FM 6-73

DEPARTMENT OF THE ARMY FIELD MANUAL

GRAPHICAL SCALES FOR

105-MM, 155-MM 8-INCH

HOWITZER

AND 762-MM ROCKET

M31 SERIES

HEADQUARTERS, DEPARTMENT OF THE ARMY

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GRAPHICAL SCALES FOR 105-MM, 155-MM, 8-INCH HOWITZER AND 762-MM ROCKET, M31 SERIES

* This manual supersedes those portions of TM 9–525, 7 June 1950, which describe graphical scales for the 105-mm, 155-mm, and 8-inch howitzers.

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Purpose

This manual is published for the use of personnel to whom the graphical scales described herein are issued.

2. Scope

This manual is limited to the description, operation, and major uses of graphical firing scales M64, M70, and M85; the graphical firing site scale M67; and the low-level wind scale M73. In appropriate chapters of this manual, reference is made to additional new graphical equipment which is identical in operation and general description to the scales mentioned above.

3. Changes or Corrections

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to Commandant, U.S. Army Artillery and Missile School, ATTN: AKPSITL, Fort Sill, Okla.

4. References

See appendix for list of references.

Section II. NEW AND OLD GRAPHICAL SCALES

5. Differences

a. General. The operation of the new and the old graphical scales is basically the same. Differences are noted in *b* through *g* below.

b. Nomenclature. The new graphical scales are designated graphical firing scales and graphical firing site scales. The old

graphical scales were designated graphical firing tables and graphical site tables.

c. Base. The base of the new graphical firing scales is $3\frac{1}{2}$ inches longer and $\frac{9}{16}$ of an inch wider than the base of the old graphical firing tables.

d. Graduations. Graduation marks are more numerous on the new graphical firing seales than on the old graphical firing scales.

e. Scales.

(1) The range scale is graduated in meters on the new graphical scales. Except for the graphical scales based on FT 8–J–2, on the old graphical tables range was graduated in yards.

(2) The deflection correction/drift scale appears at the top of the new graphical firing scales. On the old graphical firing tables, the drift scale was between the fork and the fuze setting scales.

(3) The fuze setting scale on the new graphical firing scales gives data for fuze M520. Data for fuze M500 is given on the old graphical firing tables.

f. Cursor. The cursor for the new graphical firing scales is $1\frac{3}{4}$ inches longer and $\frac{9}{16}$ of an inch wider than the cursor for the old graphical firing tables.

g. Data. The new graphical firing site scales are based on plot points which yield errors in site less than plus or minus 1 mil for heights of burst from —400 to +1,000 meters. Quadrant elevation limits for each charge are listed on the reverse side of the new graphical firing site scale. The old graphical firing site tables were based on a constant angle of site of plus or minus 25 mils, thus allowing an accurate determination of site only from zero to plus or minus 50 mils.

6. Status

The new and old graphical scales and the respective weapons and firing tables with which they are used are listed in table I.

Table I. Status of the New and Old Graphical Scales

Nomenclature	Model number		Weapon	New tabular firing table
	New	Old		
Scale, Graphical Firing	M82	M39A1	105-mm Howitzer	FT 105–H–6
Scale, Graphical Firing	M64	M43A1	155-mm Howitzer	FT 155–Q–3
Scale, Graphical Firing	M71	M65	8-inch Howitzer	FT 8–J–3
Scale, Graphical Firing	M85	None	8-inch Howitzer	FT 8–O–3
Scale, Graphical Firing (Shell, Illuminating, M314MODS)	M84	None	105-mm Howitzer	FT 105–H–6
Scale, Graphical Firing (Shell, Illuminating, M118MODS)	M70	None	155-mm Howitzer	FT 155–Q–3
Scale, Graphical Firing, Site	M83	M53A1	105-mm Howitzer	FT 105–H–6
Scale, Graphical Firing, Site	M67	M54	155-mm Howitzer	FT 155–Q–3
Scale, Graphical Firing, Site	M72	M66	8-inch Howitzer	FT 8–J–3
Scale, Graphical Firing, Site	M86	None	8-inch Howitzer	FT 8–O–3
Scale, Low-Level Wind	M73	None	762-mm Rocket	FTR 762–F–1
Scale, Low-Level Wind	M74	None	762-mm Rocket	FTR 762–D–1
Scale, Low-Level Wind	M79	None	762-mm Rocket	FTR 762–C–1
Scale, Low-Level Wind	M78	None	762-mm Rocket	FTR 762–A–2
Scale, Low-Level Wind	M81	None	762-mm Rocket	FTR 762–E–1
Scale, Low-Level Wind	M80	None	762-mm Rocket	FTR 762–B–2

CHAPTER 2
SCALE, GRAPHICAL FIRING, M64

Section I. NOMENCLATURE AND DESCRIPTION

7. General

a. Use. The Scale, Graphical Firing, M64, based on FT 155–Q–3, is a special ballistic scale to be used with high explosive (HE) projectiles, M107 and M107B2.

b. Scope. Information contained in this chapter is applicable also to Scale, Graphical Firing, M71, based on FT 8–J–3, and Scale, Graphical Firing, M82, based on FT 105–H–6. The description and operation of the graphical firing scale to be used with illuminating ammunition is discussed in chapter 4.

8. Nomenclature

The following nomenclature is standard for graphical firing scales (fig. 1 ①) :

a. Base. The base is that fixed portion of the graphical firing scale which contains the groove for the cursor. Firing data appears on both sides of the base.

b. Cursor. The cursor, which is composed of the window and hairline, slides along the top and bottom edges of the base.

　　(1) *Window.* The window is the frosted portion of the cursor.

　　(2) *Hairline.* The hairline, the fine line engraved on the under surface of the window, serves as the index for reading data.

c. Rule. The rule consists of the base and cursor. Normally, two rules, appropriately labeled RULE NO 1 and RULE NO 2, comprise the complete graphical firing scale.

d. Scale. A scale is a single line of graduations for a particular function, such as RANGE scale, EL (elevation) scale, or FS (fuze setting) scale.

e. Gage Point. A gage point is a special mark on the rule denoting a specific constant.

Defl Carr/
Drift Scale

100/R Scale

Range Scale

Elevation Scale

Fork Scale

Fuze Setting Scale

HOW 155 mm
FT 155-0-3

Conversion Gage Point

Range Gage Point

②

Base

Fuze Setting Gage Point

Window

Cursor

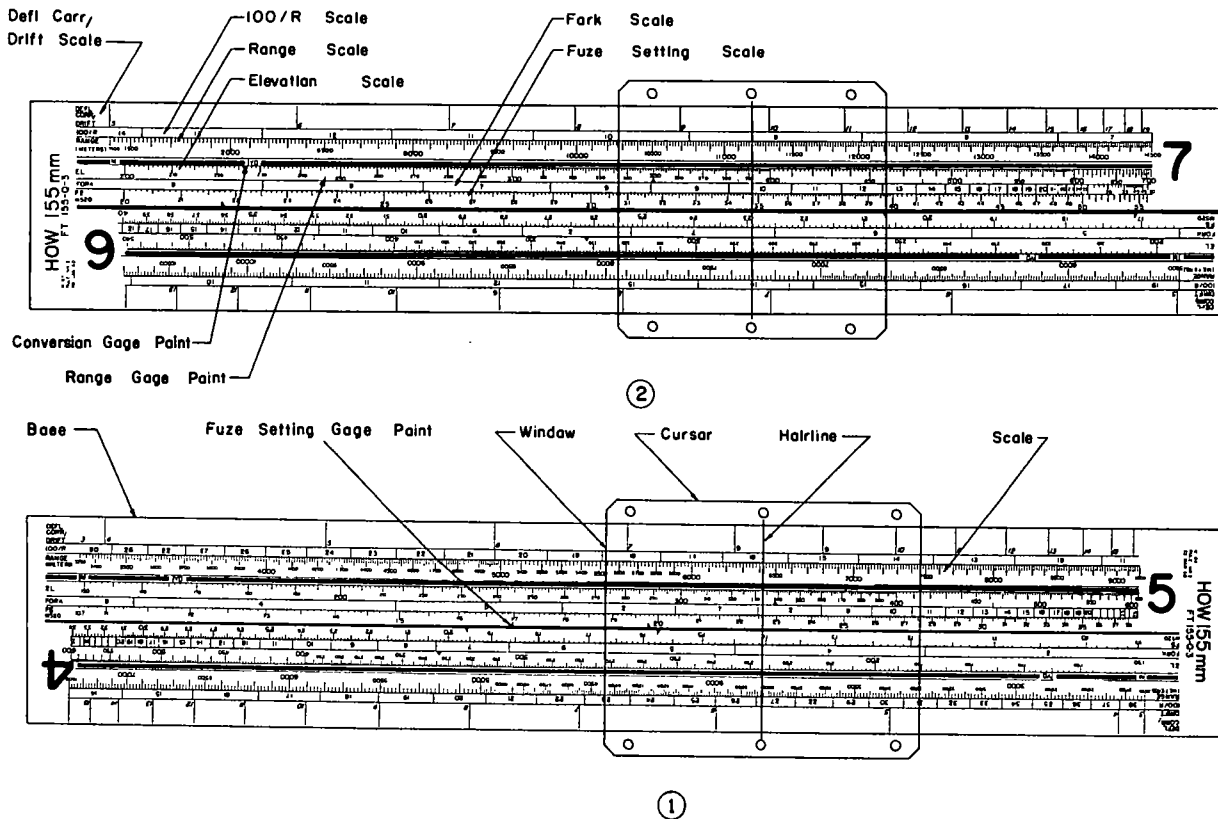Hairline

Scale

HOW 155 mm
FT 155-0-3

①

Figure 1. Scale, graphical firing, M64, rule number 2.

9. Description

a. General. The Scale, Graphical Firing, M64, based on FT 155–Q–3, consists of two rules. Low-angle firing data for charges 1 and 3 and high-angle firing data for all charges may be read from rule number 1. Low-angle firing data for charges 4, 5, 6, and 7 may be read from rule number 2.

b. Composition of Low-Angle Scales and Data. Low-angle scales (fig. 1 ②) are developed for a single charge. The scales for two charges are placed inverted to each other on one side of the base so that the scale pertaining to one particular charge can be read with the rule held in only one position.

> (1) *Deflection correction/drift scale.* The deflection correction is written in pencil on this scale by the operator. Projectile drift in mils also appears on the deflection correction/drift scale (DEFL CORR/DRIFT). Drift is always to the right.

> (2) *100/R scale.* The 100/R scale gives the number of mils necessary to shift the point of burst laterally or vertically 100 meters for a given range. Numbers on this scale are printed in red.

> (3) *Range scale.* The range (RANGE) scale is the basic scale on the graphical firing scale. All other scales are plotted with reference to it. Range is given logarithmically in meters and varies for each charge. Range is entered on the graphical firing scale to the nearest 10 or 20 meters.

> (4) *Elevation scale.* The elevation (EL) scale is graduated in mils to show elevation; elevation increases from left to right and is read to the nearest 1 mil.

> (5) *Fork scale.* The fork (FORK) scale is graduated in mils to show the change in elevation necessary to move the center of impact for range probable errors. Numbers on this scale are printed in red.

> (6) *Fuze setting scale.* The fuze setting (FS) scale gives fuze settings in fuze numbers and fractions of a fuze number for fuze M520. Fuze setting is read to the nearest 0.1 fuze number.

> (7) *Conversion gage points.* On the left portion of the red dividing line between the range and elevation scales are two gage points labeled "M" (meter) and "YD" (yard), respectively. These gage points are used to convert yards to meters or meters to yards.

(8) *Range gage points.* On the dividing line between the elevation and fork scales are a set of vertical red gage points, connected by a red horizontal line. The two gage points and the connecting line indicate the range limits within which a particular charge normally should be fired. A good range for conducting registrations is indicated by a red triangle on the red connecting line. Lower and upper range gage points approximate the efficient limiting elevations of 240 and 460 mils, respectively.

(9) *Fuze setting gage points.* For ammunition fuzed for time fire, the fuze setting at which the probable error in height of burst is 15 meters is indicated by a red triangular gage point extending above the heavy red line which separates the two charges. To the left of this gage point and also extending above the heavy red line is a second triangular gage point which indicates the range at which the probable error in height of burst for the next *lower* charge is 15 meters. Large height of burst dispersion must be expected when time fire is used with a particular charge at ranges exceeding that indicated by the fuze setting gage point.

c. Composition of High-Angle Scales. High-angle scales (fig. 2) are developed with several charges on a single line and are arranged on the rule in such a manner that the scales for all charges can be read from one side of the rule with the rule held in the same position.

(1) *100/R scale.* The scale is identical with the low-angle 100/R scale.

(2) *Range scale.* The RANGE scale is graduated in meters to show the range logarithmically. One range scale suffices for all high-angle firing data.

(3) *Elevation scale.* The elevation (EL) scale is graduated in mils to show elevation; elevation increases from right to left and is read to the nearest 1 mil.

(4) *10-Mil site scale.* This scale (10ṃ SI) gives site for each 10-mil angle of site at the elevation and charge selected. Numbers on this scale are printed in red. The sign of the site is opposite that of the angle of site.

(5) *Drift scale.* The DRIFT scale is graduated in mils to show projectile drift. Drift is always to the right.

(6) *Time of flight scale.* The time of flight (TF) scale is graduated in seconds to show projectile time of flight.
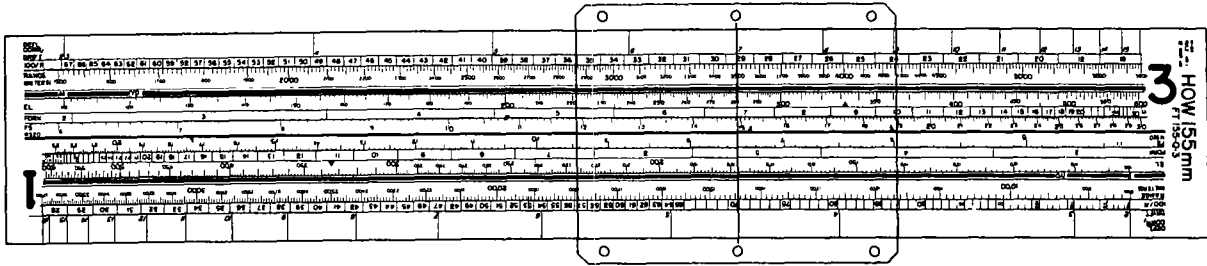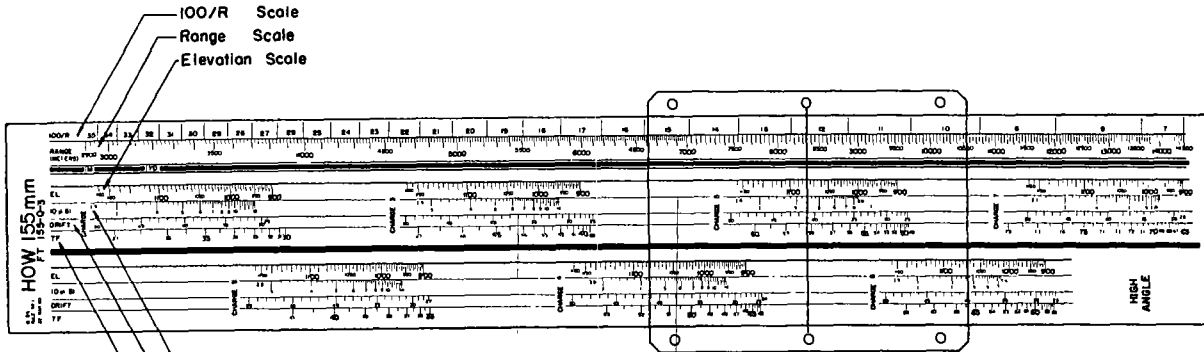
Figure 2. Scale, graphical firing, M64, rule number 1.

100/R Scale
Range Scale
Elevation Scale
10 mil Site Scale
Drift Scale
Time of Flight Scale

Fuze settings are not given because, owning to the large height-of-burst probable error encountered with mechanical time fuzes, time fire is not employed for high-angle fire.

Section II. MAJOR USES OF THE GRAPHICAL FIRING SCALE

10. Operation

The operation of the graphical firing scale is best explained by a series of illustrative examples and problems. Assume that low-angle fire is employed unless otherwise stated.

11. Determination of Elevation and Fuze Setting (No Corrections)

a. To determine elevation and fuze setting for a given range and charge, place the hairline over the desired range (rounded to nearest 10 meters) and read the elevation under the hairline on the elevation scale and the fuze setting under the hairline on the fuze setting scale. Drift, 100/R, and fork are read in the same manner.

b. Illustrative example:
   (1) *Given data:*
     (*a*) 155-mm howitzer.
     (*b*) Range to registration point: 6,420 meters.
   (2) *Required:*
     (*a*) Charge to be used.
     (*b*) Elevation.
     (*c*) Fuze setting.
   (3) *Solution (fig. 1①).*
     (*a*) Select charge 5 (par. 9*b*(8)).
     (*b*) Move hairline to range 6,420 meters.
     (*c*) Read under hairline:
       1. Elevation: 333.
       2. Fuze setting: 22.6.

12. Determination and Construction of Registration Corrections (GFT Setting)

a. Registration range and fuze corrections are usually portrayed graphically on the graphical firing scale.

Note. This graphical portrayal is commonly called the GFT setting and will be referred to as such in this manual.

The elements of this GFT setting are always expressed and recorded in the following sequence:

(1) Unit that registered.

(2) Charge.

(3) Ammunition lot.

(4) Chart range to registration point (nearest 10 meters).

(5) Adjusted elevation.

(6) Adjusted time (if available).

b. The GFT setting is placed on the graphical firing scale in the following manner (fig. 3):

(1) Place hairline over chart range to registration point.

(2) Draw a fine pencil line on the window of the cursor, parallel to the hairline, over the adjusted elevation. This elevation gageline should extend from the top of the drift scale to the top of the 100/R scale and from the bottom of the range scale to the top of the fuze setting scale. Thus, the elevation gageline does not cover the 100/R, range, and fuze setting scales.

(3) Draw another fine pencil line on the window, parallel to the hairline, over the adjusted time. This time gageline extends from the top to the bottom of the fuze setting scale.

(4) Draw a horizontal line connecting the ends of the elevation and time gagelines.

> *Note.* Care should be taken in constructing or reading the GFT setting to look directly over the cursor to avoid errors caused by parallax between the window and scale.

c. Illustrative example:

(1) *Given data:*

(a) Battery A, 155-mm howitzer, has completed registration with charge 5, lot XY.

(b) Chart range to registration point: 6,420 meters.

(c) Adjusted elevation: 350.

(d) Adjusted time: 23.1.

(2) *Required:* Construct GFT setting for Battery A.

(3) *Solution (fig. 3):*

(a) Place hairline over chart range to registration point 6,420.

(b) Draw an elevation gageline over elevation 350 as shown in figure 3.

(c) Draw a time gageline over fuze setting 23.1 as shown in figure 3.

(d) Draw a horizontal pencil line connecting the ends of the elevation and time gagelines.

Hairline over GFT
setting range

Elevotion gageline over
adjusted elevation

Time gogeline over
adjusted time

HOW 155mm
FT 155 3
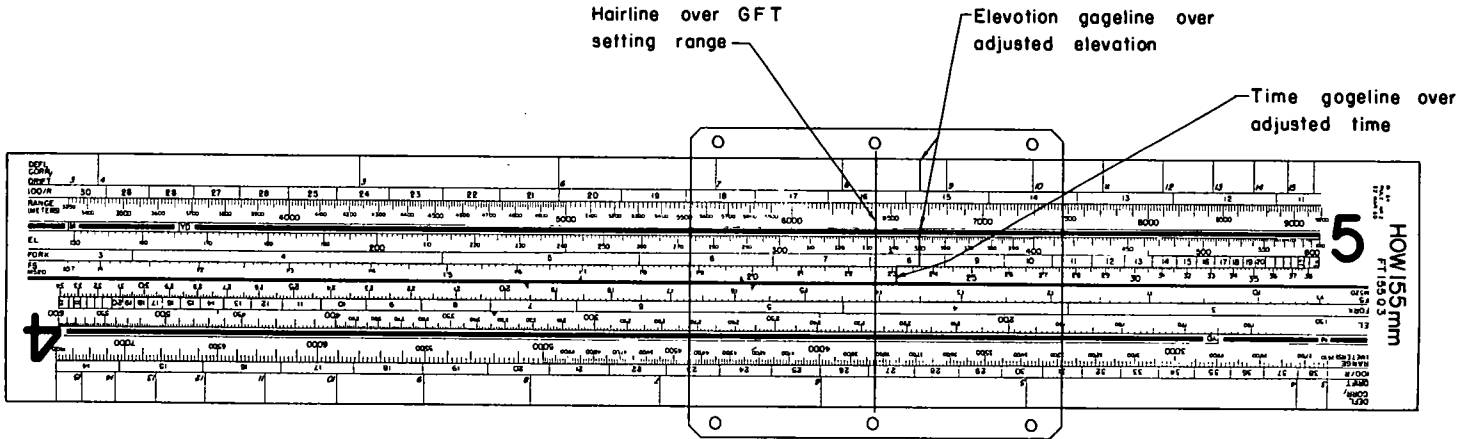
GFT A: Ch 5, Lot XY, rg 6420, el 350, Ti 23.1

Figure 3. Elevation and time gagelines on the graphical firing scale.

(*e*) Complete GFT setting: GFT A: Charge 5, lot XY, range 6,420, elevation 350, time 23.1.

13. Correction to GFT Setting for Base Piece Displacement

a. A GFT setting derived from a registration is an expression of the range achieved by firing with the adjusted elevation. The chart range is measured from the battery center to the registration point, center of impact, or high burst. If the registering piece is in front of or behind the battery center, the measured chart range is not the range achieved. Therefore, the GFT setting range should be the chart range modified by the distance from the base piece to the battery center.

b. Illustrative example:

    (1) *Given data:*

        (*a*) Battery A, 155-mm howtizer, has completed registration with charge 5, lot XY.

        (*b*) Chart range to registration point: 6,420 meters.

        (*c*) Adjusted elevation: 350.

        (*d*) Adjusted time: 23.1.

        (*e*) Base piece is displaced 30 meters in front of the battery center.

    (2) *Required:* Determine GFT setting for Battery A.

    (3) *Solution:*

        (*a*) Chart range achieved to registration point (6,420—30): 6,390 meters.

        (*b*) GFT A: Charge 5, lot XY, range 6,390, elevation 350, time 23.1.

14. Determination of Elevation and Fuze Setting (with Corrections)

a. After registration and subsequent construction of a GFT setting, data to any target within transfer limits of the registration point are determined by placing the hairline over the chart range to the target. Elevation, fork, and drift are read under the elevation gageline. Fuze setting is read under the time gageline; 100/R is read under the hairline.

b. If it becomes necessary to employ time fire and a time gageline is not available, fuze settings should be read under the elevation gageline until a time gageline can be constructed. If variable time (VT) fuzes are used, fuze settings for the VT fuze are obtained by subtracting one fuze number as read under the *elevation* gageline (not time gageline even if available), and, if the result is not a whole number, rounding down to the next lower whole fuze number. For example, if the fuze setting read under the eleva-

tion gasoline is 25.6, the fuze setting fo rthe VT fuze is 24.0. See paragraph 25e for the procedure for obtaining VT fuze settings for high-angle fire.

    c. Illustrative example:

        (1) *Given data:*

            (*a*) GFT A: Charge 5, lot XY, range 6,420, elevation 350, time 23.1.

            (*b*) Chart range to new target: 7,270 meters.

        (2) *Required:*

            (*a*) Elevation.

            (*b*) Fuze setting for fuze M520.

        (3) *Solution* (fig. 4):

            (*a*) Construct GFT setting using given data (par. 12*b* and *c*).

            (*b*) More hairline to range 7,270.

            (*c*) Read under elevation gageline: 420.

            (*d*) Read under time gageline: 27.2.

15. Graphical Firing Scale GFT Settings for More Than One Lot

If the same charge has been used for registration with more than one lot of ammunition, two GFT settings may be placed on the window. The gagelines may be marked with the lot designation or color coded according to lot. Additional GFT settings are always recorded but are placed on the window only when used.

16. Construction of the Deflection Correction Scale on the Graphical Firing Scale

a. Normally, the deflection correction scale is constructed directly on the graphical firing scale by the computer. After the GFT setting is constructed, transfer limits are determined. The hairline of the cursor is placed over the ranges for the upper and lower transfer limits. The upper and lower limits of the deflection correction scale are established by drawing lines in the drift blocks over the elevations for the upper and lower range limits. (If a GFT setting is available, upper and lower limits of the deflection correction scale are established by the elevation gageline when the hairline is placed over upper and lower transfer limits.) The deflection correction determined from registration (zero when the deflection index has been constructed after the initial registration) is written in the drift block which brackets the adjusted elevation. The deflection correction increases 1 mil to the left for each succeeding drift block to the right (elevation increasing). For each subsequent drift block to the left (elevation decreasing), the deflection correction increases 1 mil to the right.
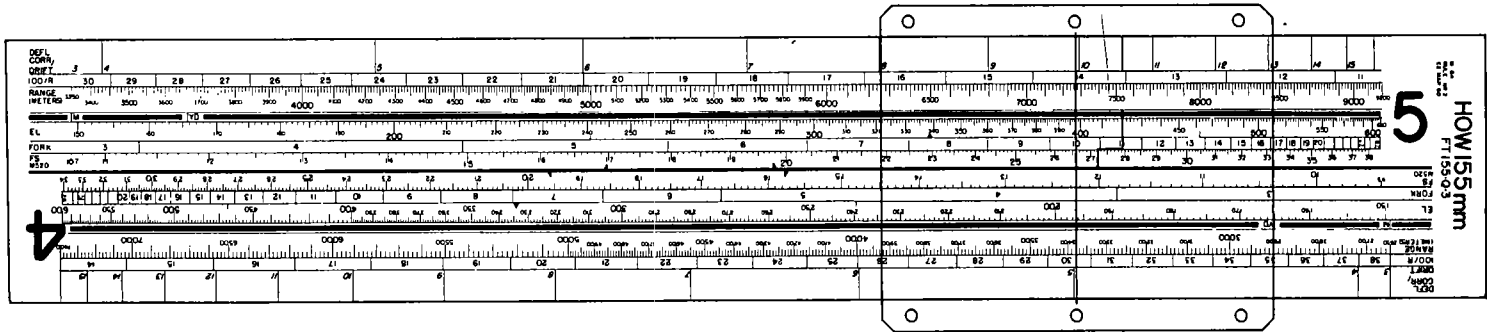
Figure 4. Determination of elevation and fuze setting with graphical firing scale GFT setting.

b. Illustrative example:

(1) *Given data:* GFT A: Charge 5, lot XY, range 6,420, elevation 350, time 23.1.

(2) *Required:* Construct the deflection correction scale on the graphical firing scale.

(3) *Solution* (fig. 5):

(*a*) Upper and lower range transfer limits are determined to be 7,920 and 4,920, respectively (1,500 meters over and short of the registration point). (If the chart range to the registration point were more than 10,000 meters, range transfer limits would be 2,000 meters over and short of the registration point.)

(*b*) The hairline is placed over range 7,920. The elevation gageline intersects the elevation scale at elevation 484. A line is constructed on the scale with a soft, fine lead pencil parallel to the hairline through the drift scale over elevation 484 (ends of the cursor provide a convenient straightedge). This is the upper transfer limit.

(*c*) The cursor is moved down the range scale until the hairline is over range 4,920. The elevation gageline intersects the elevation scale at elevation 247. The lower transfer limit is constructed by drawing a line on the scale parallel to the hairline through the drift scale over elevation 247.

(*d*) A deflection correction of 0 is entered in the drift block bracketing adjusted elevation 350. The drift at this point is 8. A deflection correction of left 1 (L1) is entered in the drift block for a drift of 9, in the drift block for a drift of 10, a deflection correction of left 2 (L2) is entered; for a drift of 11, a deflection correction of left 3 (L3) is entered; and, between the left edge of the drift block for a drift of 12 and the constructed upper transfer limit, a deflection correction of left 4 (L4) is entered.

(*e*) The lower half of the deflection correction scale is completed in a similar manner, except that the deflection correction is to the right.

17. Determination of the Deflection Correction From the Deflection Correction Scale

a. Once the deflection correction scale is constructed on the graphical firing scale, the deflection correction for any point within transfer limits can be determined by placing the hairline over the
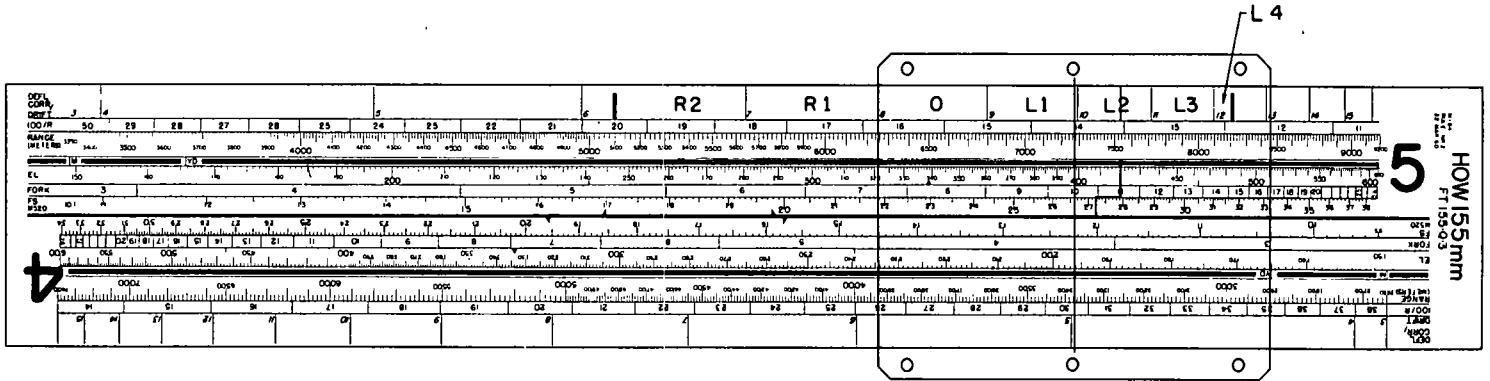
Figure 5. Graphical firing scale with GFT setting and deflection correction scale.

chart range and reading the correction in the drift block over which the *elevation gageline* falls. This correction is applied to the chart deflection, and the result is transmitted to the firing battery.

    b. Illustrative example:

       (1) *Given data:*

          (*a*) GFT A: Charge 5, lot XY, range 6,420, elevation 350, time 23.1.

          (*b*) Chart range to target: 7,270 meters.

          (*c*) Chart deflection to target: 2,450 mils.

       (2) *Required:* Deflection correction and deflection to fire.

       (3) *Solution* (fig. 5):

          (*a*) Construct deflection correction scale on the graphical firing scale (par. 16*a* and *b*).

          (*b*) Move hairline to range 7,270 meters.

          (*c*) Read the deflection correction under the *elevation gageline* in drift block: L2.

          (*d*) Deflection announced to firing battery (2,450 + L2): 2,452.

18. Application of the Graphical Firing Scale GFT Setting and Deflection Correction Scale to FDC Computer's Record

    a. The correct use of the GFT setting and the deflection correction scale is mandatory for determination of accurate firing data. Completion of a typical fire mission on the FDC computer's record (DA Form 6–16) (fig. 6) best exemplifies the use of the graphical firing scale.

    b. The GFT setting and deflection correction scale constructed in paragraphs 12 and 16, respectively, were used to determine the firing data shown in figure 6.

    c. Note that the 100/R scale is used to adjust the height of burst (20 meters initially; then, as observer adjusts) for ammunition fuzed for time fire. The increase in complementary angle of site due to this increase in elevation is insignificant and is ignored.

    d. The explanation and determination of site are found in paragraphs 34 and 41*c*, respectively.

19. Determination of Graphical Firing Scale GFT Setting From Center-of-Impact or High-Burst Registration

    a. Center-of-impact (CI) or high-burst (HB) registrations serve the same purpose as precision registrations. The principles involved in firing a high-burst registration and the methods of

FDC COMPUTER'S RECORD
(FM 6-40)

Battery	Time mission	Date	Concentration number
A	Received 1430 Completed 1436	13 APRIL	AB 416

Fire mission 26, FM		Correction L 2	Initial fire commands

COORD. 43211234,
AZ 1430, INF PLATOON IN
OPEN, FZ VT, W. A

Deflection 2450

Range 7270 EL 420

FDO order	Alt _____ ,	Site	SITE + 7

BN A   MF _____ ,

, Sp corr _____ ,

, Sh _____ ,

Lot XY   Chg 5 _____ ,

Fz Ti , 3 VOLLEYS

, Conc. nr AB 416 , 100/R   14

BTRY   Adjust, Sp corr

Sh HE   Lot XY

Chg 5   Fz Ti

MF C① BTRY ③ IN EFFECT

Corr ———   Df 2452

Si ———

Ti 27.2

QE 430   ②

20/R + 3

430

Observer Corrections					Subsequent fire commands							
Dev	Height	Rg	Fz,MF	Corr	Chart df	Piece df	Rg	HB Corr	Si	Ti	El	QE	Ammo exp
L 20	U 20	+200		L 2	2456	2458	7450	+3	+13	28.2	437	450	④
	D 10	−100			2453	2455	7340	−1	+12	27.6	427	439	⑥
	U 5	+50 OFF	B③		2454	2456	7380	+1	+13	27.8	430	443	㉔
				EM.	EST 15 CASUALTIES.								
					REMAINDER DISPERSED.								

Figure 6. Use of graphical firing scale with FDC computer's record.

obtaining corrections therefrom are fundamentally the same as those for a center-of-impact registration, except that time fire is employed in a high-burst registration (FM 6–40). Final data are adjusted data.

b. After a center-of-impact or high-burst registration is completed, the graphical firing scale GFT setting is obtained from the following data:

(1) *Chart data.*

(a) Chart range is the achieved range from the battery center to the plotted location of the center-of-impact or high-burst registration. Chart range must be corrected for base piece displacement to determine the GFT setting range, if applicable.

(b) Chart site to the center-of-impact or high-brust is computed by using the appropriate charge scale of the graphical firing site scale (par. 41). Vertical interval between the battery and the CI or HB is divided by the achieved chart range.

(2) *Adjusted data:*

(a) *Elevation.* Adjusted elevation is the final quadrant elevation (QE) fired minus the chart site.

(b) *Time.* Adjusted time is the final fuze setting fired in the HB registration.

c. Illustrative example:

(1) *Given data for high-burst registration:*

(a) Battery A, 155-mm howitzer, charge 5, lot XY.

(b) Chart range to plotted location of HB: 6,520 meters.

(c) Chart site: +3 mils.

(d) QE fired: 360 mils.

(e) Time fired: 23.7.

(f) Base piece is located over battery center.

(2) *Required:* GFT setting for the high-burst registration.

(3) *Solution:*

(a) Chart range to HB: 6,520 meters.

(b) QE fired: 360.

(c) Chart site: +3.

(d) Adjusted elevation (360 — (+3)): 357.

(e) Adjusted time: 23.7.

(f) GFT A: Charge 5, lot XY, range 6,520, elevation 357, time 23.7.

20. Construction of Deflection Correction Scale From Center-of-Impact or High-Burst Registration

After the deflection correction and GFT settings have been established, the deflection correction scale is constructed according to procedures outlined in paragraph 16.

21. Application of Meteorological Message and Velocity Error to the Graphical Firing Scale GFT Setting

a. Frequently, it is undesirable or impossible to register each time the weather changes. In order to keep corrections current in such a situation, a technique called met plus VE (velocity error) is used. The major change in range corrections is due to changes in meteorological conditions and propellant temperature, for, while a new met message provides current weather conditions, the velocity error remains virtually constant. The total range corrections determined from a current met message and velocity error may be applied to the graphical firing scale GFT setting.

b. The total range correction is the algebraic sum of the met range correction and the $\triangle V$ range correction. The symbol $\triangle V$ is used to represent the total variation from standard muzzle velocity. The met range correction is computed from a current met message. The $\triangle V$ range correction is computed by correcting the current velocity error for propellant temperature and then multiplying this $\triangle V$ in feet per second (f/s) by the muzzle velocity unit correction (Ground Data Table). The sign of the $\triangle V$ range correction is always *opposite* to the sign of the $\triangle V$. The total range correction thus determined is applied to the chart range in the same manner as a range correction determined from a registration. A GFT setting is made by placing the hairline over the chart range and constructing the elevation gageline over the elevation corresponding to the corrected range (chart range plus total range correction).

c. Illustrative example:
  (1) *Given data:*
    (*a*) Battery A, 155-mm howitzer, charge 5, lot XY.
    (*b*) Chart range to registration point: 6,420 meters.
    (*c*) Met range correction after solving met message: —227 meters.
    (*d*) Current velocity error: —12 f/s.
    (*e*) Correction to muzzle velocity (MV) for propellant temperature (from firing table): +1 f/s.
    (*f*) Muzzle velocity unit correction (from firing table): +5.2 f/s.

(2) *Required:* Current GFT setting (registration not possible).

(3) *Solution:*
(*a*) VE: —12 f/s.
(*b*) Correction to MV for propellant temperature: +1 f/s.
(*c*) △V (—12 + 1): —11 f/s.
(*d*) Muzzle velocity unit correction: +5.2 f/s.
(*e*) △V range correction (5.2 ×11): +57 meters.
(*f*) Met range correction: —227 meters.
(*g*) Total range correction (—227 + 57): —170 meters.
(*h*) Chart range: 6,420 meters.
(*i*) Corrected range (6,420 + (—170)): 6,250 meters.
(*j*) Elevation for range 6,250: 321 mils.
(*k*) GFT A: Charge 5, lot XY, range 6,420, elevation 321.

22. Determination of GFT Setting for Targets Outside Transfer Limits

a. The use of a current velocity error is not restricted to transfer limits of the point at which the velocity error was determined. However, it should be noted that corrections determined for targets close to the maximum range of the piece are not reliable.

b. Corrections for targets outside transfer limits can be computed using the met plus VE technique. Met range corrections are determined using the chart range, vertical, interval, and direction to the target in question. The △V is corrected to a △V range correction using the MV unit correction determined at the entry range for the target.

c. If a current fuze correction is available, it should be applied to the time corresponding to the elevation for the corrected range before a time gageline is constructed.

d. Illustrative example:
(1) *Given data:*
(*a*) Battery A, 155-mm howitzer, charge 5, lot XY.
(*b*) Range to target: 8,020 meters.
(*c*) Total range correction from met plus VE: —240 meters.
(*d*) Current fuze correction: —0.2.

(2) *Required:* GFT setting for the above zone of fire.

(3) *Solution:*
(*a*) Total range correction: —240 meters.
(*b*) Chart range: 8,020 meters.
(*c*) Corrected range (8,020 + (—240)): 7,780 meters.
(*d*) Elevation for range 7,780: 442 mils.

(e) Fuze setting corresponding to elevation 442: 29.3
(29.2).

(f) Fuze correction: —0.2.

(g) Corrected data for fuze setting gageline (29.3 +
(—0.2)): 29.1.

(h) GFT A: Charge 5, lot XY, range 8,020, elevation 442,
time 29.1.

23. Determination of High-Angle Firing Data with the Graphical Firing Scale

a. Determination of elevation, 10-mil site factor, drift, and time of flight for high-angle fire is identical to the procedure outlined in paragraph 11 for determination of low-angle firing data.

b. Illustrative example:

(1) *Given data:*

(a) 155-mm howitzer, charge 5, high-angle.

(b) Range to target: 8,350 meters.

(2) *Required:*

(a) Elevation.

(b) 10-mil site factor.

(c) Drift.

(d) Time of flight.

(3) *Solution* (fig. 2 ②):

(a) Place hairline over range 8,350 meters.

(b) Read under hairline.

   1. Elevation: 1,080 mils.

   2. 10-mil site factor: 4.4.

   3. Drift: 41 mils.

   4. Time of flight: 58.2 seconds.

24. Determination of Site for High-Angle Fire

a. For observed fires, site (which has a relatively small effect in high-angle fire because of the large angle of fall) normally can be ignored if the angle of site is no larger than plus or minus 30 mils. However, site must always be considered in registrations or transfers of fire. ·Whether or not site is to be included is decided by the S3 and announced in the fire order.

b. To simplify the determination of site when high-angle fire is used, a special site scale has been included on the high-angle graphical firing scales. The 10-mil site scale is located just below the elevation scale (fig. 2 ①). The readings obtained from this scale give the site for 10 mils angle of site at the elevation and charge selected. The site for any point is determined by dividing

the angle of site to that point by 10 and multiplying the quotient by the factor read from the 10-mil site scale. The 10-mil site factor, considered negative, when multiplied by the angle of site and divided by 10 will produce the proper sign and amount of site. In high-angle fire, the sign of the site is *opposite* that of the angle of site.

    c. Illustrative example:

        (1) *Given data:*

            (*a*) 155-mm howitzer, charge 5, high-angle.

            (*b*) Chart range: 8,350 meters.

            (*c*) Angle of site: +12 mils.

        (2) *Required:* Quadrant elevation to fire.

        (3) *Solution:*

            (*a*) Chart range: 8,350 meters.

            (*b*) Elevation corresponding to chart range: 1,080 mils.

            (*c*) Angle of site: +12 mils.

            (*d*) 10-mil site factor: —4.4.

            (*e*) Site $(+\frac{12}{10} \times (—4.4))$: —5.28 rounded off equals —5 mils.

            (*f*) Quadrant elevation (1,080 + (—5)): 1,075 mils.

25. Determination and Construction of the GFT Setting for High-Angle Fire

    a. During the adjustment and fire-for-effect phases of a high-angle registration, standard fire direction center (FDC), procedures are followed, except that drift is combined with chart deflection for each round.

    b. Site must be algebraically subtracted from the adjusted quadrant elevation to determine the adjusted elevation. The correct site can only be derived by successive approximation because complementary angle of site is a function of elevation and not of chart range. Correct site is determined when the site computed agrees within 1 mil of the previously computed site. The last site computed is the correct site.

    c. The GFT setting for high-angle fire is placed on the graphical firing scale in the following manner (fig. 7):

        (1) Place cursor over the chart range to the registration point.

        (2) Draw a fine pencil line on the window of the cursor, parallel to the hairline, over the adjusted elevation. This gageline extends from the bottom of the range scale down through the lower time of flight scale. Only the elevation gageline is employed in the GFT setting for high-angle fire.
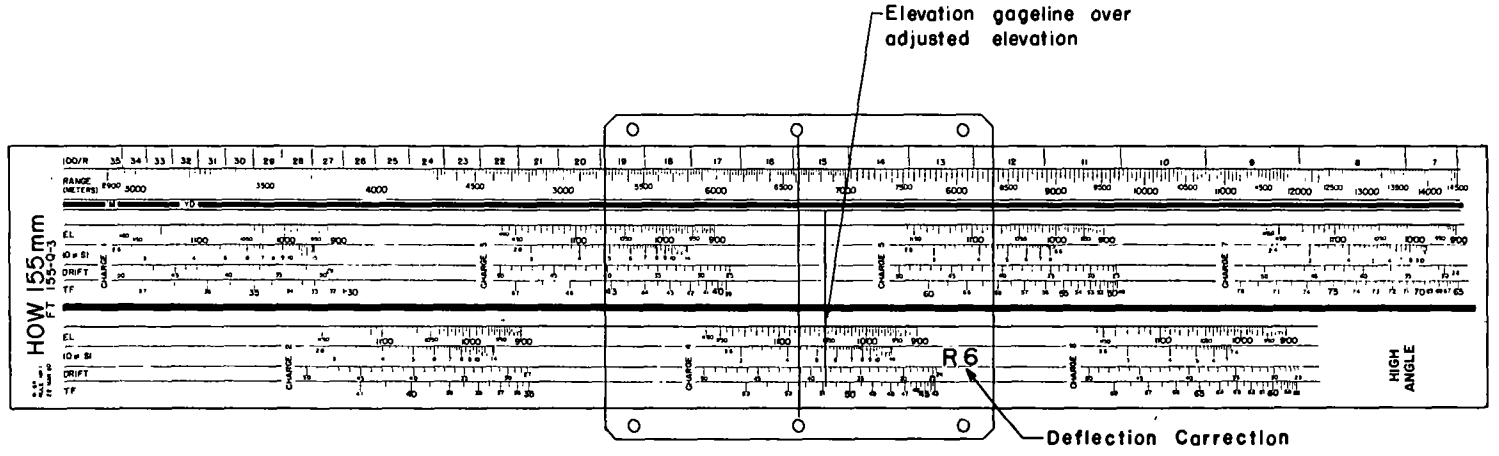
Figure 7. High-angle deflection correction and GFT setting.

d. After registration and subsequent construction of the elevation gageline, data for elevation, 10-mil site, drift, and time of flight are read under the elevation gageline.

e. Fuze settings for VT fuzes for high-angle fire are obtained by reading time of flight under the elevation gageline (or hairline if no elevation gageline is available) and, if this value is not a whole number, rounding the value down to the next lower whole second. For example, if the time of flight read under the elevation gageline is 25.6, the fuze setting for the VT fuze is 25.0.

f. If time permits, registrations should be conducted for each charge expected to be fired. Separate elevation gagelines are then constructed for each appropriate charge. Special care must be exercised in labeling the adjusted elevation gagelines on the window when it is necessary to use more than one charge.

g. Illustrative example:
  (1) *Given data:*
      (a) Battery A, 155-mm howitzer, charge 4, lot XY, high-angle.
      (b) Chart range to registration point: 6,620 meters.
      (c) Adjusted QE: 1,050 mils.
      (d) Angle of site: +6 mils.
  (2) *Required:* GFT setting for the registration in (1) above using high-angle fire.
  (3) *Solution* (fig. 7):
      (a) 10-mil site factor corresponding to elevation 1,050: —5.5.
      (b) First apparent site (0.6 × (—5.5)): —3.3 rounded off equals —3 mils.
      (c) First apparent adjusted elevation (1,050 — (—3)): 1,053 mils.
      (d) 10-mil site factor corresponding to elevation 1,053: —5.4.
      (e) Second apparent site (0.6 × (—5.4)): —3.24 rounded off equals —3 mils.
      (f) Second apparent site agrees within 1 mil with first apparent site.
      (g) Adjusted elevation: 1,053 mils.
      (h) GFT A: Charge 5, lot XY, range 6,620, elevation 1,053.

26. Determination of the Deflection Correction for High-Angle Fire

a. Drift is large in high-angle fire and increases with an increase in time of flight. Thus, in high-angle fire, drift increases as elevation increases and range decreases.

b. Drift changes too rapidly to permit the use of a deflection correction scale as used in low-angle fire. Because drift changes an appreciable amount for a relatively small range change, a correction to compensate for drift, which is determined at the elevation to be fired, is included in each deflection to be fired. Because drift is to the right, the correction is to the left and is always applied to the sum of the chart deflection correction (if any).

c. The total deflection correction is determined by comparing chart deflection and adjusted deflection. The total correction is equal to the drift correction plus unknown corrections; or, solving for unknowns, unknown corrections are equal to the total (registration) correction minus the drift correction. In high-angle fire, the value of the unknown corrections is the deflection correction used for the charge.

d. The deflection correction for each charge is written on the graphical firing scale adjacent to the data for that charge (fig. 7).

e. If high-angle registration has not been conducted and meteorological or experience factors are unknown, a deflection correction of zero will be used. If a charge other than that with which the registration was conducted is to be fired, the deflection correction for the charge nearest the charge to be fired is used.

f. Illustrative example:
    (1) *Given data:*
        (*a*) GFT A: Charge 4, lot XY, range 6,620, elevation 1,053.
        (*b*) Adjusted deflection: 2,710 mils.
        (*c*) Chart deflection to registration point: 2,677 mils.
    (2) *Required:* Deflection correction for charge 4.
    (3) *Solution* (fig. 7):
        (*a*) Total deflection correction (chart to adjusted or df 2,677 to df 2,710): L33.
        (*b*) Drift correction corresponding to adjusted elevation: L39 (or L38).
        (*c*) Deflection correction (total deflection correction minus drift correction) (L33–L39): R6.

27. High-Angle Transfer of Fires

a. The maximum ordinates and long times of flight encountered in high-angle fire make transfer of fire less reliable than with low-angle fire. However, under stable weather conditions, successful transfers of fire within a single charge are practicable. The small area of range covered by each charge prevents establishment of definite transfer limits.

b. After registration and construction of a GFT setting, data to any target is determined by placing the hairline over the chart range to the target. Elevation, 10-mil site, drift, and time of flight are read under the elevation gageline corresponding to the charge being used. If a charge is to be used for which no registration was conducted, data should be read under the elevation gageline corresponding to the charge nearest the charge to be fired (elevation gageline is extended up or down as appropriate to intersection of other charges).

28. Use of the Graphical Firing Scale in Construction of the Firing Chart

The graphical firing scale is of value in the construction of an observed firing chart inasmuch as it can be used to determine comparative ranges from firing. The range from a battery to a registration point may be determined whether from the adjusted quadrant elevation, adjusted elevation, or the adjusted fuze setting. The method used depends on the type of ammunition available and whether or not the site can be determined. The procedures used in constructing observed firing charts are explained in FM 6–40.

29. Off-Scale Charts

a. Any map, grid sheet, photograph, or photomap from which ranges are to be measured for the purpose of obtaining basic data and whose scale differs from that of the graphical instruments used in making these measurements is called an off-scale chart. The graphical firing scale can be used to correct for the variation in scale if the true distance between two points on the chart is known or can be determined.

b. The graphical firing scale is corrected for an off-scale chart in the following manner:

(1) Move the hairline to the true ground range between the two points being considered.

(2) Draw a fine pencil line on the window of the cursor through the range determined by the range-deflection protractor or GFT fan. This chart gageline extends only through the range scale (fig. 8).

c. It is now possible to convert announced chart ranges to the true ground range by moving the chart gageline to the announced chart range in each case and reading the true ground range under the hairline.

d. The GFT setting is established as outlined in paragraph 12.
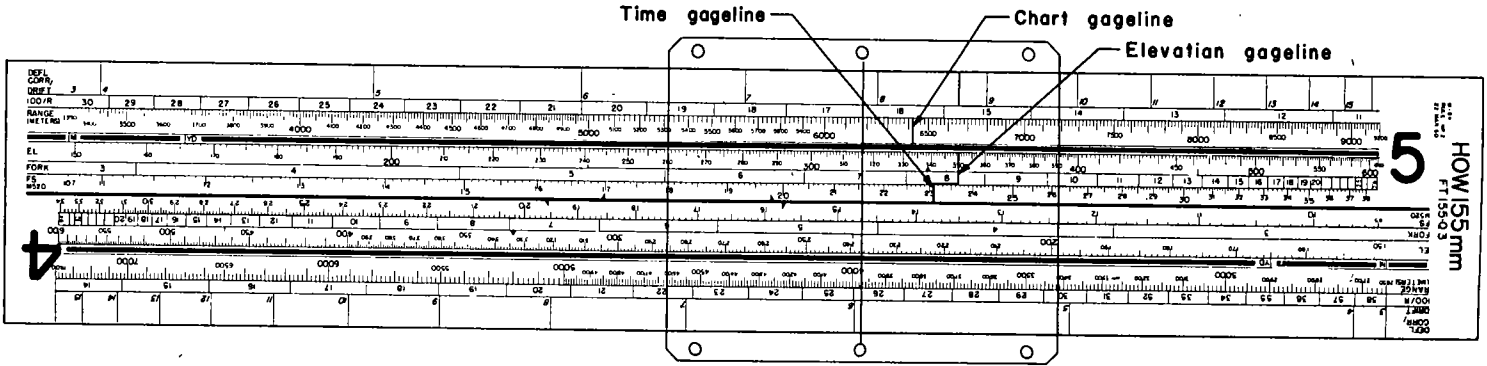
Figure 8. *Setting of graphical firing scale using an off-scale chart.*

Before the elevation and time gagelines are drawn on the window, care should be taken to place the chart gageline over the announced chart range to the registration point (fig. 8).

e. The deflection correction scale for an off-scale chart is constructed in relation to chart units, but is based on transfer limits for the true range. Transfer limits are applied to the true range to the registration point. The hairline is then placed over each of the true transfer limits to determine the value of the transfer limits in chart units under the chart gageline. The deflection correction scale is then constructed as outlined in paragraph 16, except that ranges at which drift changes are read come under the chart gageline.

f. There will be instances when the scale of the chart will be such that it will be impossible to construct the chart-ground relationship on the window as described in b above; that is, when the hairline is over true range, the window will not cover the chart range. In this case, move the window until it covers the values of both the true range and chart range. Draw two gagelines, one over the true range labeled "T" (true), and one over the chart range labeled "C" (chart). The subsequent procedure for handling an adjustment and constructing the GFT setting is the same as described in d and e above except that the hairline is ignored. For computations, caution should be taken to use the true gageline instead of the hairline.

g. Illustrative example:

   (1) *Given data:*

      (a) 155-mm howitzer, charge 5, adjusted elevation 350, adjusted time 23.1, using an off-scale map.

      (b) True distance between two known points on chart is 6,180 meters.

      (c) Chart distance between the above two points is 6,420 meters.

   (2) *Required:* Construct chart, elevation, and time gagelines.

   (3) *Solution* (fig. 8):

      (a) Move hairline to range 6,180 meters.

      (b) Draw a chart gageline over range 6,420 as shown in figure 8.

      (c) Draw an elevation gageline over elevation 350 as shown in figure 8.

      (d) Draw a time gageline over fuze setting 23.1 as shown in figure 8.

30. Miscellaneous Uses of the Graphical Firing Scale

a. *Conversion of Yards to Meters and Meters to Yards.* Distances measured in yards can be converted to meters by using the M and YD conversion gage points. On the left end of each rule under the range scale are two conversion gage points labeled "M" (meter) and "YD" (Yard), respectively. To convert yards to meters, move the hairline to the M gage point. Draw a gageline on the window over the YD gage point. When the gageline is placed over a given distance in yards, the equivalent distance in meters is read under the hairline. The conversion gageline must be made on the window using the M and YD gage points on that particular range scale which is to be used in making the conversion. If it is desired to convert meters to yards, the above procedure is reversed.

b. *For Special Ammunition.*

    (1) Occasionally it is necessary to fire ammunition for which no tabular firing table or graphical scale is available. The graphical firing scale can be used during the firing of this ammunition by employing the procedure in (2) below.

    (2) Considering caliber and muzzle velocity, select the most suitable graphical firing scale available. Fire a center-of-impact or high-burst registration at an elevation corresponding as closely as possible to the elevation opposite the red triangular gage point on the dividing line between the elevation and fork scales. Based on the registration, construct the GFT setting as described in paragraph 19. The range-elevation relation thus determined will work satisfactorily within reasonable transfer limits. Fuze settings read under the adjusted time gageline determined by this registration are sufficiently accurate. However, values of work and drift will normally be invalid.

CHAPTER 3
SCALE, GRAPHICAL FIRING, SITE M67

Section I. NOMENCLATURE AND DESCRIPTION

31. General

a. Use. The Scale, Graphical Firing Site, M67 (fig. 9) is a special slide rule used to determine site, angle of site, and vertical interval. It may also be used to solve simple problems in multiplication and division.

b. Scope. Information contained in this chapter is applicable also to the graphical firing site scales listed in table I.

32. Nomenclature

The following nomenclature is standard for the graphical firing site scale:

a. Base. The base is that fixed portion of the graphical firing site scale which contains the grooves for the slide and cursor. The base also contains the D (site and vertical interval) scale. Operating instructions appear on the back of the base.

b. Slide. The slide is the narrow strip of wood which fits into the base by a tongue and groove system. The C (range) scale, the site-range scales (graduated in meters for various charges), and the yard and meter gage points appear on both sides of the slide.

c. Cursor. The cursor, which is composed of the window and hairline, slides along the top and bottom edges of the base.

    (1) *Window.* The window is the clear plastic portion of the cursor.

    (2) *Hairline.* The hairline, the fine line engraved on the under surface of the window, serves as the index for reading data.

d. Scale. A scale is a single line of graduations for a particular function, such as the target above gun (TAG) scale.

e. Gage Point. A gage point is a special mark on the graphical firing site scale denoting a specific constant.

f. Plot Point. Each site-range scale is graduated at intervals of 100 meters. These graduations, or plot points, enable the operator

Base

Cursor

Hairline

Window

Target Above Gun Scale

Target Below Gun Scale

HOW 155 mm
FT 155-Q-3   (METERS)
PROJ. HE, M107

Range

Site and D
Vertical Interval

C Scale

D Scale

Left Indexes

Right Indexes

Yard Gage Point

Meter Gage Point
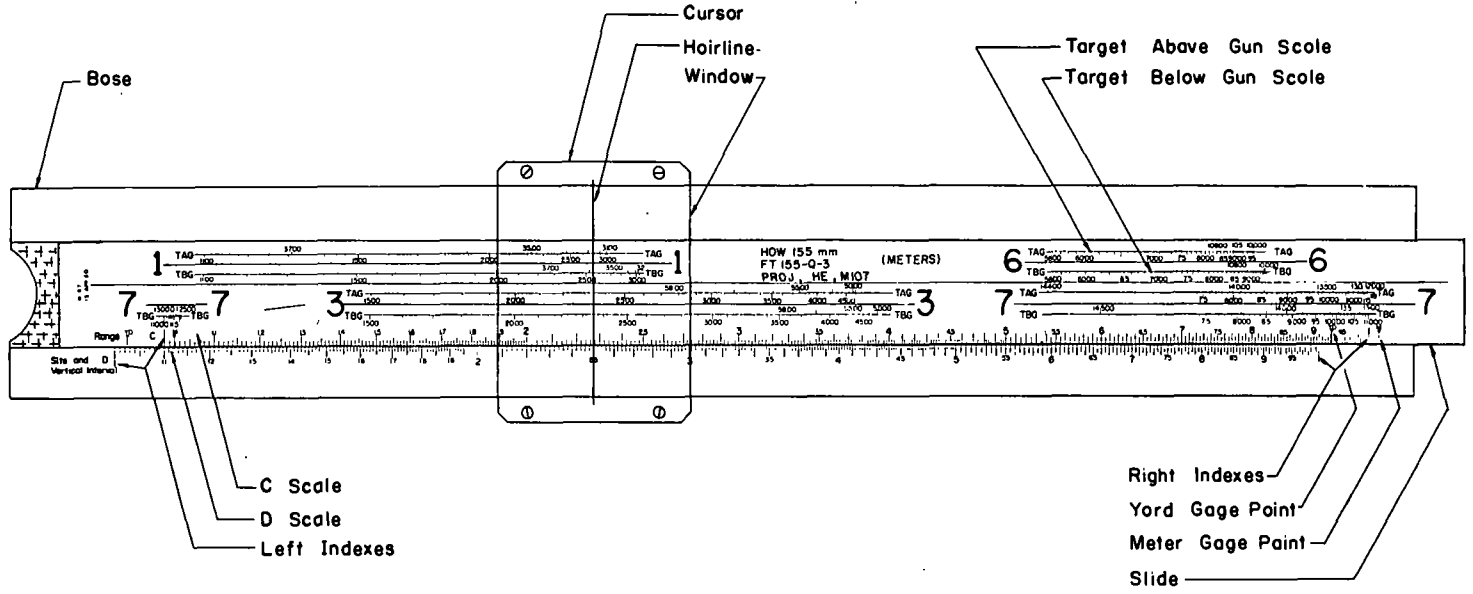
Slide

Figure 9. Scale, graphical firing, site, M67.

to determine site with one operation of the slide. The plot point (PP) is mathematically defined as PP=range/(1+CSF), when CSF is the complementary angle of site factor.

33. Description

a. General. The Scale, Graphical Firing, Site, M67, based on FT 155–Q–3, is graduated at 100-meter intervals to show low-angle firing data for charges 1, 3, 4, 5, 6, and 7. *For high-angle fire, site cannot be determined with the graphical firing site scale.*

b. Composition of Scales and Data (fig. 9).

(1) *General.* Site-range scales for targets above and below gun are provided for each charge. Data for charges 1, 3, 6, and 7 may be read from on one side of the slide, and data for charges 4 and 5, from the opposite side of the slide.

(2) *C scale.* This logarithmic scale is located on both sides of the slide and is identical with the C scale on any slide rule. It is used in conjunction with the D scale to obtain angle of site.

(3) *D scale.* This logarithmic scale is located on the bottom of the base and is used to determine site, vertical interval, and angle of site. The D scale is identical with the C scale.

(4) *Target above gun (TAG) scale.* This site-range scale enables the operator to determine site to a target that is higher than the firing battery. Numbers on this scale are printed in black.

(5) *Target below gun (TBG) scale.* This site-range scale enables the operator to determine site to a target that is lower than the firing battery. Numbers on this scale are printed in red.

(6) *Yard and meter gage points.* Yard (YD) and meter (M) gage points are shown on both ends of the slide. The M gage point accomplishes multiplication or division by 1.0186 to permit the use of the mil relationship $\mathit{m} = 1.0186$ W/R, which is a more precise relationship than $\mathit{m} = $ W/R. In the above relationship, m is the angular measurement in mils between two points in the vertical plane, W is the width in meters between the points from which angle m is measured, and R is the distance or range in thousands of meters to the known point. The YD gage point converts the value read opposite the M gage point from yards to meters.

(7) *Left and right indexes.* The left indexes consist of the gage points (each marked by the numeral 1) on the left ends of the C and D scales. The right indexes consist of the gage points (also marked by the numeral 1) on the right ends of the C and D scales.

(8) *Color.* On the Scale, Graphical Firing, Site, M86, based on FT 8–0–3, weapon and projectile nomenclature and charge and firing table designations are printed in red. This information is printed in black on all other graphical firing site scales.

Section II. MAJOR USES OF THE GRAPHICAL FIRING SITE SCALE

34. Terminology

An understanding of the following terminology is essential to effective use of the graphical firing site scale.

a. Vertical Interval (VI). Vertical interval is the difference in altitude between two points, such as the battery and target. If the target is higher than the battery, VI is positive; if the target is lower than the battery, VI is negative. To insure the determination of the proper algebraic sign, the altitude of the battery is always subtracted from the altitude of the target. Vertical interval is determined to the nearest meter or yard.

b. Elevation (El). Elevation is the required vertical angle of the howitzer to obtain a given range with a particular charge when the vertical interval is zero. Elevation is the value listed in the ground data section of the tabular firing table and on the graphical firing scale for a given range and charge.

c. Angle of Site. When the vertical interval and chart range are known, the angle of site may be determined by the mil relation formula: angle of site = vertical interval/range (in thousands of units). If the target is above the weapon, the angle of site is positive; if the target is below the weapon, the angle of site is negative.

d. Complementary Angle of Site (CAS). Complementary angle of site is a correction applied to compensate for the nonrigidity of the trajectory. In theory, the trajectory may be rotated up or down through small vertical angles about the origin without materially affecting its shape. However, when angles of site are large, this assumption will cause the introduction of significant errors. Complementary angle of site is included in the determination of site with the graphical firing site scale, but may be determined by multiplying the angle of site by the complementary angle of site factor (CSF) given in the tabular firing table.

e. Site. Site is the algebraic sum of the angle of site and the complementary angle of site. For low-angle fire, site is positive for targets whose vertical interval is positive and negative for targets whose vertical interval is negative.

f. Quadrant Elevation (QE). Quadrant elevation is the algebraic sum of the elevation and site (par. 24c). The value of this vertical angle is transmitted to the firing battery as QUADRANT (so much).

35. Operation

The operation of the graphical firing site scale is best explained by a series of illustrative examples and problems.

36. Reading the C and D Scales

a. The scales of the graphical firing site scale are read in the same manner as the scales of an ordinary ruler, except that the graduations on the slide and the base are not equally spaced. The C and D scales (the basic scales) are graduated logarithmically in the same manner. The decimal point is ignored when the digits are set on the scale initially. For example, the number 1 on the C scale may represent 0.01, 0.1, 1.0, 10.0, etc.; number 5 on the D scale may represent 0.05, 0.5, 5.0, 50, etc. Thus, numbers 1 and 5 represent the significant digits of 1 and 5, respectively, regardless of the number of zeros or the location of the decimal point.

b. The C and D scales are composed of three types of graduations:

> (1) *Primary division.* The primary divisions are the nine major graduations located between the left and right indexes. Each division represents the first digit of a number. For example, 3 represents 0.003, 0.03, 0.3, 30, etc.

> (2) *Secondary division.* Each primary division is divided into 10 parts called secondary divisions. The secondary division represents the second digit of a number.

> (3) *Tertiary division.* The third digit of a number is represented by the tertiary division. Tertiary divisions on the C and D scale vary as follows:

> > (a) From 1 (left index) to 2: 10 divisions.
> > (b) From 2 to 5: 5 divisions.
> > (c) From 5 to 1 (right index): 2 divisions.

c. The third digit of any number whose first digit is 1 can be set directly on the scales. When the first digit is 2, 3, or 4, even numbers can be set directly on the scales, but odd numbers are set

by interpolation. From 5 to 1 (right index), multiples of 5 can be set directly on the scale, and other numbers set by interpolation.

37. Multiplication of Numbers

a. Multiplication is accomplished by graphically adding the logarithms of the factors. For example, in multiplying 2 × 2, the operator is merely adding the log of 2 to the log of 2. The following procedure is used for multiplication of numbers:

(1) Move the hairline over one of the factors on the D scale.

(2) Place the C scale index under the hairline.

(3) Move the hairline to the other factor on the C scale.

(4) Read the product on the D scale under the hairline.

b. Illustrative example:

(1) To multiply 2 × 2, set the hairline over 2 on the D scale. Place the left C scale index under the hairline. Move the hairline to 2 on the C scale. Read the product 4 under the hairline on the D scale.

(2) If the product cannot be read because the second factor is on that part of the scale projecting beyond the D scale, the other C index is used. For example, to multiply 3 × 4, if the left C index is placed opposite 3 on the D scale, 4 will project beyond the D scale. Therefore, the right C scale index should be placed opposite 3 on the D scale, the hairline moved to 4 on the C scale, and the product 12 read under the hairline on the D scale. To determine where the decimal point should be placed in the answer, round off the factors and multiply them mentally for an approximate answer.

38. Division of Numbers

Division is accomplished by graphically subtracting the log of the divisor from the log of the dividend. For example, in dividing 4 by 2, the operator is merely subtracting the log 2 from the log 4. The following procedure is used for division of numbers:

a. Move the hairline to the dividend on the D scale.

b. Place the divisor on the C scale under the hairline.

c. Move the hairline to the C scale index.

d. Read the quotient on the D scale under the hairline opposite the C scale index.

Example: To divide 42 by 3, move the hairline over 42 on the D scale. Place 3 on the C scale under the hairline. Move the hair-

line to the C scale index and read the quotient 14 under the hairline on the D scale.

39. Conversion of Yards to Meters and Meters to Yards

a. Yards to Meters. To convert yards to meters, place the M gage point opposite the known measurement in yards on the D scale and read the measurement in meters opposite the YD gage point on the D scale.

Example: To convert 2,000 yards to an equivalent number of meters, place the M gage point opposite 2 on the D scale. Read 1,830 meters opposite the YD gage point on the D scale.

b. Meters to Yards. To convert meters to yards, place the YD gage point opposite the known measurement in meters on the D scale and read the measurement in yards opposite the M gage point on the D scale.

Example: To convert 1,800 meters to an equivalent number of yards, place the YD gage point opposite 18 on the D scale. Read 1,970 yards opposite the M gage point on the D scale.

40. Determining Angle of Site

a. General. The graphical firing site scale can be used for determining an accurate angle of site of 100 mils or less. (For an angle of site greater than 100 mils, the tangent function from the military slide rule or logarithmic tables should be used.) The angle of site is determined by dividing the vertical interval between the battery and target by the range in meters to the target in thousands ($\mathfrak{m} = 1.0186 \dfrac{W}{R}$). The quotient is then read on the D scale opposite the M gage point if the vertical interval is in meters; or opposite the YD gage point if the vertical interval is in yards. Unless the angle of site is zero, it is always preceded by a plus or minus sign.

b. Procedure.
    (1) Move the hairline to the vertical interval on the D (vertical interval) scale.
    (2) Place the range in thousands on the C (range) scale under the hairline.
    (3) Opposite the appropriate gage point (M or YD), read the angle of site on the D scale.

c. Illustrative Example.
    (1) *Given data:*
        (*a*) Range to target: 5,400 meters.

(*b*) Vertical interval: +35 meters.

(2) *Required:* Angle of site.

(3) *Solution* (fig. 10):

(*a*) Place hairline over 35 on the D scale.

(*b*) Set 5,400 on the C scale under the hairline.

(*c*) Read angle of site opposite M gage point on the D scale: +6.6 rounded off equals +7 mils.

41. Determination of Site

a. General. Because site includes complementary angle of site, division of the vertical interval by the range ($m = 1.0186 \dfrac{W}{R}$) must be performed by using the site-range scale (TAG or TBG) for the proper charge and relative position of weapon and target. If the target is *above* the weapon, the TAG scale is used; if the target is *below* the weapon, the TBG scale is used. Complementary angle of site is automatically included in the determination of site with the graphical firing site scale.

b. Procedure.

(1) Move the hairline to the vertical interval on the D (vertical interval) scale.

(2) Place the range in *meters* under the hairline on the appropriate TAG or TBG scale for the selected charge.

(3) Read the site opposite the appropriate gage point (M or YD) on the D (site) scale. If the vertical interval is in meters, read opposite the M gage point. If the vertical interval is in yards, read opposite the YD gage point.

c. Illustrative Example.

(1) *Given data:*

(*a*) 155-mm howitzer, charge 5.

(*b*) Range to target: 7,270 meters.

(*c*) VI: +44 meters.

(2) *Required:* Site.

(3) *Solution* (fig. 11):

(*a*) Place the hairline over 44 on the D scale.

(*b*) Place range 7,270, charge 5, TAG, under the hairline.

(*c*) Read site opposite the M gage point on the D scale: +7.33 rounded off equals +7 mils.

(4) See FDC computer's record (fig. 6), for application of the site determined in this illustrative example.
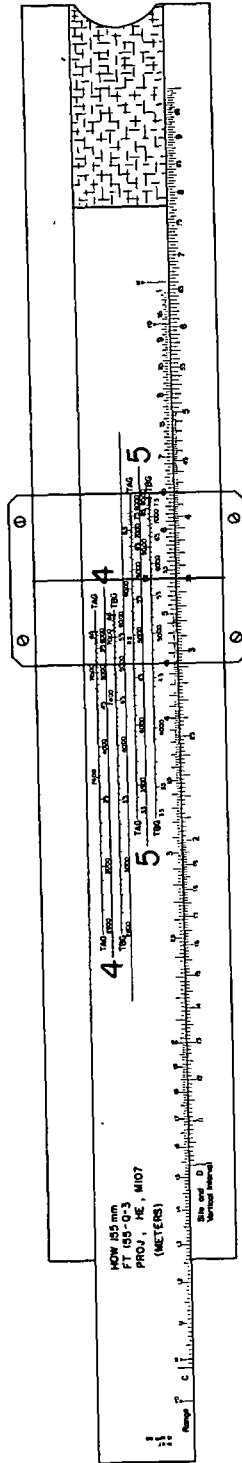
Figure 10. Determining angle of site.

41

HOW 155 mm
FT 155-Q-3
PROJ , HE , M107
(METERS)
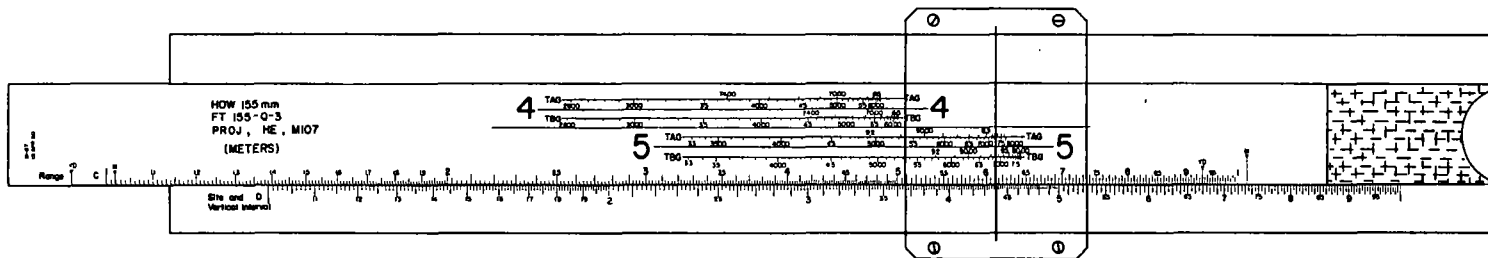
Figure 11. Determination of site.

Note. To determine where the decimal point is placed, use the mil relation of $W/R = m$ to obtain an approximate answer. In the example above, 44/7 is approximately 6.

42. Determination of Vertical Interval From Angle of Site or Site

a. Vertical interval can be determined when the range and angle of site are known by use of the relation $W = Rm/1.0186$. The procedure is as follows:

> (1) Place the appropriate gage point (M or YD) opposite the angle of site on the D scale.
>
> (2) Move the hairline to the proper range on the C scale.
>
> (3) Read vertical interval under the hairline on the D scale.

b. If the site is known from firing, the procedure for determining vertical interval is the same as described in *a* above, except that the appropriate TAG or TBG scale for the charge fired is used instead of the C scale.

c. Illustrative example:

> (1) *Given data:*
>> (a) 155-mm howitzer, charge 5.
>> (b) Range to target: 5,400 meters.
>> (c) Site: —5 mils.
>
> (2) *Required:* Vertical interval in yards.
>
> (3) *Solution:*
>> (a) Place YD gage point opposite 5 on the D scale.
>> (b) Move the hairline to charge 5, TBG, range 5,400.
>> (c) Read under hairline on D scale the vertical interval: —27.6 rounded off equals —28 yards.

CHAPTER 4

SCALE, GRAPHICAL FIRING, M70 FOR USE WITH ILLUMINATING PROJECTILE, M118 MODS

Section I. NOMENCLATURE AND DESCRIPTION

43. General

a. Use. The Scale, Graphical Firing, M70, based on FT 155–Q–3, is a special ballistic scale designed for use with illuminating projectile M118 Mods.

b. Scope. Information contained in this chapter is applicable also to the Scale, Graphical Firing, M84, based on FT 105–H–6, for use with illuminating projectile M314 Mods.

44. Nomenclature

a. The nomenclature of the graphical firing scale for use with illuminating ammunition is identical with the nomenclature of the graphical firing scale M64 discussed in paragraph 8, except that no gage points appear on graphical firing scale M70.

b. Appropriate components of graphical firing scale M70 are shown in figure 12 ①.

45. Description

a. General. The Scale, Graphical Firing, M70 consists of two rules. Firing data for charge 3 (ascending and descending trajectories) and charge 4 (descending trajectory) are read from rule number 1 (fig. 12); firing data for charges 5 and 7 (descending trajectory) are read from rule number 2 (fig. 13). Ballistic data is given in two dimensions—range and height of burst.

b. Composition of Scales and Data (fig. 12 ②).

   (1) *100/R scale.* The correction in mils necessary to shift the point of burst laterally or vertically 100 meters for a given range may be read from the 100/R scale. The entire scale is printed in red.

   (2) *Range scale.* The range (RANGE) scale is the basic scale of the graphical firing scale. All data is plotted with reference to the range scale. Range is given *linearly* in
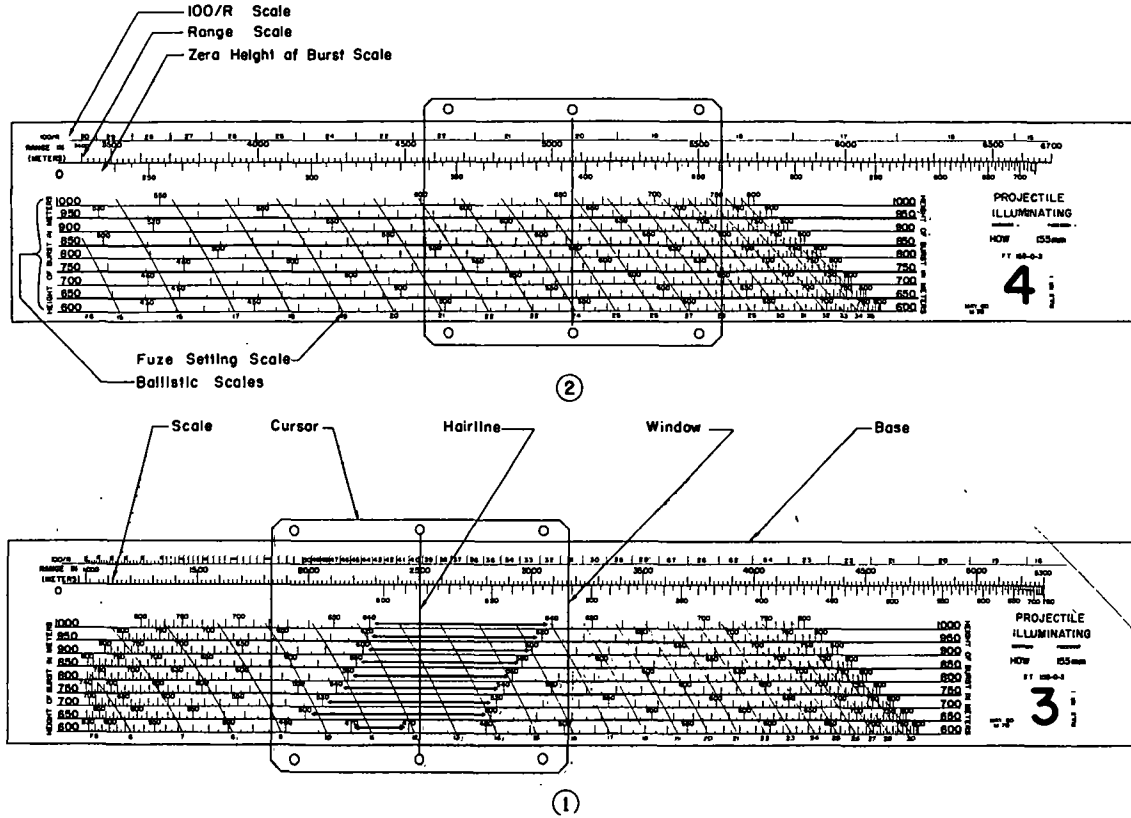
Figure 12. Scale, graphical firing, M70, rule number 1.
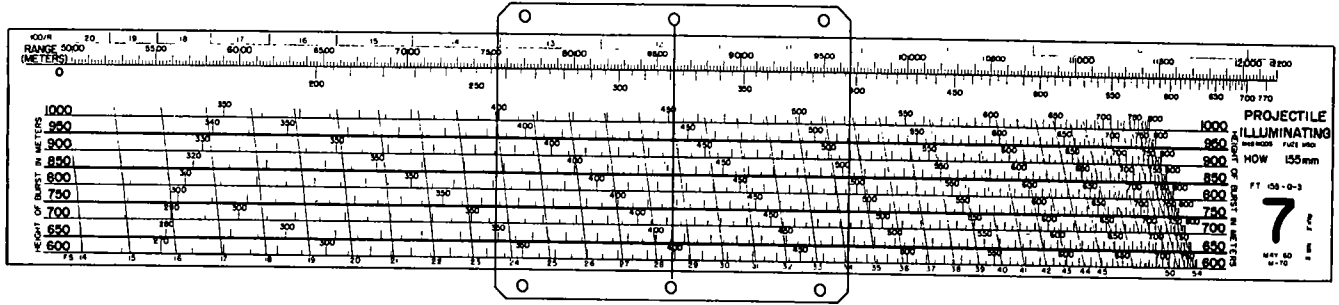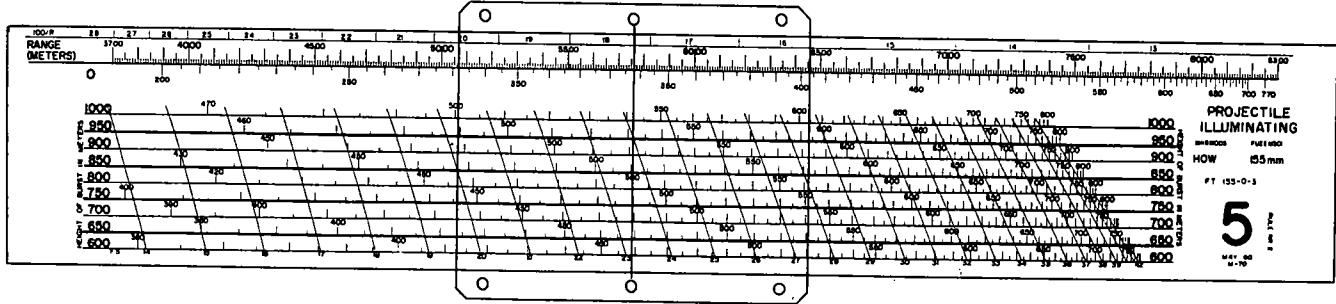
Figure 13. Scale, graphical firing, M70, rule number 2.

meters and varies for each charge. Range is entered on the graphical firing scale to the nearest 10 meters.

(3) *Zero height-of-burst scale.* The zero height-of-burst scale is plotted immediately opposite the range scale and shows the range attained for a graze burst.

(4) *Ballistic scales.* The ballistic scales provide quadrant elevations for various heights of burst (HOB) and ranges.

    (*a*) *Height of burst.* Both ends of each ballistic scale are identified for appropriate heights of burst in meters. These scales are divided according to height of burst above gun in increments of 50 meters, from plus 600 through plus 1,000 meters.

    (*b*) *Quadrant elevation.* Each ballistic scale gives the quadrant elevation for the height of burst indicated.

(5) *Fuze setting scale.* The fuze setting (FS) scale is graduated in one fuze number intervals and is superimposed in red arcs on the horizontal ballistic scales. Data given on this scale is for fuze M501.

Section II. MAJOR USES OF THE GRAPHICAL FIRING SCALE M70

46. Operation

The operation of the graphical firing scale for illuminating ammunition is best explained by a series of illustrative examples and problems.

47. Determination of Quadrant Elevation and Fuze Setting (Ascending Trajectory)

a. To determine quadrant elevation and fuze setting for a given range and charge, place the hairline over the range to the point to be illuminated. Read at the intersection of the hairline and the correct ballistic scale, the quadrant elevation to fire. (Correct ballistic scale is determined by adding algebraically the optimum height of burst (750 meters above the target) to the vertical interval in meters and rounding the sum to the nearest 50 meters.) The fuze setting to fire is obtained by interpolating between the red fuze setting lines for the point of intersection of the hairline and the correct ballistic scale.

b. It should be noted that data for both the ascending and descending branches of the trajectory are shown only for charge 3. For all other charges, data is given only for the descending branch of the trajectory. A heavy black arrow on each ballistic scale of charge 3 indicates the part of the trajectory which is

at or near the summit, but which does not exceed the respective ballistic scale which it represents by 50 meters. A minimum range capability is attained by reading data for the ascending branch of the trajectory for this charge.

c. Illustrative example:

(1) *Given data:*

(a) Chart range: 2,500 meters.

(b) Vertical interval: +210 meters.

(2) *Required:* Quadrant elevation and fuze setting to fire.

(3) *Solution* (fig. 12 ①):

(a) Select charge 3.

(b) Place hairline over chart range 2,500 meters.

(c) Determine correct ballistic scale to use:

  1. Optimum HOB above target: 750 meters.

  2. Vertical interval: +210 meters.

  3. Correct ballistic scale to use (750 + (+210)): 960 rounded off equals 950 meters.

(d) Read, at the intersection of the hairline and the 950 meter ballistic scale, the quadrant elevation to fire: 620 mils.

(e) Interpolate between the red fuze setting lines bracketing the point of intersection of the hairline and the 950-meter ballistic scale to obtain the fuze setting to fire: FS 13.2.

48. Determination of Quadrant Elevation and Fuze Setting (Descending Trajectory)

a. The determination of quadrant elevation and fuze setting for descending trajectories is identical with the procedure outlined in paragraph 47 for ascending trajectories.

b. Illustrative example:

(1) *Given data:*

(a) Chart range: 5,760 meters.

(b) Vertical interval: +35 meters.

(2) *Required:* Quadrant elevation and fuze setting to fire.

(3) *Solution* (fig. 13 ①):

(a) Select charge 5.

(b) Place hairline over chart range 5,760 meters.

(c) Determine correct ballistic scale to use:

  1. Optimum HOB above target: 750 meters.

2. Vertical interval: +35 meters.

3. Correct ballistic scale to use (750 + (+35)): 785 rounded off equals 800 meters.

(*d*) Read, at the intersection of the hairline and the 800-meter ballistic scale, the quadrant elevation to fire: 500 mils.

(*e*) Interpolate between the red fuze setting lines bracketing the point of intersection of the hairline and the 800-meter ballistic scale to obtain the fuze setting to fire: FS 23.6.

## 49. Determination of Firing Data Based on Subsequent Observed Height-of-Burst Correction

a. Data based on subsequent height-of-burst corrections are determined in the following manner:

(1) Determine correct ballistic scale to use:

(*a*) Observer corrections to height of burst are always given in multiples of 50 meters.

(*b*) Observer corrections are added algebraically to the ballistic scale previously used to obtain corrected ballistic scale.

(2) Using the corrected ballistic scale, determine the quadrant elevation and fuze setting as outlined in paragraph 47.

b. Illustrative example:

(1) *Given data:*

(*a*) Situation continued from paragraph 48*b*.

(*b*) Observer correction to HOB: UP 50 (meters).

(2) *Required:* Quadrant elevation and fuze setting to fire.

(3) *Solution* (fig. 13 ①):

(*a*) Hairline is still over range 5,760 (observer corrections in this example are only to HOB).

(*b*) Determine correct ballistic scale to use:

1. Ballistic scale previously used: 800 meters.

2. Observer correction to HOB: UP 50 (+50 meters).

3. Correct ballistic scale to use (800 + (+50)): 850 meters.

(*c*) Read, at the intersection of the hairline and the 850-meter ballistic scale, the quadrant elevation to fire: 511 mils.

(*d*) Interpolate between the red fuze setting lines on each side of the point of intersection of the hairline and the 850 meter ballistic scale to obtain the fuze setting to fire: FS 23.7.

50. Determination of Impact Range

a. The range attained for a graze burst is determined in the following manner:

(1) Place hairline over quadrant elevation fired on the zero HOB scale.

(2) Read impact range under hairline on range scale.

b. Illustrative example:

(1) *Given data:*

(*a*) Charge 5.

(*b*) Round fired at quadrant elevation 511 was a graze burst.

(2) *Required:* Impact range attained.

(3) *Solution:*

(*a*) Place hairline over quadrant elevation 511, charge 5, on the zero HOB scale.

(*b*) Read impact range under hairline on range scale: 7,350 meters.

51. Construction of Graphical Firing Scale GFT Setting

a. A GFT setting is not feasible for illuminating ammunition if weather conditions vary considerably between fire missions or if the location of the target with respect to the direction of the wind varies from that of the target from which the GFT setting was obtained. However, if weather conditions and targets remain relatively constant, it may prove expedient to obtain firing data from a GFT setting. Data obtained from such a GFT setting is sufficiently accurate, although, because the range scale is linear and not logarithmic, only a "flat range" GFT setting can be constructed.

b. The GFT setting is placed on the graphical firing scale in the following manner (fig. 14):

(1) Move the hairline over the chart range to the point illuminated.

(2) Draw a fine pencil line on the window through the *last* QE fired on the *initial* ballistic scale used. This elevation gageline extends from the 100-meter ballistic scale down through the 600-meter ballistic scale.

Time gageline over lost
fuze setting fired

Hairline over GFT
setting range

Elevation gageline over lost
quadrant elevation fired on
initial ballistic scale used
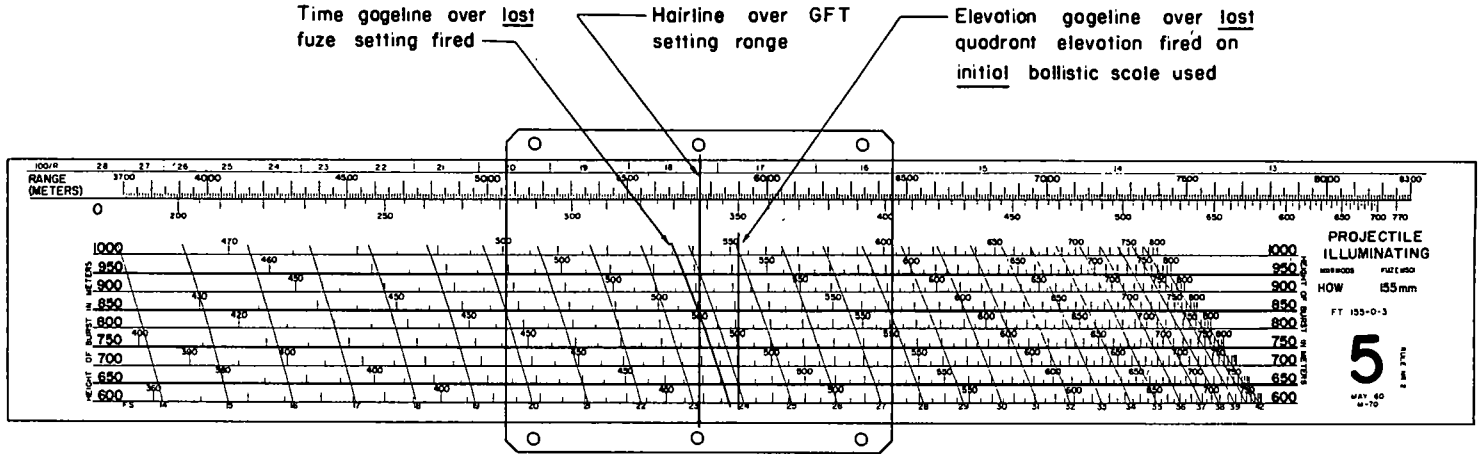
Figure 14. Elevation and time gagelines on the graphical firing scale.

(3) Draw a fine pencil line on the window over the *last* fuze setting fired. This time gageline has the same curvature and length as adjacent fuze setting lines.

c. Illustrative example:

(1) *Given data from a completed fire mission:*

(*a*) Chart range to point illuminated: 5,760 meters.

(*b*) Initial ballistic scale used: 800 meters.

(*c*) Last quadrant elevation fired: 511 mils.

(*d*) Last fuze setting fired: FS 23.7.

(2) *Required:* Construct GFT setting.

(3) *Solution* (fig. 14):

(*a*) Place hairline over chart range 5,760 meters.

(*b*) Draw an elevation gageline over QE 511 on the 800-meter ballistic scale as shown in figure 14.

(*c*) Draw a time gageline over fuze setting 23.7 as shown in figure 14.

52. Determination of Firing Data From GFT Setting

a. After construction of a GFT setting, data to a new target within transfer limits (par. 16*b*(3)(*a*)) are determined by placing the hairline over the chart range to the target and reading quadrant elevation under the elevation gageline and fuze setting under the time gageline. The 100/R scale is also read under the hairline.

b. Illustrative example:

(1) *Given data:*

(*a*) GFT setting constructed from data given in paragraph 51*c.*

(*b*) Chart range to point to be illuminated: 5,500 meters.

(*c*) Vertical interval: —50 meters.

(2) *Required:* Quadrant elevation and fuze setting to fire.

(3) *Solution* (fig. 15):

(*a*) Place hairline over chart range 5,500 meters.

(*b*) Determine correct ballistic scale to use:

1. Optimum HOB above target: 750 meters.

2. Vertical interval: —50 meters.

3. Correct ballistic scale to use (750 + (—50)): 700 meters.

(*c*) Read, at the intersection of the elevation gageline and the 700-meter ballistic scale, the quadrant elevation to fire: 471 mils.

(*d*) Interpolate between the red fuze setting lines bracketing the point of intersection of the time gageline and the 700-meter ballistic scale to obtain the fuze setting to fire: FS 22.3.
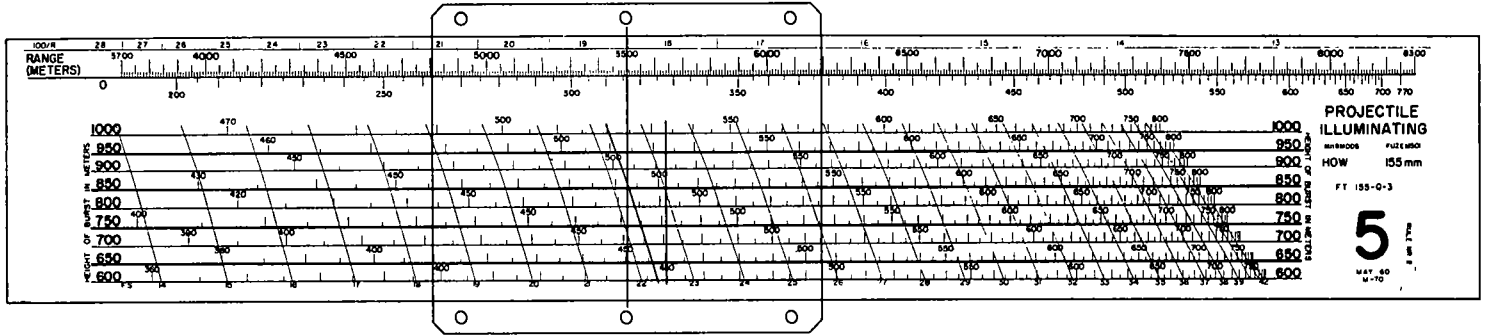
Figure 15. Determination of quadrant elevation and fuze-setting with GFT setting.

CHAPTER 5

SCALE, LOW-LEVEL WIND, M73, 762-MM ROCKET

Section I. NOMENCLATURE AND DESCRIPTION

53. General

a. Use. The Scale, Low-Level Wind, M73 (fig. 16), based on FTR 762–F–1, is a special slide rule used to determine corrections to quadrant elevation and deflection due to low-level winds as determined by wind-measuring sets AN/MNQ–1( ) and AN/PMQ–6.

b. Scope. Information contained in this chapter is applicable also to the low-level wind scales listed in table I. This rule is used only with the 762-mm rocket, M31 Series.

54. Nomenclature

The nomenclature of the low-level wind scale is identical with the nomenclature of the graphical firing site scale M67 (par. 32), with the following exceptions:

a. Gage Points. No gage points appear on the low-level wind scale.

b. Plot Point. Each wind elevation scale is grauated in intervals of 10 mils. These plot points enable the operator to determine quadrant elevation and deflection corrections with one operation of the slide. The plot point (PP) is mathematically defined as follows:

   (1) Under nighttime conditions: $PP = (0.2947)$ $(\emptyset^{0.2681})$ multiplied by the appropriate value listed in part 2, table E–3, of the firing table for the wind correction being considered (when $\emptyset$ is the quadrant elevation in mils).

   (2) Under all other than nighttime conditions: $PP = (0.5215)$ $(\emptyset^{0.1357})$ multiplied by the appropriate value listed in part 2, table E–3, of the firing table for the wind correction being considered (when $\emptyset$ is the quadrant elevation in mils).

55. Description

a. General. The Scale, Low-Level Wind, M73, based on FTR

Head Wind Elevation Scale

Tail Wind Elevation Scale

Base

Indicotes Doto For Nighttime Conditions

Cursor

Hairline

Window

HEAD +   LEFT +

TAIL −   RIGHT −

HEAD WIND ELEVATION

TAIL WIND ELEVATION

NIGHTTIME

LATERAL WIND

ELEVATION

LOW LEVEL WIND

M73

FTR 762-F-1

D Scale

C Scale

Left Indexes

Slide

Loteral Wind Elevation Scale

Right Indexes
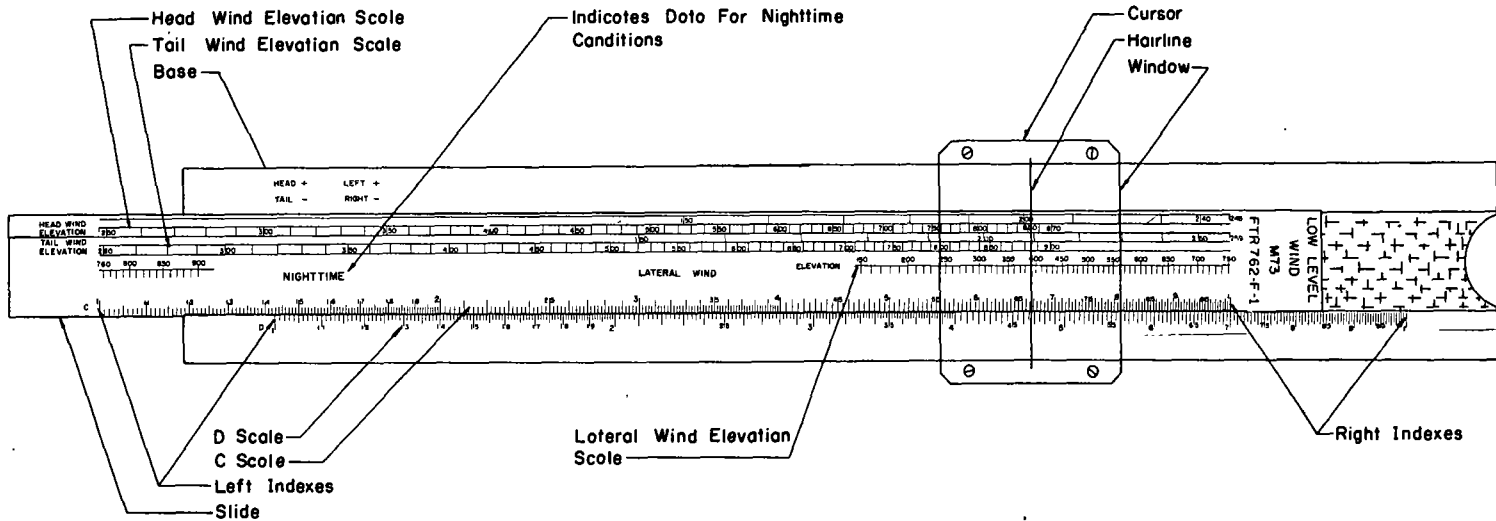
Figure 16. Scale, low-level wind, M73.

762–F–1, is graduated in 10-mil intervals to show corrections due to low-level head, tail, and lateral winds.

   b. *Composition of Scales and Data* (fig. 16).

   (1) *General.* Head, tail, and lateral wind elevation scales appear on both sides of the slide. Scales for NIGHT-TIME conditions appear on one side of the slide, and scales for ALL OTHER than nighttime conditions appear on the reverse side of the slide.

   (2) *C scale.* This logarithmic scale is located on both sides of the slide and is identical with the C scale on any slide rule.

   (3) *D scale.* This logarithmic scale is located on the bottom of the base and is used to determine corrections to quadrant elevation and deflection. The D scale is identical with the C scale.

   (4) *Lateral wind elevation scale.* The lateral wind elevation scale enables the operator to determine corrections to deflection due to lateral wind correction components.

   (5) *Head wind elevation scale.* The head wind elevation scale enables the operator to determine corrections to quadrant elevation due to head wind correction components. Numbers on this scale are printed in black.

   (6) *Tailwind elevation scale.* The tailwind elevation scale enables the operator to determine correction to quadrant elevation due to tailwind correction components. Numbers on this scale are printed in red.

   (7) *Left and right indexes.* The left indexes consist of the gage points (each marked by the numeral 1) on the left ends of the C and D scales. The right indexes consist of the gage points (also marked by the numeral 1) on the right ends of the C and D scales.

Section II. MAJOR USES OF THE LOW-LEVEL WIND SCALE

56. Definitions

   a. *NIGHTTIME Conditions.* Nighttime conditions prevail only when all of the conditions in (1) through (3) below exist simultaneously:

   (1) During the period from 1 hour before sunset to 1 hour after sunrise.

   (2) When there are clear skies or few clouds.

   (3) When winds are under 10 mph.

b. ALL OTHER than Nighttime Conditions. These conditions exist when one or more of the conditions listed under NIGHTTIME do not exist.

57. Operation

The operation of the low-level wind scale is best explained by a series of illustrative examples.

58. Determination of Deflection Correction

a. To determine the deflection correction, the wind set reading for lateral wind in miles per hour is multiplied by the met corrected quadrant elevation on the lateral wind elevation scale. The deflection correction in mils is then read on the D scale to the nearest mil.

b. Illustrative examples:
  (1) *Given data:*
    (*a*) Nighttime conditions exist.
    (*b*) Data from wind set: Right 7 mph.
    (*c*) Met corrected QE: 390 mils.
  (2) *Required:* Deflection correction.
  (3) *Solution* (fig. 16):
    (*a*) Use slide face marked NIGHTTIME.
    (*b*) Place the right C scale index over 7 on the D scale.
    (*c*) Place the hairline over 390 on the lateral wind elevation scale.
    (*d*) Read the deflection correction on the D scale under the hairline: —46.7 mils rounded off equals —47 mils. The sign is minus because the correction component from the wind set is right, giving a deflection correction of right (left, add; right, subtract (LARS)).

      Note. In order to determine the placement of the decimal point in the final answer, a general familiarity with the low-level wind correction tables for the particular firing table is needed. For instance the actual operation in this problem was simply the multiplication of R7 times 6.67 on the C scale to obtain —46.7. The factor 6.67 appears on the C scale directly below quadrant 390. This same factor (6.67) is found in table E–7, FTR 762–F–1, C1. A quick examination of this table will guide the operator in the placement of decimal points for all problems.

59. Determination of Quadrant Elevation Correction

a. To determine the quadrant elevation correction for a head or tailwind, the wind set reading for range wind in miles per hour

is multiplied by the met corrected quadrant elevation on the head-wind or tailwind elevation scale, whichever is appropriate. The quadrant elevation correction in mils is then read on the D scale to the nearest mil.

b. Illustrative example:

(1) *Given data:*

(a) All other than nighttime conditions exist.

(b) Data from wind set: Tail (depressed) 20 mph.

(c) Met corrected QE: 550 mils.

(2) *Required:* Quadrant elevation correction.

(3) *Solution* (fig. 17):

(a) Use slide face marked ALL OTHER.

(b) Place the left C scale index over 20 on the D scale.

(c) Move the hairline over 550 on the tailwind elevation scale.

(d) Read the quadrant elevation correction on the D scale under the hairline: —49.7 rounded off equals —50 mils. The sign is minus because the correction component from the wind set is tail (depressed), giving a quadrant elevation correction of minus.
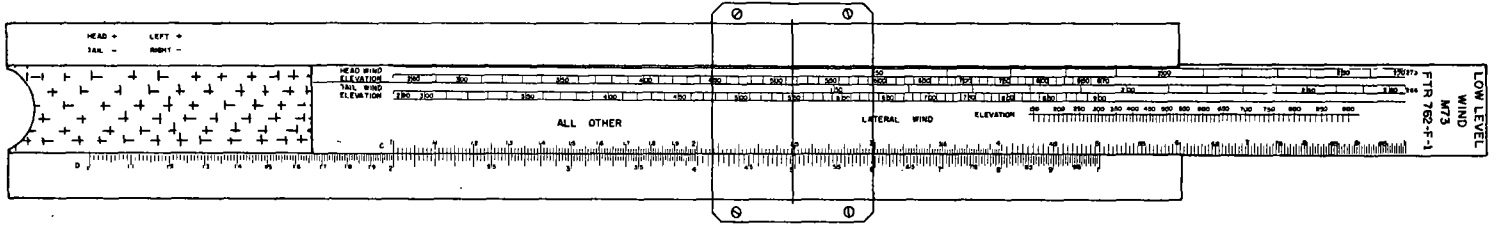
Figure 17. Determination of quadrant elevation correction.

CHAPTER 6

SCALE, GRAPHICAL FIRING, M85 FOR PROJECTILE, HES, M424 (8-INCH HOWITZER NUCLEAR DELIVERY)

Section I. NOMENCLATURE AND DESCRIPTION

60. General

The Scale, Graphical Firing, M85 (fig. 18), based on FT8–0–3, is a special ballistic scale designed for use with projectile, HES, M424 (formerly shell, T347).

61. Nomenclature

The nomenclature of the graphical firing scale M85 is identical with the nomenclature of the graphical firing scale M64 discussed in paragraph 8 (fig. 1).

62. Description

a. General. The Scale, Graphical Firing, M85, has only one rule. The scales for charges 1 and 2 are shown on one side of the rule; the scale for charge 3 and a minimum elevation scale are shown on the opposite side of the rule. Only low-angle firing data may be read from this graphical firing scale (fig. 18).

b. Composition of Scales and Data. The description of the graphical firing scale M85 is identical with the description of the low-angle scales discussed in paragraph 9*b* with the following exceptions:

    (1) *Fuze.* Data shown on the fuze setting (FS) scale applies to fuze M543.

    (2) *Minimum elevation scale.* The minimum elevation scale is graduated at 100-meter intervals (from 100 to 2,000 meters) to show range and elevation. The scale is also graduated to show complementary angle of site and fork at 500 meter intervals. This scale does not appear on other graphical firing scales. It is to be used only for the determination of minimum elevation. Procedures for the determination of minimum elevation are discussed in FM 6–40.

    (3) *Color.* Weapon and projectile nomenclature and charge

Figure 18. Scale, graphical firing, M85.

and firing table designations are printed in red. This information is printed in black on all other graphical firing scales.

Section II. MAJOR USES OF THE GRAPHICAL FIRING SCALE M85

63. Preferred Delivery Techniques

a. Preferred. techniques for the delivery of nuclear projectiles from an 8-inch howitzer are as follows:

    (1) Met plus (velocity error) VE (applied directly to target —no graphical solution exists).

    (2) K-transfer (optional graphical solution).

    (3) Met plus VE (applied to GFT setting from previous registration—optional graphical solution).

    (4) Adjustment and fire for effect (optional graphical solution).

b. The graphical techniques listed in *a*(2), (3), and (4) above parallel conventional graphical HE delivery techniques discussed in paragraphs 18 and 21, respectively, except for the determination of fuze setting. This procedure is discussed in paragraph 64 (see also FM 6–40). (See pars. 11, 12, 14, and 16 for a discussion of the basic uses of the graphical firing scale.)

64. K-Transfer (Graphical Solution)

a. This graphical solution is similar to that developed for the conventional HE delivery technique. The only difference between the two methods is the manner in which the fuze setting is determined. Due to the large vertical intervals normally encountered, complementary angle of site (CAS) should be considered before the fuze setting to fire is determined. This complementary angle of site is added to the adjusted elevation to the target (as determined under the elevation gageline), and the fuze setting corresponding to this sum plus the fuze correction (if any) is the fuze setting for the spotting projectile (projectile, HES, M424). The ballistic correction is then determined from the tabular firing table for projectile M422 (formerly shell T317E1) and applied to obtain the final FS for the nuclear projectile.

b. Illustrative example:

    (1) *Given data:*

        (*a*) High-burst registration:

            1. Btry A, 8-inch howitzer, charge 1, lot XY.

            2. Chart range: 3,510 meters.

3. Adjusted QE: 388 mils.

4. Adjusted time: 16.7 seconds.

5. Altitude of btry: 318 meters.

6. Altitude of high burst: 493 meters.

7. Deflection correction: Right 4 mils.

(*b*) Target:

1. Chart range: 3,720 meters.

2. Chart deflection: 2,785 mils.

3. Altitude of target: 333 meters.

4. HOB above target: +150 meters.

5. Rg corr for proj and prop (from firing table): +16 meters.

6. Bal corr for QE for Proj M422 (from firing table): +16 mils.

7. Bal corr for FS for Proj M422 (from firing table): +0.5 second.

(2) *Required:*

(*a*) DF to fire.

(*b*) FS for Proj M422.

(*c*) QE for Proj M422.

(3) *Solution* (fig. 19):

(*a*) Determine and construct GFT setting (from HB Reg):

1. Adjusted QE: 388 mils.

2. Vertical interval to HB (493—318): +175 meters.

3. Site to HB using scale, graphical firing site, M86 (+175/chg 1, TAG: Rg 3,510): +57 mils.

4. Adjusted elevation (388 — (+57)): 331 mils.

5. GFT A: Chg 1, lot XY, Rg 3,510, E1 331.

(*b*) Construct deflection correction scale (par. 16) (df corr of R4 is written in drift block which brackets the adjusted elevation).

(*c*) Determine fuze correction (from HB Reg):

1. Adjusted elevation: 331 mils.

2. Site to HB (3)(*a*)*3* above: +57 mils.

3. Angle of site to HB (GFSS, C and D scales, +175/3,510): +51 mils.

4. CAS (+57 — (+51)): +6 mils.

5. Elevation plus CAS (331 + (+6)): 337 mils.

6. Fuze setting corresponding to E1 plus CAS: 16.7 seconds.

7. Adjusted time from HB Reg: 16.7 seconds.

8. Fuze correction (16.5 to 16.7): +0.2 seconds.

(d) Deflection to fire:

1. Chart deflection to target: 2,785 mils.

2. Deflection correction from GFT: Right 3 mils.

3. Deflection to fire (2,785 + R3): 2,782 mils.

(e) FS for projectile M422:

1. Vertical interval to target HOB (483—318): +165 meters.

2. Angle of site to target HOB (GFSS, C and D scales, +165/3,720): +45 mils.

3. Site to target using Scale, Graphical Firing, Site, M86 (+165/Chg 1, TAG; Rg 3,720): +52 mils.

4. CAS (+52 — (+43)): +7 mils.

5. Chart range to target: 3,720 meters.

6. Rg corr for proj and prop: +16 meters.

7. Corrected range (3,720 + (+16)): 3,736 (3,740) meters.

8. Elevation for range 3,736 (3,740) (use GFT setting from HB Reg): 359 mils.

9. CAS plus elevation ((+7) + 359): 366 mils.

10. Fuze setting corresponding to elevation 366: 17.8 seconds.

11. Fuze correction: +0.2 seconds.

12. FS for Proj M424 (17.8 + 0.2)): 18.0 seconds.

13. Bal corr for FS for Proj M422: +05 seconds.

14. FS for Proj M422 (18.0 + (+0.5)): 18.5 seconds.

(f) QE for Projectile M422:

1. Corrected range ((e)7) above: 3,736 (3,740) meters.

2. Elevation for range 3,736 (3,740) meters ((e)8) above: 359 mils.

3. Site to target ((e)3) above: +52 mils.

4. QE for Proj M424 (+359 + (+52)): 411 mils.

5. Bal corr for QE for Proj M422: +16 mils.

6. QE for Proj M22 (411 + (+16)): 427 mils.
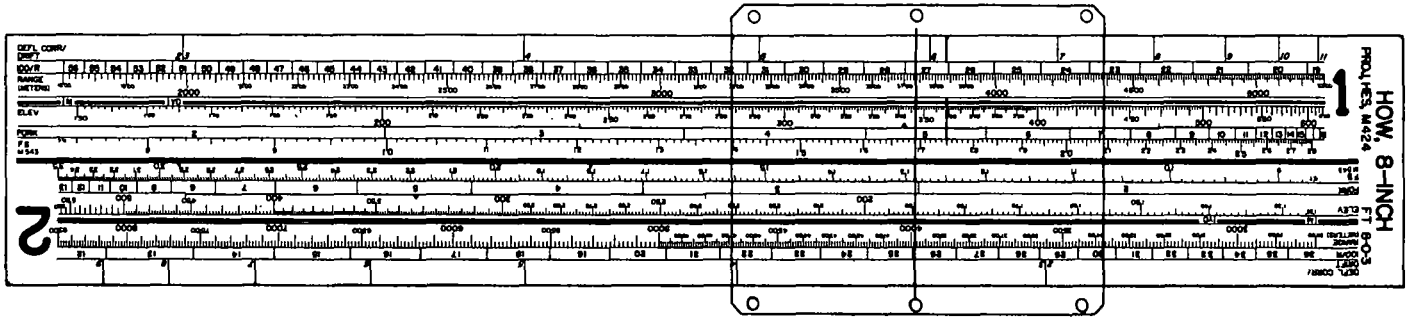
Figure 19. K-transfer, graphical solution.

APPENDIX

REFERENCES

1. Publication Indexes

Department of the Army Pamphlets of the 310-series should be consulted frequently for latest changes or revisions of references given in this appendix and for new publications relating to material covered in this manual.

2. Department of the Army Pamphlets

DA Pam 108–1	Index of Army Motion Pictures, Film Strips, Slides, and Phono-Recordings.
DA Pam 310-series	Index of Military Publications.

3. Field Manuals

FM 6–40	Field Artillery Cannon Gunnery.
FM 6–61	Field Artillery Missile Battalion, HONEST JOHN Rocket, Self-Propelled.

4. Technical Manuals

TM 9–524	12-inch Graphical Firing Tables.
TM 9–525	Graphical Firing Tables M39, M40, M41, M42, M43, M44, M45, M46, M47, M48, M49, M50, and M51.

5. Firing Tables

FT 8–J–3	Firing Tables; Howitzer, 8-Inch, M1.
FT 8–O–3	Firing Tables; Howitzer, 8-Inch, M1.
FT 105–H–6	Firing Tables; Howitzer, 105-mm, M2A1 and M4.
FT 155–Q–3	Firing Tables; Howitzer, 155-mm, M1.
FTR 762–A–2	Firing Tables; Rocket, 762-mm, M21A1 and M31A1C.
FTR 762–B–2	Firing Tables; Rocket, 762-mm, M31A1 and M31A1C.
FTR 762–C–1	Firing Tables; Rocket, 762-mm, M31 Mods.

FTR 762–D–1	Firing Tables; Rocket, 762-mm, M31 Mods.
FTR 762–E–1	Firing Tables; Rocket, 762-mm, M31 Mods.
FTR 762–F–1	Firing Tables; Rocket, 762-mm, M31 Mods.

6. DA Forms

DA Form 6–12	Record of Precision Fire.
DA Form 6–16	FDC Computer's Record.
DA Form 6–55	High-Burst (Center-of-Impact) Registration. Computation of HB (CI) Location.

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Distribution:

Active Army:

DCSLOG (2)	FA Gp (3)
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USAR: Units—Same as Active Army except allowance is one copy for each unit.

For explanation of abbreviations used, see AR 320–50.

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