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HANDBOOK OF BALLISTIC AND ENGINEERING DATA FOR AMMUNITION

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dtd 10 Mar 59
By: H H Lambert
(Name of Officer)
HERALD H. LAMBERT
Security Officer
(Grade, Orgn.)
Ballistic Research Laboratories
Date: 10 Mar 59

VOLUME III

120-1-73 to 240-1-114 incl.

[redacted]

Regraded:
By Authority of: EO 10501
(Officer) 15 Dec 53
By: Herald H. Lambert
(Name of Officer)
(Grade, Orgn.)
Date: 18 Dec 56

JULY 1950

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BALLISTIC RESEARCH LABORATORIES

ABERDEEN PROVING GROUND, MD.

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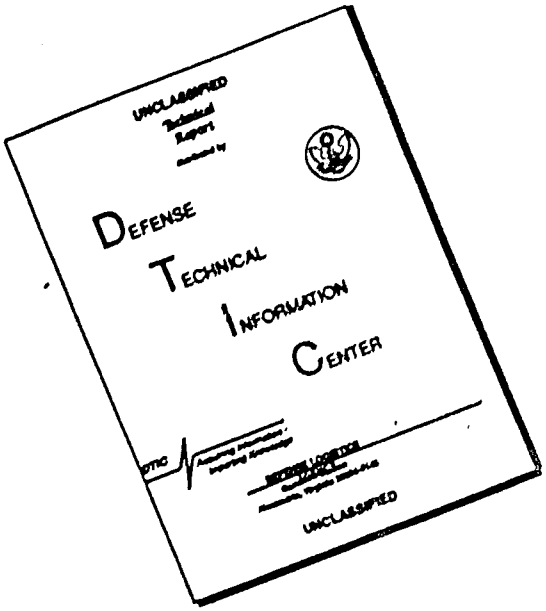

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Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 120 - 1 - 73

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
9 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 120-mm, M73
with
Fuze, MT, M61A1

Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
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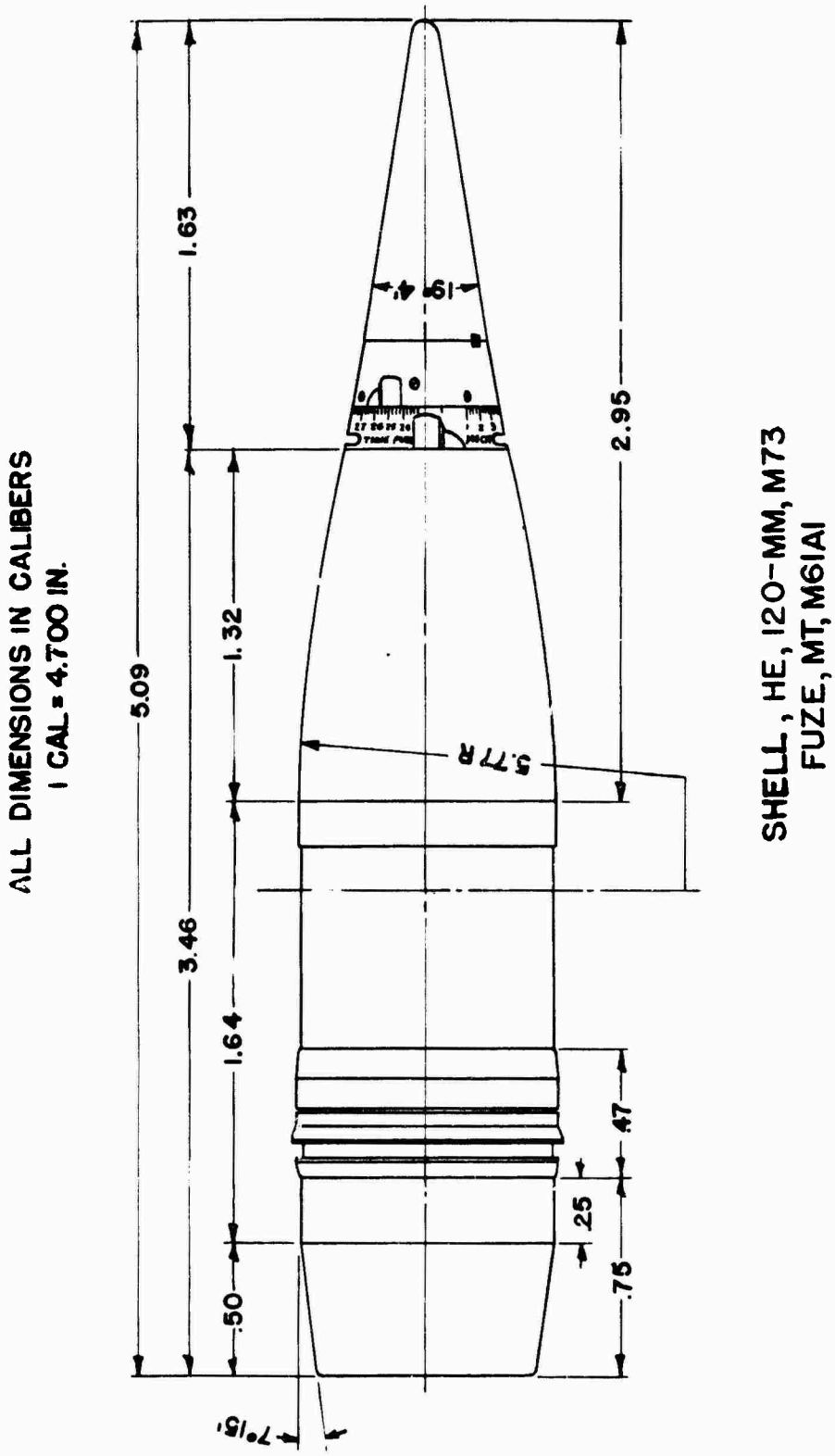
SECTION I
GENERAL

Paragraph
Purpose - 1

1. Purpose. The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 120-mm High Explosive Shell M73 with the Mechanical Time Fuze M61A1. This information is collected from the drawings, reports, firing tables, and technical manuals pertaining to this ammunition.



SHELL, HE, 120-MM, M73
FUZE, MT, M61A1

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

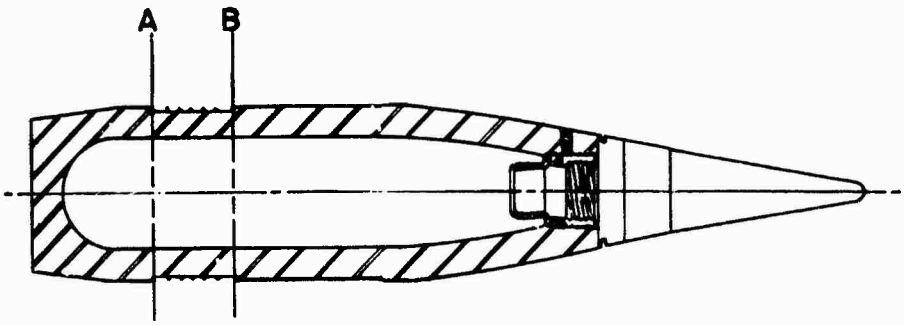
Shell: Metal parts assembly and details	75-18-40
Fuze: Assembly	73- 7-71
Shell and fuze: Assembly and marking diagram	75-18-48

3. Dimensions.

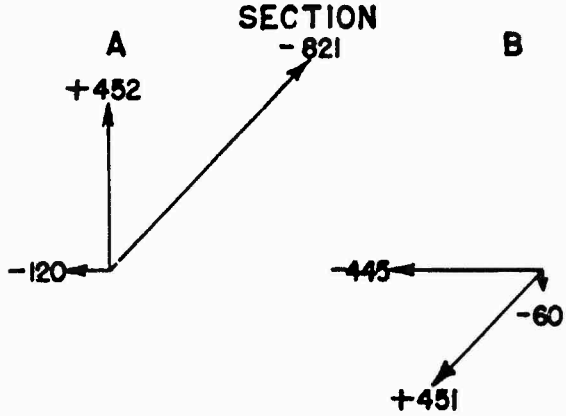
Boat-tail: Angle	7°15'
Length	0.50 cal
Band: Distance from boat-tail	0.25 cal
Distance from base	0.75 cal
Width	0.47 cal
Cylindrical body: Length	1.64 cal
Ogive: Radius of arc	5.77 cal
Length	1.32 cal
Fuze: Outside length	1.63 cal
Conical angle	19°4'
Length: Shell	3.46 cal
Shell and fuze	5.09 cal
Ogive and fuze	2.95 cal

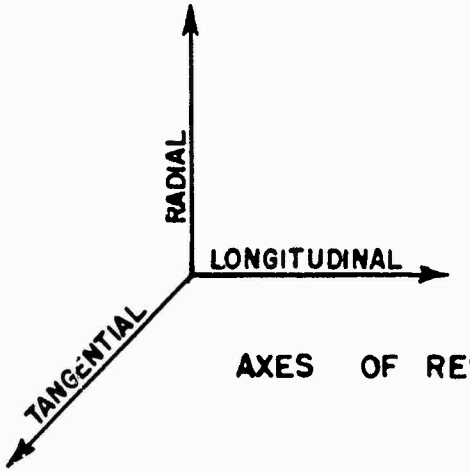
4. Physical characteristics.

Mean weight: Marking ■ ■ ■	49.25 lb
Marking ■ ■ ■■(standard	50.00 lb
Marking ■ ■ ■■■	50.75 lb
Base to center gravity	1.681 cal
Axial moment of inertia	1.072 lb. ft^2
Transverse moment of inertia	8.550 lb. ft^2



SECTION





AXES OF RESULTANT STRESS

DIAGRAM OF RESULTANT STRESSES

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Stresses	5
Theoretical yaw in bore	6

5. Stresses. The following table and the graphical representation on page 4 show the longitudinal, radial and tangential resultant stresses at each of two sections: (A) the rear corner of the band seat and (B) the front of the band seat.

Gun	4.7-in. AA T2*
Twist of rifling	1/25
Cross-sectional area of bore	17.95 sq in.
Rated maximum pressure	38,000 psi
Total weight of projectile	50 lb
Muzzle velocity	3,150 fps
Density of filler (TNT)	0.057 lb per cu in.

Resultant Stress**	Section	
100 psi	A	B
Longitudinal	- 120	- 445
Radial	+ 452	- 60
Tangential	- 821	+ 451

* Different stresses would occur in the 120-mm AA Gun M1 (T2E1), which is rifled with a twist of 1/30, with a muzzle velocity of 3,100 fps.

** + denotes tension; - denotes compression.

6. Theoretical yaw in bore.

Minimum	3.1 min
Maximum	5.4 min

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data	7
Firing table data	8

7. Aerodynamic data.

a. Drag. The data observed in air burst firings, reduced by the use of the G_2 drag function, yielded a constant form factor of 0.893. At a velocity of 3,100 fps, the corresponding drag coefficient K_D is 0.0857.

b. Stability. Ballistic Research Laboratory Report No. 237, "Stability firings of 4.7-inch AA Shell T5", gives data obtained from stability firings of the HE Shell M73 (T5) loaded with barium sulfate, with inert Fuze M61 (T31E2), in a 6-inch Gun M1900 with a 4.7-inch liner T2, rifled with a twist of 1/25, at a muzzle velocity of 3,040 fps. The Mach number was 2.64. The stability factor was found to be 2.84. The 120-mm (4.7-inch) AA Gun M1 (T2E1) is rifled with a twist of 1/30. With this twist, the stability factor would be 1.97. The moment coefficient K_M is 1.079.

c. Loss of spin. Ballistic Research Laboratory Report No. 569, "Spin of 120-mm HE Shell M73", gives data obtained by means of a radio spin sonde from an inert M73 Shell with a dummy Fuze T75E6, which has a plastic cap with the same contour as the MT Fuze M61, fired from a 120-mm Gun M1 at a muzzle velocity of 3,010 fps. The Reynolds' number R, based on the translational velocity and the caliber of the shell and the kinematic viscosity of the air, varied from 1.12×10^6 to 3.79×10^6. The average axial couple coefficient K_A is 0.00482. The average skin friction drag coefficient C'_{DF} is 0.00158.

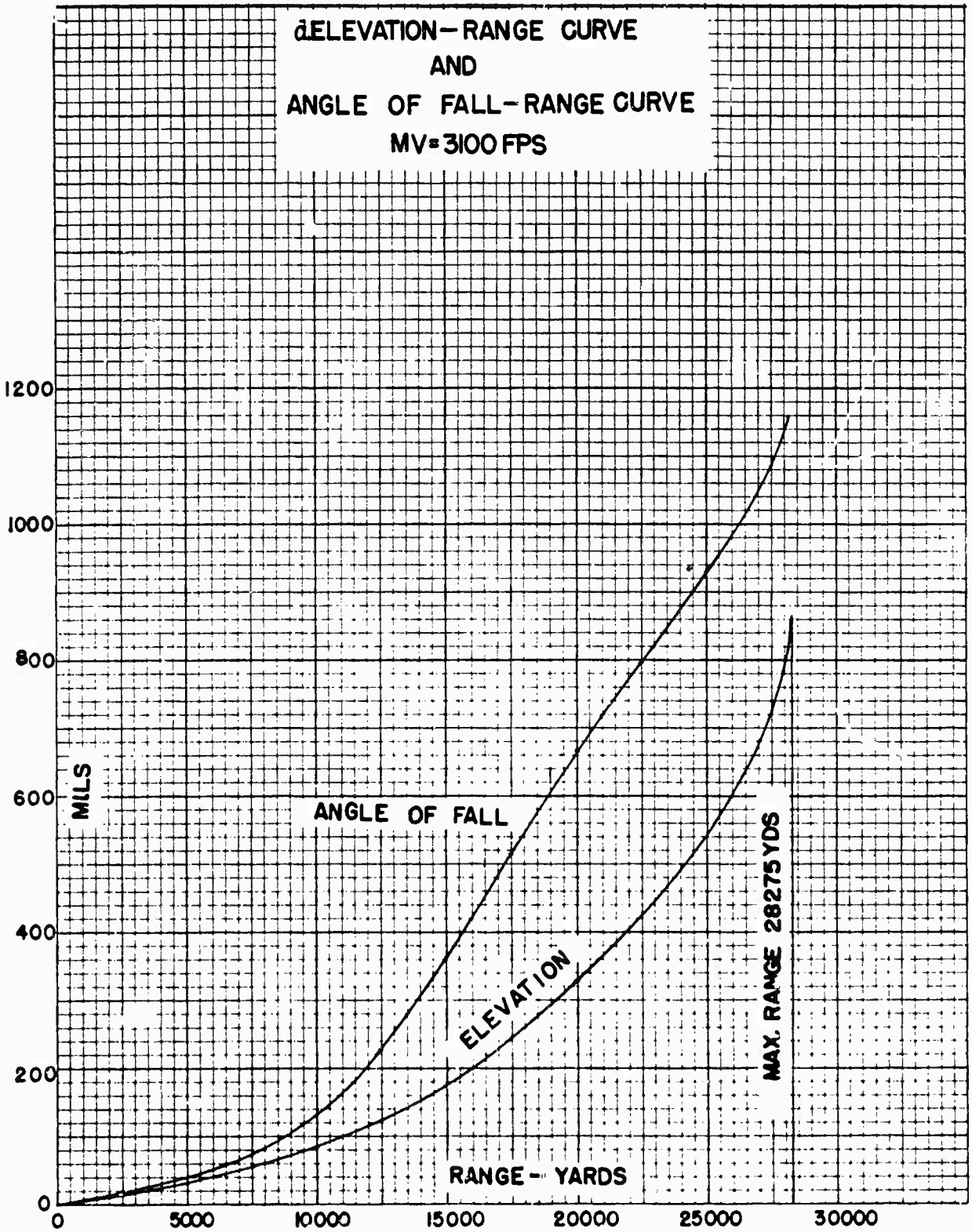
8. Firing table data. FT 4.7AA-C-1 (antiaircraft firing tables FT 4.7AA-C-1, C-2 (terrestrial firing tables). Gun, 120-mm (4.7-inch) AA, M1. Twist of rifling: 1/30. MV: 3000 fps for AA tables; 3100 fps (standard) for terrestrial. OCM items 17238 and 17324 recommended and approved standardization of the 4.7-inch HE Shell M73. OCM item 23657 changed its designation to 120-mm AA Gun M1, which was standardized by OCM item 21389.

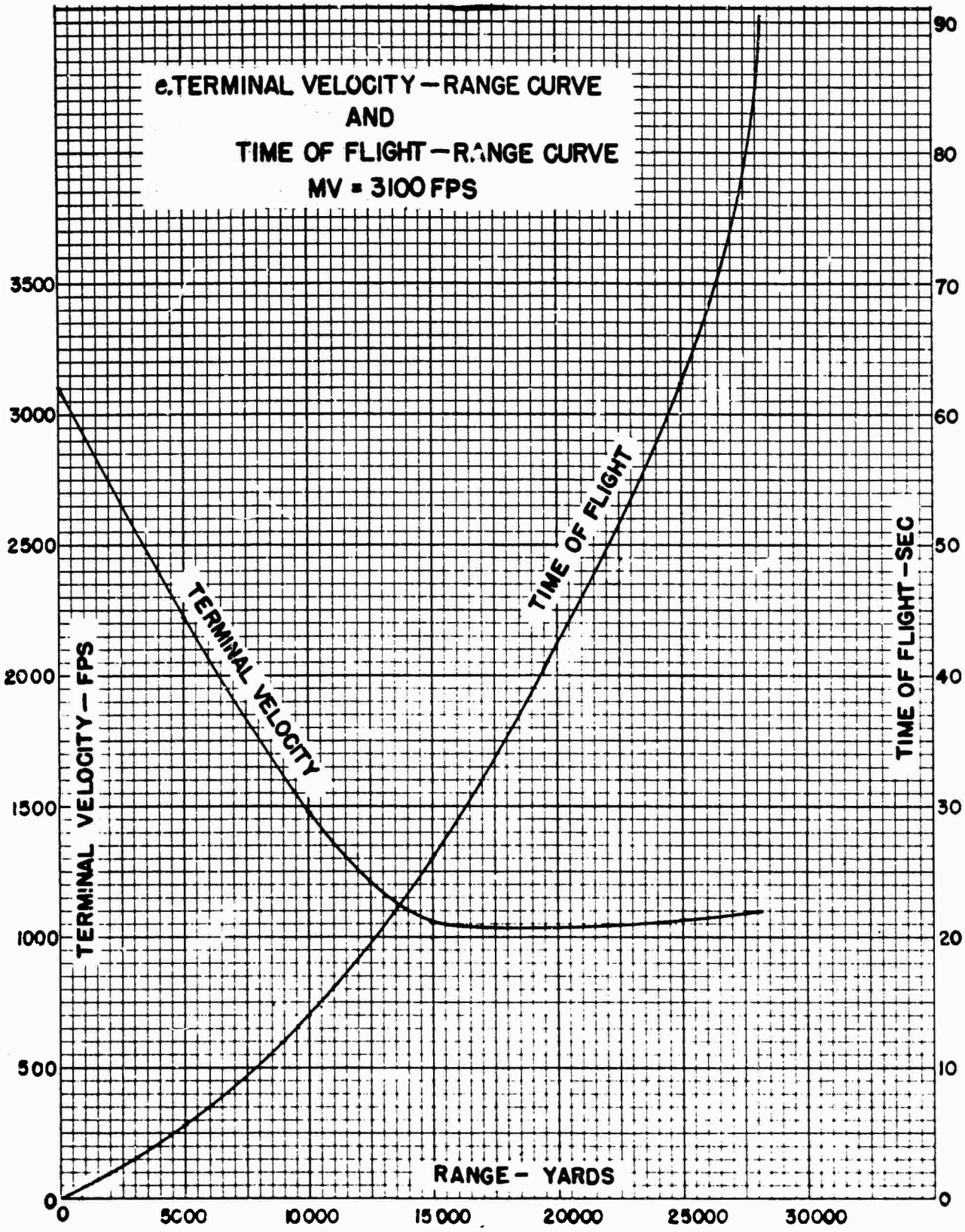
a. Form factor. (Proj Type 2). $i_2 = 0.893$.

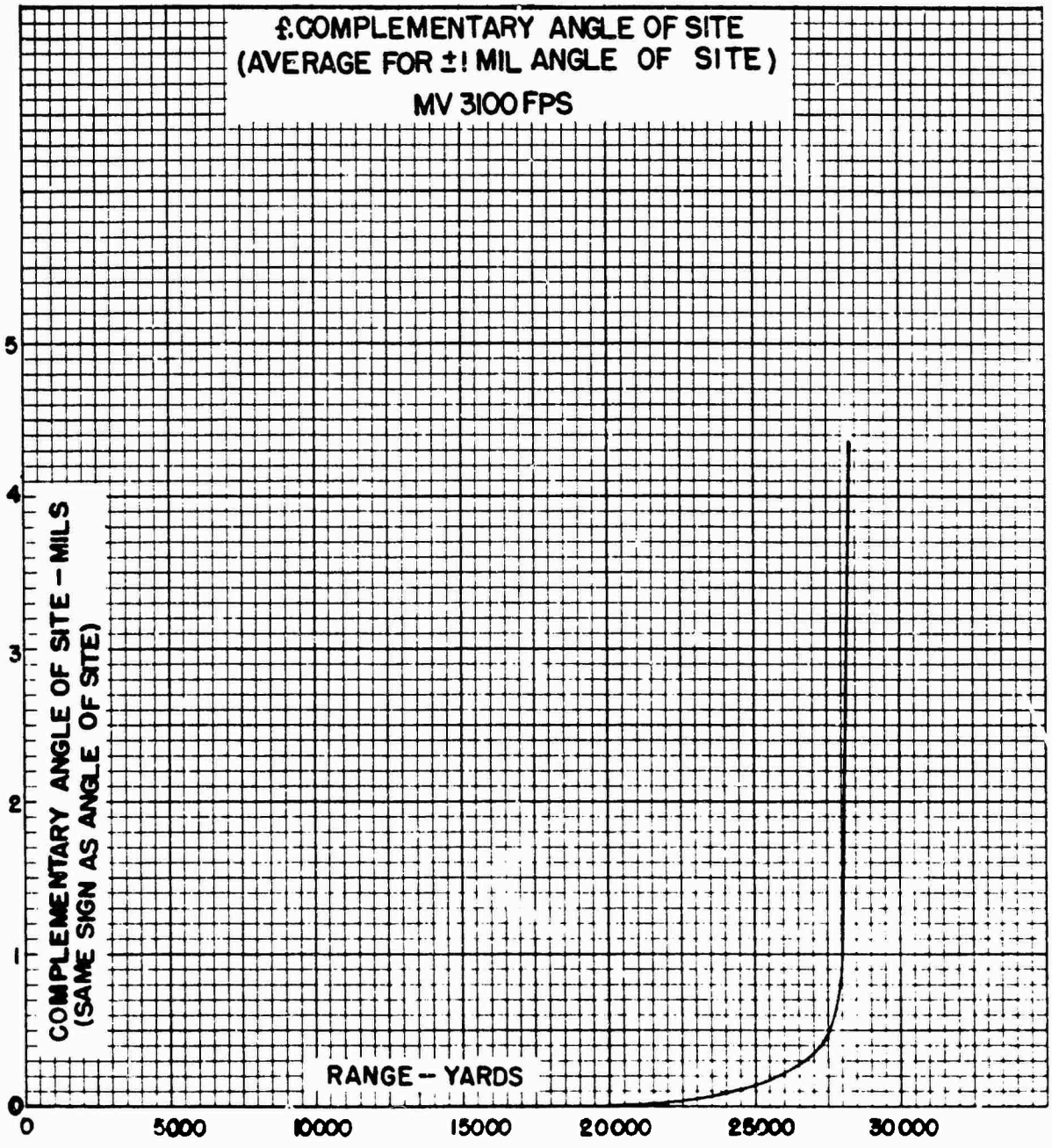
b. Ballistic coefficient. (Proj Type 2). $C_2 = 2.535$.

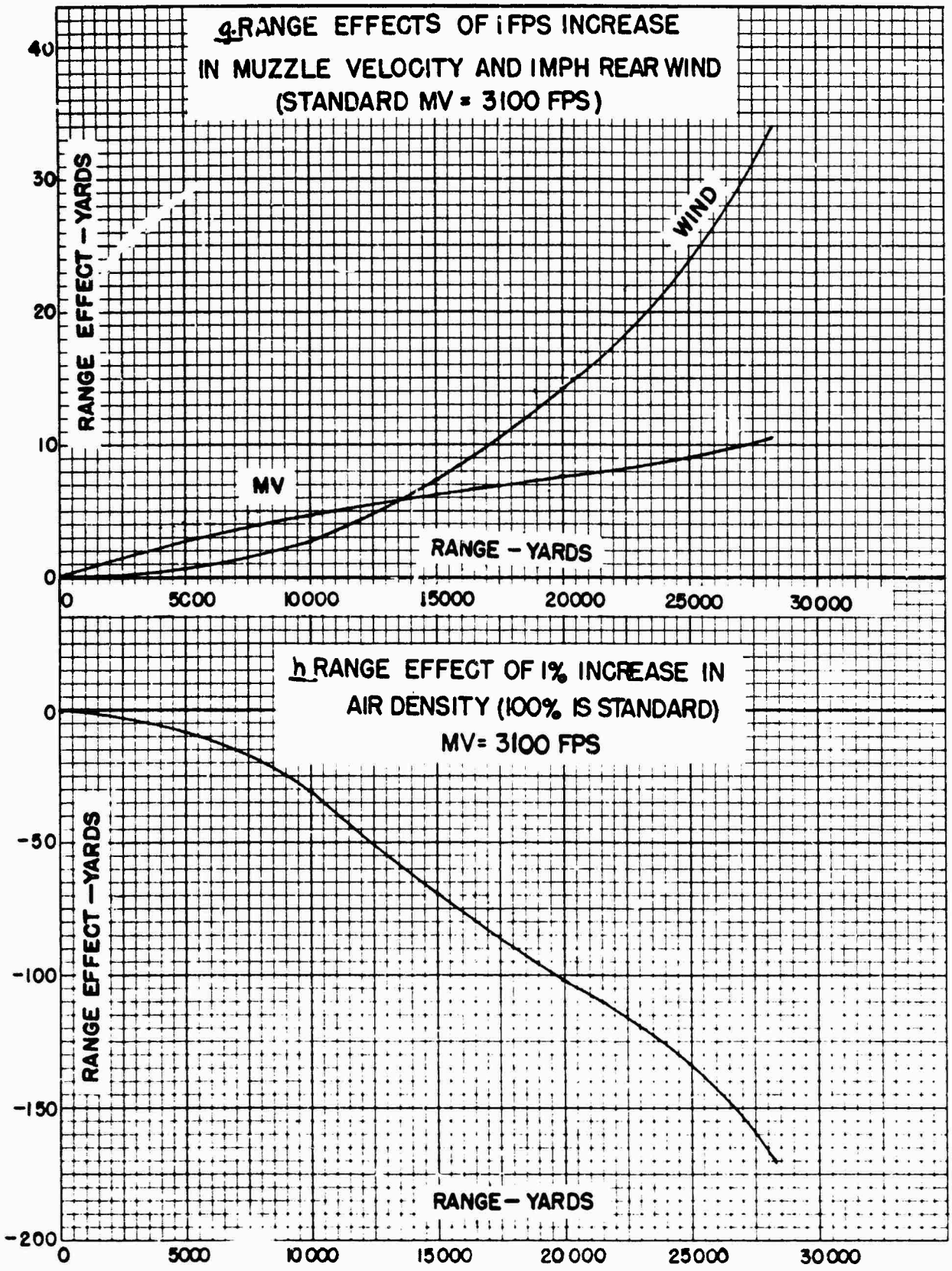
c. Trajectory data. The firing table contains trajectory and fuze setter data. With the fuze set 'safe':

Maximum horizontal range	27,160 yd
Maximum ordinate	19,150 yd


ELEVATION—RANGE CURVE
AND
ANGLE OF FALL—RANGE CURVE
MV=3100 FPS
MILS
1200
1000
800
600
400
200
0
ANGLE OF FALL
ELEVATION
MAX. RANGE 28275 YDS
RANGE—YARDS
0
5000
10000
15000
20000
25000
30000


e. TERMINAL VELOCITY — RANGE CURVE
AND
TIME OF FLIGHT — RANGE CURVE
MV = 3100 FPS
TERMINAL VELOCITY — FPS
TIME OF FLIGHT — SEC
TERMINAL VELOCITY
TIME OF FLIGHT
RANGE — YARDS
0
500
1000
1500
2000
2500
3000
3500
0
10
20
30
40
50
60
70
80
90
0
5000
10000
15000
20000
25000
30000


£ COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ±1 MIL ANGLE OF SITE)
MV 3100 FPS
COMPLEMENTARY ANGLE OF SITE – MILS
(SAME SIGN AS ANGLE OF SITE)
RANGE – YARDS
0
1
2
3
4
5
0
5000
10000
15000
20000
25000
30000


g. RANGE EFFECTS OF 1 FPS INCREASE
IN MUZZLE VELOCITY AND 1 MPH REAR WIND
(STANDARD MV = 3100 FPS)
RANGE EFFECT – YARDS
WIND
MV
RANGE – YARDS
0
10
20
30
40
0
5000
10000
15000
20000
25000
30000
h. RANGE EFFECT OF 1% INCREASE IN
AIR DENSITY (100% IS STANDARD)
MV = 3100 FPS
RANGE EFFECT – YARDS
RANGE – YARDS
0
-50
-100
-150
-200
0
5000
10000
15000
20000
25000
30000

SECTION V
EFFECT DATA

Paragraph

Fragmentation - 9

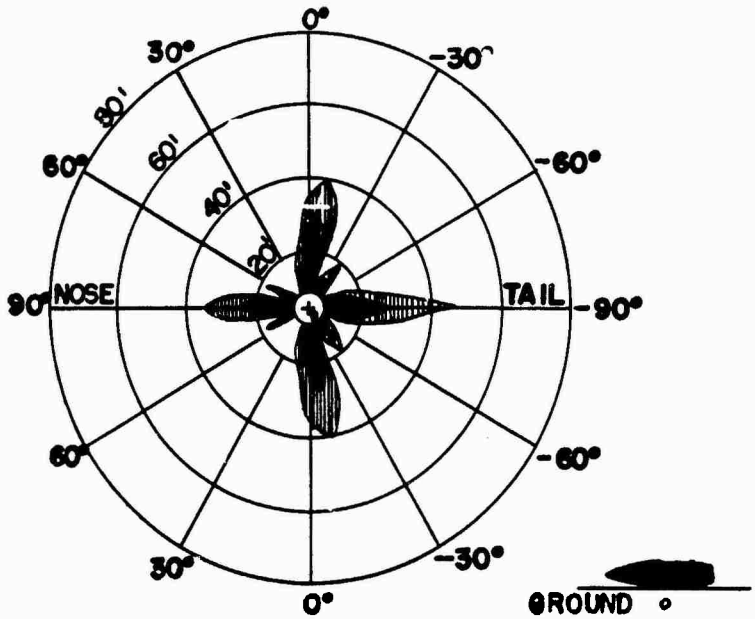
9. **Fragmentation.** The following data were taken from volume III of "Terminal Ballistic Data" and from TM9-1907, "Ballistic Data, Performance of Ammunition". The initial fragment velocity of the 120-mm HE Shell M73 is 2,410 fps.

a. Casualties.

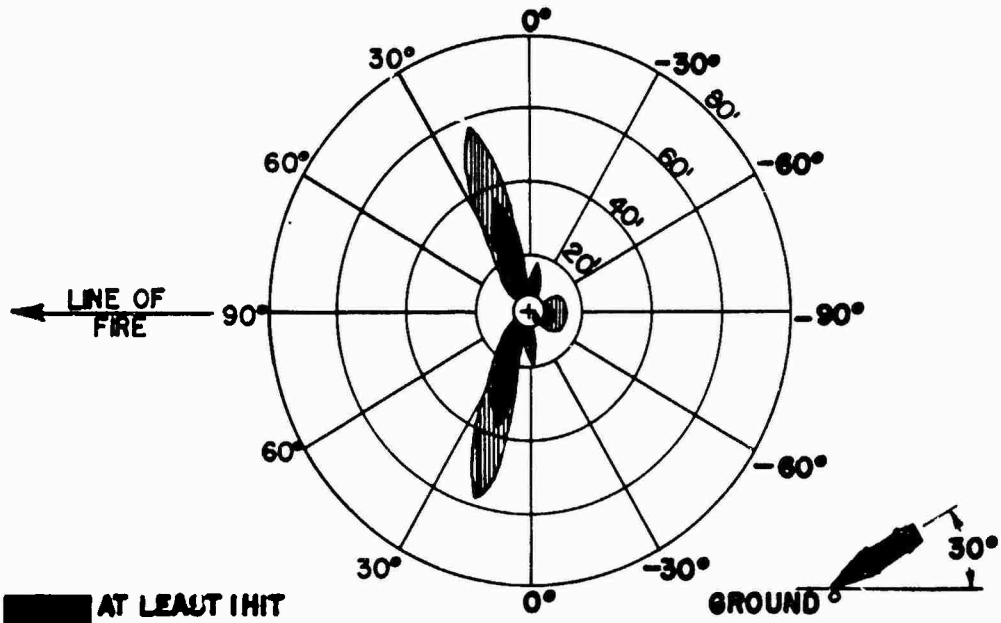
TABLE 54
CASUALTIES

Distance from burst (ft)	Total number of effective fragments	Average number of effective fragments per sq ft	For the lightest effective fragment	
			Weight (oz)	Velocity (fps)
r	N	B	m	v
20	484	0.0963	0.022	1,640
30	467	0.0413	0.028	1,460
40	458	0.0228	0.036	1,280
60	435	0.0096	0.051	1,080
80	413	0.0051	0.065	958
100	398	0.0032	0.077	880
150	367	0.0013	0.103	760
200	333	0.0007	0.133	669
300	290	0.0003	0.199	547
400	263	0.0001	0.275	465
500	239	0.0001	0.366	403

CASUALTIES



INCLINATION 0°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 0 FPS



AT LEAST 1 HIT PER 4 SQ FT

AT LEAST 1 HIT PER 10 SQ FT

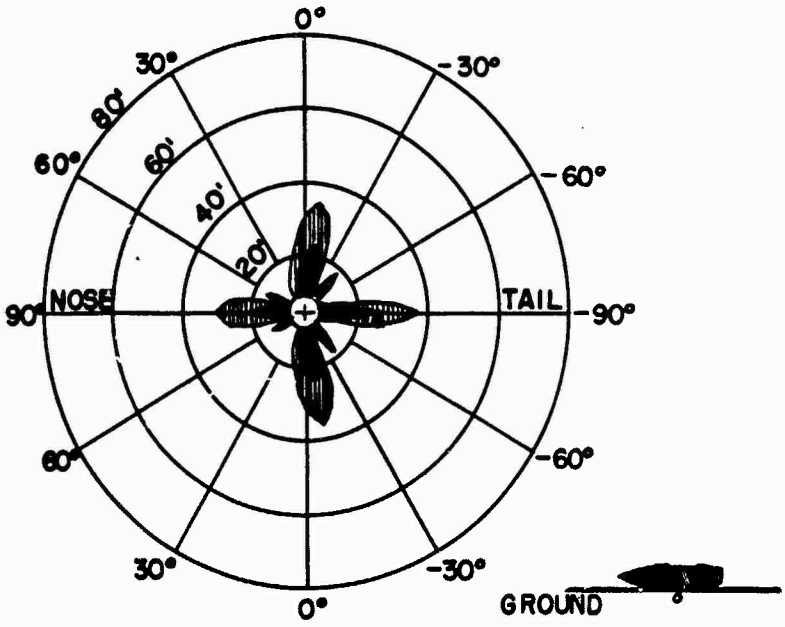
INCLINATION 30°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 960 FPS

b. Perforation of 1/8-inch mild steel.

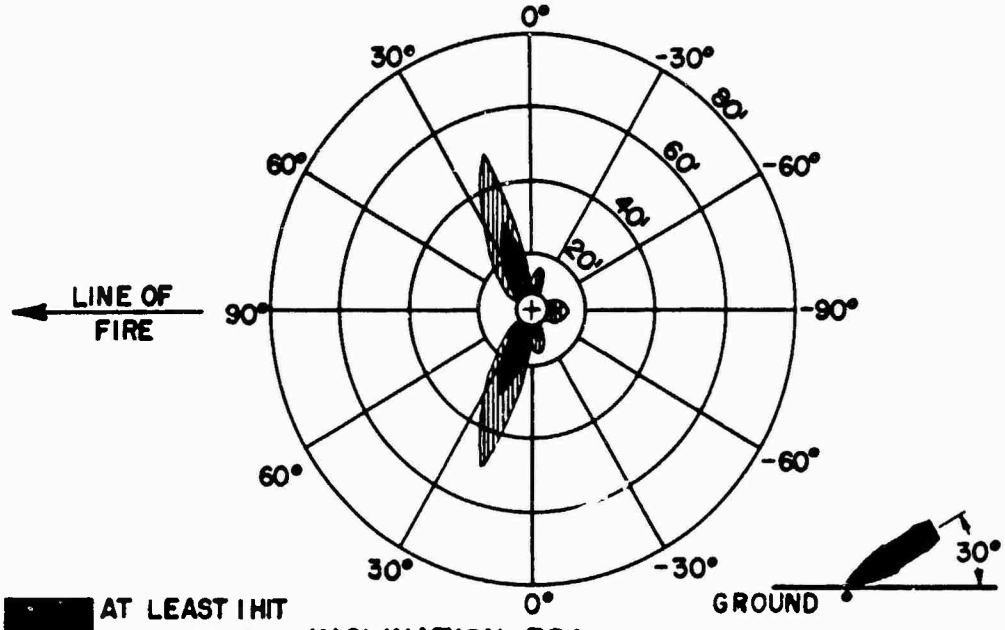
TABLE 55
PERFORATION OF 1/8 IN. MILD STEEL

Distance from burst (ft)	Total number of effective fragments	Average number of effective fragments per sq ft	For the lightest effective fragment	
			Weight (oz)	Velocity (fps)
r	N	B	m	v
20	376	0.0748	0.089	1,960
30	350	0.0309	0.117	1,820
40	319	0.0159	0.149	1,710
60	278	0.0061	0.230	1,470
80	246	0.0031	0.333	1,310
100	228	0.0018	0.427	1,220
120	212	0.0012	0.531	1,150
140	198	0.0008	0.640	1,090
170	178	0.0005	0.809	1,020
200	160	0.0003	0.987	968
300	118	0.0001	1.58	859

PERFORATION OF 1/8-INCH MILD STEEL



INCLINATION 0°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 0 FPS



AT LEAST 1 HIT PER 4 SQ FT

AT LEAST 1 HIT PER 10 SQ FT

INCLINATION 30°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 960 FPS

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 155 - 1 - 3

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
9 February 1949

BALLISTIC AND ENGINEERING DATA

for

Shell, HE, 155-mm, Mark 3 and Mark 3A1

with

Fuzes, PD, M46 and M51A4; TSQ, M55A3; and MT, M67A3

Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 8
V	Effect data	9

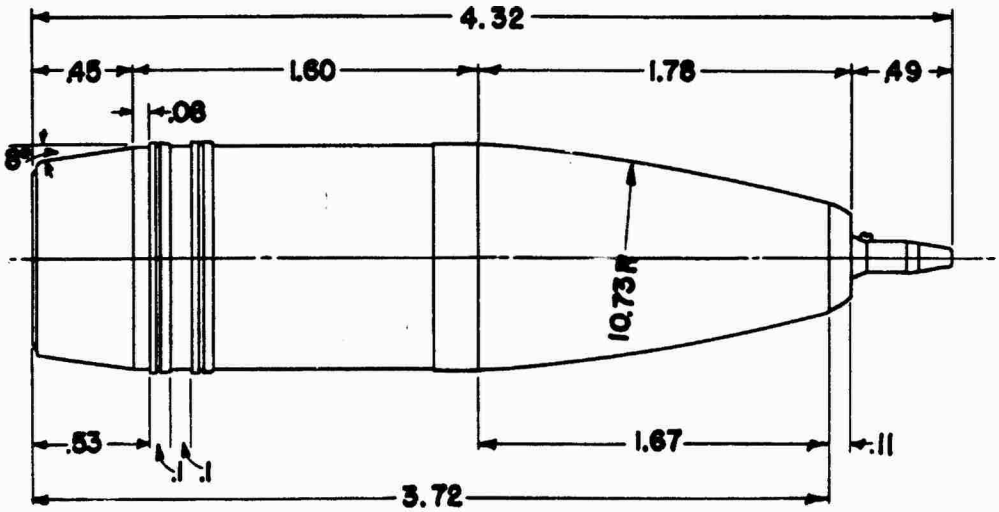
SECTION I

GENERAL

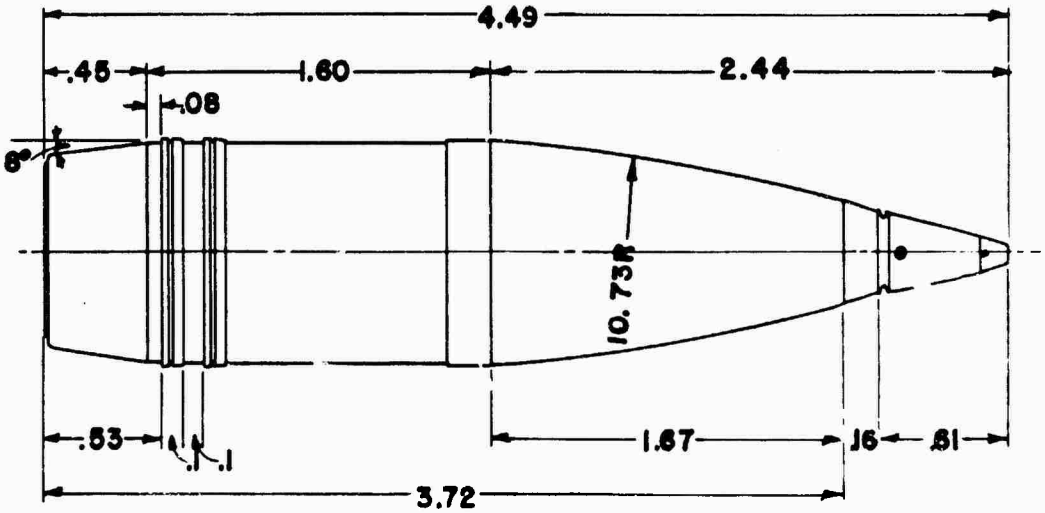
	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 155-mm High Explosive Shell Mark 3 with the Point Detonating Fuze M46 and the 155-mm High Explosive Shell Mark 3A1 with the Point Detonating Fuze M51A4, the Time and Superquick Fuze M55A3, and the Mechanical Time Fuze M67A3. This information is collected from the drawings, reports, and firing tables pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 6.102"



SHELL, HE, 155-MM, MARK 3
FUZE, PD, M46



SHELL, HE, 155-MM, MARK 3A1
FUZE, PD, M51A4

SECTION II
DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell, HE, Mark 3: Assembly and details	75-4- 36
Shell, HE, Mark 3A1 (consisting of Shell Mark 3 and adapter 75-4-83B): Metal parts assembly and details	75-4- 83
Adapter and Booster Mark 3AM2 (fits Shell Mark 3): Assembly and details	73-1-105
Booster M21A4 (fits adapter of Shell Mark 3A1): Assembly	73-2-154
Fuze, PD, M46 (fits Adapter and Booster Mark 3AM2): Assembly and details	73-2-126
Details	73-2-127
Fuze, PD, M51A4 (fits Booster M21A4): Assembly	73-2-145
Details	73-2-143
Fuze, TSQ, M54: Assembly	73-3-154
Fuze, TSQ, M55A3 (consisting of Booster M21A4 and Fuze M54): Assembly and detail	73-3-155
Fuze, MT, M67A3 (fits Booster M21A4): Assembly	73-7- 77

3. Dimensions.

Boat-tail:	Angle	8°00'
	Length	0.45 cal
Bands:	Distance from boat-tail to rear band	0.08 cal
	Distance from base to rear band	0.53 cal
	Width of each band	0.10 cal
	Distance between bands	0.10 cal
Cylindrical body:	Length	1.60 cal
Ogive:	Length	1.67 cal
	Radius of arc	10.73 cal
Shell Mark 3:	Length	3.72 cal
	Adapter and Booster Mark 3AM2	0.11 cal
	Fuze M46	0.49 cal
	Shell, adapter and fuze	4.32 cal
	Ogive and adapter	1.78 cal

Shell Mark 3A1:	Length without adapter	3.72 cal
	Adapter	0.16 cal
	Length with adapter	3.88 cal
	Fuze M51A4, M55A3 or M67A3	0.61 cal
	Shell and fuze	4.49 cal
	Ogive, adapter and fuze	2.44 cal

4. Physical characteristics.

Shell		Mark 3	Mark 3A1
Fuze		M46	M51A4, M55A3, M67A3
Mean weight (lb):	Zone 2	92.5	92.8
	Zone 3	93.6	93.9
	Zone 4 (standard)	94.7	95.0
	Zone 5	95.8	96.1
	Zone 6	96.9	97.2
Base to center of gravity		1.536 cal	
Axial moment of inertia		3.349 lb. ft^2	
Transverse moment of inertia		29.73 lb. ft^2	

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Stresses	5
Theoretical yaw in bore	6

5. Stresses. The stresses of the HE Shell Mark 3A1 in the 155-mm Guns M1, M2, M3 and M4 are approximately, tho not exactly, the same as those of the HE Shell M101. These are given in BRLH 155-1-101.

6. Theoretical yaw in bore.

Minimum	12 min
Maximum	19 min

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data	7
Firing table data	8

7. Aerodynamic data.

a. Drag. The ballistic coefficients, based on range firings and extrapolated to zero elevation, and the corresponding form factors and drag coefficients are tabulated below.

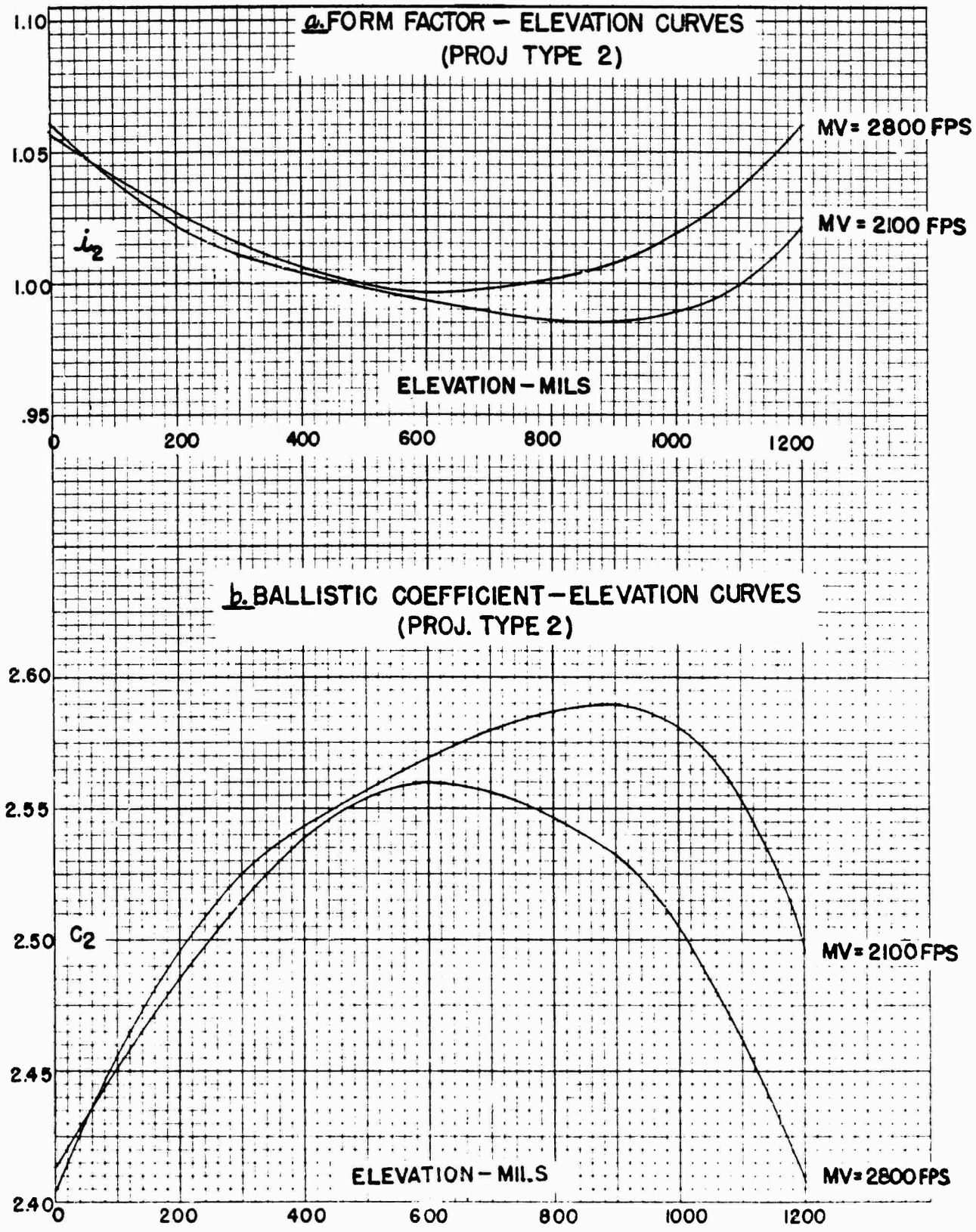
HE Shell	Fuze	Drag Function	Muzzle Velocity	Ball. Coef.	Form Factor	Drag Coef.
			fps	C	i	K_D
Mark 3	M46	G_5	1956	2.94	.87	.143
			2412	2.66	.96	.139
Mark 3A1	M51A4, M55A3, M67A1	G_2	2100	2.405	1.061	.128
			2800	2.414	1.057	.108

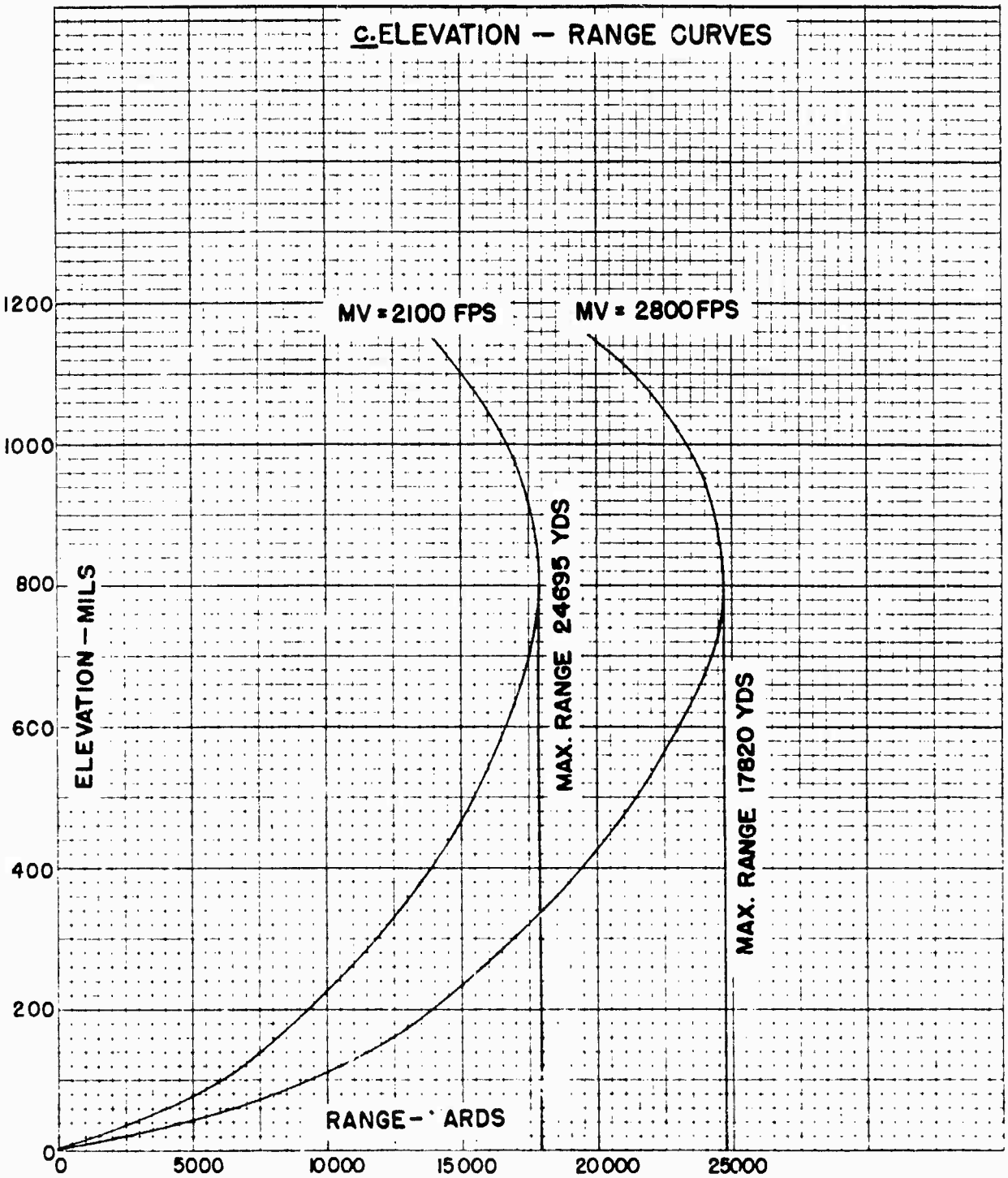
b. Stability. Ballistic Research Laboratory Report No. 162, "Stability of 155-mm Shell Mark III and T2", gives the stability factor and moment coefficient of the HE Shell Mark 3 with the PD Fuze M46, fired from the 155-mm Gun M1918:

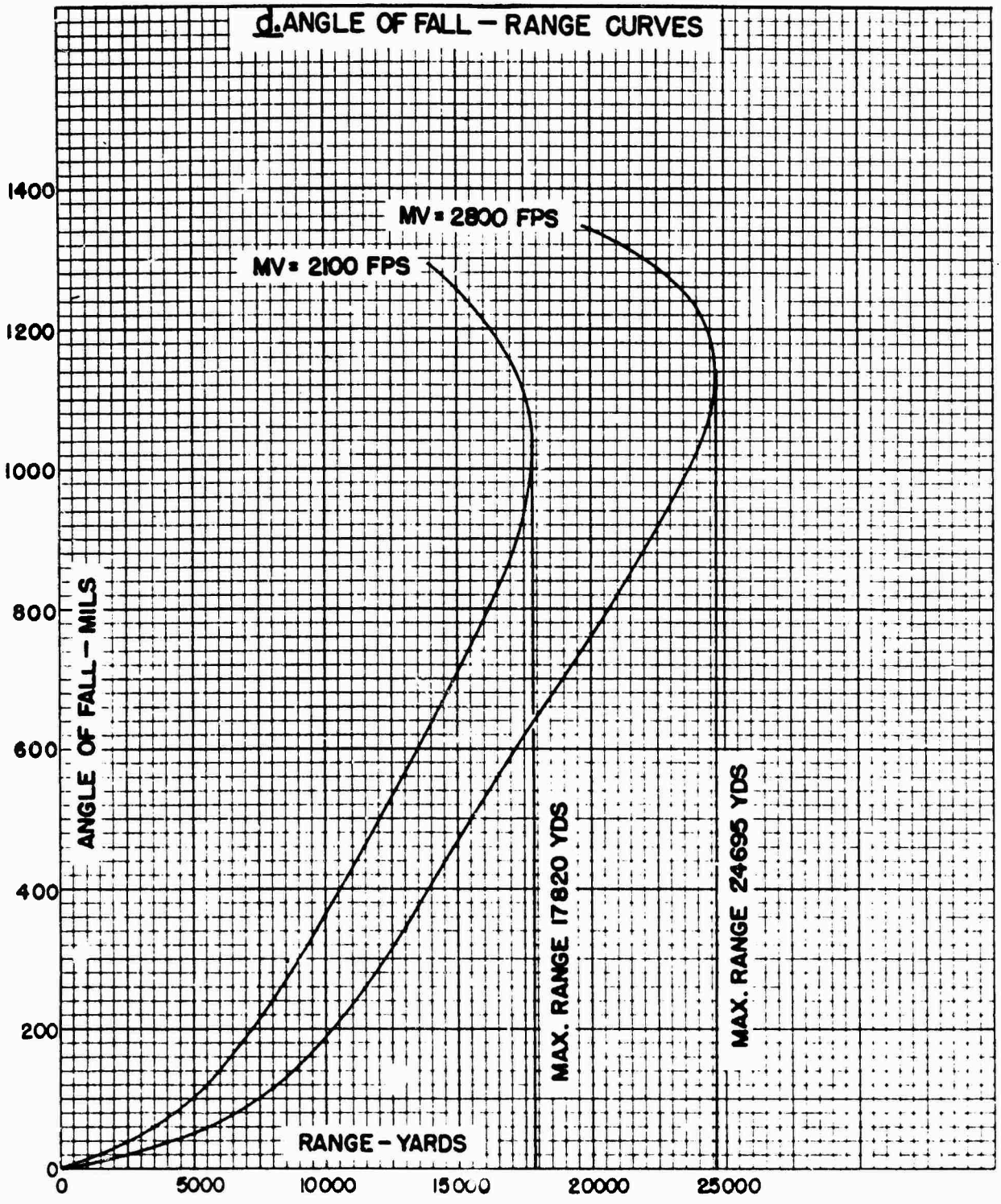
Muzzle velocity	1929 fps
Mach number	1.689
Moment coefficient K_M	1.22
Twist of rifling	1/29.9
Stability factor	1.41

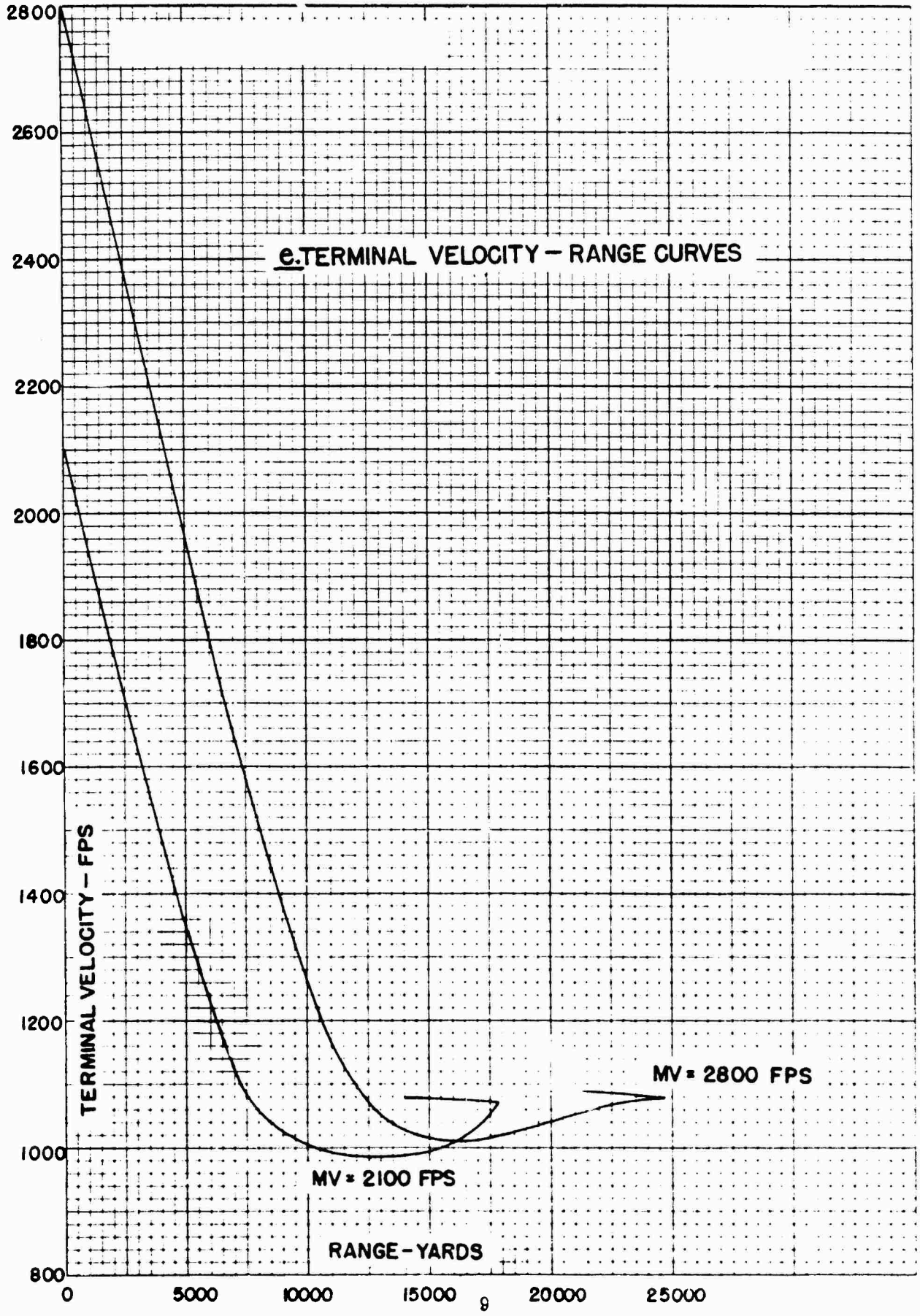
8. Firing table data. FT 155-S-2, C-7.

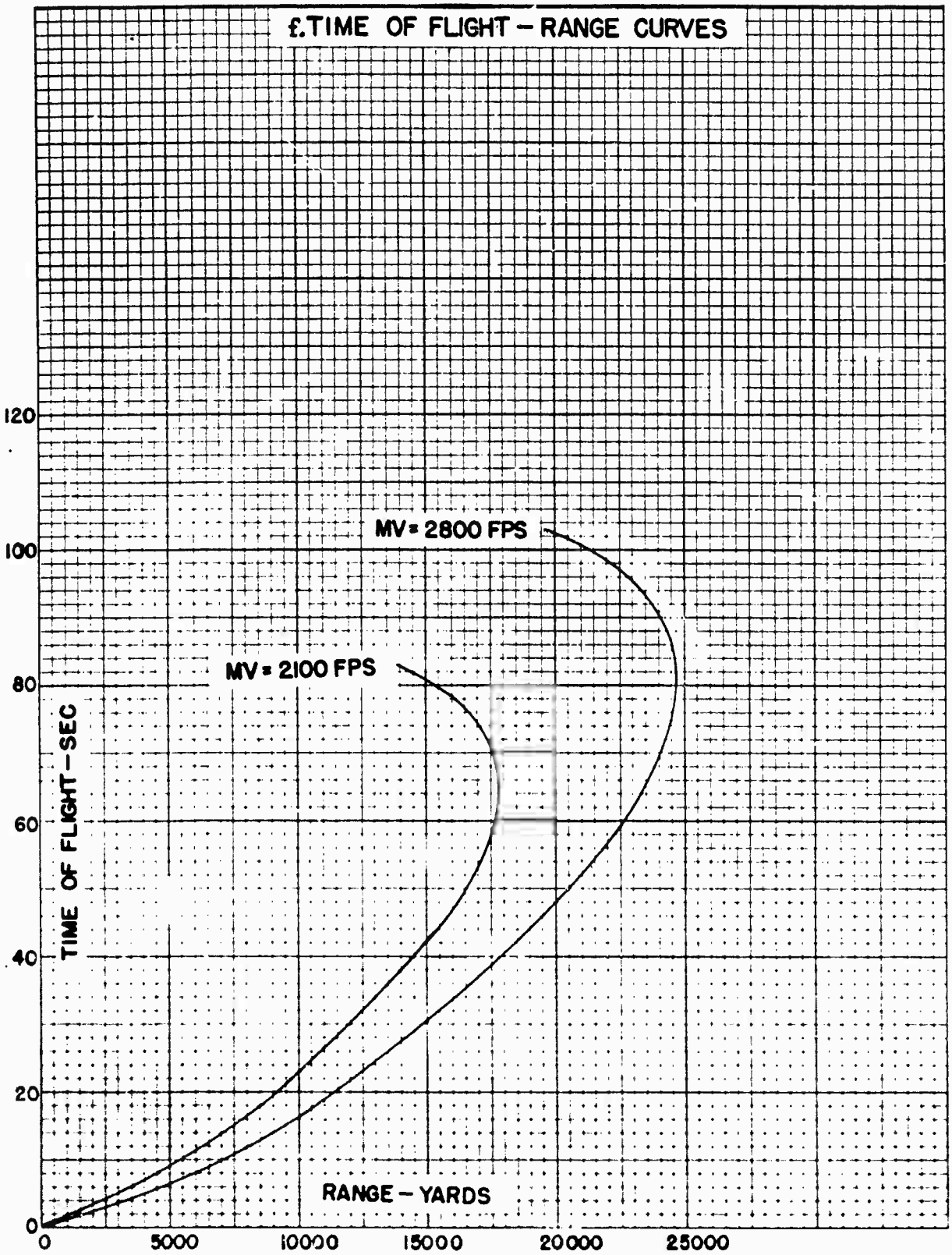
Guns, 155-mm, M1, M1A1, M1C, M2, M3 and M4.
Twist of rifling: 1/25.
Shell: Mark 3A1.
Fuzes: PD, M51A4; TSQ, M55A3; and MT, M67A3.
OCM items 22121 and 22438 recommended and approved the classification of this shell as substitute standard for use in the 155-mm Gun M1. OCM items 29646 and 30180 recommended and approved its reclassification as limited standard for use in the 155-mm Gun M2.

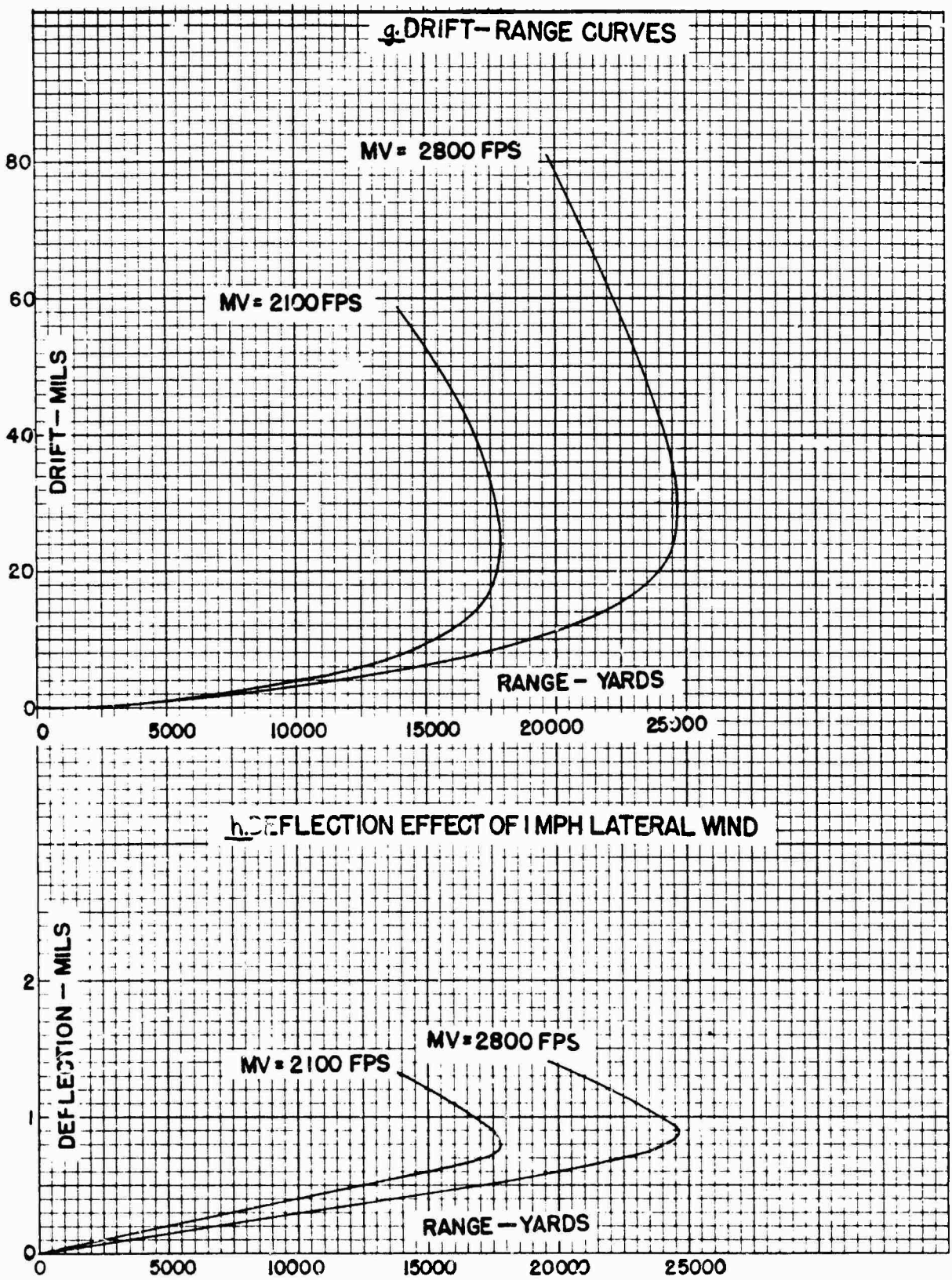

a. FORM FACTOR – ELEVATION CURVES
(PROJ TYPE 2)
MV = 2800 FPS
MV = 2100 FPS
i_2
ELEVATION – MILS
1.10
1.05
1.00
.95
0
200
400
600
800
1000
1200
b. BALLISTIC COEFFICIENT – ELEVATION CURVES
(PROJ. TYPE 2)
2.60
2.55
2.50
2.45
2.40
C_2
MV = 2100 FPS
MV = 2800 FPS
ELEVATION – MILS
0
200
400
600
800
1000
1200

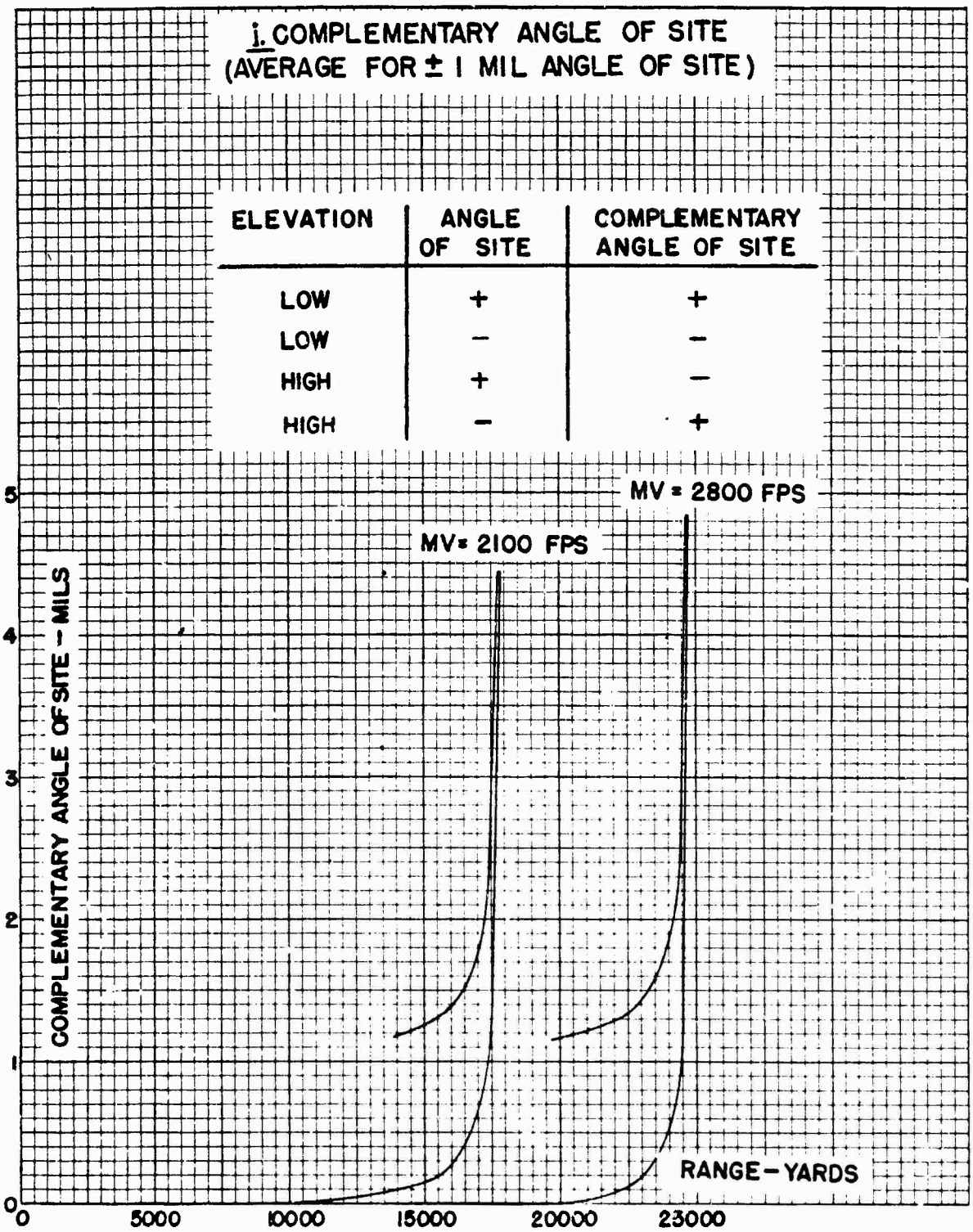

C. ELEVATION — RANGE CURVES
MV = 2100 FPS
MV = 2800 FPS
MAX. RANGE 24695 YDS
MAX. RANGE 17820 YDS
ELEVATION — MILS
RANGE — YARDS
0
200
400
600
800
1000
1200
0
5000
10000
15000
20000
25000


d. ANGLE OF FALL – RANGE CURVES
MV = 2800 FPS
MV = 2100 FPS
ANGLE OF FALL – MILS
1400
1200
1000
800
600
400
200
0
MAX. RANGE 17820 YDS
MAX. RANGE 24695 YDS
RANGE – YARDS
0
5000
10000
15000
20000
25000

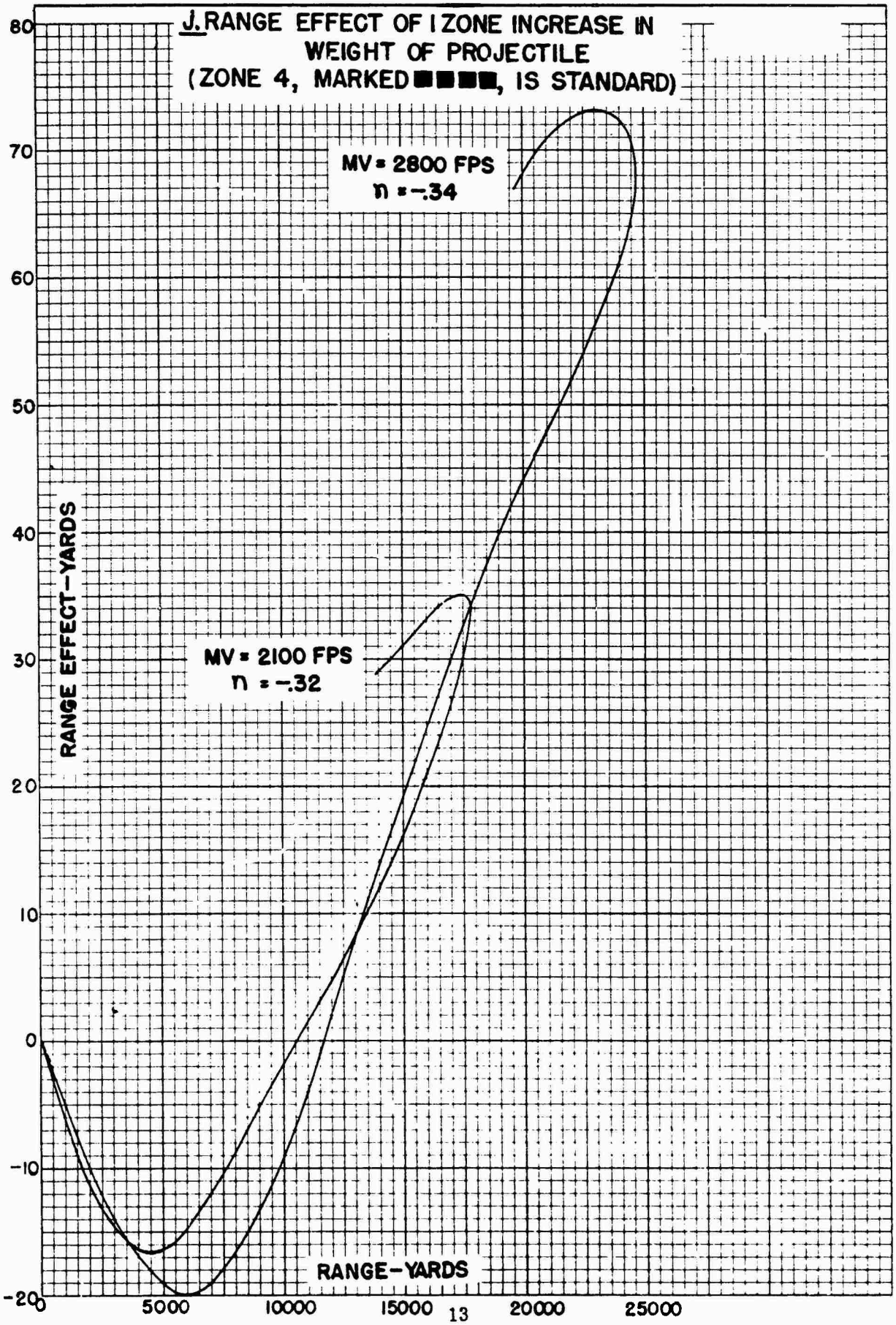

e. TERMINAL VELOCITY – RANGE CURVES
TERMINAL VELOCITY – FPS
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
MV = 2800 FPS
MV = 2100 FPS
RANGE – YARDS
0
5000
10000
15000
20000
25000

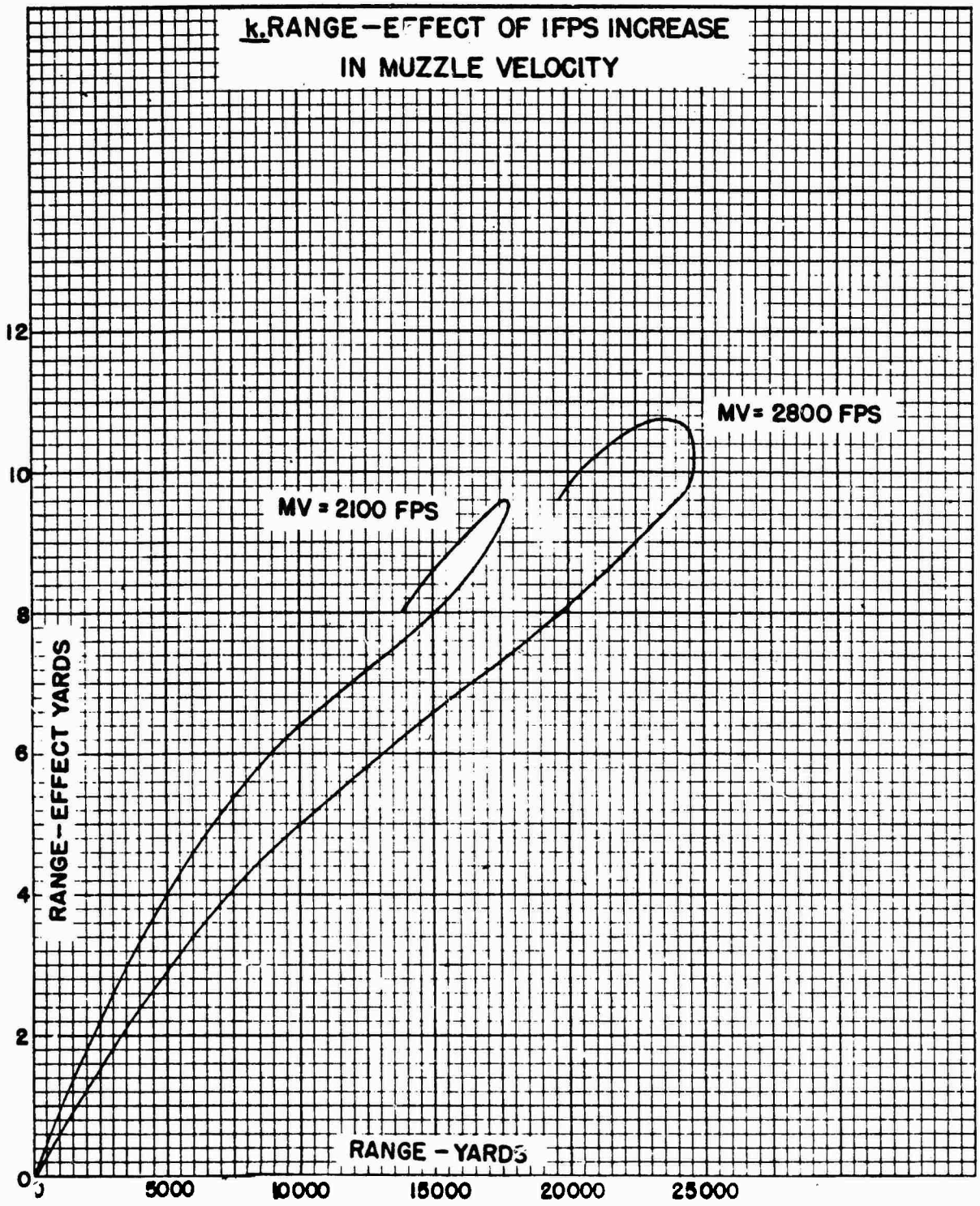

£.TIME OF FLIGHT – RANGE CURVES
MV = 2800 FPS
MV = 2100 FPS
TIME OF FLIGHT – SEC
RANGE – YARDS
0
20
40
60
80
100
120
0
5000
10000
15000
20000
25000

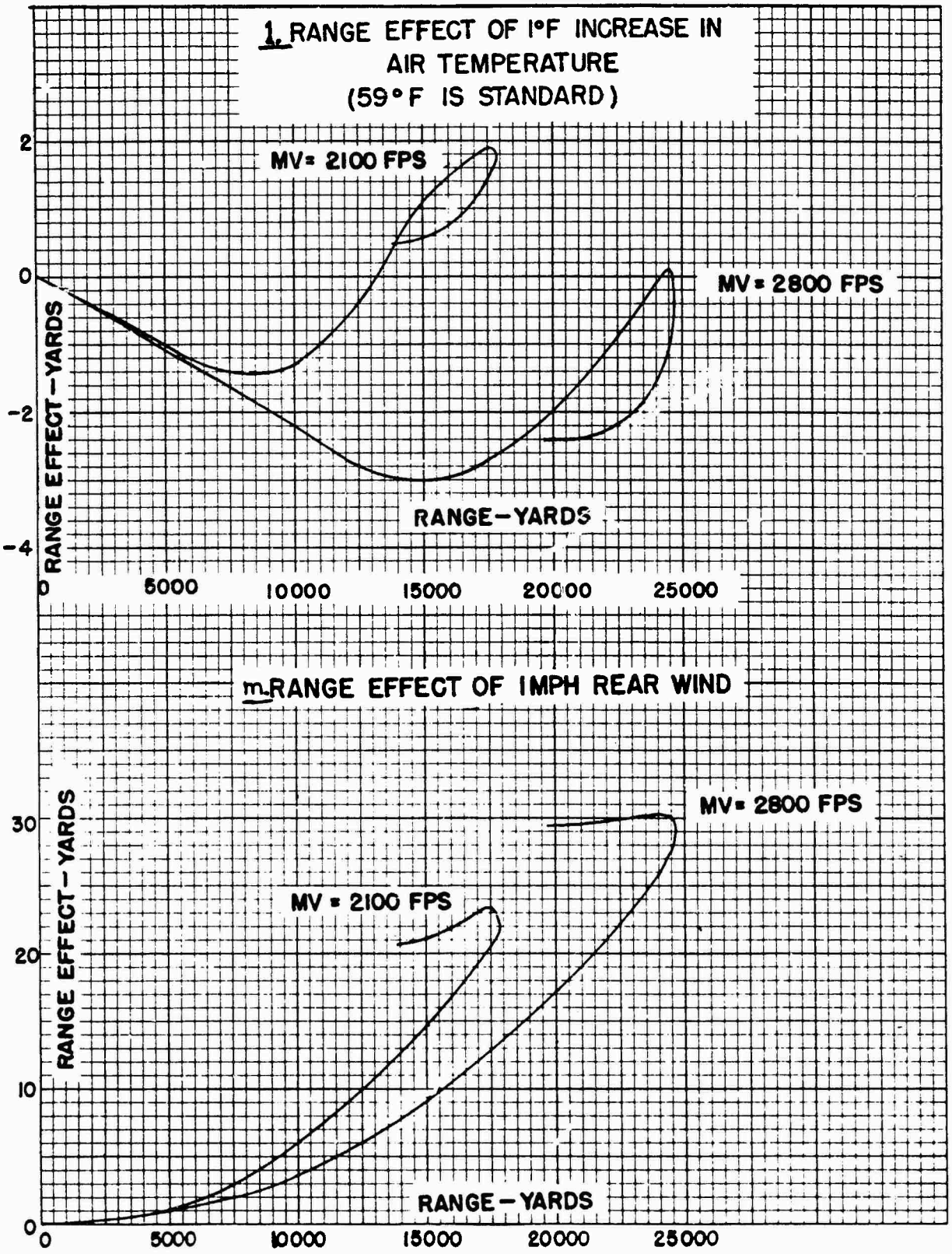

g. DRIFT-RANGE CURVES
MV = 2800 FPS
MV = 2100 FPS
DRIFT - MILS
RANGE - YARDS
0
20
40
60
80
0
5000
10000
15000
20000
25000
h. DEFLECTION EFFECT OF 1 MPH LATERAL WIND
MV = 2800 FPS
MV = 2100 FPS
DEFLECTION - MILS
RANGE - YARDS
0
1
2
0
5000
10000
15000
20000
25000

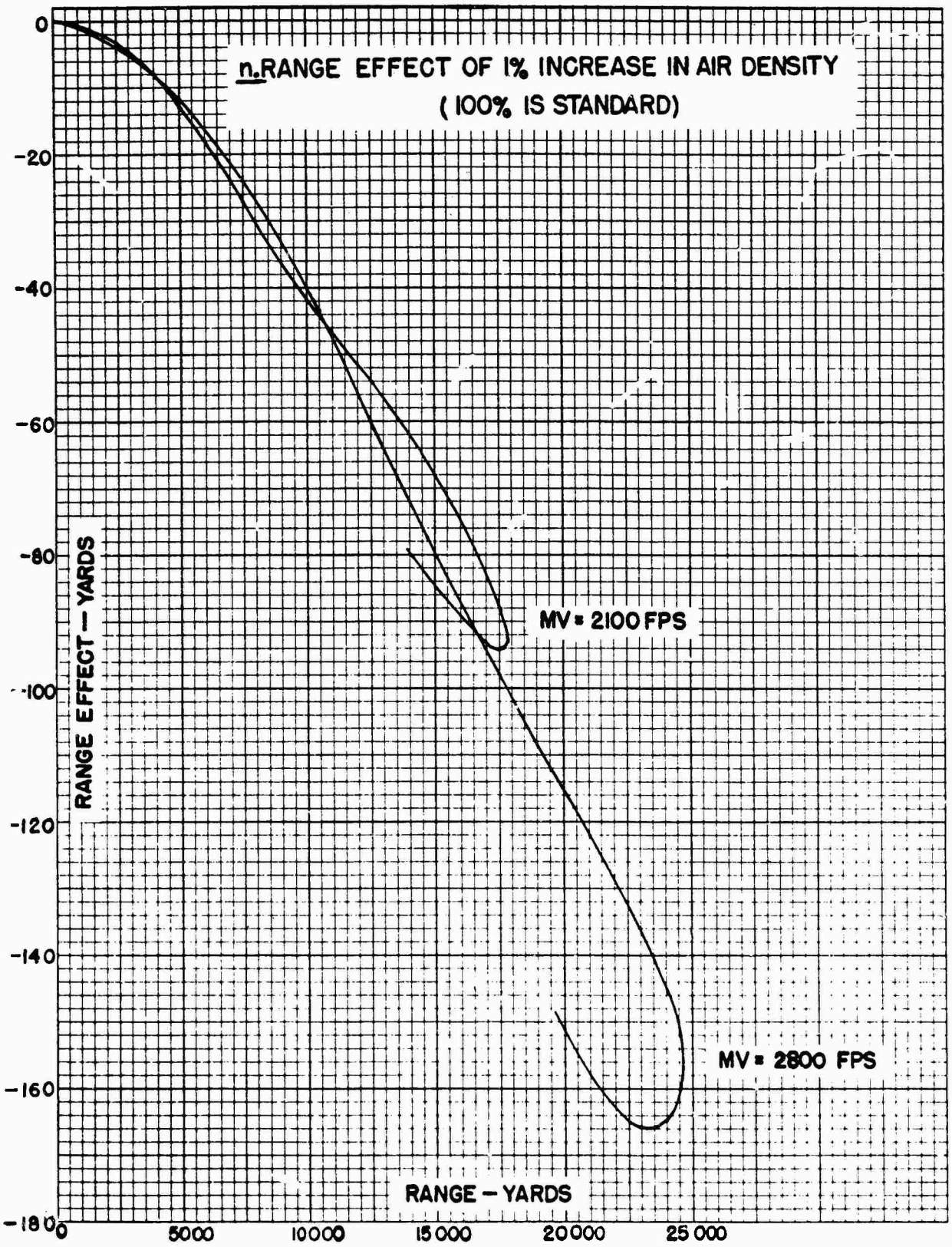


ELEVATION	ANGLE OF SITE	COMPLEMENTARY ANGLE OF SITE
LOW	+	+
LOW	–	–
HIGH	+	–
HIGH	–	+


J. RANGE EFFECT OF 1 ZONE INCREASE IN WEIGHT OF PROJECTILE
(ZONE 4, MARKED ■■■■, IS STANDARD)
MV = 2800 FPS
n = -.34
MV = 2100 FPS
n = -.32
RANGE EFFECT-YARDS
RANGE-YARDS
80
70
60
50
40
30
20
10
0
-10
-20
0
5000
10000
15000
20000
25000


k. RANGE-EFFECT OF 1FPS INCREASE IN MUZZLE VELOCITY
MV = 2800 FPS
MV = 2100 FPS
RANGE-EFFECT YARDS
RANGE - YARDS
0
2
4
6
8
10
12
5000
10000
15000
20000
25000


1. RANGE EFFECT OF 1°F INCREASE IN AIR TEMPERATURE (59°F IS STANDARD)
MV= 2100 FPS
MV= 2800 FPS
RANGE EFFECT—YARDS
RANGE—YARDS
2
0
-2
-4
0
5000
10000
15000
20000
25000
m. RANGE EFFECT OF 1MPH REAR WIND
MV= 2800 FPS
MV = 2100 FPS
RANGE EFFECT—YARDS
RANGE—YARDS
30
20
10
0
0
5000
10000
15000
20000
25000


n. RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
MV = 2100 FPS
MV = 2800 FPS
RANGE EFFECT — YARDS
RANGE — YARDS
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
5000
10000
15000
20000
25000

SECTION V
EFFECT DATA

	Paragraph
Fragmentation and Penetration -	9

9. Fragmentation and Penetration. The effectiveness of the fragments in causing casualties and perforating mild steel, and the penetration of the shell into earth and logs should be about the same with the HE Shell Mark 3A1 as with the HE Shell M101. OH 155-1-101 gives fragmentation and penetration data for the latter shell.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 155 - 1 - 101

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
10 February 1949

BALLISTIC AND ENGINEERING DATA

for

Shell, HE, 155-mm, M101

with

Fuzes, PD, M51A4; TSQ, M55A3; MT, M67A3; and CP, M78

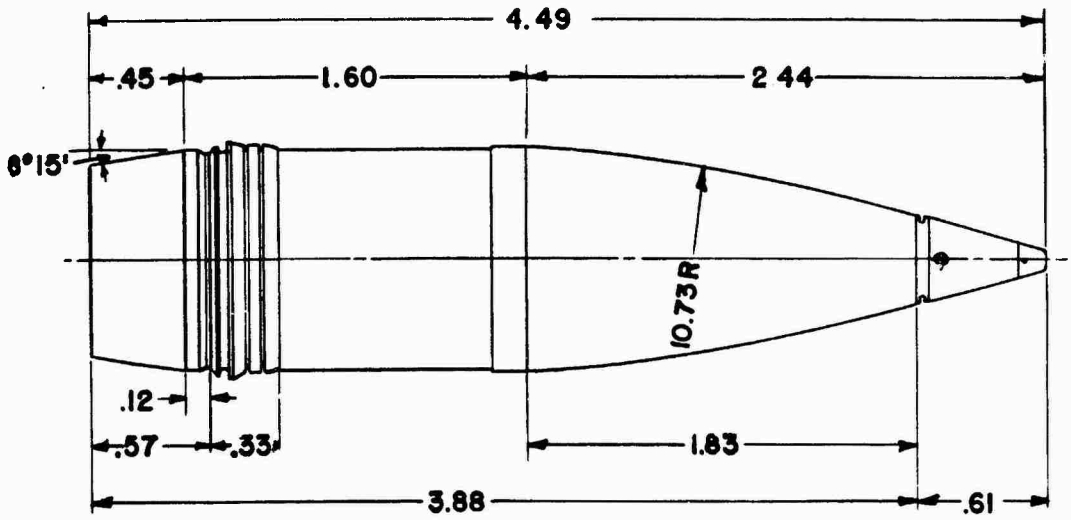
Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 8
V	Effect data	9

SECTION I

GENERAL

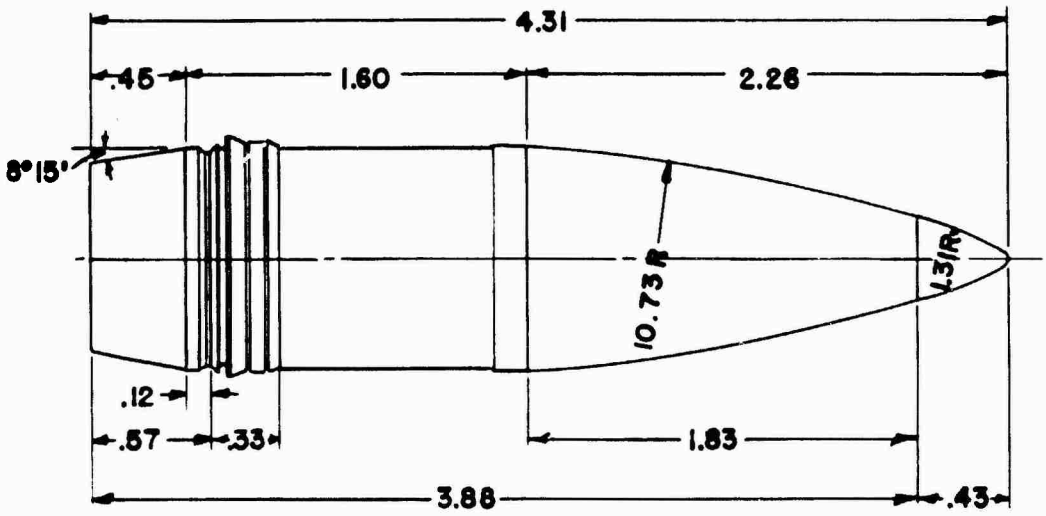
	Paragraph
Purpose	1

1. Purpose. The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 155-mm High Explosive Shell M101 with the Point Detonating Fuze M51A4, the Time and Superquick Fuze M55A3, the Mechanical Time Fuze M67A3, and the Concrete Piercing Fuze M78. This information is collected from the drawings, reports, firing tables, and technical manual pertaining to this ammunition.



SHELL, HE, 155-MM, M101
FUZE, PD, M51A4

ALL DIMENSIONS IN CALIBERS
1CAL = 6.102"



SHELL, HE, 155-MM, M101
FUZE, CP, M78

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell: Assembly, list of drawings, etc.	75-4-80
Booster, M21A4: Assembly	73-2-154
Fuze, PD, M51A4: Assembly	73-2-145
Details	73-2-143
Fuze, TSQ, M54: Assembly	73-3-154
Fuze, TSQ, M55A3: Assembly and detail	73-3-155
(The Booster, M21A4, and the Fuze, TSQ, M54 are components of the Fuze, TSQ, M55A3)	
Fuze, MT, M67A3: Assembly	73-7-77
Fuze, CP, M78: Body assembly and details	73-2-214

3. Dimensions.

Boat-tail: Angle	8°15'
Length	0.45 cal
Band: Distance from boat-tail	0.12 cal
Distance from base	0.57 cal
Width	0.33 cal
Cylindrical body: Length	1.60 cal
Ogive: Length	1.83 cal
Radius of arc	10.73 cal
Shell, unfuzed: Length	3.88 cal
Fuze, PD, M51A4; TSQ, M55A3; or MT, M67A3:	
Outside length	0.61 cal
Shell and fuze	4.49 cal
Ogive and fuze	2.44 cal
Fuze, CP, M78: Outside length	0.43 cal
Radius of arc	1.31 cal
Shell and fuz	4.31 cal
Ogive and fuze	2.26 cal

4. Physical characteristics. The location of the center of gravity and the moments of inertia of the HE Shell M101 with the Booster M21A4 and the PD Fuze M51A4, TSQ Fuze M54, or MT Fuze M67A3 are approximately the same as those of the HE Shell M101 with the Booster M20 and the PD Fuze M48, which are given in the table below. With the CP Fuze M78, the values would be slightly different.

Fuze		PD, TSQ, MT	CP
Mean weight (lb):	Zone 2	92.80	93.52
	Zone 3	93.90	94.62
	Zone 4 (standard)	95.00	95.72
	Zone 5	96.10	96.82
	Zone 6	97.20	97.92

Base to center of gravity	1.538 cal
Axial moment of inertia	3.434 $lb.ft^2$
Transverse mement of inertia	28.88 $lb.ft^2$

SECTION III

INTERIOR BALLISTIC DATA

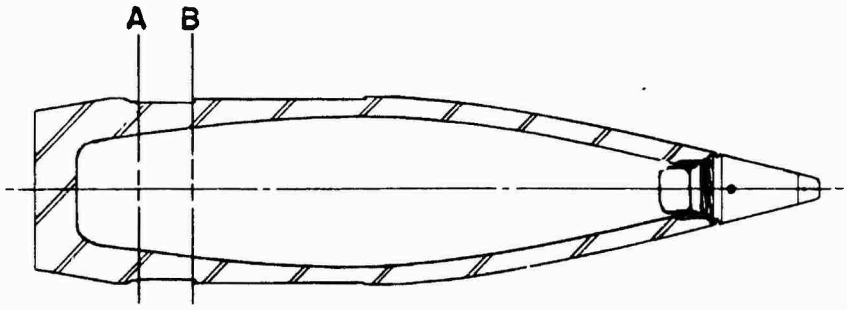
	Paragraph
Stresses -	5
Theoretical yaw in bore -	6

5. Stresses. The following table and the graphical representation on page 5 show the longitudinal, radial and tangential stress at each of two sections: (A) the rear corner of the band seat and (B) the front of the band seat.

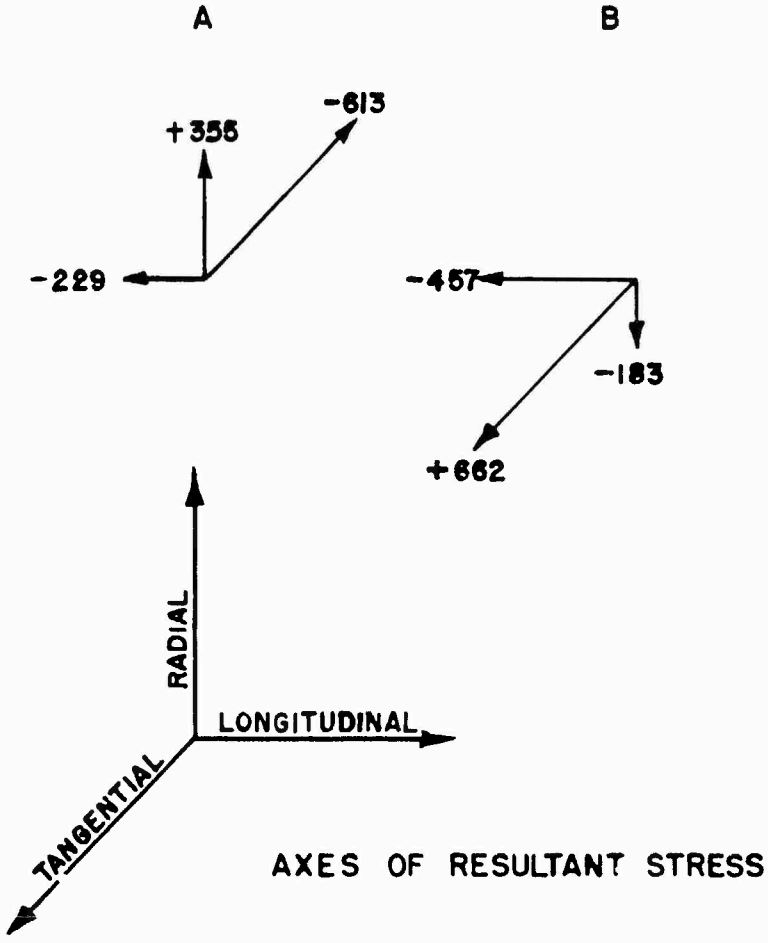
Gun, 155-mm	M1, M1A1, M1C, M2, M3 and M4
Twist of rifling	1/20
Cross-sectional area of bore	29.846 sq in.
Rated maximum pressure	38,000 psi
Total weight of projectile	95 lb
Muzzle velocity	2800 fps
Density of filler (TNT)	0.057 lb per cu in.

Resultant Stress* 100 psi	Section A	Section B
Longitudinal	- 220	- 457
Radial	+ 355	- 183
Tangential	- 613	+ 662

* + denotes tension, - denotes compression.



SECTION



AXES OF RESULTANT STRESS

DIAGRAM OF RESULTANT STRESSES

6. Theoretical yaw in bore.

Minimum	7 min
Maximum	12 min

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data	7
Firing table data	8

7. Aerodynamic data.

a. Drag. The trajectories for the 155-mm Guns were based on the G_2 drag function, with ballistic coefficients determined from range firings (see par. 8b). The extrapolated values of the ballistic coefficients are tabulated below.

Fuze	Muzzle Velocity fps	Ball. Coef. C_2	Form Factor i_2	Drag Coef. K_D
PD, TSQ and MT	2100	2.731	.935	.112
	2800	2.696	.946	.097
CP	2095	2.712	.948	.114
	2793	2.594	.991	.102

b. Stability. Ballistic Research Laboratory Report No. 162, "Stability of 155-mm Shell Mark III and T2", gives the stability factors and moment coefficients which were determined for the HE Shell M101 (T2) with the PD Fuze M48 and Booster M20, fired from the 155-mm Gun M1916. This fuze and booster are similar to the PD Fuze M51A4 and Booster M21A4. The M1916 Gun is rifled with a twist of 1/28.88; the M1, M1A1, M1C, M2, M3 and M4 Guns are rifled with a twist of 1/25. At a velocity of 2415 fps, the moment coefficient should be less, and the stability factor more, than at 2415 fps.

Muzzle velocity (fps)	1934	2415
Mach number	1.685	2.132
Moment coefficient	1.36	1.21
Twist of rifling	1/25	1/25
Stability factor	1.63	2.02

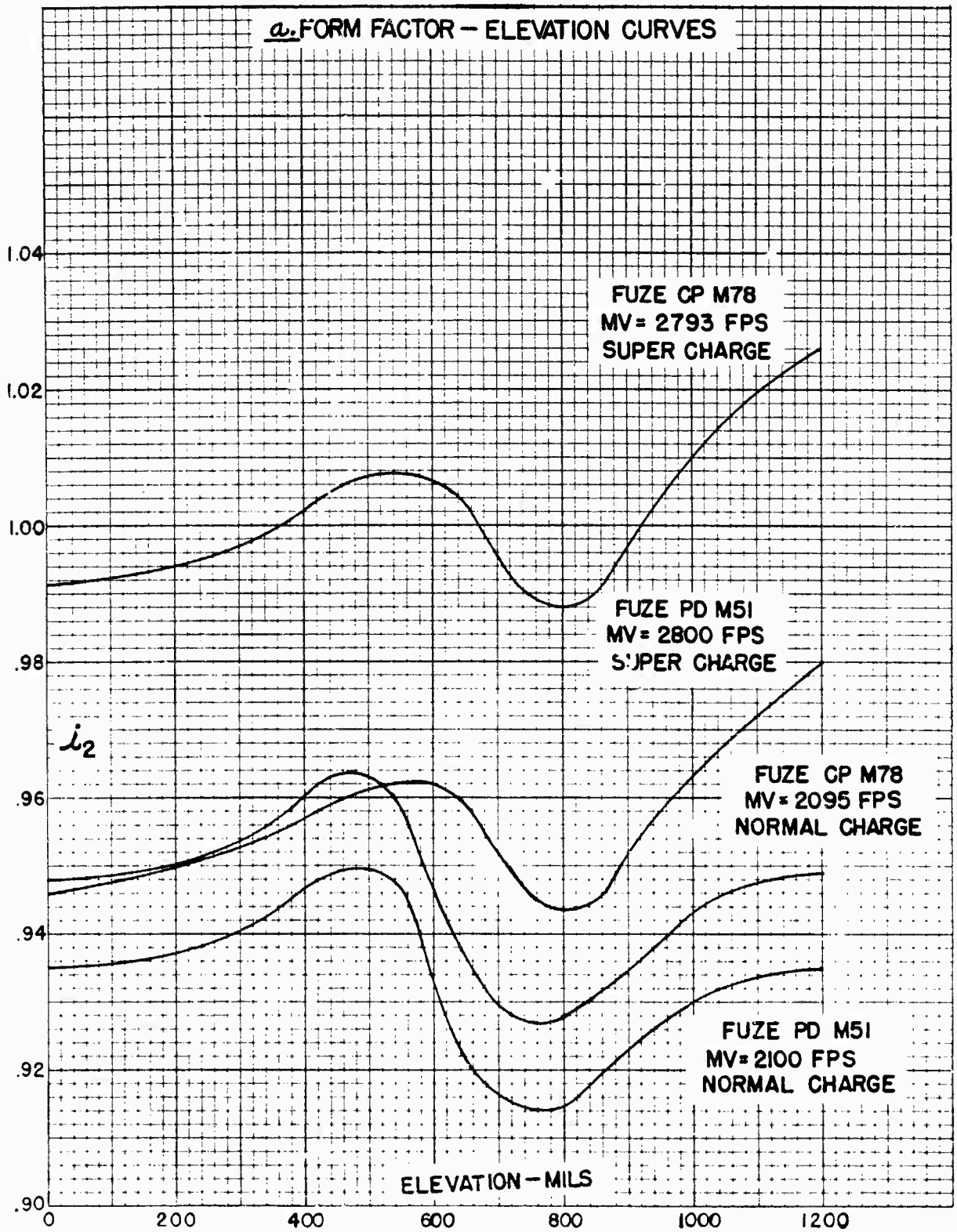
c. Loss of spin. Ballistic Research Laboratory Report No. 408, "Loss of Spin and Skin Friction Drag of Projectiles", gives data obtained by means of a radio spin sonde from an inert M101 Shell with a dummy fuze that has the same contour as the PD M51A4, fired from a 155-mm Gun M1 at muzzle velocities of 2114 and 2813 fps. Below are average data for the two rounds at times of flight from 7 to 27 seconds:

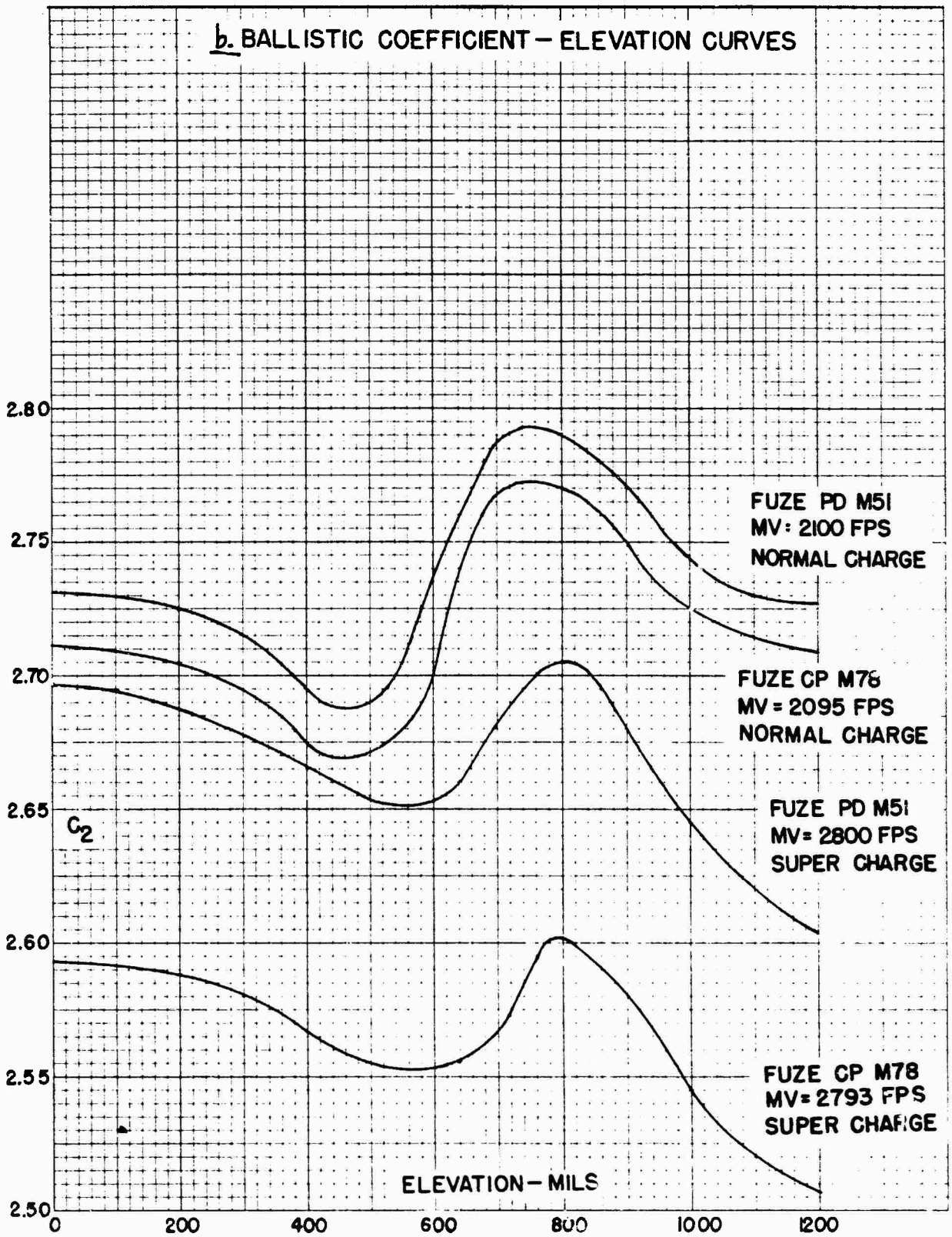
Reynolds' number, based on the translational velocity and the caliber of the shell and the kinematic viscosity of the air	5.38×10^6
Axial couple coefficient K_A	0.00395
Skin friction drag coefficient C'_{DF}	0.00147

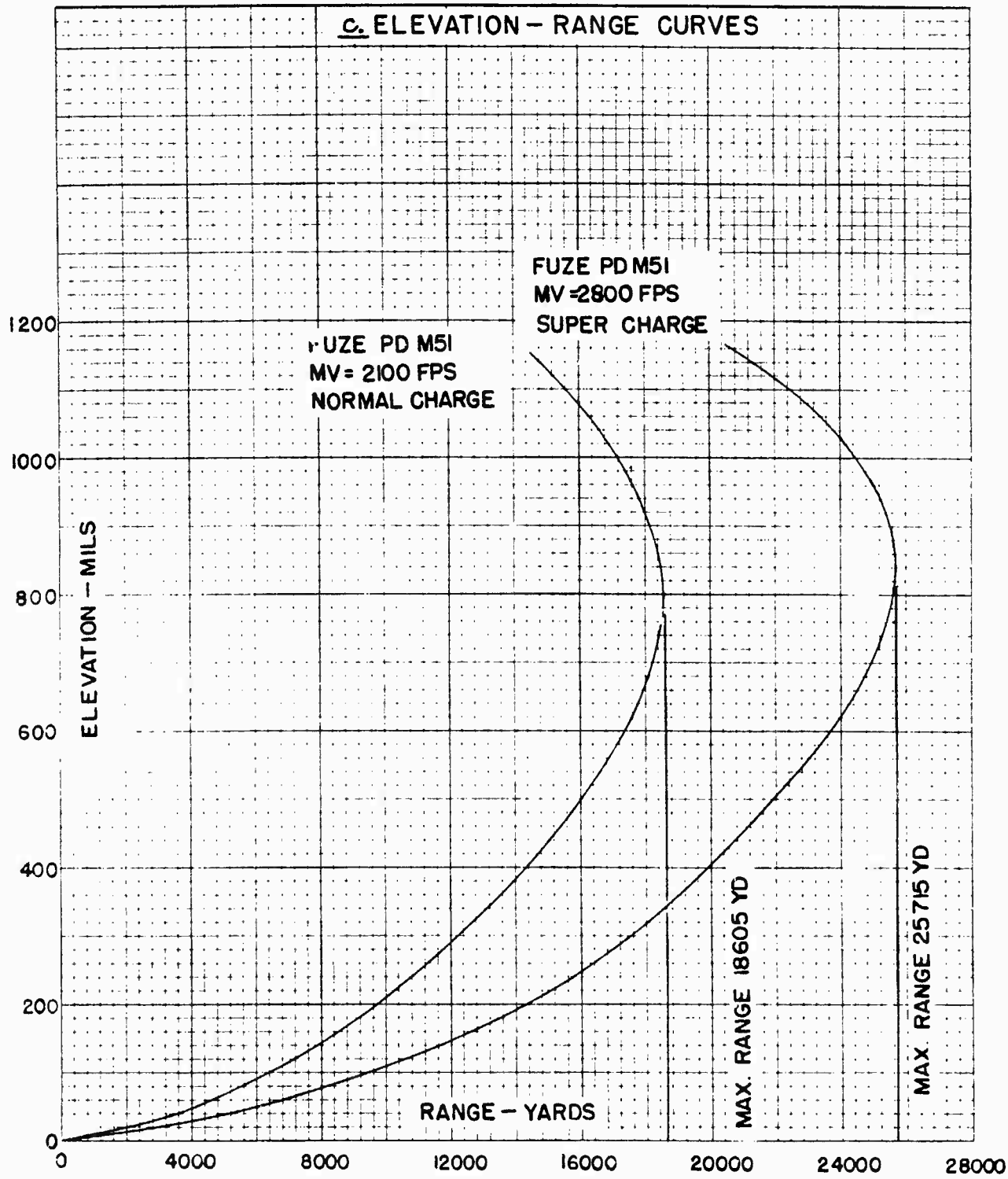
8. Firing table data. FT 155-S-2 with C-8.

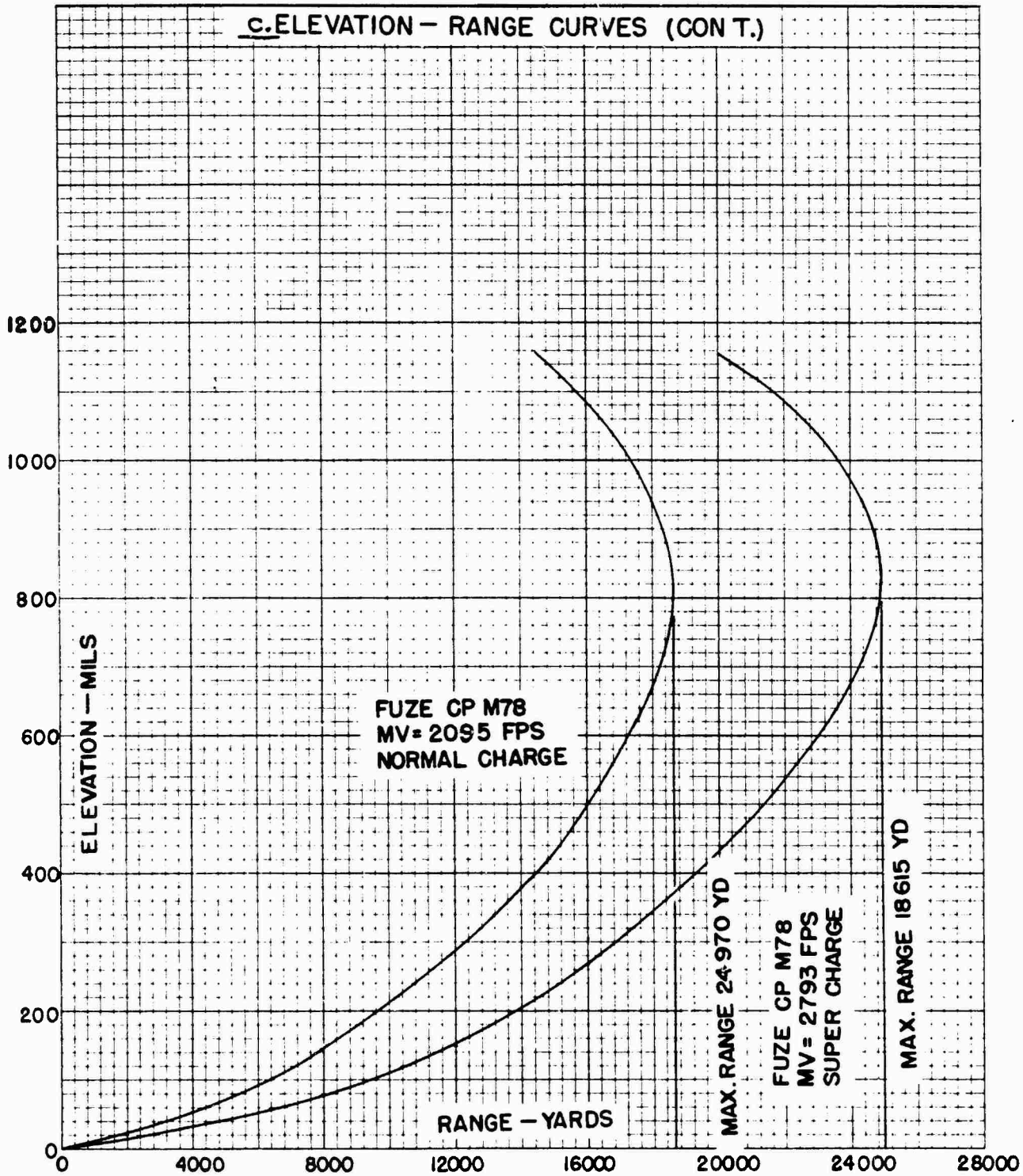
Guns, 155-mm, M1, M1A1, M1C, M2, M3 and M4.
Twist of rifling: 1/25.

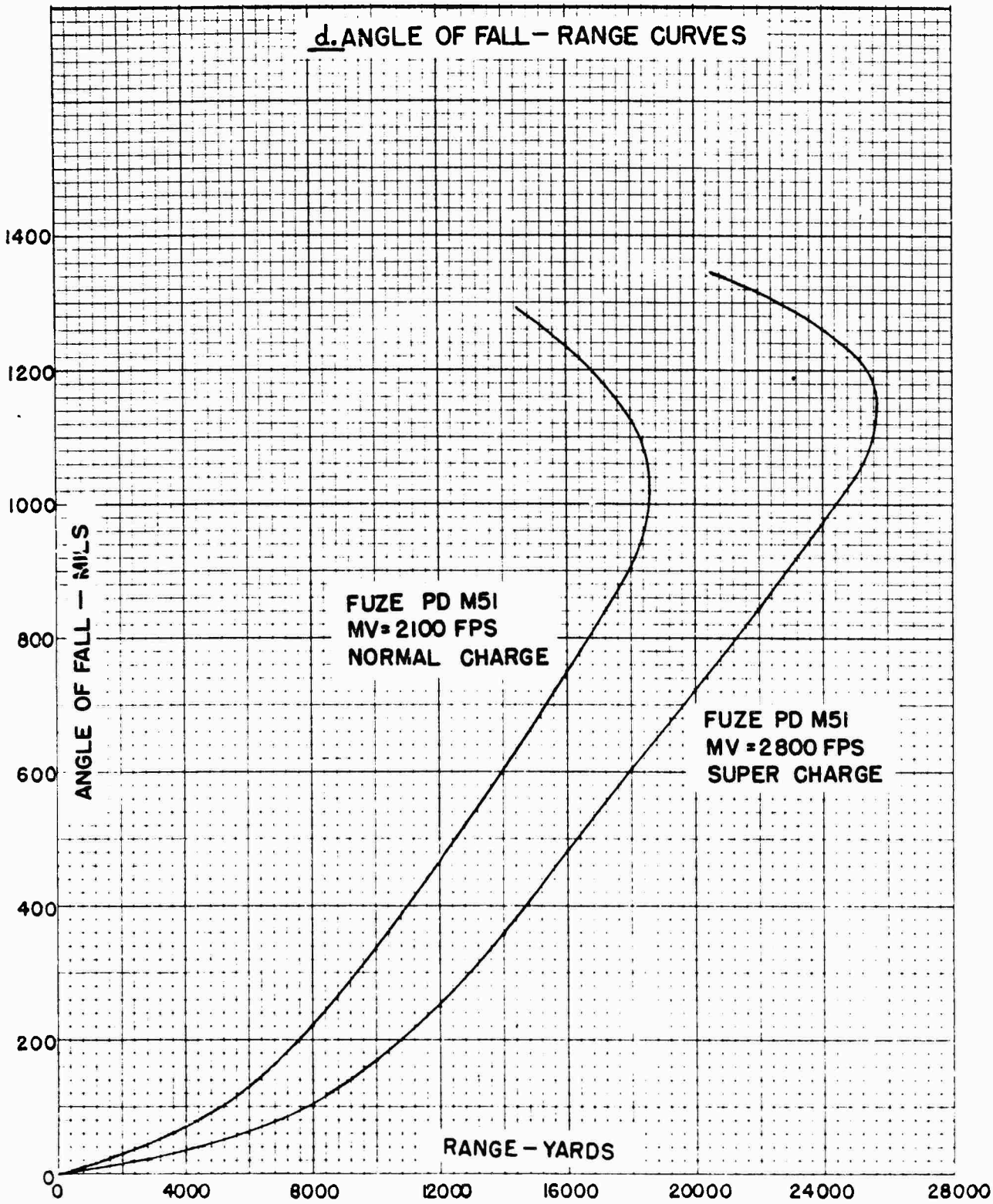
The HE Shell M101 was standardized by OCM item 15167.

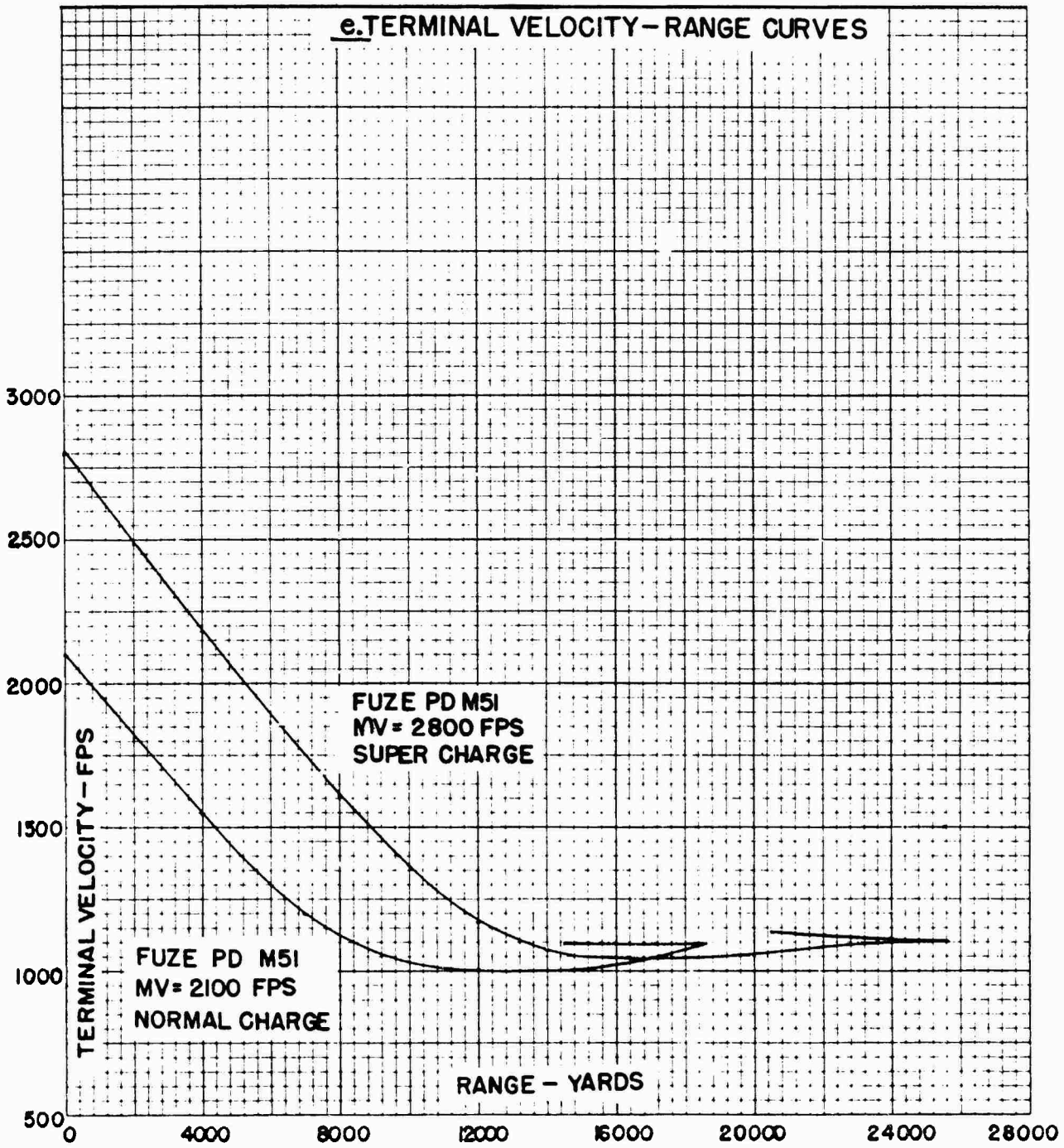

a. FORM FACTOR – ELEVATION CURVES
FUZE CP M78
MV = 2793 FPS
SUPER CHARGE
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
FUZE CP M78
MV = 2095 FPS
NORMAL CHARGE
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
i_2
ELEVATION – MILS
1.04
1.02
1.00
.98
.96
.94
.92
.90
0
200
400
600
800
1000
1200

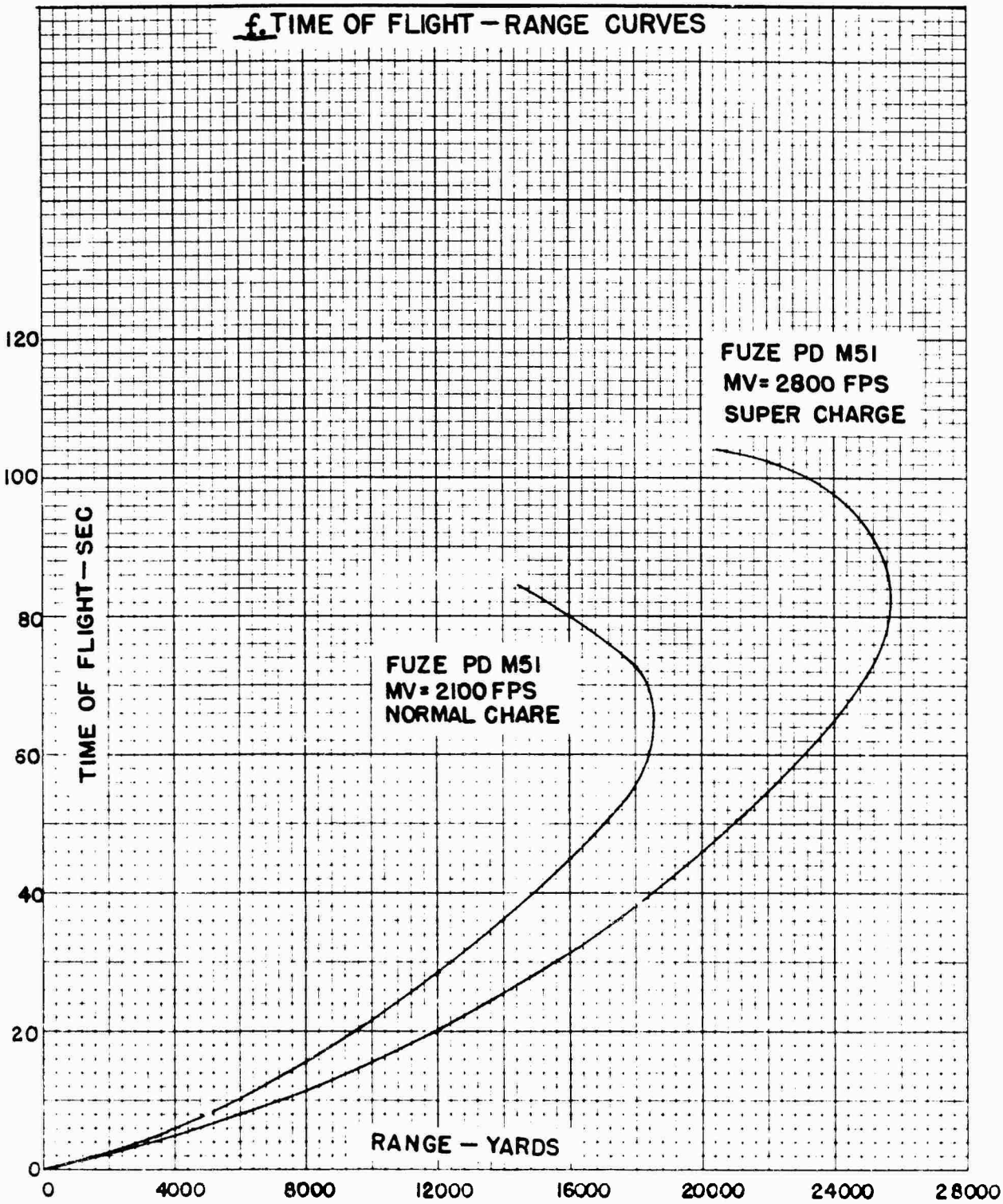

b. BALLISTIC COEFFICIENT – ELEVATION CURVES
2.80
2.75
2.70
2.65
2.60
2.55
2.50
C_2
FUZE PD M51
MV: 2100 FPS
NORMAL CHARGE
FUZE CP M78
MV = 2095 FPS
NORMAL CHARGE
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
FUZE CP M78
MV = 2793 FPS
SUPER CHARGE
ELEVATION – MILS
0
200
400
600
800
1000
1200

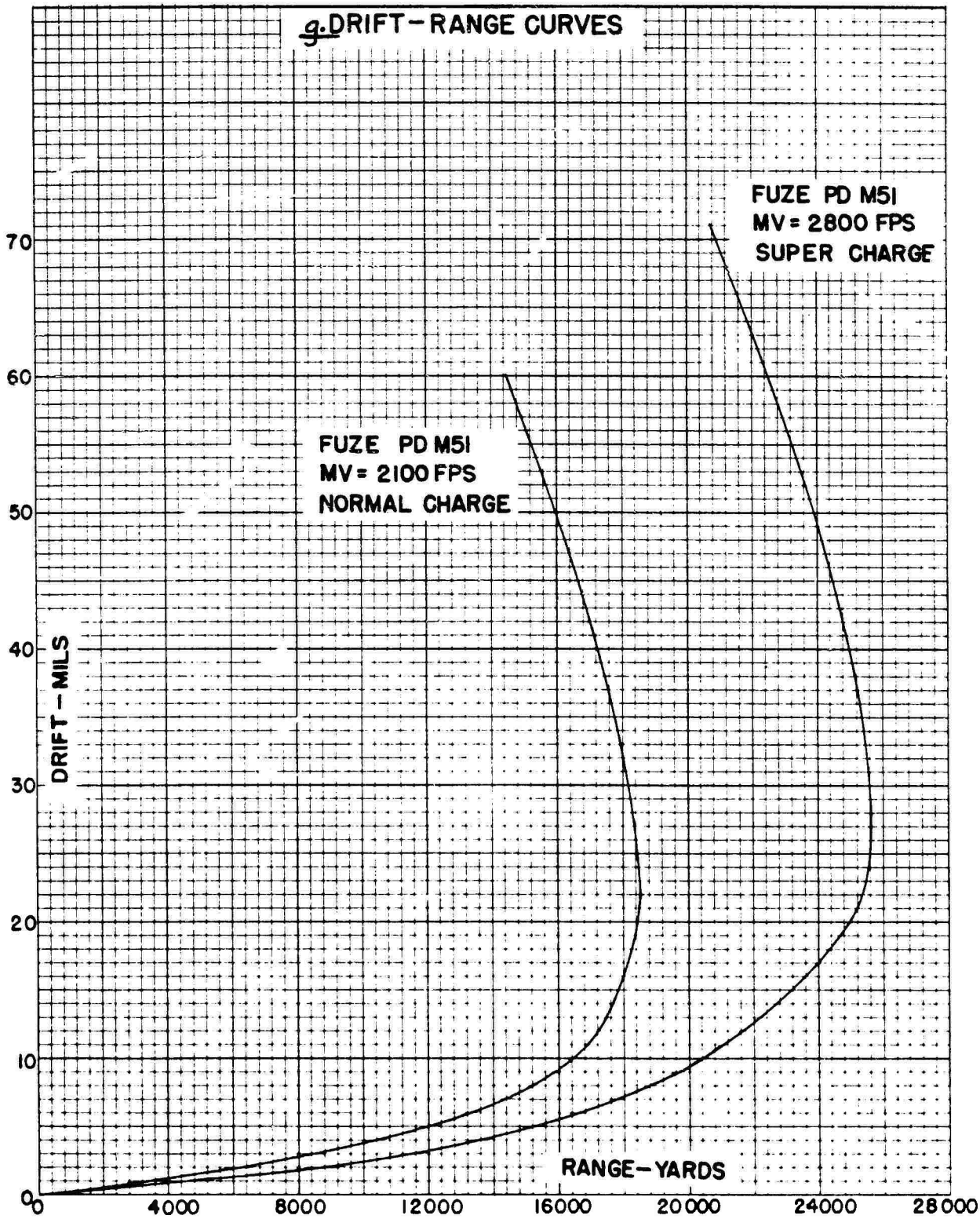

c. ELEVATION – RANGE CURVES
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
ELEVATION – MILS
RANGE – YARDS
MAX. RANGE 18605 YD
MAX. RANGE 25715 YD
0
200
400
600
800
1000
1200
0
4000
8000
12000
16000
20000
24000
28000

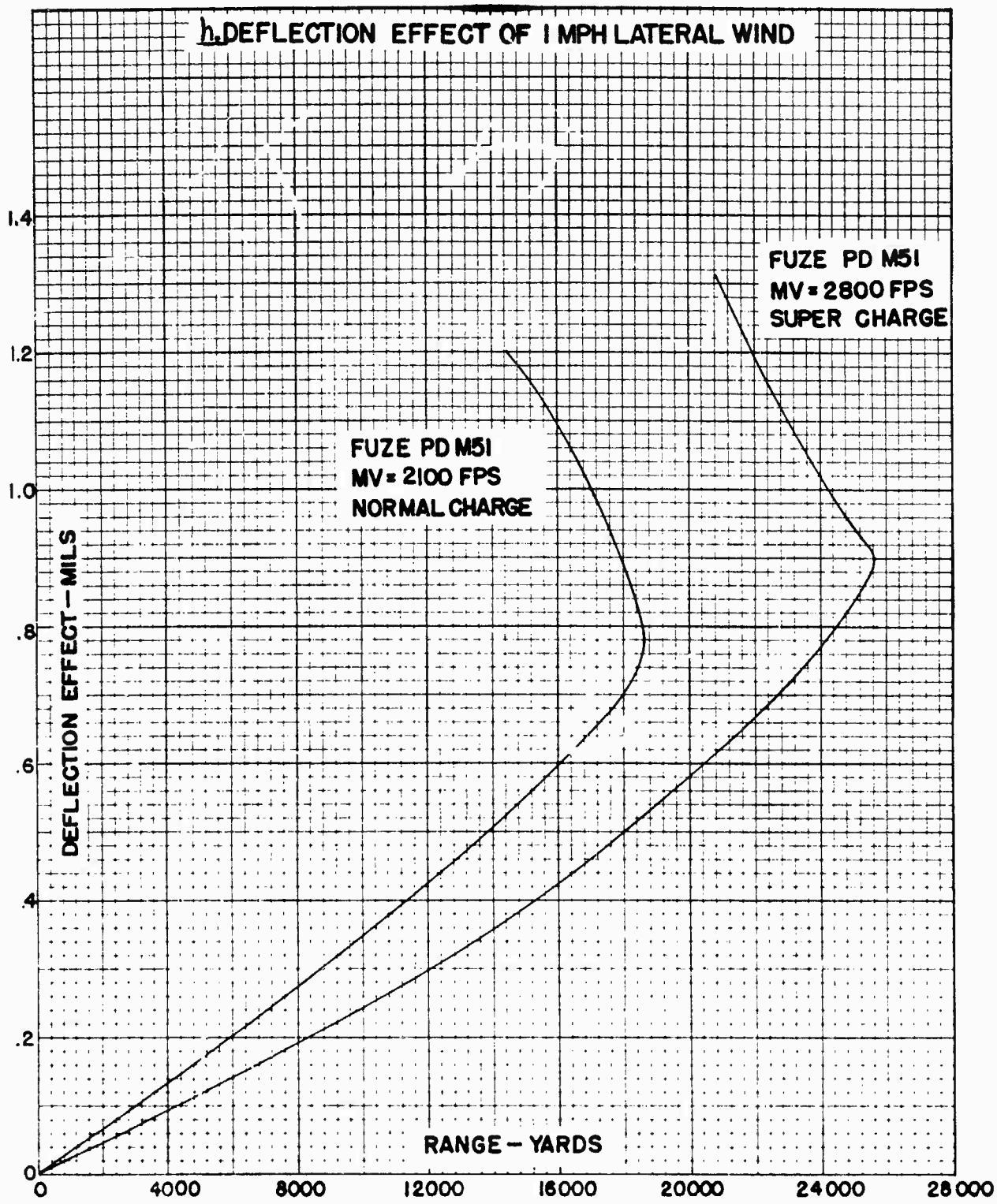

c. ELEVATION – RANGE CURVES (CON T.)
ELEVATION – MILS
RANGE – YARDS
0
200
400
600
800
1000
1200
0
4000
8000
12000
16000
20000
24000
28000
FUZE CP M78
MV= 2095 FPS
NORMAL CHARGE
MAX. RANGE 24 970 YD
FUZE CP M78
MV= 2793 FPS
SUPER CHARGE
MAX. RANGE 18615 YD

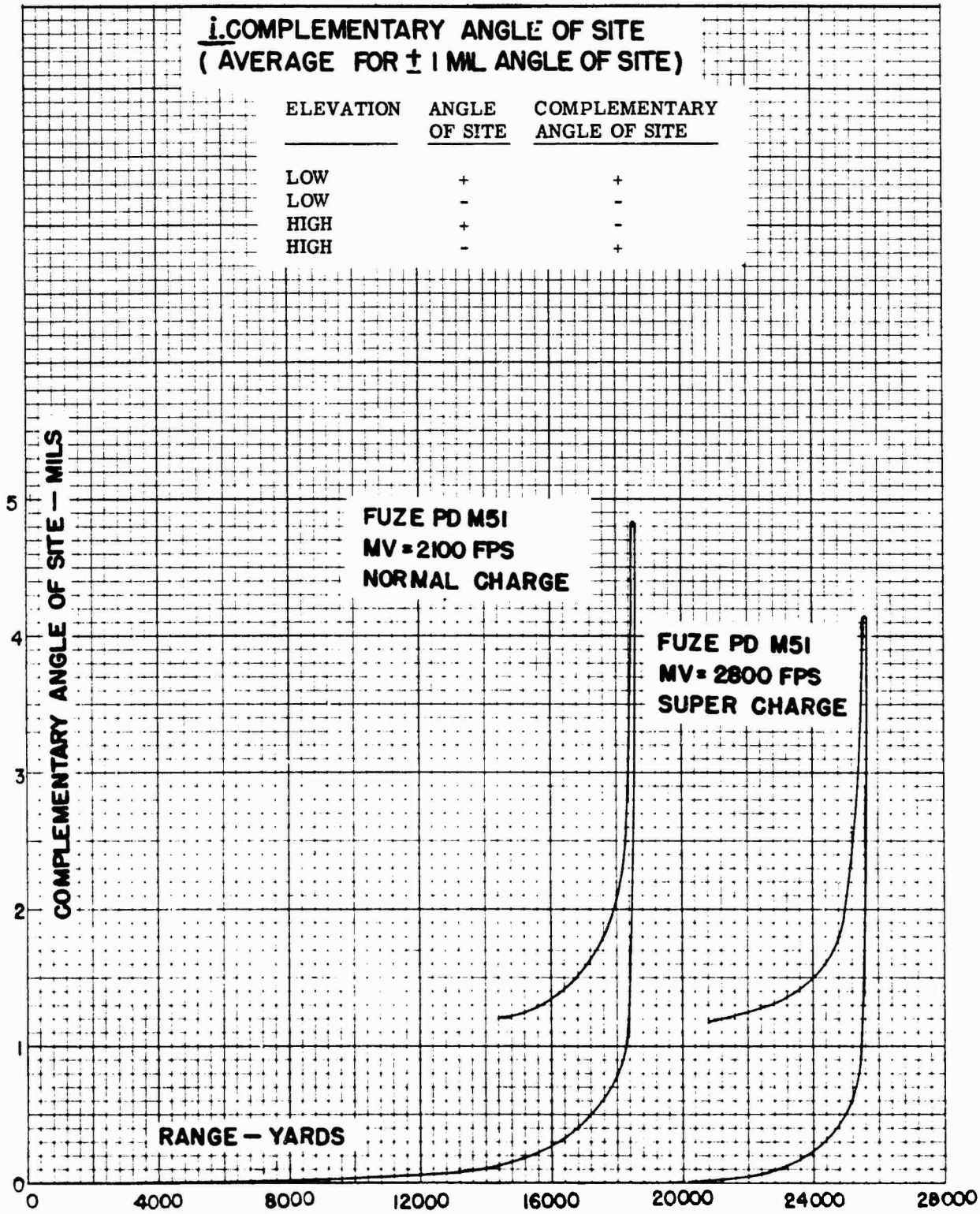

d. ANGLE OF FALL – RANGE CURVES
ANGLE OF FALL – MILS
1400
1200
1000
800
600
400
200
0
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
RANGE – YARDS
0
4000
8000
12000
16000
20000
24000
28000

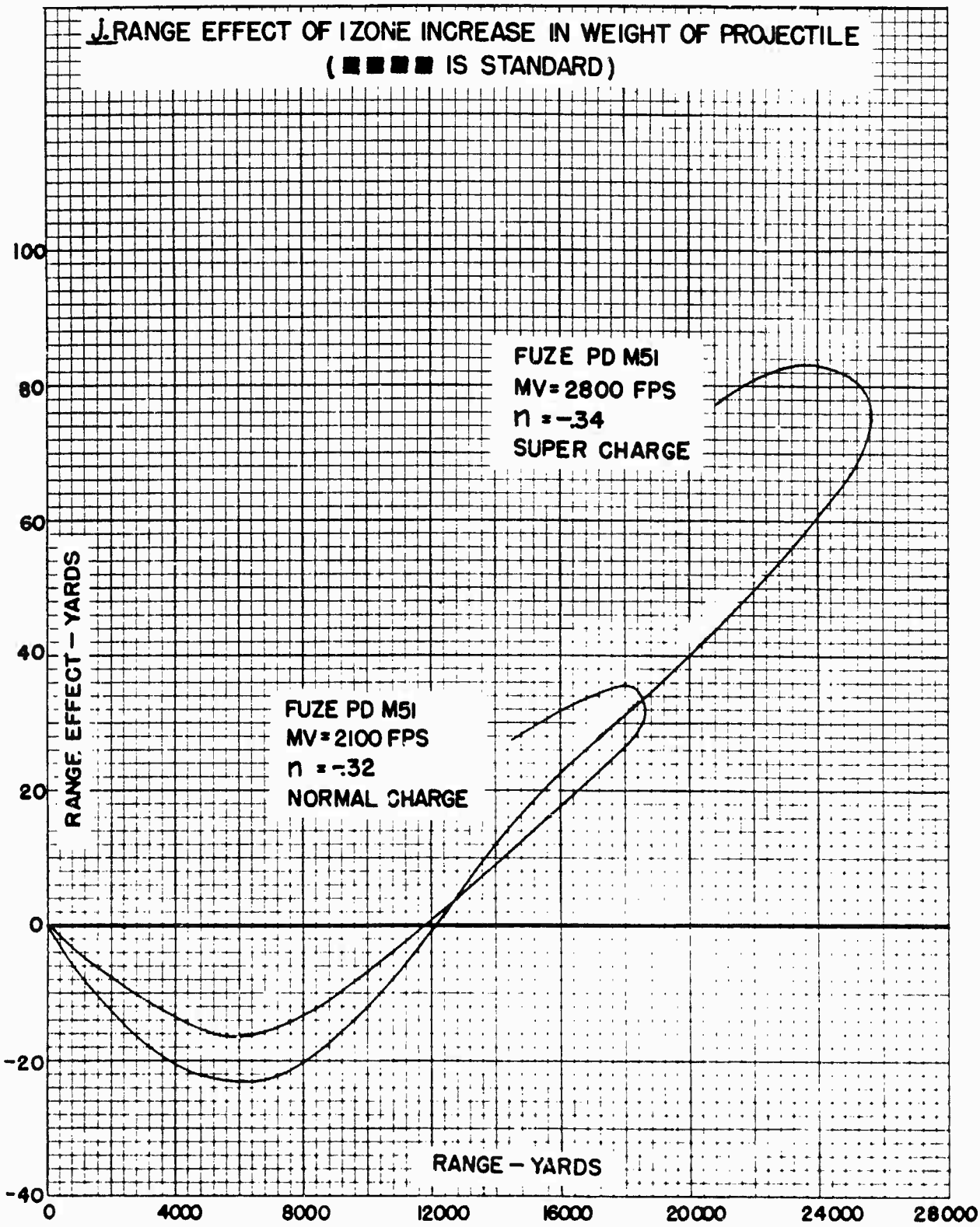

e. TERMINAL VELOCITY-RANGE CURVES
3000
2500
2000
1500
1000
500
TERMINAL VELOCITY-FPS
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
RANGE - YARDS
0
4000
8000
12000
16000
20000
24000
28000

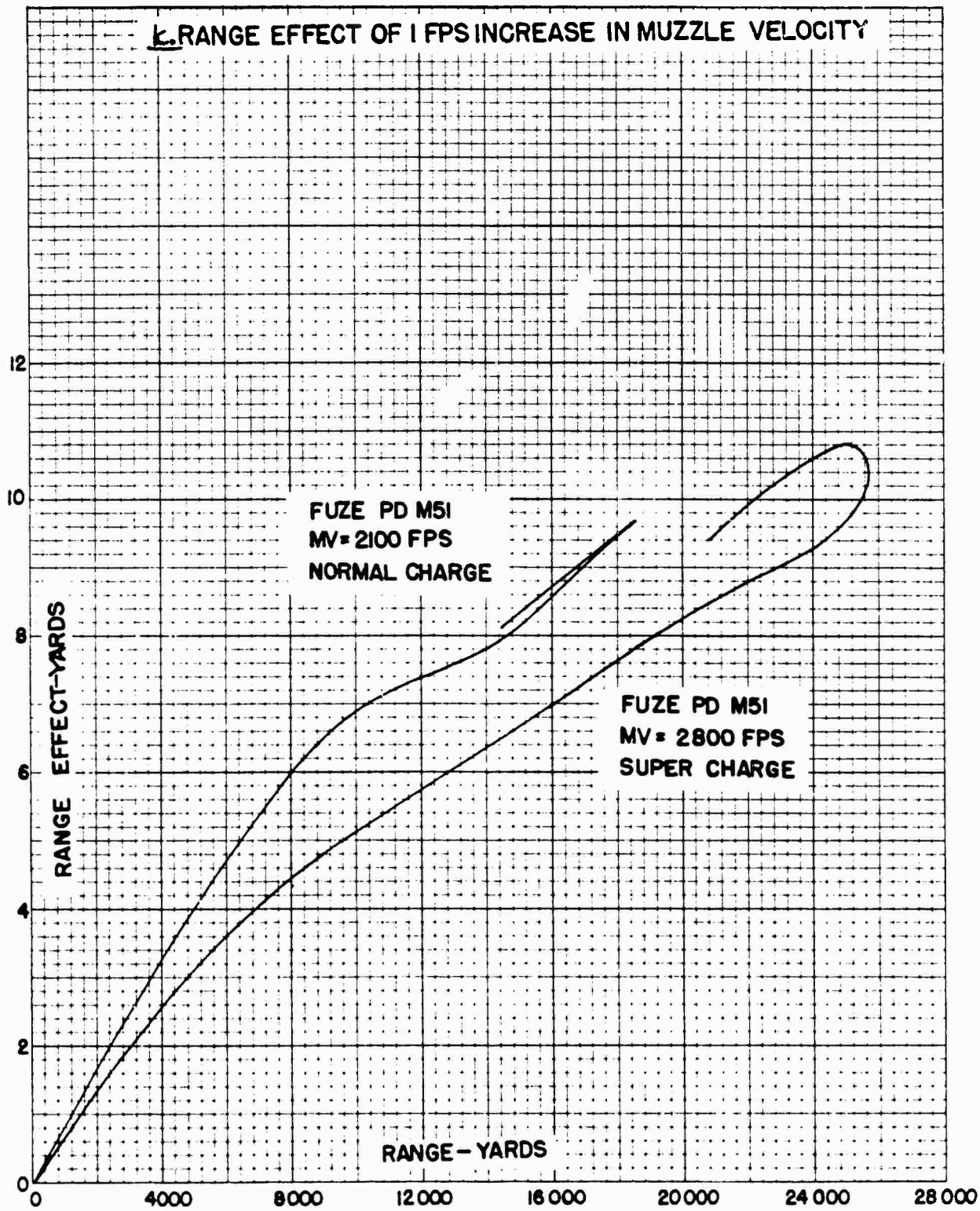

f. TIME OF FLIGHT — RANGE CURVES
FUZE PD M51
MV= 2800 FPS
SUPER CHARGE
FUZE PD M51
MV= 2100 FPS
NORMAL CHARE
TIME OF FLIGHT — SEC
RANGE — YARDS
0
20
40
60
80
100
120
0
4000
8000
12000
16000
20000
24000
28000

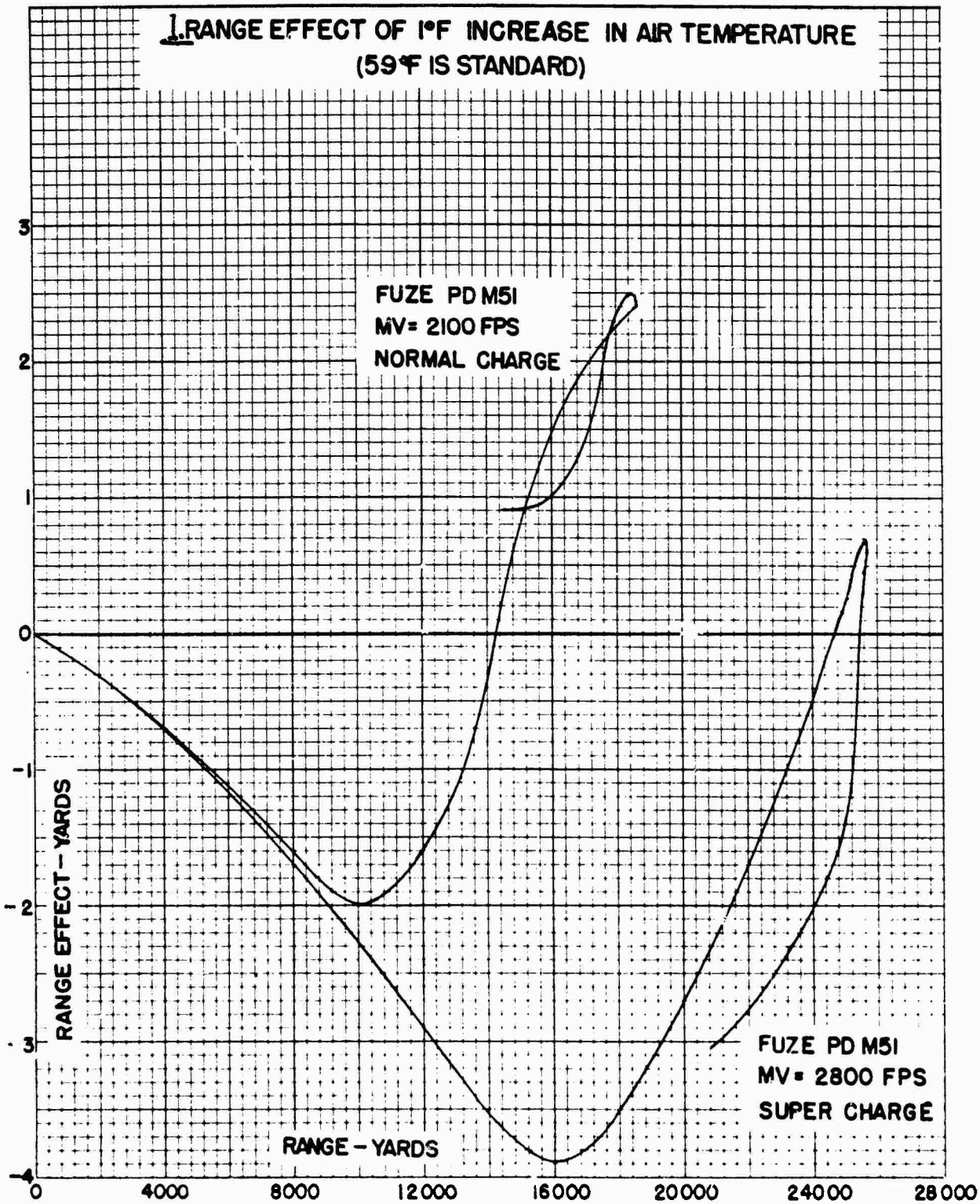

g. DRIFT-RANGE CURVES
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
DRIFT - MILS
RANGE-YARDS
0
10
20
30
40
50
60
70
0
4000
8000
12000
16000
20000
24000
28000

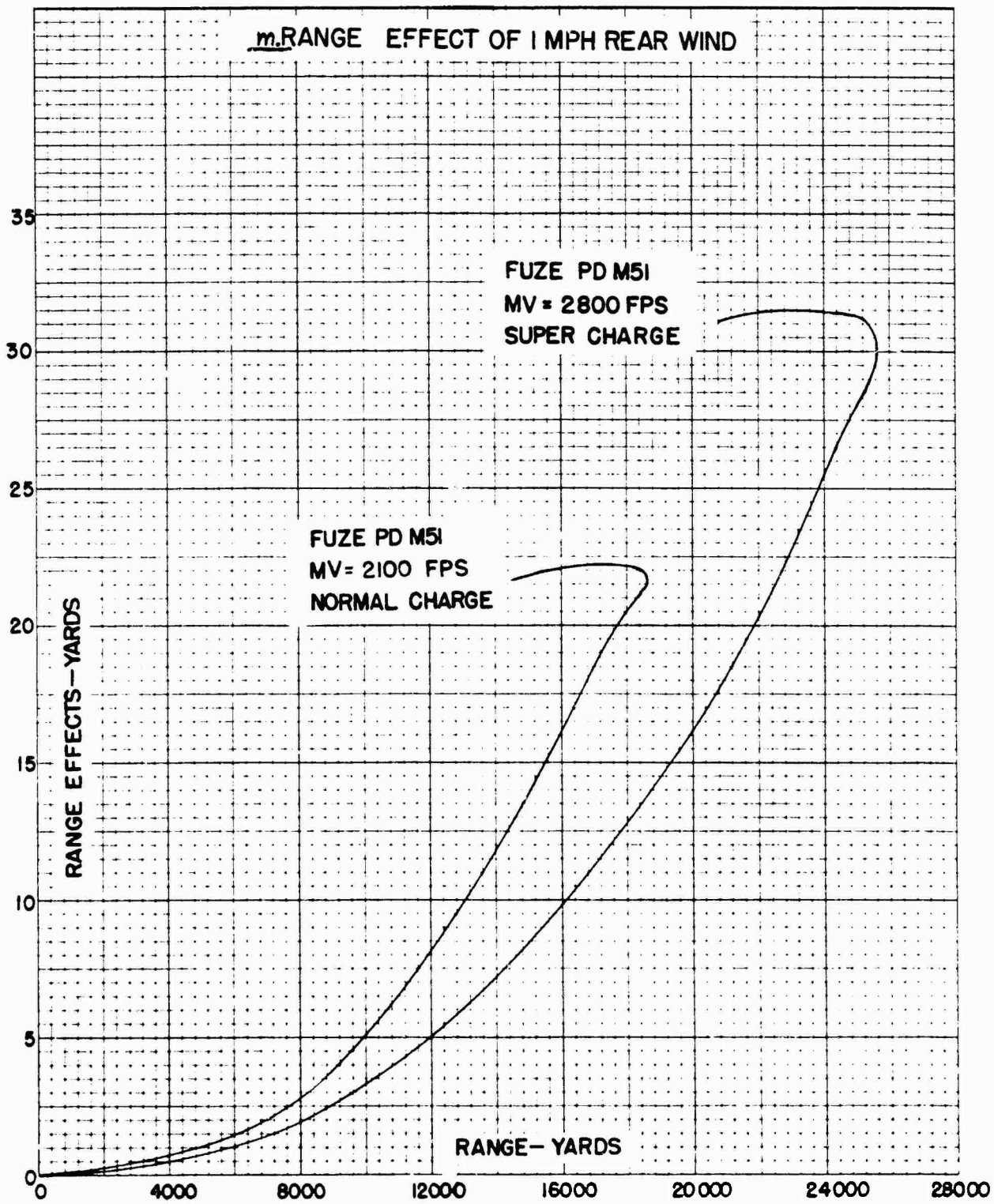

h. DEFLECTION EFFECT OF 1 MPH LATERAL WIND
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
DEFLECTION EFFECT — MILS
RANGE — YARDS
0
.2
.4
.6
.8
1.0
1.2
1.4
0
4000
8000
12000
16000
20000
24000
28000

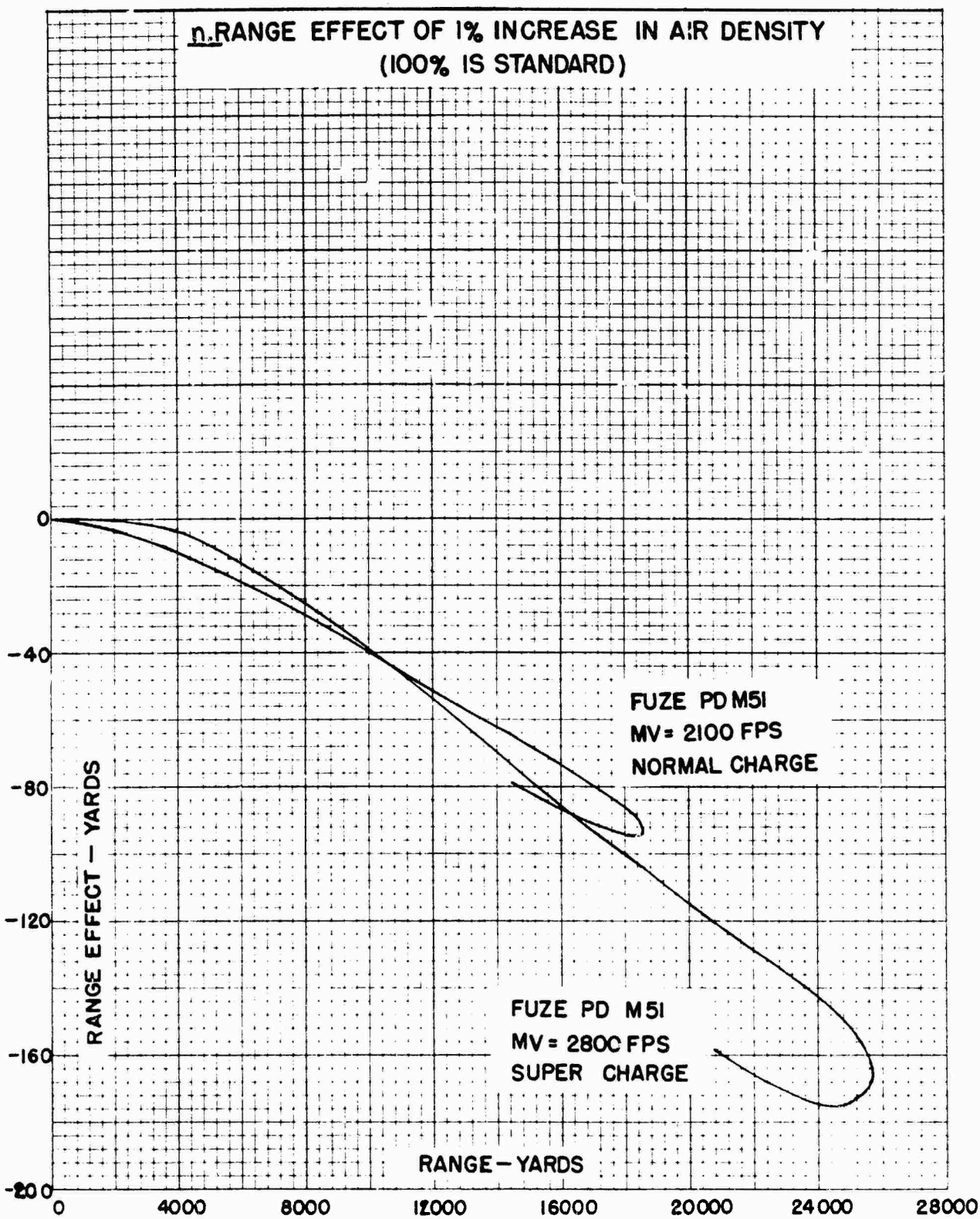

i. COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ± 1 MIL ANGLE OF SITE)
ELEVATION
ANGLE OF SITE
COMPLEMENTARY ANGLE OF SITE
LOW + +
LOW - -
HIGH + -
HIGH - +
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
COMPLEMENTARY ANGLE OF SITE — MILS
RANGE — YARDS
0
1
2
3
4
5
0
4000
8000
12000
16000
20000
24000
28000


J. RANGE EFFECT OF 1 ZONE INCREASE IN WEIGHT OF PROJECTILE
(■■■■ IS STANDARD)
FUZE PD M51
MV = 2800 FPS
n = -.34
SUPER CHARGE
FUZE PD M51
MV = 2100 FPS
n = -.32
NORMAL CHARGE
RANGE EFFECT - YARDS
RANGE - YARDS
100
80
60
40
20
0
-20
-40
0
4000
8000
12000
16000
20000
24000
28000


k. RANGE EFFECT OF 1 FPS INCREASE IN MUZZLE VELOCITY
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
RANGE EFFECT-YARDS
RANGE-YARDS
0
2
4
6
8
10
12
0
4000
8000
12000
16000
20000
24000
28000


1. RANGE EFFECT OF 1°F INCREASE IN AIR TEMPERATURE
(59°F IS STANDARD)
FUZE PD M51
MV= 2100 FPS
NORMAL CHARGE
FUZE PD M51
MV= 2800 FPS
SUPER CHARGE
RANGE EFFECT – YARDS
RANGE – YARDS
3
2
1
0
-1
-2
-3
-4
0
4000
8000
12000
16000
20000
24000
28000


m. RANGE EFFECT OF 1 MPH REAR WIND
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
RANGE EFFECTS—YARDS
RANGE—YARDS
0
5
10
15
20
25
30
35
0
4000
8000
12000
16000
20000
24000
28000


n. RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
FUZE PD M51
MV = 2100 FPS
NORMAL CHARGE
FUZE PD M51
MV = 2800 FPS
SUPER CHARGE
RANGE EFFECT — YARDS
RANGE — YARDS
0
-40
-80
-120
-160
-200
0
4000
8000
12000
16000
20000
24000
28000

SECTION V

EFFECT DATA

	Paragraph
Ricochet data	9
Effectiveness	10
Fragmentation	11
Penetration	12

9. **Ricochet data.** The following data on ricochet of the 155-mm HE Shell M101 with PD Fuze M51A4 were taken from volume III of "Terminal Ballistic Data".

TABLE 82

	Range	Angle of Fall	Angle of Recovery	Impact to Burst	Height of Burst	PE in Height of Burst
	yd	mils	mils	yd	ft	ft
Normal Charge MV 2,100 fps	1,000	12	25	96	7	1
	2,000	28	50	86	13	2
	3,000	47	75	77	17	3
	4,000	70	105	67	21	4
	5,000	98	140	58	24	5
	6,000	132	180	49	26	5
	7,000	173	215	40	26	5
	8,000	221	255	33	25	5
	9,000	276	285	26	22	5
	10,000	336	305	20	18	5
	11,000	399	315	14	14	4
Super Charge MV 2,800 fps	1,000	7	20	130	7	1
	2,000	14	30	121	10	2
	3,000	22	40	112	13	3
	4,000	33	55	102	17	3
	5,000	46	75	93	21	4
	6,000	62	95	84	24	4
	7,000	82	120	74	26	5
	8,000	107	150	65	29	6
	9,000	135	180	56	30	6
	10,000	169	215	47	30	6
	11,000	207	245	39	29	6
	12,000	252	275	31	26	6
	13,000	302	295	24	22	5
	14,000	358	310	19	18	5
	15,000	419	315	14	14	5

10. Effectiveness. The following data on effectiveness of HE Shell M101 with PD Fuze M51A4 or MT Fuze M67A3, fired from the 155-mm Gun M1, M1A1 or M2, were taken from volume III of "Terminal Ballistic Data".

a. NUMBER OF ROUNDS REQUIRED AGAINST ENEMY ARTILLERY FOR 50% EFFECT FOR 10,000 SQ YD IN AREA FIRE

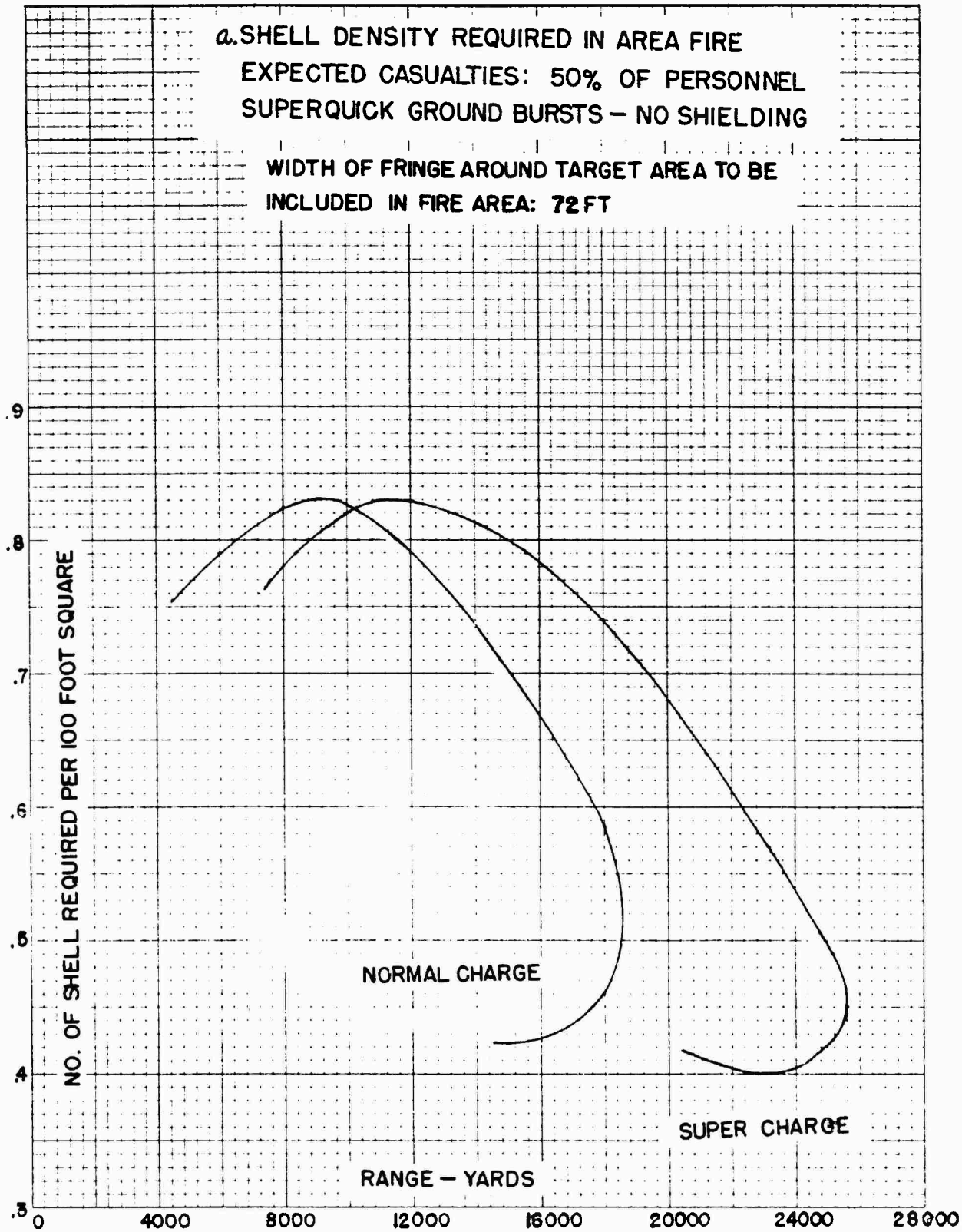
Supercharge: MV 2800 fps

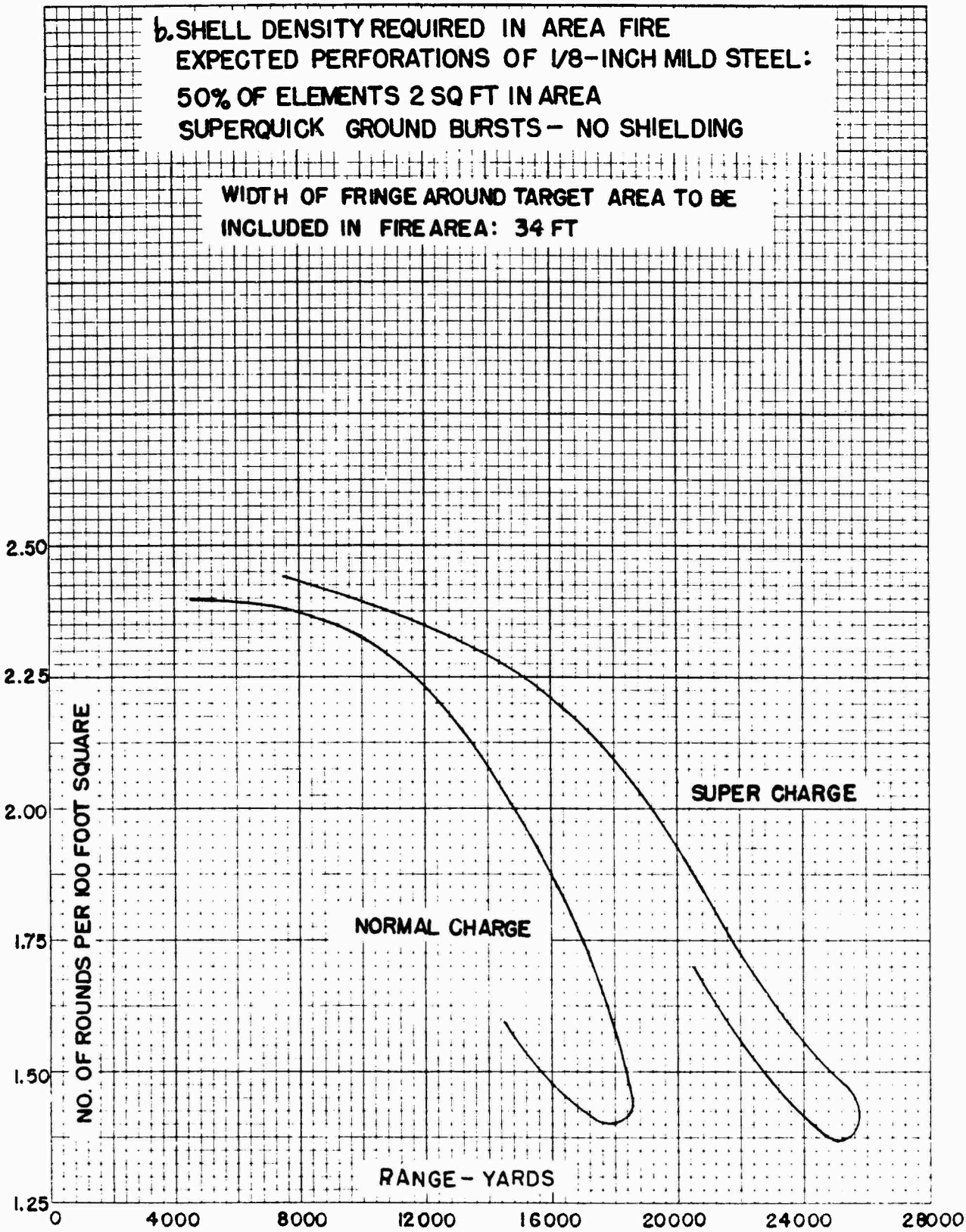
Range yd	Type of Fire		
	Impact	Time	Time and Impact
2,000	27	26	26
5,000	92	53	48
10,000	330	92	83
15,000	810	180	160
20,000	1300	320	290
25,000	1700	---	---

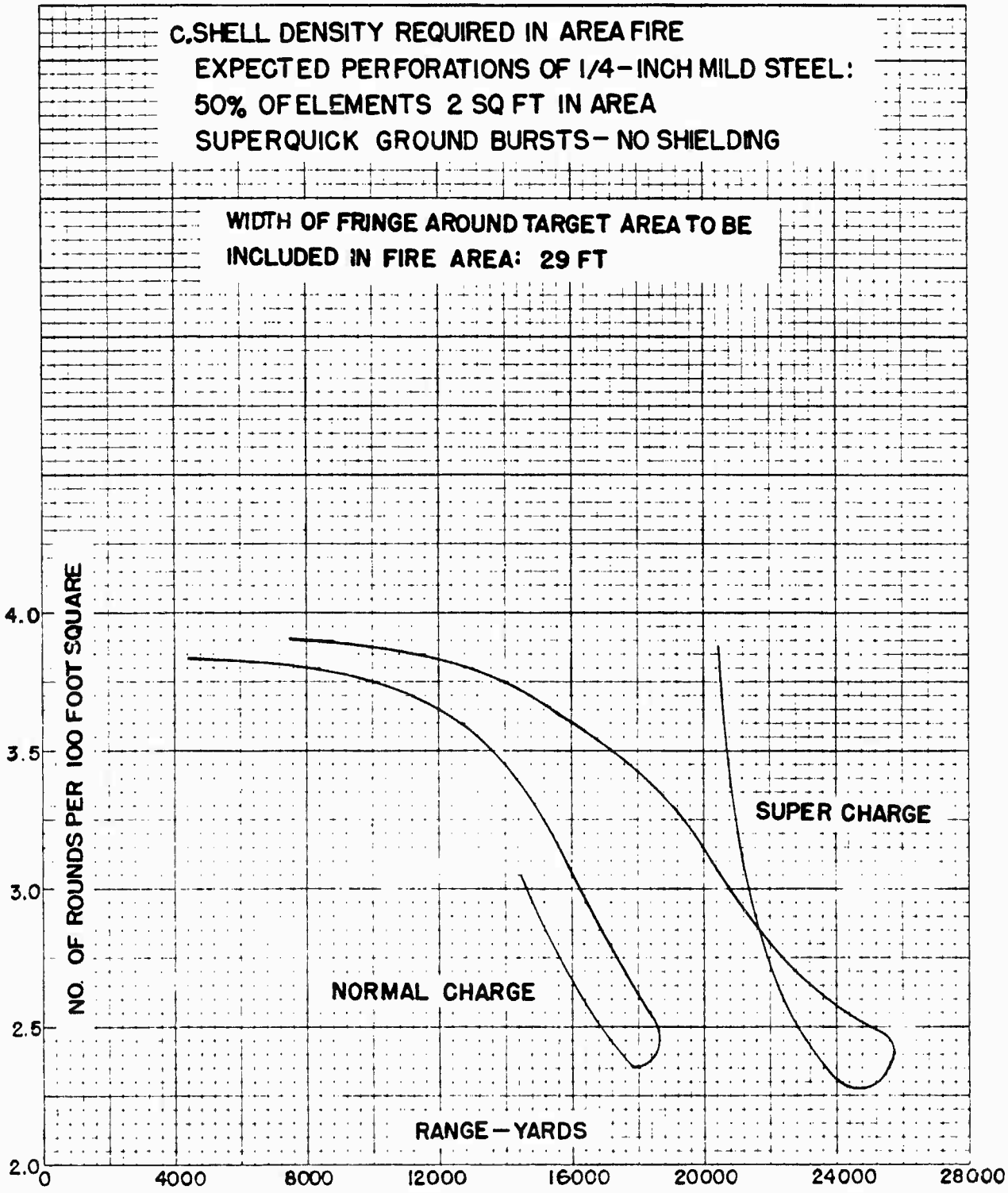
b. NUMBER OF ROUNDS REQUIRED AGAINST ENEMY ARTILLERY FOR 90% PROBABILITY OF AT LEAST ONE EFFECTIVE HIT IN AIMED FIRE

Charge	MV fps	Range yd	Type of Fire		
			Impact	Time	Time and Impact
Normal	2100	5,000	81	330	110
		10,000	570	700	430
		15,000	2300	1800	1300
Super	2800	2,000	9	520	18
		5,000	48	460	80
		10,000	330	590	310
		15,000	2300	960	790
		20,000	4500	2500	1800
		25,000	11000	4500	4000

11. Fragmentation. The following curves showing the expected damage by fragments of the HE Shell M101 with TSQ Fuze M55A3, fired from the 155-mm Gun M1, M1A1 or M2, were taken from volume III of "Terminal Ballistic Data".

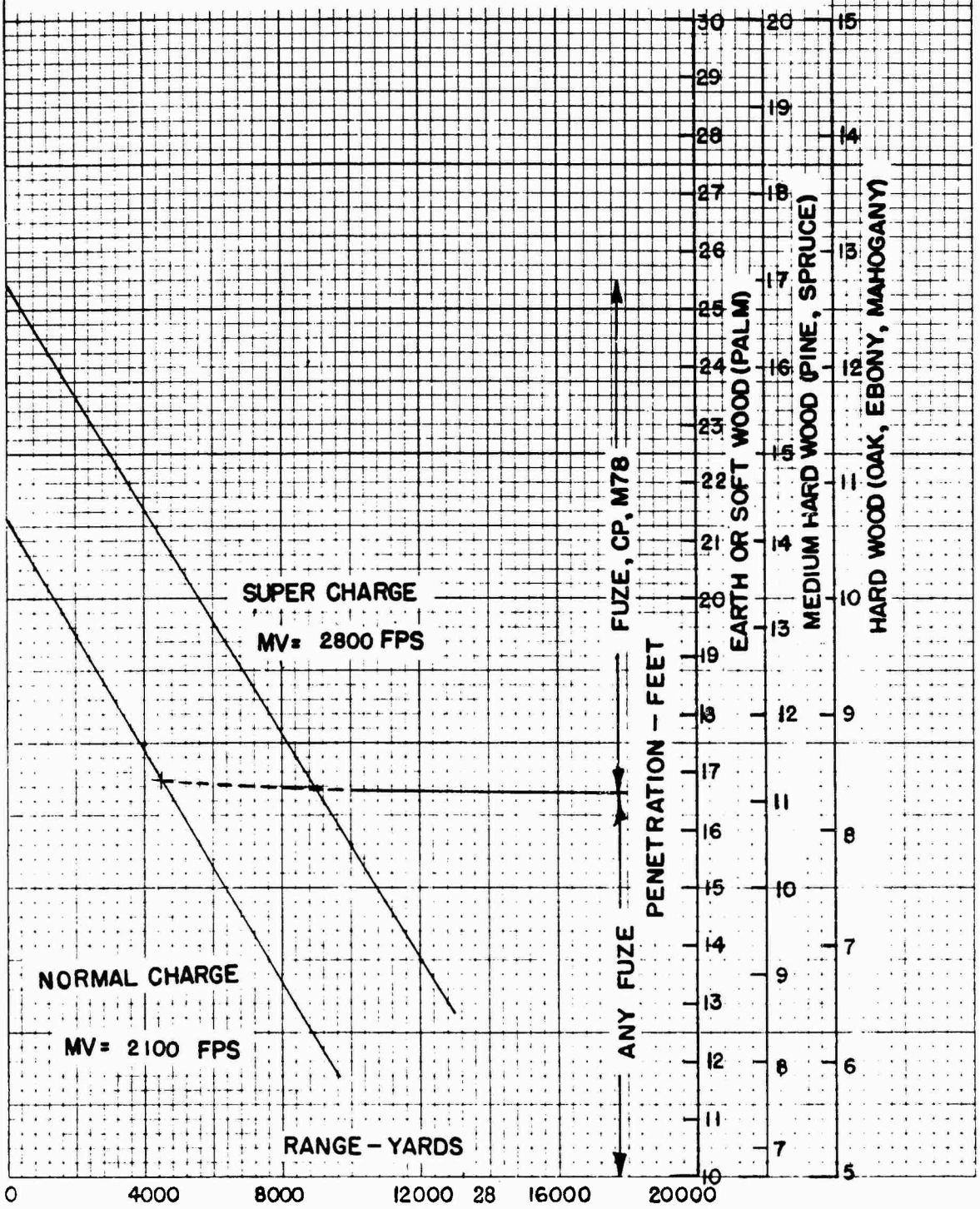

a. SHELL DENSITY REQUIRED IN AREA FIRE
EXPECTED CASUALTIES: 50% OF PERSONNEL
SUPERQUICK GROUND BURSTS – NO SHIELDING
WIDTH OF FRINGE AROUND TARGET AREA TO BE INCLUDED IN FIRE AREA: 72 FT
NO. OF SHELL REQUIRED PER 100 FOOT SQUARE
.9
.8
.7
.6
.5
.4
.3
NORMAL CHARGE
SUPER CHARGE
RANGE – YARDS
0
4000
8000
12000
16000
20000
24000
28000

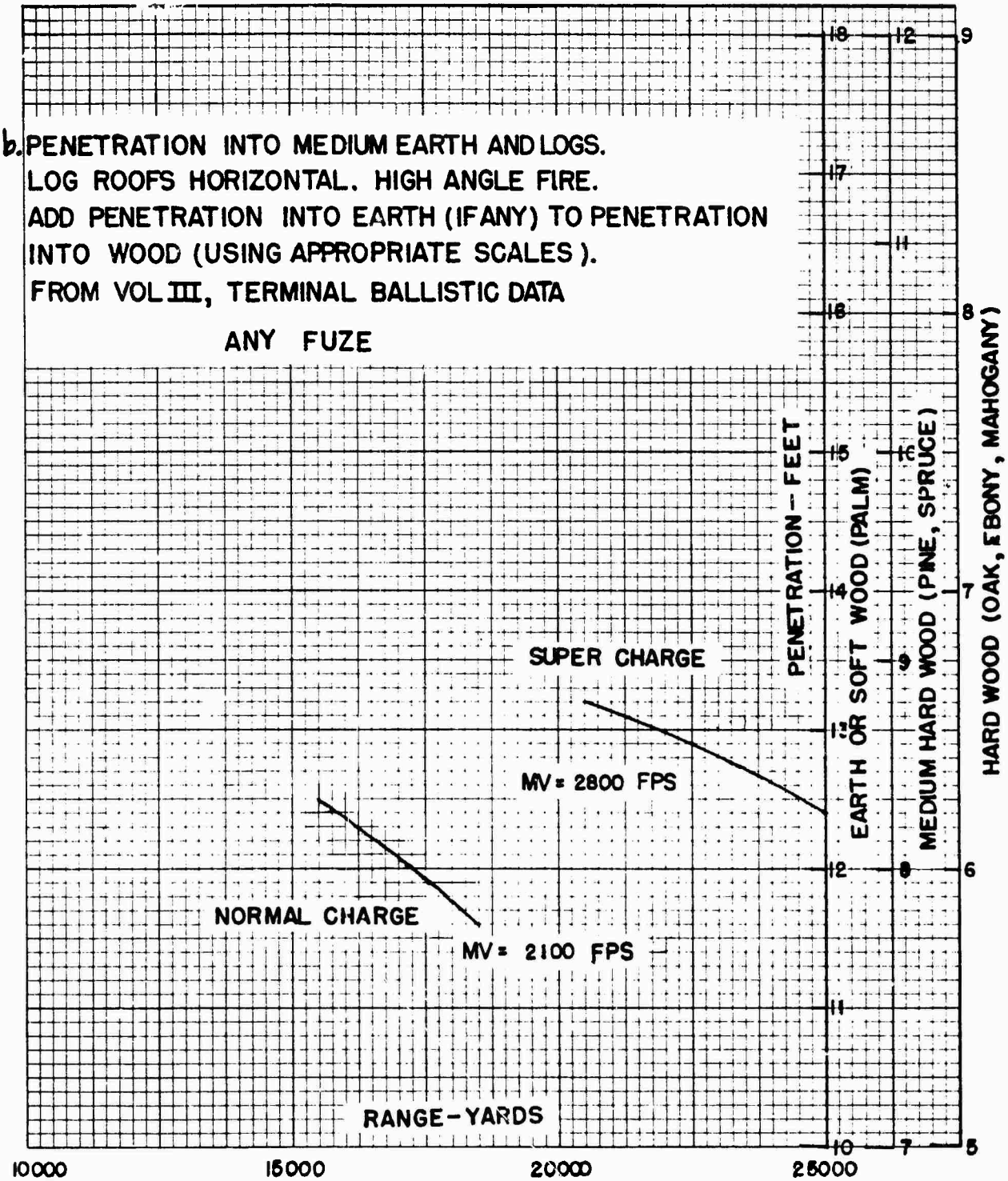

b. SHELL DENSITY REQUIRED IN AREA FIRE
EXPECTED PERFORATIONS OF 1/8-INCH MILD STEEL:
50% OF ELEMENTS 2 SQ FT IN AREA
SUPERQUICK GROUND BURSTS - NO SHIELDING
WIDTH OF FRINGE AROUND TARGET AREA TO BE
INCLUDED IN FIRE AREA: 34 FT
NO. OF ROUNDS PER 100 FOOT SQUARE
2.50
2.25
2.00
1.75
1.50
1.25
SUPER CHARGE
NORMAL CHARGE
RANGE - YARDS
0
4000
8000
12000
16000
20000
24000
28000

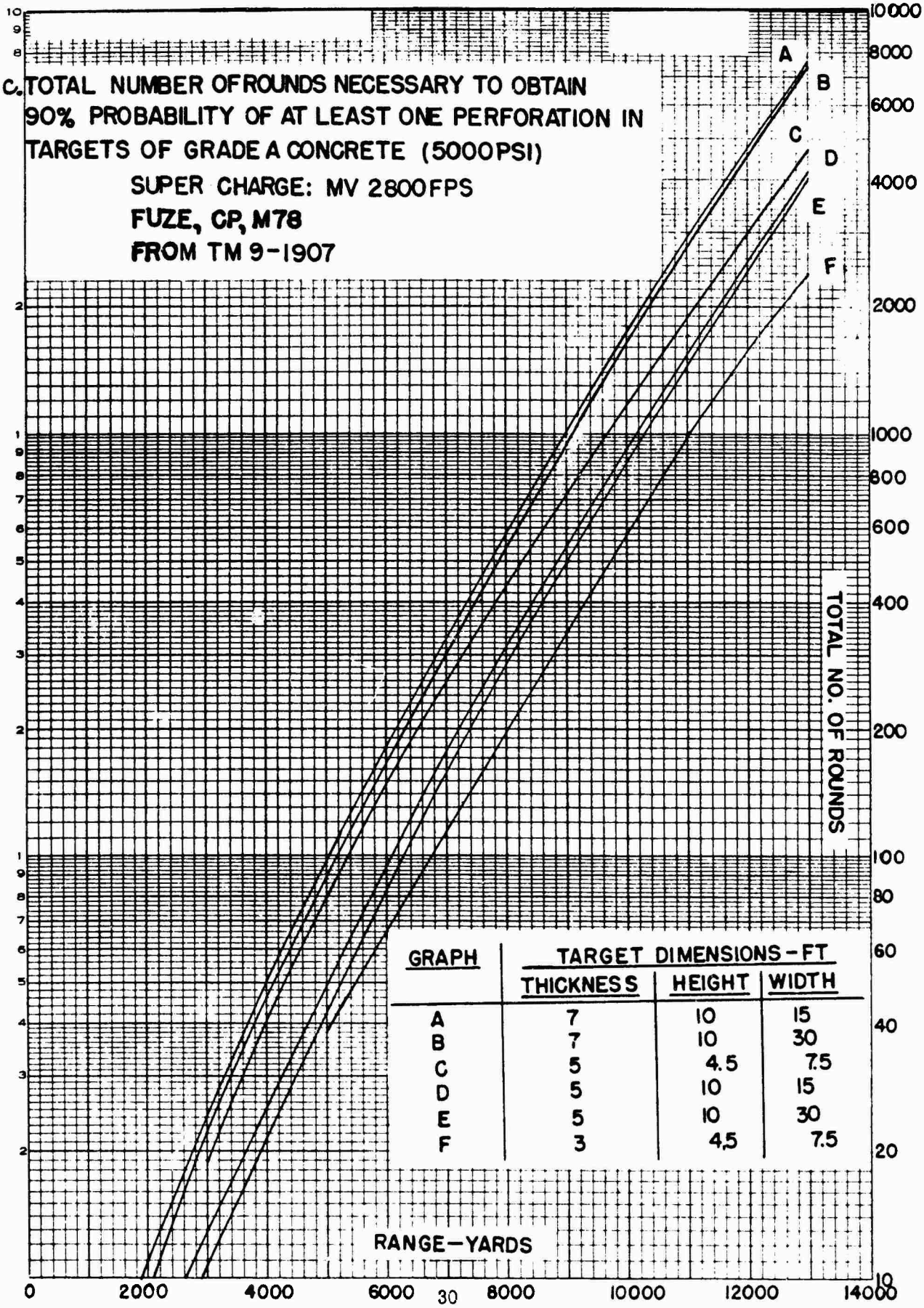

C. SHELL DENSITY REQUIRED IN AREA FIRE
EXPECTED PERFORATIONS OF 1/4-INCH MILD STEEL:
50% OF ELEMENTS 2 SQ FT IN AREA
SUPERQUICK GROUND BURSTS - NO SHIELDING
WIDTH OF FRINGE AROUND TARGET AREA TO BE INCLUDED IN FIRE AREA: 29 FT
NO. OF ROUNDS PER 100 FOOT SQUARE
4.0
3.5
3.0
2.5
2.0
SUPER CHARGE
NORMAL CHARGE
RANGE - YARDS
0
4000
8000
12000
16000
20000
24000
28000

12. PENETRATION

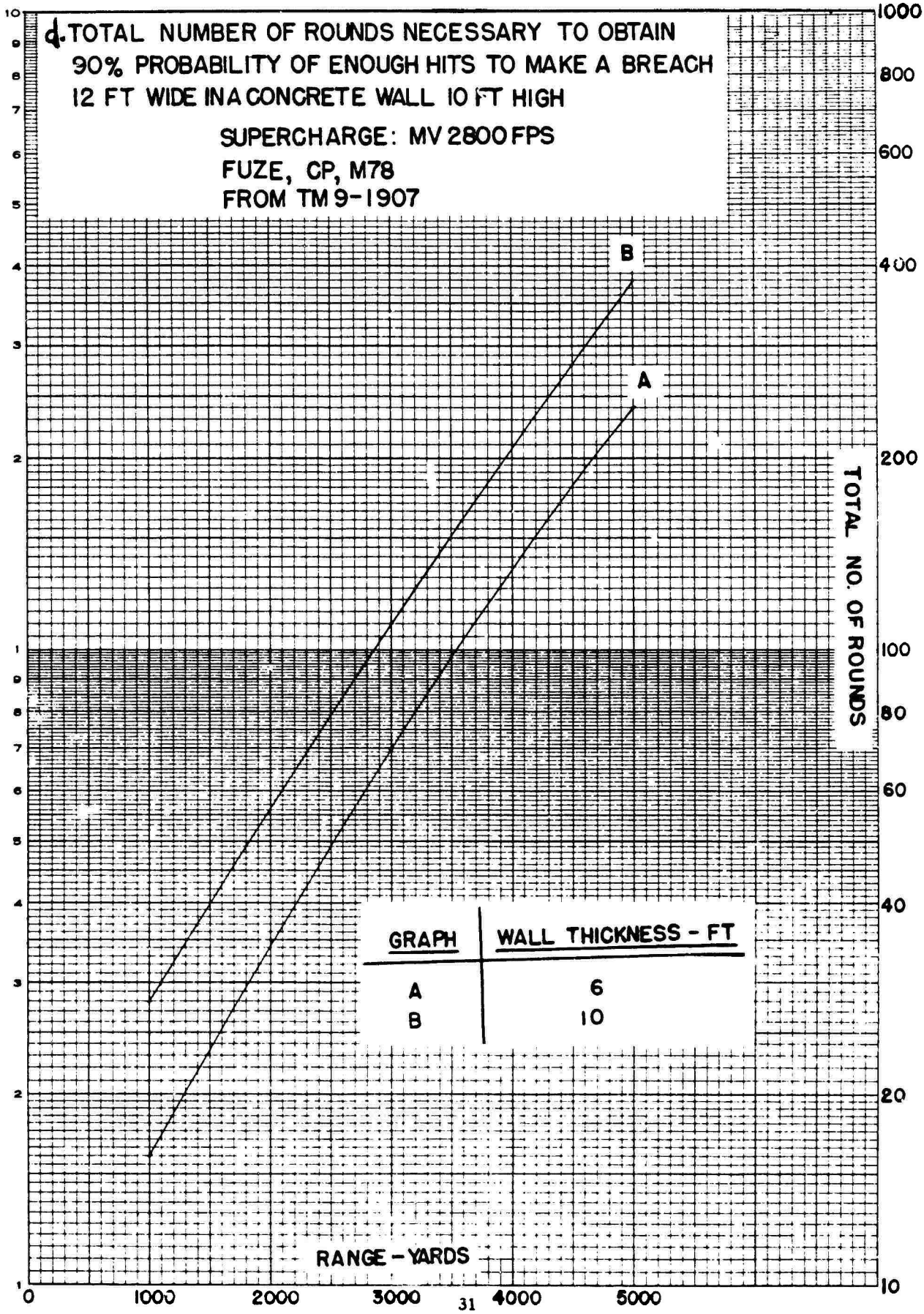
a. PENETRATION INTO MEDIUM EARTH AND LOGS
INCLINATION OF EMBANKMENT GREATER THAN 25°
LOG WALLS VERTICAL. LOW ANGLE FIRE.
ADD PENETRATION INTO EARTH (IF ANY) TO PENETRATION INTO WOOD (USING APPROPRIATE SCALES).
FROM VOL. III, TERMINAL BALLISTIC DATA




b. PENETRATION INTO MEDIUM EARTH AND LOGS.
LOG ROOFS HORIZONTAL. HIGH ANGLE FIRE.
ADD PENETRATION INTO EARTH (IF ANY) TO PENETRATION
INTO WOOD (USING APPROPRIATE SCALES).
FROM VOL III, TERMINAL BALLISTIC DATA
ANY FUZE
SUPER CHARGE
MV = 2800 FPS
NORMAL CHARGE
MV = 2100 FPS
RANGE-YARDS
10000
15000
20000
25000
PENETRATION - FEET
EARTH OR SOFT WOOD (PALM)
MEDIUM HARD WOOD (PINE, SPRUCE)
HARD WOOD (OAK, EBONY, MAHOGANY)
18
17
16
15
14
13
12
11
10
12
11
10
9
8
7
6
5
9
8
7



GRAPH	TARGET DIMENSIONS - FT		
	THICKNESS	HEIGHT	WIDTH
A	7	10	15
B	7	10	30
C	5	4.5	7.5
D	5	10	15
E	5	10	30
F	3	4.5	7.5


d. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF ENOUGH HITS TO MAKE A BREACH 12 FT WIDE IN A CONCRETE WALL 10 FT HIGH
SUPERCHARGE: MV 2800 FPS
FUZE, CP, M78
FROM TM 9-1907
B
A
TOTAL NO. OF ROUNDS
1000
800
600
400
200
100
80
60
40
20
10
GRAPH
WALL THICKNESS - FT
A
6
B
10
RANGE - YARDS
0
1000
2000
3000
4000
5000

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 155 - 1 - 107

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
11 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 155-mm, M107
with
Fuzes, PD, M51A4; TSQ, M55A3; MT, M67A3; and CP, M78

Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 8
V	Effect data	9 - 11

SECTION I
GENERAL

Paragraph
Purpose - 1

1. Purpose. The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 155-mm High Explosive Shell M107 with the Point Detonating Fuze M51A4, the Time and Superquick Fuze M55A3, the Mechanical Time Fuze M67A3, and the Concrete Piercing Fuze M78. This information is collected from the drawings, reports, firing tables, and technical manual pertaining to this ammunition.

SECTION II

DESCRIPTION

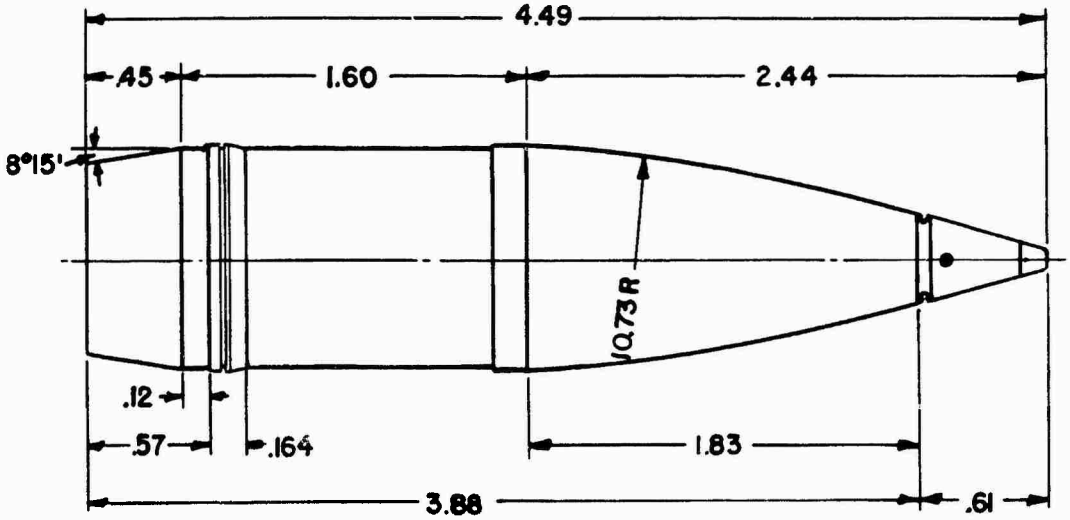
	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell: Metal parts assembly	75-4-99
Booster M21A4: Assembly	73-2-154
Fuze, PD, M51A4: Assembly	73-2-145
Details	73-2-143
Fuze, TSQ, M54: Assembly	73-3-154
Fuze, TSQ, M55A3: Assembly and detail	73-3-155
(The Booster, M21A4, and the Fuze, TSQ, M54, are components of the Fuze, TSQ, M55A3)	
Fuze, MT, M67A3: Assembly	73-7-77
Fuze, CP, M78: Body assembly and details	73-2-214

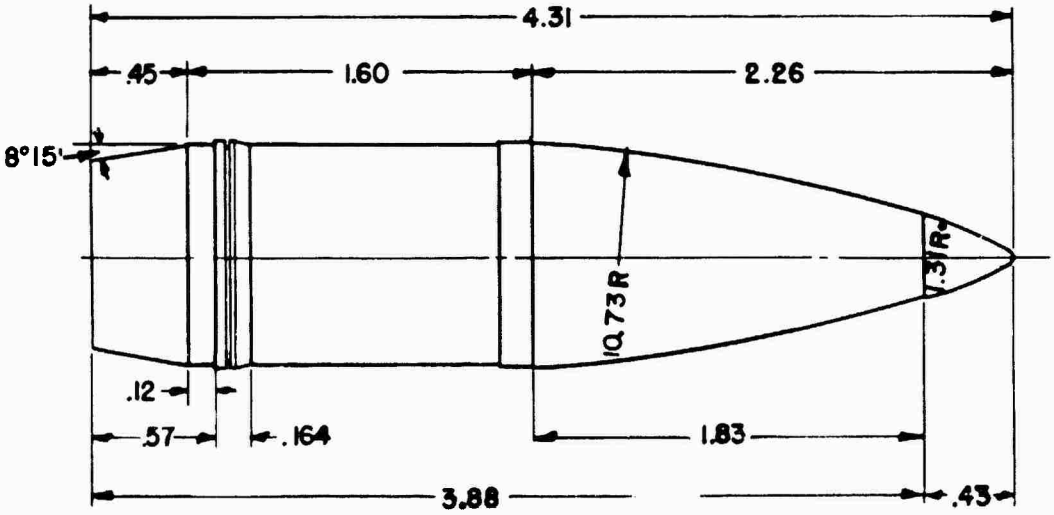
3. Dimensions.

Boat-tail: Angle	8°15'
Length	0.45 cal
Band: Distance from boat-tail	0.118 cal
Distance from base	0.568 cal
Width	0.164 cal
Cylindrical body: Length	1.606 cal
Ogive: Length	1.828 cal
Radius of arc	10.73 cal
Shell: Length (without fuze)	3.884 cal
Fuze, PD, M51A4; TSQ, M55A3; or MT, M67A3:	
Outside length	0.613 cal
Ogive and fuze	2.441 cal
Shell and fuze	4.497 cal
Fuze, CP, M78: Outside length	0.435 cal
Radius of arc	1.31 cal
Ogive and fuze	2.363 cal
Shell and fuze	4.319 cal



SHELL, HE, 155MM, M107
FUZE, PD, M51A4

ALL DIMENSIONS IN CALIBERS
1 CAL = 6.102"



SHELL, HE, 155-MM, M107
FUZE, CP, M78

4. Physical characteristics.

a. PD, TSQ and MT Fuzes. The location of the center of gravity and the mements of inertia of the HE Shell M107 with any of these fuzes are approximately the same as those of the HE Shell M101 with the PD Fuze M48, which are tabulated below.

Mean Weight:	Zone 2	92.8 lb
	Zone 3	93.9 lb
	Zone 4 (standard)	95.0 lb
	Zone 5	96.1 lb
	Zone 6	97.2 lb
Base to center of gravity		1.538 cal
Axial moment of inertia		3.434 lb. ft^2
Transverse moment of inertia		28.88 lb. ft^2

b. CP Fuze. The HE Shell M107 with the CP Fuze weighs 0.34 lb more than with the other fuzes. Its other characteristics would also be slightly different, but have not been measured.

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Stresses	5
Theoretical yaw in bore	6

5. Stresses. The following table and the graphical representation on page 6 show the longitudinal, radial and tangential resultant stress at each of three sections: (A) the rear corner of the band seat, (B) the front of the band seat, and (C) immediately behind the bourrelet.

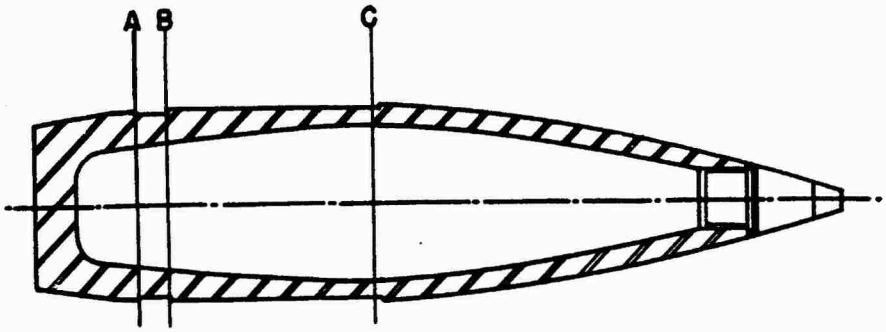
Howitzer	155-mm, M1
Twist of rifling	1/25
Cross-sectional area of bore	29.846 sq in.
Rated maximum pressure	32,000 psi
Total weight of projectile	95 lb
Muzzle velocity	1850 fps
Density of filler (TNT)	0.057 lb per cu in.

Resultant Stress*	Section		
100 psi	A	B	C
Longitudinal	- 176	- 479	- 425
Radial	- 289	- 82	- 81
Tangential	- 547	+ 505	+ 500

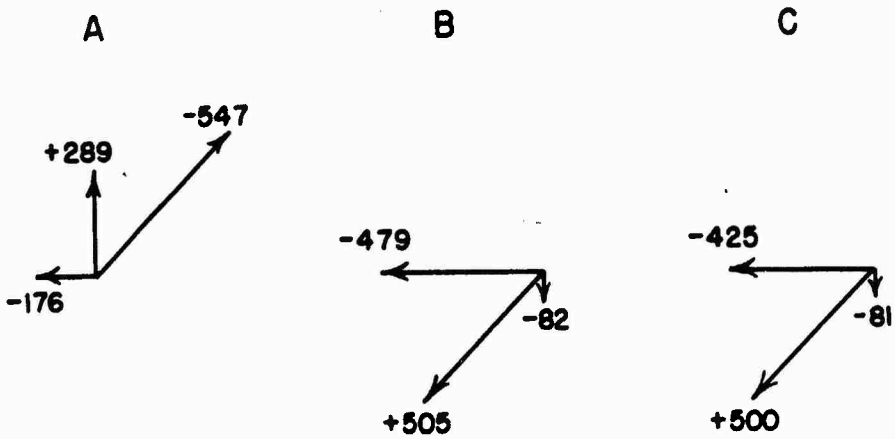
6. Theoretical yaw in bore.

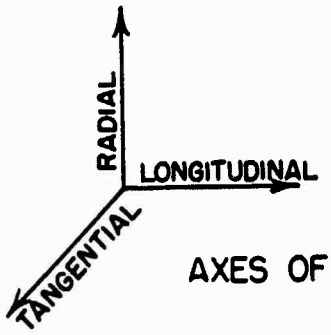
Minimum	7 min
Maximum	12 min

* + denotes tension, - denotes compression.



SECTION





AXES OF RESULTANT STRESS

DIAGRAM OF RESULTANT STRESSES

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data	7
Firing table data	8

7. Aerodynamic data.

a. Drag. The trajectories for the 155-mm Howitzer M1 were based on the G_2 drag function, with ballistic coefficients determined from range firings (see paragraph 8b). The extropolated values of the ballistic coefficient at zero elevation and the corresponding form factors and drag coefficients are tabulated below. These pertain to the HE Shell M107 with the PD, TSQ or MT Fuze; the drag is one percent higher with the CP Fuze.

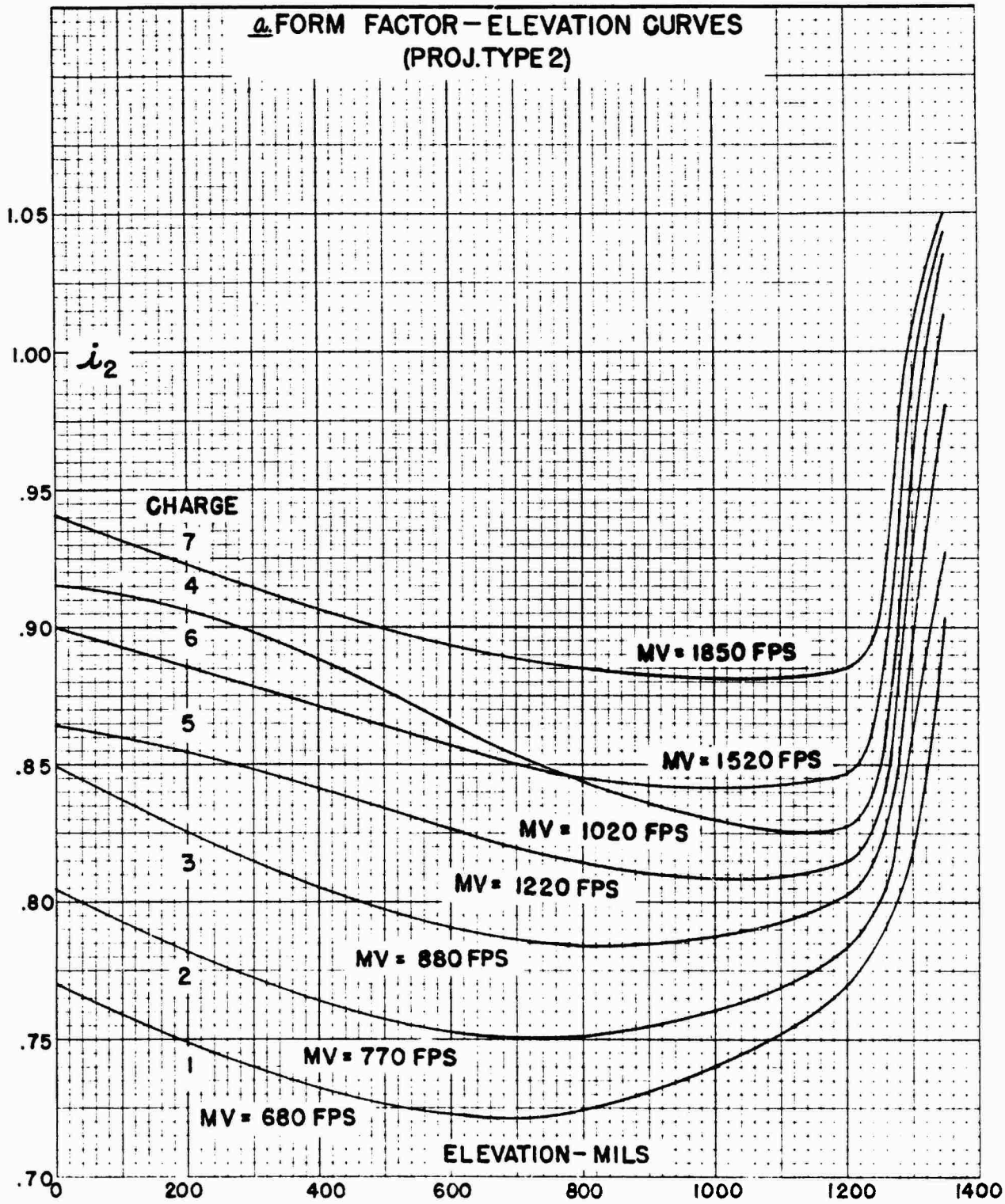
Charge	Muzzle Velocity	Ball. Coef.	Form Factor	Drag Coef.
No.	fps	C_2	i_2	K_D
1	680	3.315	.77	.005
2	770	3.178	.80	.054
3	880	3.010	.85	.055
4	1020	2.790	.91	.068
5	1220	2.952	.86	.139
6	1520	2.837	.90	.135
7	1850	2.710	.94	.124

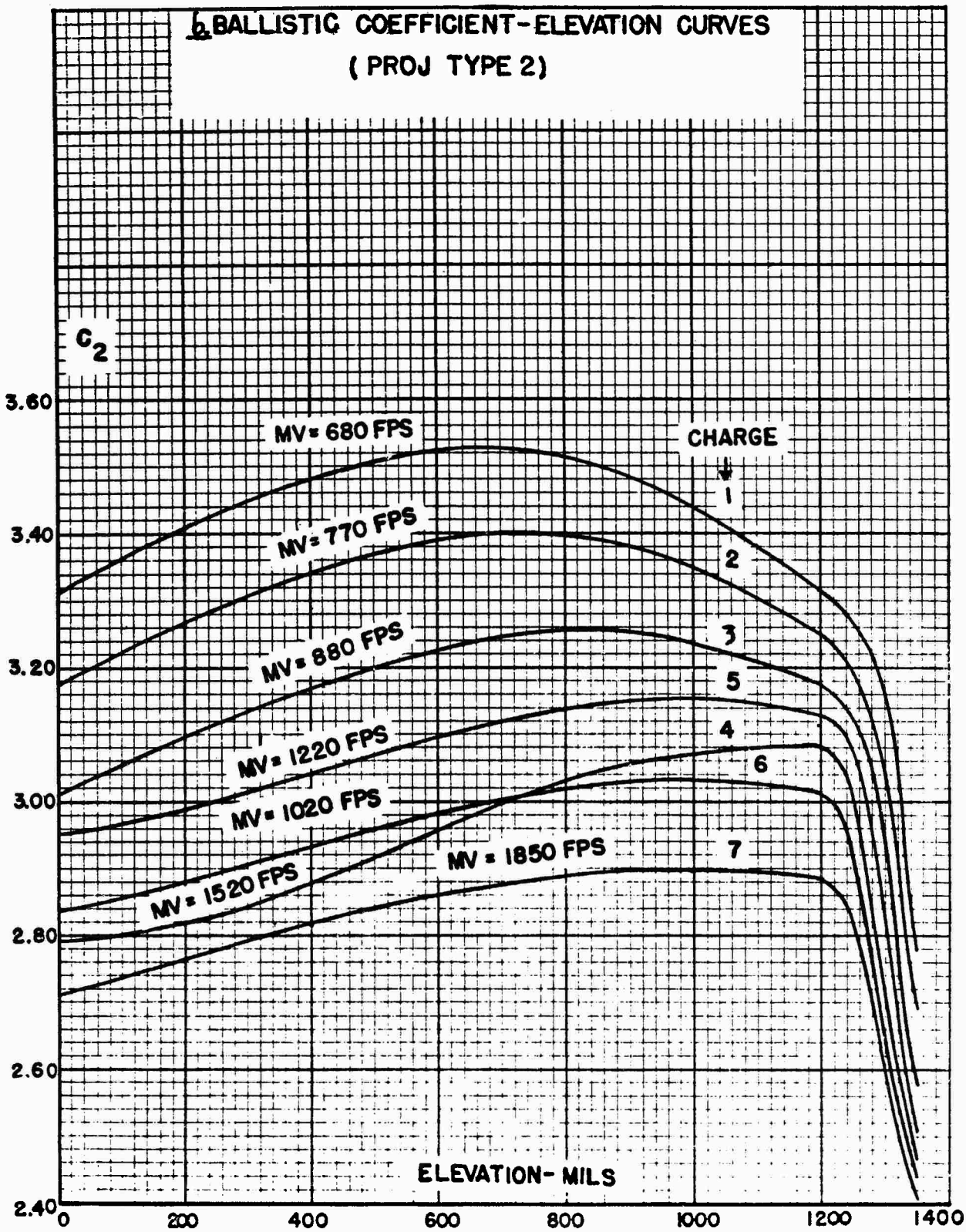
b. Stability. No stability firings have been done with this shell. However, an approximate stability factor may be deduced from that of the HE Shell M101 (T2) with the PD Fuze M48 and Booster M20, fired from the 155-mm Gun M1918 (OH 155-1-101). At a Mach number of 1.685 (MV 1934 fps), the moment coefficient was found to be 1.36. With a twist of one turn in 25 calibers, which is that of the 155-mm Howitzer M1, the stability factor would be 1.83 if the above moment coefficient were valid.

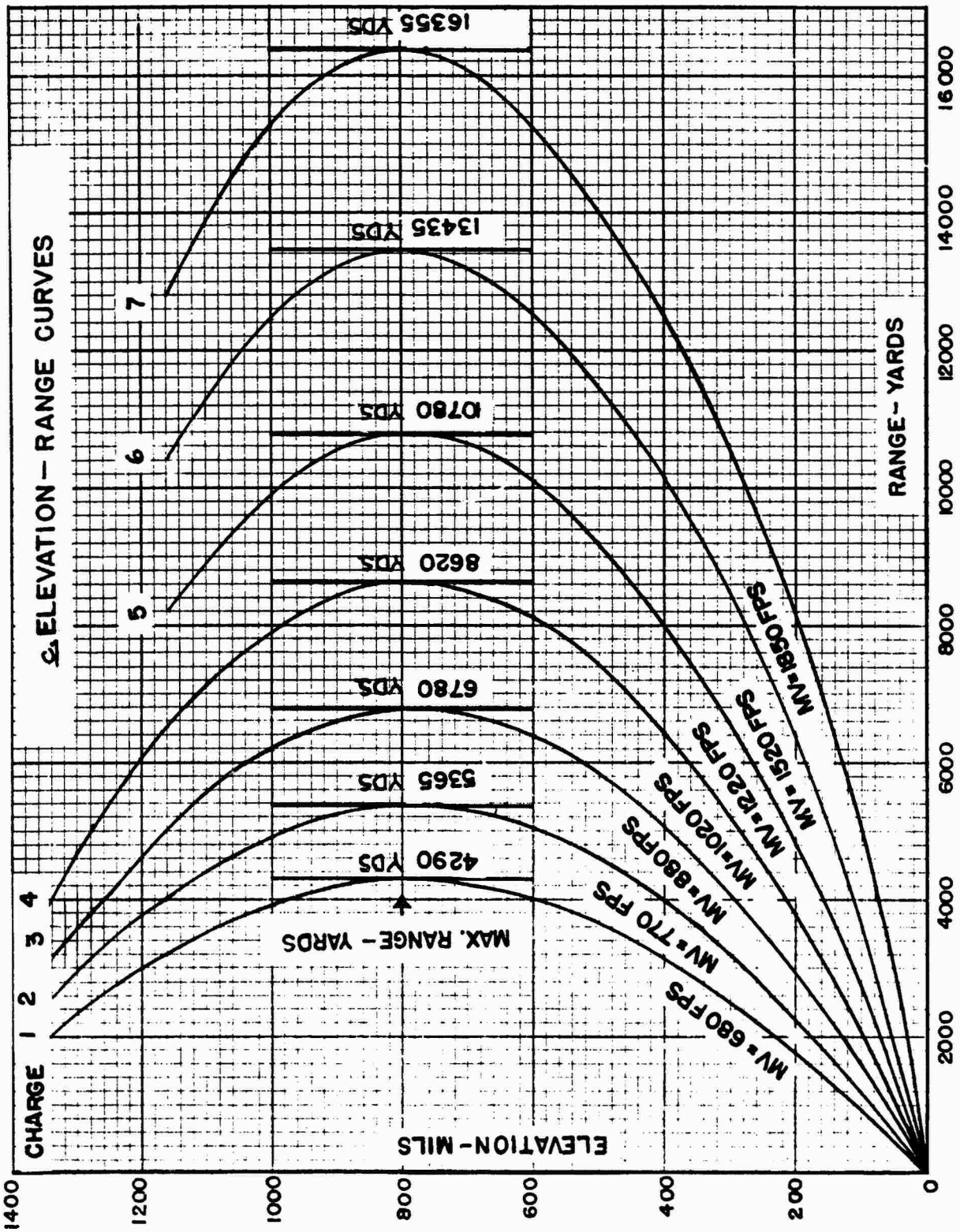
Actually, at the lower velocities obtained in the howitzer, the moment coefficient may be higher and the stability factor lower.

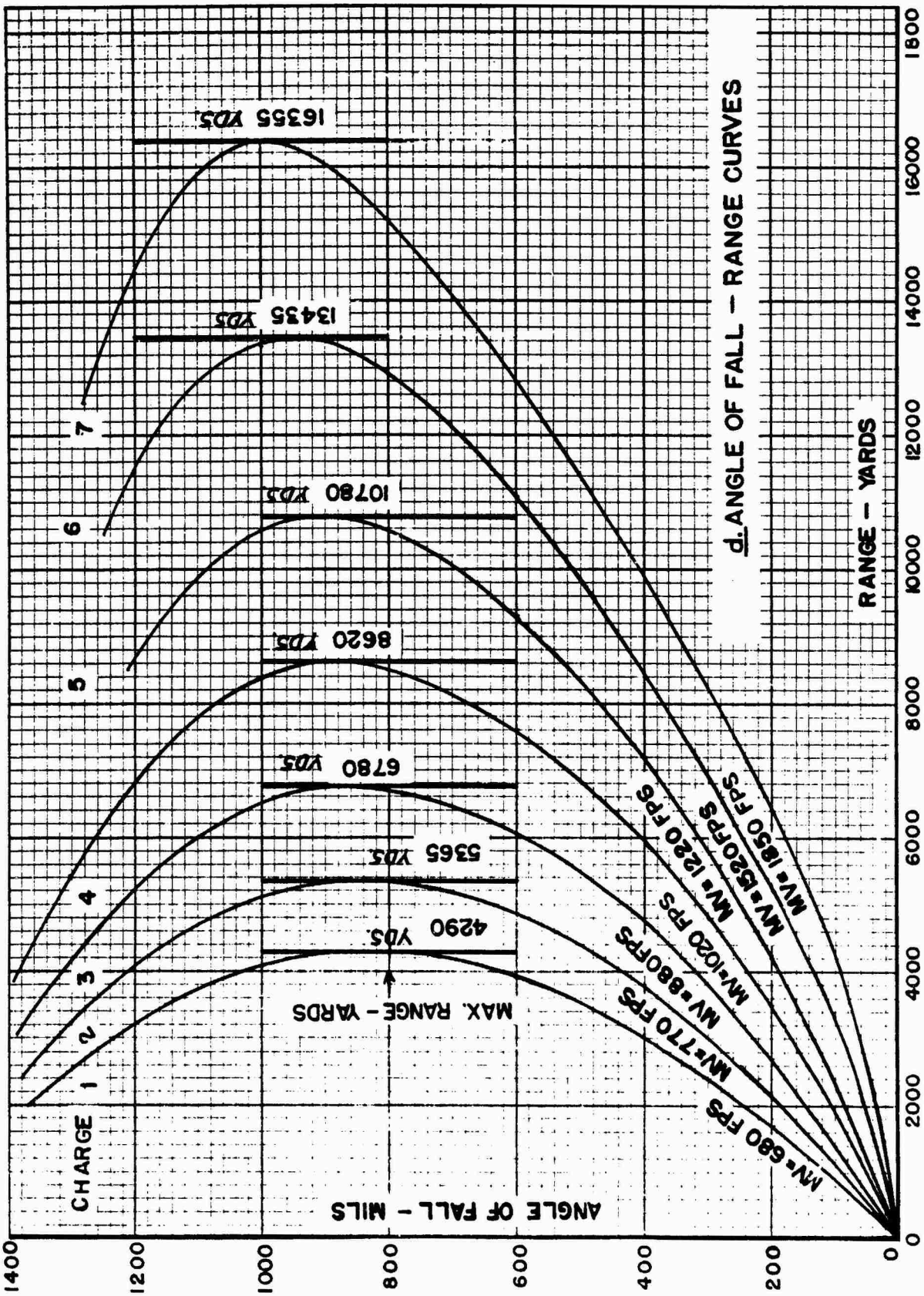
8. Firing table data. FT 155-Q2 with C-5 and C-7.

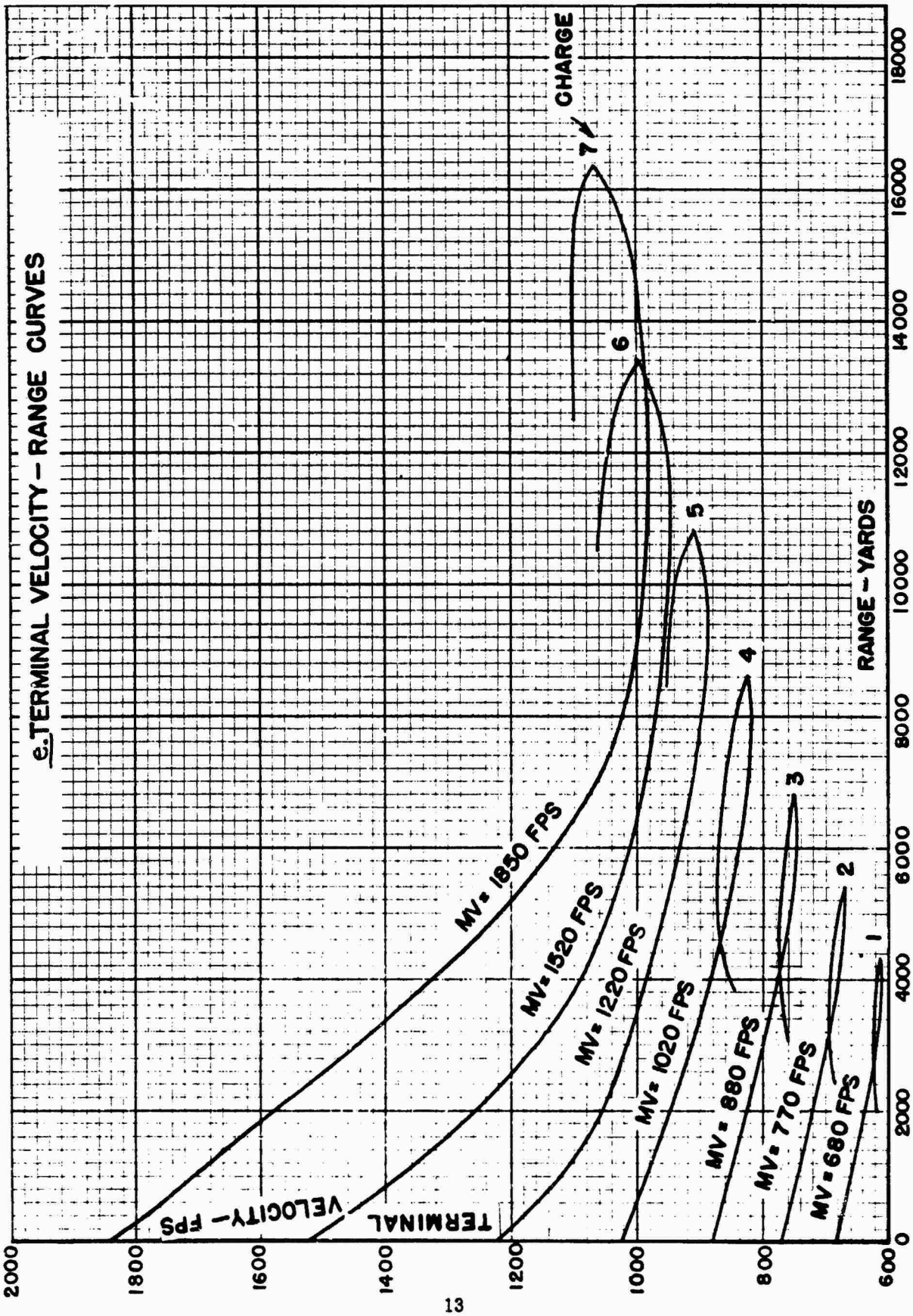
Howitzer, 155-mm, M1. Twist of rifling: 1/25.
Standardization of the 155-mm HE Shell M107 and Propelling Charges M3 and M4, to be used with the PD Fuze M51 and the TSQ Fuze M55, was recommended and approved by OCM items 16776 and 16904.

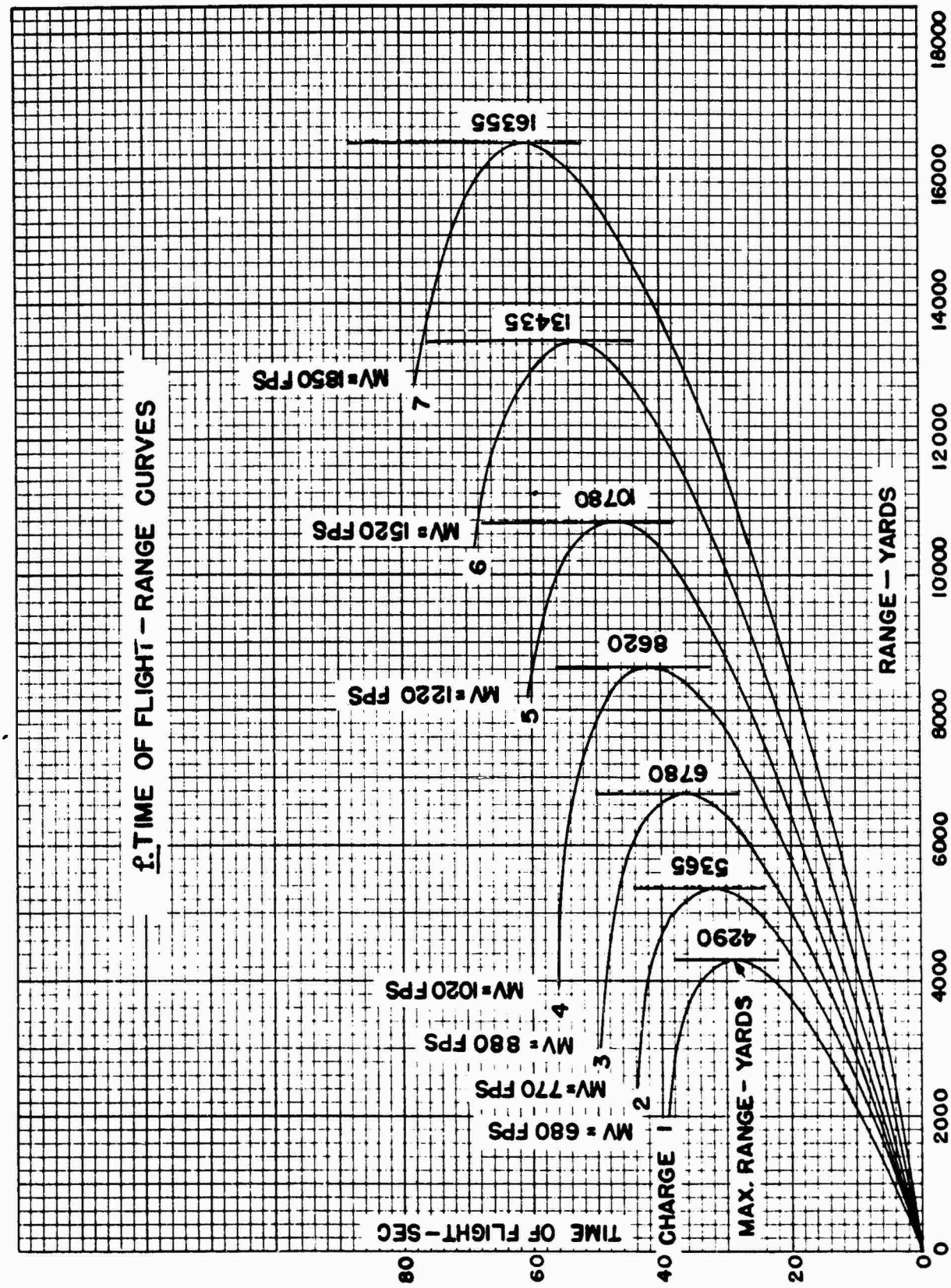

a. FORM FACTOR – ELEVATION CURVES
(PROJ. TYPE 2)
i_2
1.05
1.00
.95
.90
.85
.80
.75
.70
CHARGE
7
4
6
5
3
2
1
MV = 1850 FPS
MV = 1520 FPS
MV = 1020 FPS
MV = 1220 FPS
MV = 880 FPS
MV = 770 FPS
MV = 680 FPS
ELEVATION – MILS
0
200
400
600
800
1000
1200
1400

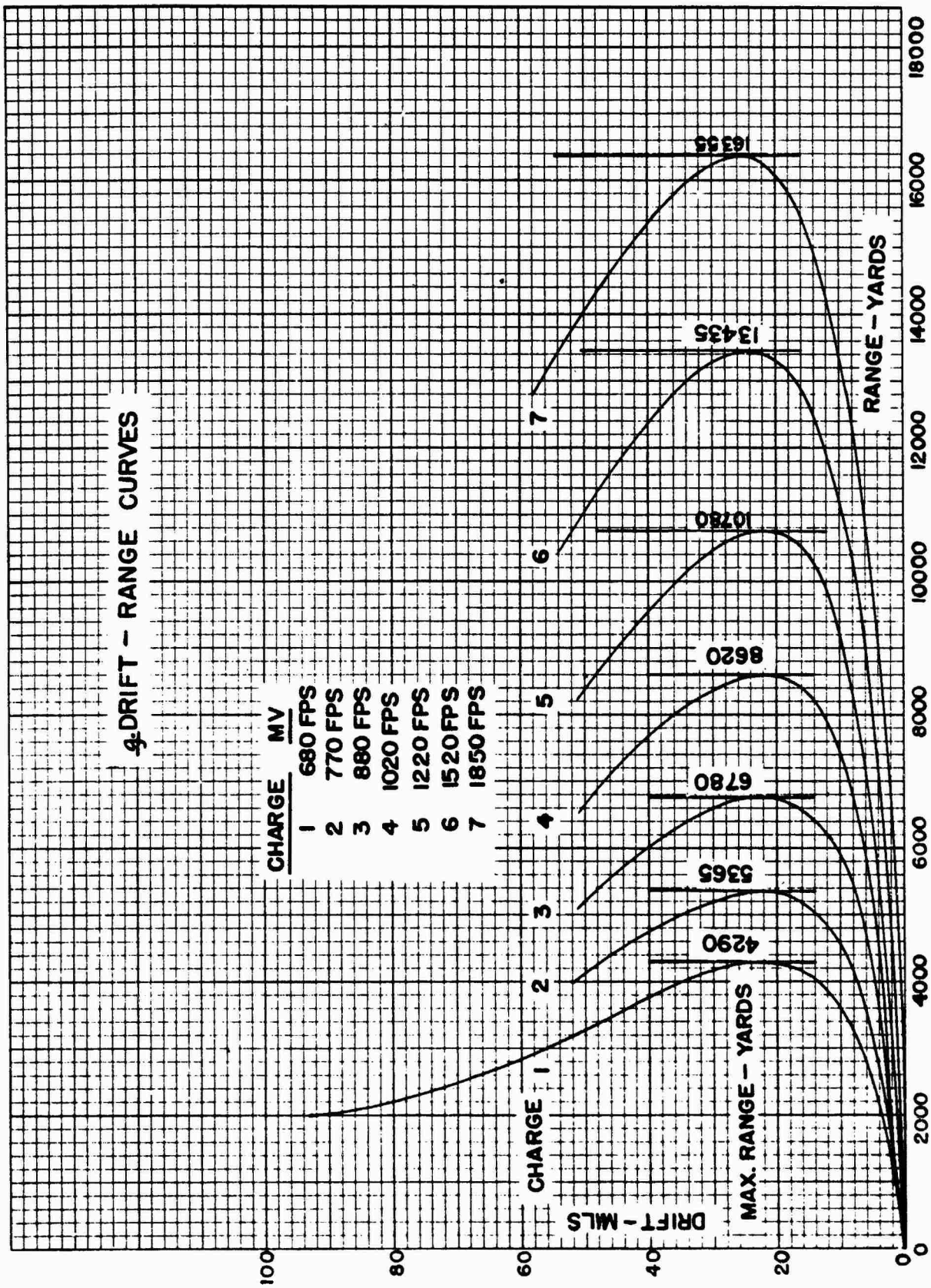

b. BALLISTIC COEFFICIENT-ELEVATION CURVES
(PROJ TYPE 2)
C_2
3.60
3.40
3.20
3.00
2.80
2.60
2.40
MV= 680 FPS
MV= 770 FPS
MV= 880 FPS
MV= 1220 FPS
MV= 1020 FPS
MV= 1520 FPS
MV = 1850 FPS
CHARGE
1
2
3
5
4
6
7
ELEVATION- MILS
0
200
400
600
800
1000
1200
1400

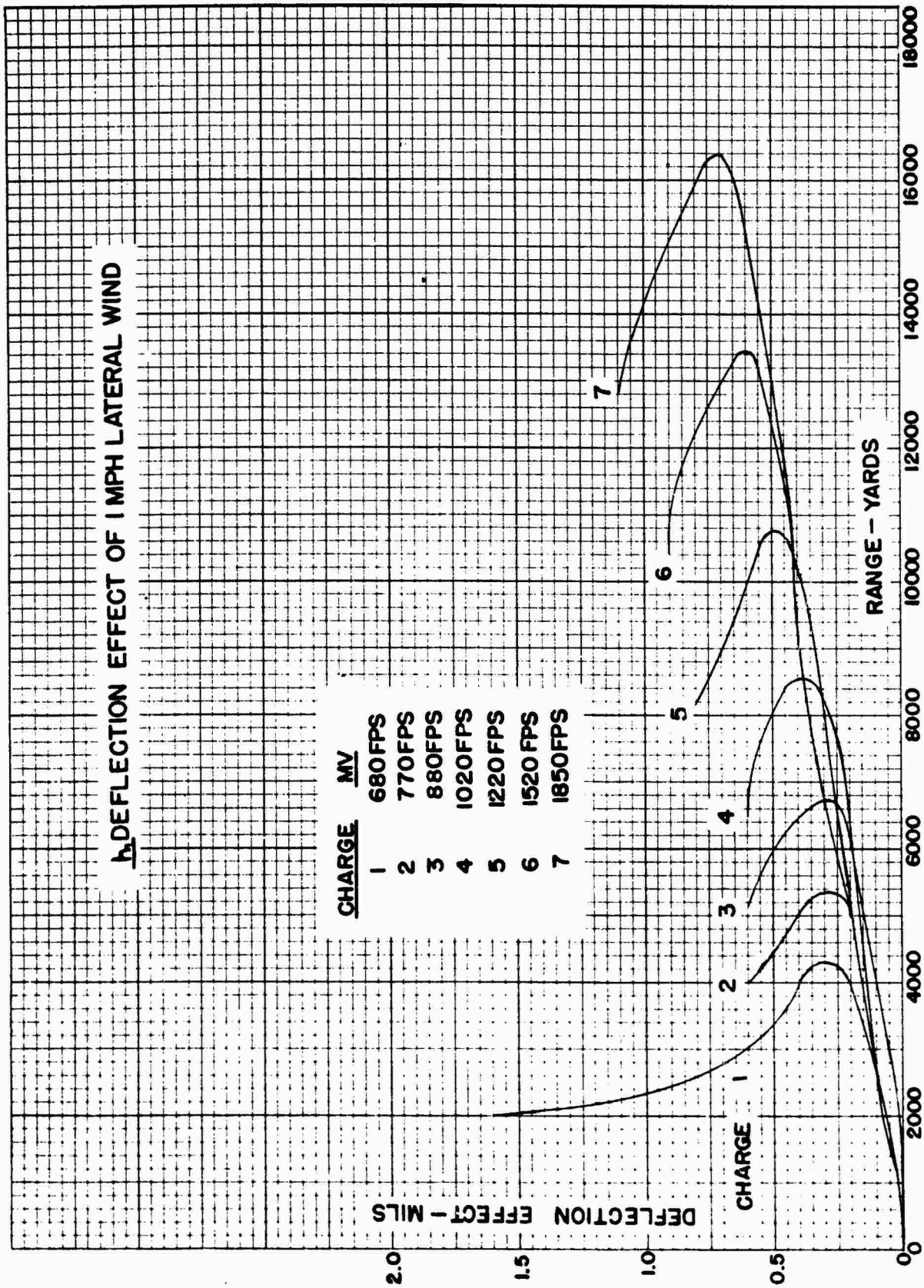

ELEVATION – RANGE CURVES
CHARGE 1 2 3 4 5 6 7
MAX. RANGE – YARDS
4290 YDS
5365 YDS
6780 YDS
8620 YDS
10780 YDS
13435 YDS
16355 YDS
MV = 680 FPS
MV = 770 FPS
MV = 880 FPS
MV = 1020 FPS
MV = 1220 FPS
MV = 1520 FPS
MV = 1850 FPS
ELEVATION – MILS
0
200
400
600
800
1000
1200
1400
RANGE – YARDS
2000
4000
6000
8000
10000
12000
14000
16000

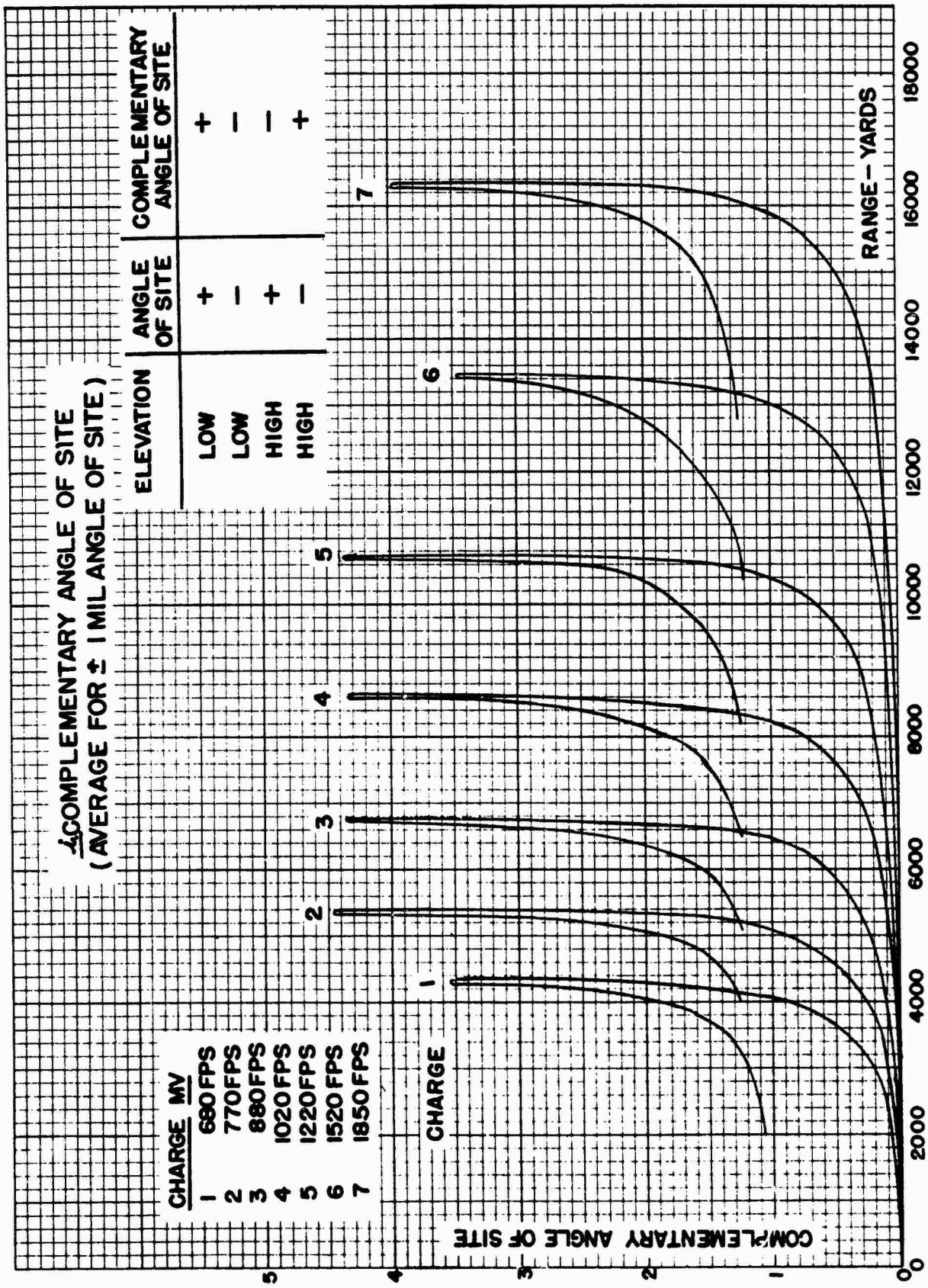

d. ANGLE OF FALL – RANGE CURVES
RANGE – YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
ANGLE OF FALL – MILS
0
200
400
600
800
1000
1200
1400
CHARGE
1
2
3
4
5
6
7
MAX. RANGE – YARDS
4290 YDS.
5365 YDS.
6780 YDS.
8620 YDS.
10780 YDS.
13435 YDS.
16355 YDS.
MV=680 FPS
MV=770 FPS
MV=880FPS
MV=1020 FPS
MV=1220 FPS
MV=1520FPS
MV=1850 FPS

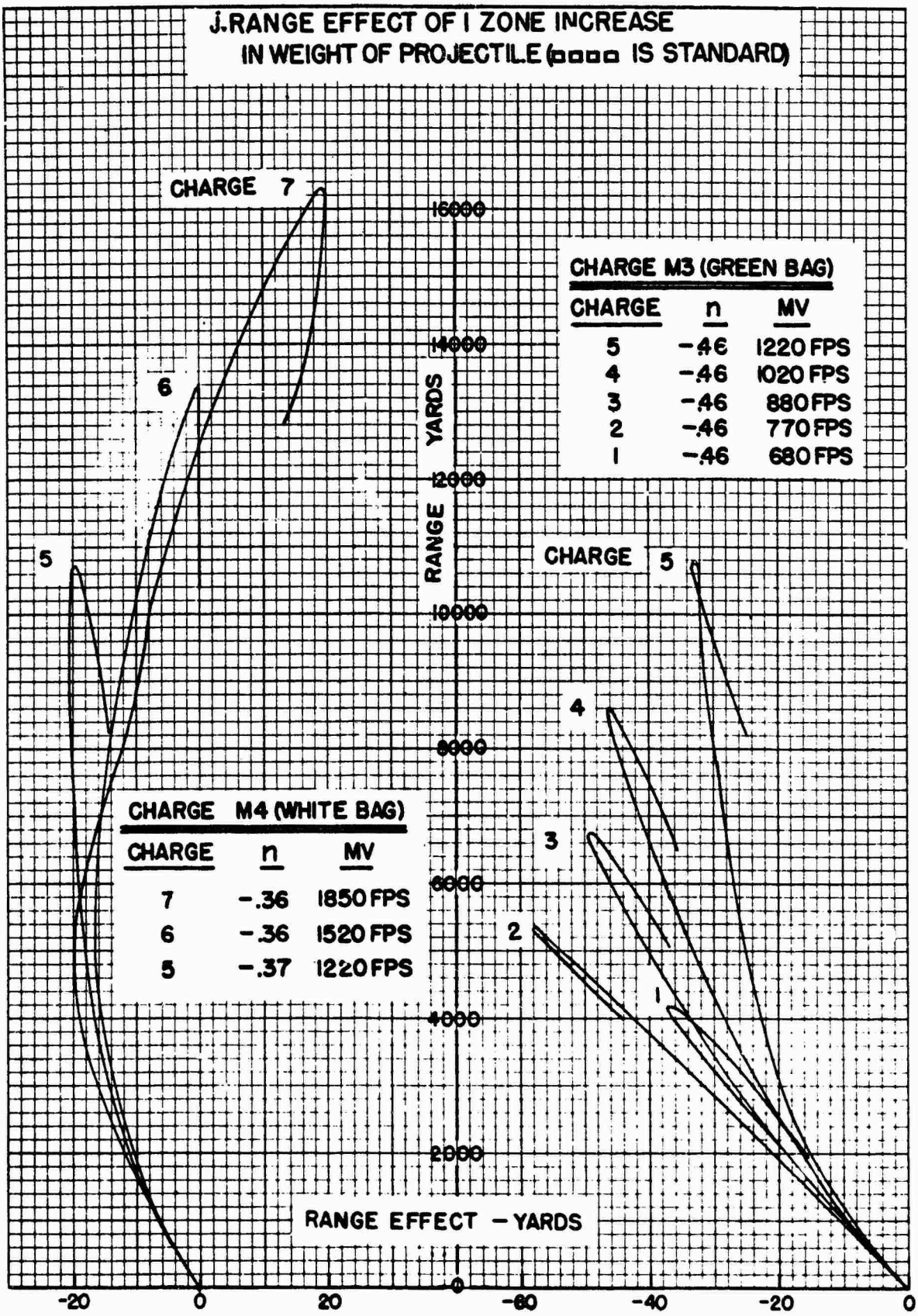

e. TERMINAL VELOCITY – RANGE CURVES
TERMINAL VELOCITY – FPS
RANGE – YARDS
MV = 1850 FPS
MV = 1520 FPS
MV = 1220 FPS
MV = 1020 FPS
MV = 880 FPS
MV = 770 FPS
MV = 680 FPS
CHARGE
7
6
5
4
3
2
1
2000
1800
1600
1400
1200
1000
800
600
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

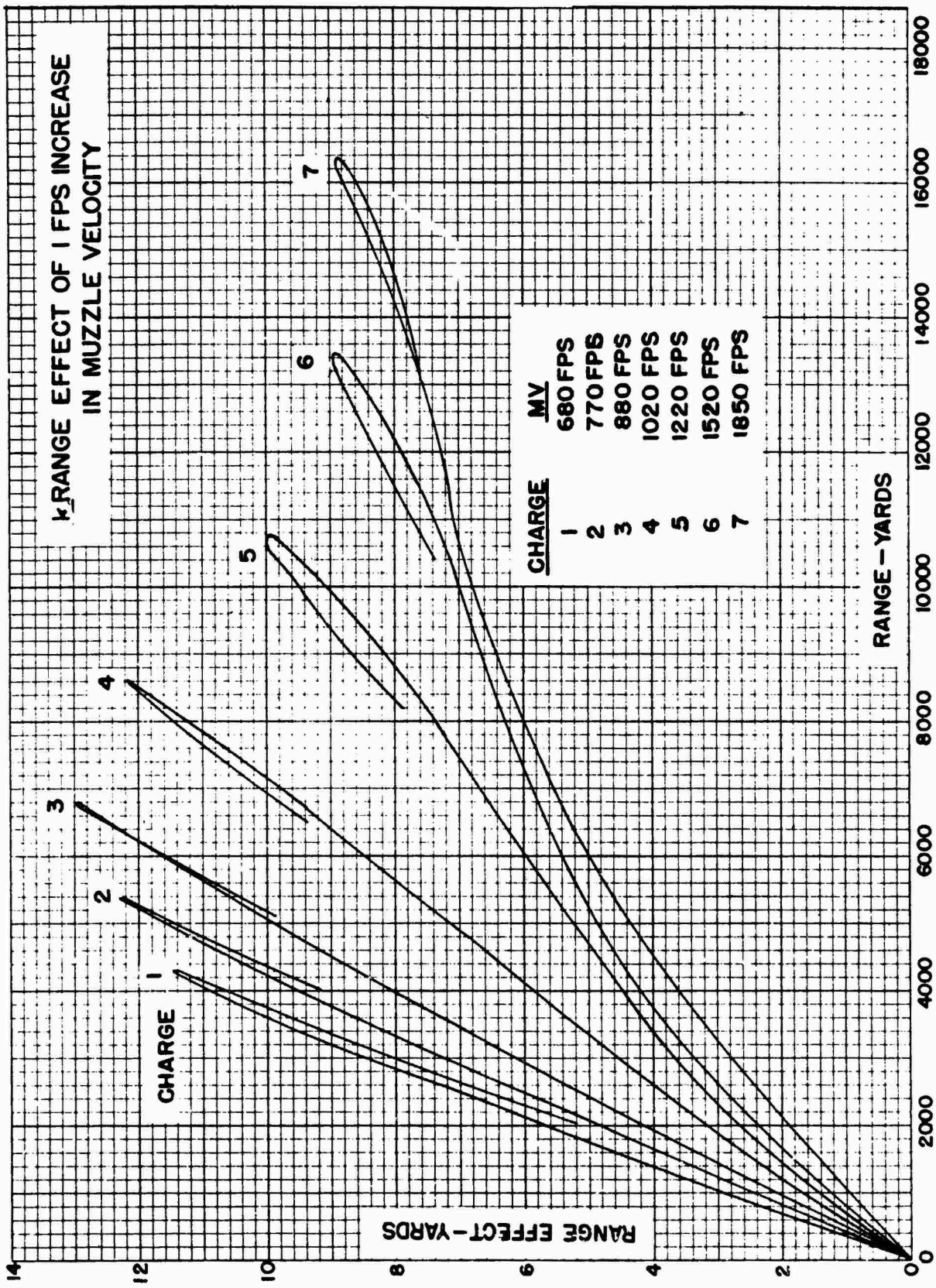

f. TIME OF FLIGHT – RANGE CURVES
TIME OF FLIGHT – SEC
RANGE – YARDS
MAX. RANGE – YARDS
CHARGE 1
MV = 680 FPS
MV = 770 FPS
MV = 880 FPS
MV = 1020 FPS
MV = 1220 FPS
MV = 1520 FPS
MV = 1850 FPS
4290
5365
6780
8620
10780
13435
16355
1
2
3
4
5
6
7
0
20
40
60
80
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

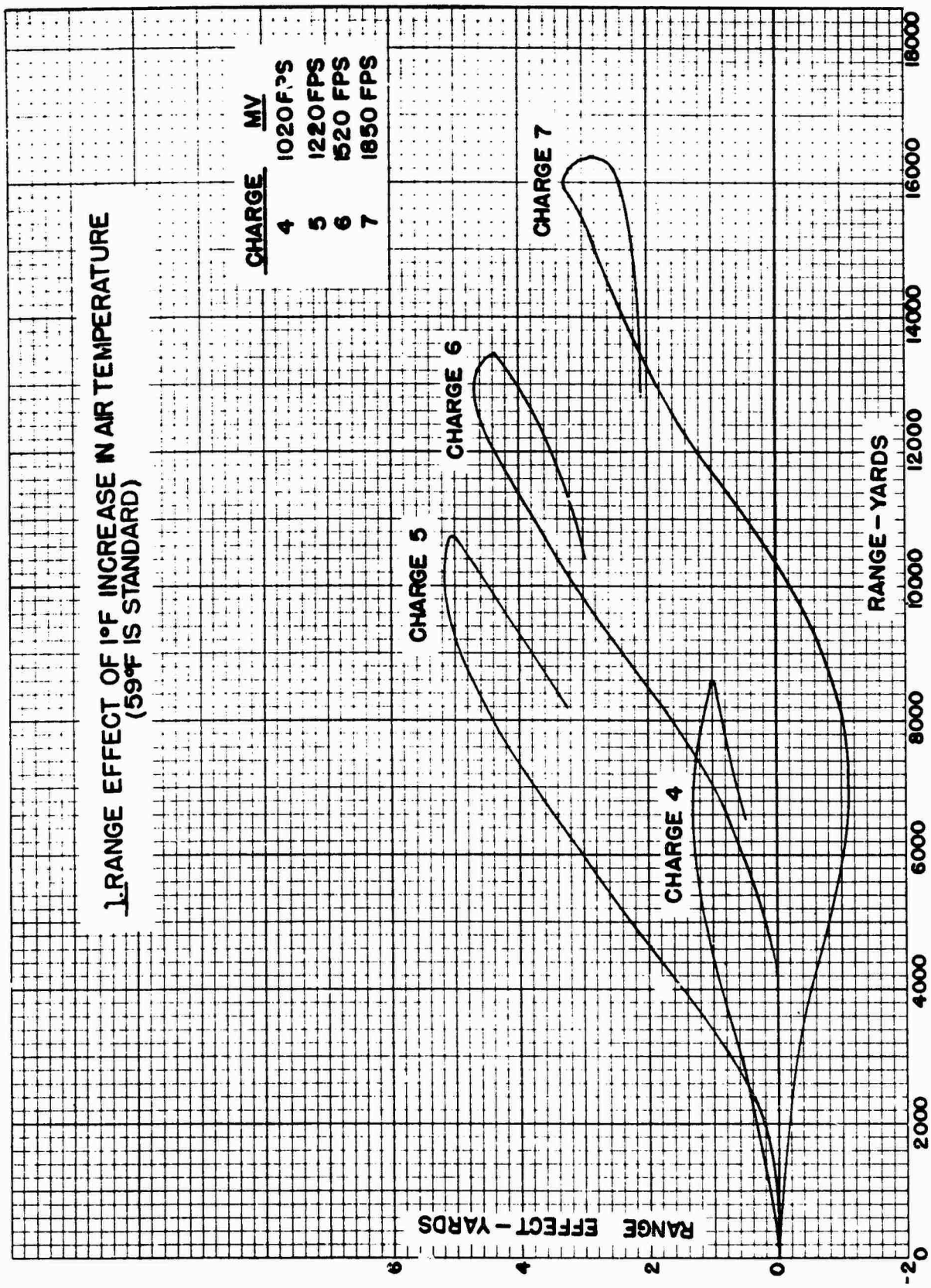

DRIFT - RANGE CURVES
CHARGE MV
1 680 FPS
2 770 FPS
3 880 FPS
4 1020 FPS
5 1220 FPS
6 1520 FPS
7 1850 FPS
CHARGE 1
2
3
4
5
6
7
4290
5365
6780
8620
10780
13435
16355
MAX. RANGE - YARDS
DRIFT - MILS
RANGE - YARDS
0
20
40
60
80
100
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

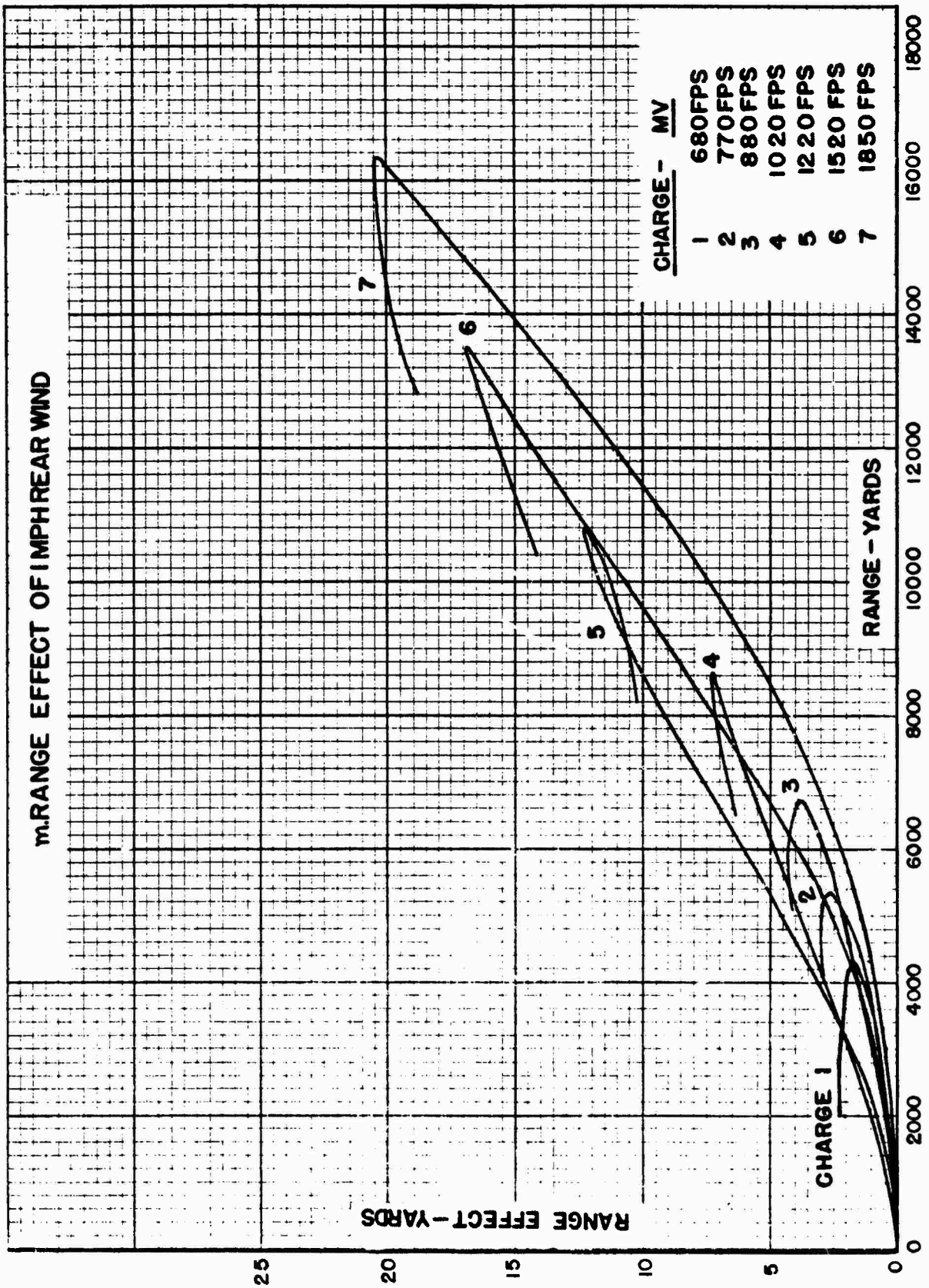

h DEFLECTION EFFECT OF 1 MPH LATERAL WIND
CHARGE MV
1 680FPS
2 770FPS
3 880FPS
4 1020FPS
5 1220FPS
6 1520FPS
7 1850FPS
DEFLECTION EFFECT – MILS
RANGE – YARDS
CHARGE 1
2
3
4
5
6
7
0
0.5
1.0
1.5
2.0
2000
4000
6000
8000
10000
12000
14000
16000
18000

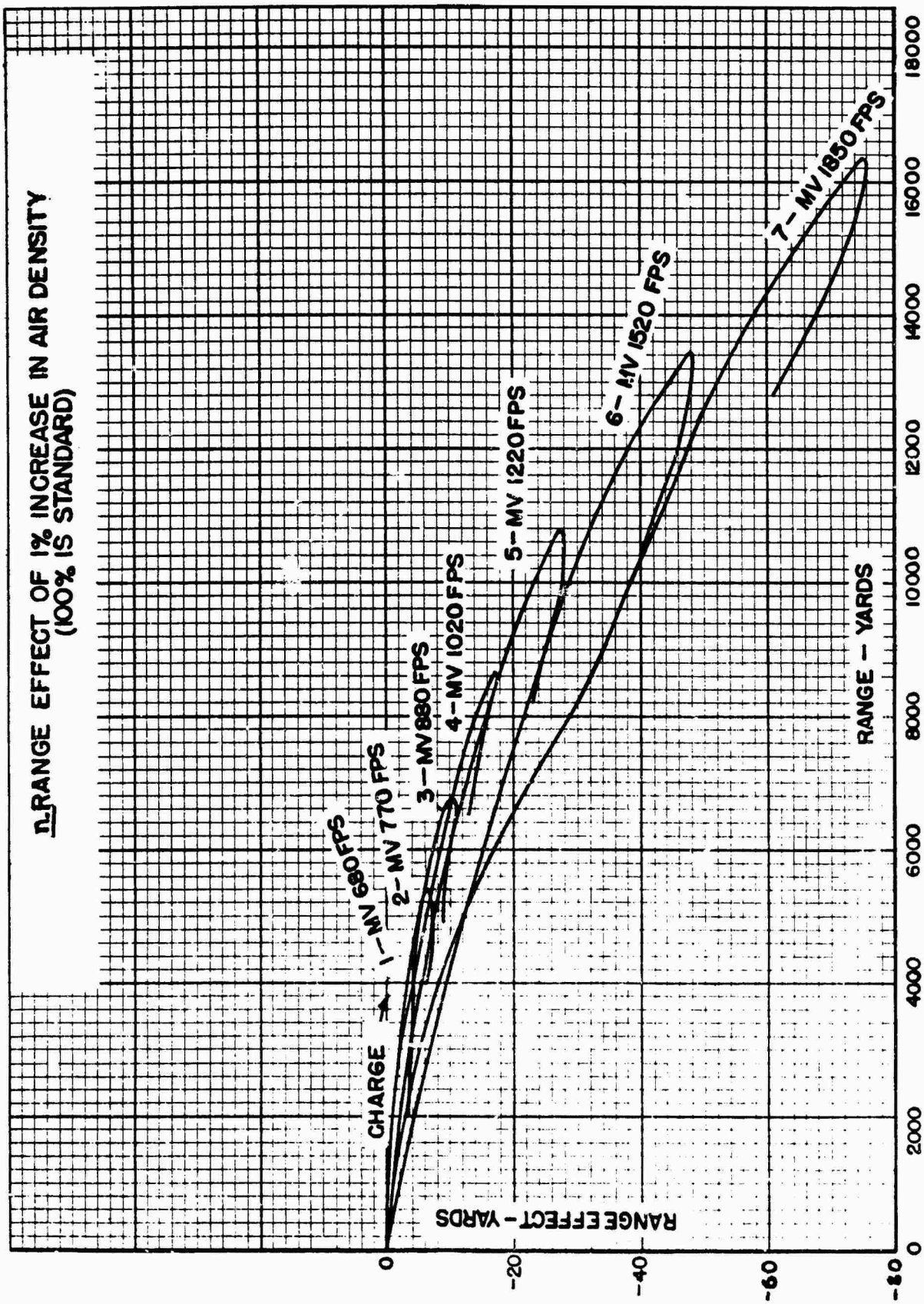

∠COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ± 1 MIL ANGLE OF SITE)
ELEVATION
ANGLE OF SITE
COMPLEMENTARY ANGLE OF SITE
LOW + +
LOW − −
HIGH + −
HIGH − +
CHARGE MV
1 680 FPS
2 770 FPS
3 880 FPS
4 1020 FPS
5 1220 FPS
6 1520 FPS
7 1850 FPS
CHARGE
1
2
3
4
5
6
7
COMPLEMENTARY ANGLE OF SITE
5
4
3
2
1
0
RANGE – YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

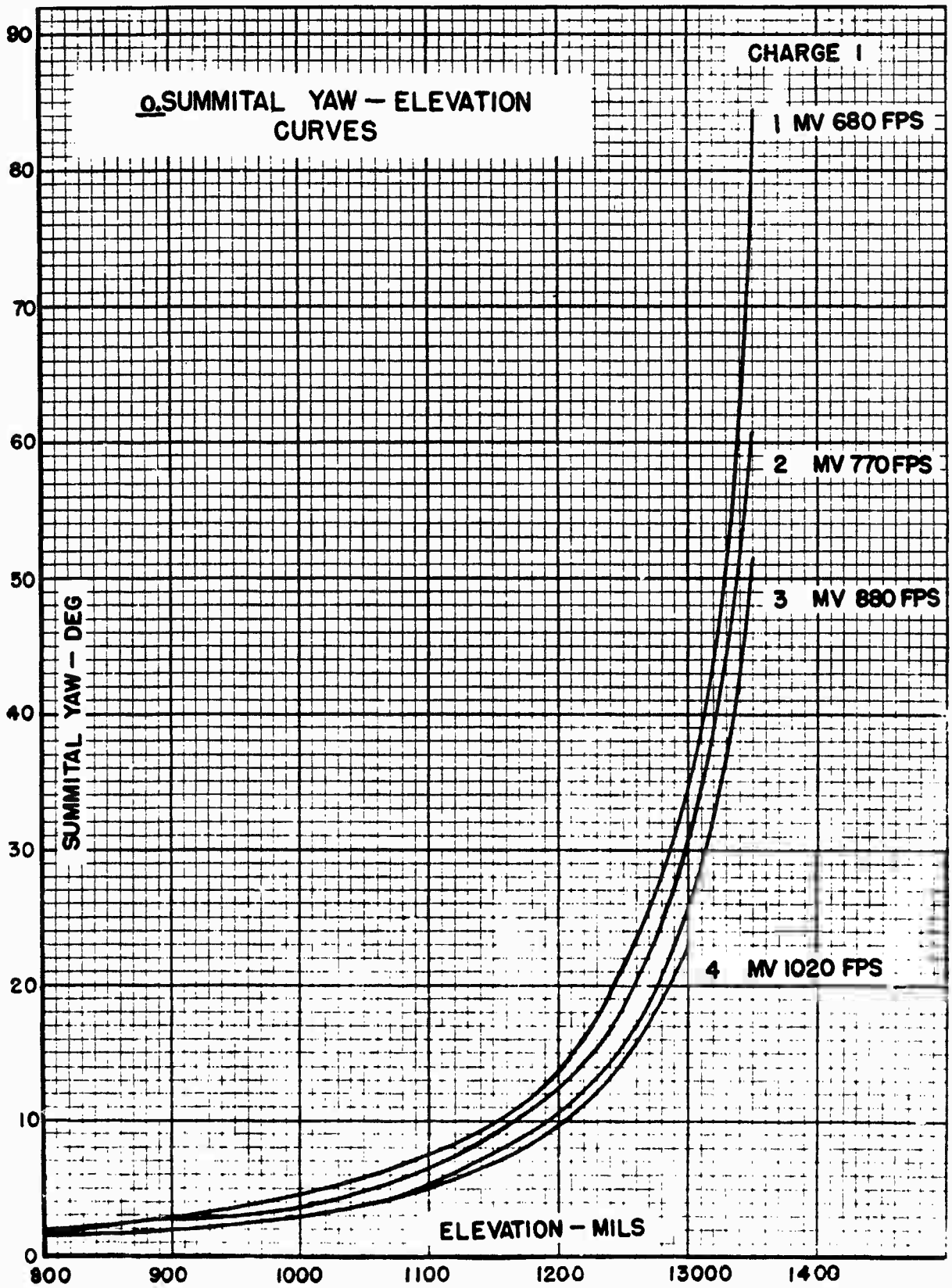

J. RANGE EFFECT OF 1 ZONE INCREASE
IN WEIGHT OF PROJECTILE (▫▫▫▫ IS STANDARD)
CHARGE 7
6
5
CHARGE 5
4
3
2
1
16000
14000
12000
10000
8000
6000
4000
2000
RANGE YARDS
CHARGE M3 (GREEN BAG)
CHARGE n MV
5 -.46 1220 FPS
4 -.46 1020 FPS
3 -.46 880 FPS
2 -.46 770 FPS
1 -.46 680 FPS
CHARGE M4 (WHITE BAG)
CHARGE n MV
7 -.36 1850 FPS
6 -.36 1520 FPS
5 -.37 1220 FPS
RANGE EFFECT — YARDS
-20
0
20
-60
-40
-20
0


k RANGE EFFECT OF 1 FPS INCREASE
IN MUZZLE VELOCITY
CHARGE
1
2
3
4
5
6
7
CHARGE MV
1 680 FPS
2 770 FPS
3 880 FPS
4 1020 FPS
5 1220 FPS
6 1520 FPS
7 1850 FPS
RANGE EFFECT-YARDS
RANGE-YARDS
0
2
4
6
8
10
12
14
2000
4000
6000
8000
10000
12000
14000
16000
18000


1. RANGE EFFECT OF 1°F INCREASE IN AIR TEMPERATURE
(59°F IS STANDARD)
CHARGE MV
4 1020FPS
5 1220FPS
6 1520 FPS
7 1850 FPS
CHARGE 7
CHARGE 6
CHARGE 5
CHARGE 4
RANGE - YARDS
RANGE EFFECT - YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
-2
0
2
4
6


m.RANGE EFFECT OF 1 MPH REAR WIND
CHARGE - MV
1 680FPS
2 770FPS
3 880FPS
4 1020FPS
5 1220FPS
6 1520 FPS
7 1850FPS
RANGE - YARDS
RANGE EFFECT - YARDS
CHARGE 1
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
0
5
10
15
20
25


n RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
CHARGE
1-MV 680 FPS
2-MV 770 FPS
3-MV 880 FPS
4-MV 1020 FPS
5-MV 1220 FPS
6-MV 1520 FPS
7-MV 1850 FPS
RANGE EFFECT - YARDS
0
-20
-40
-60
-80
RANGE - YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
18000


0. SUMMITAL YAW — ELEVATION CURVES
CHARGE 1
1 MV 680 FPS
2 MV 770 FPS
3 MV 880 FPS
4 MV 1020 FPS
SUMMITAL YAW — DEG
ELEVATION — MILS
0
10
20
30
40
50
60
70
80
90
800
900
1000
1100
1200
13000
1400

SECTION V

EFFECT DATA

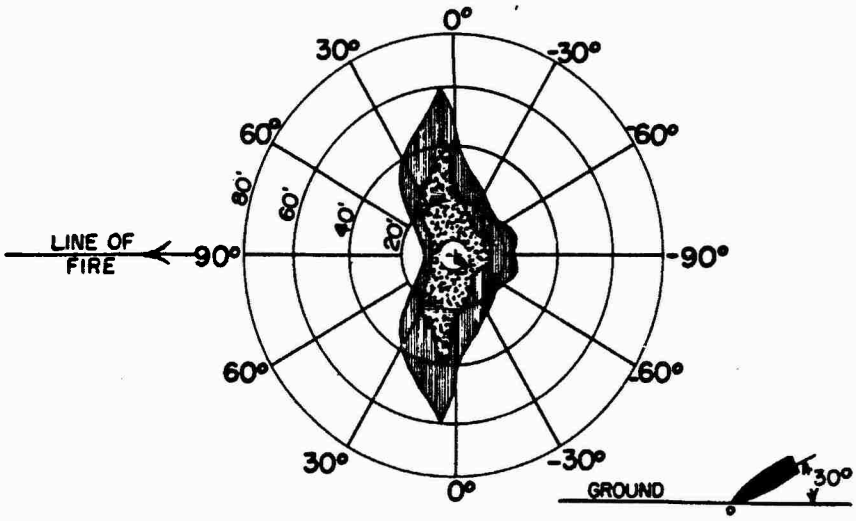
	Paragraph
Fragmentation	9
Penetration	10
Effectiveness	11

9. Fragmentation. The data on fragmentation of the 155-mm H E Shell M107 were taken from TM 9-1907, "Ballistic Data, Performance of Ammunition". The initial fragment velocity is 3500 fps.

a. Casualties.

Distance from burst ft	Total number of effective fragments	Average No. of effective fragments per sq. ft	For the lightest effective fragment Weight oz	Velocity fps
20	1460	.291	.010	2440
30	1400	.124	.014	2060
40	1360	.0676	.019	1770
60	1280	.0283	.030	1410
80	1190	.0148	.043	1180
100	1130	.0090	.055	1040
150	990	.0034	.083	846
200	900	.0018	.109	738
300	767	.0007	.161	598
400	669	.0003	.233	505
600	540	.0001	.402	383

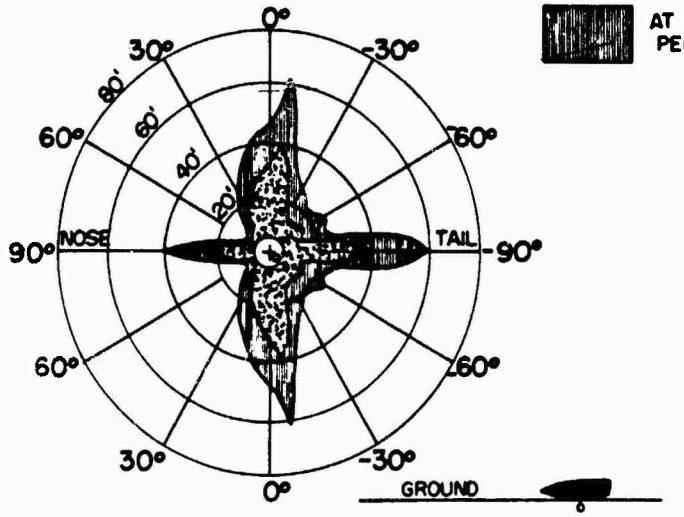
CASUALTIES



INCLINATION 30°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 900 FPS

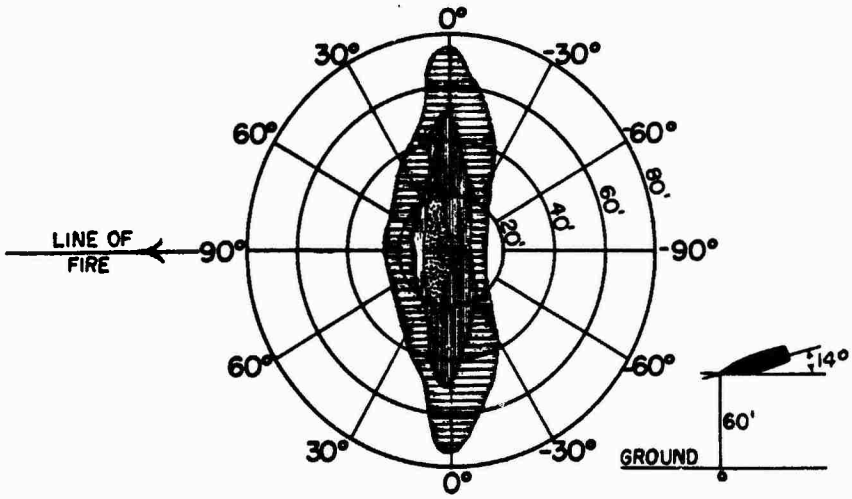
AT LEAST 1 HIT PER 4 SQ FT

AT LEAST 1 HIT PER 10 SQ FT

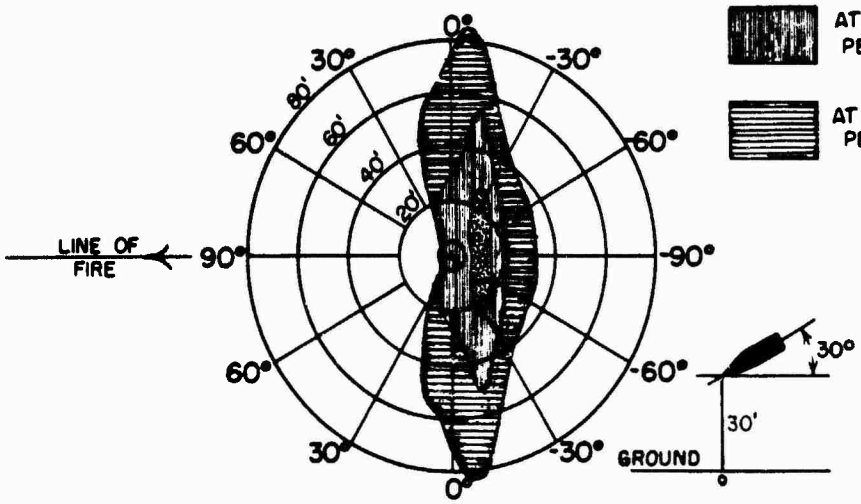


INCLINATION 0°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 0 FPS

CASUALTIES



INCLINATION 14°
HEIGHT OF BURST 60 FT
REMAINING VELOCITY 900 FPS



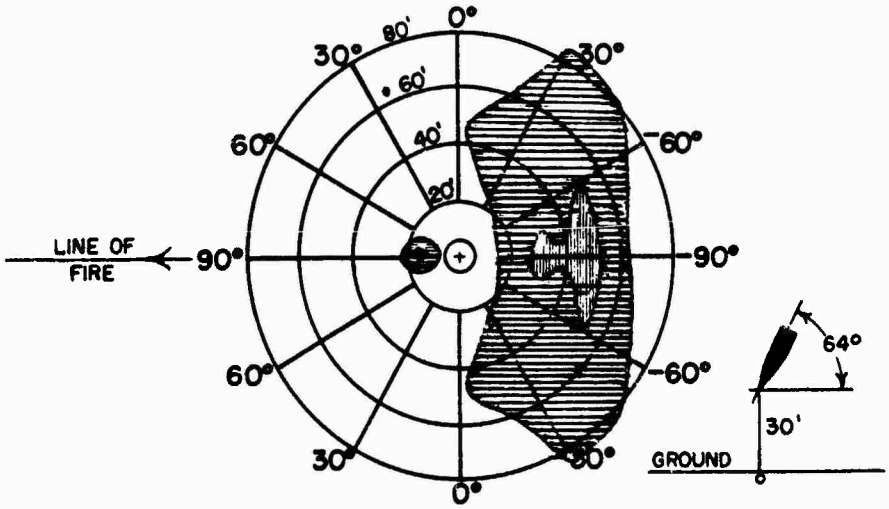
AT LEAST 1 HIT PER 4 SQ FT

AT LEAST 1 HIT PER 10 SQ FT

AT LEAST 1 HIT PER 25 SQ FT

INCLINATION 30°
HEIGHT OF BURST 30 FT
REMAINING VELOCITY 900 FPS

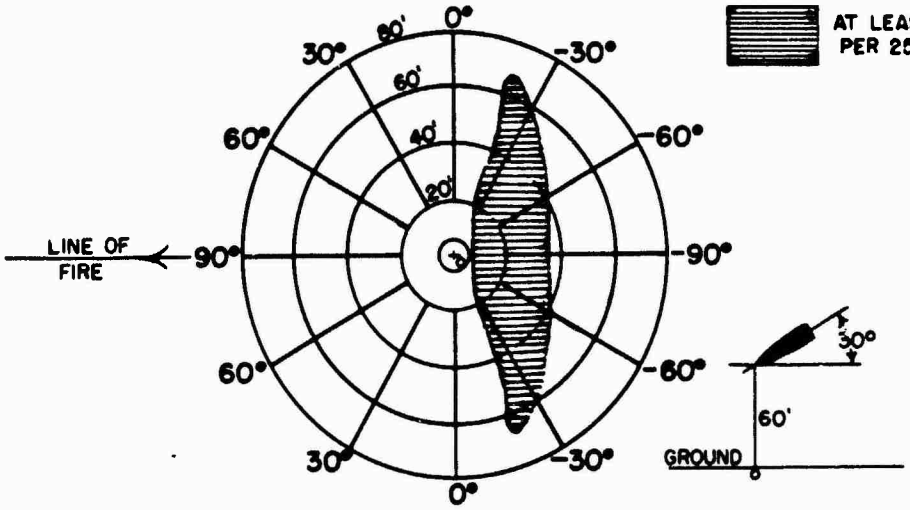
CASUALTIES



INCLINATION 64°
HEIGHT OF BURST 30 FT
REMAINING VELOCITY 950 FPS

AT LEAST 1 HIT PER 10 SQ FT

AT LEAST 1 HIT PER 25 SQ FT

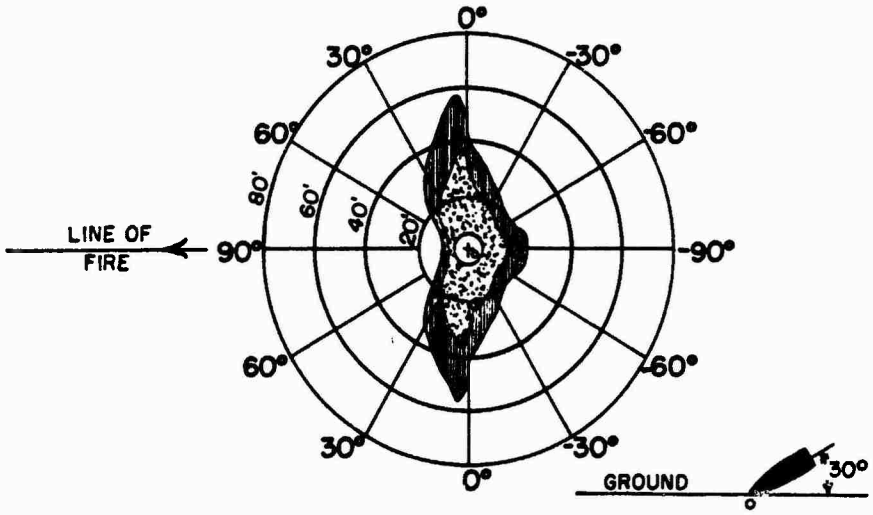


INCLINATION 30°
HEIGHT OF BURST 60 FT
REMAINING VELOCITY 950 FPS

b. **Perforation of 1/8-inch Mild Steel.**

Distance from burst ft	Total number of effective fragments	Average No. of effective fragments per sq. ft	For the lightest effective fragment Weight oz	Velocity fps
20	1240	.247	.035	2700
30	1170	.104	.047	2430
40	1100	.0547	.061	2220
60	945	.0209	.095	1920
80	820	.0102	.137	1750
100	717	.0057	.192	1550
120	648	.0036	.255	1420
140	592	.0024	.326	1320
170	513	.0014	.448	1200
200	440	.0009	.580	1120
300	265	.0002	1.05	955
400	111	.0001	1.61	865

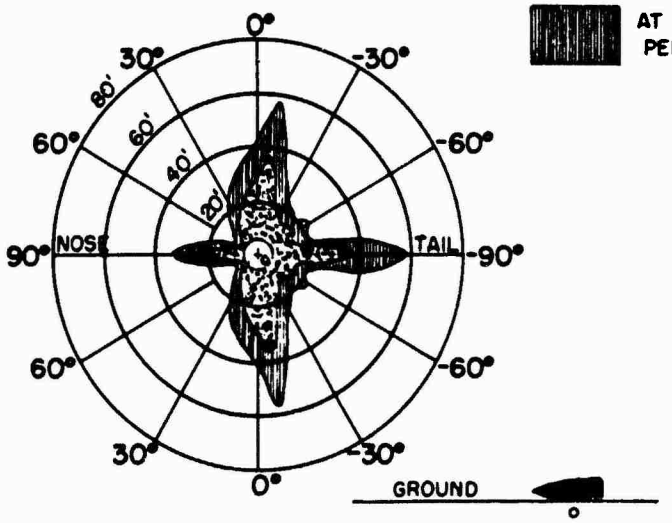
PERFORATION OF 1/8-INCH MILD STEEL



INCLINATION 30°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 900 FPS

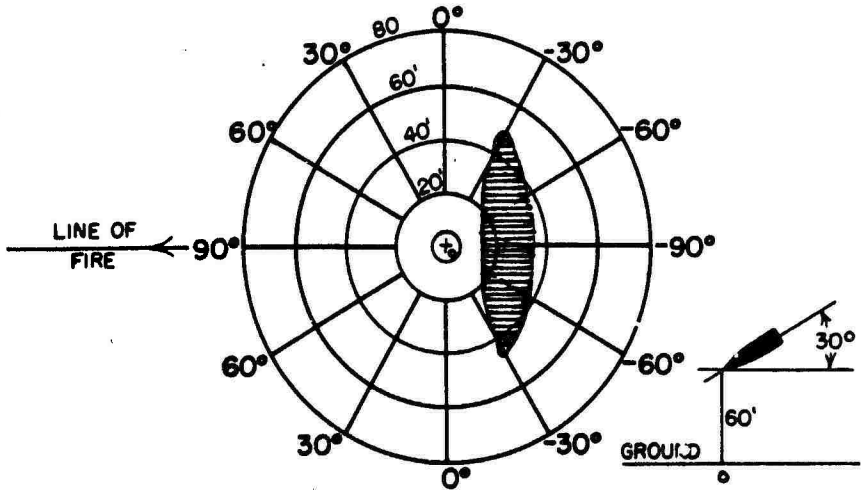
AT LEAST 1 HIT PER 4 SQ FT

AT LEAST 1 HIT PER 10 SQ FT

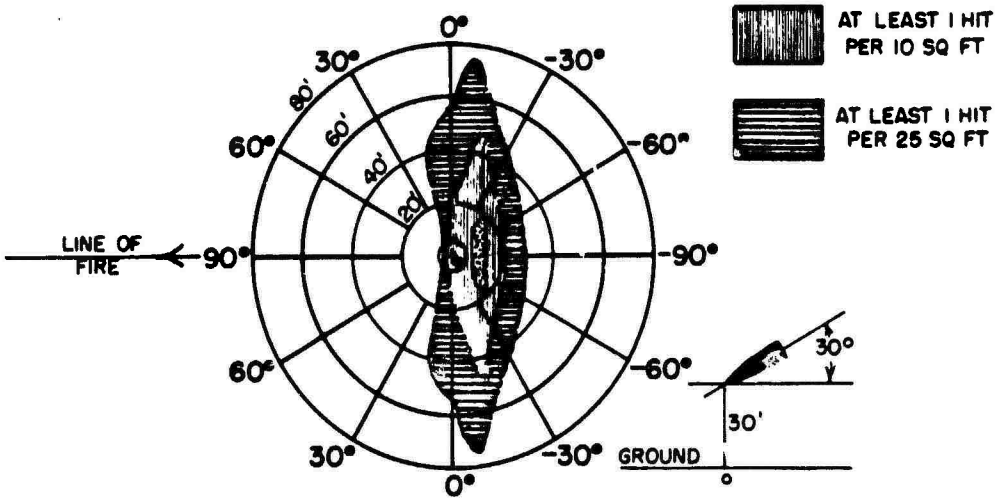


INCLINATION 0°
HEIGHT OF BURST 0 FT
REMAINING VELOCITY 0 FPS

PERFORATION OF 1/8-INCH MILD STEEL

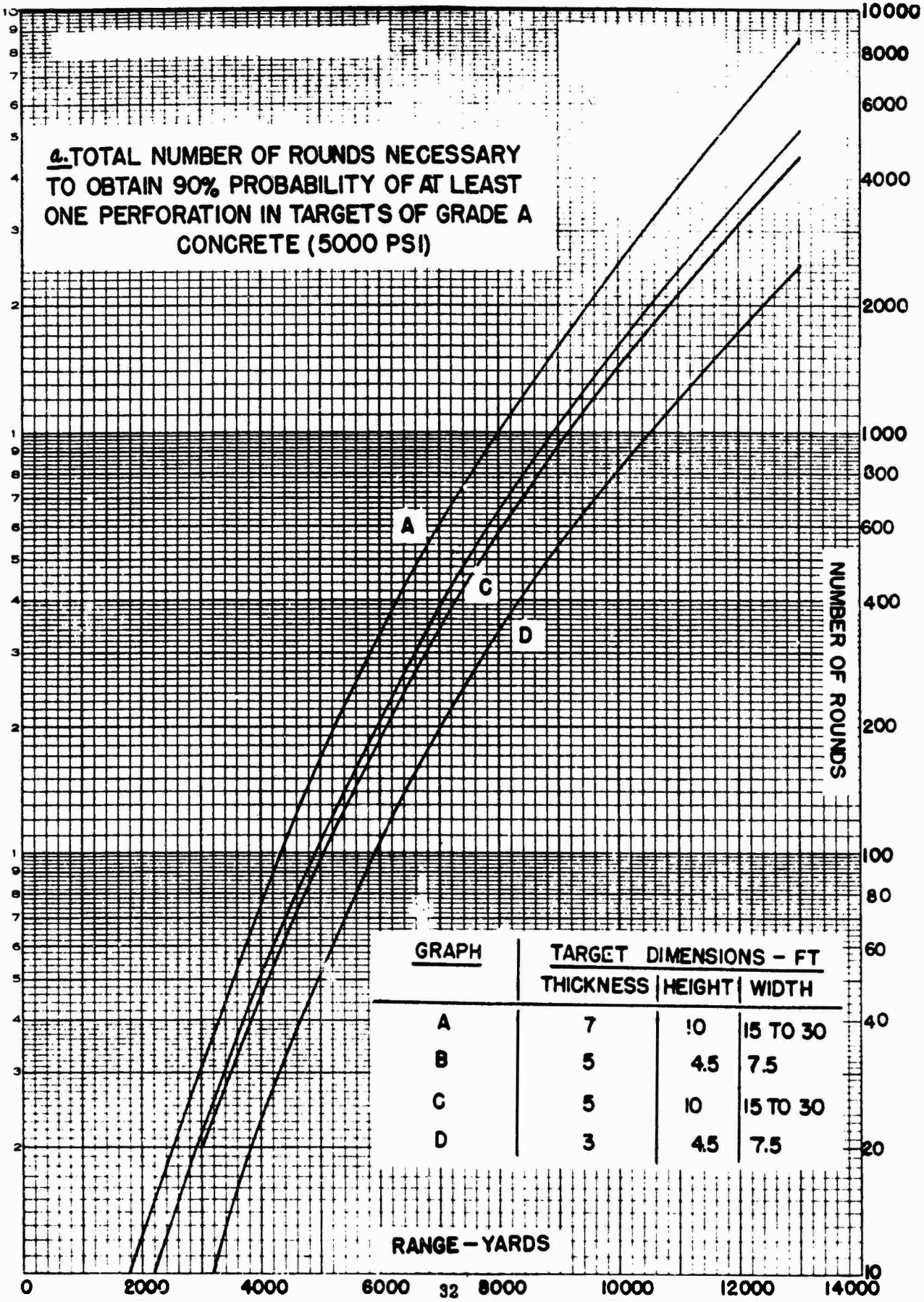


INCLINATION 30°
HEIGHT OF BURST 60 FT
REMAINING VELOCITY 900 FPS

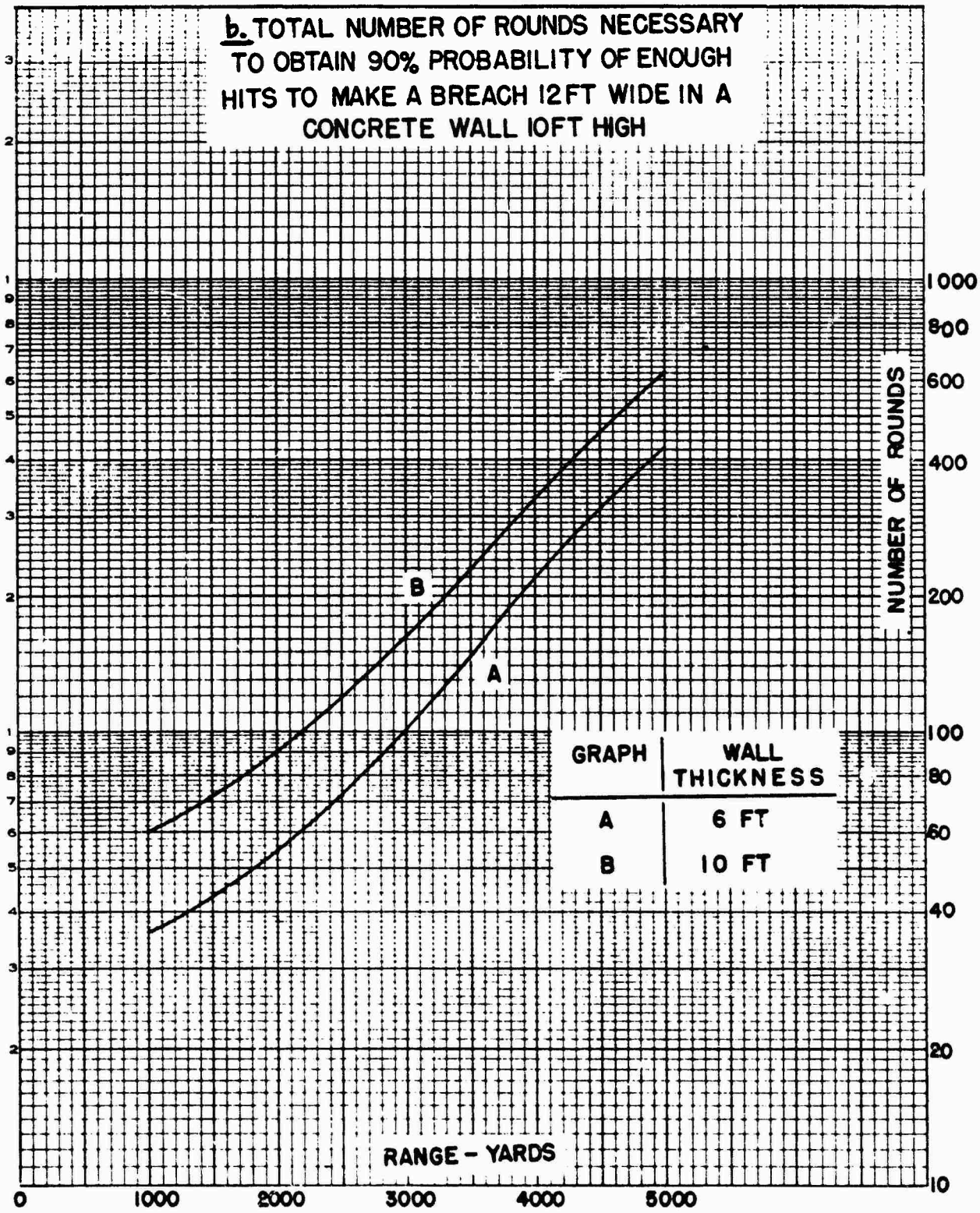


INCLINATION 30°
HEIGHT OF BURST 30 FT
REMAINING VELOCITY 900 FPS

10. Penetration. The data on penetration of concrete by the HE Shell M107 with the CP Fuze M78, fired from the 155-mm Howitzer M1 with a muzzle velocity of 1850 fps, were taken from TM 9-1907, "Ballistic Data, Performance of Ammunition".



GRAPH	TARGET DIMENSIONS – FT		
	THICKNESS	HEIGHT	WIDTH
A	7	10	15 TO 30
B	5	4.5	7.5
C	5	10	15 TO 30
D	3	4.5	7.5


b. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF ENOUGH HITS TO MAKE A BREACH 12 FT WIDE IN A CONCRETE WALL 10 FT HIGH
NUMBER OF ROUNDS
1000
800
600
400
200
100
80
60
40
20
10
RANGE - YARDS
0
1000
2000
3000
4000
5000
A
B
GRAPH
WALL THICKNESS
A
6 FT
B
10 FT

11. Effectiveness. The following data on effectiveness of HE Shell M107 with PD Fuze M51A4 or MT Fuze M67A3, fired from the 155-mm Howitzer M1, were taken from volume III of "Terminal Ballistic Data".

a. NUMBER OF ROUNDS REQUIRED AGAINST ENEMY ARTILLERY FOR 50% EFFECT FOR 10,000 SQ YD IN AREA FIRE

Charge 7: MV 1850 fps

Range yd	Type of Fire		
	Impact	Time	Time and Impact
2,000	70	43	38
5,000	260	67	59
10,000	790	160	150
15,000	1400	300	280

b. NUMBER OF ROUNDS REQUIRED AGAINST ENEMY ARTILLERY FOR 90% PROBABILITY OF AT LEAST ONE EFFECTIVE HIT IN AIMED FIRE

Charge No.	MV fps	Range yd	Type of Fire		
			Impact	Time	Time and Impact
5	1220	2,000	7	240	14
		5,000	69	320	96
7	1850	2,000	3	340	7
		5,000	23	320	41
		10,000	250	590	270
		15,000	2300	1900	1400

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 155 - 1 - 112

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
21 February 1949

BALLISTIC AND ENGINEERING DATA

for

Projectile, AP, 155-mm, M112

with

Fuze, BD, M60

Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5
IV	Exterior ballistic data	6 - 7
V	Effect data	8

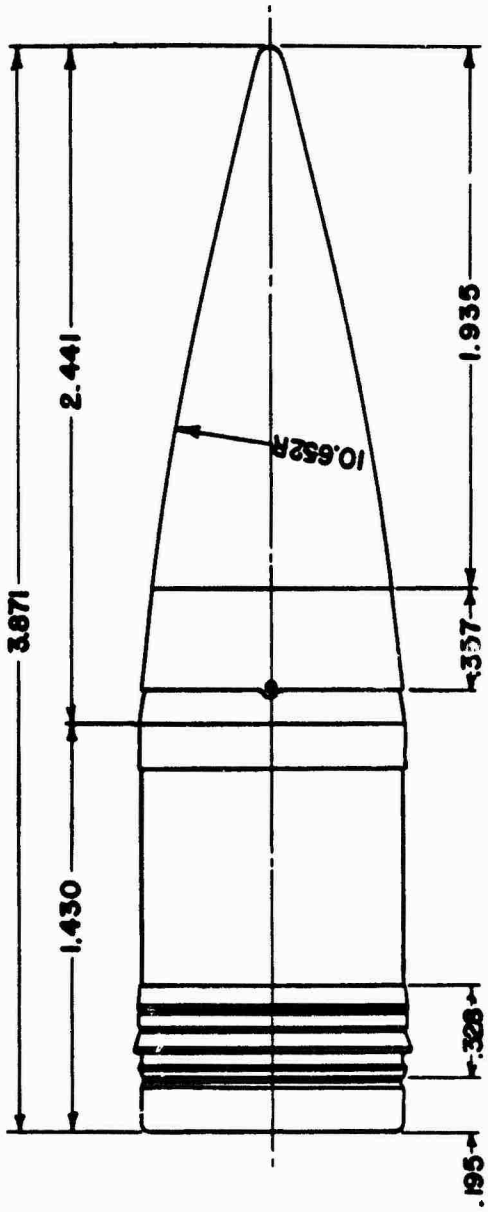
SECTION I

GENERAL

	Paragraph
Purpose	1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 155-mm Armor-piercing Projectile M112 with the Base Detonating Fuze M60. This information is collected from the drawings, reports, firing tables, and technical manual pertaining to this ammunition. It also pertains to the Armor-piercing Projectile M112B2.

ALL DIMENSIONS IN CALIBERS
1 CAL = 6.102"



PROJECTILE, AP, 155-MM, M112
FUZE, BD, M60

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Projectile: Metal parts assembly and details	75-4-101
Fuze: Assembly	73-2-74

3. Dimensions.

Band: Distance from base	0.195 cal
Width	0.328 cal
Cylindrical body: Length	1.430 cal
Ogive: Length	2.441 cal
Radius of arc	10.652 cal
Projectile: Length	3.871 cal

4. Physical characteristics.

Weight (standard)	100 lb

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Theoretical yaw in bore	5

5. Theoretical yaw in bore.

Minimum	3.9 min
Maximum	5.9 min

SECTION IV

EXTERIOR BALLISTIC DATA

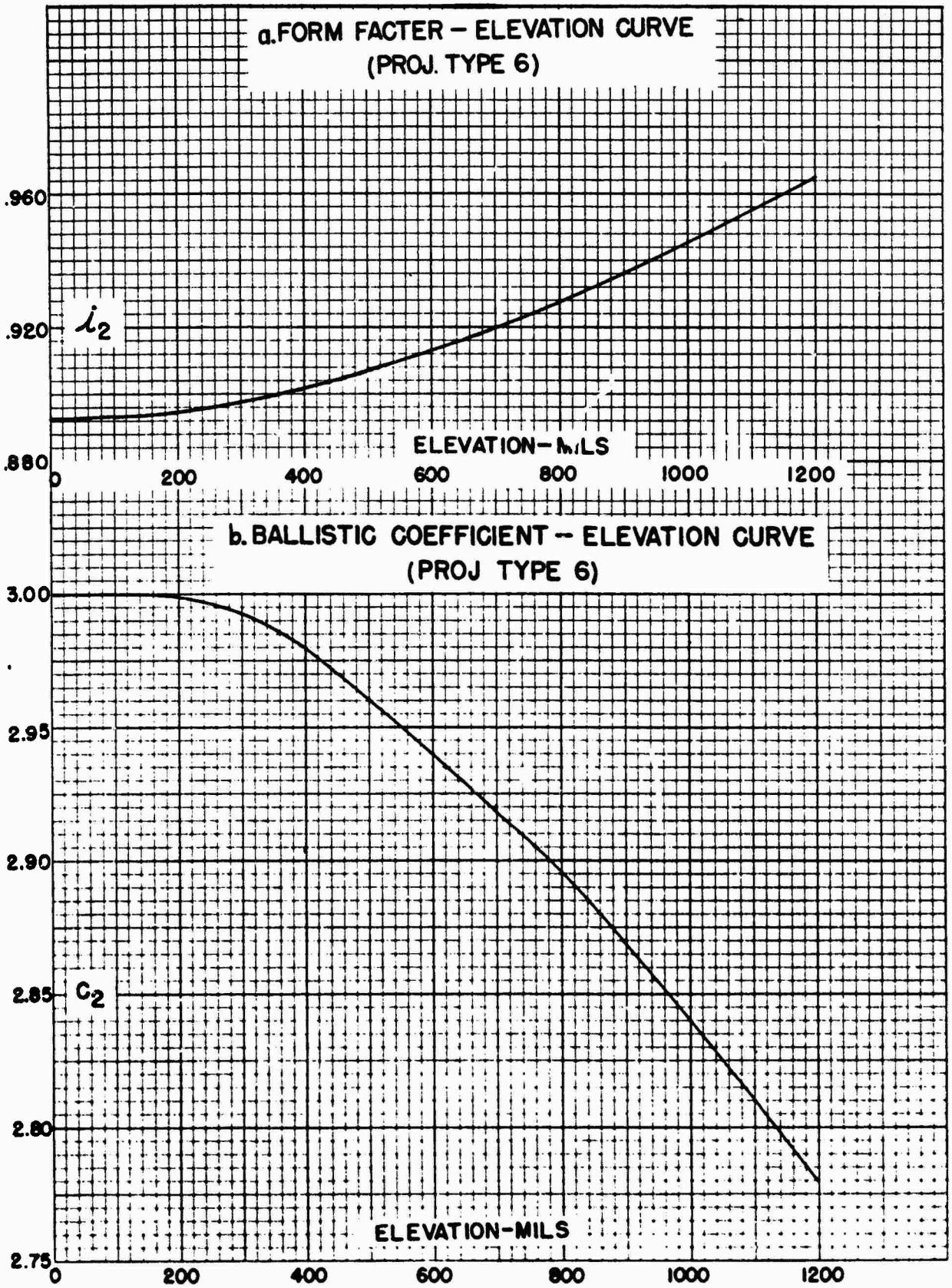
	Paragraph
Aerodynamic data	6
Firing table data	7

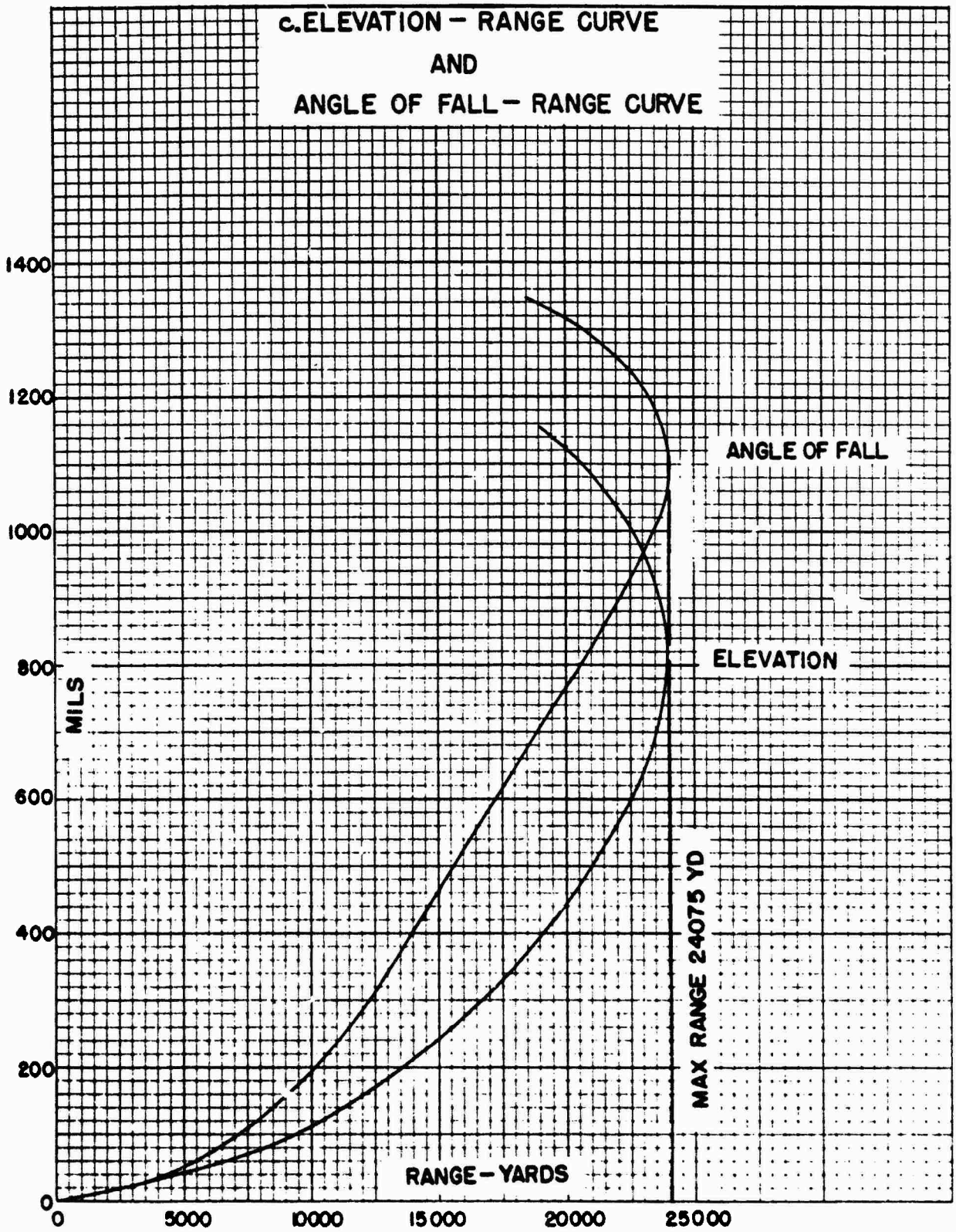
6. Aerodynamic data.

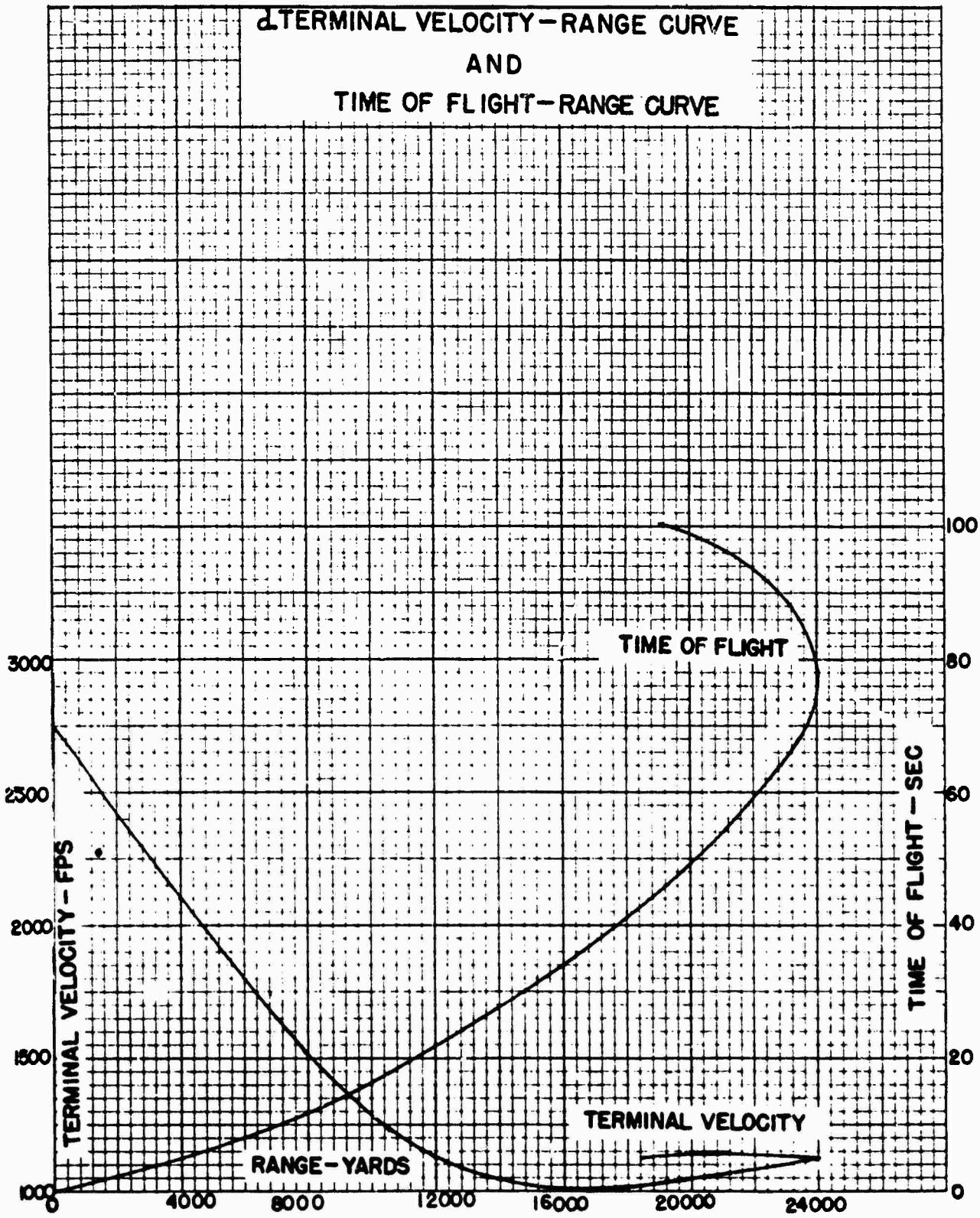
Muzzle Velocity fps	Firings	Ballistic Coefficient C	Form Factor i	Drag Function	Drag Coef. K_D
2341	Resistance	2.95	.91	G_6	.122
2745	Range	3.00	.895	G_6	.104

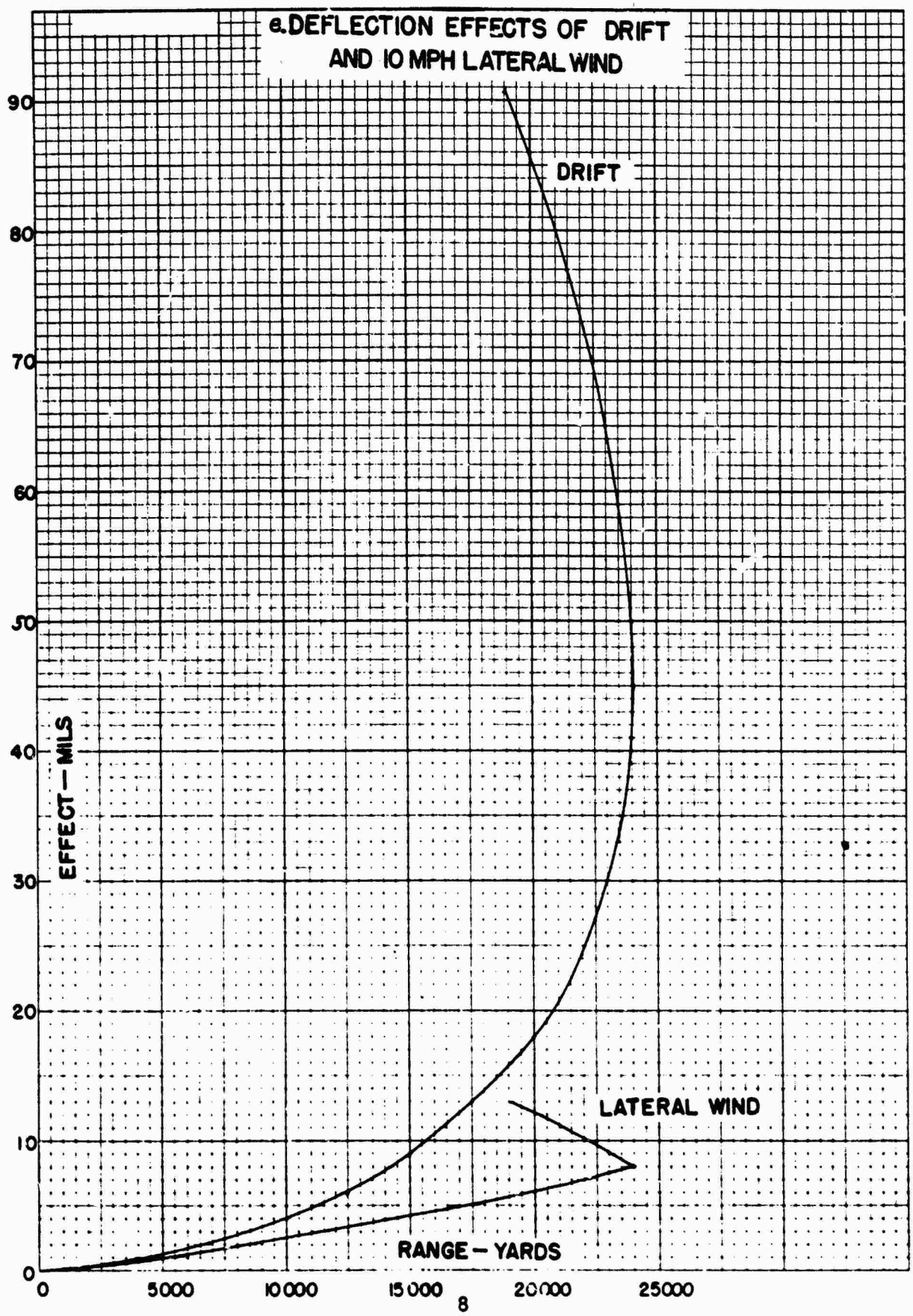
7. Firing table data. FT 155-Z-1.

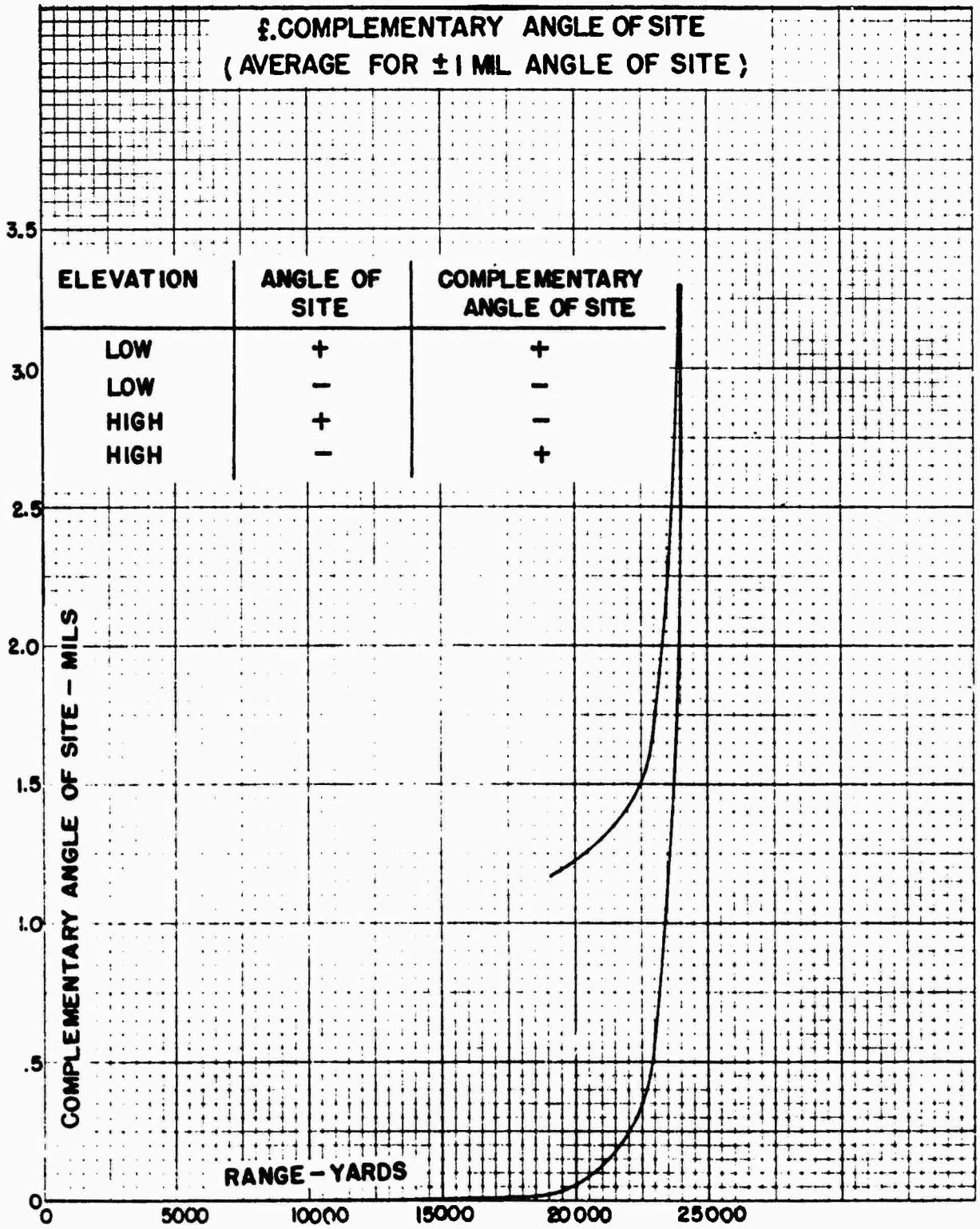
Guns, 155-mm, M1, M1A1, M1C, M2, M3 and M4.
Twist of rifling: 1/25.
Muzzle velocity: 2745 fps.
OCM item 17379 standardized the AP Projectile M112 for use in the 155-mm Guns M1917A1 and M1918MI, which are now obsolete. OCM item 18593 authorized the use of this projectile in the M1 Gun with the supercharge.

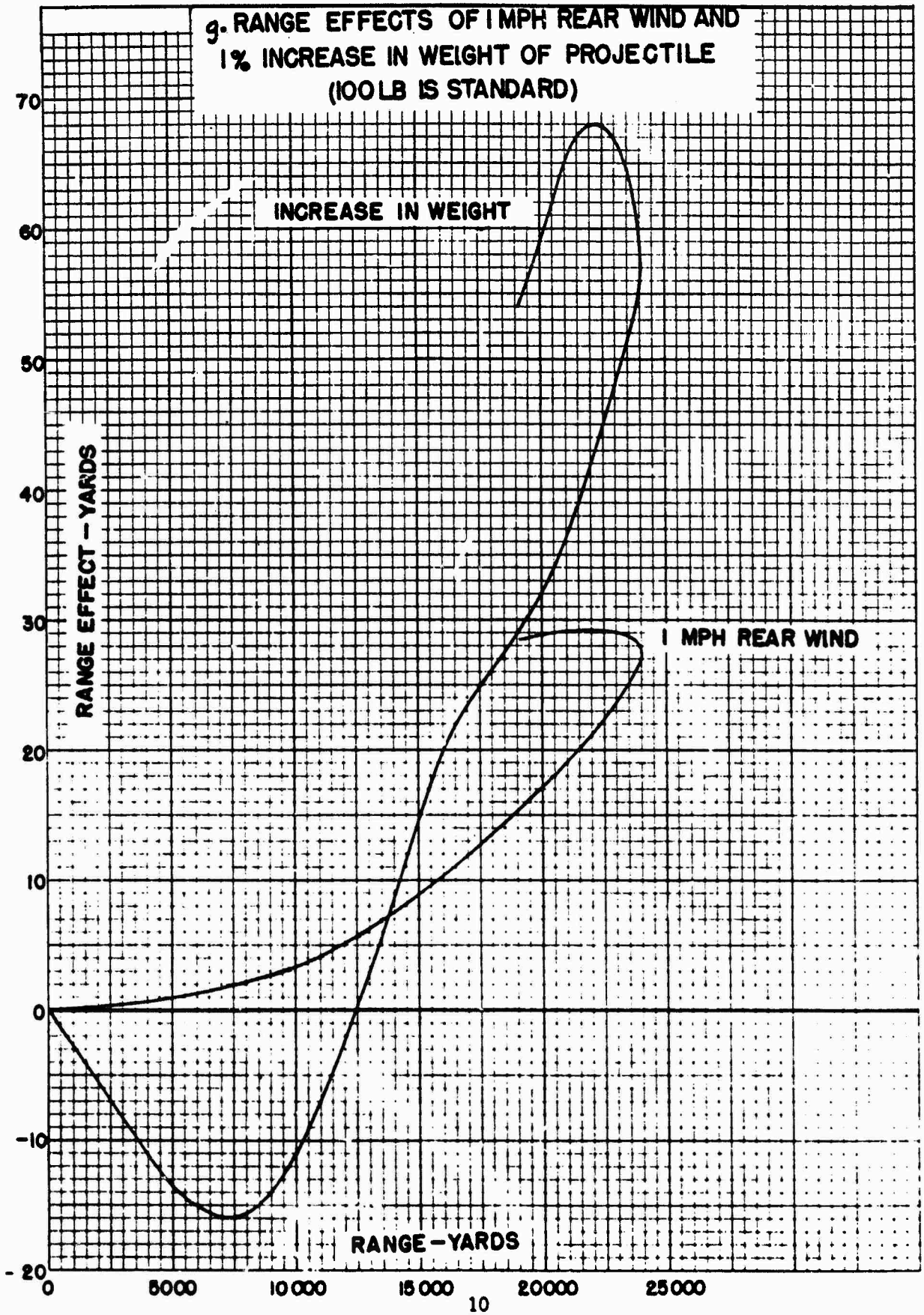

a. FORM FACTER – ELEVATION CURVE
(PROJ. TYPE 6)
.960
.920
.880
i_2
ELEVATION–MILS
0
200
400
600
800
1000
1200
b. BALLISTIC COEFFICIENT – ELEVATION CURVE
(PROJ TYPE 6)
3.00
2.95
2.90
2.85
2.80
2.75
C_2
ELEVATION-MILS
0
200
400
600
800
1000
1200

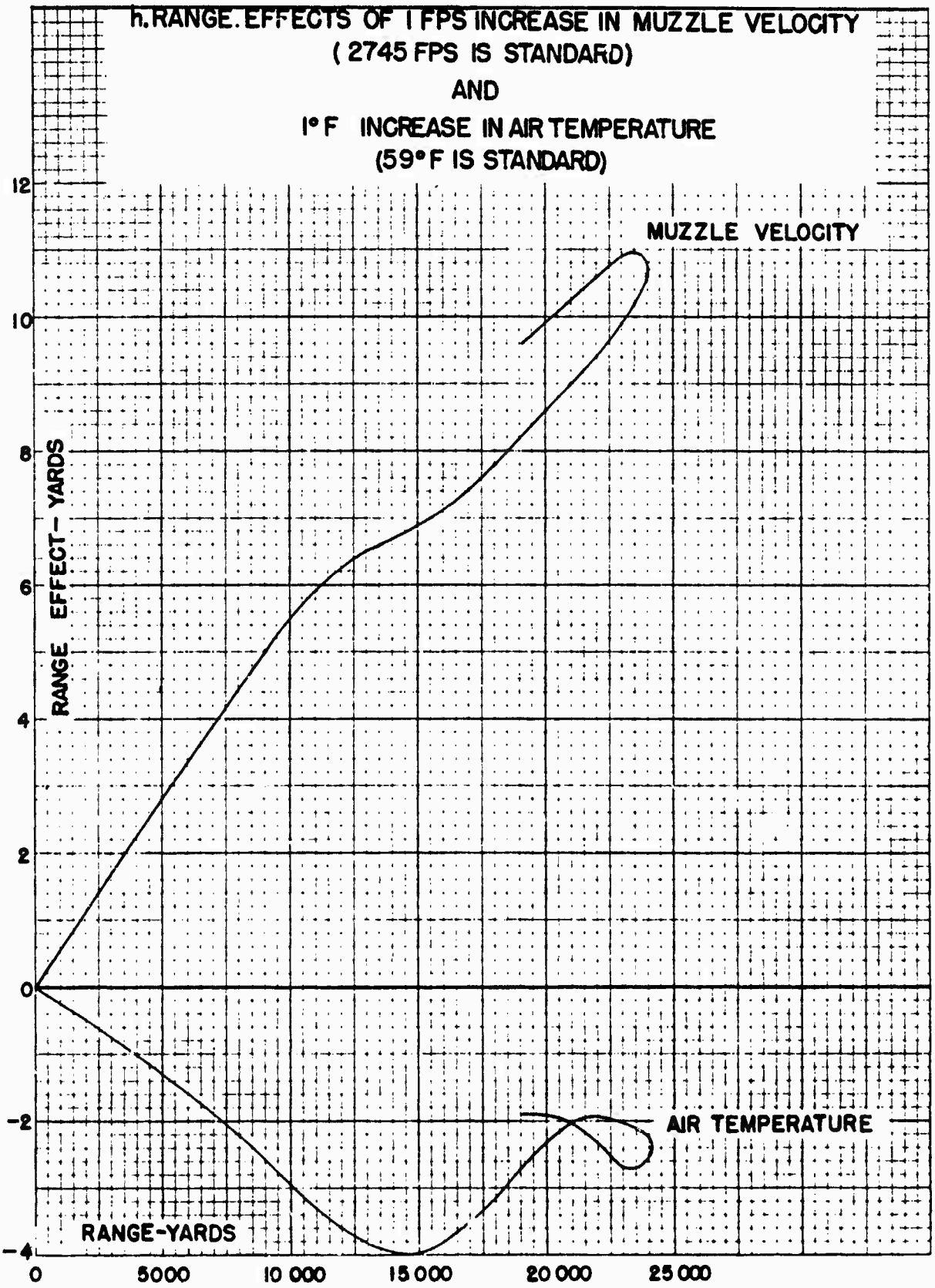

c. ELEVATION – RANGE CURVE
AND
ANGLE OF FALL – RANGE CURVE
ANGLE OF FALL
ELEVATION
MILS
MAX RANGE 24075 YD
RANGE – YARDS
0
200
400
600
800
1000
1200
1400
0
5000
10000
15000
20000
25000

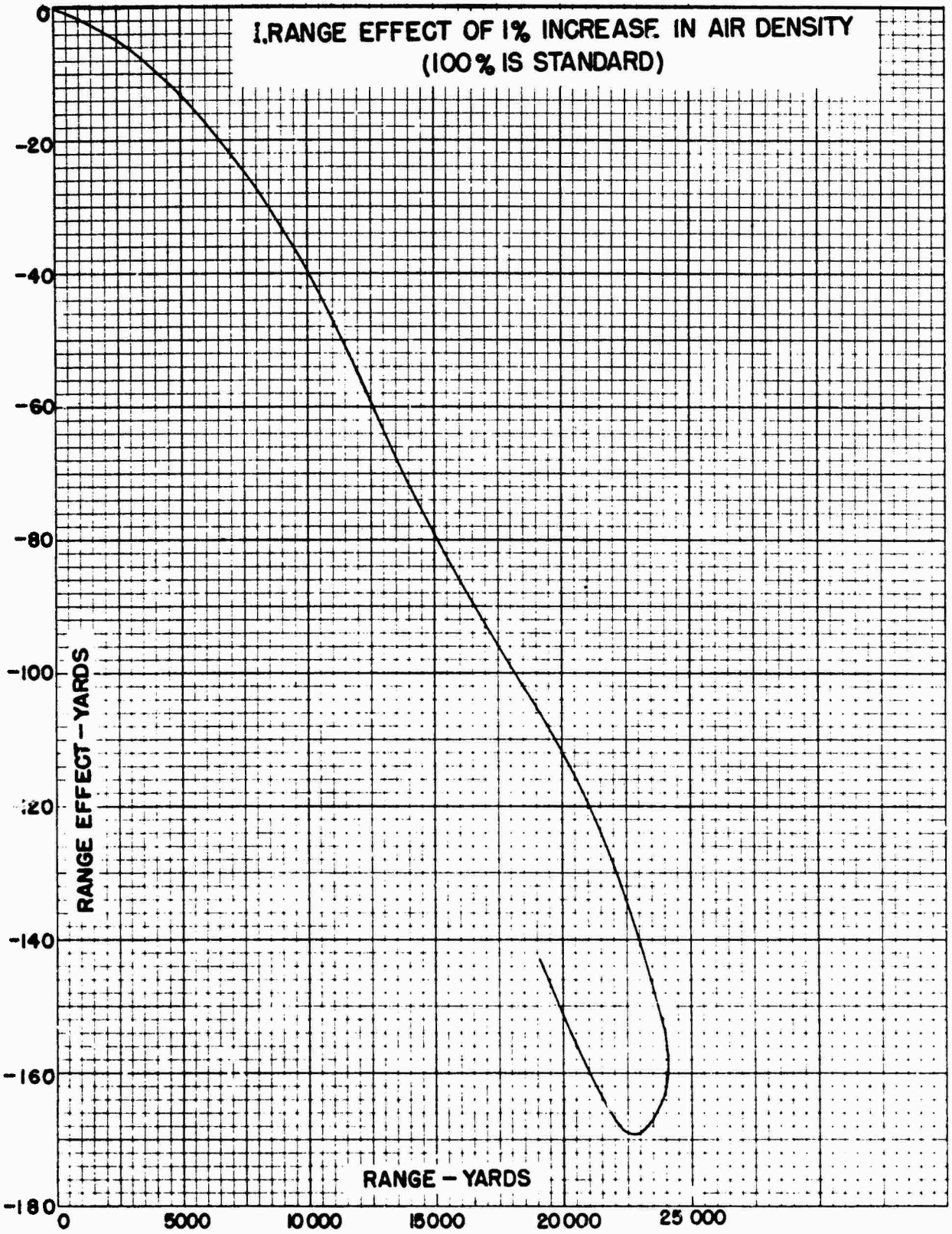

TERMINAL VELOCITY—RANGE CURVE
AND
TIME OF FLIGHT—RANGE CURVE
TIME OF FLIGHT
TERMINAL VELOCITY
RANGE—YARDS
TERMINAL VELOCITY—FPS
TIME OF FLIGHT—SEC
3000
2500
2000
1500
1000
100
80
60
40
20
0
0
4000
8000
12000
16000
20000
24000


a. DEFLECTION EFFECTS OF DRIFT AND 10 MPH LATERAL WIND
DRIFT
LATERAL WIND
EFFECT — MILS
RANGE — YARDS
0
10
20
30
40
50
60
70
80
90
0
5000
10000
15000
20000
25000


ε.COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ±1 MIL ANGLE OF SITE)
ELEVATION
ANGLE OF SITE
COMPLEMENTARY ANGLE OF SITE
LOW + +
LOW − −
HIGH + −
HIGH − +
COMPLEMENTARY ANGLE OF SITE – MILS
RANGE – YARDS
0
.5
1.0
1.5
2.0
2.5
3.0
3.5
0
5000
10000
15000
20000
25000


9. RANGE EFFECTS OF 1 MPH REAR WIND AND 1% INCREASE IN WEIGHT OF PROJECTILE (100 LB IS STANDARD)
INCREASE IN WEIGHT
1 MPH REAR WIND
RANGE EFFECT – YARDS
RANGE – YARDS
70
60
50
40
30
20
10
0
-10
-20
0
5000
10000
15000
20000
25000

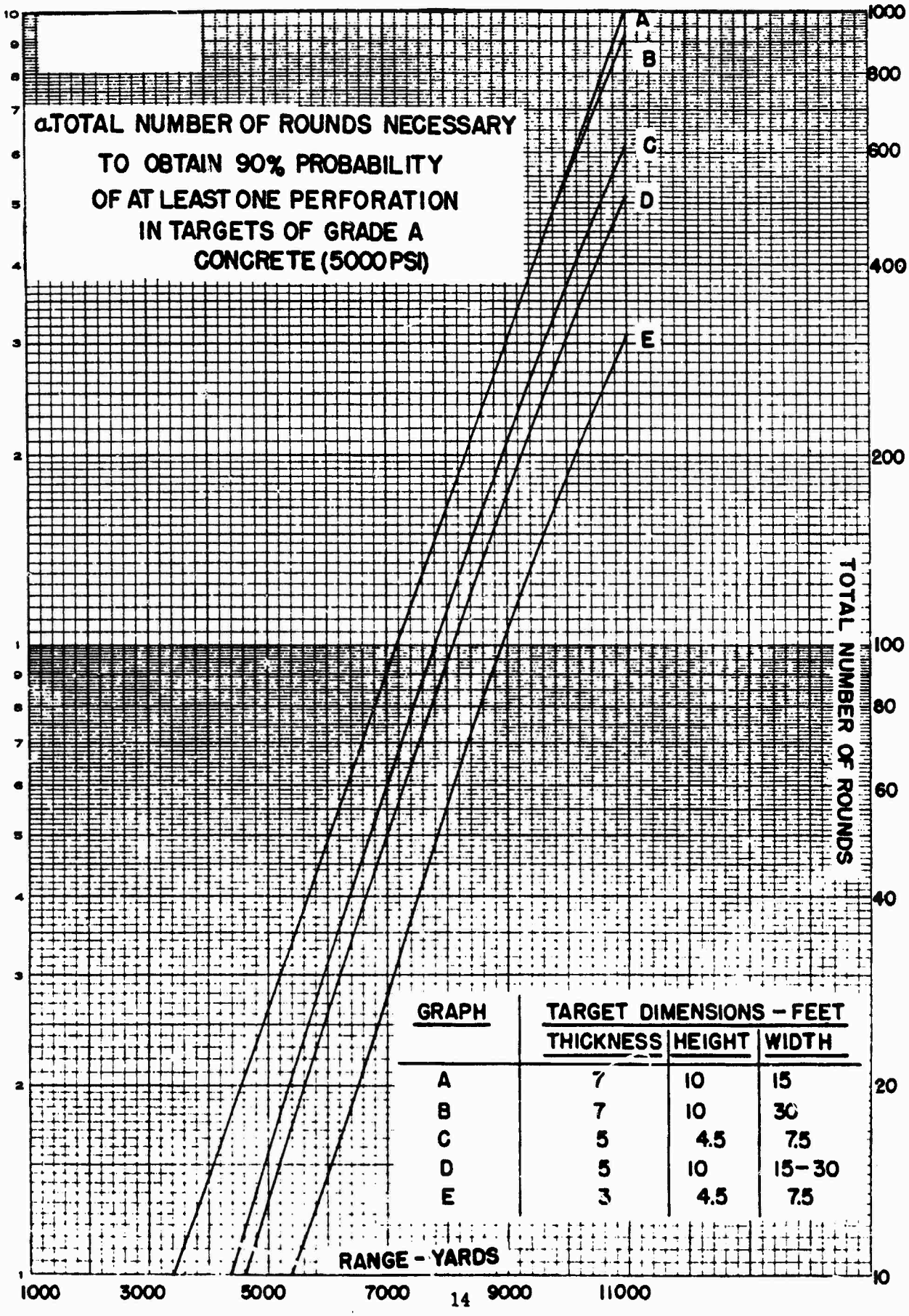

h. RANGE. EFFECTS OF 1 FPS INCREASE IN MUZZLE VELOCITY
(2745 FPS IS STANDARD)
AND
1° F INCREASE IN AIR TEMPERATURE
(59° F IS STANDARD)
MUZZLE VELOCITY
AIR TEMPERATURE
RANGE EFFECT - YARDS
RANGE-YARDS
12
10
8
6
4
2
0
-2
-4
0
5000
10 000
15 000
20 000
25 000


I. RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
RANGE EFFECT – YARDS
RANGE – YARDS
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
5000
10000
15000
20000
25 000

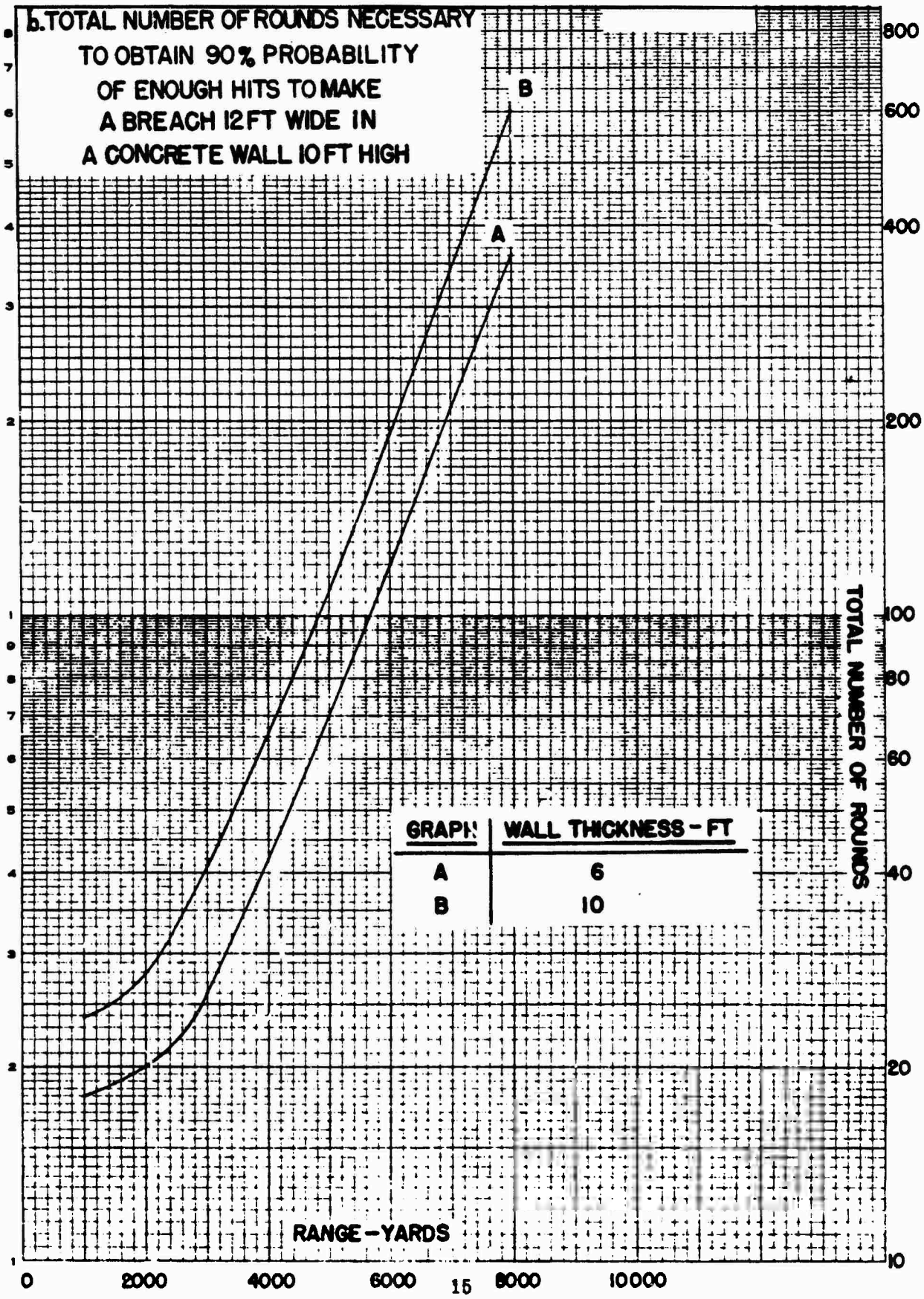
SECTION V
EFFECT DATA

	Paragraph
Penetration	8

8. Penetration. The data on penetration of concrete by the AP Projectile M112, fired from the 155-mm Guns M1, M1A1, M1C, M2, M3 and M4 at a muzzle velocity of 2,745 fps, were taken from TM9-1907, "Ballistic Data, Performance of Ammunition."



GRAPH	TARGET DIMENSIONS – FEET		
	THICKNESS	HEIGHT	WIDTH
A	7	10	15
B	7	10	30
C	5	4.5	7.5
D	5	10	15–30
E	3	4.5	7.5


b. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF ENOUGH HITS TO MAKE A BREACH 12 FT WIDE IN A CONCRETE WALL 10 FT HIGH
A
B
GRAPH
WALL THICKNESS - FT
A 6
B 10
TOTAL NUMBER OF ROUNDS
800
600
400
200
100
80
60
40
20
10
RANGE - YARDS
0
2000
4000
6000
8000
10000

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 155 - 1 - 116

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
21 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, Smoke, M116 (BE)
with
Fuze, TSQ, M54

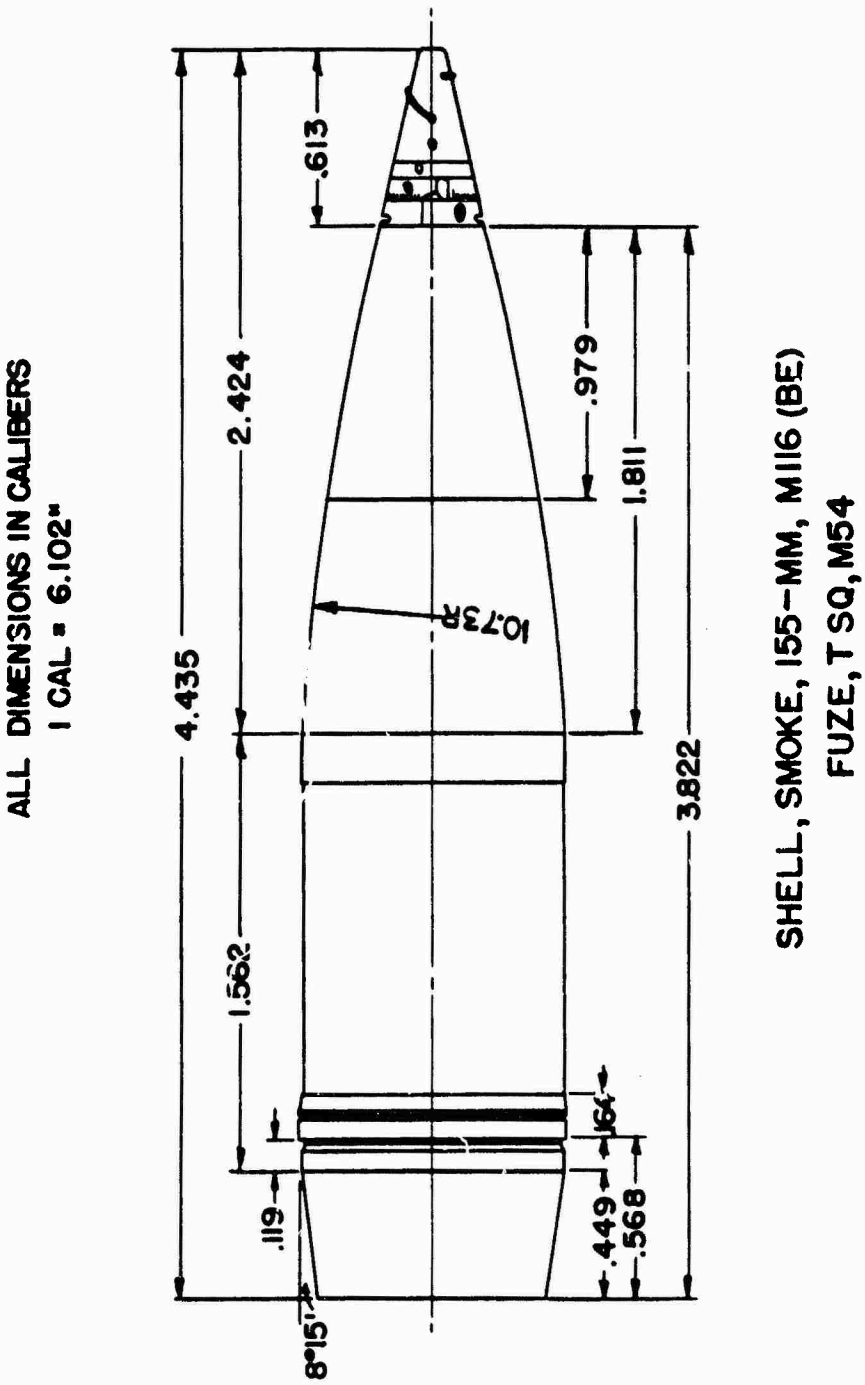
Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5
IV	Exterior ballistic data	6 - 7
V	Effect data	8 - 9

SECTION I
GENERAL

Paragraph

Purpose - 1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 155-mm Smoke Shell M116 (Base Ejection) with the Time and Superquick Fuze M54. This information is collected from the drawings, reports, and firing tables pertaining to this ammunition.



SHELL, SMOKE, 155-MM, M116 (BE)
FUZE, T SQ, M54

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell: Metal parts assembly and details	75-4-110
Loading assembly, marking diagram and details	75-14-381
Fuze: Assembly	73-3-154
Booster, M21A4: Assembly	73-2-154

3. Dimensions.

Boat-tail: Angle	8°15'
Length	0.449 cal
Band: Distance from boat-tail	0.119 cal
Distance from base	0.568 cal
Width	0.164 cal
Cylindrical body: Length	1.562 cal
Ogive: Length	1.811 cal
Radius of arc	10.73 cal
Shell: Body	2.843 cal
Adapter	0.979 cal
Total	3.822 cal
Fuze: Outside length	0.613 cal
Shell and fuze	4.435 cal
Ogive and fuze	2.424 cal

4. Physical characteristics.

Loading	Standard Weight - lb
HC Mixture	85.10
Colored Smoke mixture	86.45

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Theoretical yaw in bore -	5

5. Theoretical yaw in bore.

Minimum	7.6 min
Maximum	12.1 min

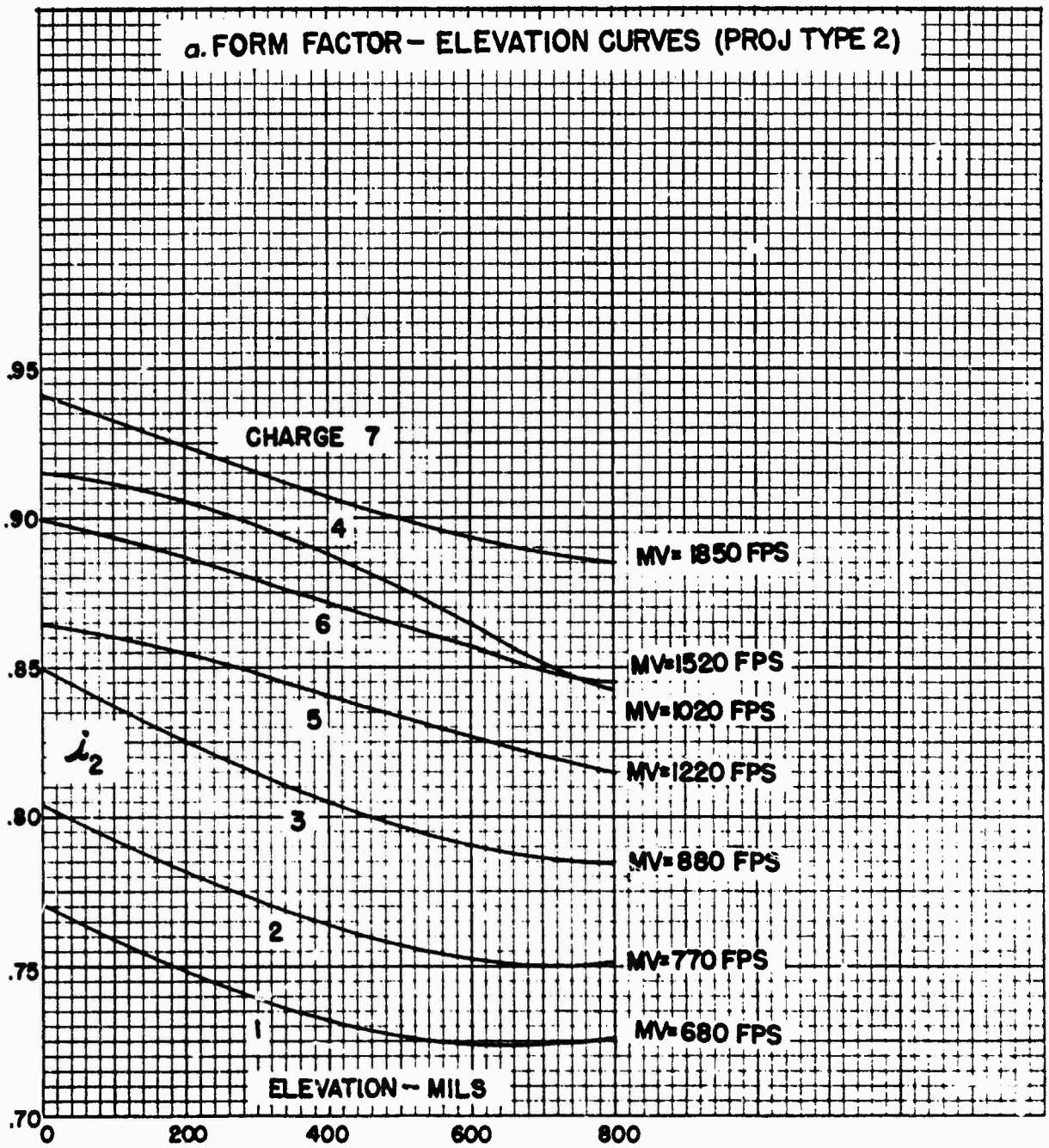
SECTION IV

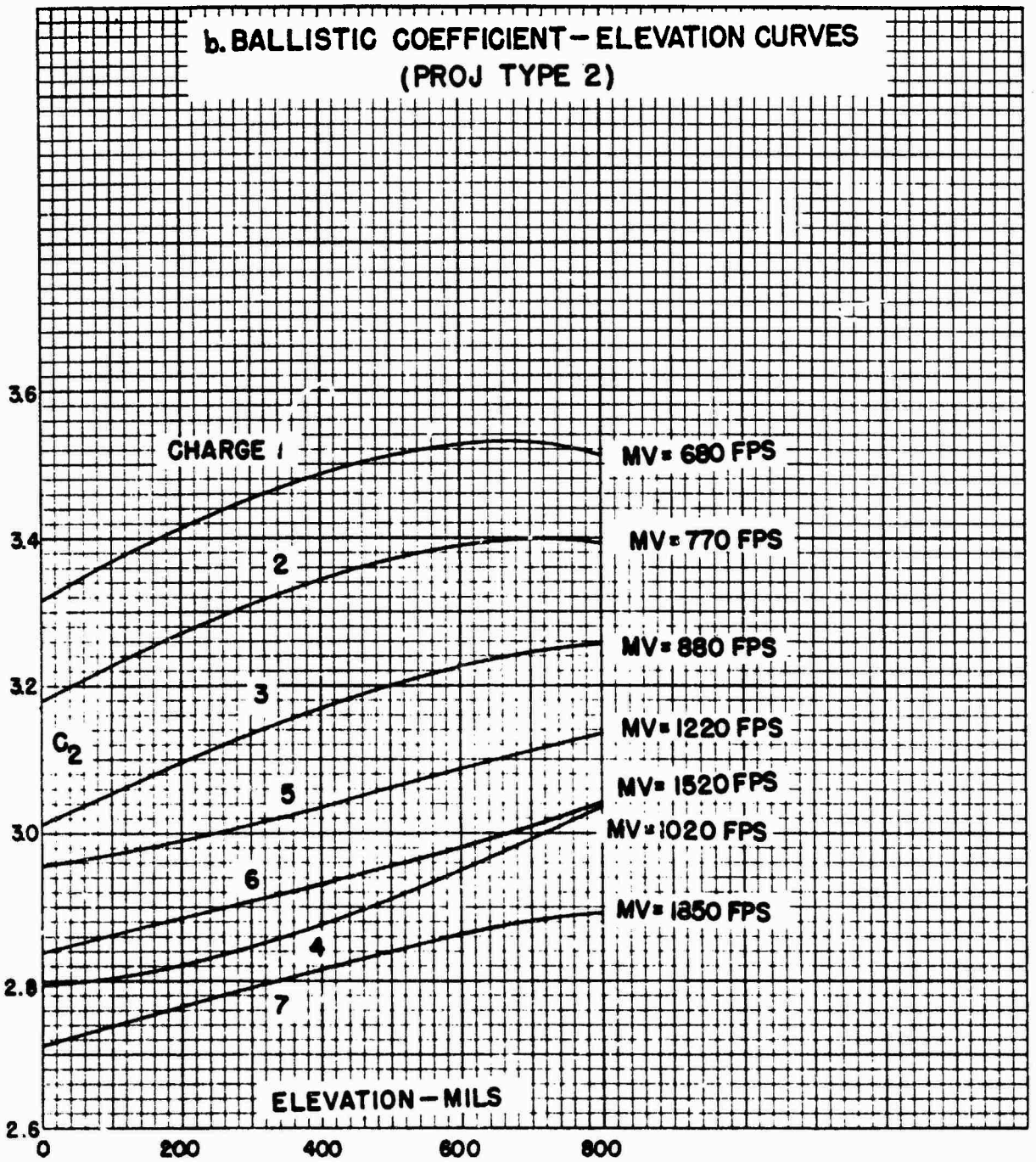
EXTERIOR BALLISTIC DATA

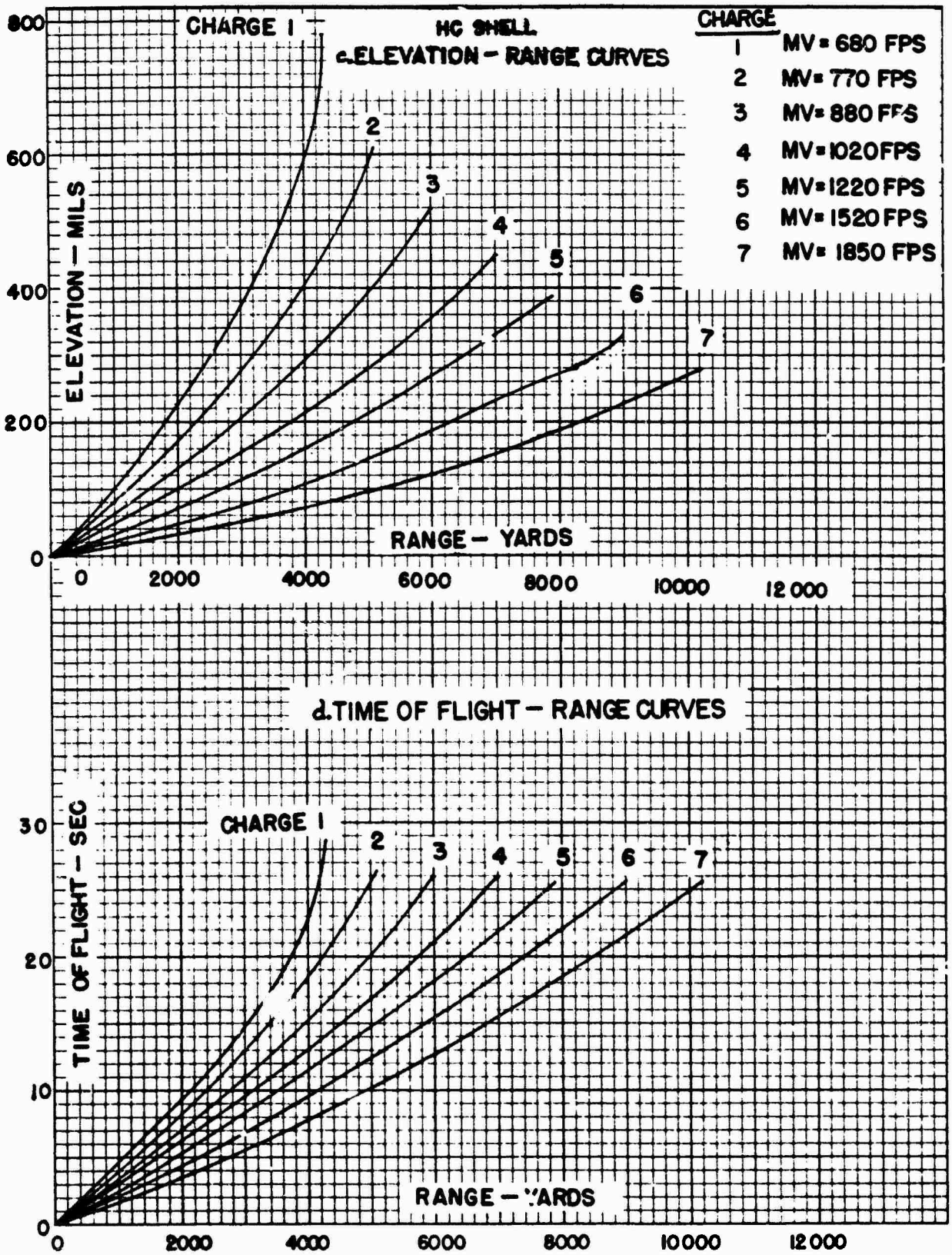
	Paragraph
Firing table data: HC Shell -	6
Firing table data: Colored Smoke Shell -	7

6. Firing table data: HC Shell. FT 155-Q-2

Howitzer, 155-mm, M1. Twist of rifling: 1/25. Proj Wt: 95.10 lb. Standardization of the Smoke Shell M116 filled with HC mixture was recommended by OCM item 18992 and approved by item 19205.

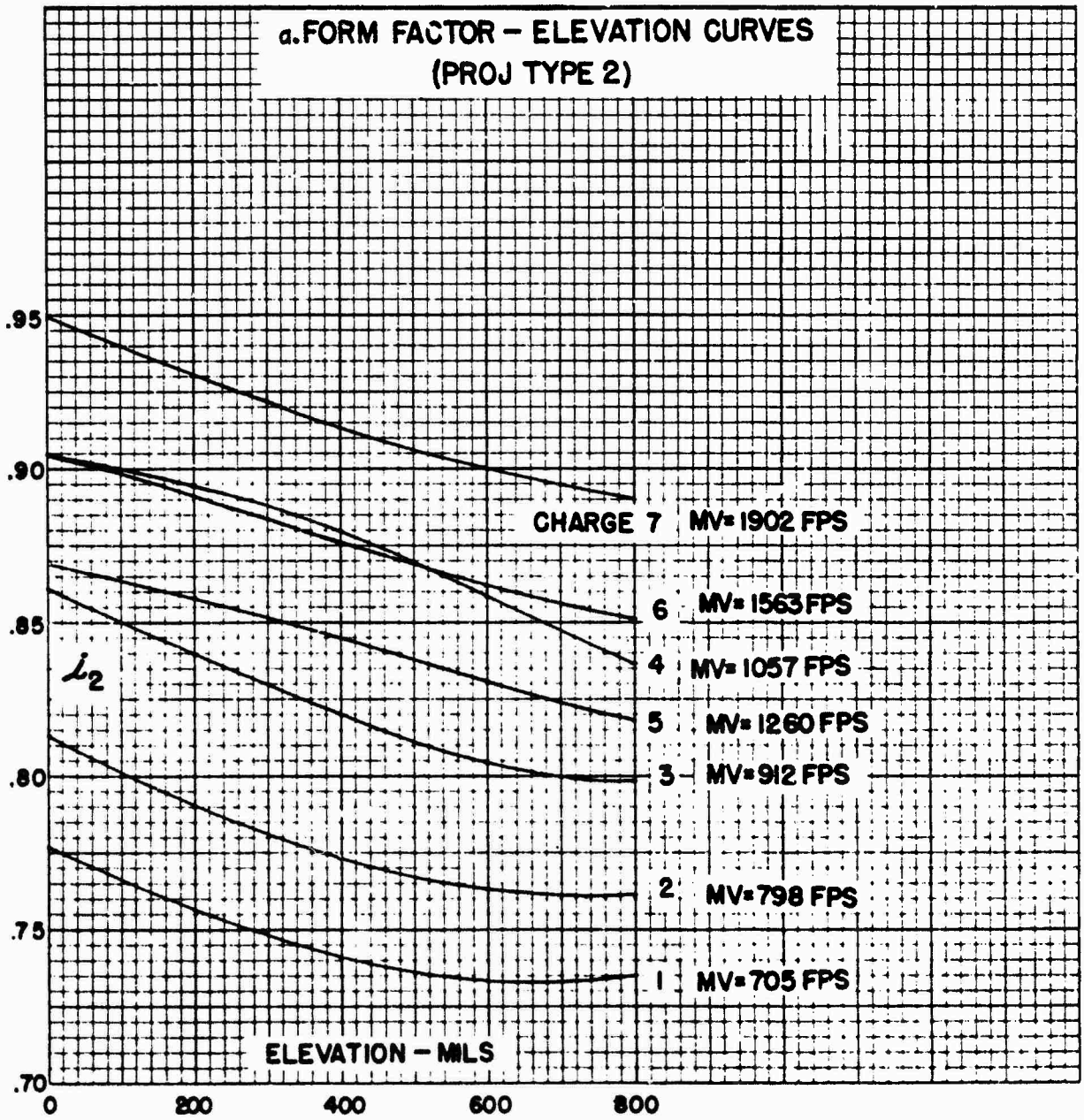

a. FORM FACTOR – ELEVATION CURVES (PROJ TYPE 2)
CHARGE 7
4
6
5
3
2
1
MV= 1850 FPS
MV=1520 FPS
MV=1020 FPS
MV=1220 FPS
MV=880 FPS
MV=770 FPS
MV=680 FPS
i_2
ELEVATION – MILS
.95
.90
.85
.80
.75
.70
0
200
400
600
800

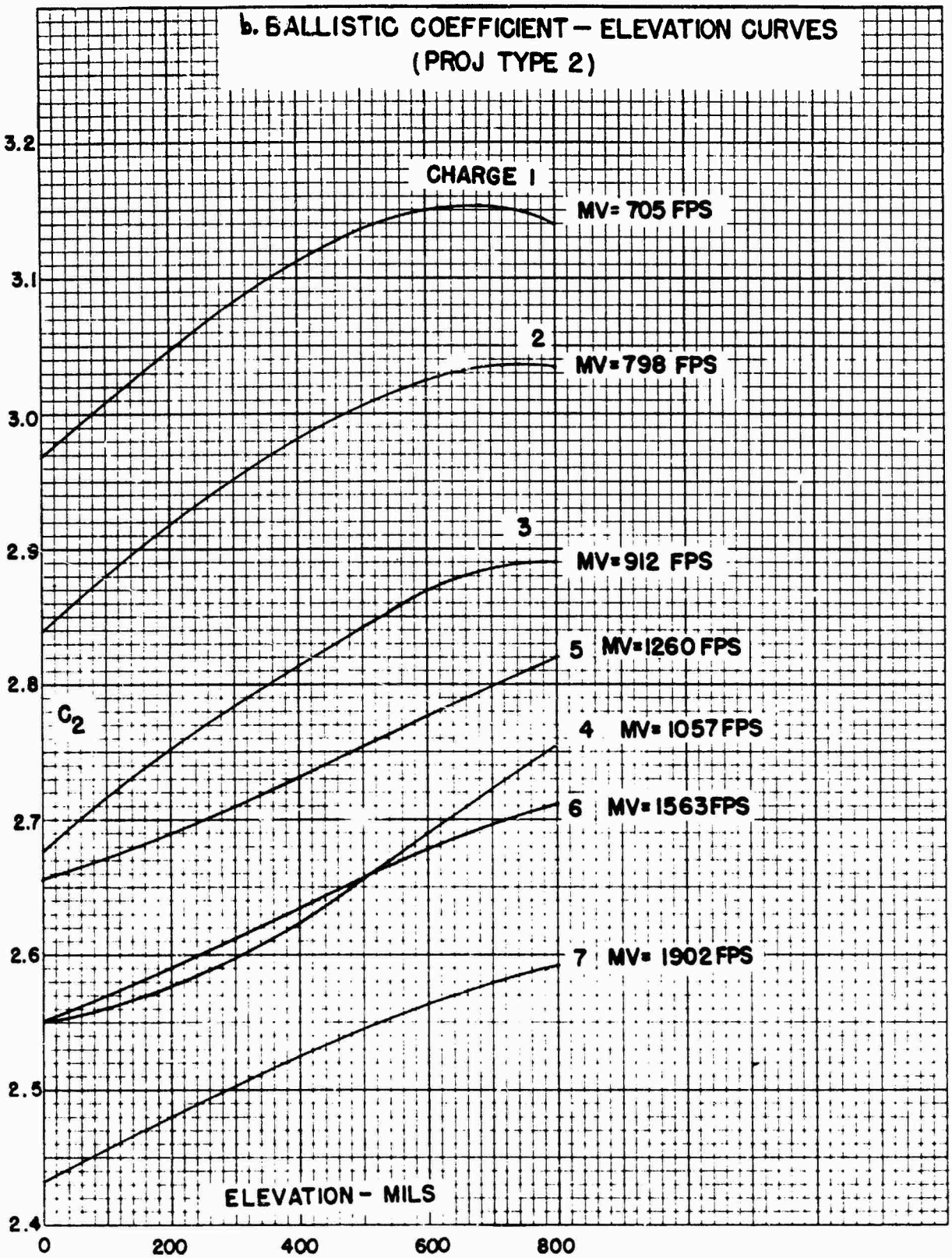

b. BALLISTIC COEFFICIENT – ELEVATION CURVES
(PROJ TYPE 2)
CHARGE 1
2
3
5
6
4
7
MV = 680 FPS
MV = 770 FPS
MV = 880 FPS
MV = 1220 FPS
MV = 1520 FPS
MV = 1020 FPS
MV = 1850 FPS
C_2
3.6
3.4
3.2
3.0
2.8
2.6
0
200
400
600
800
ELEVATION – MILS

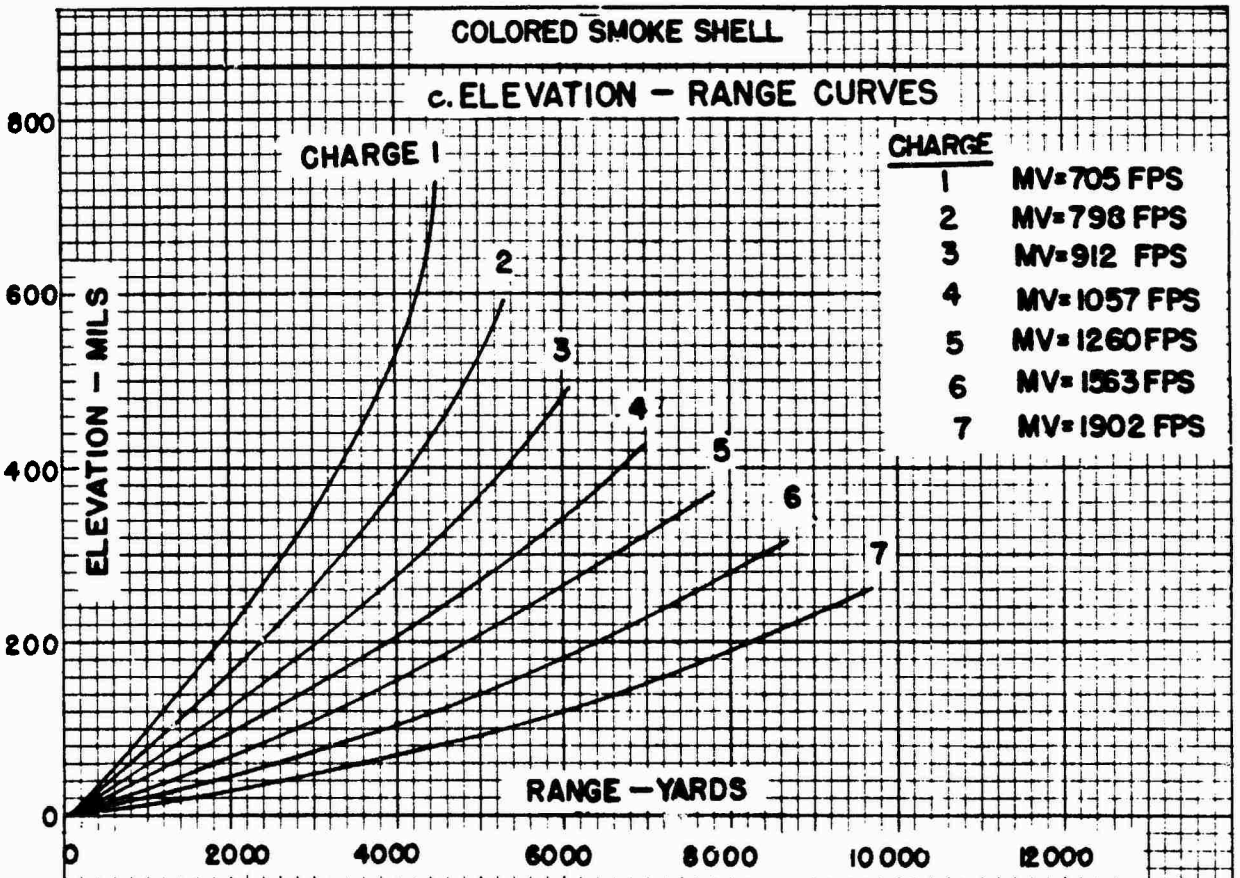

HC SHELL
c. ELEVATION – RANGE CURVES
CHARGE
1 MV = 680 FPS
2 MV = 770 FPS
3 MV = 880 FPS
4 MV = 1020 FPS
5 MV = 1220 FPS
6 MV = 1520 FPS
7 MV = 1850 FPS
CHARGE 1
2
3
4
5
6
7
ELEVATION – MILS
0
200
400
600
800
RANGE – YARDS
0
2000
4000
6000
8000
10000
12000
d. TIME OF FLIGHT – RANGE CURVES
TIME OF FLIGHT – SEC
0
10
20
30
CHARGE 1
2
3
4
5
6
7
RANGE – YARDS
0
2000
4000
6000
8000
10000
12000

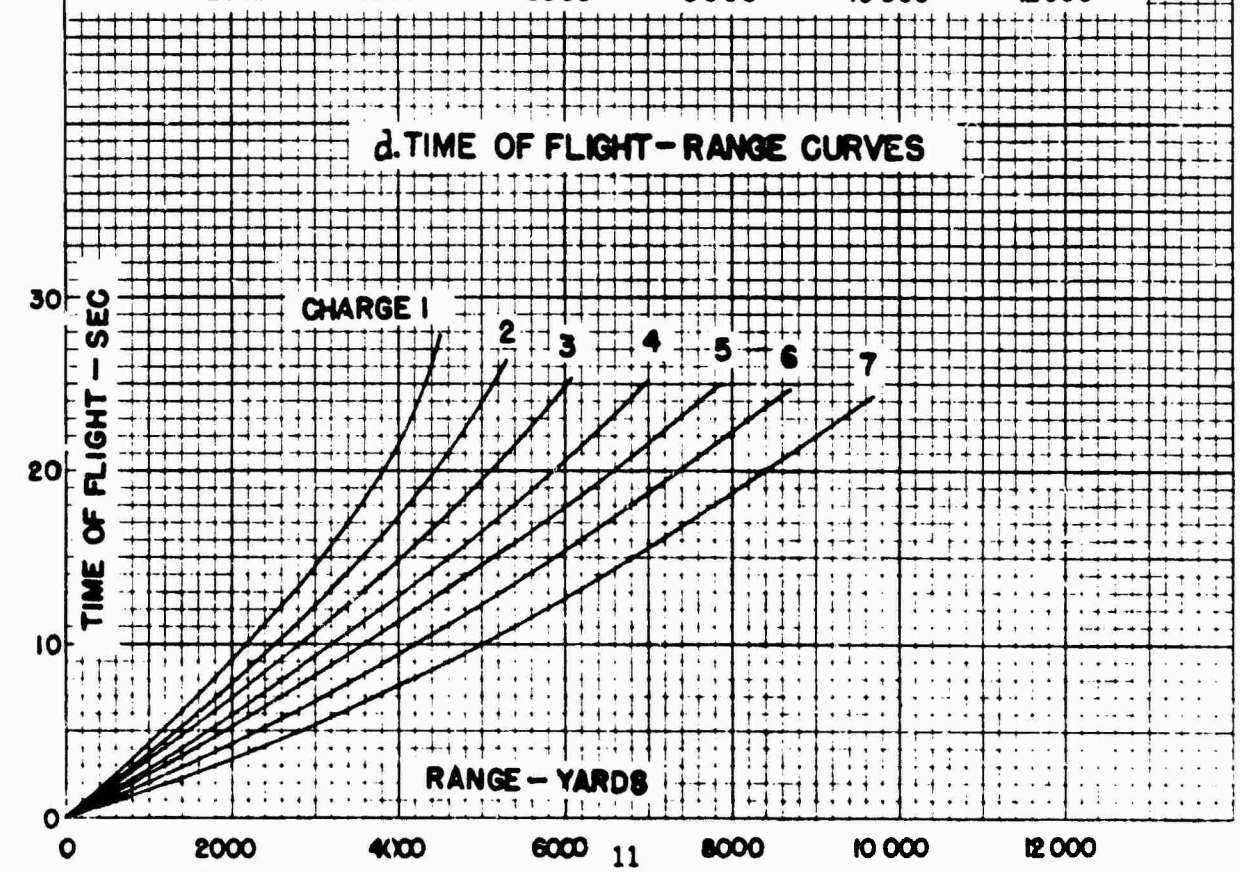
7. **Firing table data:** Colored Smoke Shell. FT 155-Q-2, C6.

Howitzer, 155-mm, M1. Twist of rifling: 1/25. Proj Wt: 85.92 lb. Authorization for using the Smoke Shell M110 filled with red, yellow, green and violet smoke mixtures in the M1 Howitzer was recommended by OCM item 24436 and approved by item 24709.


a. FORM FACTOR – ELEVATION CURVES
(PROJ TYPE 2)
.95
.90
.85
.80
.75
.70
i_2
CHARGE 7 MV= 1902 FPS
6 MV= 1563 FPS
4 MV= 1057 FPS
5 MV= 1260 FPS
3 MV= 912 FPS
2 MV= 798 FPS
1 MV= 705 FPS
ELEVATION – MILS
0
200
400
600
800


b. BALLISTIC COEFFICIENT – ELEVATION CURVES
(PROJ TYPE 2)
CHARGE 1
MV= 705 FPS
2
MV=798 FPS
3
MV=912 FPS
5 MV=1260 FPS
4 MV= 1057 FPS
6 MV=1563 FPS
7 MV= 1902 FPS
C_2
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
0
200
400
600
800
ELEVATION – MILS


COLORED SMOKE SHELL
c. ELEVATION – RANGE CURVES
CHARGE 1
2
3
4
5
6
7
CHARGE
1 MV=705 FPS
2 MV=798 FPS
3 MV=912 FPS
4 MV=1057 FPS
5 MV=1260 FPS
6 MV=1563 FPS
7 MV=1902 FPS
ELEVATION – MILS
800
600
400
200
0
RANGE – YARDS
0
2000
4000
6000
8000
10 000
12 000


d. TIME OF FLIGHT – RANGE CURVES
CHARGE 1
2
3
4
5
6
7
TIME OF FLIGHT – SEC
30
20
10
0
RANGE – YARDS
0
2000
4000
6000
8000
10 000
12 000

SECTION V
EFFECT DATA

	Paragraph
HC	8
Colored Smoke	9

8. HC. When solid gray HC mixture is burned, it produces a white to gray smoke. This smoke has a sharp acrid odor, but is harmless to the body. It is used to screen small operations and for training purposes.

9. Colored Smoke. Four kinds of colored smoke mixtures are used in the 155-mm Shell M116. They produce red, yellow, green and violet smoke. The color is indicated by a marking on the Shell. Colored smoke is used for signalling purposes. The average time of effective smoke screen, observed in a test to determine the functioning characteristics of the shell, is shown in the following table.

Color	Time - min
Red	2.30
Yellow	1.88
Green	1.89
Violet	2.13

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 155 - 1 - 117

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
21 February 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, Smoke, HC, M117 (BE)
with
Fuze, TSQ, M54

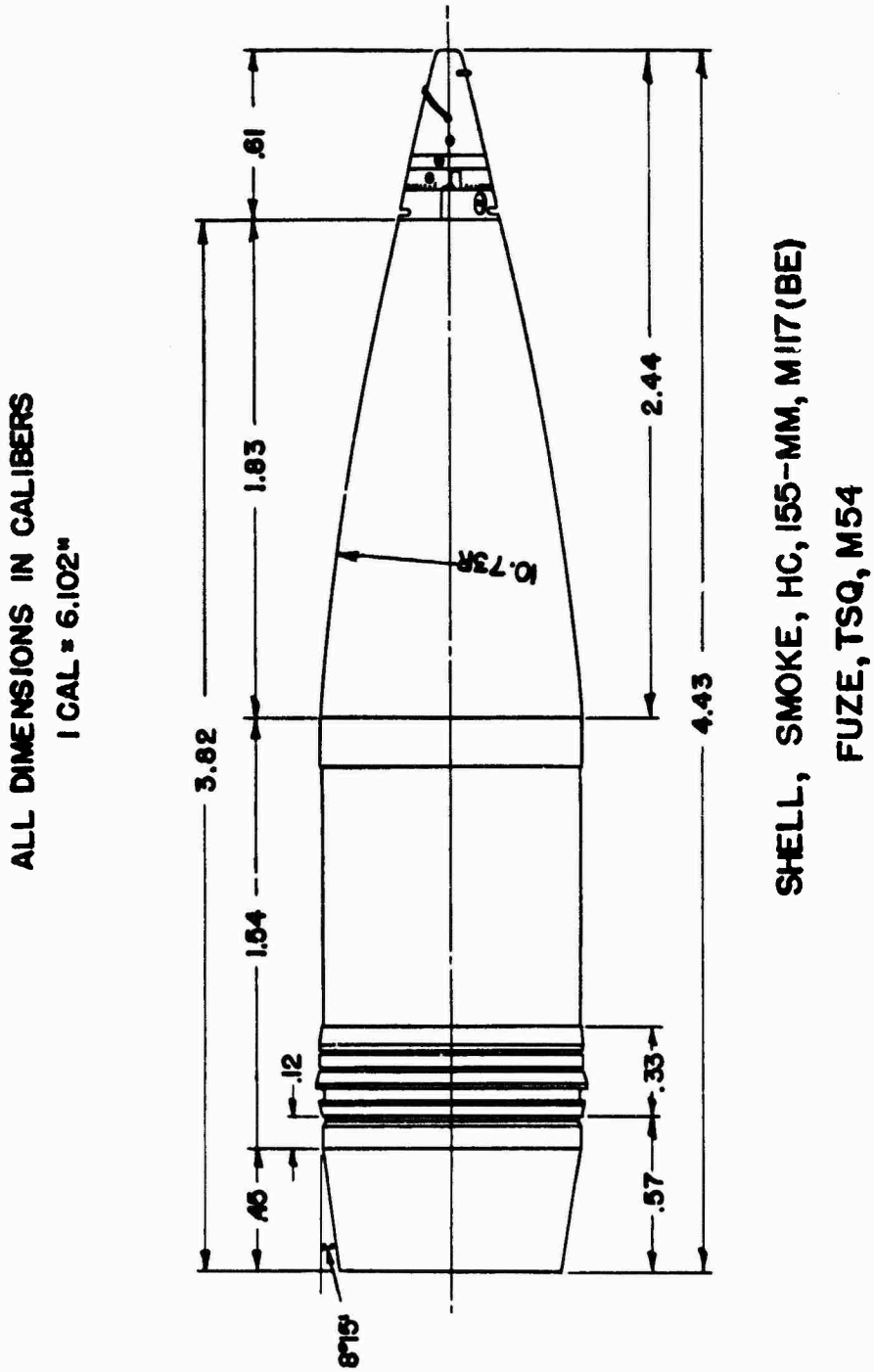
Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5
IV	Exterior ballistic data	6
V	Effect data	7

SECTION I
GENERAL

Paragraph

Purpose - 1

1. **Purpose.** The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics, and effects of the 155-mm HC Smoke Shell M117 (Base Ejection) with the Time and Superquick Fuze 54. This information is collected from the drawings, reports, and firing tables pertaining to this ammunition.



SHELL, SMOKE, HC, 155-MM, M117(BE)
FUZE, TSQ, M54

SECTION II
DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell: Metal parts assembly and details	75-4-117
Fuze: Assembly	73-3-154
Booster, M21A4: Assembly	73-2-154

3. Dimensions.

Boat-tail: Angle	8°15'
Length	0.45 cal
Band: Distance from boat-tail	0.12 cal
Distance from base	0.57 cal
Width	0.33 cal
Cylindrical body: Length	1.54 cal
Ogive: Length	1.83 cal
Radius of arc	10.73 cal
Fuze: Outside length	0.61 cal
Length: Shell	3.82 cal
Ogive and fuze	2.44 cal
Shell and fuze	4.43 cal

4. Physical characteristics.

Standard weight of fuzed shell loaded with HC mixture: 94.73 lb

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Theoretical yaw in bore	5

5. Theoretical yaw in bore.

Minimum	7.7 min
Maximum	12.2 min

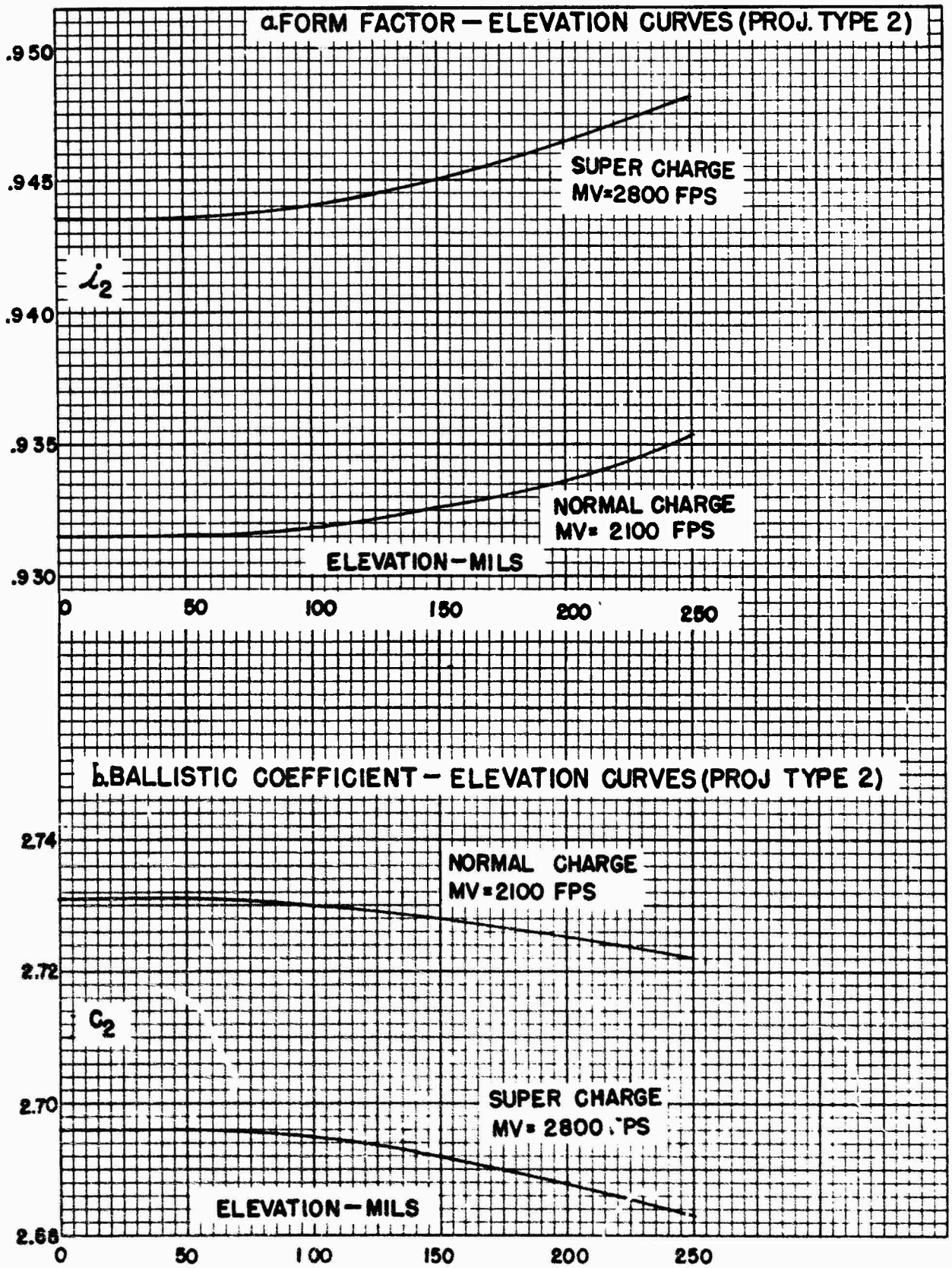
SECTION IV

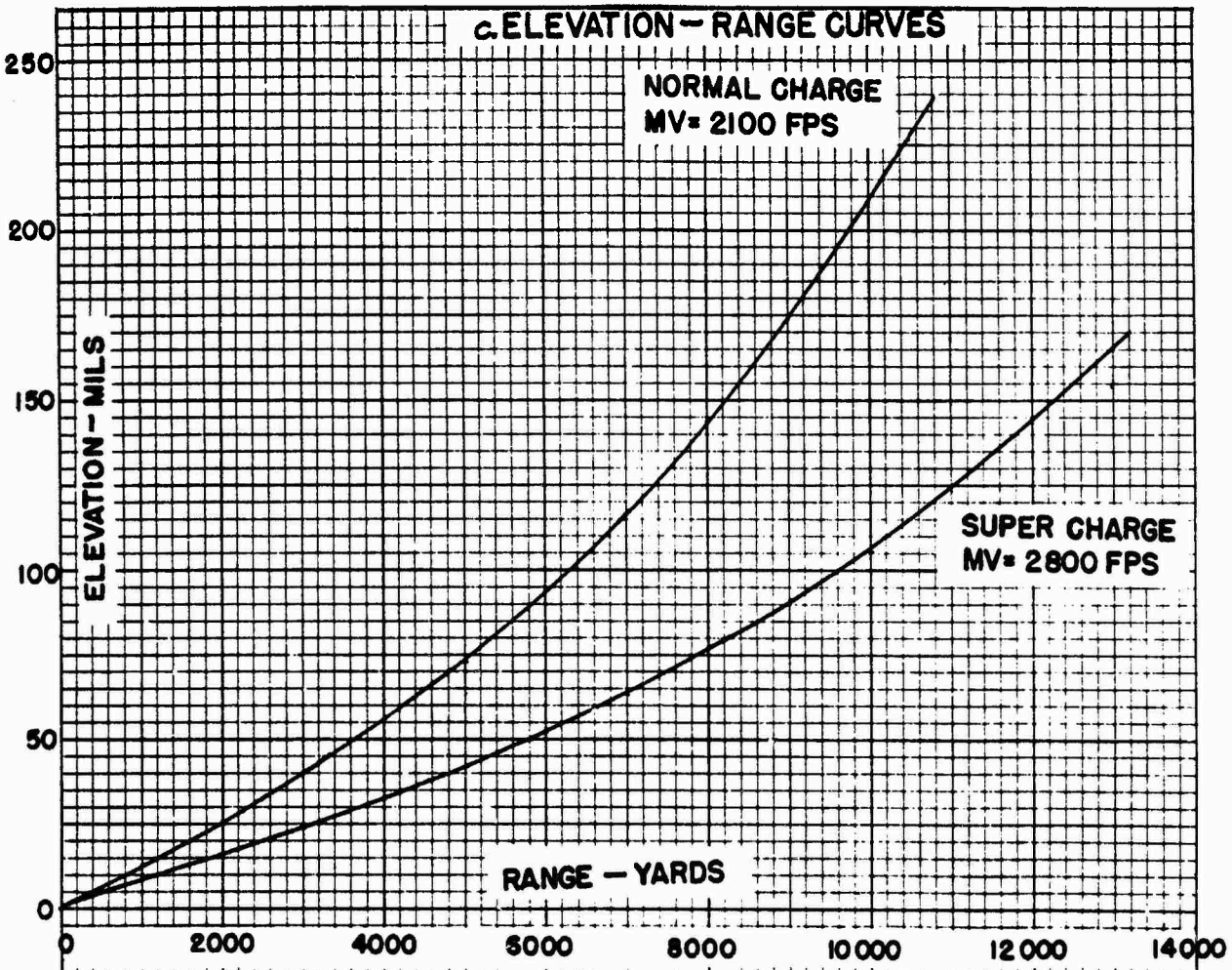
EXTERIOR BALLISTIC DATA

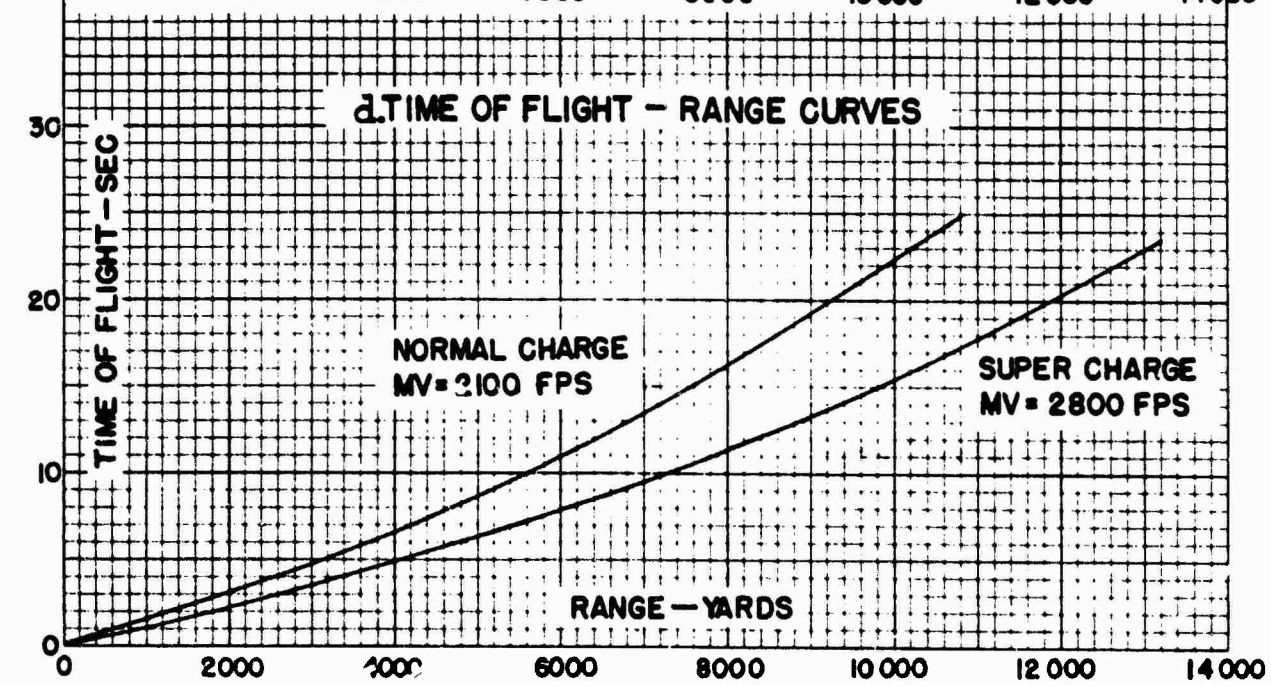
	Paragraph
Firing table data	6

6. Firing table data. FT 155-S-2, C8.

Guns, 155-mm, M1, M1A1, M1C, M2, M3 and M4.
Twist of rifling: 1/25.
Projectile weight: 94.73 lb.
OCM items 24287 and 24596 recommended and approved the standardization of the HC Smoke Shell M117 (BE) with the TSQ Fuze M54.


a. FORM FACTOR — ELEVATION CURVES (PROJ. TYPE 2)
.950
.945
.940
.935
.930
i_2
SUPER CHARGE
MV=2800 FPS
NORMAL CHARGE
MV= 2100 FPS
ELEVATION—MILS
0
50
100
150
200
250
b. BALLISTIC COEFFICIENT — ELEVATION CURVES (PROJ TYPE 2)
2.74
2.72
2.70
2.68
C_2
NORMAL CHARGE
MV=2100 FPS
SUPER CHARGE
MV= 2800 FPS
ELEVATION—MILS
0
50
100
150
200
250


c. ELEVATION — RANGE CURVES
NORMAL CHARGE
MV= 2100 FPS
SUPER CHARGE
MV= 2800 FPS
ELEVATION — MILS
RANGE — YARDS
0
50
100
150
200
250
0
2000
4000
6000
8000
10 000
12 000
14000


d. TIME OF FLIGHT — RANGE CURVES
NORMAL CHARGE
MV= 2100 FPS
SUPER CHARGE
MV= 2800 FPS
TIME OF FLIGHT — SEC
RANGE — YARDS
0
10
20
30
0
2000
4000
6000
8000
10 000
12 000
14 000

SECTION V

EFFECT DATA

	Paragraph
HC	7

7. HC. When solid gray HC mixture is burned, it produces a white to gray smoke. This smoke has a sharp acrid odor, but is harmless to the body. It is used to screen small operations and for training purposes.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 155-1-118

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
9 March 1949

BALLISTIC AND ENGINEERING DATA
for
Shell, Illuminating, 155-mm, M118 and M118B1
with
Fuze, TSQ, M54

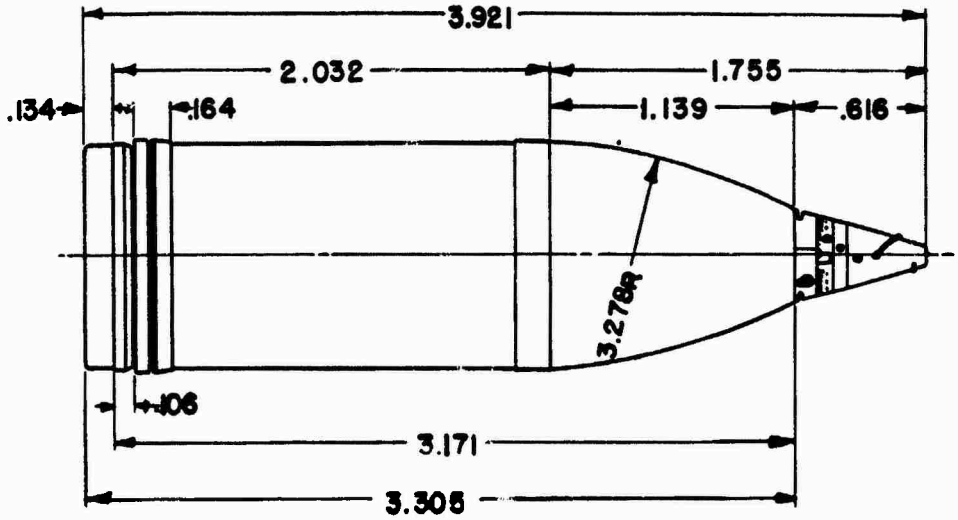
Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5
IV	Exterior ballistic data	6 - 8
V	Effect data	9

SECTION I
GENERAL

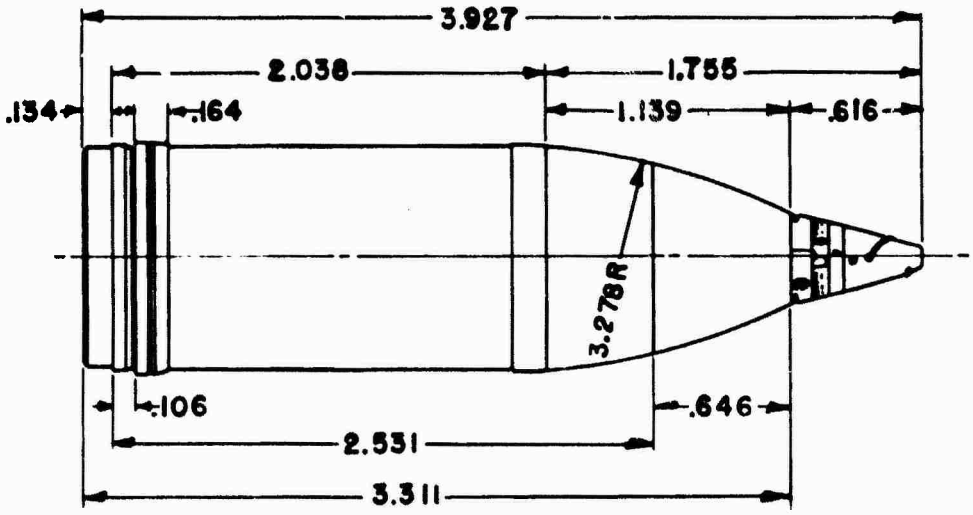
Paragraph
Purpose - 1

1. Purpose. The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 155-mm Illuminating Shell M118 and M118B1 with the Time and Superquick Fuze M54. This information is collected from the drawings, reports, firing tables, and firing records pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 6.102"



SHELL, ILLUMINATING, 155-MM, M118
FUZE, TSQ, M54



SHELL, ILLUMINATING, 155-MM, M118B1
FUZE, TSQ, M54

SECTION II
DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell M118: Metal parts assembly	75-4-120
Metal parts details	75-4-121
Shell M118B1: Metal parts assembly	75-4-124
Metal parts details	75-4-125
Booster M21A4: Assembly	73-2-154
Fuze M54: Assembly	73-3-154

3. Dimensions.

Shell:	M118	M118B1
Base plug: Length (outside)	0.134 cal	0.134 cal
Band: Distance to base of shell body	0.106 cal	0.106 cal
Width	0.164 cal	0.164 cal
Cylindrical body: Length	2.032 cal	2.038 cal
Ogive: Length	1.139 cal	1.139 cal
Radius of arc	3.278 cal	3.278 cal
Shell: Body (length)	3.171 cal	2.531 cal
Adapter (outside length)	None	0.646 cal
Body, adapter and base plug	3.305 cal	3.311 cal
Fuze: Length (outside)	0.616 cal	0.616 cal
Fuze and shell	3.921 cal	3.927 cal
Fuze and ogive	1.755 cal	1.755 cal

4. Physical characteristics.

Shell:	M118	M118	M118B1
Fuze:	M54	M59	M54
Mean Weight (lb): Standard	103.06		101.51
Measured		101.44	
Base to center of gravity (cal)		1.413	
Axial moment of inertia (lb.ft^2)		3.78	
Transverse moment of inertia (lb.ft^2)		23.80	

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Theoretical yaw in bore	5

5. Theoretical yaw in bore.

Shell:	M118	M118B1
Minimum	5.8	5.8
Maximum	9.3	10.2

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data	6
Firing table data: Guns, 155-mm, M1, M1A1, M1C, M2, M3 and M4	7
Firing table data: Howitzer, M1	8

6. Aerodynamic data. The following data were obtained from resistance firings of the Illuminating Shell T21 (M118) with the Dummy Fuze M59, which has approximately the same weight and contour as the TSQ Fuze M54, and from range firings of the Illuminating Shell M118B1 with the TSQ Fuze M54. The G_6 drag function was used in the reductions. The tabulated ballistic coefficients apply to a weight of 103.06 lb.

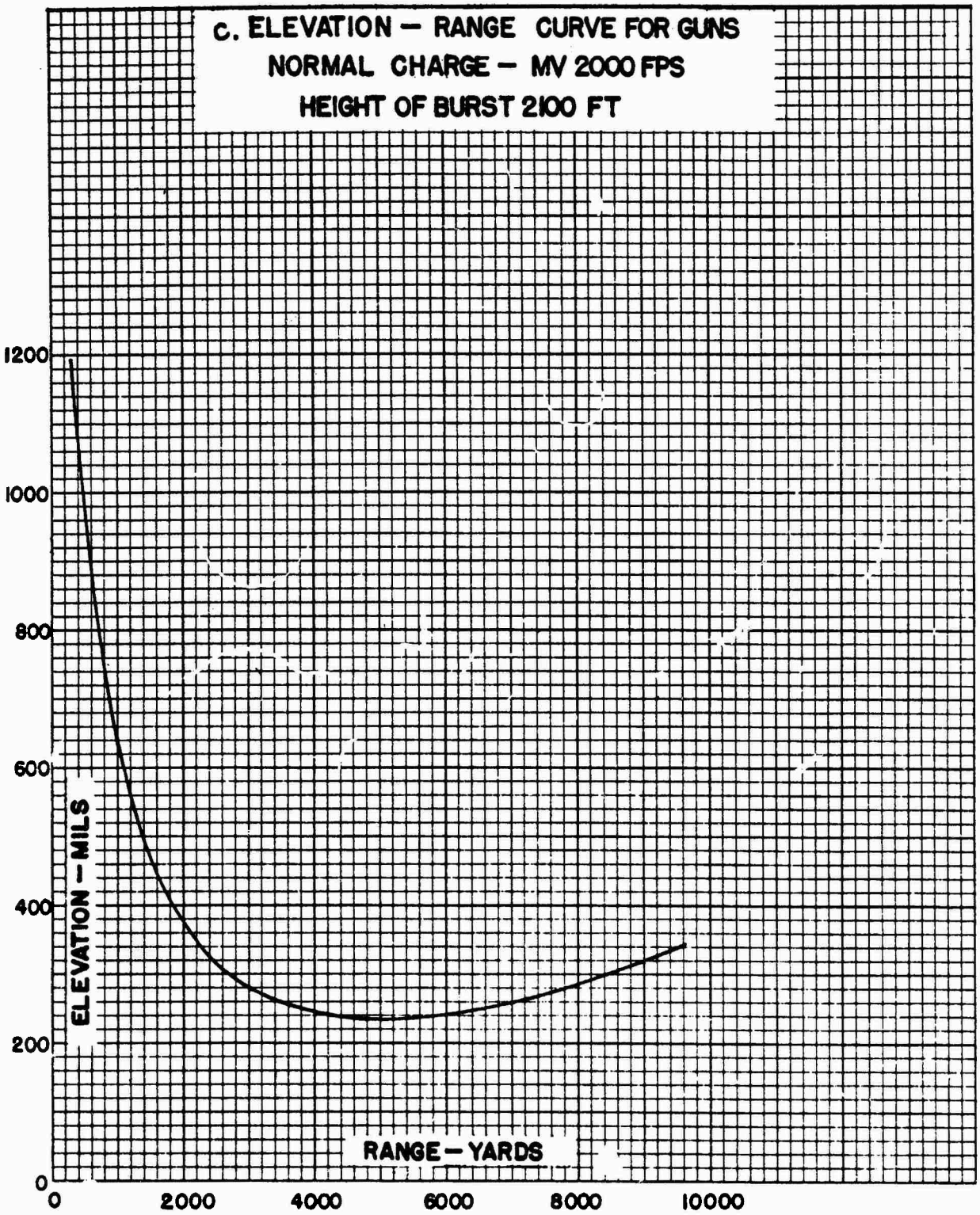
Firings	Velocity fps	Ballistic Coefficient C_6	Form Factor i_6	Drag Coefficient K_D
Resistance	640	2.96	0.935	.078
	969	2.71	1.02	.089
Range	650	2.545	1.09	.091
	735	2.572	1.08	.090
	840	2.575	1.075	.090
	970	2.534	1.09	.095
	1160	2.385	1.16	.190
	2000	2.337	1.185	.162

7. Firing table data: Guns, 155-mm, M1, M1A1, M1C, M2, M3 and M4.

FT 155-S-2, C8.
Twist of rifling: 1/25.
Normal charge, Muzzle velocity: 2000 fps.
Height of burst: 2100 ft.
OCM items 24928 and 25265 recommended and approved standardization of the Illuminating Shell M118 for use in the 155-mm Gun M1 with normal charge. The range firings were conducted with Shell M118B1, but the observations were reduced to a weight of 103.06 lb.

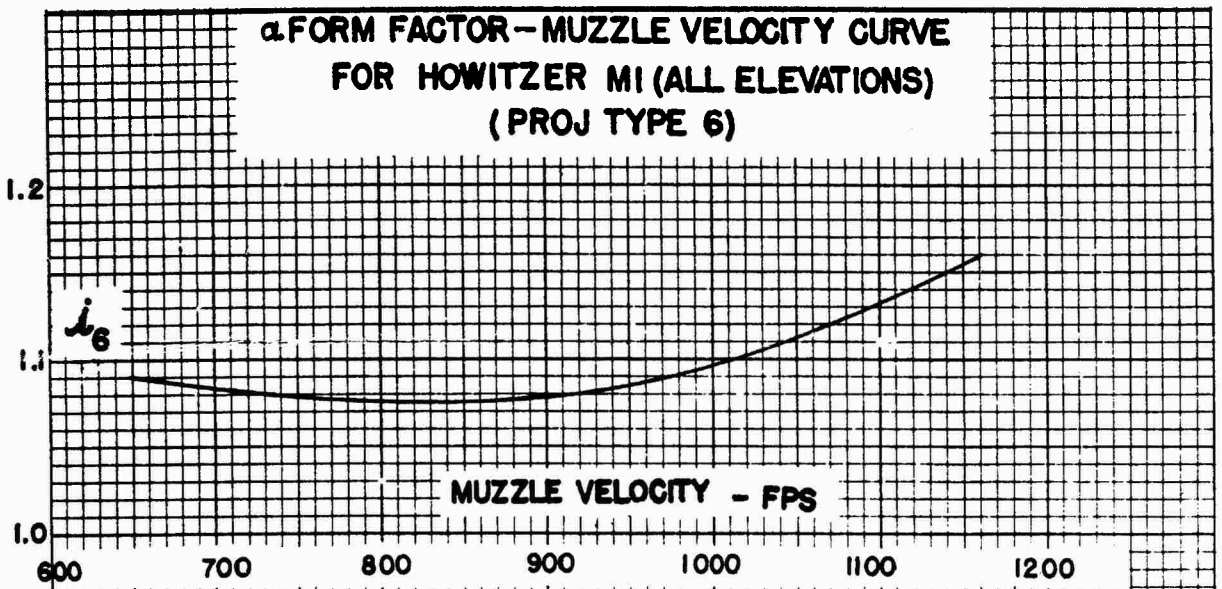
a. **Form factor** (Proj Type 6). $i_6 = 1.185$ (constant).

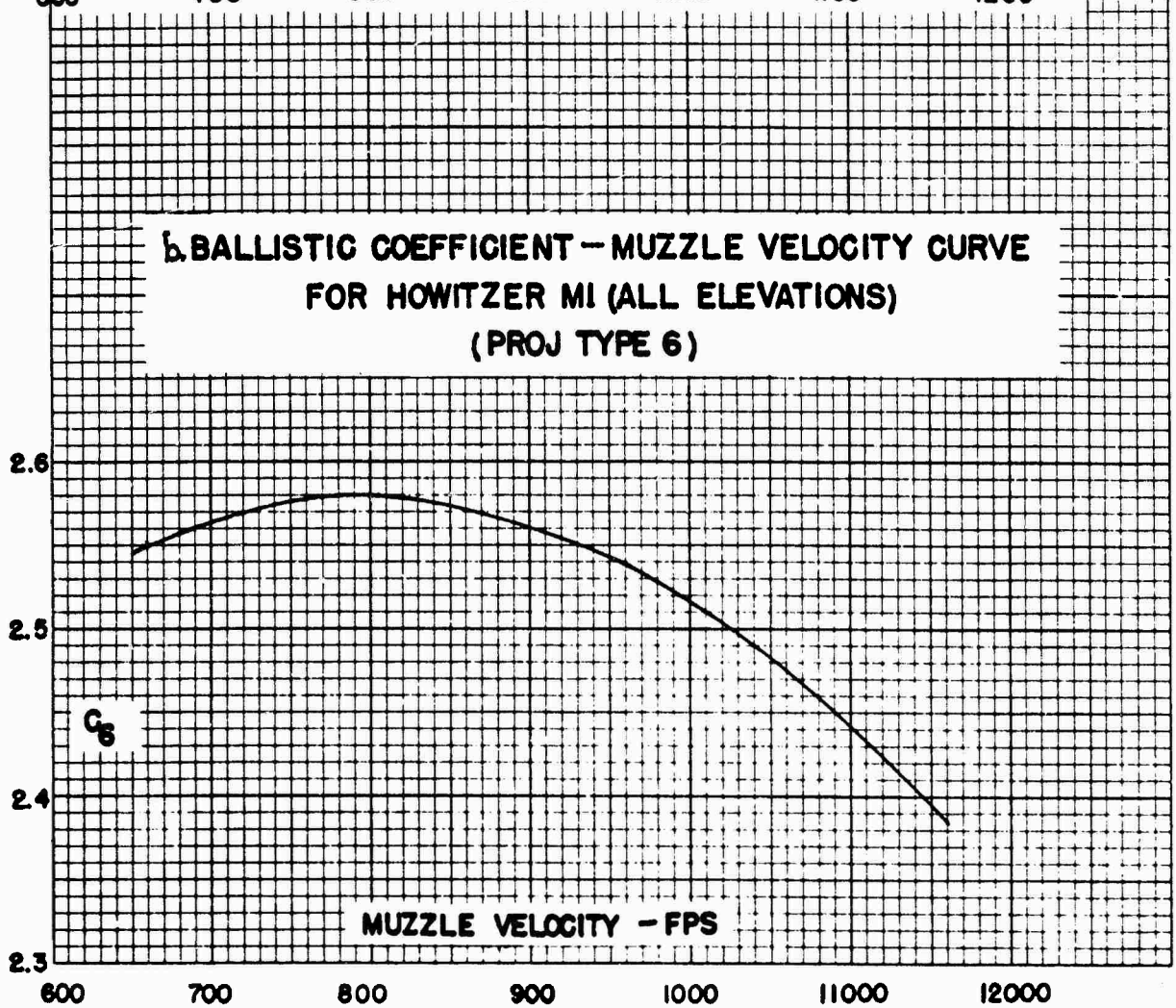
b. **Ballistic Coefficient** (Proj Type 6). $C_6 = 2.337$ (constant).

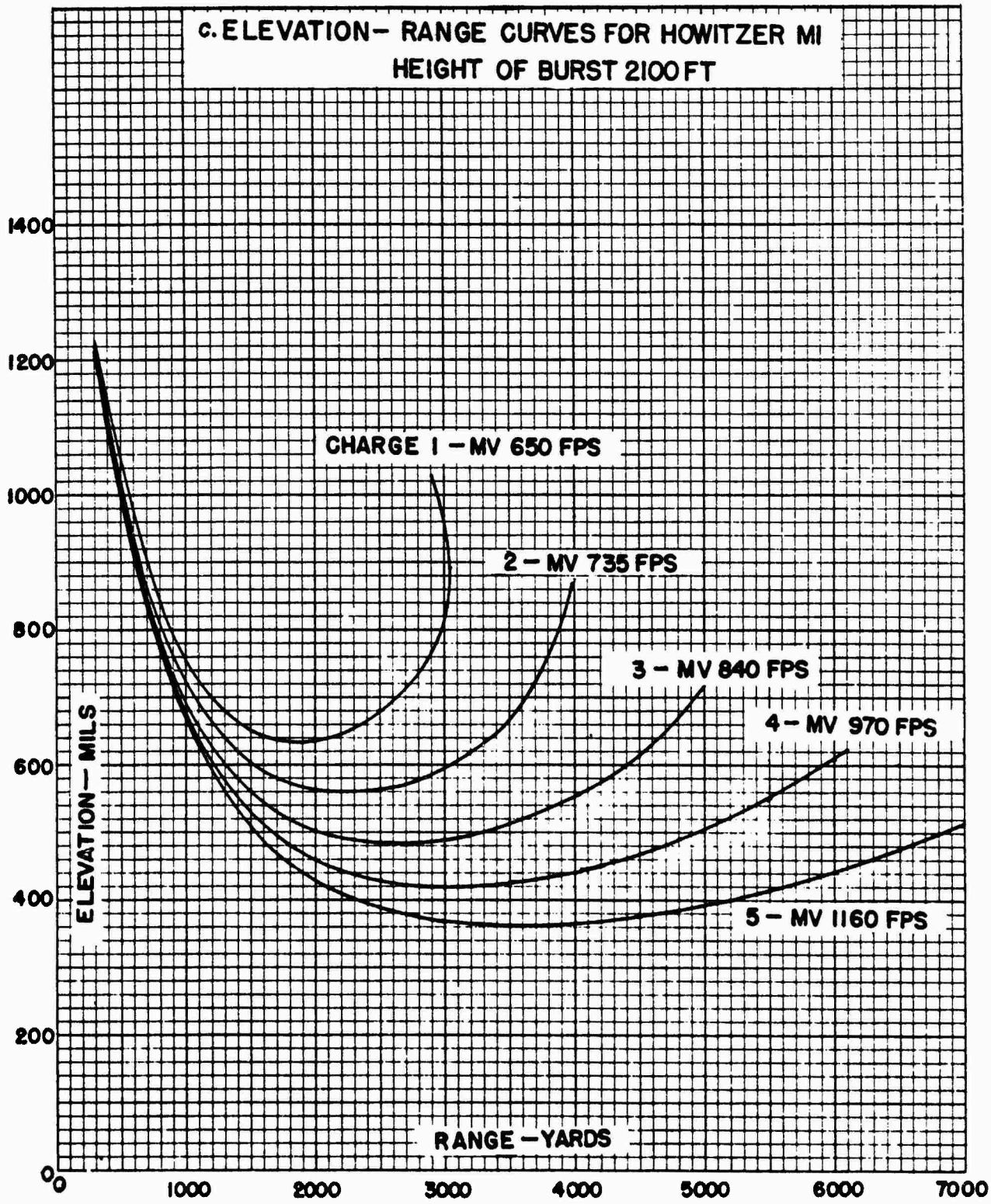

c. ELEVATION — RANGE CURVE FOR GUNS
NORMAL CHARGE — MV 2000 FPS
HEIGHT OF BURST 2100 FT
ELEVATION — MILS
RANGE — YARDS
0
200
400
600
800
1000
1200
0
2000
4000
6000
8000
10000

8. Firing table data: Howitzer, M1.

FT 155-Q-2, C7.
Twist of rifling: 1/25.
Height of burst: 2100 ft.
OCM items 24928 and 25625 recommended and approved standardization of the Illuminating Shell M118 for use in the 155-mm Howitzer M1 with Charge M3 (green bag). The range firings were conducted with Shell M118B1, but the observations were reduced to a weight of 103.06 lb.


a. FORM FACTOR – MUZZLE VELOCITY CURVE
FOR HOWITZER M1 (ALL ELEVATIONS)
(PROJ TYPE 6)
1.2
1.1
1.0
i_6
MUZZLE VELOCITY - FPS
600
700
800
900
1000
1100
1200


b. BALLISTIC COEFFICIENT – MUZZLE VELOCITY CURVE
FOR HOWITZER M1 (ALL ELEVATIONS)
(PROJ TYPE 6)
2.6
2.5
2.4
2.3
C_6
MUZZLE VELOCITY - FPS
600
700
800
900
1000
11000
12000


c. ELEVATION– RANGE CURVES FOR HOWITZER M1
HEIGHT OF BURST 2100 FT
CHARGE 1 – MV 650 FPS
2 – MV 735 FPS
3 – MV 840 FPS
4 – MV 970 FPS
5 – MV 1160 FPS
ELEVATION – MILS
RANGE – YARDS
0
200
400
600
800
1000
1200
1400
1000
2000
3000
4000
5000
6000
7000

SECTION V
EFFECT DATA

	Paragraph
Candle burning -	9

9. Candle burning. The functioning of the fuze, which is set for an altitude of 2100 feet, releases a parachute which carries a candle. In function tests of the Illuminating Shell M1 .8B1 with TSQ Fuze M54, fired from the Guns M1A1 and M2 and the Howitzer M1, the time from fuze functioning to parachute opening varied from 1.3 to 16 seconds, and the burning time of the candle varied from 8.5 to 59 seconds.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 8-1-1

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
9 March 1949

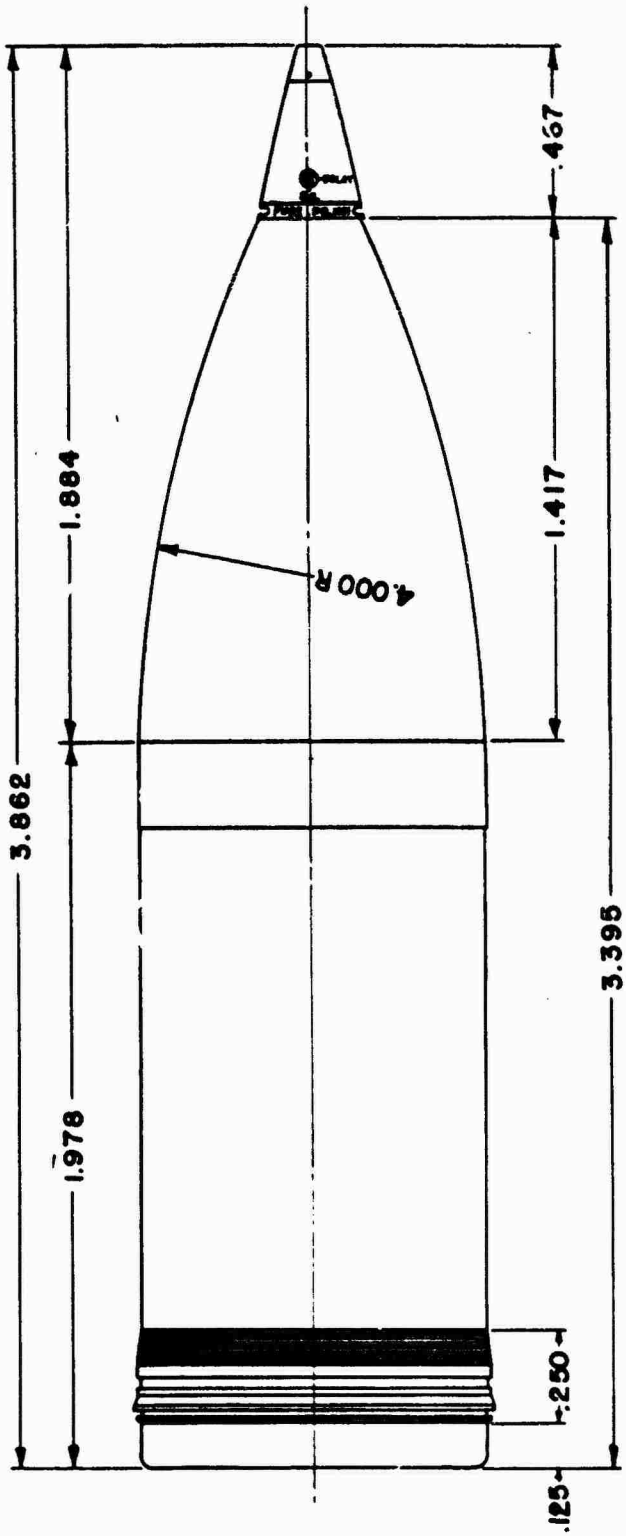
BALLISTIC AND ENGINEERING DATA
for
Shell, HE, 8-inch, Mark 1A1
with
Fuzes, PD, M51A4; TSQ, M55A3, and MT, M67A3

Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 8
V	Effect data	9

SECTION I
GENERAL

	Paragraph
Purpose	1

1. Purpose. The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 8-inch High Explosive Shell Mark 1A1 with the Point Detonating Fuze M51A4, the Time and Superquick Fuze M55A3, and the Mechanical Time Fuze M67A3. This information is collected from the drawings, reports, and firing tables pertaining to this ammunition.



SHELL, HE, 8-INCH, MARK IA1
FUZE, PD, M51A4

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

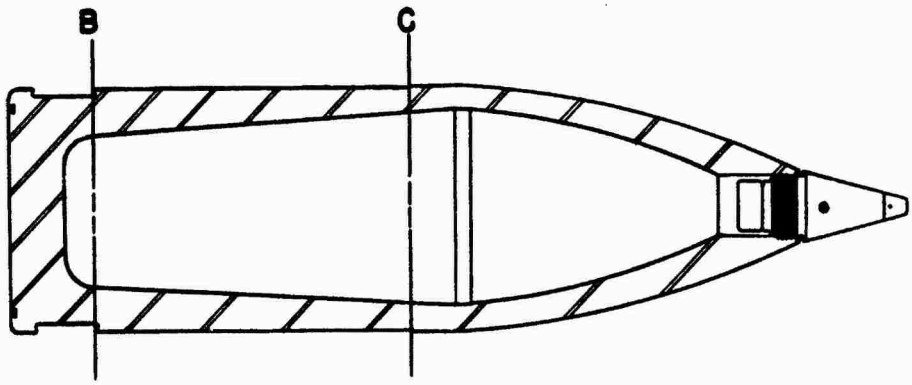
Shell: Metal parts assembly and details	75-4-23
Booster M21A4: Assembly	73-2-154
Fuze, PD, M51A4: Assembly	73-2-145
Details	73-2-143
Fuze, TSQ, M54: Assembly	73-3-154
Fuze, TSQ, M55A3 (consisting of Booster M21A4 and Fuze M54): Assembly and detail	73-3-155
Fuze, MT, M67A3: Assembly	73-7-77

3. Dimensions.

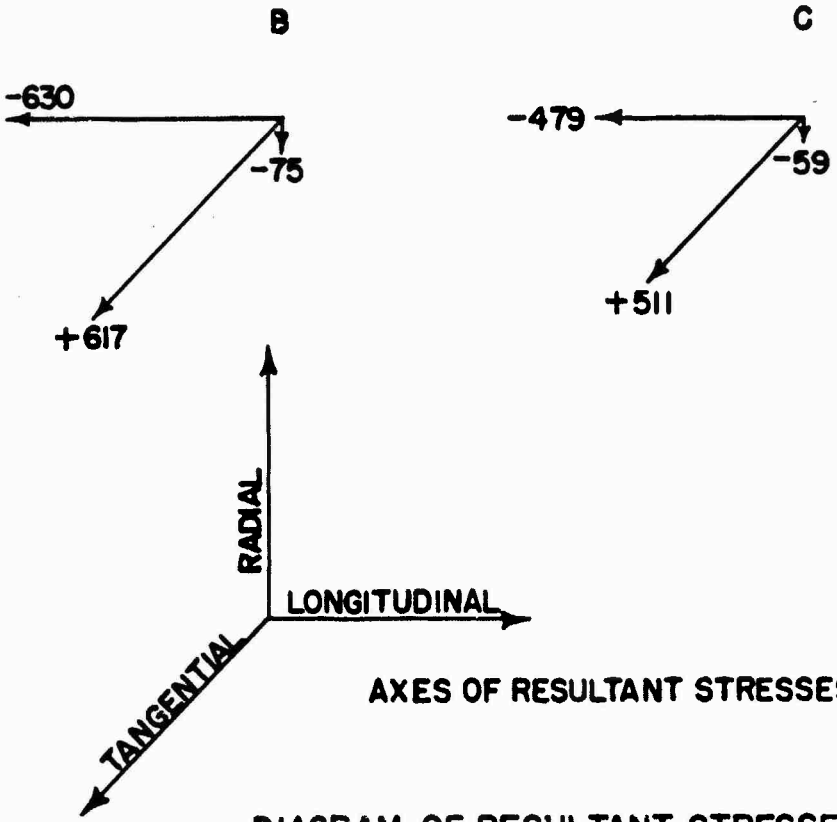
Band: Distance from base	0.125 cal
Width	0.250 cal
Cylindrical body: Length	1.978 cal
Ogive: Length	1.417 cal
Radius of arc	4.000 cal
Fuze: Outside length	0.467 cal
Length: Shell	3.395 cal
Shell and fuze	3.862 cal
Ogive and fuze	1.884 cal

4. Physical characteristics.

Weight Zone (No. of squares)	Mean Weight (lb)
2	195.0
3	197.5
4 (standard)	200.0
5	202.5



SECTIONS



AXES OF RESULTANT STRESSES

DIAGRAM OF RESULTANT STRESSES

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Stresses	5
Theoretical yaw in bore	6

5. Stresses. The following table and the graphical representation on page 4 show the longitudinal, radial and tangential resultant stresses at each of two sections: (B) the front of the band seat and (C) immediately behind the bourrelet. The rear of the band seat in this shell is 0.9 inch behind the rear of the cavity; therefore, this is not a weak section as in most high explosive shells.

Howitzer	8-inch M2
Twist of rifling	1/25.5
Cross-sectional area of bore	51.321 sq in.
Rated maximum pressure	33,000 psi
Total weight of projectile	200 lb
Muzzle velocity	1880 fps
Density of filler (TNT)	0.057 lb per cu in.

Resultant Stress* 100 psi	Section B	Section C
Longitudinal	-630	-479
Radial	- 75	- 59
Tangential	+617	+511

* + denotes tension - denotes compression.

6. Theoretical yaw in bore.

Minimum	6.0 min
Maximum	9.2 min

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data	7
Firing table data	8

7. Aerodynamic data. The ballistic coefficients relative to the G_6 drag function, which were determined by range firing and extrapolated to zero elevation, and the corresponding form factors and drag coefficients are tabulated below.

Muzzle Velocity fps	Ballistic Coefficient C_6	Form Factor i_6	Drag Coefficient K_D
795	2.920	1.07	.089
873	2.920	1.07	.090
970	2.920	1.07	.093
1115	2.950	1.06	.150
1339	2.907	1.075	.189
1590	2.860	1.09	.182
1880	2.805	1.11	.172

8. Firing table data.

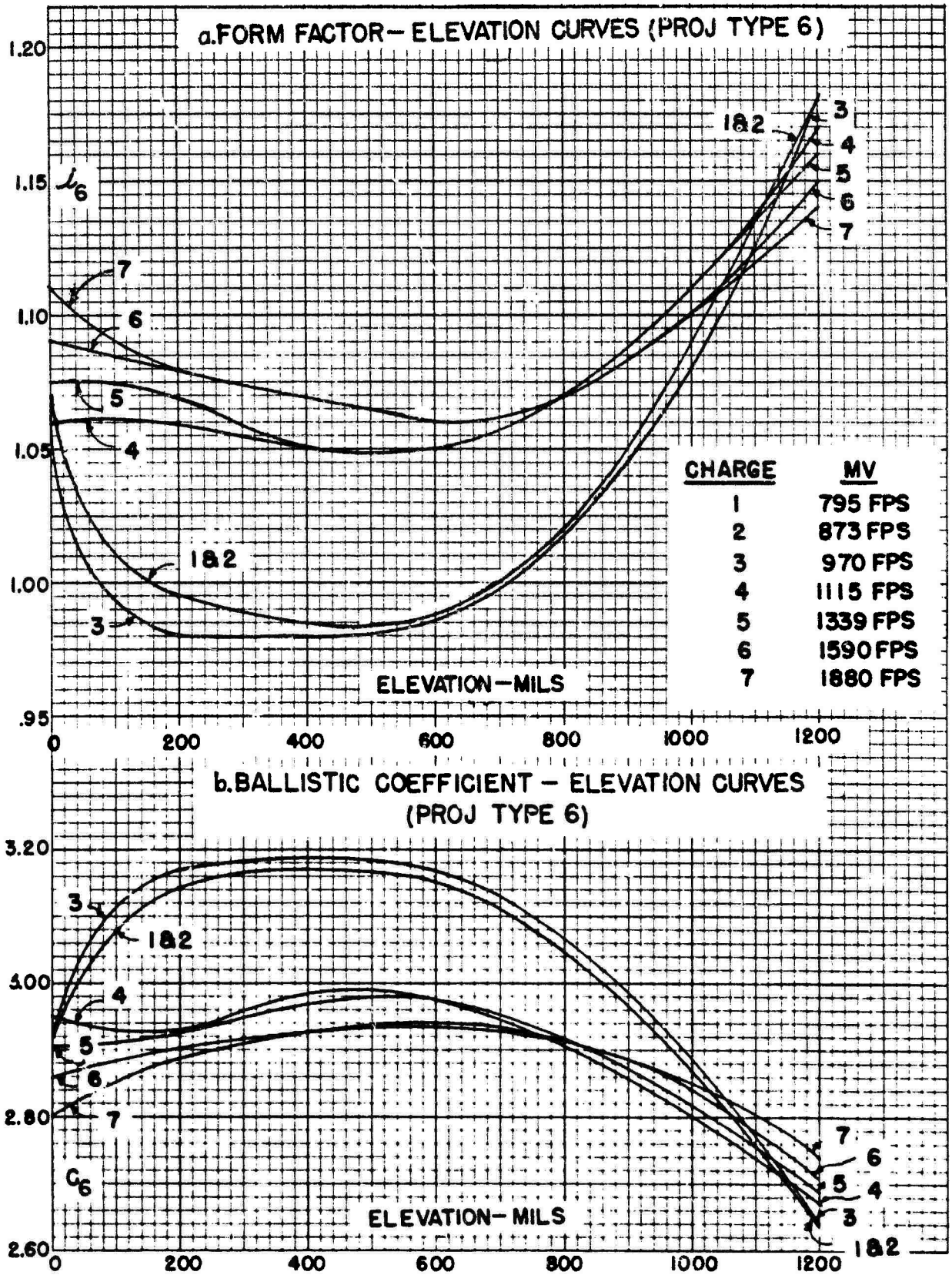
FT 8-K-1 contains tables for the HE Shell Mark 1A1 with the PD Fuze M51A4, propelled by Charge M1 (green bag) zones 1 to 5.

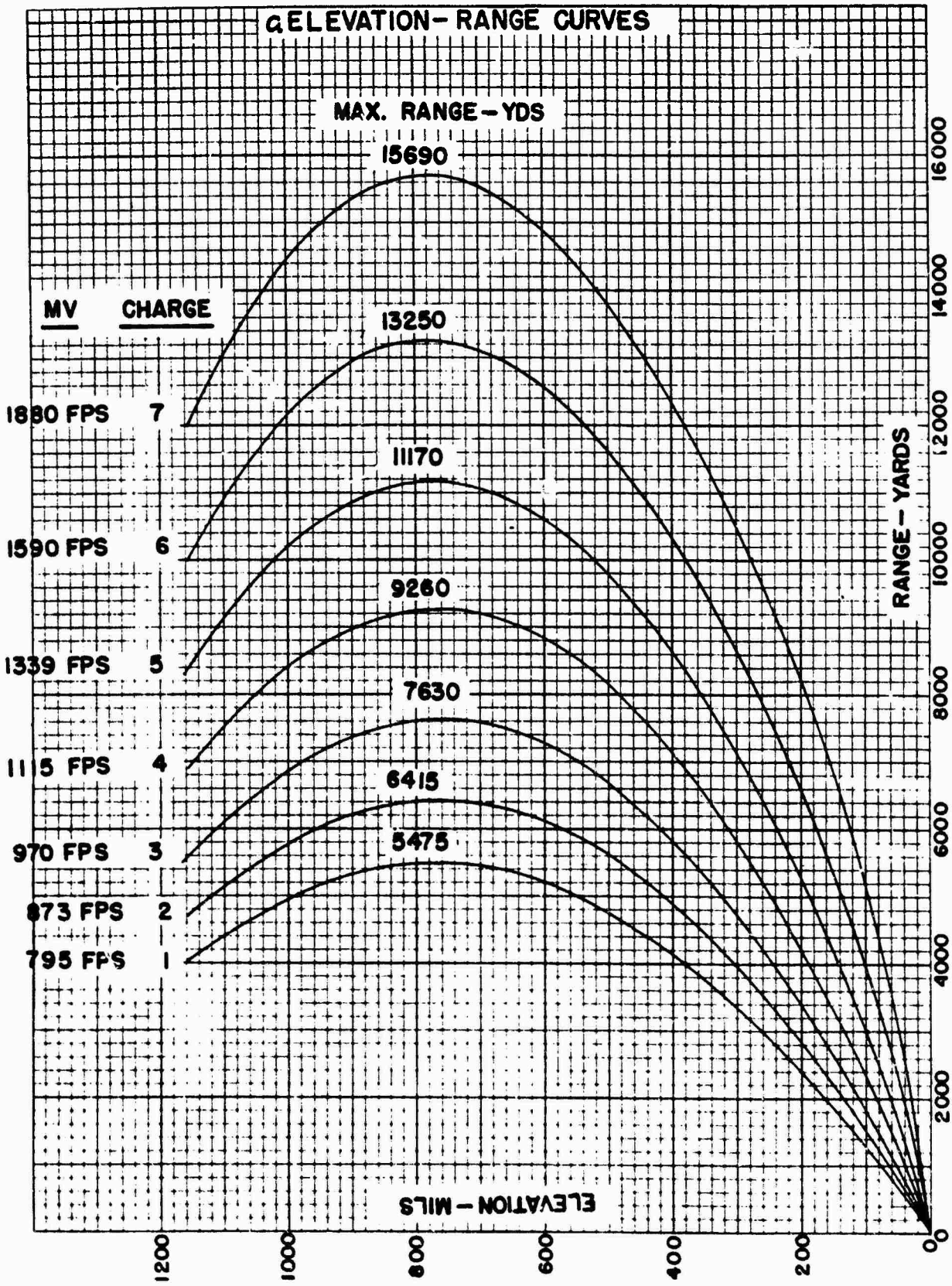
FT 8-K-1, C1, contains tables for the HE Shell Mark 1A1 with the PD Fuze M51A4, propelled by Charge M2 (white bag) zones 6 and 7.

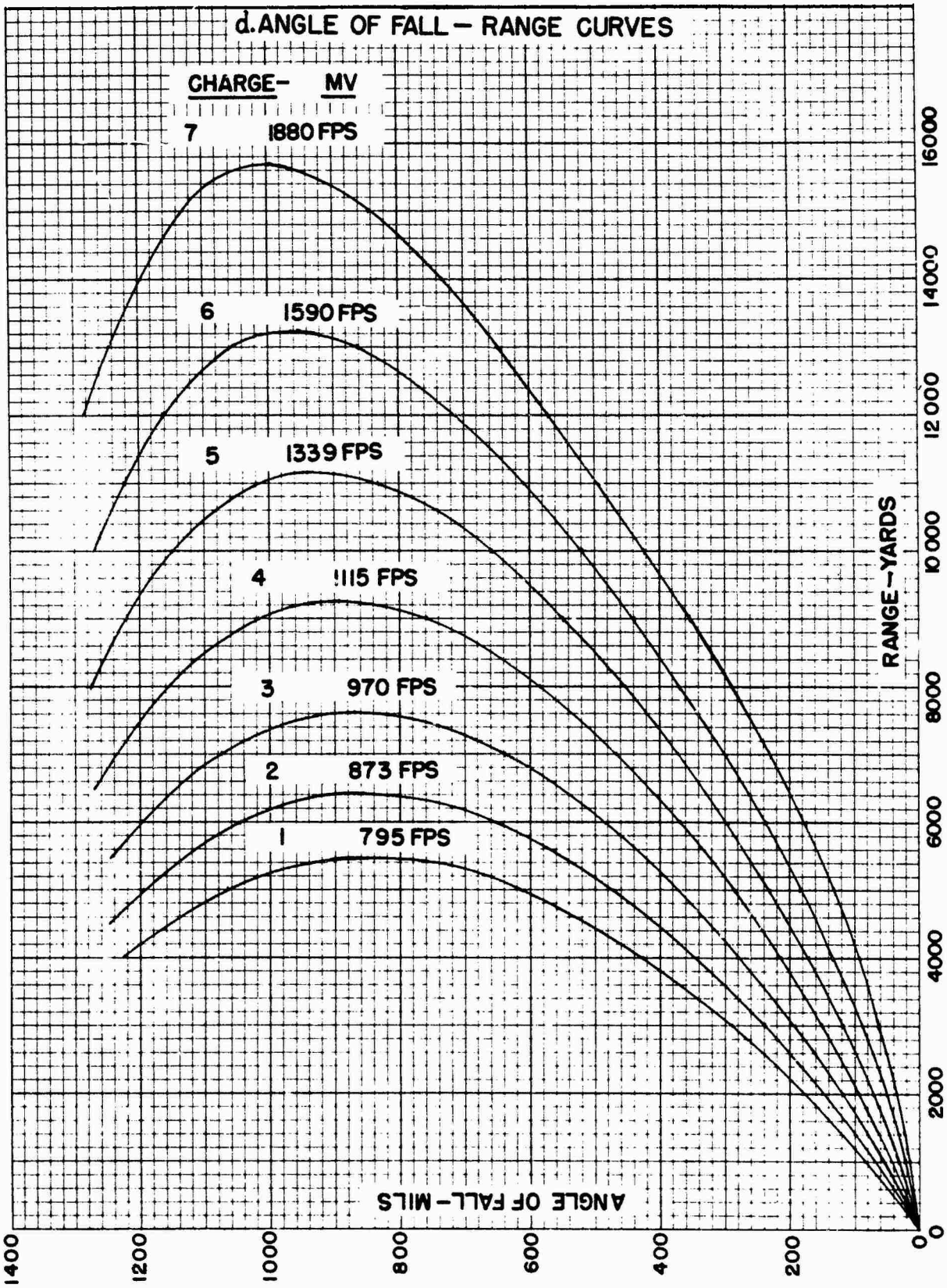
FT 8-K-1, C2, gives Projectile Weight Effects and Powder Temperature Effects to be substituted for those in FT 8-K-1 when Charge M2 is used instead of Charge M1 for zone 5 firings; it also gives fuze setting data for the TSQ Fuze M55A3, which is used when air bursts are desired.

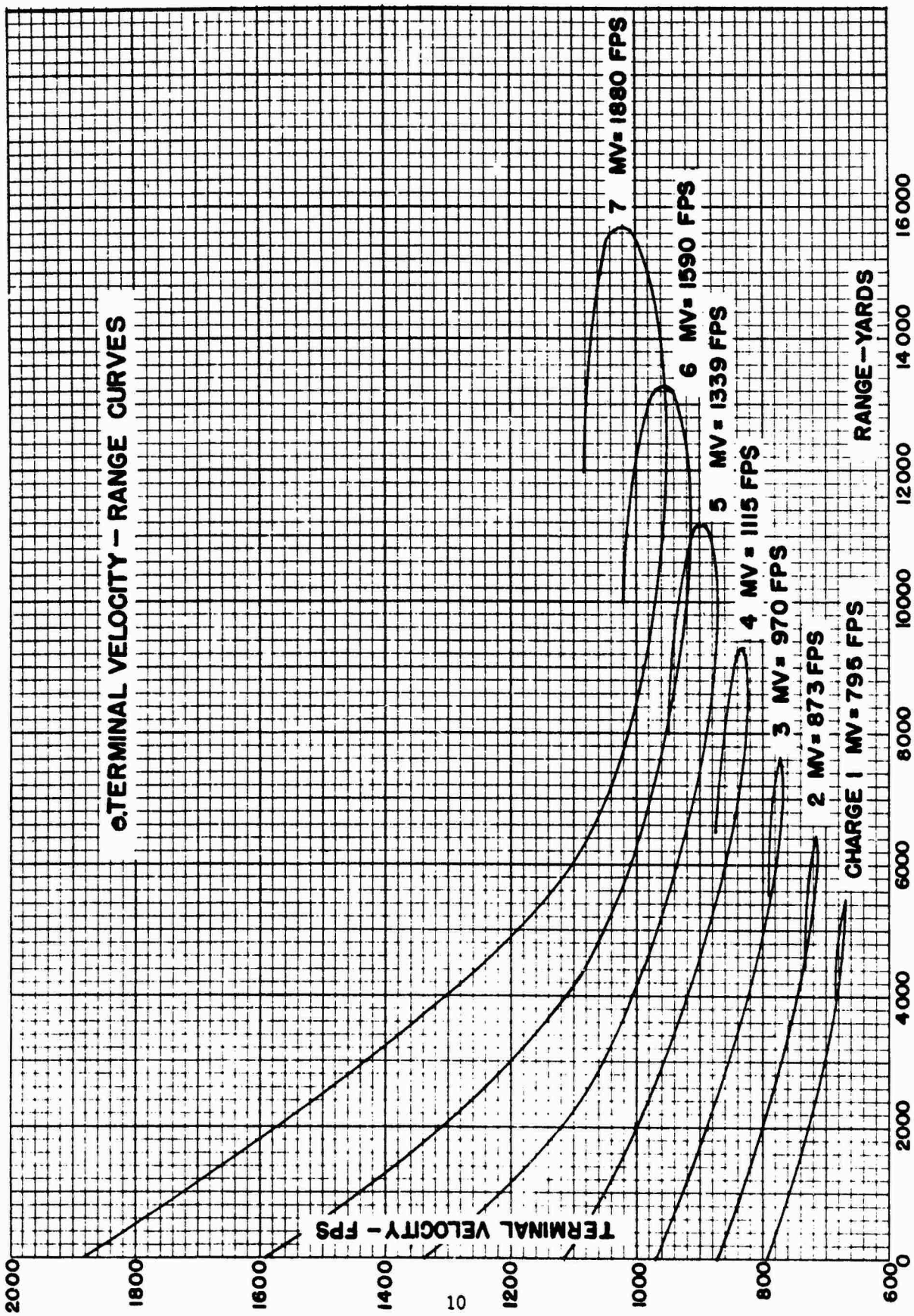
Howitzer, 8-inch, M2. Twist of rifling: 1/25.5.

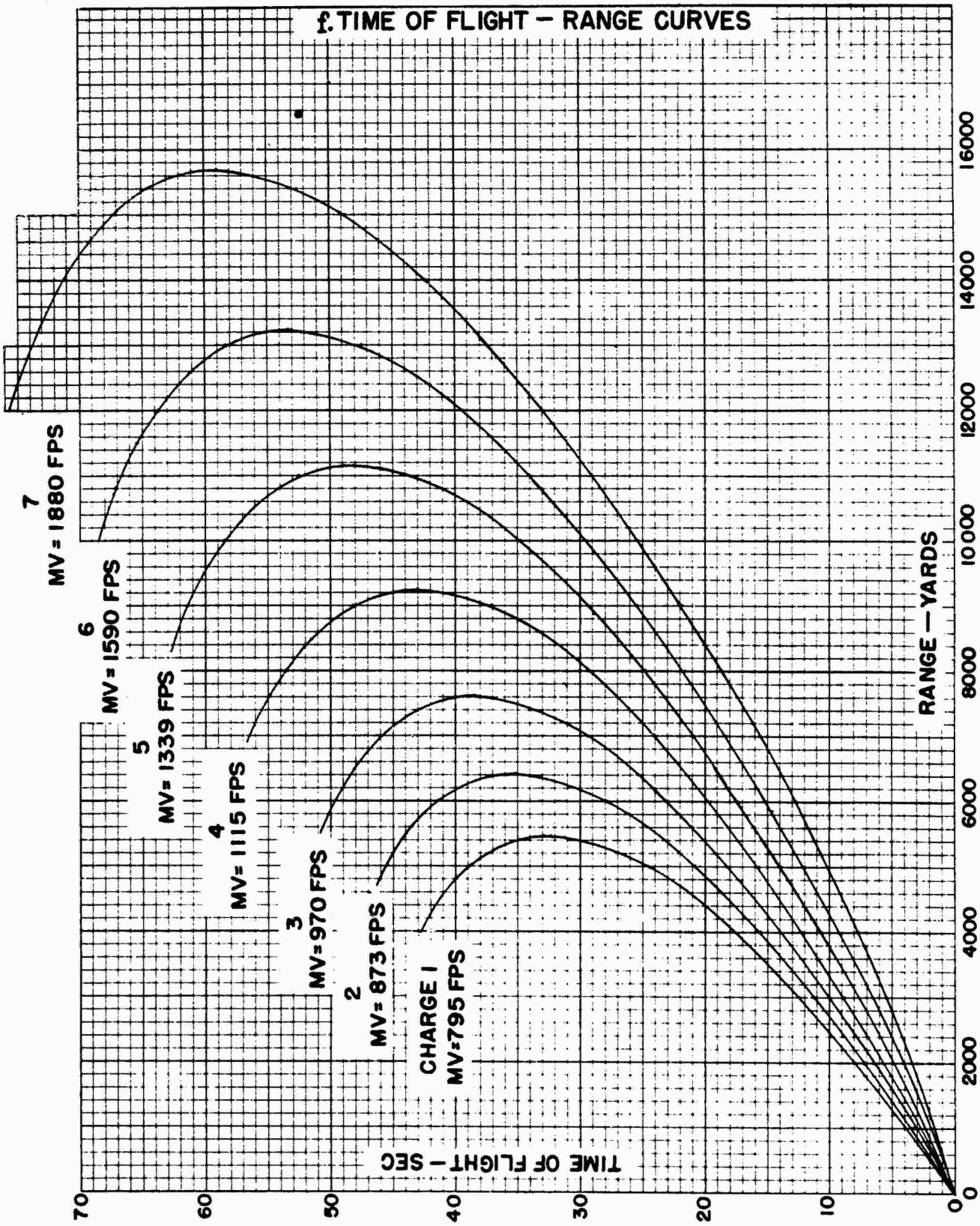
OCM items 17850 and 17883 authorized and approved limited use of the HE Shell Mark 1A1 with Propelling Charge M1 (green bag) zones 1 to 5 in the 8-inch Howitzer M1, which is now obsolete. OCM items 25379 and 25765 recommended and approved the classification of the HE Shell Mark 1A1 and Propelling Charge M2 (white bag) as limited standard for use in the 8-inch Howitzer M1. OCM items 29646 and 30180 recommended and approved the retention of this ammunition in the limited standard category for the 8-inch Howitzer M2, which has a stronger breech ring than the Howitzer M1 but is otherwise similar to it.

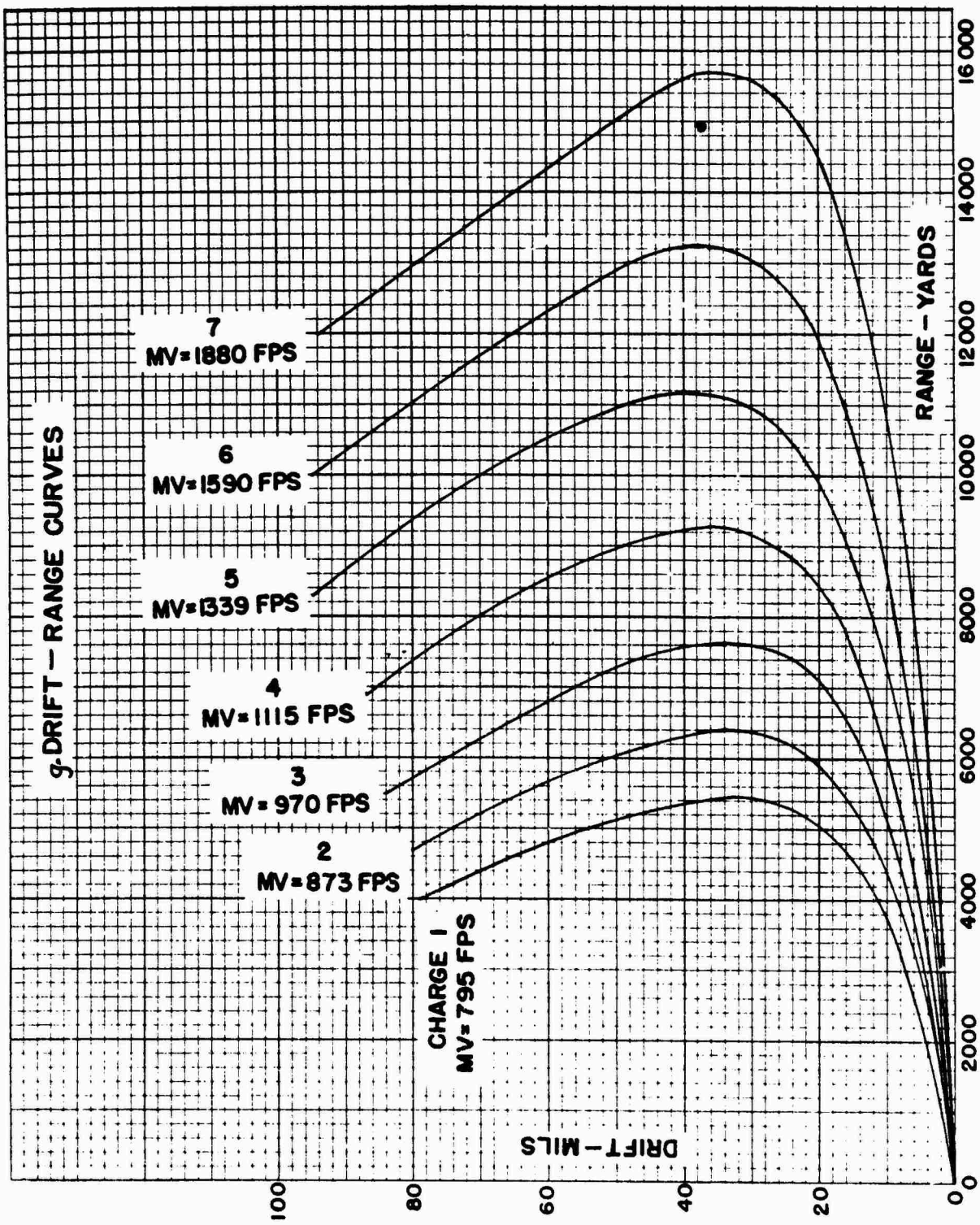

a. FORM FACTOR – ELEVATION CURVES (PROJ TYPE 6)
i_6
1.20
1.15
1.10
1.05
1.00
.95
0
200
400
600
800
1000
1200
ELEVATION – MILS
1&2
3
4
5
6
7
CHARGE MV
1 795 FPS
2 873 FPS
3 970 FPS
4 1115 FPS
5 1339 FPS
6 1590 FPS
7 1880 FPS
b. BALLISTIC COEFFICIENT – ELEVATION CURVES (PROJ TYPE 6)
C_6
3.20
3.00
2.80
2.60
0
200
400
600
800
1000
1200
ELEVATION – MILS
3
1&2
4
5
6
7

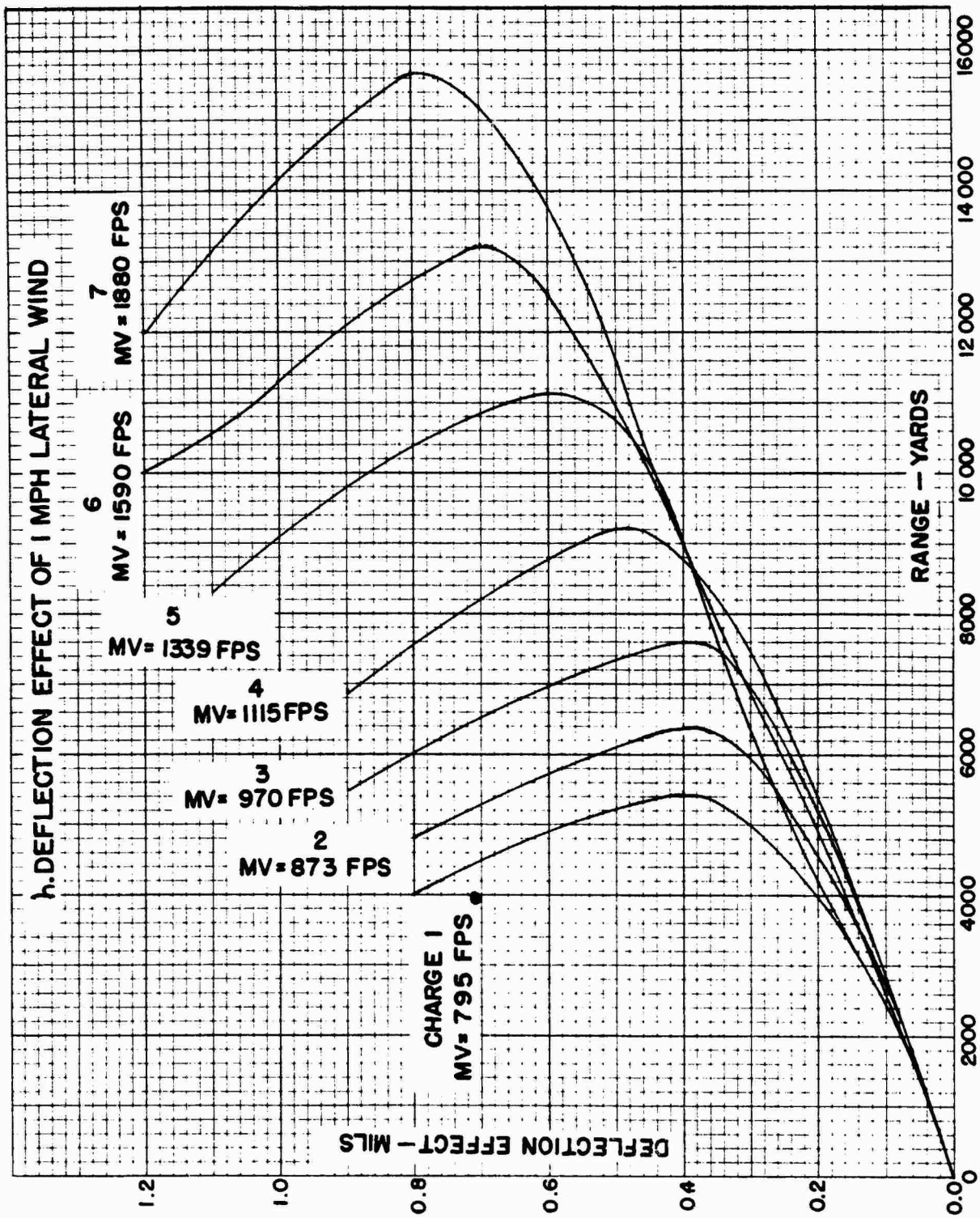

α ELEVATION-RANGE CURVES
MAX. RANGE-YDS
15690
13250
11170
9260
7630
6415
5475
MV
CHARGE
1880 FPS 7
1590 FPS 6
1339 FPS 5
1115 FPS 4
970 FPS 3
873 FPS 2
795 FPS 1
RANGE-YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
ELEVATION-MILS
0
200
400
600
800
1000
1200

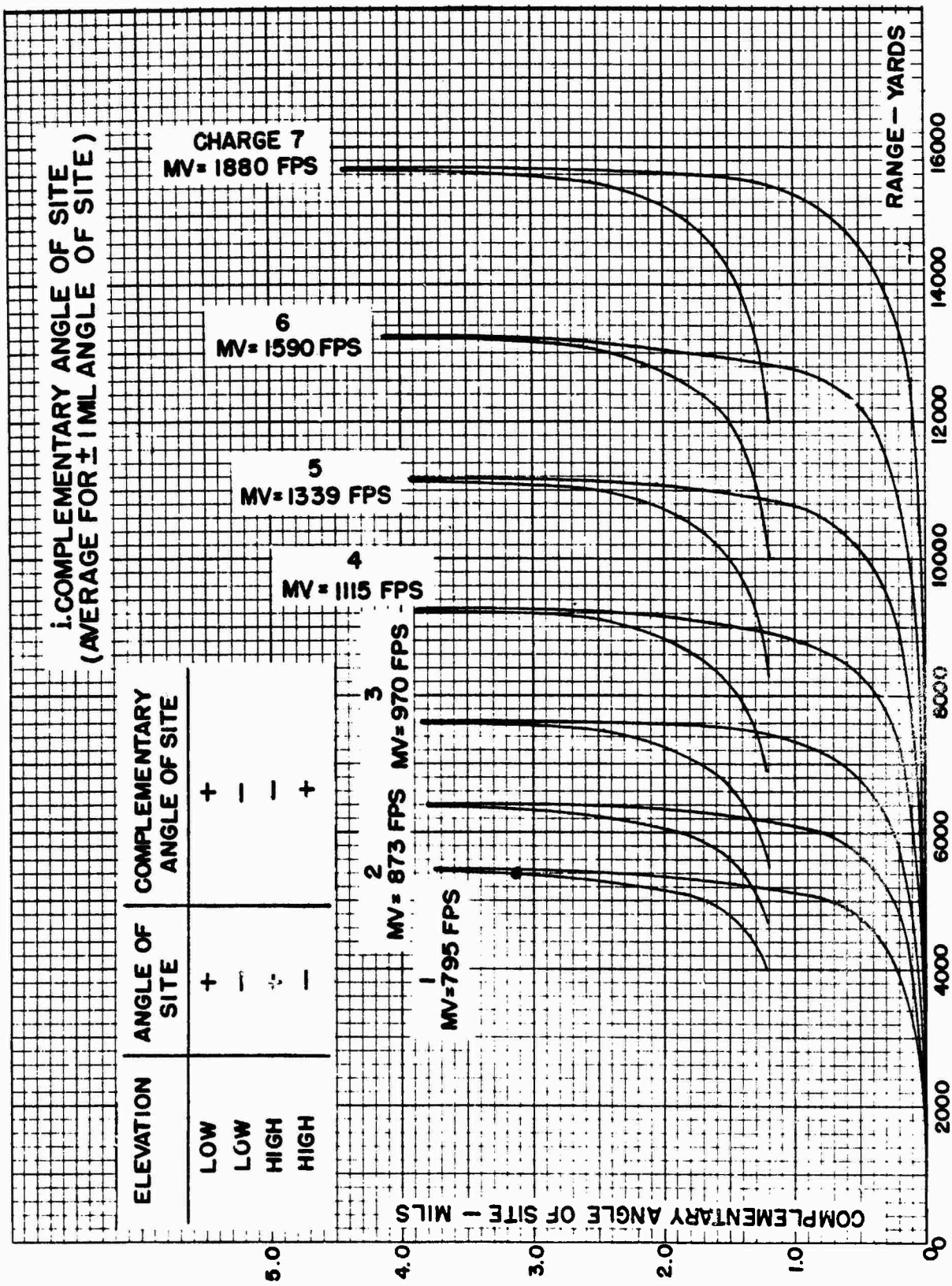

d. ANGLE OF FALL — RANGE CURVES
CHARGE- MV
7 1880 FPS
6 1590 FPS
5 1339 FPS
4 1115 FPS
3 970 FPS
2 873 FPS
1 795 FPS
ANGLE OF FALL — MILS
0
200
400
600
800
1000
1200
1400
RANGE — YARDS
0
2000
4000
6000
8000
10 000
12 000
14000
16000

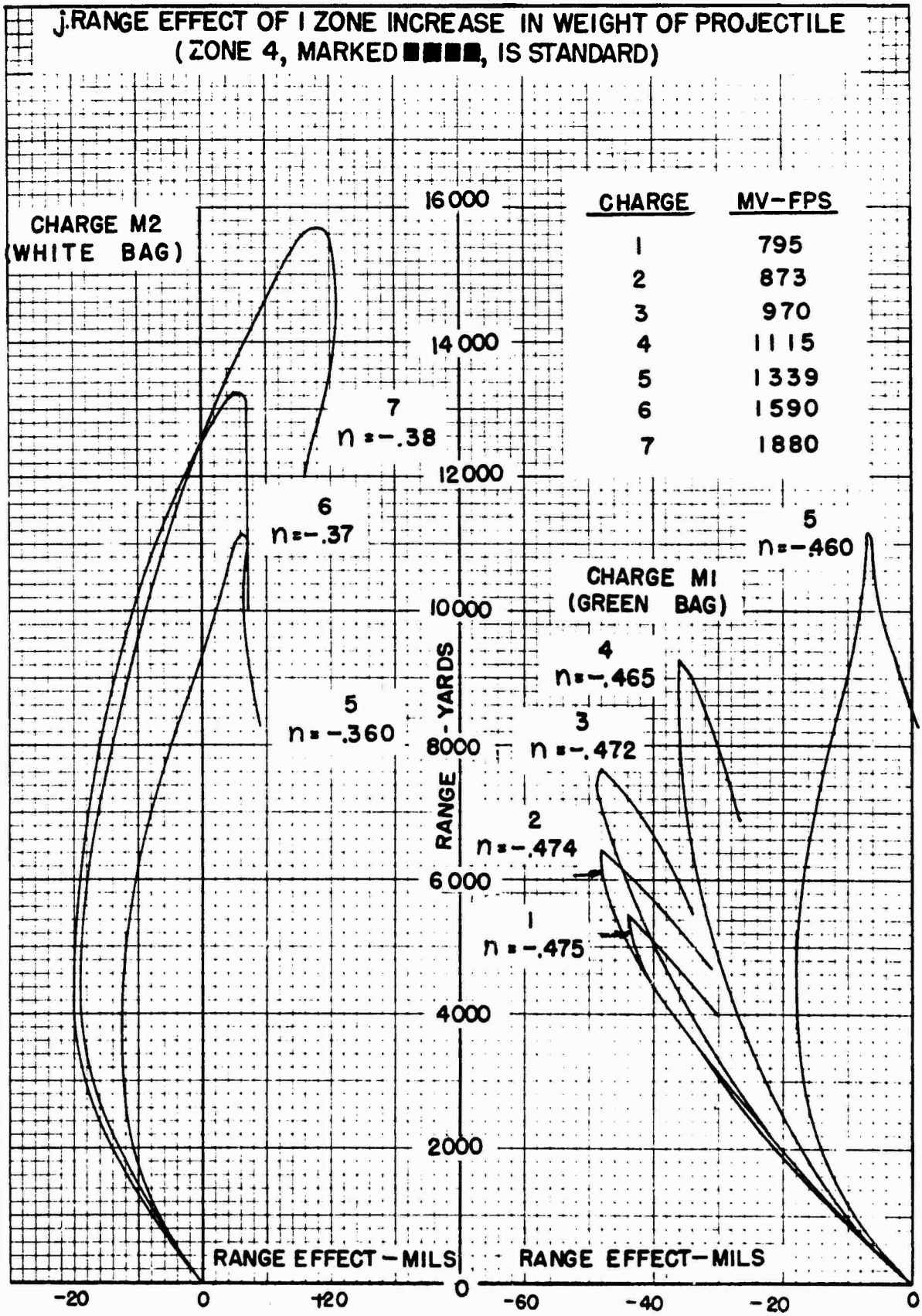

θ, TERMINAL VELOCITY – RANGE CURVES
7 MV= 1880 FPS
6 MV= 1590 FPS
5 MV= 1339 FPS
4 MV= 1115 FPS
3 MV= 970 FPS
2 MV= 873 FPS
CHARGE 1 MV= 795 FPS
RANGE–YARDS
TERMINAL VELOCITY – FPS
0
2000
4000
6000
8000
10000
12000
14000
16000
600
800
1000
1200
1400
1600
1800
2000

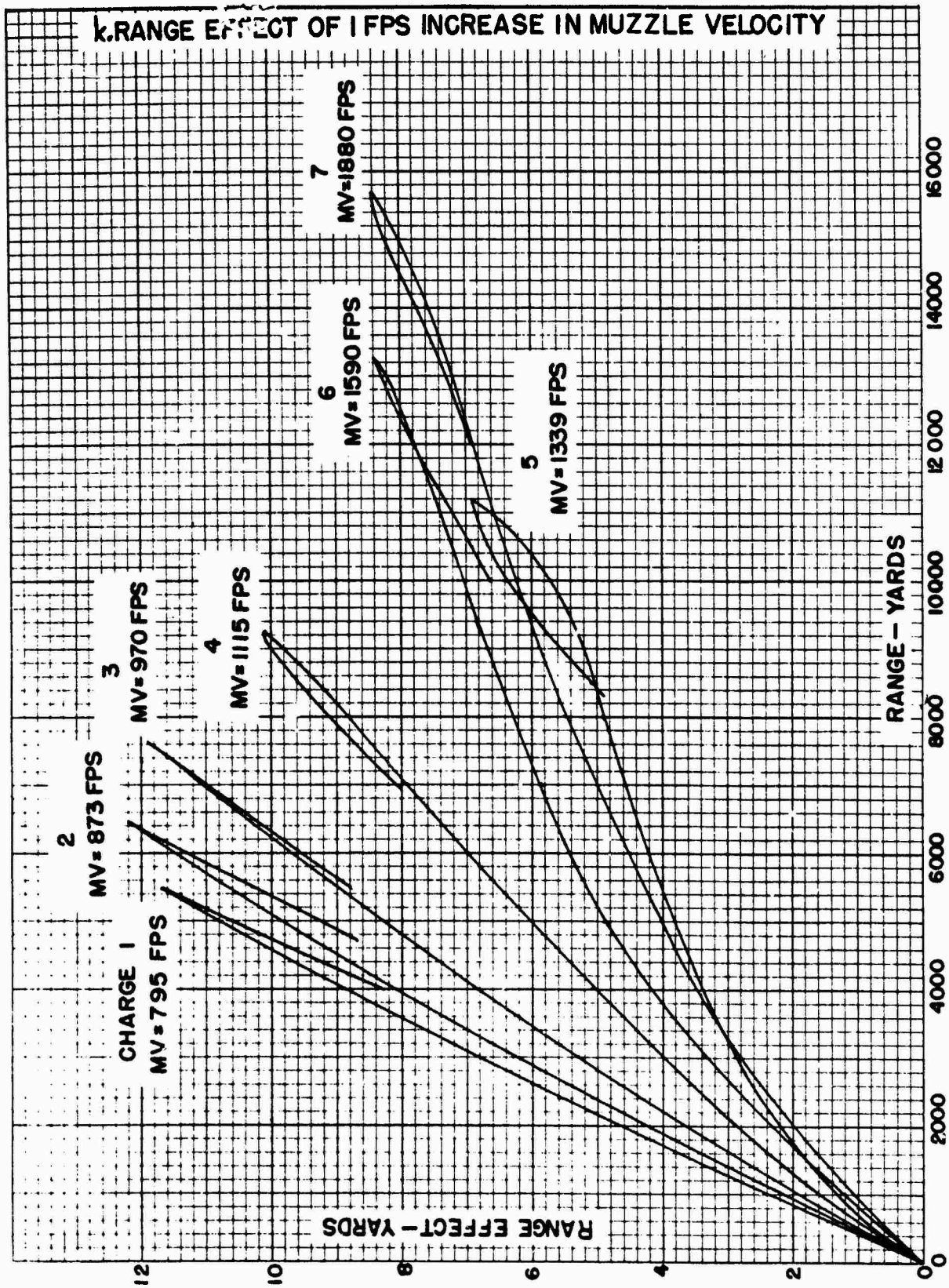

f. TIME OF FLIGHT — RANGE CURVES
7
MV = 1880 FPS
6
MV = 1590 FPS
5
MV = 1339 FPS
4
MV = 1115 FPS
3
MV = 970 FPS
2
MV = 873 FPS
CHARGE I
MV = 795 FPS
TIME OF FLIGHT — SEC
RANGE — YARDS
0
10
20
30
40
50
60
70
0
2000
4000
6000
8000
10000
12000
14000
16000

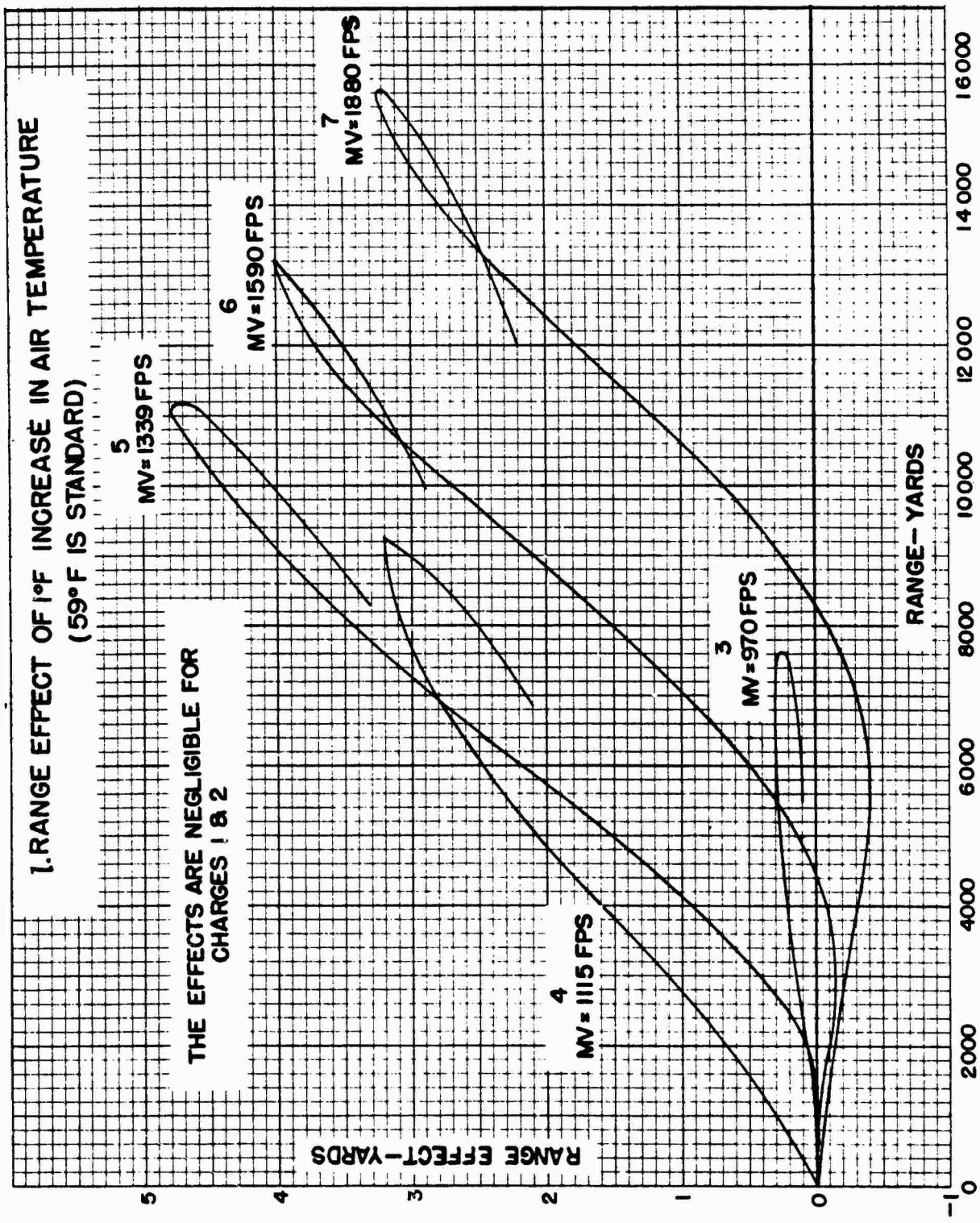

g-DRIFT – RANGE CURVES
7
MV=1880 FPS
6
MV=1590 FPS
5
MV=1339 FPS
4
MV=1115 FPS
3
MV=970 FPS
2
MV=873 FPS
CHARGE I
MV=795 FPS
DRIFT – MILS
0
20
40
60
80
100
RANGE – YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000

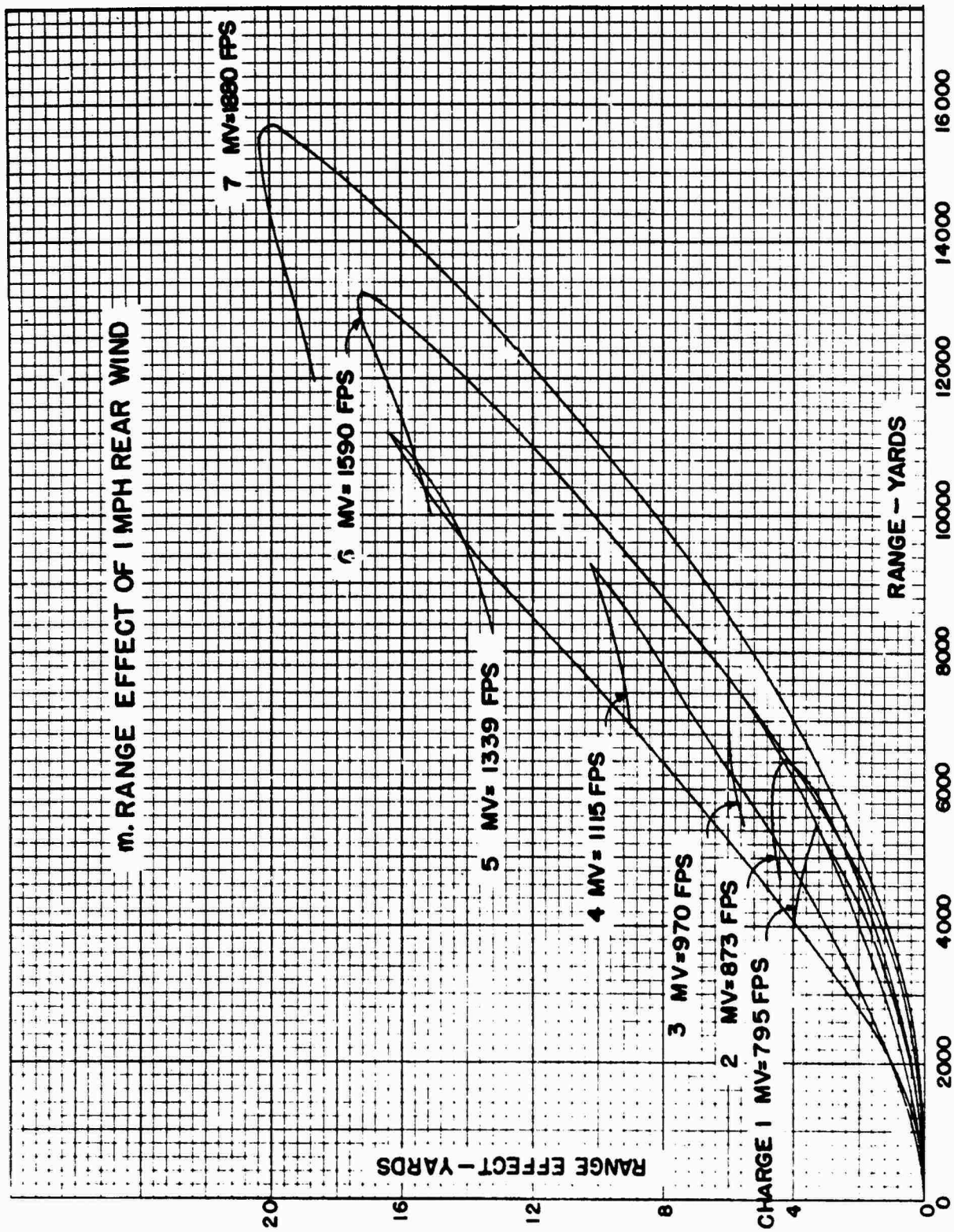

h. DEFLECTION EFFECT OF 1 MPH LATERAL WIND
7
MV = 1880 FPS
6
MV = 1590 FPS
5
MV = 1339 FPS
4
MV = 1115 FPS
3
MV = 970 FPS
2
MV = 873 FPS
CHARGE 1
MV = 795 FPS
DEFLECTION EFFECT — MILS
1.2
1.0
0.8
0.6
0.4
0.2
0.0
RANGE — YARDS
0
2000
4000
6000
8000
10 000
12 000
14 000
16000

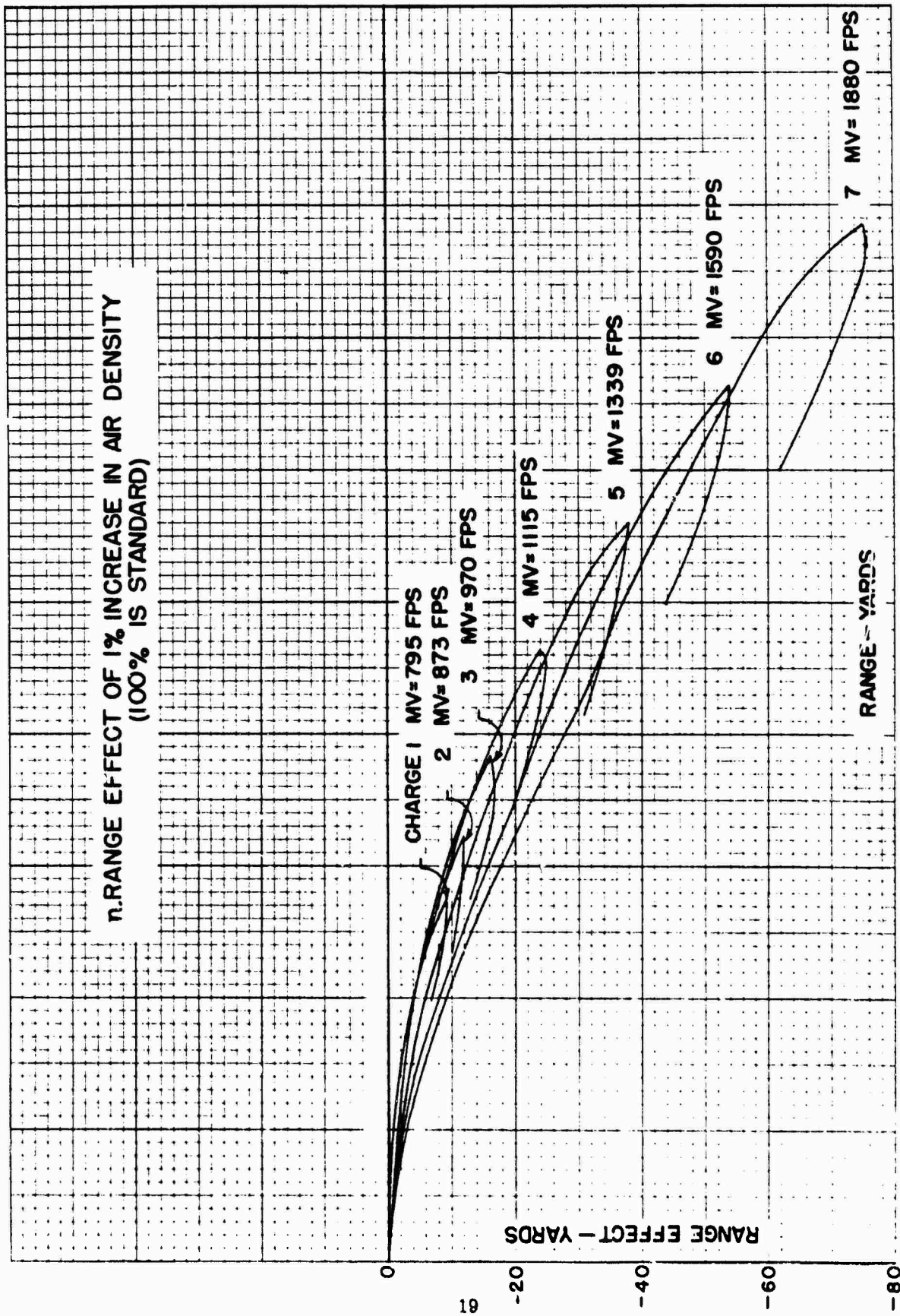

i. COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ± 1 MIL ANGLE OF SITE)
CHARGE 7
MV= 1880 FPS
6
MV= 1590 FPS
5
MV= 1339 FPS
4
MV = 1115 FPS
3
MV= 970 FPS
2
MV= 873 FPS
1
MV=795 FPS
ELEVATION
ANGLE OF SITE
COMPLEMENTARY ANGLE OF SITE
LOW + +
LOW − −
HIGH + −
HIGH − +
RANGE — YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
COMPLEMENTARY ANGLE OF SITE — MILS
0
1.0
2.0
3.0
4.0
5.0


j. RANGE EFFECT OF 1 ZONE INCREASE IN WEIGHT OF PROJECTILE
(ZONE 4, MARKED ■■■■, IS STANDARD)
CHARGE M2
(WHITE BAG)
CHARGE M1
(GREEN BAG)
CHARGE MV-FPS
1 795
2 873
3 970
4 1115
5 1339
6 1590
7 1880
7
n = -.38
6
n = -.37
5
n = -.360
5
n = -.460
4
n = -.465
3
n = -.472
2
n = -.474
1
n = -.475
RANGE - YARDS
16000
14000
12000
10000
8000
6000
4000
2000
0
RANGE EFFECT - MILS
-20
0
+20
RANGE EFFECT - MILS
-60
-40
-20
0


k. RANGE EFFECT OF 1 FPS INCREASE IN MUZZLE VELOCITY
CHARGE 1
MV = 795 FPS
2
MV = 873 FPS
3
MV = 970 FPS
4
MV = 1115 FPS
5
MV = 1339 FPS
6
MV = 1590 FPS
7
MV = 1880 FPS
RANGE EFFECT – YARDS
0
2
4
6
8
10
12
RANGE – YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000


1. RANGE EFFECT OF 1°F INCREASE IN AIR TEMPERATURE
(59° F IS STANDARD)
THE EFFECTS ARE NEGLIGIBLE FOR CHARGES 1 & 2
3
MV=970 FPS
4
MV=1115 FPS
5
MV=1339 FPS
6
MV=1590 FPS
7
MV=1880 FPS
RANGE EFFECT—YARDS
RANGE—YARDS
5
4
3
2
1
0
-1
0
2000
4000
6000
8000
10000
12000
14000
16000


m. RANGE EFFECT OF 1 MPH REAR WIND
7 MV=1880 FPS
6 MV= 1590 FPS
5 MV= 1339 FPS
4 MV= 1115 FPS
3 MV=970 FPS
2 MV=873 FPS
CHARGE 1 MV=795 FPS
RANGE EFFECT – YARDS
RANGE – YARDS
0
4
8
12
16
20
0
2000
4000
6000
8000
10000
12000
14000
16000


n.RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
CHARGE 1 MV=795 FPS
2 MV=873 FPS
3 MV=970 FPS
4 MV=1115 FPS
5 MV=1339 FPS
6 MV=1590 FPS
7 MV=1880 FPS
RANGE EFFECT — YARDS
RANGE — YARDS
0
-20
-40
-60
-80
0
2000
4000
6000
8000
10000
12000
14000
16000

SECTION V
EFFECT DATA

	Paragraph
Penetration	9

9. Penetration. The HE Shell Mark 1A1 is used as a substitute for the standard HE Shell M106. For the penetration of the HE Shell M106, see BRLH 8-1-106.

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 8-1-106

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
14 March 1949

BALLISTIC AND ENGINEERING DATA

for

Shell, HE, 8-inch, M106

with

Fuzes, PD, M51A4; TSQ, M55A3; MT, M67A3; and CP, M78

Section		Paragraphs
I	General	1
II	Description	2 - 4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 8
V	Effect data	9 -11

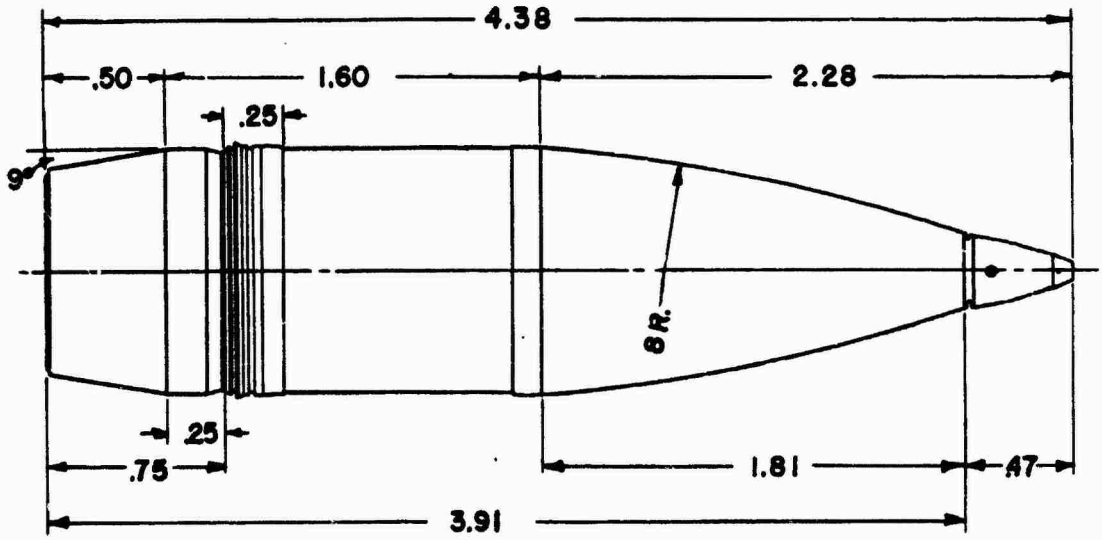
SECTION I

GENERAL

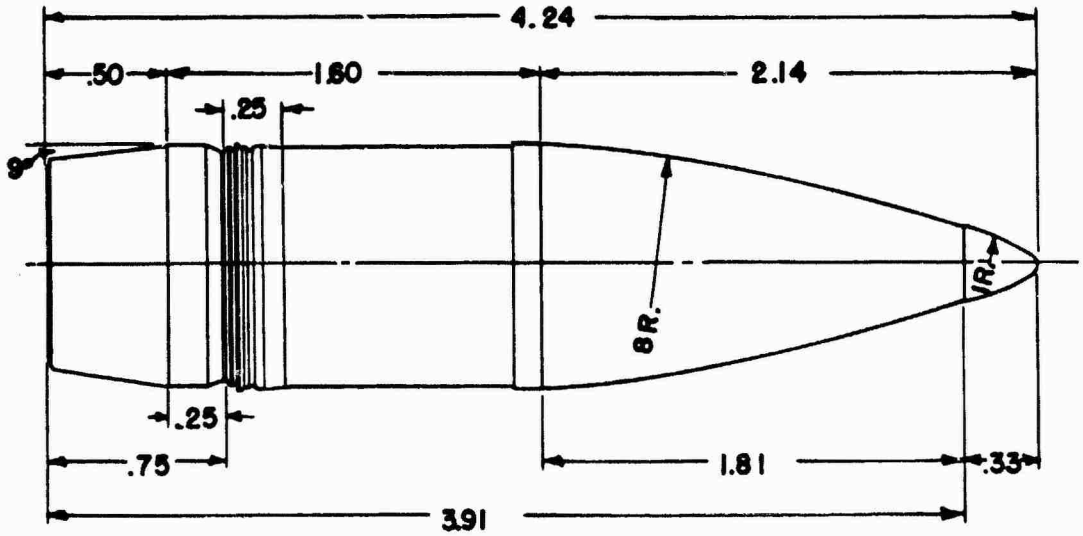
	Paragraph
Purpose	1

1. Purpose. The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 8-inch High Explosive Shell M106 with the Point Detonating Fuze M51A4, the Time and Superquick Fuze M55A3, the Mechanical Time Fuze M67A3, and the Concrete Piercing Fuze M78. This information is collected from the drawings, reports, firing tables, and technical manual pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 8.000" (203.2 MM)



SHELL, HE, 8-INCH, M106
FUZE, PD, M51A4



SHELL, HE, 8-INCH, M106
FUZE, CP, M78

SECTION II

DESCRIPTION

	Paragraph
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

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Details	73-2-143
Fuze, TSQ, M54: Assembly	73-3-154
Fuze, TSQ, M55A3: Assembly and details	73-3-155
(The Booster, M21A4, and the Fuze, TSQ, M54 are components of the Fuze, TSQ, M55A3)	
Fuze, MT, M67A3: Assembly	73-7-77
Fuze, CP, M78: Body assembly and details	73-2-214

3. Dimensions.

Boattail: Angle	9°00'
Length	0.50 cal
Band: Distance from boattail	0.25 cal
Distance from base	0.75 cal
Width	0.25 cal
Cylindrical body: Length	1.60 cal
Ogive: Length	1.81 cal
Radius of arc	8.00 cal
Shell, unfuzed: Length	3.91 cal
Fuze, PD, M51A4; TSQ, M55A3; or MT, M67A3:	
Outside length	0.47 cal
Shell and fuze	4.38 cal
Ogive and fuze	2.28 cal
Fuze, CP, M78: Outside length	0.33 cal
Radius of arc	1.00 cal
Shell and fuze	4.24 cal
Ogive and fuze	2.14 cal

4. Physical characteristics.

Fuze

		PD, TSQ, MT	CP
Mean weight (lb):	Zone 3	198.40	198.74
	Zone 4 (standard)	200.00	200.34
	Zone 5	201.60	201.94

Axial moment of inertia (estimated) 12.7 lb ft ^{2}

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Stresses -	5
Theoretical yaw in bore -	6

5. Stresses. The following table and the graphical representation on page 5 show the longitudinal, radial and tangential stress at each of two sections: (A) the rear corner of the band seat and (B) the front of the band seat.

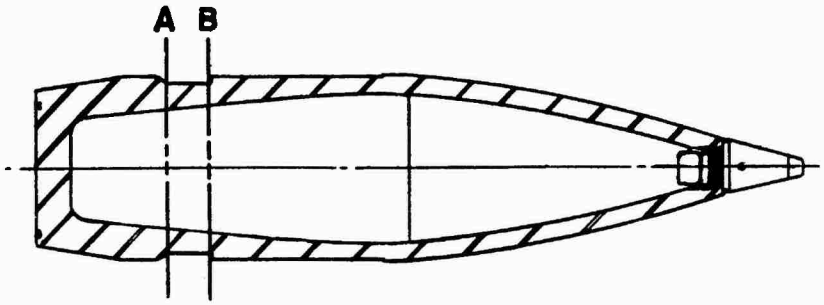
Howitzer	8-inch M2
Twist of rifling	1/25.5
Cross-sectional area of bore	51.321 sq in.
Rated maximum pressure	33,000 psi
Total weight of projectile	200 lb
Muzzle velocity	1,950 fps
Density of filler (TNT)	0.057 lb per cu in.

Resultant Stress* 100 psi	Section A	Section B
Longitudinal	- 205	- 465
Radial	+ 288	- 231
Tangential	- 564	+ 749

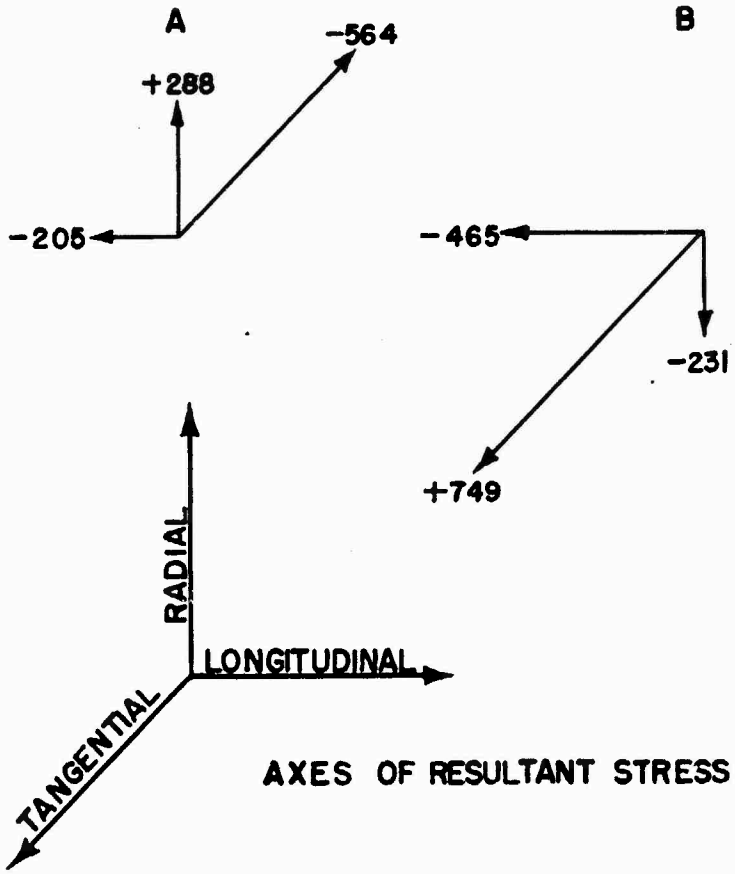
* + denotes tension, - denotes compression.

6. Theoretical yaw in bore.

Minimum	4.0 min
Maximum	7.5 min



SECTIONS



AXES OF RESULTANT STRESS

DIAGRAM OF RESULTANT STRESSES

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data	7
Firing table data	8

7. Aerodynamic data.

a. Resistance firings. The following table gives the form factors of the HE Shell M106 with the PD Fuze M51 relative to Projectile Type 5, which were determined from resistance firings, and the corresponding ballistic coefficients and drag coefficients.

Velocity fps	Form Factor i_5	Ballistic Coefficient C_5	Drag Coefficient K_D
815	.86	3.63	.050
1370	.92	3.40	.157
1940	.79	3.96	.130

b. Range firings. The trajectories for the 8-inch Howitzer M2 were based on the following drag functions:

G_5 for Charges 1 to 5 inclusive.

G_5 + .0061 for Charge 6.

G_5 + .0133 for Charge 7.

The modifications for Charges 6 and 7 were chosen to give closer agreement between the computed and observed values of both time of flight and range than the G_5 function could give. The ballistic coefficients of the HE Shell M106 with the PD Fuze M51 relative to the G_5 function, which are equivalent to the ballistic coefficients relative to the above functions determined from range firings and extrapolated to zero elevation, are tabulated below, together with the corresponding form factors and drag coefficients.

Charge No.	Muzzle Velocity fps	Form Factor i_5	Ballistic Coefficient C_5	Drag Coefficient K_D
1	820	.89	3.50	.051
2	900	.91	3.44	.053
3	1000	.92	3.39	.064
4	1150	.93	3.36	.142
5	1380	.94	3.34	.161
6	1640	.89	3.53	.154
7	1950	.82	3.79	.135

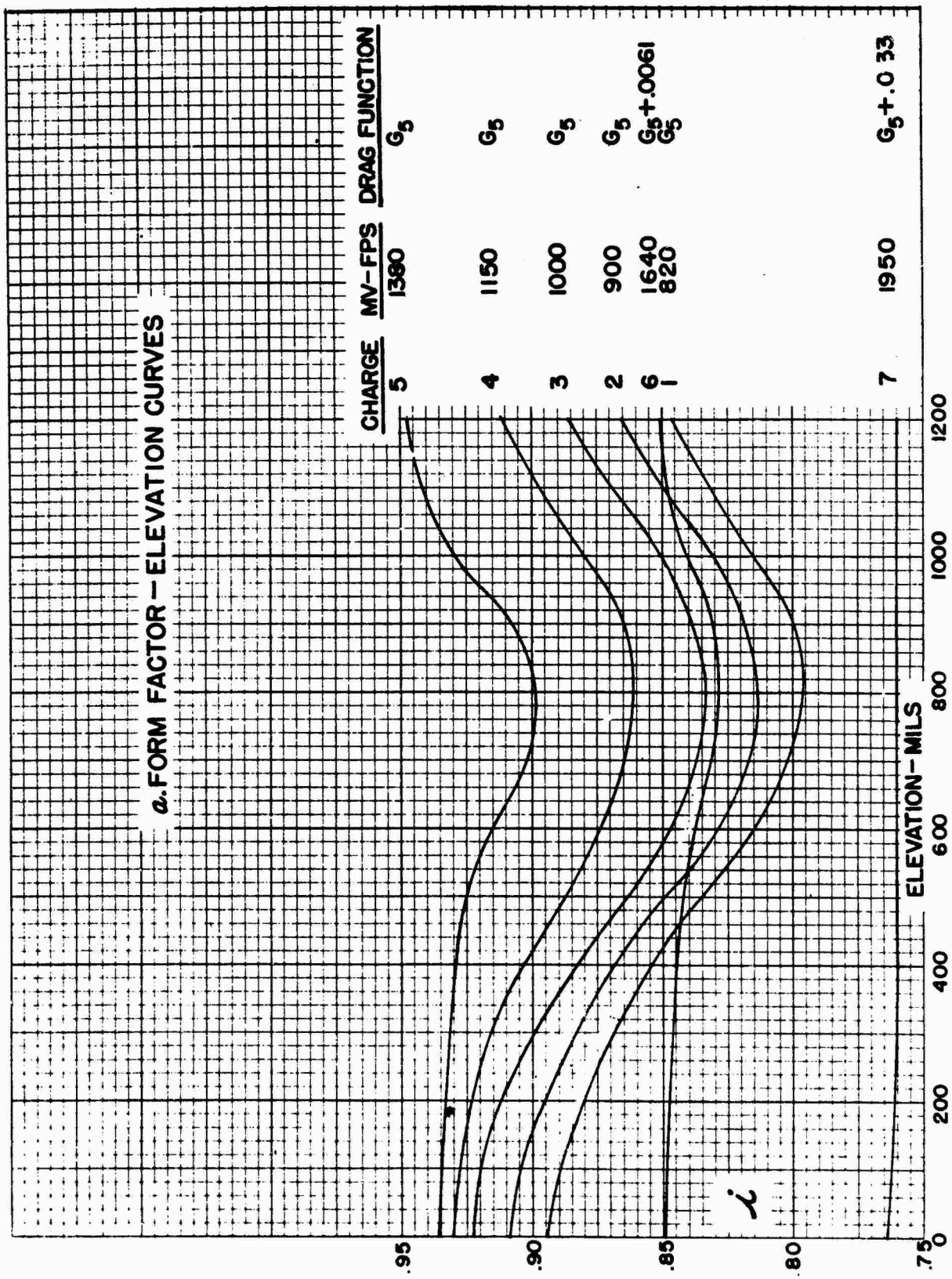
c. Spin firings. Ballistic Research Laboratory Report No. 408, "Loss of Spin and Skin Friction Drag of Projectiles", gives the data obtained by means of a radio spin sonde from an inert M106 Shell with a dummy fuze that has the same contour as the PD Fuze M51A4, fired from an 8-inch Howitzer M1E1 (twist of rifling: 1/25) at a muzzle velocity of 1948 fps (avg of 2 rounds). Below are average data for times of flight from 0 to 24 seconds:

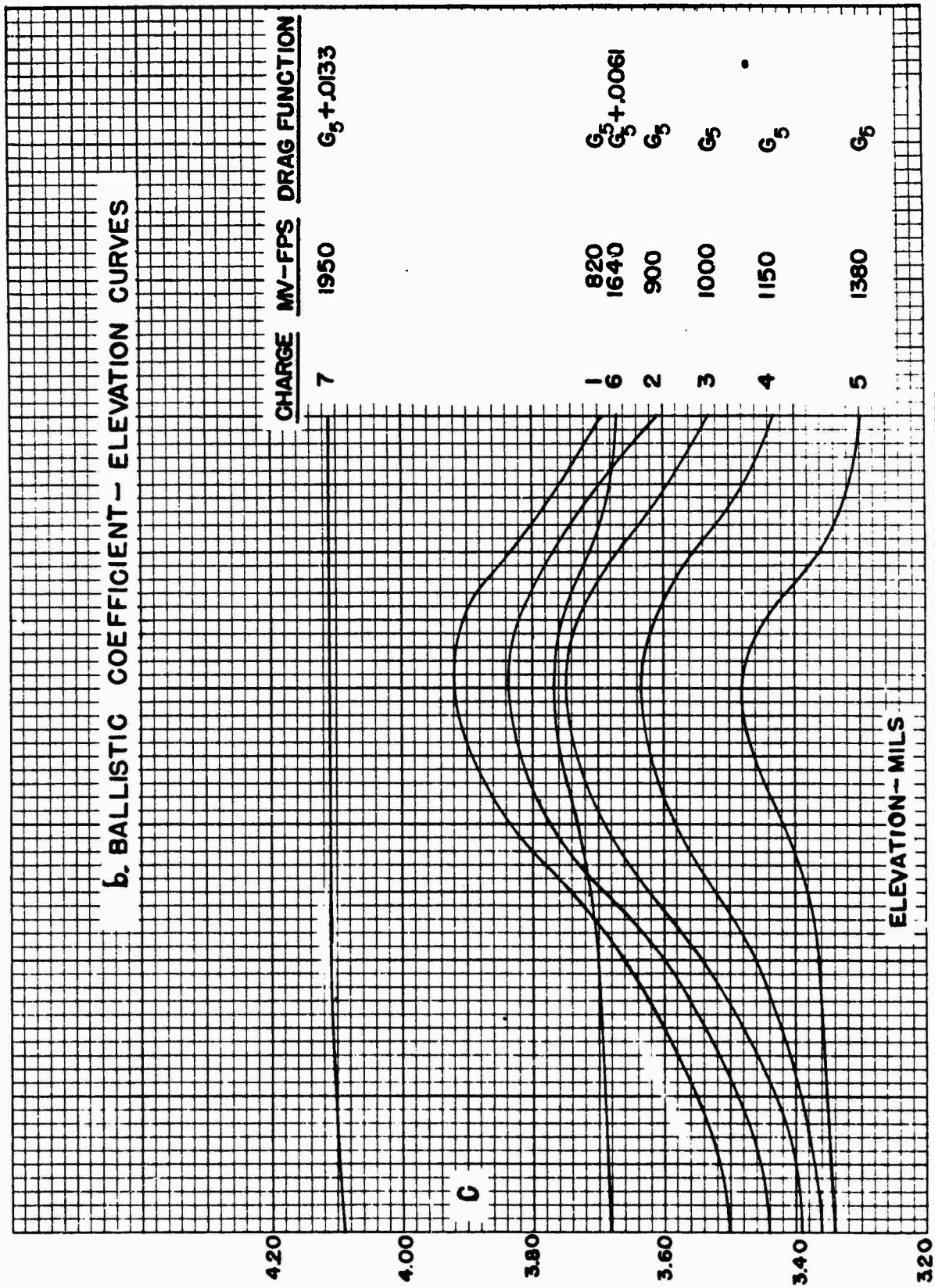
Reynolds' number, based on the translational velocity and the caliber of the shell and the kinematic viscosity of the air	6.10×10^6
Axial couple coefficient, K_A	0.0045
Skin friction drag coefficient, C'_{DF}	0.00172

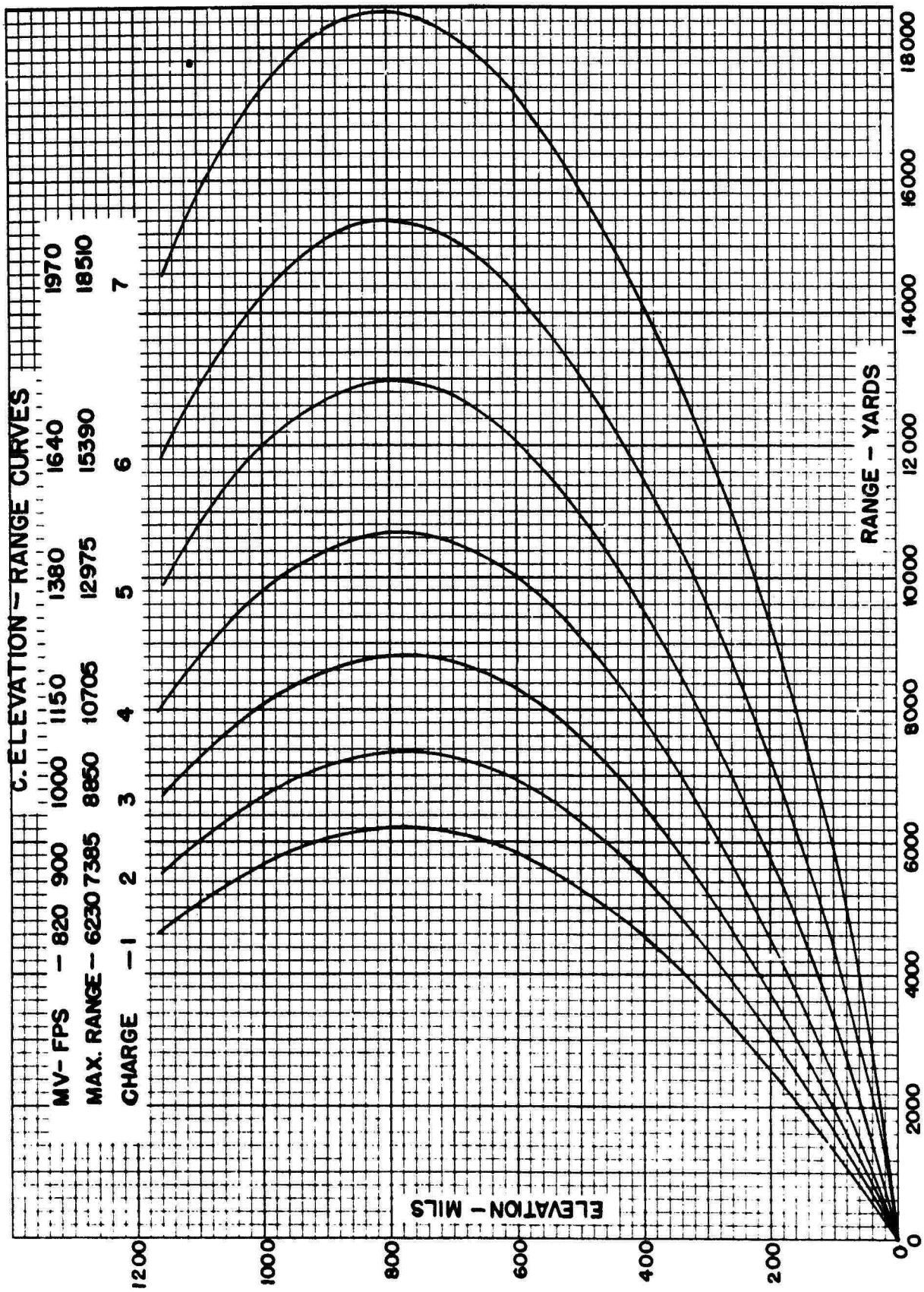
8. Firing table data.

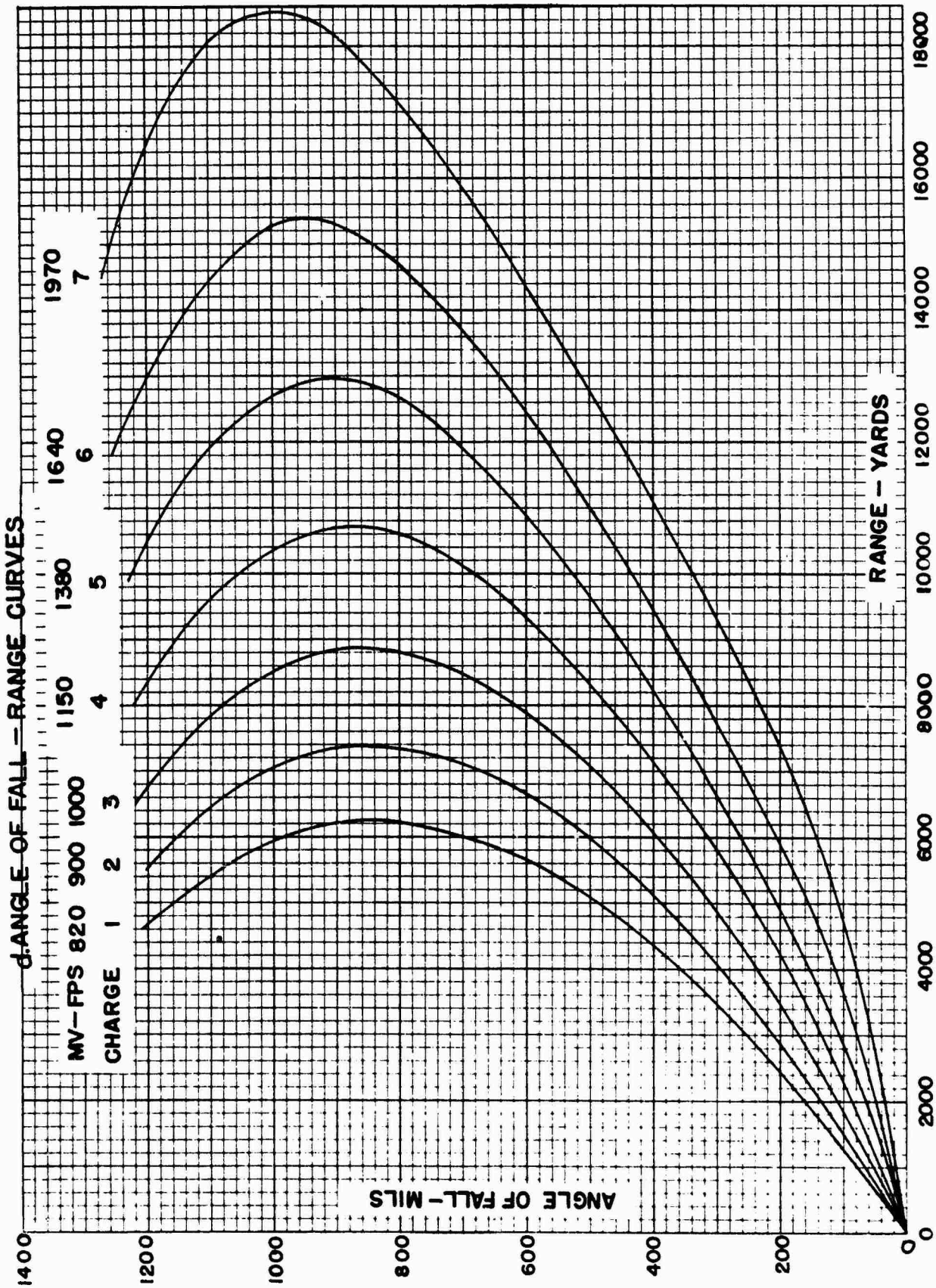
FT 8-J-1 contains tables for the HE Shell M106 with the PD Fuze M51A4, propelled by Charge M1 (green bag) zones 1 to 5 and by Charge M2 (white bag) zones 5 to 7. FT 8-J-1, C3, contains range and deflection effects of the earth's rotation and fuze setting data for the MT Fuze M67A3. FT 8-J-1, C4, states that the increase in air resistance due to using the CP Fuze M78 instead of the PD Fuze M51A4 has the same effect on range as a 1% increase in air density. FT 8-J-1, C5, contains fuze setting data for the TSQ Fuze M55A3.

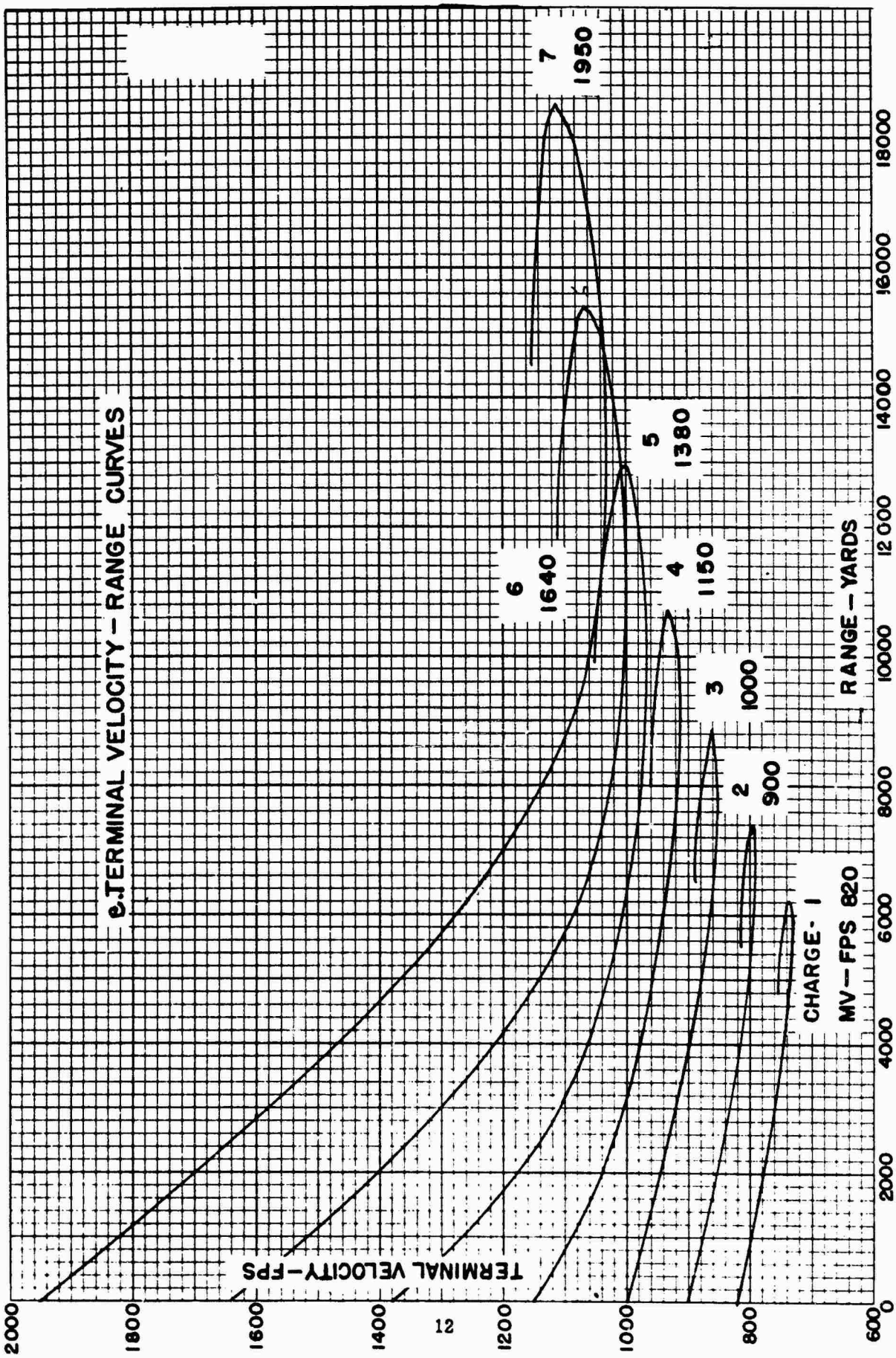
Howitzer, 8-inch, M2. Twist of rifling: 1/25.5. OCM items 16056 and 16178 standardized the HE Shell M106 with Propelling Charges M1 (green bag) and M2 (white bag) for use in the 8-inch Howitzer M1, which is now obsolete. The Howitzer M2 has a stronger breech ring than the Howitzer M1, but is otherwise similar to it.

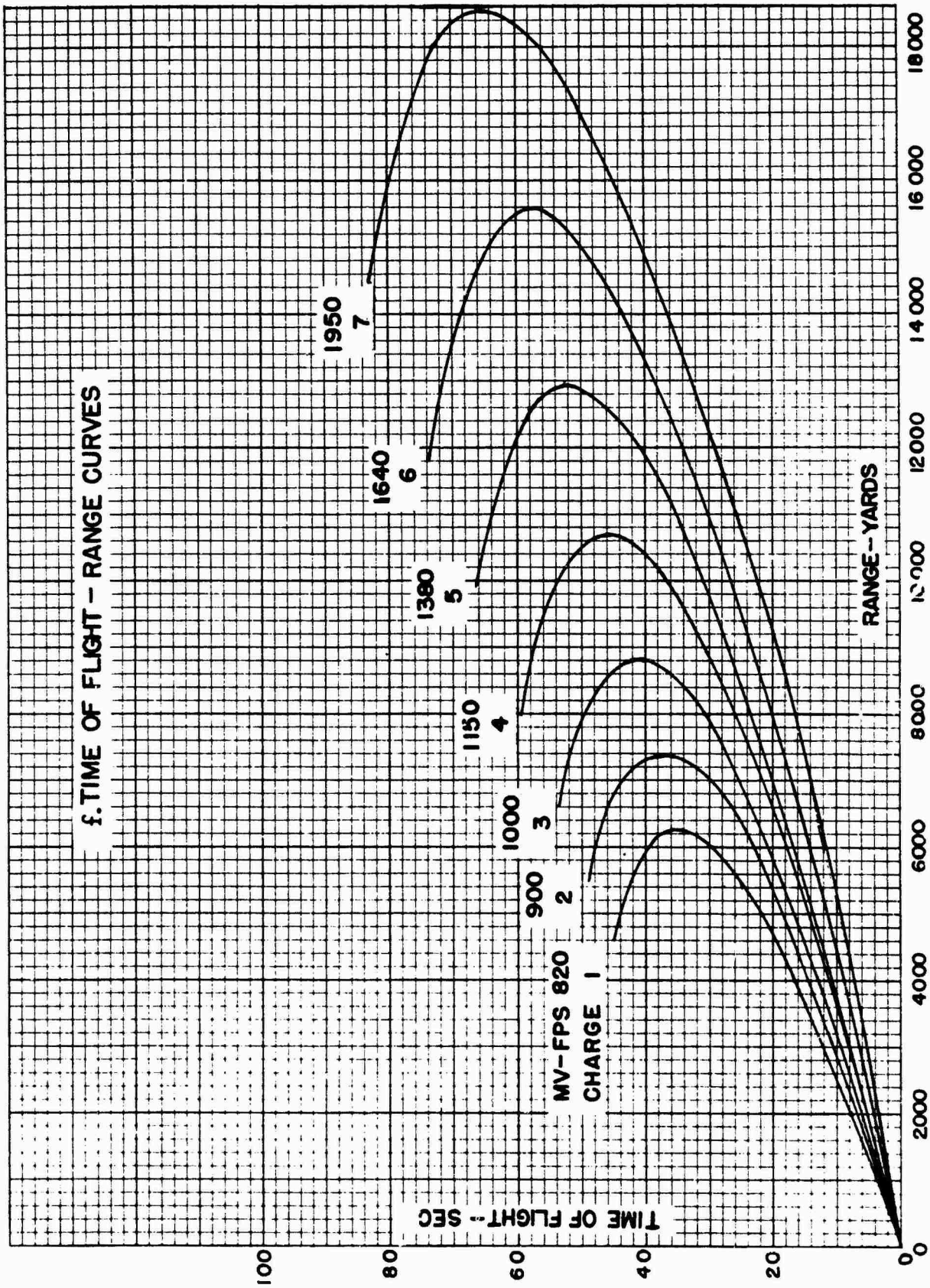

a. FORM FACTOR – ELEVATION CURVES
CHARGE
MV–FPS
DRAG FUNCTION
5
1380
G5
4
1150
G5
3
1000
G5
2
900
G5
6
1640
G5+.0061
1
820
G5
7
1950
G5+.033
ELEVATION–MILS
0
200
400
600
800
1000
1200
.95
.90
.85
.80
.75
i

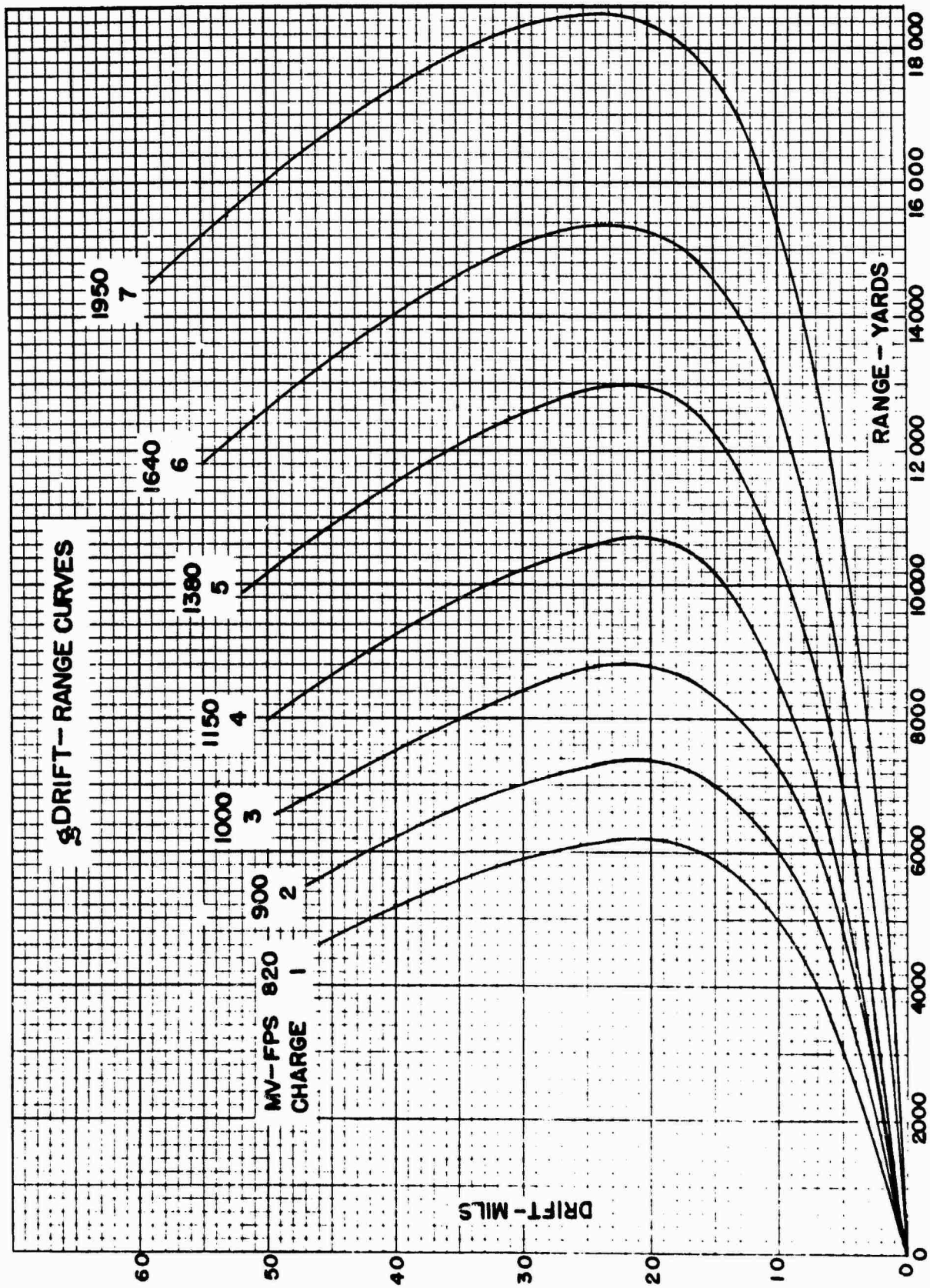

b. BALLISTIC COEFFICIENT – ELEVATION CURVES
CHARGE
MV–FPS
DRAG FUNCTION
7
1950
G5+.0133
1
6
820
1640
G5
G5+.0061
2
900
G5
3
1000
G5
4
1150
G5
5
1380
G5
C
4.20
4.00
3.80
3.60
3.40
3.20
0
200
400
600
800
1000
1200
ELEVATION–MILS

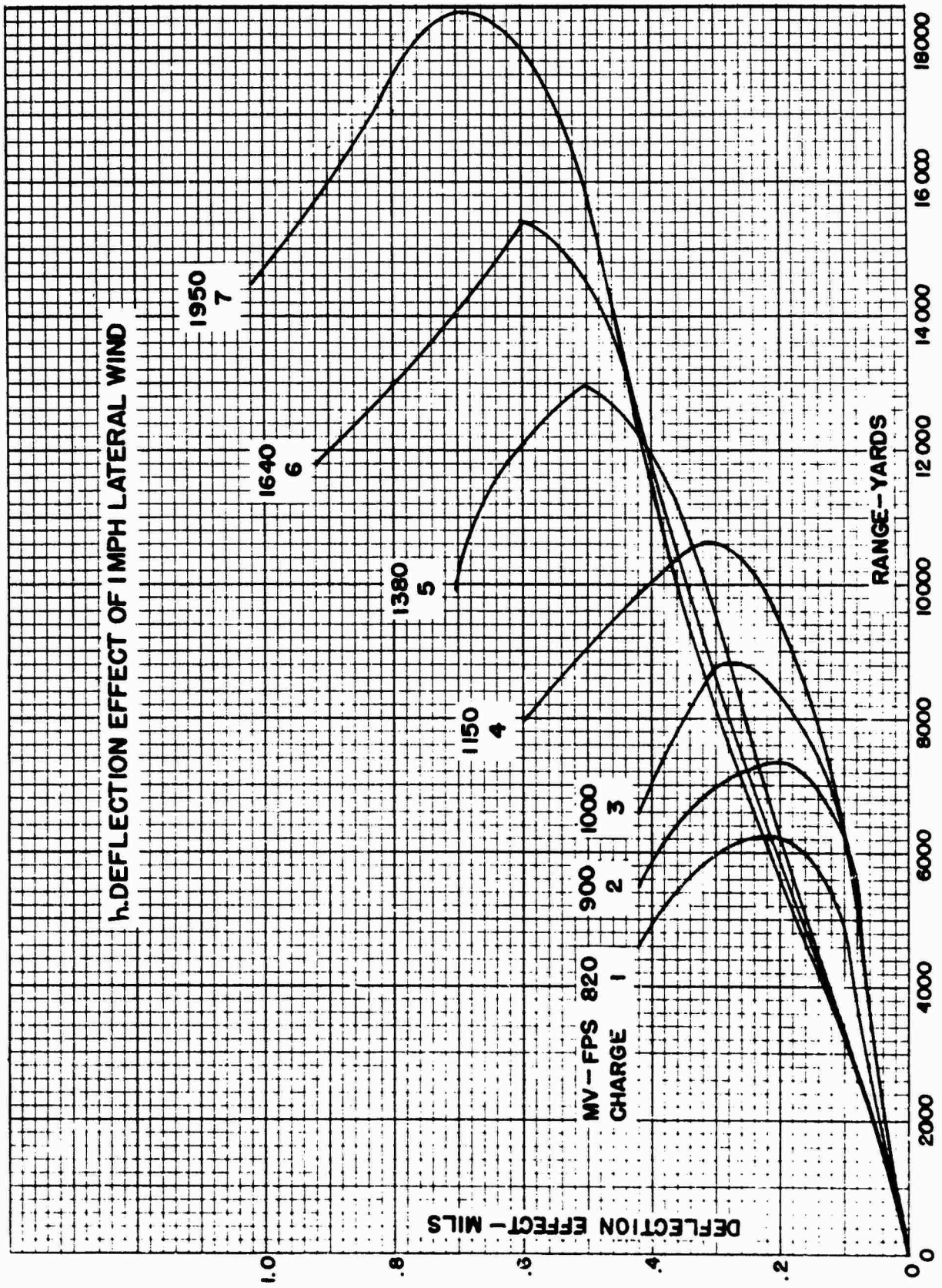

C. ELEVATION – RANGE CURVES
MV- FPS – 820 900 1000 1150 1380 1640 1970
MAX. RANGE – 6230 7385 8850 10705 12975 15390 18510
CHARGE – 1 2 3 4 5 6 7
ELEVATION – MILS
RANGE – YARDS
0
200
400
600
800
1000
1200
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

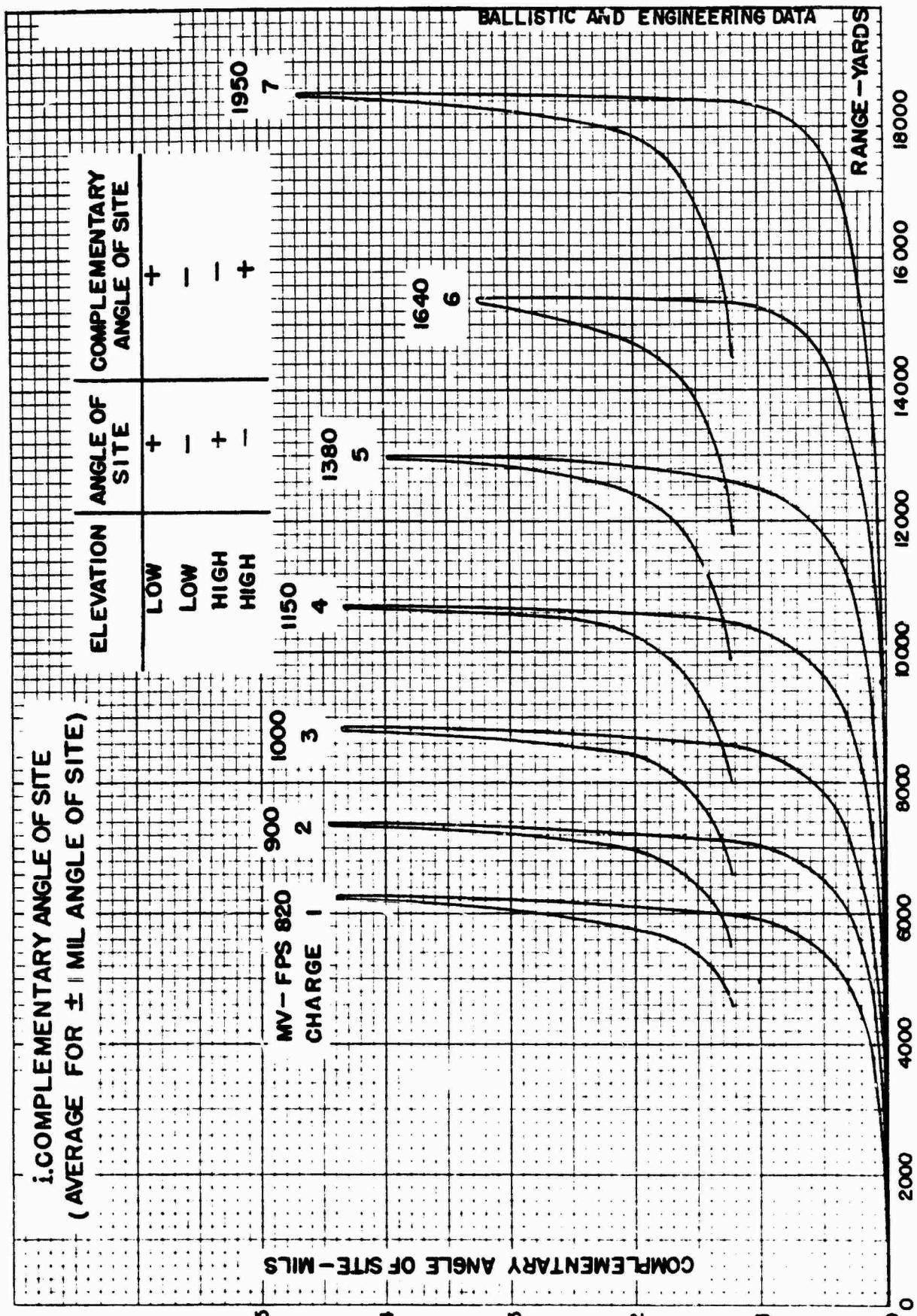

ANGLE OF FALL – RANGE CURVES
MV–FPS 820 900 1000 1150 1380 1640 1970
CHARGE 1 2 3 4 5 6 7
ANGLE OF FALL – MILS
RANGE – YARDS
0
200
400
600
800
1000
1200
1400
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

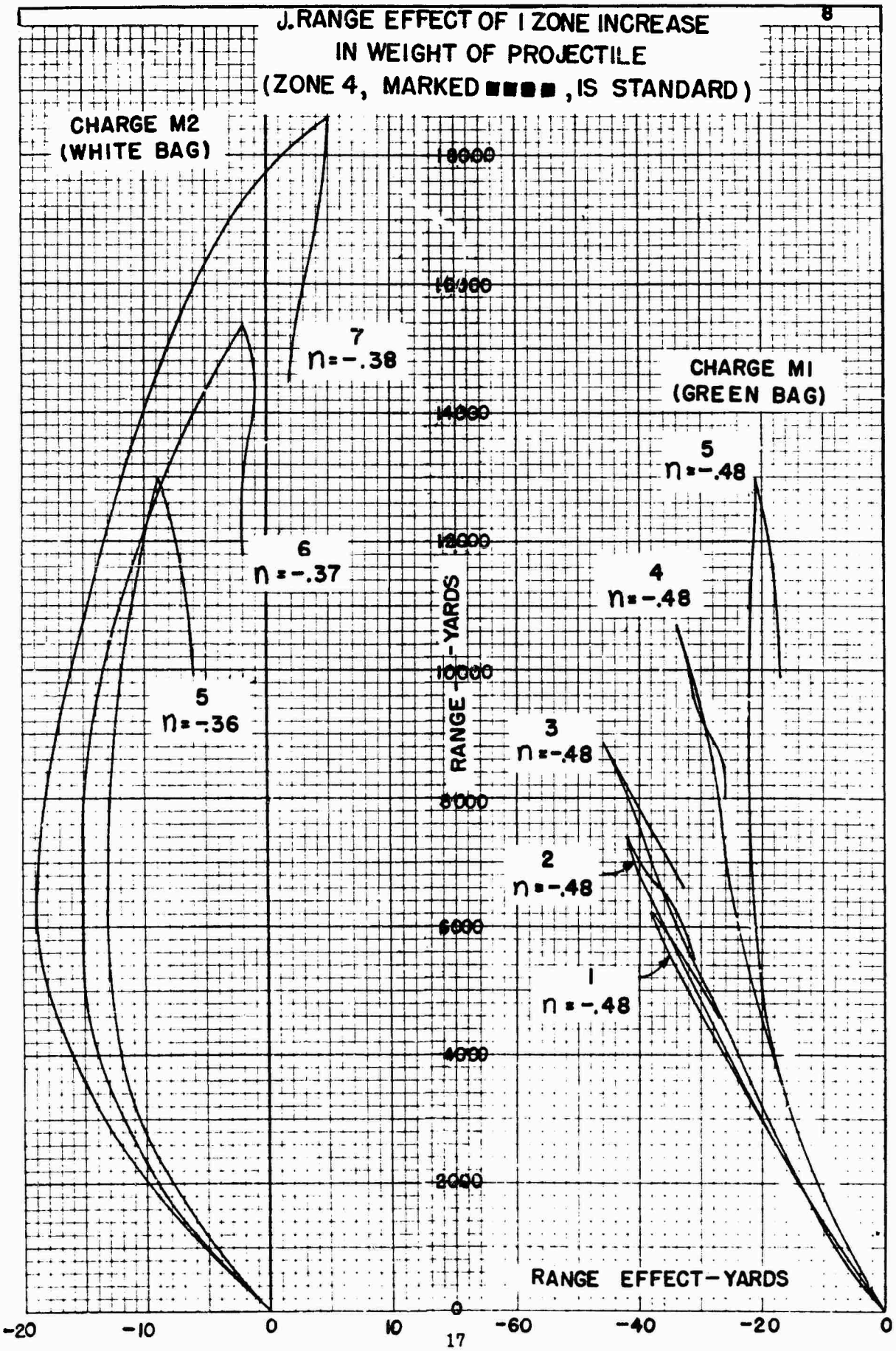

e. TERMINAL VELOCITY – RANGE CURVES
TERMINAL VELOCITY – FPS
RANGE – YARDS
CHARGE - I
MV – FPS 820
7
1950
6
1640
5
1380
4
1150
3
1000
2
900
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
600
800
1000
1200
1400
1600
1800
2000

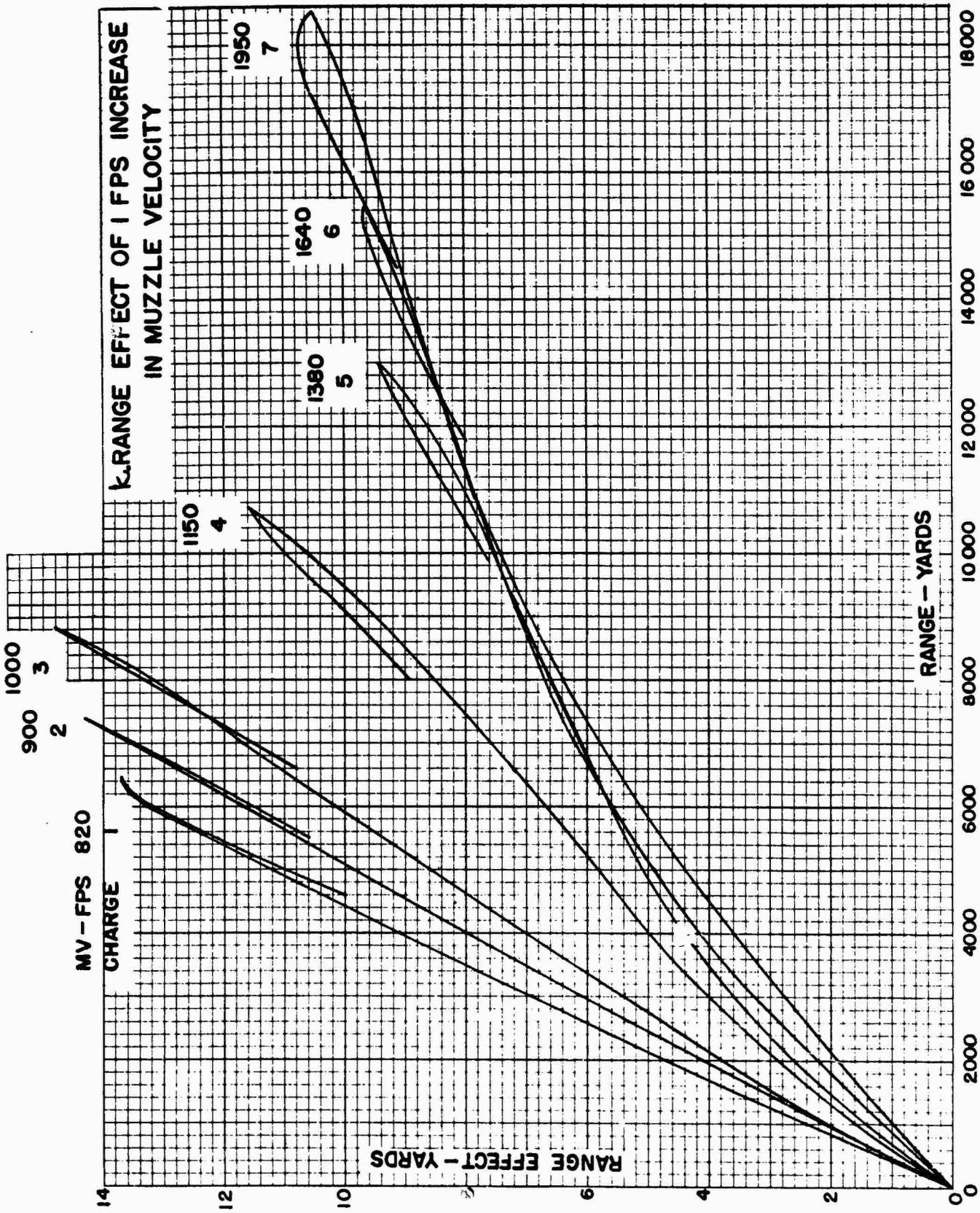

£. TIME OF FLIGHT – RANGE CURVES
MV-FPS 820
CHARGE 1
900 2
1000 3
1150 4
1380 5
1640 6
1950 7
RANGE-YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
TIME OF FLIGHT-- SEC
0
20
40
60
80
100

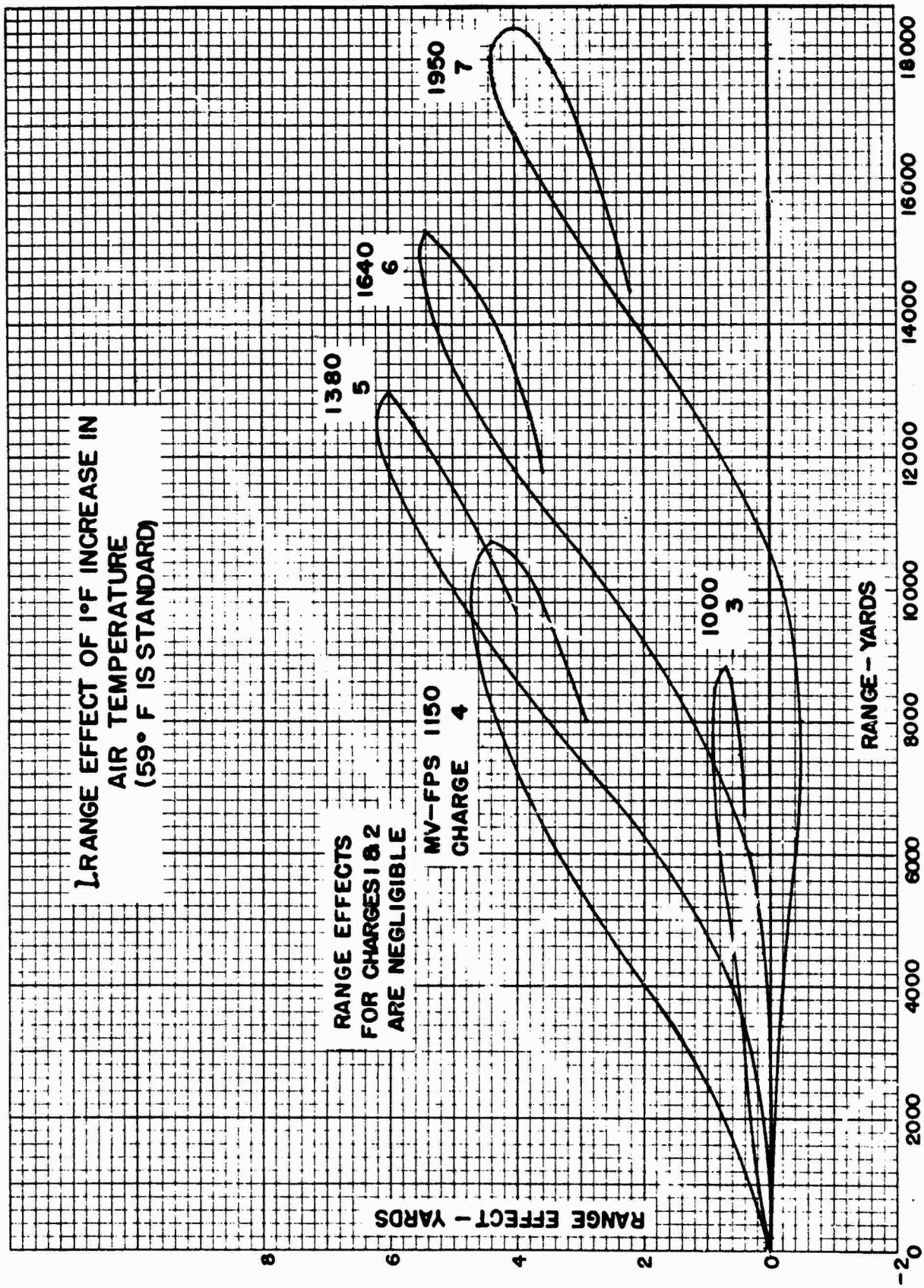

DRIFT-RANGE CURVES
MV-FPS 820 900 1000 1150 1380 1640 1950
CHARGE 1 2 3 4 5 6 7
DRIFT-MILS
RANGE-YARDS
0
10
20
30
40
50
60
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

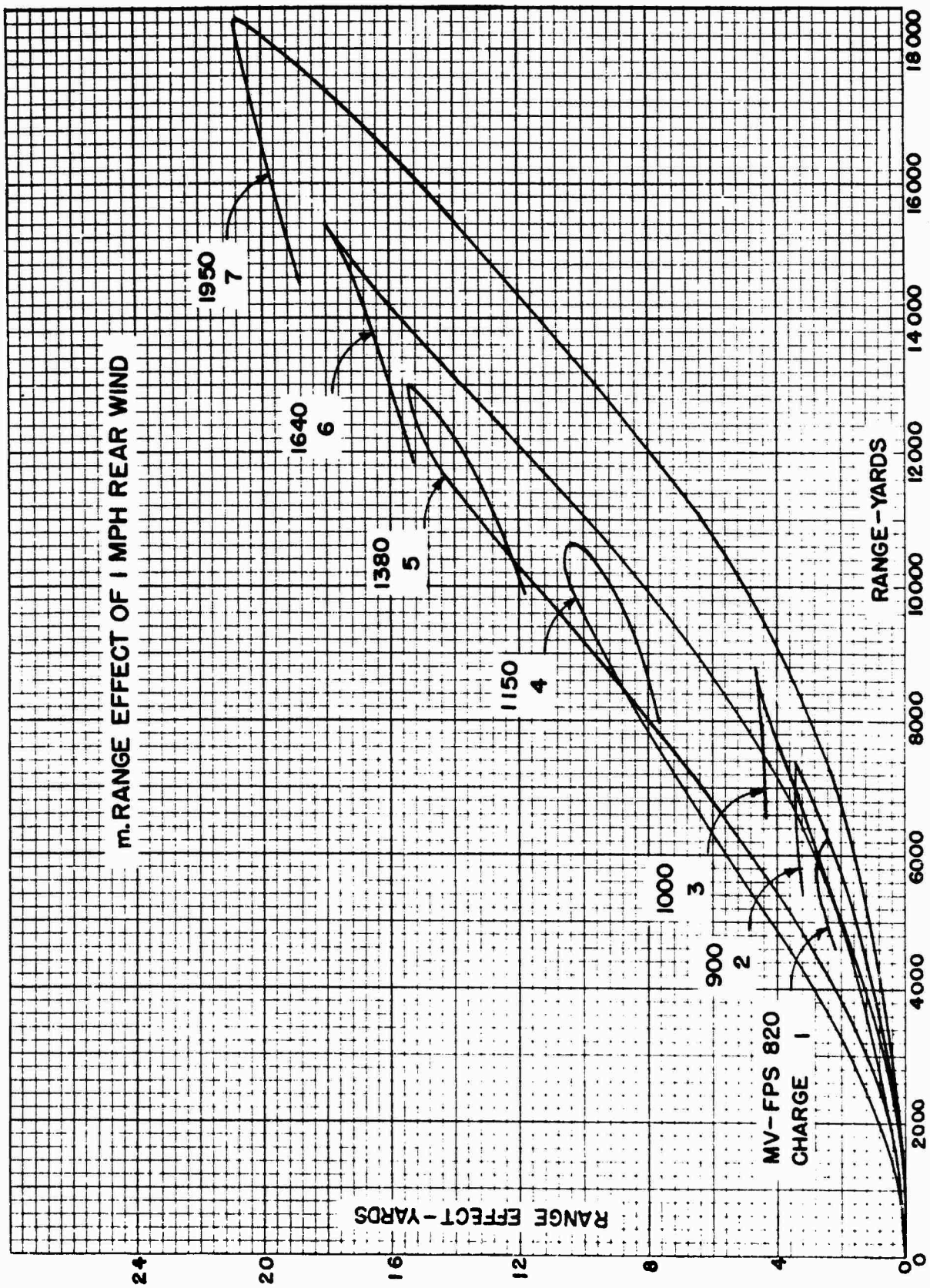

h.DEFLECTION EFFECT OF 1MPH LATERAL WIND
1950
7
1640
6
1380
5
1150
4
1000
3
900
2
820
1
MV-FPS
CHARGE
RANGE-YARDS
DEFLECTION EFFECT-MILS
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
.2
.4
.6
.8
1.0

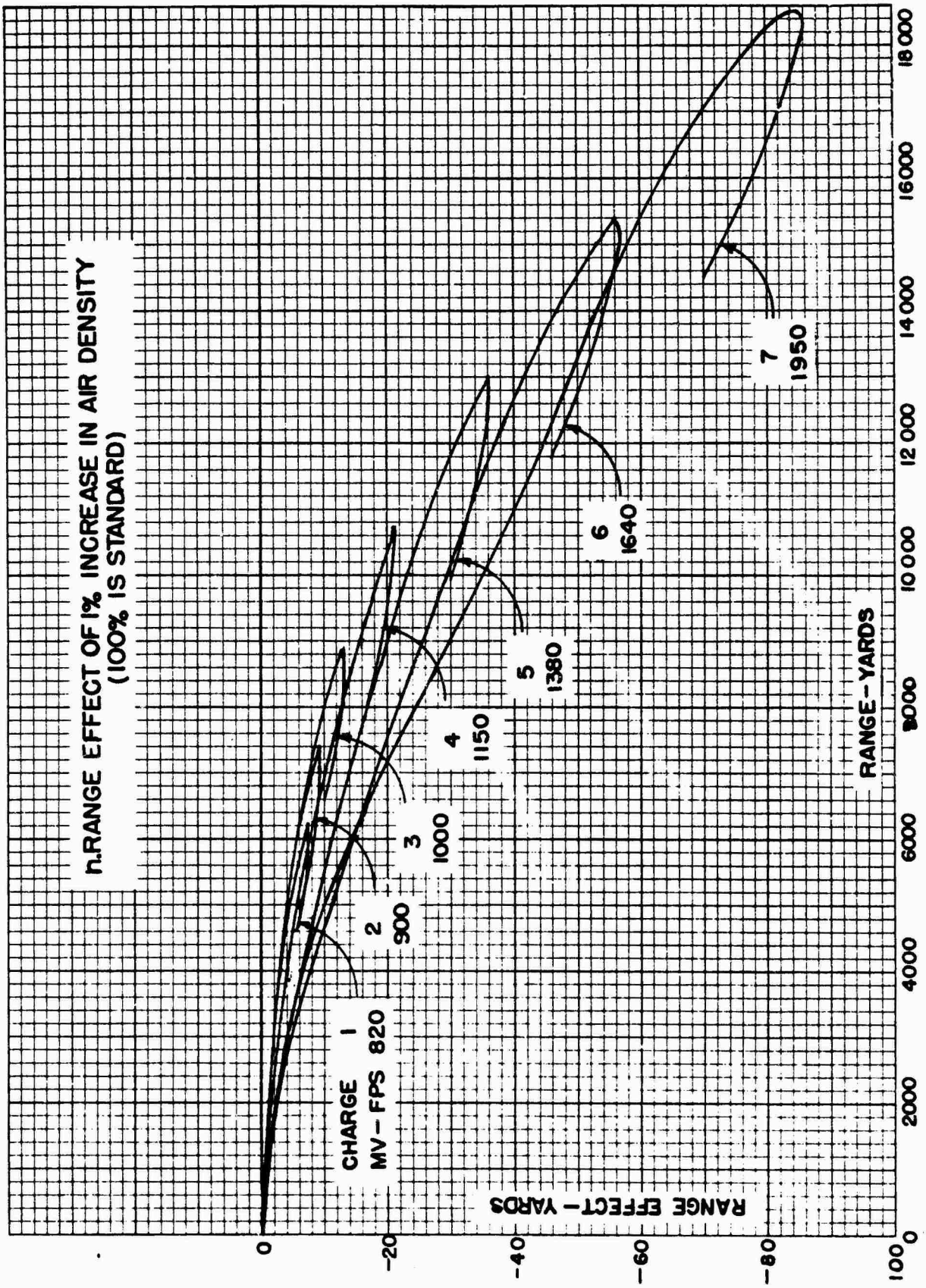

BALLISTIC AND ENGINEERING DATA
i.COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ± ‖ MIL ANGLE OF SITE)
ELEVATION
ANGLE OF SITE
COMPLEMENTARY ANGLE OF SITE
LOW + +
LOW − −
HIGH + −
HIGH − +
MV-FPS 820
CHARGE 1
900
2
1000
3
1150
4
1380
5
1640
6
1950
7
RANGE-YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
COMPLEMENTARY ANGLE OF SITE-MILS
0
1
2
3
4
5


J. RANGE EFFECT OF 1 ZONE INCREASE
IN WEIGHT OF PROJECTILE
(ZONE 4, MARKED ■■■■, IS STANDARD)
8
CHARGE M2
(WHITE BAG)
CHARGE M1
(GREEN BAG)
7
n=-.38
6
n=-.37
5
n=-.36
5
n=-.48
4
n=-.48
3
n=-.48
2
n=-.48
1
n=-.48
RANGE—YARDS
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
RANGE EFFECT—YARDS
-20
-10
0
10
-60
-40
-20
0


k RANGE EFFECT OF 1 FPS INCREASE
IN MUZZLE VELOCITY
MV-FPS 820
CHARGE 1
900
2
1000
3
1150
4
1380
5
1640
6
1950
7
RANGE EFFECT - YARDS
RANGE - YARDS
0
2
4
6
8
10
12
14
0
2000
4000
6000
8000
10000
12000
14000
16000
18000


RANGE EFFECT OF 1°F INCREASE IN
AIR TEMPERATURE
(59° F IS STANDARD)
RANGE EFFECTS
FOR CHARGES 1 & 2
ARE NEGLIGIBLE
MV-FPS 1150
CHARGE 4
1000
3
1380
5
1640
6
1950
7
RANGE EFFECT - YARDS
8
6
4
2
0
-2
RANGE - YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
18000


m. RANGE EFFECT OF 1 MPH REAR WIND
RANGE EFFECT - YARDS
RANGE - YARDS
0
4
8
12
16
20
24
2000
4000
6000
8000
10000
12000
14000
16000
18000
MV - FPS 820
CHARGE 1
900
2
1000
3
1150
4
1380
5
1640
6
1950
7


n.RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
CHARGE 1
MV-FPS 820
2
900
3
1000
4
1150
5
1380
6
1640
7
1950
RANGE-YARDS
RANGE EFFECT-YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
0
-20
-40
-60
-80
-100

SECTION V

EFFECT DATA

	Paragraph
Ricochet data	9
Penetration	10
Effectiveness	11

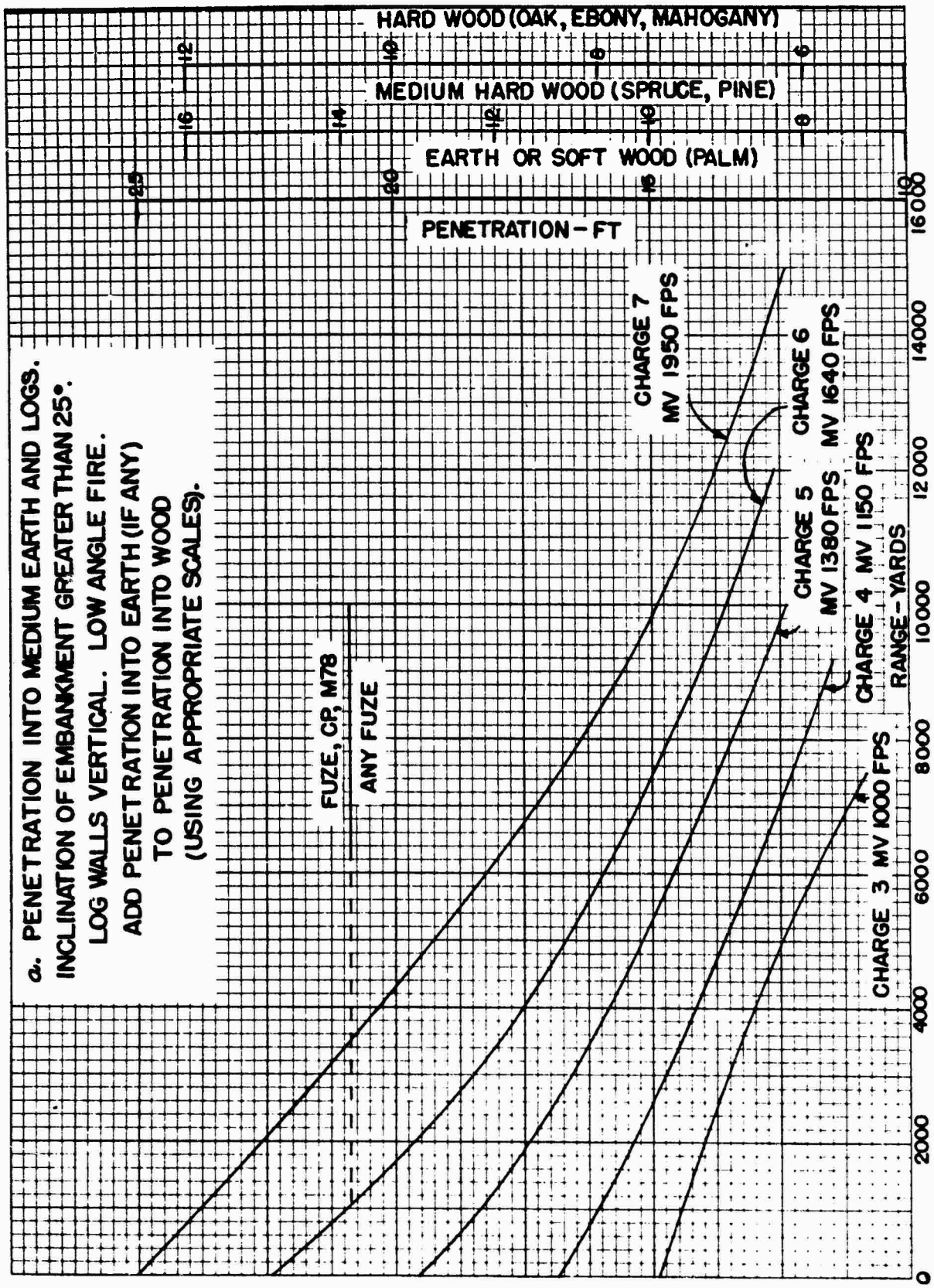
9. Ricochet data. The following data on ricochet of the 8-inch HE Shell M106 with PD Fuze M51A4 were taken from volume III of "Terminal Ballistic Data".

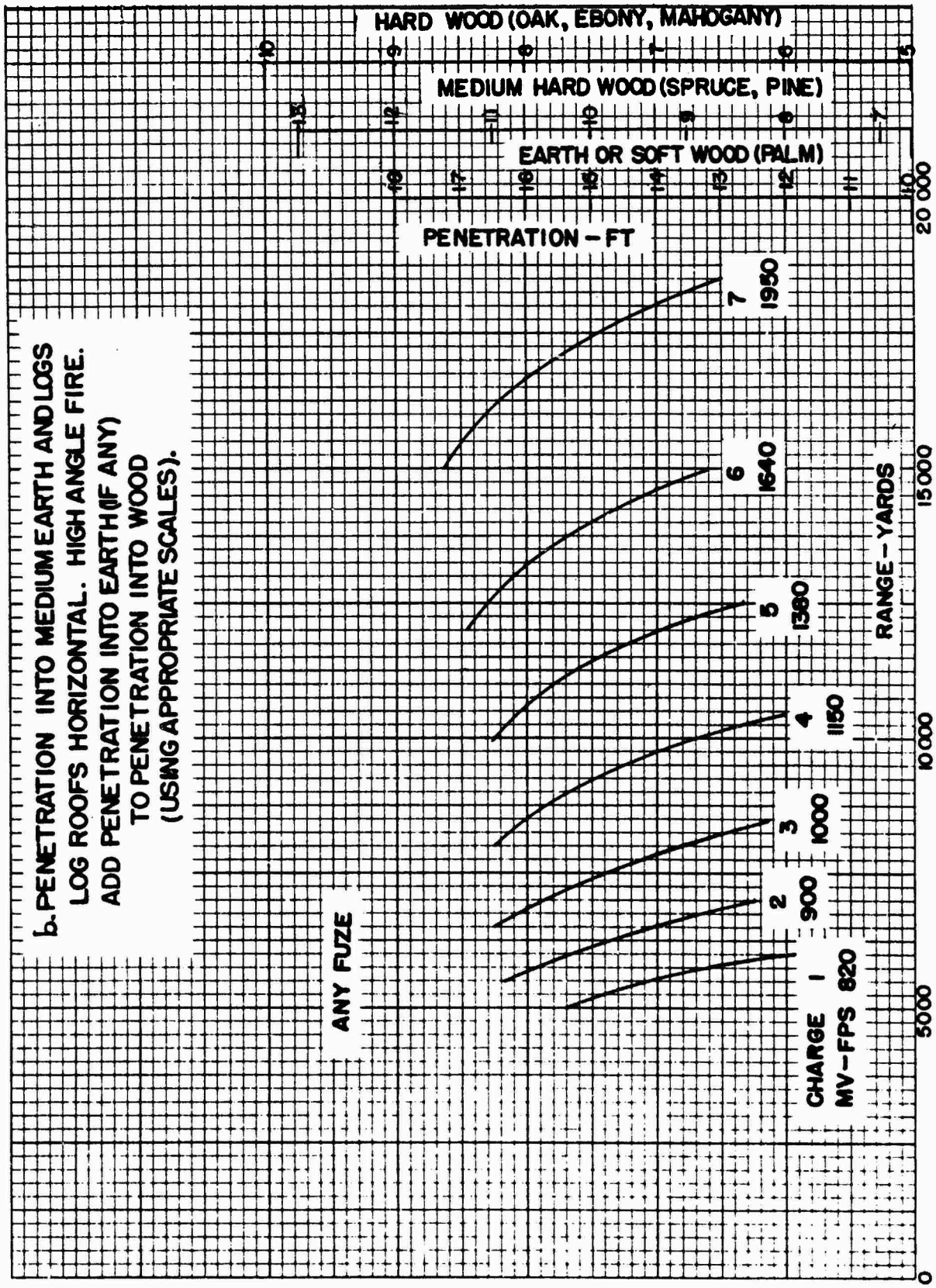
TABLE 83

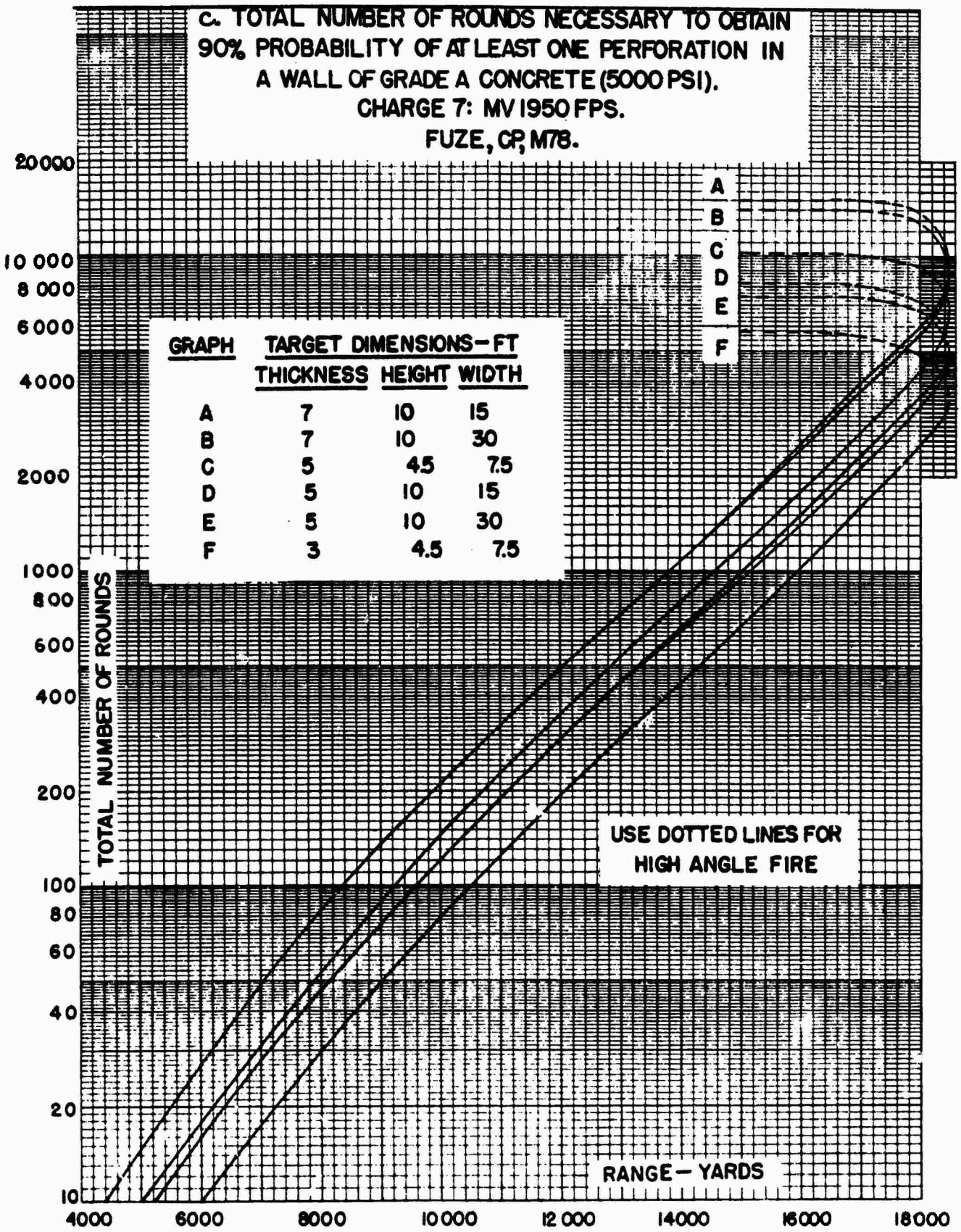
	Range	Angle of Fall	Angle of Recovery	Impact to Burst	Height of Burst	PE in Height of Burst
	yd	mils	mils	yd	ft	ft
Charge 1						
MV 820 fps	1,000	76	110	34	11	2
	2,000	158	205	27	17	4
	3,000	251	275	20	17	4
	4,000	358	310	13	12	3
Charge 2						
MV 900 fps	1,000	63	95	39	11	2
	2,000	132	180	32	17	3
	3,000	206	245	26	19	4
	4,000	291	290	19	17	4
	5,000	387	315	12	11	3
Charge 3						
MV 1,000 fps	1,000	50	80	44	10	2
	2,000	106	150	38	17	3
	3,000	167	215	31	20	4
	4,000	235	265	25	20	4
	5,000	309	300	19	17	4
	6,000	393	315	13	12	4
Charge 4						
MV 1,150 fps	1,000	41	65	50	10	2
	2,000	86	125	44	16	3
	3,000	137	185	38	21	4
	4,000	192	235	32	22	5
	5,000	252	275	26	21	5
	6,000	317	300	19	18	4
	7,000	388	315	14	13	4
Charge 5						
MV 1,380 fps	1,000	28	50	60	9	2
	2,000	64	100	52	15	3
	3,000	107	150	45	20	4
	4,000	154	200	38	23	5
	5,000	206	245	32	23	5
	6,000	262	280	26	22	5
	7,000	321	300	20	19	5
	8,000	384	315	15	14	4

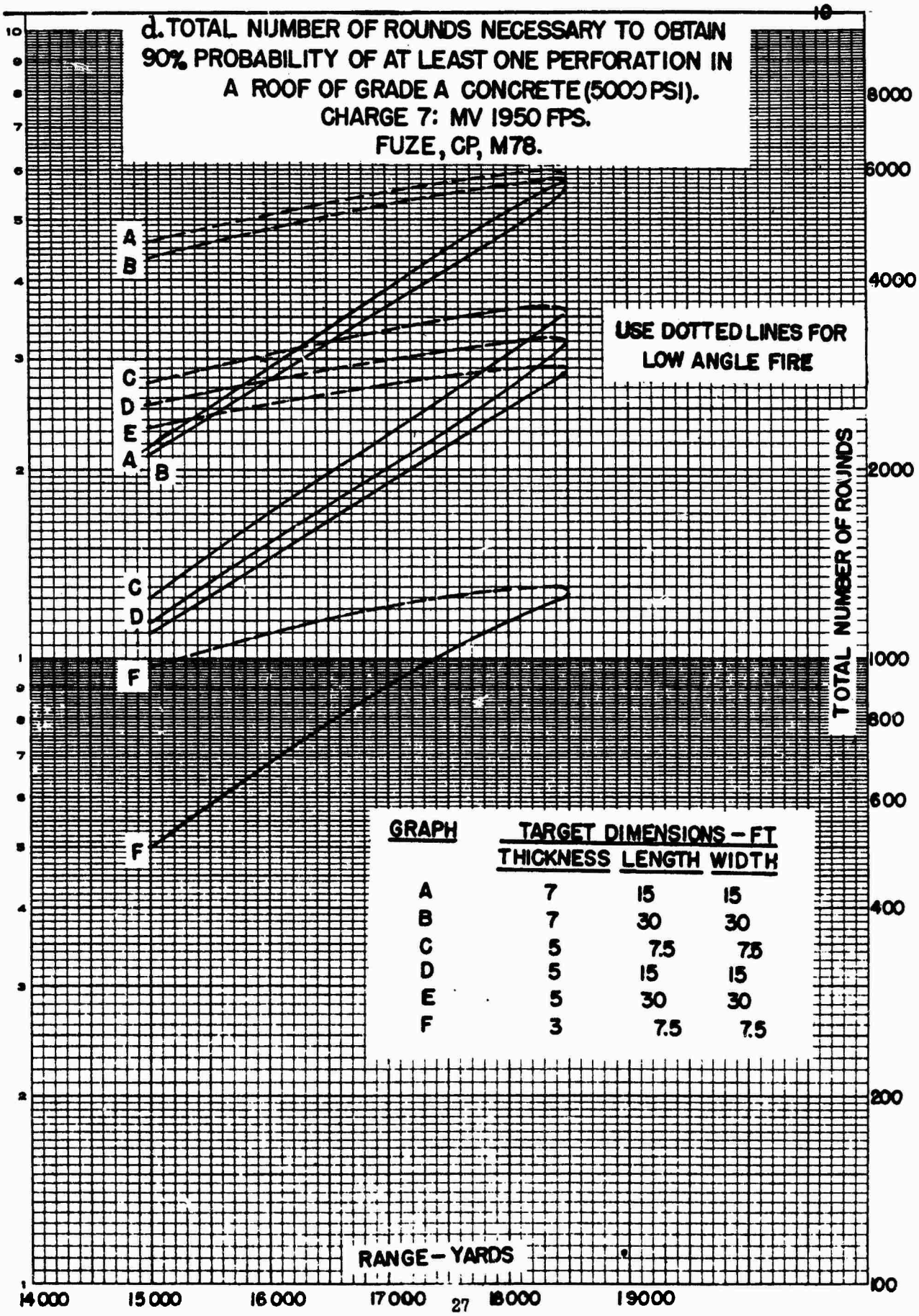
	Range	Angle of Fall	Angle of Recovery	Impact to Burst	Height of Burst	PE in Height of Burst
	yd	mils	mils	yd	ft	ft
Charge 6						
MV 1,640 fps	1,000	20	35	73	8	2
	2,000	45	70	65	14	3
	3,000	75	110	56	19	4
	4,000	111	155	48	22	4
	5,000	154	200	41	24	5
	6,000	203	240	34	24	5
	7,000	256	275	28	23	5
	8,000	313	300	22	20	5
	9,000	372	310	17	16	5
	10,000	434	315	11	11	4
Charge 7						
MV 1,950 fps	1,000	16	30	92	8	2
	2,000	33	55	80	13	3
	3,000	53	85	71	18	4
	4,000	76	110	63	21	4
	5,000	105	150	55	24	5
	6,000	139	185	47	26	5
	7,000	180	225	40	27	6
	8,000	227	260	33	26	6
	9,000	279	285	26	23	5
	10,000	335	305	21	19	5
	11,000	393	315	15	14	4

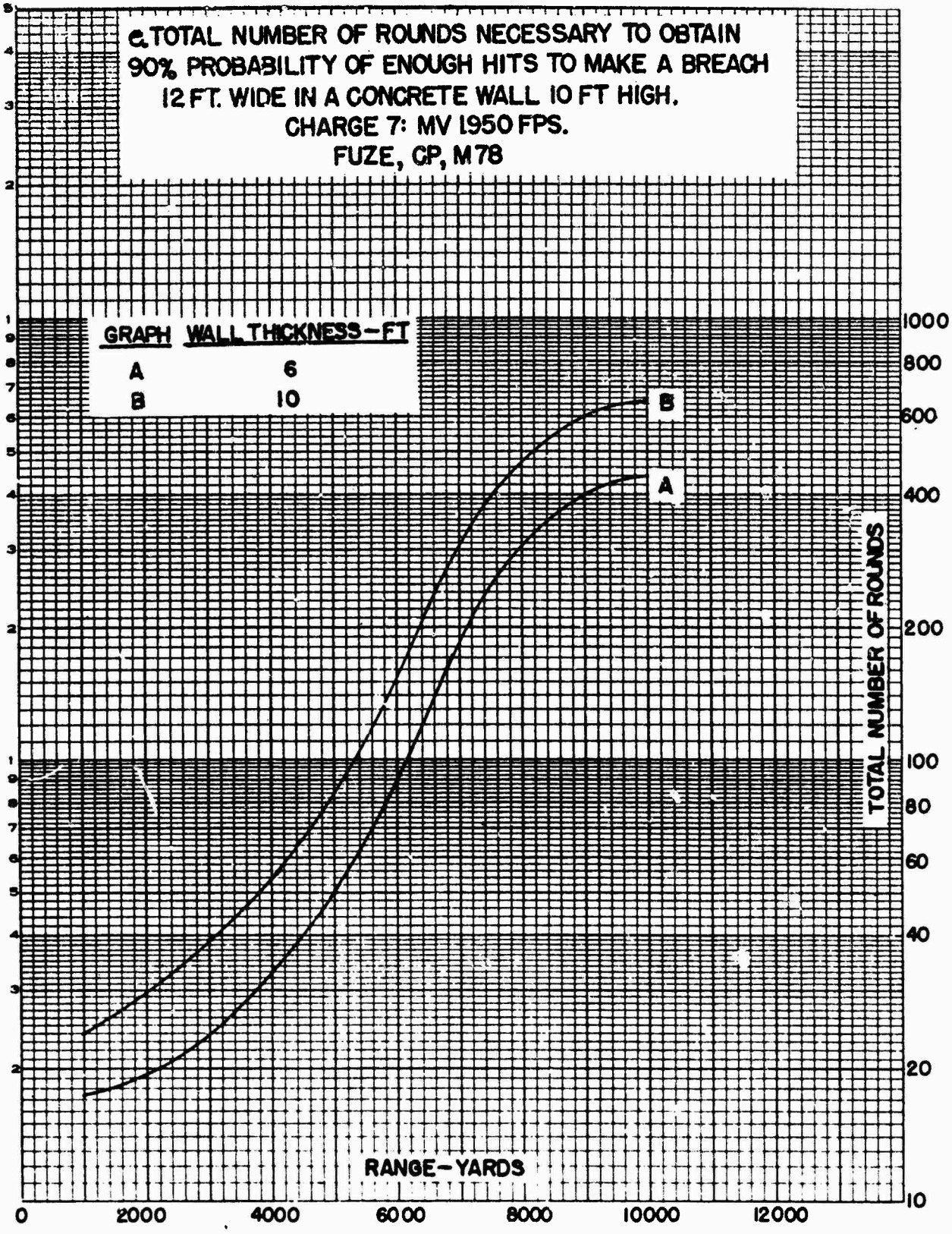
10. Penetration. The curves of penetration into medium earth and logs by the HE Shell M106 with the PD Fuze M51A4 or the CP Fuze M78 were taken from volume III of "Terminal Ballistic Data". The curves of perforation in concrete by the HE Shell M106 with the CP Fuze M78 were taken from TM 9-1907, "Ballistic Data, Performance of Ammunition".


a. PENETRATION INTO MEDIUM EARTH AND LOGS.
INCLINATION OF EMBANKMENT GREATER THAN 25°.
LOG WALLS VERTICAL. LOW ANGLE FIRE.
ADD PENETRATION INTO EARTH (IF ANY)
TO PENETRATION INTO WOOD
(USING APPROPRIATE SCALES).
FUZE, CP, M78
ANY FUZE
HARD WOOD (OAK, EBONY, MAHOGANY)
MEDIUM HARD WOOD (SPRUCE, PINE)
EARTH OR SOFT WOOD (PALM)
PENETRATION - FT
CHARGE 7
MV 1950 FPS
CHARGE 6
MV 1640 FPS
CHARGE 5
MV 1380 FPS
CHARGE 4 MV 1150 FPS
CHARGE 3 MV 1000 FPS
RANGE - YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000


b. PENETRATION INTO MEDIUM EARTH AND LOGS
LOG ROOFS HORIZONTAL. HIGH ANGLE FIRE.
ADD PENETRATION INTO EARTH (IF ANY)
TO PENETRATION INTO WOOD
(USING APPROPRIATE SCALES).
ANY FUZE
HARD WOOD (OAK, EBONY, MAHOGANY)
MEDIUM HARD WOOD (SPRUCE, PINE)
EARTH OR SOFT WOOD (PALM)
PENETRATION – FT
CHARGE
MV–FPS
1
820
2
900
3
1000
4
1150
5
1380
6
1640
7
1950
RANGE – YARDS
0
5000
10000
15000
20000


c. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF AT LEAST ONE PERFORATION IN A WALL OF GRADE A CONCRETE (5000 PSI).
CHARGE 7: MV 1950 FPS.
FUZE, CP, M78.
A
B
C
D
E
F
GRAPH | TARGET DIMENSIONS—FT
THICKNESS HEIGHT WIDTH
A 7 10 15
B 7 10 30
C 5 4.5 7.5
D 5 10 15
E 5 10 30
F 3 4.5 7.5
USE DOTTED LINES FOR HIGH ANGLE FIRE
TOTAL NUMBER OF ROUNDS
20000
10 000
8 000
6000
4000
2000
1000
800
600
400
200
100
80
60
40
20
10
RANGE—YARDS
4000
6000
8000
10000
12 000
14000
16000
18000


d. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF AT LEAST ONE PERFORATION IN A ROOF OF GRADE A CONCRETE (5000 PSI).
CHARGE 7: MV 1950 FPS.
FUZE, CP, M78.
USE DOTTED LINES FOR LOW ANGLE FIRE
TOTAL NUMBER OF ROUNDS
RANGE – YARDS
A
B
C
D
E
A
B
C
D
F
F
GRAPH | TARGET DIMENSIONS – FT THICKNESS | LENGTH | WIDTH
A 7 15 15
B 7 30 30
C 5 7.5 7.5
D 5 15 15
E 5 30 30
F 3 7.5 7.5
14000
15000
16000
17000
18000
19000
100
200
400
600
800
1000
2000
4000
6000
8000


e. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN
90% PROBABILITY OF ENOUGH HITS TO MAKE A BREACH
12 FT. WIDE IN A CONCRETE WALL 10 FT HIGH.
CHARGE 7: MV 1950 FPS.
FUZE, CP, M78
GRAPH WALL THICKNESS-FT
A 6
B 10
A
B
TOTAL NUMBER OF ROUNDS
1000
800
600
400
200
100
80
60
40
20
10
RANGE-YARDS
0
2000
4000
6000
8000
10000
12000

11. Effectiveness. The following data on effectiveness of the HE Shell M106 with PD Fuze M51A4 or MT Fuze M67A3, fired from the 8-inch Howitzer M2, were taken from volume III of "Terminal Ballistic Data."

NUMBER OF ROUNDS REQUIRED AGAINST ENEMY ARTILLERY FOR 90% PROBABILITY OF AT LEAST ONE EFFECTIVE HIT IN AIMED FIRE

Range	Charge 5: MV 1380 fps			Charge 7: MV 1950 fps		
	Type of Fire			Type of Fire		
yd	Impact	Time	Time & Impact	Impact	Time	Time & Impact
2,000	3	210	7	---	---	---
5,000	28	220	45	3	290	7
10,000	380	390	250	54	280	78
15,000	---	---	---	330	430	200

Ballistic Research Laboratories
Handbook of Ballistic and
Engineering Data for Ammunition,
No. 240 - 1 - 114

Ballistic Research Lab.
Aberdeen Proving Ground,
Maryland.
16 March 1949

BALLISTIC AND ENGINEERING DATA

for

Shell, HE, 240-mm, M114

with

Fuzes, PD, M51A4; MT, M67A3; and CP, M78

Section		Paragraphs
I	General	1
II	Description	2 -4
III	Interior ballistic data	5 - 6
IV	Exterior ballistic data	7 - 8
V	Effect data	9 -13

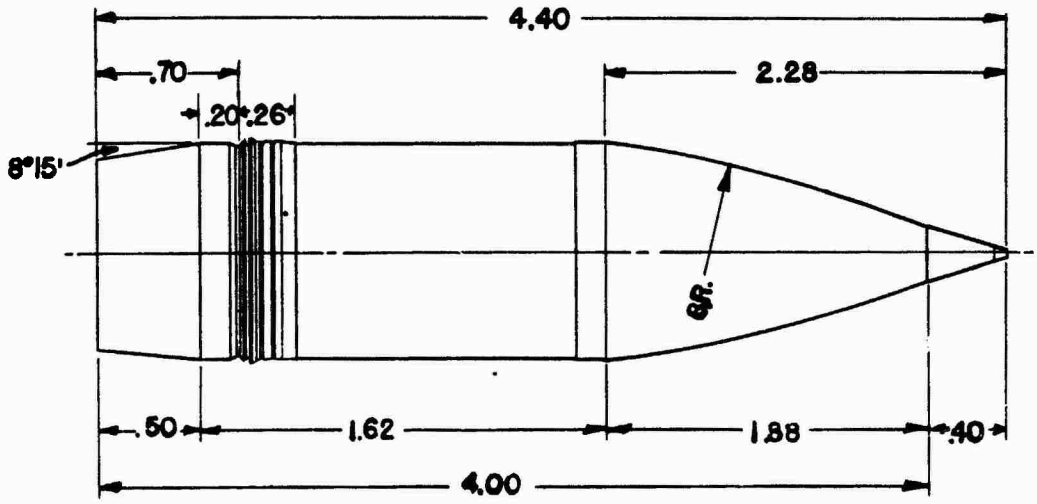
SECTION I

GENERAL

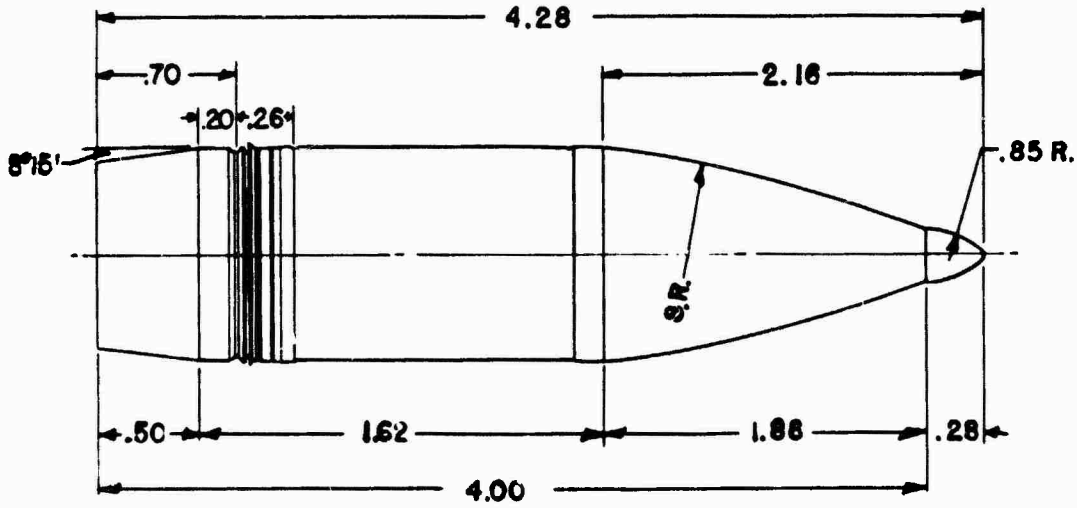
	Paragraph
Purpose	1

1. Purpose. The purpose of this number of the handbook is to furnish a concise collection of information regarding the shape, dynamics, ballistics and effects of the 240-mm High Explosive Shell M114 with the Point Detonating Fuze M51A4, the Mechanical Time Fuze M67A3, and the Concrete Piercing Fuze M78. This information is collected from the drawings, reports, firing tables, and technical manuals pertaining to this ammunition.

ALL DIMENSIONS IN CALIBERS
1 CAL = 9.449"



SHELL, HE, 240-MM, M114
FUZE, PD, M51A4



SHELL, HE, 240-MM, M114
FUZE, CP, M78

SECTION II

DESCRIPTION

	Paragraphs
Drawings	2
Dimensions	3
Physical characteristics	4

2. Drawings.

Shell: Metal parts assembly and details	75-4-92
Booster, M21A4: Assembly	73-2-154
Fuze, PD, M51A4: Assembly	73-2-145
Details	73-2-143
Fuze, MT, M67A3: Assembly	73-7-77
Fuze, CP, M78: Body assembly and details	73-2-214

3. Dimensions.

Boattail: Angle	8°15'
Length	0.50 cal
Band: Distance from boattail	0.20 cal
Distance from base	0.70 cal
Width	0.26 cal
Cylindrical body: Length	1.62 cal
Ogive: Radius of arc	8.00 cal
Length	1.88 cal
Shell, unfuzed: Length	4.00 cal
Fuze, PD, M51A4, or MT, M67A3: Outside length	0.40 cal
Shell and fuze	4.40 cal
Ogive and fuze	2.28 cal
Fuze, CP, M78: Outside length	0.28 cal
Radius of arc	0.85 cal
Shell and fuze	4.28 cal
Ogive and fuze	2.16 cal

4. Physical characteristics.

Fuze		PD, MT	CP
Mean weight (lb):	Zone 2	350.00	350.72
	Zone 3	355.00	355.72
	Zone 4 (standard)	360.00	360.72
	Zone 5	365.00	365.72
Axial moment of inertia (estimated)		32 lb ft^2	

SECTION III

INTERIOR BALLISTIC DATA

	Paragraph
Stresses	5
Theoretical yaw in bore	6

5. Stresses. The following table and the graphical representation on page 5 show the longitudinal, radial and tangential stress at each of two sections: (A) the rear corner of the band seat and (B) the front of the band seat.

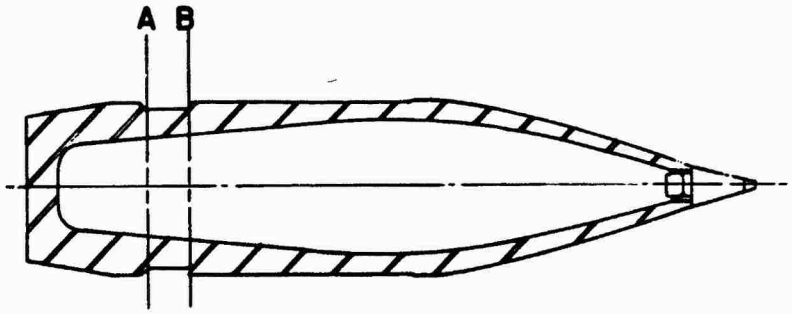
Howitzer	240-mm, M1
Twist of rifling	1/25
Cross-sectional area of bore	71.545 sq in.
Rated maximum pressure	36,000 psi
Total weight of projectile	360 lb
Muzzle velocity	2,300 fps
Density of filler (TNT)	0.057 lb per cu in.

Resultant Stress* 100 psi	Section A	Section B
Longitudinal	- 198	- 379
Radial	+ 209	- 210
Tangential	- 577	+ 532

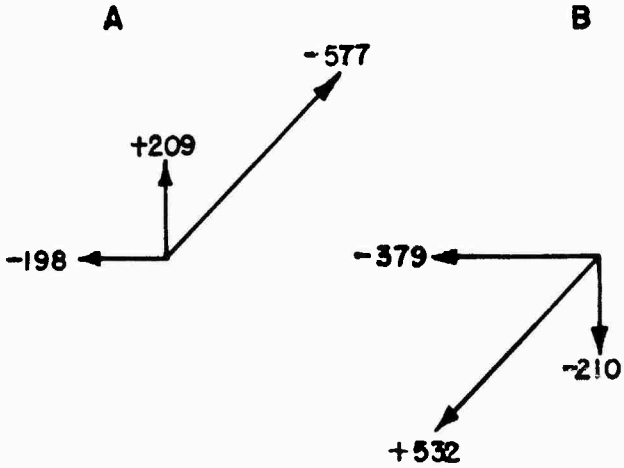
* + denotes tension, - denotes compression.

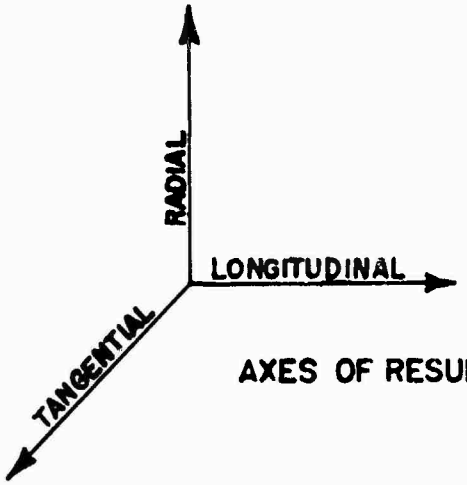
6. Theoretical yaw in bore.

Minimum	8 min
Maximum	11 min



SECTIONS





AXES OF RESULTANT STRESS

DIAGRAM OF RESULTANT STRESSES

SECTION IV

EXTERIOR BALLISTIC DATA

	Paragraph
Aerodynamic data	7
Firing table data	8

7. Aerodynamic data.

a. Drag. The trajectories for the 240-mm Howitzer M1 were based on the G_2 drag function, with ballistic coefficients determined from range firings (see par. 8b). The extrapolated values of the ballistic coefficient at zero elevation and the corresponding form factors and drag coefficients are tabulated below.

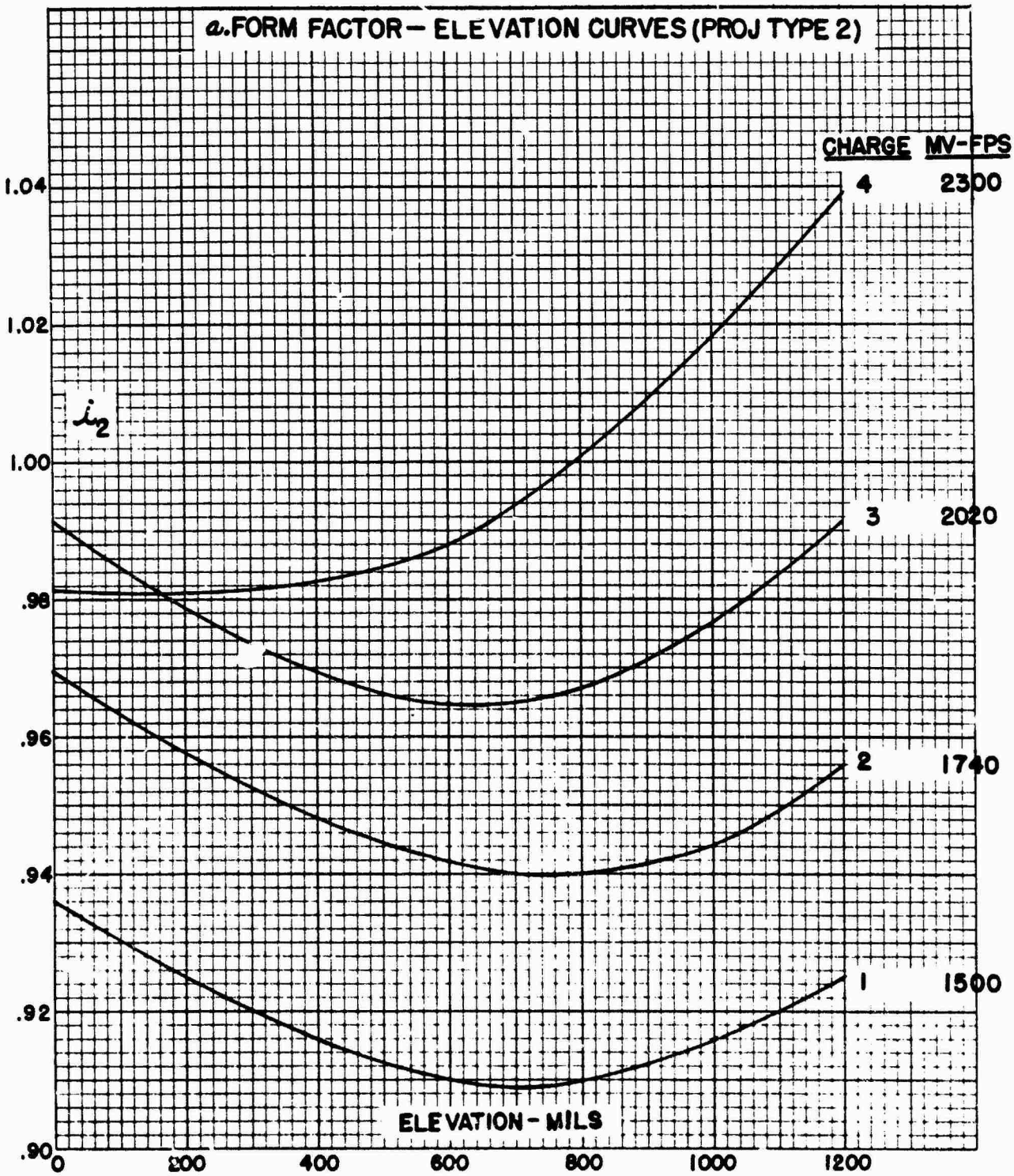
Muzzle Velocity fps	Ballistic Coefficient C_2	Form Factor i_2	Drag Coefficient K_D
1500	4.31	.94	.142
1740	4.16	.97	.134
2020	4.07	.99	.122
2300	4.11	.98	.111

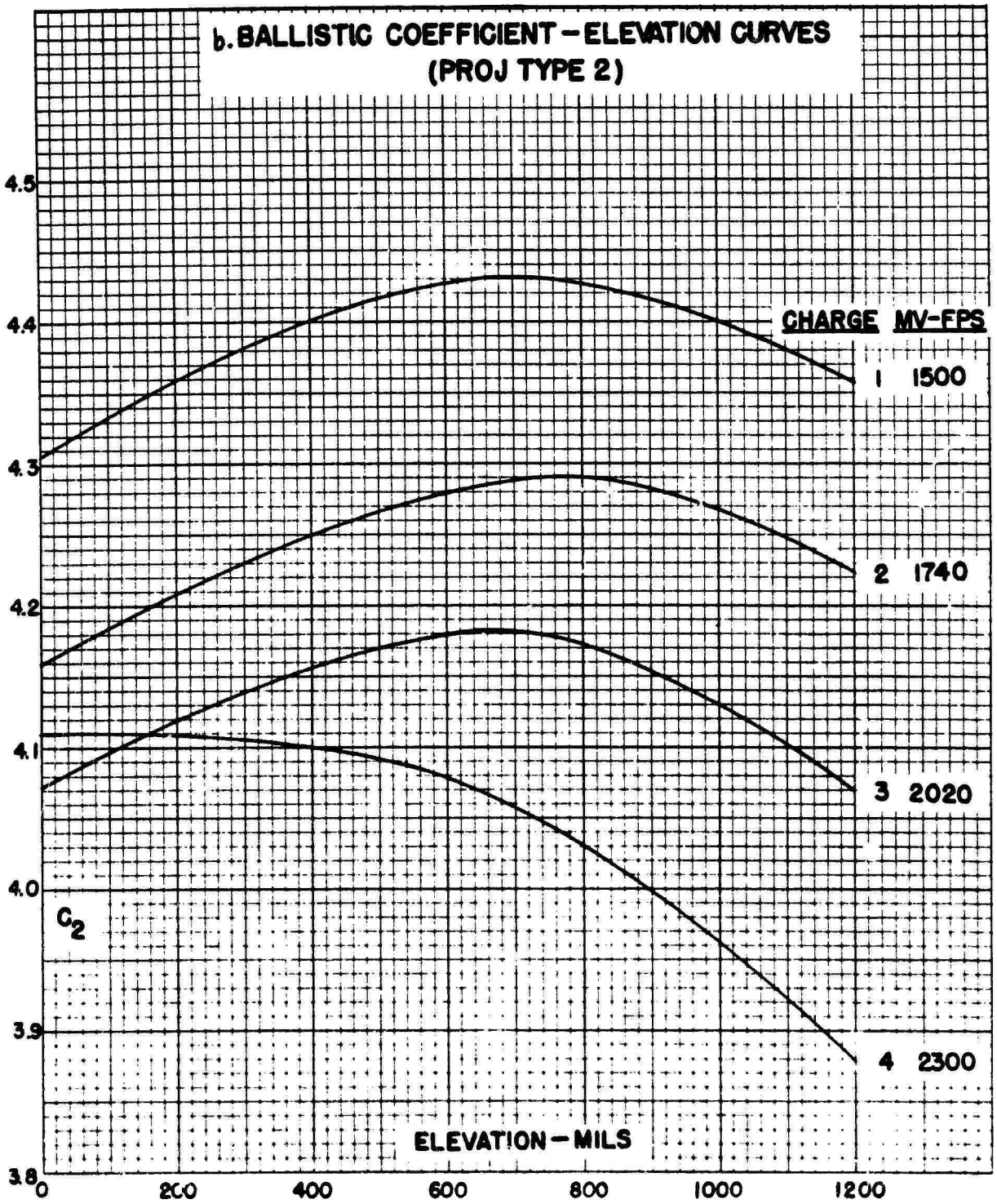
b. Loss of spin. Ballistic Research Laboratory Report No. 408, "Loss of Spin and Skin Friction Drag of Projectiles", gives data obtained by means of a radio spin sonde from an inert M114 Shell with a dummy fuze that has the same contour as the PD Fuze M51A4, fired from a 240-mm Howitzer M1 at muzzle velocities of about 2300 and 1500 fps. Below are average data for the six rounds at times of flight from 3 to 34 seconds:

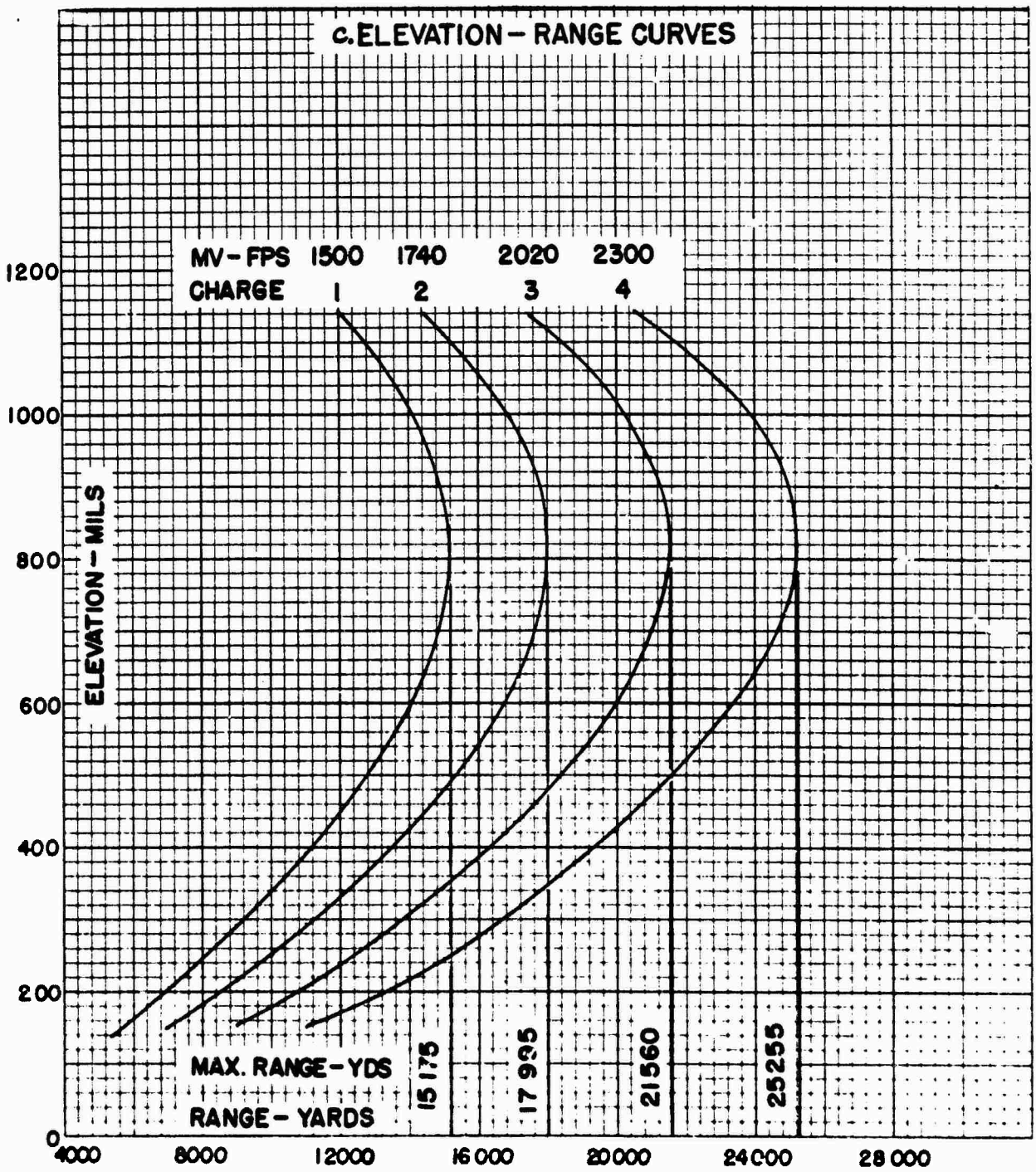
Reynolds' number, based on the translational velocity and the caliber of the shell and the kinematic viscosity of the air	7.48×10^6
Axial couple coefficient, K_A	0.0026
Skin friction drag coefficient, C'_{DF}	0.00097

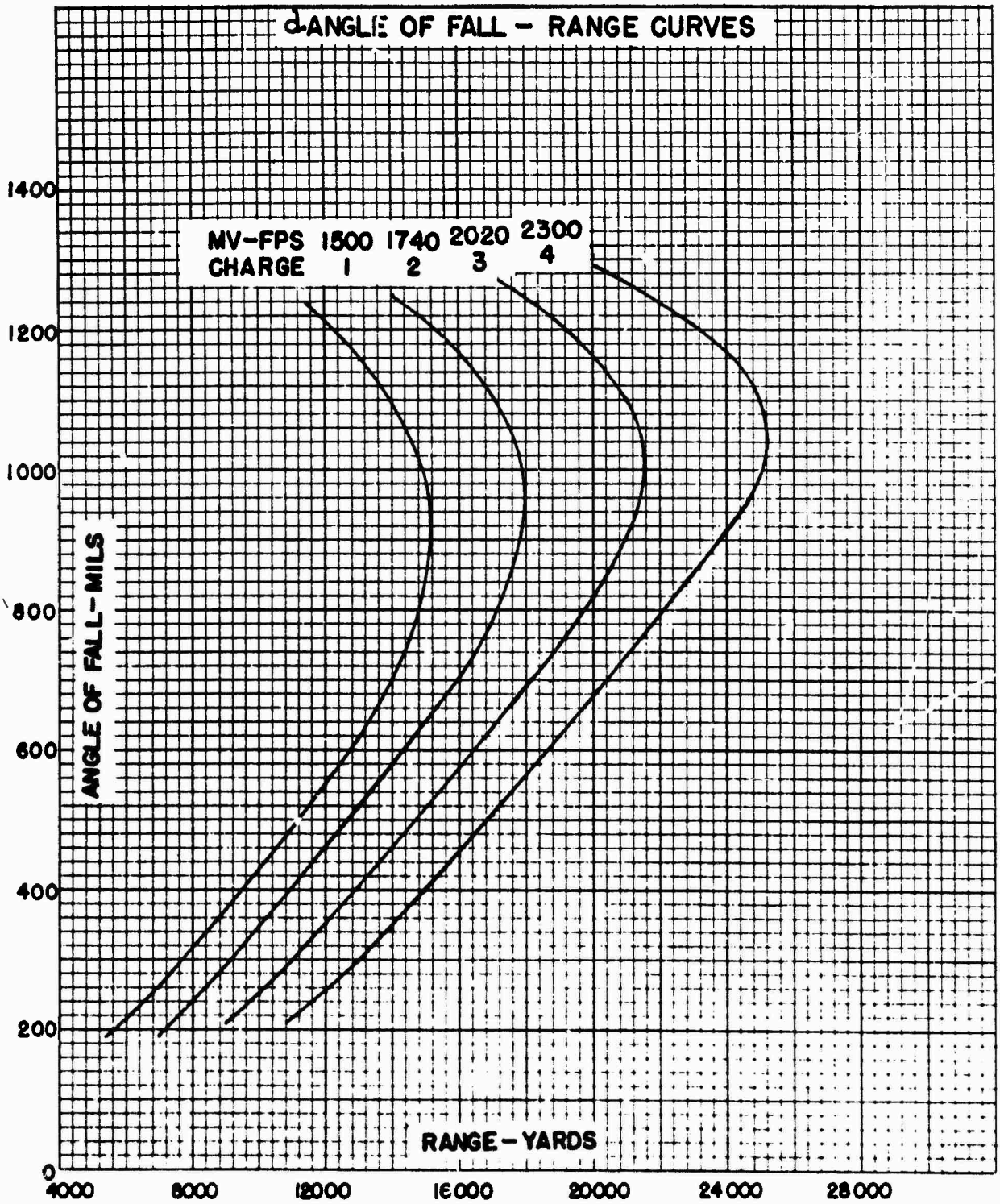
8. Firing table data. FT 240-C-1 with C2 and C5.

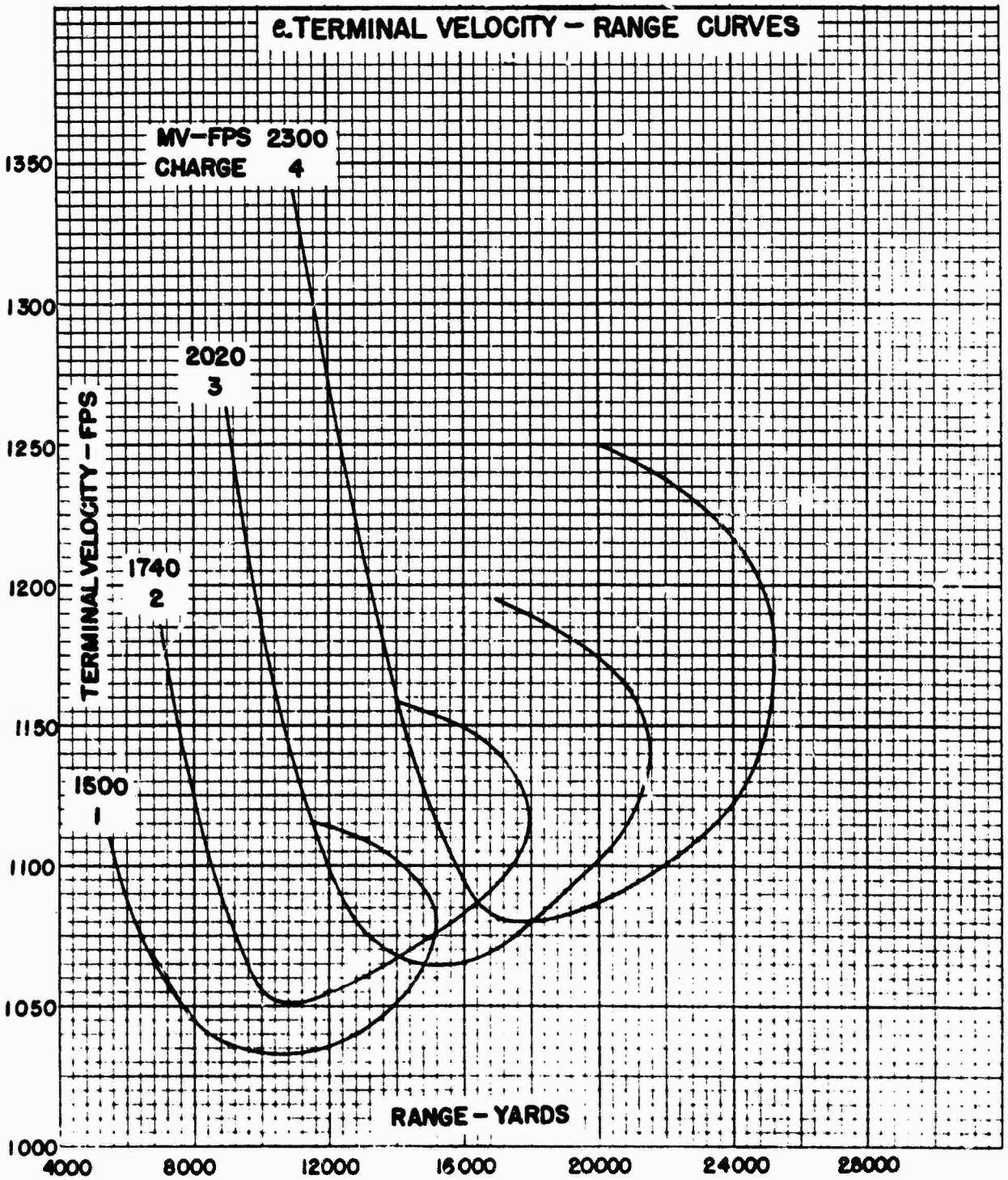
Howitzer, 240-mm, M1. Twist of rifling: 1/25. OCM items 18460 and 18566 recommended and approved standardization of the HE Shell M114.

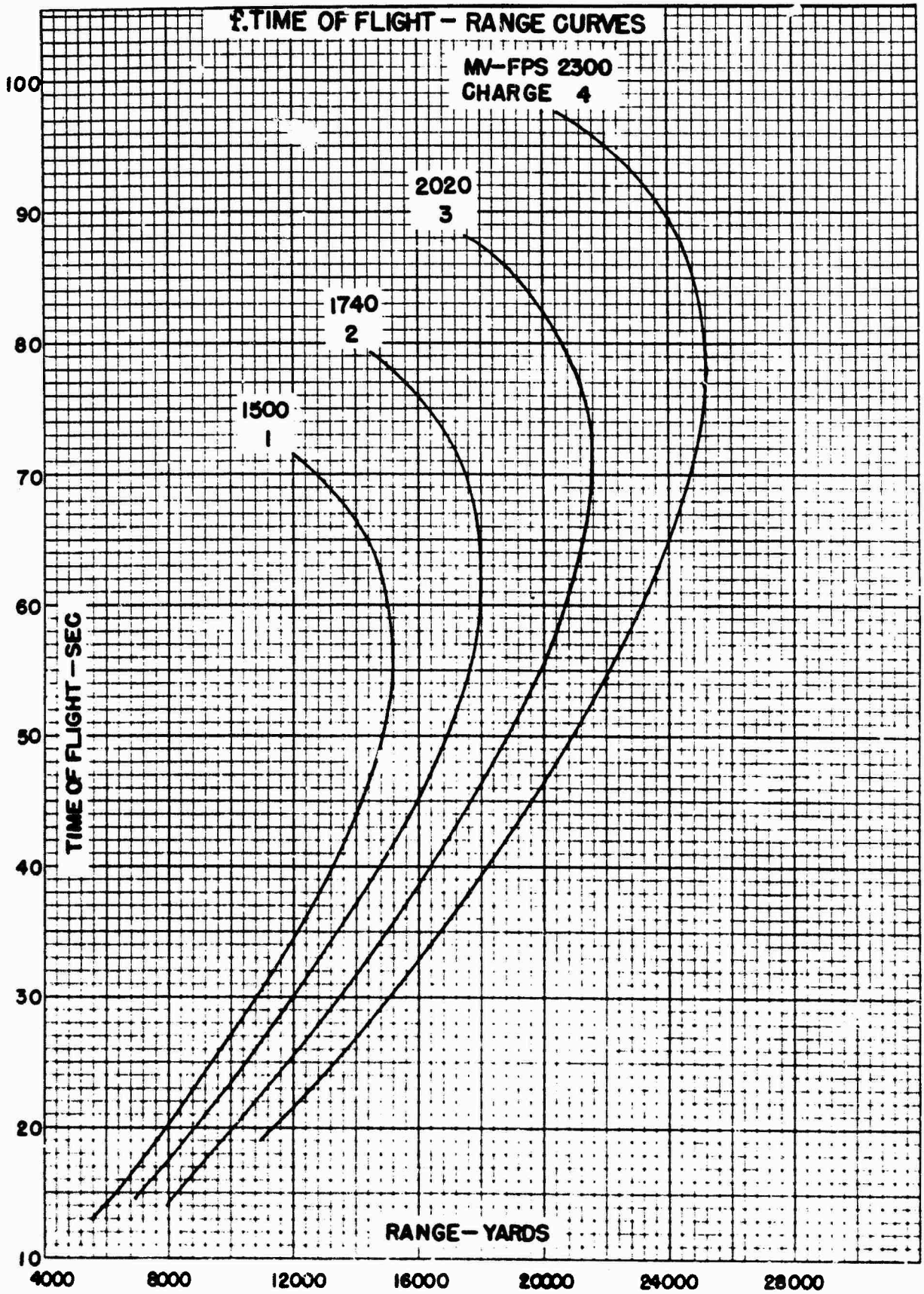

a. FORM FACTOR — ELEVATION CURVES (PROJ TYPE 2)
CHARGE MV-FPS
4 2300
3 2020
2 1740
1 1500
i_2
1.04
1.02
1.00
.98
.96
.94
.92
.90
0
200
400
600
800
1000
1200
ELEVATION - MILS

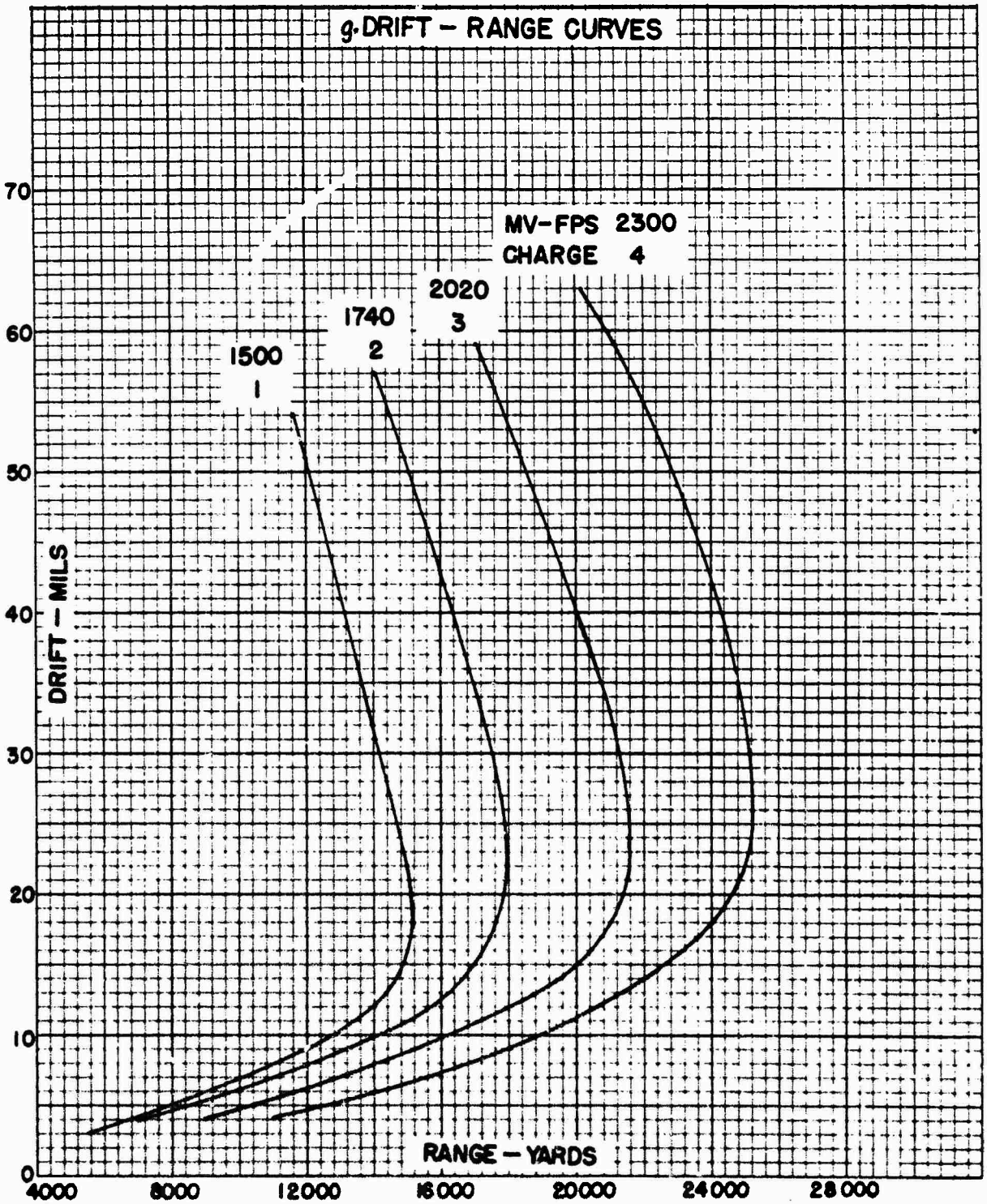

b. BALLISTIC COEFFICIENT – ELEVATION CURVES
(PROJ TYPE 2)
CHARGE MV-FPS
1 1500
2 1740
3 2020
4 2300
C_2
ELEVATION – MILS
4.5
4.4
4.3
4.2
4.1
4.0
3.9
3.8
0
200
400
600
800
1000
1200

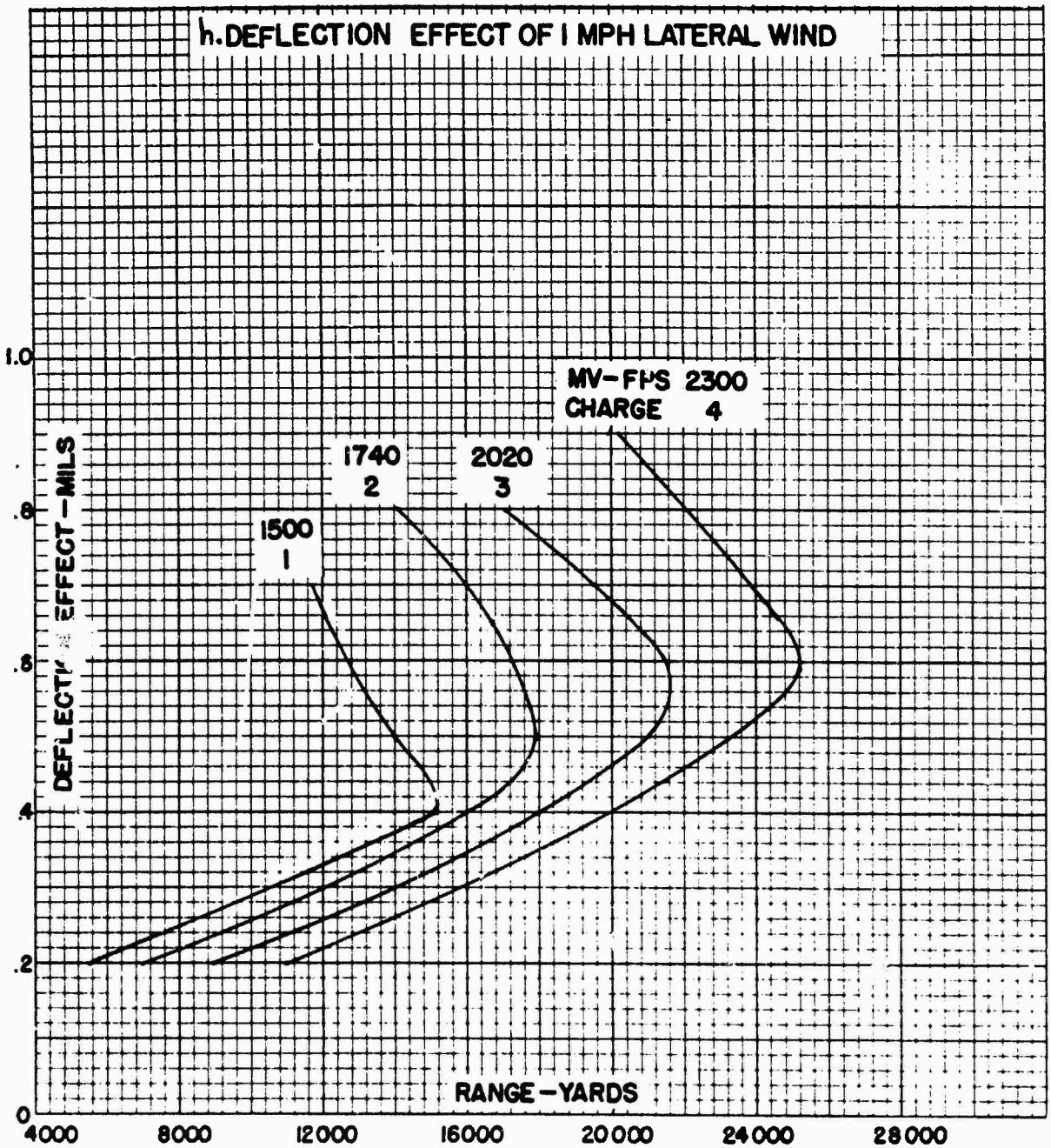

c. ELEVATION – RANGE CURVES
MV – FPS 1500 1740 2020 2300
CHARGE 1 2 3 4
ELEVATION – MILS
1200
1000
800
600
400
200
0
MAX. RANGE – YDS
15 175
17 995
21560
25255
RANGE – YARDS
4000
8000
12000
16000
20000
24000
28000

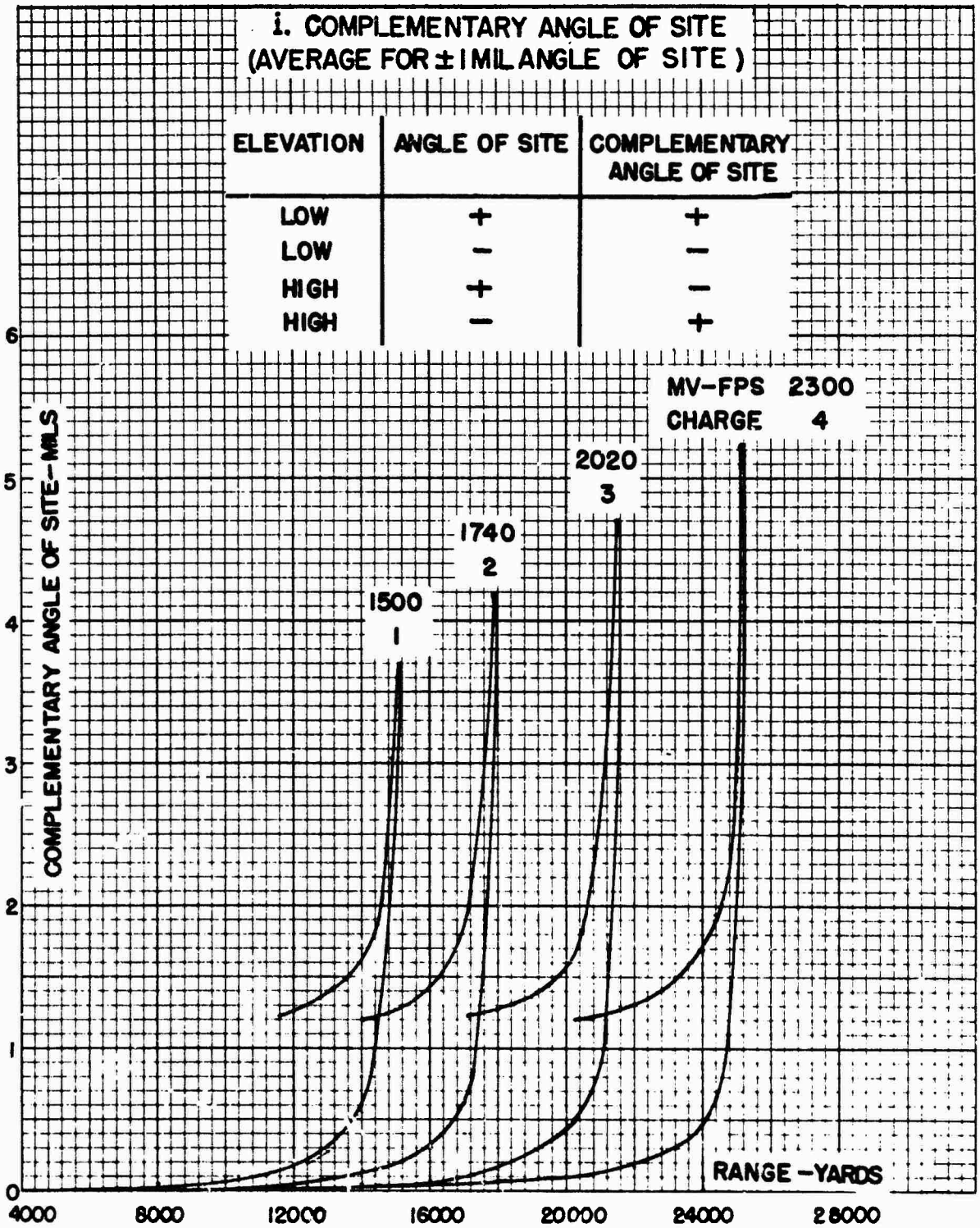

d-ANGLE OF FALL - RANGE CURVES
MV-FPS 1500 1740 2020 2300
CHARGE 1 2 3 4
ANGLE OF FALL-MILS
RANGE-YARDS
0
200
400
600
800
1000
1200
1400
4000
8000
12000
16000
20000
24000
28000

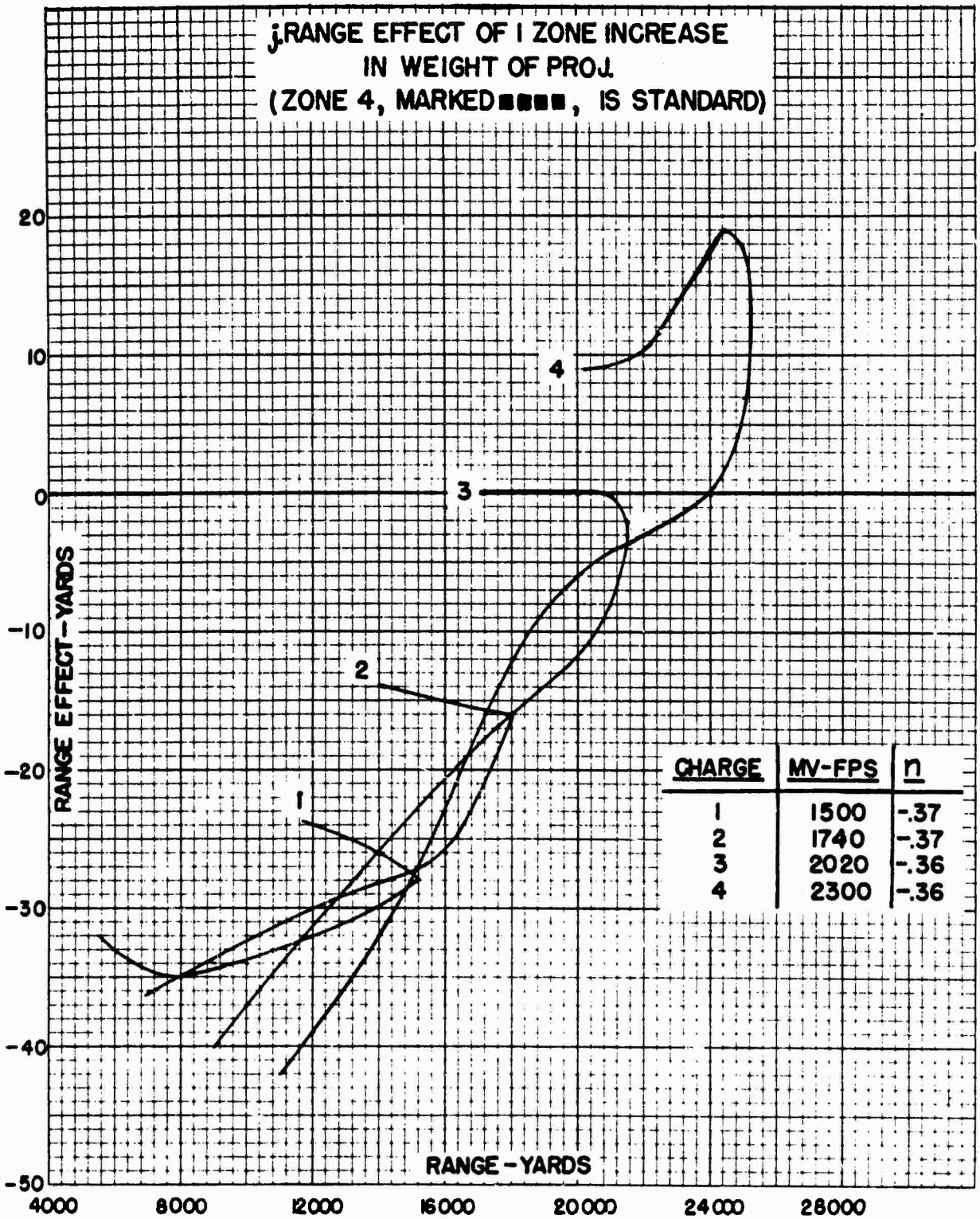

e. TERMINAL VELOCITY – RANGE CURVES
MV–FPS 2300
CHARGE 4
2020
3
1740
2
1500
1
TERMINAL VELOCITY – FPS
1350
1300
1250
1200
1150
1100
1050
1000
RANGE – YARDS
4000
8000
12000
16000
20000
24000
28000

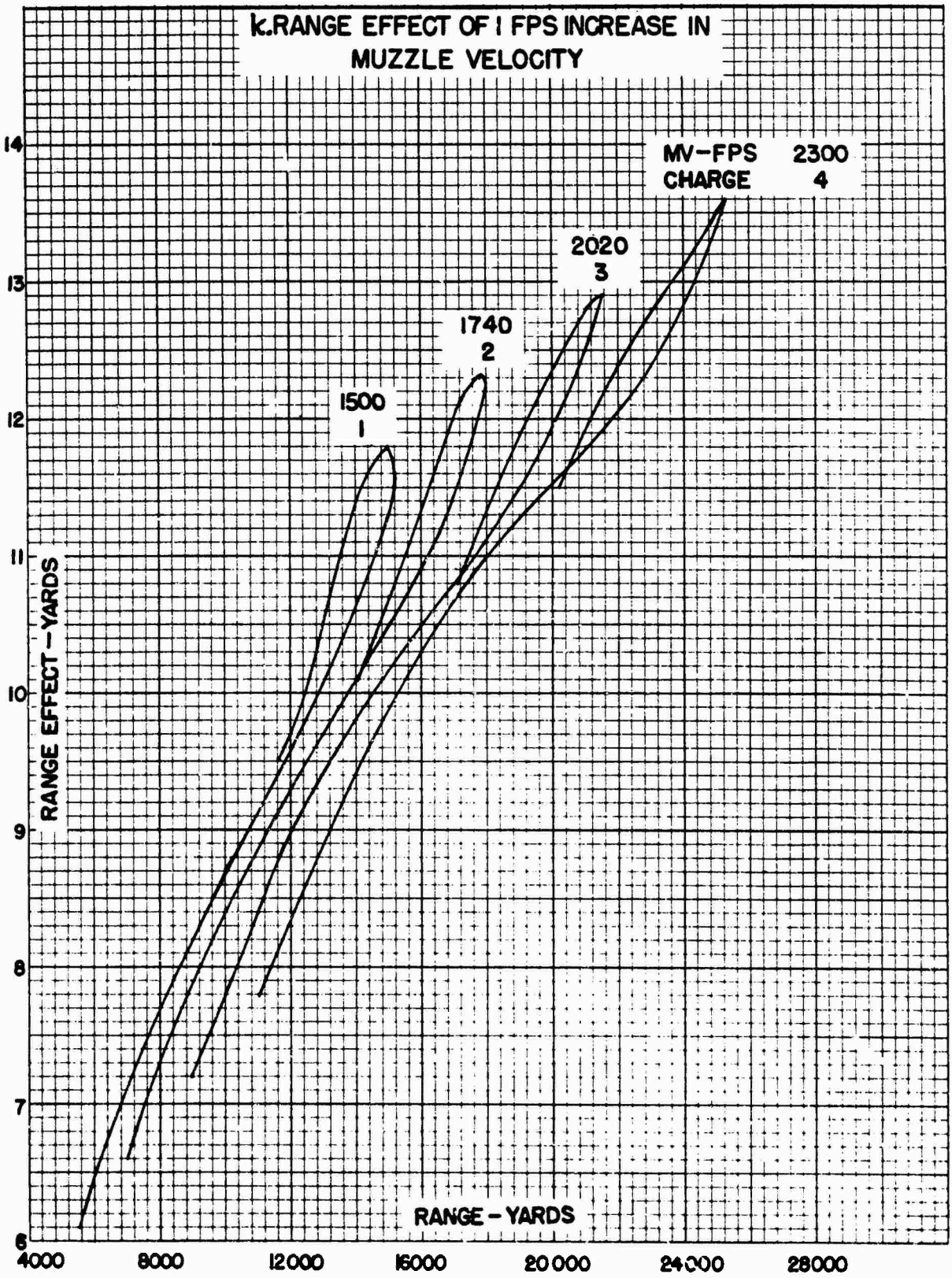

TIME OF FLIGHT – RANGE CURVES
MV–FPS 2300
CHARGE 4
2020
3
1740
2
1500
1
TIME OF FLIGHT – SEC
RANGE – YARDS
10
20
30
40
50
60
70
80
90
100
4000
8000
12000
16000
20000
24000
28000

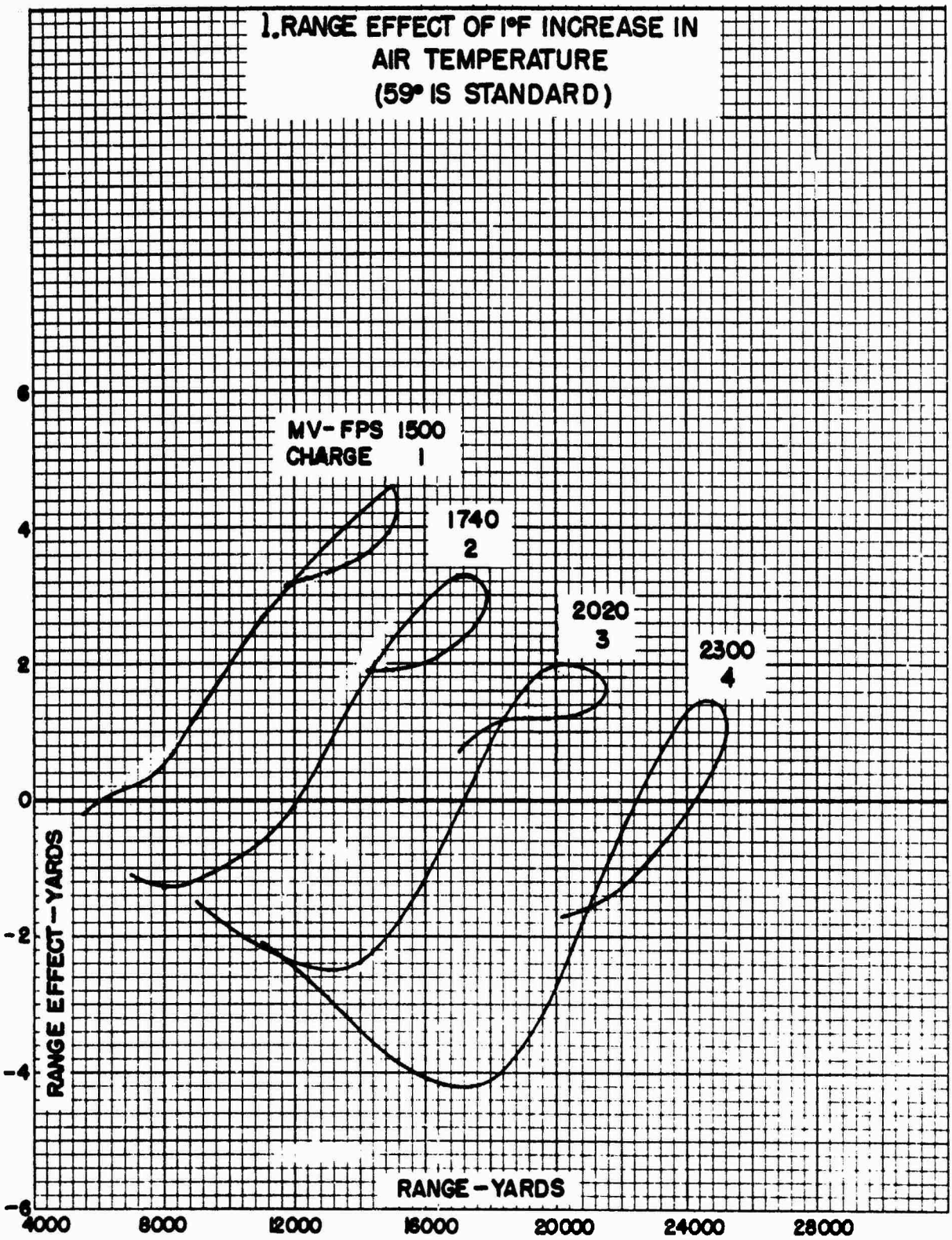

g-DRIFT – RANGE CURVES
MV-FPS 2300
CHARGE 4
2020
3
1740
2
1500
1
DRIFT – MILS
RANGE – YARDS
0
10
20
30
40
50
60
70
4000
8000
12000
16000
20000
24000
28000

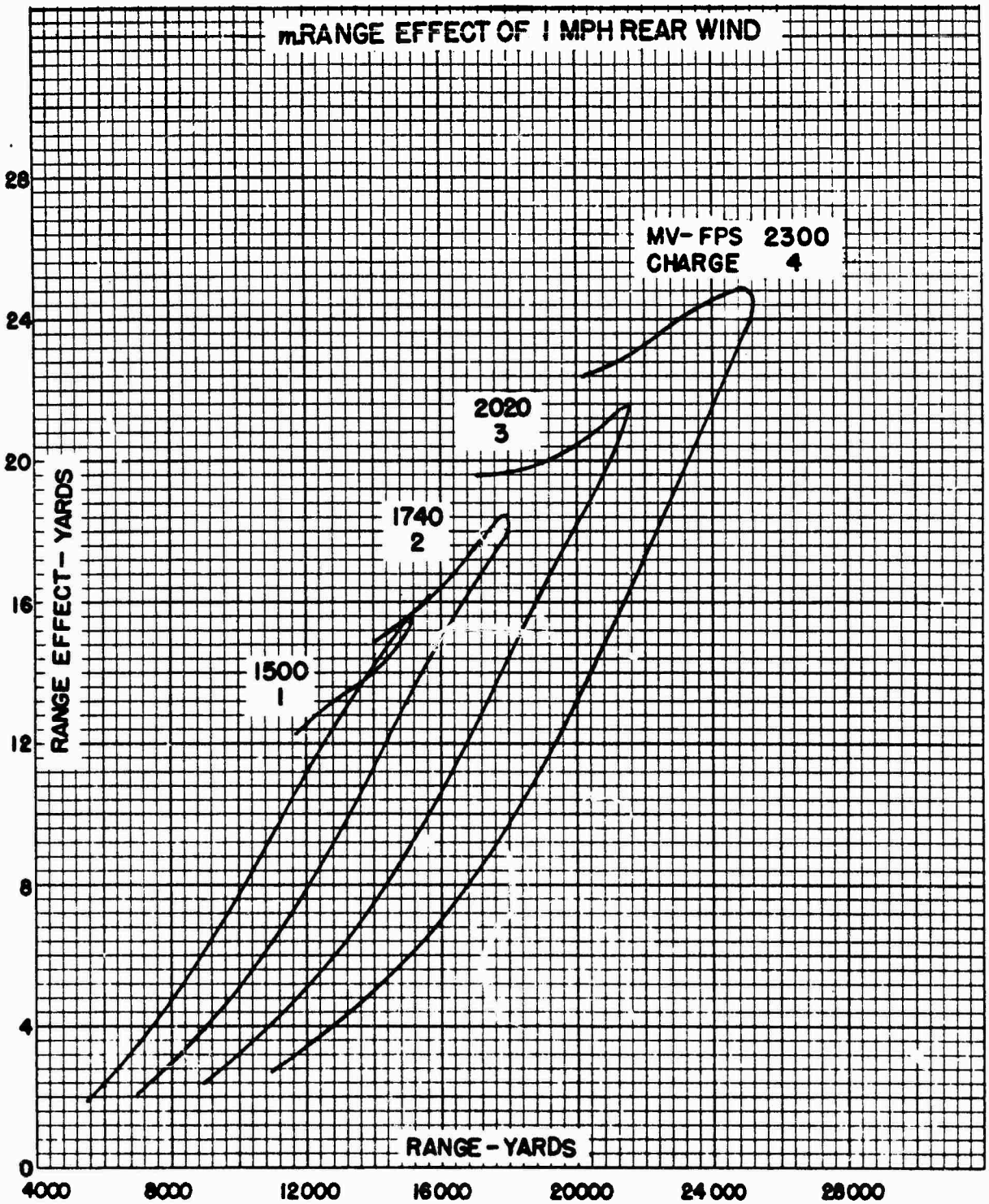

h. DEFLECTION EFFECT OF 1 MPH LATERAL WIND
MV-FPS 2300
CHARGE 4
1740
2
2020
3
1500
1
DEFLECTION EFFECT-MILS
1.0
.8
.6
.4
.2
0
RANGE-YARDS
4000
8000
12000
16000
20000
24000
28000

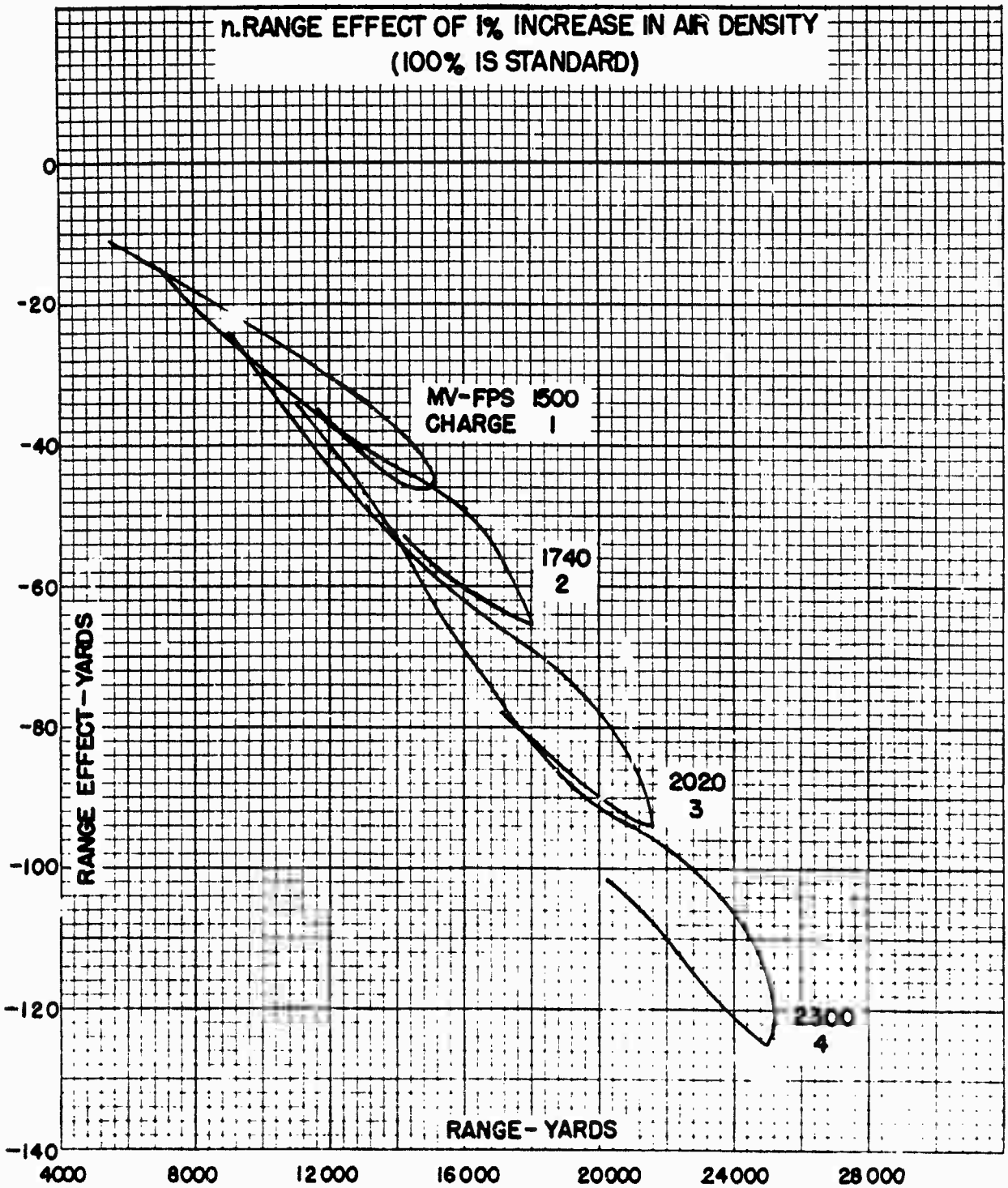

i. COMPLEMENTARY ANGLE OF SITE
(AVERAGE FOR ± 1 MIL ANGLE OF SITE)
ELEVATION
ANGLE OF SITE
COMPLEMENTARY ANGLE OF SITE
LOW + +
LOW − −
HIGH + −
HIGH − +
MV-FPS 2300
CHARGE 4
2020
3
1740
2
1500
1
COMPLEMENTARY ANGLE OF SITE-MILS
0
1
2
3
4
5
6
4000
8000
12000
16000
20000
24000
28000
RANGE-YARDS


RANGE EFFECT OF 1 ZONE INCREASE
IN WEIGHT OF PROJ.
(ZONE 4, MARKED ■■■■, IS STANDARD)
RANGE EFFECT - YARDS
RANGE - YARDS
20
10
0
-10
-20
-30
-40
-50
4000
8000
12000
16000
20000
24000
28000
1
2
3
4
CHARGE | MV-FPS | n
1 | 1500 | -.37
2 | 1740 | -.37
3 | 2020 | -.36
4 | 2300 | -.36


k. RANGE EFFECT OF 1 FPS INCREASE IN MUZZLE VELOCITY
MV-FPS 2300
CHARGE 4
2020
3
1740
2
1500
1
RANGE EFFECT - YARDS
RANGE - YARDS
14
13
12
11
10
9
8
7
6
4000
8000
12000
16000
20000
24000
28000


1. RANGE EFFECT OF 1°F INCREASE IN AIR TEMPERATURE (59° IS STANDARD)
MV-FPS 1500
CHARGE 1
1740
2
2020
3
2300
4
RANGE EFFECT-YARDS
RANGE-YARDS
6
4
2
0
-2
-4
-6
4000
8000
12000
16000
20000
24000
28000


mRANGE EFFECT OF 1 MPH REAR WIND
MV-FPS 2300
CHARGE 4
2020
3
1740
2
1500
1
RANGE EFFECT - YARDS
RANGE - YARDS
0
4
8
12
16
20
24
28
4000
8000
12000
16000
20000
24000
28000


n. RANGE EFFECT OF 1% INCREASE IN AIR DENSITY
(100% IS STANDARD)
MV-FPS 1500
CHARGE 1
1740
2
2020
3
2300
4
RANGE EFFECT - YARDS
RANGE - YARDS
0
-20
-40
-60
-80
-100
-120
-140
4000
8000
12000
16000
20000
24000
28000

SECTION V

EFFECT DATA

	Paragraph
Ricochet	9
Effectiveness	10
Functioning	11
Fragmentation	12
Penetration	13

9. Rocochet data. The following data on ricochet of the HE Shell M114 with PD Fuze M51A4, fired from the 240-mm Howitzer M1, were taken from volume III of "Terminal Ballistic Data".

Charge and No.	MV fps	Range yd	Angle of Fall mils	Angle of Recovery mils	Impact to Burst yd	Height of Burst ft	PE in Height of Burst ft
1	1500	9,000	371	310	17	16	5
1	1500	10,000	428	315	11	11	4
2	1740	11,000	405	315	15	14	4
3	2020	13,000	407	315	15	14	4

10. Effectiveness. The following data on effectiveness of HE Shell M114 with PD Fuze M51A4 or MT Fuze M67A3, fired from the 240-mm Howitzer M1, were taken from volume III of "Terminal Ballistic Data".

a. NUMBER OF ROUNDS REQUIRED AGAINST ENEMY ARTILLERY FOR 50% EFFECT FOR 10,000 SQ YD IN AREA FIRE

Charge 4: MV 2300 fps

Range yd	Type of Fire		
	Impact	Time	Time and Impact
20,000	1100	120	110
25,000	1400	160	150

b. NUMBER OF ROUNDS REQUIRED AGAINST ENEMY ARTILLERY FOR 90% PROBABILITY OF AT LEAST ONE EFFECTIVE HIT IN AIMED FIRE

Charge No.	MV fps	Range yd	Type of Fire		
			Impact	Time	Time and Impact
1	1500	10,000	330	320	220
1	1500	15,000	2300	1200	950
2	1740	15,000	1100	1600	930
4	2300	20,000	2300	1000	820
4	2300	25,000	7700	2400	2100

11. Functioning.

a. Source of data. The data on functioning of the HE Shell M1 (T1) were extracted from the "First Report in Connection with Tests of 240-mm Howitzer High Explosive Shell T1 Inert and TNT Loaded and Second Report on Ordnance Program No. 5774". Twenty shell, loaded with cast TNT and fitted with live M51A1 Fuzes and M21A1 Boosters, were fired in the functioning test. They all functioned with a high order detonation.

b. Data. The zone of the propellant, the elevation of the Howitzer, the setting of the Fuze (its action was the same as the setting in all cases), and the dimensions of the crater are shown in the following table.

Zone No.	Round No.	Elevation	Fuze Setting	Crater Dimensions (ft) Length	Width	Depth
4	158	36°50'	SQ	18.6*	17.0*	3.3*
4	159	37°50'	SQ	**		
4	160	38°50'	SQ	11.0	13.3	1.5
4	161	39°00'	SQ	13.4	15.0	1.8
4	162	40°00'	SQ	14.0	13.5	2.0
4	163	40°00'	Delay	5.5	7.0	3.2
4	164	40°00'	Delay	15.0	5.6	3.7
4	165	40°00'	Delay	24.6***	19.0***	1.7***
4	166	40°00'	Delay	24.6***	19.0***	1.7***
4	167	40°00'	Delay	9.7	8.3	3.2
1	168	17°30'	SQ	9.0	9.0	2.7
1	169	19°00'	SQ	7.4	6.5	3.0
1	170	19°00'	SQ	7.7	7.7	2.7
1	171	19°00'	SQ	8.0	8.8	3.0
1	172	19°00'	SQ	7.5	8.8	2.7
1	173	19°00'	Delay	18.0	13.6	6.9
1	174	19°00'	Delay	****		
1	175	19°00'	Delay	****		
1	176	19°00'	Delay	****		
1	177	19°00'	Delay	****		

* Functioned in mud at edge of swamp.
** Functioned by hitting tree.
*** Rounds 165 and 166 formed one double-crater.
**** These four rounds functioned on ricochet, 22 to 26 feet from point of impact and 6 to 10 feet above ground.

c. Remarks. The proof officer, Lt. M. T. Smith, made the following remarks in his report:

(1) "The superquick action of the fuzes was judged to be normal. The depths of craters were judged to be normal based on similar firings of other heavy caliber artillery. The vegetation was clipped around the crater over a diameter of about 35 feet, which was evidence of good superquick functioning.

(2) "The typical crater of the rounds fired at Zone IV charge and 40 degrees elevation with delay fuzes was a small open crater with some cracking and raising of the ground about the opening. Below the open crater, the ground was broken to undetermined depths. Since very little ground was heaved from the crater, the power of the detonation was just about sufficient to break the ground up to the surface. The depths of the detonations were almost great enough to result in camouflets."

12. Fragmentation.

a. Static test. The report cited in paragraph 11a also describes a static test of the T1 Shell, conducted for the purpose of determining their fragmentation characteristics. Two shell, loaded with cast TNT and fitted with live modified M51 Fuzes and M21 Boosters, were fired statically by means of electric blasting caps. Both projectiles functioned with superquick action and high order detonation. The fragmentation pit was 16 feet in depth, 18 feet in diameter at the bottom, and 20 feet in diameter at the top. The shell was supported in a wooden box, with at least 9.5 inches clearance between the shell and the box. The box, containing the shell in a vertical position, was placed in the center of the pit after the bottom of the pit had been covered with sand three feet deep. The pit was then filled with sand. The total weight of the sand was 121 tons. The top of the pit was covered with a large rope mat, 3" x 8" wooden planks, and eleven 500-pound armor plates. After the shell were fired, the sand was screened and the recovered fragments were classified and weighed.

b. Screens. The average dimensions of the screens are shown in the following table.

Screen Number	Meshes per inch	Diameter of Wire, inch	Length of Side of Square Opening, inch
1	1	.162	.838
2	2	.135	.315
3	3	.105	.228
4	4	.080	.165

c. Fragments. According to the drawing of the shell, the weight of the TNT is 54 pounds. The average weight of the shell as fired was 362.625 pounds. Hence, the average weight of the shell and fuze, without TNT, was 308.625 pounds. The following table gives the average number and weight of the fragments retained by each screen.

Screen	Fragments		Weight	
No.	No.	% of total	lb.	% of 308.625 lb
1	448	10.5	199.01	64.48
2	1859	43.4	93.24	30.21
3	1147	26.8	5.06	1.64
4	662	15.5	1.01	0.33
Thru 4	164	3.8	0.10	0.030
Total	4278	100.0	298.42	96.69

d. Casualties. The next four tables were taken from volume III of "Terminal Ballistic Data". The initial fragment velocity of the 240-mm HE Shell M114 is 3,300 fps.

TABLE 62
CASUALTIES

Distance from burst (ft)	Total number of effective fragments	Average number of effective fragments per sq ft	For the lightest effective fragment	
			Weight (oz)	Velocity (fps)
r	N	B	m	v
20	4,160	0.825	0.013	2,140
30	4,080	0.360	0.017	1,870
50	3,660	0.117	0.028	1,460
70	3,310	0.0538	0.040	1,220
100	3,000	0.0239	0.060	1,000
150	2,720	0.0096	0.087	827
250	2,360	0.0030	0.140	652
400	1,990	0.0010	0.240	498
700	1,520	0.0002	0.521	338
1,000	1,050	0.0001	0.928	253

e. Perforation of 1/8-inch mild steel.

TABLE 63
PERFORATION OF 1/8 IN. MILD STEEL

Distance from burst (ft)	Total number of effective fragments	Average number of effective fragments per sq ft	For the lightest effective fragment	
			Weight (oz)	Velocity (fps)
r	N	B	m	v
20	3,250	0.647	0.042	2,530
30	3,070	0.271	0.055	2,300
50	2,720	0.0865	0.087	1,970
70	2,420	0.0393	0.132	1,770
100	2,040	0.0162	0.220	1,480
150	1,670	0.0059	0.412	1,230
200	1,360	0.0027	0.639	1,090
275	1,010	0.0011	0.980	970
400	638	0.0003	1.70	841
600	379	0.0001	3.05	729

f. Perforation of 1/4-inch mild steel.

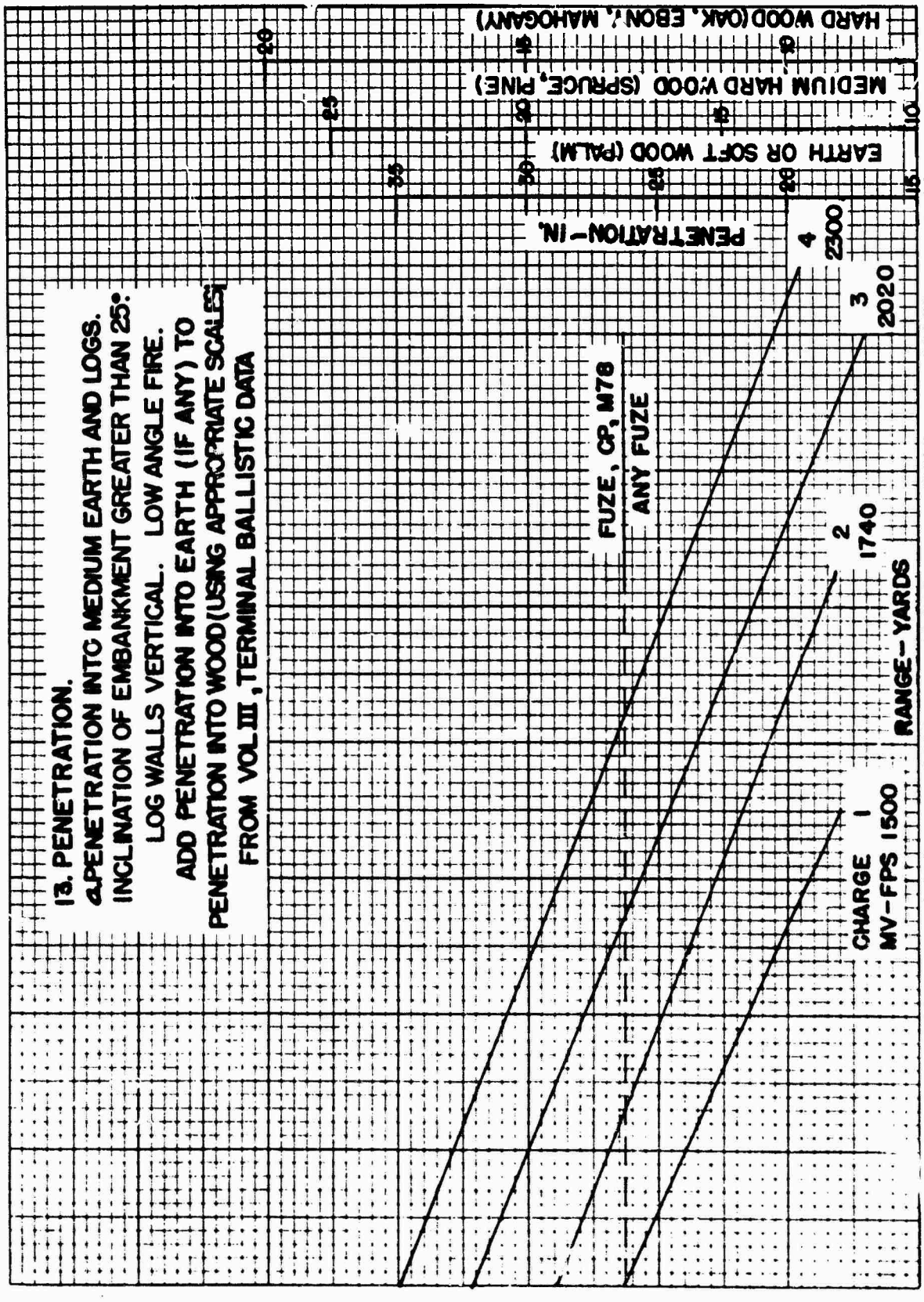
TABLE 64
PERFORATION OF 1/4 IN. MILD STEEL

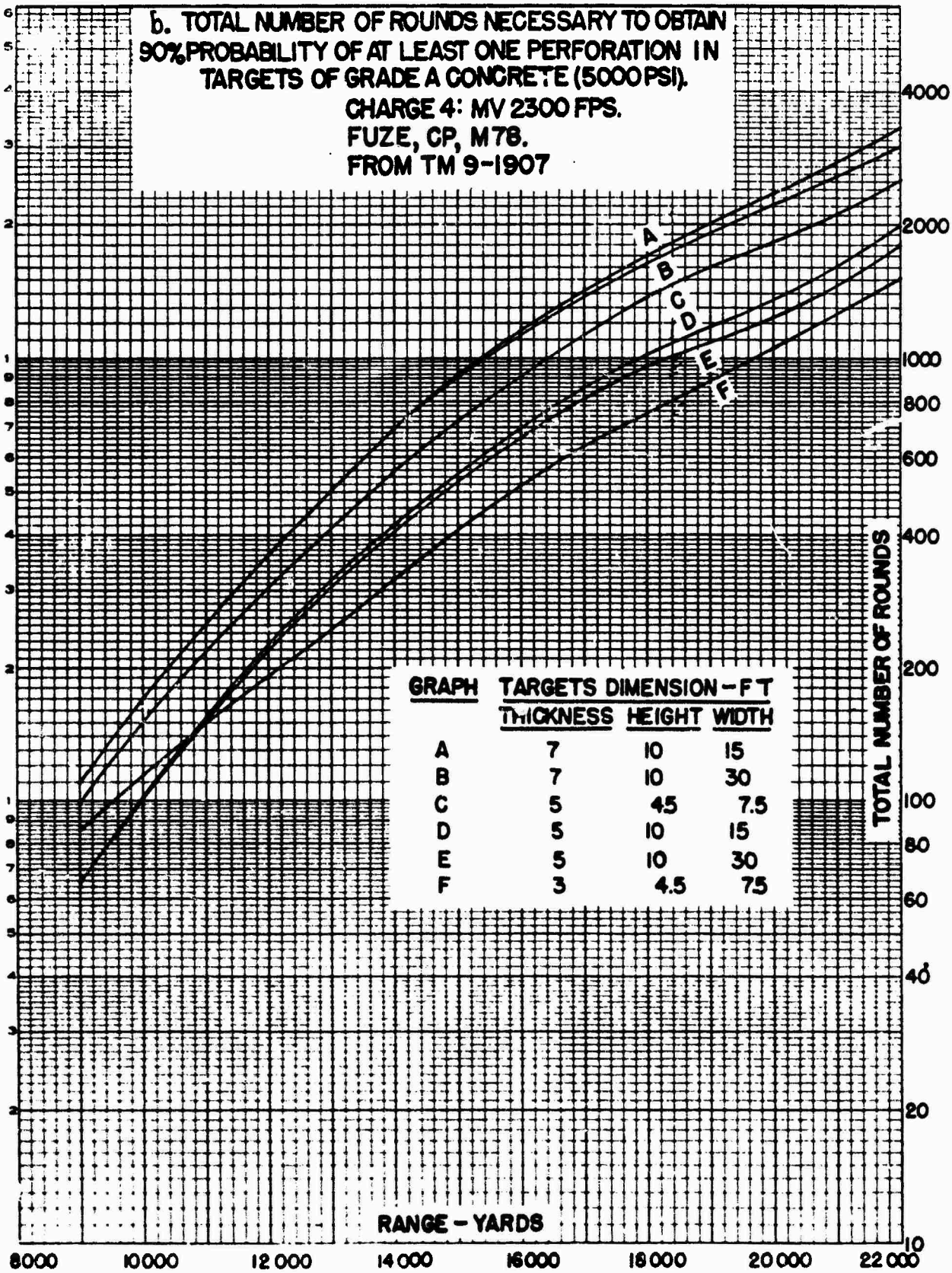
Distance from burst (ft)	Total number of effective fragments	Average number of effective fragments per sq ft	For the lightest effective fragment	
			Weight (oz)	Velocity (f/s)
r	N	B	m	v
20	2,000	0.399	0.235	2,880
30	1,910	0.169	0.276	2,720
40	1,820	0.0903	0.325	2,560
60	1,640	0.0362	0.436	2,310
80	1,460	0.0182	0.560	2,120
100	1,280	0.0102	0.700	1,970
150	885	0.0031	1.17	1,680
200	622	0.0012	1.75	1,480
300	362	0.0003	3.28	1,230
500	177	0.0001	7.05	997

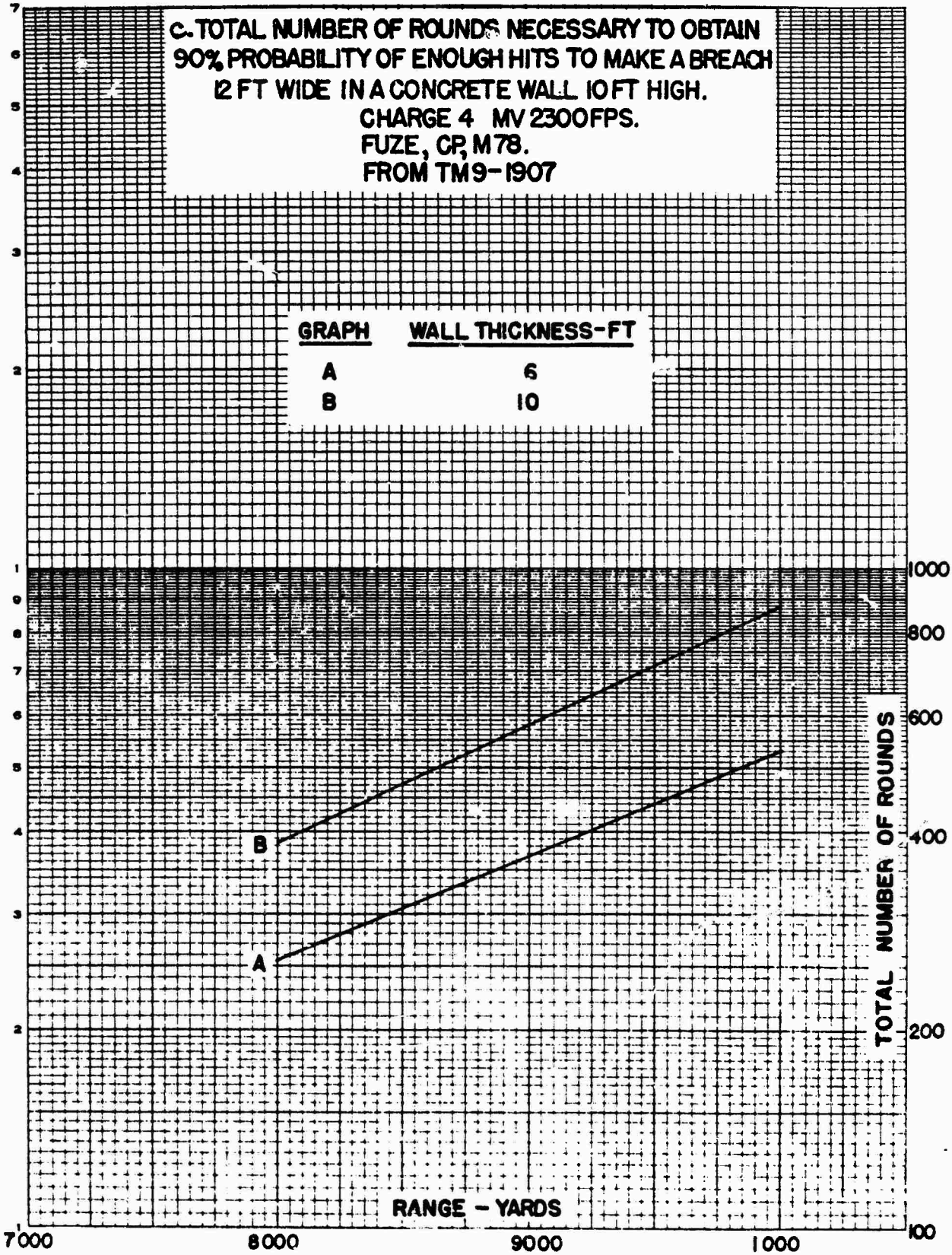
g. Perforation of 1/2-inch mild steel.

TABLE 65
PERFORATION OF 1/2 IN. MILD STEEL

Distance from burst (ft)	Total number of effective fragments	Average number of effective fragments per sq ft	For the lightest effective fragment	
			Weight (oz)	Velocity (fps)
r	N	B	m	v
20	700	0.139	1.54	3,070
30	638	0.0564	1.70	2,980
40	597	0.0297	1.85	2,880
60	498	0.0110	2.23	2,700
80	432	0.0054	2.60	2,550
100	383	0.0030	3.01	2,420
150	333	0.0012	4.22	2,160
200	251	0.0005	5.60	1,970
250	165	0.0002	7.27	1,810
300	82	0.0001	9.15	1,680


13. PENETRATION.
a. PENETRATION INTO MEDIUM EARTH AND LOGS.
INCLINATION OF EMBANKMENT GREATER THAN 25°.
LOG WALLS VERTICAL. LOW ANGLE FIRE.
ADD PENETRATION INTO EARTH (IF ANY) TO
PENETRATION INTO WOOD (USING APPROPRIATE SCALES)
FROM VOL III, TERMINAL BALLISTIC DATA
PENETRATION – IN.
HARD WOOD (OAK, EBON, MAHOGANY)
MEDIUM HARD WOOD (SPRUCE, PINE)
EARTH OR SOFT WOOD (PALM)
FUZE, CP, M78
ANY FUZE
CHARGE 1
MV-FPS 1500
2
1740
3
2020
4
2300
RANGE – YARDS
0
2000
4000
6000
8000
10000
12000
14000
16000


b. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN 90% PROBABILITY OF AT LEAST ONE PERFORATION IN TARGETS OF GRADE A CONCRETE (5000 PSI).
CHARGE 4: MV 2300 FPS.
FUZE, CP, M78.
FROM TM 9-1907
A
B
C
D
E
F
GRAPH | TARGETS DIMENSION - FT
THICKNESS | HEIGHT | WIDTH
A 7 10 15
B 7 10 30
C 5 4.5 7.5
D 5 10 15
E 5 10 30
F 3 4.5 7.5
TOTAL NUMBER OF ROUNDS
4000
2000
1000
800
600
400
200
100
80
60
40
20
10
RANGE - YARDS
8000
10000
12000
14000
16000
18000
20000
22000


c. TOTAL NUMBER OF ROUNDS NECESSARY TO OBTAIN
90% PROBABILITY OF ENOUGH HITS TO MAKE A BREACH
12 FT WIDE IN A CONCRETE WALL 10 FT HIGH.
CHARGE 4 MV 2300 FPS.
FUZE, CP, M78.
FROM TM 9-1907
GRAPH
WALL THICKNESS-FT
A
6
B
10
B
A
TOTAL NUMBER OF ROUNDS
1000
800
600
400
200
100
RANGE - YARDS
7000
8000
9000
1000