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Field Artillery Notes
No. 2

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WAR DEPARTMENT,
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The following compilation of British official instructions governing the use of artillery is published for the information of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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Major General, Acting Chief of Staff.

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ABBREVIATIONS AND EQUIVALENT TERMS.

British.	United States.
Add	More (obsolete).
Ammunition wagon	Caisson.
A. of S., Angle of sight	Angle of site.
Battery in action	Battery in position.
C. R. A., Commander, Royal Artillery.	
D. P., Datum point.	
Director	Aiming circle.
Drop	Less (obsolete).
F. A. T., Field Artillery Training	Drill Regulations.
F. O. O., Forward observing officer.	
Lengthen	Down.
M. P. I., Mean point of impact	Burst center.
Minus	Short.
O. P., Observation post (point)	Observing station.
Pivot gun	Directing piece.
Plus	Over.
R. T., Range table.	
Section	Platoon.
Shorten	Up.
x, Yards.	

FIELD ARTILLERY NOTES.

NOTES ON TRAINING OF HORSE AND FIELD ARTILLERY.

It is important that the points enumerated should be brought to the personal notice of those concerned, and the value of close adherence to the approved methods of ranging must be impressed upon all officers.

1. Sequence of orders.—Care must be taken to insure that during shooting, orders by telephone are passed in the correct sequence. No departure from the sequence laid down in F. A. T. should be permitted.

The order "Report when ready," except for the first round or first group of rounds, should not be given.

Except in special circumstances, the order for an elevation to be put on is to be considered as the order to fire the gun.

Officers must take care that only orders in a proper form are sent to the battery during a shoot; e. g., such an order as "Get No. 2 gun on the same line as No. 1" must never be sent to a battery. Accuracy and precision in the issue of verbal orders are all important.

2. Add and drop.—The practice of using the word "add" or "drop" during ranging is to cease. The same applies to the custom which has arisen among officers of ordering "lengthen" or "shorten" corrector.

With the one exception mentioned below the exact elevation or range should be invariably ordered. Thus, if 3,700 is observed plus and it is desired to shorten the range by 100, the order is "3,600," not "drop 100." Similarly with the corrector—the setting is to be ordered on each occasion.

3. Repeat.—The order "Repeat" is never to be used unless the whole of the previous order is to be repeated.

For example: First round was fired at 5°R.—A. of sight 1° elevation—Corrector 156—3,800. As an order for the second round "20′ more right, repeat" would not be allowed; the order will be "20′ more right, 3,800."

If no correction was required for the second round, the order "Repeat" could be given, and the second round would be fired the same as the first.

Again, a round of battery fire might have been fired at the above range, etc. For the next round "Corrector 152, repeat" would be wrong. The order should be "Corrector 152—One round battery fire."

4. REGISTERING A DATUM POINT WITH A SINGLE GUN.—The following is to be the recognized procedure:

(*a*) Obtain 100 yards bracket; say 3,900 plus, 3,800 minus.

(*b*) Verify it.

(*c*) Order the range which is most likely to be correct, say 3,850, and henceforward think and work in groups of four.

The series might run:

5° right of zero—Angle of sight 1° elevation—Percussion shrapnel—No. 85 fuse—Cordite—3,800—Fire!

Round.	Range.	Plus or minus.	Order after observation of round.
1	3,800	Minus.....	4,100.
2	4,100	Plus.....	3,900.
3	3,900	Plus.....	3,800.
4	3,800	Minus.....	3,900.
5	3,900	Plus.....	The 100-yard bracket is now verified; both the 3,800 were just minus, the two at 3,900 were a good deal plus. So order: "3,825—Fire 4 rounds."
6	3,825	Minus.....	In this group of 4 there are 3 minus to 1 plus. So order: "3,850—Fire 4 rounds."
7	3,825	Minus.....	
8	3,825	Plus.....	
9	3,825	Minus.....	
10	3,850	Plus.....	As this group contains 2 plus and 2 minus it may be accepted as the range that gives the mean point of impact nearest the target.
11	3,850	Minus.....	
12	3,850	Plus.....	
13	3,850	Minus.....	

As an indication as to whether the angle of sight is correct, a group of air bursts may be fired by 18-pounders. *Example.*—Barom. reading 29.5—for guns with Mark II, range dial and barometer 30 inches, the normal corrector is 150—therefore, for barometer 29.5 inches, corrector should be 147. The order is given therefore, "Corrector 146—3,850—fire four rounds." If this gives effective bursts, the inference is that the angle of sight is correct.

If, observing from the gun, the mean height of burst is 1° too high, the inference is that the A. of S. is 1° too high; in which case lower A. of S. 1°. It is seen from the range table that 5′ alters range by about 30 yards at 3,850, so 1° alters range about 360 yards. The order may then be given, "A. of S. zero—Corrector 146—4,200—fire

four rounds." If this gives effective bursts, four rounds percussion should be fired to verify that 4,200 is the correct range.

It would be quite in order to commence with four rounds of time shrapnel at normal corrector, to see that no big error has been made in the A. of S.; but in this case it would be advisable to overestimate the A. of S. to insure air bursts. The mean height of burst is measured, and the A. of S. lowered, by the number of minutes that this height is in excess of 10.

At the order "Fire four rounds" the gun is fired (as soon as it is loaded and laid correctly) by order of the No. 1. The order only differs from "four rounds gunfire" in that neither speed nor any fixed interval between rounds is considered important.

5. Finding the corrector.—In ordinary circumstance the corrector setting depends on the barometer reading at the moment. Other factors affecting it are—

(*i*) A change in lot of fuses which will sometimes necessitate an alteration in length of corrector.

(*ii*) A very worn gun with which the time of flight of the shell is affected. This can only be satisfactorily dealt with by experience, pending the provision of a special fuse indicator to compensate for difference in muzzle velocities.

(*iii*) An unusual change in the temperature or density of the air, concerning which exhaustive experiments are now in progress. Normally the length of corrector should remain the same at all ranges, and perpetual ranging to ascertain the correct setting to produce the desired height of burst is entirely unnecessary.

PROCEDURE WHEN RELIEVING A BATTERY IN ACTION.

(HORSE AND FIELD ARTILLERY.)

6. When a battery is about to take over a position from another battery in action, the battery commander and a party of telephonists proceed to the position at least one day in advance. In future switchboards will probably be left in position and handed over on relief, but if not, telephonists take their own switchboards; in any case they take their instruments with them. All telephone wires are invariably left in position by the outgoing battery.

7. The battery commander makes himself acquainted with the country as seen from the various observing stations. He obtains as much information as possible as to the tactical situation, etc., from the outgoing battery commander and should visit the various battalion headquarters with him.

He takes over:

Defense scheme.
Artillery board and fighting map (par. 17).
Intelligence map.
Diagram of communications.
Intelligence summary (23).
Panoramic sketches.
Air photographs.

8. When a battery takes over the outgoing battery's guns in position, the detachments march in and the reliefs are carried out, responsibility for the support of the infantry being taken over at such an hour as the C. R. A. may direct. The guns are taken over "stripped," except for the sights and aiming posts; the latter must always be left in position. Particular care must be taken to insure that the calibration records of the guns are handed over.

9. If a battery takes its own guns into action, suitable arrangements must be made for the relief, but in all cases the outgoing battery leaves its aiming posts in position and takes over others from the incoming battery.

Such reliefs usually take place at night, but detachments should, if possible, take over during daylight.

Two nights are usually taken to carry out a relief. In a 6-gun battery one section should be relieved the first night and the other two on the following night.

10. Batteries keep their own limbers and ammunition wagons complete, the arrangements for the occupation of the wagon lines being made by the divisions concerned.

11. Whenever possible, one officer of the outgoing battery remains behind for 24 hours to give any required information to the relieving battery and to accompany the new battery commander on a second visit to the O. P's.

12. The divisional artillery is informed when the relief has been completed.

NOTES FOR COMMANDERS OF SIEGE BATTERIES ON COMING INTO ACTION.

The following notes form a guide, which should be followed as far as circumstances permit:

13. Communications.—Ascertain to what extent existing lines can be utilized. Set telephonists on to connecting battery with O.P's. If no O.P. is definitely settled upon, communication should be established with some central spot near which an O.P. will

probably be chosen. As soon as communications are complete a diagram of the routes followed should be made and inserted in the intelligence summary.

14. Zero Line and Zero Point.—Select the zero line which must pass through the position of the pivot gun and contain a definite point called the "Zero point"; if this point is visible and at a suitable range for calibration and for determining the atmospheric correction, it would become a datum point.

Auxiliary aiming points must now be selected; these points should preferably be in front or rear of the battery as with some equipments owing to the carriage moving considerably when firing, a side aiming point becomes unreliable.

15. Parallel Lines of Fire.—Have guns laid parallel to zero line by most convenient method (the line of the pivot gun being coincident with zero line).

16. Checking Line of Fire.—Check the line of fire by firing a few rounds from each gun on the zero point and correct auxiliary aiming point readings accordingly, remembering to keep lines of fire parallel.

17. Fighting map.—Always keep fighting map up to date by entering upon it any new work, trenches, etc., constructed by the enemy and by our own troops.

18. Datum points.—Select a datum point for each charge likely to be used. These datum points should be at or near the mean ranges of the charges for which selected, and a good view both in front and behind these datum points must be obtainable. The zero point may have been already selected as a datum point.

If muzzle velocities are not known, calibration should be carried out at the earliest opportunity.

19. Calibration.—Whenever possible, double line observation should be employed for calibration, so that results can be plotted and elevation for datum point accurately deduced.

If, however, it is found impossible to use double line observation, a single observer, as close as possible to the line of fire, must be employed.

The M. P. I. should in both these cases be verified by a large group of rounds, say at least 12 rounds fired at the same elevation and, where double observation can not be obtained, verification must not be accepted unless an equal number of "pluses" and "minuses" are obtained from any one group.

The range at which calibration is carried out should be near the mean range for the charge used.

A day on which conditions (especially wind) are as near normal as possible should be chosen.

Example of calibration:

8-inch B. L. howitzer V. Fourth charge 8,000ˣ.

	°	′
Say calculated elevation (R. T. elevation, angle of sight and initial correction)	31	00
Elevation for M. P. I. from shooting	32	00
Difference	1	00

From R. T.—	Yards.
∴.5 minutes elevation at 8,000ˣ	18
∴.1° 00′ elevation at 8,000ˣ	216
□10 foot-seconds variation in M. V.	55
∴.39.2 foot-seconds variation in M. V.	216

The differences of muzzle velocities from that of the range table should be noted for each gun at each charge, and correction tables for these differences at the various ranges can be made for the guns concerned and kept in the emplacements of those guns and form one of the No. 1's stores. A record of these muzzle velocities should be kept in the intelligence summary.

Correction tables for charge temperature variations can also be similarly prepared and form one of the No. 1's stores.

20. Map Shooting.—Before engaging a target which is not visible, range on a suitable datum point, if time permits, in order to check the initial correction. The procedure is as follows:

(*a*) Calculate the "atmospheric correction" (due to air temperature, height of barometer, and wind) and apply it with "gun correction" for charge temperature, weight of shell (if necessary), and muzzle velocity to the elevation due to map range, plus or minus the angle of sight.

(*b*) Range on datum point on the bracketing system with one gun and verify the M. P. I. with a group of not less than eight rounds fired at the same elevation. This verification is most important, as 50 per cent length zones are, as a rule, rather large and a small group of rounds may give misleading results.

(*c*) If the final elevation differs from that previously calculated, the difference is likely to be due either to a wrong estimation of the wind or to the propellant giving an abnormal muzzle velocity, or to both.

(*d*) If the propellant is marked A. C., i. e., adjusted to give normal muzzle velocities in a fairly new gun, and is in good condition, the above difference may be taken as being due to wrong estimation of the wind. The true strength of wind affecting range and also deflection should then be calculated.

Example:

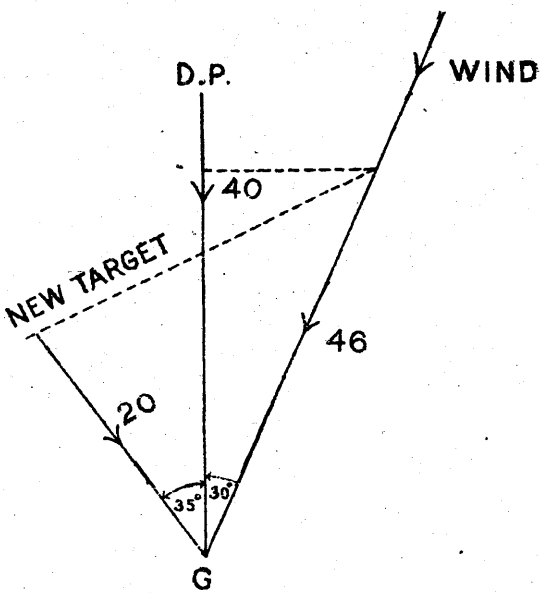
8-inch B. L. howitzer. Full charge. Range to D. P. 8,000^x.

	°	′	
Calculated elevation	31	00	(say)
Elevation found by shooting	31	30	
Difference		+30	

From R. T. 30 foot-seconds wind requires correction of 220^x, i. e., 61 minutes elevation.

∴The difference found, i. e., 30 minutes elevation, corresponds to an increase of 15 foot-seconds wind, which must be allowed for before proceeding to engage a target in the same direction.

Suppose the original estimation of wind velocity resolved to line



of fire was 25 foot-seconds *against* the shell, this must now be taken as 40 foot-seconds on the line of fire.

If the target to be engaged is on a line, differing widely from that of the datum point this new estimation of wind velocity on the line of fire to datum point must be resolved back to direction of wind and these recalculated for the new line of fire.

Example: New value of wind velocity on line to datum point=40 foot-seconds and wind makes an angle of 30° against the above line as in the diagram. Forty foot-seconds resolved back to wind direction=46 foot-seconds.

If line of fire for new target is as shown in figure, 46 foot-seconds resolved to this line becomes 20 foot-seconds and this amount must be taken as the wind velocity resolved to the new line of fire when calculating correction to elevation.

Again, if the deflection found by shooting on the datum point differs from that originally calculated a similar procedure must be followed.

(*e*) If the difference in elevation found by shooting is considered to be due to the propellant, then this difference must be converted to foot-second muzzle velocity.

Say difference in elevation found by shooting = +30′ from R.T. 10 foot-seconds muzzle velocity at 8,000ˣ =55 yards (15.2 minimum elevation).

Then 19.8 (say 20) foot-seconds =30′ elevation.

So an allowance for a decrease of 23 foot-seconds muzzle velocity must be made before engaging a target with that lot.

21. Group your shells according to weight and mark of shell, and your cartridges according to lot, as they reach the battery. See that all shell in any one group have the same nature of driving band.

22. As an assistance at the O. P's. prepare a map for each with degree rays drawn from the O. P's. and from the battery position covering the target area; the rays from the O. P's. and from the battery should be drawn in different colors. Make a panoramic sketch from the chief O. P.

23. Keep an "Intelligence summary" showing:

(*a*) Auxiliary aiming point readings of each gun when parallel to zero line.

(*b*) Datum points with switches from zero line, their angles of sight, and their map ranges.

(*c*) Loss or gain in muzzle velocity of each gun, with each charge and each propellant, compared to that of range table.

(*d*) Ground visible from each O. P.

(*e*) "Night lines" with switches from zero line, angles of sight, and map ranges.

(*f*) Any information regarding the enemy's habits, etc.

TERMS USED IN GUNNERY, WITH EXPLANATORY NOTES.

[N. B.—The calculations refer to the 18-pounder gun.]

24. Map range is the distance from the gun to the target measured on the ground.

It is found by measuring the distance between the two points on the map and applying to it the distortion error of the particular map in use.

Maps, after they are mounted, should be tested for distortion by measuring the distances between the various grid lines. The map will seldom be found to have stretched or shrunk by a similar amount both up the map and across it.

Suppose the line of fire runs east to west. Measure with a good scale the distance from east to west between two grid lines, which should be 6,000 yards apart on the map. Suppose this to measure on the scale 6,040 yards, then write on the map "From ranges read off this map by scale deduct 7 yards from every 1,000 yards range." This deduction is the *distortion error.*

If the line of fire runs north and south act similarly.

If the line of fire runs northeast to southwest measure the distortion error east to west and from north to south. Between these two errors interpolate an error that seems likely to be correct for the particular line of fire.

Unless the zone be very wide, one distortion error calculated for the center of the zone, should be good enough for the whole zone.

25. If a number of rounds are fired at a target from a gun the sights of which are set to map range, the mean point of impact of these rounds is most unlikely to be on the target. This is due to a variety of causes:

(*a*) OUTSIDE THE BORE.

(*i*) Variations in temperature of the air from 60° F.

(*ii*) Variations in height of barometer from 30 inches.

(*iii*) Variations in wind from nil.

The correction to map range necessitated by the above three variables constitutes the correction for *atmospheric error.*

(*b*) INSIDE THE BORE.

(*i*) Wear of the gun. This causes loss of muzzle velocity. The amount by which the muzzle velocity of a gun with any particular propellant differs from the muzzle velocity for which the range table is calculated is called the "*Calibration error*" of that gun with that propellant. The correction necessary at any particular range to counteract this calibration error is called the

"*Gun correction*" for that gun for that range with that propellant.[1]

(*ii*) Variation in temperature of charge from 60° F. This also causes a change in muzzle velocity. The change caused by 10° variation in temperature of each propellant is given in the range table of the gun. Each propellant is differently affected by heat, and the amount varies with each charge in a howitzer.

(*c*) MISCELLANEOUS SOURCES OF ERROR.

(*i*) Faulty range dial (e. g., one graduated for wrong muzzle velocity).

(*ii*) Weight and shape of shell and fuse.

(*iii*) Other causes, such as wrong angle of sight, faulty estimate of atmospheric conditions, propellant affected by damp or age, inaccuracies in the map, sights out of adjustment, etc.

The corrections due to the causes mentioned in par. 25 (*c*) have no special name, and in practice it is not always feasible to dissociate them from the correction for the wear of the gun, par. 25 (*b*) (*i*). Their effect would generally be common to all the guns in a battery. The result, if the causes are not recognized and allowed for, would be a false calibration error for the gun.

26. The range on the range dial of a gun that gives "effective" fire on a target is called the "*gun range*" of that gun to that target. This gun range will vary according to the atmospheric conditions at the time of firing par. 25 (*a*). For record, therefore, this "gun range" should be converted to what it would have been under normal conditions, i. e., air temperature 60° F., barometer 30″, no wind, a particular type and nature of shell, and charge temperature 60° F. The resulting range is called the "normal gun range" for this gun, target, and propellant. It differs from the "gun range," by the corrections for atmospheric error, temperature of charge, and type of shell and fuse. It differs from the "map range" by the "gun correction" and any correction as explained in par. 25 (*c*) (*iii*). It will only apply to the propellant with which the firing was carried out.

27. *Datum points* are points which can be clearly seen on the ground, and to which the normal gun range can be accurately found.

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[1] Charges of different lots and of different propellants are adjusted as far as possible to give the same muzzle velocity in a new gun. Different propellants are, however, unequally affected by the wear of the gun; consequently out of an old gun different propellants will fail to give even approximately the same muzzle velocity. As the differences may be great, and as it has been found impossible to find any proportionate rule to which they will conform, it is necessary to calibrate each gun with each of the propellants with which it is supplied.

When their positions and contour heights have been accurately fixed they can be used for calibrating purposes. They must be easy to range on; a point such as a single bush does not fulfill this condition.

28. *Calibration* is the process of finding, by shooting, the muzzle velocities of the different guns of a battery, relative to the range table.

29. *The zero point* is the point on which the aiming posts of the pivot gun, preferably No. 1, are laid. It need not necessarily be visible from the battery but must be suitable for use as a *datum point.*

30. *The zero line* is the line of fire of the pivot gun to the *zero point.* From it all horizontal angles are measured. Parallel lines to this zero line from each of the other guns are their zero lines.

PREPARATION FOR OPENING FIRE FROM A NEW POSITION.

The occupation of each new position requires a somewhat different procedure, but the following principles form a guide that should be followed as far as circumstances permit.

31. Set the communication staff to work to link up the battery position either to the O. P. or if no O. P. is known, to some central spot near which an O. P. will probably be established.

32. See that the daily testing of sights has been completed.

33. Select a likely zero point; have aiming posts put out on to it for whichever gun is selected as the pivot gun.

34. Have aiming posts put out for the other guns parallel to those of the pivot gun. This parallelism should then be thoroughly checked (pars. 44–46).

35. Send forward an officer to get into touch with the infantry whom the battery is to support, or over whom the battery is to fire. Give this officer instructions which should include:

(*a*) To whom he should report.

(*b*) What information he should obtain from the infantry.

(*c*) The form in which the infantry will get their artillery support and to whom they should apply for it. The officer should see that the infantry understand this.

(*d*) Means of communication with the infantry and for what communication he is responsible.

(*e*) Verification of "night lines" (see last part of par. 36).

(*f*) When he is to return to the battery.

36. Having selected a possible O. P., located the zero point, and established communication with the battery position, the

battery commander will proceed to range the pivot gun on the zero point. If, when at the O. P., the zero point selected can not be located on the ground, some other zero point must be chosen that can be so located. (The requirements of a zero point are indicated in par. 29.)

In practice there is often great difficulty in carrying out registration accurately before dark. It is most important, however, to get the pivot gun ranged thoroughly on some point, the map location of which is known.

Having completed this ranging, the battery commander knowing the muzzle velocities of his guns and that the lines of fire are parallel, is enabled to bring fire to bear on any point of his zone with a certain amount of confidence.

If, however, the "night lines" (i. e., the protective barrage) of the battery are within a short distance of our infantry and can be seen by the officer sent forward under par. 35, this officer should test the battery's fire on its "night lines."

It would usually be wise to arrange beforehand that, in case communication has broken down, the battery will fire (say) four rounds of battery fire on its "night lines" at two distinct times, separated by at least a quarter of an hour, in order to enable the forward officer to observe at least one of these bursts of fire. The rate of battery fire ordered should be sufficiently slow to allow the observer to write down the result of each round and he should send back a messenger as soon as possible with a written report as to the accuracy of the shooting. The times may if necessary be toward dusk in order to give the battery commander as much time as possible to get the zero point registered.

37. The battery commander in ranging the pivot gun on the zero point (pars. 42, 43) must be quite certain that he has obtained at least two pluses and two minuses at the same range, and at the same angle of sight. The setting of these should be carefully checked at the battery.

He should also check his angle of sight to the zero point by firing time shrapnel at it. Knowing the "corrector of the moment" a few rounds should be fired with that corrector. If the angle of sight has been correctly read off the map, an "effective" mean height of burst should be obtained. If the mean height of burst is much out, the angle of sight must be wrong.

38. When the battery commander has found the range and line to the zero point accurately with the pivot gun, the deflection due to wind is taken off the sight, and the aiming posts of that gun are replanted in the line thus found, care being taken that the gun, in so doing, is not shifted.

The aiming posts of the other guns will then be replanted in a similar manner to those of the pivot gun.

Provided the officer who checked the lines of fire at the battery has done his work accurately, the guns of the battery should then have their lines of fire parallel to each other. It is advisable, however, to fire a round of battery fire to see that no mistake has been made.

The normal gun range to the zero point is then carefully worked out. This will enable ranges to be ascertained for the shooting during the first night.

39. A fighting map should be prepared on the approved plan (pars. 47–53).

40. Although in a battle, the above may be as much as can be accomplished during the first day, every effort must be made to complete the necessary ranging as quickly as possible, working on the following principles:

(*a*) Test the parallelism of "Aiming posts" (par. 46).

(*b*) Select a few good datum points in the zone. If possible these should be at ranges differing by 800 or 1,000 yards. Range on these accurately with the pivot gun, taking care that the angle of sight is correct.

For each datum point convert "gun range" as verified to the "normal gun range."

41. Have the "gun corrections" for each propellant for each gun posted on a conspicuous board in the gunpit for that gun.

On the same board may also be written orders for "S.O.S." or other defensive barrages, the object being that on a demand for "S.O.S." the only order necessary is to say "S.O.S., G. 11, add 125." "Add 125"[1] is the total correction for atmospheric error and charge temperature. This correction must always be known to the officer and senior N.C.O in charge at the gun position, either by night or day.

The battery commander during a series does not give orders concerning "gun corrections," i. e., corrections to counteract the wear of the guns. These gun corrections are applied *as a matter of routine by the Nos. 1* to all orders for elevation that are received.

CALIBRATION AND MAP SHOOTING.

42. Calibration with the 18-pounder will be carried out normally with shrapnel, fuse 80, and with all propellants with which the battery is being supplied.

[1] This order "Add 125" does not contravene the provision of par. 2, which forbids the use of the term "add" or "drop" *during ranging.*

It should be carried out on a datum point (i. e., a point the exact map reference and contour height of which are known) as nearly as possible at the range at which most of the shooting is carried out. There should be little or no wind.

The following example shows the method:

Conditions: Shrapnel, fuse 80, percussion, cordite, temperature of charge 40°, temperature of air 45°, barometer 29.5″, wind 5 foot-seconds against, map range 4,000.

The battery commander first corrects the map range for the atmospheric conditions, thus:

Air 45° (15° below normal)	+36x	
Baro. 29.5″ (.5 inches below normal)		−20x
Wind 5 foot-seconds against	+14x	
	+50x	−20x

Total atmospheric correction=+30x

4,000 +30=4,030x.

This means that the gun must be laid as if the map range was 4,030x under normal conditions (i. e., temperature of air 60°, barometer 30″, wind nil). This would be the necessary elevation for a gun giving 1,615 foot-seconds muzzle velocity, for which the range table is constructed, but with a worn gun an increased elevation will be necessary.

The battery commander therefore shoots at the datum point and obtains (say) 6 pluses and 6 minuses at a gun range of 4,200x.

That is this particular gun requires to have the range dial set at 4,200 to send the shell a mean distance of 4,030 yards under normal atmospheric conditions. The difference is 170 yards, which is the gun correction for this gun at 4,030x or say 4,000x. Now according to page 3 of the rubber range table, a fall in muzzle velocity of 12.5 foot-seconds decreases the range by 31x at 4,000x and 32x at 4,500x. Therefore, at 4,200x the range will be decreased by 170x if the fall of muzzle velocity is—

$$\frac{12.5 \times 170 \text{ f.s.}}{31.5} = 67\tfrac{1}{2} \text{ f.s.}$$

Take this as 70 foot-seconds.

The muzzle velocity of the gun at the moment was therefore 1,615−70=1,545 foot seconds.

This was with cordite at a temperature of 40°.

With cordite at 60° the muzzle velocity would be—

$$1{,}545 + (12.5 \times 2) = 1{,}570 \text{ foot-seconds.}$$

Charges of all natures are adjusted as far as possible to give the same muzzle velocity in a new gun. With an old gun, however,

they will not shoot the same, and the differences may be considerable. Although charges are adjusted, nevertheless owing to difficulties of supply under war conditions and to other circumstances, absolute reliance must not be placed on the results of such adjustments. It will be found in practice that quite unaccountable differences will occasionally occur in the muzzle velocity developed by different lots of the same propellant even in a new gun. Where different propellants are in use a gun should be calibrated, if possible, at least three times with each propellant and the mean muzzle velocity of the three recorded in each case.

The muzzle velocity to be recorded is that which would have been realized with a charge temperature of 60° F., e. g., 1,570 foot-seconds in the example given above.

As soon as the muzzle velocity is satisfactorily established it should be painted on the gun itself or on the top flap of the shield together with the number of the gun. Underneath should be shown the gun corrections necessary, thus:

GUN No. 3714.

Charge Temperature 60° F.

CORDITE.	*N. C. T.*
M. V.=1,570 f. s.	M. V.=. . . . . f. s.[1]

GUN CORRECTIONS.

CORDITE.	*N. C. T.*
Below 4,500 add 50.	[1]
Above 4,500 add 75.	. . . . .

43. Map shooting (with the aid of a datum point).—(*i*) *When time and opportunity permit*, and there is any doubt about the atmospheric error, better results will usually be obtained by first checking the error of the moment on a datum point near the target. The procedure is:

(*a*) Note the map range to datum point, say 4,500 yards.

(*b*) Calculate the gun range that should hit the datum point, as follows:

Example: Wind, temperature of air and barometer normal.

Charge temperature, 45° F.

Cordite, shrapnel, No. 80 fuse.

Map range, 4,500.

The charge temperature correction in this case will be for—

$$60-45=15°$$

[1] Figures to be filled in when calibration with N. C. T. has been carried out.

By the range table this is $32 \times 1.5 = 48$. The battery commander will, therefore, order 4,550. To this 4,550 will be added in the usual way by Nos. 1 the gun corrections for individual guns as painted on their shields.

NOTE.—If N. C. T. had been used the correction for N. C. T. would have been applied instead of that for cordite.

For 15° allow 4.5 foot-seconds, say 12 yards.

Therefore 4,500 would have been the order sent to the battery, as the charge temperature correction is inappreciable.

The N. C. T. corrections may be taken as one-quarter those for cordite, the correct figure being 3/12.5.

(*c*) Find by shooting the gun range that gives an equal number of pluses and minuses at the datum point. Suppose this gun range is 4,600. There is thus a total error of 50 yards in the calculations. The point to determine is where this error lies. Assuming that the angle of sight is correct the correction for wind may have been wrongly computed, or there may be a variation in muzzle velocity caused by the propellant, or there may be some other cause.

(*d*) Assuming that the error is due to a wrong estimation of the wind, it must be ascertained from the range table what force of wind would cause an alteration to range of 50 yards at 4,500. It is found that this amounts to 15 f. s. for 18-pdr. and the force of the wind as now found should form the basis of calculation.

(*ii*) *If time is important* the following method may be used:

Having established as above that the true correction to a map range of 4,500 is 100 yards, then with this as a basis, a proportionate allowance can be made for the correction necessary to another target whose map range is also known.

e. g. If the map range to the new target is 5,800, a correction of 150 would be required, and 5,950 would therefore be the order to the battery.

PARALLELISM OF AIMING POSTS.

44. The exact parallelism of aiming posts can be checked at the battery by various methods. The following is a good practical method, the completion of which may be expected to occupy an hour:

(*a*) Lay out the aiming points by any of the methods given in Field Artillery Training.

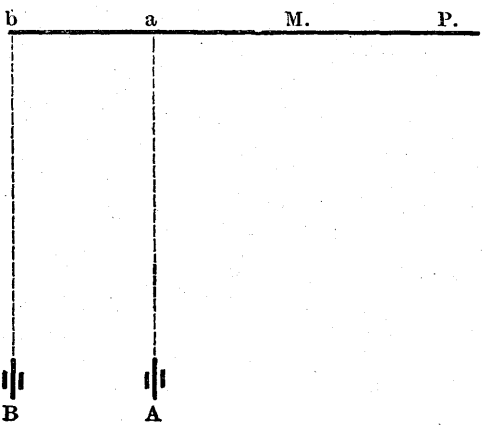
(*b*) Take the best director available, place it in front of the aiming points of the pivot gun, say at "a."

(*c*) Select some clearly defined point "P" to a flank, and put up a mark "M" between the director and "P."

(*d*) Measure the angle P. a. A several times. Let us say that the mean of three readings is 94° 15′.

(*e*) Move the director to "b" in prolongation of the aiming points of the next gun. Measure the angle P. b. B. It should read 94° 15′. If it does not, move the director slightly toward or away from "P" taking care to keep "M" and "P" in line. From the new position read the angle between "P" and the dial sight of the gun. When a position has been found for the director at which the angle between the dial sight and "P" measures 94° 15′, then that position is in the required line of fire.

Pick up the aiming points for that gun and replant them between the director and the dial sight.



(*f*) Move the director to a similar spot in front of the next gun and test as before.

45. Guns that fire time shrapnel (as distinct from howitzers) should always have their parallelism checked by observing "kites" from the battery, thus:

(*a*) From the pivot gun measure the angle of sight to whatever constitutes the sky-line in front; suppose a line of trees obstructs the view, and that the angle of sight to their top is 2° 20′. Give the order to the battery "angle of sight 3° elevation"; with this angle of sight a normal corrector would give bursts observable from the battery above the tree tops.

(*b*) Select a suitable range. *Provided that it will not cause danger to the infantry*, 3,600 yards will be found to save a certain amount of

calculation, as at that range one yard subtends one minute as measured by graticules.

(c) Note down the intervals in minutes by which the bursts should be separated in the air: Thus, suppose No. 3 gun pit contains the pivot gun, and that No. 2 gun is 10 yards to the right of No. 3 gun, its bursts should be 10 minutes to the right of that from No. 3 gun.

No. 1 gun is 55 yards to the right of No. 3 gun, its bursts should be 55 minutes to the right of that from No. 3 gun.

Similarly with Nos. 4, 5, and 6, to the left of No. 3 gun.

(*d*) From a suitable position near the pivot gun observe a round of battery fire with angle of sight 3 degrees elevation and range 3,600, and measure by means of graticules the number of minutes that the bursts of the other guns are right or left of that from the pivot gun. If any interval is found incorrect, give the necessary correction and repeat as required.

(*e*) Having by this method got the lines of fire of all guns parallel to that of the pivot gun, aiming posts should be replanted where necessary through the dial sight set at zero.

46. To secure parallel lines by observation from the O. P., register each gun in turn accurately on to the zero point. Leave the pivot gun in that line; switch the other guns out the correct amount (calculated mathematically) that will compensate for the intervals at which the guns are placed. *For example:* The perpendicular distance between No. 5 gun and the pivot gun is paced to be 65 yards (not 40 yards). Range to zero point 3,600. Give the order "No. 5, 1° 5′ M. L." Aiming posts are laid out in these lines, and a round of battery fire fired so as to see that no mistake has been made either in the calculation or at the guns.

PREPARATION OF THE FIGHTING MAP.

47. Before the fighting map can be prepared, the exact location of the pivot gun and of the zero point must be accurately determined.

The survey company will determine it, but the battery commander must be prepared to fix the location himself, as nearly as he can until the services of the survey company can be obtained.

48. The zero line is then drawn in colored chalk through the zero point and the position of the pivot gun, and should be extended right across the map to prevent any chance of a mistake in reading right or left.

49. Arcs are drawn in colored chalk at 2,000, 3,000, 4,000 yards, etc., and in chalk of a different color at 2,500, 3,500, 4,500 yards, etc., from the position of the pivot gun.

50. An arc is drawn at 8,000 yards from the position of the pivot gun and is marked in degrees right and left of the zero line. Rays at 10°, 20°, etc., right and left are drawn in chalk of one color; 5°, 15°, 25°, etc., right and left are drawn in chalk of another color.

51. The intermediate degrees and hundreds of yards may be marked in thin black lines if required; and in many cases it is useful to draw in degree lines right and left of the zero point from the position of the main observing station.

52. In one corner of the map should be pasted particulars regarding the various datum points; the location, the angle of sight and normal gun range to each must be recorded.

In the opposite corner a concentration table similar to that below may be shown but the figures must be correct for the actual intervals between the lines of fire of the guns.

CONCENTRATION TABLE.

[Calculated for 20× gun intervals.]

Range in yards.	More right guns.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
		′	° ′	° ′	° ′	° ′
2,000	0	35	1 0	1 30	2 0	2 40
3,000	0	25	40	1 0	1 20	1 50
4,000	0	20	30	45	1 0	1 20
5,000	0	15	25	35	50	1 5
6,000	0	10	20	30	40	55

On the back of the board it is convenient to paste the windgraph, and, for batteries concerned, the table on page 3 of the 18-pounder range table. An angle of sight table may also be included.

53. To prevent distortion, the artillery boards are prepared by cutting the map into squares, and pasting each square carefully on to stretched drawing paper with the grids marked in. It is not always possible for the fighting map to be thus accurately mounted, and some distortion is almost inevitable. To allow for this the error should be carefully measured as explained in par. 24.

TECHNICAL NOTES ON 18-POUNDER BARRAGES.

DEPTH OF BARRAGE.

54. A barrage, whether of shrapnel or of high explosive, will ordinarily cover a zone of some 200 yards depth. The better the drill and the more careful the preliminary work, the less deep will this zone be.

ESSENTIALS OF A GOOD BARRAGE.

55. The following points must receive attention if a satisfactory barrage is to be achieved:

(*a*) Smart and accurate drill.

(*b*) Rehearsals, to insure that the barrage shall progress exactly as required and that there shall be no thin places in it. Rehearsals are particularly necessary where the ground is undulating.

(*c*) Timekeeping. This is all important. The barrage is divided into periods of so many minutes. If the rate of fire is 4 rounds per gun per minute for two minutes there will be 8 rounds prepared at each gun for the first two minutes, after which fuses set at different fuse lengths will be required. If the rate of fire is not kept up as ordered, the 8 rounds will be fired either too soon, in which case there will be a pause before the signal to lift or the gun will lift before receiving the signal, or, on the other hand, the lift will be ordered before the 8 rounds have been fired, and rounds are either lost or fired at a wrong elevation.

It is generally as well, owing to the difficulty of accurate time-keeping, when ammunition has been prepared to have a spare round or two with each gun for each fuse in case the firing has been at too rapid a rate. It is better to have extra rounds than pauses in the fire at critical moments.

(*d*) Simplicity in "lifts." Straightforward lifts where there is but little alteration to sights do not require much rehearsal, but where in lifting a change in direction is also required, difficulties crop up. A battery frequently requires different elevation on all its guns at a lift, and at the next lift fresh changes both in line and in elevation on the sights. It is essential that where such lifts as these are ordered that several rehearsals without ammunition should take place.

(*e*) Sorting of ammunition by propellants.

(*f*) Adjustment of sights. If any particular range dial shows a tendency to slip, the laying with that gun should be by field clinometer. In any case during a prolonged barrage, as for instance during a big attack, an officer should occasionally go around the

battery with the field clinometer to make sure that range dials have not slipped and that the sights are still in adjustment.

(*g*) Calibration and consequent gun corrections.

AMMUNITION FOR BARRAGES.

56. Creeping barrages.—*Time shrapnel* affords the best screen and the best forward effect, and so presents marked advantages over high explosives for this purpose. Fifty per cent of shell bursting on graze is the ideal arrangement. It is often thought that a percussion shrapnel is a wasted round, but this is not altogether the case. On very bad ground probably most of the percussion rounds will be wasted, but there will be considerable forward effect from a certain proportion of them, whereas the 50 per cent which burst in air should nearly all be very effective, and all of those which burst on percussion will produce their share of the screening effect.

High explosive with delay gives less forward effect, as the majority of the fragments fly laterally, and the screening effect is slight and too high. Infantry can not keep so close to a barrage of this ammunition as they can to a shrapnel one, as the high explosive shell bursts some 30 to 40 yards beyond the point of impact. Moreover, short rounds of high explosive are more dangerous to our own infantry than short rounds of time shrapnel, as with the former the fragments fly sidewise down the line. It is sometimes said the advantage of a high explosive barrage over a time shrapnel barrage is that the error of the fuse is eliminated as well as errors in fuse setting. Where, however, a barrage is fired according to program there should be no errors in fuse setting, and where the long corrector is selected the error in fuse burning may be largely ignored. There will, it is true, be a few short high bursts, but these will probably not cause casualties and are far less objectionable than short high explosive shell as explained above.

It must be remembered that the ricochet action of this shell will not take place at ranges over about 3,500 yards. The fuse functions better the shorter the range and the firmer and the less pitted the ground.

High explosive without delay is unsuitable for a barrage. The screening effect is much the same as in the case of high explosive with delay, but material effect upon the enemy's infantry in trenches would only occur where a shell burst actually in the trenches.

57. Standing barrages.—Apart from the nature of the projectile to be employed, these are also of two kinds:

(*i*) That which is fired to keep down the heads of occupants of a trench which itself is not to be attacked.

(*ii*) To keep down the heads of infantry in a trench which forms the immediate objective of our own assaulting troops.

In the first case either high explosive with delay or without delay or time shrapnel may be employed. If high explosive with delay is used, the fire should be frontal, and not oblique or enfilade, owing to the direction of flight of the splinters.

If without delay, the effect is likely to be small and consequently more rounds should be fired.

In either case the range must be exactly found or the effect will be very small indeed.

Time shrapnel is the best of all, fired either frontally, obliquely, or in enfilade, but it is also the most difficult, as it is important that the height of burst of the fuses should be correct. For such a barrage the height of burst should be 10 minutes. The height should be arrived at by calculation or by observation of a sufficient number of rounds by an observer in the battery. In the latter case when the proper length of corrector has been ascertained by observation from the battery, a short series should be fired at the trench to insure that it is effective. The corrector setting should have been obtained correctly, then, if the height of burst is observed to be wrong, it merely means that the angle of site is incorrect. The latter must be adjusted and not the corrector setting.

When a trench is to be barraged immediately previous to the assault by our infantry, the most important point is that our infantry should get as close to the trench as possible before the barrage lifts. The barrage may be composed of either high explosive or shrapnel for this purpose. High explosive with delay if placed with absolute accuracy (i. e., with the M. P. I. 25 yards short of the trench and the burst immediately over the trench) will be the most effectual in damaging the defenders, but the infantry can not get up so close and but little screening effect is afforded.

Time shrapnel with a long corrector is therefore again probably the best.

58. Protective barrages during consolidation.—Screening effect is generally required for this purpose and therefore time shrapnel with a long corrector is to be preferred.

59. Protective barrages by night and defensive ("S. O. S.") barrages.—As our infantry are stationary under these barrages and screening effect is not required, high explosive is a suitable projectile. The stopping power of the shell is good against troops moving across the open, and its employment enables shrapnel to be reserved for other occasions. At night the use of high explosive has the further advantage that fuses do not have to be set.

60. Enfilade barrages.—Enfilade barrages offer an advantage in that infantry can approach closer to the trench fired at than with any other form of barrage. The projectile employed must invariably be time shrapnel, as the fragments of high explosive shell fly sidewise. The front covered by shrapnel shell bursting 10 minutes above the line of sight at a mean range is some 20 yards, and if the line be correct this means only 10 yards on either side of the trench.

As the effect of shrapnel is mainly forward, a very much greater proportion of bullets are in the trench than with any other nature of barrage, provided the line is right. For this reason an enfilade barrage is economical, and it is estimated that in ordinary circumstances one gun per 40 yards firing at 4 rounds per minute should be sufficient.

At the same time enfilade barrages present the grave disadvantage that guns placed for this purpose are soon masked. This type of barrage should therefore be regarded as suitable for raids and minor operations with limited objectives, but as unsuitable for a battle.

61. Flanking barrages.—Flanking barrages may consist of either shrapnel or high explosive; but if the latter is used, care must be taken that the shell are burst at a sufficient distance from the flanks of the infantry.

Experiments have shown that this distance, in the case of high explosive with delay fuse, should be 300 yards, assuming the line of fire to be parallel to the line of advance.

NOTES ON THE BEHAVIOR, EFFECT, AND EMPLOYMENT OF PROJECTILES AND FUSES.

62. There are three principal types of shell used in the service. They are—

1. Shrapnel shell.
2. High explosive shell.
3. Chemical shell.

SHRAPNEL SHELL.

63. The behavior and effect of shrapnel shell are well understood and do not require to be described here. The idea, however, that shrapnel shell bursting on percussion are practically useless requires some qualification. At short and medium ranges, and on suitable ground, the effect of percussion shrapnel is by no means inconsiderable.

With both percussion and time shrapnel the effect is all forward, and the width of the zone swept by the bullets is comparatively narrow (15–25 yards).

Employment:

(*a*) Frontal barrages, with long corrector to cover an advance.
(*b*) Enfilade barrages, with effective corrector.
(*c*) Defensive barrages.
(*d*) Neutralizing trenches.
(*e*) Firing on communication trenches, roads, tracks, etc., by day and night.
(*f*) Troops in the open.
(*g*) Wire cutting.
(*h*) Counterbattery work (neutralization), especially if the hostile batteries have not had time to dig themselves in.

Shrapnel shell are fired by guns only and not by howitzers.

HIGH-EXPLOSIVE SHELL.

64. High-explosive shell are fired by all natures of guns and howitzers. Their behavior and effect depend largely on the type of fuse used, and, when the fuse is provided with delay action, on whether the shell is fired by a gun or a howitzer.

There are three types of fuses employed with high-explosive shell.

(*i*) Instantaneous.
(*ii*) Nondelay (so-called, but giving a slight though appreciable delay action).
(*iii*) Delay fuses.

65. High explosive shell with instantaneous fuses.—Used with 4.5-inch, 6-inch, 8-inch, and 9.2-inch howitzers. Can also be used with 12-inch and 15-inch. Not at present supplied for use with guns (the present No. 106 instantaneous fuse will not act with certainty at angles of descent of less than about 8°).

Behavior.—The instantaneous fuse causes the shell to detonate immediately it strikes the ground.

Effect.—The shell makes a very shallow crater and gives very good concussion and splinter effect.

The effect of the detonation is mainly sideways and slightly forwards (i. e., at about 120° to the line of fire). The effect straight to the front and the backward effect are both comparatively small.

Employment:

(*a*) Against personnel in the open.
(*b*) Defensive barrages.
(*c*) Counter-battery work (neutralization).
(*d*) Neutralizing machine guns, especially those sited for flanking fire.
(*e*) Neutralizing trenches commanding the progress or the objective of an attack.

Employment—Continued.

(*f*) Distant barrages on roads and tracks.

(*g*) Bombardment of camps, bivouacs and billets.

(*h*) Destruction of wire entanglements. (The effect is similar to that of a medium trench mortar bomb with No. 107 fuse.)

NOTE.—(*a*) The distance sideways covered by the splinters from high explosive shell with instantaneous fuse renders their employment dangerous if burst to the flank of our own infantry in the open, or if burst close in front when fired from the flank.

The following table gives a rough guide as to the margin of safety which is considered desirable:

Nature of shell.	Laterally.	Forward or backward.
	Yards.	
4.5-inch	500–600	⅓ to ½ these amounts.
6-inch	600–700	
8-inch and 9.2-inch	800–1,000	

(*b*) Good effect may be expected from high-explosive shell with instantaneous fuse for neutralizing guns and machine guns if the shell can be burst opposite the embrasure. This will be especially so if the embrasure faces to a flank.

66. High-explosive shell with non-delay fuses.—Can be used with all natures of gun and howitzers.

Behavior.—The non-delay fuse detonates the shell almost immediately after it has penetrated into the ground, forming a crater similar in shape to an inverted cone.

Apart from the weight of the shell and the hardness or otherwise of the ground, the size of the crater appears to depend principally upon the remaining velocity of the shell. For instance, the crater formed by an 8-inch howitzer shell fired at a short range using the first charge is somewhat similar to the crater formed by a 6-inch howitzer shell fired with the full charge.

Employment with guns:

(*a*) Destruction of vertical cover, barricades, walls, etc.

(*b*) High-explosive barrages beyond the range at which shell will ricochet or where the ground is too broken for ricochet effect.

(*c*) Bombardment of dumps, railway stations, villages, etc.

Employment with howitzers:

(*a*) Bombardment of trenches and light cover.

(*b*) Counter battery work—destruction and neutralization.

Employment with howitzers—Continued.

(*c*) Bombardment of villages, railway stations, observation stations, etc.

(*d*) Destruction of wire when No. 106 (instantaneous) fuse is not available. The area destroyed, however, is limited and very much less in extent than when the instantaneous fuse is used.

NOTE.—The splinter effect with shell fused with non-delay fuses is comparatively small and infantry may be said to be reasonably safe within 200 yards of the burst.

67. H. E. shell with delay fuses.—*Behavior.*—This depends on the angle of descent and the nature of the ground. If the range is such that the angle of descent does not exceed about 8° and the ground is not very much cut up, the shell will ricochet and burst in the air.

With the 18-pounder gun the point of burst is from 10 to 50 yards in advance of where the shell strikes the ground and from 10 to 100 feet up in the air.

The strike of the splinters is downwards and slightly forwards and some will fly a considerable distance to a flank.

If the angle of descent is more than about 8°, the shell will penetrate and detonate some feet below the surface.

At long ranges the shell may penetrate so far that the noise of the burst is almost entirely muffled and there is no splinter effect or apparent crater. The reason of this is that the shell bursts so far below the surface that the cavity formed by the detonation is entirely below the ground and all that is visible is a small mound of earth forced up from below. It does not follow, however, that the shell is ineffective, as this is the effect desired with howitzer shell for the destruction of overhead cover, dugouts, magazines, etc.

Sometimes detonation takes place earlier and good crater effect is produced analogous but superior to the effect obtained with a non-delay fuse. This effect may be regarded as normal at short ranges when the lower charges are used.

(In this respect) the angle of descent, provided that it is sufficient to prevent the shell from ricochetting, appears to have little influence on the size of the crater.

Employment of high-explosive shell with delay fuses:

(1) With guns—

(*a*) Frontal barrages for ricochet effect.

(*b*) Strong vertical cover.

(*c*) Counterbattery work (destruction).

(*d*) Fire against trenches which are known to be manned.

Employment of high-explosive shell with delay fuses—Contd.

(2) With howitzers—

(*a*) Destruction of strong overhead cover, dugouts, magazines, etc.

(*b*) Bombardment of fortified villages.

(*c*) Counterbattery work (destruction).

(*d*) Bombardment of trenches, especially when firing with reduced charges.

CHEMICAL SHELL.

68. Lethal and lachrymatory shell.—These are fully dealt with in "Instructions on the use of lethal and lachrymatory shell" (S. S. 134) and will not be touched upon here.

69. Smoke shell.—These are at present supplied for the 18-pounder gun and are fused with non-delay fuses. A certain number of 4.5-inch fused with No. 44 fuse have also been supplied.

A white and opaque column of smoke is liberated from each shell. These columns merge with each other and form a dense screen. With a high barometer and a low wind the smoke tends to rise rather rapidly.

The most favorable conditions for the employment of these shell appear to be with a cross wind of moderate force and a low barometer. In such conditions the shell should be concentrated on a point well to windward of the locality which it is desired to screen, so that the smoke will be blown across it in a thick curtain. If there is a valley to the windward flank, the shell should be burst in it, as this to a certain extent mitigates the disadvantage of the tendency of the smoke to rise.

If the wind is blowing up or down the range it will be necessary to burst the shell at intervals all along the front to be screened, and a high expenditure of ammunition will be required.

With the 18-pounder it has been found necessary to burst the shell 10 yards apart at a rate of two rounds per minute. With the 4.5-inch shell an interval of 15 yards should be suitable.

The phosphorus with which these smoke shell are filled is highly inflammable and has been found to have considerable incendiary effect on occasions.

Employment:

(*a*) Blinding commanding ground from which rifle or machine-gun fire could be brought to bear on the progress of an attack or on its objective.

Employment—Continued.

(*b*) Blinding the enemy's observation stations, both in attack and defense.

(*c*) In a barrage of shrapnel or H. E. to improve the screening effect.

DUTIES OF OBSERVING OFFICERS, F. O. O.'s, LIAISON OFFICERS, AND FORWARD LIAISON OFFICERS.

70. The duties of observing officers, F. O. O.'s., liaison officers, and forward liaison officers have not been always clearly understood either by the officers filling these posts or by the infantry commanders. These instruction, therefore, are issued with a view to defining their duties clearly and will serve as a basis on which they will be carried out during the forthcoming operations.

71. The *observing officer* is the officer controlling the fire of his battery from the main observation station, which should be at the place where he can best see the situation and observe his fire. The battery commander will himself carry out important registration, and observe fire during destructive shoots, but as the strain of continuous observation is heavy, reliefs must be arranged when necessary. The battery commander is responsible that the officer controlling the fire is fully conversant with the situation, and is thoroughly capable of carrying out the work of observation efficiently.

72. The *F. O. O.* is the officer sent out by brigade, group, or battery commander to assist in observation of fire from a forward position. He is the "forward eyes" of the commander who sent him out. After the successful advance of the infantry, it will be his duty to establish communication with his commander from the observation station in the German lines allotted to him, and to carry on the work of observation from there.

73. *The liaison officer.*—Liaison between the C. R. A. of a division and his divisional commander is maintained by the two headquarters being established close together, thus allowing of frequent personal interviews.

If the double group commander of the heavy artillery covering a divisional front is not able to live very close to the divisional commander, it may be necessary to attach a liaison officer from one of the batteries to the staff of the division to insure maintenance of the closest touch between the heavy artillery and the general staff and C. R. A. of the division. The divisional commander will decide whether he wishes to have a heavy-artillery liaison officer attached to his staff.

During operations the infantry brigade headquarters are usually situated so far forward that the commander of field or heavy artillery affiliated to the brigade can not live close to them, as the necessary and intricate system of communication essential to the exercising of his command could not be maintained.

In such circumstances an officer, if possible not under the rank of captain, will be attached to the staff of the infantry brigadier both from the field and siege artillery covering the brigade front to maintain the closest touch between the arms concerned.

74. *Forward liaison officer.*—In order to maintain touch between the infantry immediately engaged in the attack and the field artillery supporting them, a field artillery subaltern will normally be attached to the headquarters of each battalion in the front line. As during the progress of the attack a battalion reaches the final objective allotted to it, and is passed by another battalion, this forward liaison officer will be transferred, so that liaison with the most advanced battalions is always maintained.

75. *All liaison officers* must appreciate—

(*a*) That it is their duty and privilege to act as advisers on all artillery matters to the commanders to whom they are attached.

(*b*) That it is their duty to be fully conversant with all the artillery dispositions, and actions arranged for, covering the infantry to whom they are attached and the neighboring bodies of infantry. For this purpose they must be specially instructed under arrangements to be made by the C. R. A.s and double siege group commanders.

(*c*) That they are the "forward ears" of the commanders who send them out and with whom they must maintain close touch. In order to follow the changes in the situation that takes place, their best position is the report center.

(*d*) That the success of operations largely depends on the accuracy of information and the speed with which this information is passed to the commanders in rear, and that they have unequaled opportunities of collecting information.

(*e*) That no amount of information is of any use unless they have the means of passing it back to the proper quarters.

(*f*) That it is part of their duty to investigate reported cases of the shelling of our own troops by our own guns, and to trace the source of the trouble and to stop it. Four essentials for finding out the battery whose fire is causing losses to our men are—

1. The time the shells were falling.
2. The rate of fire.

3. The caliber and nature of shell (shrapnel, high explosive, etc.).
4. Direction from which shell were coming.

Infantry officers should carefully note these four points.

(*g*) That it is not part of their duty to take part in bombing or other enterprises of like nature, and that they must not do so.

(*h*) That it is the special duty of the liaison officer at infantry brigade headquarters to keep his map up to date from information obtained from the staff of the infantry brigadier and other suitable sources. That he will pass the information so received on to the representatives of units, who should be sent to collect it at times which should be fixed in consultation with the staff of the infantry brigadier.

76. *Observing officers and F. O. O's.* must appreciate that in addition to the important work of observing fire it is their duty to keep the commanders in rear informed of the situation as far as they can see it from their O. P's.; frequently they will be the first people to see changes in the progress of operations, and their timely and accurate reports may have far-reaching results. It is their duty to keep their maps accurately up to date, and for this purpose they will refer constantly to the liaison officer. There were constant cases during the Somme battle when the maps of artillery observers were not kept up to date.

77. The following point with regard to sending back information requires particular attention and is frequently omitted. The *time* at which the occurrence which is the subject of the report took place must be given in the text. Negative information is frequently of the very greatest value.

78. It is of the first importance that the infantry should clearly understand the duties allotted to the various artillery officers as set forth above and that they should appreciate that whether they are efficiently carried out or not depends very largely on the assistance given to them.

It takes two to form a liaison.

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