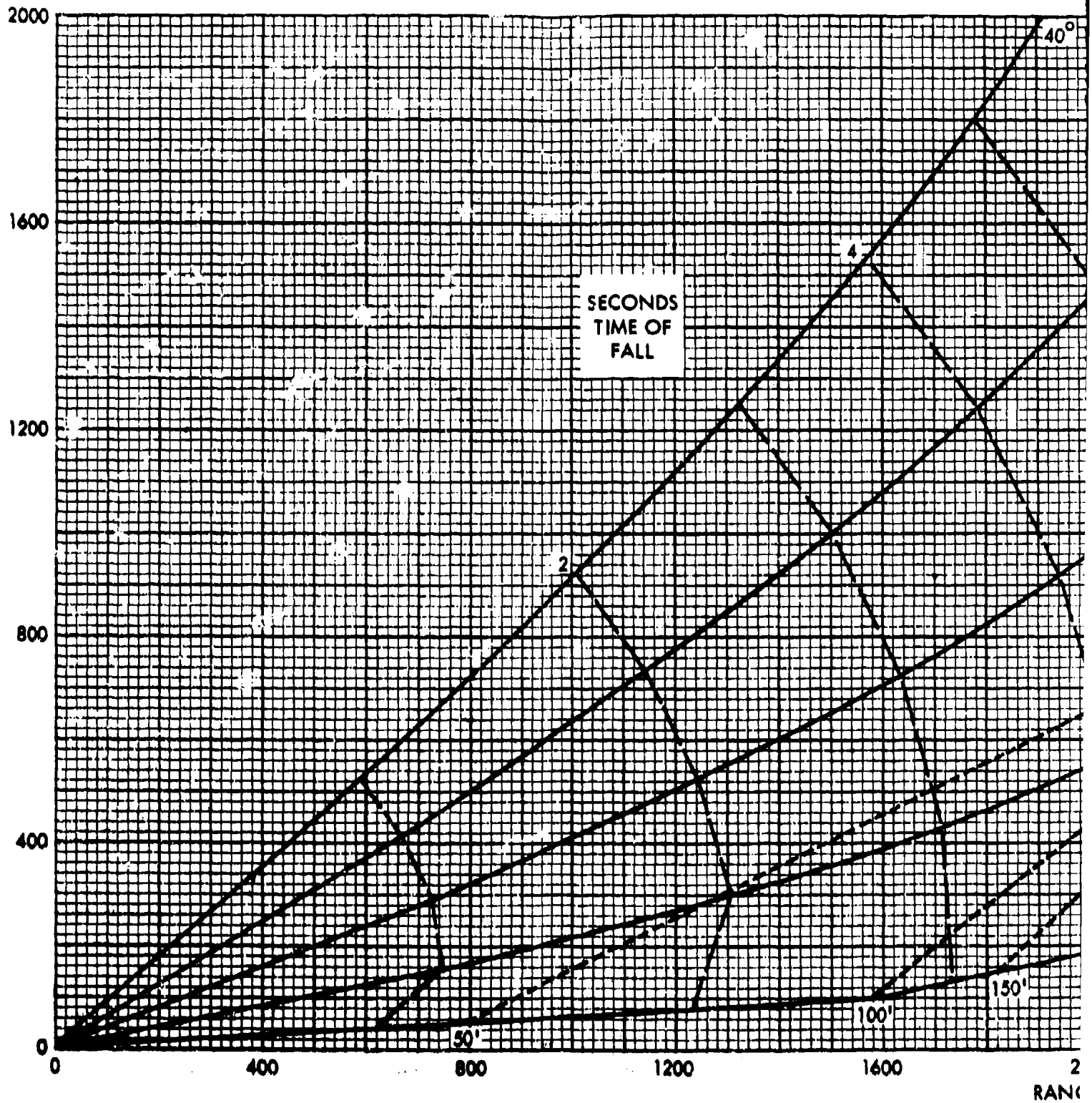


FIG. 60 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
2
RANG
SECONDS
TIME OF
FALL
40°
4
2
150'
100'
50'

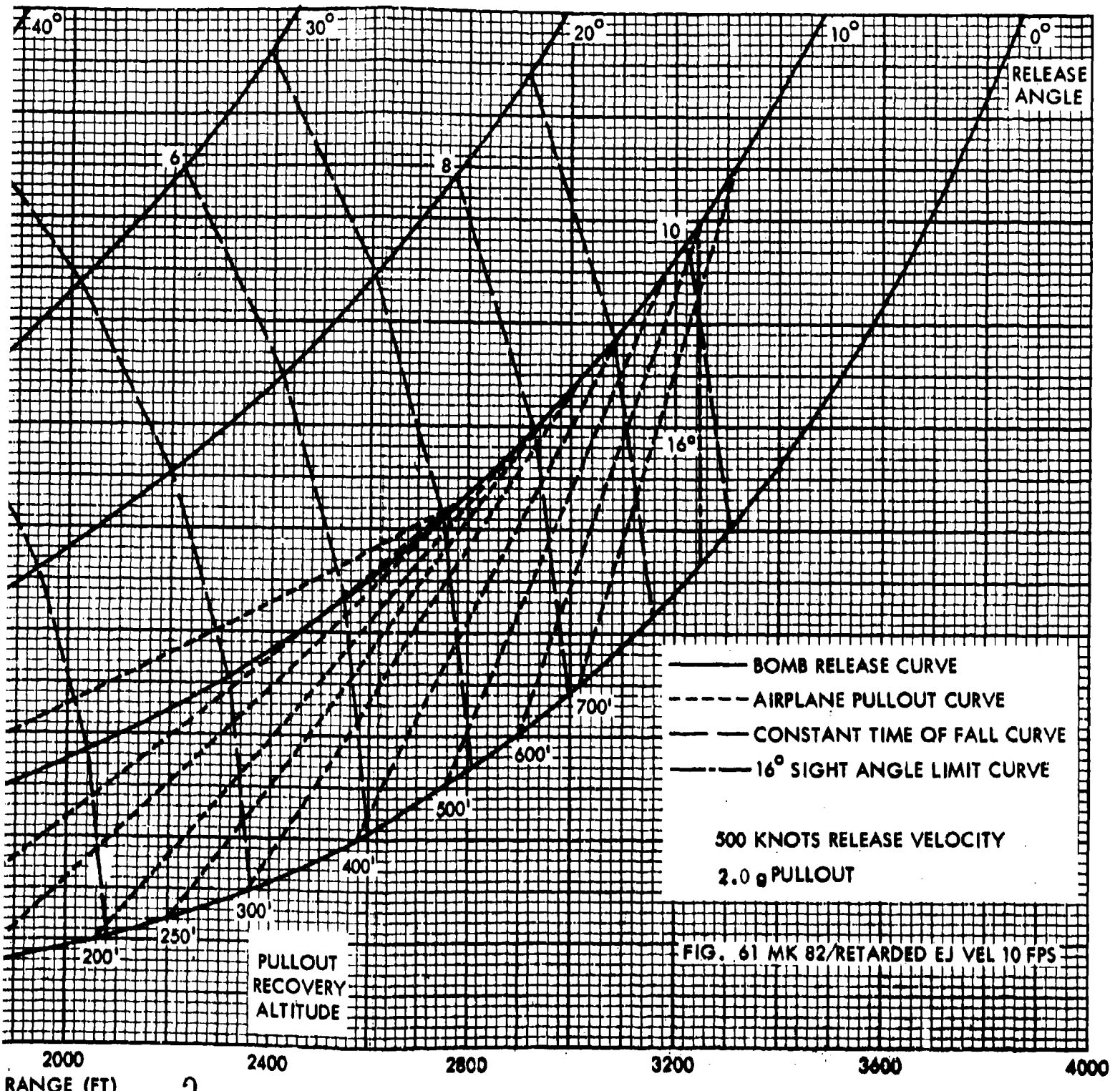
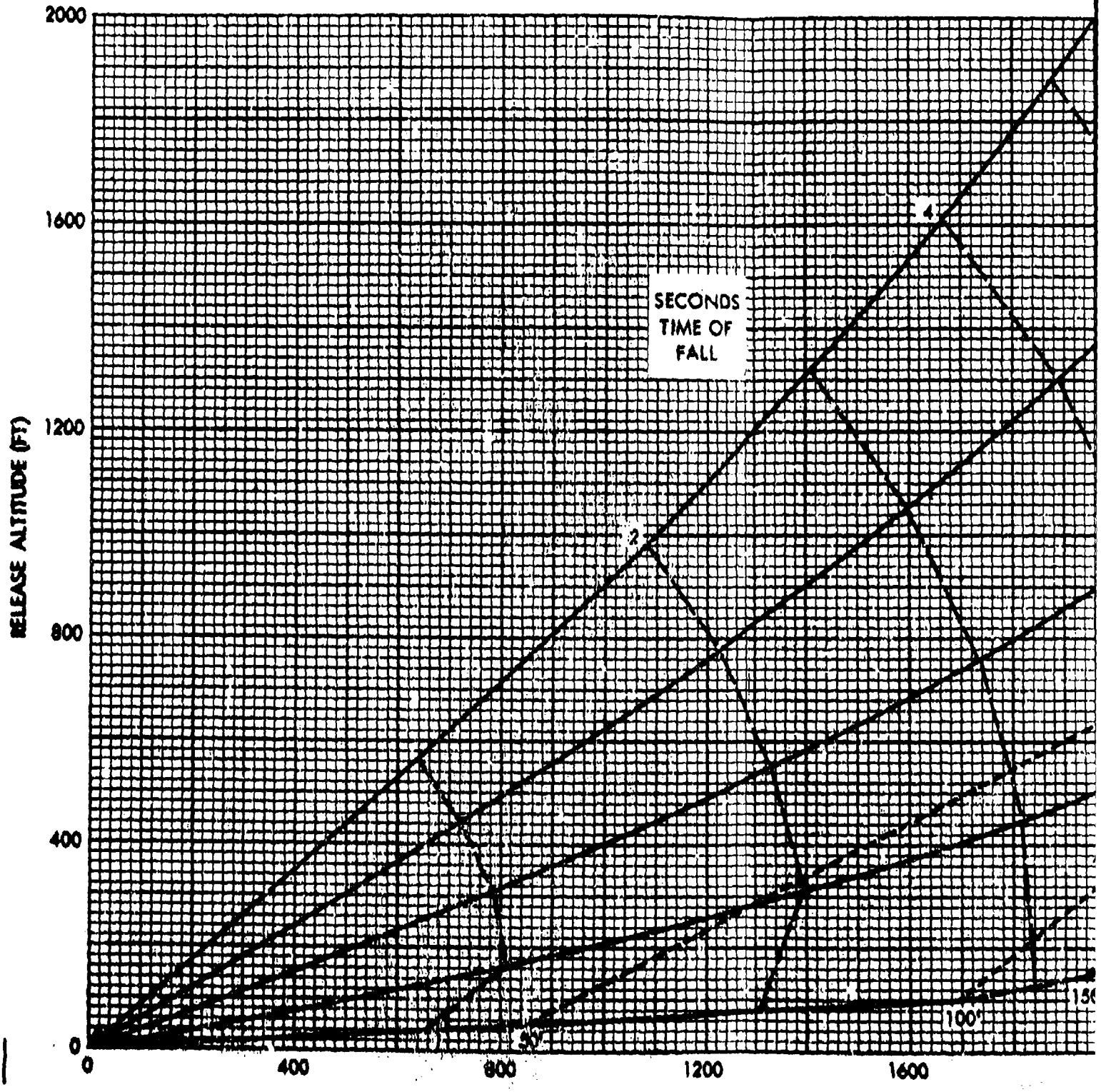


FIG. 61 MK 82/RETARDED EJ VEL 10 FPS

2


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
SECONDS
TIME OF
FALL
4
2
100'
0
400
800
1200
1600

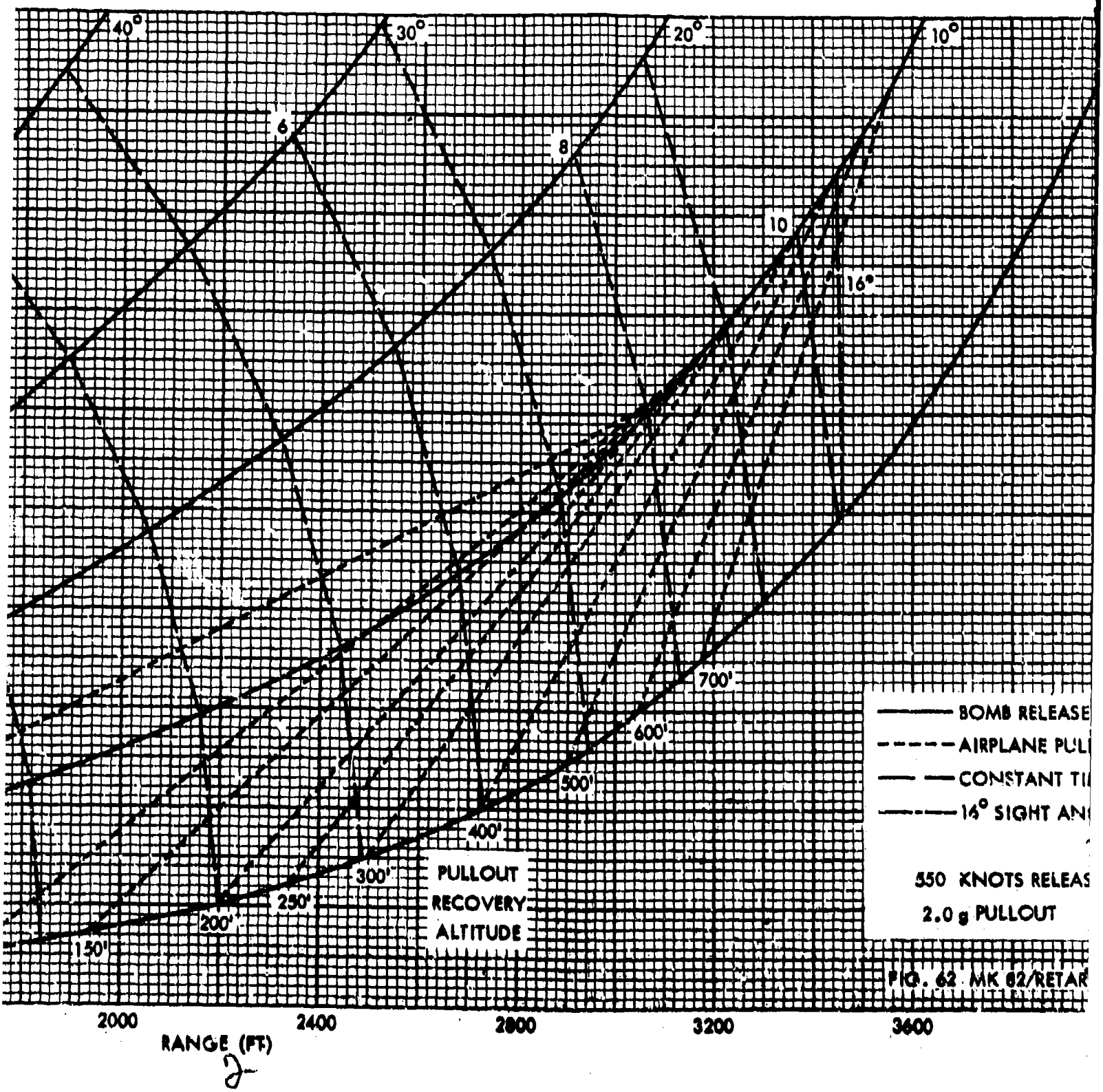


FIG. 62 MK 82/RETAR

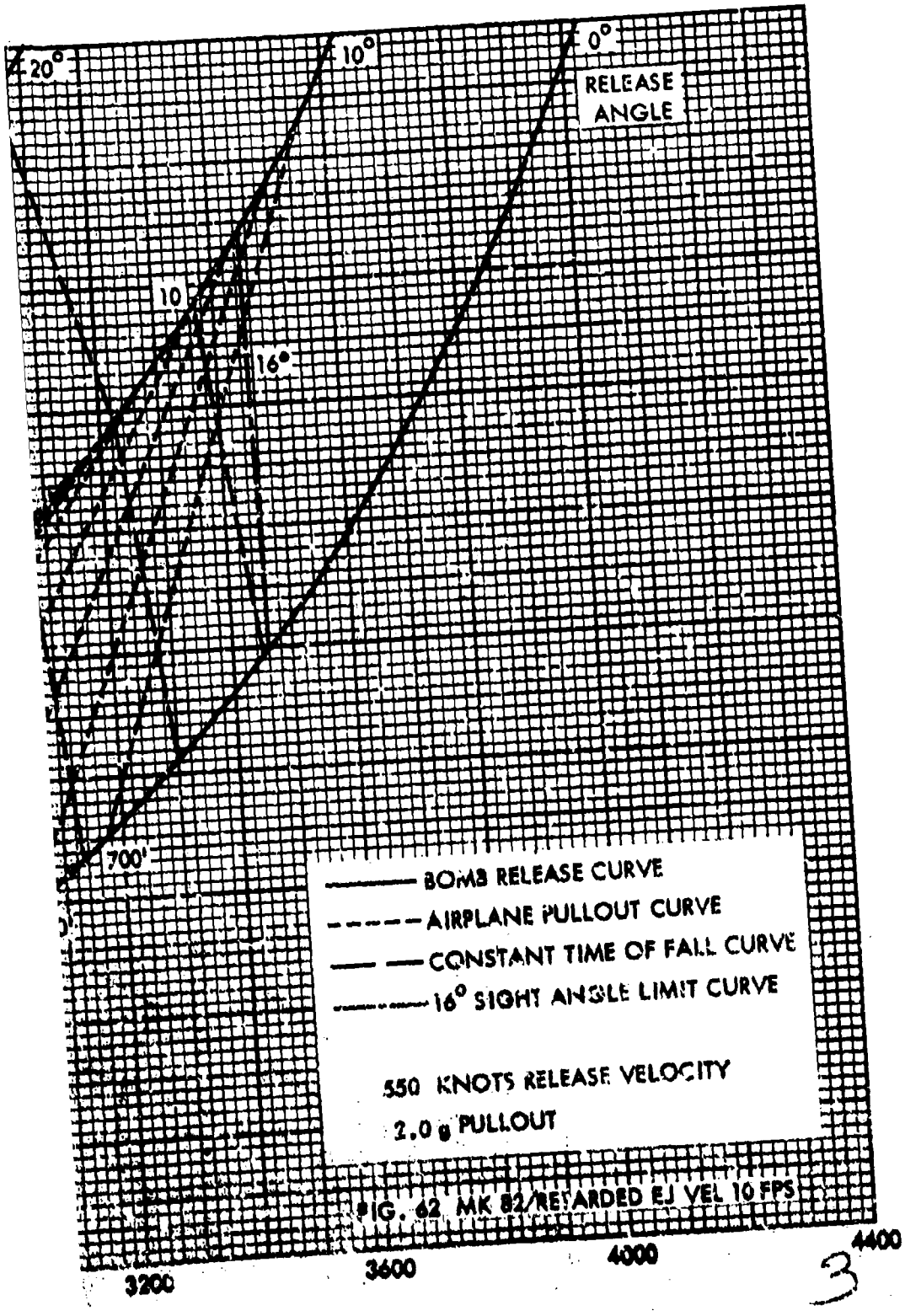
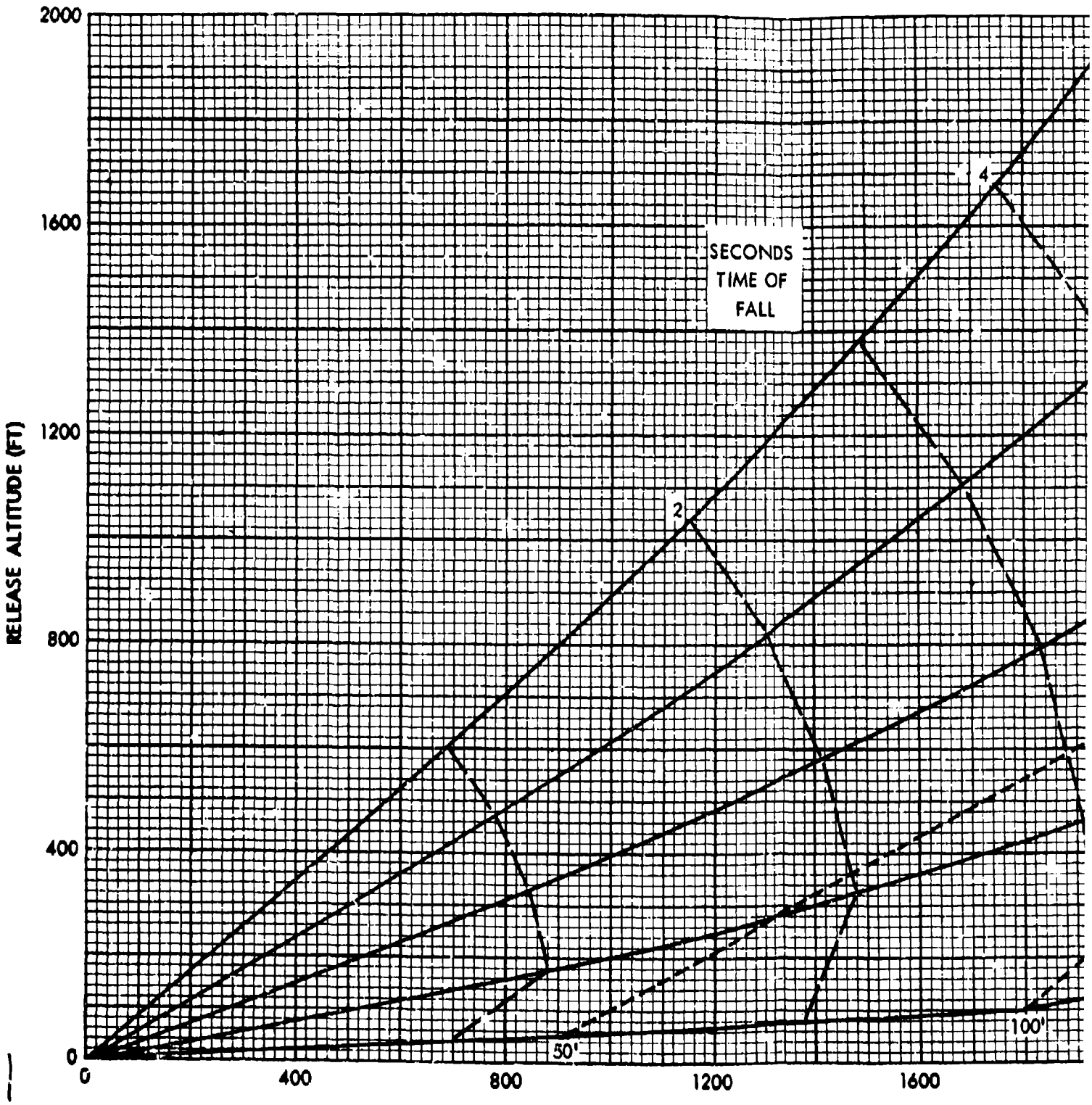


FIG. 62 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
SECONDS
TIME OF
FALL
4
2
50'
100'

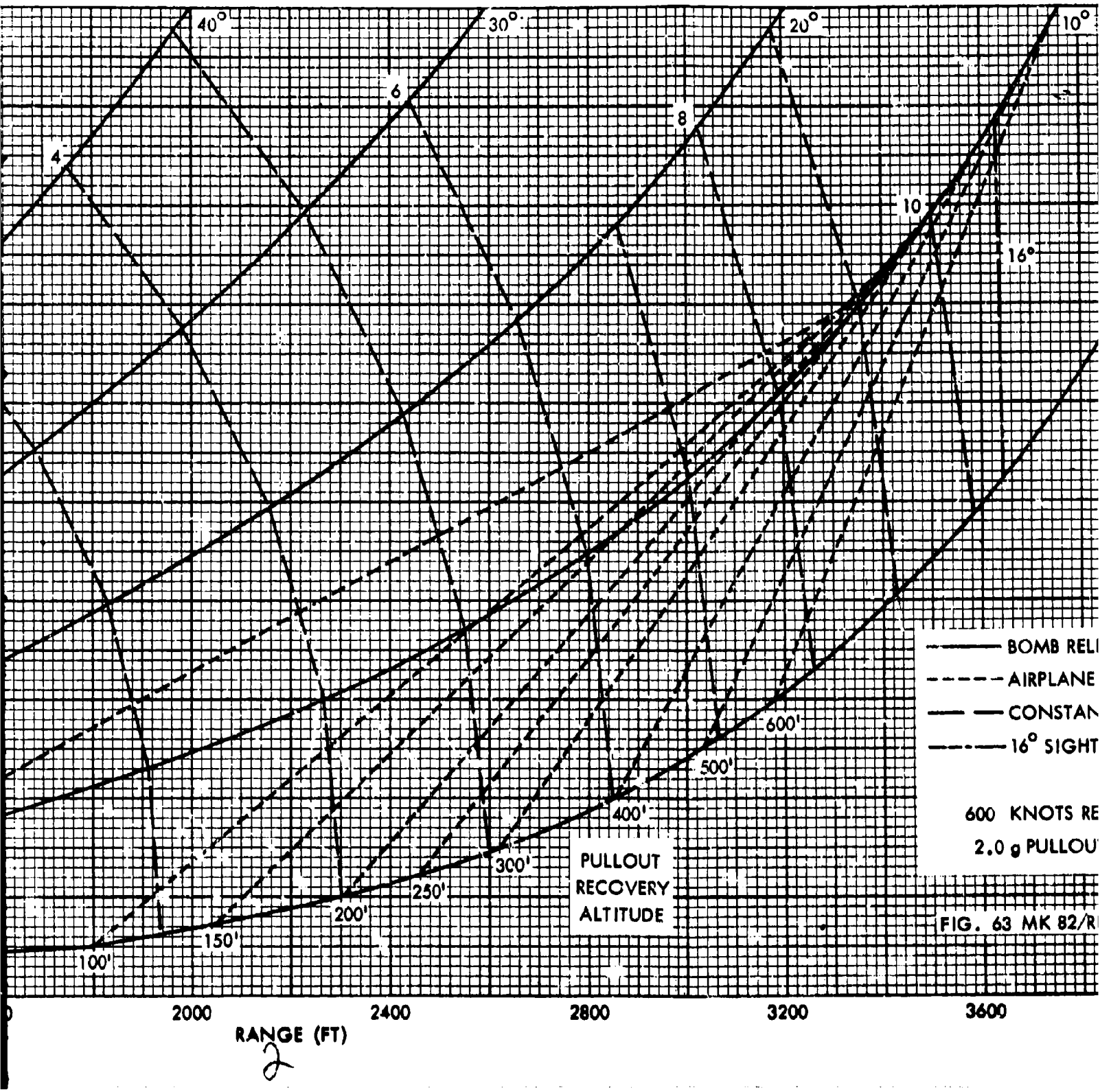

40°
30°
20°
10°
6
8
4
10
16°
600'
500'
400'
300'
250'
200'
150'
100'
PULLOUT
RECOVERY
ALTITUDE
BOMB RELI
AIRPLANE
CONSTAN
16° SIGHT
600 KNOTS RE
2.0 g PULLOU
2000
2400
2800
3200
3600
RANGE (FT)

FIG. 63 MK 82/R

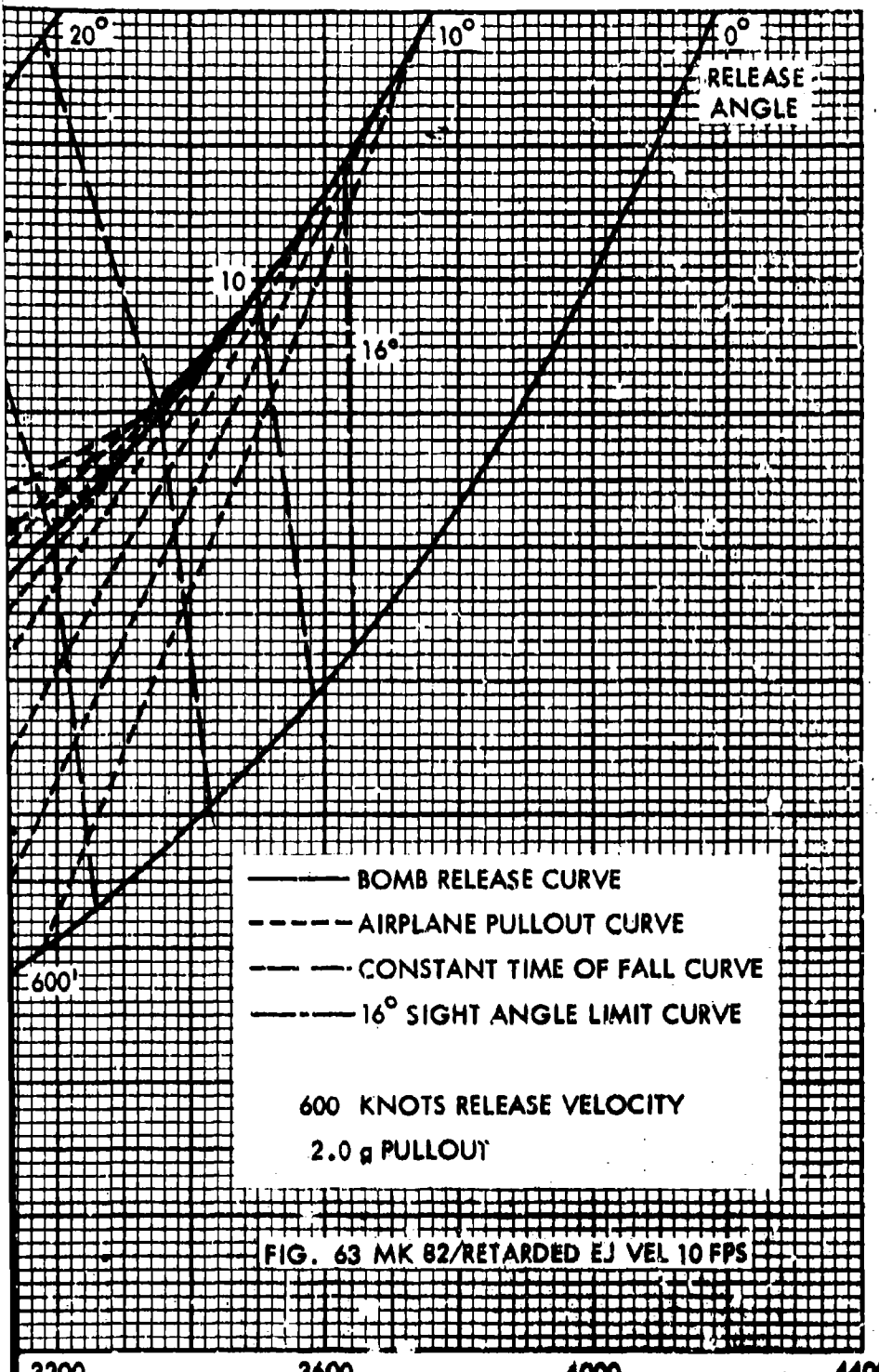
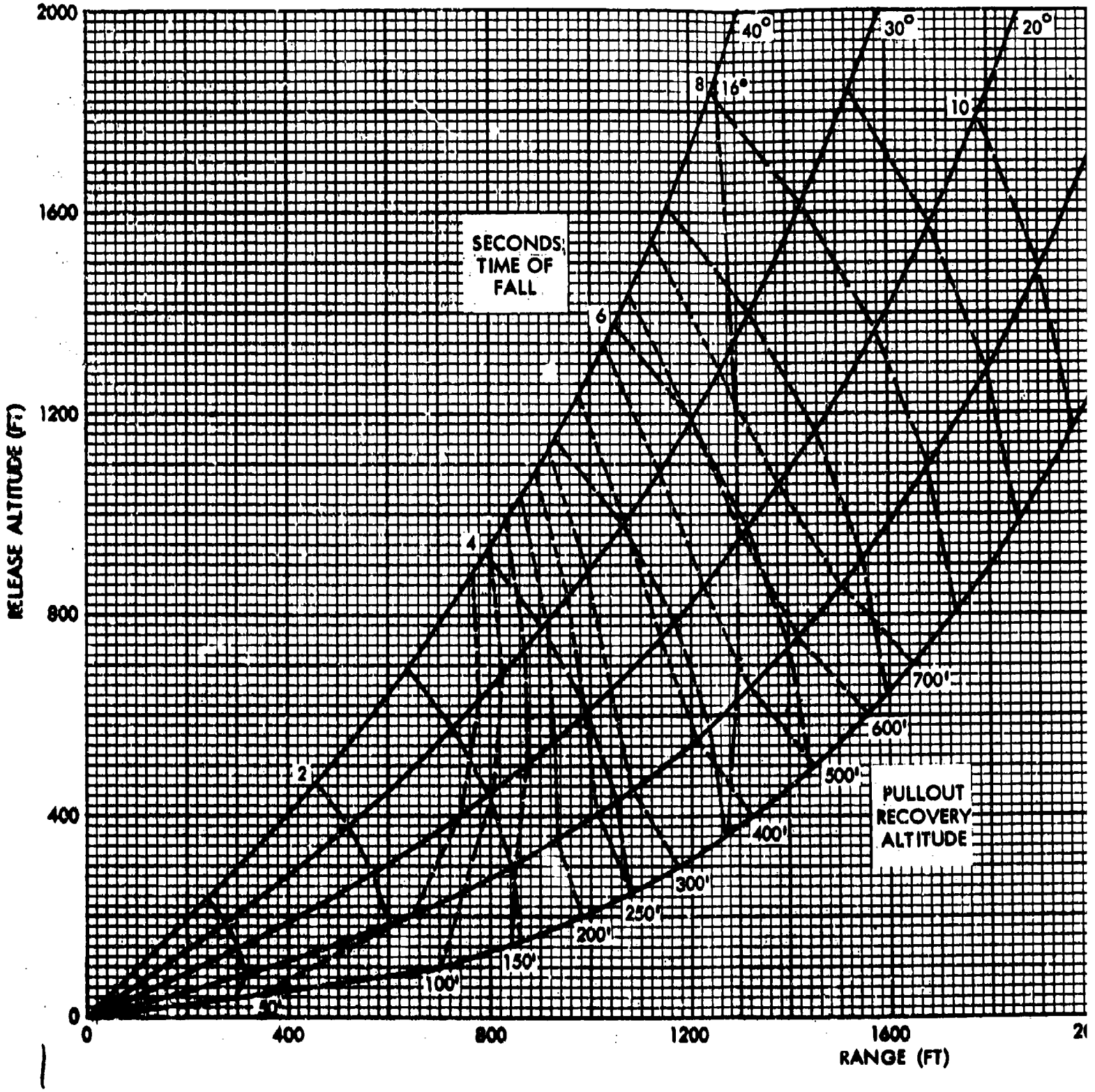


FIG. 63 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
40°
30°
20°
16°
10
8
6
4
2
SECONDS TIME OF FALL
700'
600'
500'
400'
300'
250'
200'
150'
100'
50'
PULLOUT RECOVERY ALTITUDE

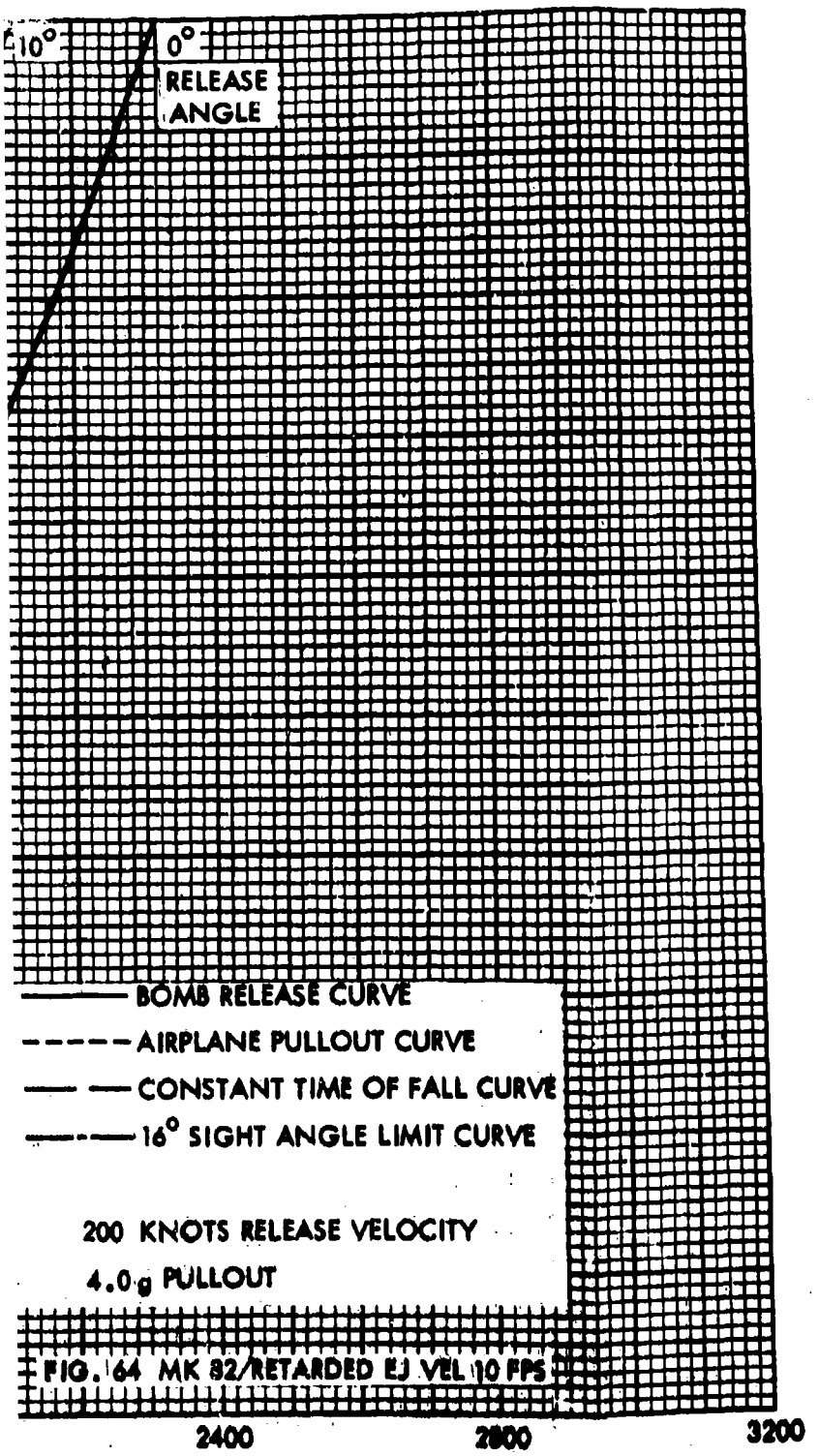
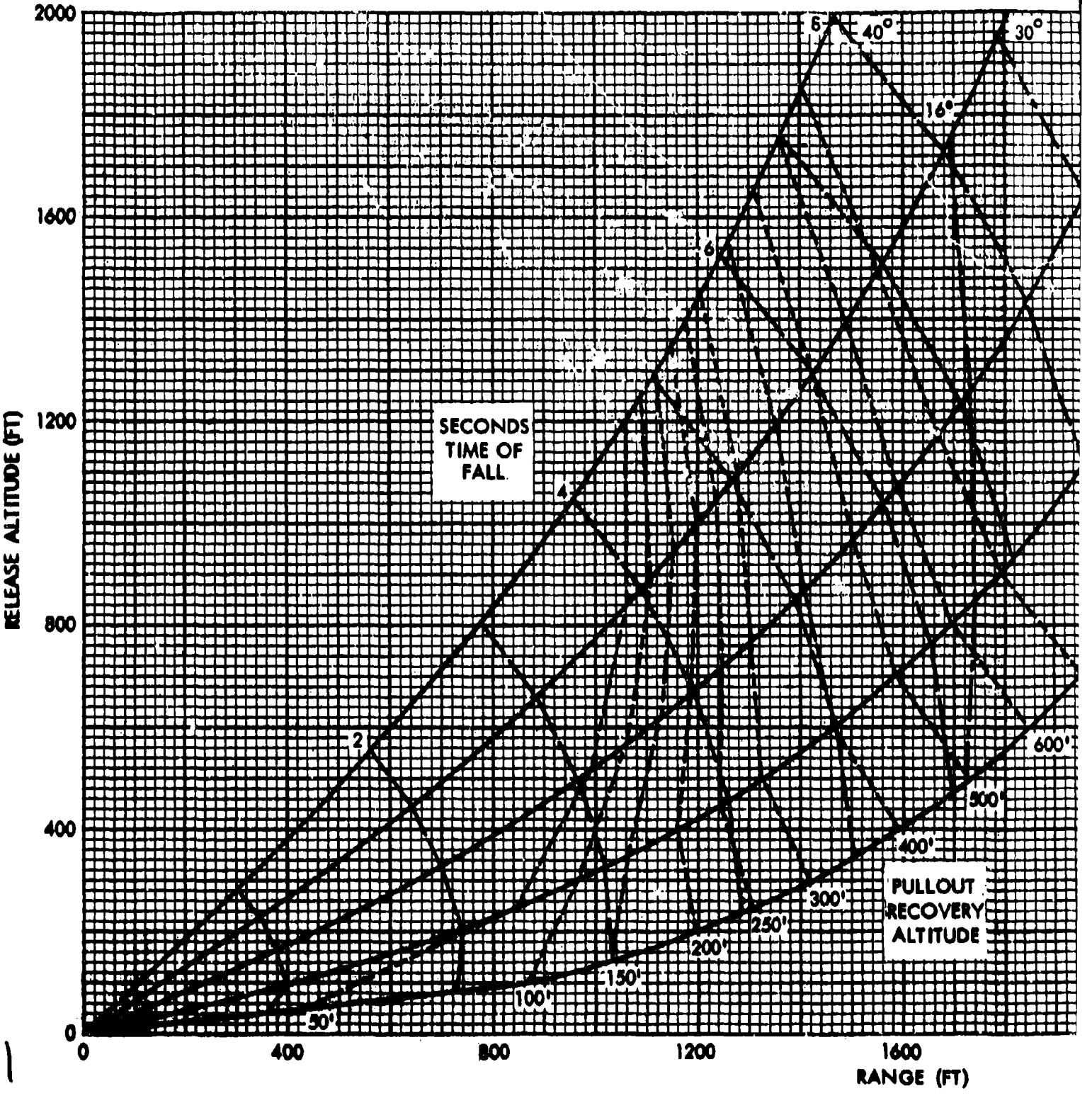


FIG. 64 MK 82/RETARDED EJ VEL 10 FPS

2


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
6
4
2
40°
30°
16°
6
600'
500'
400'
300'
250'
200'
150'
100'
50'
PULLOUT RECOVERY ALTITUDE

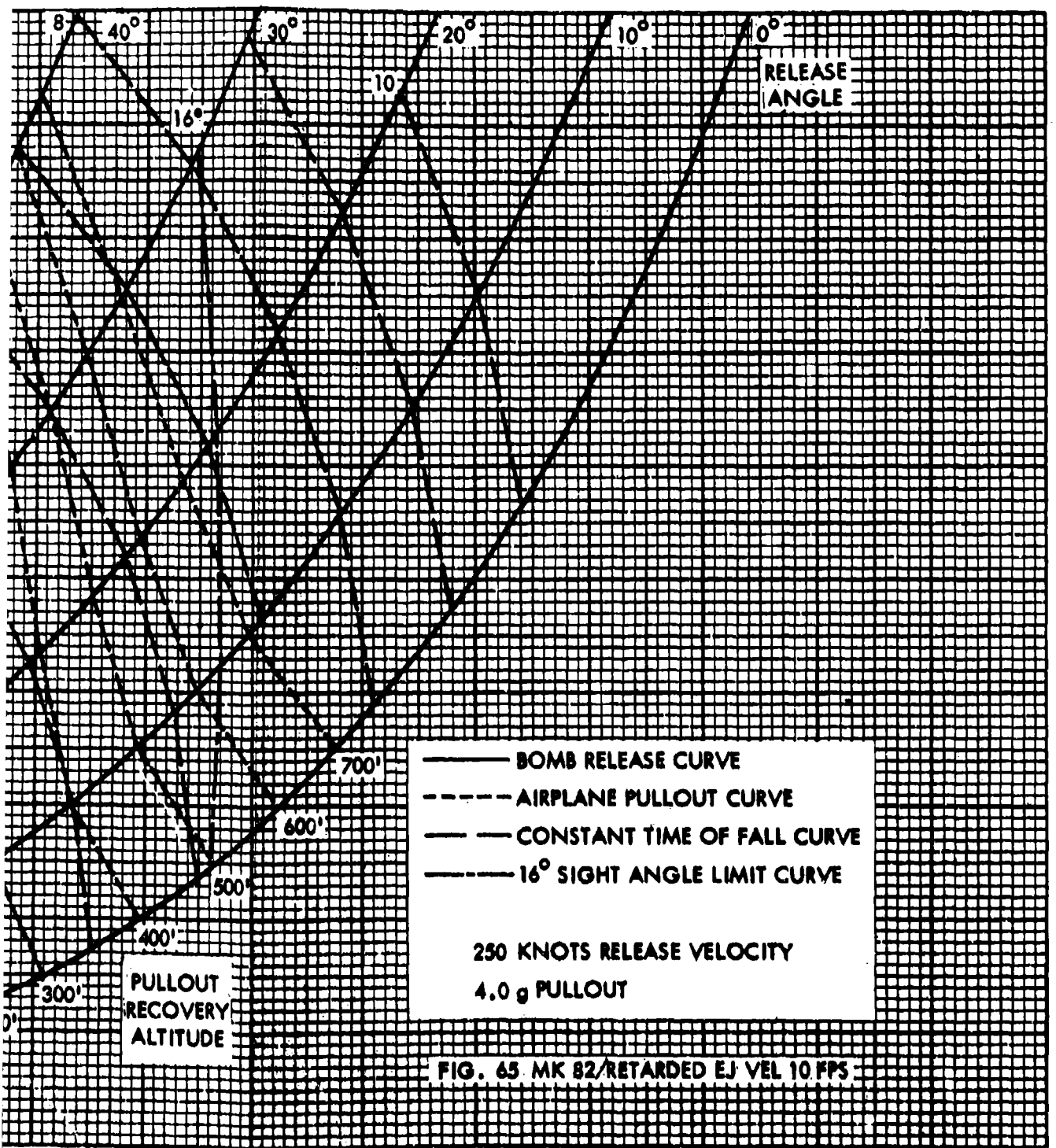
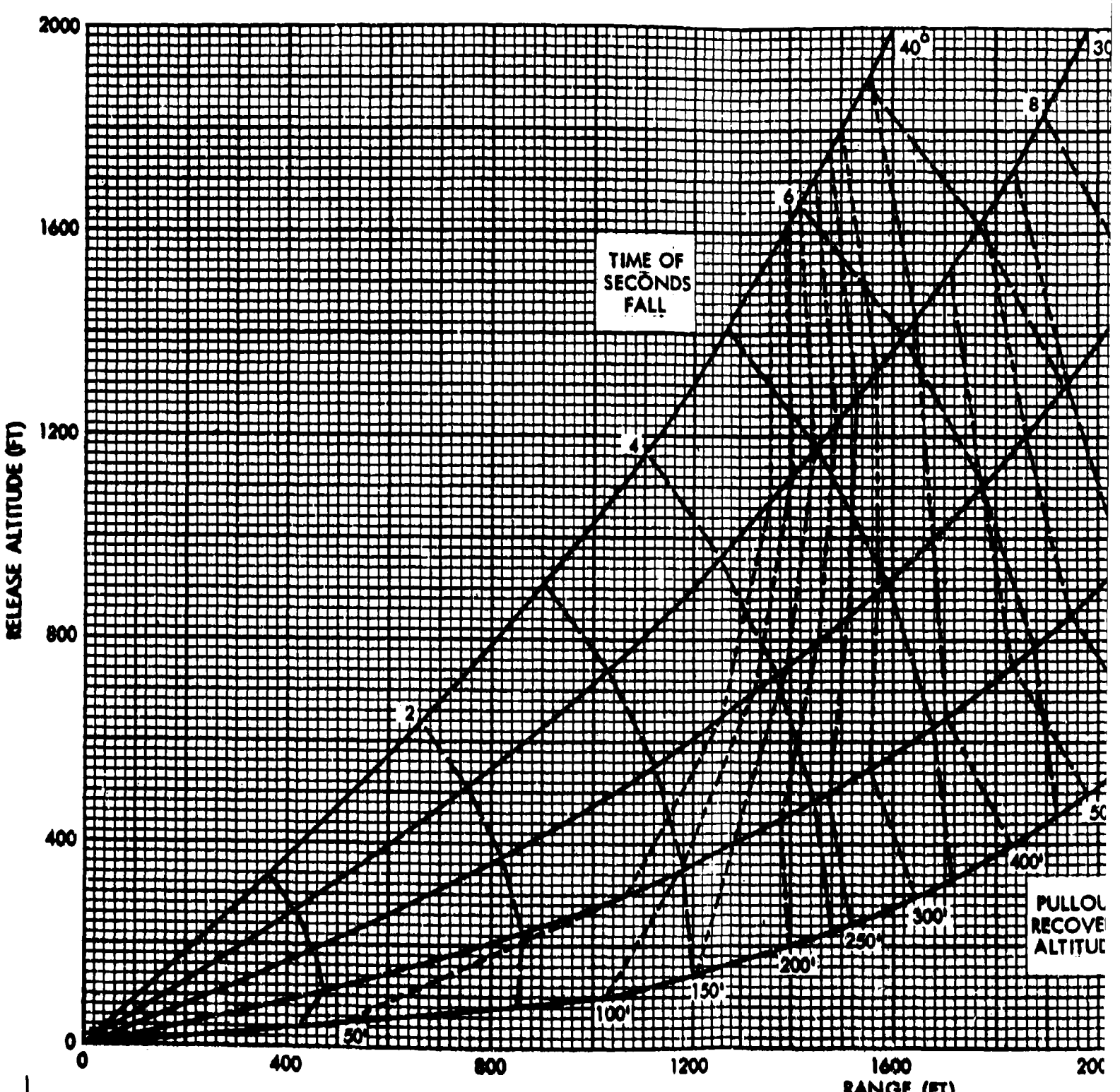


FIG. 65 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
TIME OF SECONDS FALL
40°
8
6
4
2
50'
100'
150'
200'
250'
300'
400'
PULLOU
RECOVE
ALTITUD

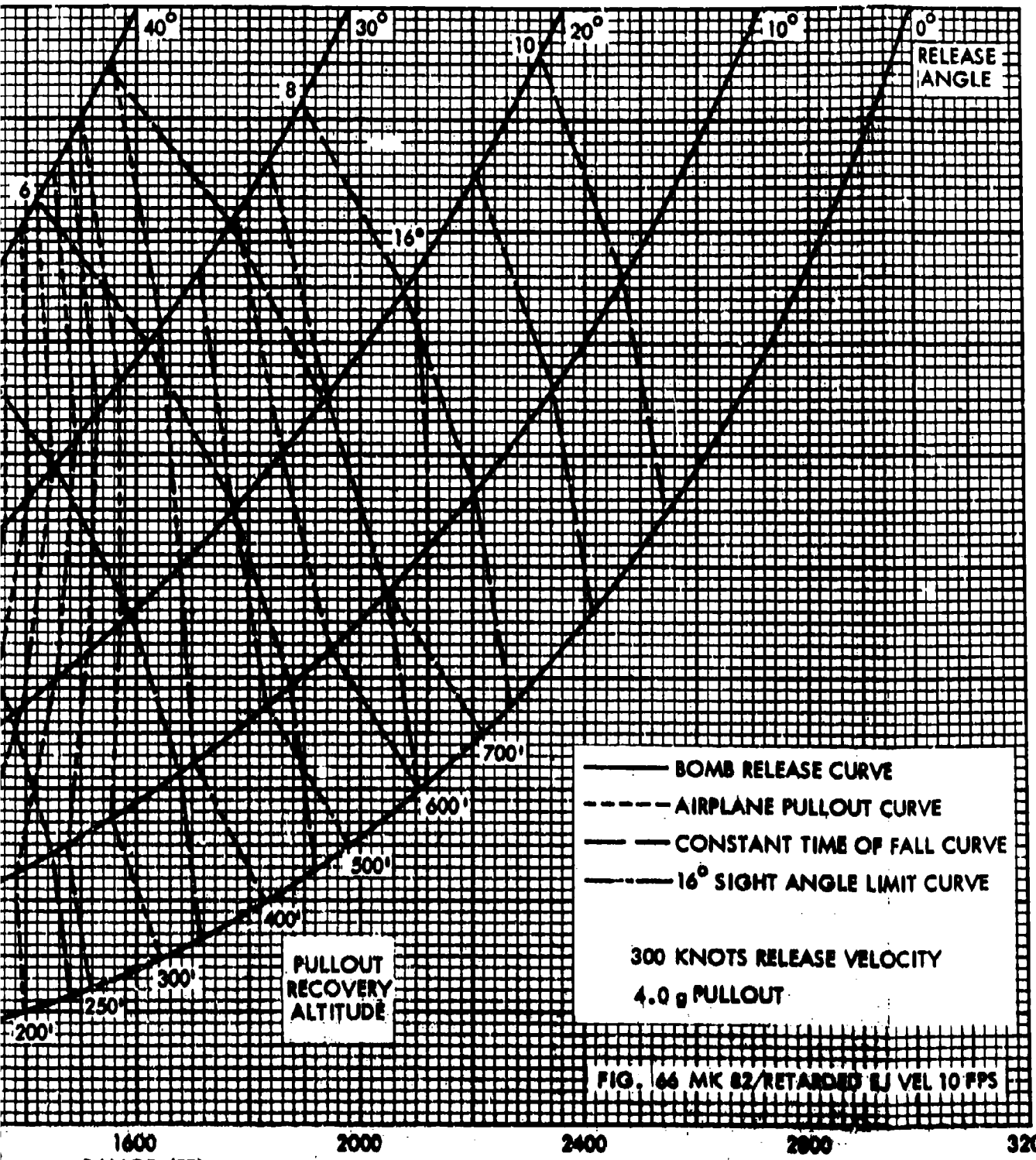
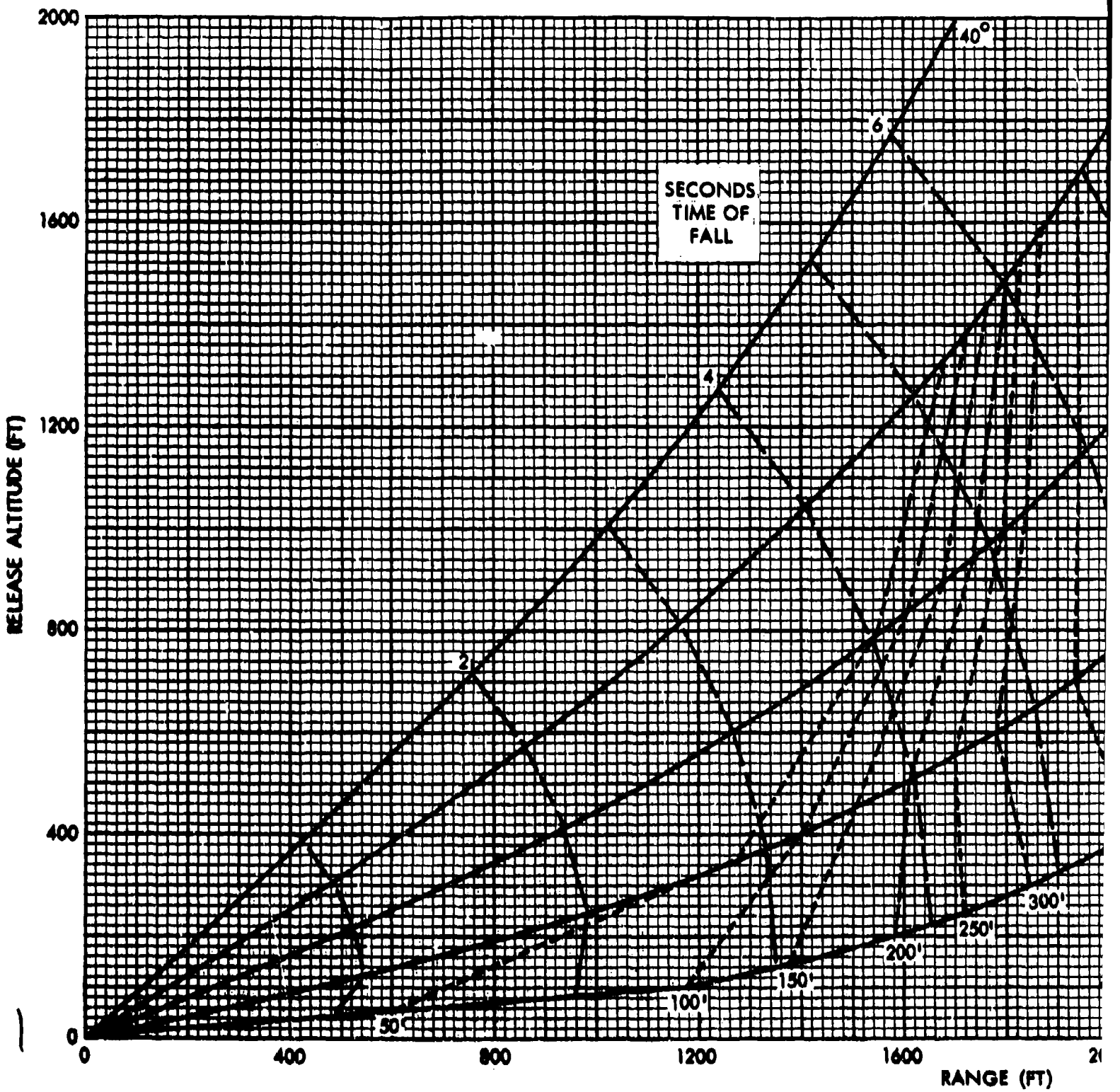


FIG. 66 MK 82/RETARDED EJ VEL 10 FPS

2


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
40°
50°
100'
150'
200'
250'
300'

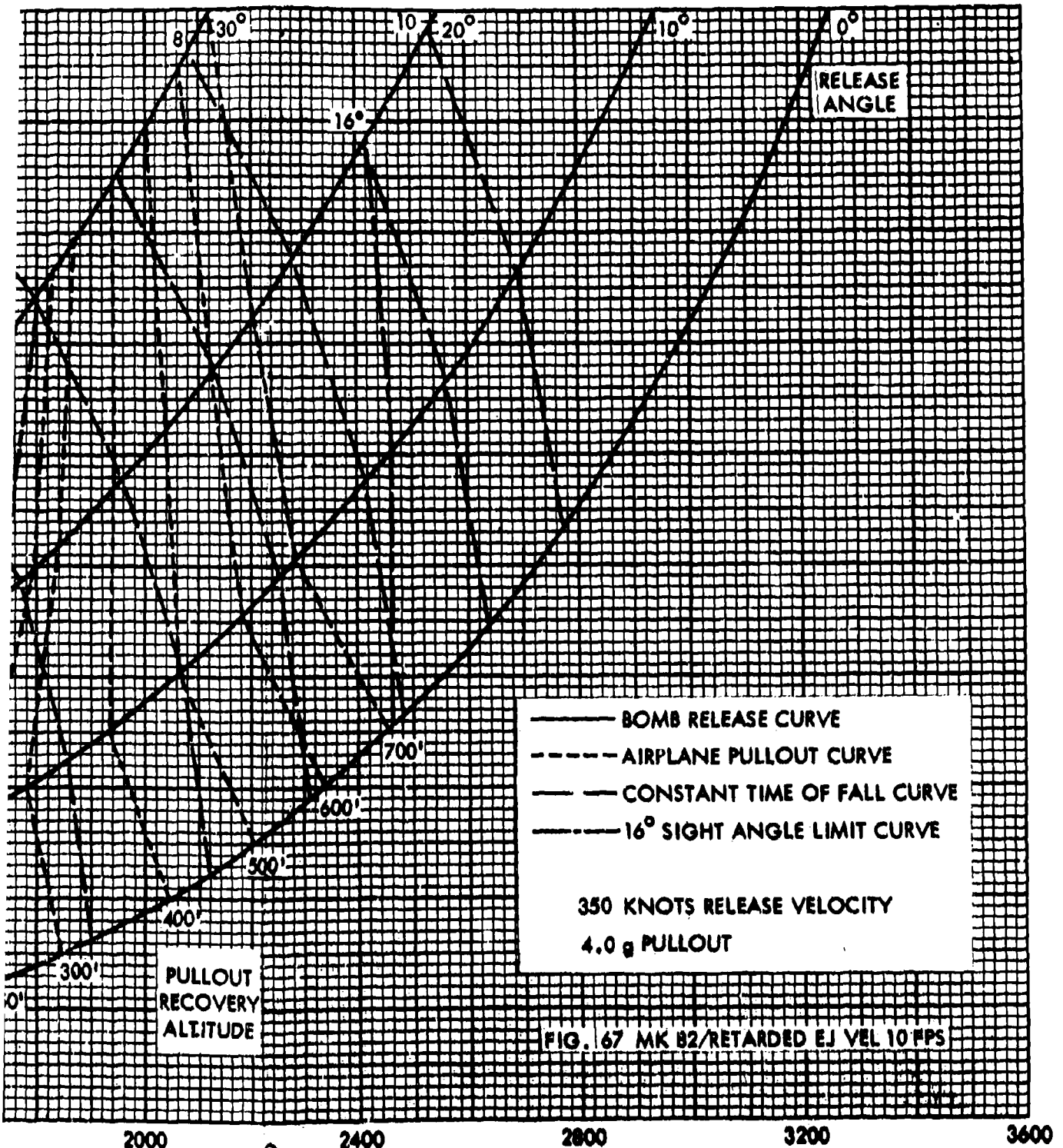
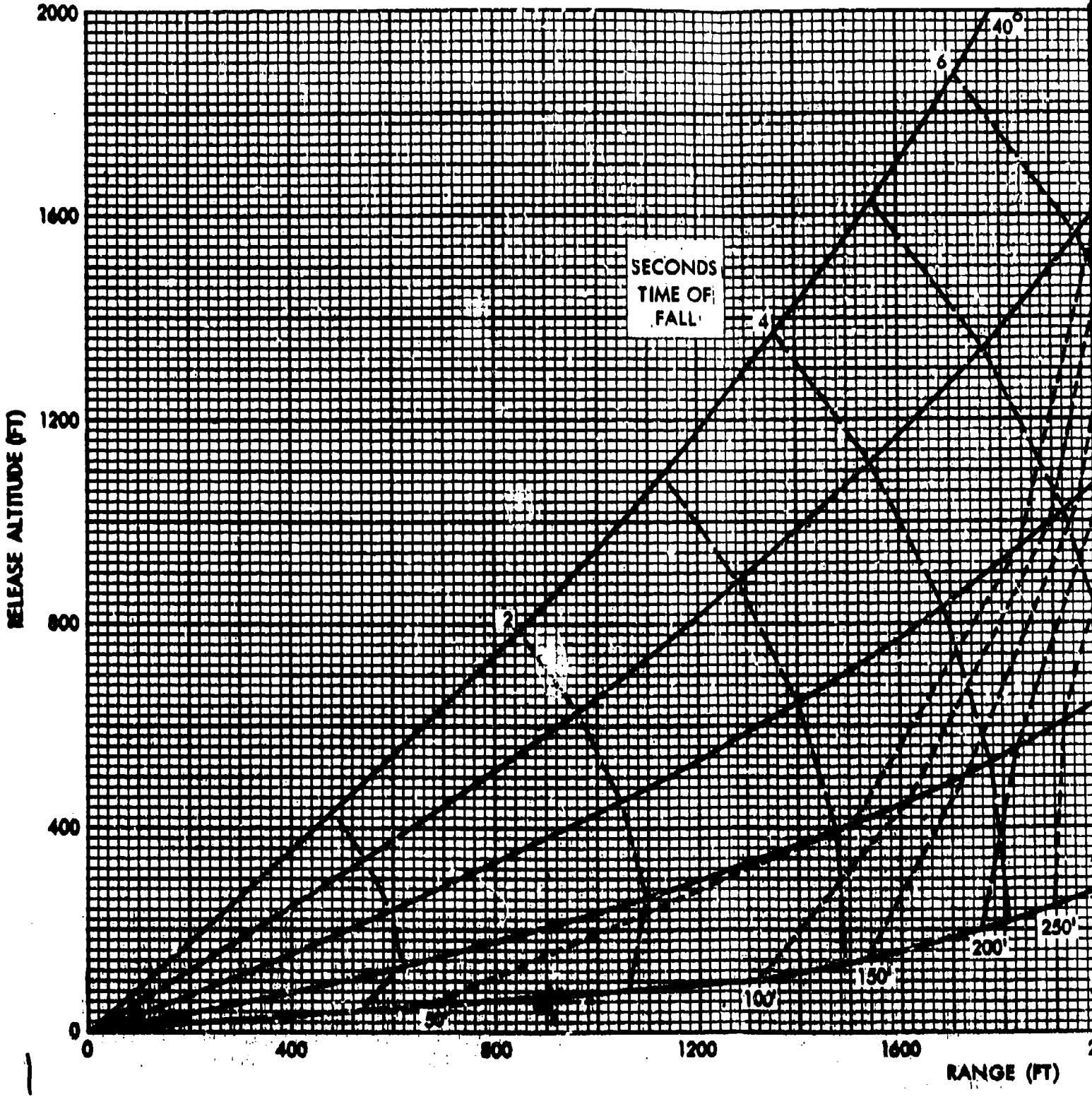
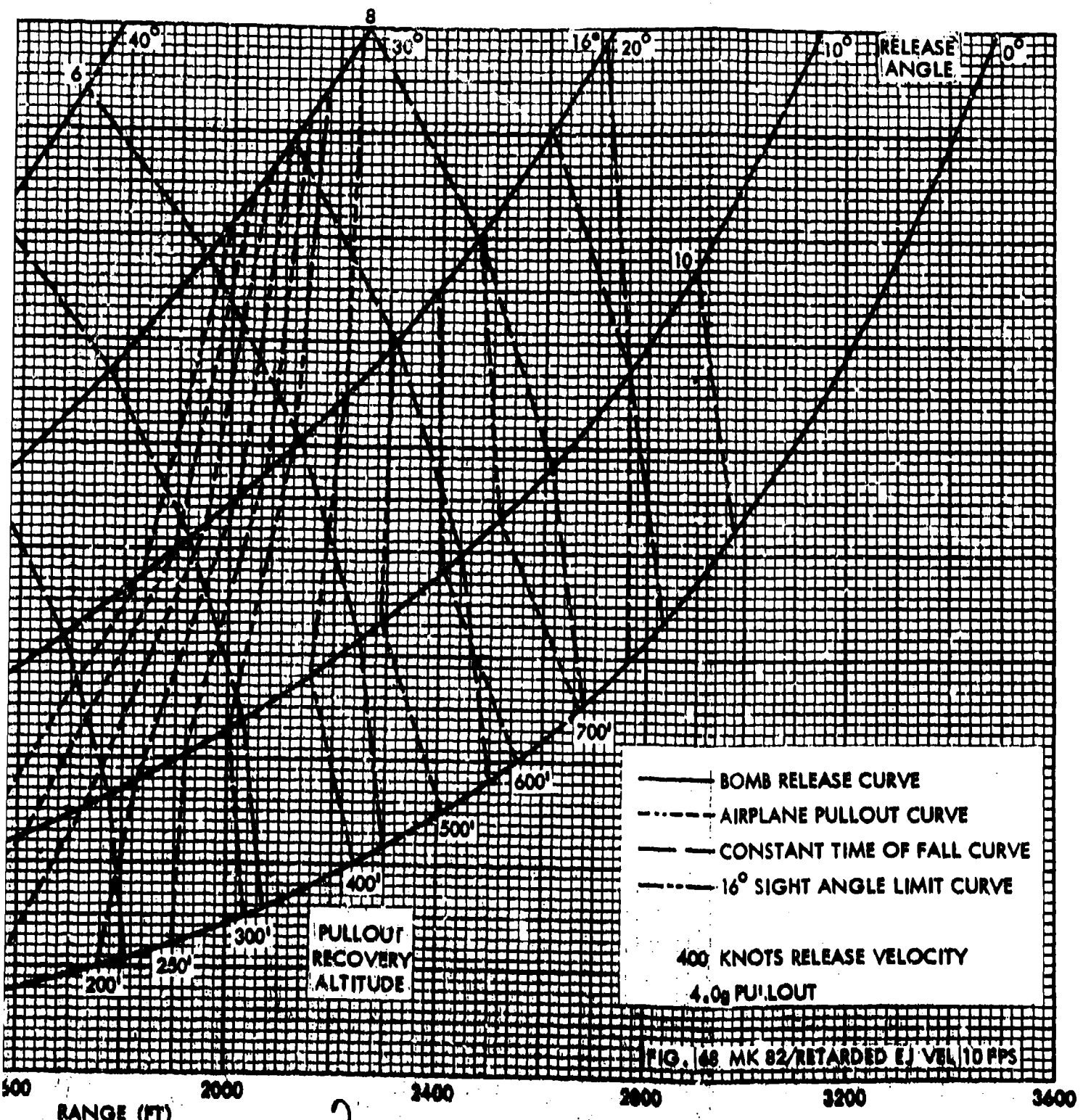
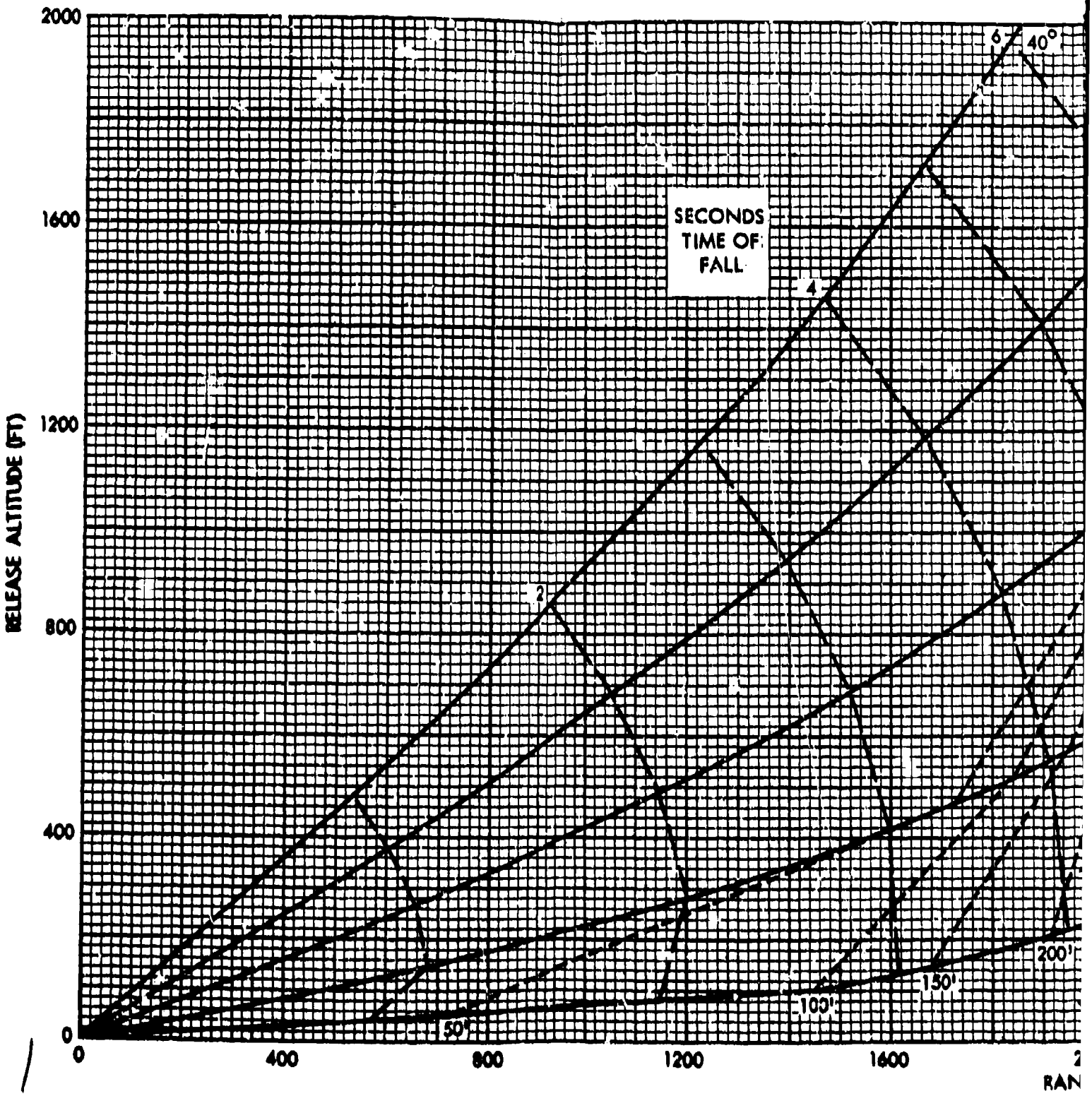


FIG. 67 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RANGE (FT)
SECONDS TIME OF FALL
2
4
6
40°
50'
100'
150'
200'
250'


8
6
40°
30°
16°
20°
10°
0°
RELEASE ANGLE
10
700'
600'
500'
400'
300'
250'
200'
PULLOUT RECOVERY ALTITUDE
BOMB RELEASE CURVE
AIRPLANE PULLOUT CURVE
CONSTANT TIME OF FALL CURVE
16° SIGHT ANGLE LIMIT CURVE
400 KNOTS RELEASE VELOCITY
4.0g PULLOUT
FIG. 68 MK 82/RETARDED EJ VEL 10 FPS
500
2000
2400
2800
3200
3600
RANGE (FT)


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
RAN
SECONDS
TIME OF
FALL
6
40°
4
2
200'
150'
100'
50'

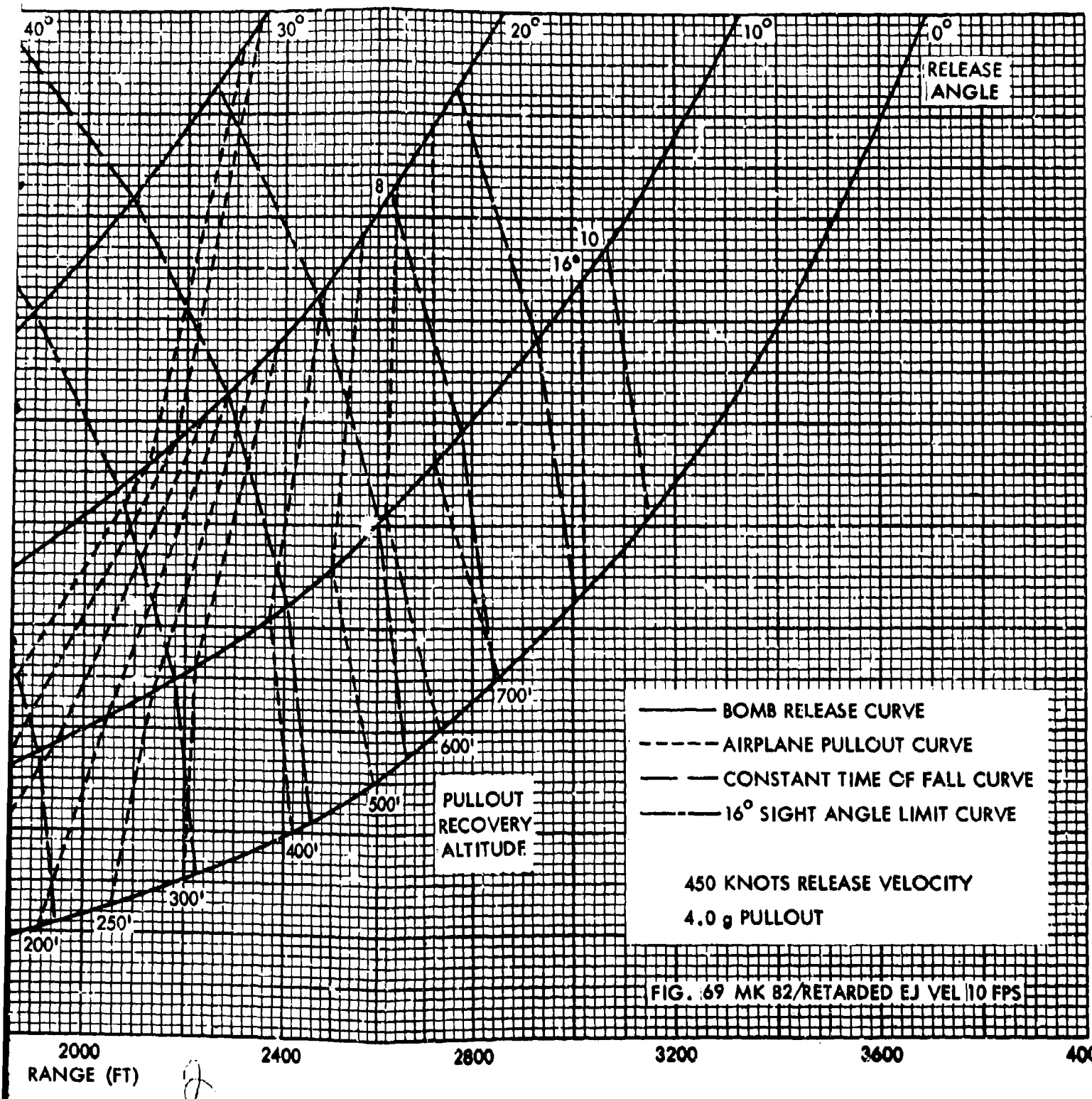
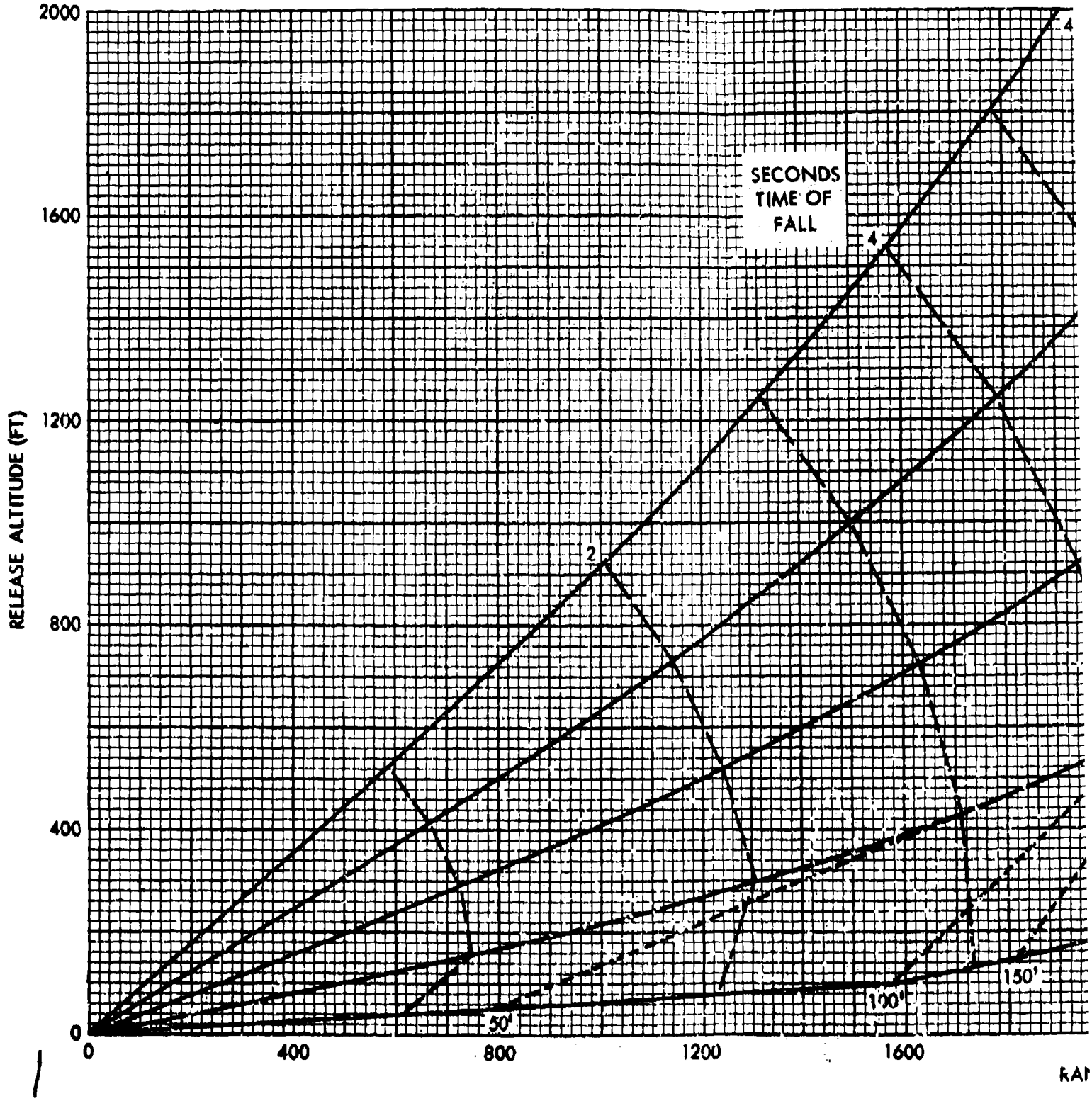


FIG. 69 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
SECONDS
TIME OF
FALL
4
4
2
50'
100'
150'

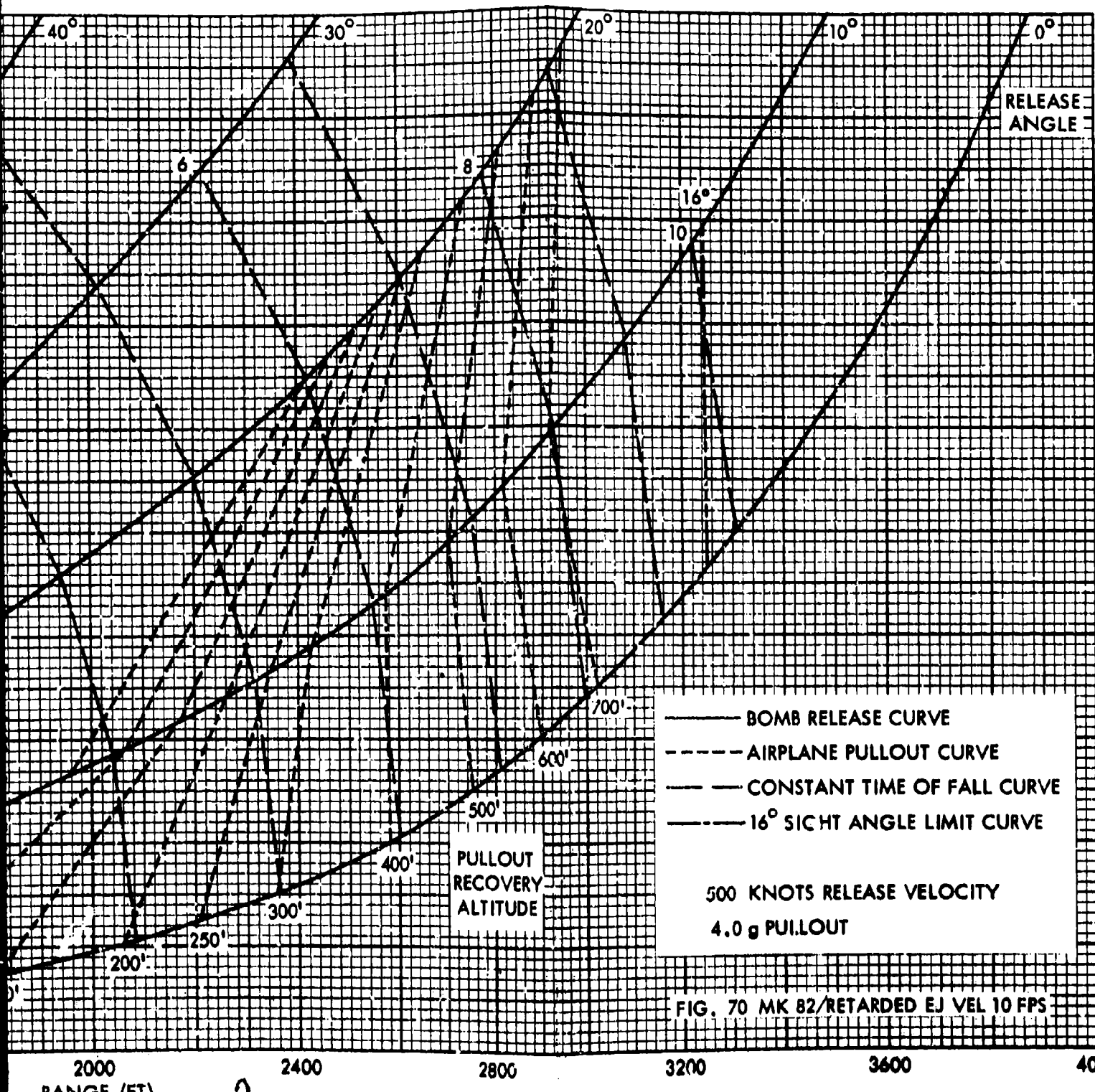
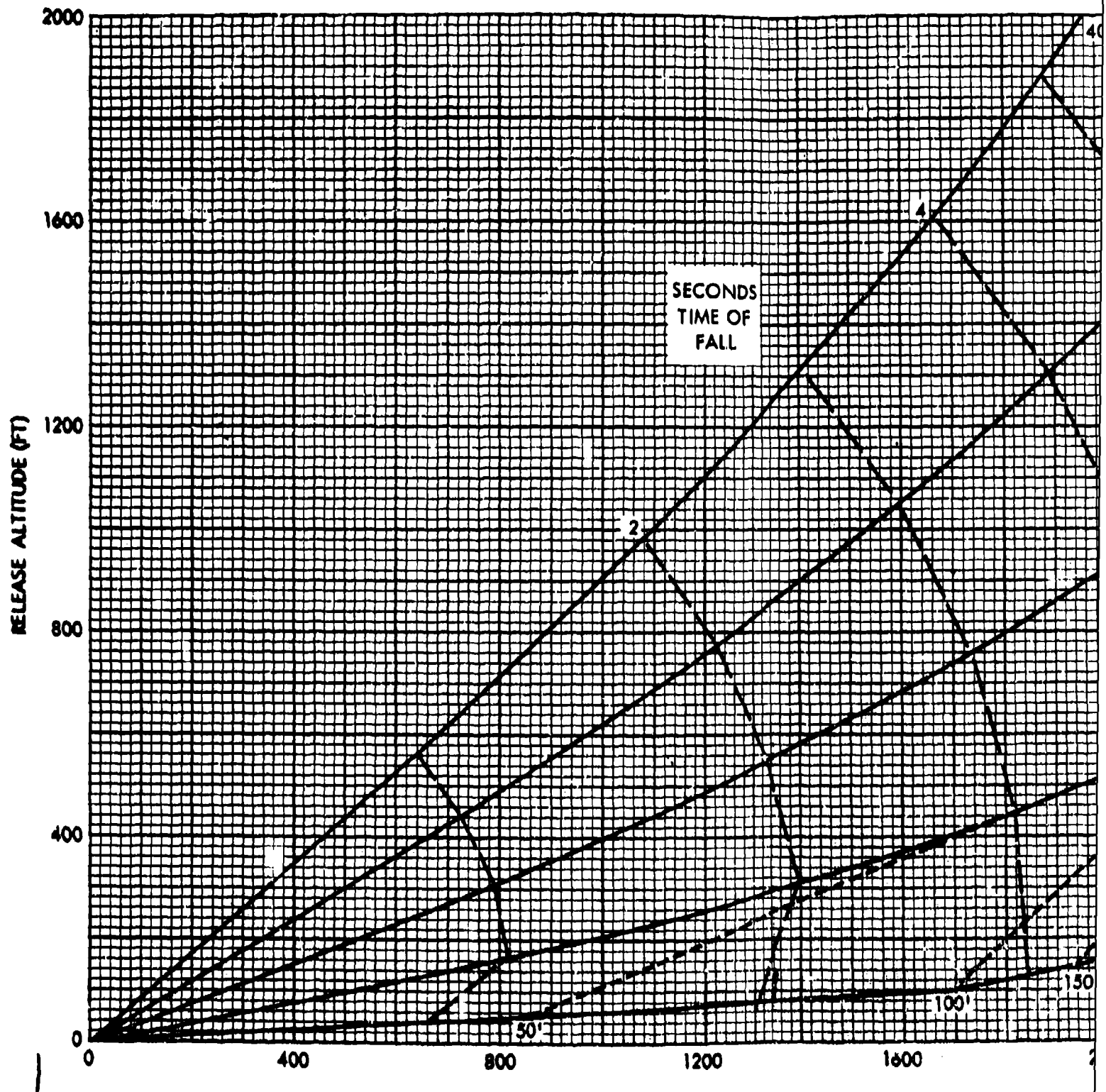


FIG. 70 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
0
400
800
1200
1600
SECONDS
TIME OF
FALL
4
2
150
100'
50'

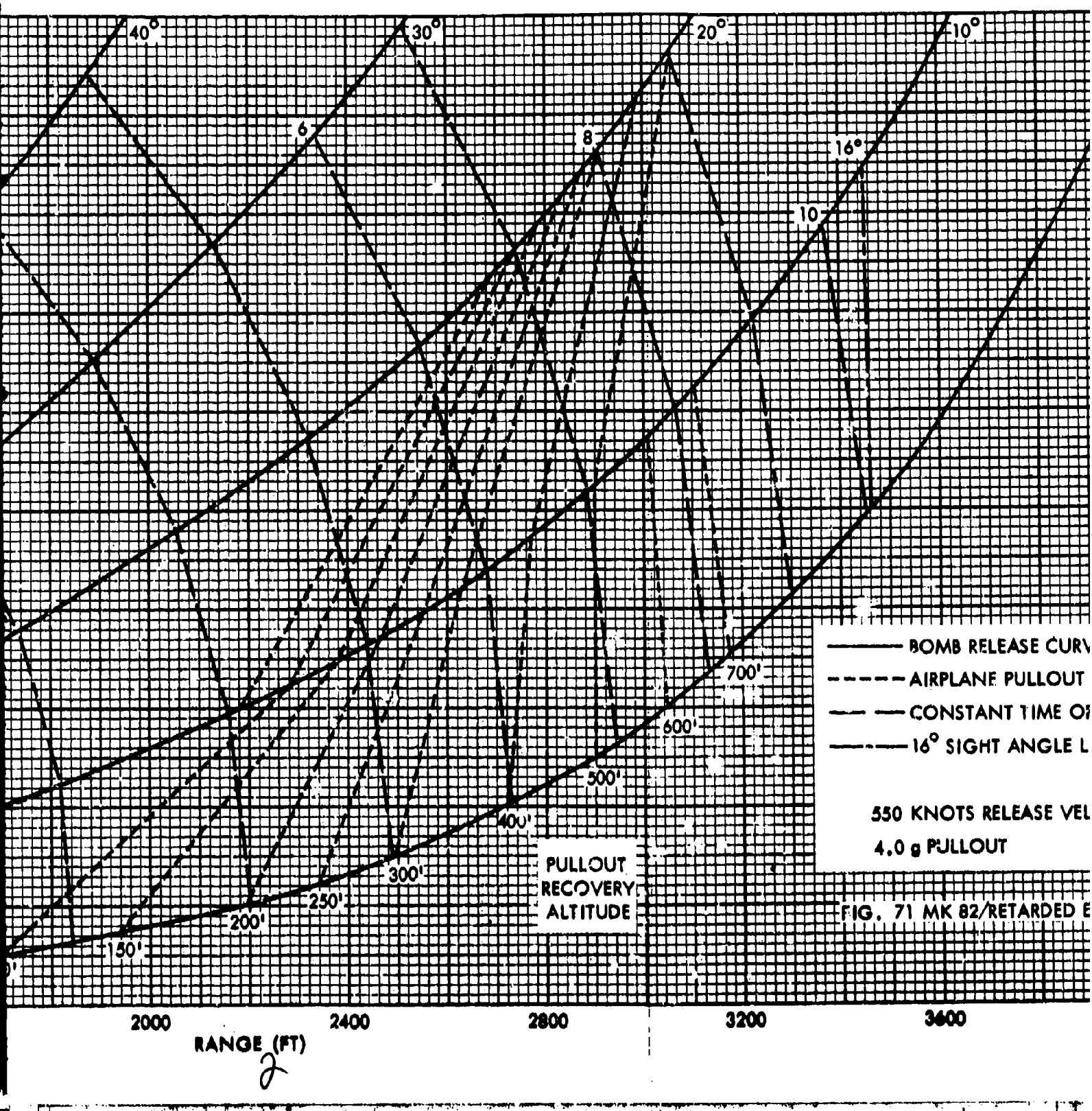


FIG. 71 MK 82/RETARDED E

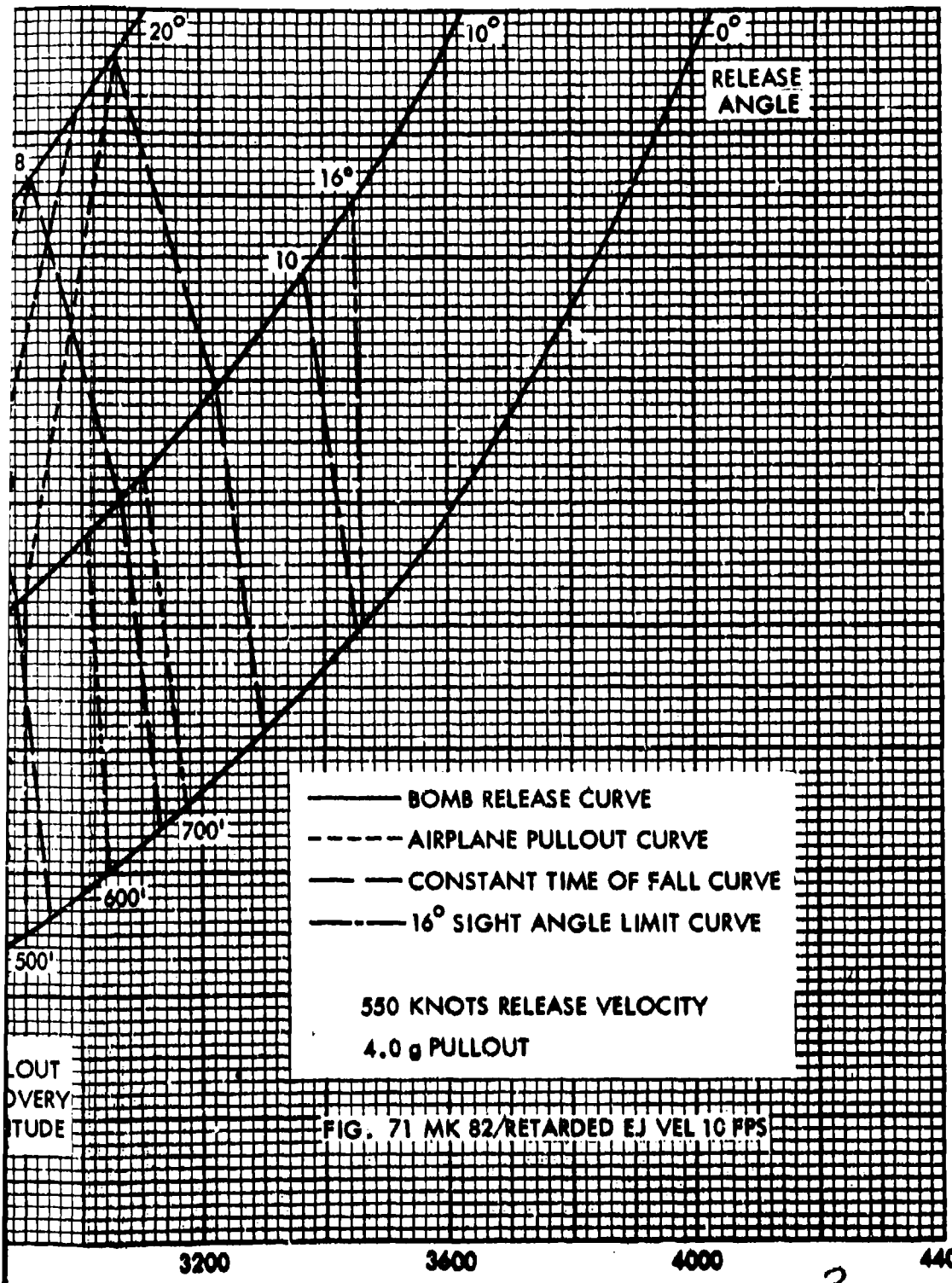
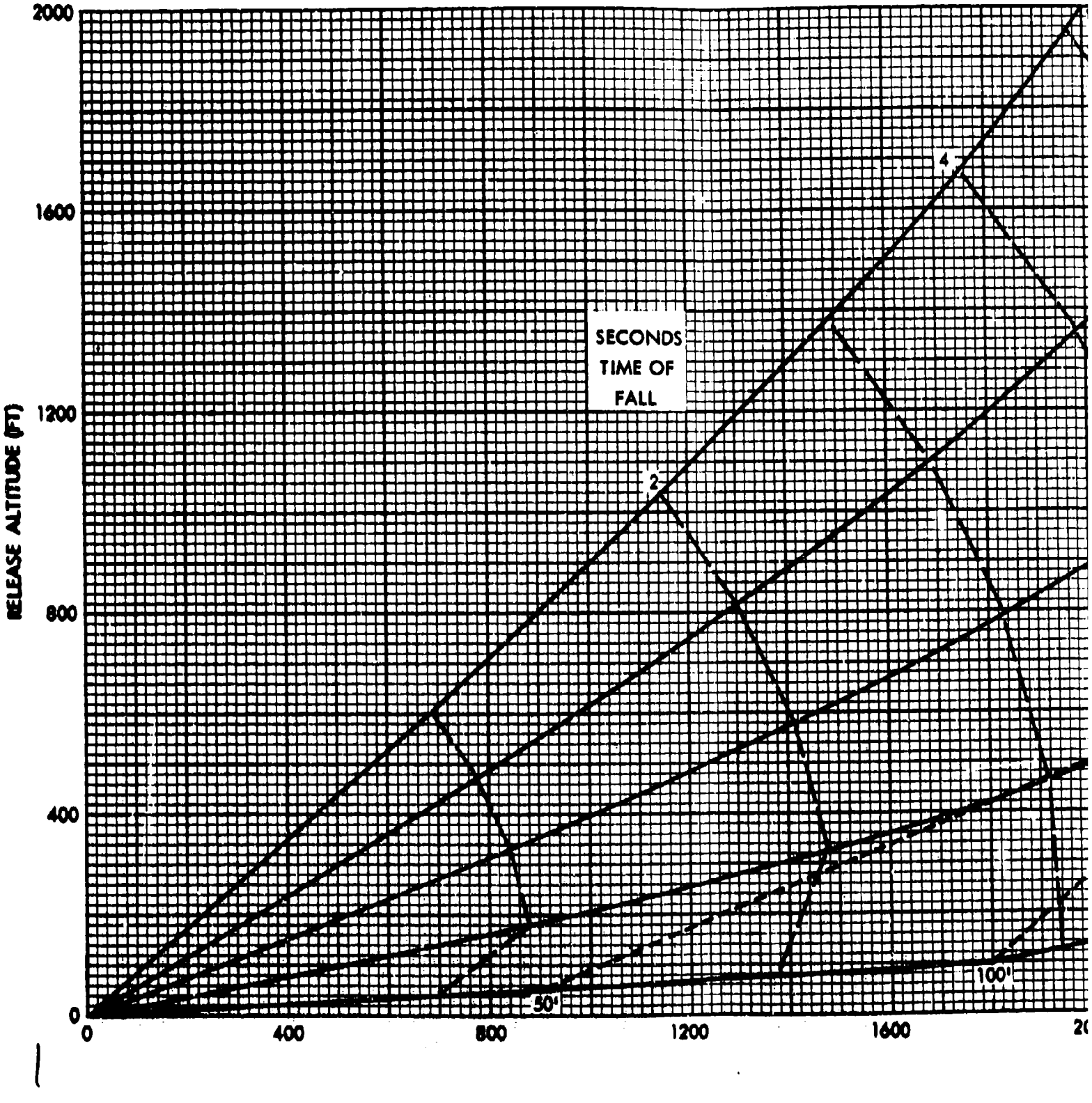


FIG. 71 MK 82/RETARDED EJ VEL 10 FPS


2000
1600
1200
800
400
0
RELEASE ALTITUDE (FT)
SECONDS
TIME OF
FALL
4
2
100'
50'
0
400
800
1200
1600

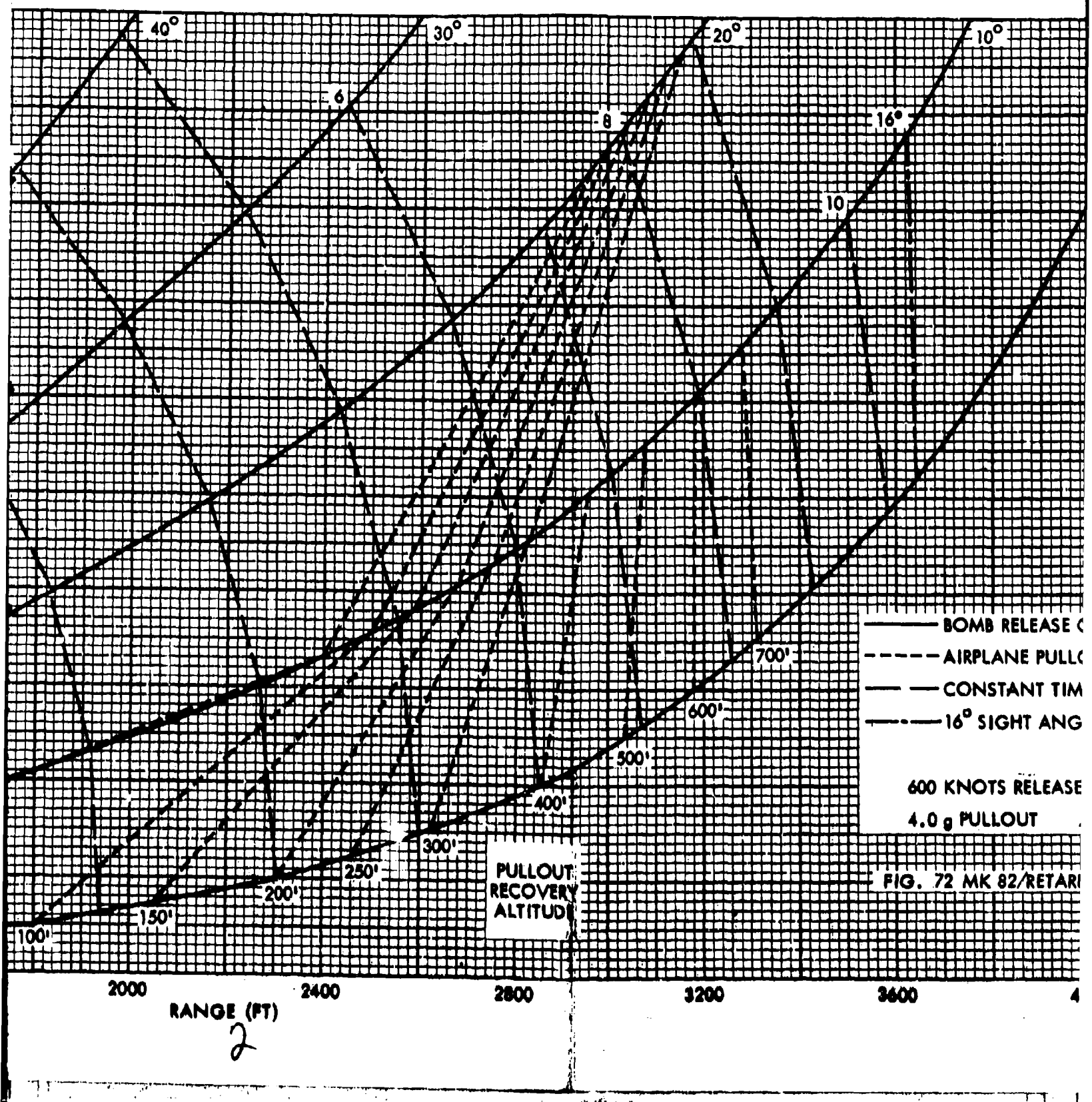


FIG. 72 MK 82/RETARI

2

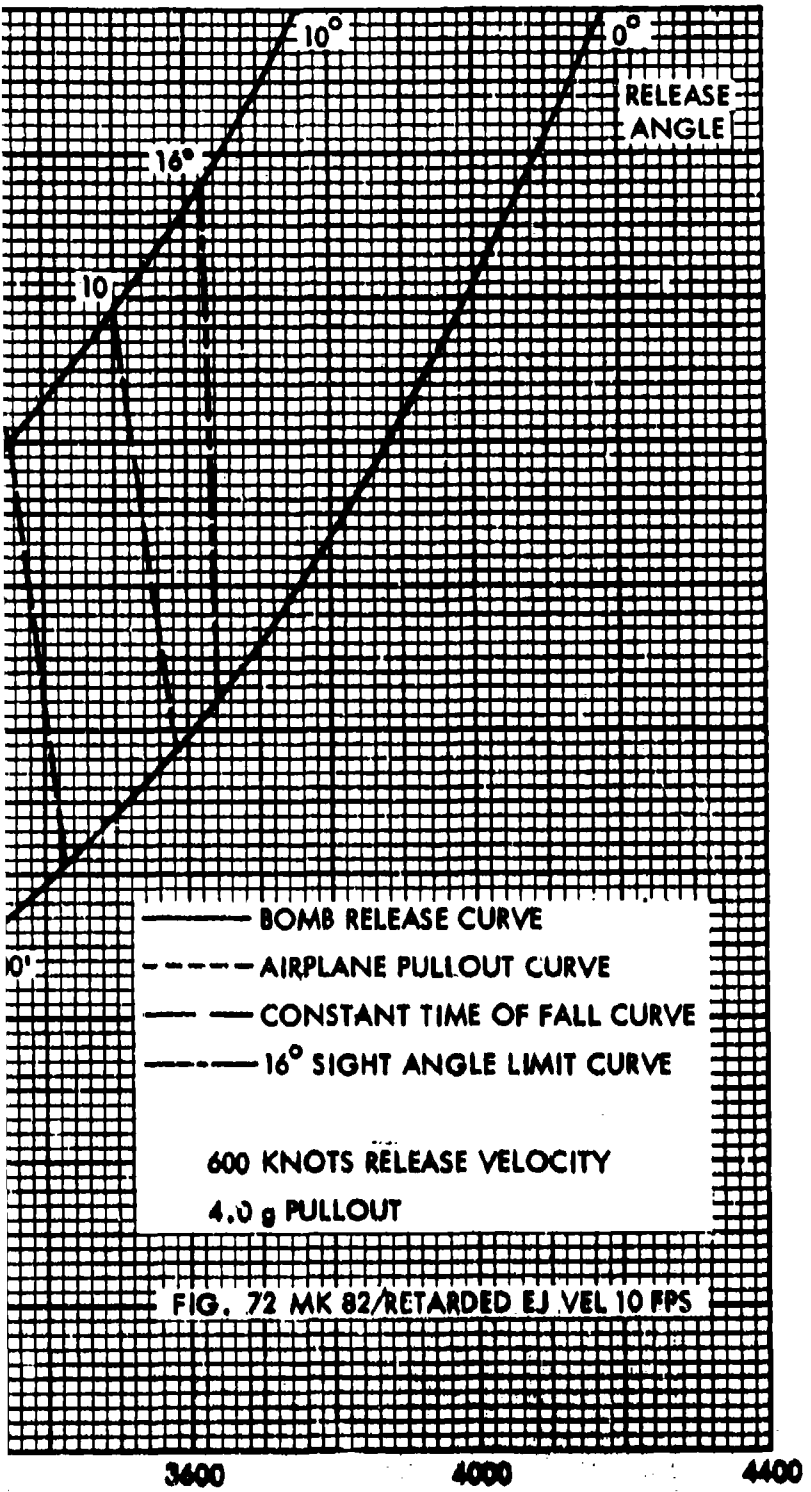
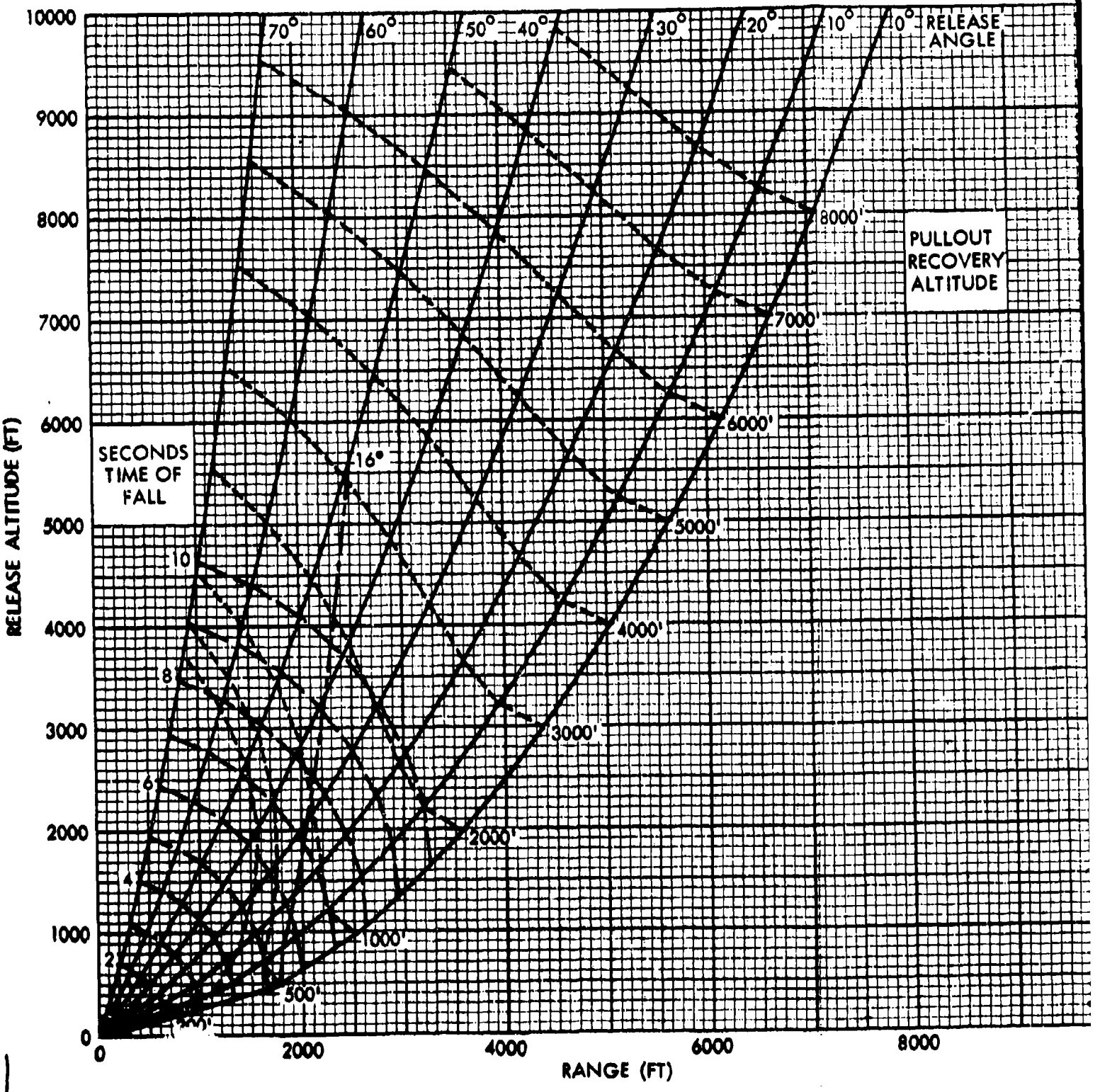
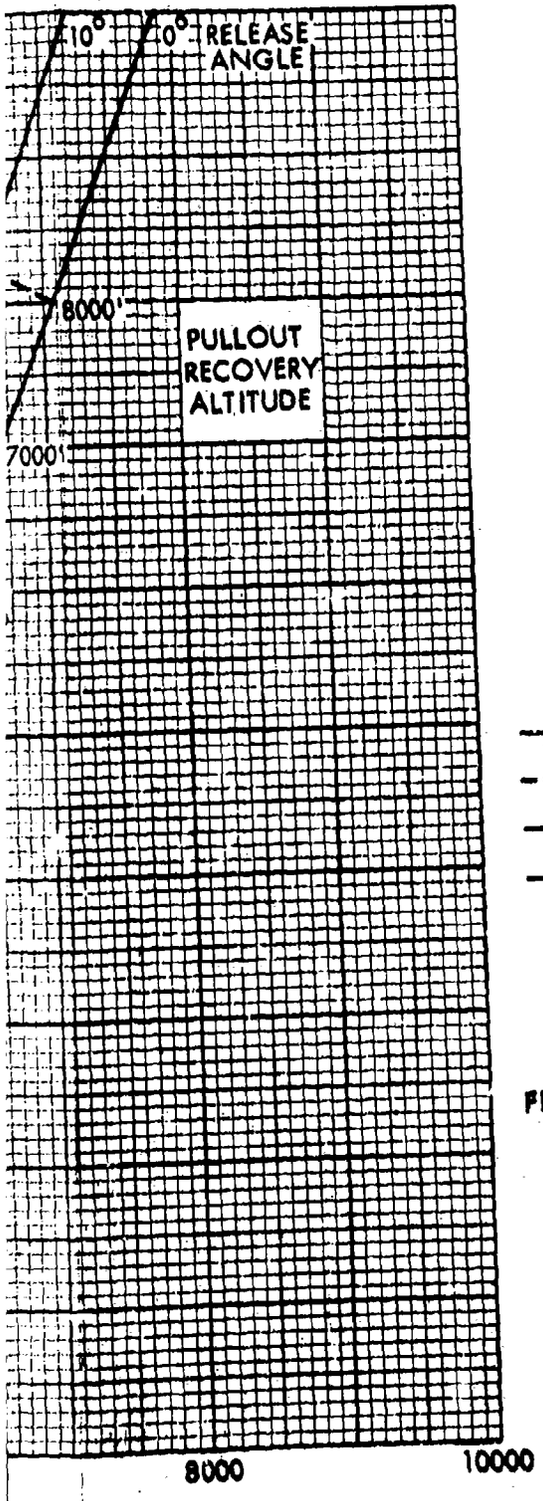


FIG. 72 MK 82/RETARDED EJ VEL 10 FPS


RELEASE ANGLE
70°
60°
50°
40°
30°
20°
10°
0°
PULLOUT RECOVERY ALTITUDE
8000'
7000'
6000'
5000'
4000'
3000'
2000'
1000'
500'
SECONDS TIME OF FALL
16"
10
8
6
4
2
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
RANGE (FT)



——— BOMB RELEASE CURVE

– – – – – AIRPLANE PULLOUT CURVE

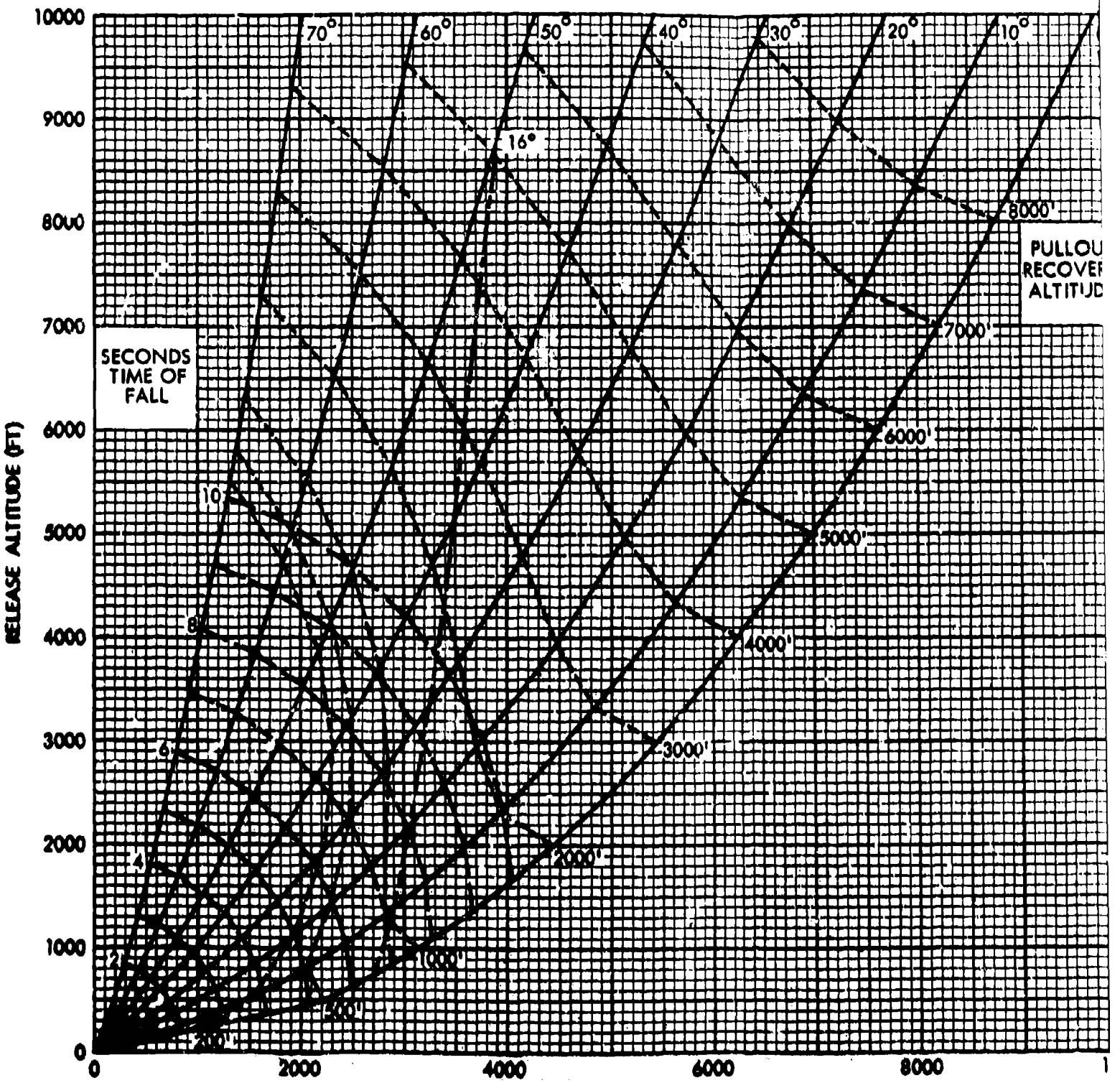
— — CONSTANT TIME OF FALL CURVE

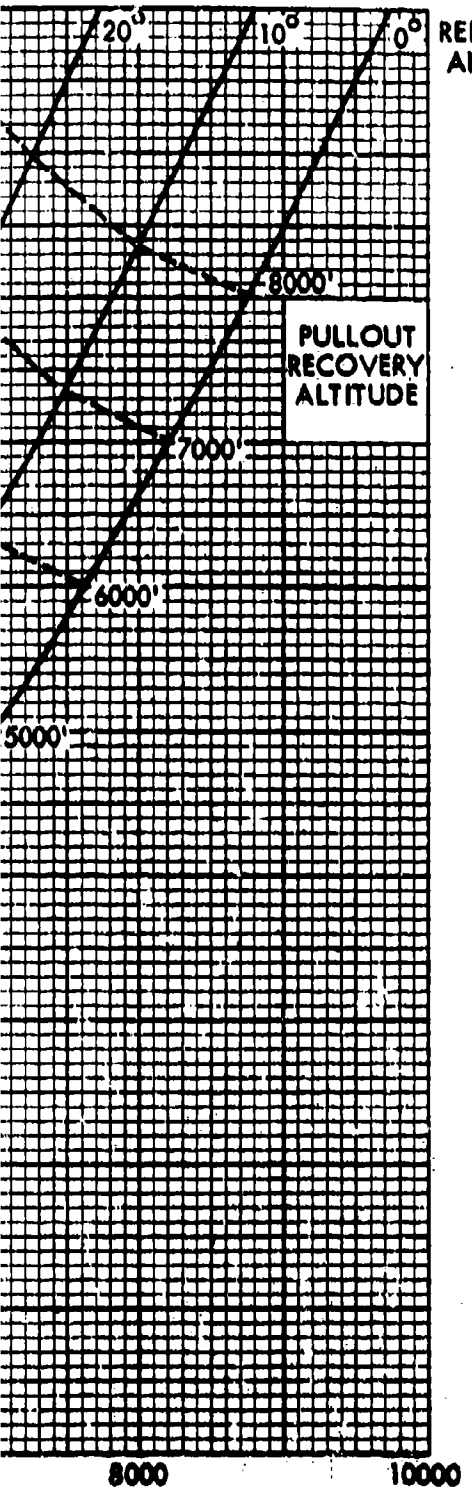
———— 16° SIGHT ANGLE LIMIT CURVE

200 KNOTS RELEASE VELOCITY

2.0 g PULLOUT

FIG. 73 MK 81/UNRETARDED EJ VEL 10 FPS


RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
70°
60°
50°
40°
30°
20°
10°
16°
8000'
7000'
6000'
5000'
4000'
3000'
2000'
1000'
500'
200'
SECONDS TIME OF FALL
10
8
6
4
2
PULLOU
RECOVE
ALTITUD



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

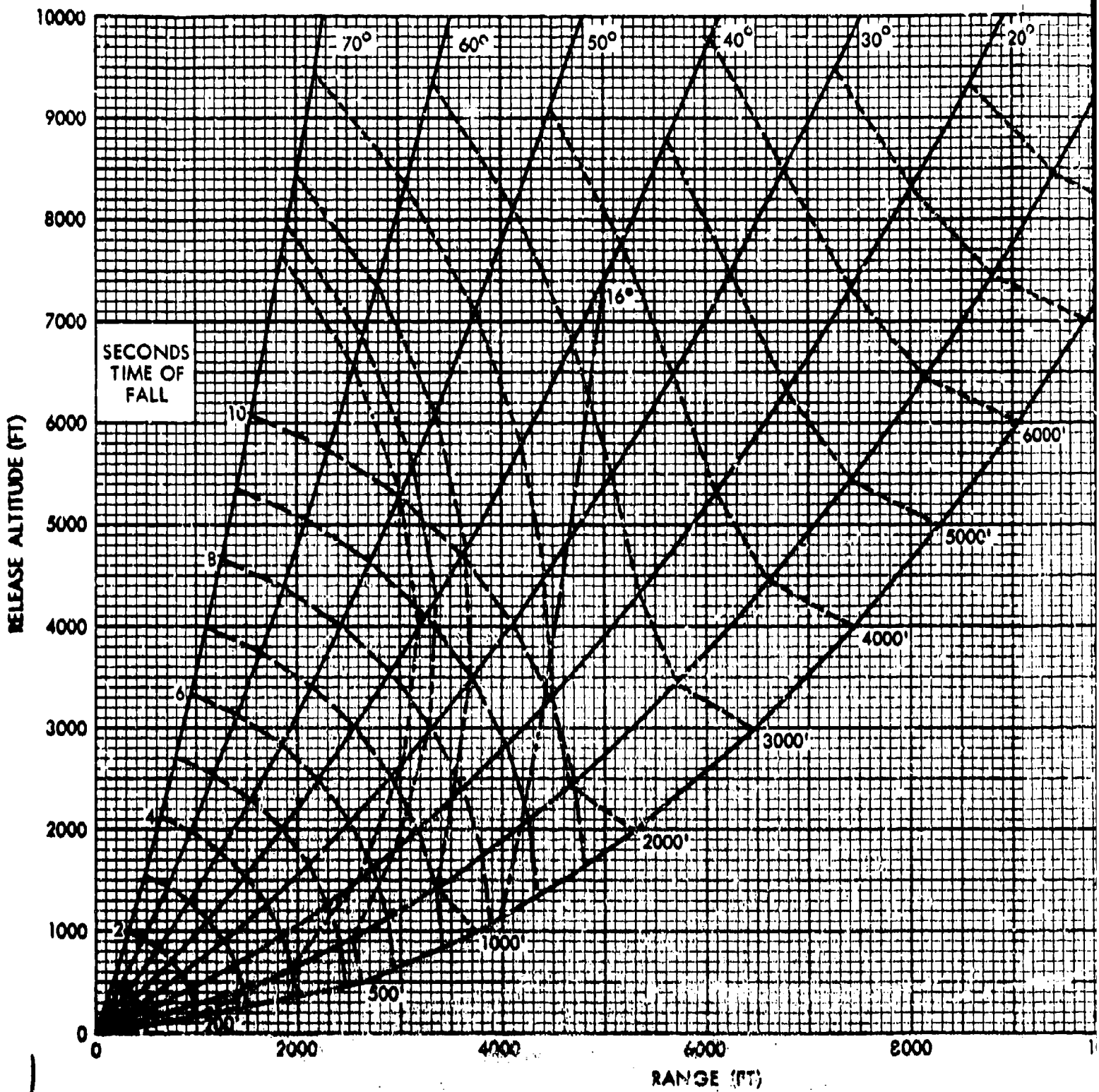
— — CONSTANT TIME OF FALL CURVE

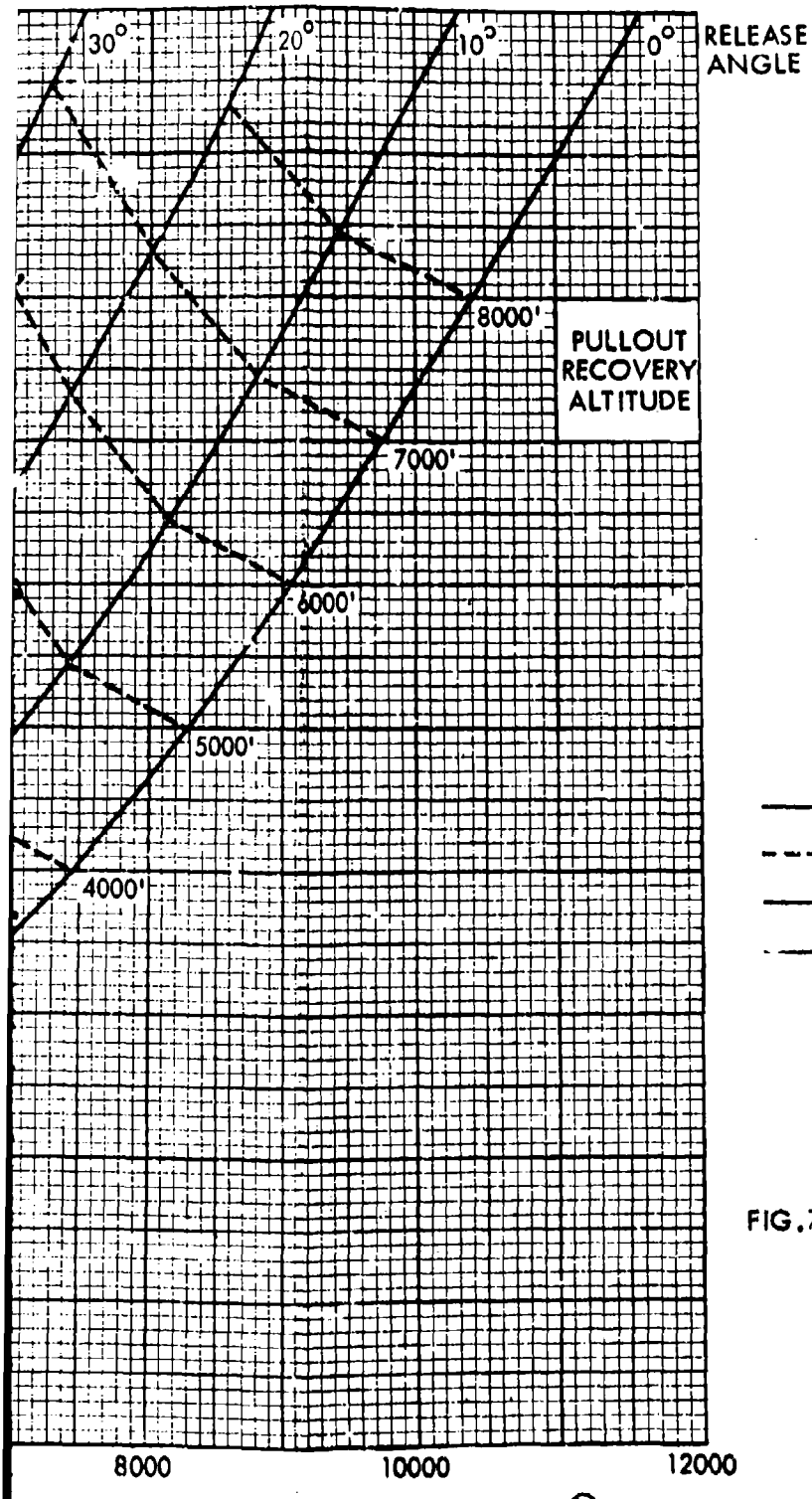
—·—·— 16° SIGHT ANGLE LIMIT CURVE

250 KNOTS RELEASE VELOCITY

2.0 g PULLOUT

FIG. 74 MK 81/UNRETARDED EJ VEL 10 FPS


70°
60°
50°
40°
30°
20°
16°
SECONDS TIME OF FALL
10
8
6
4
2
6000'
5000'
4000'
3000'
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
RANGE (FT)
0
2000
4000
6000
8000
10000
9000
7000
5000
3000
1000



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

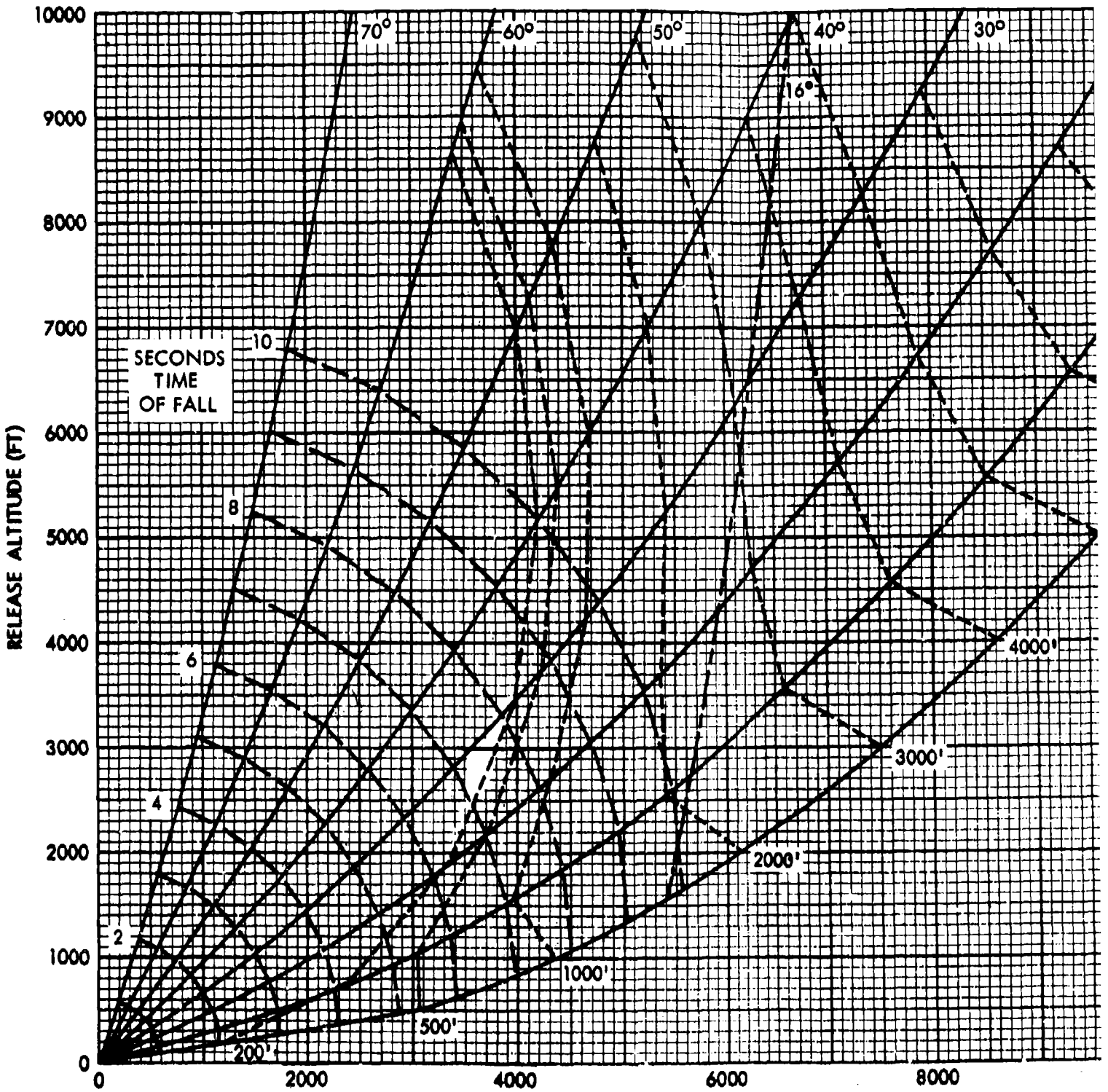
— — CONSTANT TIME OF FALL CURVE

·—·—· 16° SIGHT ANGLE LIMIT CURVE

300 KNOTS RELEASE VELOCITY

2.0g PULLOUT

FIG. 75 MK 81/UNRETARDED EJ VEL 10 FPS


RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
70°
60°
50°
40°
30°
16°
SECONDS
TIME
OF FALL
10
8
6
4
2
4000'
3000'
2000'
1000'
500'
200'

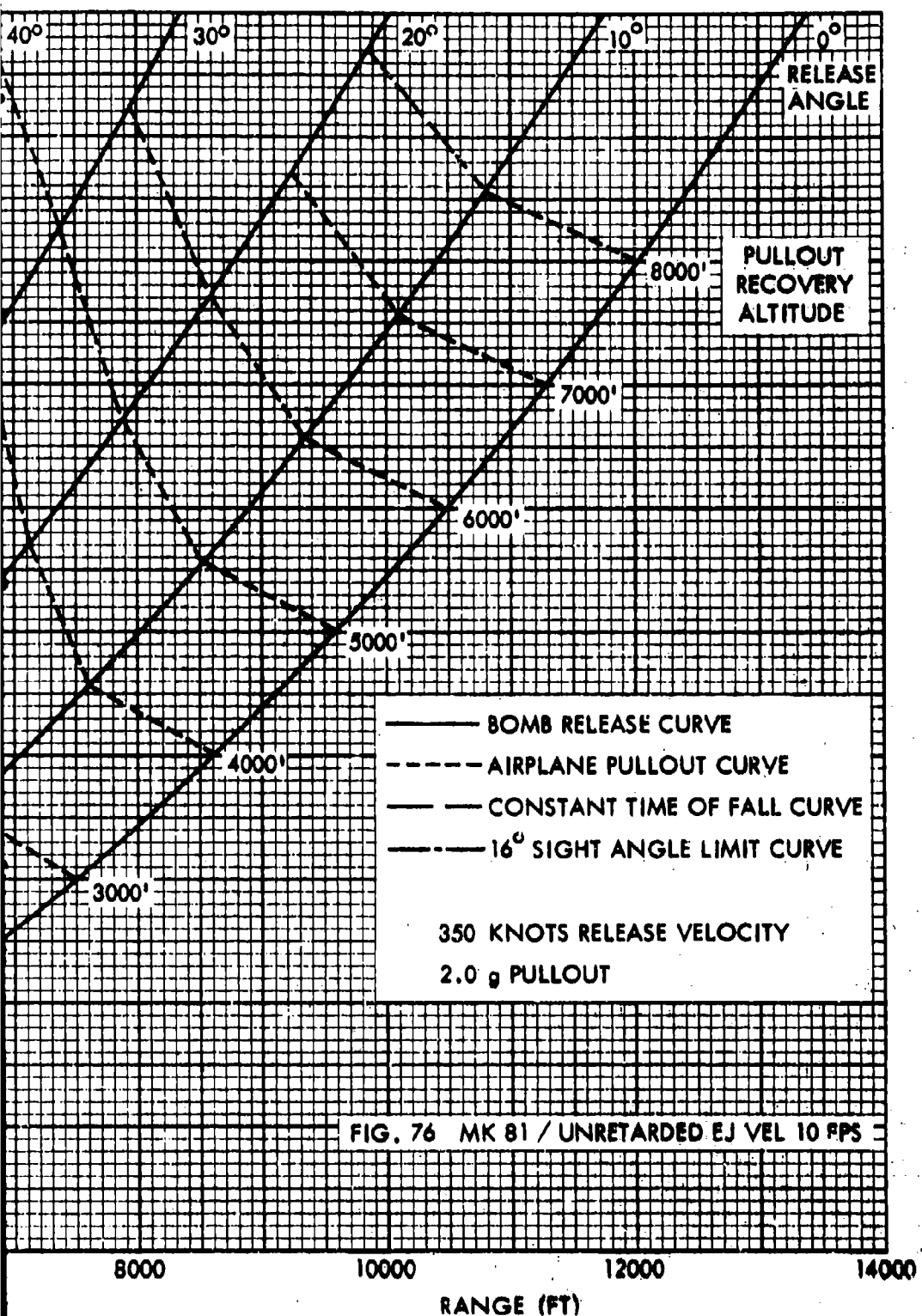
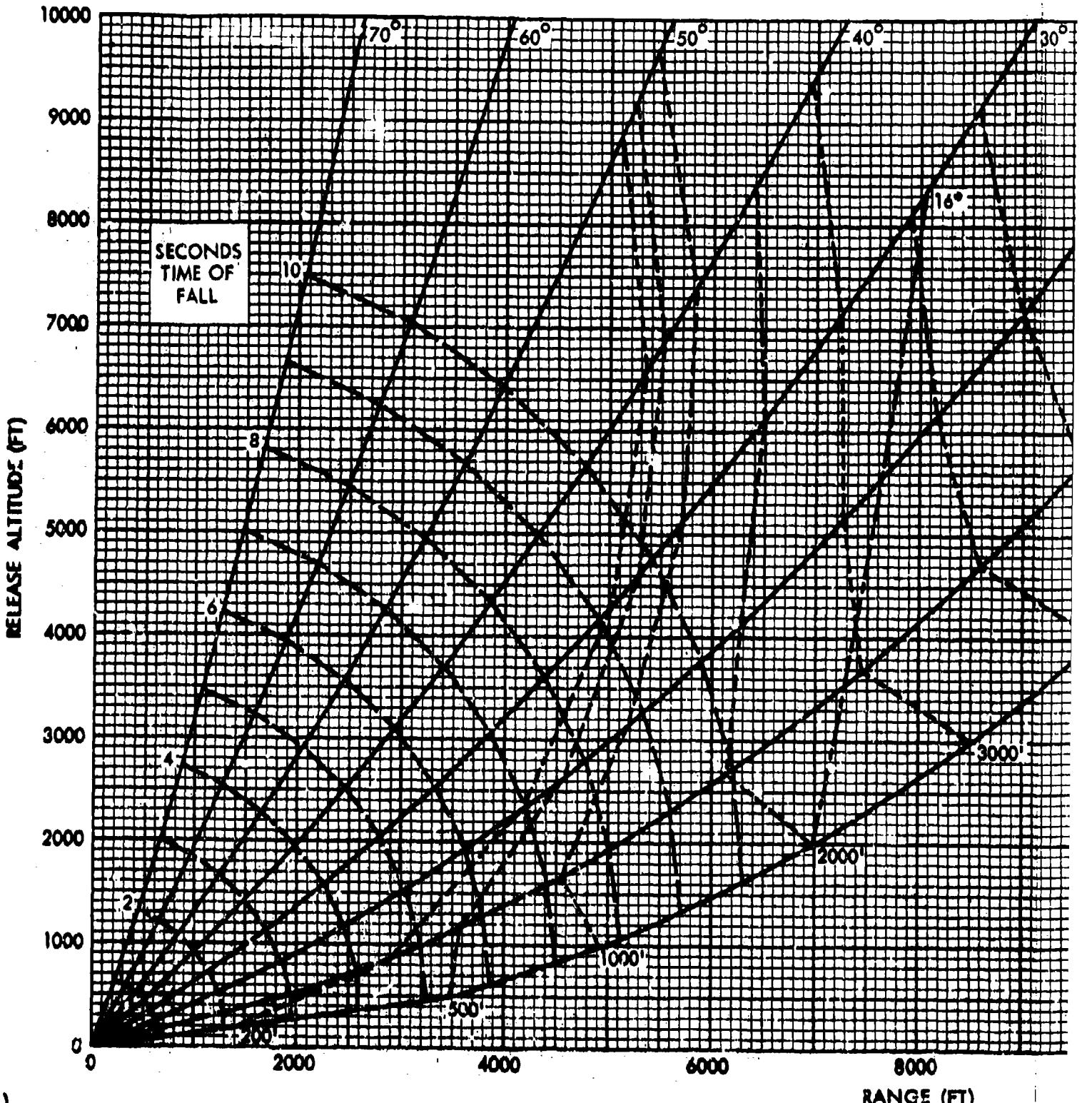


FIG. 76 MK 81 / UNRETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
70°
60°
50°
40°
30°
16°
10
8
6
4
2
1
.5
3000'
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
RANGE (FT)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
2000
4000
6000
8000

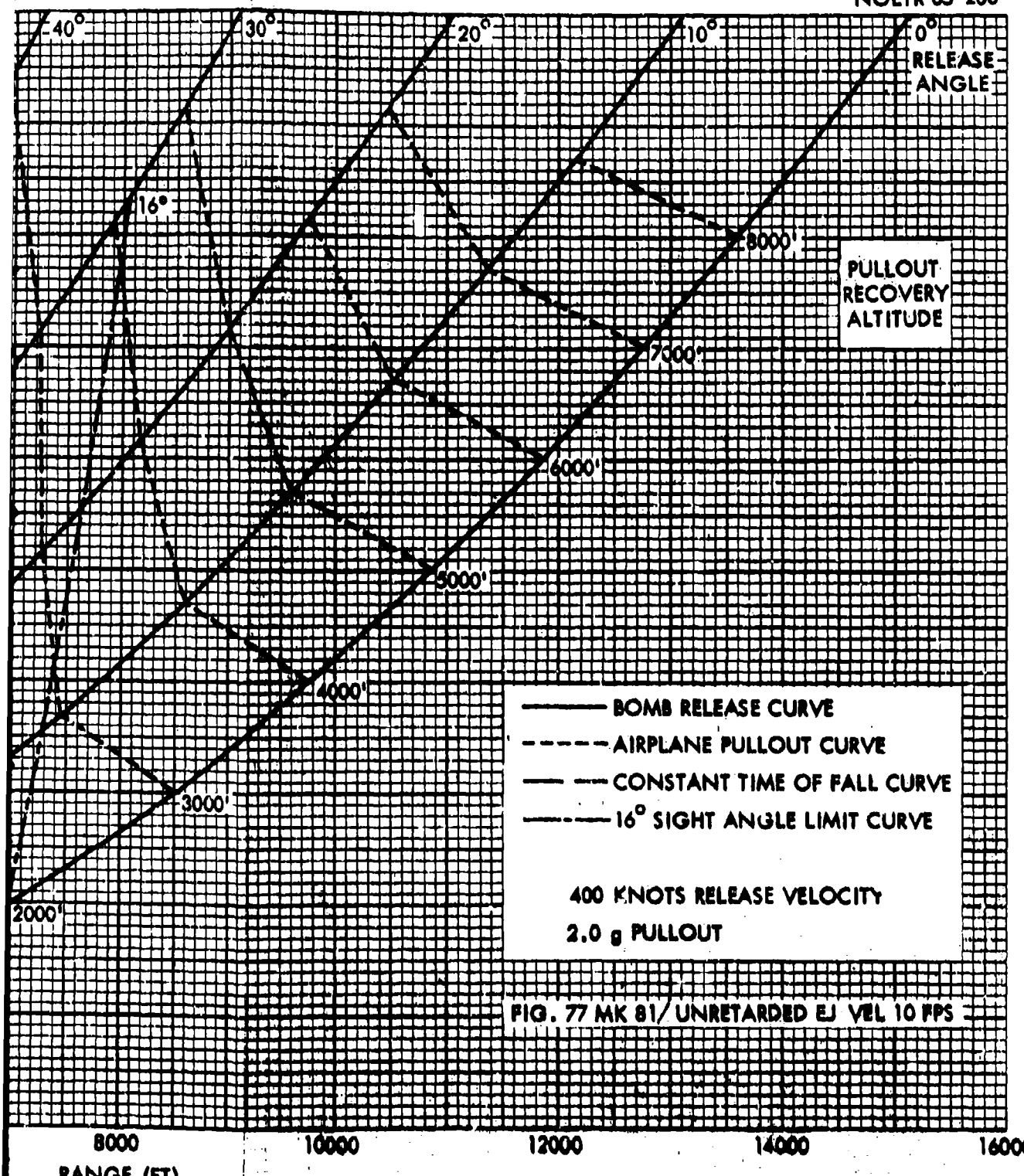
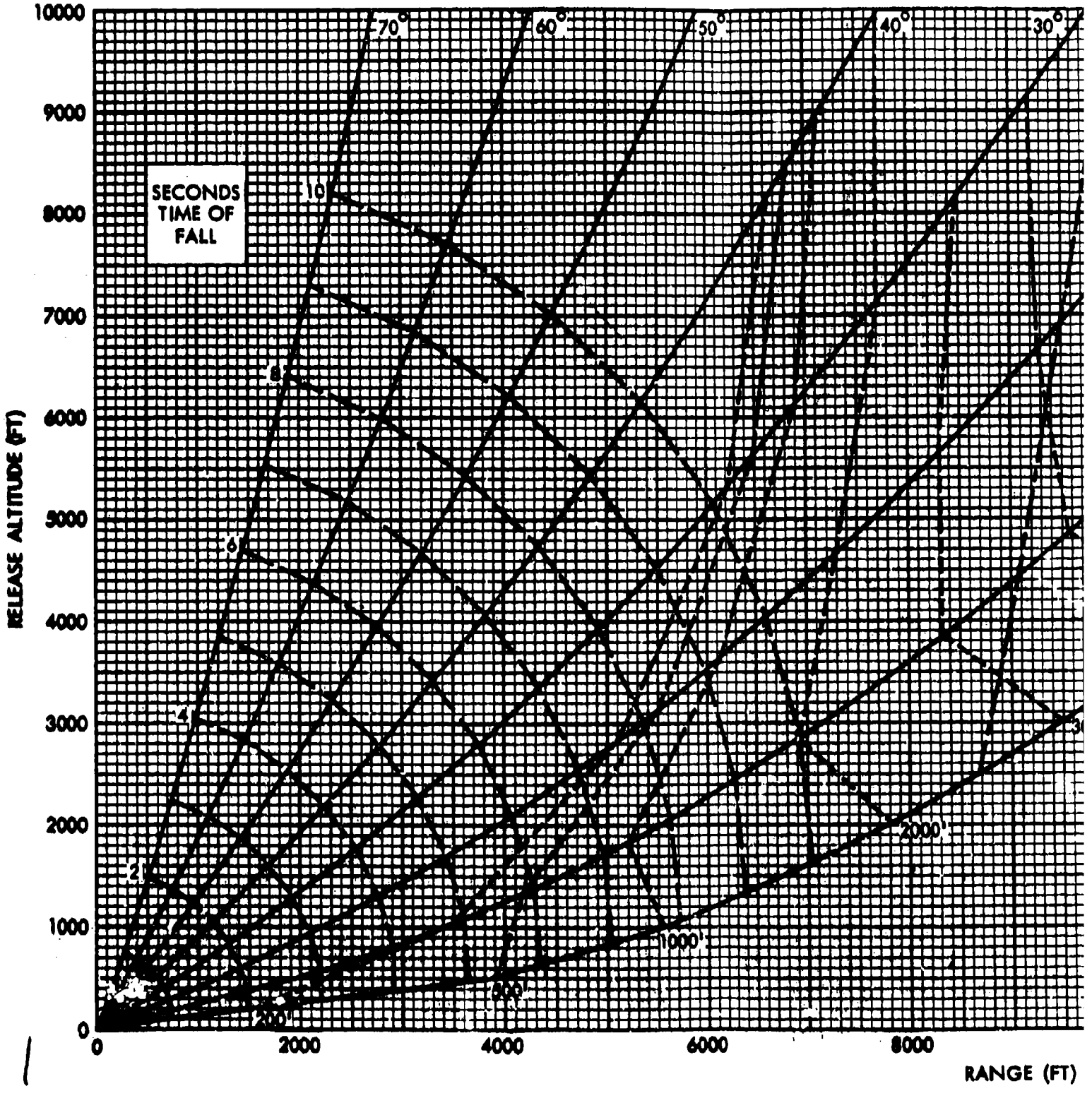


FIG. 77 MK 81/ UNRETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
70°
60°
50°
40°
30°
10
8
6
4
2
1000'
2000'
200'
RELEASE ALTITUDE (FT)
RANGE (FT)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
2000
4000
6000
8000

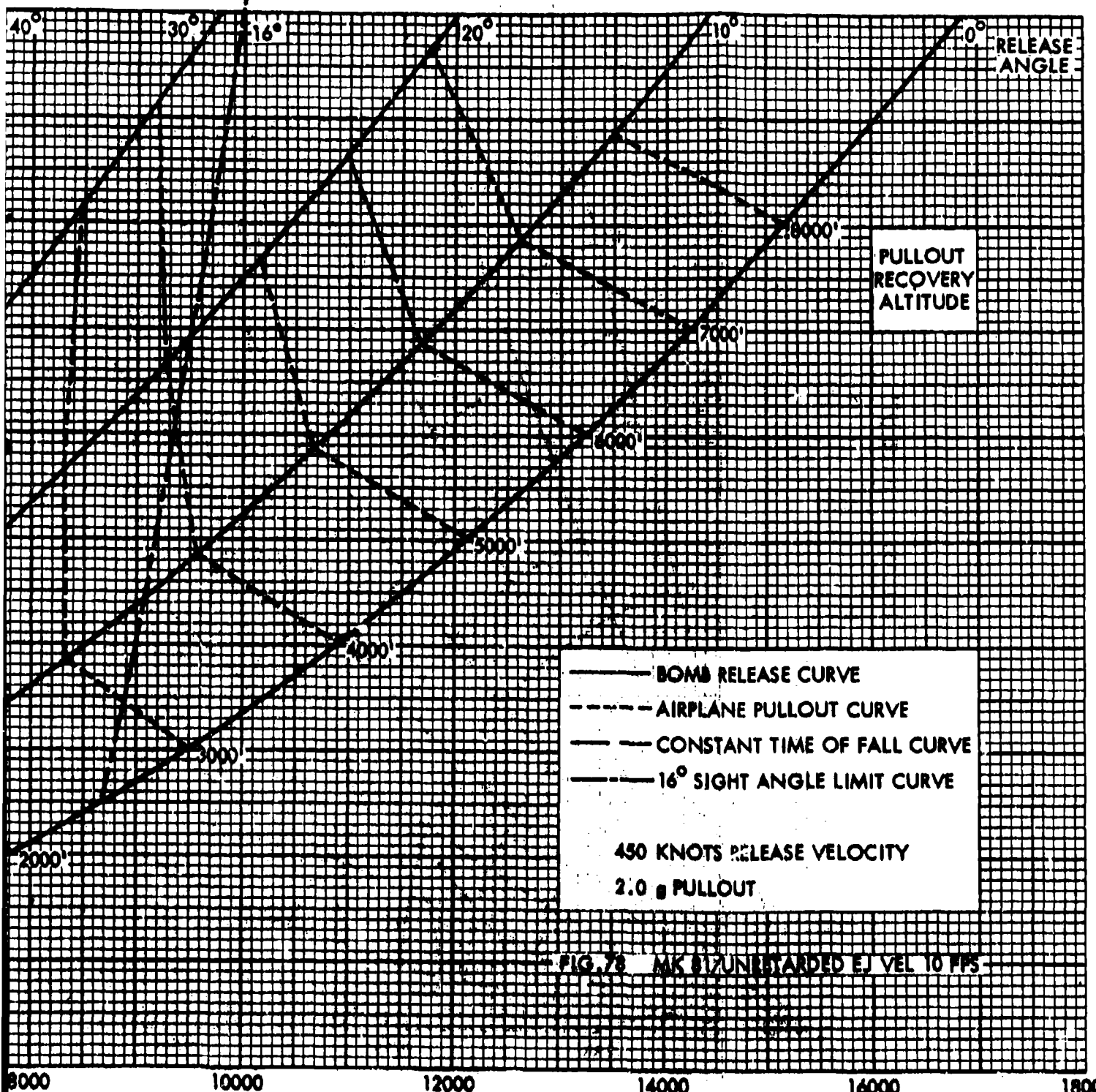
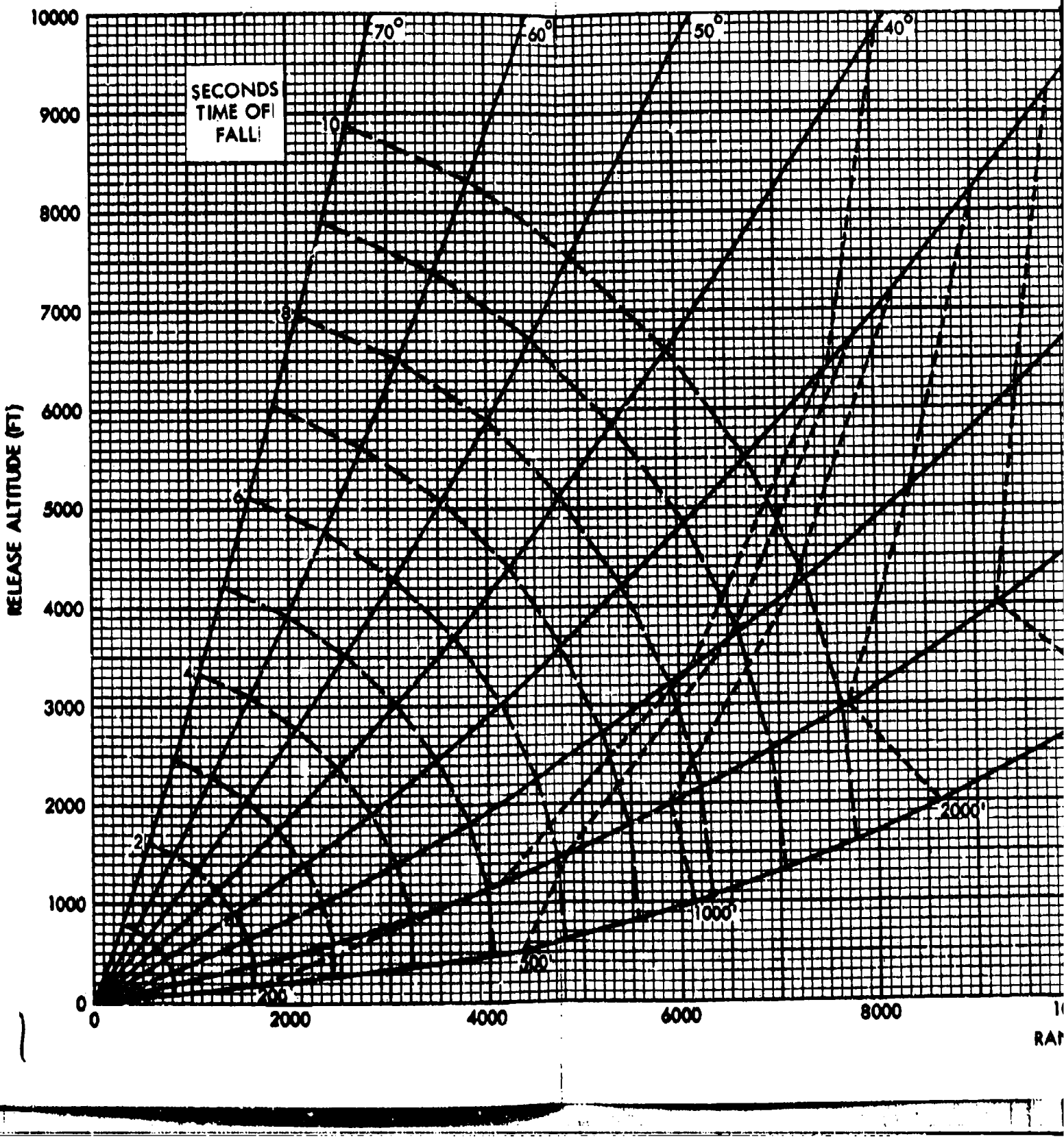


FIG. 78 MK 81 UNRETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
70°
60°
50°
40°
10
8
6
4
2
1000'
2000'
500'
200'
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000

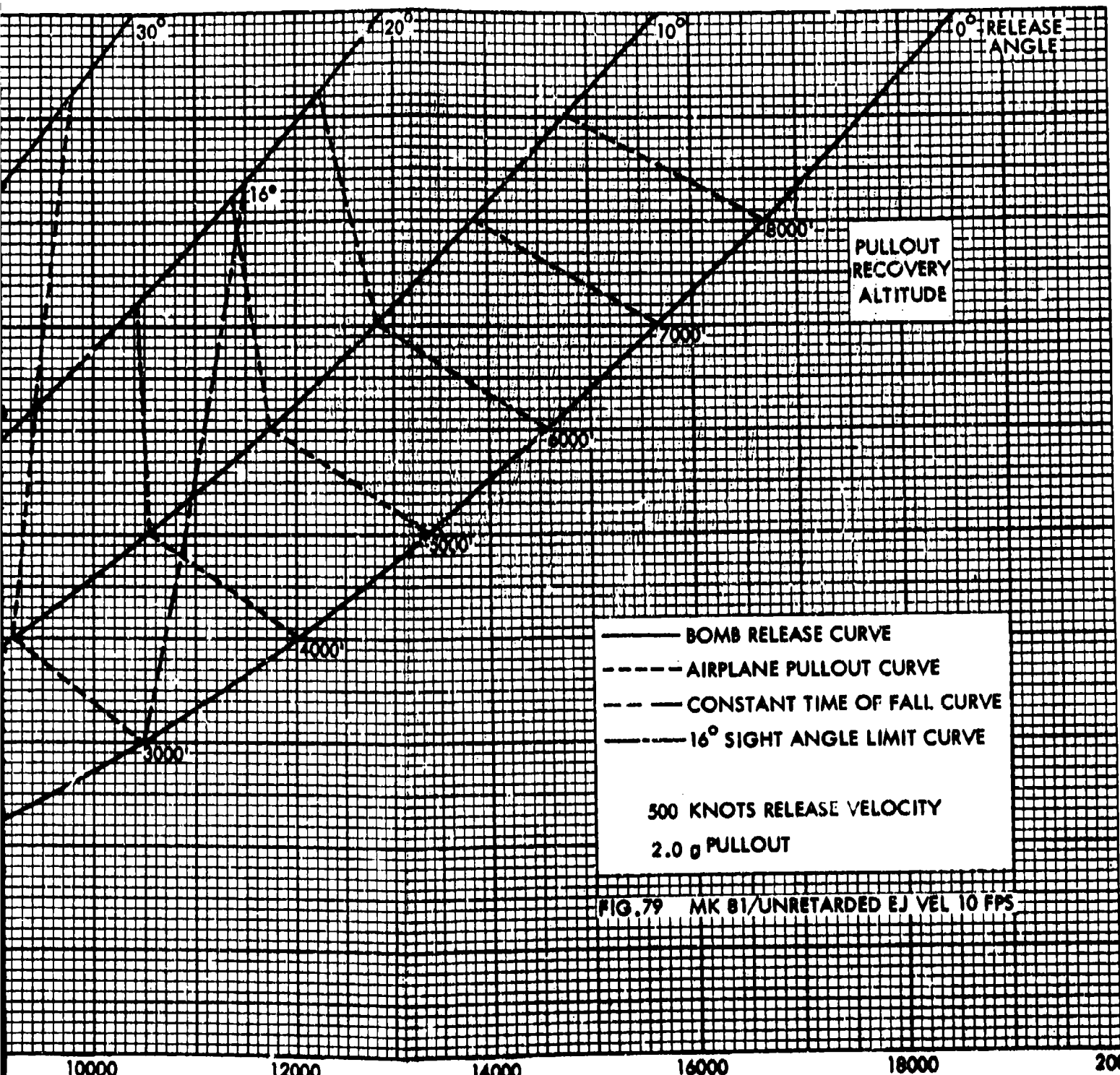
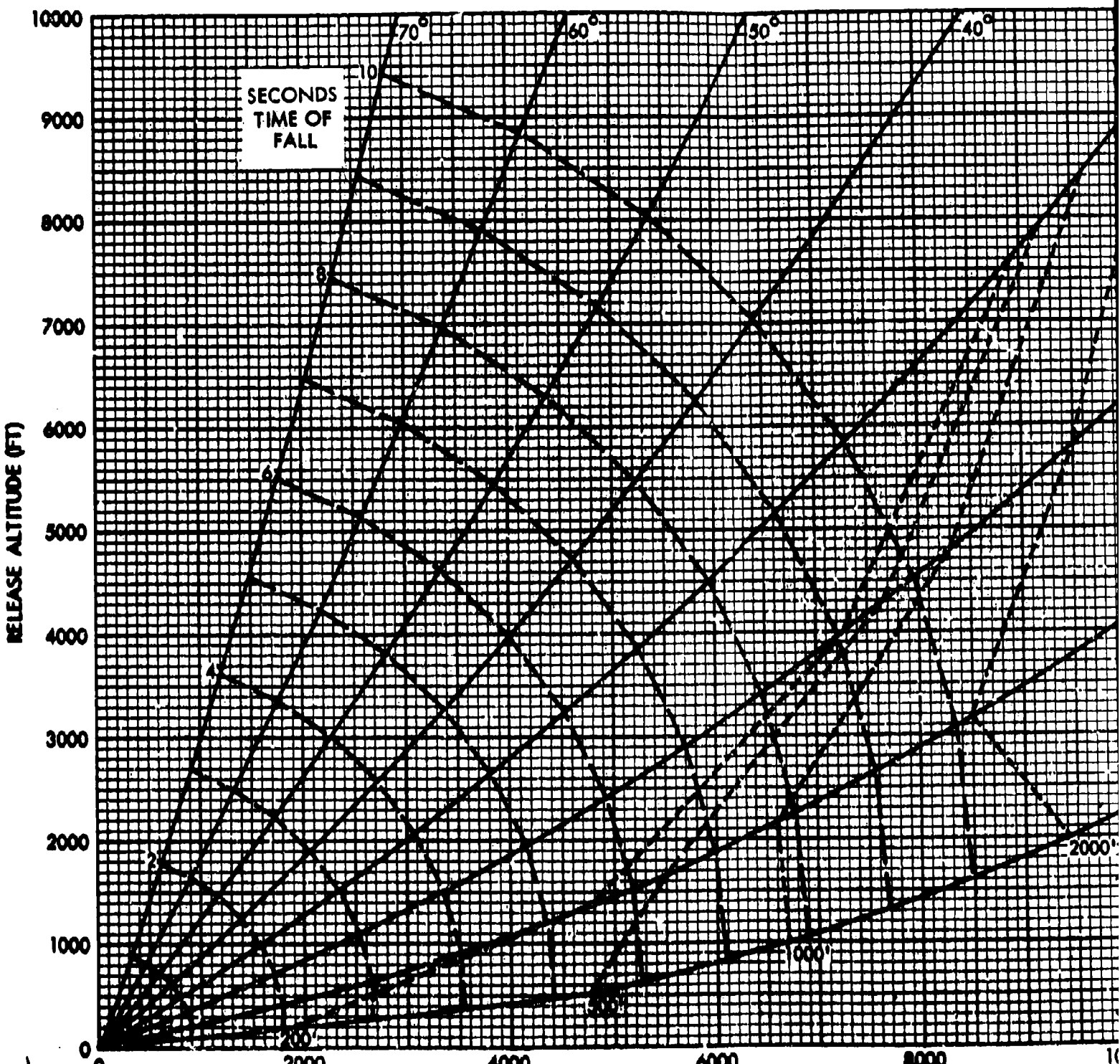


FIG. 79 MK 81/UNRETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
70°
60°
50°
40°
10
8
6
4
2
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000

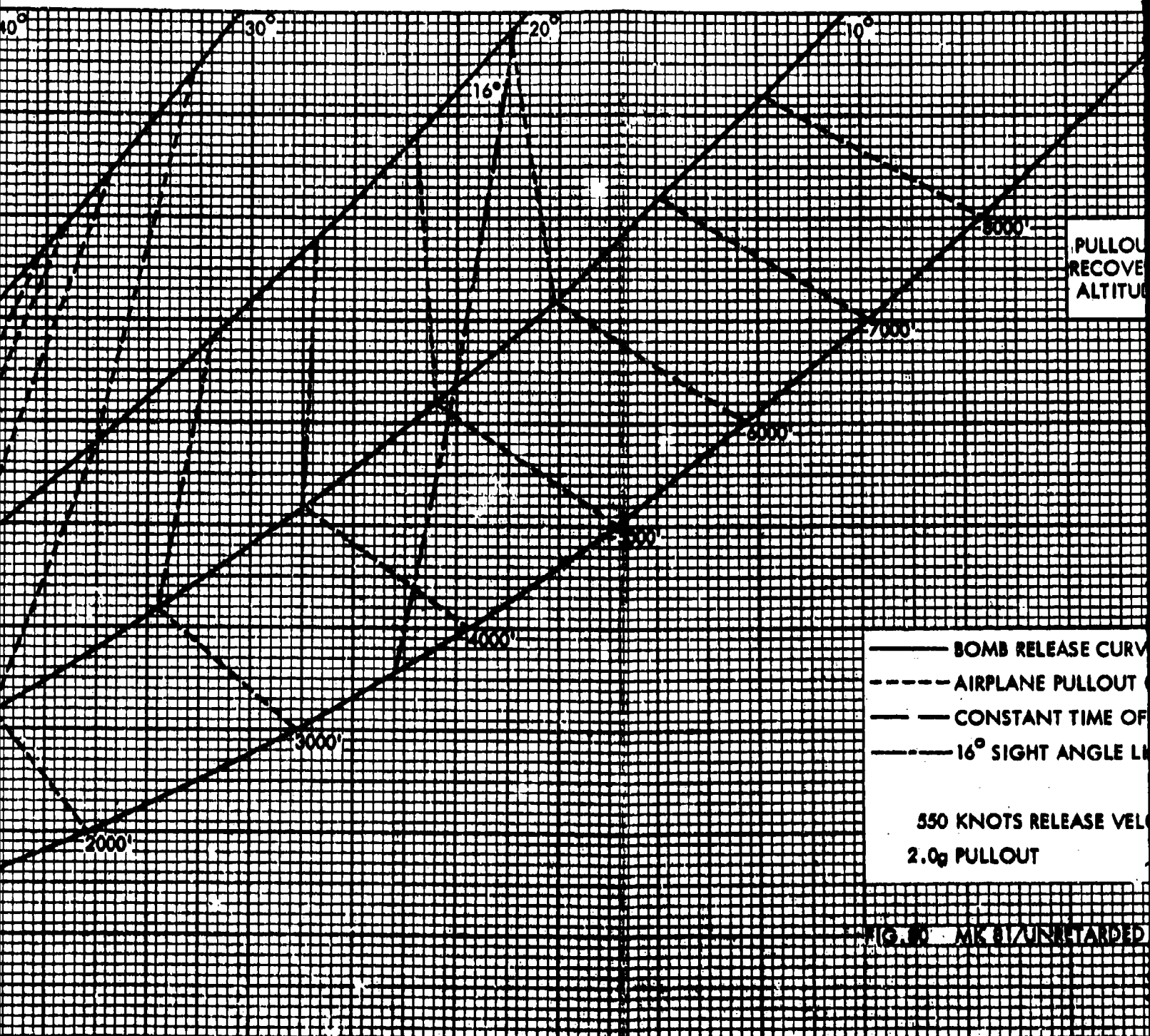


FIG. 80 MK 81/UNRETARDED

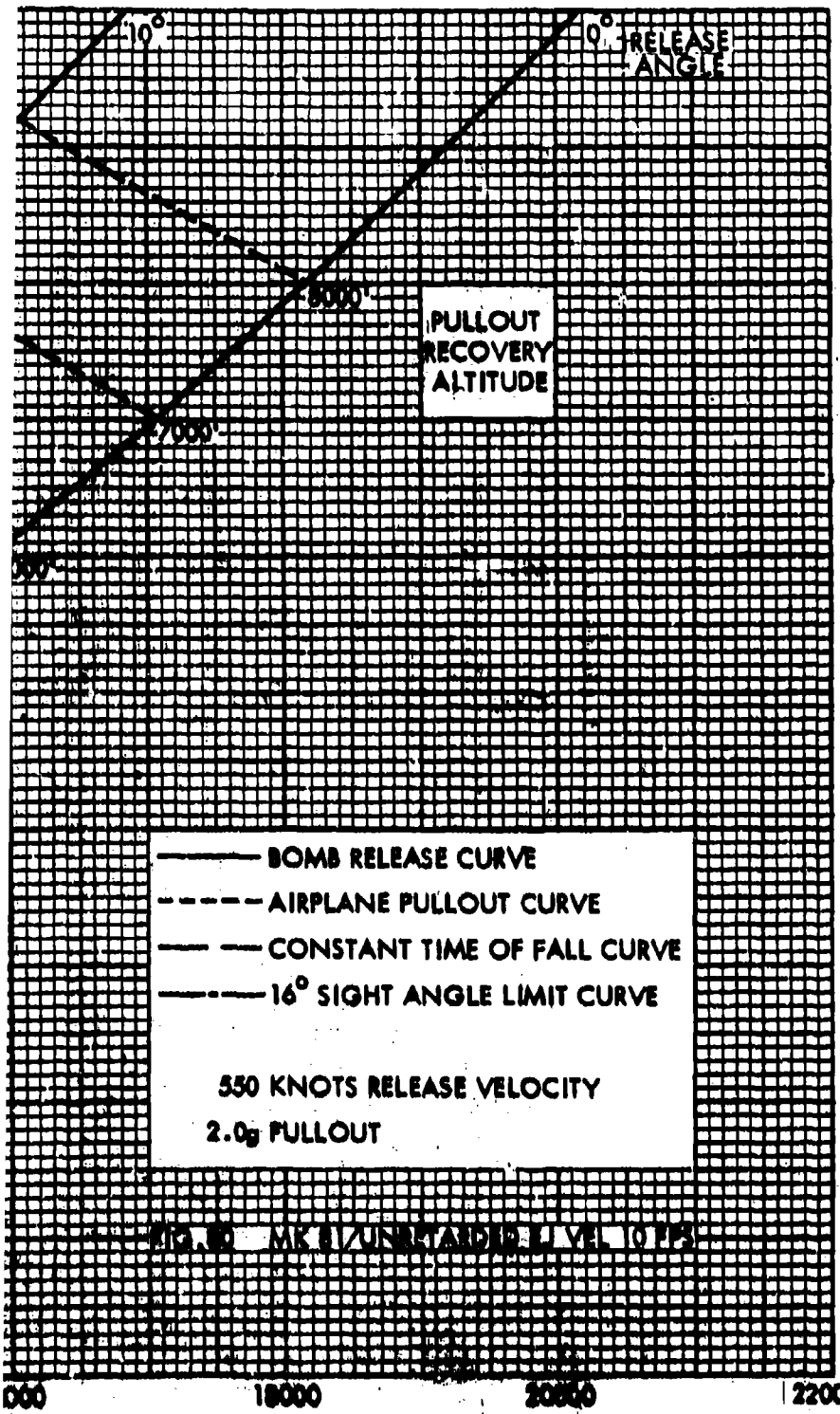
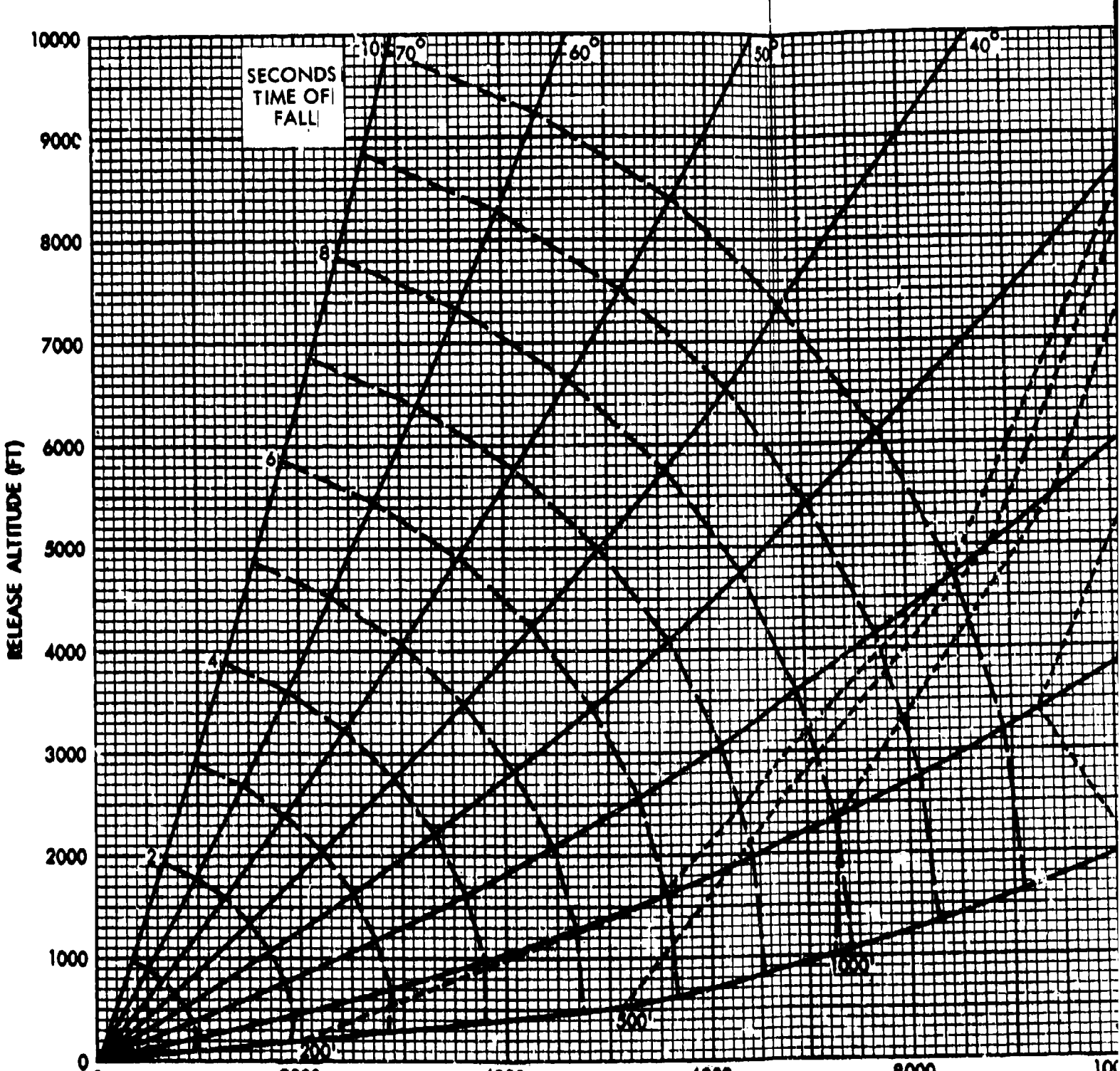


FIG. 10 MK 81/UNRETARDED LV (U)


SECONDS
TIME OF
FALL
70°
60°
50°
40°
10
8
6
4
2
1000'
500'
200'
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000

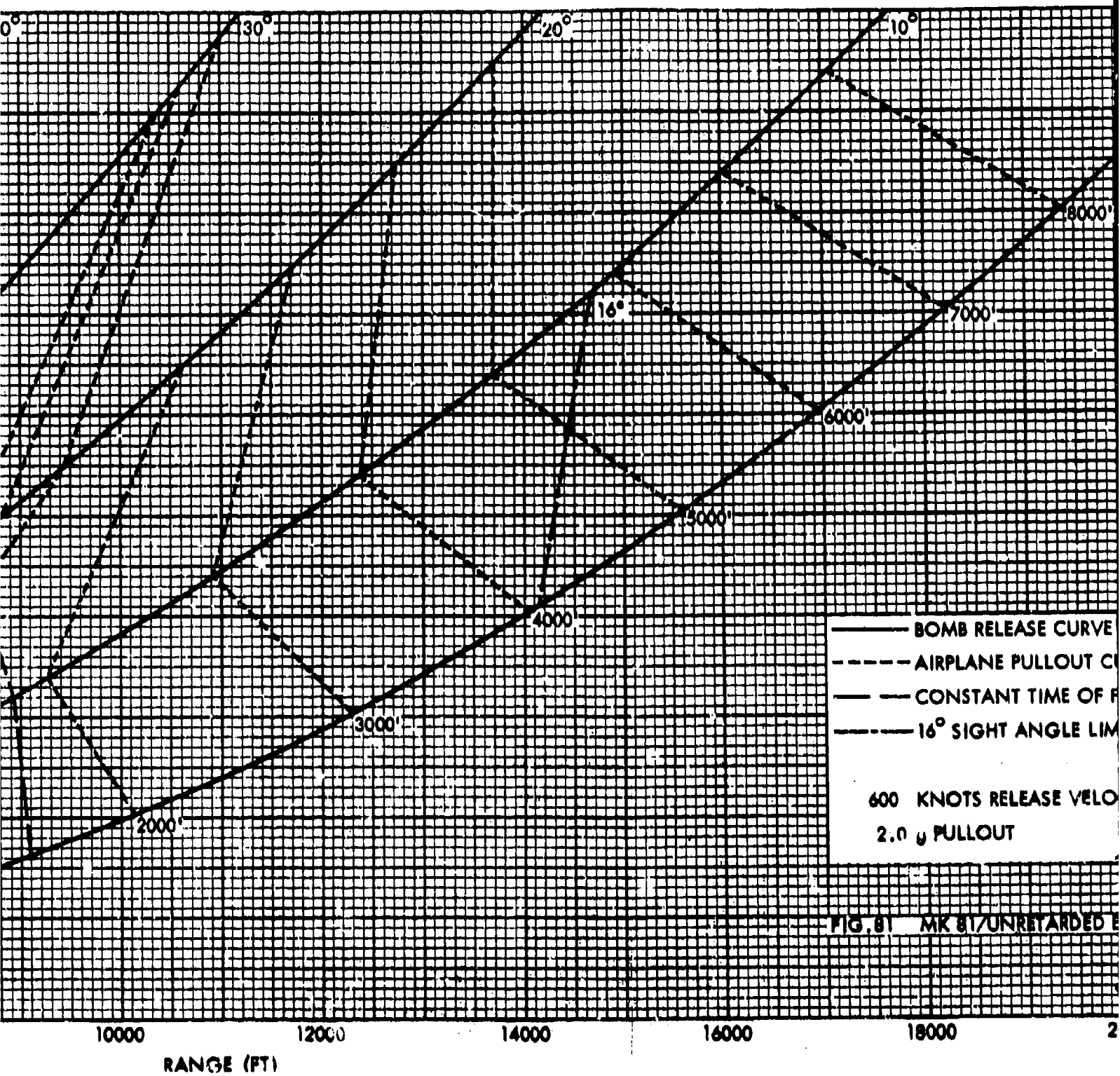


FIG. 81 MK 81/UNRETARDED

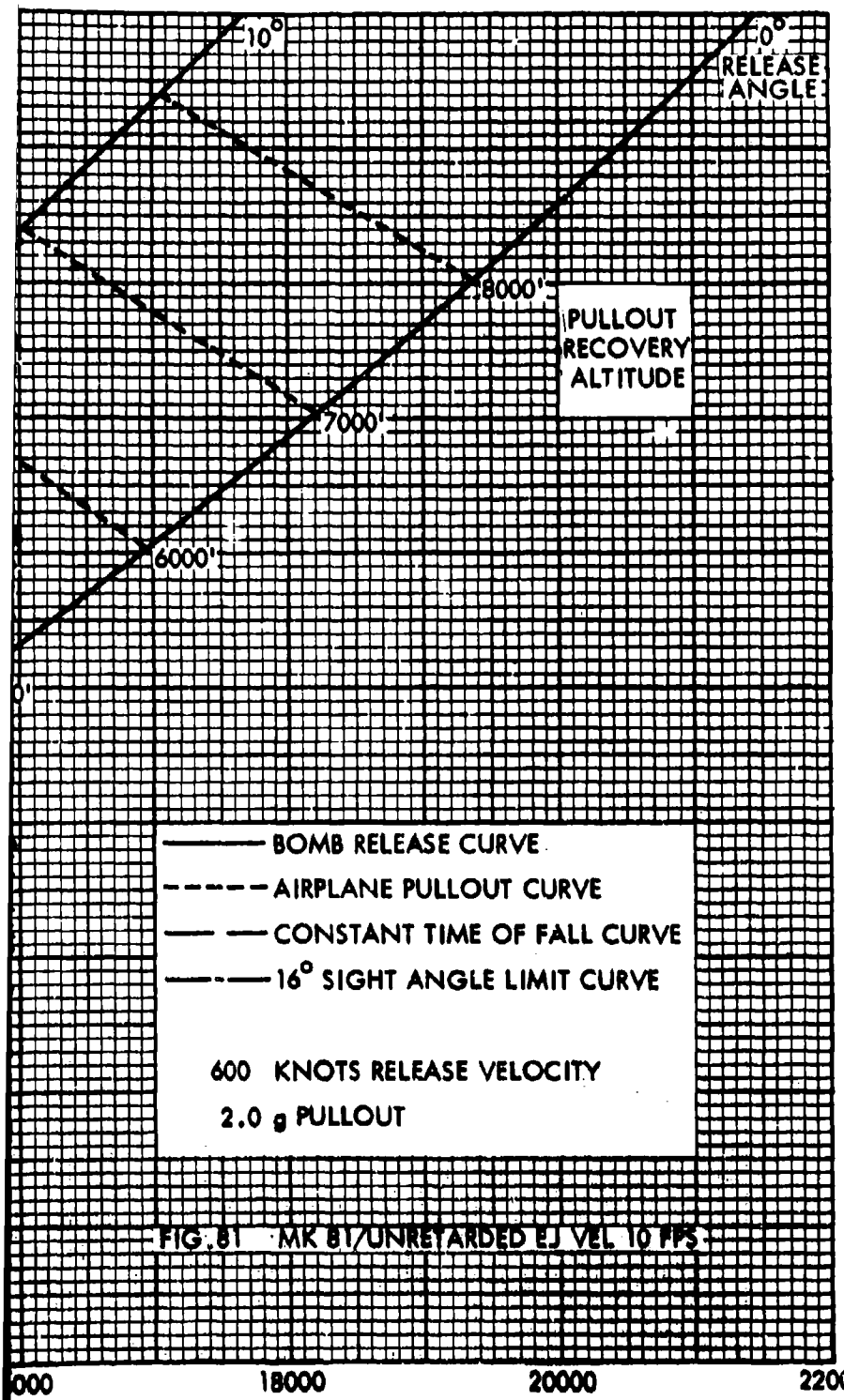


FIG. 81 MK 81/UNRETARDED EJ VEL 10 FPS

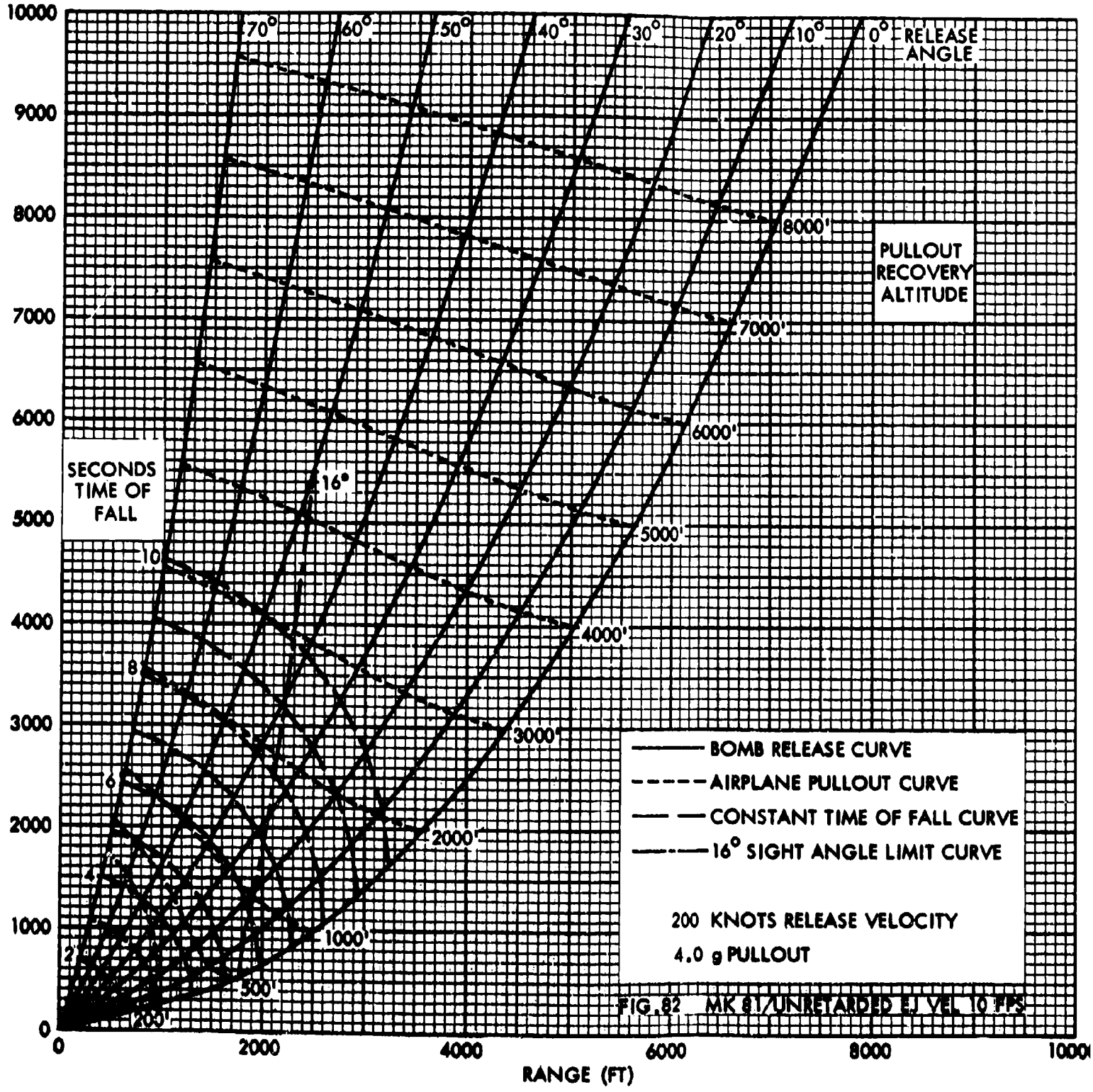
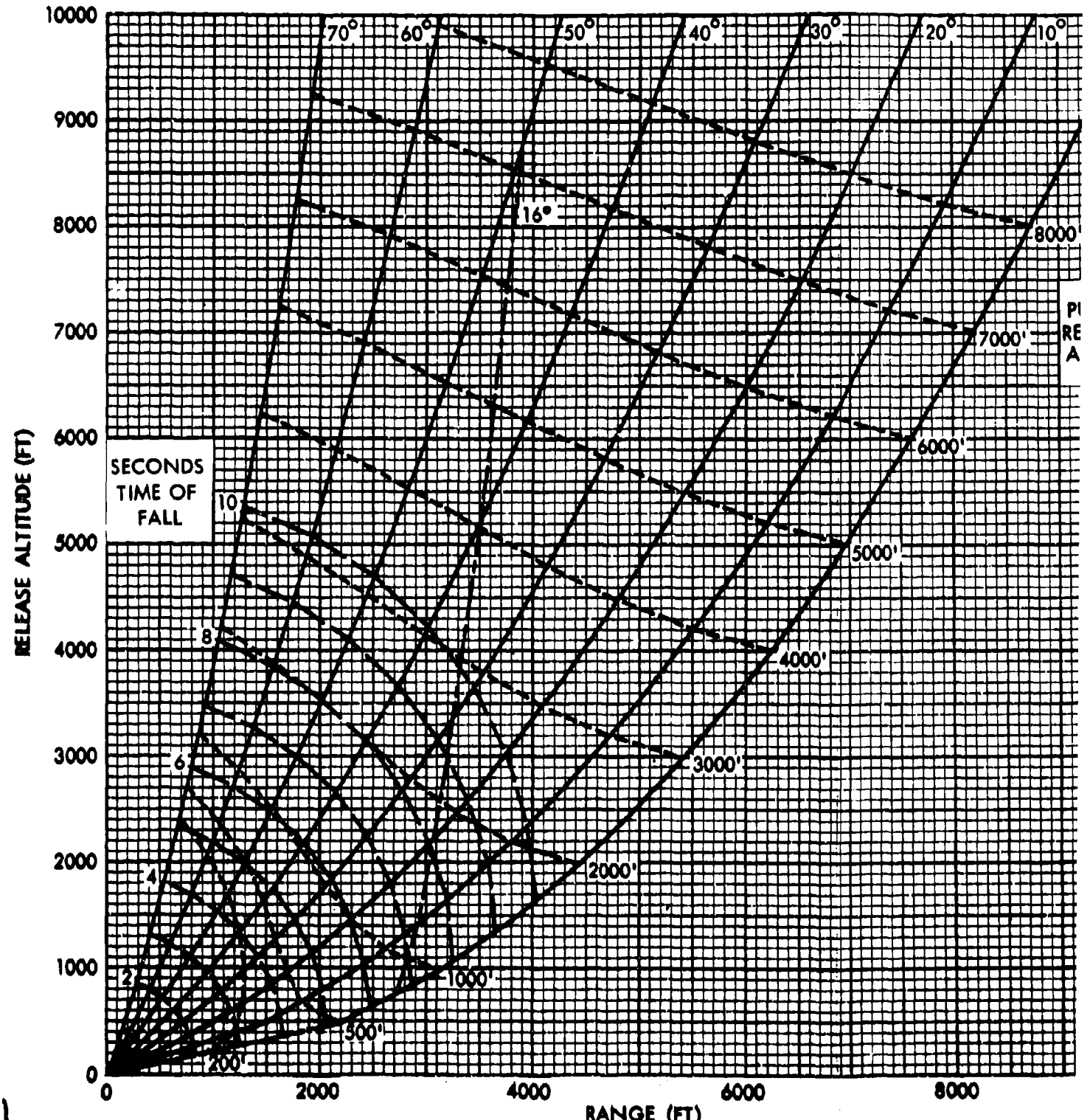
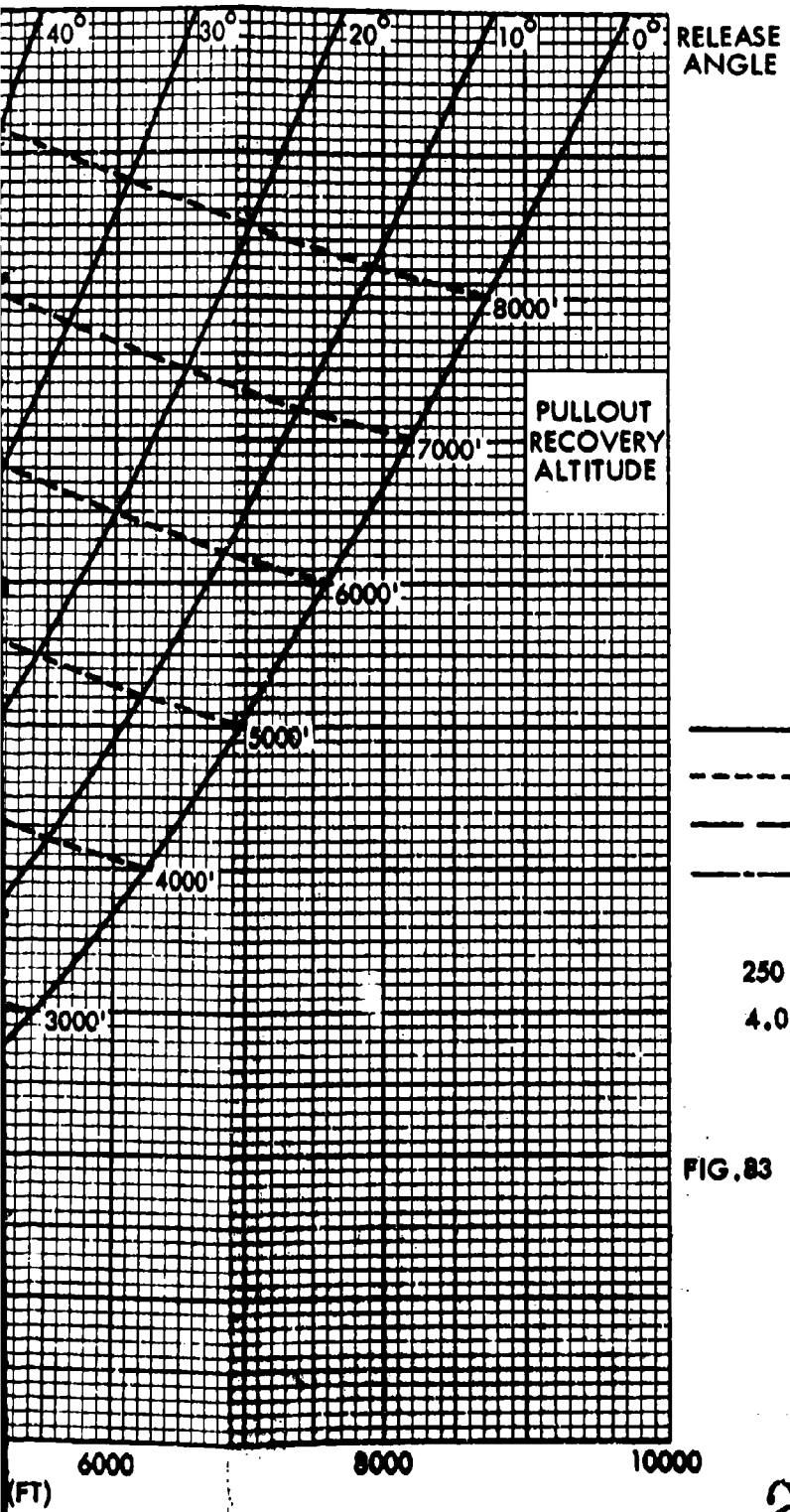


FIG. 82 MK 81/UNRETARDED EJ VEL 10 FPS


RELEASE ALTITUDE (FT)
RANGE (FT)
SECONDS TIME OF FALL
70°
60°
50°
40°
30°
20°
10°
16°
8000'
7000'
6000'
5000'
4000'
3000'
2000'
1000'
500'
200'
10
8
6
4
2
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

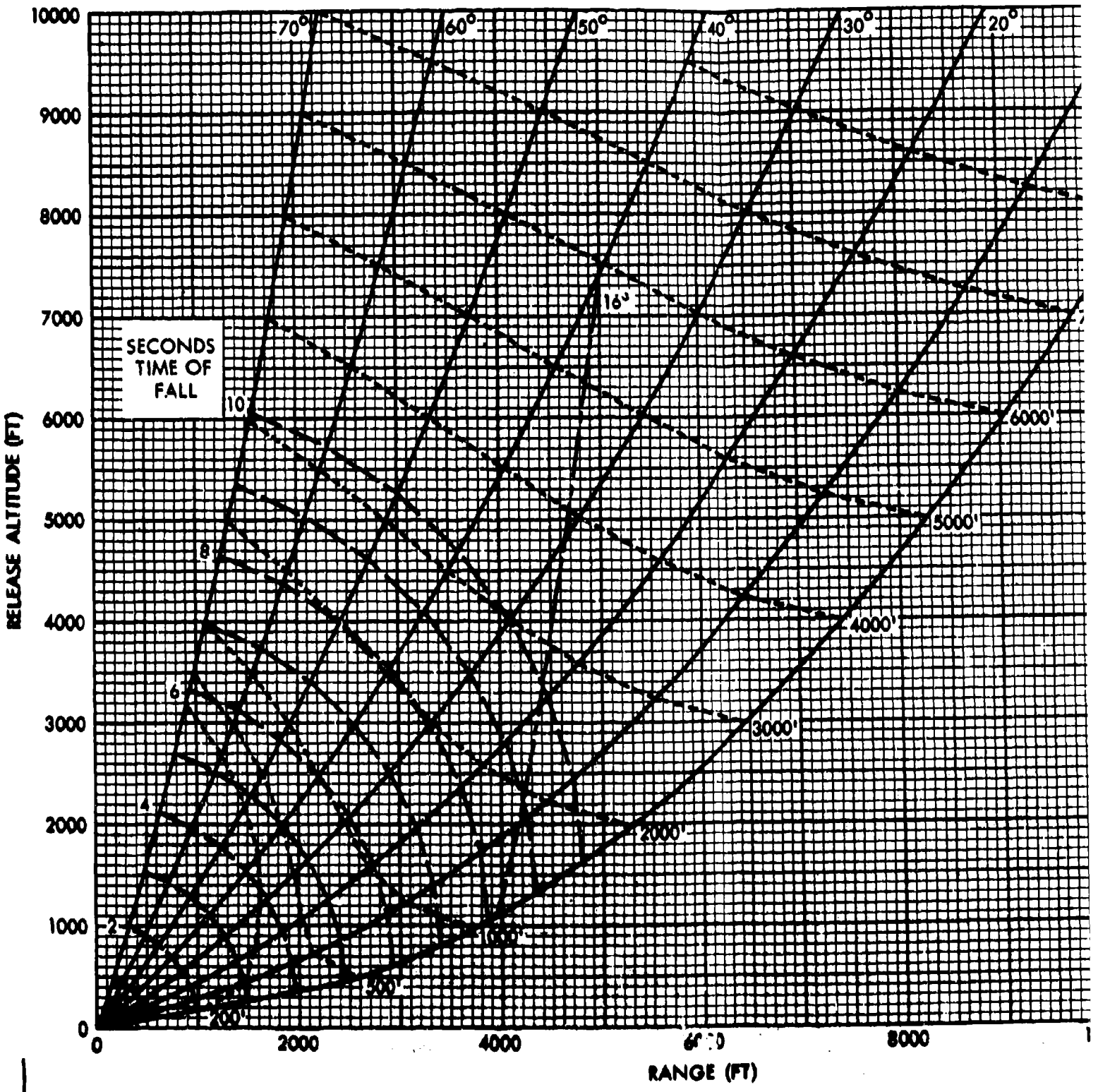
— — CONSTANT TIME OF FALL CURVE

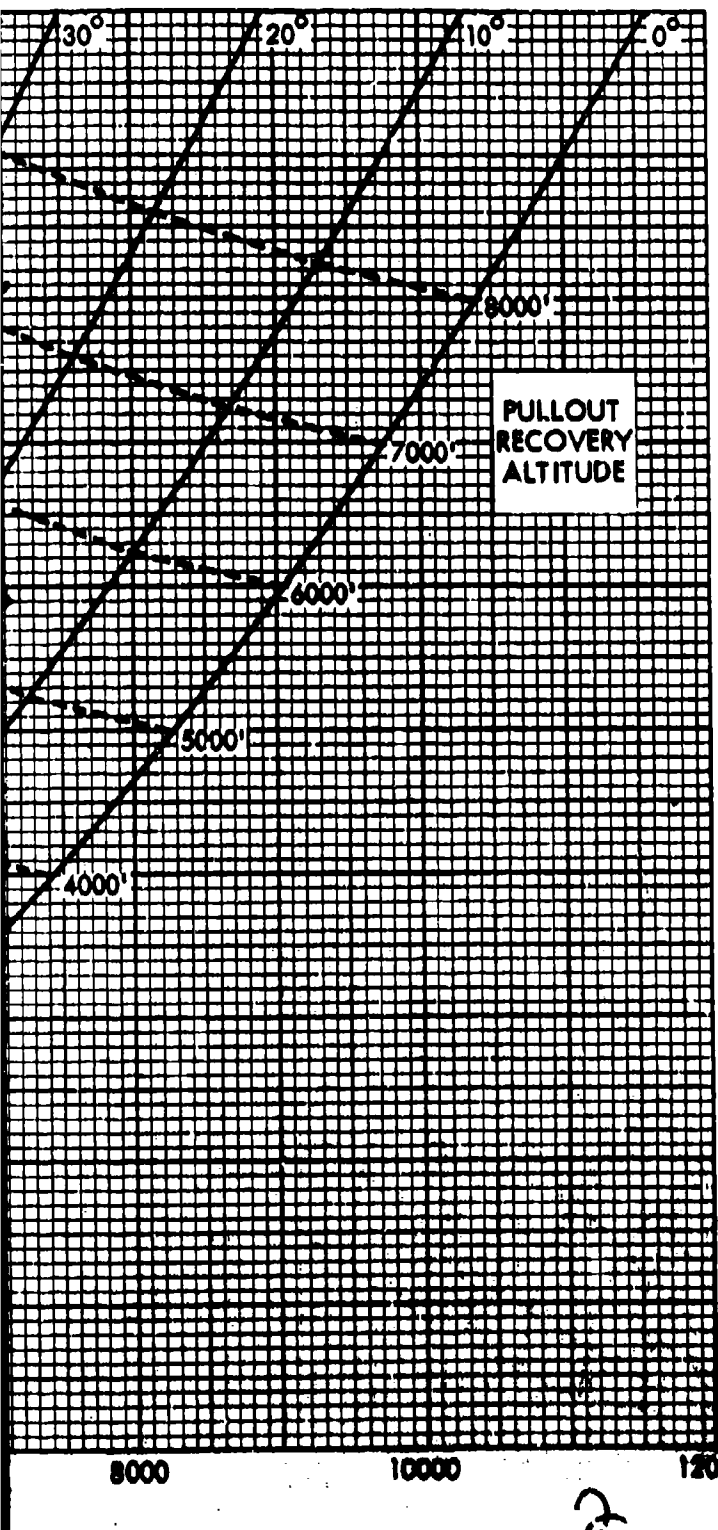
——·—— 16° SIGHT ANGLE LIMIT CURVE

250 KNOTS RELEASE VELOCITY

4.0 g PULLOUT

FIG. 83 MK 81/UNRETARDED EJ VEL 10 FPS


70°
60°
50°
40°
30°
20°
SECONDS TIME OF FALL
10
8
6
4
2
16"
6000'
5000'
4000'
3000'
2000'
1000'
500'
200'
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
RELEASE ALTITUDE (FT)
0
2000
4000
8000
RANGE (FT)



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

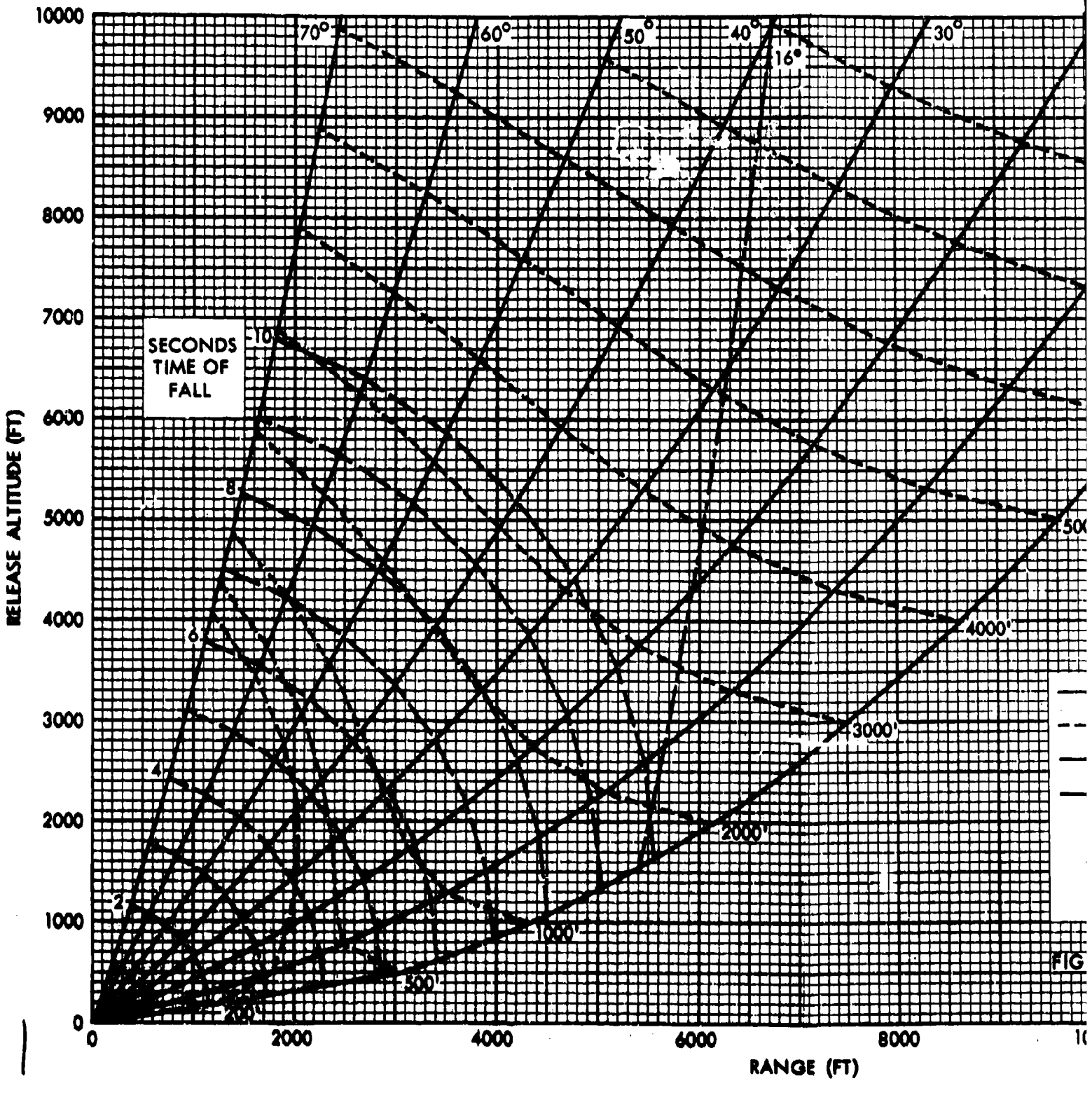
— — CONSTANT TIME OF FALL CURVE

—·— 16° SIGHT ANGLE LIMIT CURVE

300 KNOTS RELEASE VELOCITY

4.0 g PULLOUT

FIG. 84 MK 81/UNRETARDED EJ VEL 10 FPS


70°
60°
50°
40°
30°
16°
SECONDS TIME OF FALL
10
8
6
4
2
4000'
3000'
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
RANGE (FT)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
2000
4000
6000
8000

FIG

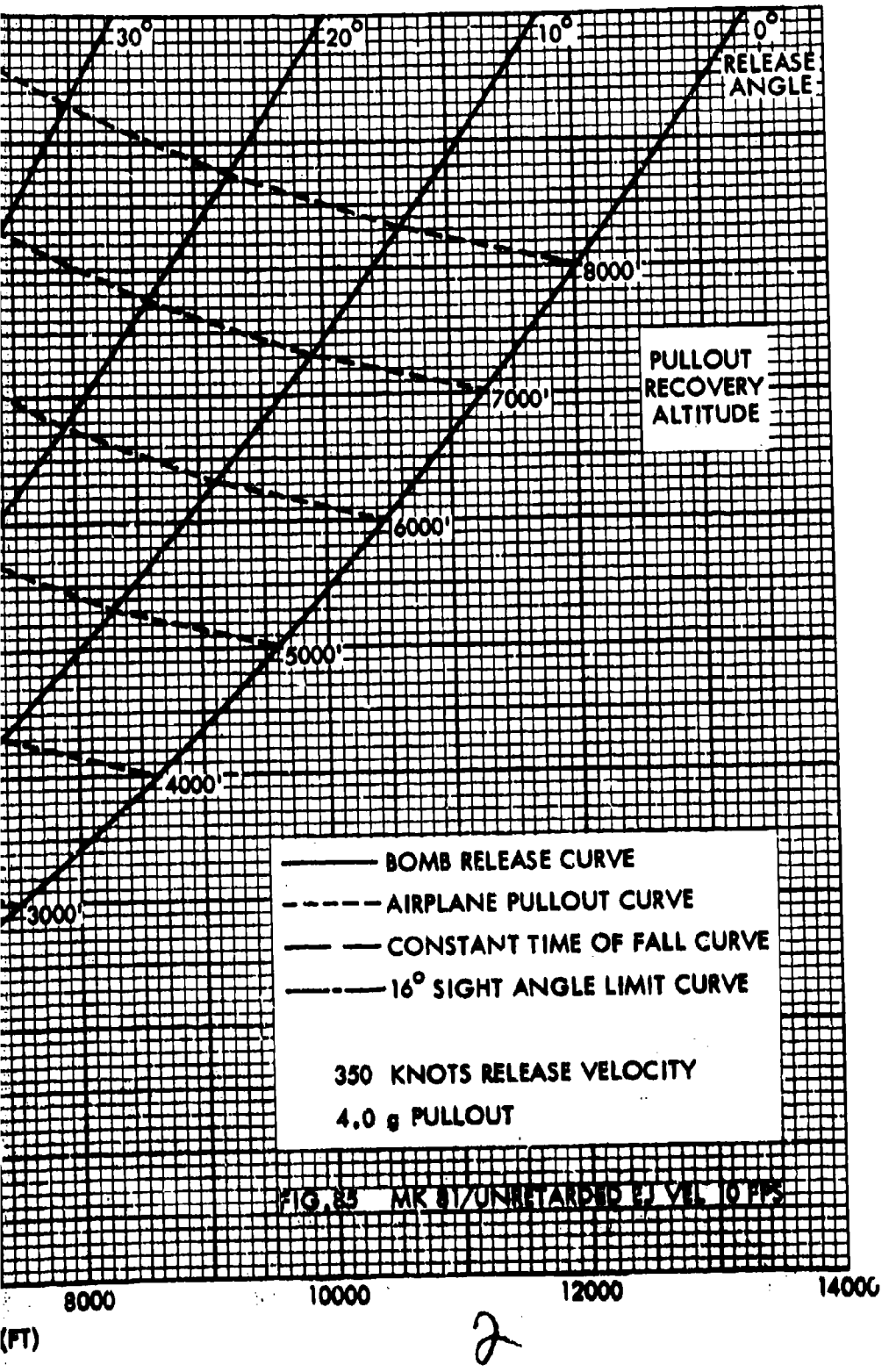
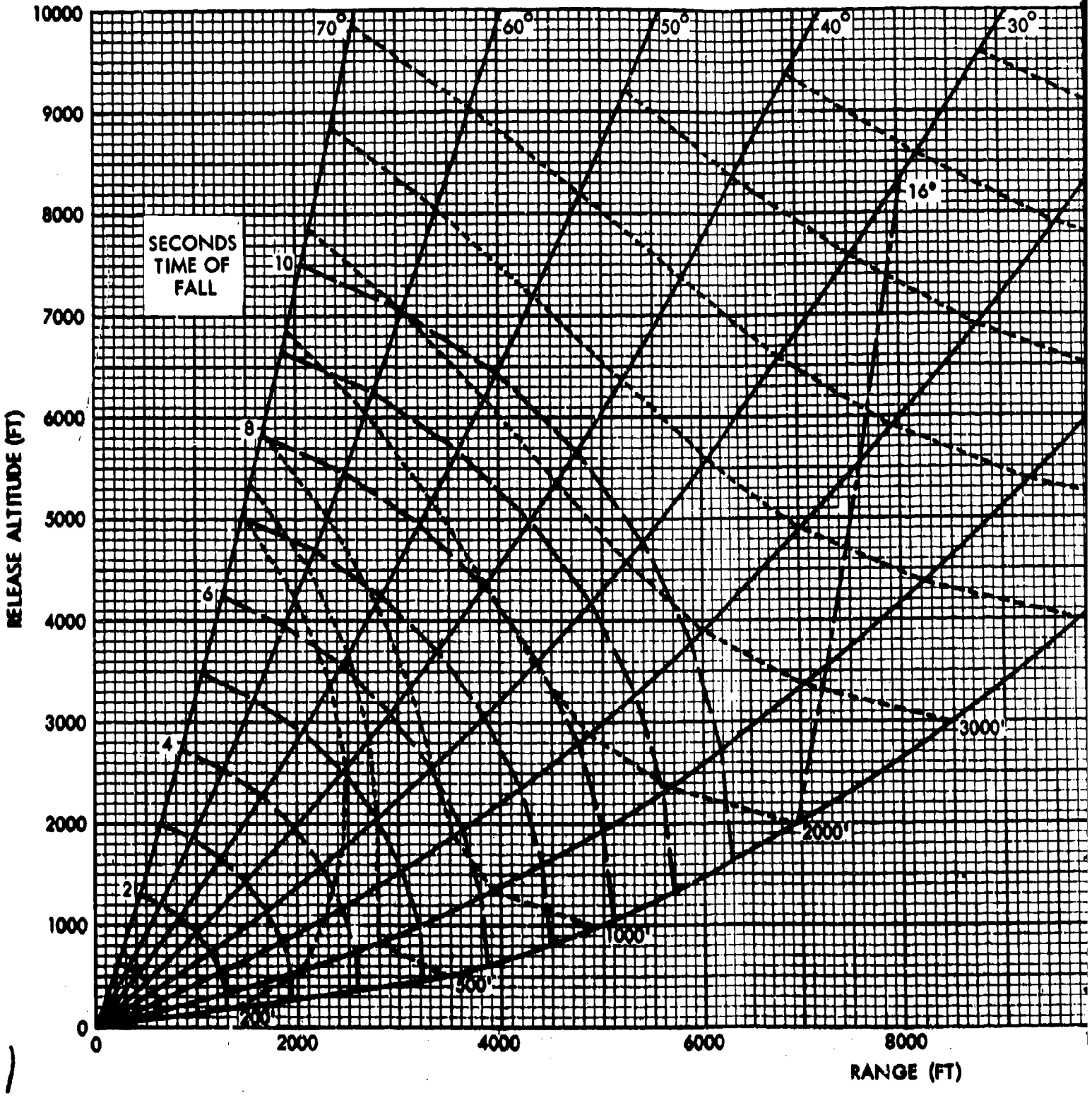


FIG. 83 MK 81/UNRETARDED LJ VEL 10 FPS


70°
60°
50°
40°
30°
16°
SECONDS TIME OF FALL
10
8
6
4
2
3000'
2000'
1000'
500'
200'
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
RELEASE ALTITUDE (FT)
0
2000
4000
6000
8000
RANGE (FT)

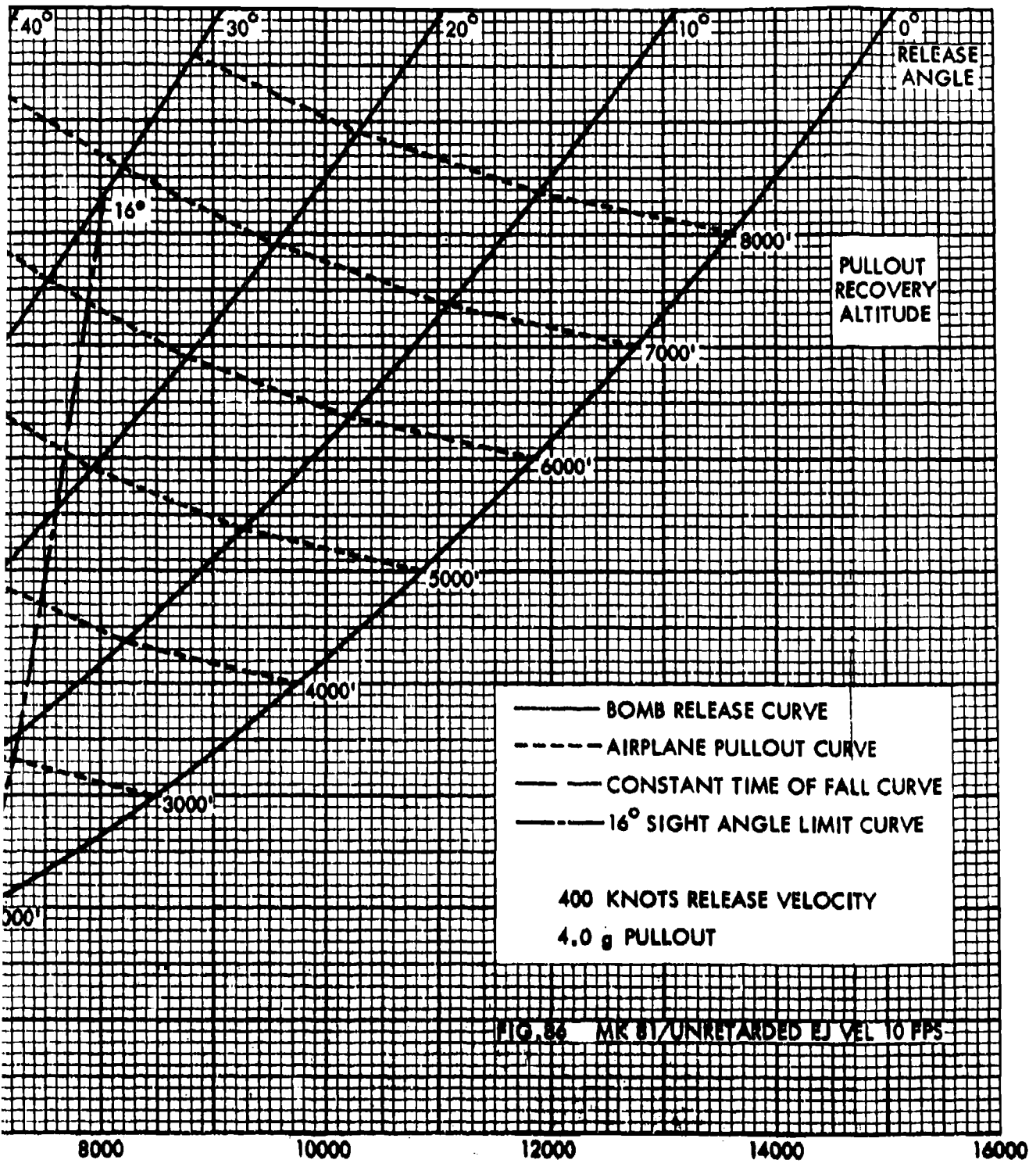
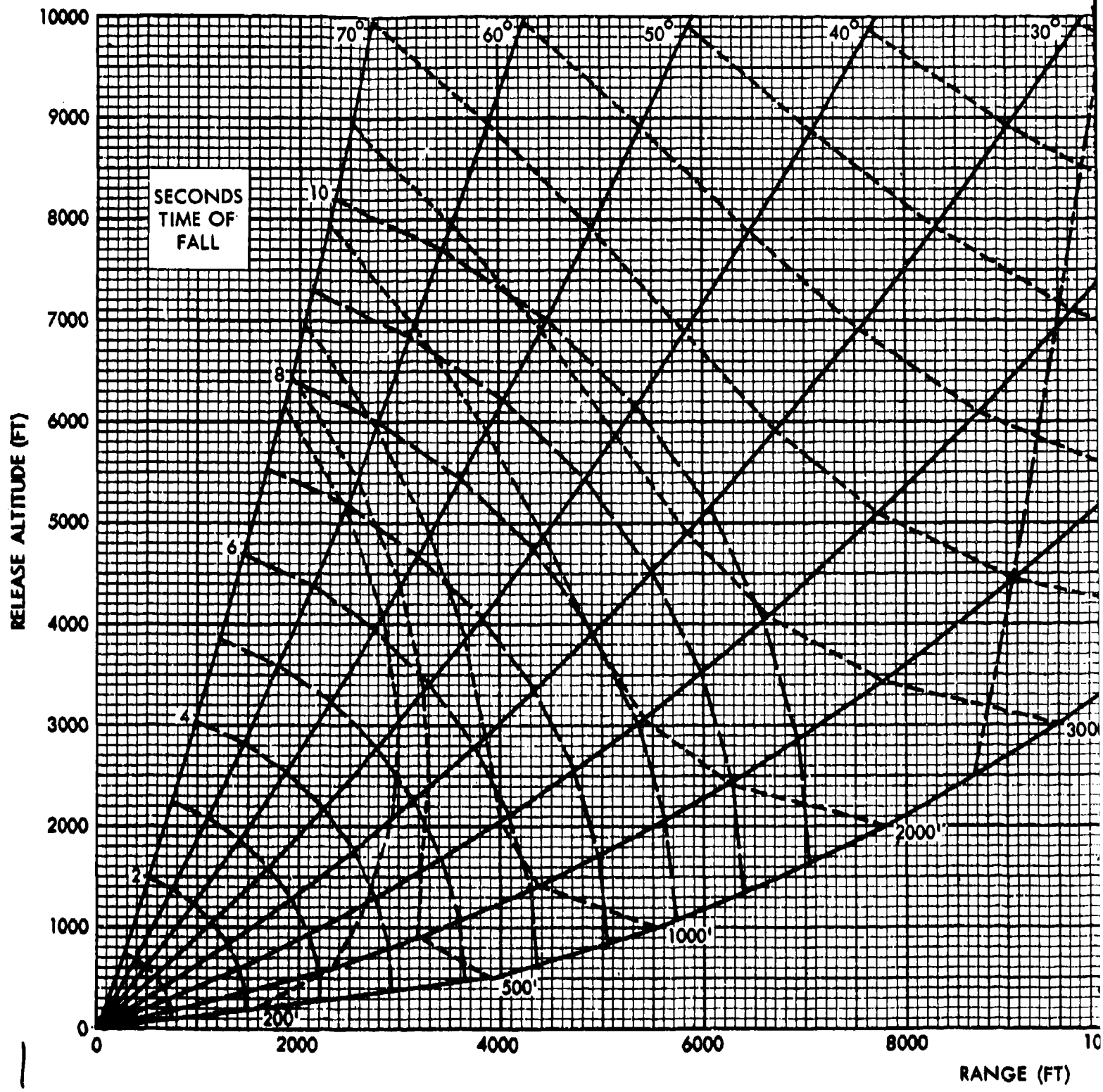


FIG. 86 MK 81/UNRETARDED EJ VEL 10 FPS


70°
60°
50°
40°
30°
SECONDS TIME OF FALL
10
8
6
4
2
1000'
500'
200'
2000'
300
RELEASE ALTITUDE (FT)
RANGE (FT)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
2000
4000
6000
8000
10

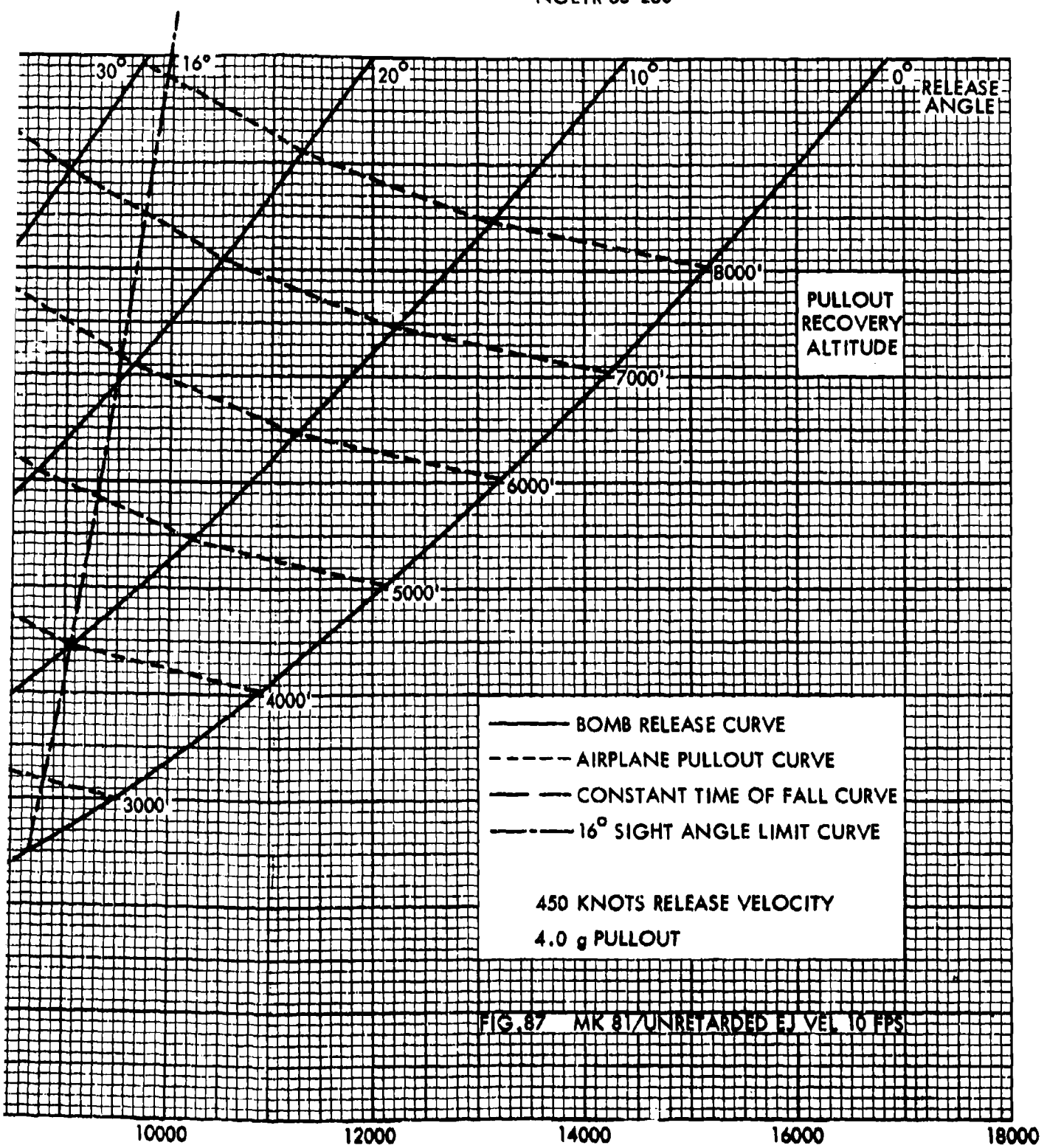
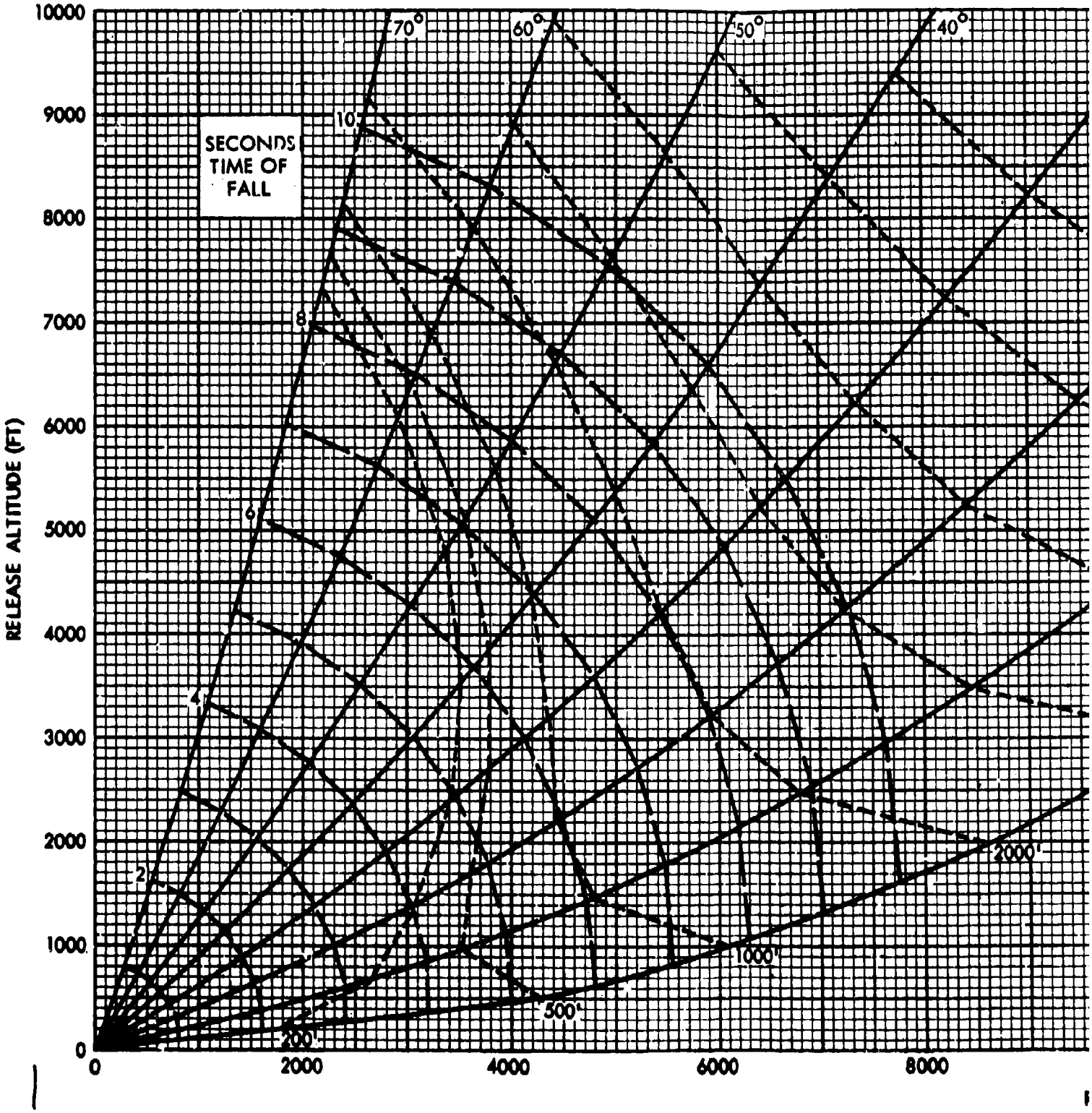


FIG. 87 MK 81/UNRETARDED EJ VEL 10 FPS


RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
70°
60°
50°
40°
SECONDS TIME OF FALL
10
8
6
4
2
2000'
1000'
500'
200'

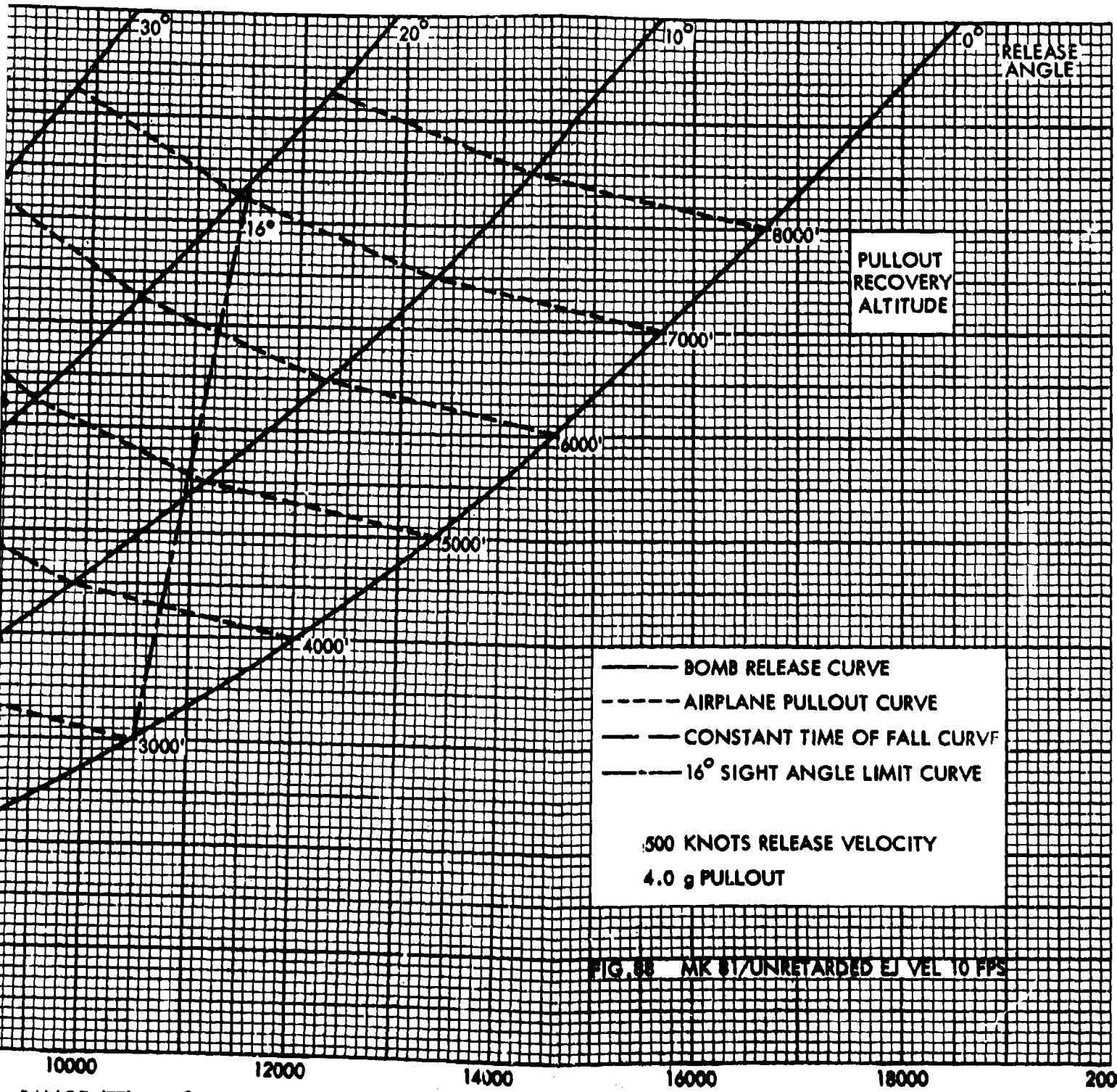
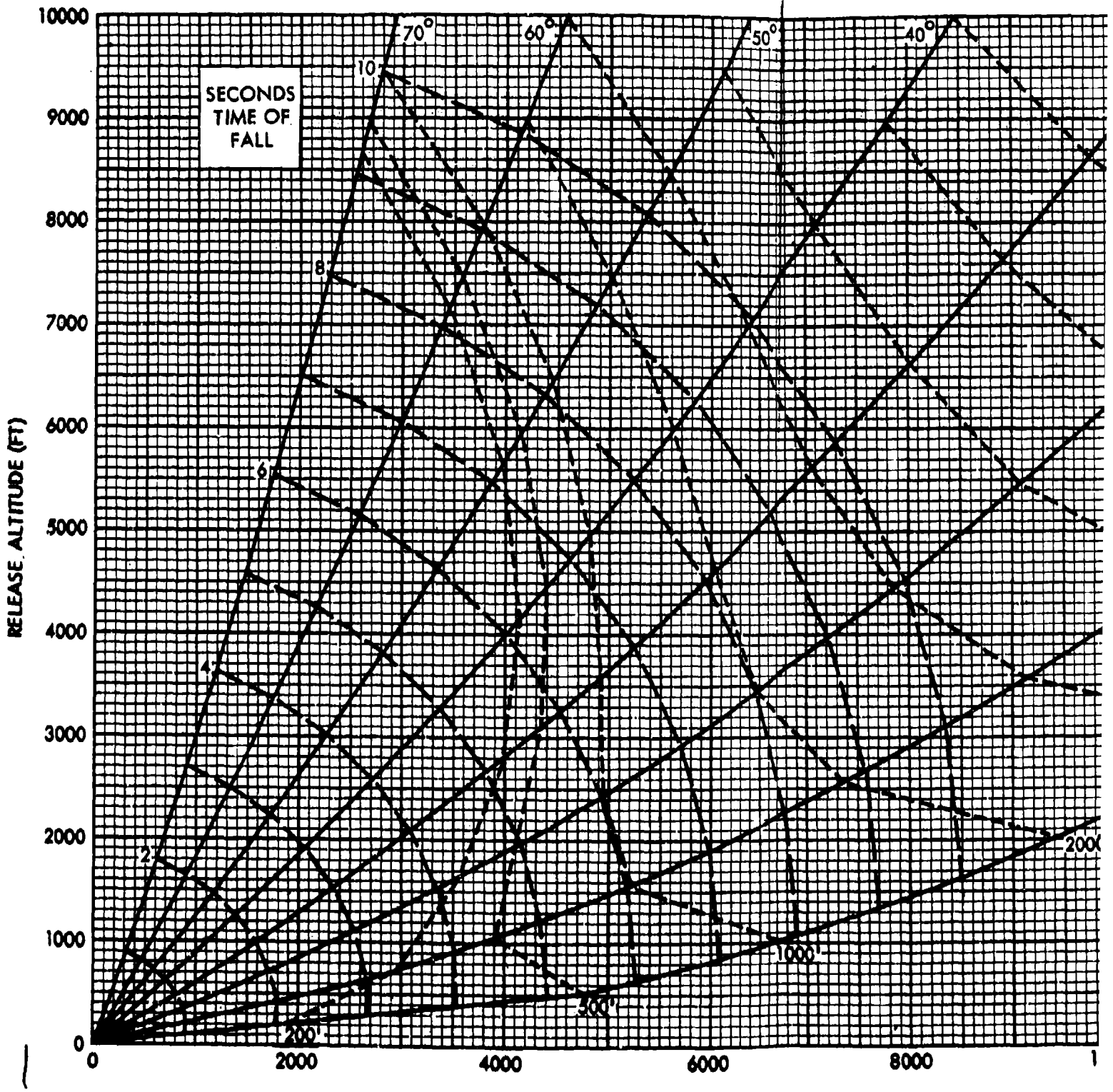


FIG. 88 MK 81/UNRETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
70°
60°
50°
40°
10
8
6
4
2
200'
300'
1000'
2000
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000

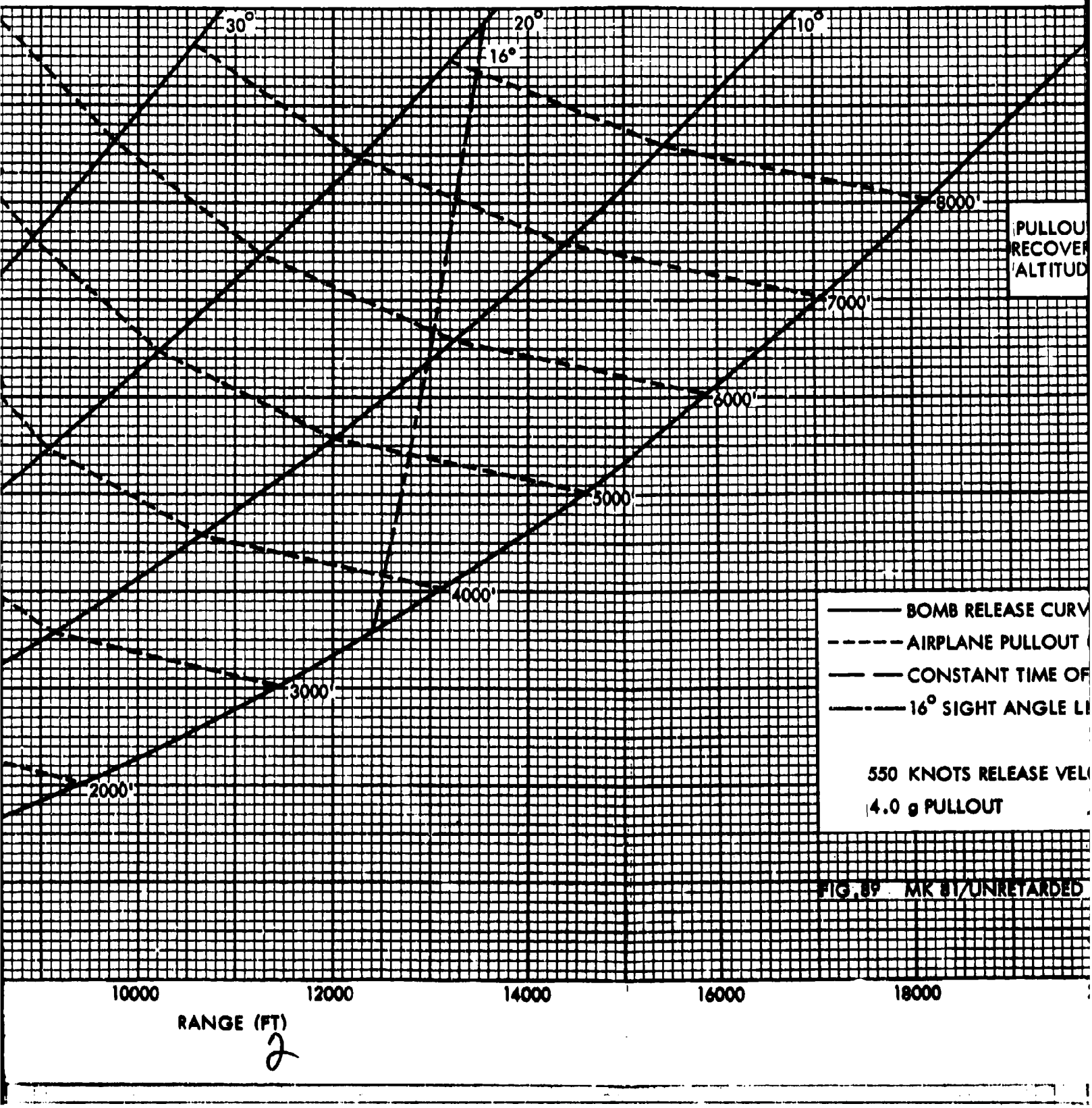


FIG. 89 MK 81/UNRETARDED

2

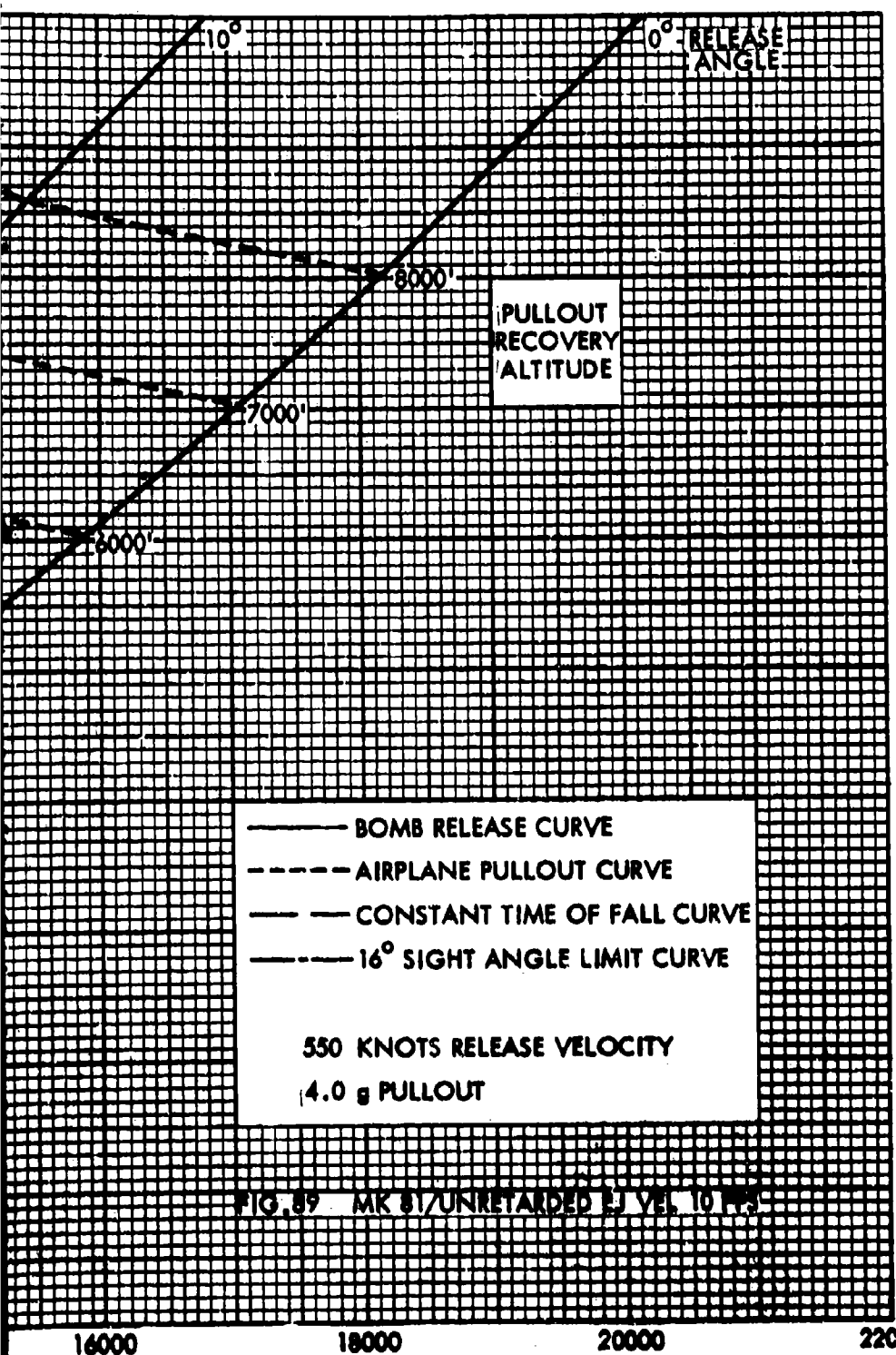
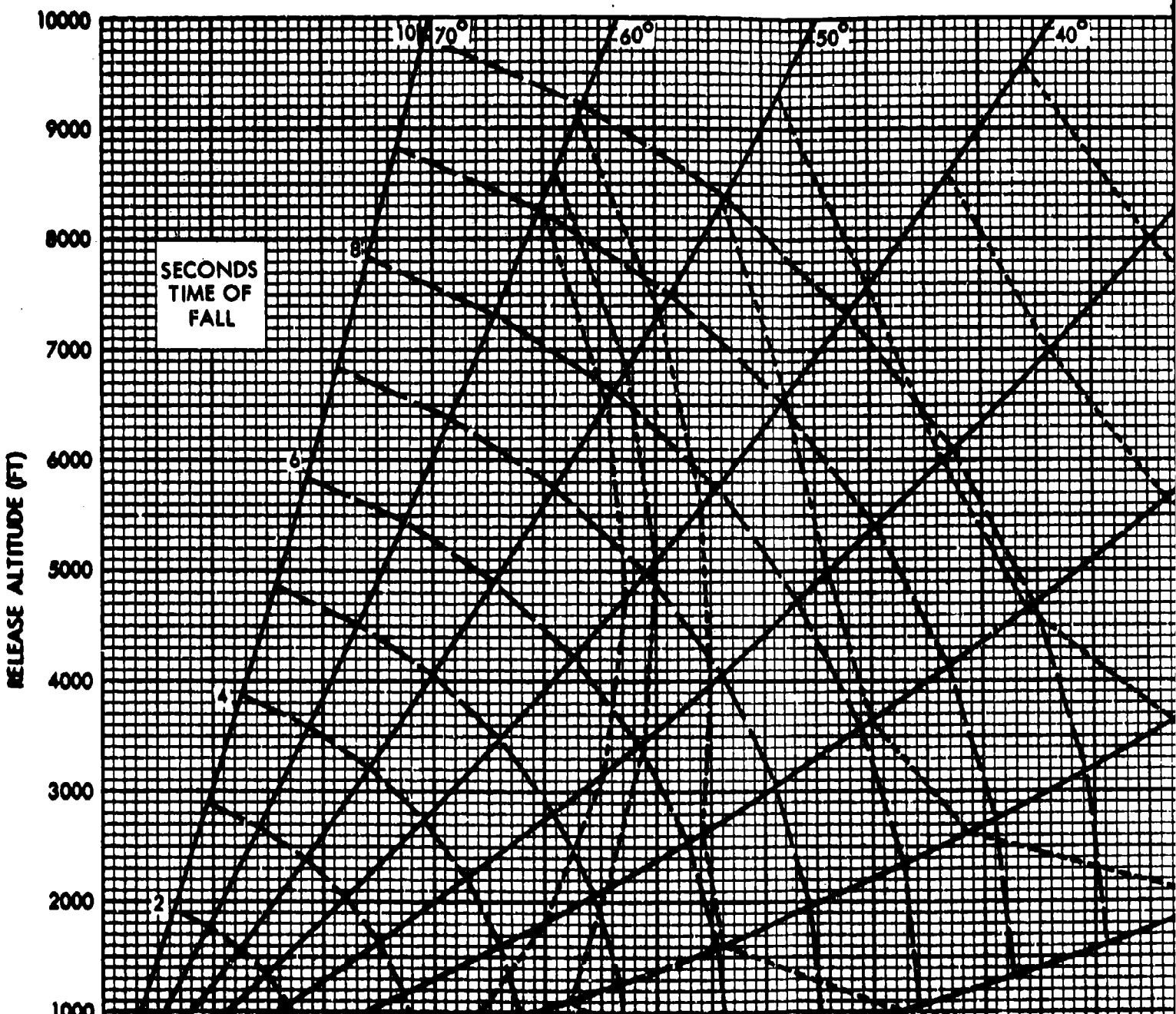


FIG. 89 MK 81/UNRETARDED 3 J VEL 10 FPS


RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
SECONDS TIME OF FALL
10
8
6
4
2
70°
60°
50°
40°
1000'
500'
200'

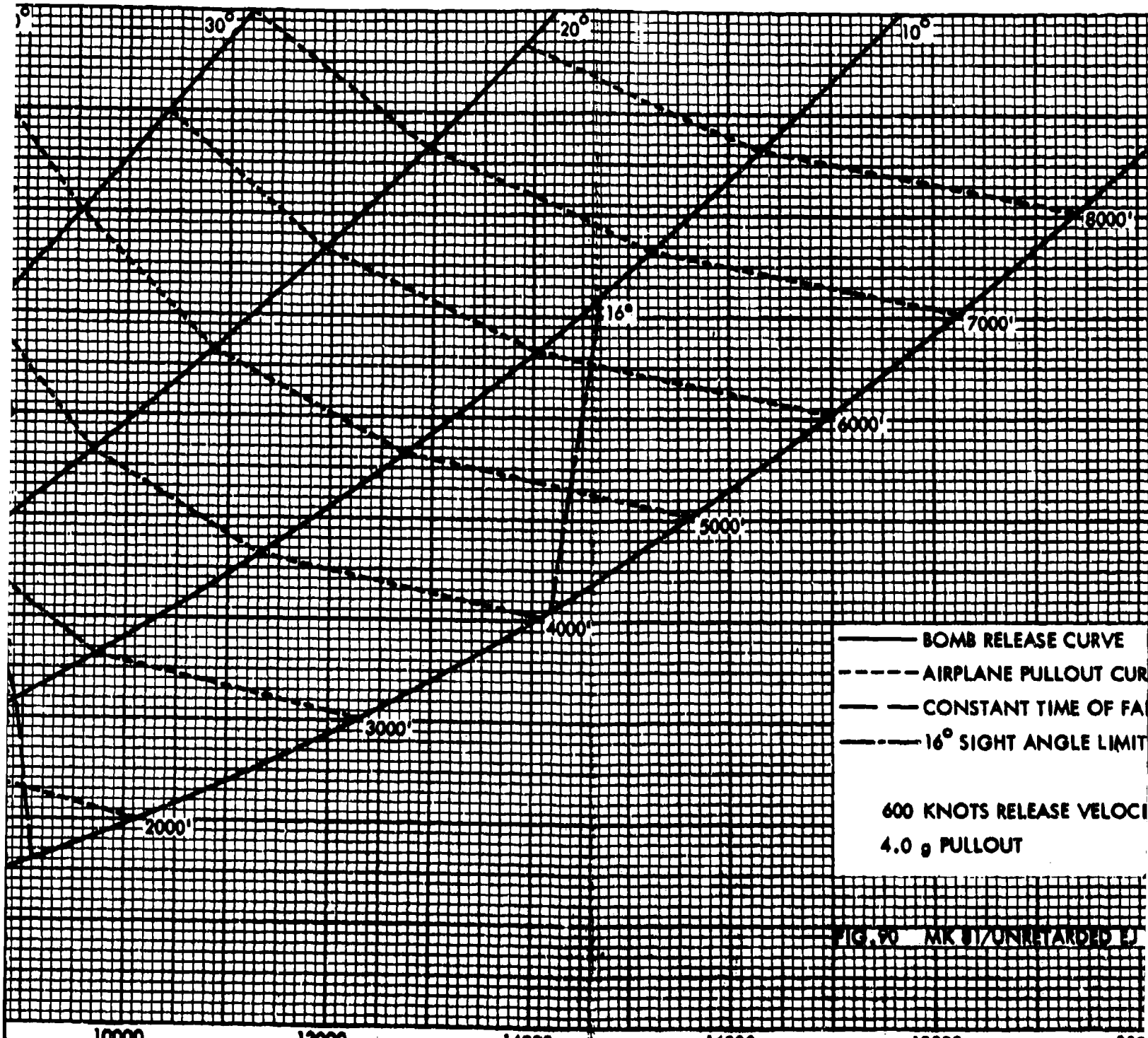


FIG. 90 MK 81/UNRETARDED BO

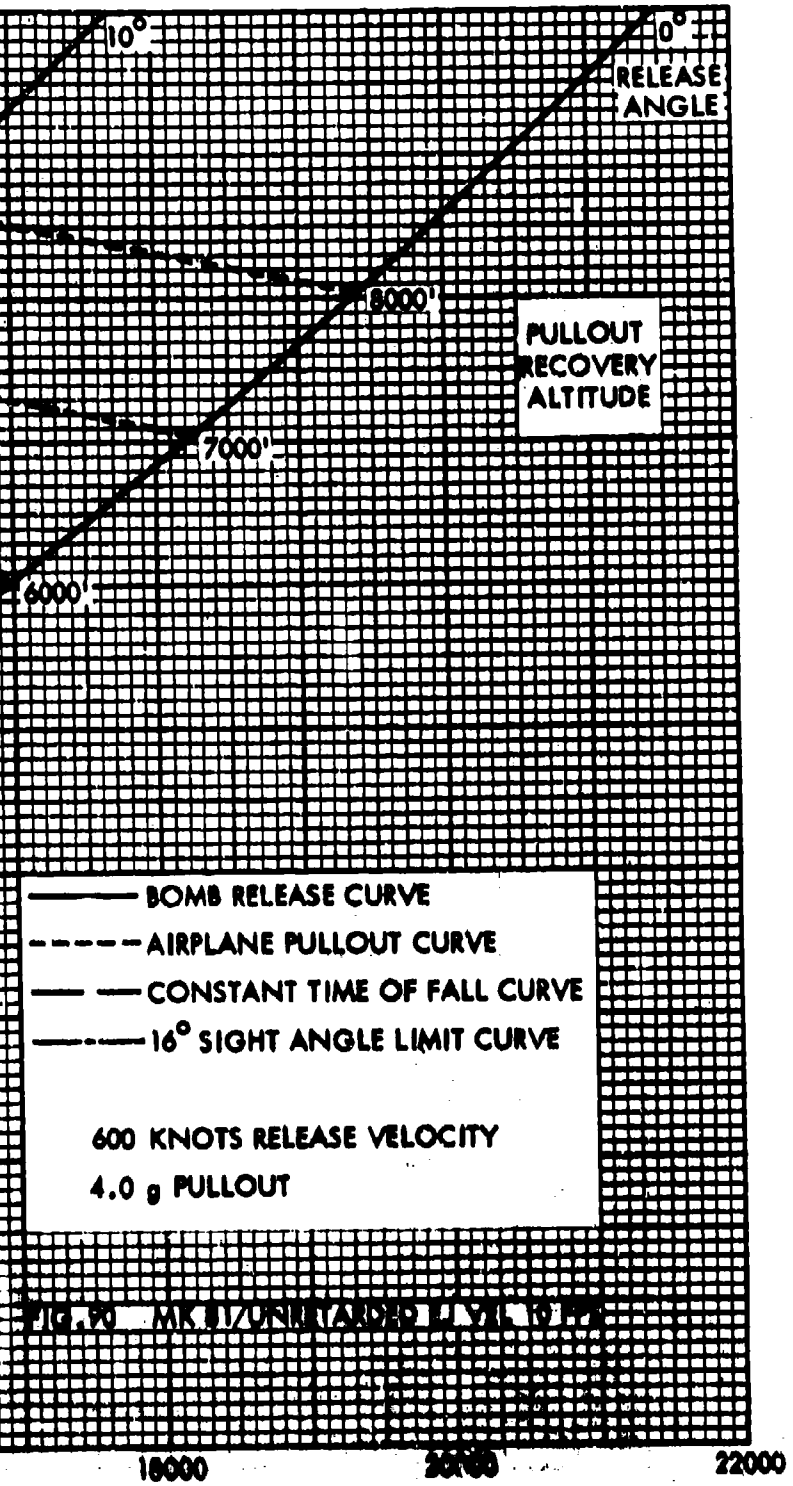
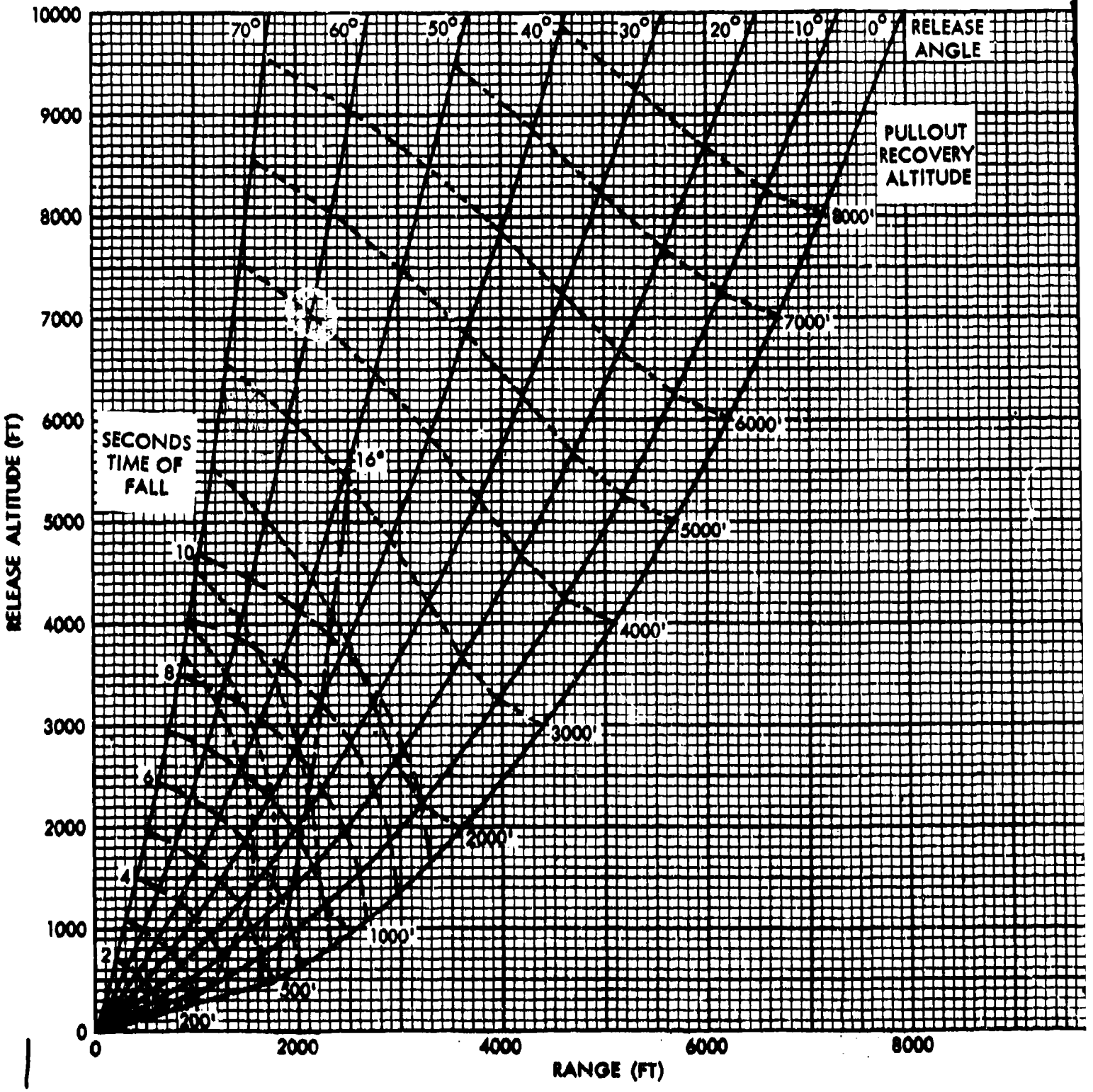
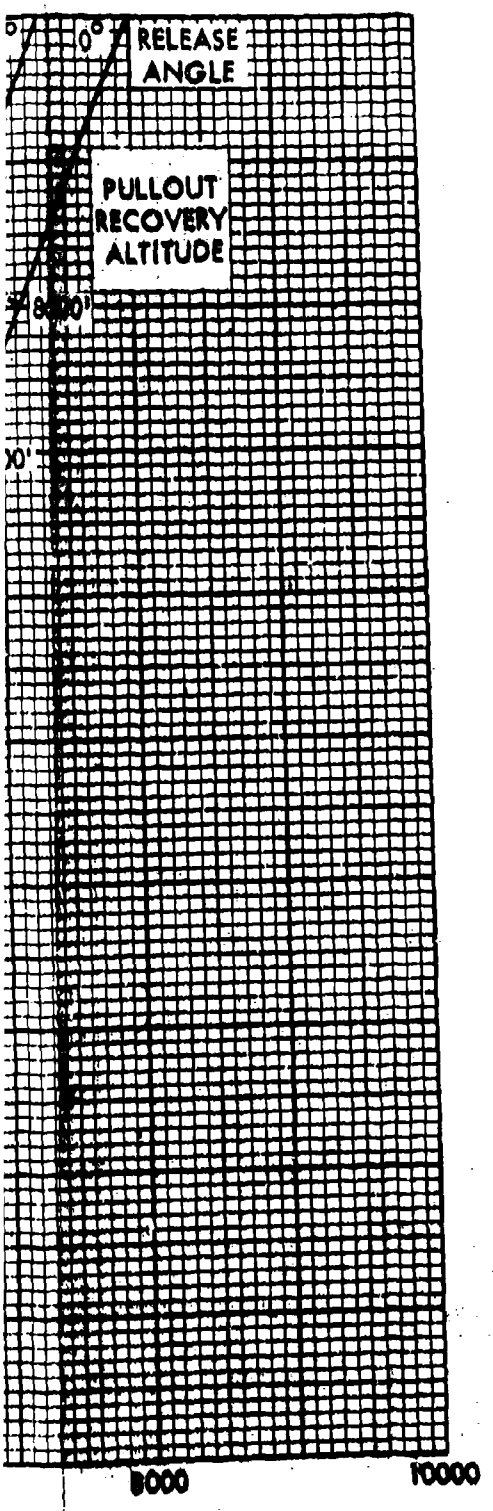


FIG. 90 MK 81/UNRETARDED LEVEL TOSS


RELEASE ANGLE
70°
60°
50°
40°
30°
20°
10°
0°
PULLOUT RECOVERY ALTITUDE
8000'
7000'
6000'
5000'
4000'
3000'
2000'
1000'
500'
200'
SECONDS TIME OF FALL
16
10
8
6
4
2
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
RANGE (FT)



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

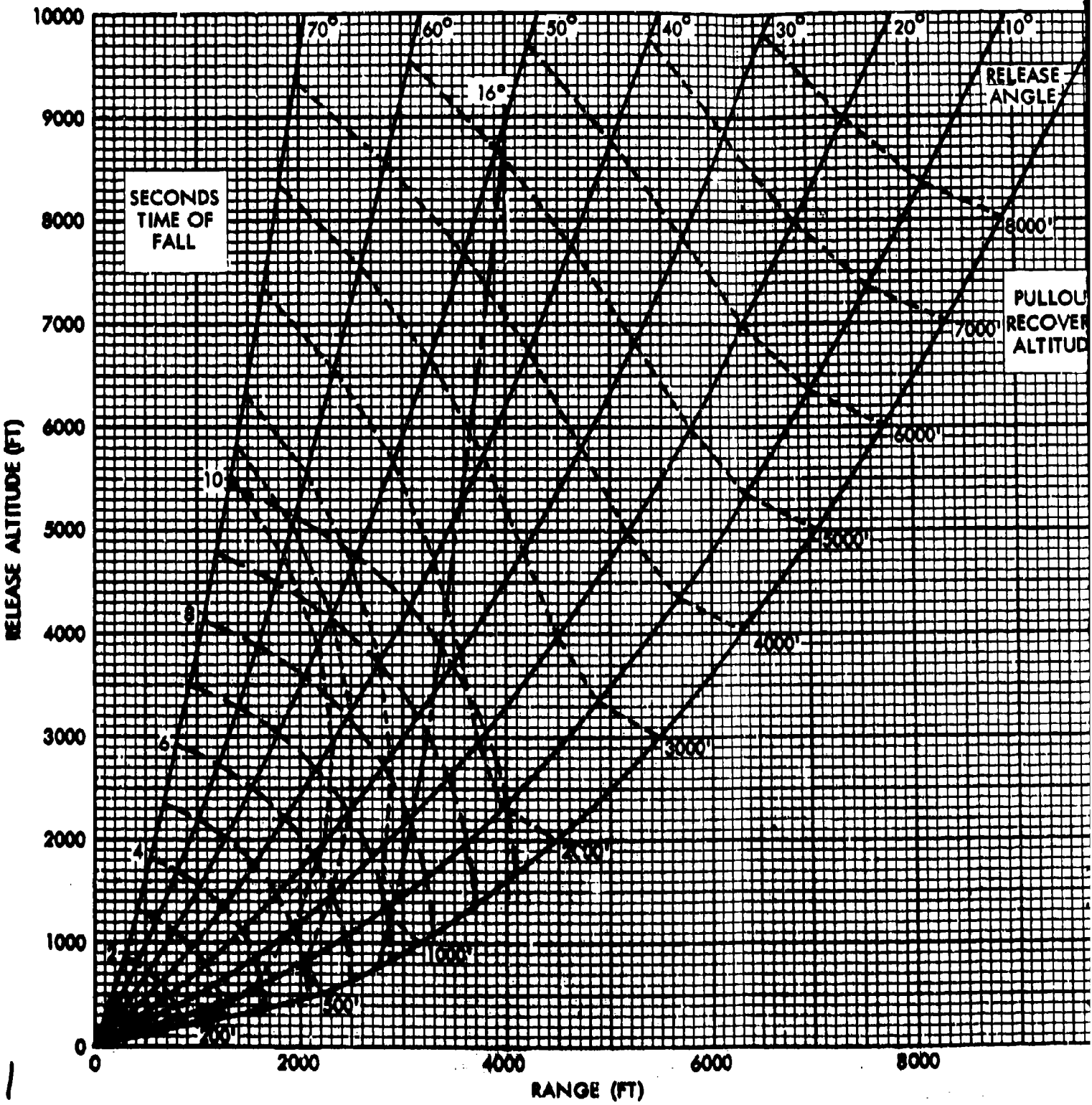
— — CONSTANT TIME OF FALL CURVE

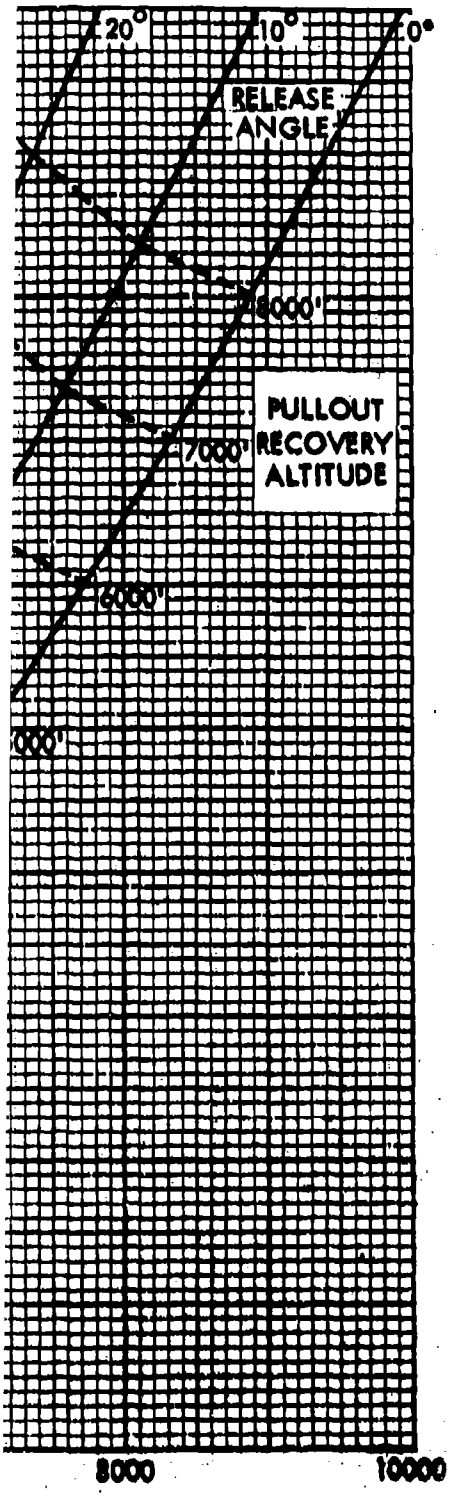
——·—— 16° SIGHT ANGLE LIMIT CURVE

200 KNOTS RELEASE VELOCITY

2.0 g PULLOUT

FIG. 91 MK 82/UNRETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
RELEASE ANGLE
PULLOU
RECOVER
ALTITUD
70°
60°
50°
40°
30°
20°
10°
16°
10"
8"
6"
4"
2"
8000'
7000'
6000'
5000'
4000'
3000'
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
RANGE (FT)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
2000
4000
6000
8000



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

— — CONSTANT TIME OF FALL CURVE

——·—— 16° SIGHT ANGLE LIMIT CURVE

250 KNOTS RELEASE VELOCITY

2.0 g PULLOUT

FIG. 92 MK 82/UNRETARDED EJ VEL 10 FPS

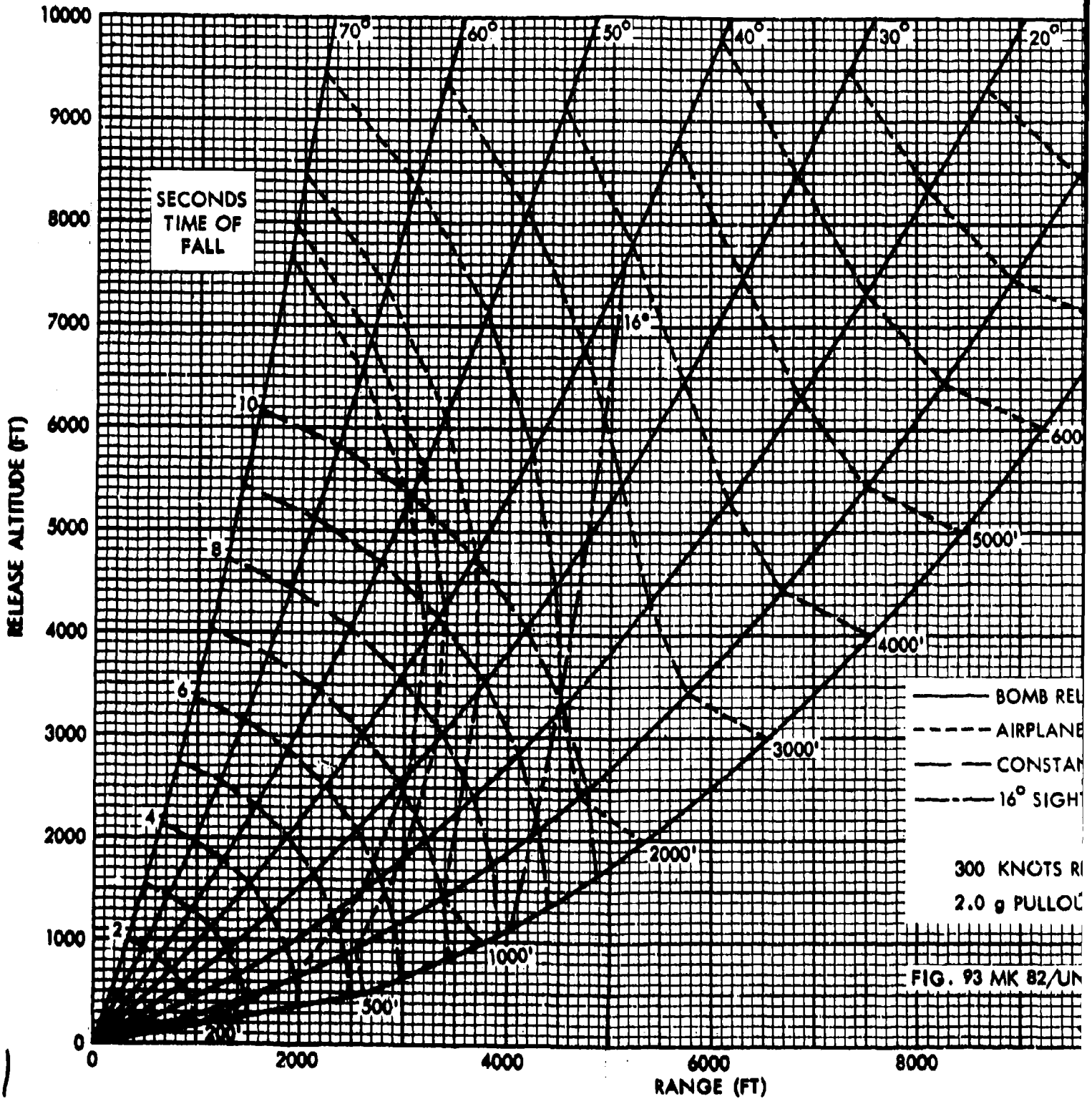


FIG. 93 MK 82/UN

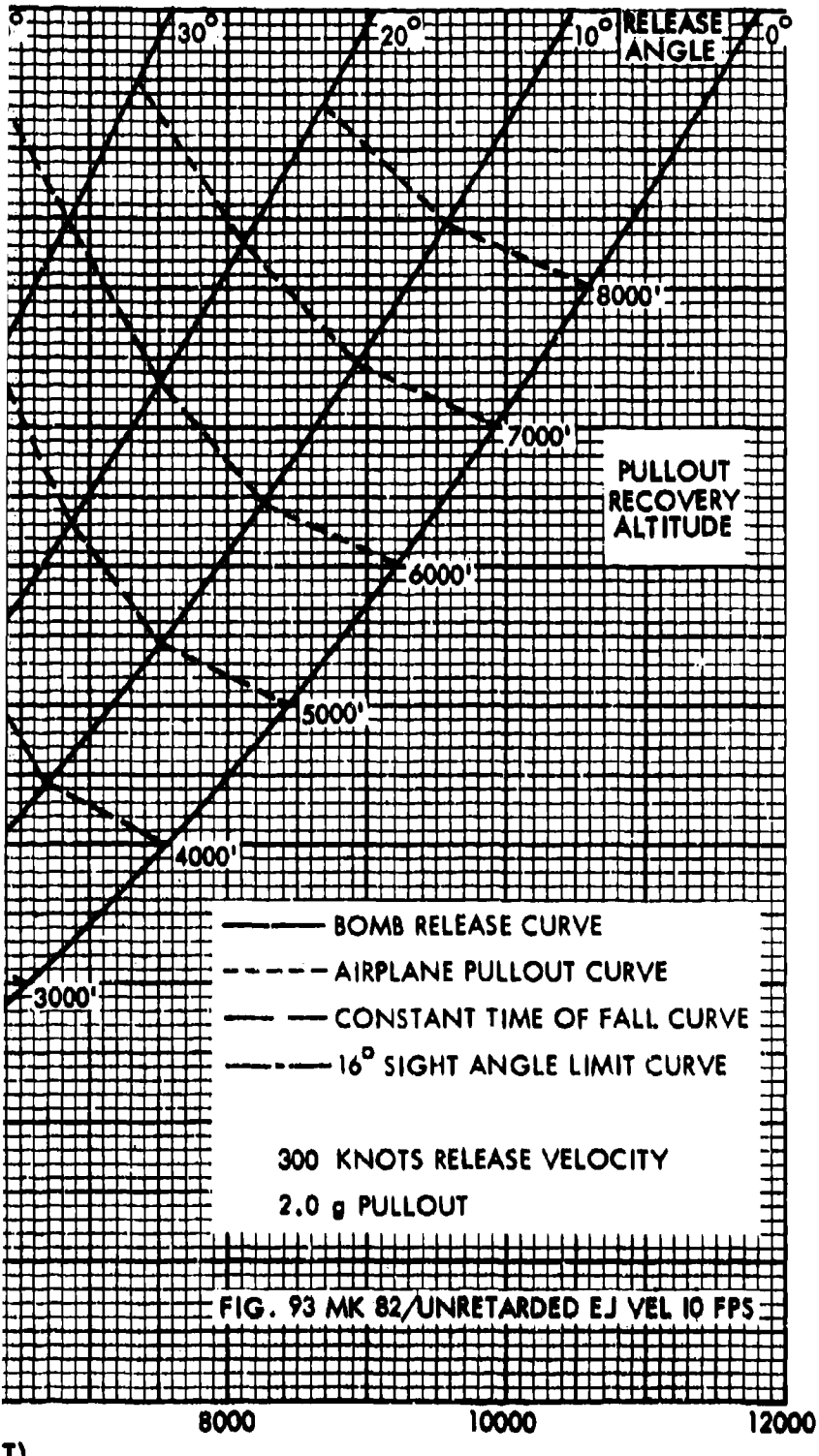
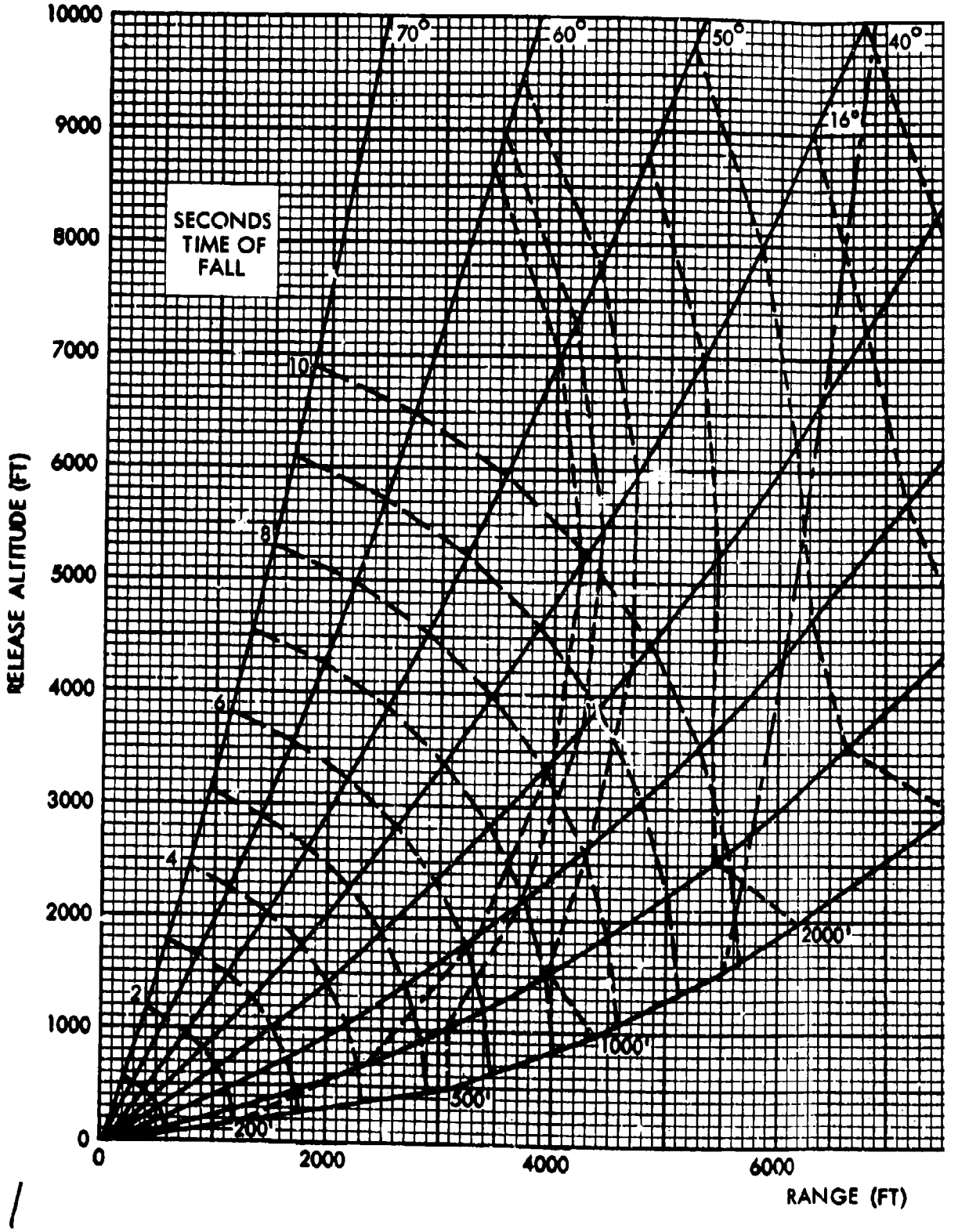


FIG. 93 MK 82/UNRETARDED EJ VEL 10 FPS

T)


10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
RELEASE ALTITUDE (FT)
0
2000
4000
6000
RANGE (FT)
70°
60°
50°
40°
16°
SECONDS
TIME OF
FALL
10
8
6
4
2
2000'
1000'
500'
200'

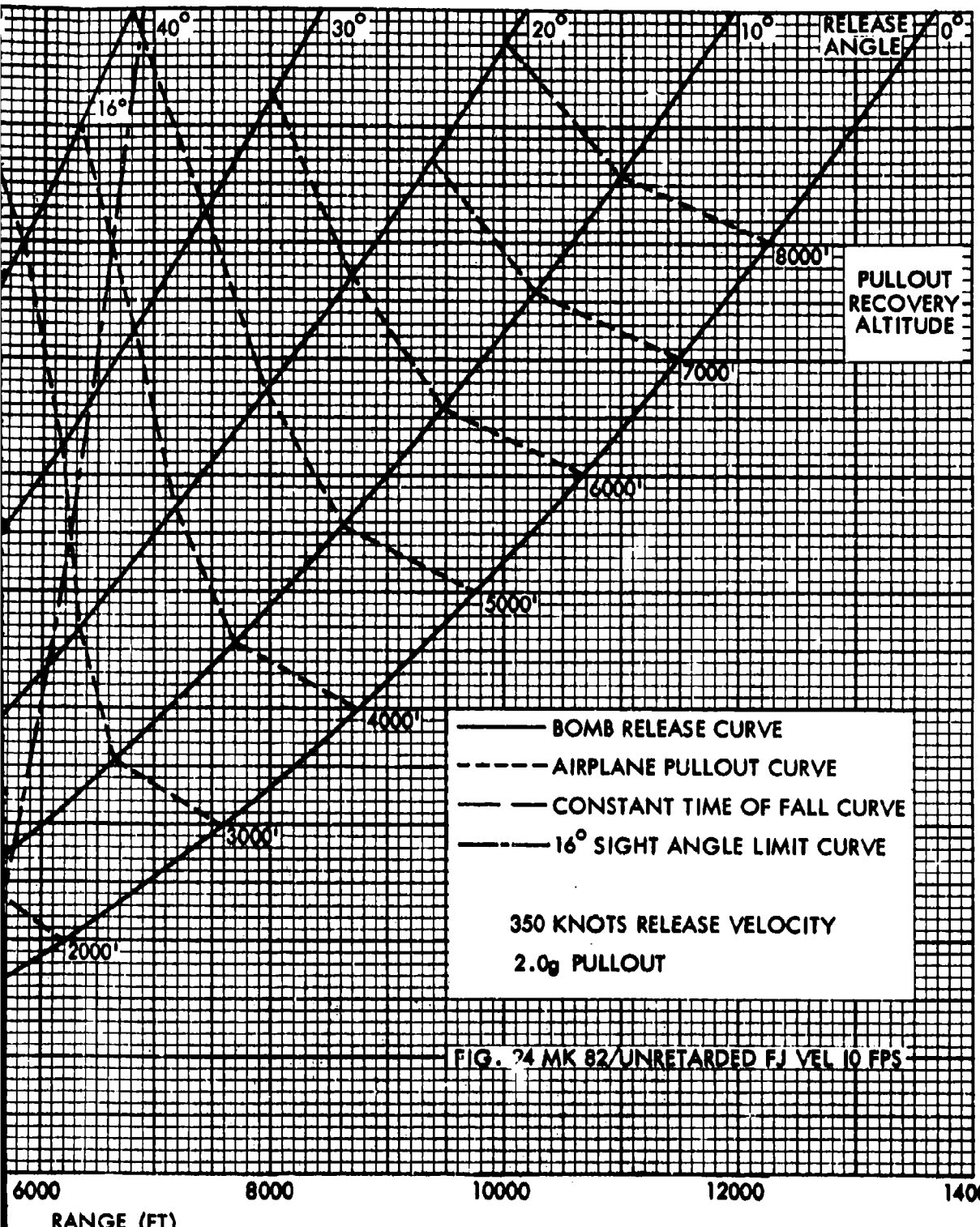
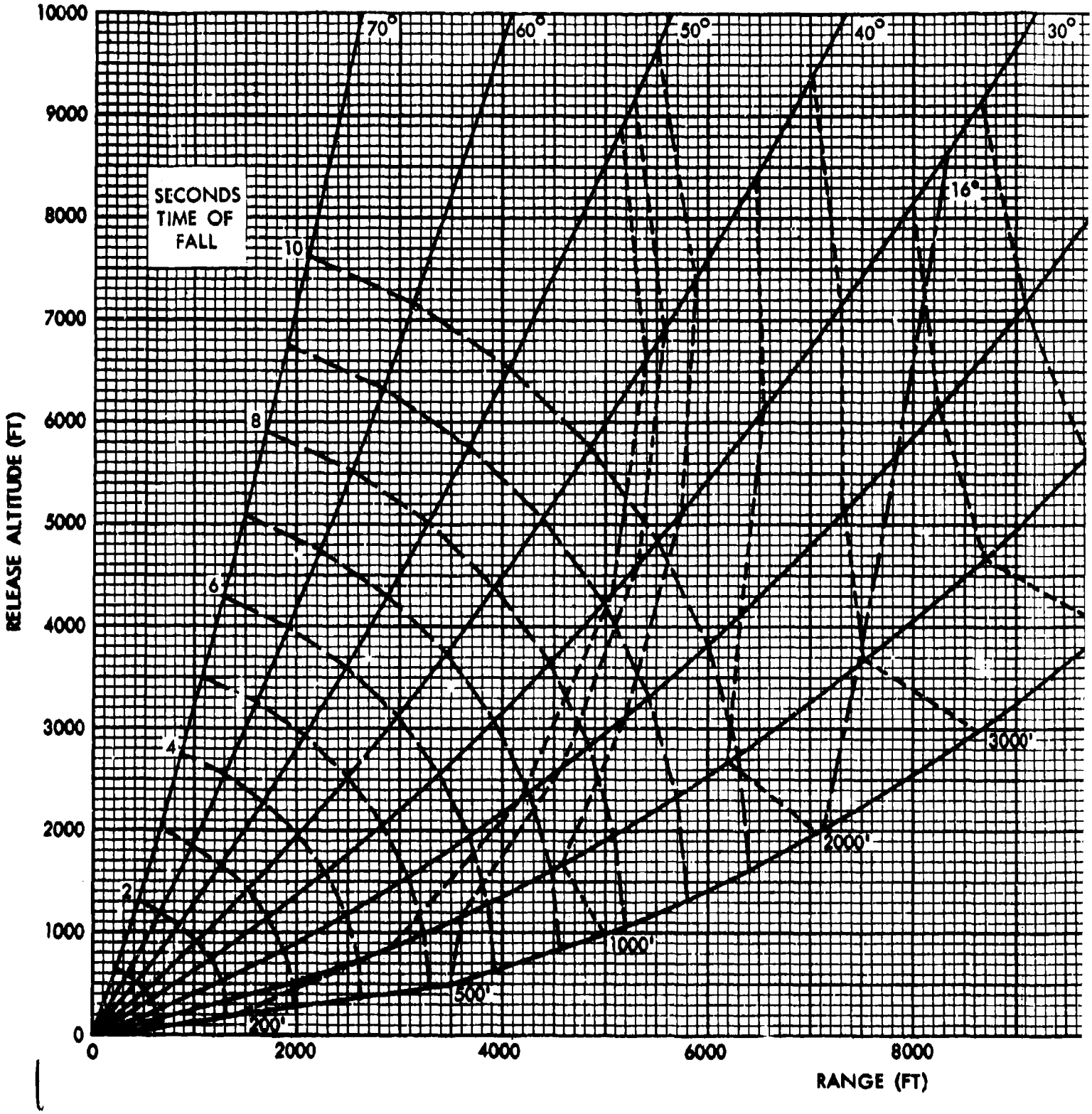


FIG. 24 MK 82/UNRETARDED FJ VEL 10 FPS


SECONDS TIME OF FALL
70°
60°
50°
40°
30°
16°
10
8
6
4
2
3000'
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
RANGE (FT)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
2000
4000
6000
8000

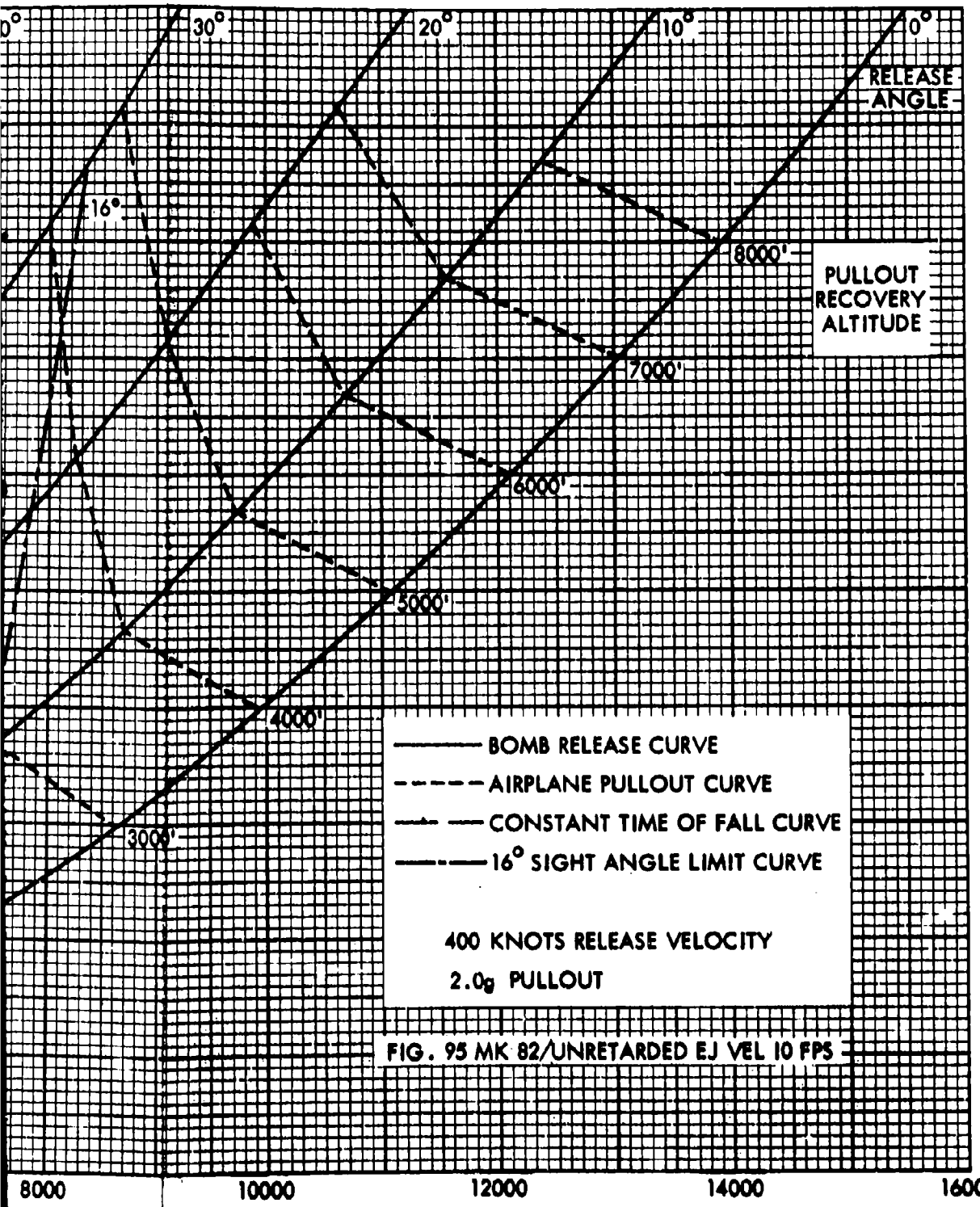
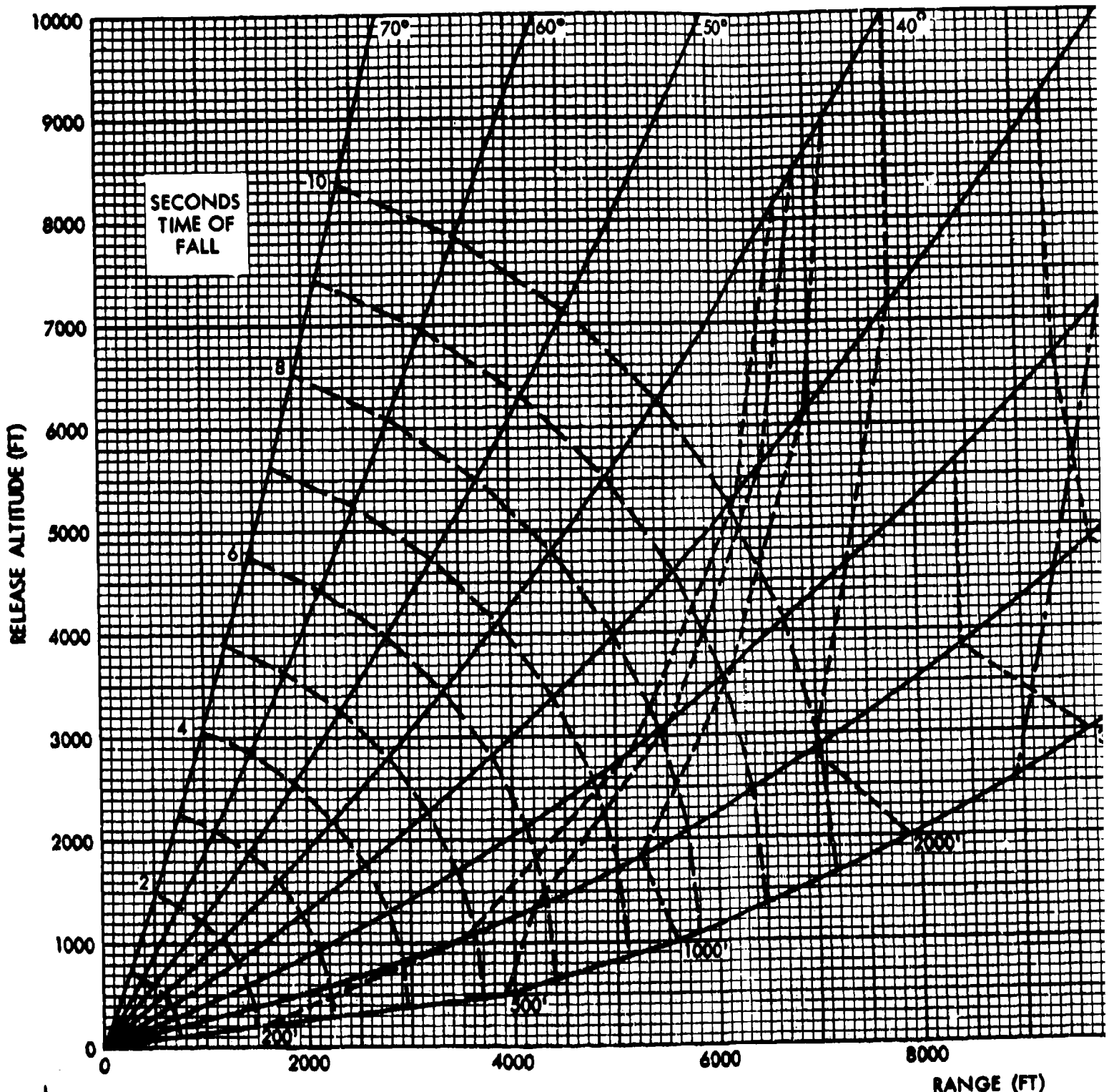


FIG. 95 MK 82/UNRETARDED EJ VEL 10 FPS


10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
RELEASE ALTITUDE (FT)
70°
60°
50°
40°
SECONDS TIME OF FALL
10
8
6
4
2
2000'
1000'
500'
200'
0
2000
4000
6000
8000
RANGE (FT)

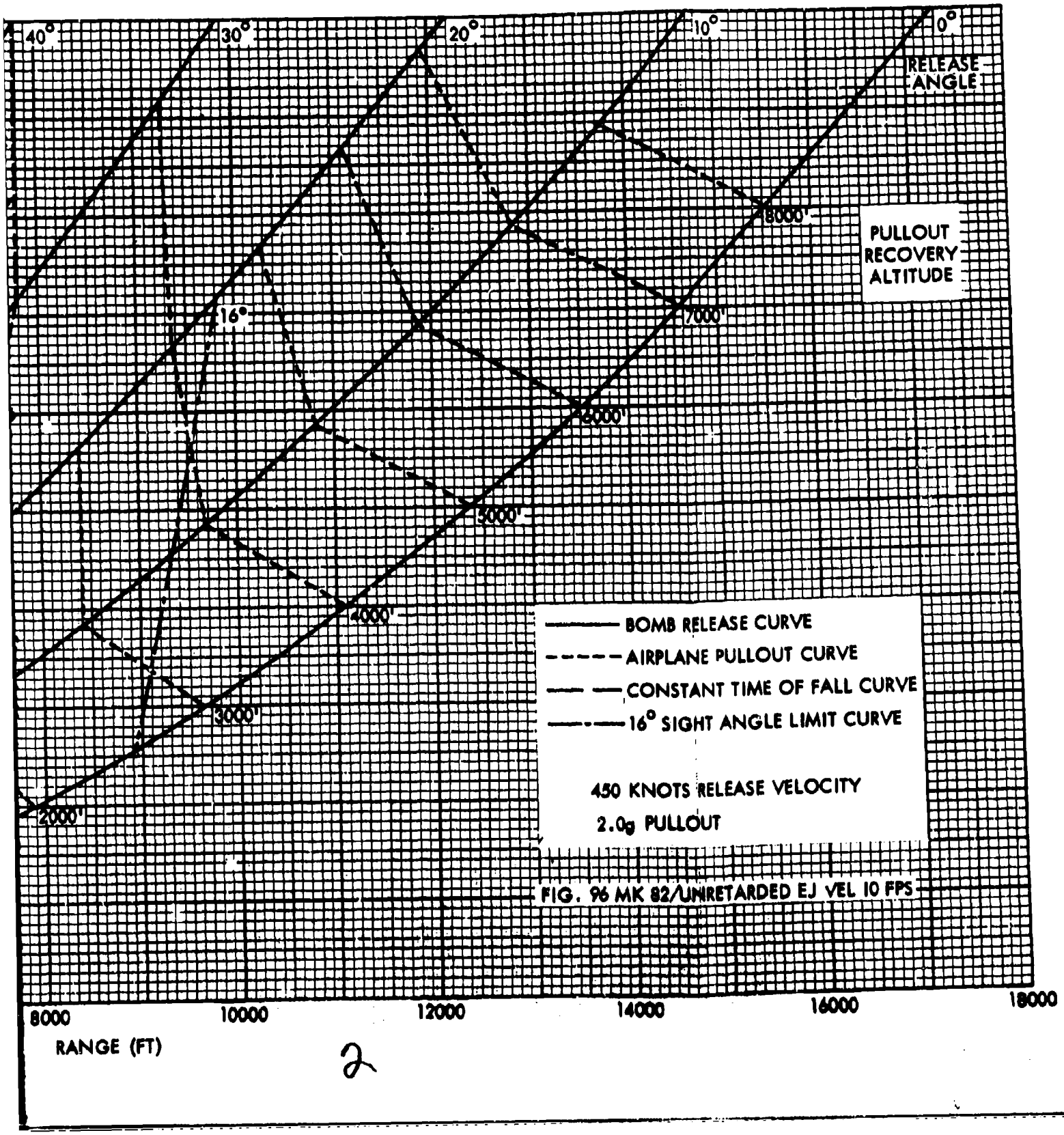
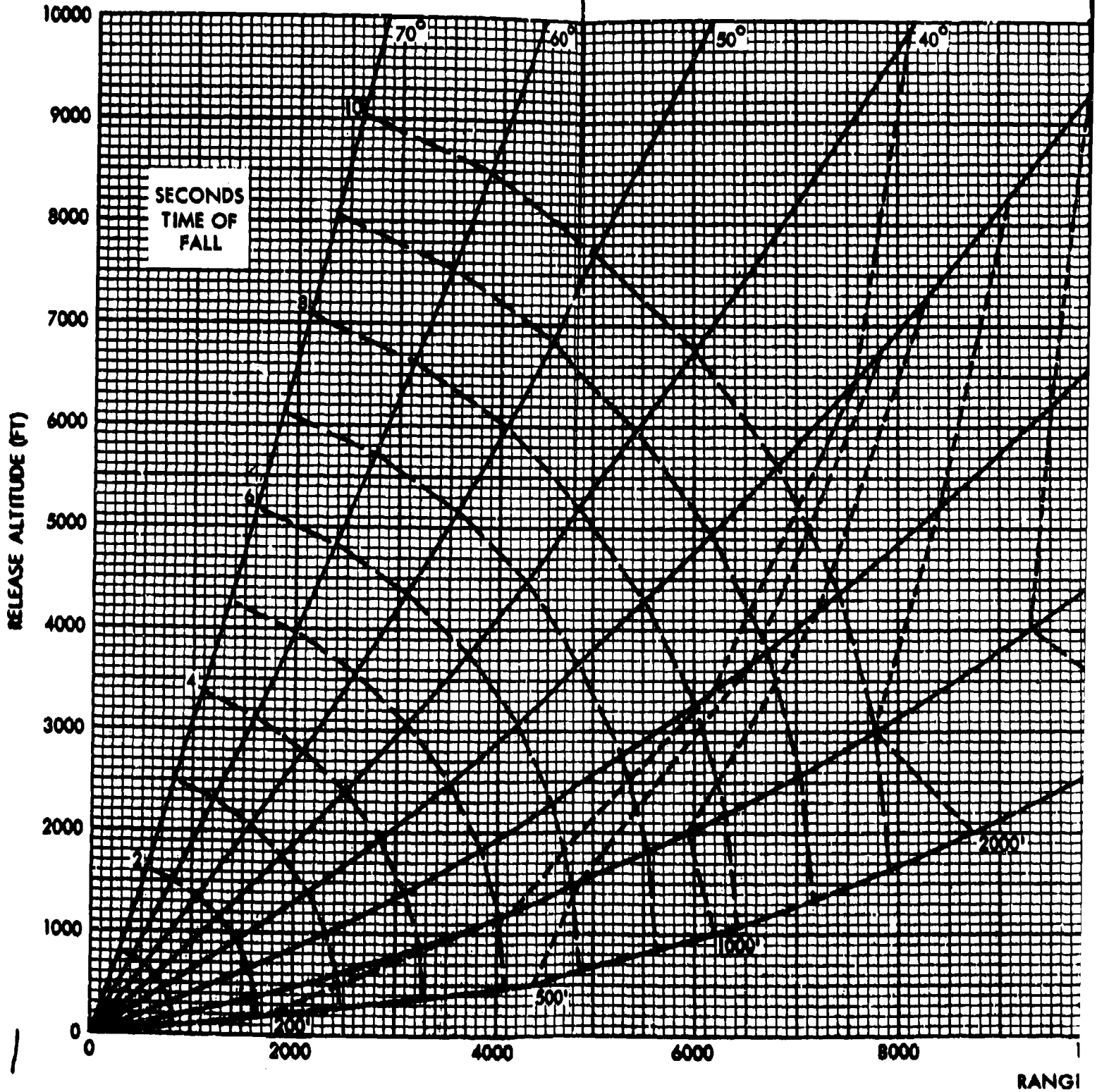


FIG. 96 MK 82/UNRETARDED EJ VEL 10 FPS

2


SECONDS
TIME OF
FALL
70°
60°
50°
40°
10
8
6
4
2
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
RANGI

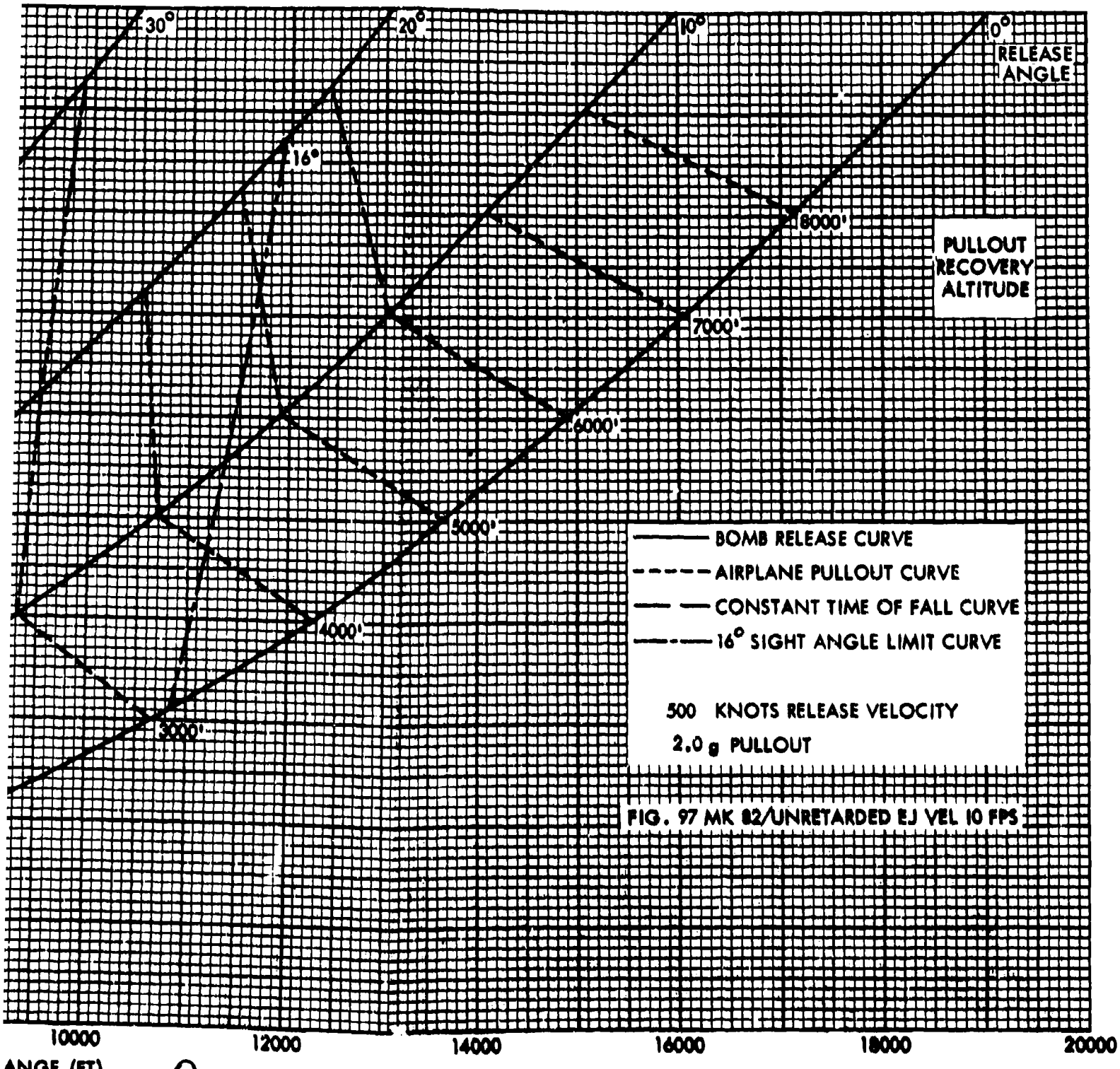
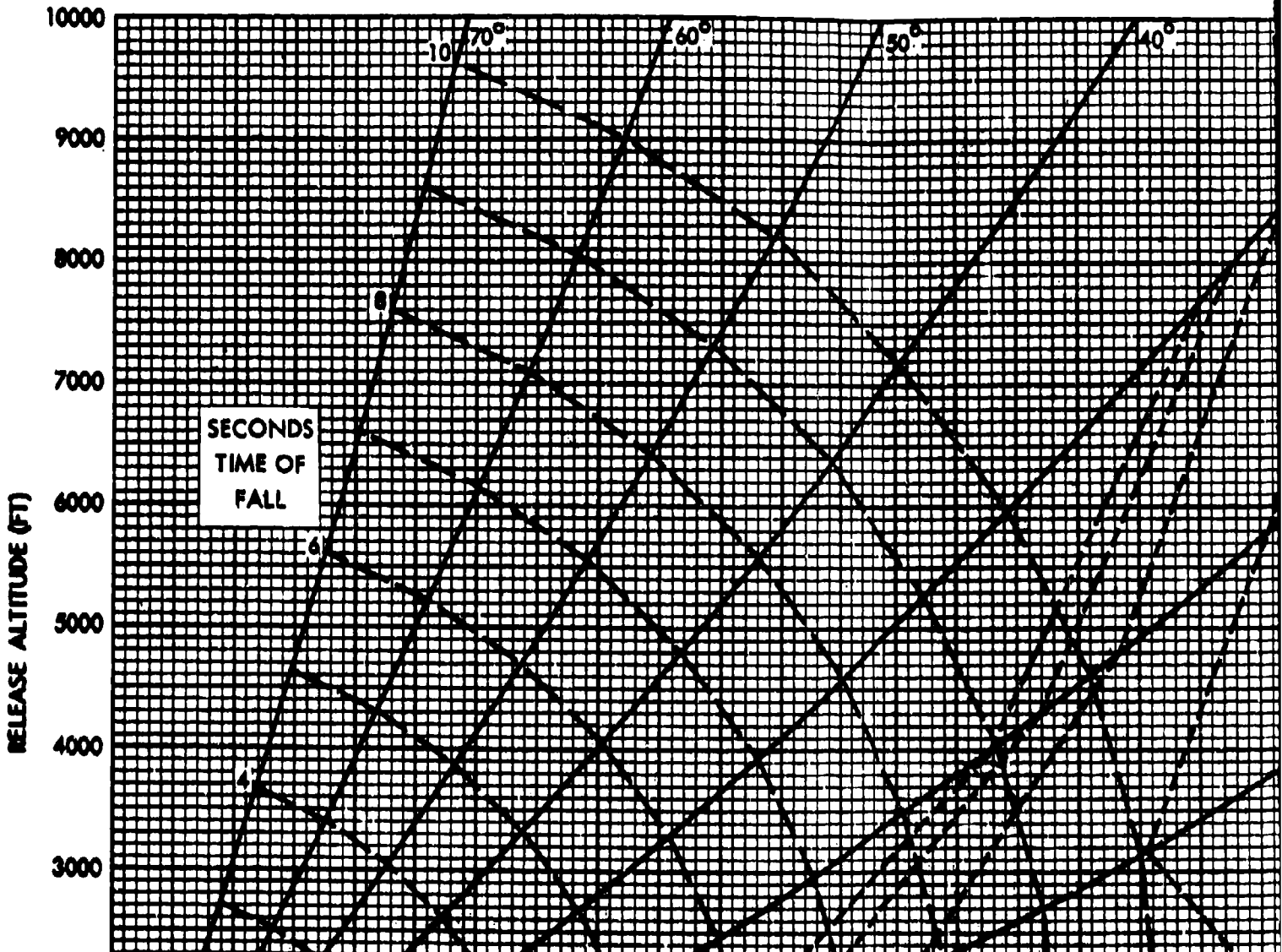


FIG. 97 MK 82/UNRETARDED EJ VEL 10 FPS

2


RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
SECONDS TIME OF FALL
70°
60°
50°
40°
10
8
6
4
2
1000'
500'

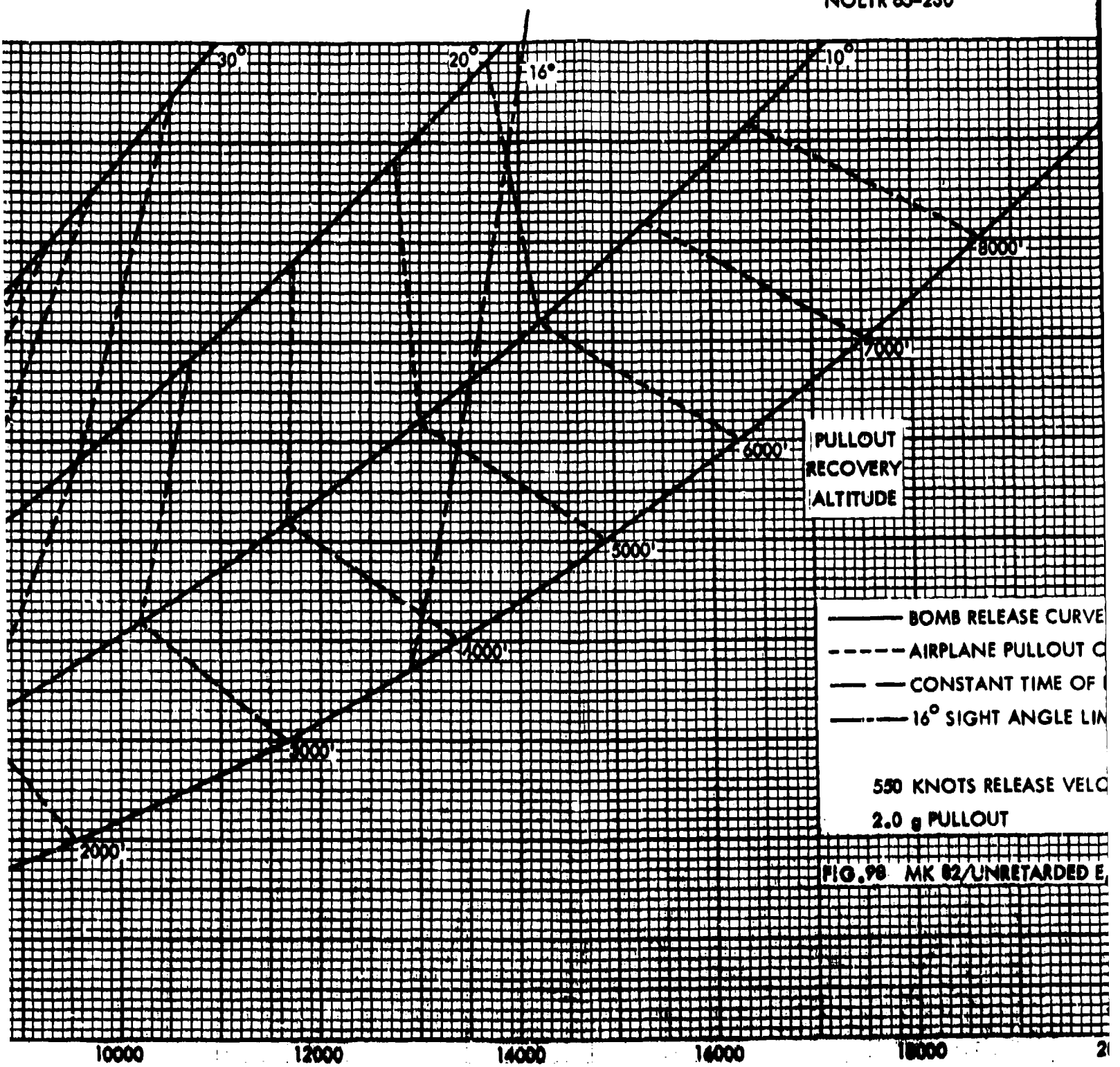


FIG. 98 MK 82/UNRETARDED E

2

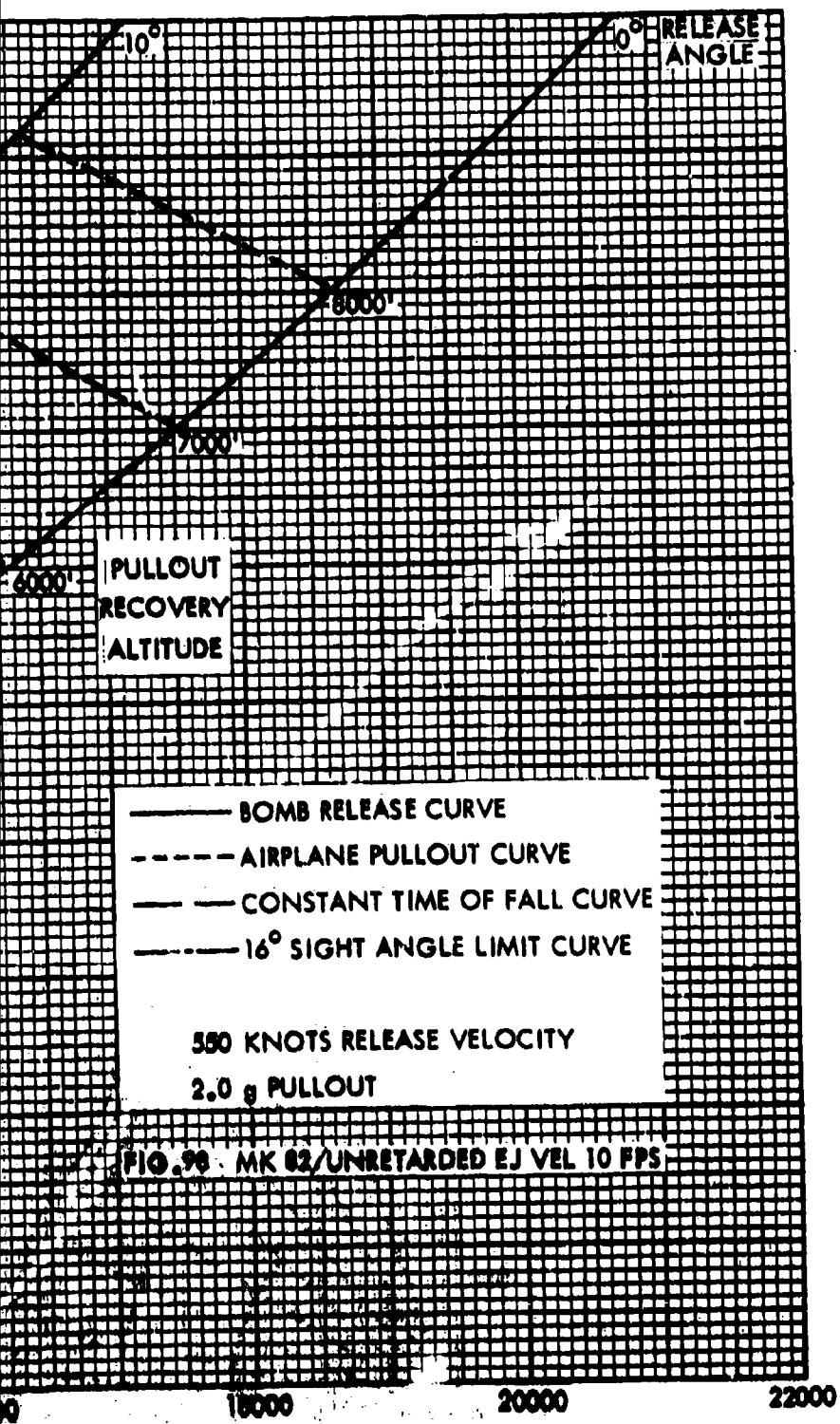
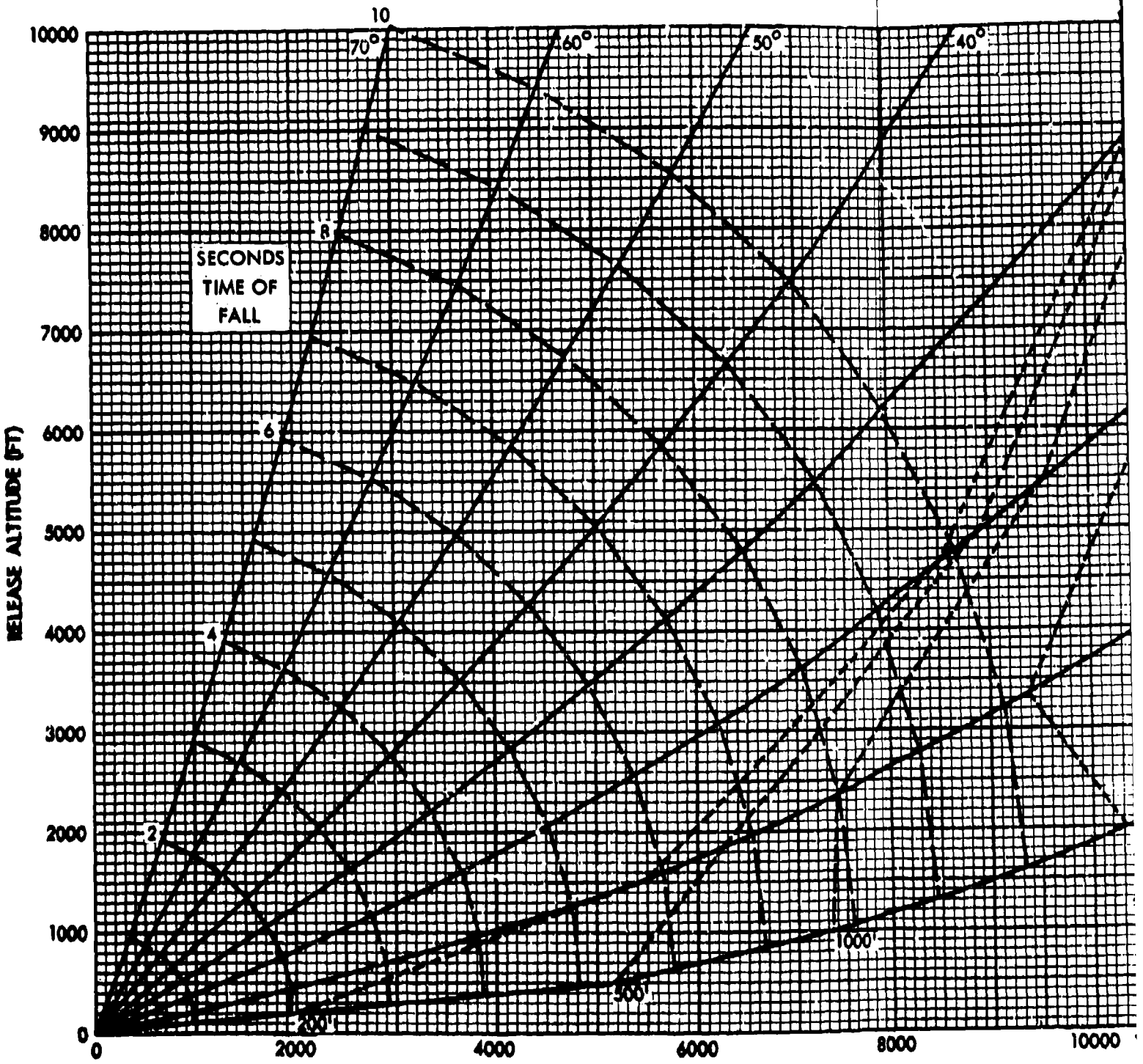
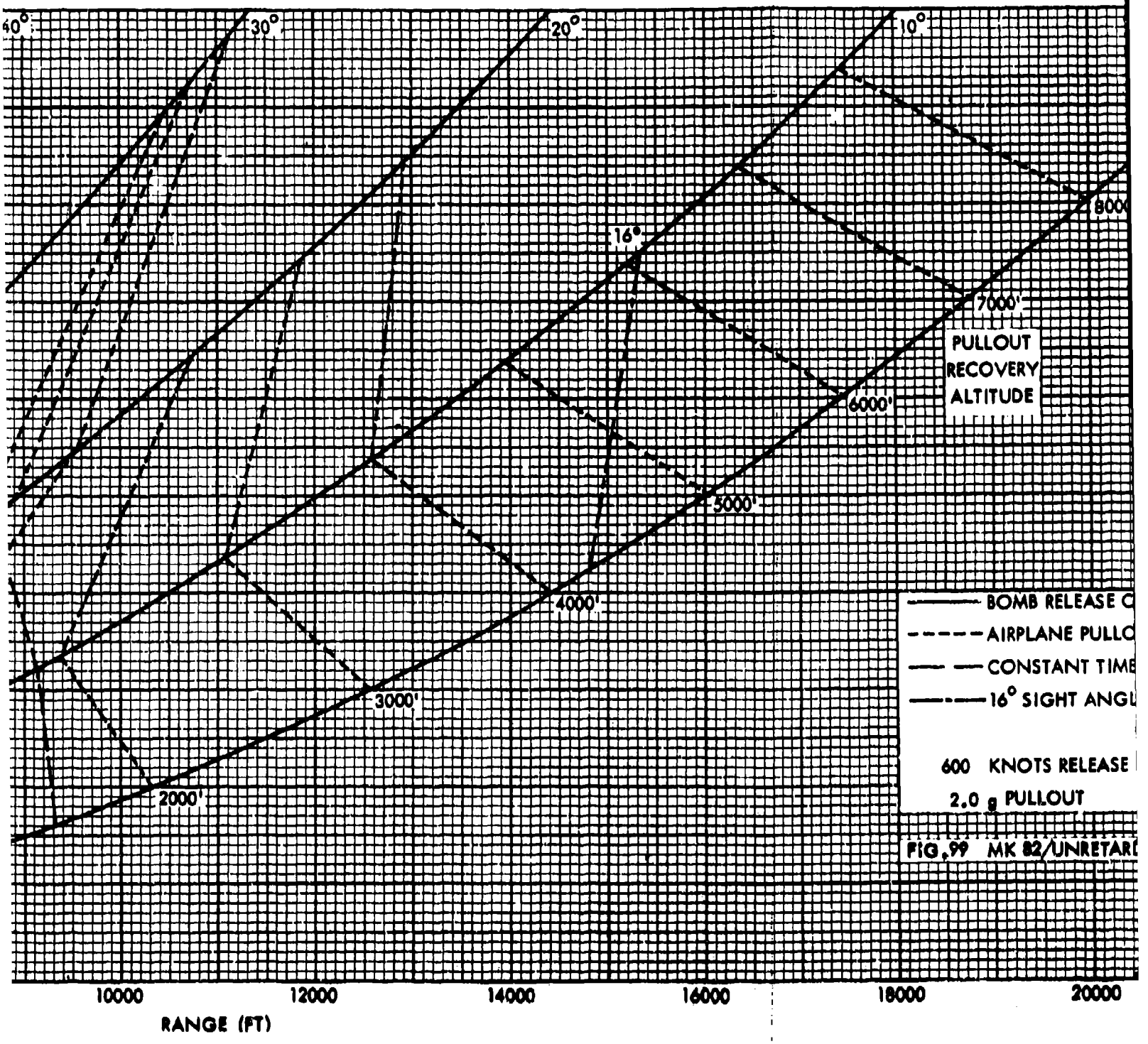


FIG. 98 MK 82/UNRETARDED EJ VEL 10 FPS


10
70°
60°
50°
40°
SECONDS
TIME OF
FALL
8
6
4
2
1000'
500'
200'
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
10000


40°
30°
20°
10°
16°
8000'
7000'
6000'
5000'
4000'
3000'
2000'
PULLOUT
RECOVERY
ALTITUDE
BOMB RELEASE C
AIRPLANE PULLO
CONSTANT TIME
16° SIGHT ANGL
600 KNOTS RELEASE
2.0 g PULLOUT
FIG. 99 MK 82/UNRETARD
10000
12000
14000
16000
18000
20000
RANGE (FT)

2

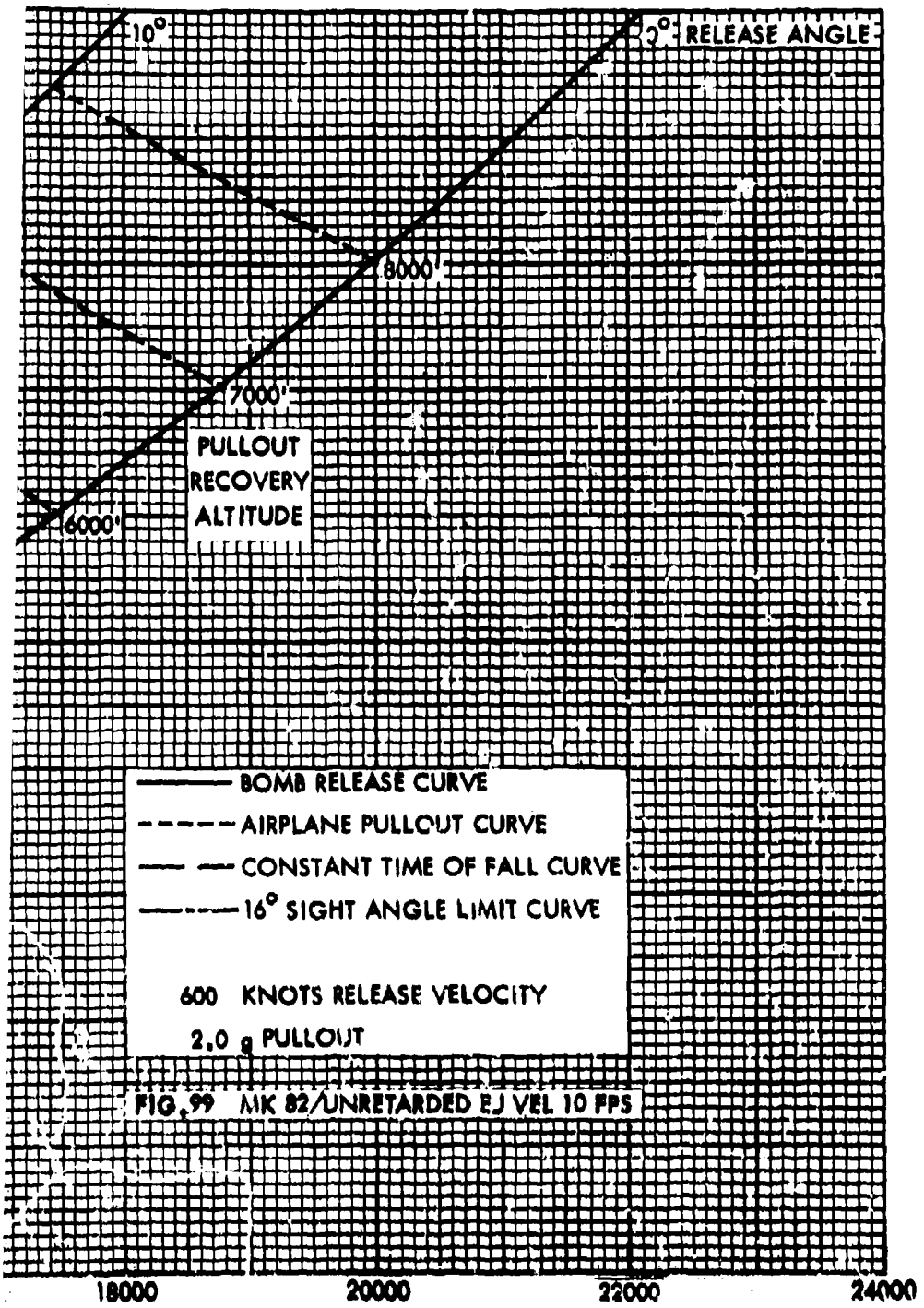


FIG. 99 MK 82/UNRETARDED EJ VEL 10 FPS

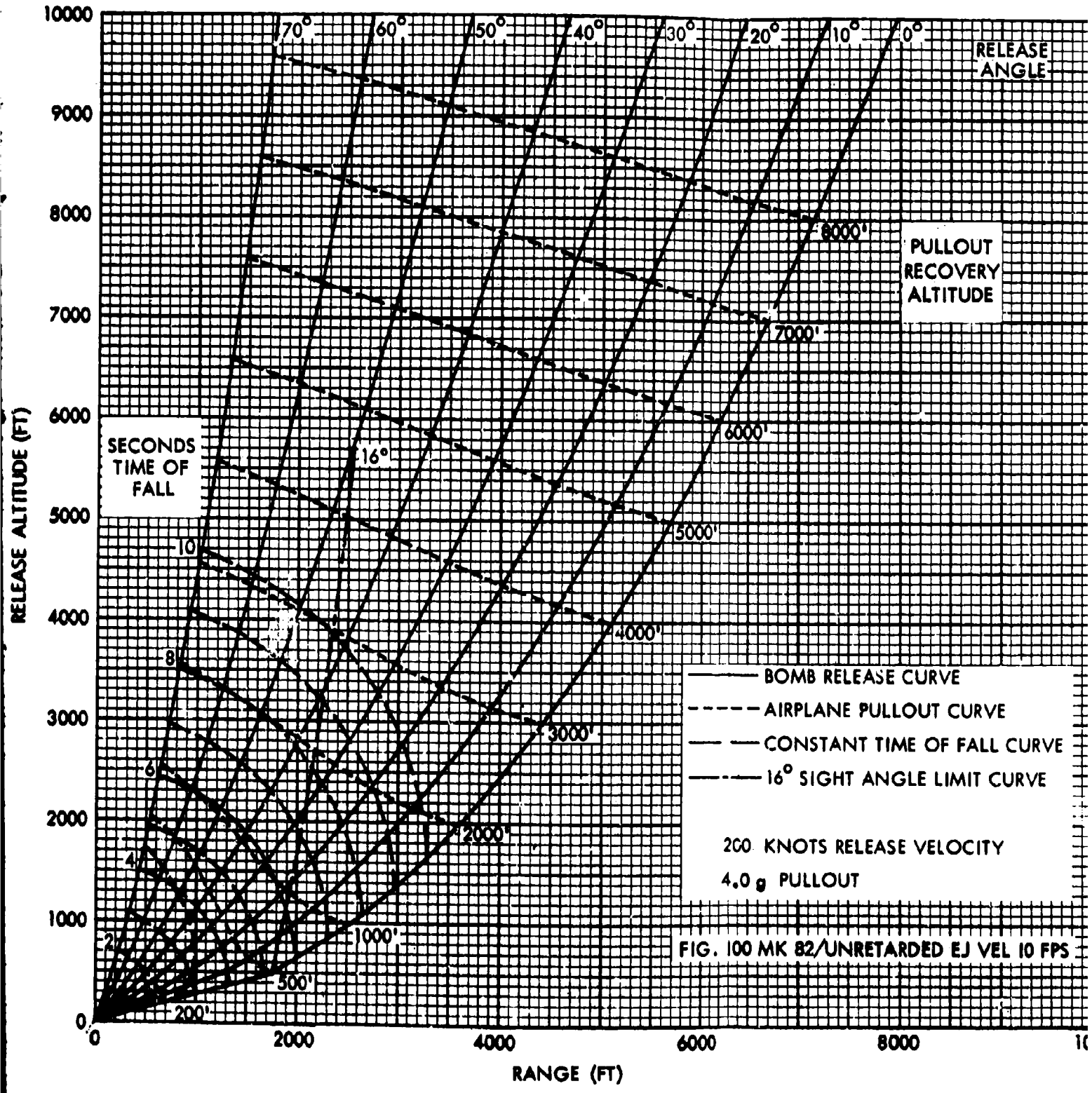
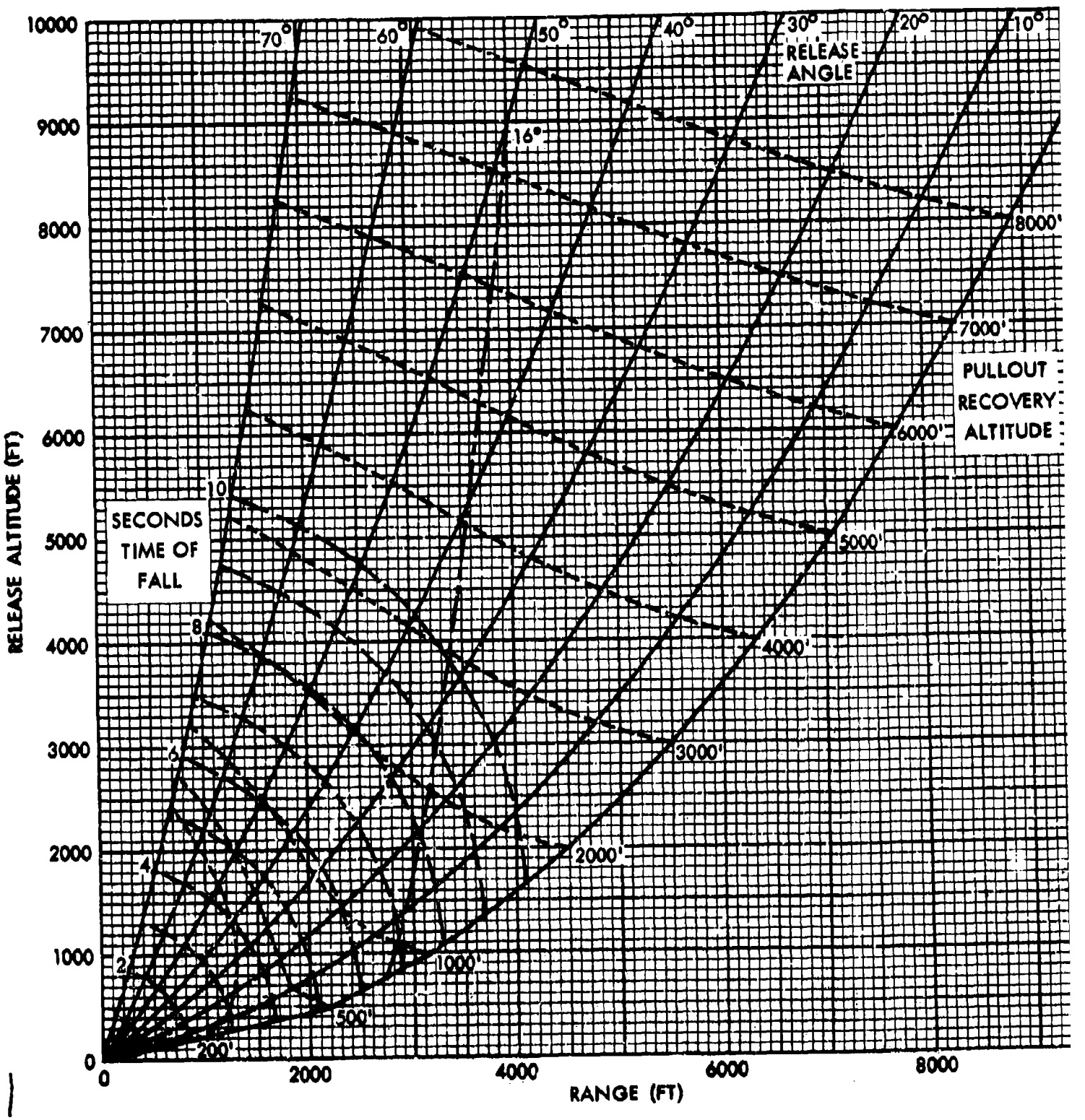
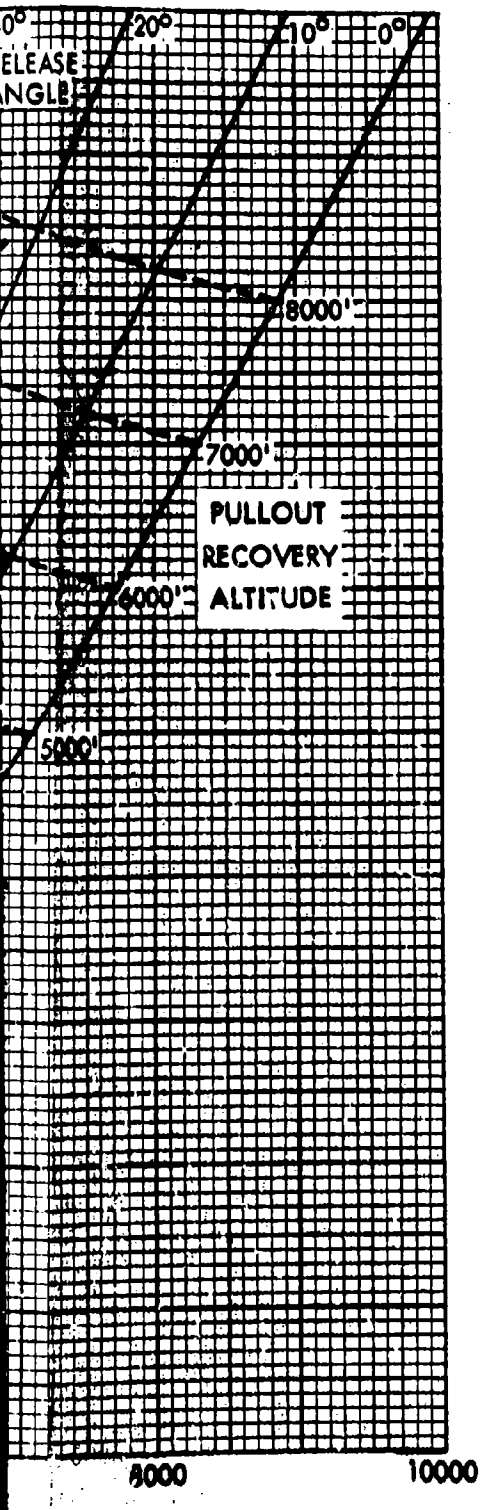


FIG. 100 MK 82/UNRETARDED EJ VEL 10 FPS


RELEASE ALTITUDE (FT)
RANGE (FT)
RELEASE ANGLE
70°
60°
50°
40°
30°
20°
10°
16°
SECONDS TIME OF FALL
10
8
6
4
2
PULLOUT RECOVERY ALTITUDE
8000'
7000'
6000'
5000'
4000'
3000'
2000'
1000'
500'
200'
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000



——— BOMB RELEASE CURVE

- - - - - AIRPLANE PULLOUT CURVE

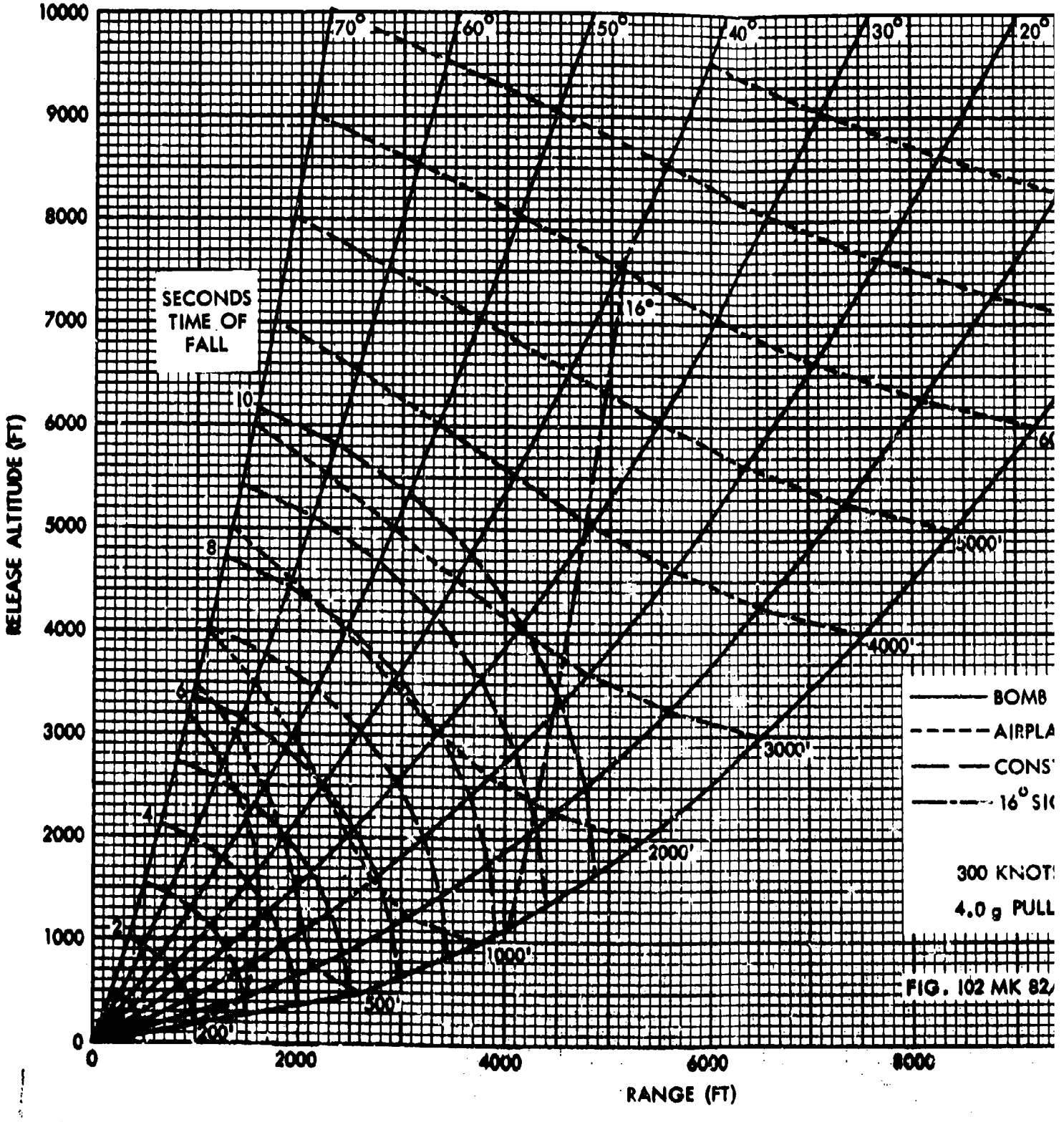
— — CONSTANT TIME OF FALL CURVE

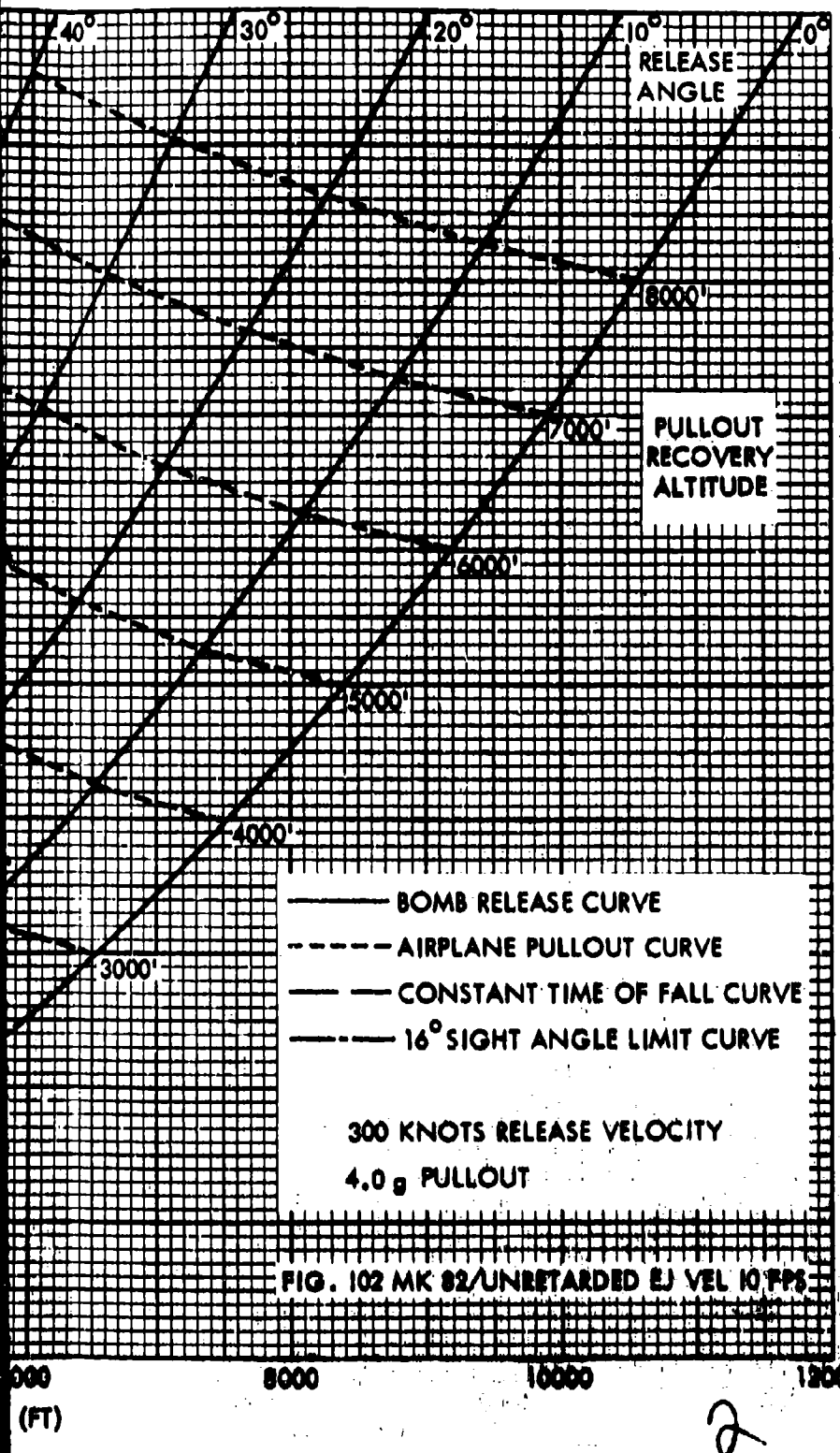
——·—— 16° SIGHT ANGLE LIMIT CURVE

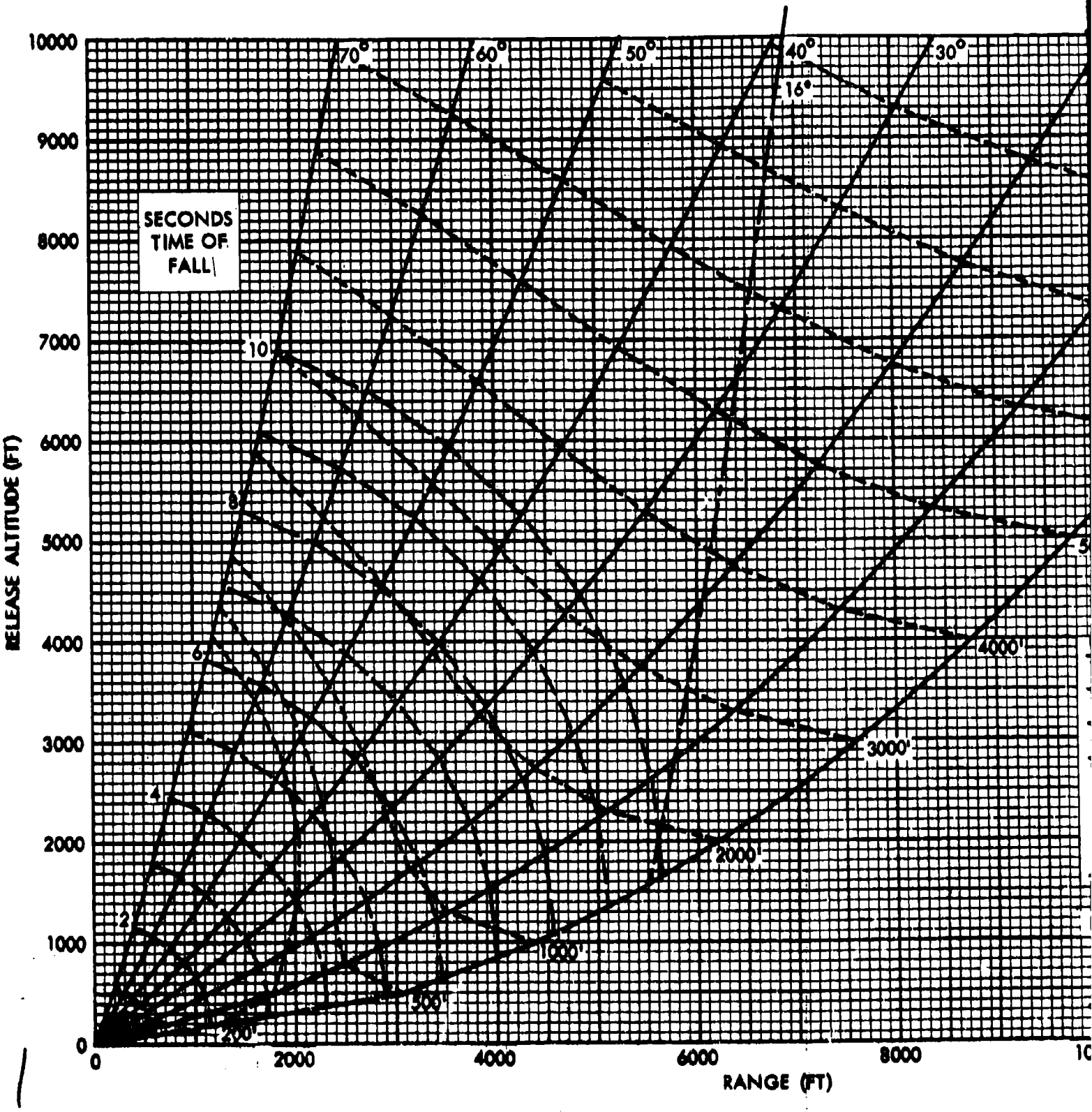
250 KNOTS RELEASE VELOCITY

4.0 g PULLOUT

FIG.101 MK 82/UNRETARDED EJ VEL 10 FPS


70°
60°
50°
40°
30°
20°
16°
SECONDS TIME OF FALL
10
8
6
4
2
5000'
4000'
3000'
2000'
1000'
500'
200'
BOMB
AIRPLA
CONS
16° SI
300 KNOT
4.0 g PULL
FIG. 102 MK 82
RELEASE ALTITUDE (FT)
RANGE (FT)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
2000
4000
6000
8000


40°
30°
20°
10°
0°
RELEASE ANGLE
8000'
7000'
6000'
5000'
4000'
3000'
PULLOUT RECOVERY ALTITUDE
BOMB RELEASE CURVE
AIRPLANE PULLOUT CURVE
CONSTANT TIME OF FALL CURVE
16° SIGHT ANGLE LIMIT CURVE
300 KNOTS RELEASE VELOCITY
4.0 g PULLOUT
FIG. 102 MK 82/UNRETARDED EJ VEL 10 FPS
000
8000
10000
12000
(FT)


SECONDS TIME OF FALL
70°
60°
50°
40°
30°
16°
10
8
6
4
2
4000'
3000'
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
RANGE (FT)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
2000
4000
6000
8000

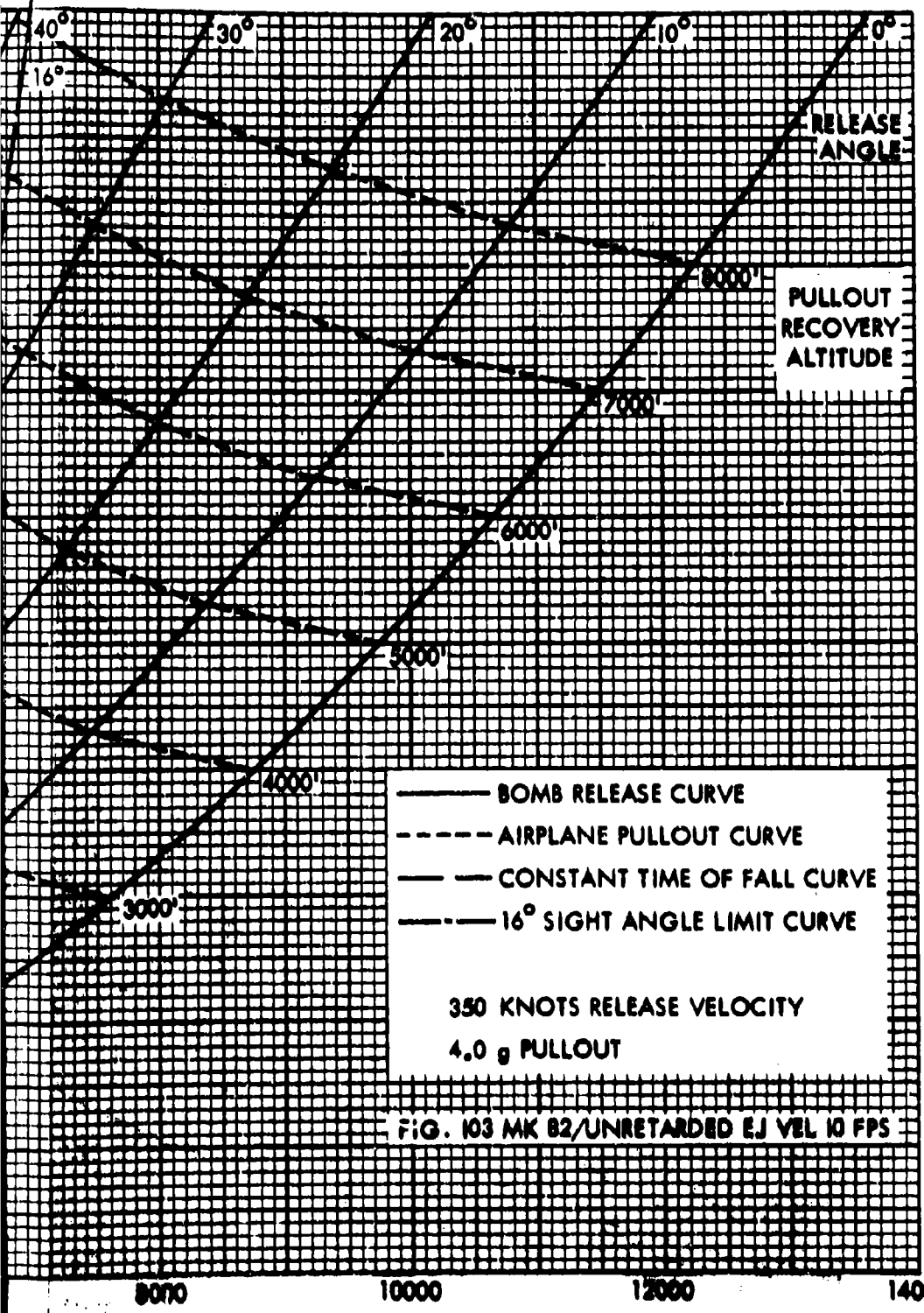
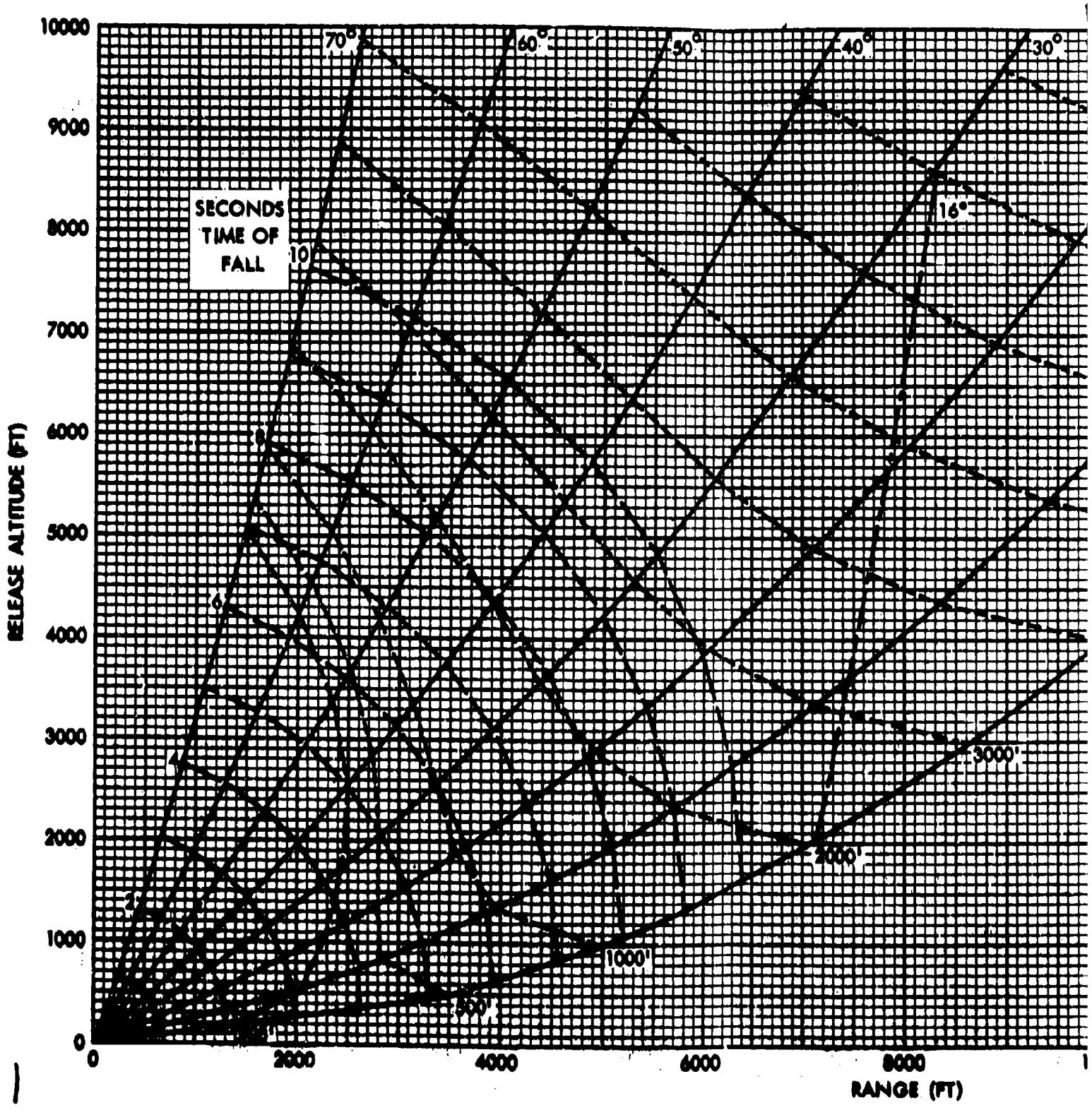


FIG. 103 MK 82/UNRETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
70°
60°
50°
40°
30°
16°
10
8
6
4
2
3000'
2000'
1000'
500'
RELEASE ALTITUDE (FT)
RANGE (FT)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
2000
4000
6000
8000

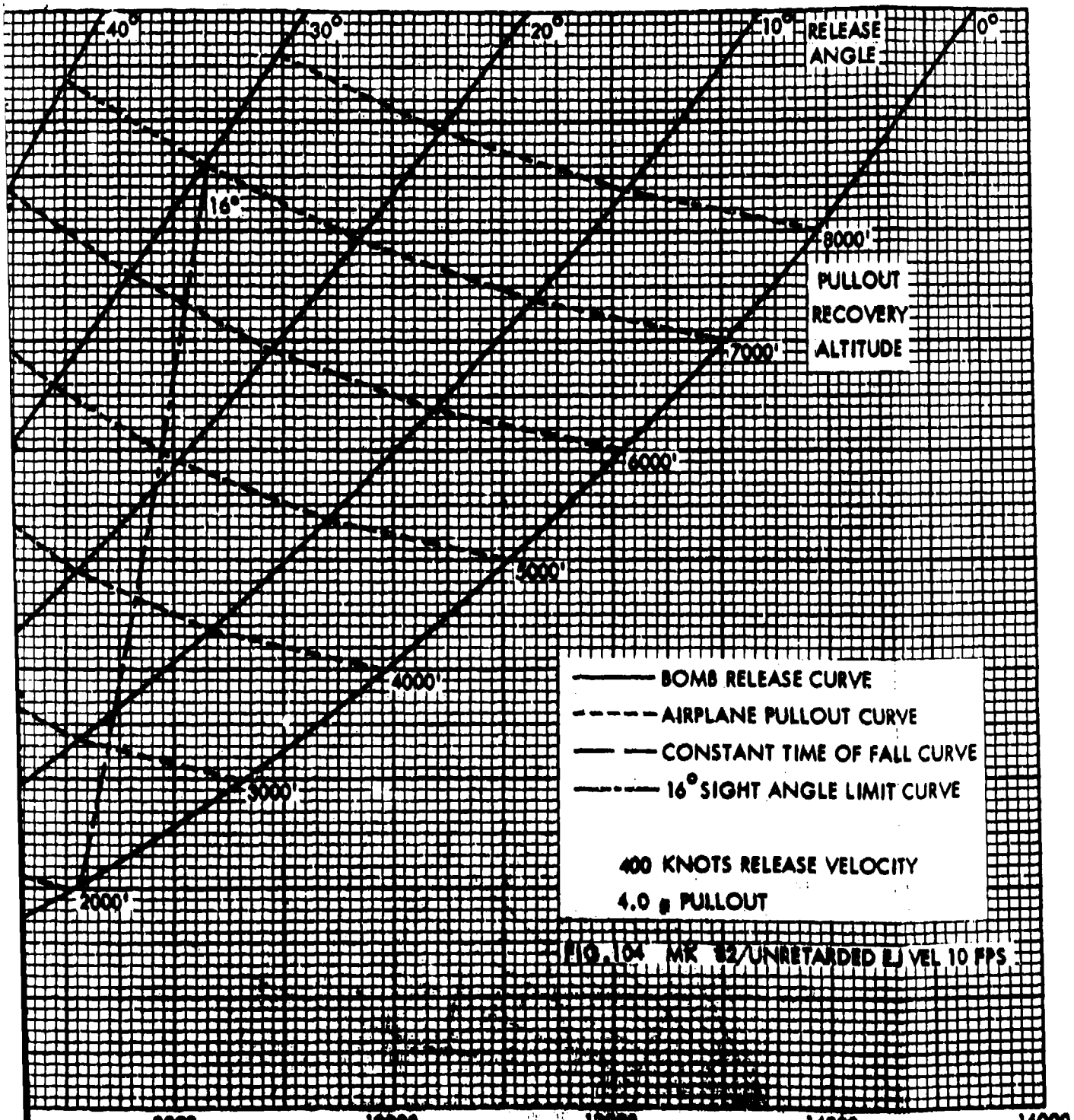
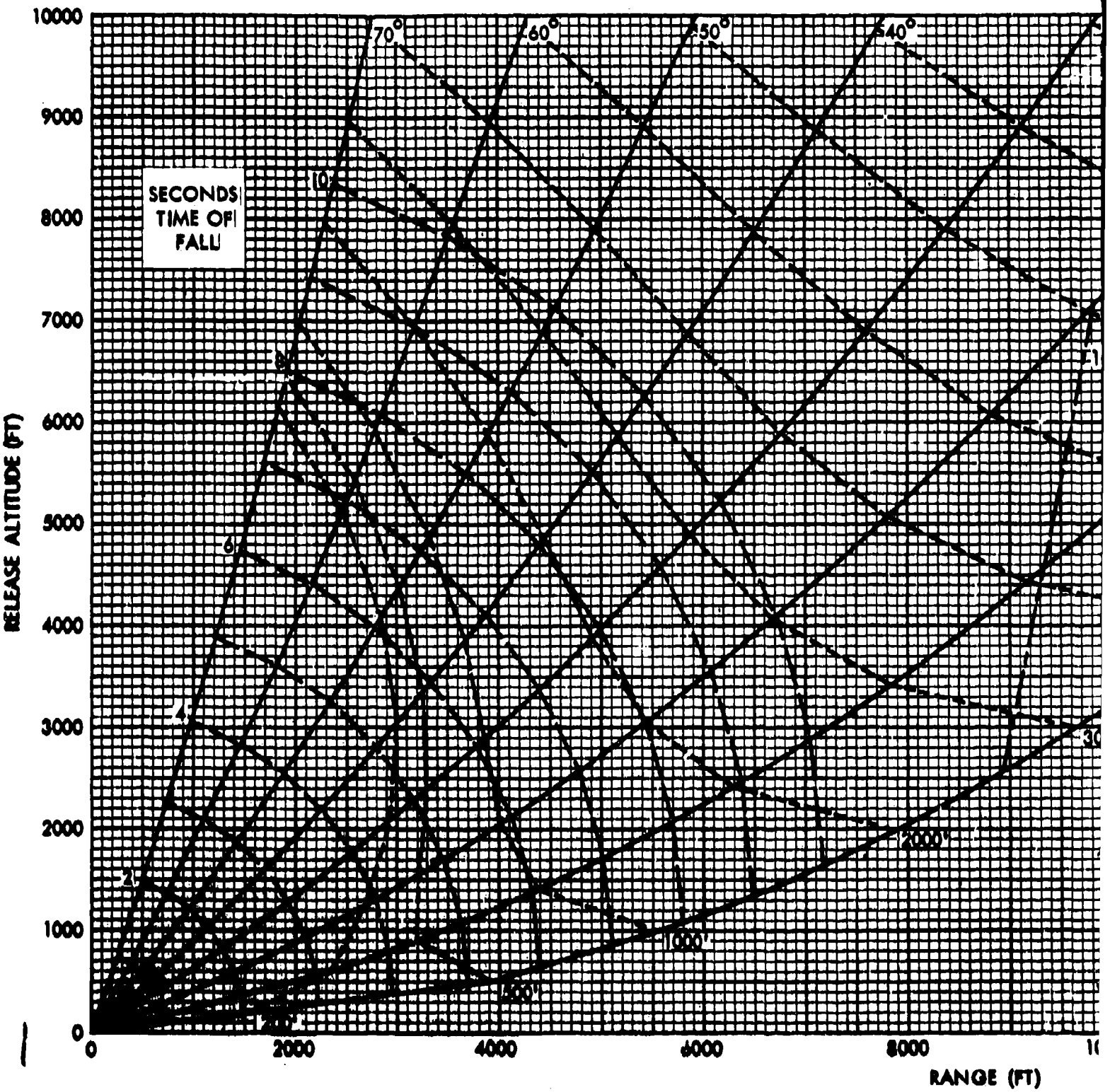


FIG. 104 MK 82/UNRETARDED EJ VEL 10 FPS


70°
60°
50°
40°
SECONDS
TIME OF
FALL
10
8
6
4
2
2000'
1000'
200'
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
RELEASE ALTITUDE (FT)
0
2000
4000
6000
8000
RANGE (FT)

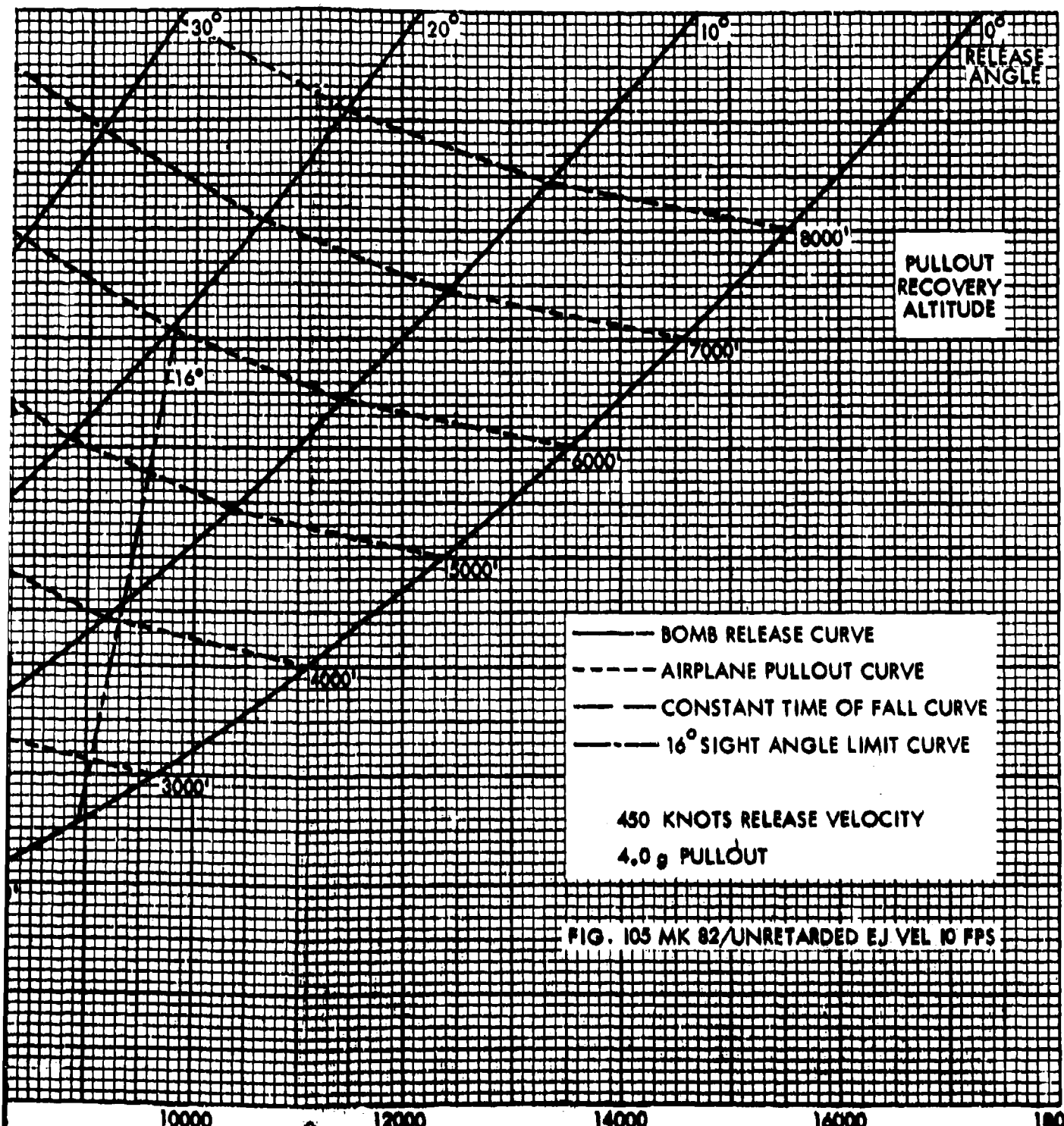
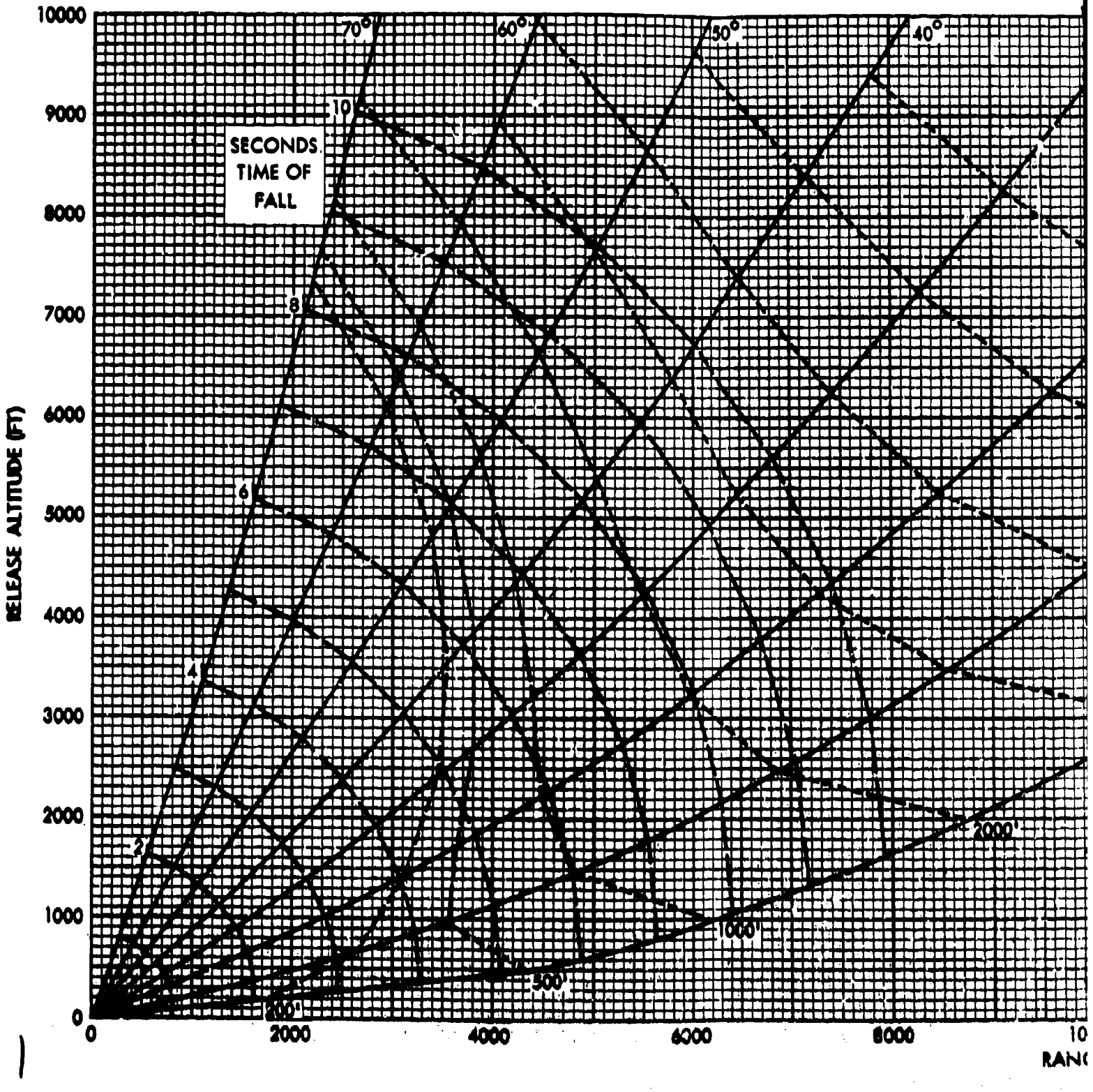


FIG. 105 MK 82/UNRETARDED EJ VEL 10 FPS


SECONDS TIME OF FALL
70°
60°
50°
40°
10
8
6
4
2
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
RANG

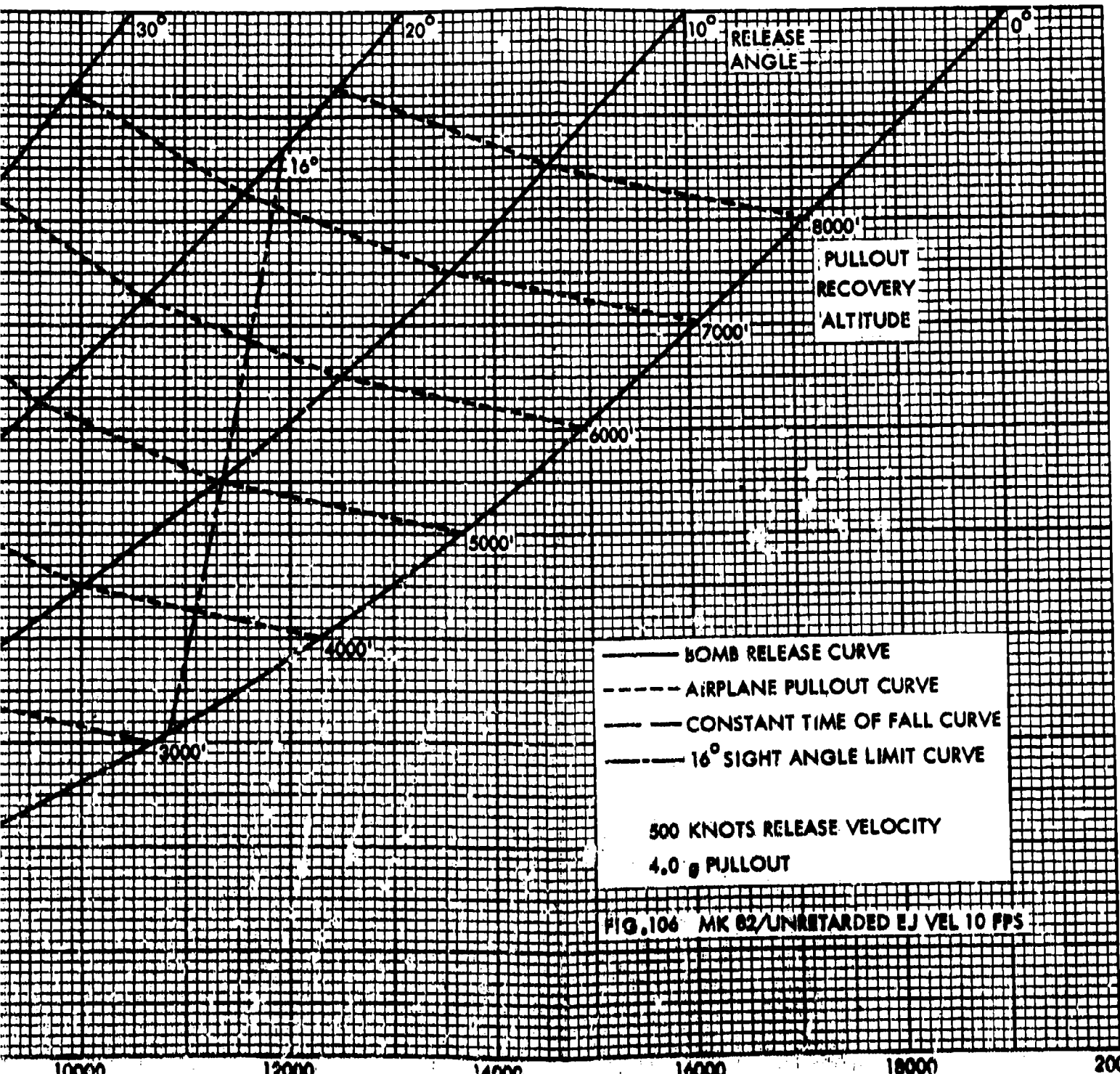
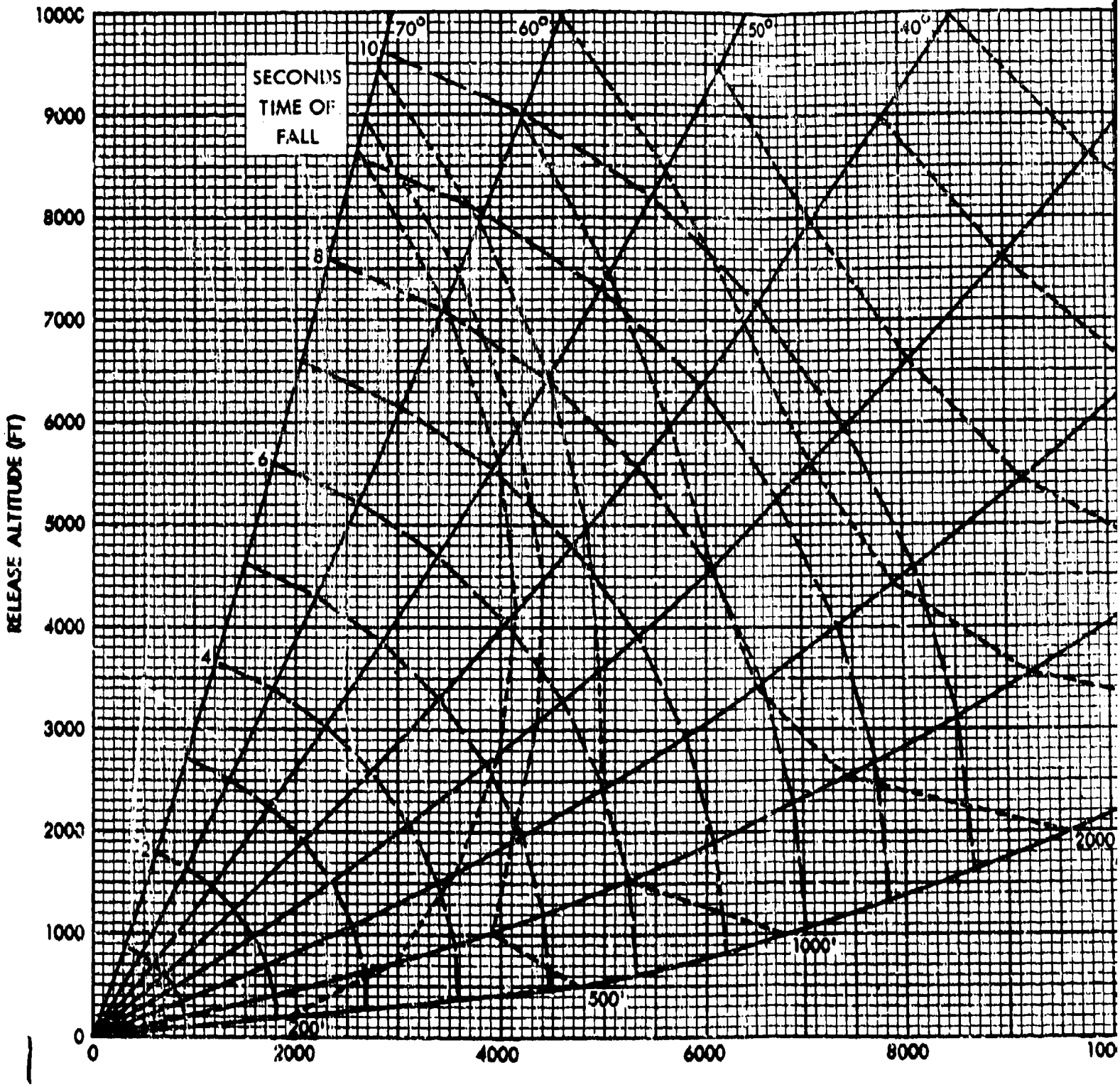


FIG. 106 MK 82/UNRETARDED EJ VEL 10 FPS


SECONDS
TIME OF
FALL
70°
60°
50°
40°
10
8
6
4
2
2000'
1000'
500'
200'
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000

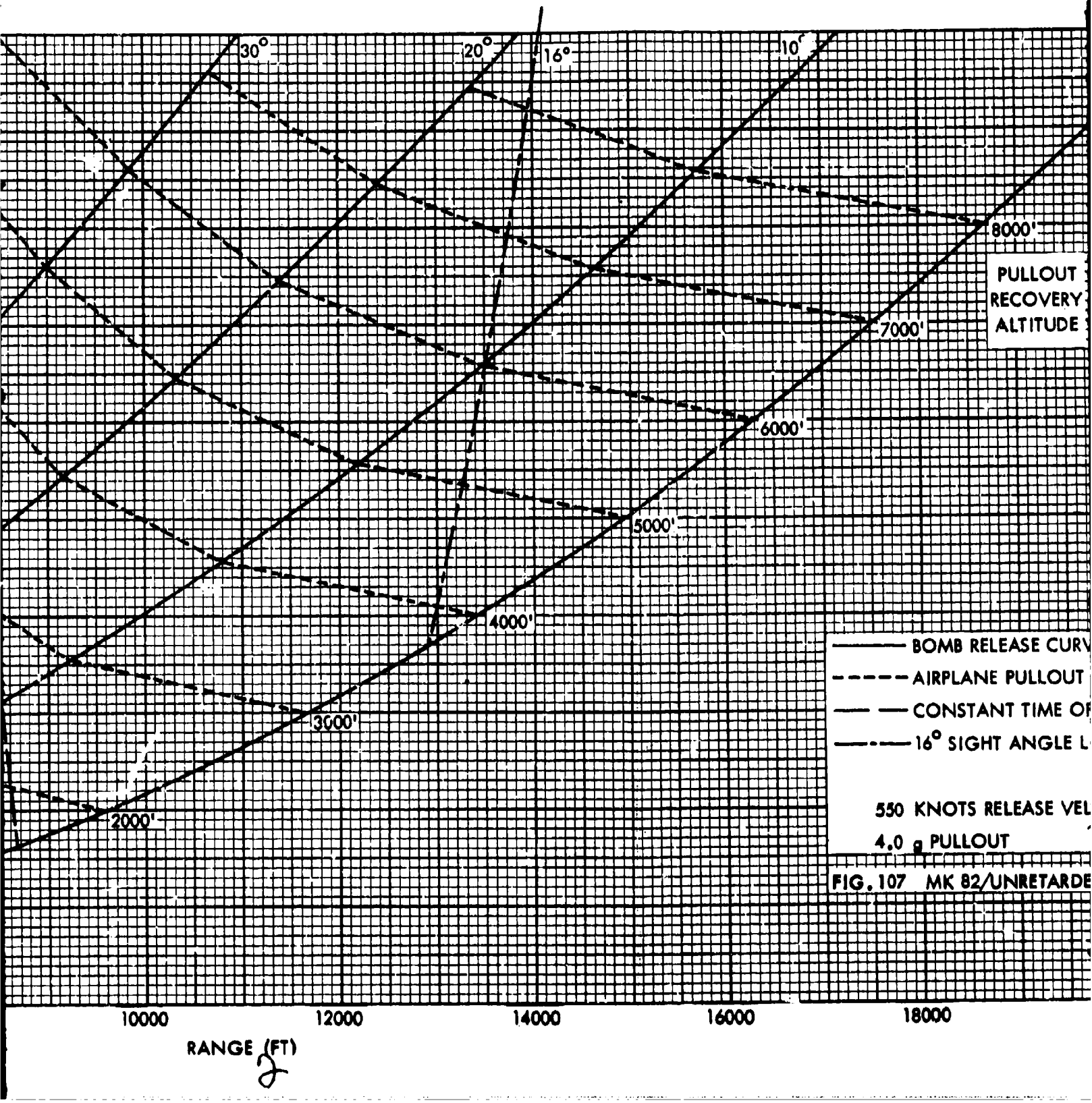


FIG. 107 MK 82/UNRETARDE

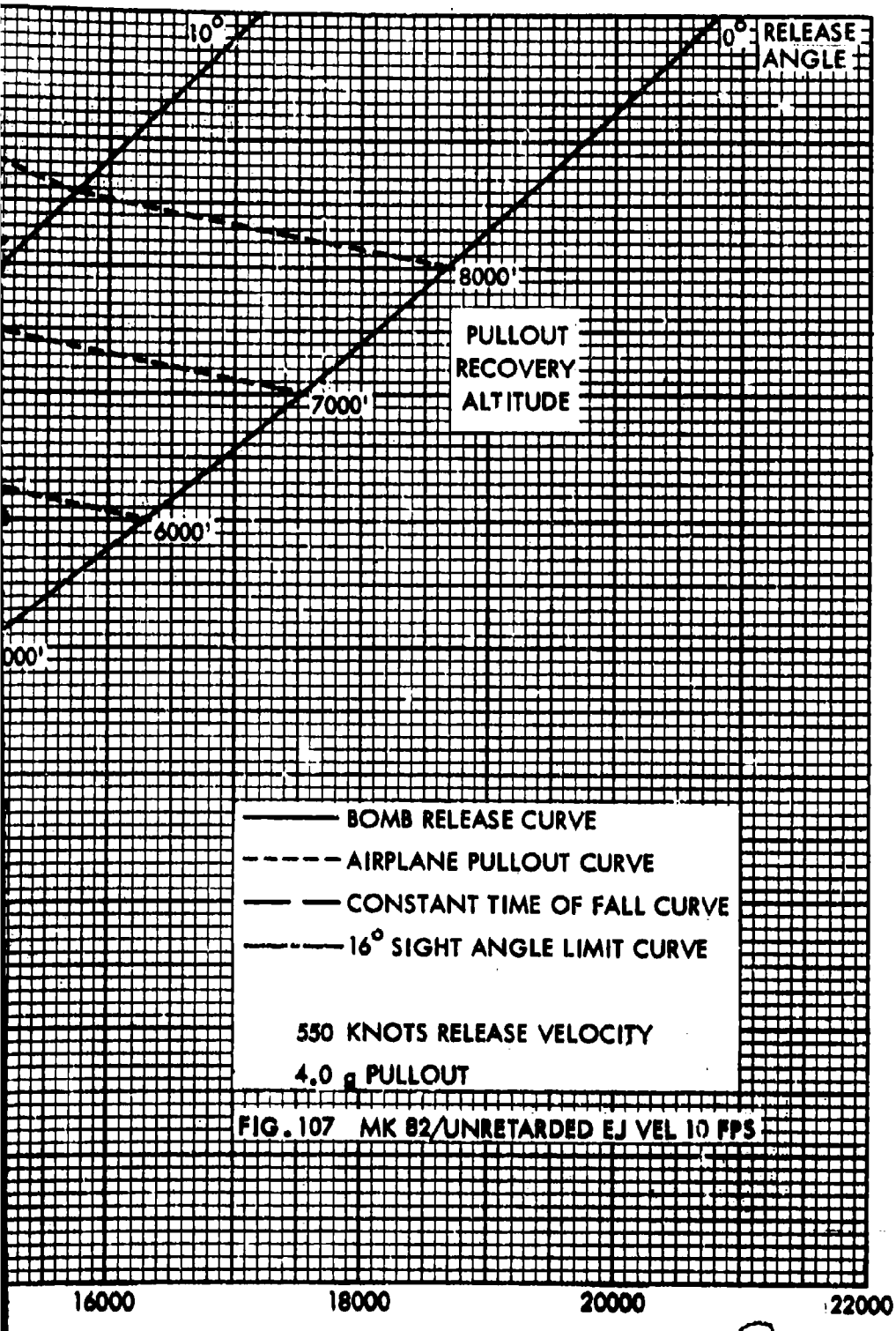
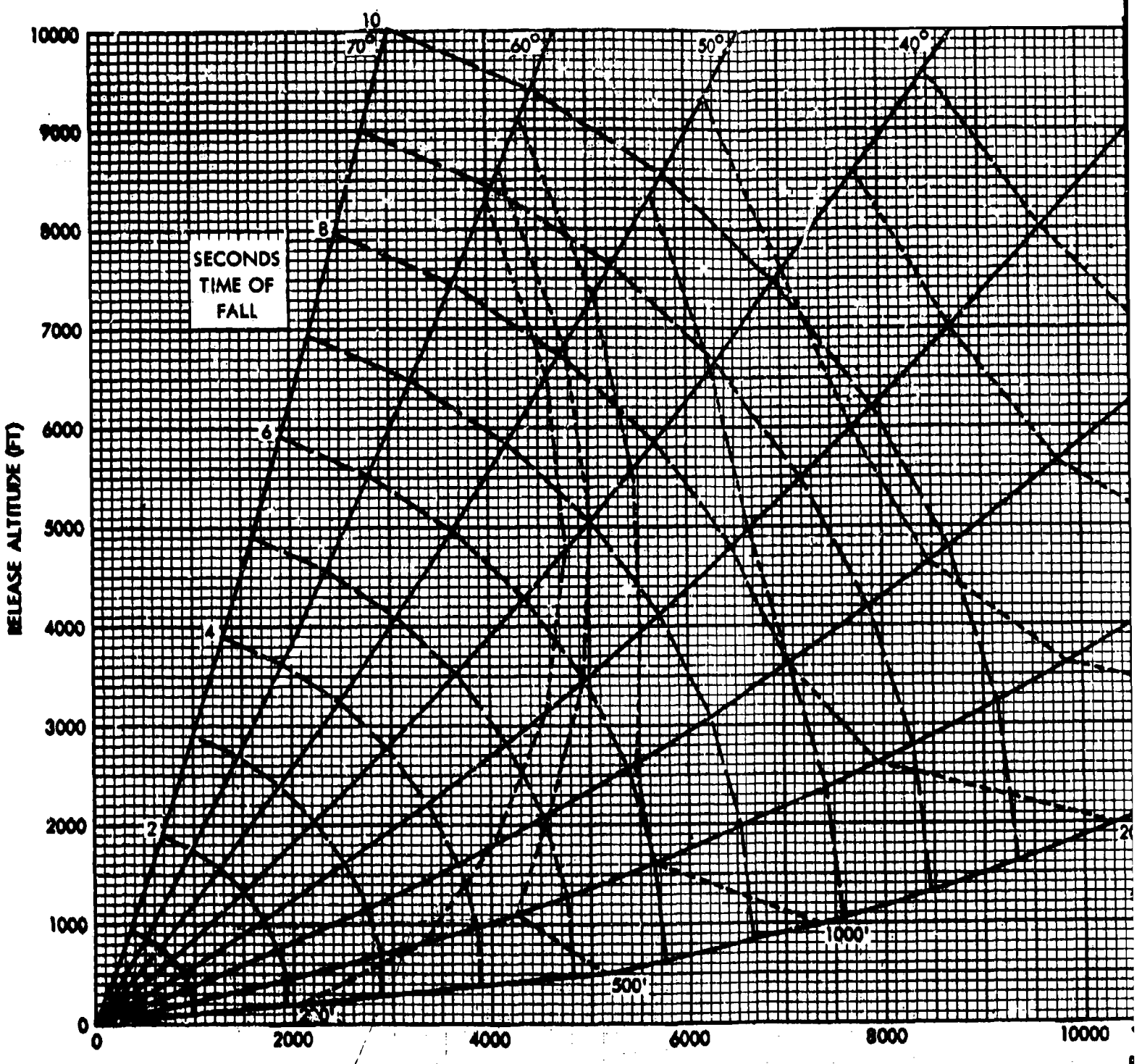


FIG. 107 MK 82/UNRETARDED EJ VEL 10 FPS


SECONDS
TIME OF
FALL
10
8
6
4
2
70°
60°
50°
40°
1000'
500'
250'
RELEASE ALTITUDE (FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
10000

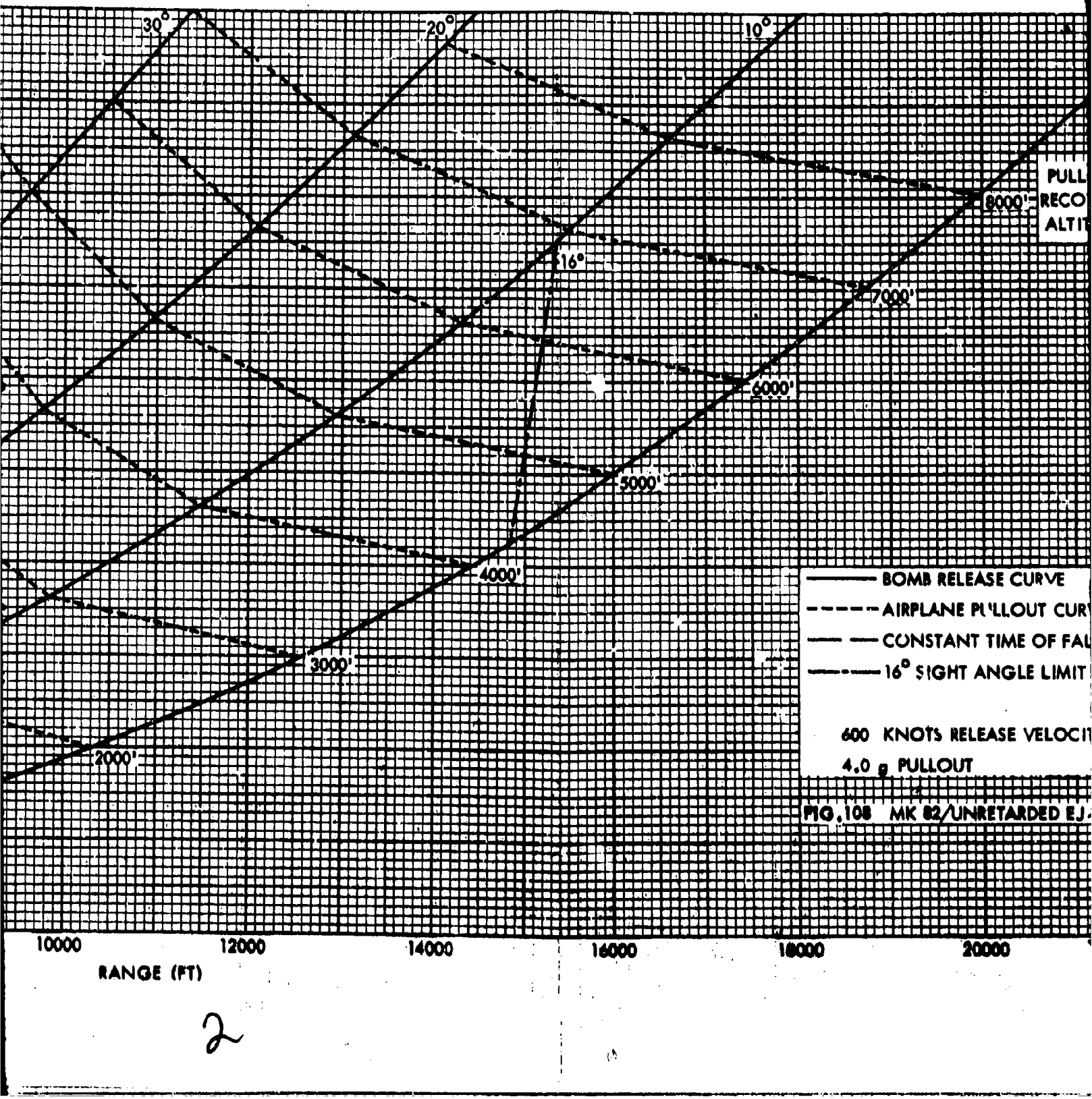
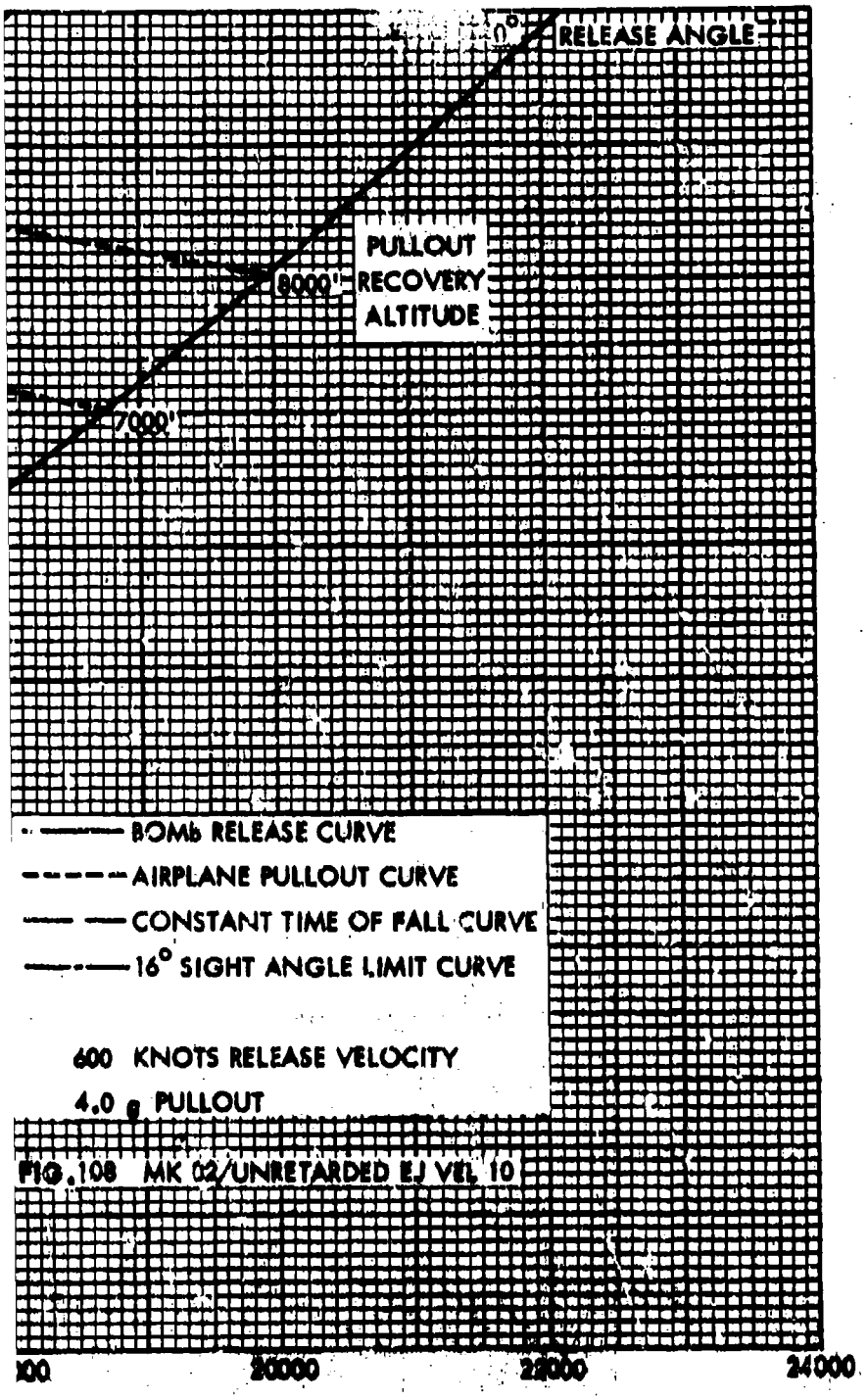


FIG. 108 MK 82/UNRETARDED EJ


0° RELEASE ANGLE
PULLOUT RECOVERY ALTITUDE
8000'
7000'
BOMb RELEASE CURVE
AIRPLANE PULLOUT CURVE
CONSTANT TIME OF FALL CURVE
16° SIGHT ANGLE LIMIT CURVE
600 KNOTS RELEASE VELOCITY
4.0 g PULLOUT
FIG. 108 MK 02/UNRETARDED EJ VEL 10
20000
22000
24000

NOLTR 65-230

DISTRIBUTION

	Copies
Commander U. S. Naval Air Systems Command Washington, D. C. 20360	5
(Library)	2
Commander U. S. Naval Ordnance Test Station China Lake, California	
(code 3561)	1
(code 3551)	1
(code 403)	1
(code 4036)	1
(code 5563)	1
Air Development Squadon 5 VX5, Naval Air Facilities China Lake, California 93557	3
Office of Chief of Naval Operations Operations Evaluation Group (OPO3EG) Washington, D. C.	2
Commander Operational Test and Evaluation Force Norfolk, Virginia 23511	1
Deputy Commander Operational Test and Evaluation Force, Pacific Naval Air Station North Island, San Diego, California 92135	1
Commanding Officer U. S. Naval Air Development Center Johnsville, Pennsylvania	1
Commander Naval Air Test Center (WST) Patuxent, Maryland	1
Commander U. S. Naval Weapons Laboratory Dahlgren, Virginia	2

DISTRIBUTION (cont'd.)

	Copies
Commanding Officer Eglin Air Force Base, Florida 32542	
(AFATL, ATB, Mr. E. S. Martin)	1
(AFATL, ATZS, Mr. Valentine)	1
Center for Naval Analyses 1401 Wilson Boulevard Arlington, Virginia	
(Mr. DePoy)	1
Commanding Officer Harry Diamond Laboratories Connecticut Avenue & Van Ness Street, N. W. Washington, D. C. 20438	1
Commander in Chief, Atlantic Fleet Norfolk, Virginia 23511	3
Commander, Naval Air Force U. S. Pacific Fleet Box 1210 Naval Air Station North Island, San Diego, California 92135	3
Commander in Chief U. S. Pacific Fleet F.P.O., San Francisco, California 96610	3
Director Office of Naval Research Washington, D. C.	1
Defense Documentation Center Cameron Station Alexandria, Virginia 21314	20

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Naval Ordnance Laboratory White Oak, Silver Spring, Maryland	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Mk 81 and Mk 82 BOMB RELEASE CURVES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Kasper, Marvin
Wrenn, Arthur

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
20 May 1966	105	3

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
BUWEPS WEPTASK b. PROJECT NO. RM37 73002/212 1/9470 BO 02 c. d.	NOLTR 65-230 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Each transmittal of this document outside the agencies of the U. S Government must have prior approval of NOL.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

A study was conducted to determine the release envelopes for the Mark 81 and Mark 82 bombs in the retarded and unretarded modes. Release curves are presented for release velocities between 200 and 600 knots. Aircraft pullout limits and line of sight between pilot and target limits are indicated on the release curves. The time of fall of the bomb is also indicated on the curves.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Mk 81 - 82 Bomb release curves						

INSTRUCTIONS

1. **ORIGINATING ACTIVITY:** Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE:** Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S):** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U).*

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

Unclassified
Security Classification

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 65-230)
MK 81 AND MK 82 BOMB RELEASE CURVES, by Marvin Kasper and Arthur Wrenn. 20 May 1966. v.p. charts, tables, diagrs. BuWeps task RM37 73002/212 1/9470 B0 02.

UNCLASSIFIED

A study was conducted to determine the release envelopes for the Mark 81 and Mark 82 bombs in the retarded and unretarded modes. Release curves are presented for release velocities between 200 and 600 knots. Aircraft pullout limits and line of sight between pilot and target limits are indicated on the release curves. The time of fall of the bomb is also indicated on the curves.

1. Bombs - Mark 81
2. Bombs - Mark 82
3. Bombs - Release
I. Title
II. Kasper, Marvin
III. Wrenn, Arthur, jt. author
IV. Project

Abstract card is unclassified.

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 65-230)
MK 81 AND MK 82 BOMB RELEASE CURVES, by Marvin Kasper and Arthur Wrenn. 20 May 1966. v.p. charts, tables, diagrs. BuWeps task RM37 73002/212 1/9470 B0 02.

UNCLASSIFIED

A study was conducted to determine the release envelopes for the Mark 81 and Mark 82 bombs in the retarded and unretarded modes. Release curves are presented for release velocities between 200 and 600 knots. Aircraft pullout limits and line of sight between pilot and target limits are indicated on the release curves. The time of fall of the bomb is also indicated on the curves.

1. Bombs - Mark 81
2. Bombs - Mark 82
3. Bombs - Release
I. Title
II. Kasper, Marvin
III. Wrenn, Arthur, jt. author
IV. Project

Abstract card is unclassified.

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 65-230)
MK 81 AND MK 82 BOMB RELEASE CURVES, by Marvin Kasper and Arthur Wrenn. 20 May 1966. v.p. charts, tables, diagrs. BuWeps task RM37 73002/212 1/9470 B0 02.

UNCLASSIFIED

A study was conducted to determine the release envelopes for the Mark 81 and Mark 82 bombs in the retarded and unretarded modes. Release curves are presented for release velocities between 200 and 600 knots. Aircraft pullout limits and line of sight between pilot and target limits are indicated on the release curves. The time of fall of the bomb is also indicated on the curves.

1. Bombs - Mark 81
2. Bombs - Mark 82
3. Bombs - Release
I. Title
II. Kasper, Marvin
III. Wrenn, Arthur, jt. author
IV. Project

Abstract card is unclassified.

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 65-230)
MK 81 AND MK 82 BOMB RELEASE CURVES, by Marvin Kasper and Arthur Wrenn. 20 May 1966. v.p. charts, tables, diagrs. BuWeps task RM37 73002/212 1/9470 B0 02.

UNCLASSIFIED

A study was conducted to determine the release envelopes for the Mark 81 and Mark 82 bombs in the retarded and unretarded modes. Release curves are presented for release velocities between 200 and 600 knots. Aircraft pullout limits and line of sight between pilot and target limits are indicated on the release curves. The time of fall of the bomb is also indicated on the curves.

1. Bombs - Mark 81
2. Bombs - Mark 82
3. Bombs - Release
I. Title
II. Kasper, Marvin
III. Wrenn, Arthur, jt. author
IV. Project

Abstract card is unclassified.