CONFIDENTIAL

Notes on Fire Control Instruments for use with Heavy Railway Artillery in Land Service

Coast Artillery Board
Fort Monroe, Va.
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The T-O-B Clock

The T-O-B Clock is designed to give a graphic solution of the TOB problem.

The principles involved are as follows:

In figure 1, T is the target, O the observer, and B the battery. It is the duty of the observer to place himself so he can observe the target T on which fire is

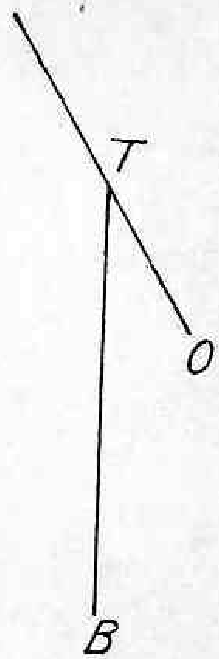


Fig. 1.

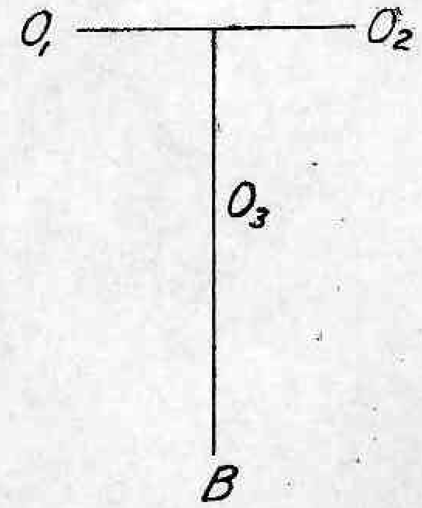


Fig. 2.

to be adjusted, and send to the battery commander the information required for adjusting his fire on the target. Experience has shown that the observer can bracket T only along the OT line, so that in adjusting on T, two problems occur.

Problem 1: To bring the shots on to the OT line.
Problem 2: To bracket the target on the OT line.

Problem 1

The deviation of the shot from the line OT is measured by the observer, employing a suitable field glass or telescope with an internal mil scale. From an inspection of Fig. 1 it is evident that this can be accomplished in the case there illustrated either by changing the battery deflection or the battery elevation.

If the observer were at O, or O_2 as shown in Fig. 2, the failure of the burst to fall on the OT line would be due to range errors only, while if he were at O_1 the failure would be due to deflection error only, hence the rule: that if the angle made by the line OT with the line BT is greater than 45°, the shots are brought to the OT line by changing the battery elevation, and if this angle is less than 45° the shots are brought to the OT line by changing the battery deflection.

In Fig. 3 suppose a burst at S. An observer at O_1 would apply the correction ....yds. left, corresponding to sd, to bring the shots to his O_1T line, while if he were at O_2 he would apply the correction ....yds. down, corresponding to se, to bring the shots to his O_2T line.

Problem 2

Having brought the shots to the OT line, it is necessary to establish a bracket on the OT line by placing a shot on the OT line on the opposite side of the target.

To accomplish this result, it is necessary to change both the battery elevation and deflection except where the OT line coincides with the line of fire, or is normal to it.

In Fig. 4 suppose a shot struck at C. To bracket, the next shot should be placed at D, and to accomplish this, it is necessary to apply the corrections; ....yds. right, corresponding to ED, and ....yds. down, corresponding to CE.

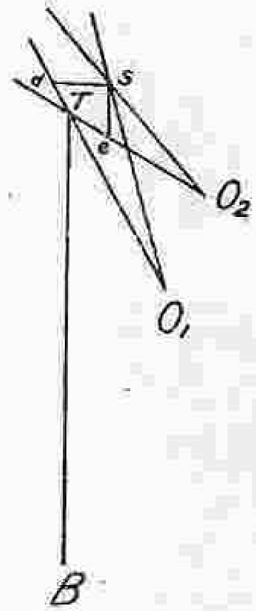


Fig. 3.

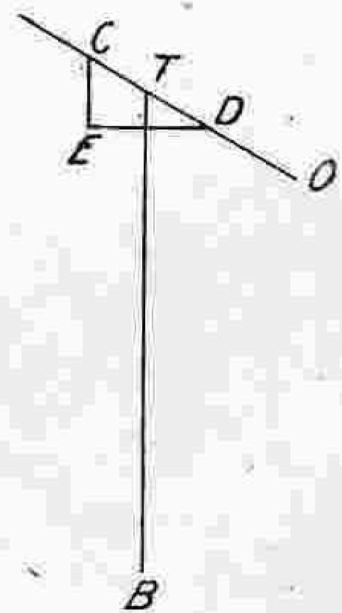


Fig. 4

The T-O-B clock is designed to solve these two problems graphically. It is shown on page 5. It consists of a deviation chart (L), a target pivot (T), an OT arm (K) and a mil scale platen (H).

The following definitions are established:

Range is the distance in yards from the battery to the target.

OT Distance is the distance in yards from the observation point to the target.

T Angle is the angle OTB measured from the line BT in the shortest direction.

Over and *Short* are the range deviations from T measured along the BT line.

Right and *Left* are the lateral deviations from T measured along a line normal to BT. They are also used to denote the deflection corrections for the battery.

Down and *Up* denote the range corrections for the battery.

Beyond and *Under* are the deviations from T along the OT line.

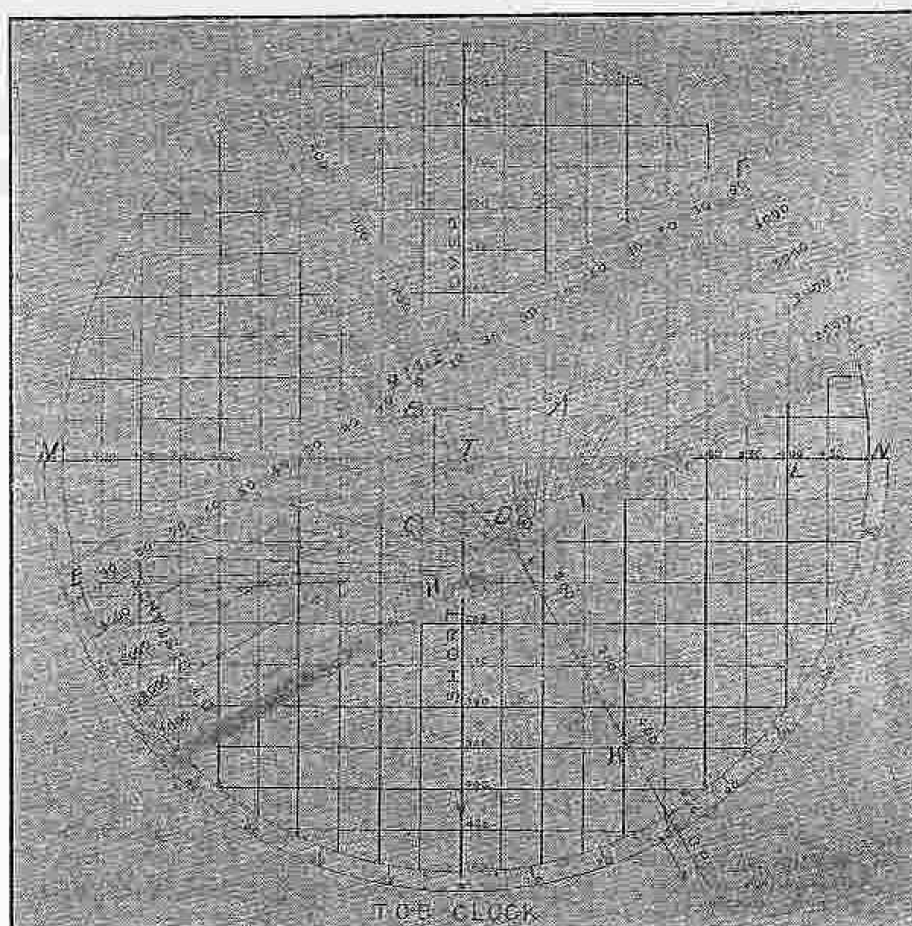
The deviation chart consists of a circle of 5 inches radius with coördinate axes intersecting at the center. The surface of the chart is divided into 50 yard squares, by lines parallel to the coördinate axes, the scale being 100 yards to an inch. The intersection of the coördinate axes locates the target, the vertical axis representing the BT line.

Range deviations, Over and Short, are indicated along the vertical axis, and deflection deviations, Right and Left, are indicated on the horizontal axis. The arc MN is used to lay off the T angle.

The target pivot is a brass bolt and extends through the OT arm and the chart. It is fitted with a milled nut and washer, so that the OT arm may be clamped for any definite setting.

The OT arm is made of amberoid. The OT line is engraved on it, and an arrow at one end indicates the direction of OP (observation point). A deviation scale, 100 yards to an inch, is graduated along the OT line.

The mil scale platen is made of amberoid, and is constructed so as to slide along the OT arm. The upper line is graduated so that the distance EF is that sub-



The T-O-B Clock

tended by 200 mils (100 mils each side of the OT line) normal to the OT line, at a scale of 100 yards to an inch for an OT distance of 5,000 yds. The lower line is graduated so that the distance HI is that subtended by 200 mils in a similar manner, for an OT distance of 1,000 yds. The graduations on the 1,000 yd. OT distance line and the graduations on the 5,000 yd. OT distance line are joined by straight, diagonal lines. Lines parallel to the 1,000 yd. OT distance line are engraved for OT distances of 2,000, 3,000, and 4,000 yds. The intersection of the diagonal lines with the OT distance lines therefore give mil scales for the corresponding OT distance. OT distance may, therefore, be set off to the nearest 100 yds., interpolating between the 1,000 yd. lines by eye.

The instrument is used by the observer at the observation point as follows:

The T angle is measured on the map or by a compass, and the OT distance is taken from the map or estimated.

Assume: T = 31° Right of the BT line.
OT Distance = 3,100 yards.

Set the OT arm, using the OP end of the OT line as an index, 31° right on the T arc.

Place the mil scale platen on the OT arm so that an OT distance of 3,100 yards is over the center of the target pivot. The instrument is now ready for use.

Problem 1

Deviation of burst, as observed at O, is 35 mils right. As T is less than 45°, bring the shots on the OT line by changing the battery deflection. The correction required in this case is 135 yards left (AB distance).

Problem 2

The shots having been brought to the OT line, remove the mil scale platen from the OT arm. A burst having been observed at B 70 yards beyond, the bracket is established by putting a shot at D, 70 yds. under.

The corrections required to lay the battery on D are:

120 yds. Down (BC Distance)
70 yds. Right (CD Distance)

THE ELEVATION SLIDE RULE

The Elevation Slide Rule is a device for obtaining the quadrant elevation at which to set the gun, employing the horizontal range, difference of level between target and gun and the data relating to the muzzle velocity, atmospheric density and wind which are established for the locality and time of firing.

Where the horizontal range is employed as a basis, it is therefore necessary to apply corrections for variations from ballistic conditions.

Placing:
δX_v = the range correction for velocity.
δX_a = the range correction for atmosphere.
δX_w = the range correction for wind.
δX_h = the range correction for difference in height of gun and target.
X = the actual range.
X_c = the corrected range.

We have:—

$$X_c = X + \delta X_v + \delta X_a + \delta X_w + \delta X_h \qquad (1)$$

From (1) the total correction ΔX to be applied to the actual range is:

$$\Delta X = \delta X_v + \delta X_a + \delta X_w + \delta X_h \qquad (2)$$

Hence,

$$X_c = X + \Delta X \qquad (3)$$

Placing

$$X_c = FX \qquad (4)$$

Where F is a factor to be determined, we have:

$$X + \Delta X = FX$$

Whence,

$$F = 1 + \frac{\Delta X}{X} \qquad (5)$$

and $\Delta X = FX - X$

Applying this principle to each of the separate variables, there results::

$$\left.\begin{aligned} \delta X_v &= F_v X - X \\ \delta X_a &= F_a X - X \\ \delta X_w &= F_w X - X \\ \delta X_h &= F_h X - X \end{aligned}\right\} \qquad (6)$$

Where

F_v = The correction factor for difference in velocity.

F_a = The correction factor for difference in atmospheric density.

F_h = The correction factor for difference in level.

F_w = The correction factor for difference in wind.

Substituting from (6) in (1).

$$X_c = X + F_v X - X + F_a X - X + F_w X - X + F_h X - X$$

Hence

$$X_c = X (F_v + F_a + F_w + F_h - 3) \qquad (7)$$

And substituting from (7) in (4) there is finally obtained:

$$F = F_v + F_a + F_w + F_h - 3 \qquad (8)$$

The Elevation Slide Rule consists of an adding device to solve equation (8), a multiplying device to solve equation (4) and an elevation scale to obtain

the tabular quadrant elevation, corresponding to the corrected range.

The adding device consists of four sliding scales, five pointers and one fixed scale.

The scales are of uniform graduation, extending from 0.900 to 1.100, the sliding scales increasing from right to left, and the fixed scale increasing from left to right. A pointer is attached to each sliding scale and one pointer is attached to the base in which the slides operate. The central value of each scale (1.000) is at the center of the slide and all pointers are attached there.

The device is assembled in the following order, commencing from the bottom:

Fixed pointer, which is the index of the F_h scale.

F_h slide, which carries the F_h scale and the pointer, which is the index for the F_a scale.

F_a slide, which carries the F_a scale and the pointer, which is the index for the F_w scale.

F_w slide, which carries the F_w scale and the pointer, which is the index for the F_v scale.

F_v slide, which carries the F_v scale and the pointer, which is the index for the F scale.

F scale, which is stationary and indicates the solution of equation (8)

The multiplying device consists of a movable, logarithmic scale of ranges, a fixed logarithmic scale of F, a fixed index and a movable index.

The normal of the Log F scale (1.000) is opposite the fixed index.

The device is assembled so that when the actual range is set opposite the fixed index, and the movable index is set opposite the proper reading on the Log F scale, the movable index will indicate the corrected range on the range scale.

The elevation scale is graduated on the Logarithimic range scale so that the movable index indicates the quadrant elevation at the same time that it does the corrected range.

To Operate

(1) Set the actual range on the range scale of the multiplying device, opposite the fixed range index. (Marked Set on the Rule).

(2) Set the scales of the adding device in succession, commencing at the bottom, observing the following order:

Height	(Marked H)
Atmosphere	(Marked A)
Wind	(Marked W)
Velocity	(Marked V)

(The data for setting these scales is obtained from the Correction Book.)

(3) Read off the value of F as obtained on the fixed scale of the adding device (Marked F).

(4) Set the movable index of the multiplying device to read the value of F obtained above on the Log Factor scale of the multiplying device (Marked Log Factor Scale) and the movable index will then indicate the quadrant elevations on the elevation scale.

Inverse Problem

(1) Set the actual range to the center of impact of the trial shots opposite the fixed index on the multiplying device.

(2) Set the movable index of the multiplying device opposite the quadrant elevation used in firing.

(3) Set the scales H, A and W on the adding device in accordance with conditions that obtained at time of firing the trial shots.

(4) Set the V scale on the adding device until the index on the F scale reads the same as the index on the Log Factor scale.

(5) Read the index on the V scale and with this value of F_v and the actual range to the center of impact of the trial shots as arguments, obtain the velocity from the correction book.

The T-A-B Clock

The T–A–B Clock is an instrument designed to reduce the deviations signalled by an aerial observer to range and lateral deviations for the battery firing. The azimuth circle employed by the artillery is graduated to degrees, with its zero north. The observation clock circle employed by the aerial observer is graduated to even hours from 1 to 12, with the 12 north. Radial lines are drawn from the center of the clock through each hour, and distances from the target, which is assumed to be at the center of the clock, are measured along these radial lines and indicated by means of letters.

Z for shots within 25 yds. of the target.
A for shots 50 yds. from the target.
B for shots 100 yds. from the target.
C for shots 200 yds. from the target.
D for shots 300 yds. from the target
E for shots 400 yds. from the target.
F for shots 500 yds. from the target.

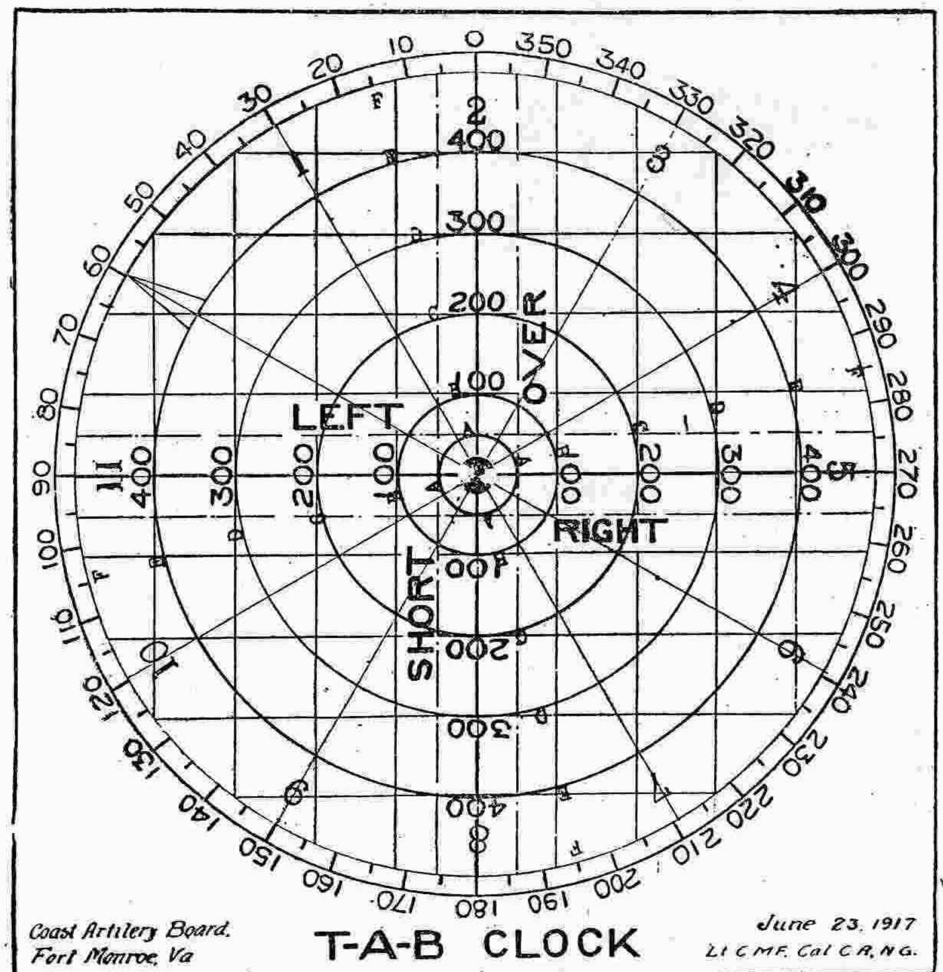


Figure 5 represents the lay out of the clock. If a shot strikes 500 yds. east of the target, the aerial observer signals 3F. For a shot within 25 yds. and north of the target, 12Z.

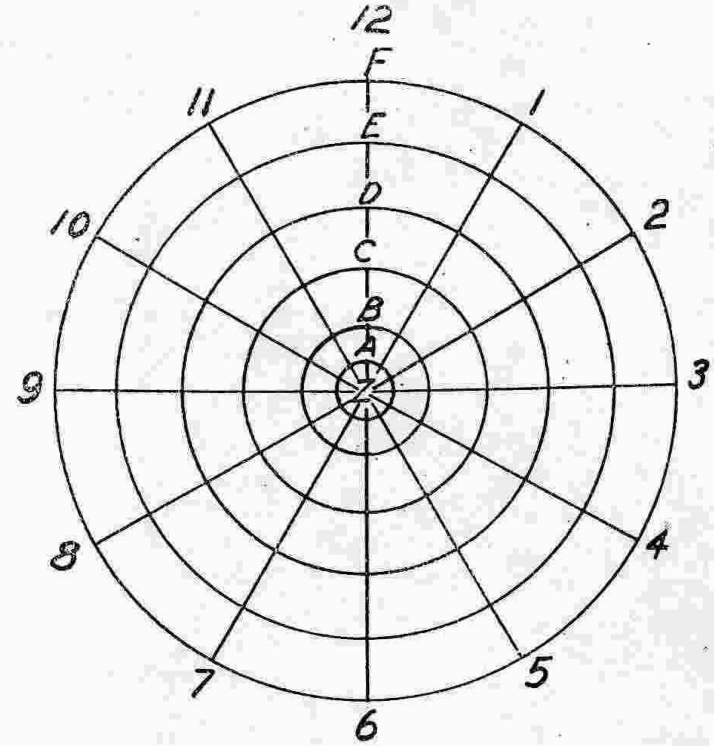


Fig. 5.

To transform these clock deviations into range and lateral deviation, the following principles are employed.