EXTERIOR BALLISTIC CHARTS

PREPARED BY

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SMOKELESS POWDER DEPARTMENT

E. I. DU PONT DE NEMOURS & COMPANY, Inc., WILMINGTON, DELAWARE

A SHORT CUT TO EXTERIOR BALLISTICS

Nearly every rifleman is interested in the trajectory of a bullet in flight. While trajectories can be worked out from ballistic tables the calculations are long and arduous and, for that reason, seldom undertaken. We are, therefore, offering a series of drawings as a short cut to such calculations which can be used to approximate trajectory values in a very short time and with sufficient accuracy to prove serviceable.

An intricate mathematical problem can be worked out by the aid of logarithms in considerably less time than by straight algebra, and the solution of the problem will be equally as accurate. There are times, however, when accuracy is not the prime essential, and an approximate solution of the problem is desired that will be within the variations normally encountered. It is then that the slide rule comes into its own. The construction of the slide rule is based upon logarithms, but is, of course, not nearly so accurate, as the fourth place must be estimated.

When the problem is concerned with the trajectory of a bullet in flight, Col. Ingalls' Ballistic Tables can be used in place of a table of logarithms, but, like the logarithmic tables, Ingalls' Ballistic Tables cannot be used for rapid calculations, as any one who has ever worked out a trajectory table can testify.

The computation of the first table may be very interesting, but interest wanes with the second table; the computation of third and subsequent tables invokes much labor and patience.

Like the ordinary slide rule, these charts are not capable of being read very closely; the thickness of a pencil line will often lead to a slight error. But they will prove of assistance in making rapid calculations and are well within the limit of errors introduced by variations in loading, in different lots of ammunition and components, and in the individual variations which are characteristic of any rifle.

More explicitly, it is a very unusual combination of rifle, ammunition and holding that will produce a target with a group within one minute of angle. (A minute of angle is approximately equal to one inch per 100 yards; i. e., one inch at 100 yards, two inches at 200 yards, etc.) A group within two minutes of angle is usually considered satisfactory. In calculating a trajectory by means of these charts, the angle of departure can be determined within an error of one minute of angle as compared to the calculations worked out from Ingalls' Tables direct, and similarly with the other functions of a trajectory.

The drawings have been made for all rifle bullets between .22 and .50 caliber; .50 caliber was considered the high limit; as any man shooting a larger gun is naturally more interested in recoil pads than trajectories. The first curve deals with the coefficient of form, sometimes called the coefficient of ignorance and usually designated by the symbol "i."

Ingalls' Ballistic Tables depend upon the determination of "i," the coefficient of form by trial or approximation, and the determination of "C," the Ballistic Coefficient by calculation, since these values are not included in the Tables. The coefficient "i" is, therefore, the subject of the first drawing.

The ballistic coefficient "C" depends on the diameter and weight of the bullet as well as the coefficient "i" and consequently, is the subject of the second drawing. The other elements of the trajectory can be found from the Tables and the drawings are arranged accordingly. Intermediate functions such as "Z," etc., are used as reference lines in the nomographs and consequently no reference to the Tables is necessary.

The first drawing, which covers the coefficient of form, is the starting point for all trajectory calculations. The coefficient of form is a somewhat unknown factor. It can be accurately determined by firing, which, however, is seldom undertaken with most sporting bullets and is not absolutely necessary except for long range work. As the coefficient of form depends primarily upon the conformation of the point of the bullet and the effect of the air resistance upon the point, bullets of the same or other calibers which have the same shape are given the same coefficient. In the course of time, a series of tables have been developed in the various ballistic stations which are used as guides in assigning coefficients to bullets. These tables are based not only upon firing tests but upon some system of comparing the shapes of the bullets. Naturally the tables do not agree exactly.

The table given on the first page has been compiled from several sources, both in this country and abroad. The different values for bullets of the same ogive were averaged to render the table consistent. Although this coefficient of form can be determined by actual firing in two different localities, the resulting coefficients will differ, owing to variations in climatic conditions as well as the physical variables previously mentioned. The table is not intended to contradict results of actual firing tests, but to furnish the rifleman, who has no means of determining the coefficient by trial with a table which will permit him to approximate the value for the coefficient of form of various bullets.

In order to assist in determining the ogive of a given bullet, a diagram is given in chart No. 1 for the various common calibers. In preparing such a diagram it is only necessary to draw two vertical parallel lines, the same distance apart as the diameter of the bullet. To draw a profile of a bullet with an ogive of 0.5, a radius of one-half caliber is used to describe a semi-circle tangent to the two vertical lines. For a bullet profile with an ogive of 1.0, a radius of one caliber or the full diameter of the bullet is used to describe two arcs, tangent to the vertical lines and meeting in a point. Profiles for bullets of other ogives or for calibers other than those included in chart No. 1 can be prepared in a similar fashion.

In gauging the profile by matching the bullet with the diagram, special attention must be paid to the point of the bullet. In the diagram, the profile is brought to a sharp point but no bullet could be made into such a sharp point, as it could not be removed from the die, consequently, it is necessary to blunt the point slightly. Therefore, in matching the bullet profile, the point of the bullet should not be placed exactly on the point of the diagram. It is better to watch the slope and match the bearing surface of the bullet with the parallel guide lines.

An interesting example of this point is the .45 A.C.P. Service bullet. This bullet is rounded but has an ogive greater than a semi-circle. It will not exactly coincide with the ogive of 0.5 or 1.5 nor 1.0 marked on the diagram, for the bullet is not sharp pointed.

Furthermore, on observing the slope of the sides, it will be seen that the profile approximates an ogive of 1.5 if the point is not considered. The very tip of the bullet point is but a small factor at most; even long pointed streamlined bullets will be found to have the tip of the point slightly blunted.

While the bluntness of the tip may be ignored in a pointed bullet, the contrary holds when the bullet is made with a flat or a hollow point. In the second case, the flattened nose offers considerable area to the air resistance and reduces the efficiency of the tapered sides by a large amount. The diameter of the flat nose in drawing No. 1, is given in tenths of calibers rather than in inches. If given in inches, it would be necessary to have a separate table for every caliber, but since the reduction in efficiency due to the flattened nose is proportional to the caliber, diameters in calibers simplify the table.

For example, a 0.30 caliber bullet or a bullet having a diameter of 0.30 inches with a flat nose 0.1 inch in diameter can be described as a .30 caliber bullet, with a flat nose having a diameter of one-third (the diameter of the flat nose in inches divided by the diameter of the bullet in inches) the diameter of the bullet. Expressed in decimals, the flat nose has a diameter of 0.33 of the bullet diameter or as more commonly expressed, a diameter of 0.33 calibers.

A .25 caliber bullet with a flat nose of 0.08 inches can also be described as having a flat nose of 0.32 calibers and if the two bullets have the same profile, the coefficient of form will have the same value. For practical purposes 0.3 caliber diameter can be used for the flat point, or the value for 0.32 or 0.33 can be obtained by interpolation. A double ogive is somewhat of a problem but by moving the bullet up and down on the chart, an average can be decided upon.

There is a tendency to push the bullet too high on the chart when trying to read its profile. This is due to the eye being ahead of the bullet instead of directly above it and thereby making the point appear shorter than it actually is. It is advisable to read the profile in two ways: first, hold the chart so that the parallel lines are vertical and look directly down on the bullet; second, turn the chart through 90 degrees so that the parallel lines are in a horizontal position and push the bullet across the line of vision, keeping the eye slightly above the surface of the paper but quite a distance from the bullet. This second reading gives a side view of the bullet and should check the first reading.

In many cases there is a choice in assigning either one of two ogives to a bullet according to the visual inspection. For this reason two readers will not always check each other nor is it absolutely necessary that the readings be checked exactly for they are sufficiently accurate for practical purposes within normal hunting ranges.

For those who are mathematically inclined, the following formulas from Ingalls' Artillery Circular M were used in designing these nomographs:

For Chart No.1: = No formula used.

The coefficient of form is determined graphically.

For Chart No. 2:

$$C = \frac{w}{i\,d^2} \qquad (1)$$

where,
- C = The Ballistic Coefficient.
- w = The weight of the projectile in pounds.
- d = The diameter of the bullet in inches.
- i = The coefficient of form.

For Chart No. 3:

$$x = C\,(Su - SV) \qquad (2)$$

where,
- x = The range in feet.
- C = The Ballistic Coefficient.
- Su = A primary function used in Ingalls' Table I in which u is a pseudo velocity.
- SV = A primary function used in the same table as Su.
- V = The initial velocity in feet per second.

$$Z = \frac{x}{C} \qquad (3)$$

where,
- Z = Horizontal range in feet for a standard projectile having a Ballistic Coefficient. (C) = 1.

For Chart No. 4:

$$\sin 2\text{Ø} = AC \qquad (4)$$

where,
- Ø = Angle of Departure.
- A = Secondary function depending upon range.
- C = Ballistic Coefficient.

For Chart No. 5:

$$t = Ct' \sec \text{Ø} \qquad (5)$$

where,
- t = Time of flight in seconds.
- C = Ballistic Coefficient.
- Sec Ø = Secant of Angle of Departure (For all small angles Sec = 1).
- t′ = Secondary function depending upon Range, Ballistic Coefficient and Velocity.

For Chart No. 6:

$$Y_o = HX \tan \text{Ø} \qquad (6)$$

where,
- Y = Maximum height of trajectory in feet.
- H = Secondary function depending upon Range, Ballistic Coefficient and Velocity.
- X = Range in feet.
- tan Ø = Tangent of Angle of Departure.

For Chart No. 7:

$$\tan \omega = B' \tan \qquad (7)$$

where,
- tan ω = Tangent of the Angle of Fall.
- B′ = Secondary function depending upon Range, Ballistic Coefficient and Velocity.
- tan Ø = Tangent of the Angle of Departure.

For Chart No. 8:

$$D = \frac{WZ \quad D_{ow}}{V \cos \text{Ø}} \qquad (8)$$

where,
- D = Wind Deflection in Degrees.
- W = Velocity of wind in miles per hour across the plane of fire.
- D_{ow} = Secondary function depending upon Velocity and Value of Z.
- Z = Horizontal range in feet for a standard projectile having a Ballistic Coefficient. (C) = 1
- V = Muzzle Velocity in feet per second.
- Cos Ø = Cosine of Angle of Departure.

For Chart No. 9:

$$E = \frac{MV^2}{2} \text{ or } \frac{WV^2}{2g} \qquad (9)$$

where,
- E = Kinetic energy of projectile in foot seconds.
- W = Weight of projectile in pounds.
- V = Remaining Velocity.
- g = The Acceleration of gravity.

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Edgar Beugless, Ass't Ballistic Engineer
Burnside Laboratory,
December, 1935.

Chart No. 1 for Determining Coefficient of Bullet Form

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers of E. I. du Pont de Nemours & Company, Inc.
Burnside Laboratory, Wilmington, Delaware

GIVEN: A BULLET

Coefficient of Form (i) for Bullets of Various Shapes; Cylindrical, Tapered, Pointed, and also for Pointed Bullets with Hollow Points or Flat Noses

Example—Find the coefficient of bullet form of the 172 grain Frankford Arsenal 1925 National Match .30 caliber bullet whose muzzle velocity is 2700 feet per second.

First Step—Place the bullet on the chart over the .30 caliber guide lines and slide it up or down until the curved lines on the chart coincide with the form of the bullet. In this case a head radius or ogive of 8 calibers is too blunt and a head radius of 10 calibers is too sharp so the ogive lies between 8 and 10 or is equal to 9 calibers.

Second Step—Locate from table the value corresponding to a normal point bullet with a head radius of 9.0 calibers. The table shows a bullet with a head radius of 8 calibers moving between 2000 and 3500 feet per second has a coefficient of form = .49 and a bullet with a head radius of 10 calibers moving between the same limits has a coefficient of form = .44. Therefore a bullet with a head radius of 9 calibers moving at a velocity of 2700 feet per second would have a coefficient of form equal to

$$\frac{.49 + .44}{2} \text{ or } .465.$$

BULLET FORM	NORMAL POINT	VALUE OF i — Diam. of Hollow Point or Flat Nose in Calibers 0.1	0.2	0.3	0.4	0.5
Blunt Projectile, Cylindrical	2.30					
Blunt Projectile, Taper Sides 0.9 Cal.	1.85					
Blunt Projectile, Taper Sides 0.8 Cal.	1.50					
Blunt Projectile, Taper Sides 0.7 Cal.	1.30					
Blunt Projectile, Taper Sides 0.6 Cal.	1.10					
Head Radius of 0.5 Cal.	1.40					
Head Radius of 1.0 Cal.	1.10	1.15	1.20	1.25	1.30	1.40
Head Radius of 1.5 Cal.	0.95	1.00	1.10	1.15	1.25	1.35
Head Radius of 2.0 Cal.	0.85	0.90	0.95	1.00	1.10	1.25
Head Radius of 3.0 Cal. M.V. 2000–3500 f.s.	0.70	0.75	0.80	0.90	1.00	1.10
Head Radius of 3.0 Cal. M.V. under 2000 f.s.	0.75	0.80	0.85	0.95	1.05	1.15
Head Radius of 4.0 Cal. M.V. 2000–3500 f.s.	0.60	0.65	0.70	0.75	0.85	1.00
Head Radius of 4.0 Cal. M.V. under 2000 f.s.	0.70	0.75	0.80	0.85	0.95	1.10
Head Radius of 6.0 Cal. M.V. 2000–3500 f.s.	0.55	0.60	0.65	0.70	0.80	0.95
Head Radius of 6.0 Cal. M.V. under 2000 f.s.	0.65	0.70	0.80	0.85	0.95	1.10
Head Radius of 8.0 Cal. M.V. 2000–3500 f.s.	0.49	0.55	0.60	0.65	0.75	0.90
Head Radius of 8.0 Cal. M.V. under 2000 f.s.	0.60	0.65	0.70	0.75	0.85	1.00
Head Radius of 10.0 Cal. M.V. 2000–3500 f.s.	0.44	0.50	0.55	0.60	0.70	0.85
Head Radius of 10.0 Cal. M.V. under 2000 f.s.	0.55	0.60	0.65	0.70	0.80	0.95
Balls with M.V. under 1000 f.s.	2.00					
Balls with M.V. between 1000–1300 f.s.	1.70					
Balls with M.V. over 1300 f.s.	1.40					

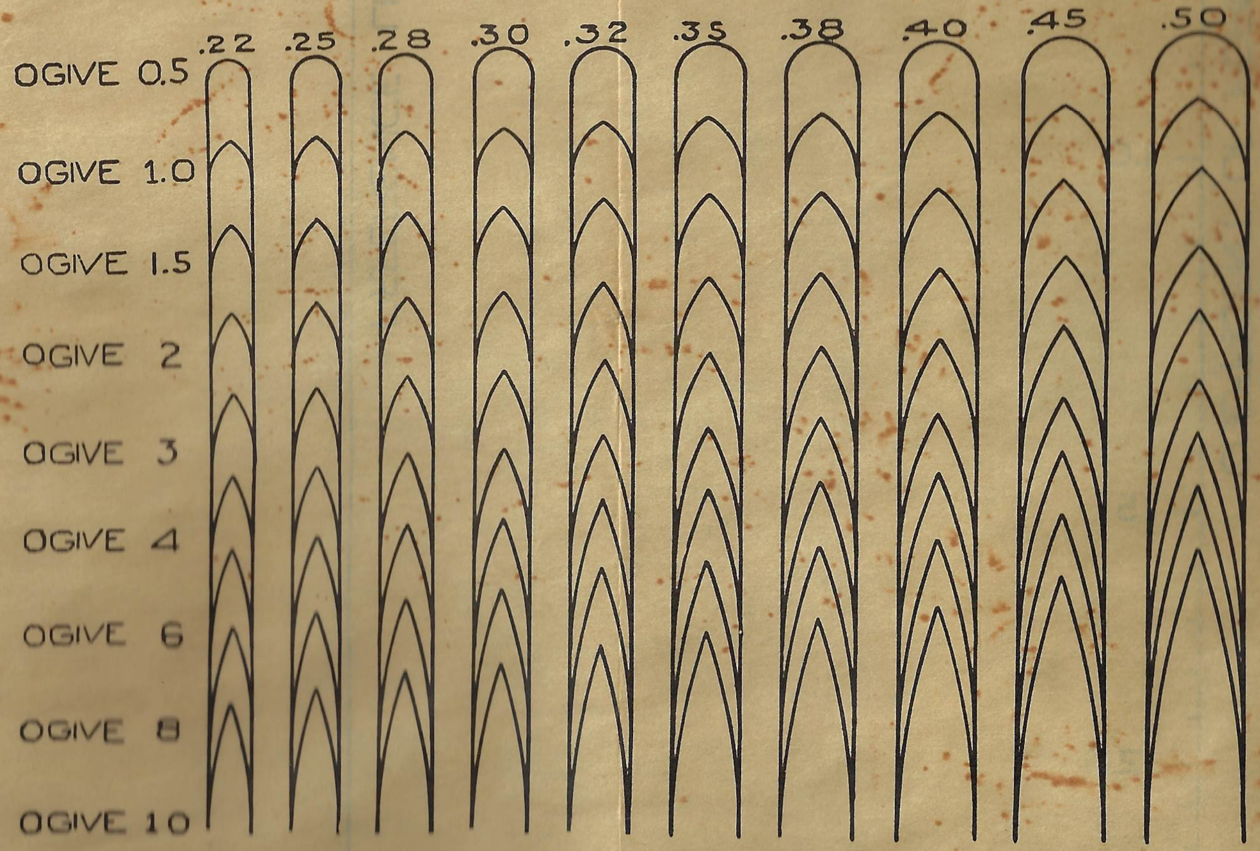


Chart No. 2 for Determining Ballistic Coefficient (C)

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers of E. I. du Pont de Nemours & Company, Inc., Burnside Laboratory, Wilmington, Del.

GIVEN: Coefficient of Form (i)
Weight of Bullet in Grains (w)
Diameter of Projectile in Inches (d)

Example —Find the Ballistic Coefficient of the Frankford Arsenal 172-Grain 9° Boattail 1925 National Match .30-06 Bullet.
Coefficient of Form (i) = 0.465
Weight of Bullet (w) = 172 Grains.
Diameter of Projectile (d) = .308 Inches.

First Step —Locate the value 0.465 on the i axis.

Second Step—Locate the value 172 on the w axis.

Third Step —Connect these two points with a straight line, giving Line No. 1 on Chart.

Fourth Step—Locate the value of .308 on the D axis.

Fifth Step —Connect this point with the intersection of Line No. 1 and the Reference line, Giving line No. 2 on Chart.

Sixth Step —The value of .56 where Line No. 2 crosses the C axis is the required value, or the Ballistic Coefficient.

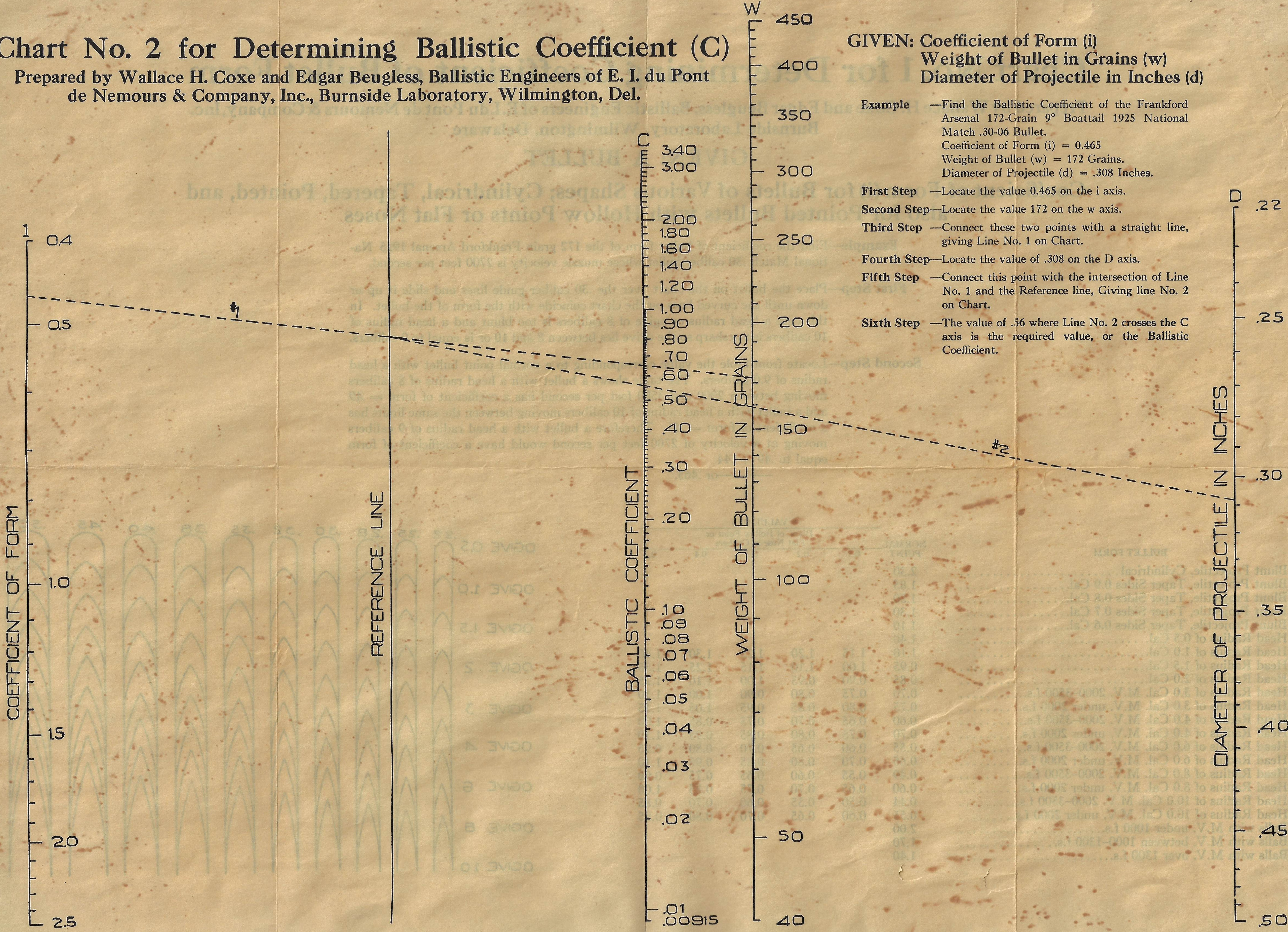


Chart No. 3 for Determining Remaining Velocity

(Ranges from 1 to 3000 feet)

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers of E. I. du Pont de Nemours & Company, Inc., Burnside Laboratory, Wilmington, Delaware

GIVEN: Ballistic Coefficient (C) Range in Feet (X) Muzzle Velocity in Foot Seconds (M.V.)

Example —Find the remaining velocity of the 172-gr. Frankford Arsenal 1925 National Match Bullet at 500 Yards when starting with a muzzle velocity of 2750 foot-seconds.
Ballistic Coefficient (C) = .56.
Muzzle Velocity (M.V.) = 2750 Foot Seconds.
Range (X) = 500 Yards = 1500 Feet.

First Step —Locate the Value .56 on the C Axis.

Second Step —Locate the Value 1500 on the X Axis.

Third Step —Connect these two points with a straight line giving line No. 1 on Chart.

Fourth Step —Ascertain the value, from logarithmic graduations on the right side where line No. 1 crosses the Z Axis. In this case 2700.

Fifth Step —Locate this value of Z (2700) on the left side of the Z Axis from the Natural Graduations.

Sixth Step —Locate the Value 2750 on the M.V. Axis.

Seventh Step—Connect these two points with a straight line, giving line No. 2 on Chart.

Eighth Step —The Value 1975 where line No. 2 crosses the R.V. Axis is the required value of the remaining velocity at 500 Yards.

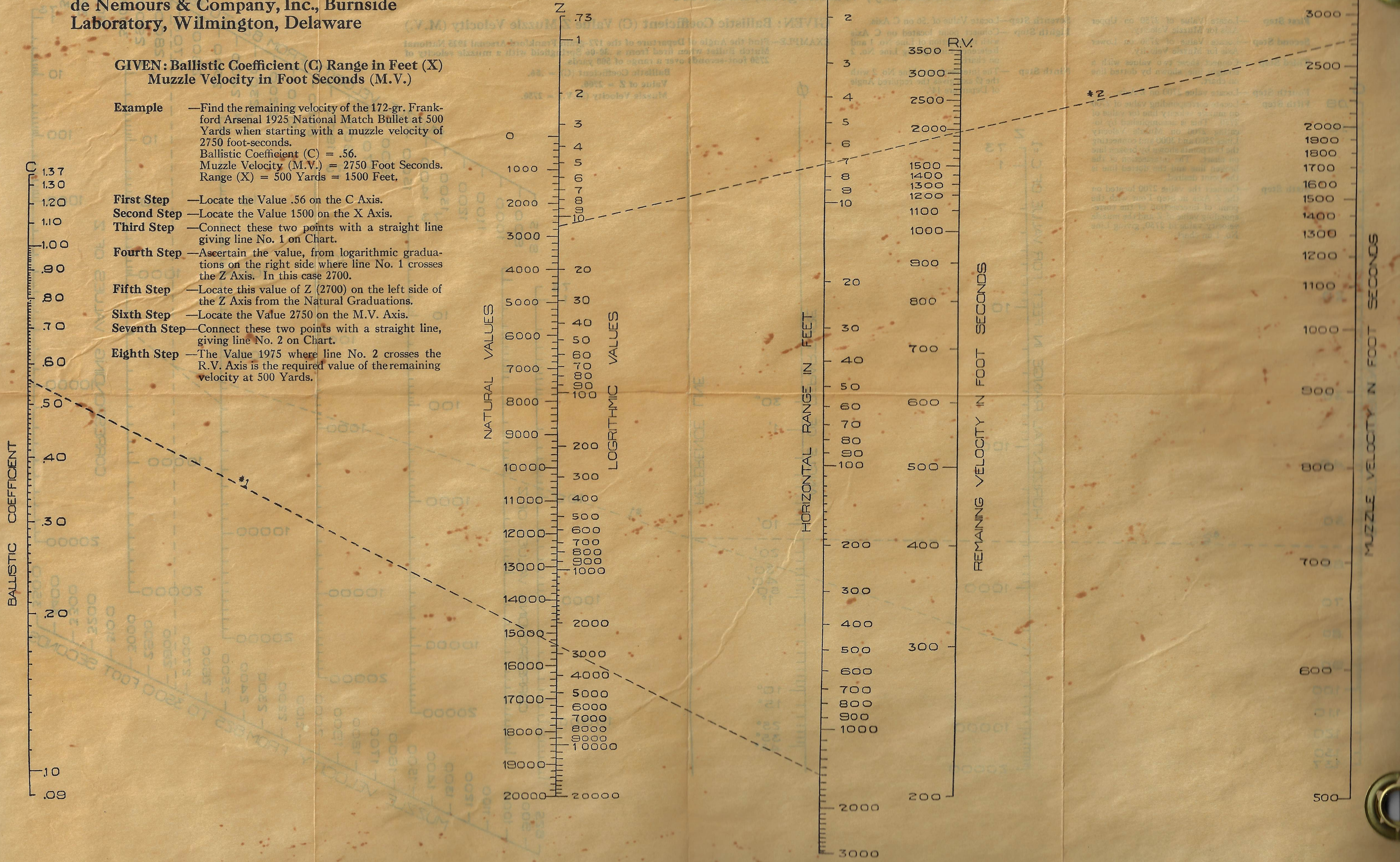


Chart No. 4 for Determining Angle of Departure

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers of E. I. du Pont de Nemours & Company, Inc., Burnside Laboratory, Wilmington, Delaware

First Step —Locate Value of 2750 on Upper Axis for Muzzle Velocity.

Second Step —Locate Value of 2750 on Lower Axis for Muzzle Velocity.

Third Step —Connect these two values with a straight line, shown by dotted line on chart.

Fourth Step —Locate value 2700 on Z Axis.

Fifth Step —Locate corresponding value of 2700 on muzzle velocity line for value of 2750. This is accomplished by locating 2700 on Muzzle Velocity Lines 2500 and 3000 and connecting the two points shown by broken line on chart. The intersection of the broken line and the dotted line is the point desired.

Sixth Step —Connect the value 2700 located on the Z Axis in Step Four with the point of intersection of the corresponding value of Z and the muzzle velocity value of 2750, giving Line No. 1 on chart.

Seventh Step—Locate Value of .56 on C Axis.

Eighth Step —Connect point located on C Axis with intersection of Line No. 1 and Reference Line, giving Line No. 2 on chart.

Ninth Step —The intersection of Line No. 2 with the Ø axis gives the required Angle of Departure 14′.

GIVEN: Ballistic Coefficient (C) Value Z Muzzle Velocity (M.V.)

EXAMPLE—Find the Angle of Departure of the 172-grain Frankford Arsenal 1925 National Match Bullet when fired from a .30-06 Springfield with a muzzle velocity of 2750 foot-seconds over a range of 500 yards.

Ballistic Coefficient (C) = .56.
Value of Z = 2700.
Muzzle Velocity (M.V.) = 2750.

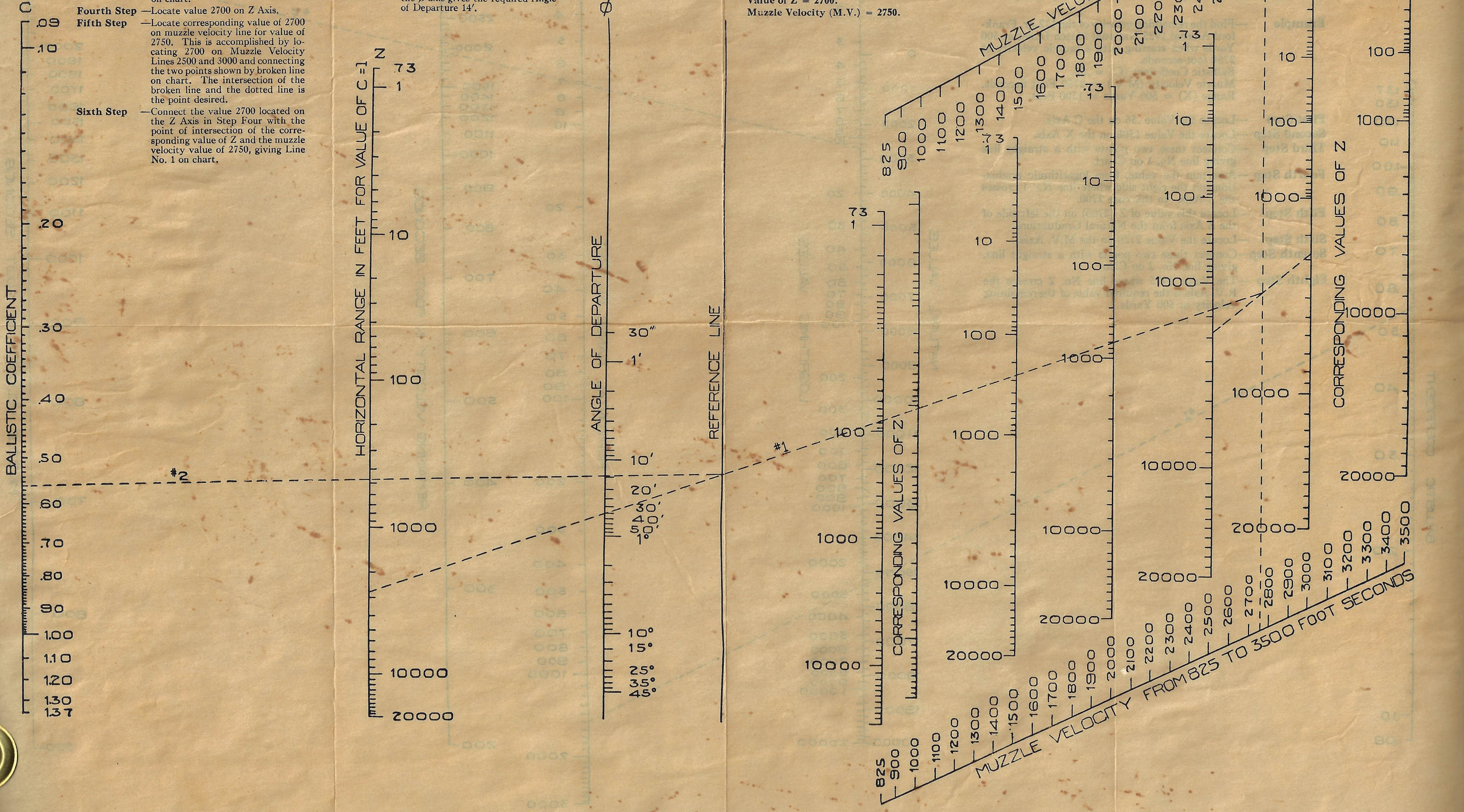


Chart No. 5 for Determining Time of Flight

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers
of E. I. du Pont de Nemours & Company, Inc.,
Burnside Laboratory, Wilmington, Delaware

GIVEN—Angle of Departure (Ø)
Ballistic Coefficient (C) Value of Z
Muzzle Velocity (M.V.)

Example—Find the time of flight of the 172-grain Frankford Arsenal 1925 National Match Bullet when fired from a .30-06 Springfield with a Muzzle Velocity of 2750 foot seconds over a range of 500 Yards.

Muzzle Velocity (M.V.) = 2750 Ft. Secs.

Angle of Departure (Ø) = 14′.

Value of Z = 2700.

Ballistic Coefficient (C) = .56.

First Step—Locate Value of 2750 on Upper Axis for Muzzle Velocity.

Second Step—Locate Value of 2750 on Lower Axis for Muzzle Velocity.

Third Step—Connect these two values with a straight line, shown by dotted line on chart.

Fourth Step—Locate Value of 2700 on Z Axis.

Fifth Step—Locate corresponding values of 2700 on muzzle velocity line for value of 2750. This is accomplished by locating 2700 on Muzzle Velocity lines 2500 and 3000 and connecting the two points, shown by broken line on chart. The intersection of the broken line and the dotted line is the point desired.

Sixth Step—Connect the value 2700 located on the Z Axis in Step Four with the point of intersection of the corresponding value of Z and the muzzle velocity value of 2750 and continue this line to the right until it intersects the Reference Line, giving Line No. 1 on chart.

Seventh Step—Locate value 14′ on Ø Axis.

Eighth Step—Connect point located on Ø Axis with point of intersection of Line No. 1 and Reference Line, giving Line No. 2 on Chart.

Ninth Step—Locate Value .56 on C Axis.

Tenth Step—Connect the point located on the C Axis with point of intersection of Line No. 2 and the Dummy Axis, giving Line No. 3 on Chart.

Eleventh Step—The intersection of Line No. 3 and the T Axis gives the required time of flight, .65 seconds.

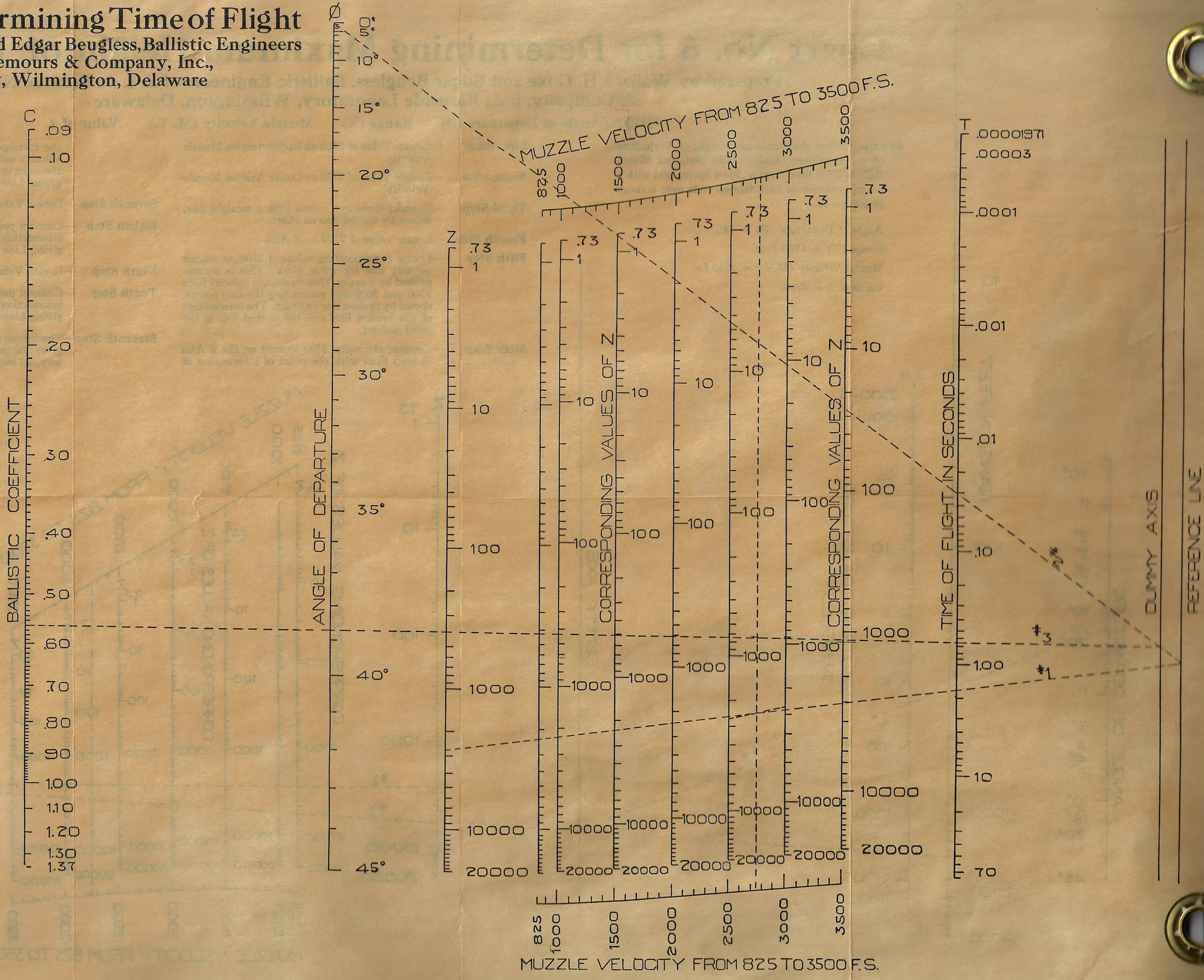


Chart No. 6 for Determining Maximum Height of Trajectory

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers of E. I. du Pont de Nemours & Company, Inc., Burnside Laboratory, Wilmington, Delaware

GIVEN: Angle of Departure (Ø) Range (X) Muzzle Velocity (M. V.) Value of Z

Example—Find the maximum Height of Trajectory of the Frankford Arsenal 1925 National Match Bullets when fired from a .30-06 Springfield with a muzzle velocity of 2750 foot-seconds over a range of 500 yards.

Angle of Departure (Ø) = 14′.

Range (X) = 1500 Feet.

Muzzle Velocity (M.V.) = 2750 f.s.

Value of Z = 2700.

First Step —Locate Value of 2750 on Upper Axis for Muzzle Velocity.

Second Step —Locate Value of 2750 on Lower Axis for Muzzle Velocity.

Third Step —Connect these two values with a straight line, shown by dotted line on chart.

Fourth Step —Locate value of 2700 on Z Axis.

Fifth Step —Locate corresponding values of 2700 on muzzle velocity line for value 2750. This is accomplished by locating 2700 on muzzle velocity lines 2500 and 3000 and connecting the two points, shown by broken line on chart. The intersection of the broken line and the dotted line is the point desired.

Sixth Step —Connect the value 2700 located on the Z Axis in Step Four with the point of intersection of the corresponding value of Z and the muzzle velocity value of 2750 and continue this line to the right until it intersects the Reference Line, giving Line No. 1 on Chart.

Seventh Step —Locate Value 1500 on X Axis.

Eighth Step —Connect point located on X Axis with point of intersection of Line No. 1 and Reference Line, giving Line No. 2 on chart.

Ninth Step —Locate Value 14′ on Ø Axis.

Tenth Step —Connect point located on Ø Axis with point of intersection of Line No. 2 and Dummy Axis, giving Line No. 3 on Chart.

Eleventh Step—The intersection of Line No. 3 and the Y° Axis gives the required maximum height of Trajectory, 20 inches.

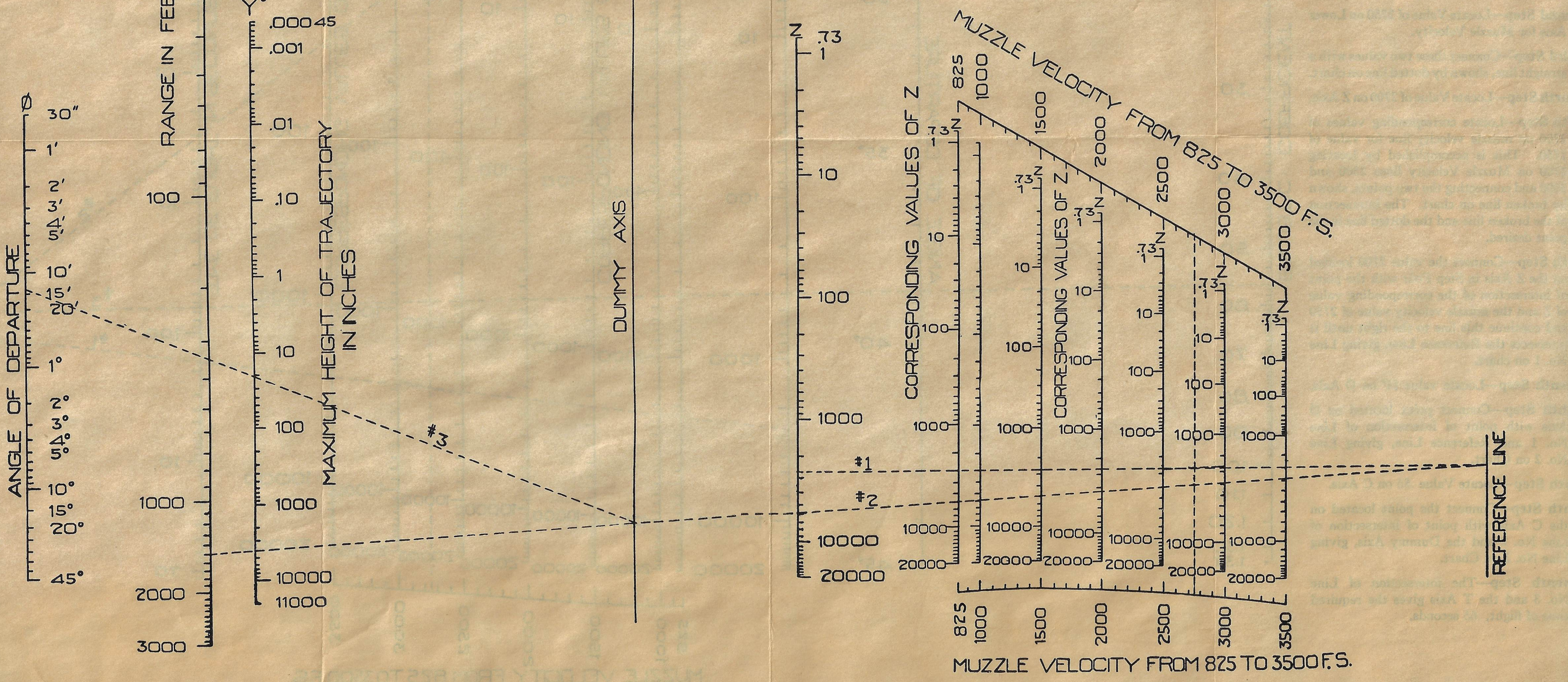


Chart No. 7 for Determining Angle of Fall

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers of E. I. du Pont de Nemours & Company, Inc.,
Burnside Laboratory, Wilmington, Delaware

GIVEN: Angle of Departure (Ø). Value of Z. Muzzle Velocity (M.V.)

Example—Find the Angle of Fall of the 172-Grain Frankford Arsenal 1925 National Match Bullet when fired from a .30-06 Springfield with a muzzle velocity of 2750 foot-seconds over a range of 500 yards.

Angle of Departure (Ø) = 14′
Value of Z = 2750
Muzzle Velocity (M.V.) = 2700

First Step—Locate Value of 2750 on Upper Axis for Muzzle Velocity.
Second Step—Locate Value of 2750 on Lower Axis for Muzzle Velocity.
Third Step—Connect these two lines with a straight line, shown by dotted line on chart.
Fourth Step—Locate Value 2700 on Z Axis.
Fifth Step—Locate corresponding values of 2700 on muzzle velocity line for value of 2750. This is accomplished by locating 2700 on Muzzle Velocity Lines 2500 and 3000 and connecting the two points, shown by broken line on chart. The intersection of the broken line and the dotted line is the point desired.
Sixth Step—Connect the Value 2700 located on the Z Axis in Step Four with the point of intersection of the corresponding value of Z and the muzzle velocity value of 2750, and carry this line to the right until it intersects the Reference Line giving line No. 1 on chart.
Seventh Step—Locate Value of 14′ on Ø Axis.
Eighth Step—Connect point located on Ø Axis with point of intersection of Line No. 1 and Reference Line giving Line No. 2 on chart.
Ninth Step—The intersection of Line No. 2 with the w axis gives the required angle of Fall, 17′-30″.

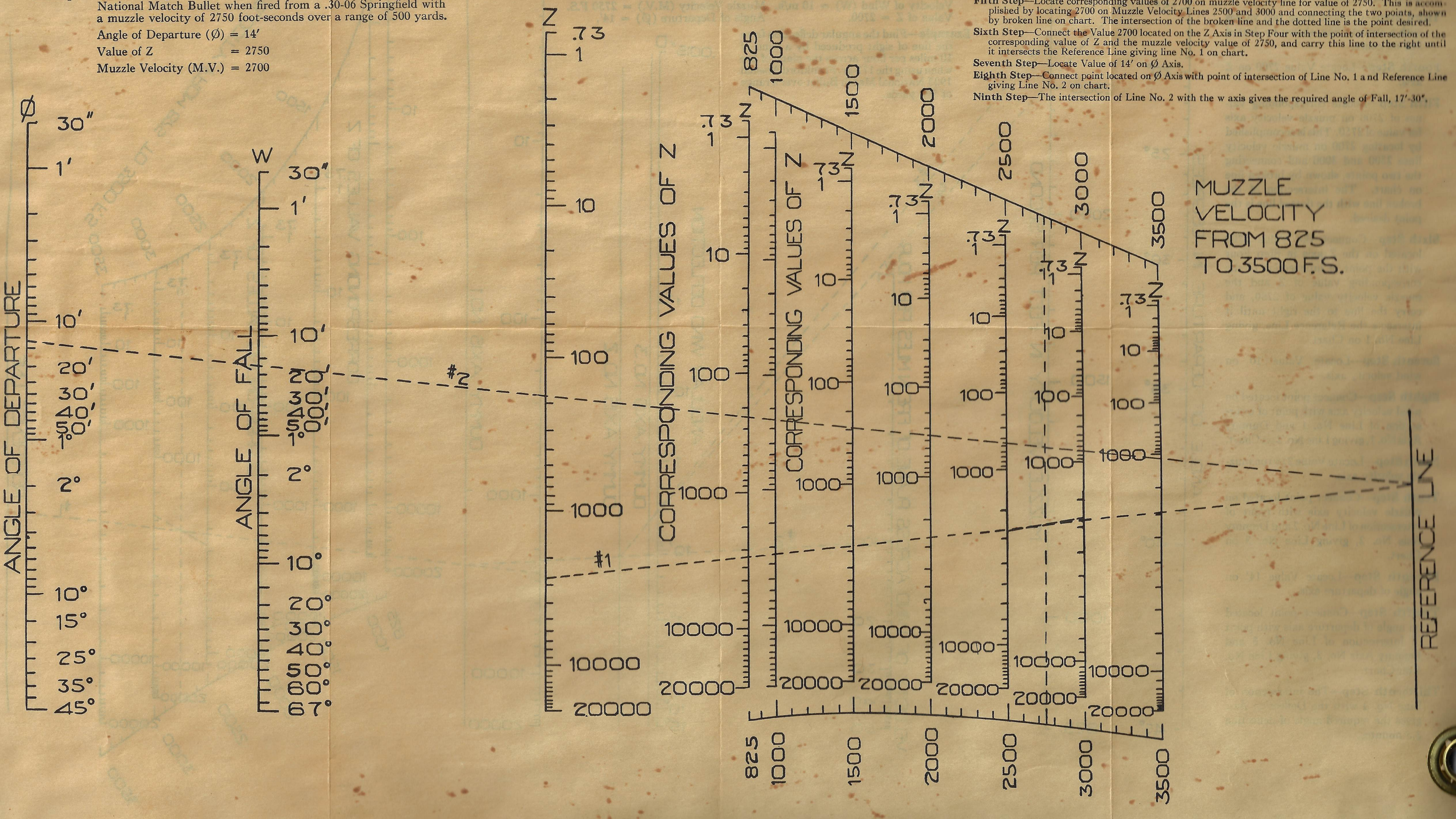


Chart No. 8 for Determining Wind Deflection

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers of E. I. du Pont de Nemours & Company, Inc., Burnside Laboratory, Wilmington, Delaware

Given—Velocity of Wind (W) across plane of fire in Miles per Hour. Value of Z. Muzzle Velocity (M.V.). Angle of Departure (Ø).

Velocity of Wind (W) = 10 m/h. Muzzle Velocity (M.V.) = 2750 F.S.
Value of Z = 2700. Angle of Departure (Ø) = 14′.

Example—Find the angular deflection from the line of sight produced by a wind of 10 miles per hour across the plane of fire when using the 172-gr. Frankford Arsenal 1925 National Match Bullet over a range of 500 yards.

INSTRUCTIONS

First Step—Locate Value 2750 in upper axis for muzzle velocity.

Second Step—Locate Value 2750 in lower axis for muzzle velocity.

Third Step—Connect these two values with a straight line, shown by dotted line on chart.

Fourth Step—Locate Value 2700 on Z axis.

Fifth Step—Locate corresponding values of 2700 on muzzle velocity axis for value of 2750. This is accomplished by locating 2700 on muzzle velocity lines 2500 and 3000 and connecting the two points, shown by broken line on chart. The intersection of the broken line with the dotted line is the point desired.

Sixth Step—Connect the Value 2700 located on the Z axis in Step Four with the point of intersection of the corresponding value of Z and the muzzle velocity value of 2750, and carry the line to the right until it intersects the Reference Line, giving Line No. 1 on Chart.

Seventh Step—Locate Value 10 on wind velocity axis.

Eighth Step—Connect point located on wind velocity axis with point of intersection of Line No. 1 and Dummy Axis No. 1, giving Line No. 2 on Chart.

Ninth Step—Locate Value 2750 on muzzle velocity axis.

Tenth Step—Connect point located on muzzle velocity axis with point of intersection of Line No. 2 and Dummy Axis No. 2, giving Line No. 3 on Chart.

Eleventh Step—Locate Value 14′ on angle of departure axis.

Twelfth Step—Connect point located on angle of departure axis with point of intersection of Line No. 3 and Dummy Axis No. 3, giving Line No. 4 on Chart.

Thirteenth Step—The intersection of Line No. 4 with the Deflection Axis gives the required angle of deflection 3.5 minutes.

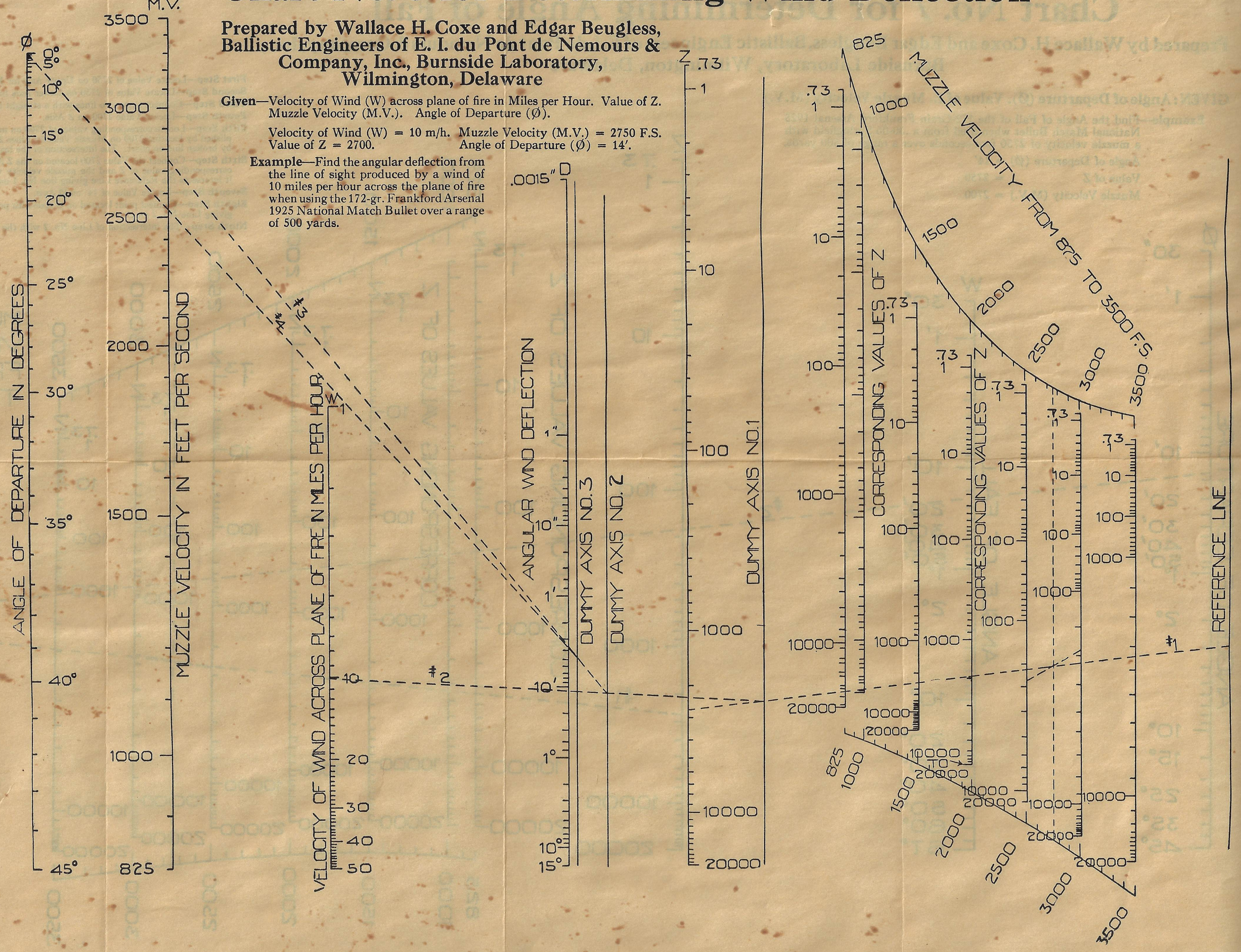
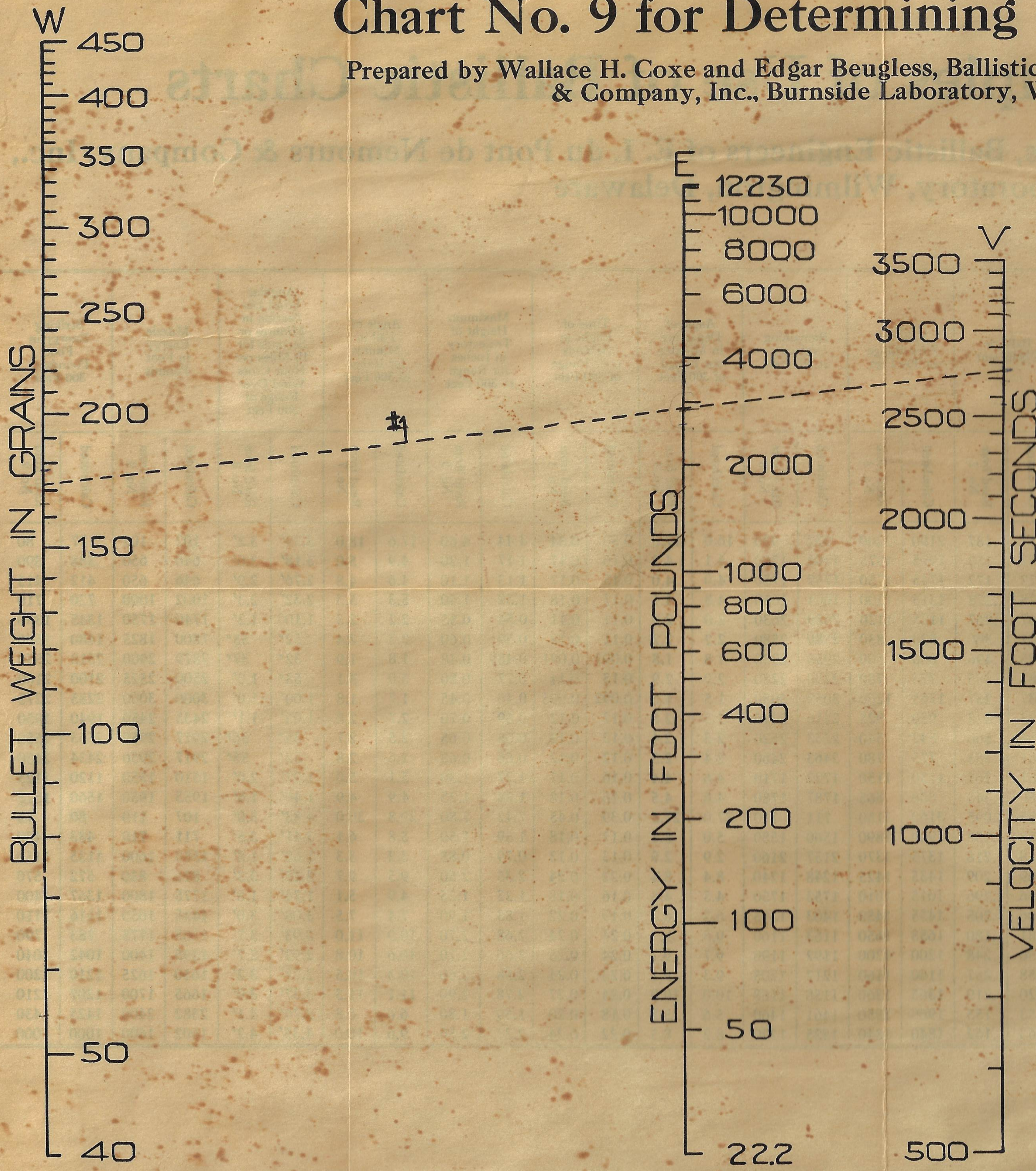


Chart No. 9 for Determining Energy of Projectile

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers of E. I. du Pont de Nemours & Company, Inc., Burnside Laboratory, Wilmington, Delaware



GIVEN—Weight of bullet (W) Velocity of bullet (V)

Example —Find the muzzle energy of the 172-grain Frankford Arsenal 1925 National Match bullet when fired from a .30/06 Springfield with a muzzle velocity of 2750 foot-seconds.
Weight of bullet (w) = 172 grains.
Velocity of bullet (V) = 2750 foot-seconds.

First Step —Locate value 172 on w axis.

Second Step—Locate value 2750 on V axis.

Third Step —Connect these two values with a straight line, giving Line No. 1 on Chart.

Fourth Step—The intersection of Line No. 1 with the E axis gives the required muzzle energy, 2900 foot-seconds.

Chart No. 10—Examples of Use of Ballistic Charts

Prepared by Wallace H. Coxe and Edgar Beugless, Ballistic Engineers of E. I. du Pont de Nemours & Company, Inc., Burnside Laboratory, Wilmington, Delaware

Caliber	Bullet	Muzzle Velocity in Foot Seconds	Ogive from Chart No. 1	Measured Diameter of Flat Nose in Inches	Coefficient of Form from Chart No. 1	Measured Diameter of Bullet in Inches	Ballistic Coefficient — Calculated	Ballistic Coefficient — Read from No. 2	Value of Z for Range of 300 Feet — Calculated	Value of Z for Range of 300 Feet — Read from No. 3	Remaining Velocity at 300 Feet — Calculated	Remaining Velocity at 300 Feet — Read from No. 3	Angle of Departure in Minutes for Range of 300 Feet — Calculated	Angle of Departure in Minutes for Range of 300 Feet — Read from No. 4	Time of Flight in Seconds over Range of 300 Feet — Calculated	Time of Flight in Seconds over Range of 300 Feet — Read from No. 5	Maximum Height of Trajectory in Inches for Range of 300 Feet — Calculated	Maximum Height of Trajectory in Inches for Range of 300 Feet — Read from No. 6	Angle of Fall in Minutes for Range of 300 Feet — Calculated	Angle of Fall in Minutes for Range of 300 Feet — Read from No. 7	Angular Wind Deflection in Minutes or Seconds for 10 Miles per Hour Cross Wind Over Range of 300 Feet — Calculated	Angular Wind Deflection in Minutes or Seconds for 10 Miles per Hour Cross Wind Over Range of 300 Feet — Read from No. 8	Muzzle Energy in Foot Pounds — Calculated	Muzzle Energy in Foot Pounds — Read from No. 9	Striking Energy in Foot Pounds at 300 Feet — Calculated	Striking Energy in Foot Pounds at 300 Feet — Read from No. 9
.22 Long Rifle	R. A. 40 gr. Lead	1070	2	......	0.85	0.222	.137	.137	2190	2200	932	930	16.0	17.0	0.30	0.34	4.44	4.60	17.6	18.0	3.29′	3.3′	102	102	77	80
.25/20 W. C. F.	R. A. 60 gr. Hi-Speed	2200	4	0.10	0.85	0.258	.152	.152	1975	1975	1706	1700	4.1	4.2	0.16	0.17	1.17	1.20	4.9	5.0	3.18′	3.0′	646	650	388	390
.25/20 W. C. F.	Peters 60 gr. Hi-Speed	2200	4	0.08	0.75	0.258	.172	.172	1745	1750	1759	1750	4.0	4.0	0.15	0.17	1.13	1.10	4.6	4.8	2.76′	2.9′	646	650	412	415
.25/35 W. C. F.	Peters 117 gr. Hi-Speed	1975	4	0.12	1.10	0.258	.228	.228	1315	1300	1664	1650	4.8	4.7	0.17	0.18	1.32	1.40	5.3	5.3	2.32′	2.3′	1002	1000	720	710
.250/3000 Savage	Western 87 gr. H. P. Expanding	3000	6	0.08	0.70	0.258	.267	.267	1125	1120	2639	2630	2.0	2.0	0.11	0.11	0.54	0.55	2.2	2.3	1.10′	1.2′	1740	1750	1345	1350
.250/3000 Savage	Western 100 gr. Lubaloy S. P.	2850	4	......	0.60	0.257	.361	.360	830	830	2589	2580	2.2	2.2	0.11	0.12	0.59	0.60	2.3	2.4	52″	55″	1800	1825	1480	1500
.270 Winchester	W. R. A. 130 gr. Ex. Pt.	3160	8	......	0.49	0.277	.495	.496	606	600	2958	2930	1.8	1.8	0.097	0.091	0.489	0.48	1.8	1.9	32″	37″	2879	2900	2518	2550
.30 Newton	Western 180 gr. Lubaloy Ex. Pt.	2500	8	0.70	0.70	0.308	.387	.385	775	780	2290	2280	2.9	2.9	0.13	0.14	0.77	0.80	3.0	3.1	58″	1.0′	2500	2525	2100	2100
.30/06 Spld.	R. A. 110 gr. Hi-Speed	3500	6	......	0.70	0.308	.237	.237	1265	1260	3059	3050	1.5	1.6	0.092	0.095	0.40	0.45	1.7	1.8	1.00′	1.0′	3000	3000	2285	2275
.30/06 Spld.	Western 150 gr. Lub. Ex. Pt.	2700	6	0.10	0.70	0.308	.323	.323	930	925	2416	2410	2.5	2.5	0.12	0.12	0.69	0.70	2.7	2.8	1.05′	1.1′	2435	2450	1940	1950
.30/06 Spld.	R. A. 180 gr. Hi-Speed	2700	8	......	0.49	0.308	.554	.560	542	540	2533	2520	2.3	2.4	0.12	0.12	0.63	0.65	2.5	2.7	35″	36″	2917	2950	2563	2550
.30/06 Spld.	Western 180 gr. Ex. Pt.	2700	6	0.10	0.70	0.308	.387	.385	775	780	2463	2460	2.4	2.5	0.12	0.12	0.66	0.68	2.6	2.8	52″	55″	2917	2950	2434	2450
.30/30 W. C. F.	Peters 170 gr. H. C. S. P.	2000	1.5	......	1.00	0.305	.261	.261	1150	1150	1722	1710	4.6	4.4	0.16	0.17	1.27	1.30	5.1	5.0	1.97′	2.0′	1510	1550	1120	1125
.30/40 Krag.	W. R. A. 220 gr. M. C.	2000	1.5	......	0.95	0.308	.350	.348	868	865	1787	1780	4.6	4.5	0.16	0.18	1.24	1.25	4.9	4.9	1.46′	1.6′	1955	1950	1560	1575
.32 Colt Auto.	R. A. 71 gr. M. C.	825	1	......	1.10	0.312	.095	.095	3160	3150	711	710	27.0	27.5	0.39	0.45	7.42	7.80	29.8	30.0	4.83′	5.0′	107	110	80	75
.32 W. C. F.	W. R. A. 80 gr. Super-Speed	2000	4	......	0.75	0.311	.158	.158	1900	1890	1560	1550	5.0	5.1	0.17	0.18	1.39	1.50	5.8	6.1	3.41′	3.5′	711	710	433	430
.32 Win. Spl.	R. A. 110 gr. Hi-Speed	2550	6	0.10	0.70	0.321	.218	.218	1375	1370	2157	2160	2.9	2.9	0.13	0.13	0.79	0.85	3.2	3.3	1.68′	1.8′	1588	1600	1135	1150
.32/40 W. C. F.	W. R. A. 165 gr. M. C. S. P.	1500	3	0.17	1.10	0.320	.209	.209	1435	1425	1248	1240	8.4	8.4	0.22	0.24	2.35	2.50	9.5	9.7	3.27′	3.3′	825	830	572	570
.35 Remington	Western 200 gr. Lub. Ex. Pt.	2000	4	0.10	0.75	0.359	.296	.296	1015	1010	1753	1750	4.5	4.6	0.16	0.18	1.23	1.25	4.9	5.1	1.74′	1.8′	1775	1800	1367	1400
.38/55 W. C. F.	Peters 255 gr. M. C.	1700	2	0.20	1.25	0.376	.206	.205	1455	1450	1403	1395	6.5	6.3	0.19	0.22	1.83	1.90	7.4	7.5	3.08′	3.0′	1635	1650	1116	1110
.40/65 W. C. F.	R. A. 260 gr. Lead	1420	2	0.22	1.25	0.405	.181	.180	1658	1650	1163	1160	9.5	9.2	0.24	0.24	2.68	2.70	10.9	11.0	3.93′	3.7′	1165	1175	783	790
.40/70 W. C. F.	R. A. 330 gr. Lead	1380	3	0.23	1.15	0.405	.250	.248	1200	1200	1192	1190	9.7	9.7	0.24	0.25	2.66	2.70	10.6	10.8	2.92′	2.7′	1395	1400	1042	1040
.40/90 Sharps	R. A. 370 gr. Paper Patch	1400	1.5	0.18	1.25	0.405	.258	.257	1160	1160	1212	1205	9.3	9.1	0.23	0.24	2.58	2.60	10.3	10.5	2.78′	3.2′	1610	1625	1210	1200
.45/70 W. C. F.	R. A. 405 gr. Lead	1360	1.5	0.20	1.25	0.459	.220	.219	1365	1360	1158	1160	10.0	10.0	0.24	0.27	2.78	2.90	11.1	11.3	3.37′	3.0′	1665	1700	1207	1210
.45/70 W. C. F.	W. R. A. 300 gr. M. C. S. P.	1890	1.5	0.25	1.35	0.456	.153	.153	1960	1950	1461	1460	5.6	5.8	0.18	0.20	1.59	1.80	6.6	6.8	3.79′	4.1′	2382	2400	1425	1430
.45/90 W. C. F.	W. R. A. 300 gr. Lead	1550	2	0.25	1.25	0.458	.163	.162	1840	1840	1225	1220	8.2	8.5	0.22	0.24	2.33	2.50	9.6	10.0	4.35′	4.2′	1602	1600	1000	1000