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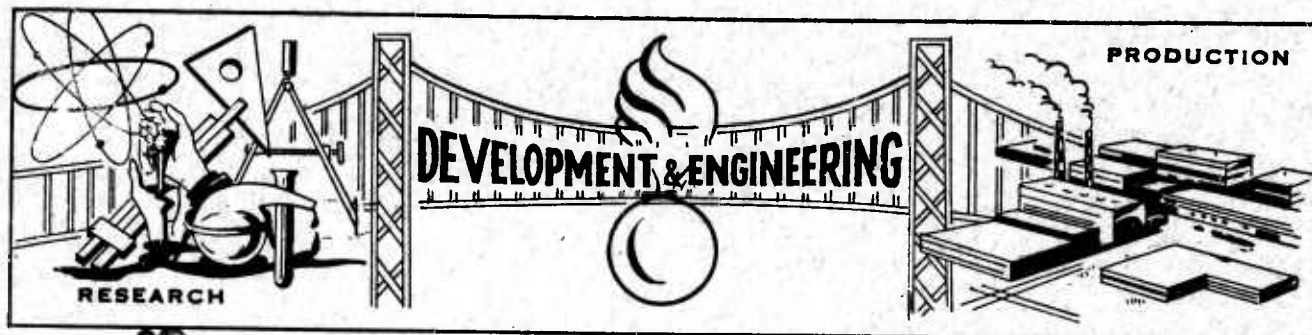


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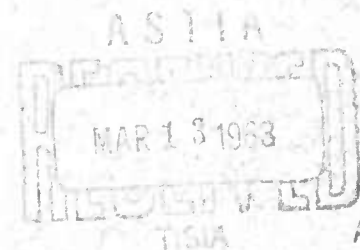
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TECHNICAL REPORT 3035

NOMOGRAPHS
FOR
INTERIOR BALLISTICS

BY

SIDNEY KRAVITZ



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JANUARY 1963

PICATINNY ARSENAL - DOVER, NEW JERSEY

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Dover, New Jersey
ATTN: SMUPA-DR3 (Mr. Sidney Kravitz)

TECHNICAL REPORT 3035
AMMUNITION GROUP

NOMOGRAPHS
FOR
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BY
SIDNEY KRAVITZ

JANUARY 1963

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SECTION I

INTRODUCTION

In April 1959 "Interior Ballistic Calculations with a Special Slide Rule" (Picatinny Arsenal Technical Report 2603) was published. This report presented the theory, design and use of a special slide rule for performing certain interior ballistic calculations. However, since slide rule calculations can always be duplicated with parallel-scale nomographs, it has been possible to construct a set of four nomographs for performing the same calculations.

The purpose of this report is to show how these nomographs are to be used. These calculations can be performed many times faster than is possible by any other method of calculation except the large-scale electronic computer.

SECTION II

SUMMARY

A set of four nomographs are presented which will accurately perform certain interior ballistic calculations.

SECTION III

CONCLUSION

The nomographs presented have been checked against many standard guns and howitzers. It has been found that where pressure and charge are given, muzzle velocity can be accurately determined more rapidly than possible by any other method except large-scale electronic computers.

SECTION IV

RECOMMENDATION

That this set of interior ballistic nomographs be used for the rapid calculation of muzzle velocity.

SECTION V

STUDY

Use of The Nomographs

The following example shows how to use the interior ballistic nomographs when considering the 155mm Howitzer.

Quantities Given:

1. Propellant Weight, $C = 13.4875$ lbs.
2. Projectile Weight, $W = 95$ lbs.
3. Travel, $L = 115$ in.
4. Chamber Volume, $V_o = 795$ cu. in.
5. Pressure, $P = 36,530$ psi
6. Caliber, $D = 6.102$ in. (155mm)

Calculate The Following Quantities

1. Propellant Weight To Projectile Weight Ratio, $\epsilon = C/W = 13.4875/95 = 0.142$ lbs
2. Bore Area, $A = \frac{\pi D^2}{4} = \frac{\pi (6.102)^2}{4} = 29.244$ in²
3. Expansion Ratio, $X_m/X_o = 1 + \frac{AL}{V_o} = 1 + \frac{(29.244)(115)}{795} = 5.230$
4. Density Of Loading, $\Delta = \frac{27.68 C}{V_o} = \frac{27.68(13.4875)}{795} = 0.4696$, or 0.47 grams/cc.

NOMOGRAPH I

Line 1

Draw a straight line between $P = 36,530$ psi on the left scale to $\Delta = 0.47$ on the right scale. Note the intersection point of this line with the vertical center line.

Line 2

Draw a straight line between $M1$ on the right scale and the intersection point on the vertical center line. Read $p = 0.40$ on the left scale. Also read $X_b = 2.2$ on left scale.

NOMOGRAPH II

Line 3

Draw a straight line between $\Delta = 0.47$ on the right scale and $(X_m/X_o) = 5.23$ on the center scale. Read $X_m = 7.0$ on the left scale. Proceed with Nomograph III only if $X_m > X_b$. In this case, $7.0 > 2.2$.

NOMOGRAPH III

Line 4

Connect $X_m = 7.0$ on the left scale to $p = 0.40$ on the center scale. Read $\mu_m = 1.58$ on the right scale.

NOMOGRAPH IV

Line 5

Connect $\mu_m = 1.58$ on the left scale with $\epsilon = 0.142$ on the right scale. Note the intersection point with the center scale, then connect $M1$ on the right scale with the intersection point on the center scale. Read

the muzzle velocity on the left scale, $V_m = 1,850 \text{ ft/sec.}$

Note:

The "p" center scale of Nomograph III is based on the assumption of zero starting pressure, propellant of constant burning surface, no co-volume excess, burning rate exponent equal to one, and ratio of specific heats equal to 1.3. A similar scale may be constructed for any other set of conditions. This will be the subject of a future report. However, it will be found that where pressure and charge are given and muzzle velocity is required, the nomographs will give accurate answers even when these conditions are not satisfied.

APPENDIX A

FIGURES

INTERIOR BALLISTICS NOMOGRAPHS

SIDNEY KRAVITZ

GIVEN (FOR 155 mm HOWITZER)

M1 PROPELLANT

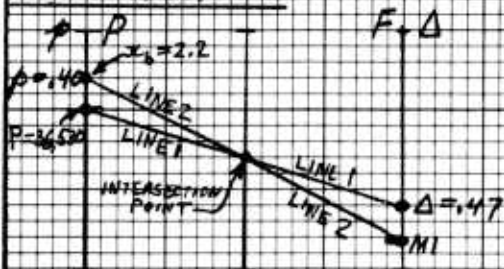
PROPELLANT TO PROJECTILE WEIGHT RATIO, $E = .142$

DENSITY OF LOADING, GRAMS/CC, $\Delta = .47$

MAXIMUM PRESSURE, PSI, $P = 36,530$

EXPANSION RATIO, $X_m/X_0 = 5.23$

NOMOGRAPH I



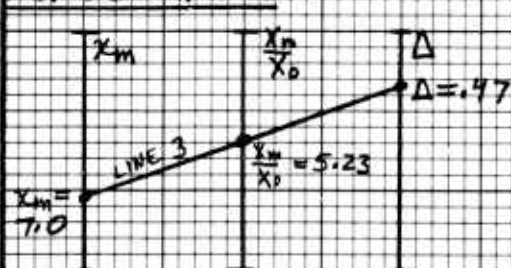
LINE 1

CONNECT $P = 36,530$ TO $\Delta = .47$.
NOTE INTERSECTION POINT.

LINE 2

CONNECT MI TO INTERSECTION
POINT. READ $p = .40$. READ $X_0 = 2.2$

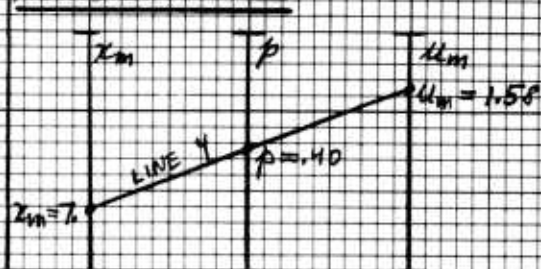
NOMOGRAPH II



LINE 3

CONNECT $\Delta = .47$ TO $X_m/X_0 = 5.23$.
READ $X_m = 7.0$. PROCEED
ONLY IF $X_m > X_0$. IN THIS
CASE $7.0 > 2.2$.

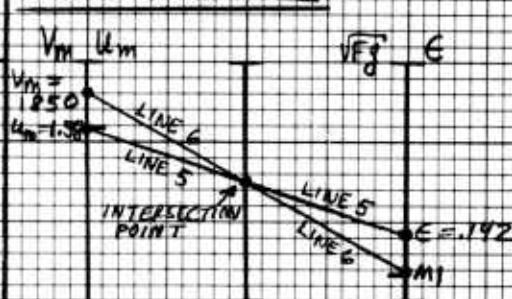
NOMOGRAPH III



LINE 4

CONNECT $X_m = 7.0$ TO $p = .40$.
READ $u_m = 1.58$

NOMOGRAPH IV



LINE 5

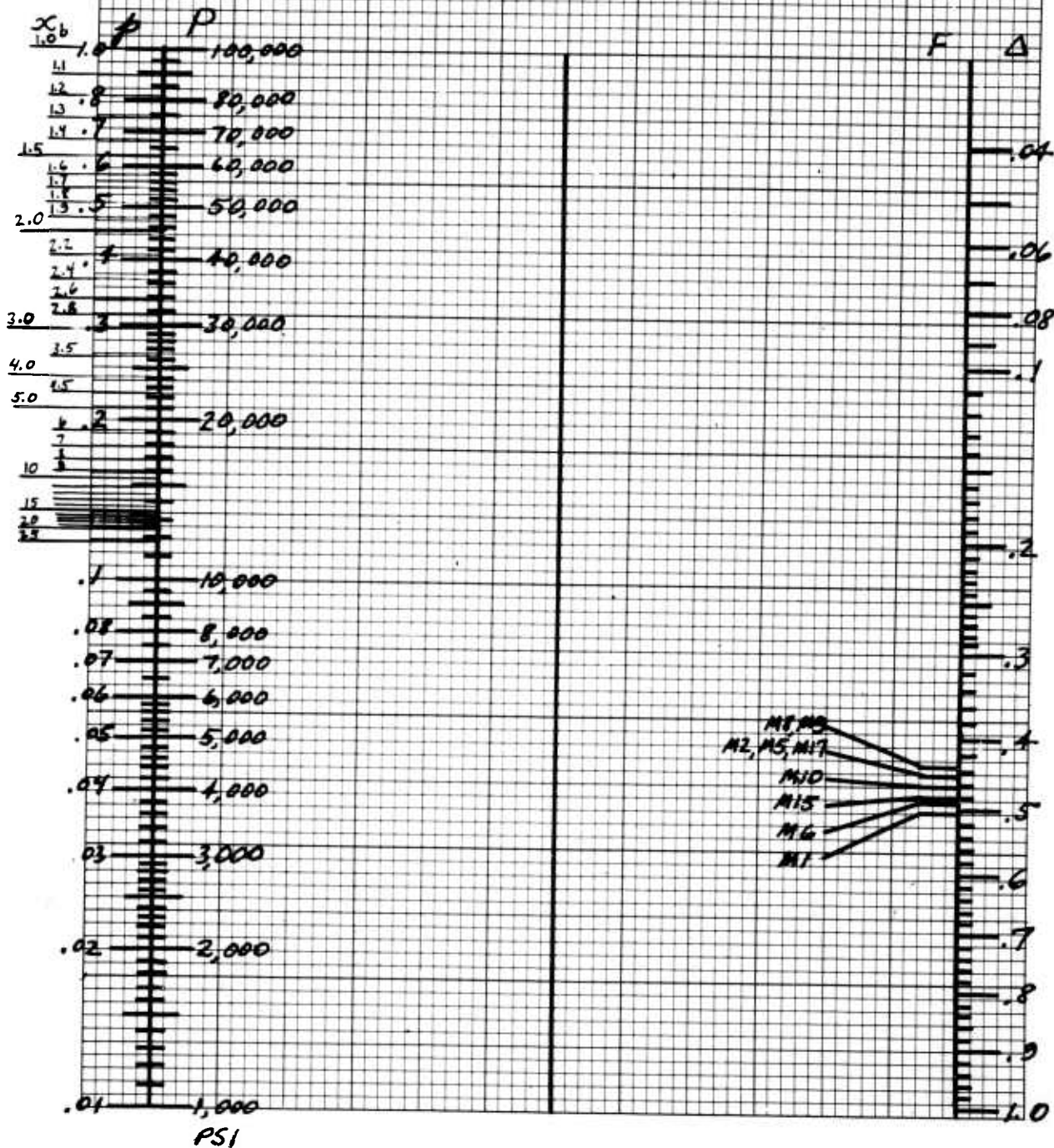
CONNECT $u_m = 1.58$ TO $E = .142$.
NOTE INTERSECTION POINT.

LINE 6

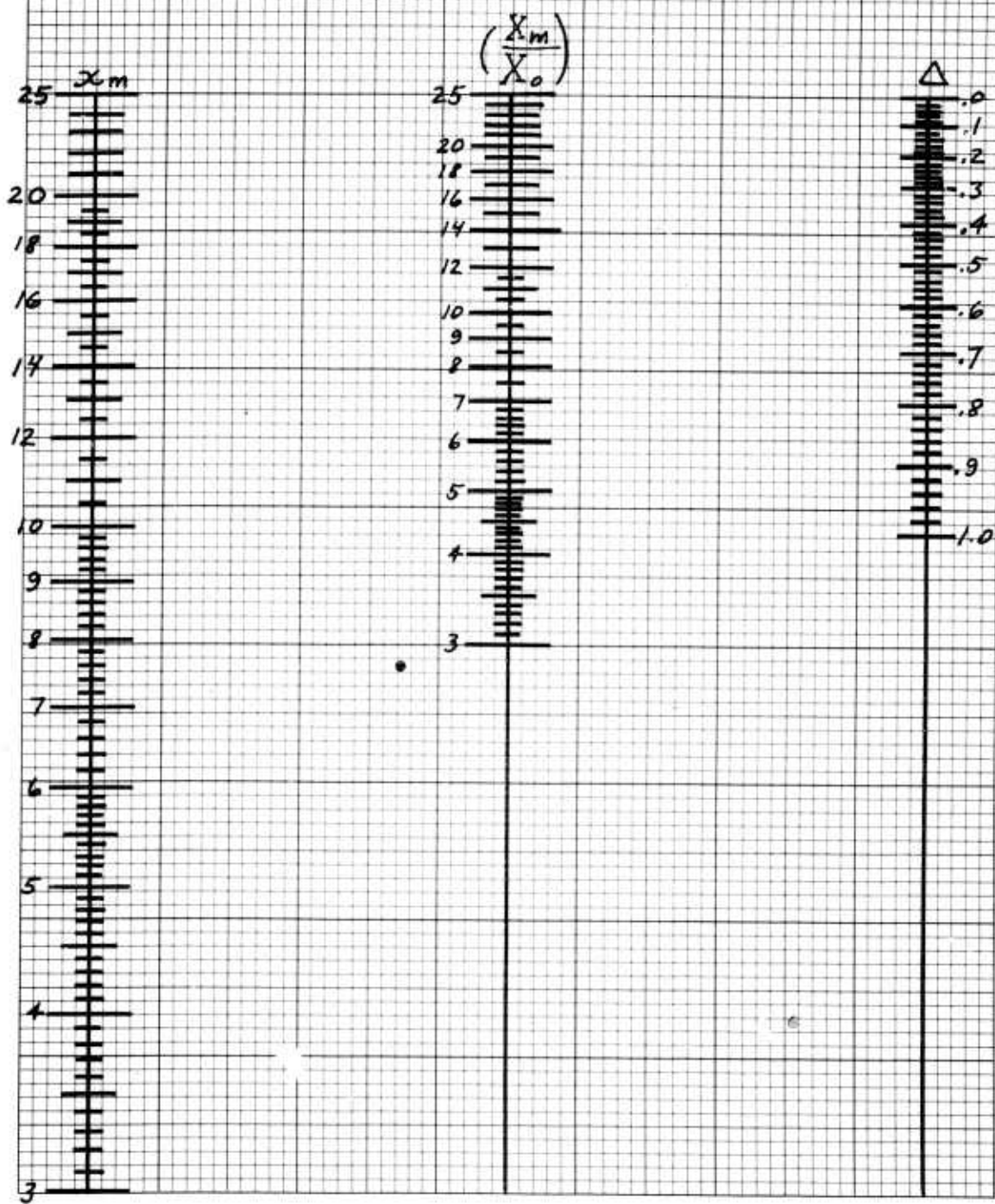
CONNECT MI TO INTERSECTION
POINT. READ MUZZLE VELOCITY,
 $V_m = 1850$ FT/SEC

$p \leftrightarrow F$
 $P \leftrightarrow \Delta$

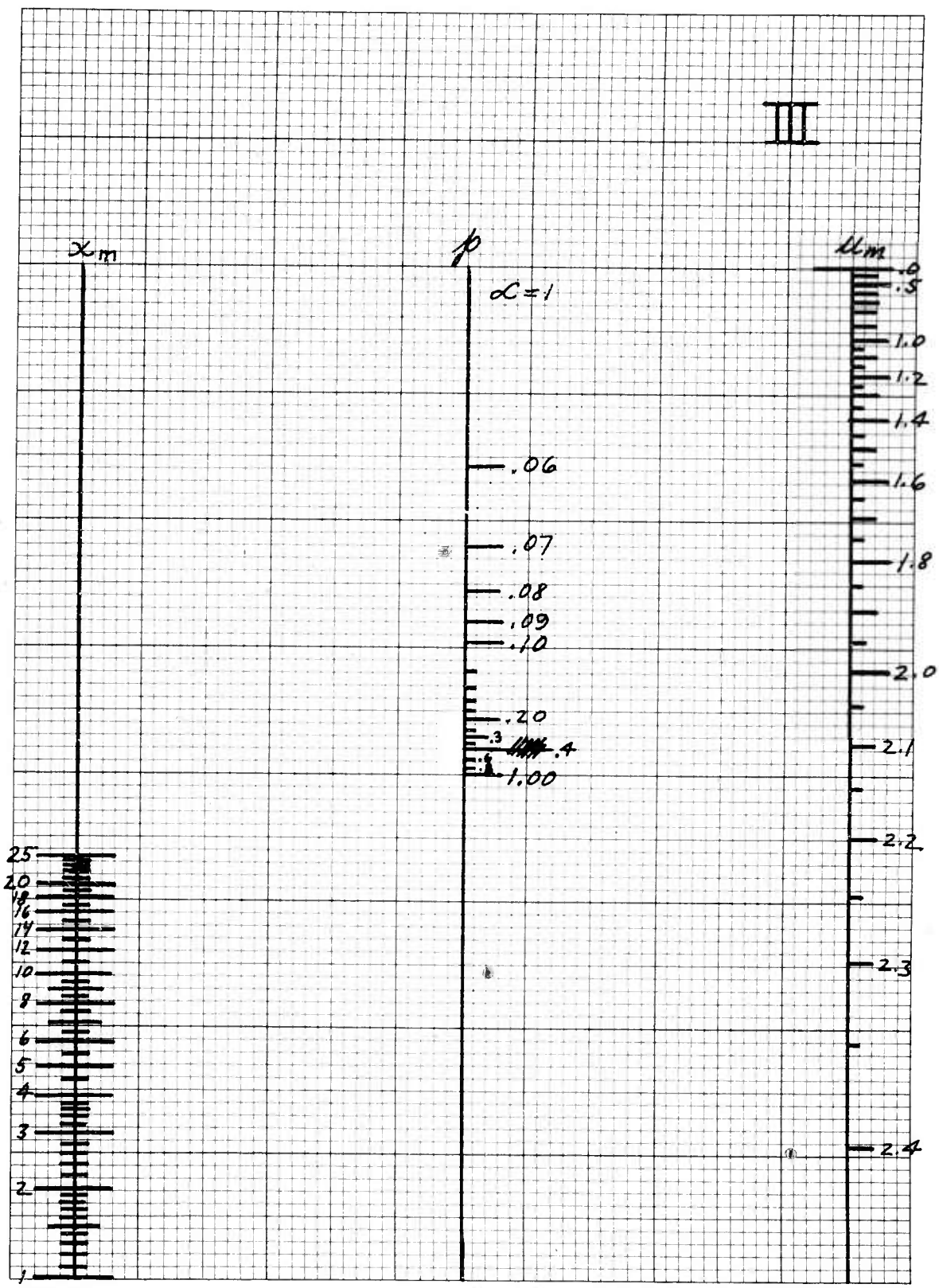
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II



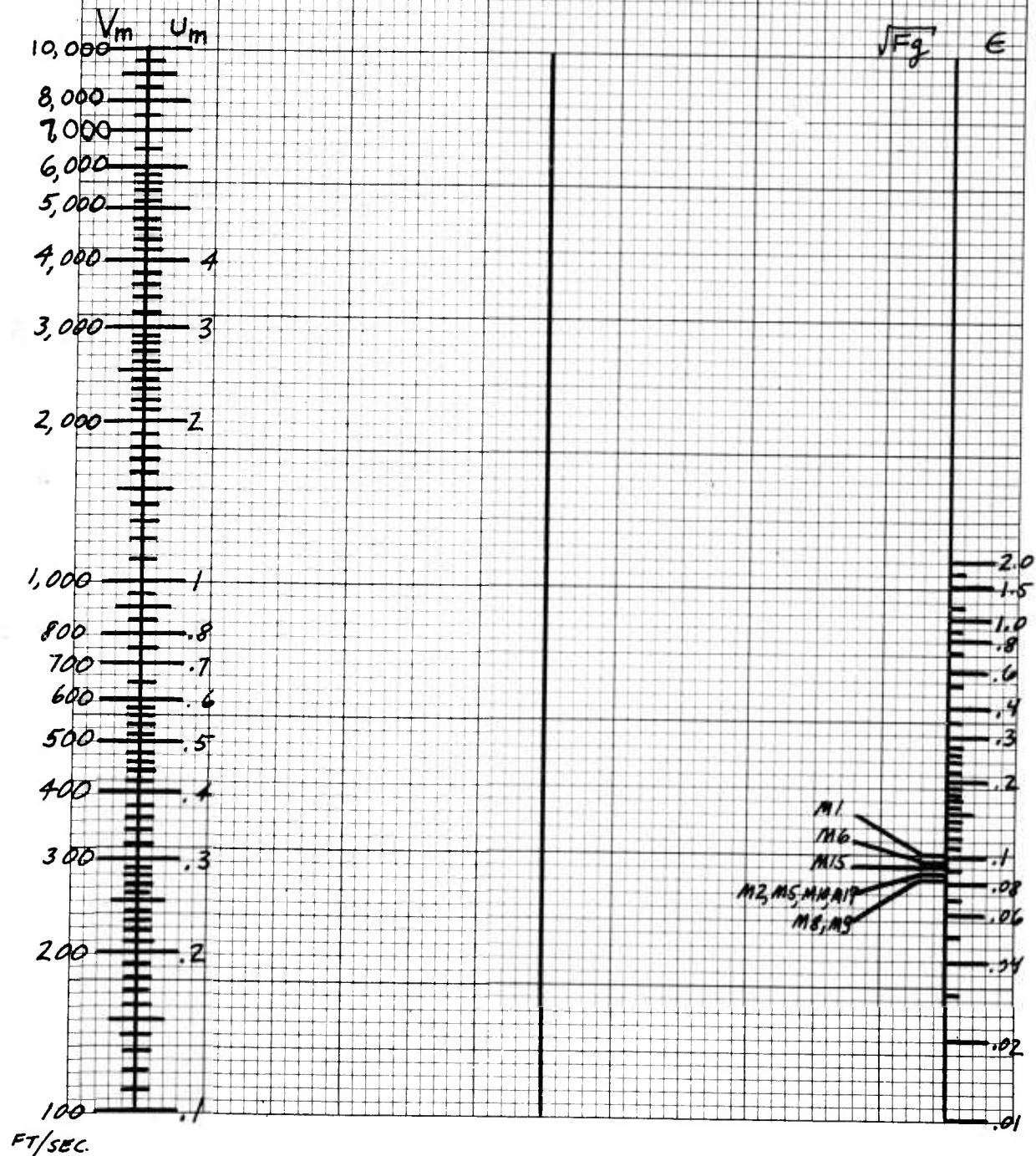
III



$$V_m \leftrightarrow \sqrt{Fg}$$

$$U_m \leftrightarrow \epsilon$$

IV



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NOMOGRAPHS FOR INTERIOR BALLISTICS

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Technical Report 3035, January 1963
12pp, figures.

Unclassified Report from the Artillery Ammunition
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A set of four nomographs are presented which will
accurately perform certain interior ballistic calcula-
tions many times faster than is possible by any other
method except the large-scale computer.

The study describes how to use these nomographs to
accurately determine muzzle velocity for the 155mm
howitzer when pressure and charge are given.

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Calculations.
2. Muzzle velocity --
155mm Howitzer.

- I. Kravitz, Sidney
- II. Nomographs

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