**Referred Deflection**

12-5. The aiming circle operator gives the referred deflection to the FDC after the section is laid. The referred deflection can be any 100-mil deflection from 0 to 6300, as long as all of the mortars can place out their aiming posts on the same deflection. Normally, the referred deflection used is 2800 to the front or 0700 to the rear. If one or more mortars has a sight block at the given deflection, the gunner may slip the scale to a point where his poles can be set out at the proper interval. For more information about slipping the scales, see FM 3-22.90.

**NOTE:** Use 2800 and 0700 to avoid any sight blocks caused by the cannon.



**Figure 12-1. Preparation of the plotting board.**

**Superimposition of Referred Deflection**
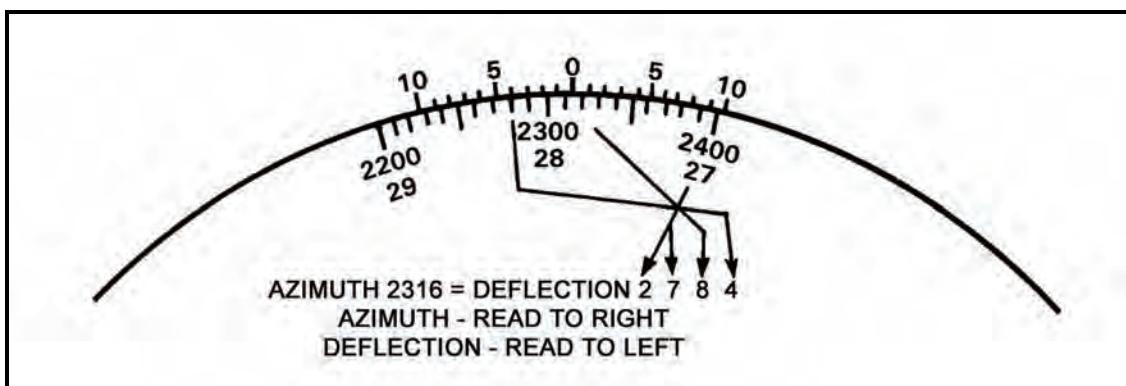
12-6. The referred deflection is superimposed (written) on the azimuth disk under the mounting azimuth using the LARS rule. The disk is normally numbered 400 mils left and right of the referred deflection, which is usually enough to cover the area of operation (Figure 12-2). However, if needed, the deflection scale can be superimposed all the way around the azimuth disk.



**Figure 12-2. Superimposition of referred deflection scale under the mounting azimuth.**

**Determination of Firing Data**

12-7. After plotting the first round on the DOF at the determined range and superimposing the deflection scale, the computer rotates the azimuth disk until the first round is over the vertical centerline. He determines the deflection to fire the first round by using the deflection scale and the left portion of the vernier scale (Figure 12-3).



**Figure 12-3. Determination of the deflection.**

12-8. Read the first two digits from the deflection scale. Since deflections increase to the left, read the first number (100-mil indicator) to the right of the index mark. In this example, it is 27.

12-9. Read the third digit from the 10-mil graduations between deflection scale numbers 27 and 28 (100-mil indicators). Count the 10-mil graduations on the azimuth disk (from 27 to the index mark) to find that the index mark is between the eighth and ninth 10-mil graduations, making the third digit 8.

12-10. Read the fourth digit at the vernier scale. For deflections, use the left half of the vernier scale. Count the 1-mil graduations, starting at the 0, to the left until one of the 1-mil graduations of the vernier scale and one of the 10-mil graduations on the azimuth disk are aligned. In this example, the fourth 1-mil graduation is aligned, making the fourth digit 4.

12-11.   Determine the range by rotating the plot over the vertical centerline and reading the range to the nearest 25 meters. Enter the firing table (such as FT 81-AI-3) and determine the charge as follows: Locate the Charge vs. Range table (Figure 12-4) in the appropriate firing table (normally the last page of the introduction or the last page preceding Part I). This page is the charge vs. range chart. It can be used to determine the lowest charge to engage the target. To use the chart, find the range to the target using the range bar at the bottom of the chart. The range bar is numbered every 500 meters from 0 to 5,000 meters. Since the range to the target was determined to be 2,600 meters, estimate the 2,600 meters on the range bar. After determining the 2,600-meter point on the range bar, place a straightedge at the point so that it crosses the charge lines (Figure 12-5). The first charge line the straightedge crosses is the lowest charge possible to engage the target.
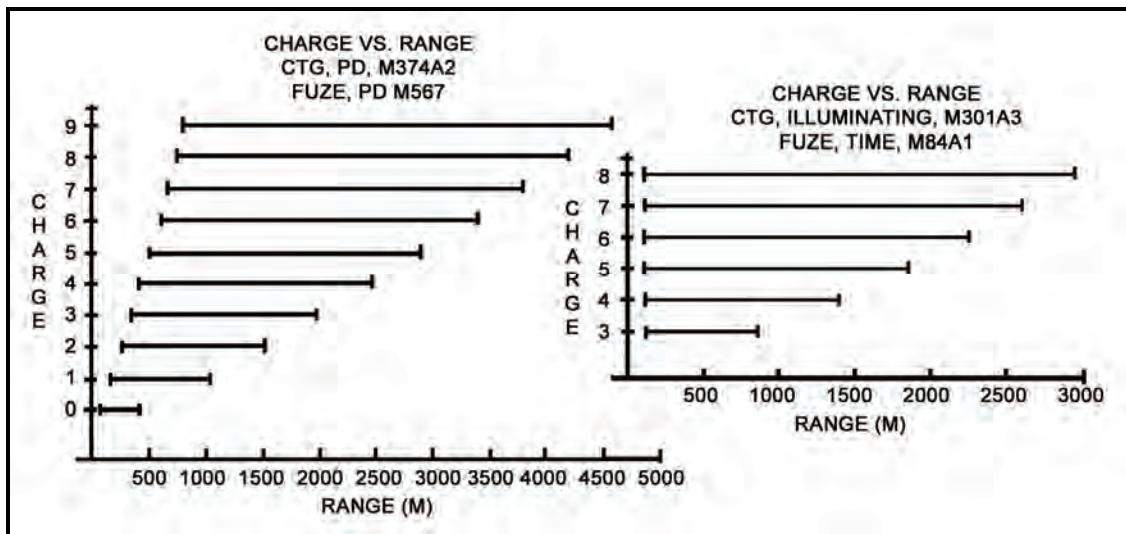


**Figure 12-4. Charge versus range chart.**



**Figure 12-5. Determination of charge.**

12-12.   Another method that can be used is to turn to page II in the firing table. There is a listing of charges for M374A2 (HE) and M375A2 (WP) from charge 0 through charge 9. Below that listing is the charge listing for M301A3 illumination (ILLUM) from charge 0 through charge 8. Write in after each charge the minimum and the maximum ranges that each charge zone covers (Figure 12-6). By looking at the maximum range, the correct charge to use can easily be determined.
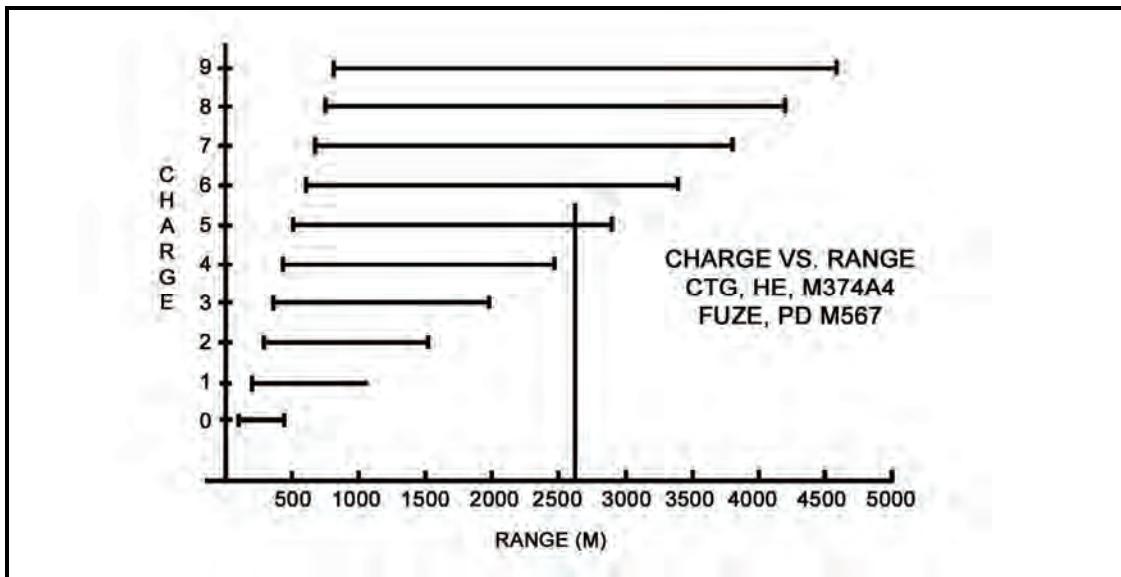


**Figure 12-6. Charge zone and range.**

**Plotting of Observer Corrections**

12-13.   To plot the FO's corrections, the computer first indexes the FO's direction to the target. That OT direction is given in the CFF or with the first correction. Going from the last round, he applies the FO's corrections.

12-14.   For example, assume that the OT direction is 3050, and the FO sends these corrections: "Right 50, drop 200." Ensuring that OT direction is indexed, make these corrections from the first plot (Figure 12-7).

12-15.   To do this, move to the right one small square (50 meters), then straight down the board four small squares (200 meters). Then, make a small plot, circle it, and label it "No. 2." To determine the firing data, rotate the disk until the No. 2 plot is over the vertical centerline. Then, read the deflection and range (Figure 12-8). Using the firing table, determine the charge and elevation to fire the round, and compute the subsequent fire command.
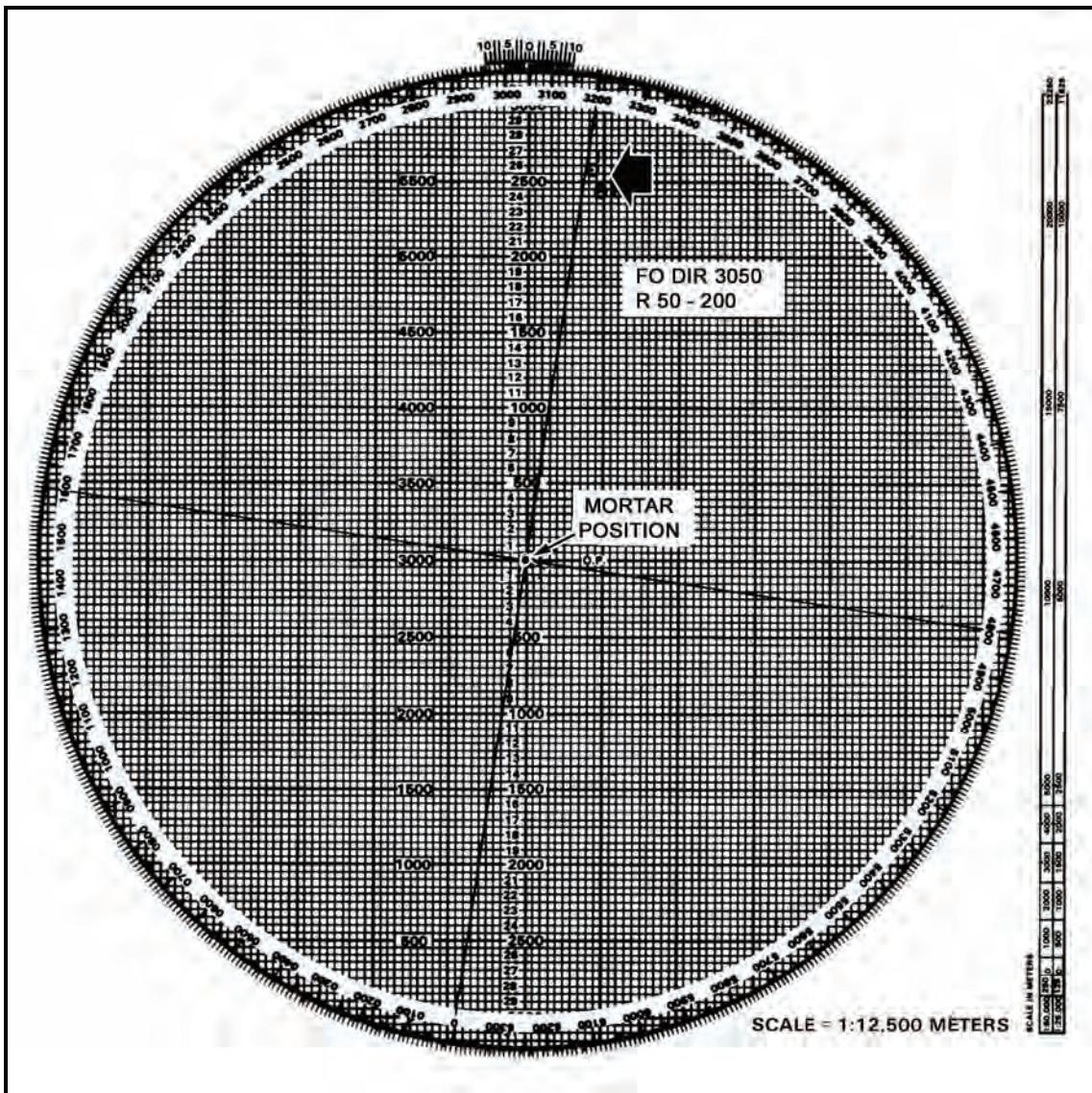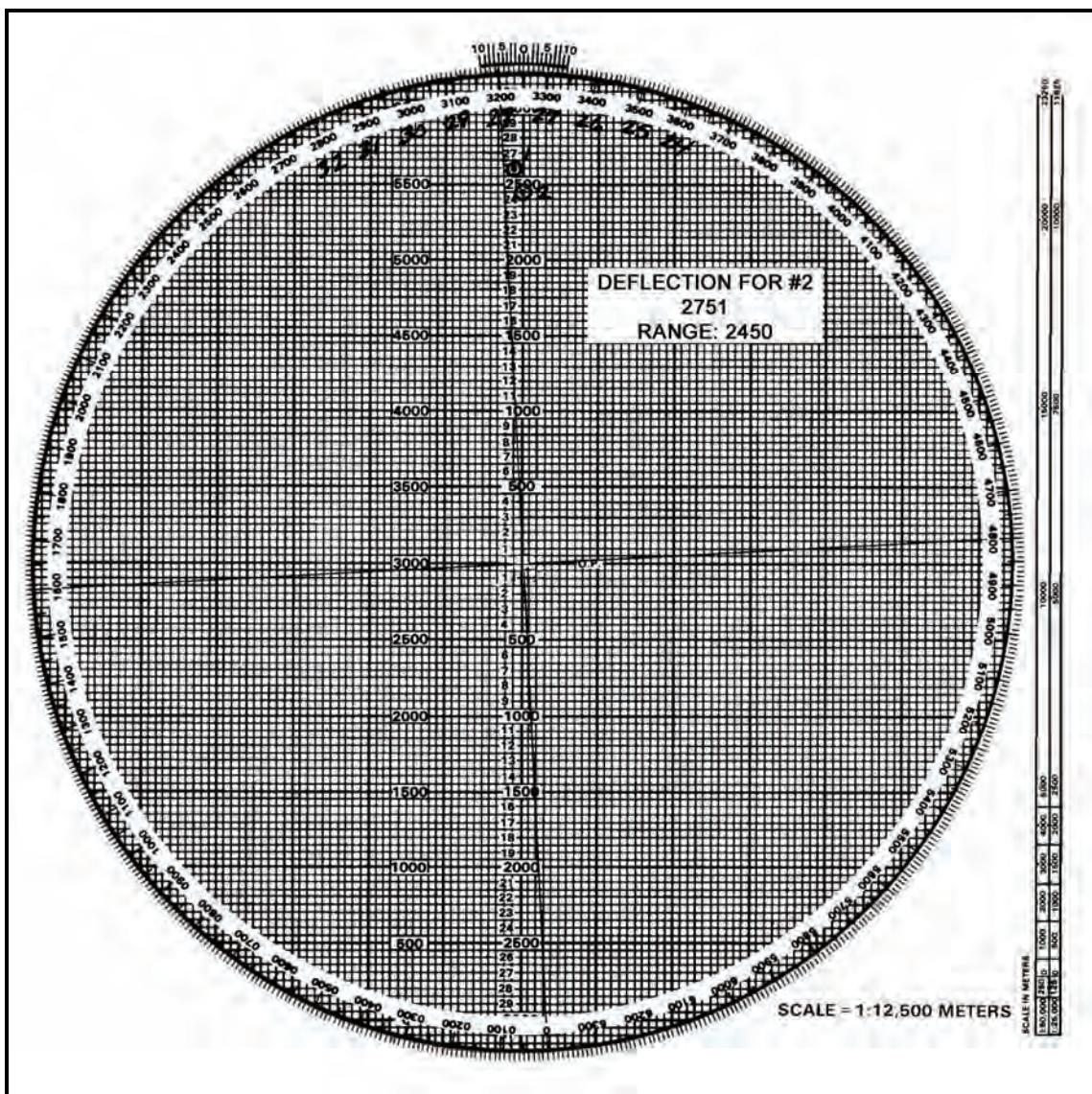


**Figure 12-7. Plotting of observer's correction.**

**Figure 12-8. Determination of deflection and range.**

12-16. Once the EOM has been given, update the M16/M19 plotting board (Figure 12-9). To do this, erase all the plots except the final plot. Then enclose that plot with a hollow cross and number it with the target number (Figure 12-10).

**Engagement of Other Targets**

12-17.  To fire other targets on this chart, the computer must perform the following actions:
- Grid. Go back to the map, plot the target location, and determine the range and direction.
- Shift. Index the FO's direction to the target and apply the correction from the known point, which must be plotted on the chart.
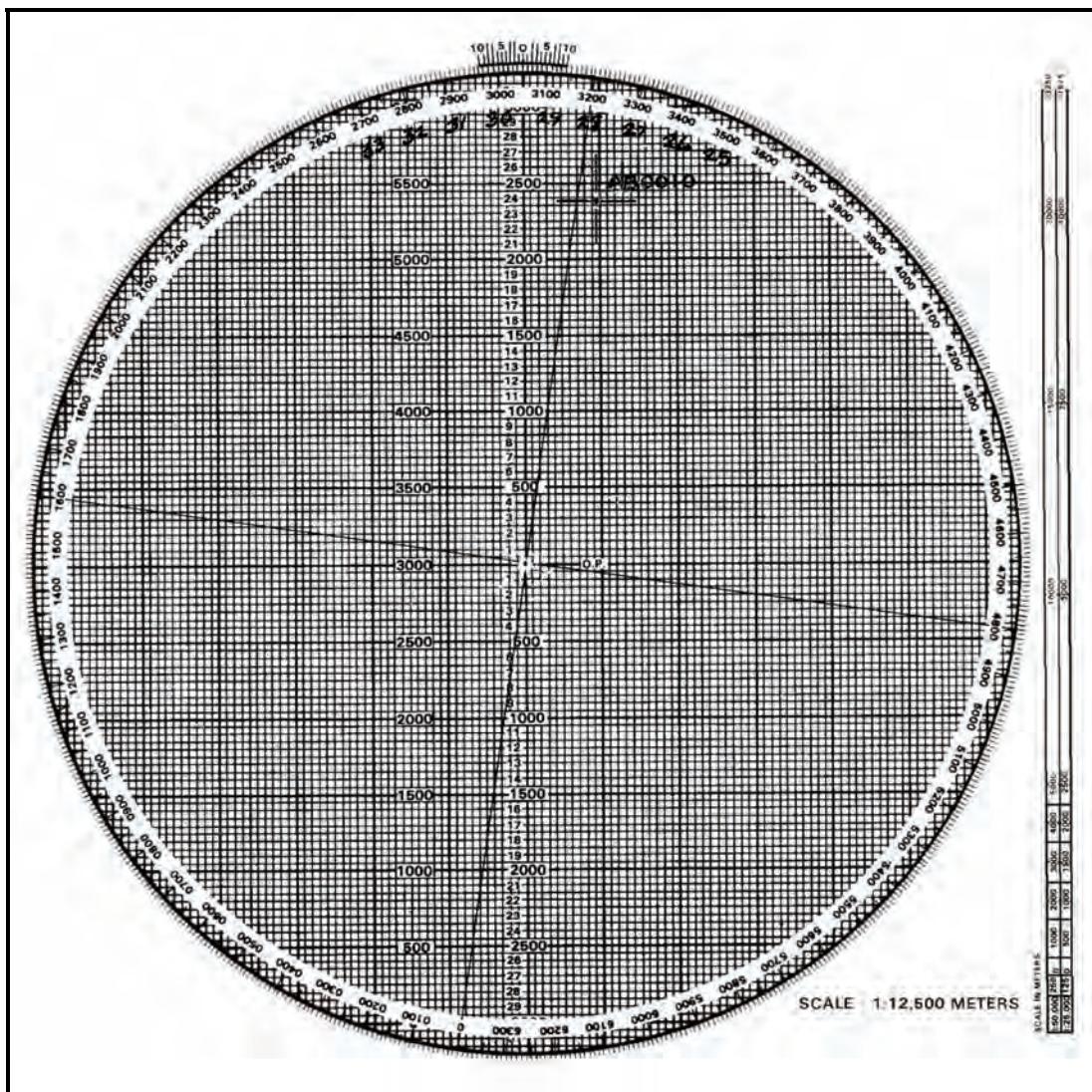
**Figure 12-9. Board updated.**
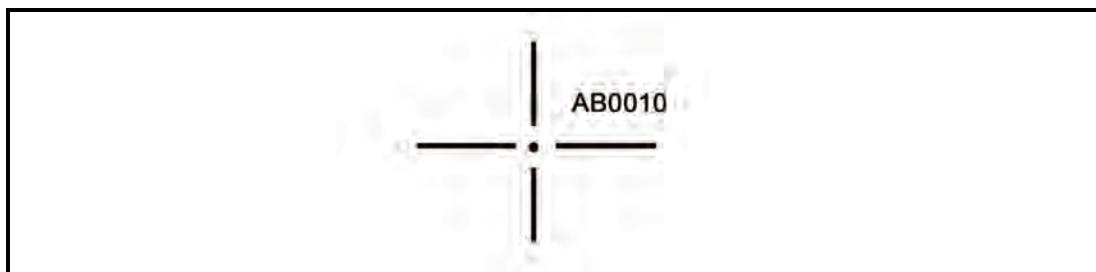
**Figure 12-10. Hollow cross with target number.**

## BELOW PIVOT-POINT METHOD

12-18.   The observed firing chart (with mortars plotted below pivot point) is used when the ranges to the targets being engaged are over 2,900 meters. When the initial range to the target is 2,900 meters or more, mortars are always plotted below the pivot point.

12-19.   Two items are needed to set up the board for operation: a gun-target azimuth and a range from the mortar position to the target. To construct the chart—
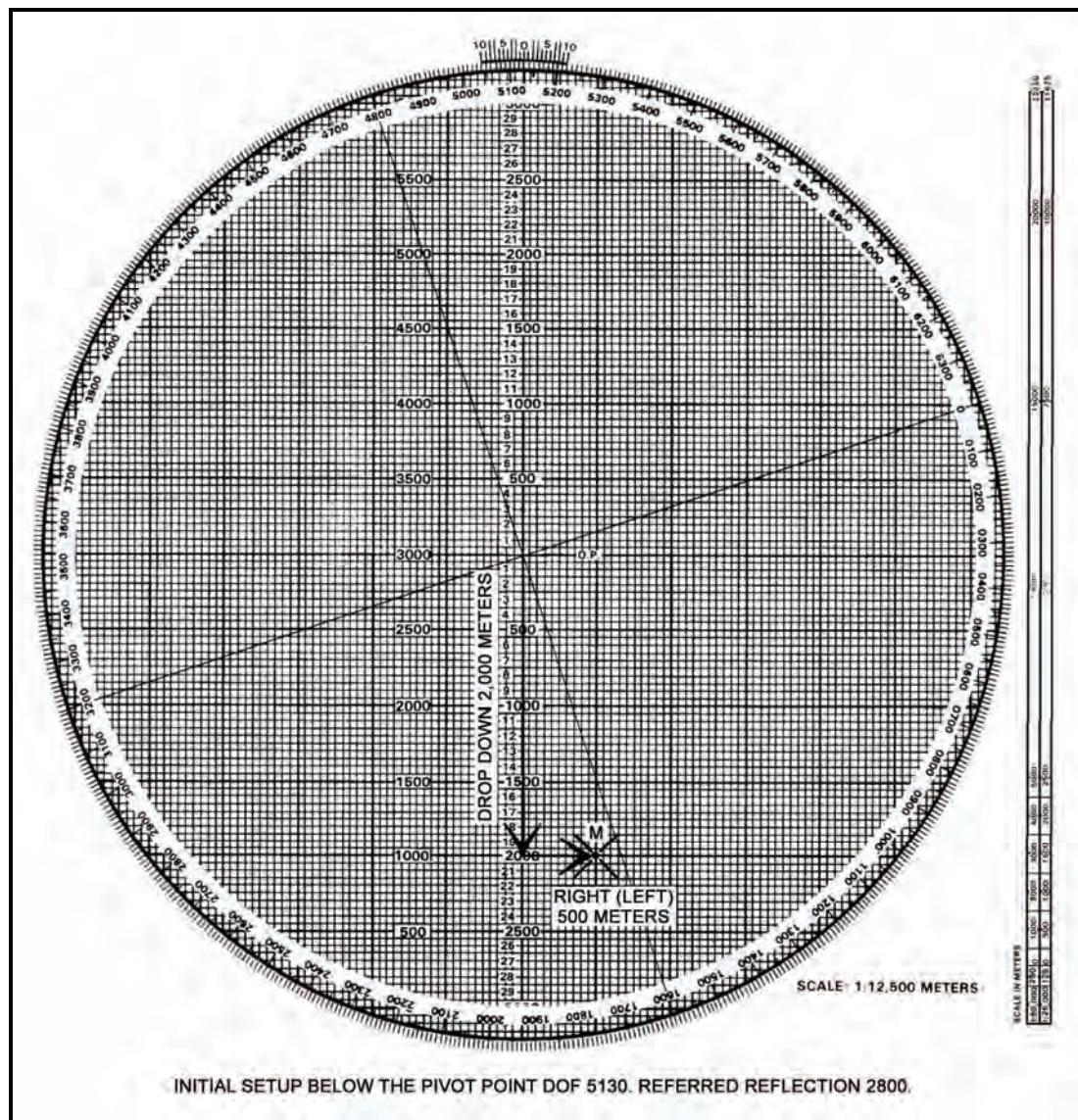
   (1)   Index the gun-target azimuth.
   (2)   Drop below the pivot point 1,000 meters for 60-mm mortars, 2,000 meters for 81-mm mortars, and 3,000 meters for 120-mm mortars.

   **NOTE:**  When firing 800-series ammunition with the 81-mm mortar, drop 3,000 meters below the pivot point to accommodate the extended range.

   (3)      Plot the mortar position 500 meters left or right of the vertical centerline (Figure 12-11).



**Figure 12-11. Plotting of mortar position.**

12-20.   Once these actions have been taken, ensure that the azimuth disk is still indexed on the gun target azimuth. Then, from the mortar position, plot the first round at the range determined using the parallel-line method of plotting (Figure 12-12). Determine the mounting azimuth and referred deflection the same way as with the pivot-point method.
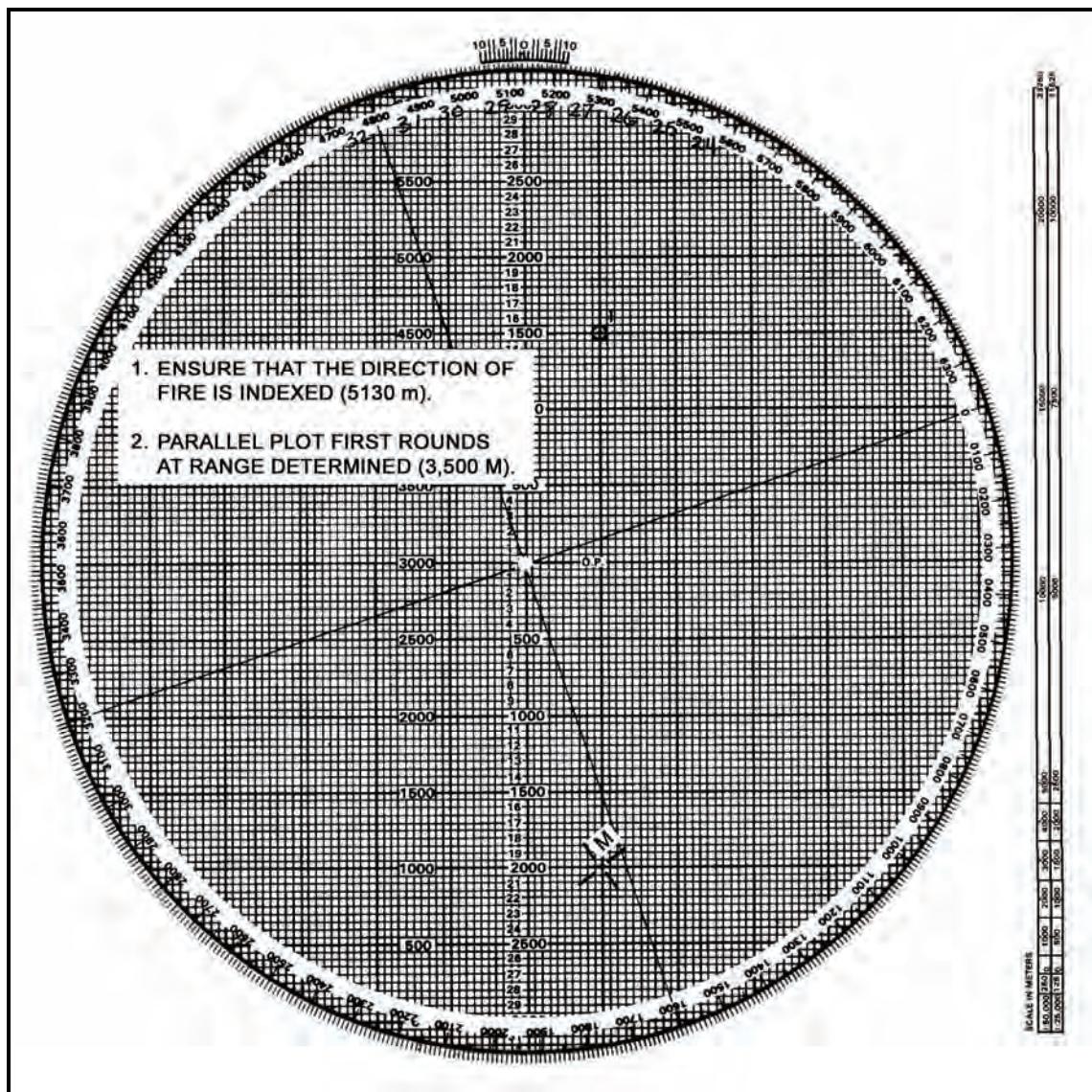


**Figure 12-12. Plotting of first round.**

12-21.   To determine the firing data to send to the mortar, align the mortar position below the target being engaged using the parallel-line method of plotting. Then read the deflection using the azimuth disk and vernier scale and measure the range between the mortars and target. To align the mortar position and target, since the mortar position is being plotted away from the pivot point, use the parallel-line method of plotting. With the mortar position and target plotted, rotate the disk until the mortar position and the target are an equal distance from, or on, the same vertical line (Figure 12-13).

**NOTE:**   All directions are read from bottom to top.
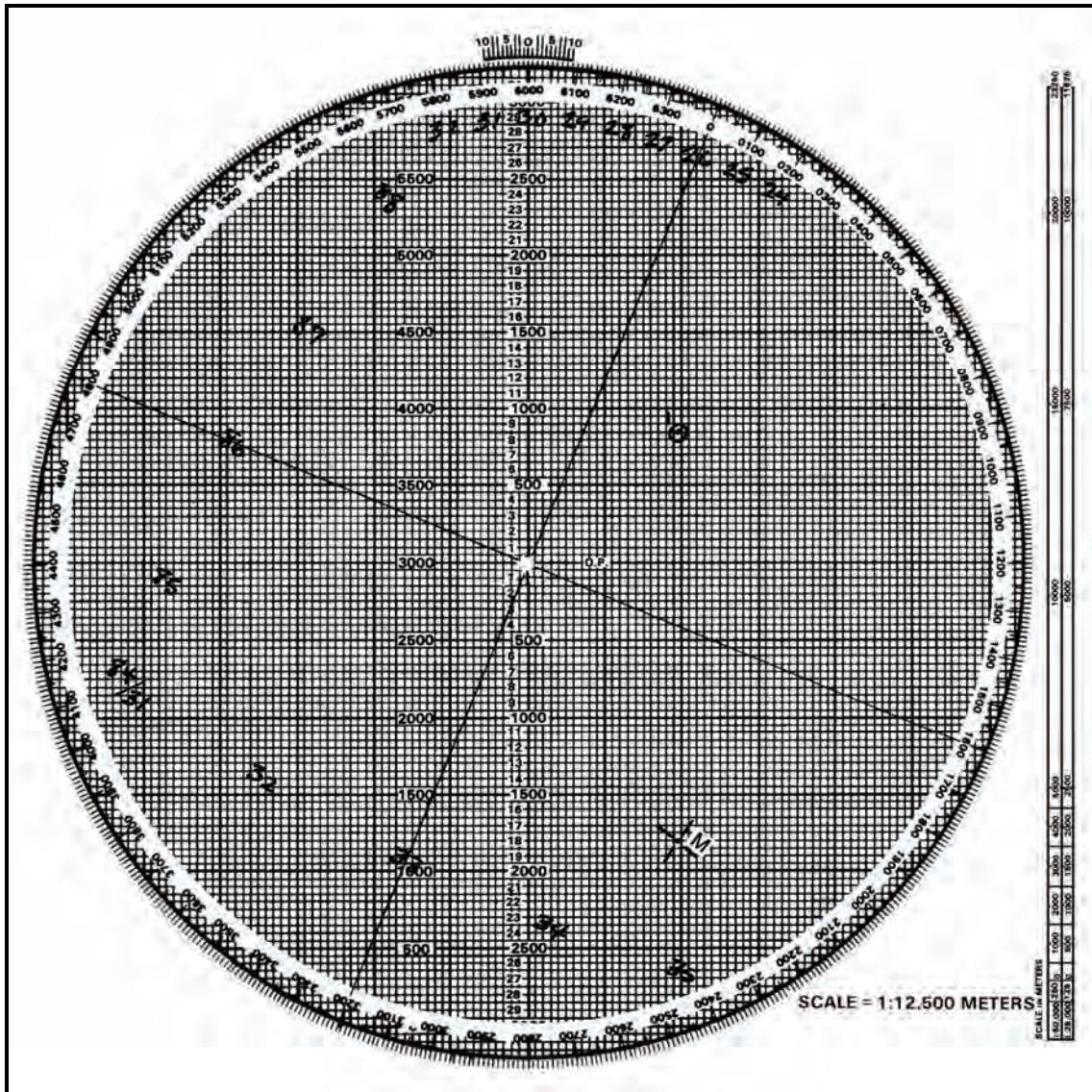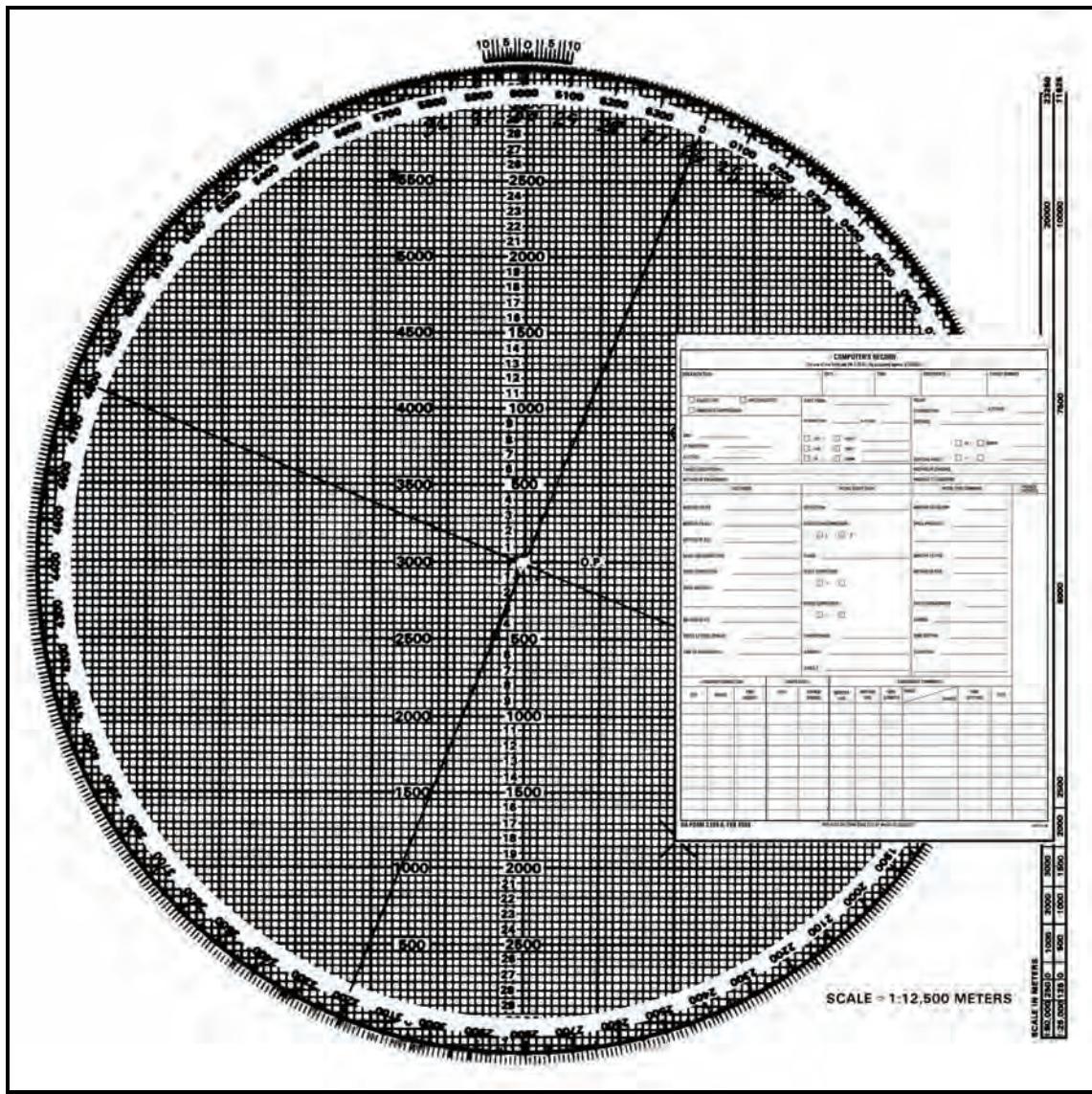


**Figure 12-13. Parallel-line plotting.**

12-22.   Range must now be determined using one of the following 3 techniques:

- Count each of the 50-meter squares from the mortar position to the target.
- Use the scale on the left edge of the range arm to measure the distance from the mortar position to the target.
- Place the edge of the DA Form 2399-R alongside the two plots on the plotting board (mortar and target). Then make a tick mark on the edge of the DA Form 2399-R at each plot. Using the alternate range scale to the left of the pivot point, lay the DA Form 2399-R along this scale with the mortar tick mark at 0 and read the range (Figure 12-14).



**Figure 12-14. Determination of range with edge of DA Form 2399-R (Computer's Record).**

12-23.   To update the board after the EOM is given or to engage other targets, use the same method as with the pivot-point method.

> **NOTE:**  When operating the M16 plotting board as an observed firing chart (pivot-point or below-pivot-point methods), no correction factors are applied to the data.

## MORTARS PLOTTED AT PIVOT POINT

12-24.   With the pivot pin inserted in the pivot point of the plotting board, the computer can use the range scale arm or the range arm to determine deflections and range to both the initial and subsequent rounds.

(1) Determine the range and direction to the center of the sector from a map or by visual observation. Round off the azimuth to the initial round or DOF to the nearest 50 mils to determine a mounting azimuth, and superimpose a deflection scale on the azimuth disk.

(2) Make the initial plot by indexing the DOF (or initial azimuth) to the initial round at the index mark. This may be different from the mounting azimuth because of the round-off rule. Use the scale on the vertical centerline to make the initial plot at the correct range.

(3) When the FO calls in a target direction (the OT azimuth), index the azimuth disk on the M16/M19 plotting board at the OT azimuth. It remains indexed on that azimuth until the mission is completed. Plot corrections from the FO IAW procedures. Once a correction has been plotted, rotate the range arm until the right edge of the range arm is over the new plot. Determine the range to the nearest 25 meters, and read the deflection to the nearest mil using the vernier scale.

(4) Plot additional corrections, and use the range scale arm to determine range and deflection. Once the azimuth disk is indexed on the OT azimuth, the disk does not have to be rotated to determine ranges or deflections.

## MORTARS PLOTTED BELOW PIVOT POINT

12-25.   With the pivot pin inserted in the pivot point, the computer can use the left edge of the range scale arm to plot the initial round. The mounting azimuth and azimuth to the initial round are determined as for mortars plotted at pivot point. The computer indexes the azimuth disk on the DOF and aligns the right edge of the range scale arm on the vertical centerline. Next, he makes a small plot at the zero range on the left edge of the range scale arm. Then, still using the left edge, he makes a small plot at the range for the initial round. The mortar position plot must be marked with a hollow cross to further identify its position. Once the initial round is fired, the range scale arm is removed, and the left edge is used as a range scale.

## CARE AND CLEANING OF PLOTTING BOARDS

12-26.Plotting boards must be handled with care to prevent bending, scratching, or chipping. They must be kept away from excessive heat or prolonged exposure to the sun, which may cause them to warp. When storing a board, place it in its carrying case, base down, on a horizontal surface. Do not place the board on an edge or have other equipment stored on it. Normally the plotting board is cleaned with a nongritty (art gum) eraser. If the board is excessively dirty, a damp cloth should be used. The contact surfaces of the disk and base are cleaned often. The disk is removed by pushing a blunt instrument through the pivot point hole from the back of the base.

# MODIFIED-OBSERVED FIRING CHART

12-27.   The modified-observed firing chart can be constructed on the M16 plotting board. It is constructed when the mortar position or target is known to survey accuracy. The three basic items needed to construct a modified observed chart are a DOF (usually to the center of the platoon area of responsibility), one point (mortar position, target, or reference point) that must be known to surveyed accuracy (eight-digit grid coordinates), and a grid intersection to represent the pivot point.

**NOTE:**  See survey firing chart in Chapter 14.
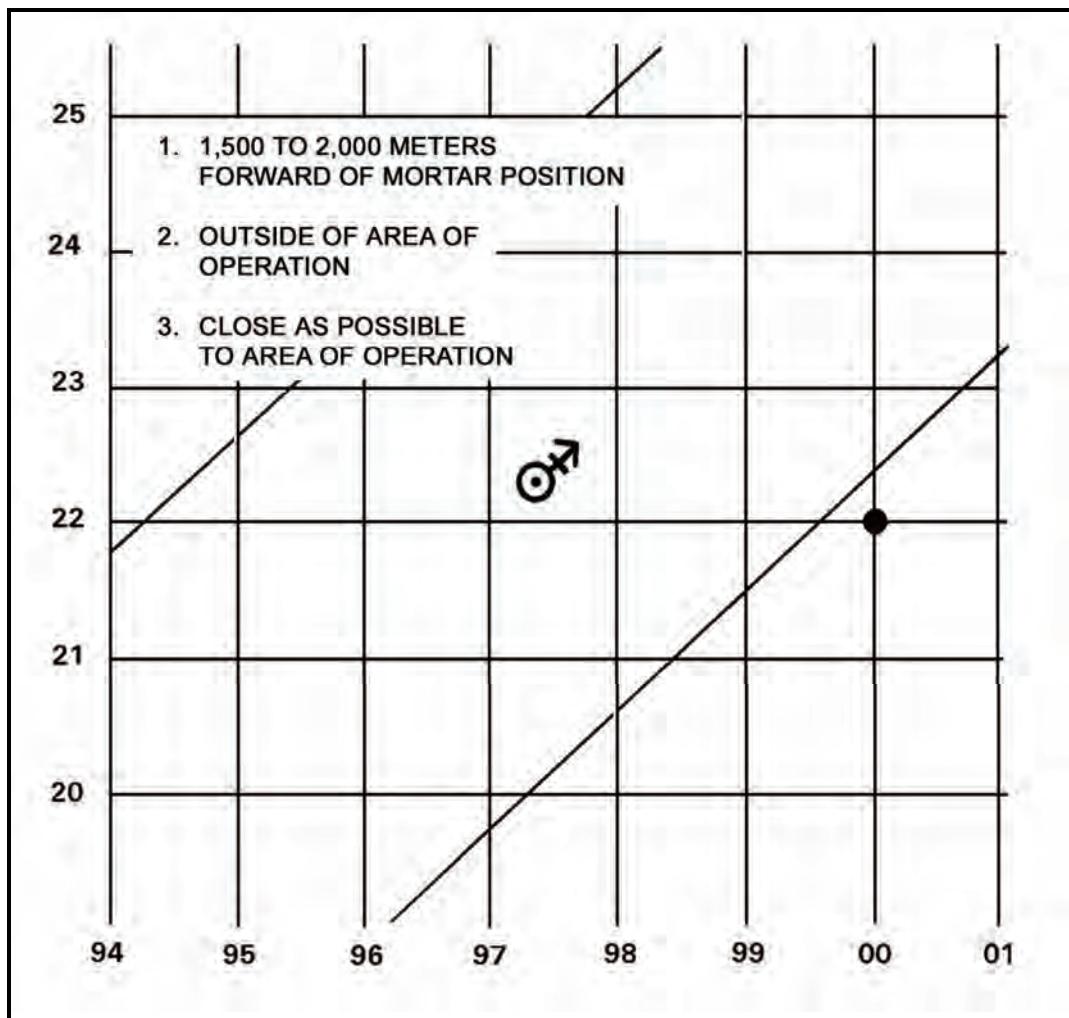
**DETERMINATION OF DIRECTION OF FIRE**

12-28.   The section sergeant usually determines DOF. In most cases, it is to the center of sector. The mortar location can be surveyed by map inspection, terrain inspection, or pacing from a known point on an azimuth, as long as the position of the base gun is known to a valid eight digits.

12-29.   For the 60-mm and 81-mm mortars, the grid intersection representing the pivot point is between 1,500 and 2,000 meters forward of the mortar location. This allows the full range of the mortar to be used (Figure 12-15).

> **NOTE:**  With the 120-mm mortar, the grid intersection should be 3,000 to 4,000 meters forward of the mortar position.



**Figure 12-15. Grid intersection to represent pivot point.**

12-30.   The grid intersection should be outside the area of responsibility. This ensures that the pivot point does not interfere with plotting targets or corrections. The grid intersection is also as close as possible to the area of responsibility. This ensures that as much of the area of responsibility as possible will be on the plotting board.

## SUPERIMPOSITION OF GRID SYSTEM ON PLOTTING BOARD

12-31.   Once the grid intersection has been determined, the computer indexes "0" on the azimuth disk. He then drops down 2,000 meters below the pivot point and writes in the east/west indicator on the vertical centerline at the 2,000-meter mark. Next, he goes 2,000 meters to the left of the pivot point on the heavy center horizontal line and writes the north/south indicator. To complete the grid system, the computer writes in the other north/south, east/west grid numbers as though looking at a map. By numbering every other heavy dark line (two large squares) on the plotting board, he retains a scale of 1:12,500 on the board (Figure 12-16).
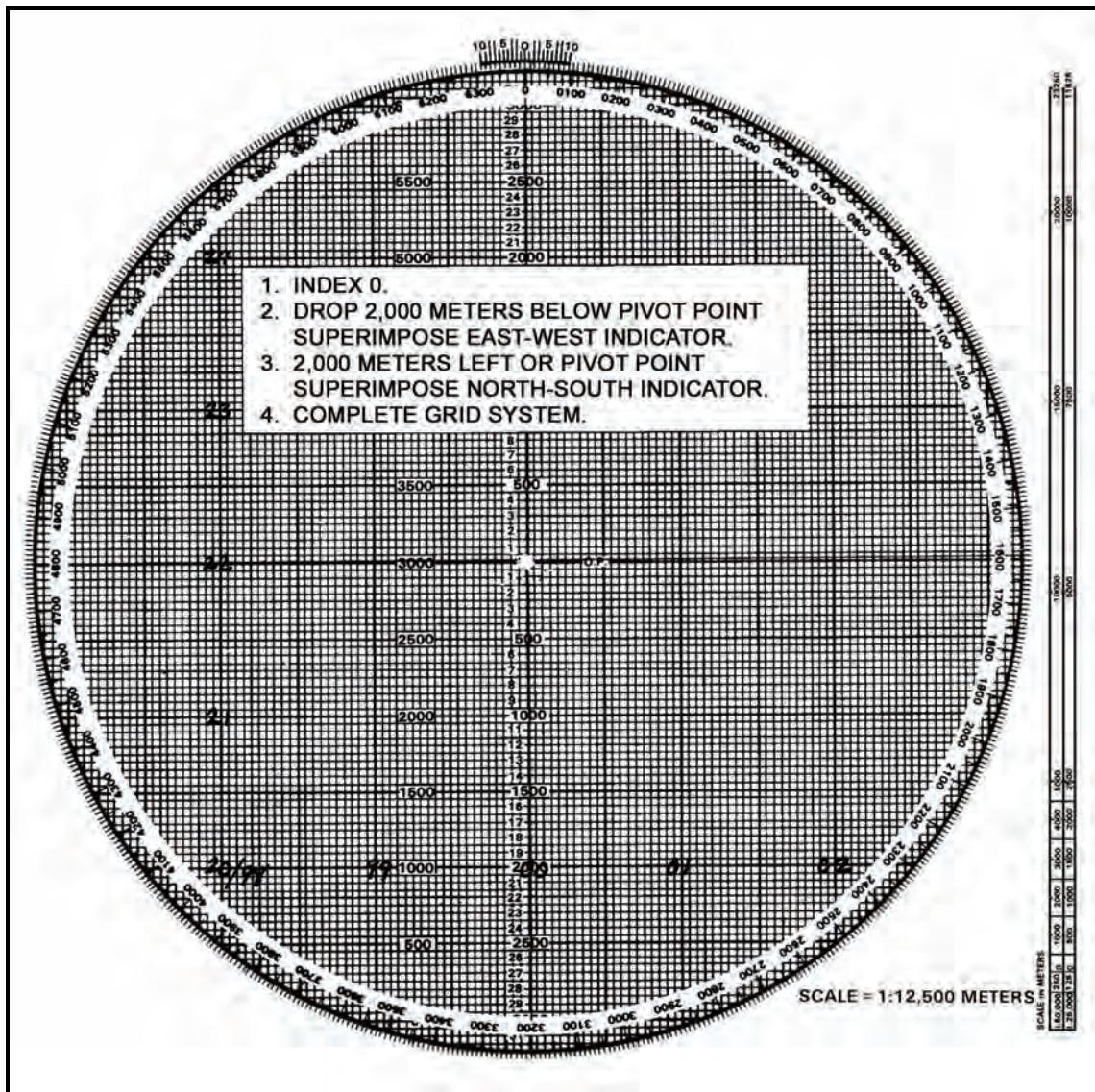


**Figure 12-16. Superimposition of the grid.**

**PLOTTING OF MORTAR POSITION**

12-32.   Now that a grid system is on the board, the computer can plot any grid coordinates. To do this, he must—

    (1)  Ensure that the azimuth disk is indexed at 0.

    (2)  Read like a map: RIGHT and UP.

    (3)  Remember that the scale is 1:12,500 (each small square is 50 meters by 50 meters) (Figure 12-17).

12-33.   To superimpose the deflection scale, the computer writes the referred deflection on the board the same way as with the observed chart. Firing data are determined by using the parallel-line method of plotting.
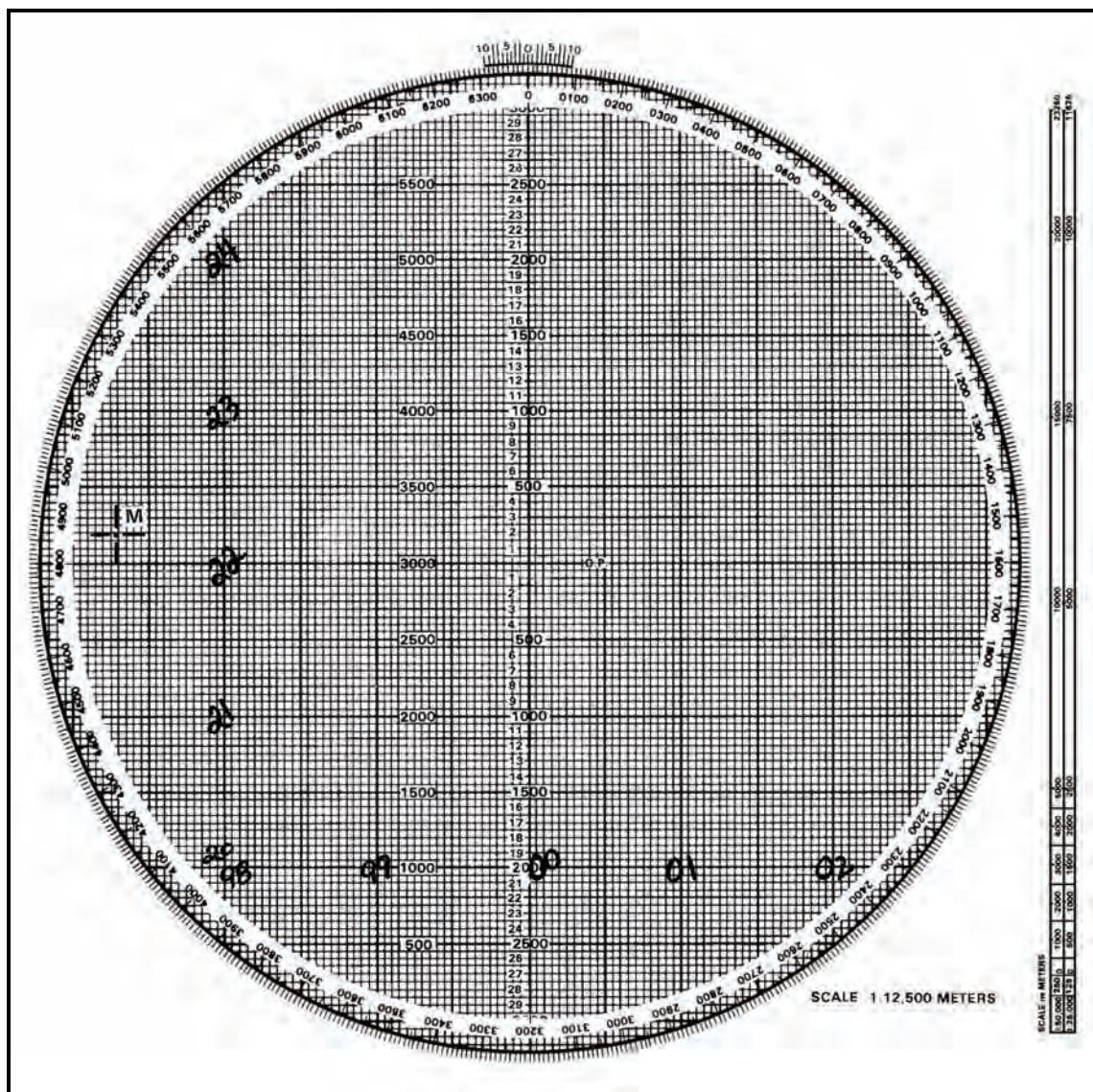


**Figure 12-17. Plotting of a mortar position.**

## FIELD-EXPEDIENT METHOD FOR CONSTRUCTION

12-34.   If the grid coordinates of the mortar position are known but a map is not available for determining the grid intersection to represent the pivot point, the computer can construct the modified-observed firing chart using the following procedures:

(1)  Index the DOF.

(2)  Drop below the pivot point on the vertical centerline 2,000 to 2,500 meters.

(3)  Go 500 to 1,000 meters left or right of the vertical centerline and make a plot (Figure 12-18).
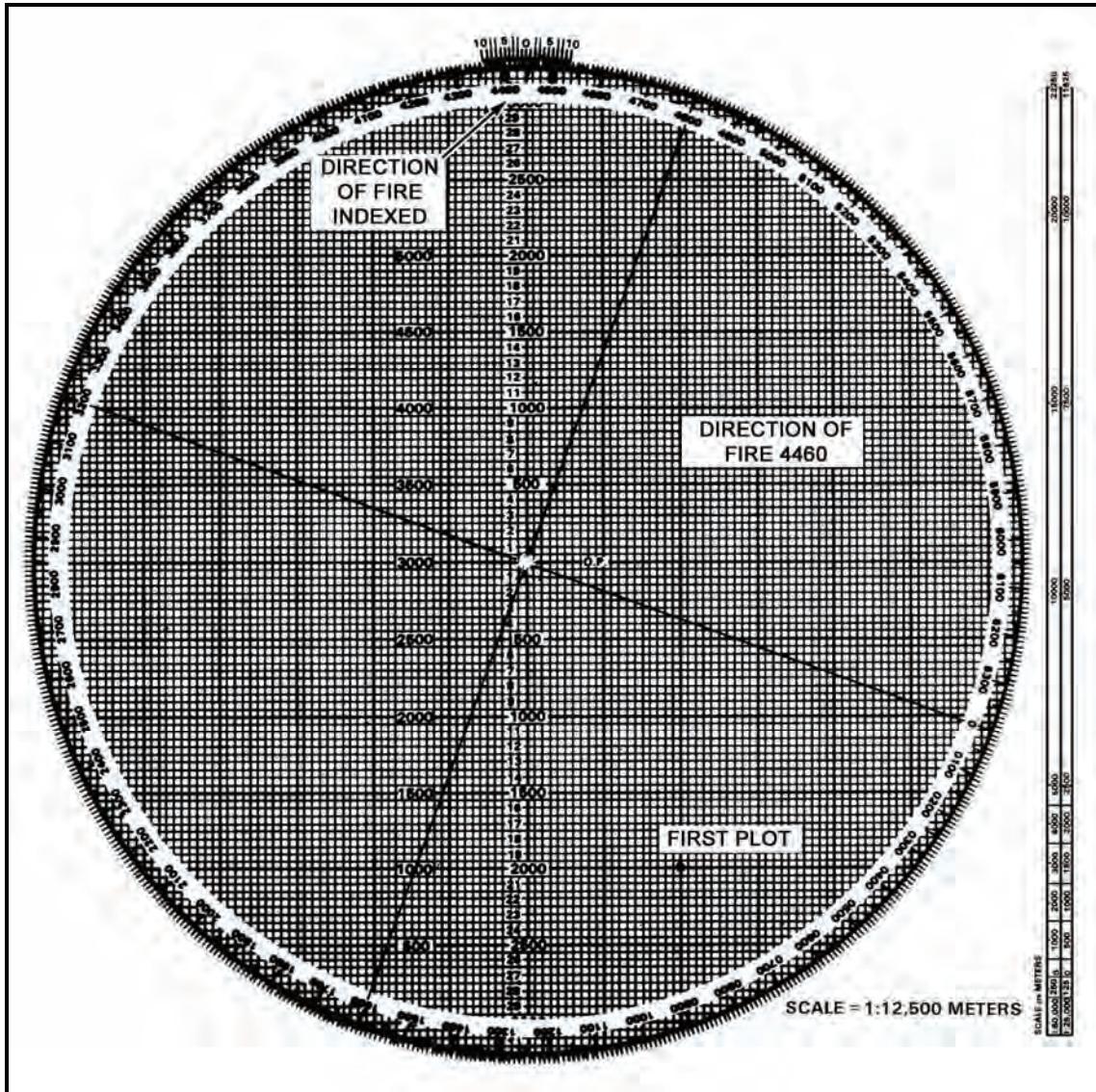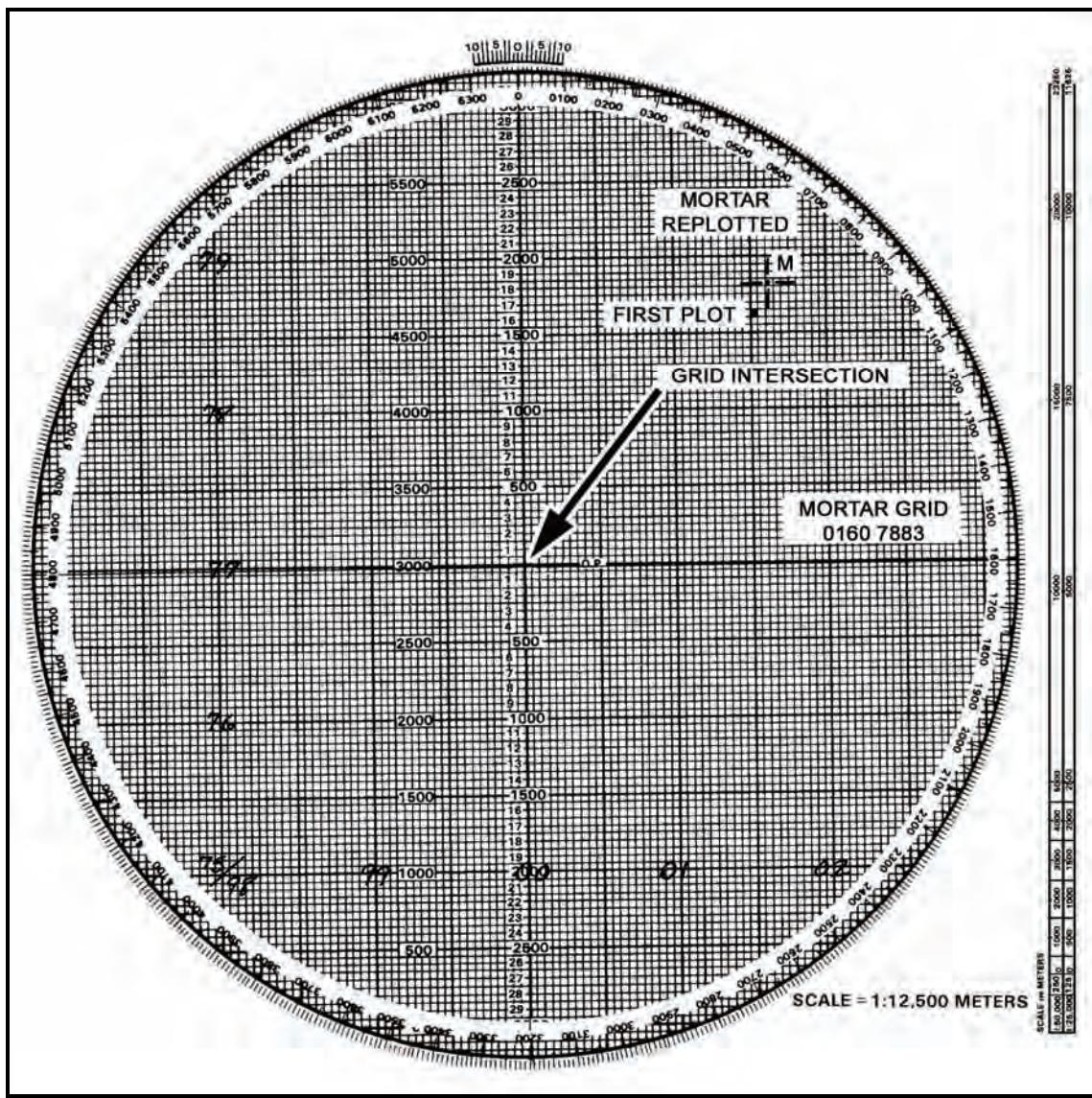


**Figure 12-18. First plot.**

(4) Rotate the azimuth disk and index "0."

(5) Determine the 1,000-meter grid that contains the mortars (Figure 12-19). The first, second, fifth, and sixth numbers of the mortar grid give the 1,000-meter grid square.



**Figure 12-19. Replotting of mortar location.**

(6) Superimpose the grid system.

(7) Replot the mortar location to the surveyed grid.

# TRANSFER OF TARGETS

12-35.  Transfer is the process of transferring a target from the observed chart to the modified-observed chart, or from the modified-observed chart to the surveyed chart, as more information becomes available. This occurs since the targets transferred are known points to the FO and FDC, and these points may be used in future missions. Transfer is always done using chart data (deflection and range to the final plot).

> **NOTE:**  No firing corrections are used with the observed chart. Once transferred to the modified-observed chart, the altitude of the target is assumed to be the same as that of the mortar position.

---

**EXAMPLE**

Assume that the mortar section is at grid 939756 (six digits: observed chart) and two targets have been fired on (Figure 12-20). The platoon leader determines that the eight-digit grid to the mortar position is 93937563 (modified-observed chart) and designates the grid intersection to represent the pivot point. The computer constructs the chart and transfers the targets from the observed chart (Figure 12-21).

---
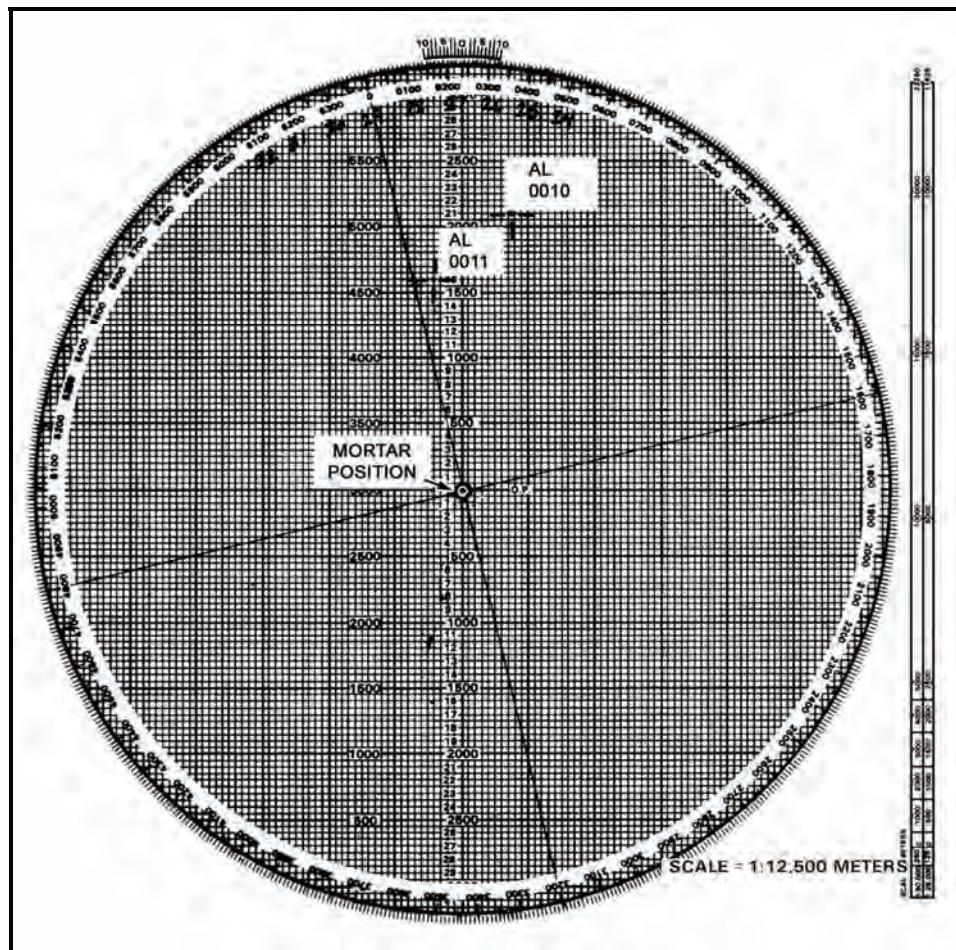


**Figure 12-20. Observed chart.**
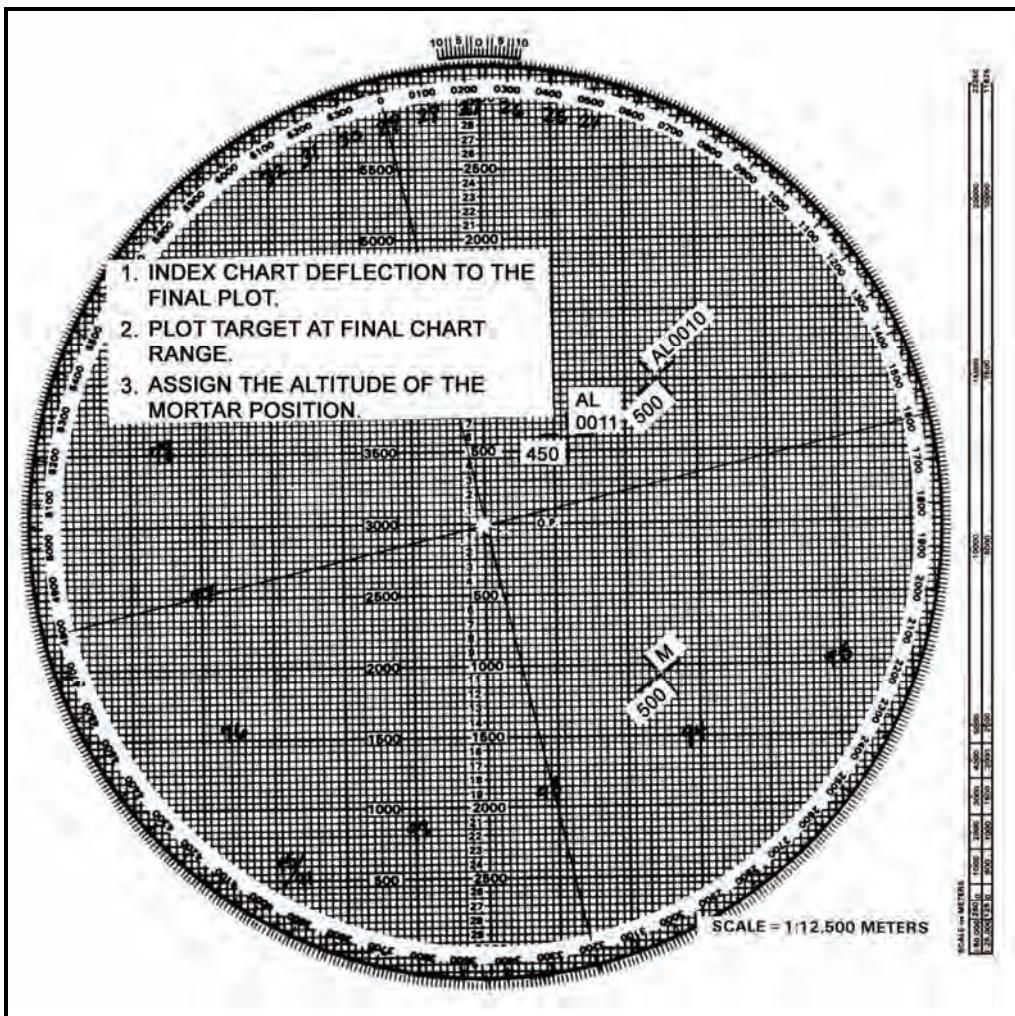
**Figure 12-21. Forward plotting target to modified-observed chart from the observed chart.**

## TARGET PLOTTING

12-36.    After transfer, through coordination with the FO, an RP or target may be identified to valid eight-digit coordinates. The plotting board is then reconstructed as a surveyed chart. When the situation permits, a registration mission should be conducted on the point for which the valid eight-digit coordinates were determined. Then, firing corrections are computed.

- When transferring targets from one type of chart to another, remember that the target plots on the observed chart are plotted at the data it takes to hit the target. This is not always the locations of the targets.

- The same holds true for the modified-observed chart, except that with some targets, altitude correction (VI) may have been used. When replotting the target at the end of the mission, strip this altitude correction from the command range and plot the target using this range. Using this procedure gives a more accurate picture of the exact location of the target than the observed chart; however, it is not always the actual location of the target.

## PLOTTING OF PREVIOUSLY FIRED TARGETS

12-37. At the completion of the surveyed registration mission and the computation of the firing corrections, previously fired targets plotted on the plotting board must be forward plotted. Since the surveyed chart is the most accurate chart to use, all information on it should be the most accurate possible.

---

**EXAMPLE**

When targets AL0010 and AL0011 were fired before the surveyed registration, the data and the plots included all firing corrections, even though they may have been unknown at the time of firing (Table 12-1). To forward plot these targets, the computer strips the firing correction from the range and deflection to plot them at their actual location.

---

**NOTE:** To strip out the corrections, the signs must be reversed.

**Table 12-1. Replotting of previously fired targets.**

| COMMAND DATA | FIRING CORRECTIONS | COMPUTATIONS | CHART DATA FOR REPLOT |
|---|---|---|---|
| TARGET AL0010 | | | |
| Deflection 2786 | Deflection R12<br>RCF - 18 | 2786 + L12 = 2798<br>+18 X 1.8 = +32 | Deflection 2798 |
| Range 1825 | Altitude Correction +25 | 1825 + 32 - 25 = 1832 | Range 1825 |
| TARGET AL0011 | | | |
| Deflection 3115 | Deflection R12<br>RCF - 18 | 3115 + L12 = 3127<br>+18 X 2.9 = +52 | Deflection 3127 |
| Range 2850 | Altitude Correction +25 | 2850 + 52 - 25 = 2877 | RANGE 2875 |

# DEFLECTION CONVERSION TABLE

12-38.   When an adjustment is made to a sheaf, such as after the completion of the registration, the sheaf is paralleled or converged if engaging a point-type target, or opened when engaging a wider target. In these situations, the computer must determine the new data and convert the deviation corrections required into mils. He can use the deflection conversion table (Figure 12-22) or the mil-relation formula.

> **NOTE:** If the target has been mechanically surveyed, enter the DCT at the initial range plot. If the target is non-surveyed (even if it is an eight-digit grid), enter the DCT at the final range plot.

12-39.   To use the DCT, first round off the range at which the section is firing to the nearest 100 meters. This is required because the ranges on the table are divided into 100-meter increments. Next, go down the range column to find the range. The deflection is in meters across the top of the card.

12-40.   Using the number of meters the FO requested to move the strike of the round, find that number of meters and go straight down that column until it intersects with the range. This number is the number of mils that would have to be applied to the mortar sight to move the strike of the round the required meters. If the range is greater than 4,000 meters, divide the range and mil correction by two.

| RANGE IN METERS | DEFLECTION IN METERS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 10 | 20 | 30 | 40 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 300 | 400 | 500 |
| 500 | 3.0 | 20 | 41 | 61 | 81 | 102 | 152 | 201 | 250 | 297 | 34 | 388 | 550 | 687 | 800 |
| 600 | 1.7 | 17 | 34 | 51 | 68 | 85 | 127 | 168 | 209 | 250 | 289 | 328 | 472 | 599 | 708 |
| 700 | 1.5 | 15 | 29 | 44 | 58 | 73 | 109 | 145 | 180 | 215 | 250 | 284 | 412 | 529 | 632 |
| 800 | 1.3 | 13 | 25 | 33 | 51 | 64 | 95 | 127 | 158 | 189 | 219 | 250 | 365 | 472 | 569 |
| 900 | 1.1 | 11 | 22 | 34 | 45 | 57 | 85 | 113 | 141 | 168 | 195 | 223 | 328 | 426 | 517 |
| 1000 | 1.0 | 10 | 20 | 31 | 41 | 51 | 76 | 102 | 127 | 152 | 176 | 201 | 297 | 388 | 473 |
| 1100 | .93 | 9 | 18 | 28 | 37 | 46 | 69 | 92 | 115 | 138 | 161 | 183 | 271 | 355 | 435 |
| 1200 | .85 | 8 | 17 | 25 | 34 | 42 | 64 | 85 | 106 | 127 | 148 | 168 | 249 | 328 | 402 |
| 1300 | .79 | 8 | 16 | 23 | 31 | 39 | 59 | 78 | 98 | 117 | 136 | 155 | 231 | 304 | 374 |
| 1400 | .73 | 7 | 15 | 22 | 29 | 36 | 55 | 73 | 91 | 109 | 127 | 145 | 215 | 283 | 349 |
| 1500 | .68 | 7 | 14 | 20 | 27 | 34 | 51 | 68 | 85 | 102 | 118 | 135 | 201 | 265 | 328 |
| 1600 | .63 | 6 | 13 | 19 | 25 | 32 | 48 | 64 | 80 | 95 | 111 | 127 | 189 | 250 | 309 |
| 1700 | .60 | 6 | 12 | 18 | 24 | 30 | 45 | 60 | 75 | 90 | 104 | 119 | 178 | 235 | 291 |
| 1800 | .57 | 6 | 11 | 17 | 23 | 28 | 42 | 57 | 71 | 85 | 99 | 113 | 168 | 223 | 276 |
| 1900 | .54 | 5 | 11 | 16 | 21 | 27 | 40 | 54 | 67 | 80 | 94 | 107 | 160 | 211 | 262 |
| 2000 | .51 | 5 | 10 | 15 | 20 | 25 | 38 | 51 | 64 | 76 | 89 | 102 | 152 | 201 | 250 |
| 2100 | .49 | 5 | 10 | 15 | 19 | 24 | 36 | 48 | 61 | 73 | 85 | 97 | 145 | 192 | 238 |
| 2200 | .46 | 5 | 9 | 14 | 19 | 23 | 35 | 46 | 58 | 69 | 81 | 92 | 138 | 183 | 228 |
| 2300 | .44 | 4 | 9 | 13 | 18 | 22 | 33 | 44 | 55 | 66 | 77 | 88 | 132 | 175 | 218 |
| 2400 | .43 | 4 | 8 | 13 | 17 | 21 | 32 | 42 | 53 | 63 | 74 | 85 | 127 | 168 | 209 |
| 2500 | .41 | 4 | 8 | 12 | 16 | 20 | 31 | 41 | 51 | 61 | 71 | 81 | 122 | 162 | 201 |
| 2600 | .39 | 4 | 8 | 12 | 16 | 20 | 29 | 39 | 49 | 59 | 68 | 78 | 117 | 155 | 194 |
| 2700 | .38 | 4 | 8 | 11 | 15 | 19 | 28 | 38 | 47 | 57 | 66 | 75 | 113 | 150 | 187 |
| 2800 | .37 | 4 | 7 | 11 | 15 | 18 | 27 | 36 | 45 | 55 | 64 | 73 | 109 | 145 | 180 |
| 2900 | .35 | 4 | 7 | 11 | 14 | 18 | 26 | 35 | 44 | 53 | 61 | 70 | 105 | 140 | 174 |
| 3000 | .34 | 3 | 7 | 10 | 14 | 17 | 25 | 34 | 42 | 51 | 59 | 68 | 102 | 135 | 168 |
| 3100 | .33 | 3 | 7 | 10 | 13 | 16 | 25 | 33 | 41 | 49 | 57 | 66 | 98 | 131 | 163 |
| 3200 | .32 | 3 | 6 | 10 | 13 | 16 | 24 | 32 | 40 | 48 | 56 | 64 | 95 | 127 | 158 |
| 3300 | .31 | 3 | 6 | 9 | 12 | 15 | 23 | 31 | 39 | 46 | 54 | 62 | 92 | 123 | 153 |
| 3400 | .30 | 3 | 6 | 9 | 12 | 15 | 22 | 30 | 37 | 45 | 52 | 60 | 90 | 119 | 149 |
| 3500 | .30 | 3 | 6 | 9 | 12 | 15 | 22 | 29 | 36 | 44 | 51 | 58 | 87 | 116 | 145 |
| 3600 | .29 | 3 | 6 | 8 | 11 | 14 | 21 | 28 | 35 | 42 | 49 | 57 | 85 | 113 | 141 |
| 3700 | .28 | 3 | 6 | 8 | 11 | 14 | 21 | 28 | 34 | 41 | 48 | 55 | 82 | 110 | 137 |
| 3800 | .27 | 3 | 5 | 8 | 11 | 13 | 20 | 27 | 33 | 40 | 47 | 54 | 80 | 107 | 133 |
| 3900 | .27 | 3 | 5 | 8 | 10 | 13 | 20 | 26 | 33 | 39 | 46 | 52 | 78 | 104 | 130 |
| 4000 | .26 | 3 | 5 | 8 | 10 | 13 | 19 | 26 | 32 | 38 | 45 | 51 | 76 | 102 | 127 |

**Figure 12-22. Deflection conversion table.**

**EXAMPLE**

The mortar section has completed a registration mission and is prepared to adjust the sheaf. The initial range for the RP is 2,750 meters. The No. 1 and No. 3 mortars fire one round each. The FO sends the following corrections: NUMBER 3, R30; NUMBER 1, L20; END OF MISSION, SHEAF ADJUSTED. Any corrections of 50 meters or more must be refired.

For this example, the last deflection fired from No. 1 and No. 3 was 2931 mils. Using the DCT, round off the range to the nearest 100 meters (2,800). Find 2,800 meters in the range column and using the FO's corrections, find 30 and 20 in the deflection-in-meters column. Go across and down those columns to where they intersect. The table shows that the requirements are 11 mils for 30 meters and 7 mils for 20 meters.

Using this information, use the previous deflection fired, which was 2931 mils. Since the FO's correction for the No. 3 mortar was R30, which equals R11 mils (using the LARS rule), subtract 11 mils from 2931 mils. This gives a new deflection of 2920 mils. The correction for No. 1 mortar was L20, which equals L7 mils. Using the LARS rule for deflection, add 7 mils to 2931, which gives a new deflection of 2938 mils.

If there is no deflection conversion table available, use the mil-relation formula (W/R x M) to convert the corrections from meters to mils. To use the formula for the same FO's corrections of R30 and L20 used in the example cited, cover the item needed (in this case M [mils]). The remainder of the formula states: divide W (width in meters) by R (range in thousandths).

W/R = 20/2.8 = M        20 ÷ 2.8 =  7.1  =  7 mils

W/R = 30/2.8 = M        30 ÷ 2.8 = 10.7  =  11 mils

These are exactly the same figures determined using the DCT.

# GRID MISSION

12-41.  For an observed chart, the grid coordinates of the target must be plotted on the map, and a direction and distance determined from the mortar location to the target. For modified and surveyed charts, index "0" and plot the target using the grid coordinates.

**NOTE:** Corrections for VI can be used on the modified and surveyed charts.

# SHIFT FROM A KNOWN POINT MISSION

12-42.  For an observed chart, the known point must be plotted on the firing chart. This may be a fired-in target or a mark-center-of-sector round. The OT azimuth is indexed, and the correction applied is sent in the CFF. For modified and surveyed charts, the same procedure is used as for the observed chart.

# POLAR PLOT MISSION

12-43.   The FO's location must be plotted on the plotting board before a polar plot mission can be fired. For an observed chart, the location can be plotted in three ways:

- By resection.
- By direction and distance.
- By range and azimuth from a known point.

## RESECTION

12-44.   Plot two known points on the plotting board. Then index the azimuths the FO sends from these two points, and draw lines from the known points toward the bottom of the board. The intersection of these lines is the FO's location. (Figure 12-23).
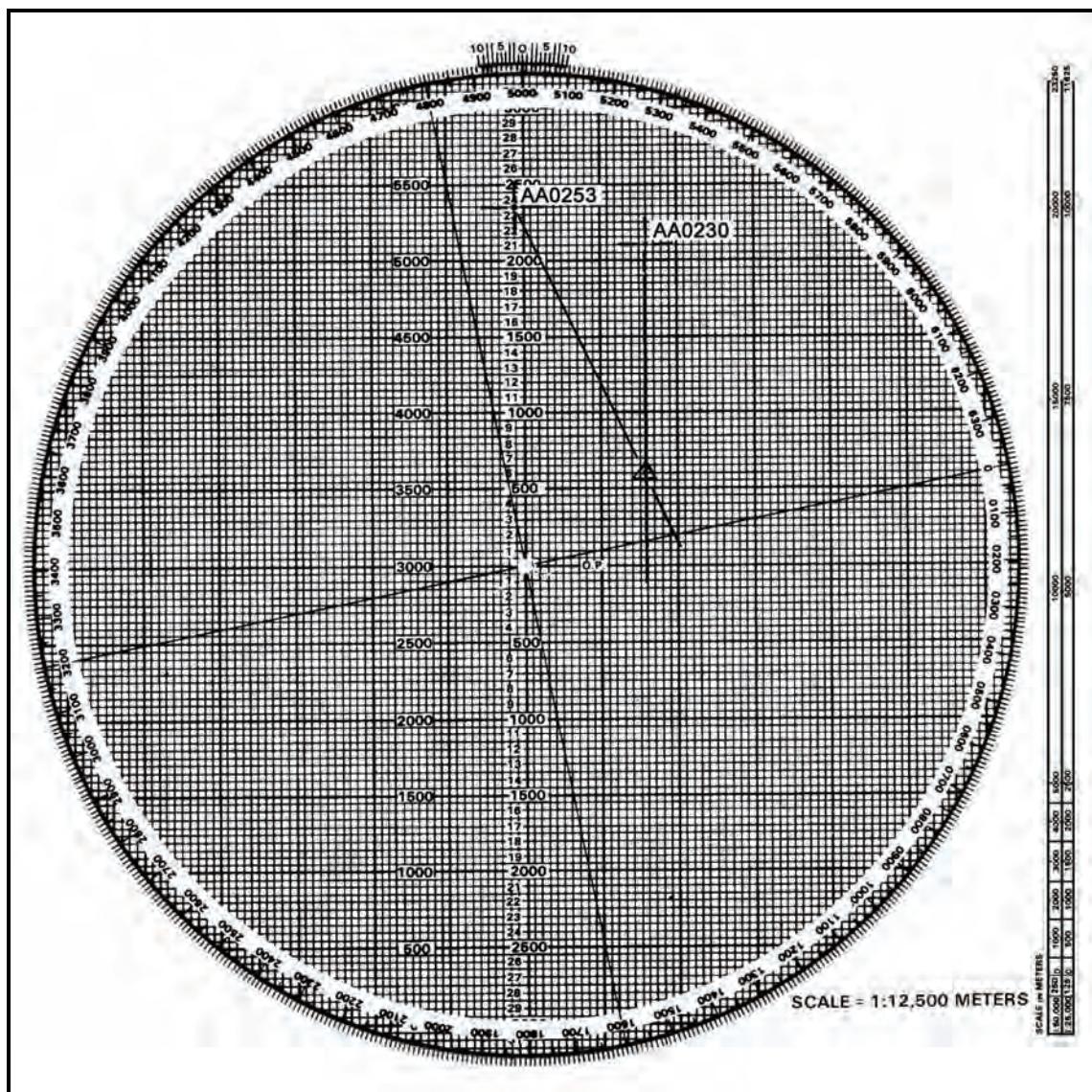
**Figure 12-23. Resection.**

## INTERSECTION

12-45.   Similar to resection, intersection (Figure 12-24) is a method of location that requires two separate observers that can see the same target/point of interest. Plot the two FOs on the plotting board. Index the azimuth from the first FO to the target/point of interest. Draw a line from the first FO to the top of the board. Next, index the azimuth from the second FO to the target/point of interest. Draw a line from the second FO to the top of the board. These two lines intersect at the location of the target/point of interest.
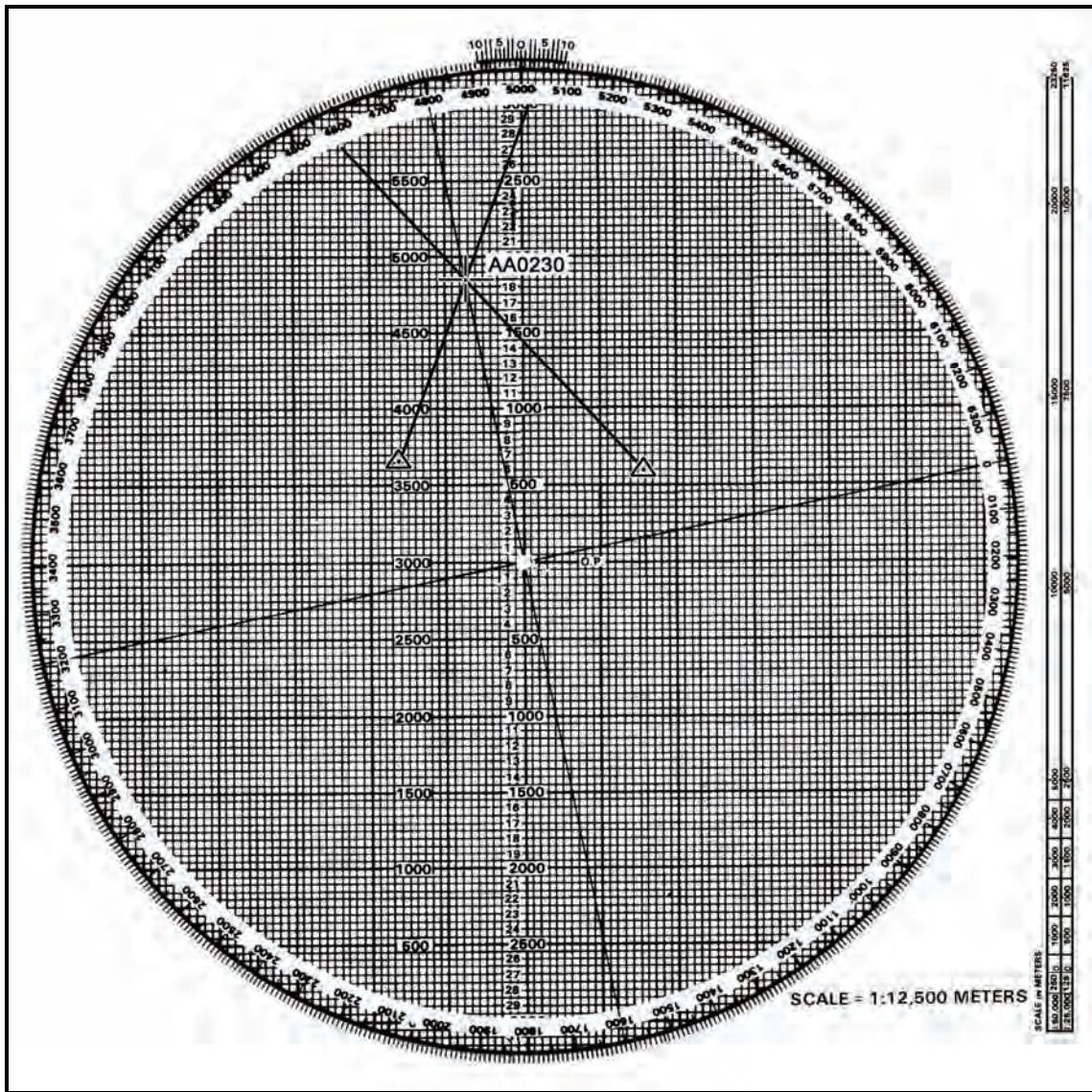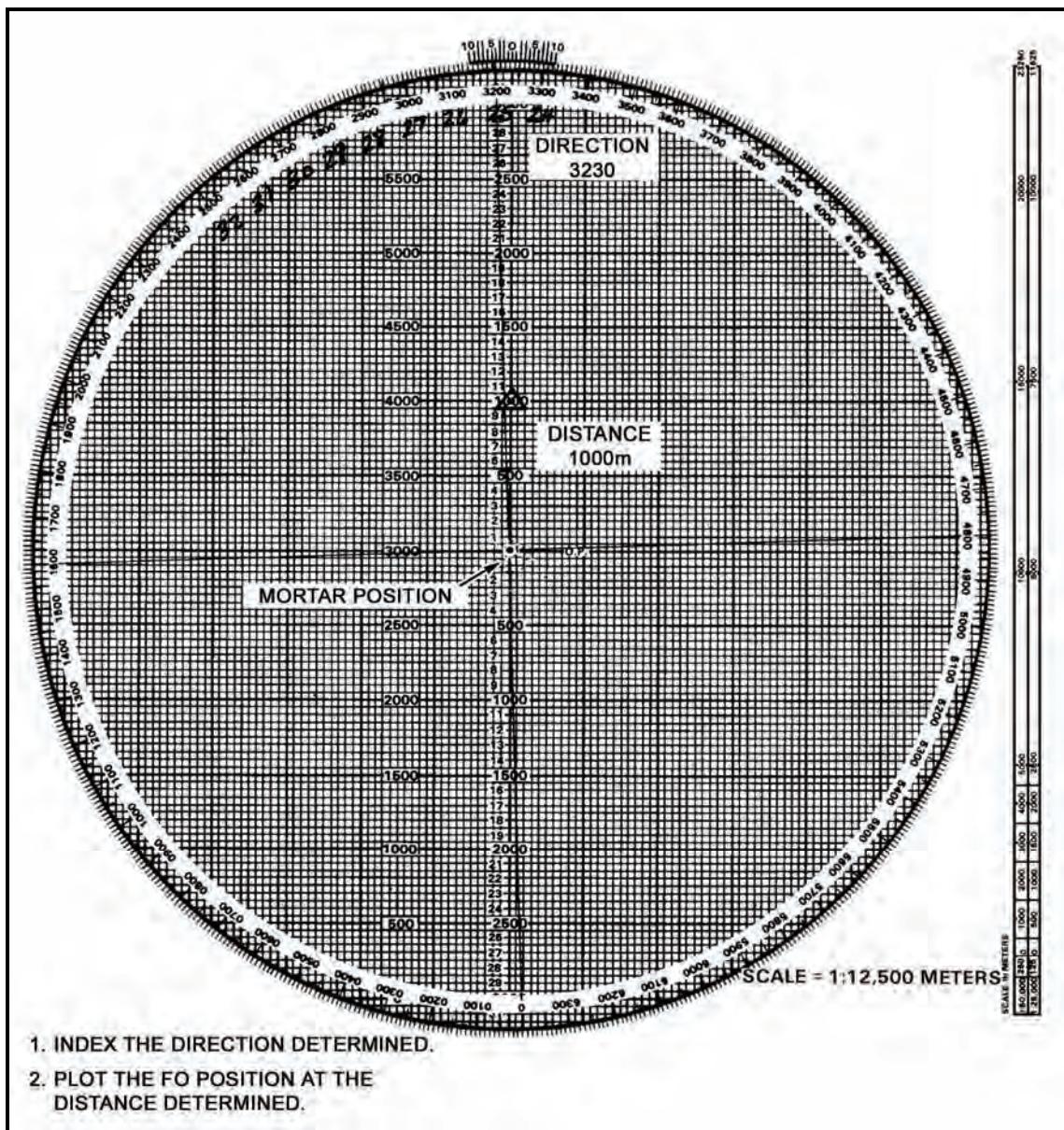


**Figure 12-24. Intersection.**

## DIRECTION AND DISTANCE

12-46.   The FO sends the computer the grid to the FO position. The computer then plots the grid on the map, determines the direction and distance from the mortar position to that grid, transfers the direction and distance to the plotting board, and plots the FO's location. (Figure 12-25).

**Figure 12-25. Direction and distance.**

### RANGE AND AZIMUTH FROM A KNOWN POINT

12-47.   The FO must send the range from the known point and the azimuth on which that point is seen. Once that is known, the computer can index the azimuth, drop below the known point the range given, and plot the FO's location (Figure 12-26). For modified and surveyed charts, the FO's location can be plotted if the grid of the FO is known, by indexing "0" and plotting the FO grid. If the grid is not known, then the computer can use resection, direction and distance, or range and azimuth from a known point.
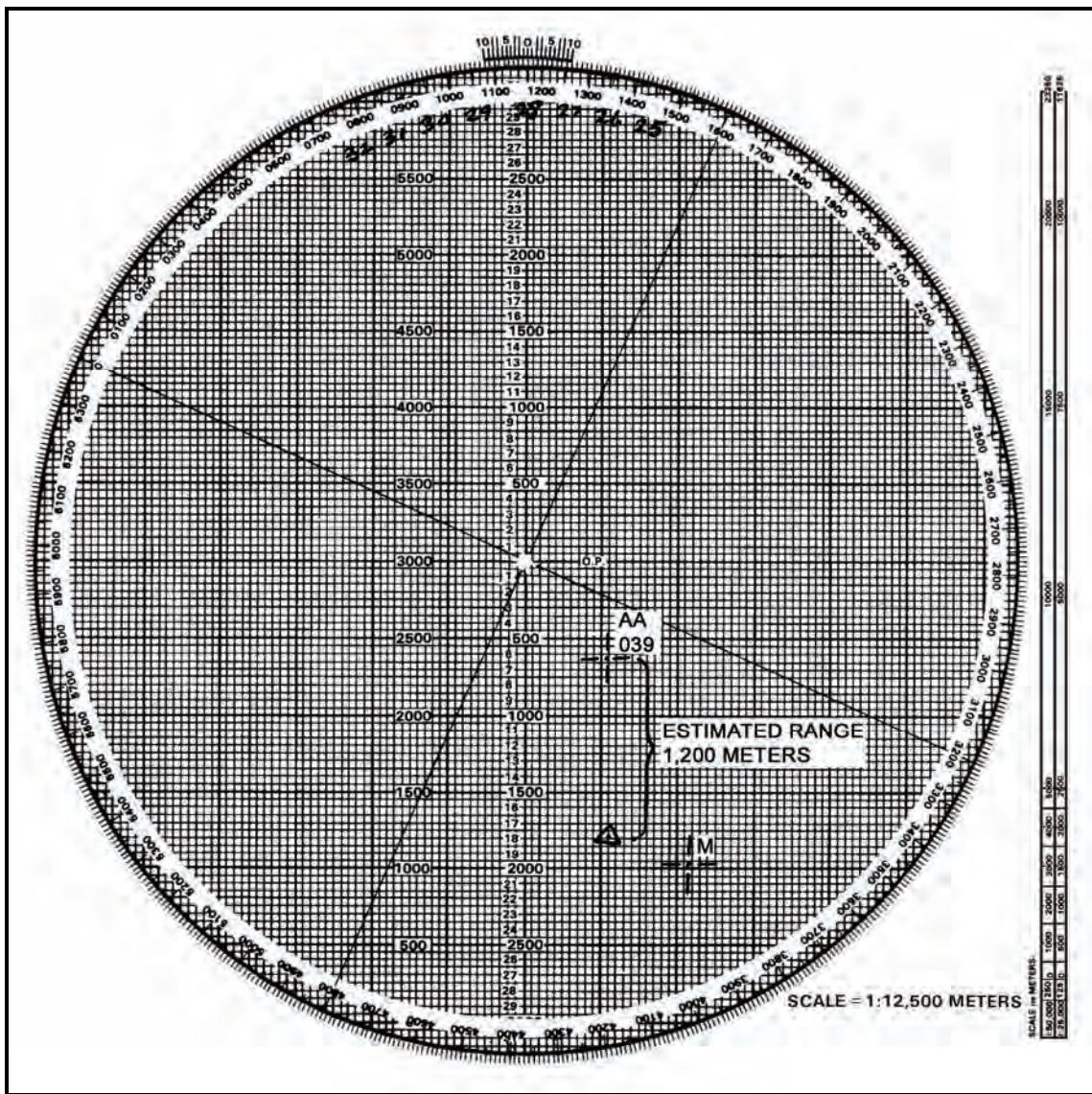


**Figure 12-26. Estimate of range from the reference point of the forward observer's location.**

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## Chapter 13

# Types of Missions

Certain missions require special procedures for the effective engagement of targets; therefore, these missions should not be fired on the observed chart. Area targets have width or depth (or both), requiring the mortar section to use either searching or traversing fire, or a combination of both.

## TRAVERSING FIRE

13-1. Traversing fire is used when the target has more width than a section firing a parallel sheaf can engage. Each mortar of the section covers part of the total target area and traverses the area.

13-2. The M16/M19 plotting board can be constructed as any of the three firing charts. The following data are used to set up the plotting board for traversing fire:

- Grid intersection.
- Direction of fire.
- Mounting azimuth.
- Mortar position.
- Mortar position attitude.
- Mortar altitude.
- Referred deflection.

13-3. Upon receiving the CFF, the section sergeant determines from the target's size and description that traversing fire must be used to cover the target. To effectively engage a target using traversing fire, the section sergeant ensures that the target's attitude is within 100 mils of the firing section's attitude. The section sergeant then completes the FDC order (Figure 13-1).

13-4. The three or four mortars are plotted separately on the M16/M19 plotting board, using the section's attitude. During the mission, the computer ensures that the correct plots are used to determine the data required.

---

### EXAMPLE

Table 13-1 lists the data used to set up the M16 plotting board for traversing fire.

**Table 13-1. M16 plotting board data for traversing fire.**

| | |
|---|---|
| Grid Intersection | 04/64 |
| Direction of Fire | 2700 mils |
| Mounting Azimuth | 2700 mils |
| Mortar Position | FB02006500 |
| Mortar Position Attitude | 1080 mils |
| Mortar Altitude | 400 meters |
| Referred Deflection | 0700 mils |

During the adjustment phase of the mission, the impact point is aligned with the No. 2 mortar plot. Using the information in the CFF, the FDC order, and the observer corrections, compute the data to adjust the No. 2 mortar onto the target's center of mass. After the adjustment is complete (Figure 13-2)—

    (1)  Plot the target's length (250 meters) on the plotting board using the target's attitude.

    (2)  Divide the target into segments.

    (3)  Determine the number of rounds for each segment.

    (4)  Determine the mil width of one segment.

    (5)  Determine the number of turns required to cover one segment.

    (6)  Determine the number of turns that must be taken between rounds.



**Figure 13-1. Example of DA Form 2399-R (Computer's Record) with a completed call for fire and fire direction center order.**

**COMPUTER'S RECORD**
For use of this form, see FM 3-22.91; the proponent agency is TRADOC

| ORGANIZATION | DATE | TIME | OBSERVER ID | TARGET NUMBER |
|---|---|---|---|---|
| B Co 1/29 IN | | | D61 | CA 0701 |

☐ ADJUST FIRE  ☐ FIRE FOR EFFECT
☐ IMMEDIATE SUPPRESSION

GRID 038 629
OT DIRECTION 2400
ALTITUDE 420

SHIFT FROM _____
OT DIRECTION _____ ALTITUDE _____
☐ LEFT / ☐ RIGHT _____
☐ ADD / ☐ DROP _____
☐ UP / ☐ DOWN _____

POLAR
OT DIRECTION _____ ALTITUDE _____
DISTANCE _____
☐ UP / ☐ DOWN _____
VERTICAL ANGLE ☐ + / ☐ - _____

TARGET DESCRIPTION   CIO 250×50 ATT 0720
METHOD OF CONTROL

METHOD OF ENGAGEMENT
MESSAGE TO OBSERVER

| FDC ORDER | INITIAL CHART DATA | INITIAL FIRE COMMAND | ROUNDS EXPENDED |
|---|---|---|---|
| MORTART TO FFE   SEC | DEFLECTION   0918 | MORTAR TO FOLLOW   SEC | |
| MORTAR TO ADJ   #2 | DEFLECTION CORRECTION ☐ L ☐ R | SHELL AND FUZE   HEQ | |
| METHOD OF ADJ   1 Rd | | | |
| BASIS FOR CORRECTION | RANGE | MORTAR TO FIRE   #2 | |
| SHEAF CORRECTION   Open | VI/ALT CORRECTION ☑ . ☐ . 20 | METHOD OF FIRE   1 Rd | |
| SHELL AND FUZE   HEQ IN ADJ | | 3 Rds PROX IN FFE | ① HE |
| PROX IN FFE | RANGE CORRECTION ☐ . ☐ . 0 | DEFLECTION/AZIMUTH   0918 | |
| METHOD OF FFE   3 Rds | | CHARGE   5 | |
| RANGE LATERAL SPREAD | CHARGE/RANGE   5 | TIME SETTING | |
| TIME OF OPENING FIRE   W/R | AZIMUTH   2320 | ELEVATION   0963 | |
| | ANGLE T   80 | | |

| OBSERVER CORRECTION | | | CHART DATA | | SUBSEQUENT COMMANDS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DEV | RANGE | TIME (HEIGHT) | DEFL | CHARGE (RANGE) | MORTAR FIRE | METHOD FIRE | DEFL AZIMUTH | RANGE / CHARGE | TIME (SETTING) | ELEV | |
| L120 | | | 0960 | 2750 | | | 0960 | | | 0963 | ① HE |
| | -100 | | 0962 | 2650 | | | 0962 | | | 1010 | ② HE |
| | -50 | FFE | 0963 | 2600 | PREPARE TO TRAVERSE RIGHT | | | | | | |

DA FORM 2399-R, FEB 2005          REPLACES DA FORM 2399, DEC 91 WHICH IS OBSOLETE          APO V1.00

**Figure 13-2. Example of DA Form 2399-R (Computer's Record) with completed adjustment.**

(1) To plot the target on the plotting board, the computer rotates the azimuth disc until the target attitude (taken from the CFF) is indexed. The computer erases all of the plots except the last one. After ensuring that the attitude is indexed, the computer divides the total target area into segments. These plots represent the starting points for each mortar. The area between the plots is the area each mortar must cover with fire (Figure 13-3).
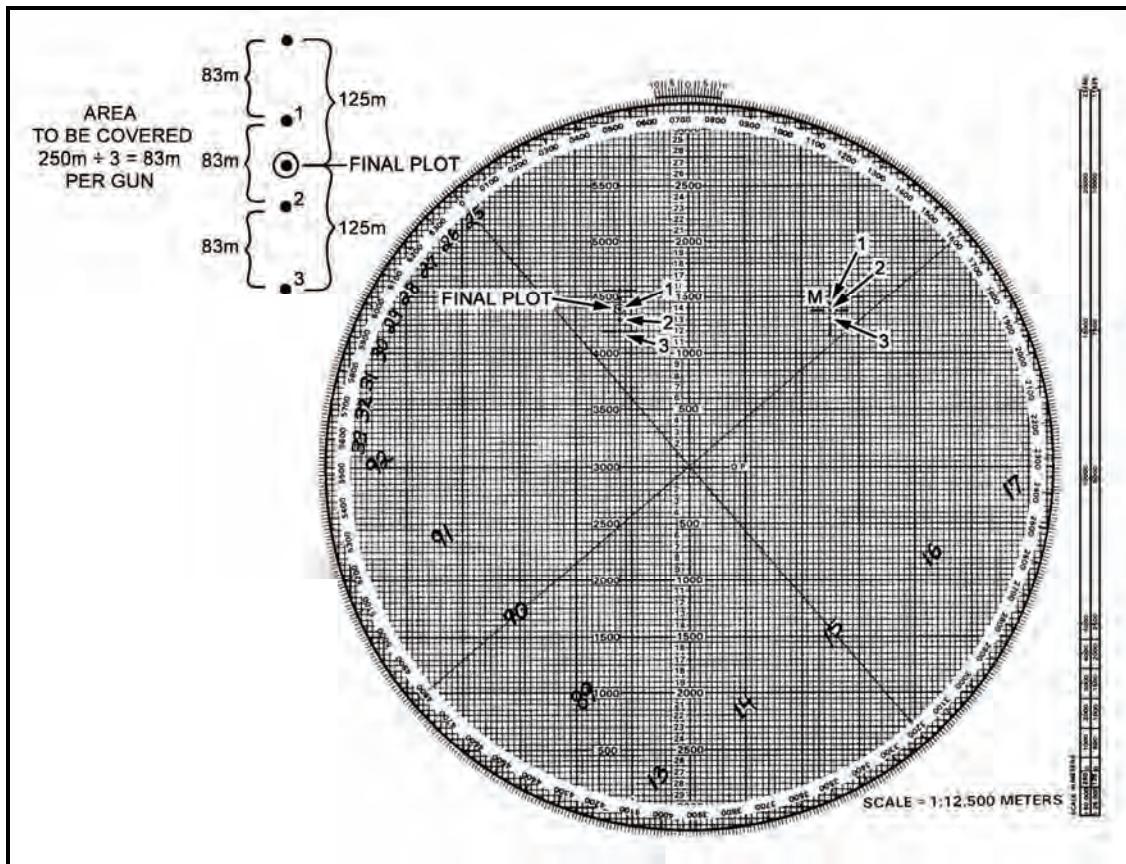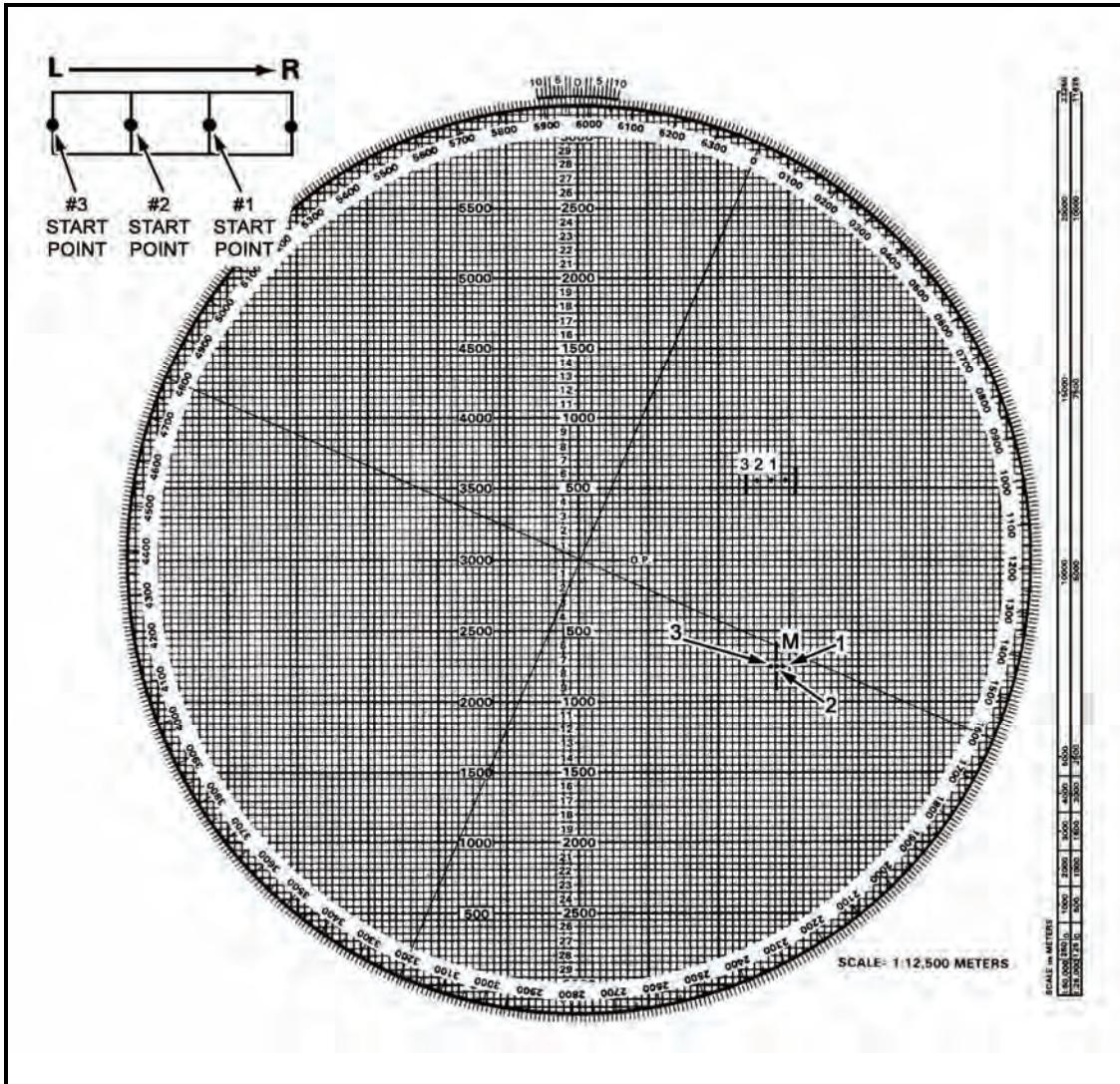


**Figure 13-3. Plotting of starting points.**

(2) The target is now divided into three segments (each being 83 meters, in the example). Once the remaining data for one segment have been determined, the data will apply to all three mortars. If the computer determines the mil width of one segment, the other two will be the same. The computer can use one of two methods to determine the mil width of one segment.

■ In the first method, the computer knows the deflection that was used to hit the No. 3 point. First, he aligns the No. 2 plot and No. 3 mortar to determine the proper deflection for the mortars to hit the start point for the No. 2 mortar (Figure 13-4). Then, he subtracts these two numbers to determine the segment's mil width.



**Figure 13-4. Alignment of No. 2 and No. 3 plots.**

---

**EXAMPLE**

2993 mils (No. 3 plot deflection) - 2942 mils (No. 2 plot deflection) = 51 mils (mil width of segment)

---

■ The second method uses the DCT to determine the mil width of one segment. The computer enters the DCT at the final chart range (rounded off to the nearest 100 meters). He follows the Deflection in Meters line to the closest number of meters (75) needed to cover the segment. The point at which the Range line and the Deflection line meet is the number of mils that will cover the segment. Each turn of the traversing handwheel is about 10 mils. By dividing the mil width of each segment (29) by 10, the computer obtains the total number of turns needed to cover the segment (round off to the nearest whole turn).

---

**EXAMPLE**

29.0 (mil width of each segment) ÷ 10 = 2.9

Round to the nearest whole turn = 3 (turns needed to cover the segment)

---

(3) To compute the number of turns that must be taken between rounds, the computer must know how many rounds will be fired for each segment. This information is given in the FDC order (three rounds, in the example). To determine the number of turns that must be taken between rounds, the computer divides the total number of turns by the interval between rounds.

---

**RULES:**  1.  There will always be one less interval than the number of rounds. Three rounds = two intervals, for example.

2.  The turns taken between rounds are rounded to the nearest half turn.

3.  The number of rounds to fire is based on the rule: four rounds per 100 meters of target width, or one round per 30 meters for 81-mm mortars; or two rounds per 100 meters of target width, or 1 round for 60 meters for 120-mm mortars.

---

**EXAMPLE**

3.0 (total number of turns) ÷ 2 (interval between rounds) = 1.5 = 1 1/2 (turns taken between rounds)

In this instance, there is no need to round to the nearest half turn.

---

(4) The computer determines the deflection and range for each mortar by aligning each mortar with its start point. Then, he completes the subsequent command and issues it to the mortar section.

---

**NOTE:**  If there is a range change of 25 meters or more, the mortar will receive its own elevation.

---

(5) Upon completion of the adjustment phase of the mission, the section is given the command, "Prepare to traverse right (left)." The gunners then traverse the mortars in the direction opposite to that given, back off two turns, and await further instructions (Figure 13-5).

**COMPUTER'S RECORD**

For use of this form, see FM 3-22.91; the proponent agency is TRADOC

| ORGANIZATION | DATE | TIME | OBSERVER ID | TARGET NUMBER |
|---|---|---|---|---|
| B Co 1/3q IN | | | D 61 | CA 0701 |

☐ ADJUST FIRE  ☐ FIRE FOR EFFECT
☐ IMMEDIATE SUPPRESSION

GRID _038 629_
OT DIRECTION _2400_
ALTITUDE _420_

SHIFT FROM _____
OT DIRECTION _____ ALTITUDE _____
☐ LEFT /  ☐ RIGHT _____
☐ ADD /  ☐ DROP _____
☐ UP /  ☐ DOWN _____

POLAR
OT DIRECTION _____ ALTITUDE _____
DISTANCE _____
☐ UP /  ☐ DOWN _____
VERTICAL ANGLE ☐ + /  ☐ - _____

TARGET DESCRIPTION _CIO 250 × 50 ATT 0720_    METHOD OF CONTROL

METHOD OF ENGAGEMENT     MESSAGE TO OBSERVER

| FDC ORDER | INITIAL CHART DATA | INITIAL FIRE COMMAND | ROUNDS EXPENDED |
|---|---|---|---|
| MORTART TO FFE _Sec_ | DEFLECTION _0918_ | MORTAR TO FOLLOW _SEC_ | |
| MORTAR TO ADJ _#2_ | DEFLECTION CORRECTION | SHELL AND FUZE _HEQ_ | |
| METHOD OF ADJ _1 Rd_ | ☐ L  ☐ R | | |
| BASIS FOR CORRECTION _____ | RANGE _____ | MORTAR TO FIRE _#2_ | |
| SHEAF CORRECTION _Open_ | VI/ALT CORRECTION ☑ +  ☐ -  20 | METHOD OF FIRE _1 Rd_ | ① HE |
| SHELL AND FUZE _HEQ in Adj_ _PROX in FFE_ | | _3 Rds PROX in FFE_ | |
| METHOD OF FFE _3 Rds_ | RANGE CORRECTION ☐ +  ☐ - | DEFLECTION/AZIMUTH _0918_ | |
| | | CHARGE _5_ | |
| RANGE LATERAL SPREAD _____ | CHARGE/RANGE _5_ | TIME SETTING _____ | |
| TIME OF OPENING FIRE _W/R_ | AZIMUTH _2320_ | ELEVATION _0963_ | |
| | ANGLE T _80_ | | |

| OBSERVER CORRECTION | | | CHART DATA | | SUBSEQUENT COMMANDS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DEV | RANGE | TIME (HEIGHT) | DEFL | CHARGE (RANGE) | MORTAR FIRE | METHOD FIRE | DEFL AZIMUTH | RANGE / CHARGE | TIME (SETTING) | ELEV | |
| L120 | | | 0960 | 2750 | | | 0960 | | | 0963 | ① HE |
| | -100 | | 0962 | 2650 | | | 0962 | | | 1010 | ② HE |
| | -50 | FFE | 0963 | 2600 | PREPARE | TO TRAVERSE RIGHT | | | | | |
| | | | | | Sec | 3 RDS PROX | TRAVERSE RIGHT 1½ TURNS | | | | |
| | | | | | | | ① 0958 | 2625 | | 1021 | |
| | | | | | | | ② 0974 | 2600 | | 1031 | |
| | | | | | | | ③ 1000 | 2575 | | 1041 | ④ PROX |

DA FORM 2399-R, FEB 2005     REPLACES DA FORM 2399, DEC 91 WHICH IS OBSOLETE     APD V1.00

**Figure 13-5. Example of a completed DA Form 2399-R (Computer's Record) for a completed mission.**

# SEARCHING FIRE

13-5. Mortars can cover area targets more than 50 meters deep by either elevating or depressing the barrel during the FFE. Sections can cover areas up to 50 meters (three mortars firing four rounds on the same elevation and deflection) due to range and deflection dispersion.

13-6. In the CFF, the FO sends the target's size and attitude since it has more depth than a section firing a linear sheaf can engage. The FO gives the width and depth of the target's attitude. Attitude is the direction (azimuth) through the target's long axis.

13-7. For the mortar section to effectively engage a target using only searching fire with the M16/M19 plotting board, the target's attitude cannot be more than 100 mils difference from the gun section's attitude. If the difference is more than 100 mils, the target should be engaged using a combination of searching and traversing fire, or traversing fire only. When a section fires a searching mission, the adjustment phase is the same as that of a regular mission using the base mortar (No. 2) as the adjusting mortar. The base mortar is adjusted to the target's center of mass.

13-8. Upon completion of the adjustment phase of the mission, the computer must compute the data needed to cover the target with fire using the target area given in the CFF. He must determine the number of rounds necessary to cover the target, the number of turns required to cover the target, and the number of turns taken between rounds.

---

**NOTES:**   1.   When firing on a target using traversing or searching fire, the computer uses four rounds for every 100 meters of target width or depth, or one round for every 30 meters for 81-mm mortars; or two rounds per 100 meters of target width, or 1 round for 60 meters for 120-mm mortars.

2.   The computer must always consider the number of rounds on hand and the resupply rate when determining the number of rounds to fire.

---

**EXAMPLE**

Assume that the target's depth is 350 meters, and the engagement is with 81-mm mortars.

(1)   Four rounds are required to cover 100 meters.

$350 \div 100 = 3.5$ (or 3 even 100s)

4 x 3 (for 300, the number of 100s of meters) = 12

(2)   For the remainder of the target depth (50 meters), add one round for every 30 meters.

12 + 1 = 13 (rounds)

(3)   At this point, 20 meters of target is left. To cover the 20 meters, add one more round.

13 + 1 = 14 (rounds to cover 350 meters)

(1) When determining the number of turns needed to cover the target, the computer can use one of two methods.

- If the computer is using the unabridged firing table, the number of turns in elevation required for a 100-meter change in range is given in column 4 of Table D (Basic Data).

---

**EXAMPLE**

Assume the target is 350 meters in depth, the range to the target's center of mass is 2,125 meters (always use chart range), and the firing charge is 4.

To determine the number of turns needed to cover the target —

(1) Determine the range to the target's center of mass (2,125).
(2) Enter the firing table at charge 4, range 2,125, and go across to column 4.
(3) Four turns are needed to cover 100 meters.
(4) Multiply 4 by 3.5 (range in hundreds) to get the number of turns needed to cover the target.

4 x 3.5 (range in hundreds) = 14 (turns needed to cover the target area)

The mortars are adjusted to the center of mass. To obtain the range to the far edge (search up), add half of the target area to the range to the center of mass.

175 (half of the target area) + 2,125 (range to the center of mass) = 2,300 (range to the far edge)

---

**EXAMPLE**

The range to the center of mass is 2,125 meters; the target area is 100 meters by 350 meters; and the range to the far end is 2,300 meters.

(1) Divide the target's depth by two.

350 (target's depth) ÷ 2 = 175 meters (half of the target depth)

(2) To search down, start at the near edge and subtract half of the target depth from target center.

2125 (target center) – 175 meters (half of the target depth) = 1950meters

---

■ To apply the second method, the computer must determine the mil length of the target using FTs. He uses the elevation for the far end of the target (adjusting point) and the elevation to hit the near end of the target.

---

**EXAMPLE**

Range to adjusting point     2,300 meters        Elevation    974 mils

Range to near end        1,950 meters        Elevation    1128 mils

(1) Subtract the two elevations to determine the mil length of the target.

    1128 mils (elevation for the range to the near end)
  - 974 mils (elevation for the range to the adjusting point)
    154 mils (length of the target)

---

NOTE: Each turn of the elevating crank is 10 mils (5 mils for the 120-mm mortars).

---

(2) Divide the mil length of the target (154 mils) by 10 to get the total number of turns needed to cover the target. Round to the nearest whole turn.

154.0 (mil length of the target) ÷ 10 = 15.4 = 15 (total turns needed to cover the target)

---

**NOTE:** Table D (Basic Data) gives the number of turns per 100 meters difference in range. This data may be used to determine the total number of turns needed to cover the target.

---

(2) To compute the number of turns that must be taken between rounds, the computer must know how many rounds each mortar will fire. The computer computes this information or finds it in the FDC order (14 rounds, in the example). To determine the number of turns that must be taken between rounds, he divides the total number of turns by the intervals between rounds. The computer rounds the product to the nearest half turn.

---

**NOTE:**     1.    There will always be one less interval than the number of rounds. For example, 14 rounds = 13 intervals.

             2.    Turns between rounds will be rounded to the nearest half turn.

---

**EXAMPLE**

15.0 (total number of turns) ÷ 13 (intervals between rounds) = 1.15 = 1 (turn between rounds).

---
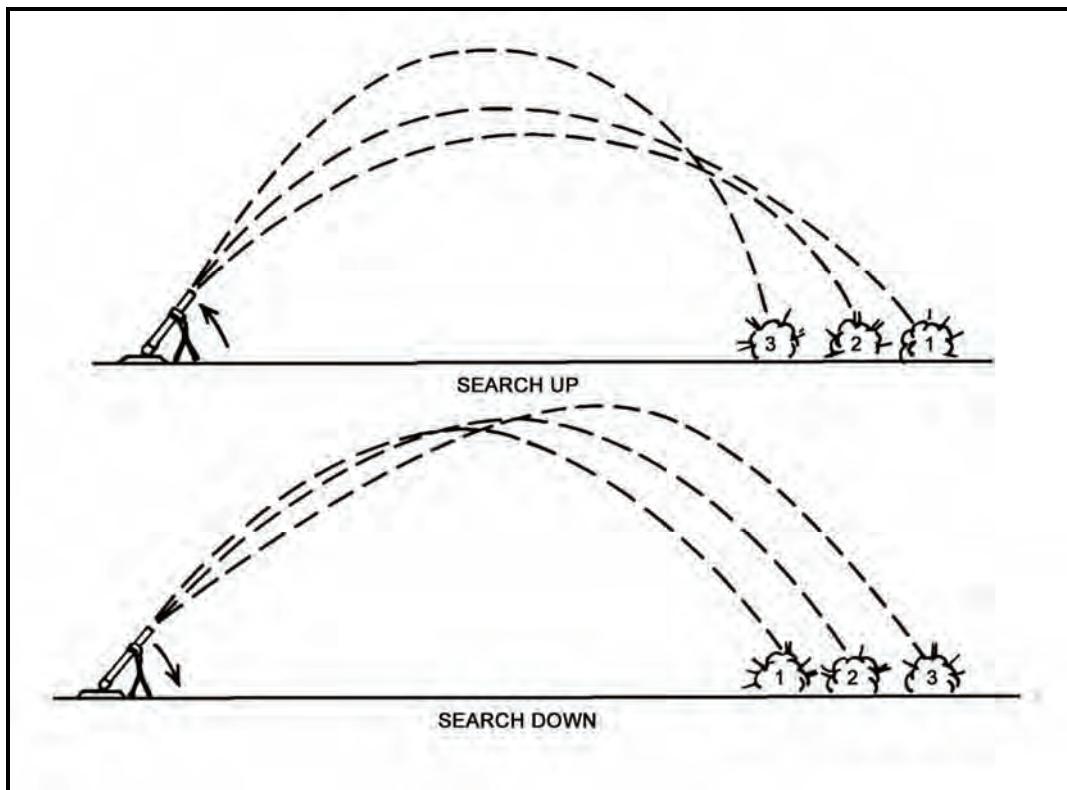
**RULE:**   The number of rounds to fire is based on the rule: four rounds per 100 meters of target depth, or one round per 30 meters for 81-mm mortars; or two rounds per 100 meters of target width, or 1 round for 60 meters for 120-mm mortars.

---

(3) At this point, the computer has all of the information needed to complete the subsequent command. The command can then be issued to the mortars (Figure 13-6).

**COMPUTER'S RECORD**
For use of this form, see FM 3-22.91; the proponent agency is TRADOC

| ORGANIZATION | DATE | TIME | OBSERVER ID | TARGET NUMBER |
|---|---|---|---|---|
| B Co 1/29 IN | | | G 35 | AL 0015 |

☑ ADJUST FIRE  ☐ FIRE FOR EFFECT  ☐ IMMEDIATE SUPPRESSION

SHIFT FROM _____

POLAR
OT DIRECTION _____ ALTITUDE _____
DISTANCE _____

GRID  149 908
OT DIRECTION  5840
ALTITUDE _____

OT DIRECTION _____ ALTITUDE _____
☐ LEFT /  ☐ RIGHT _____
☐ ADD /  ☐ DROP _____
☐ UP /  ☐ DOWN _____

☐ UP /  ☐ DOWN _____
VERTICAL ANGLE  ☐ +/  ☐ - _____

TARGET DESCRIPTION  Supply Depot  100 X 350  ATT 5400

METHOD OF CONTROL

METHOD OF ENGAGEMENT

MESSAGE TO OBSERVER

| FDC ORDER | INITIAL CHART DATA | INITIAL FIRE COMMAND | ROUNDS EXPENDED |
|---|---|---|---|
| MORTART TO FFE  SEC | DEFLECTION  3472 | MORTAR TO FOLLOW  SEC | |
| MORTAR TO ADJ  #2 | DEFLECTION CORRECTION  ☐ L  ☐ R | SHELL AND FUZE  HEQ | |
| METHOD OF ADJ  1 Rd | | | |
| BASIS FOR CORRECTION ___ | RANGE  2300 | MORTAR TO FIRE  #2 | |
| SHEAF CORRECTION ___ | V/ALT CORRECTION  ☐ +  ☑ -30 | METHOD OF FIRE  1 Rd | |
| SHELL AND FUZE  HEQ | | 14 Rds in FFE | ① |
| | RANGE CORRECTION  ☐ +  ☐ - | DEFLECTION/AZIMUTH  3472 | |
| METHOD OF FFE  14 Rds | | CHARGE  4 | |
| RANGE LATERAL SPREAD ___ | CHARGE/RANGE  4 | TIME SETTING ___ | |
| TIME OF OPENING FIRE  W/R | AZIMUTH  5440 | ELEVATION  0974 | |
| | ANGLE T  450 | | |

| OBSERVER CORRECTION | | | CHART DATA | | SUBSEQUENT COMMANDS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DEV | RANGE | TIME (HEIGHT) | DEFL | CHARGE (RANGE) | MORTAR FIRE | METHOD FIRE | DEFL AZIMUTH | RANGE / CHARGE | | TIME (SETTING) | ELEV | |
| L100 | -100 | | 3534 | 2250 | | | 3534 | 2250 | | 1002 | ② |
| | -100 | | 3558 | 2175 | | | 3558 | 2175 | | 1039 | ③ |
| | +50 | FFE | 3544 | 2200 | SEC | AMC 14 Rds Search up 1 turn | 3544 | 2375 | (FAa EDGE) | 0922 | ㊺ |

DA FORM 2399-R, FEB 2005        REPLACES DA FORM 2399, DEC 91 WHICH IS OBSOLETE        APD V1.00

**Figure 13-6. Example of completed DA Form 2399-R (Computer's Record) for a search mission.**

13-9. The only difference between a search up mission and a search down mission is the starting point. Normally, a search mission is fired by searching up. This allows the FO to better observe the effect of the rounds on a target, as the rounds walk toward him (Figure 13-7).



**Figure 13-7. Fall of rounds during a search mission.**

# ILLUMINATION

13-10.   Illumination assists friendly forces with light for night operations. The M16/M19 can be set up for illumination as any of the three types of firing charts. Determining firing data is the same as with any type of mission, only now the FDC uses one of the flank mortars to adjust the illumination, leaving the base mortar ready to adjust HE. The FO enters range corrections for the illumination rounds.

> **NOTE:**  Deviation corrections are no less than 200 meters, and height corrections (up/down) are no less than 50 meters.

## OBSERVERS

13-11.   Observers who adjust illumination should be informed when 81-mm mortars are firing M301A3 illumination rounds.
- The M301A3 has a HOB of 600 meters (Figure 13-8), while the M301A1 and M301A2 rounds have a 400-meter HOB.
- There is a difference in adjustment procedures. M301A1 and M301A2 rounds are adjusted to a ground-level burnout; the M301A3 round should have a burnout of 150 to 200 meters above the ground. This procedure is based on the fact that all three of the rounds fall at a rate of 6 meters per second (Table 13-2).
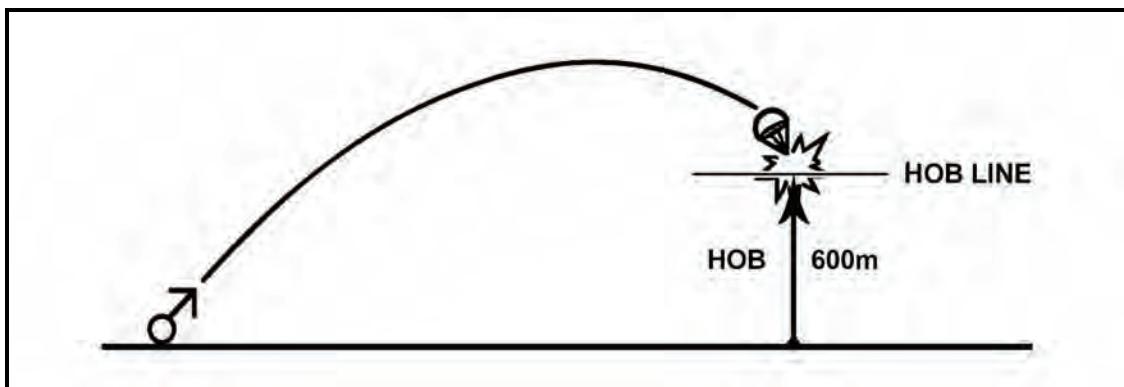
**Table 13-2. Example of illumination adjustment.**

| ROUNDS | RATE OF FALL (MPS) | BURN TIME (SECONDS) | HOB (METERS) | FALL BEFORE BURNOUT (METERS) |
|--------|---------|----------|---------|---------------|
| M301A1 | 6 | 60 | 400 | 6 x 60 = 360 |
| M301A2 | 6 | 60 | 400 | 6 x 60 = 360 |
| M301A3 | 6 | 60 | 600 | 6 x 60 = 360 |

## CORRECTIONS

13-12.   Corrections to the HOB are used to move the round up or down in relation to the HOB line (Figure 13-8).



**Figure 13-8. Height of burst line for an M301A3.**

## ADJUSTMENTS

13-13.   Adjustments are made after the initial illumination CFF has been made. This is done by observing the initial illumination burst in relation to the target. The observer will call in his corrections to the FDC.

## FIRST EXAMPLE

13-14.   The example will help illustrate the adjustments computed by the FDC. Once information has been given to the FDC from the FO, the FDC computes the data and sends the corrections to the gun section.

---

**EXAMPLE**

Consider the chart range to the first round fired: 2,525 meters.

(1)  Enter 2,550 meters into FT 81-A1-3 (Figure 13-9).

Optimum charge to use: charge 8

(2)  Columns 1 (Range to Burst), 2 (Elevation), and 3 (Fuze Setting) of Basic Data will give the basic HOB for 600 meters above the mortar position.
- Range to burst   =   2,550 meters
- Elevation   =   1107 mils
- Fuze setting   =   31.0

FT 8I-AI-3

CTG, ILLUMINATING, M301A3
FUZE, TIME, M84A1

CHARGE
8

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| RANGE TO BURST | ELEV | FUZE SETTING | CHANGE IN ELEV / FS FOR 50M INCREASE IN HEIGHT OF BURST | | MAX ORD | RANGE TO IMPACT |
| M | MILS | | MILS | | M | M |
| 1500 | 1351 | 34.6 | -2 | -0.4 | 1903 | 1621 |
| 1550 | 1342 | 34.5 | -2 | -0.4 | 1895 | 1675 |
| 1600 | 1332 | 34.4 | -2 | -0.4 | 1886 | 1730 |
| 1650 | 1322 | 34.3 | -3 | -0.4 | 1876 | 1784 |
| 1700 | 1313 | 34.2 | -3 | -0.4 | 1866 | 1839 |
| 1750 | 1303 | 34.1 | -3 | -0.4 | 1856 | 1894 |
| 1800 | 1293 | 34.0 | -3 | -0.4 | 1845 | 1949 |
| 1850 | 1282 | 33.8 | -3 | -0.4 | 1834 | 2004 |
| 1900 | 1272 | 33.7 | -3 | -0.4 | 1822 | 2060 |
| 1950 | 1261 | 33.6 | -3 | -0.4 | 1809 | 2115 |
| 2000 | 1250 | 33.4 | -4 | -0.4 | 1796 | 2171 |
| 2050 | 1239 | 33.3 | -4 | -0.4 | 1782 | 2226 |
| 2100 | 1227 | 33.1 | -4 | -0.4 | 1768 | 2282 |
| 2150 | 1216 | 32.9 | -4 | -0.4 | 1753 | 2338 |
| 2200 | 1204 | 32.7 | -5 | -0.4 | 1737 | 2395 |
| 2250 | 1191 | 32.5 | -5 | -0.4 | 1720 | 2451 |
| 2300 | 1179 | 32.3 | -5 | -0.5 | 1703 | 2508 |
| 2350 | 1165 | 32.1 | -6 | -0.5 | 1684 | 2565 |
| 2400 | 1152 | 31.9 | -6 | -0.5 | 1664 | 2623 |
| 2450 | 1137 | 31.6 | -7 | -0.5 | 1643 | 2681 |
| 2500 | 1123 | 31.3 | -7 | -0.5 | 1621 | 2739 |
| 2550 | 1107 | 31.0 | -8 | -0.5 | 1597 | 2798 |
| 2600 | 1091 | 30.7 | -9 | -0.6 | 1571 | 2858 |
| 2650 | 1073 | 30.4 | -10 | -0.6 | 1543 | 2919 |
| 2700 | 1054 | 30.0 | -12 | -0.6 | 1512 | 2981 |
| 2750 | 1034 | 29.5 | -14 | -0.7 | 1478 | 3045 |
| 2800 | 1011 | 29.0 | -17 | -0.8 | 1439 | 3110 |
| 2850 | 985 | 28.4 | -22 | -1.0 | 1394 | 3179 |
| 2900 | 953 | 27.6 | -34 | -1.3 | 1337 | 3253 |
| 2950 | 907 | 26.5 | | | 1254 | 3342 |

**Figure 13-9. FT 81-A1-3, charge 8, used in determination of location of round in relation to the height of burst.**

(3) The round is fired, and the FO sends, "Add two zero zero (200). Up one zero zero (100)" (Figure 13-10). The computed range is now:

2,725 = 2,750

The Basic Data only gave a HOB of 600 meters, but the FO requested an "up 100" correction, meaning that the round needs more height.

(4) To compute this change, determine where this round will be in relation to the HOB line.

HOB = 600 meters
"Up 100" is two increments above the HOB line.

(5) Once the number of increments has been determined, go to column 4 (Change in Elevation for 50-meter Increase in HOB) and column 5 (Changes in Fuze Setting for 50-meter Increase in HOB).

(6) Multiply the increments by the correction factors given in these columns. Use FT 81-A1-3, charge 8 (Figure 13-9).

- Range to burst: 2,750 meters, +2 increments
- Column 4 = -14
  -14 (number in column 4) x 2 (increments)
  (100 meters above HOB) = -28 mils
- Column 5 = -0.7
- -0.7 (number in column 5) x 2 increments
  (100 meters above HOB) = -1.4 seconds

(7) Basic data:
- 1034 mils (number in column 2) -28 mils = 1006 mils (elevation)
- 29.5 (number in column 3) -1.4 sec = 28.1 (fuze setting)
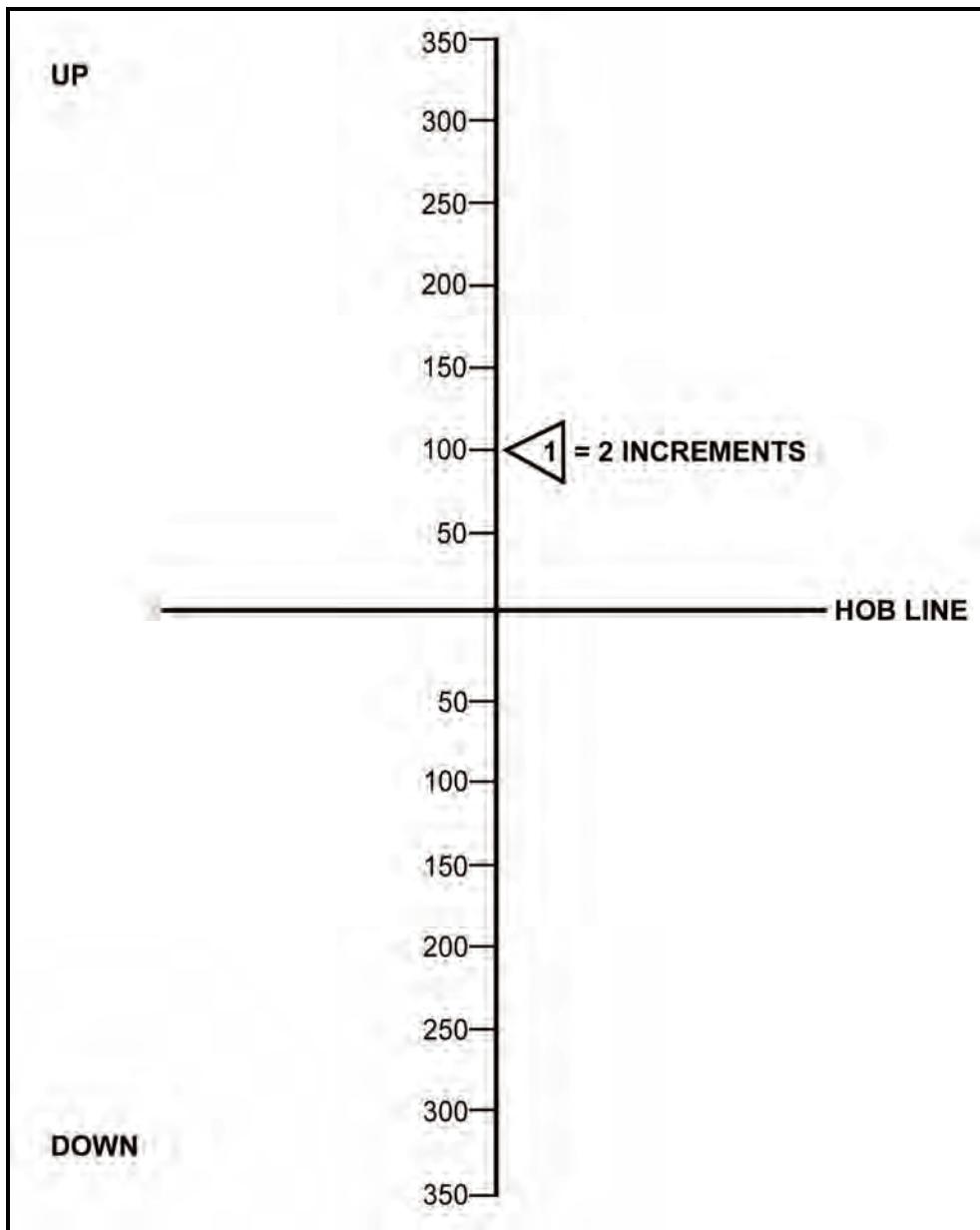
**Figure 13-10. Firing adjustment.**

(8) Assume that the second round is fired and the FO sends, "Down fifty (50)" (Figure 13-11). Note that a range change was not sent, but a HOB correction was sent.

(9) Again, determine the relation to the HOB line, and apply the correction factors to the Basic Data to obtain the firing data.

- Range to burst 2,750 meters, charge 8, down 50.
- The computer is now working with one increment above the HOB line.
- Increments (relationship to HOB, 600 meters)
  1 x -14 (number in column 4) = -14
  1 x -0.7 (number in column 5) = -0.7
- New data:
  1034 mils (basic data) -14 = 1020 mils (elevation)
  29.5 (basic data) -0.7 = 28.8 (fuze setting)
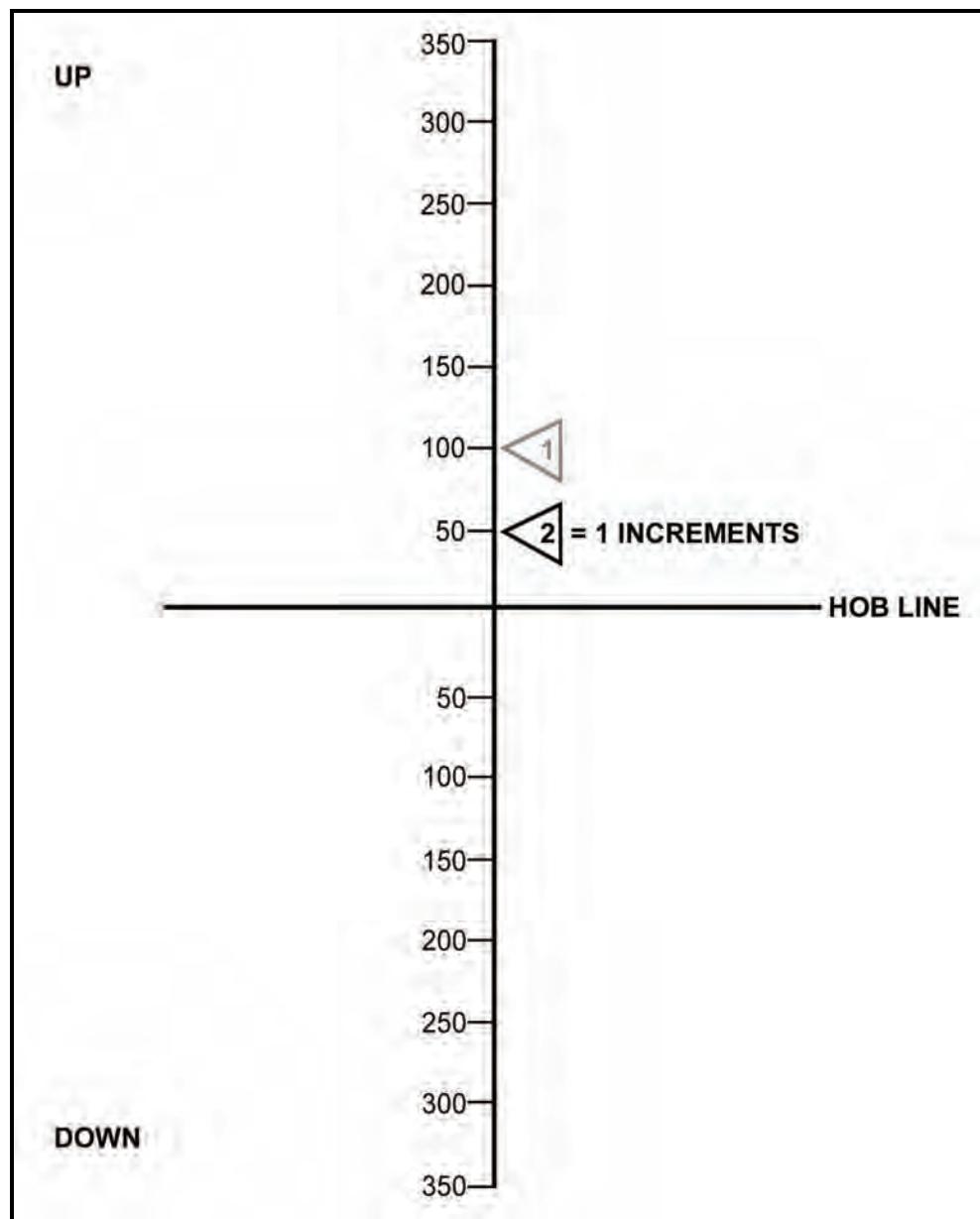
**Figure 13-11. Firing adjustment.**

## SECOND EXAMPLE

13-15.   This example will help illustrate the adjustments that the FDC computes when the round is below the HOB line. Charge 5 will be used, as shown in FT 81-A1-3 (Figure 13-12).

```
CHARGE                                              FT 81-AI-3
  5
                                      CTG, ILLUMINATING, M301A3
                                           FUZE, TIME, M84A1
```

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| RANGE TO BURST | ELEV | FUZE SETTING | CHANGE IN ELEV | FOR 50M INCREASE IN HEIGHT OF BURST FS | MAX ORD | RANGE TO IMPACT |
| M | MILS | | MILS | | M | M |
| 100 | 1450 | 4.5 | 13 | 0.4 | 600 | 714 |
| 150 | 1378 | 4.5 | 19 | 0.4 | 600 | 1033 |
| 200 | 1309 | 4.6 | 24 | 0.4 | 600 | 1317 |
| 250 | 1244 | 4.7 | 29 | 0.4 | 600 | 1561 |
| 300 | 1183 | 4.9 | 33 | 0.4 | 600 | 1766 |
| 350 | 1127 | 5.0 | 36 | 0.4 | 600 | 1933 |
| ••••••••••••••••••••••••••••••••••••••••••••••••••••••••••• | | | | | | |
| 400 | 1506 | 28.0 | −1 | −0.4 | 1348 | 453 |
| 450 | 1494 | 27.9 | −2 | −0.4 | 1345 | 510 |
| 500 | 1482 | 27.9 | −2 | −0.4 | 1341 | 567 |
| 550 | 1469 | 27.8 | −2 | −0.4 | 1337 | 624 |
| 600 | 1457 | 27.8 | −2 | −0.4 | 1333 | 681 |
| 650 | 1445 | 27.7 | −2 | −0.4 | 1328 | 738 |
| 700 | 1432 | 27.6 | −3 | −0.4 | 1323 | 795 |
| 750 | 1419 | 27.6 | −3 | −0.4 | 1317 | 853 |
| 800 | 1406 | 27.5 | −3 | −0.5 | 1311 | 910 |
| 850 | 1393 | 27.4 | −3 | −0.5 | 1305 | 967 |
| 900 | 1380 | 27.3 | −4 | −0.5 | 1298 | 1025 |
| 950 | 1366 | 27.2 | −4 | −0.5 | 1290 | 1083 |
| 1000 | 1352 | 27.0 | −4 | −0.5 | 1282 | 1141 |
| 1050 | 1338 | 26.9 | −5 | −0.5 | 1273 | 1199 |
| 1100 | 1324 | 26.8 | −5 | −0.5 | 1263 | 1258 |
| 1150 | 1309 | 26.6 | −5 | −0.5 | 1253 | 1317 |
| 1200 | 1294 | 26.5 | −6 | −0.5 | 1242 | 1376 |
| 1250 | 1278 | 26.3 | −6 | −0.5 | 1230 | 1436 |
| 1300 | 1262 | 26.1 | −7 | −0.6 | 1218 | 1495 |
| 1350 | 1245 | 25.9 | −8 | −0.6 | 1204 | 1556 |
| 1400 | 1228 | 25.7 | −8 | −0.6 | 1189 | 1617 |
| 1450 | 1210 | 25.4 | −9 | −0.6 | 1173 | 1679 |
| 1500 | 1190 | 25.1 | −11 | −0.7 | 1155 | 1742 |

```
NOTE − FOR RANGES UP TO 350 METERS THE BURST WILL APPEAR ON THE ASCEND-
       ING BRANCH OF THE TRAJECTORY.
```

**Figure 13-12. FT 81-A1-3, charge 5, used in determination of location of round
in relation to the height of burst.**

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**CAUTION**

When the correction is below the HOB line, use the sign opposite of that found in columns 4 and 5 to obtain the same HOB.

---

**EXAMPLE**

The FO sends, "Drop two zero zero (200). Down one five zero (150)" (Figure 13-13). Assume that the new range is 1,325 meters (= 1,350), and the optimum charge is 5. The procedure for determining the increments is the same as with the last example.

600-meter basic HOB, down 150 = 3 increments below the HOB line

(1) Determine the correction factors as before, but reverse the signs since columns 4 and 5 are set up for increases in HOB.

3 x -8 (number in column 4) = -24 mils = +24 mils
3 x -0.6 (number in column 5) = -1.8 sec = +1.8 sec

(2) Determine new firing data as before.

- Basic data:
  1245 mils (number in column 2) +24 mils = 1269 mils (elevation)
  25.9 (number in column 3) +1.8 sec = 27.7 (fuze setting)

(3) Assume that the second round is fired, and the FO sends, "Drop two zero zero (-200)," and the new range is 1,150 meters. Note that a range change is given, but not a HOB correction.

---

NOTE: When only a range change is sent, only the increments below the HOB line for the old range must be applied to the new range to keep the HOB correct.

---

(4) To determine the data, apply the steps as before.

- Increments below HOB = 3
  Correcting factors: 3 (increments) x -5 = -15 = +15 (sign reversed)
  3 (increments) x -0.5 = -1.5 = +1.5 (sign reversed)
- New data:
  1309 mils + 15 mils = 1,324 mils elevation
  26.6 + 1.5 = 28.1 (fuze setting)
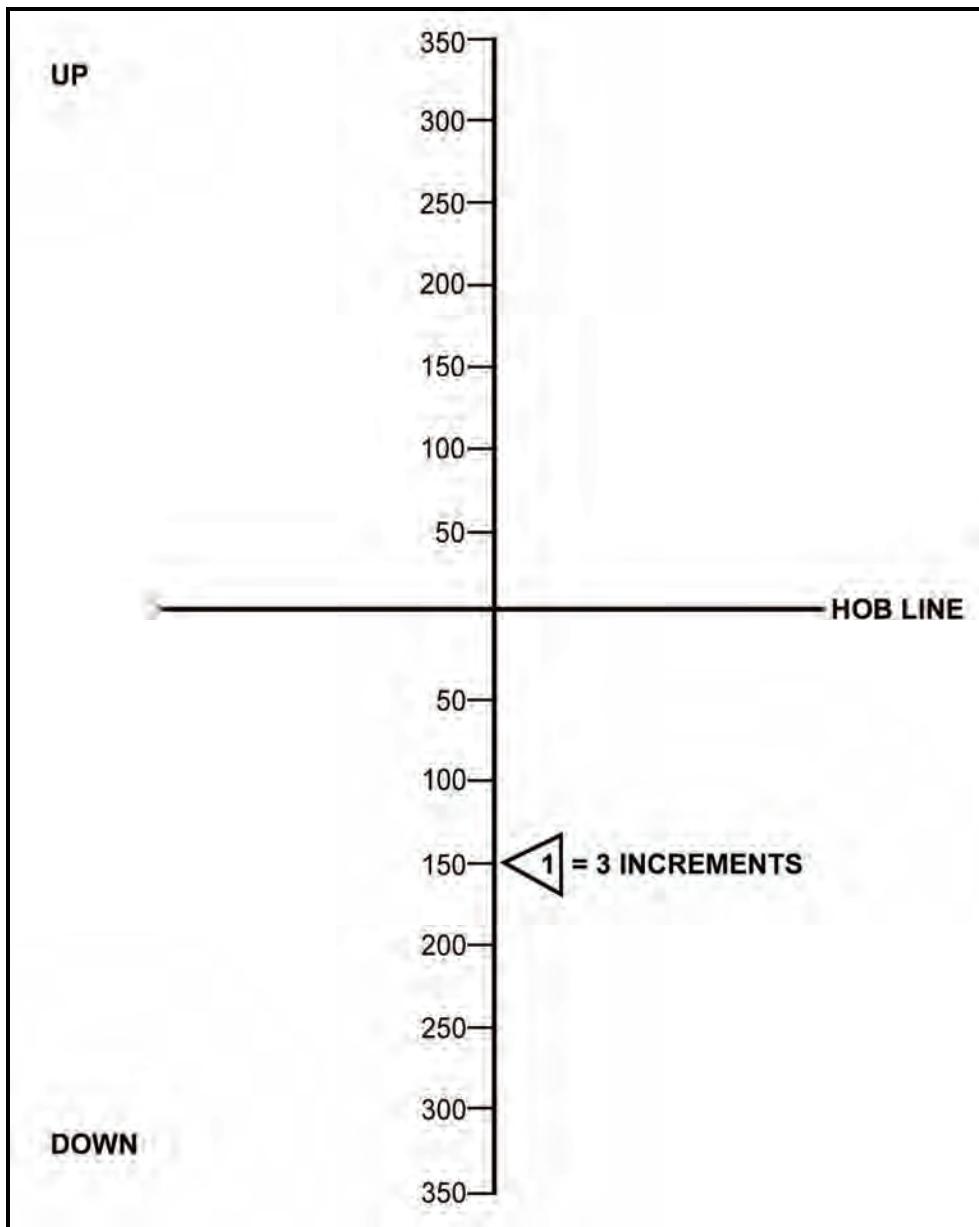
**Figure 13-13. Firing adjustment.**