

BACK OF SCALE.

The scales have been made up for use with 13-pr. and 18-pr. Q.F. guns and 4.5" Q.F. Howitzer. The back of an 18-pr. and a 4.5" Q.F. Howitzer scale are shown in the Diagrams.

On the back of the slide rule for the 18-pr. Q.F. is a fuze scale for ranges under 2000 yards. Below the fuze scale is a short table giving the Times of Flight (T of F) in seconds for every thousand yards of range from 2000 to 6000 yards, also the necessary alterations to be made in the corrector setting at those ranges to lower the mean point of burst of the shell by 10 minutes.

Below the table is a short synopsis of "Orders."

On the left hand side of the rule is an arm's length (26") degree scale. The intervals between each of these degrees is equivalent to 800 yards on a 1" map.

For the 4.5" Q.F. Howitzer, the correct average height of burst for each charge is given.

With the 4th charge, the correct average height is 20', (shown on back of scale in red as + 20').

The actual correct heights to burst shell 60 yards short at the various ranges are as under :—

1000 yards	17 minutes up.
2000 "	18 " "
3000 "	20 " "
4000 "	24 " "
5000 "	32 " "

(1). ANGLE OF SIGHT PROBLEMS.

The angle of sight for the battery is given by the formula :—

$$\text{A. of S.} = \frac{OTa + BO\beta}{BT} = \frac{OT}{BT}a + \frac{BO}{BT}\beta.$$

Now if OT and BT do not differ by more than 100 or 200 yards, the formula becomes :—

$$\text{A. of S.} = a + \frac{BO}{BT}\beta.$$

The angle "a" might be called the main angle of sight, as the factor $\frac{OT}{BT}$ seldom causes much change; the angle "β," on the other hand is changed very greatly by the factor $\frac{BO}{BT}$.

Example I :—

$$\begin{aligned} OT &= 4000 \text{ Yards, } a = + 2^\circ 10' \\ BO &= 450 \text{ " } \beta = + 3^\circ 0' \\ BT &= 4100 \text{ " } \end{aligned}$$

As OT is nearly equal to BT, the angle of sight for the battery is $a + \frac{BO}{BT}\beta = 2^\circ 10' + \frac{450}{4100}3^\circ$.

A SLIDE RULE FOR INDIRECT FIRE.

By MAJOR H. W. HILL, R.F.A.

This scale has been designed to solve the following problems which constantly occur in Field Artillery work.

- (1). Angle of Sight problems.
- (2). Finding of the Battery Angle, or
- (3). Displacement due to flank Observing Station.
- (4). Distribution or Concentration when using an Aiming Point.
- (5). Distribution or Concentration for targets of widths other than 100 yards.
- (6). Finding the range OB when using a sub-base.

Example II :—

It is required to find the range to a four gun battery which subtends an angle of 50 minutes.

If the guns are at 20 yards interval, the battery will occupy 60 yards of frontage.

Set the arrow over 60 yards, then above 50' the range to the battery is shown as 4100 yards; this may serve as a useful guide in deciding on the initial ranging bracket.

MILITARY SKETCHING.

The scale is useful in military sketching, since the heights of all points above or below the observer's position can be ascertained, if the ranges and angles of sight to those points are known. In this work, the angle of sight is set below the range, the arrow then shows the difference in altitude in yards between the observer and the point selected.

Example :—

Clump of trees, range 4000 yards.
Angle of Sight, + 1° 50'.

Set 1° 50' below 4000 yards, the arrow now points to 129 yards. Hence the difference in altitude is + 129 yards or 387 feet.

2800 yards the guns require a distribution of 25 minutes. ($D_1 = 25'$).

Set arrow over 100 yards (the extent of battery). It will be seen that at 4500 yards the battery covers $1^\circ 15'$ of the target. As the extent of the target is 2 degrees, there is a further 45 minutes to be accounted for. One fifth of 45 minutes is 9 minutes, call it 10 minutes. ($D_2 = 10'$).

The total distribution required is therefore, $= D_1 + D_2 = 25' + 10' = 35'$.

(6.) FINDING THE RANGE OF "OB" USING A SUB-BASE.

Set arrow over the sub-base in yards, then above the angle subtended by the sub-base (measured by the director) the range of OB is read off.

Example I :—

Length of Sub-base, 50 yards.
Angle subtended, $4^\circ 20'$.

Set arrow over 50 yards, then above $4^\circ 20'$ the range of OB is shown to be about 650 yards.

The method can occasionally be used to find the range to a hostile battery provided that their gun intervals are known.

Example III :—

Difference in height, 90 feet = 30 yards.
Range = 5000 "

Set arrow over 30 yards, then below 5000 yards the angle of sight is seen to be $20'$.

NOTE I.—The usual care about the signs plus and minus must be observed in working out the formula.

NOTE II.—It will usually be found that the angle of sight for the battery varies only slightly from the main angle of sight; this variation seldom exceeds 30 minutes.

It frequently happens that the angle of sight can be found without any calculation by laying the director or angle of sight instrument as much above the target as the observing station is estimated to be above the battery.

(2). TO FIND THE BATTERY ANGLE.

The scales to be used are the top yards scale and the red central degree scale.

With the director measure the angle TOB' (i.e. $180^\circ - \text{TOB}$).

Set TOB' — 5° under OT on yards scale, below OB, of same scale, the apex angle in degrees is read off the red central scale.

Then TOB' — apex angle is the battery angle.

To solve the latter part, the two top scales of the slide rule are used. The 3° is set mid-way between 400 and 500 yards and the angle below 4100 yards is read off; in this case it is just about $20'$.

So Angle of Sight for battery is $2^\circ 10' + 20' = 2^\circ 30'$.

Example II :—

OT = 3400 yards, $\alpha = + 2^\circ 40'$
BO = 700 " $\beta = + 1^\circ 25'$
BT = 3900 "

As in this case OT and BT differ considerably, two settings of the scale are necessary.

1st Setting. Set $2^\circ 40'$ below 3400 yards, then under (BT) 3900 yards, the angle $2^\circ 20'$ is read off.

2nd Setting. Set $1^\circ 25'$ below 700 yards, then under (BT) 3900 yards, the angle $15'$ is read off.

Hence, the angle of sight for the battery is $2^\circ 20' + 15' = 2^\circ 35'$.

If using a contoured map, determine the difference in altitude in feet between the battery and the target. Reduce this difference to yards. Set "Arrow" over this height in yards on the bottom scale, then below the range BT (on top scale) read off the angle of sight for the battery.

cover $3^\circ 15'$ (195') more frontage. One fifth of 195' is 39, call it 35 minutes.

Hence the orders will be :—

"Distribute 35 minutes from named gun."
"Sweep $\frac{1}{4}$ degree."

NOTE I.—Orders for sweeping are given in quarter degrees. Generally speaking, the amount of sweep should be half the ordered distribution.

NOTE II.—35 minutes is given in preference to 40 minutes in the above example as it is better to leave the guns slightly concentrated on the target than to have the flank guns on the extreme edges of the target, subsequent sweeping will cause the whole target to be engaged.

There are many intricate problems connected with concentration and distribution; for instance, if guns are concentrated at one range and it is required to distribute the fire over a target at a different range. In these cases it is advisable to work out the correction for parallelism for the range at which you are firing, and then work out the new distribution for the second range; the sum or difference of these results being given as the necessary total correction for the guns.

Example III :—

The guns are concentrated at a range of 2800 yards. It is required to cover a target subtending 2 degrees at 4500 yards.

Set arrow over 20 yards, hence for parallelism at

(3). DISPLACEMENT.

When the Observing Station is within 300 yards of the battery, the displacement angle due to the flank position of the Observing Station, can be found by the scale without working out TOB.

In this case the arrow, bottom scale and the two top scales are made use of.

Example. The Observing Station is 250 yards to the flank of the battery; the range to the target is 3600 yards.

To find the displacement angle:—

Set arrow over 250 yards of bottom scale.

Below 3600 yards of top scale is seen 4° .

Hence a correction of 4° is required to the angle read off by the Battery Commander's director. If the B.C. is on the left flank of the battery, the correction will be 4° Left.

NOTE.—The 250 yards referred to above is the perpendicular distance from O to the line BT.

(4). DISTRIBUTION OR CONCENTRATION USING AN AIMING POINT.

The scales used are the bottom black degree scale of slider, the bottom yards scale, and the two upper black scales.

Example I:—

Angle to Aiming Point 65° .*

Range to Aiming Point ... 1500 yards.

It is required to find the distribution for parallelism.

Set 65° of the black degree scale over 20 yards (the gun interval) of bottom scale; below 1500 yards of top scale the necessary distribution is read off, in this case $20'$.

Hence orders to be given are:—

"All Guns, 65° Right (or Left) of Aiming Point."

"Distribute $20'$ from No. 1 (or named) Gun."

Example II:—

Angle to Aiming Point 130° .*

Range to Aiming Point ... 2900 yards.

As 130 is not marked on black degree scale, use $180^\circ - 130^\circ = 50^\circ$.

Set black 50° over 20 yards (the gun interval).

Below 2900 yards is found $15'$.

Hence orders to be given are:—

"All Guns, 130° Right (or Left) of A.P."

"Concentrate $15'$ on No. 1 (or named) Gun."

NOTE.—If the Aiming Point is behind the battery concentration is required.

*This is the angle from the Aiming Point to the Target, not the angle from the Aiming Point to the line of guns.

No distribution or concentration is necessary if the angle is between 85° and 95° ; for angles between 80° and 85° , it is quite accurate enough to use the 80° mark.

(5). CONCENTRATION OR DISTRIBUTION FOR TARGETS OF WIDTHS OTHER THAN 100 YARDS.

To concentrate the guns of a battery to a point at any given range.

Set the arrow over 20 yards (the gun interval), then the necessary concentration will be found below the given range.

Example I:—

It is required to concentrate the fire of a battery on to a single hostile gun at a range of 4200 yards.

Set arrow over 20 yards, then below 4200 yards the necessary concentration is shown to be 17 minutes. This would be taken as $15'$. If the range had been 2700 yards, $25'$ would have been required.

Example II:—

A target at 4500 yards subtends $4\frac{1}{2}^\circ$. It is required to distribute and sweep the frontage.

Set arrow over 100 yards (the extent of battery), below 4500 yards it will be seen that the battery at present covers $1^\circ 15'$. It is therefore necessary to

Example I:—

OT = 3100 yards

OB = 550 yards

TOB' = 68° , (TOB = 112°).

Set $68^\circ - 5^\circ = 63^\circ$ of red scale below 3100 yards, below 550 yards, the angle 9° is seen.

Hence the battery angle is $68^\circ - 9^\circ = 59^\circ$.

Example II:—

OT = 4100 yards

OB = 550 yards

TOB' = 122° , (TOB = 58°).

Set $122^\circ - 5^\circ = 117^\circ$ below 4100 yards; the apex angle below 550 yards is 7° .

Hence the battery angle is $122^\circ - 7^\circ = 115^\circ$.

NOTE.—In calculating the apex angle, an approximation is taken to the battery angle by using TOB' - 5° . The scale is truly set when the sum of the angles below OT and OB are equal to TOB'; but as the battery angle is only required to the nearest whole degree, the above approximation is good enough for all requirements in the field. It must be remembered that the ranges OB and OT are not really accurately known.

It will, therefore, be seen that at all likely ranges the height of 20 minutes up is fairly correct for the 4th Charge. At short ranges the height is slightly less than 20 minutes whilst at long ranges it is rather over 20 minutes.

The corrector alterations given at each range are the actual amounts required to raise the mean point of burst from graze to the effective height of burst.

It will be noticed that with all charges at elevations of over 2000 yards (on the range drum), the initial corrections to the corrector should be made as a general rule in intervals of 6.

The use of the scale can be readily taught to the Battery Commander's trained staff and it can then be used to the best advantage as the B.C. is relieved of the necessity of remembering and employing a variety of different methods of calculation. When once grasped, the scale can be used with very great rapidity and accuracy.

PRECAUTIONS..

Note that the black degree scale on sliding portion reads from right to left. Care must be taken that when setting an angle such as $2^{\circ} 10'$ that the true angle is

employed, not $1^{\circ} 50'$. The red degree scale for angles of from 90 to 160 degrees also reads from right to left.

In the event of difficulty being experienced in working the scale owing to the stiffness of the slider, the scale should be placed in hot water for a few minutes. This will cause the xylonite to become slightly plastic; if the scale is now bent backwards, it will be found that the slider will again run freely.

NOTE.

The slide rule should occasionally be cleaned by rubbing it with a soapy flannel in cold water.

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