establishes and maintains a device-based program of three to four hours a month for each crew, this training strategy will pay dividends, because over an annual gunnery cycle, the devices will enable a crew to increase its number of engagements from 121 to more than 1,400. (These figures are based on 40 engagements per hour for three to four hours per month using both the U-COFT and the BGMTS.)

At the same time, these devices will save on ammunition and vehicle operation costs; will reduce planning time, range congestion, and range personnel requirements; and will enable a unit to train more soldiers.

In the final analysis, the Infantry School can only recommend how these training devices should be used. Their integration into unit training will be a task for leaders in the field. But they *will* work. In fact, *given the live-fire limitations*, they *must*.

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Why Deflection?

MAJOR PETER R. MOORE

In INFANTRY's November-December 1985 issue, there appeared an article entitled "Mortaring: Can We Now Move Forward?" by Warrant Officer-1 Keith F. Hoyle of the British Army. The author, then attached to Fort Benning as part of a U.S.-British exchange program, discusses some problems with our current mortars and considers some possibilities new technology will make available. I am in partial agreement with Mr. Hoyle's proposals and would like to address one particularly interesting question — specifically, his proposal that we do away with deflection and lay mortars by azimuth, thereby simplifying fire direction procedures.

Field artillery has been laying on deflection angles ever since modern panoramic sights (6400 mil) were invented around the turn of the century, and mortars eventually adopted the same system.

Azimuths increase as the barrel turns clockwise, so the rule is Right Add, Left Subtract (RALS). Deflections increase as the barrel turns counterclockwise, so the rule is Left Add, Right Subtract (LARS) (or, as the Marines say, Port Increase, Starboard Subtract). Although fire direction center (FDC) students find this distinction a bit confusing, they eventually get used to it.

Mr. Hoyle is most unusual in refusing to take deflection for granted, in investigating the matter, and in concluding that deflection should be abolished. Indeed, it seems that plotting and laying on azimuths is simpler, and simplicity is certainly to be desired. Mr. Hoyle is slightly in error, however, in the following statement from his article:

The sight scale rings, now numbered progressively in a counterclockwise direction, should be numbered in a clockwise direction in the same way as the aiming circle. This very simple modification would allow the complicated and unnecessary use of deflection to fade into obscurity.

This implies that deflection is a counterclockwise angle. Although this does seem natural — when deflection increases, the barrel traverses left (counterclockwise) — deflection is actually a clockwise angle. The coarse deflection scales on the M53 sight are numbered counterclockwise simply because the index is stationary — if a sight is set at 0 deflection and then the micrometer knob is turned to cause the telescope to rotate clockwise, one can see that the coarse scale also goes clockwise and the number against the index increases.

In short, the sight is already like the aiming circle, which is why a mortar can be reciprocally laid with the sight of another mortar substituted for the aiming circle. If the sight were changed to read counterclockwise angles, then something would have to be done either to the aiming circle or to its procedures.

Most mortarmen are not even aware that the sight reads clockwise, and most would have difficulty defining *deflection*. This is not surprising, because the mortar manuals that discuss the sight and the aiming circle don't define *deflection* either. They do provide some diagrams of deflections, but these diagrams are not all drawn consistently.

For example, Figure 42 of FM 23-92 (4.2-Inch Mortar, M30) shows a mortar with an M53 sight (that is, it has two deflection scales), but it shows a deflection angle that would be measured by an M34 sight (for an M53, the reading should be 5200 mils instead of 2000). Another example is Figure 43 in the same manual, which is geometrically equivalent to the true situation but which shows angles equal to 3200 minus the actual deflection. In fact, more than half of the

diagrams in FM 23-90 (81mm Mortar) and FM 23-92 make similar errors. A mortarman who wants to know what this strange angle is must dig the definition out of paragraph 12-5a, FM 23-91 (Mortar Gunnery): Deflection is the "horizontal, clockwise angle measured from the rearward extension of the axis of the mortar tube to the line connecting the sight and a designated aiming point."

EFFECT

Nevertheless, the effect of deflection is to increase counterclockwise. The reason for this backward result is found in the way the sight and the barrel work. Angles are measured from a base (or zero) line to a reference line. Normally, the base line is fixed, while the reference line shifts. For example, when an aiming circle is oriented for reciprocal lay, its base or zero is the mounting azimuth, and it measures from that fixed base line to the reference lines of the different and shifting mortar sights. In contrast, the base line for the sight is the rearward extension of the barrel, which shifts whenever the weapon is traversed.

Consider what happens when a mortar has just been reciprocally laid, with its sight reading 2800 and the vertical hairline on the aiming posts, and the crew is ordered to shift to deflection 2900. First, the gunner refers the sight to 2900 — this moves the vertical hairline clockwise to the right. Next, he traverses left to the aiming posts — the base (the rearward extension of the tube) shifts counterclockwise, and the vertical hairline returns to its original reference line (the aiming posts). Thus, the counterclockwise effect results from a clockwise angle.

Nevertheless, Mr. Hoyle is correct in stating that renumbering the deflection scales (coarse and micrometer) in reverse would allow the mortar to lay on azimuths. Other changes would have to be made, however, and we would have to choose among several methods of doing this.

In the first of these methods, the black deflection scales (coarse and micrometer) would be reversed to read counterclockwise angles, while the red scales and the aiming circle were left unchanged. Reciprocal lay and boresighting would not need to be changed and would be accomplished with the red scales. When reciprocal lay was complete, the telescope would be referred to the direction in which aiming posts were to be emplaced (red 2800, at present, though Mr. Hoyle suggests that we not lock ourselves into this direction), and the black scales would be slipped to read the mounting azimuth. The black scale would be used for firing, and the FDC could forget about deflections and work with azimuths. Whichever way the barrel was pointed, if the sight was on the aiming posts, then the black scale would read the azimuth of aim.

The disadvantages of this method include the fact that every mortar sight would need a deflection scale and an azimuth scale working in opposite directions. Also, the M53 sight would lose the four ways in which the black scale can now be used.

(Incidentally, another deficiency of the mortar manuals is that they provide no coherent explanation of the black scale. They simply tell us in different places that in a certain situation we must slip the black scale and take readings from it. FM 23-91's definition of *deflection*, therefore, is incorrect for the black scale and for the M34 sight.)

In the second possible method, all sight deflection scales would be reversed into counterclockwise azimuth scales, while the aiming circle would be left unchanged and oriented for reciprocal lay in accordance with current doctrine. The gun would be set up with its 0-3200 line as

Mortar crewmen lay mortar during annual ARTEP.

at present (0 along the rearward extension of the tube). The aiming circle operator would then have to subtract his reading to the sight from 6400 to correct for the reversed sight scale. The gunner would index this difference on his sight and ask for a recheck. When each mortar was laid on the mounting azimuth, the gunner would refer to the direction in which aiming posts were to be emplaced and then slip his scale to read the mounting azimuth. Aiming posts would be emplaced, and the sight thereafter would read the azimuth of aim.

This method would require that the sight's scales be reversed and that index marks be put on the coarse scale and micrometer to allow the gunner to identify the axis of the tube. The disadvantage of this method is that the aiming circle operator would have to perform a subtraction problem for each deflection reading, and the gunner would also have one step added to his reciprocal lay procedure — slipping the scale.

In the third method, both the mortar sight and the aiming circle would be reversed to read counterclockwise angles. The aiming circle would be oriented for reciprocal lay by subtracting the declination constant from the mounting azimuth (reversing the present procedure) and then orienting on magnetic north. This would put the aiming circle's zero line on the mounting azimuth. The mortar would begin reciprocal lay with its zero line along the rearward extension of the tube, as at present. Lay would then proceed as at present until the barrel was on the mounting azimuth ("zero mils — mortar laid"). The gunner would then refer his telescope to the direction in which aiming posts were to be emplaced. The FDC would work with azimuths only, and the mortars would be laid on azimuths.

The disadvantages to this method are that both the sight and the aiming circle would have to be altered. Also, the aiming circle could no longer be used conveniently for measuring azimuths — unless it was given two scales, one clockwise and one counterclockwise. This method would be simpler than the other two.

From this, we can see that the idea of discarding deflections in favor of azimuths is perfectly feasible. Some retraining and equipment modification costs would be incurred, of course, but if laying by azimuth resulted in real gains, these costs should be accepted.

Crew prepares to fire.

Let's consider, then, the advantages and disadvantages of discarding deflection, using the third of the three possible methods, since it is simpler.

The advantages would go to the FDC. Forward observers would report target locations instead of gun-to-target direction, and mortar crew members would also have no real concern with the azimuth on which their weapons were laid. But FDC training would be simplified, as the puzzling matter of deflection and deflection indexes would no longer exist. FDC procedures upon arrival at a firing position would be one step simpler because the computers wouldn't need to mark deflection indexes, and the firing chart or plotting board would have one less set of marks on it.

The disadvantages of laying by azimuth would mostly go to the gunners. First, gunners would have one extra step in reciprocal lay. The command "Refer to 2800 and emplace aiming posts" would become "Refer to 3600, slip your scales to (the mounting azimuth), and emplace aiming posts."

Also, when a platoon went out of action, the gunners would have to be told (or have to remember) to reslip their scales so that the 0-3200 line was once more parallel to the axis of the tube. This step would be necessary to make the sights ready for reciprocal lay at the next position, and index marks (as on the M64

sight) would be needed on deflection scales so that the 0-3200 line could be identified. (If this step were forgotten, reciprocal lay would be fouled up considerably.)

Next, instruction in the geometry of the sight would be more complicated — the 0-3200 line would be along one constant orientation during reciprocal lay but afterwards would be in different directions as dictated by the mounting azimuth.

Finally, the value of the aiming circle as an azimuth measuring instrument would be considerably reduced, unless we accepted the complication of two sets of scales — one clockwise and the other counterclockwise.

I can envision a few other aspects of this question, and INFANTRY readers may think of still others, but the discussion here seems to cover the mechanics and the major *pros* and *cons* of deflection versus azimuth. I believe deflection is simpler and therefore preferable, but the case is not overwhelming. Nevertheless, Mr. Hoyle has done us all a favor by asking us to think through an ancient procedure that we have tended to take for granted.

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Antiarmor Weapons in Cities

CAPTAIN FRANK A. EMERY

Because of the extensive urbanization in Western Europe, we have known for a long time that any future war there is likely to include combat in cities. The Soviets have known this, too, and have prepared for it. (See "Soviet Military Operations in Built-Up Areas," by Major A.E. Hemsley, INFANTRY, November-December 1977, pages 30-34, and "MOUT and the Soviet Motorized Rifle Battalion," by Lieutenant Colonel Lester W. Grau, INFANTRY, January-February 1985, pages 24-27.)

The current Soviet doctrine for combat in cities shows that a Soviet division will operate in two echelons at each level of command and use frontages of four to six kilometers, with two to three kilometers for a regiment, 400 to 600 meters for a battalion, and 200 to 300 meters for a company.

The divisional and regimental axes of advance will be along major roads so that these units can capture key areas, disrupt the defense, and cross the area in the shortest possible time. A battalion might advance on two or three parallel streets, with one company axis per street.

During offensive combat in cities, Soviet artillery will be decentralized. Up to half of it may be attached to assault groups and used in its direct fire role. Howitzers and mortars will be used for counter-battery tasks. Preparatory fires will be shorter than normal, 5 to 20 minutes usually. Tanks will be used to sup-

TOW crew prepares for a shot during training with the Berlin Brigade.