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NOT TO BE TAKEN INTO FRONT-LINE TRENCHES

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Field Artillery Notes
No. 7

ARMY WAR COLLEGE
AUGUST, 1917

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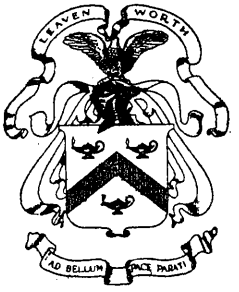
1917



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WAR DEPARTMENT,
WASHINGTON, *August 23, 1917.*

The following pamphlet "Field Artillery Notes No. 7," is published for the information of all concerned.

[300.8 A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

H. L. SCOTT,
Major General, Chief of Staff.

OFFICIAL:

H. P. McCAIN,
The Adjutant General.

WAR DEPARTMENT,
THE ADJUTANT GENERAL'S OFFICE,
Washington, June 19, 1917.

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By order of the Secretary of War:

H. P. MCCAIN,
The Adjutant General.

TABLE OF CONTENTS.

RANGING ON THE LINE OF OBSERVATION.

GENERAL STAFF, WAR OFFICE,
1916.

[This supersedes the pamphlet entitled "A Few Notes on Ranging Siege Howitzers with Visual Observation," issued November, 1915, all copies of which should now be destroyed.]

When observation takes place from a forward observing station, it is obvious that the observing officer will be approximately in the line of fire to only a small portion of the area allotted to his battery.

The farther forward he is the smaller will be this portion.

It follows that, with the majority of objectives, his line of vision will make a considerable angle with the line of fire from the battery.

From a position such as this, it is in many cases impossible to say how shells are falling as regards the line of fire; all that an observer can generally do is to measure the amount the shell falls right or left of his line of observation, unless the shell falls in line with the target, when he can also say if the round is plus or minus of the target *on his line of observation.*

When, therefore, observing from a position to a flank, a round must first be placed on the observer's line to the target.

When this has been done, bracketing is carried out in the usual way, but on the observer's line to the target, instead of the line battery target. This is called "ranging on the line of observation," and the following is the system.

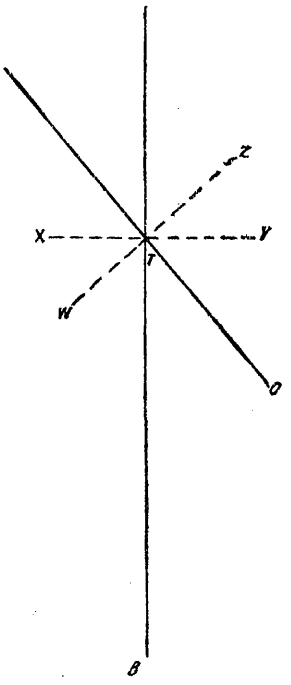


FIG. 1.

It must be borne in mind that a round that can be judged plus from O is not necessarily plus from B and vice versa. For instance, in Fig. 1, rounds in the sector X T W are plus from the

observer and minus from the battery, whereas rounds in the sector Z T Y are minus from the observer and plus from the battery. Also rounds observed left from the observer are not necessarily minus, and rounds observed right are not necessarily plus.

When ranging along the L. of O, it is better to speak of plus and minus and right and left as referring to O T and not B T.

The positions of the battery, observation station, and approximate position of the target are marked on the map. Hence the distances O T and the angle O T B can be obtained.

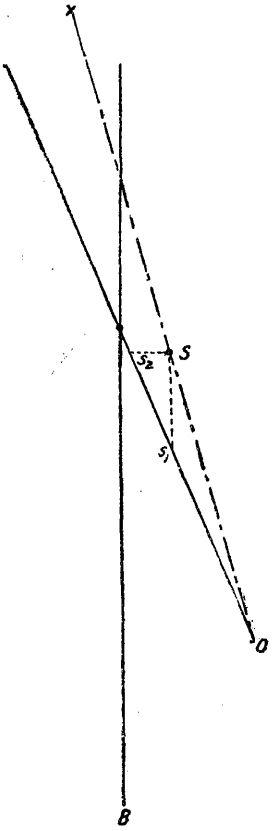


FIG. 2.

Presuming in Fig. 2, the first shot falls at S, all the observer can tell is that it is on the line O X, and so many degrees and minutes right of his line O T. He can not judge if the round is plus or minus; all he can do is to measure the amount right. He must now give a correction to bring the next shot on to his line.

He can either decrease his elevation and bring the next shot to S_1 or give more left deflection and bring it to S_2. Which is preferable will be discussed later on.

The problem, then, is to convert the degrees or minutes which the B.C. has observed the shot fall right or left of his line to degrees and minutes of gun elevation or gun deflection. The factors:

(1) $\frac{\text{Minutes of gun elevation}}{\text{Minutes of observation R. or L.}} = \frac{E}{O}$

(2) $\frac{\text{Minutes of gun deflection}}{\text{Minutes of observation R. or L.}} = \frac{D}{O}$

are found either by taking them from the "Table of Angles" or by calculation. The method of calculation is shown on page 7.

One of these factors is now applied.

Presume $\frac{E}{O}=\frac{1}{3}$ and $\frac{D}{O}=\frac{1}{6}$ and the shot falls 3° right, it is brought on to the L. of O by giving $\frac{1}{3}\times 3°=1°$ less elevation, or by giving $\frac{1}{6}\times 3°=30$ minutes more left deflection.

Presuming in Fig. 3 that $\frac{E}{O}$ is used. The next round should therefore fall at S_2, and can be observed as line and minus (along the L. of O). It is now required to bring the shot to the other side of the target and keep it on the L. of O.

It is clear that if only elevation is given, the shot will fall at Z, and if only deflection is given, it will fall at Y, and that to bring it to the desired spot, namely, S_3, the elevation must be increased, and a corresponding correction made for the deflection. To get this corresponding deflection, a third factor, generally called the combined factor, namely, $\frac{\text{minutes of gun deflection*}}{\text{minutes of gun elevation*}}=\frac{D}{E}$ is used. Presume this is $\frac{1}{2}$

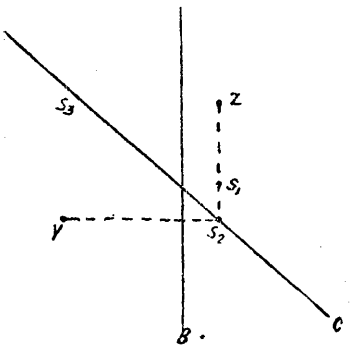


FIG. 3.

Then if the short bracket=20′, and the B.C. goes up 80′; $\frac{1}{2}\times 80=40$, more left is also required. Ranging is then proceeded with until the target is found. When close to the target, and it is a small one, judgment is required by the B.C. to determine whether the final small corrections required are those of deflection or elevation.

Theoretically, the above system is perfect, and if a gun had no 50 per cent zone the target is bound to be found very quickly. Practically, with small 50 per cent zones, there should be very little more difficulty in finding the target than when ranging

* Required to bring a shot which is + or − 100 yards on B T on to the L. of O.

along the battery line. Big 50 per cent zones, however, cause difficulties to many B.C.'s, especially with a narrow target, and it is found that B.C.'s do not sufficiently study the 50 per cent zones and the effect caused by them when ranging on the L. of O. A big 50 per cent zone will cause shell which are expected to fall on the observer's line to often fall right or left of it. B.C.'s make the mistake of correcting on these rounds instead of repeating them.

E. g.: R=8,000, O T=700, O T B=40°, 50 per cent zone=45 yards, target a group of houses 20 yards square. The target subtends about 1¼° either side of the L. of O. Fifty per cent of the rounds will fall right or left of the target, and, unless there is a favorable wind, will not admit of being observed plus or minus and will require repeating. With a very big 50 per cent zone, and a very narrow target, it may even be necessary to fire a group of four rounds before correcting.

Should the first round not fall on the line O T, the question arises as to how the second round shall be brought on to the line, whether by elevation or deflection. If the line is considered approximately correct, or if the use of the deflection factor would entail a large alteration of deflection, it is best to get on to the line by the elevation factor at all angles over about 20°, and this is especially necessary at very large angles where an accurate measurement of the amount plus or minus is possible. On the other hand with very small angles under about 20°, the deflection factor should be used to obviate large increases or decreases of range.

The next consideration is how to bracket the target. It is better to bracket by deflection with very big angles, and by elevation with very small angles. With medium angles some doubt may arise, and the range must be considered. With ranges of about 5,000 yards and over, bracket for deflection at angles of 45° and over, but bracket for elevation at small angles. At ranges of under 5,000 yards bracket by deflection at all angles down to about 20°, where factors cease to be essential. The reason for this is that if the combined factor or the S.B. is large, then when the B.C. has arrived at the mean of his S.B., his last order for deflection will still be a big one, and he still has to continue bracketing with deflection. Thus, if the combined factor is 4, and the S.B. is 20′, then, when the B.C. splits the S.B., the corresponding alteration of deflection will be 40′, and

he now has to continue bracketing with deflection to reduce this 40′.

It would, under such conditions, be simpler, therefore, as soon as a round has been observed as plus or minus along O T to start bracketing with deflection, making a convenient bracket of 20′ or 40′, and giving the corresponding alteration of elevation when necessary. When the deflection has been found, the elevation will also be correct.

An example of bracketing a target both by elevation and deflection is given.

It will be seen that in the extreme case with the observer at right angles to the line of fire, a round that falls "line" is "range" and bracketing *must* be done by deflection. This applies to angles approximating a right angle. It will be seen that the resulting alteration of elevation between angles of 70 and 90 is practically negligible, and between angles of 50 and 70 is small, unless the rounds are much out for line.

It is important to realize that the consequent alteration of elevation found by the combined factor should not be applied if it is less than the 50 per cent zone of the gun until the range has been verified and some last small corrections are required.

It is possible that an extreme case may occur when the line O T makes an angle of over 90° with B T. In this case it is best to get on to the L. of O. by means of the elevation factor and to bracket by deflection, as the right angle will generally not be much exceeded. In the rare event, however, of this happening and bracketing by elevation resorted to, it must be remembered that a round observed minus on the L. of O. requires a minus correction of elevation.

It is not necessary in all cases when the observation station is to a flank to range on the L. of O. If the target is a broad one and a good view of it is obtainable, or if the observer is very close up, he should be able to spot the fall of the rounds in relation to the target by making a mental picture of the line battery target. In this case he should range on the line battery target.

The principal points to remember are—

(1) A round should not be judged plus or minus unless it is a certainty.

(2) On the other hand, a round that is off the line may still be judged plus or minus if there is a wind favorable to observation; i. e., at right angles or nearly so to the L. of O., or there

is some feature by which the B. C. can judge it as plus or minus. It is not always necessary to get a round exactly on the L. of O.

(3) Having started to get on to the L. of O. by using the elevation factor, the B. C. should keep to it, and should not change to his deflection factor. Cases often occur where B. C.'s start correcting on each round instead of repeating, and when not getting a round on the L. of O. give it up and try the deflection factor, thereby wasting the rounds they had fired.

(4) The most important point of all is to repeat a round which does not fall where expected. If a B. C. has made a correction and expects a round to fall on the L. of O., and it does not do so, he should always repeat. The 50 per cent zones may bring the next round on to his line. Nearly all failures to find the target are caused by B. C.'s correcting on rounds which should have been repeated.

Ranging in yards.—In the case of guns and howitzers ranging in yards E will always be 100, and the three factors will be—

$$\frac{E}{O} = \frac{100}{0}$$

$$\frac{D}{O} = \text{is unaltered}$$

$$\frac{D}{E} = \frac{D}{100}$$

To find the factors by calculation—

Presume O T=1,300.
B T=8,000.
B T O=35°.

Presume the range increased or decreased 100 yards.

It is required to find—

(1) Minutes observation at O corresponding to this 100 yards.

(2) Minutes deflection at B to bring a round±100 yards on B T on to O T.

(3) Minutes of gun elevation corresponding to 100 yards.

For (1). Set 35° under 1,300 yards, and under 100 yards read 152′ (O).

For (2). Set 55° under 100 yards, and over 35° read 70 yards =210′=by 1,146 rule deflection=30′ (D).

For (3). See R T=27′ (E).

Example 1.—Target. House about 10 yards square. Wind, nil. Two 9.2-inch B. L. howitzers. Third charge. Observer left of battery line.
O T=1,300. B T O=30°. R.=4,000.
Factors $\frac{E}{O}=\frac{1}{8}$. $\frac{D}{O}=\frac{2}{5}$. $\frac{D}{E}=3$.
50 per cent zone=25 yards. S B=10 mins. B. C. has concentrated on No. 1 before opening fire.

Bracketing by elevation.

Round.	Elevation.	Result.	Orders.	Remarks.
1	10°	5° R	All 2° M. L. repeat.	B. C. elects to use deflection factor.
2	10°	Line—	All 1° M. R., 10° 20′	B. C. goes up twice S B, and gives consequent deflection.
3	10° 20′	1½° L.?	Repeat	B. C. repeats doubtful round.
4	10° 20′	Line+	All 30′ M.L., 10° 10′	Long bracket obtained. B. C. halves it, and gives consequent deflection.
5	10° 10′	Line—	All 15 M.R., 10° 15′ 2 rounds B Y F.	S. B. obtained B. C. halves S. B., brings in other gun and goes to B Y F.
6	10° 15′	1° R.?		
7	10° 15′	2° L.?		
8	10° 15′	Target right edge.		
9	10° 15′	10′ L.?	No. 2, 50′ M. R., 2 rounds, B Y F.	B. C. brings No. 2 onto his line by deflection factor.
10	10° 15′	Line+	No. 1, 10′ M. L.	Rounds 8 and 10 point to line of No. 1 being slightly right.
11	10° 15′	Target		
12	10° 15′	Target		
13	10° 15′	Line+		

Example.—Target. House about 10 yards square. Wind, nil. Two 9.2-inch B. L. howitzers. Third charge. Observers left of battery line.

O T=1,300. B T O=30°. R.=4,000.

Factors $\frac{E}{O}=\frac{1}{8}$. $\frac{D}{O}=\frac{2}{5}$. $\frac{D}{E}=3$.

B. C. has concentrated on No. 1.

Bracketing by deflection.

Round.	Elevation.	Result.	Orders.	Remarks.
1	10°	5° R.	10° 40′	B. C. uses elevation factor.
2	10° 40′	Line+	All 80′ M.L., 10° 15′	Brackets for deflection giving consequent elevation.
3	10° 15′	1° L.?	Repeat	Repeats doubtful round.
4	10° 15′	Line−	All 40′ M.R., 10° 30′	Reduces deflection bracket and gives corresponding alterations of elevation.
5	10° 30′	10′ L.+	All 20′ M.L., 10° 20′	
6	10° 20′	Line+	All 10′ M.L., 10° 15′	
7	10° 15′	5′ R.+	All 5′ M.L., 10° 15′ 4 rounds B Y F.	Line having been obtained within 10 minutes B. C. gives 5′ M. L., 10° 15′ and goes to B Y F verifying each howitzer on its own shooting.
8	10° 15′	Target		
9	10° 15′	2° L.?	No. 2, 50′ M. R.	Brings No. 2 on to line by deflection factor.
10	10° 15′	10′ R.+		
11	10° 15′	10 L.		

NOTES ON METEOROLOGICAL TELEGRAMS TO THE ARTILLERY.

The following notes are intended to meet difficulties which artillery officers have felt and experienced in connection with meteorological reports issued to them:

I. *Time of flight.*—There is an impression that the meteorological factors, temperature and wind, appropriate for a given time of flight will be different for guns and howitzers. There will be a slight difference, but in practice it is unimportant. The meteorological factors depend mainly on the height to which the shell goes and on the fraction of the whole time which the shell spends in different layers. For a given time of flight, T seconds, the height of the trajectory both for guns and howitzers is very nearly

$$h = 4\ T^2 \text{ feet.}$$

The time spent in the part of the trajectory below a height $\frac{3}{4}h$ is the same as that spent in the part of the trajectory above this height both for guns and howitzers.

II. *Temperature.*—The range tables are made out for standard conditions of temperature in which the temperature at the surface is 60° F.

Temperature at the surface is 60° F.
Temperature at 3,000 feet is 50° F.
Temperature at 6,000 feet is 40° F.
Temperature at 9,000 feet is 30° F.
Temperature at 12,000 feet is 20° F.

In shooting under actual conditions, what is required is not merely or even mainly the difference of the surface temperature from 60° F. but the mean difference (properly weighted) of the temperatures at all heights up to the maximum height from the standard temperatures for those heights.

For example, at 7 a. m. on February 3:

		Difference from standard.
The temperature at ground level was	3° F.	57
The temperature at 1,000 feet was	15° F.	42
The temperature at 3,000 feet was	15° F.	35
The temperature at 6,000 feet was	16° F.	24
The temperature at 9,000 feet was	12° F.	18

For a time of flight 50 seconds for which the trajectory reaches 10,000 feet the appropriately weighted mean difference from standard is about 24° F. This is the same as a difference of a ground temperature of 36° F. from the standard ground temperature.

Thus, as the correction tables are made out for differences of ground temperature from 60° F., the proper value to use on that occasion was 36° F. for a 50-second time of flight and not 3° F., the actual observed ground temperature.

III. *Wind.*—The correction tables are made out for a uniform wind blowing up or down the range. But as the shell is traveling for the most part in the upper air, the surface wind is much less important than the upper wind.

For example, on February 3 at 10 a. m.—

The surface wind was calm.
1,000 feet wind was 12 f/s at 79°.
2,000 feet wind was 20 f/s at 48°.
4,000 feet wind was 34 f/s at 25°.
6,000 feet wind was 34 f/s at 39°.

Here for a time of flight of 50 seconds the appropriate wind was about 32 f/s at 38° and not the surface value, which would give a zero correction.

IV. Even for low trajectories the surface values may be very misleading. On the average the wind at 200 feet is double that at the surface, but on some occasions it is four times the surface value. General rules can not be laid down except that for the middle of the day the 200 feet wind will in most cases be about 50 per cent above the surface value. In the evening, at night, and in the early morning, differences from a rule occur about as frequently as agreement with it.

Similarly for temperature. In the middle of the day the surface temperature is good enough if taken in the shade. (The reason for not taking it in the sun is this: The sun shines through the air without appreciably affecting its temperature, so

that air in the sun and in the shade has the same temperature. But when the sun shines on a thermometer it heats it appreciably and the thermometer no longer gives the temperature of the air, but something which may be 10 or 20° higher. A thermometer in the shade, on the other hand, gives the true temperature of the air after it has hung in the shade for some time.) In the night and early morning the air near the surface cools much more than that 100 feet or more above it, and the surface temperature may be 10 or 20° F. too low.

V. The telegrams issued at frequent intervals each day by meteor ought to be applied "hot." It is courting failure to be applying information from one telegram when another is available. Scrap what is out of date immediately up to date information comes in. During active operations you should receive a fresh meteorological report about every four hours.

VI. A specimen telegram, with interpretation and examples of its use in correcting ranges is given below:

The telegrams are numbered:

X1. This gives information to be applied between 4 a. m. and 8 a. m.

X2. This gives information to be applied between 8 a. m. and noon.

X3. This gives information to be applied between noon and 3 p. m.

X4. This gives information to be applied between 3 p. m. and 7 p. m.

X5. This gives information to be applied between 7 p. m. and 11 p. m.

X6. This gives information to be applied between 11 p. m. and 4 a. m.

VII. *Example of meteorological report to artillery.*—A complete telegram would be:

X 501		23d	AAA
5056	41267	4058	34262
3055	27256	2052	23242
1050	19231	0746	16223

Meteor 10.45 a. m.

The first two figures in each four-figure group give the time of flight to which the next two figures and the following five-figure group refer; the second two figures give the temperature; the first two figures of the five-figure group give the velocity in f/s, and the last three figures the direction in degrees from North.

Thus the above telegram means:

For 50 seconds time of flight temperature is 56° F. and wind 41 f/s at 267° (3° S. of W.).

For 40 seconds time of flight temperature is 58° F. and wind 34 f/s at 262° (8° S. of W.)

For 30 seconds time of flight temperature is 55° F. and wind 27 f/s at 256° (14° S. of W.).

For 20 seconds time of flight temperature is 52° F. and wind 23 f/s at 242° (28° S. of W.).

For 10 seconds time of flight temperature is 50° F. and wind 19 f/s at 231° (39° S. of W.).

For 7 seconds time of flight temperature is 46° F. and wind 16 f/s at 223° (47° S. of W.).

The directions are given true as distinguished from magnetic, e. g., 223° is 47° south of true west, but it is only about 33° south of magnetic west.

The velocities are always given in f/s and never in m. p. h.

NOTE.—If the velocity is less than 10 f/s a "0" is inserted, and similarly if the direction angle is less than 100°. For example, five-figure groups:

(*a*) 29043 (*b*) 09187

mean (*a*) the wind is 29 f/s at 43° (43° E. of N.).

(*b*) the wind is 9 f/s at 187° (7° W. of S.).

If the velocity is 100 f/s or more, the five-figure group becomes a six-figure group and the first three figures give the velocity, e. g., 112270 means the wind is 112 f/s at 270° (west).

VIII. *Examples of application of corrections from meteorological results given in above telegram if the barometer reading is 30.40 inches.*

1. (*a*) 4.5″ Q. F. howitzer. Firing due east at a range of about 3,000 yards with fourth charge. The time of flight is 12.4″: Take the value for the nearest time, 10″, viz, 19 f/s at 231° and 50° F.

Map range	3,000 yards.
Barometer 30.40	+ 5
Air temperature 50	+ 8
Following wind 15 f/s	−21

Cross wind blows from right to left as we look along the trajectory: Therefore *Right* deflection to correct for cross wind 12 f/s=5′.

(*b*) 4.5″ Q. F. howitzer. Firing due east. Range 5,000 yards with fourth charge. The time of flight is 25.3″. Take the value midway between those for 20″ and for 30″, viz, 25 f/s at 249° and 53° F.

Map range	5,000 yards.
Barometer 30.40	+14
Air temperature 53	+14
Following wind 23 f/s	−87

Right deflection to correct for cross wind 9 f/s=6′.

2. (*a*) 8″ B. L. howitzer. Firing due east at 6,000 yards with fourth charge. Time of flight is 18.3″. Take values for 20″ as near enough, e, g., 23 f/s at 242° and 52° F.

Map range	6,000 yards.
Barometer 30.40	+18
Air temperature 52	+21
Following wind 20 f/s	−96

Right deflection to correct for cross wind 11 f/s=8′.

(*b*) 8″ B. L. howitzer. Firing due east at 10,000 yards with fourth charge. Time of flight 39.5″. Take values for 40″, viz, 34 f/s at 262° and 58° F.

May range	10,000 yards.
Barometer[1] 30.40	+ 37
Air temperature 58	+ 11
Following wind 34 f/s	−344

Right deflection to correct for cross wind 5 f/s=7′.

(*c*) 8″ B. L. howitzer. Firing N. E. at 10,000 yards with fourth charge.

Map range	10,000 yards.
Barometer 30.40	+ 37
Air temperature	+ 11
Following wind 27 f/s	−273

In this case cross wind blows from left to right of trajectory, and, therefore,

Left deflection to correct for cross wind 20 f/s=25′.

[1] NOTE.—For high trajectories the actual reading of the barometer ought to be corrected before use in the correction tables, owing to the fact that the decrease of pressure with height depends upon the temperature.

3. (*a*) 18-pdr. Q. F. gun. Firing due east at 3,000 yards with cordite charge. Time of flight is 7.5″. Take values for 7″, viz, 16 f/s at 223° and 46° F.

Map range	3,000 yards.
Barometer 30.40	+12
Air temperature 46	+22
Following wind 11 f/s	−22

Right deflection to correct for cross wind 12 f/s=7′.

(*b*) 18-pdr. Q. F. gun. Firing due east at 7,000 yards with cordite charge. Time of flight 23.0″. Take values for 20″, viz, 23 f/s at 242° and 52° F.

Map range	7,000 yards.
Barometer 30.40	+36
Air temperature 52	+42
Following wind 20 f/s	−132

Right deflection to correct for cross wind of 11 f/s=15′.

The following table shows the values to be added to or subtracted from the actual readings. The temperature to be used in this table is that given in the telegram.

Time of flight.	Altitude of trajectory.	Temperature.						
		20	30	40	50	60	70	80
Sections.	Feet.	Subtract from barometer reading (inches).					Add to barometer reading (inches).	
27	3,000	0.17	0.12	0.08	0.04	0	0.04	0.08
39	6,000	0.31	0.23	0.15	0.07	0	0.07	0.14
47	9,000	0.44	0.32	0.21	0.10	0	0.10	0.20
55	12,000	0.56	0.41	0.27	0.13	0	0.13	0.25

NOTES FOR ARTILLERY OFFICERS ON SHOOTS WITH AEROPLANE OBSERVATION.

Recent operations have shown that artillery commanders can do much to assist in securing the success of aerial observation. The following notes indicate certain points which closely affect success and which every artillery commander concerned should bear in mind.

1. *Avoidance of delay.*—(*a*) An aeroplane carries a limited quantity of petrol and may, therefore, if delays occur during a shoot, have to return home before the task is completed.

(*b*) If delay is unavoidable and the signal "guns not ready to fire" or "go home" has to be put out, the bars or figures signifying the probable duration of the delay (vide card of "Signals between Aeroplanes and Artillery") must invariably be displayed.

(*c*) Once a shoot has begun, every endeavor should be made to avoid interruption and the observer should not be recalled to the battery by a cessation of fire unless this is absolutely necessary.

(*d*) It is because aeroplanes move at a high speed and the observer can only see the target in certain positions that it is laid down that a gun must be fired within 10 seconds of the signal "G" being received. If this can not be done the gun must wait for another "G"; otherwise the round will be unobserved.

2. *Ground signals.*—(*a*) Promptitude of reply by ground signals to signals sent from the aeroplanes is essential. Artillery officers must be thoroughly acquainted with all the ground signals in use.

(*b*) Artillery officers must remember that the observer when flying over a target during a shoot can not see a ground signal at the battery. If it is necessary to recall the observer to read a ground signal, fire must be stopped (but see par. 1 (*c*)).

(*c*) If a battery is called up by an aeroplane and can not engage the target, a ground signal must be put out for the information of the observer.

(*d*) Artillery commanders must see that the ground signals are complete, correct, and suitably placed. An open dark-colored piece of ground should be selected away from other objects, such as trenches, chalk heaps, etc., likely to catch an observer's eye. A man must be detailed to work the ground signals. The wireless operator is fully employed receiving signals.

3. *Wireless stations.*—(*a*) In the absence of a R. F. C. officer, artillery commanders must see that the wireless mast is erected on the highest ground in the vicinity and is correctly arranged (vide the attached "Notes on wireless").

(*b*) Artillery commanders are responsible that a strong and suitable dugout is provided for the operator. It should be as sound proof as possible and not too close to the guns.

Telephone communication between the battery commander and the operator must be quick and certain.

(*c*) It is better to erect the wireless station on a rise at some distance from the guns and to connect up by telephone than to avoid the use of the telephone by placing the operator in the same dugout as the battery commander, if this dugout is in a hollow or close to the guns.

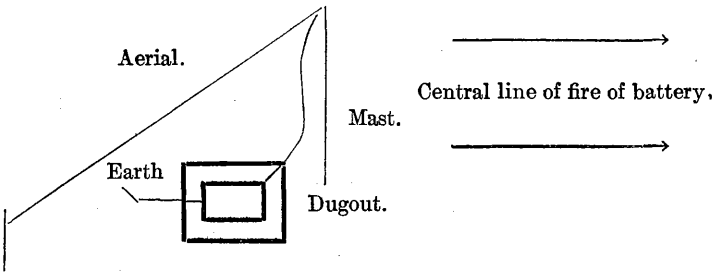
4. *Investigation of failures.*—Thorough investigation of every failure that occurs must be made immediately as a matter of routine. The R. F. C. is prepared to give every assistance in this matter.

Battery commanders should make a point of frequently seeing the R. F. C. observers and wireless officers with whom they work and of discussing matters with them.

NOTES ON WIRELESS.

Erection of stations.—A great improvement may still be made in the erection of stations with batteries. The following points require most careful attention:

1. Experiment has proved the following arrangement of aerial to give the best results. (*See sketch.*)



In future all stations will be erected on this principle—i. e., mast toward the target. Dugout and lead at mast end of aerial.

2. Earth leads are seldom properly arranged.

The ideal is a straight short lead direct to the earth.

The following faults are commonly found:

Earth lead brought round instrument—twisted round aerial lead—taken through same hole in dugout as aerial lead—unnecessarily long and winding.

In the case of a deep dugout it is far better to arrange the earth mat in the dugout than to bring it up to the surface by a long lead.

Experiment seems to prove that the best position for the earth mat is parallel to and immediately under the aerial as close to the tuner as possible, and buried.

3. Aerial leads. More attention should be paid to insulation. The lead, even though insulated, should not touch or be led through earth. Nor must leads be, as is often the case at present, in contact with the iron or earth roofs of dugouts.

The position of the mast must be such as to facilitate a direct aerial lead to the instrument.

4. It is important that dugouts should be as quiet as possible, and that an elevated position should be chosen for the mast.

NOTES ON COOPERATION BETWEEN AIRCRAFT AND ARTILLERY DURING RECENT OPERATIONS ON THE SECOND ARMY FRONT.

1. The very successful cooperation between the artillery and the R. F. C. during the operations against the Wytschaete-Messines Ridge was largely due to the fact that the principles laid down in the various official manuals were followed.

In view of the constant changes in the location of artillery and R. F. C. units, and the short training and limited experience of much of their personnel, it is essential that procedure should be both systematized and simple.

2. The following points are specially worthy of notice:

A.—COUNTER-BATTERY WORK.

(i) The necessity for careful and early allotment of counter-battery areas.

Artillery Notes No. 3, par. 2 (S. S. 139/3).

Cooperation of Aircraft with Artillery, par. 5 (S. S. 131).

(ii) The necessity of allotting batteries to deal with NF calls from specified areas without reference to Group H. Q. The latter must keep in touch with the situation and see that NF calls are answered, but previous reference only causes delay and inadequate fire.

(iii) The procedure best adapted to the various situations before, during, and after the infantry attack as regards co-operation between Artillery and Aircraft.

(*a*) Before the attack the large majority of shoots should be prearranged. As many aeroplanes as possible will be working on these, and other active hostile batteries should normally be sent down under the NF call and dealt with by the battery allotted to the area. Not much observation of neutralizing fire will be possible, as aeroplanes will be busy with prearranged shoots.

(*b*) During the assault the neutralization of all known hostile batteries must be prearranged. Machines must be allotted an area to watch and must report active batteries in their area under the NF call. They should preferably have one or two batteries ready to engage particularly active or troublesome hostile batteries on receipt of a MQNF call. If batteries can not be so allotted the ANF call should be used, but will not give such good results. Batteries employed on bombardment and barrage which will complete their tasks early and be no longer required for this work may be detailed beforehand to take up counter-battery work subsequently and be allotted areas of responsibility.

(*c*) After the attack every effort must be made to resume prearranged shoots as early as possible. The chief difficulty occurs when our artillery is moving up. Where prearrangement is impossible MQNF and ANF calls must be used, and observers must be prepared to work without ground strips if necessary. Shooting by the map without observation is unlikely to give accurate results when batteries have moved and have not their own positions accurately located. New counter-battery areas must be allotted at once and notified to all concerned without delay. With a limited objective it may be possible to allot the new counter-battery areas beforehand.

(iv) Photography of counter-battery areas must be systematic and kept up to date. Photographing the results of shoots only is not sufficient, as a heavy demand for photographs is bound to arise when a concentration of artillery takes place (*see* Artillery Notes No. 3—IV. (14)). Good results were obtained by some counter-battery machines carrying cameras on Z day and photographing areas of new artillery activity.

B.—BOMBARDMENT.

(i) Aerial observation during the preliminary bombardment demands very careful arrangements. A detailed program is necessary for each day and must be drawn out by the B. G. C. Corps H. A. If this is left to H. A. group commanders, coordination becomes very difficult and more work is thrown on the squadron commander R. F. C. than he can perform.

Programs should show:

(*a*) Tasks giving coordinates of the flanks of each task and the number and position of the battery to engage it.

(*b*) The point or points on which the battery is to be ranged.

(*c*) The time at which aerial observation of each task is to commence and finish.

The program must be made out to commence at a zero hour, the latter being decided according to weather, and all concerned informed. Once zero hour has been decided the program must be adhered to, and if bad weather or other causes prevent work starting at zero, the program must be taken up at the hour at which work does start, and shoots thereby lost must be reintroduced in a subsequent program.

If the program is sufficiently detailed and is got out early the previous evening, telephoning will be reduced to a minimum and personnel will get proper rest. In one corps programs were always out by 7 p. m. They should not be later than this, and the earlier the better. A suitable allotment of work is four batteries to a machine on a three-hour flight, two being ranged during the first hour and two during the second, and the fire of all four watched and kept on their targets during the remaining hour.[1] During the time air observation is provided no battery of similar caliber should fire within 200 yards of the battery being ranged. The bombardment of Oosttaverne line (final objective) during the five hours' halt in the operations which preceded the infantry assault on this line was regulated by aerial observations. A special call OL (Oosttaverne line) was used, and mostly corrections given on the portion of the line in any particular map square, e. g., OL O.22.a.M.A.3, meaning that the batteries bombarding the line in O.22.a. were shooting A.3 from the line.

(ii) Practice barrages with aerial observation are of great value.

(iii) Stoppage of fire for photographing the results of bombardment is unnecessary. With careful prearrangement portions of the trenches on which a slow rate of fire is being maintained can be photographed while other portions are being more heavily bombarded and vice versa.

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[1] This, of course, is only to be regarded as a general guide to procedure; the period for which fire must be continued naturally varies with the target.

C.—ENGAGEMENT OF FLEETING TARGETS.

Very careful prearrangement is necessary if fleeting targets are to be adequately engaged. Such targets are sent down under the zone call, followed by a description of the target, e. g., FAN (infantry), COL (column), or if of sufficient importance by the zone call preceded by LL. (Cooperation of aircraft with artillery, S. S. 131, pars. 19 and 24, ii.)

Fleeting targets sent down under the ordinary zone call require one or more short, rapid bursts of concentrated fire, and should be engaged by sections of all available batteries of counter-battery groups within whose arcs of fire they are situated. and also, if possible, by sections of any field artillery battery which can reach them.

The LL call is only used for a target of great importance. Such a target requires an intense burst of concentrated fire and should be engaged by at least sections of all heavy artillery batteries and by all field batteries which can reach it.

As regards field artillery's participation in replying to all calls on fleeting targets and LL calls, it will rarely be possible to spare guns for this purpose while the infantry is actually advancing. During periods of consolidation, on the other hand, the participation of sections or batteries of field artillery can generally be arranged by superimposing the fire of a certain number of units so that they can reply to these calls without creating a gap in the protective barrage.

Periods of consolidation are of particular importance, as it is then that the enemy's troops are most likely to be on the move.

During this time bombardment troops will normally be keeping up a slow rate of fire and will have batteries available to deal with fleeting targets. These should be previously detailed, and should engage all such targets within their arcs of fire.

Long-range gun batteries employed on searching communications and similar duties should engage distant targets sent down under the zone call or LL call whenever such targets come within their arc of fire.

Detailed orders are very necessary, defining the responsibilities of groups and batteries as regards engaging fleeting targets before, during, and after the assault. The necessity for making a large number of batteries responsible for answering such calls is shown by the fact that an LL call on 1,000 infantry was missed by a group H. Q. and all its batteries.

The history of one hostile battery, on the other hand, shows the value of careful prearrangement. It was situated due east of the ridge and was reported as active under the NF call and engaged by batteries of both the II. Anzac and X. Corps. It then moved and was reported on the move by LL call and was engaged by several batteries. On coming into action again it was engaged under the MQNF call and destroyed by a battery of the II. Anzac Corps.

D.—LIMITATION OF THE NUMBER OF MACHINES USING WIRELESS ON ANY FRONT.

Coordination of bombardment and counter-battery work with aerial observation is very necessary. The number of machines using wireless which can work on any front at one time is limited (Cooperation of Aircraft with Artillery, S. S. 131, par. 39), and any attempt to increase them may result in dislocating the whole of the wireless communication. The relative importance of aerial observation for the various natures of counter-battery work and bombardment must therefore be carefully weighed at all stages of the operations so that a suitable allotment of aeroplanes can be made.

For instance, if five machines could work at one time on a corps front a suitable allotment during the preliminary bombardment would be four to prearranged counter-battery work and bombardment, and one to report active hostile batteries by zone call. During the infantry attack four at least would normally be best employed in reporting targets by zone call, one or two batteries per aeroplane being detailed for deliberate shoots. The fifth might be employed on special duties, such as ranging long-range guns on back areas or the like. Subsequently, as the artillery fight became more stationary, the bulk of the machines would be best employed on prearranged work.

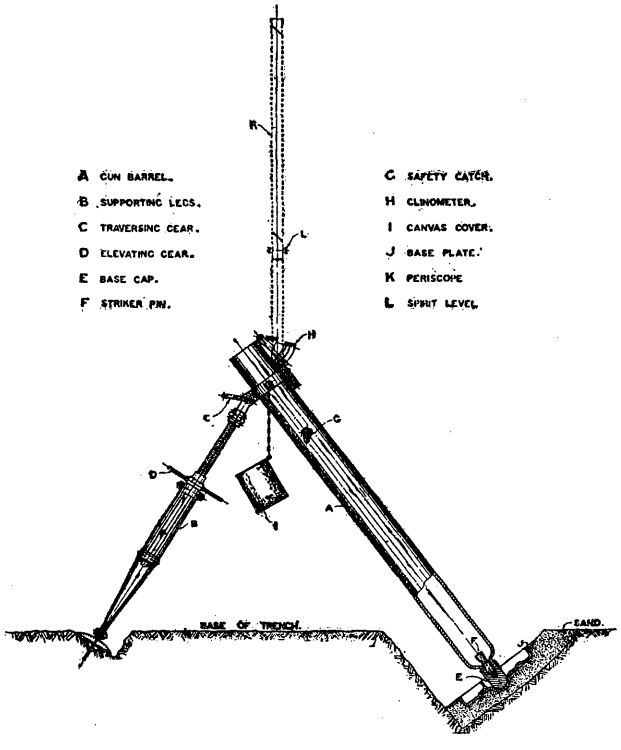
E.—LIMITATION OF THE NUMBER OF INDIVIDUALS WITH WHOM THE SQUADRON COMMANDER, R. F. C., HAS TO DEAL.

It is essential that the squadron commander, R. F. C., should only be asked to deal direct with the corps and heavy artillery H. Q. If he is required to deal with groups and batteries, he can not pay the necessary attention to his machines and the personnel of his squadron.

STOKES' TRENCH HOWITZER

3-INCH MARK I.

DIAGRAM OF STOKES' HOWITZER.



GENERAL DESCRIPTION.

Each howitzer equipment is issued in a case complete, and consists of—

1. The barrel.
2. The supporting legs with traversing and elevating screws.
3. The base plate.
4. The clinometer.
5. The periscope.
6. Cleaning rods, tommy bar, spanner, oil can, 2 pounds cotton waste.

1. *The barrel* is made with a removable screw cap to close the base and to carry the striker, which explodes the cartridge.

A tommy bar is provided for removing the cap.

A catch or bolt is fitted in the side of the barrel which, when in position, prevents the shell sliding down the barrel. The end of this bolt is fitted with an L-shaped shackle, to which is attached a lanyard for withdrawing the bolt to fire the shell.

When rapid fire is to be carried out, the shackle should be placed so that the short projecting arm prevents the bolt from accidentally sliding into the barrel. Shell can then be hand-fed into the muzzle as soon as each preceding shell has left the barrel.

2. *The supporting legs* consist of an A-frame arranged to fold up for transport, the horizontal cross-bars hinging upward as the legs come together.

The bottom of each side frame is fitted with a dished disk and spike to facilitate supporting the legs firmly and steadily on the ground.

The traversing and elevating motions can be operated by turning the handles in the required direction.

3. *Base plate.*—The base plate is formed of pressed steel, stiffened so as to take the recoil of the barrel. Three hemispherical depressions are provided to receive the base cap of the howitzer and to facilitate rapid traversing by transferring the cap from one depression to another.

A rope handle is provided for carrying the plate.

4. *The clinometer*, when in position, indicates the angle of elevation of the barrel. It should be placed on the barrel with the feet resting against the leg collar. It should be upright and in line with the barrel axis.

Range tables are marked on the clinometer; on one side in yards and seconds corresponding to the distances and times which the shell will travel with the red cartridges, and on the other side the distances and times for green cartridges, when the spirit level bubble is central at the respective readings.

5. *The periscope* is arranged with a tail piece which, when inserted in the leg collar, and *when the periscope* is vertical, as indicated by the spirit level, will give the line of fire of the barrel.

Any desired object can be brought into the field of view by traversing and inclining the periscope forward or backward.

DESCRIPTION OF SHELL.

The shell is filled with high explosive, which is exploded by means of a short length of Bickford time fuze and a detonator.

The fuze is lighted by a cap fitted to its end, which is struck at the moment of firing. The length of the fuze determines the time the shell explodes, and the fuze must therefore be cut to the required length before the detonator is attached.

The accompanying diagram shows the construction of the shell and fuze.

The container A holds the propellant cartridge; the body B has two ends C screwed into it, and contains the high explosive. The detonator tube D passes through the fuze head nipple E, and contains the time fuze F and detonator G. The fuze cap holder H is attached to the time fuze F and has vent holes covered with waterproof paper to keep the end of the fuze dry.

The fuze head I screws on to the nipple E and keeps the fuze in position.

When the spring-controlled striker L is released by the fly-off lever J, the fuze cap is struck and the fuze is lighted.

The fly-off lever J is kept in position by a set-back release K, kept in position by a spring and a safety pin M. The safety pin N prevents the striker accidentally coming in contact with the fuze cap.

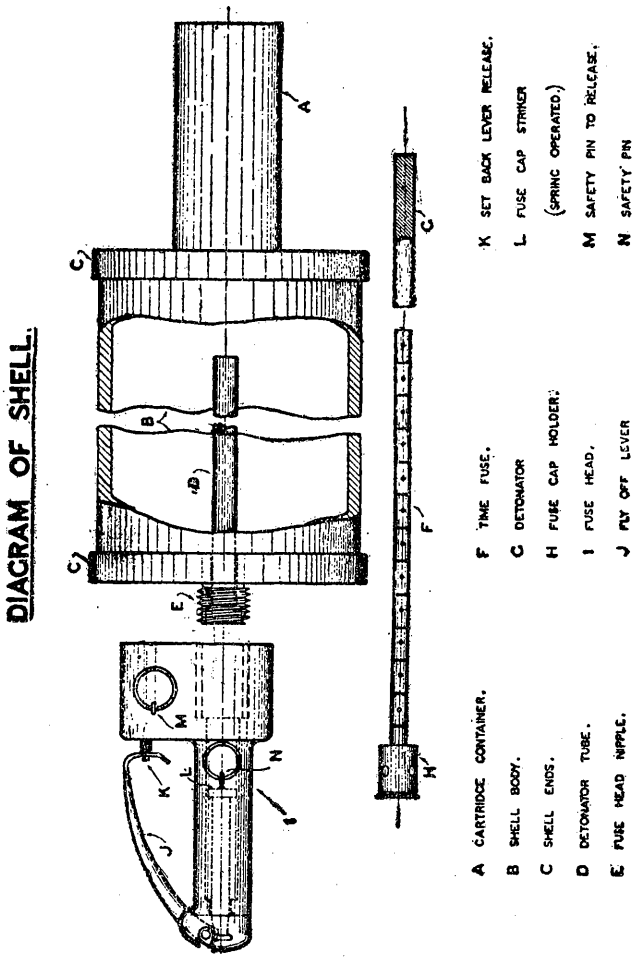
Unless the safety pin is withdrawn the set-back release can not operate, and the fuze will not be lighted when the shell is fired. Just before firing, therefore, it is necessary to remove this safety pin, and also the pin under the striker.

At the moment of firing the action of the fuze is as follows:

1. The lever release K is set back, leaving the fly-off lever

free to move outward until it comes against the side of the barrel.

2. On leaving the barrel the fly-off lever becomes detached



and allows the spring behind the fuze-cap striker to force the striker against the fuze cap, which, on going off, blows the vent holes free and lights the fuze, which burns till it

reaches the detonator, which it explodes, and detonates the high explosive in the shell.

The 3-inch shell are issued in boxes containing three sets of shell, fuzes, and detonators. The cartridges are issued in boxes holding nine packets of 25 each. The red and green cartridges are issued in separate boxes. The end of the green cases has a wad with a small hole in it for identification in the dark.

DIRECTIONS FOR FIRING.

The howitzer is arranged to fire a special design of shell, in the base of which is placed a cartridge containing the propellant charge.

The howitzer is muzzle loading, and must be set up at such an angle that the shell will slide down the barrel freely. When the cap of the cartridge receives the blow resulting from the striker at the base of the barrel stopping the downward motion of the shell, the contents of the cartridge explode, driving the shell from the howitzer, carrying the cartridge case with it.

It is then ready to fire another round.

To set up howitzer, proceed as follows:

1. Dig in the trench a small excavation to receive the base plate of such a shape that the base plate can be well supported by a good sound backing. The top of the base plate should be at least 6 inches below the level of the ground.

The base plate should be as nearly as possible square with the axis of the barrel when in the firing position. That is to say, if the howitzer is set up at an angle of 45°, the base plate should also be at an angle of 45° with the horizon, and should in the other direction exactly face the object to be fired at.

When the bottom of the trench is of clay, which is not well consolidated, it is advisable to provide a backing of about 2 inches of sand, if it is procurable, otherwise the kick of the barrel may cause it to spring back out of the depression in the base plate and prevent rapid firing.

Accuracy of fire depends upon the base plate being well bedded.

If it is necessary to alter the direction or angle of the barrel from time to time, it is not necessary also to alter the position of the base plate, so long as the plate is well bedded and reasonably square with the barrel.

9786°—17——3

The shelf angle on the base plate should be below the cup-shaped depressions and the rope handle on the top side of the plate.

When the base plate is well bedded in position, place the base of the gun in the central cup depression and place the legs, with the traversing motion in mid position, so that the barrel points in the desired direction, the legs pointing forward.

When the elevating screw is at right angles to the barrel the recoil of the howitzer causes the least disturbance to the laying, and less strain is thrown on the legs. The feet of the legs should be well trodden into the ground when final adjustments are being completed.

Diagrams 1, 2, and 3 show how the howitzer should be set up so as to be quickly available for any ranges between maximum and minimum when two base plates are available, and it is important to instantly increase the range to support an attack.

To hit an object at a known distance which can be seen, set the barrel to the inclination which will give the distance as indicated by the clinometer, remove the clinometer and substitute the periscope, care being taken to see that it is vertical, as shown by the spirit level. Traverse the barrel till the object to be hit can be seen on the center of the mirrors. The periscope can be hinged backward or forward without affecting the correct result, so long as the spirit level shows it to be upright in the other direction.

If an observer can spot the position of the first shot, the necessary correction can be made by means of the periscope before again firing. The periscope should not be in position when firing.

Corrections for distance may similarly be made by means of the clinometer.

It may not always be possible to fuze the shell to suit the distance of the trench or object directly opposite the howitzer. The range may then be increased by agreement with other howitzer teams to fire obliquely at such an angle as will suit the fuzes available. A crossed or laced fire is very effective and confusing to the enemy.

Two sizes of cartridges are issued for use with shell, viz:

	3-inch howitzer.
Green cases	190 to 300 yards.
Red cases	270 to 430 yards.

When not in use the muzzle cap should be left on the barrel.

In wet weather, rain should be kept from the barrel, as it affects the range.

STOKES TRENCH HOWITZER
3-INCH MARK I.

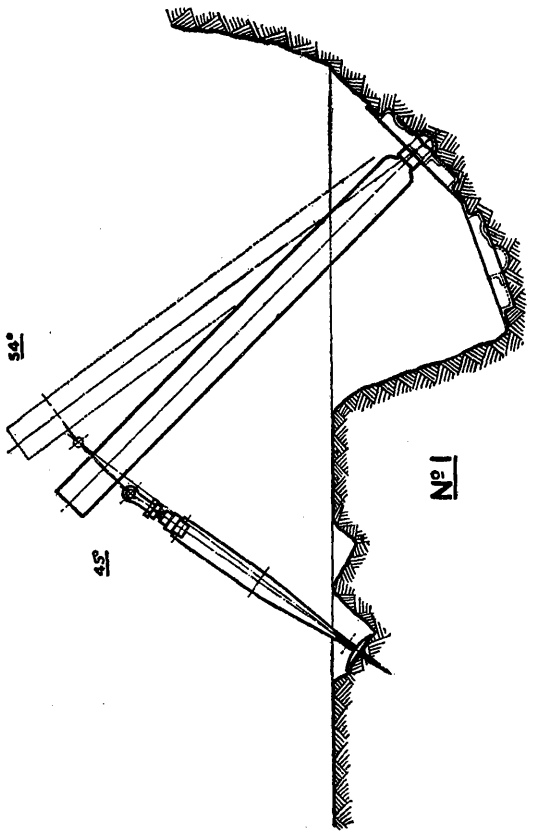


DIAGRAM SHEWING HOW TO SET UP HOWITZER SO AS QUICKLY TO CHANGE FROM MINIMUM TO MAXIMUM RANGE.

9

The cartridges, fuzes, and detonators should be kept as dry as possible, as damp is detrimental to them.

The cartridges should also be kept at an even temperature before firing, as changes in temperature affect the range.

STOKES' TRENCH HOWITZER
3-INCH MARK I.

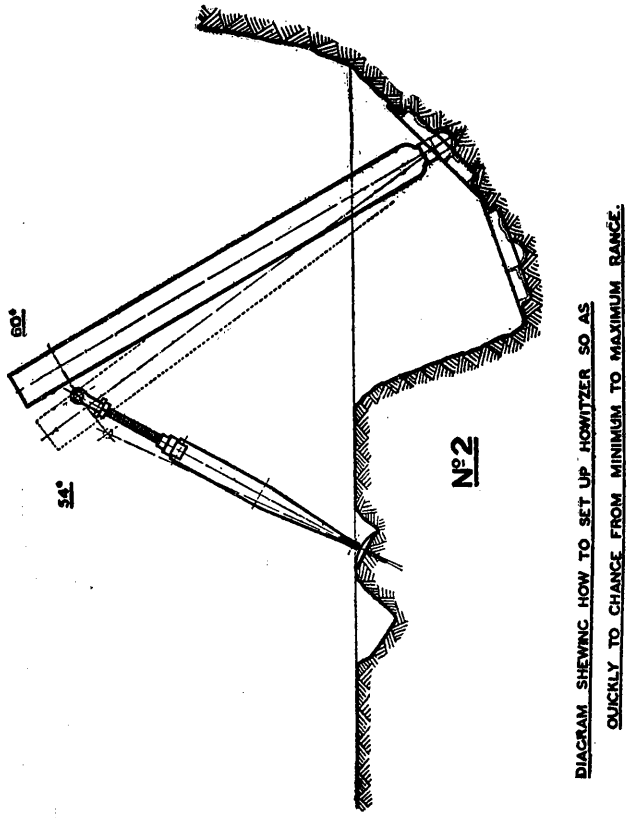


DIAGRAM SHEWING HOW TO SET UP HOWITZER SO AS QUICKLY TO CHANGE FROM MINIMUM TO MAXIMUM RANGE.

Preparation of shell.—If the shell is issued to the trenches ready fitted with time fuze and detonator, all that is necessary is to place the propellant cartridge in the container at the base of the shell.

The "turnover" at the forward end of each cartridge must first be deformed outward by pressing it against a sharp edge

STOKES' TRENCH HOWITZER
3-INCH MARK I

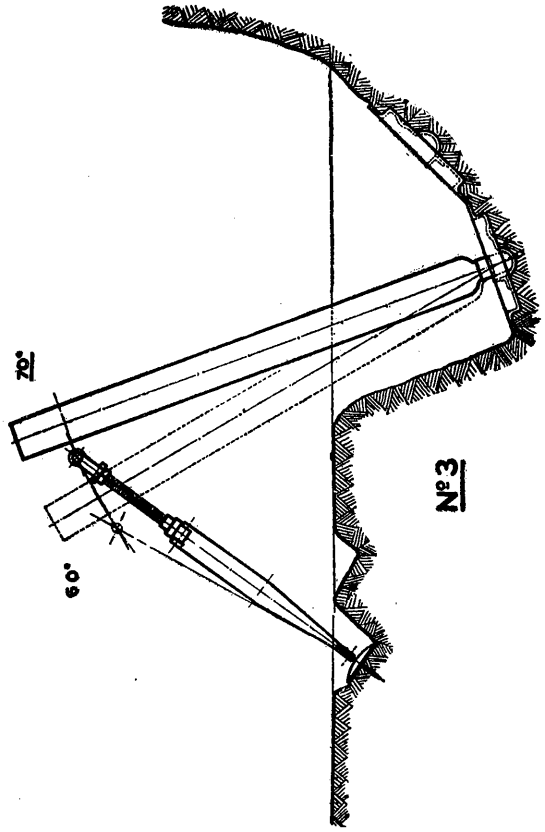


DIAGRAM SHEWING HOW TO SET UP HOWITZER SO AS QUICKLY TO CHANGE FROM MINIMUM TO MAXIMUM RANGE.

of the shell. This will cause the cartridge to be a tight fit in the cartridge container and prevent it from falling out.

Next remove both the safety pins in the head of the shell and place the shell in the muzzle of the howitzer.

For rapid firing a fresh shell can be placed in the muzzle as soon as the previous shot has been fired. For slow firing the catch bolt may be used, which maintains the shell in position until the bolt is pulled back by the lanyard.

In case of a misfire, lift the base of the howitzer as gently as possible until the shell slides out of the muzzle. When the shell has thus been removed, still further lift the base of howitzer so as to remove anything which has caused the misfire.

It may occasionally happen that the previous cartridge holder has burst open and remained in the howitzer. Sometimes small pieces of cartridge cases cause a misfire. If there does not appear to be any reason for the misfire and the cap has been well marked by the striker, remove the cartridge and replace it by another, after which again attempt to fire the shell. The machined bands at each end of the shell should be clean and free from rust, otherwise accuracy of shooting will not be obtained.

In the type of fuze head fitted with a fly-off lever this should be examined to see that it is clean and free from anything that will prevent its proper working.

In cases where the shells are delivered into the trenches without the time fuze inserted, the following directions should be followed:

Having ascertained the time which will suit the distance of shell to be fired (this may be done by consulting the reading of the clinometer), take a time fuze and detonator from the box, cut fuze to the required length, crimp detonator onto fuze, unscrew the fuze head from the shell, insert the fuze (detonator first) in the central tube, and press gently home until the top brass holder is well seated in the cavity in the shell nipple. Next screw the fuze head on the shell once more, seeing that the safety pins are in position.

The fuzes are marked with dots and dashes, representing half seconds of burning.

Great care should be taken when handling the detonators.

When detonators are being attached to the time fuze, the greatest care must be taken to insure that the crimping is well done in order to fix the detonator firmly onto the fuze; otherwise it will become detached by the setback at the moment of firing.

The end of fuze should almost touch the fulminate in the detonator.

Maintenance of howitzer.—The howitzer should be kept clean and free from rust, and lightly oiled, more particularly the screw traversing the elevating gears, and the shell catch or bolt.

The propellant used does not foul the barrel, but it encourages rust.

If the howitzer is not to be used for some time, it should be rubbed down inside with cotton waste and a little paraffin oil.

Thick lubricating oil is not suitable, as it chars and tends to clog the barrel and prevent the shell sliding down freely.

The striker pin may be examined from time to time by removing the base cap by means of the tommy bar.

If the central nipple shows signs of wear such as will result in misfires, a new striker should be placed in the howitzer. It should, however, be remembered that the central nipple should only project very slightly to produce the desired result, and that both the striker and cap *should be tightly screwed home.*

If the base plate has been fired with earth on its face between it and the howitzer, the caked earth should be removed so as to restore the depth of the depressions for receiving the howitzer base cap.

From time to time the various nuts and set screws should be gone over with a spanner and the slack ones tightened up, as the kick of the howitzer tends to shake them loose.

MISFIRES.

CAUSES.

1. Dirty or oily barrel.
2. Dirty shell.
3. Loose striker.
4. Angle of gun too low, i. e., below about 40 degrees.
5. Bad cap, or cartridge not properly home in container.
6. Cartridge débris or burst container from previous firing.

With practice shell it may be found that the cartridge container has been bent by falling on the ground from a previous shot. The cap will then not be struck centrally by the striker, and will misfire.

The shell collars may also be so badly marked as to stick in the barrel.

IMPORTANT NOTE.

The howitzer has been kept as light as possible in order to make it easily portable. It should therefore be treated with care, and set up in accordance with the instructions on pages 35, 36, and 37.

The recoil is exceptionally severe, because the barrel is only about 3 times the weight of the projectile, instead of about 100 times the weight, as in Artillery.

Unless the legs are properly set up they are liable to injury.

DEFINATION OF TERMS USED IN THE REGISTRATION OF ZONES AND IN TRENCH WARFARE BY FIELD ARTILLERY.

Map range.—The distance from the gun to the target, measured on the map.

Gun range.—The range on the range indicator (or sights), which gives effective fire on a target.

Normal gun range.—The gun range corrected to normal conditions for all the known variations due to atmospheric conditions, and (with the 18-pounder) for the variations due to the Mark I range indicator.

Registered range.—The range recorded by a B. C. in his registers. The registered range will be the gun range corrected to normal atmospheric conditions, and adjusted, if necessary, by a gun correction to the calibration of the standard gun or guns. When the 18-pounder has a Mark II indicator this will be the same as the normal gun range.

Calibration error.—The differences in the shooting of guns from their range-table form, due to wear of guns and mountings. This would be the difference between the map range and the normal gun range.

Zero point.—The selected point or object on which the line of one gun is laid on to establish zero lines.

Zero line.—The line of one gun in a zone from which all horizontal angles are measured.

Calibration points.—Objectives of which the map range is accurately known and which enables a B. C. to check the calibration corrections.

Atmospheric error.—The difference in shooting due to variations from the normal atmospheric conditions which are, temperature, 60° F.; barometer, 30″; wind, nil.

Gun correction.—The correction in yards to adjust the calibration error of any individual gun to the standard calibration error of the battery.

This is the difference between the gun range of any individual gun and the gun range of the standard gun at the same target.

Datum points.—Objectives which can be clearly seen and ranged upon and of which the registered range is accurately known. They are used to check the atmospheric error immediately before shooting at other targets.

SUPPLY OF AMMUNITION IN THE FIELD.

1. The old organization for the supply of ammunition in the field by means of brigade ammunition columns and a divisional ammunition column was designed to meet the requirements of a division acting independently, so that the division might be self-supporting. Owing to the necessity for massing far more troops on a given front and the consequent increase in depth of our present organization, the corps has now become the unit for marching and fighting. A corps, consisting of two or more divisions, must accommodate itself on a front little greater than that formerly allotted to a division, and may have to move along one road.

The density of troops on a given front automatically creates an accumulation of ammunition, and, by the system of "pooling," a considerable reduction may be made in the number of rounds per gun carried with the fighting formations.

The new organization has therefore been introduced with the objects—

(*a*) Of pooling the ammunition carried under corps control and thereby reducing the number of rounds per gun to be carried.

(*b*) Of effecting a saving in personnel, horses, and vehicles.

(*c*) Of reducing the road space occupied by a division.

(*d*) The experience of the earlier part of the war showed the necessity for separating brigade ammunition columns from their brigades and concentrating them under one central control.

2. A further change has recently been made in the organization of the divisional artillery to meet the requirements on an offensive front. One brigade of field artillery has been withdrawn from each division, and these brigades have been regrouped to form "army field artillery brigades." The divisional artillery will therefore consist of two field artillery brigades, each brigade having three 6-gun 18-pounder batteries and one 6-gun 4.5-inch howitzer battery.

The army field artillery brigades will consist of three 6-gun 18-pounder batteries and one 6-gun 4.5-inch howitzer battery, or four 6-gun 18-pounder batteries. These brigades will be

available to reinforce the artillery on any offensive front as may be required.

3. *Organization of the divisional ammunition column.*—The brigade ammunition columns as such have been abolished for divisional artillery, and the divisional ammunition columns have been reconstructed into two echelons:

A echelon.—Divided into two sections.

It consists of one ammunition wagon for each gun and howitzer in the division, and S. A. A. carts, etc., to carry the same quantities of rifle and machine-gun ammunition and grenades as were formerly carried by the brigade columns.

The sections are equally divided, the number of vehicles to each section is the same, and they contain the same percentage of gun, howitzer, and S. A. ammunition.

B echelon.—Has one section.

It consists of some of the G. S. wagons which formerly carried gun and howitzer ammunition in the old divisional ammunition column, and G. S. wagons to carry the same amount of S. A. and machine-gun ammunition and grenades as was formerly carried by the divisional ammunition column.

4. *Organization of the brigade ammunition column.*—To each brigade of the Army Field Artillery will be allotted a brigade ammunition column. It will consist of one ammunition wagon for each gun and howitzer in the brigade, with a proportion of G. S. wagons for baggage, stores, etc.

5. The new divisional ammunition column is directly under the divisional artillery commander, and forms an integral part of the divisional artillery. It may still be drawn upon as a first reserve for the batteries in men, horses, and material in an emergency.

It will normally march with the division; but, when several divisions are marching on one road, it may be necessary to withdraw the B echelons and concentrate them in rear under corps control. The A echelons always accompany their divisions, and will usually march in rear of all the batteries. The divisional ammunition column commander will remain with the A echelon.

In action, the divisional ammunition column will usually be concentrated; but, when the wagon lines are a long way from the guns, wagons from the A echelon may be attached to the batteries to assist in taking up ammunition.

If the ammunition park is a long way in rear, it may be necessary to keep back the B echelon and push up the A echelon, but this case will be the exception rather than the rule.

The normal position of the divisional ammunition column commander in action will be where he can best control the supply of ammunition.

The normal chain of supply of ammunition will be from the subpark (which has now been transferred from lines of communication to corps control) to the B echelon, and thence to any section of the A echelon.

6. In the case of the Army Field Artillery brigades, the normal chain of supply of ammunition will be from the subpark direct to the brigade ammunition column.

7. As the new organization has reduced the number of rounds carried in divisional charge, it is essential that the column be looked upon as a pool from which ammunition can be drawn by any unit. It is not intended that certain sections of the A echelons should be affiliated to certain artillery brigades, but the organization is elastic and permits of the detachment of such an amount of ammunition as may be considered necessary for a specific task.

G. H. Q. ARTILLERY CIRCULAR NO. 5.

AMENDMENT—FIELD ARTILLERY—TECHNICAL NOTES ON 18-POUNDER BARRAGES.

[Issued by the General Staff, March, 1917.]

The following amendments will be made to section 3, paragraph (*E*), Enfilade Barrages:

(I) In the last line, before the word "unsuitable," *insert* "generally."

(II) After the last word "battle," *delete* the full stop and *add* "(*see* Artillery Notes No. 4—Artillery in Offensive Operations (S.S.139/4) issued by the General Staff in February, 1917, Sec. VI, par. 12)."

TECHNICAL NOTES ON 18-POUNDER BARRAGES.

1. Depth of Barrage.

A barrage, whether of shrapnel or of H. E., 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.

2. Essentials of a Good Barrage.

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*) Time keeping. This is all important. The barrage is divided into periods of so many minutes. If the rate of fire is four rounds per gun per minute for two minutes, there will be eight rounds prepared at each gun for the first two minutes, after which fuzes set at different fuze lengths will be required. If the rate of fire is not kept up as ordered the eight 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 eight 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 fuze 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 round 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.

3. Ammunition for barrages.

(A) *Creeping barrages.*—Time shrapnel affords the best screen and the best forward effect and so presents marked advantages over H. E. 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.

H. E. 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 H. E. shell bursts some 30 to 40 yards beyond the point of impact. Moreover short rounds of H. E. are more dangerous to our own infantry than short rounds of time shrapnel, as with the former the fragments fly sideways down the line. It is sometimes said the advantage of an H. E. barrage over a T. S. barrage is that the error of the fuze is eliminated as well as errors in fuze setting. Where, however, a barrage is fired according to program there should be no errors in fuze setting, and where the long corrector is selected the error in fuze 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 H. E. 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 fuze functions better the shorter the range and the firmer and the less pitted the ground.

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

(B) *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 H. E. with delay or without delay or time shrapnel may be employed. If H. E. 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 fuzes 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 sight 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 H. E. or shrapnel for this purpose. H. E. 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.

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

(*D*) *Protective barrages by night and defensive* ("*S. O. S.*") *barrages.*—As our infantry are stationary under these barrages and screening effect is not required, H. E. 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 H. E. has the further advantage that fuzes do not have to be set.

(*E*) *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 H. E. shell fly sideways. 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 rea-

son 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.

(*F*) *Flanking barrages.*—Flanking barrages may consist of either shrapnel or H. E.; 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 H. E. with delay fuze, should be 300 yards, assuming the line of fire to be parallel to the line of advance.

March 26, 1917.

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SMALL-CALIBER GUNS—GERMAN ARMY.

37 MM. GUNS.

There are two kinds of 37 mm. guns:

(*a*) The (Hotchkiss) revolving gun with 5 tubes, firing a shell of 460 gr. and a case shot. Rapidity of fire, 40 shots per minute.

(*b*) A gun having only one tube and firing the same projectiles as the above. Rapidity of fire, 10 to 12 shots per minute.

The first seems to be the armament of detachments or batteries of revolving gun "Revolver-Kanonen-Abteilungen" or "Batterien"; the second, that of the detachments of trench guns, "Graben-Kanonen" or "Schützengraben-Kanonen-Abteilungen." This distinction does not seem to be positive.

The "Revolver-Kanonen-Abteilungen" are usually designated by the indication of the unit to which they belong (1) (R.-K.-Abt. of the 8th D. R., Bav.).

NOTE.—The only numbered formation that has been discovered is the Rev.-Kan. No. 8.

So far only eight of these formations have been discovered, but there certainly must be a good many more.

The "Graben-Kanonen-Abteilungen" are numbered. Eighteen is the highest that has been discovered to date. According to a prisoner, the strength of detachment No. 5 is 1 officer, 40 men, and 4 guns.

Most of these formations seem to be fixed organizations and remain permanently in the sector to which they are assigned; the guns are usually placed in concrete shelters.

Their duties are distinctly defensive and consist in making a quick barrage in case of attack.

5 CM. (53 MM.) GUNS.

The 5 cm. (53 mm.) gun is for flanking forts and fires a shell of 1 k. 670 (maximum range, 3,000 m.) and case shot. Rapidity of fire, 25 to 30 shots per minute.

There are not many of these guns. According to the statements of prisoners a few may be found in the above formations

(Revolver-Kanonen-Abteilungen or Graben-Kanonen-Abteilungen).

The Germans have also used the 5 cm. gun in armored turrets. In 1915 we captured one of these turrets. A deserter from the Eighth Regiment of Foot Artillery declares that he served a battery of two turrets with the 5 cm. gun in front of Rheims. The XII C., to which he was assigned, had several of these batteries. They were designated by the name of "Panzerbedienung d. XII A. K."

A prisoner of the Second Regiment of Marine Infantry, captured in January, 1917, stated that each regiment of marines had four light "Boots-Kanonen." It is probable that he meant the 5 cm. or 52 mm. guns, which are of light caliber and used by the German Navy.

In the German forts there were also guns of 6 cm. (57 mm.) in turrets firing only case shot and having a maximum range of 500 m. Rapidity of fire, 20 shots per minute. This caliber has not often been noticed at the front.

Russian Mountain Guns—3 in. (76.2 mm.).

There are two models:

Model 04: Weight in battery, 426 kg.; projectile, 6 kg. 500; maximum range, 4,200 m.

Model 09: Weight in battery, 610 kg.; projectile, 6 kg. 500; maximum range, 6,400 m.

An official document indicates that this material forms the armament of the batteries of so-called infantry guns, "Infanterie-Geschütz-Batterien." These batteries seem to be intended to be employed by single guns or sections in advanced and casemated positions for flanking fire.

Nine batteries have been discovered (Nos. 1 to 9).

According to a deserter, the strength of a battery would be 100 men, 60 horses, and 6 guns.

The ammunition is carried by pack horses.

27 mm. Guns.

A prisoner of the Ninety-eighth Reserves states that in November, 1916, at Verdun, he saw sailors manning the 27 mm. guns.

A projectile of the same caliber was found on the English front in October, 1915.

NOTES ON EMPLOYMENT OF SERVICEABLE GUNS AND TRENCH MORTARS CAPTURED FROM THE ENEMY.

1. Orders should be issued to insure that spare parts, sights, etc., are not removed from captured guns and trench mortars, and parties should be told off to take charge of such equipments and their ammunition.

2. Captured guns and trench mortars should be placed under some definite organization, and officers and other ranks should be detailed for the purpose of fighting these equipments, the various calibers being allotted to that branch of the artillery which is armed with a similar equipment. Trench-mortar batteries which can not be taken forward may be able to supply the personnel for these duties.

3. The heavier natures of guns and howitzers should form part of the counter-battery groups, so that their advanced position may be taken full advantage of.

These guns should be provided with wireless masts as early as possible.

4. It is advisable to move guns to new positions before opening fire, though it has been found possible to maintain guns in action in strong concrete pits, by turning them round and firing through the door of the emplacement.

5. Range tables as given in the bluebook of hostile guns have been found satisfactory, but they are not essential, as all sights are graduated in meters.

The range arc of the gun is graduated in meters, and shoots to map range with enemy maps.

There is a sliding scale on the face of the range arc marked in red, which is used for the error of the day corrections.

All figures are in hundreds of meters.

The dial sight is universal and interchangeable with all guns and howitzers up to 8-inch.

Graduations on the dial are the equivalent of 1 meter deviation at 1,000 meters and are subdivided on the micrometer heads into hundredths.

The angle of sight instrument is carried below the open sight and is not detachable. It is graduated on the same principle as the dial sight.

6. All breechblocks of 77 mm. guns are not interchangeable. The breechblock is removed by opening and withdrawing the bolt retaining extractor in the forward face of the breechblock. The breechblock is then closed until the lugs of the extractor pass into the groove of the retaining bolt. The breech is then opened again and can be withdrawn together with the extractor.

After firing about 200 rounds, the breech must be taken down and cleaned.

7. Corrections for atmospheric conditions have been found to correspond very closely with those necessary for our guns of a similar nature.

Different types of ammunition appear to have their charges adjusted.

Time shell have fuzes graduated in direct ratio to the range arc.

TRENCH MORTARS.

I. Employment of Trench Mortars.

1. *Characteristics of the different natures.*[1]—Light trench mortars (3-inch Stokes) are highly mobile. Their effect against material is inconsiderable, but they are useful for engaging targets in the open and for overwhelming the defense by rapid fire just previous to an assault. They are especially suitable for sending forward in support of infantry in the assault, and it will usually be advisable to hold some of them in reserve for this purpose. Though special emplacements are not essential for them, these should be constructed whenever possible.

Medium trench mortars (2-inch) can be brought into action anywhere in the trench area, but time is required to prepare emplacements and good platforms, which are necessary for accurate shooting, although they can be fired from temporary platforms with moderate accuracy for a limited number of rounds. Their chief uses are for cutting wire and for the destruction of the enemy's defenses. They are unfitted by their own weight and the weight of their ammunition to accompany infantry in the assault, but batteries should be earmarked to advance in support as soon as the position is gained.

Heavy trench mortars (9.45-inch) are more difficult to transport than the medium mortars, but there are few places in the trench area where they can not be brought into action. They can be carried up a trench 19 inches wide. They have a longer range than the medium mortars, and their material and moral effect is very great. Their chief use is for the bombardment of strong tactical points.

2. *Organization and command.*—Heavy and medium mortars are organized in 4-gun batteries. Light mortars are organized in 8-gun batteries, divided into half batteries of 4 mortars each. The medium and heavy batteries are manned by the Artillery and form an integral part of the divisional Artillery.

[1] Tables giving particulars of the different natures of trench mortars and of their ammunition are given in the Appendix.

When attached to Infantry brigades, however, these batteries will come under the command of Infantry brigadiers for all tactical purposes. The light batteries are manned by the infantry and form an integral part of Infantry brigades.

A captain is attached to divisional Artillery headquarters for trench mortars. His duties include the following:

(i) Supervision of the medium and heavy trench mortar batteries of the division as regards the care and provision of equipment and the provision of a trained reserve of personnel.

(ii) Advising Infantry brigadiers on technical matters regarding the light batteries, if required.

(iii) Commanding any special concentration of trench mortar batteries within the division.

In addition, he is available to assist in the administration of the heavy and medium trench mortar batteries should the C. R. A. of the division so desire.

He will also assist in the preparation of offensive and defensive schemes, selection of positions and observing stations, allotment of zones and tasks, and in supervising the supply of ammunition.

3. *Use in attack.*—Although the light batteries form integral parts of Infantry brigades and work directly under the orders of Infantry brigadiers, it may in some cases be advisable to mass them for special purposes. In any case their employment must be combined with that of the other natures and with the rest of the Artillery for the best results can only be obtained when all natures are employed according to their respective powers and limitations to assist in the preparation and support of the Infantry attack. The organization and distribution and the allotment of tasks and zones (especially to the medium and heavy batteries) will therefore form part of the "Artillery plan."

Light batteries.—The light mortars will, as a general rule, take little or no part in the preliminary bombardment, but they may be used with advantage to harass the enemy in the final stage of the bombardment, for which their rapidity of fire renders them particularly effective; also to form a barrage behind the hostile line to prevent reserves and ammuntion being brought up and to engage concentrations of troops or troops driven into the open. In order to develop the fullest capabilities of light batteries under these circumstances they may be put in the fire trench, or a position may be made behind the

parados of the fire trench. This forward position has the advantage that the full range of the mortar can be made effective, but it also possesses the following disadvantages:

(1) Ammunition supply is difficult.

(2) There may be difficulty in working the gun, owing to congestion in the trench.

In certain circumstances it may be possible to push forward mortars into "No man's land," establishing them in shell craters with a liberal supply of ammunition. By this means the full range of the mortar will be still further developed.

Medium and heavy batteries.—The heavy mortars will be used during the preliminary bombardment. The very great destructive effect of the heavy bombs is particularly effective against strong points within the limits of their range. The medium mortars will deal with all ordinary defenses which they can reach, thus releasing howitzers for engaging targets at longer ranges. They are particularly valuable for wire cutting and may often be used for this and for the destruction of the enemy's defenses where for any reason, such as trees, these can not be reached by ordinary artillery. Owing to the violence of their explosive effect, it will rarely be possible to employ heavy trench mortars to support the early advance of the Infantry, but it may often be possible to use the medium mortars for this purpose.

In the case of a bombardment extending over several days it may be advisable to defer opening fire with those trench mortars which are not required for cutting wire until the last day so as to avoid the risk of their being destroyed by the enemy's artillery.

Preparation and arrangements for an advance.—In all cases of moving trench mortars forward in support of an attack, careful preparation must be made beforehand as regards (*a*) the line of the advance, (*b*) the point to make for, and (*c*) ammunition supply.

Both (*a*) and (*b*) must be known to every man in the battery, as any one of them may have to carry on in the event of officers and noncommissioned officers becoming casualties. These points must also be known to the infantry whose attack is being supported, so that they may know where to find the mortars in the event of their support being required. It must be remembered that in an advance communications will probably be cut. The support which the mortars can give to the

infantry depends entirely for its efficiency on the initiative displayed by the officers, noncommissioned officers, and men of the batteries, who will be called upon to work without orders from above.

The stage at which mortars will advance must depend upon the progress of the attack and the tactical situation generally, and can only be decided on by the battery commander at the time. While it is important that the infantry should receive support as soon as possible, the indiscriminate advance of mortars, ignorant of where to go or of the situation on the front, can not lead to successful results.

In order that the detachments may keep up with the infantry, the men should be equipped as lightly as possible, and their equipment should not interfere with their carrying the gun, mounting, and ammunition. The mortars will either be brought into action on the captured position or may be collected at some central captured point in that line from which they may be sent to the support of any point where further advance is held up. The divisional trench-mortar officer will make arrangements for the collection of any mortars which are not required to take part in the advance, and for their subsequent movement and distribution.

Uses in an advance.—During the progress of the advance the light mortars may be used for the following purposes:

(1) Against personnel in the open, in shell holes, and in trenches.

(2) Making a barrage in front of bombers.

(3) Assisting bombers and Lewis guns in attacking isolated machine guns that are holding up the attack. At the same time it must be remembered that a Stokes bomb will not penetrate a well-protected machine-gun emplacement. When working with bombers it is very necessary that signals should be arranged beforehand.

(4) Assisting in repelling counter attacks when a position is being consolidated. By rapid fire an excellent barrage can be obtained.

(5) Assisting in wire cutting.

Ammunition supply during an advance.—To keep up a plentiful supply of ammunition with mortars advancing with infantry in the attack requires careful preparation beforehand. As the Stokes bomb takes some time to prepare, sufficient ammunition must be made ready, with detonator and fuze inserted, before

the advance and brought up as close to the jumping-off trench as possible.

An ammunition-carrying party must be detailed to go forward with the mortars, and a second party will be required to maintain supplies to the dumps which will have been established. The strength of the parties must depend upon circumstances, and particularly upon the distance the advance is likely to cover. All carrying parties must be divided into squads, each under a noncommissioned officer, who is directly responsible to an officer or senior noncommissioned officer. The following may be taken as a general guide to the numbers required:

Unless the distance to be traversed is very short, a man carrying his equipment and rifle can not carry more than 4 rounds. In order, therefore, to have 80 rounds with the gun, a party of 18 men in addition to the detachment will be required. If equipment is not carried, each man can carry 6 to 8 rounds, and the strength of the party can be reduced to 10 or 12 men. On the gun coming into action this party should put down this ammunition close to the gun, one-half of them returning to the jumping-off trench for more; the other half must remain with the gun, as often several positions are taken up in a short time. After an advance from the first position, arrangements should be made to meet the carrying party coming up with ammunition. As regards the dumps in the vicinity of the jumping-off trench, it is undesirable that these should be very large at the commencement of the action, owing to the danger of their being exploded. To maintain a supply to these dumps a party of from 20 to 40 men may be required. As the attack progresses so these dumps will have to be moved forward, and an adequate carrying party is necessary if ammunition supply is to be maintained. If possible, the position of forward dumps should be selected beforehand. They should be at places which can be easily found on the map. Boards should be prepared to mark the dumps clearly, showing the number of the battery, division, and the number of the dump.

4. *Use in defense.*—The part to be taken by trench mortars should be included in the defense scheme of every division. In case of hostile attack the Stokes mortar, owing to its rapid rate of fire, will usually engage the enemy's front trenches, sapheads, and trenches, or other points at which he is likely to concentrate, by this means isolating any troops that may emerge from the trenches for the attack. Medium mortars, on the other

hand, owing to their slow rate of fire, will help little in breaking down the actual assault, and if they are kept in too forward positions they run the risk of being captured in the first rush. They should, therefore, when not taken forward for special purposes, be kept in permanent emplacements covering our own first and second line fire trenches. From these positions it will generally be possible also to cover the hostile front and intervening ground and so engage the enemy during his assault. Should the enemy get a footing in our trenches, the mortars will be of great value in preventing him consolidating his position and in supporting our counter attack. Heavy mortars, being designed for the destruction of defensive works, are of more value as offensive than defensive weapons, but in case of hostile attack they can also be used to bombard important points in the enemy's lines.

In normal trench warfare the rôle of trench mortars is to harass the enemy by engaging living targets where opportunity offers, to destroy defensive works and obstacles within the limits of the range of the mortars, and to prevent the construction of new works. This will be done in cooperation with the artillery and infantry using the other trench weapons. Schemes will be carefully thought out, in order that the best use may be made of the different weapons employed, and definite results obtained. In the case of minor hostile attacks the medium and light mortars can be used to drive the enemy from any small sections of our trenches in which he may have obtained a footing, and also to bombard important points in rear and on the flanks of the enemy, thus isolating him while he is dealt with by our own infantry and bombers.

II. Selection, Preparation, and Occupation of Positions.

5. *Selection of positions*—The battery commander will receive orders as to the extent of the enemy's front to be covered, or the targets to be engaged by his battery, and also as to the area in which the battery will operate. In the case of heavy and medium mortars these orders will normally be given by the divisional trench mortar officer. Light mortars will receive them from the Infantry brigade to which they belong. On receipt of these orders the battery commander will make a thorough reconnaissance of the ground and of the enemy's defenses. He should be supplied with trench maps and air photographs.

In selecting positions the following points should be considered:

(*a*) Range and direction of objectives.

(*b*) Cover from hostile fire and view.

(*c*) Possibilities for observing fire.

(*d*) Communication between mortars and observing stations.

(*e*) The site selected must not in any way interfere with the movements of other troops in the trenches; it is, therefore, advisable in most cases to dig the emplacements in a trench cut to a flank from the communication trench.

(*f*) Facilities for ammunition supply, proximity to trench tramways, etc.

6. *Position for offensive operations.*—For offensive operations positions must be selected according to the tasks to which the mortars are allotted, and must be carefully concealed and protected. The selection will depend upon:

(*a*) The range and direction of objectives.

(*b*) The number of trench mortars to be placed on a given front.

(*c*) The facilities for cover, existing dead ground, etc.

The preparation of offensive positions entails much time and labor, and they must be reconnoitered and preparation commenced in ample time. These positions should be so arranged that if a certain extent of front is to be engaged, the mortars will cover with their fire the whole of this front. It will often be found best to arrange the mortars in pairs, each covering the whole of the zone allotted to the pair. If single targets are to be engaged, the emplacements should allow of fire being brought to bear on as large an arc as possible on either flank of the allotted target. The arcs of fire should, when possible, overlap at any specially important points in the enemy's line to enable concentrated fire to be directed on those points. Positions should be sufficiently far forward to allow of points in rear of the enemy's first line being engaged without change of position, but must be so situated that the firing of the mortars will not interfere with the movement of troops in the trenches. Opportunities for enfilade and cross-fire must be sought, and the subsequent advance in support of the infantry must always be kept in view. At least one alternative emplacement for each mortar should be selected and the exact position of all emplacements should be entered on a map. An example of how mortars should be situated and the use of enfilade and cross-fire is given in sketch, Appendix "A."

7. *Positions for holding the line.*—Permanent positions should be carefully protected and concealed from aircraft observation, and should allow of effective fire—both enfilade and cross-fire, where possible, being brought on to such of our trenches as will probably be first occupied in the event of a successful hostile attack. It may also be advisable to place some mortars to cover our support and communication trenches. More advanced positions should also be chosen and prepared, but as a general rule should not be permanently occupied.

Observing stations will be selected so that from the different stations the whole of the enemy's front covered can be observed. The exact position and the extent of front that can be observed from each will be noted on a map.

8. *Battery headquarters.*—Each battery must have a headquarters in the trenches; this should be placed in a central position in communication with company and battalion headquarters and, whenever possible, with artillery brigade headquarters also. The position must be made known to all infantry officers in the sector. The company commander and the trench-mortar officer on duty in the trenches must each know at all times where the other is to be found.

9. *Mortar emplacements.*—The exact type of emplacement and the position of dugouts, etc., can not with advantage be stereotyped, as much will depend upon local conditions. The following principles should, however, be adhered to:

Steady platforms are a matter of great importance, especially with medium and heavy mortars. The beds should be placed so that when centrally fixed the mortars cover the targets to be engaged or the center of the portion of the enemy's front allotted to each.

The greatest care should be taken in digging in the beds, as the whole accuracy of shooting depends on this. It is most important to guard against the bed, feet, etc., sinking sideways on firing. If this happens, the mortar will be thrown off the line. The clinometer can be used to correct any sinkage front or rear.

Protection must be as thorough as possible. Concrete overhead cover gives security to the detachment, and adds greatly to efficient service. Cover from aircraft observation must be provided.

Deep emplacements give better security, but reveting is necessary. With trenches 6 feet deep or more, cross shoring is also required in addition to revetment. The better the protection the fewer will be the casualties, and a grave responsibility rests upon

battery commanders to see that the fullest possible protection is provided for all under their command. Emplacements should not be larger than will allow for the service of the gun. In the case of the 2-inch and 9.45-inch it should be possible to fire the mortar from under cover. The line of fire must clear the parapet at the lowest angle of elevation.

Ammunition stores must be protected by at least a traverse from the mortar, and the very strongest possible protection should be provided against hostile fire.

Emplacements must be drained.

The construction of alternative emplacements for each mortar should be taken in hand as soon as possible after the battery is in action. Spare mortar beds should be kept in these emplacements to enable mortars which have to change position to open fire from the alternative emplacement without delay. Diagrams of typical emplacements and platforms are given in the Appendix.

10. *Communications.*—Telephone communications will be established between observing stations and mortar emplacements. Communication, by telephone if possible, will also be established with the officer under whose orders the battery commander is working.

For an offensive operation wires from observing stations to mortars should be buried.

Although the telephone is the normal method of communication, the wires are very liable to be cut. Opportunities for visual signaling should therefore be fully exploited and provision must also be made for messages to be carried by orderly. Whatever precautions are taken, the circulation of orders among trench mortars will always be difficult, and at times of sudden emergency very precarious. All ranks must therefore be fully informed of the situation, actual or likely to arise, and must consider beforehand what action should be taken in an emergency, such as: Gas attack on the front, sudden hostile bombardment, mine explosion, trenches rushed.

The course to be taken depends in almost every case upon the action of the infantry. A close understanding must be come to with the infantry and common action decided upon beforehand.

11. *Ammunition supply.*—It will be necessary to have a considerable store of ammunition always at each mortar position, and ammunition dugouts must also be of such a size that a considerable extra quantity of ammunition can be stored in them when required for offensive operations. Arrangements must also

be made for a further supply to be stored at points farther in the rear, preferably in dugouts near the entrance to communication trenches. Such reserve stores will save great labor when a bombardment is in progress and large quantities of ammunition are required.

The supply of ammunition to the mortars must be carefully organized, special carrying parties being detailed for the work (probably supplied by Infantry units), and the communications to be used carefully reconnoitered. Important communication trenches should be avoided, as these will certainly be blocked by troops when active operations are in progress; they are also subject to the enemy's barrage fire.

12. *Maps.*—Every battery commander should keep a map showing:

(1) All emplacements with their arcs of fire.

(2) All mortars in action with their night lines.

(3) All emplacements in progress of construction.

(4) All observing stations, showing exact field of view from each.

(5) Battery headquarters.

(6) Ammunition stores and routes of supply from each.

The divisional trench mortar officer should keep a similar map embodying this information for all trench mortar batteries in the division and each Infantry brigade should have a map giving this information with regard to its own front. All maps should be kept up to date and handed over to relieving units.

III. Gunnery.

13. *Lines of fire.*—These lines should be laid out by one of the following methods:

(*a*) By planting two aiming posts in line between the trench mortar and target, visible from the trench mortar, laying the trench mortar on these aiming posts and noting the reading on the graduated arc.

(*b*) By measuring the angle included between an auxiliary mark, trench-mortar position, and the target from the map and planting an aiming post by means of three pins and a board or by prismatic compass.

(*c*) By compass and map.

In any of the above cases the line must be corrected by observation.

The lines to the various objectives should always be registered; the graduated traversing arc being used for this purpose and also for applying subsequent corrections for line.

Before beginning to dig the trench-mortar emplacement the line of the center objective should be laid out and the embrasure must be dug facing in this direction.

14. *Ranging.*—Ranging consists in finding by trial shots: (*a*) the elevation; (*b*) the line.

Under present conditions it is seldom possible to estimate with any degree of accuracy the distance the burst of the projectile is short or over with regard to the target.

The principle of ranging for elevation is therefore to find two elevations, the longer of which will throw the projectile beyond the target, the other short of the target, thereby inclosing it in what is called a bracket.

The bracket should be large at first, say 40 yards with the 2 inch. That is to say, the two elevations fired at should differ by 40 yards. When this bracket has been obtained the limits should be reduced and a smaller bracket obtained, usually 20 yards with the 2 inch. This is called the short bracket. The important point is to make certain of this short bracket. It should therefore be verified by repeating the two rounds. When the short bracket has been obtained, smaller alterations in elevation may be made as found necessary.

Up to 45° an increase in elevation means increased range; over 45° the range decreases. Forty-five degrees is, therefore, the most accurate angle at which to fire, so much so that with the 2 inch an alteration of 1° at 45° means a difference of about 2 yards; at 70° an alteration of 1° means a difference of about 15 yards. Corrections for line are given in degrees after each round, as required.

1° equals 1½ yards at a range of 100 yards.

1° equals 5 yards at a range of 300 yards.

1° equals 8 yards at a range of 500 yards.

Methods of ranging.—A battery can be ranged by either of the following methods: (1) Section ranging; (2) single-gun ranging.

(1) Section ranging means firing with two guns so that each gun fires one end of a bracket, the first gun firing at the longer range.

(2) Single-gun ranging means firing all ranging rounds from one gun.

To be able to range with a section, or one gun, and then take the range found as being the range for the battery, it is necessary that the four guns of the battery should be at the same distance from the target. If this is not so, the necessary corrections for the various gun positions must be given.

After the range has been found with the ranging section or gun it is necessary to fire a round of "battery fire," with an interval, to correct the line of the rest of the battery. This round of battery fire should be repeated if necessary.

It must be remembered that once the battery has gone to "gunfire" the battery commander loses all control of the battery as regards corrections for line and range, it being impossible (especially with the Stokes mortar) to mark the round belonging to any particular gun.

Methods of fire.—(1) Battery fire with an interval; (2) section fire with an interval; (3) gunfire with or without an interval; (4) salvo fire.

"Battery fire" means that each gun in the battery fires consecutively, allowing the given interval to elapse between each round, e. g., "one round battery fire 20 seconds" means No. 1 fires, No. 2 fires 20 seconds after No. 1, No. 3 fires 20 seconds after No. 2, and so on.

"Section fire" means that each section fires at the given interval, independent of the other section; e. g., "section fire 20 seconds," No. 1 fires, No. 2 fires 20 seconds after No. 1, No. 1 20 seconds after No. 2, etc., the other sections doing the same.

"Gunfire" means that each gun loads and fires independent of any other gun.

"Salvo fire" means firing two or more guns at the same time.

1. *Example of section ranging.*

Guns of battery in sections.
Right section about 25 yards in advance of left section.
Target: An emplacement.

9786°—17——5

No. of rounds.	No. of sub-section.	Elevation.	Observation (+ or −).	Battery commander's orders.
				Target emplacement. Right section ranging.
				No. 1. 490. Charge..... No. 2. 450. Charge.....
				Fire No. 1.
1	1	490	+	No. 1, 3° more right. Fire No. 2.
2	2	450	−	No. 2, 4° more right.
				No. 1. 480. Charge..... No. 2. 460. Charge.....
				Fire No. 1.
3	1	480	+	Fire No. 2.
4	2	460	−	No. 2, 1° more right. Both guns repeat.
5	1	480	+	
6	2	460	−	Right section. 470. Charge.....
				Left section. 500. Charge.....
				One round battery fire 30 seconds.
7	1	470	R	
8	2	470	R	
9	3	500	+	No. 3, 3° more right. 490.
10	4	500	+	No. 4, 3° more right. 490.
				One round battery fire 30 seconds.
11	1	470	R	
12	2	470	R	
13	3	490	R	
14	4	490	R	Register.

NOTES.

1. With rounds 5 and 6 the battery commander verified short bracket.

2. The rounds of battery fire were given to correct the elevation and lines of fire of the left section.

2. *Example of single gun ranging.*

Guns of battery at approximately the same range from the target.

Target: Line of trench.

No. of rounds.	No. of sub-section.	Elevation.	Observation (+ or −).	Battery commander's orders.
				Target—Line of trench.
				No. 1 gun ranging 360. Charge..... Fire.
1	1	360	−	400. Charge..... Fire.
2	1	400	+	2° more left. 380. Charge..... Fire.
3	1	380	−	400. Charge..... Fire.
4	1	400	+	380. Charge..... Fire.
5	1	380	−	All guns 390. Charge..... One round battery fire 20 seconds.
6	1	390	R	
7	2	390	R	No. 2, 3° more left.
8	3	390	−	No. 3, 2° more left.
9	4	390	−	Right section 390 left section 400. Charge.....
				One round battery fire 20 seconds.
10	1	390	R	
11	2	390	−	
12	3	400	+	
13	4	400	R	Register. Section fire 10 seconds.

NOTES.

1. No. 1 round which was expected to be over was found short, the battery commander therefore added 40 yards.

2. No. 3 round gave a 20-yard bracket which was verified with rounds 4 and 5.

3. The left section was found to be shooting short by rounds 8 and 9.

3. Example of ranging on a hostile trench close in front of our own infantry.

Position of battery about 200 yards behind the front line. Right section about 30 yards in advance of left section.

No. of rounds.	No. of sub-section.	Elevation.	Observation (+ or −).	Battery commander's orders.
				Having given the necessary orders to get the guns on the line.
				No. 1. Ranging 260. Charge ..... Fire No. 1.
1	1	260	+	No. 1, 2° more right. 250. Charge ..... Fire No. 1.
2	1	250	+	240. Charge ..... Fire No. 1.
3	1	240	+	230. Charge ..... Fire No. 1.
4	1	230	−	240. Charge ..... Fire No. 1.
5	1	240	+	230. Charge ..... Fire No. 1.
6	1	230	+	Repeat.
7	1	230	−	Right section 230. Left section 260.
				Charge ..... One round battery fire 20 seconds.
8	1	230	R	
9	2	230	R	No. 2, 2° more right.
10	3	260	+	No. 3, 1° more left.
11	4	260	+	No. 4, 1° more right.
				Left section. 250. Charge ..... Register.

NOTES.

1. The battery commander deliberately overestimates the range.

2. Single gun ranging is employed, as there is no advantage in adopting section ranging.

3. The "creeping" method of ranging is adopted owing to the proximity of our own trenches.

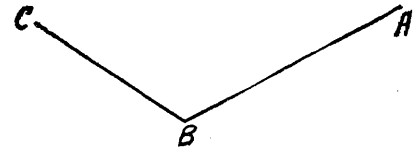
4. At rounds 4 and 6 a — and a + are obtained with 230, this range is therefore repeated and gives a —. The battery commander having got two — and one + takes this as range.

It must be remembered that even under perfect conditions the pattern made by a number of rounds fired at the same elevation is an elongated one. Consequently, when the range and line have been correctly found, subsequent corrections should not be made on the observation of single rounds, but on groups of three or four rounds. If the range is correct, a proportion of rounds will fall short of the target.

15. *Distribution of fire.*—After ranging has been completed, fire for effect must be distributed as desired (normally evenly) over the entire target. If the target runs in enfilade from the position, changes in range will alone be necessary. If, on the other hand, the target forms the arc of a circle whose center lies at the mortar, changes of line only will be required. In practice, however, these conditions are rarely obtained, and the target will often run obliquely to the position, frequent changes of range and line being necessary for even distribution.

The following method of preparing a table of fire for use in such circumstances is suggested with a view to obviating all possibility of mistake and insuring continuance of fire when casualties occur or when control from the observation post is lost.

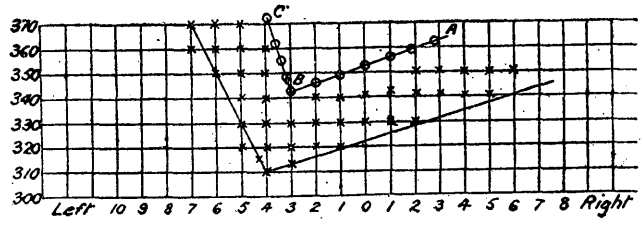
Suppose the target represents a salient thus



Registrations are found as follows:

A.	360 yards.	3° right.
B.	340 yards.	3° left.
C.	370 yards.	5° left.

A chart is then prepared on squared paper as under:



In preparing the table of fire points a suitable distance—generally 10 yards along the trench—should be selected as indicated by ⊙ in the chart, and a table of fire prepared as follows:

370	4° left.
360	4° left.
350	3° left.
340 (3½-ounce charge)	3° left.
340 (2½-ounce charge)	2°
340 (2½-ounce charge)	1° left.
340 (3½-ounce charge)	1° left.
350	Zero.
350	1° right.
350	2° right.
360	3° right.

It will be noted that 340 yards, which lies at the margin of the 2½-ounce and 3½-ounce charge for the 2-inch, rounds are fired with each charge. This is necessary to secure an even pattern. The number of rounds to be fired at each range will vary according to the special requirements of each case and to the time available. It is always advisable to make sure of covering the entire target within reasonable time, reserving some time for such portions as observation may show require further treatment.

In the case of wire cutting a suitable method is to plot lines on the chart covering the depth of the wire as indicated by dotted lines on the chart above. Fire would then be directed at points × on the chart, and a table of fire as follows, prepared:

370	7°, 6°, 5° left.
360	7°, 6°, 5° left.
350	6°, 5°, 4° left. 1°, 2°, 3°, 4°, 5° right.
340 (3½-ounce charge)	6°, 5°, 4°, 3°, 2°, 1° left. 1°, 2°, 3°, 4°, 5° right.
340 (2½-ounce charge)	6°, 5°, 4°, 3°, 2°, 1° left. 1°, 2°, 3°, 4°, 5° right.
330	6°, 5°, 4°, 3°, 2°, 1° left. 1°, 2° right.
320	5°, 4°, 3°, 2°, 1° left. Zero.
310	4°, 3° left.

It should be noted that the above chart is not geometrically correct. Lines of fire should converge and ranges should be arcs of a circle. In practice, however, this makes no substantial difference, any theoretical difference being rectified by the error of the mortar.

16. *Causes affecting accuracy of fire.*—The following causes affect the accuracy of shooting:

Variable weight of projectiles. To obtain uniform results projectiles for heavy and medium mortars must be grouped by weight. Two-inch bombs within certain limits of weight are not marked, but bombs above the high limit are marked H. V., those below the low limit are marked L. 9.45-inch bombs are marked heavy, medium, or light, according to weight.

Temperature of the charge. The higher the temperature the more powerful the charge.

Damp charges.

Variation of chamber space. If the charge or bomb is not properly rammed home a short round will result.

Force and direction of the wind.

The bed not level. The projectile will incline to the lower side.

The bed not firmly and evenly supported.

17. *Registration.*—A clear, systematic record should be kept of all registrations showing:

The number and position of the emplacement.

The target, described with reference to the map, or by its generally accepted name.

The elevation.

The line.

This record should be handed over to an incoming battery. In addition, each emplacement should have a range card of its special targets which should be kept up to date.

To avoid disclosing the position of the trench mortars it may often be desirable to carry out registration under cover of artillery.

Where a large number of trench mortars are to be employed in an offensive operation, the fact that such a concentration has taken place must be concealed up to the last moment. Some previous registration is absolutely necessary, but, by the use of an accurate map, study of aeroplane photographs, and other means, the registration on one target may be used as a basis for obtaining the line and range to other targets, thus reducing registration to a minimum. Every precaution must also be taken to conceal what is being done. Not more than two or three mortars should be firing at the same time; those firing should be some distance apart; the fire should be slow and desultory, and should be covered by artillery fire if possible.

The registration of one day is not necessarily correct for another as ranges are affected by wind and atmospheric condition. Before opening fire for effect therefore on any target the "error of the day" should be obtained by firing a few rounds on a datum point which has been carefully registered.

18. *Methods of engaging objectives.*—Accuracy of fire is always of the utmost importance, and all fire should be observed whenever possible since, however carefully a target has been registered or the error of the day obtained, slight corrections will almost always be required.

Observation from trenches is often difficult, since in many sectors nothing can be seen except the enemy's parapet and wire. Battery commanders should, therefore, get into touch with artillery observing officers, who, from their observing stations, are often able to assist trench mortar officers in observing their fire.

Firing salvos from two or more mortars has great moral effect and renders the mortars less liable to be located by the enemy. When a considerable number of rounds have been fired from one emplacement, it is advisable to remove the mortar at once to an alternative emplacement, for if the enemy has located the position heavy retaliation may be expected.

No more ammunition than is required to achieve the object in view should be used for any definite task, since the supply to the mortars will always be difficult.

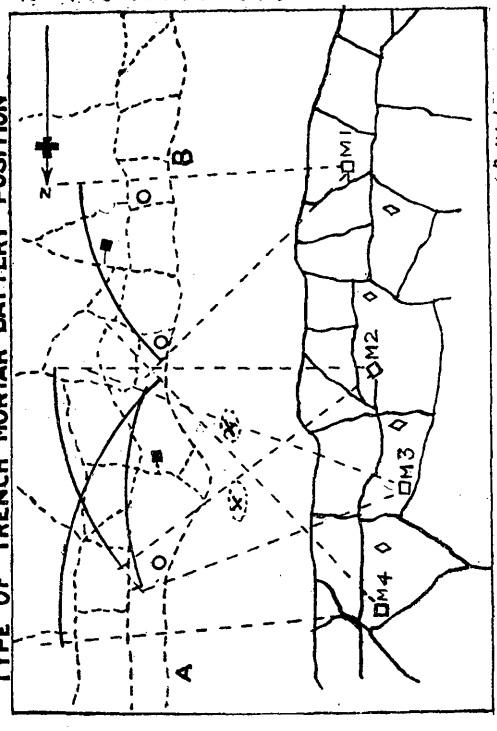
19. *Gas, smoke, and incendiary bombs.*—In the above no reference has been made to the use of trench mortars for firing gas, smoke, or incendiary bombs, since this does not as a rule form part of the work of the ordinary trench mortars which fire H. E. bombs, though the 2-inch may occasionally be used for these purposes. In such cases, however, special instructions are issued. A special trench mortar, the 4-inch Stokes, has been provided for firing gas, smoke, and incendiary bombs.

IV. Conclusion.

20. *Conclusion.*—These notes are based on the best experience available and should be carefully studied. They have been drawn up with a view to insuring in trench mortar batteries the same uniformity of method as in batteries of other natures of artillery. There is, however, no intention of cramping the initiative of trench mortar officers. New developments in the employment of these weapons may be expected and officers must be prepared to deal with them as they arise.

Appendix A.

TYPE OF TRENCH MORTAR BATTERY POSITION



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APPENDIX B.

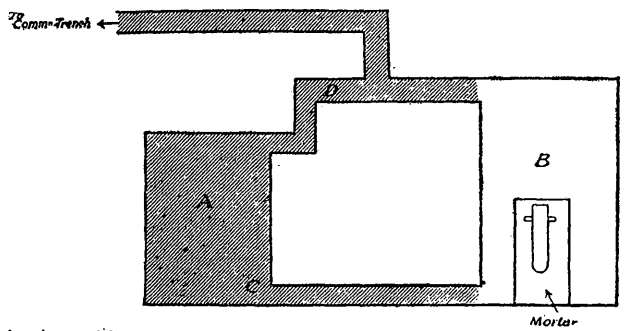
TYPES OF TRENCH MORTAR EMPLACEMENTS.

Dimensions of emplacements depend on the depth of the trenches.

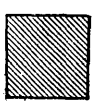
Emplacements must be as small as possible while allowing (*a*) the mortar its full "field of fire," (*b*) the efficient service of the mortar. If emplacements are too large valuable cover is lost.

They will be as deep as the nature of ground permits, but care must be taken that the bombs will clear the parapet when the mortar is laid at the lowest angle of elevation (i. e., extreme range).

1. *Permanent emplacement.*

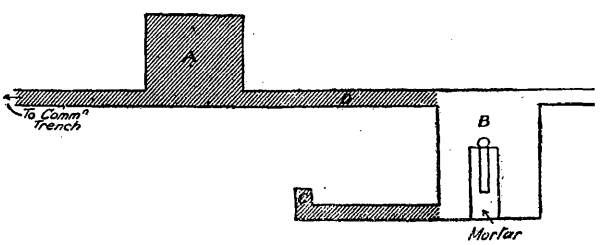


A.—Ammunition recess. B.—Mortar emplacement. C.—Point from which mortar is fired. D.—Loading trench.



Overhead cover.

2. *Temporary emplacement.*

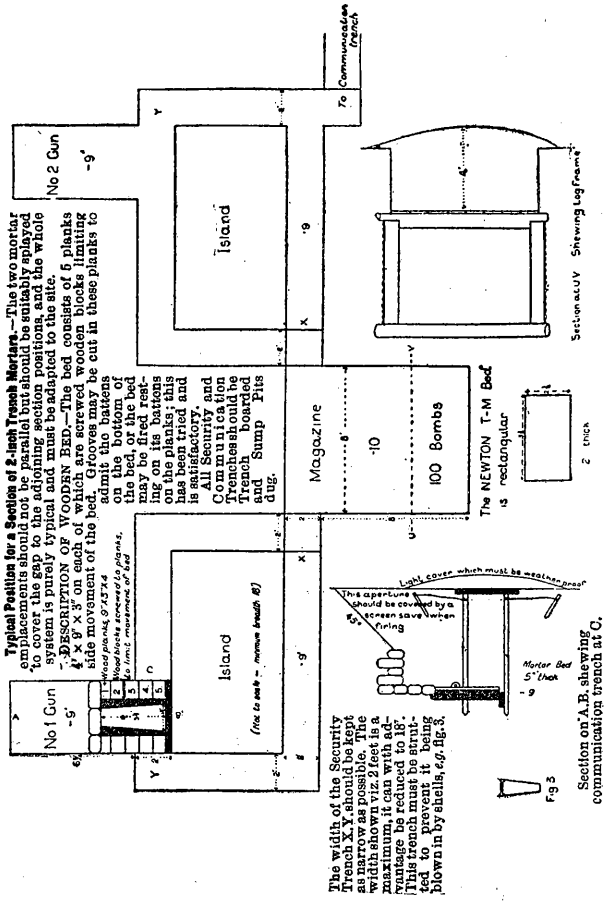


APPENDIX B. No. 2.

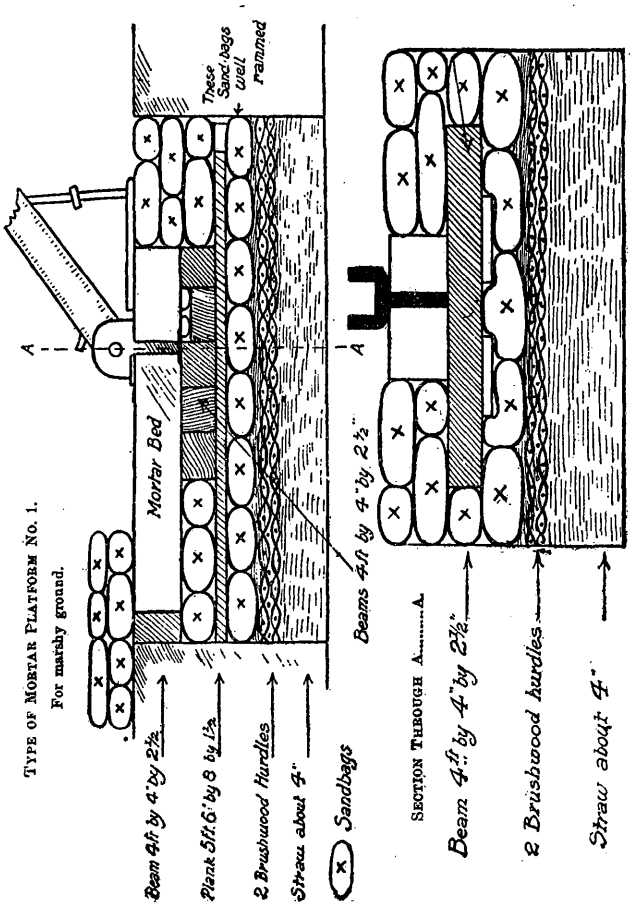
Typical Position for a Section of 2-inch Trench Mortars.—The two mortar emplacements should not be parallel but should be suitably splayed to cover the gap to the adjoining section positions, and the whole system is purely typical and must be adapted to the site.

DESCRIPTION OF WOODEN BED.—The bed consists of 5 planks 4' × 9" × 3" on each of which are screwed wooden blocks limiting side movement of the bed. Grooves may be cut in these planks to admit the battens on the bottom of the bed, or the bed may be fixed rather on its battens on the planks this has been tried and is satisfactory.

All Security and Communication Trenches should be Trench boarded and Sump Pits dug.



The width of the Security Trench X.Y. should be kept as narrow as possible. The width shown viz. 2 feet is a maximum, it can with advantage be reduced to 18". This trench must be strutted to prevent it being blown in by shells, *e.g.* fig. 3.

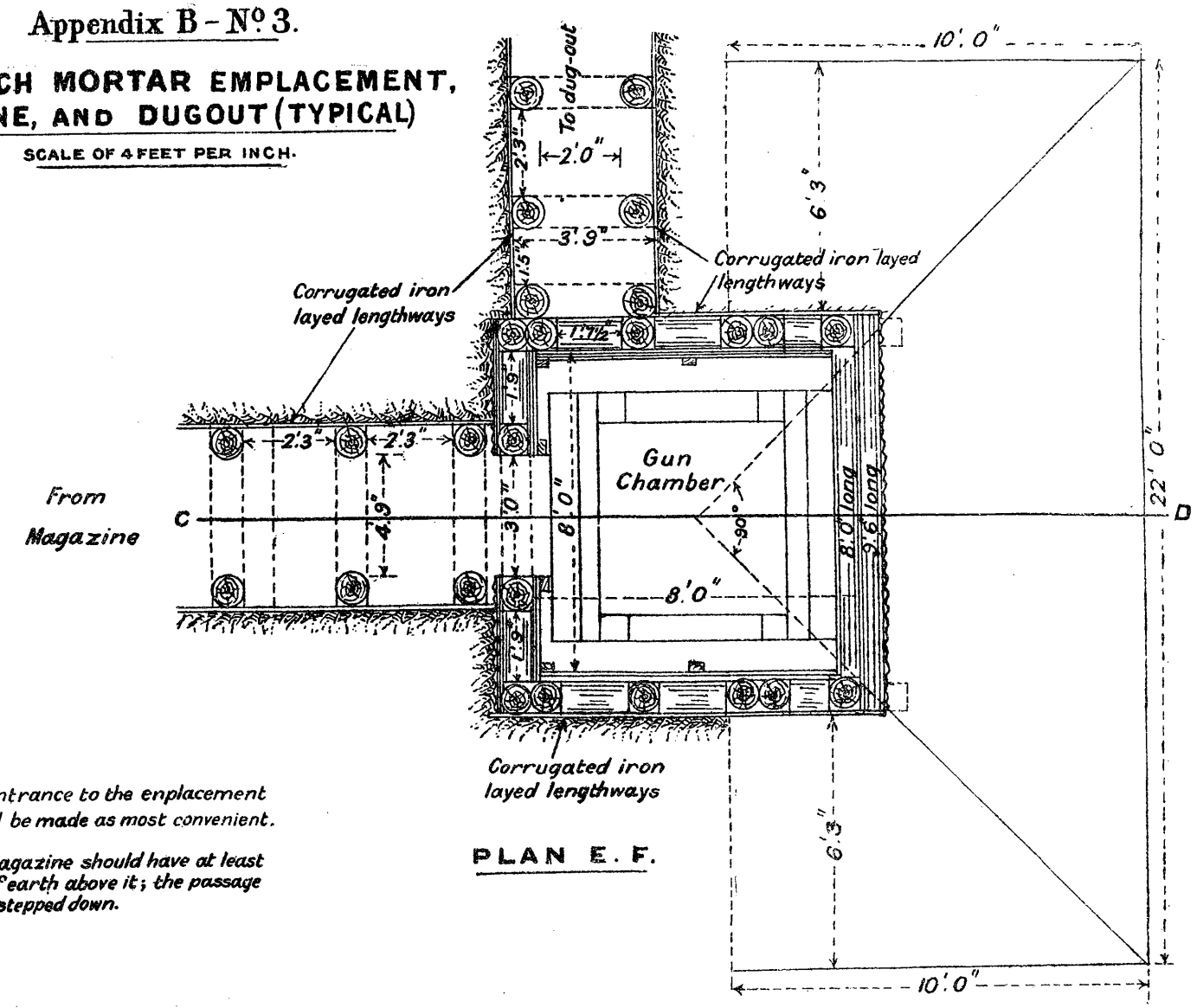


TYPE OF MORTAR PLATFORM No. 1.
For marshy ground.

Appendix B – No 3.

9·45" TRENCH MORTAR EMPLACEMENT, MAGAZINE, AND DUGOUT (TYPICAL)

SCALE OF 4 FEET PER INCH.



PLAN E. F.

Note :– The entrance to the enplacement should be made as most convenient.

The magazine should have at least 15 ft of earth above it; the passage being stepped down.

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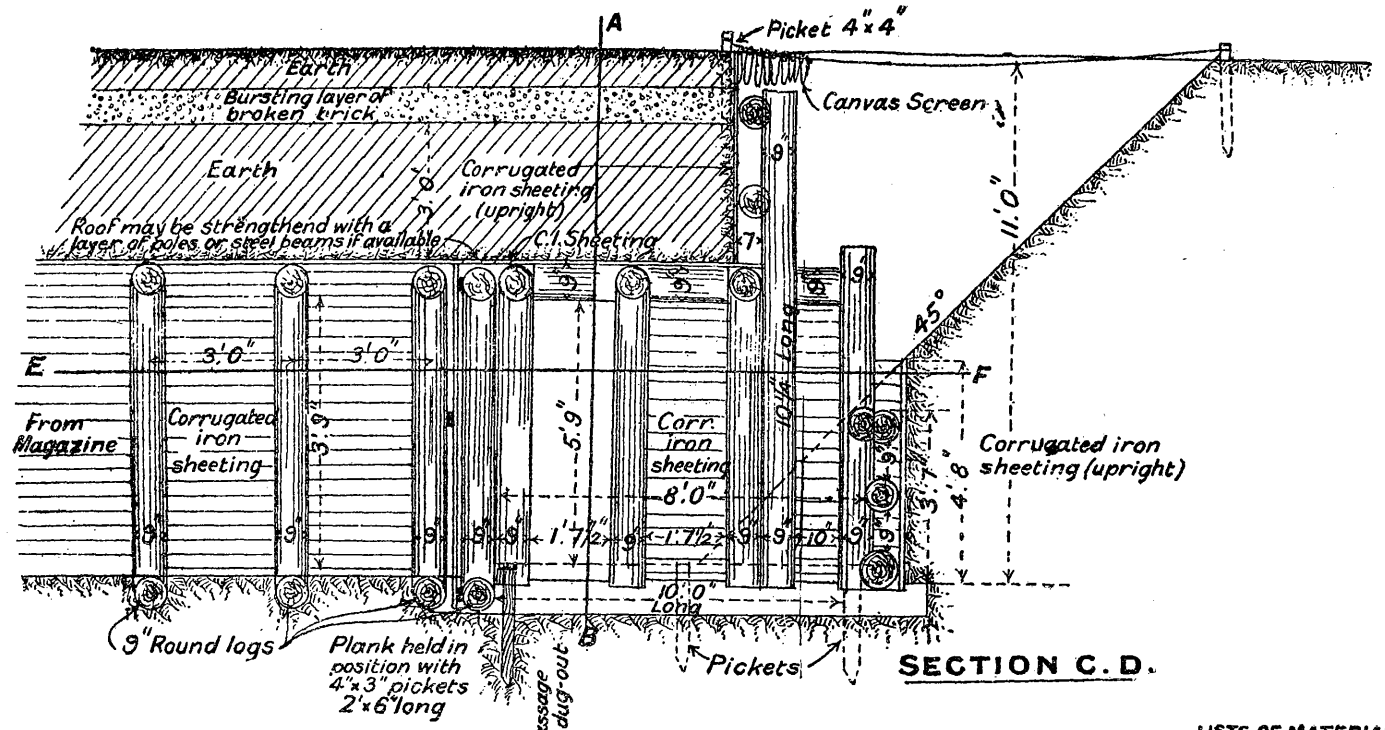
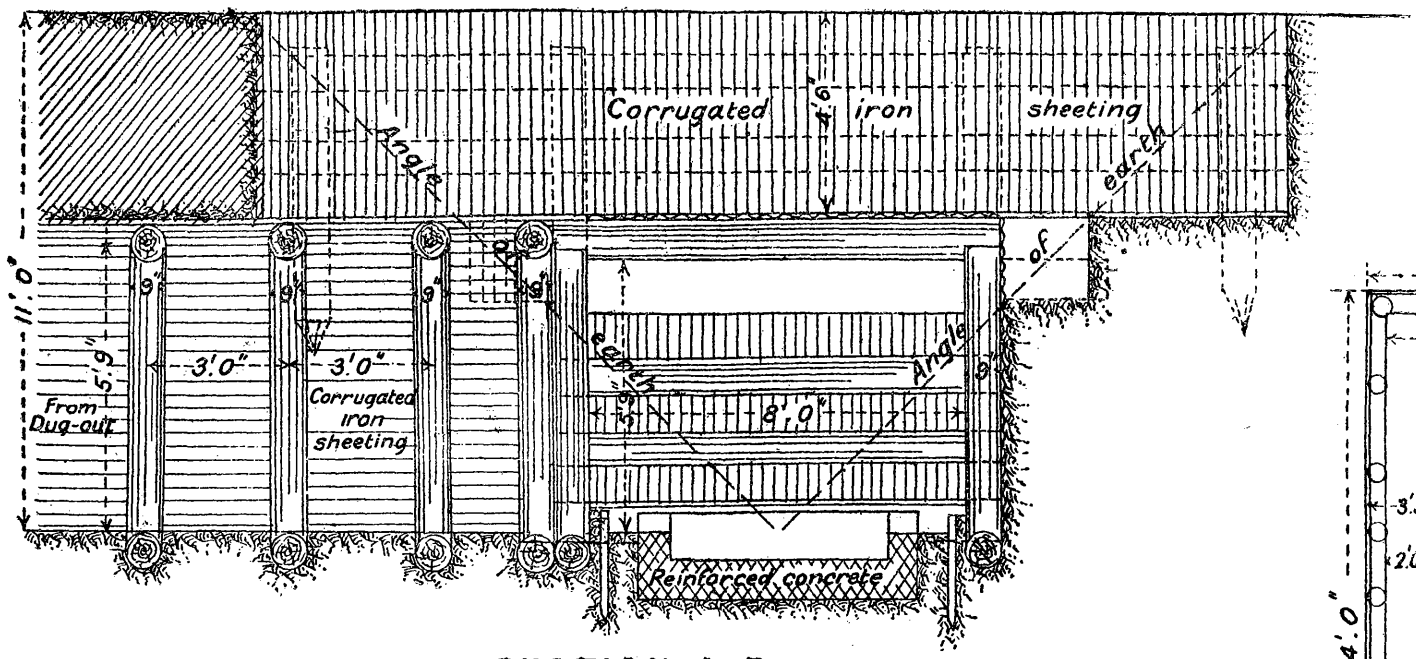
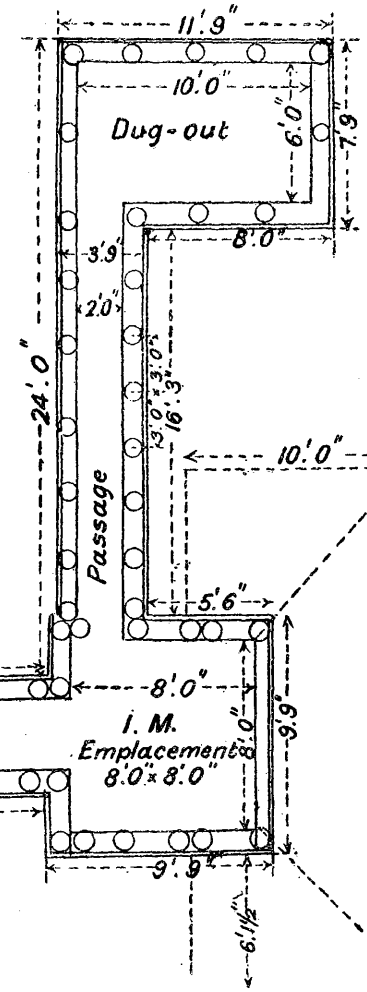


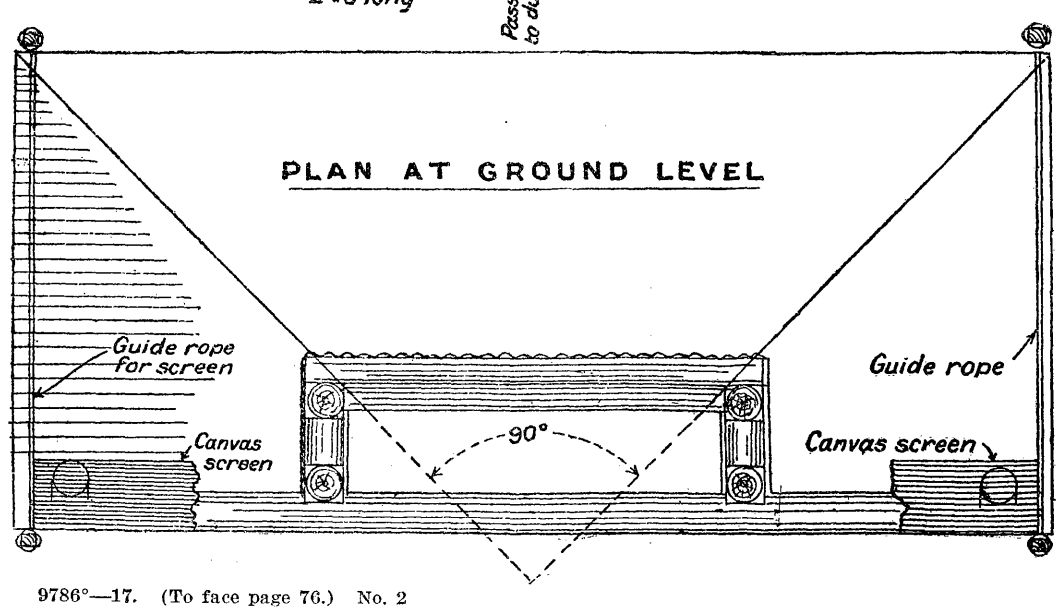
SECTION C.D.



SECTION A.B.
(Earth and bursting layer removed)



PLAN.
Scale of 8 Ft. to 1 inch



LISTS OF MATERIALS REQUIRED FOR :-

T.M Emplacement

2	Pit props	22'0" x 9"	Diam (cut up)
1	" "	12'0" x 9"	"
2	" "	10'4" x 9"	"
2	" "	10'0" x 9"	"
7	" "	9'6" x 9"	"
1	" "	8'0" x 9"	"
2	" "	7'2" x 9"	"
10	" "	6'1" x 9"	"
2	" "	6'0" x 9"	"
2	Beams	7'9" x 9" x 3"	"
2	"	2'6" x 9" x 3"	"
12	Pickets	2'6" x 4" x 3"	"
2	Pieces	3'3" x 3" x 2"	and guide rope
1	Canvas screen	10'6" x 22'0"	
9	Corr. I. sheets	7'0"	Long
7	" " "	6'0"	"
1	" " "	5'6"	"
5	" " "	4'9"	"
.	" " "	4'6"	"
3	" " "	4'6"	"

Passage from Emplacement to Dugout

12	Pit props	6'1" x 9"	Diam.
12	" "	3'6" x 9"	"
24	C.I. sheets	6'0"	Long

Passage from Emplacement to Magazine

10	Pit props	6'1" x 9"	Diam.
10	" "	4'6" x 9"	"
24	C.I. sheets	6'0"	Long

Dugout

2	Pit props	12'x9"	Diam (cut up)
1	" "	10'0" x 9"	"
8	" "	7'6" x 9"	"
12	" "	6'1" x 9"	"
1	" "	3'9" x 9"	"
6	C.I. sheets	7'0"	Long
8	" "	6'0"	"
6	" "	4'0"	"

Magazine

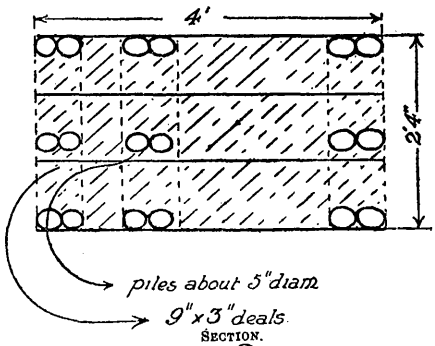
2	Pit props	14'0" x 9"	Diam (cut up)
8	" "	7'6" x 9"	"
12	" "	6'1" x 9"	"
1	" "	4'6" x 9"	"
24	C.I. sheets	7'0"	Long

25

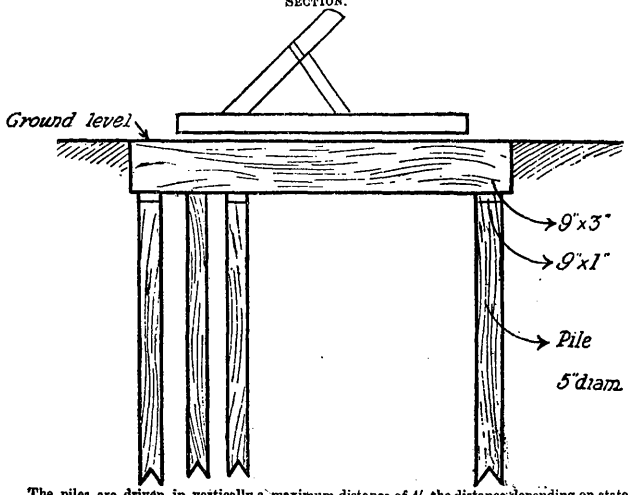
Appendix C—*continued.*

TYPE OF MORTAR PLATFORM. No. 2.

PLAN.



SECTION.



The piles are driven in vertically a maximum distance of 4', the distance depending on state of ground and resistance offered. The tops are then cut off level.

APPENDIX D.

Details of

Class.	Type.	Weight for transport.			
Heavy..	9.45-inch	9.45-inch:	*Cwts.*	*Qrs.*	*Lbs.*
		Mortar with elevating pinions, handwheel, etc	4	1	23
		Mounting	4	0	12
		Bed	4	2	23
		Truck, transporting mortar	1	2	12
		Truck, transporting mounting	1	3	10
		Truck, transporting bed	4	0	26
		Box stone filled	1	2	12
		Each. *Cwts.* *Qrs.* *Lbs.*			
		Beams, platform, inner (5) 1 0 20	5	3	16
		Beams, platform, outer (2) 3 27		7	26
		Planks, ramp (3) 1 1 0	3	3	0
		Wedges 12 13		5	16
		Tray, loading		2	24
		Total	34	1	4
Medium.	2-inch...	2-inch:			*Lbs.*
		Mortar			105
		Bed			160
		Elevating stand			50
		Tool box			60
		Periscope box			70
		Temple silencer			47
		Rifle mechanism			5
		Total			497
Light...	3-inch (Stokes).	3-inch:			
		Mortar			48
		Elevating stand			28
		Base plate			28
		Total			104

* Weights do not

APPENDIX D.

trench mortars.

Projectile.	Range.		Effect.	Uses.	Extreme rate of firing, average conditions.	
	Max.	Min.				
	Yds.	*Yds.*				
Weight, 152 pounds (aerial torpedo type)	1,140	600	Crater: Depth, 10 feet; width, 24 feet.	Destruction of works.	1 round in 6 minutes.	For hand transport barrows are provided, for mortar, mounting and platform.
Weight, 51 pounds (stick-bomb).	573	100	Crater: Depth, 5 feet; width, 14 feet.	Destruction of works. Wire cutting.	1 round in 2 minutes.	
Weight, 10 pounds 11 ounces (cylindrical bomb).	430	100	Crater: Depth, 2 feet; width, 4 feet.	Against personnel. Destruction of minor works.	25 rounds per minute.	

include stores.

APPENDIX E.

Details of ammunition.

	Weight of bomb.	Bursting charge.	Propelling charge.	Nature of fuze.	Method of firing.	Components of 1 round.
9.45-inch.....	152 pounds.....	56 pounds, H. E..	17 ounces of Cordite.	Percussion with delay. Time.	Rifle mechanism..	Bomb. Fuze. Exploder. Charge. Cartridge for firing mechanism.
2-inch.....	51 pounds with tail.	12½ pounds, H. E..	1 ounce 10 drams; 2 ounces 10 drams; 3 ounces 10 drams of Cordite.	Direct action; percussion with delay. Direct action; percussion instantaneous.	Rifle mechanism..	Bomb (42 lbs.). Tail with pin (9 lbs.). Fuze. Exploder. Charge—(one 1½ and two 1 oz. parts). Special cartridge for firing mechanism.
3-inch (Stokes)..	10 pounds 11 ounces cylindrical shell.	2¼ pounds, H. E...	12 bore ballistite cartridges, either 95 grams, 120 grams, or 175 grams.	Time (pistol head); always percussion.	Shell with cartridge inserted falling on to striker in the bore.	Bomb. Fuze and fuze-head detonator. Cartridges: 1 long range. 1 medium range. 1 short range.

APPENDIX F.

NOTES ON TRENCH ARTILLERY.

(By a French officer.)

Armament.—Trench artillery is a development of the present war and its necessity was felt as soon as the fronts were established.

The Germans surpassed us at first and we were obliged to improvise, but now we surpass the Germans, as can be concluded from the following order, from the commander of a group of German armies, dated October, 1915:

> The French, who at first entirely lacked trench artillery, naturally suffered severely from the violence of our devices. They started manufacturing with the means at hand and kept improving their products constantly. In a short time they have gained the superiority.

A certain amount of matériel is formed into organized units and served by artillery troops. Other types are also in use in the armies and served by the infantry troops constituting the trench artillery of the sector.

The matériel proper belonging to the larger units are:

Mortars	58
Mortars	Van Deuren.
Mortars	75 T—model 1915.
Mortars	150 T.
Mortars	240 T, 340 T } Howitzer and guns.

Together these mortars form a close range heavy artillery with shell carrying a large amount of explosive matter.

Most of the projectiles (excepting the 240 and 340) have a lower penetrating capacity (through shelters) than heavy artillery, but their disorganizing effect on trenches and boyaux as well as on the auxiliary defenses is great. They can therefore be used as an offensive weapon against organized positions.

The value of the error is absolutely the same as that of heavy artillery placed at its usual distance from the target. Thus, a 58 trench mortar firing at 500 meters will usually place its fire within the same rectangle as a 155 howitzer firing at 4,000 meters.

An equal number of projectiles fired either from a trench or a heavy-artillery gun will produce the same explosive effect.

9786°—17——6

When the target does not require the penetrating effect of heavy artillery, the 58 bomb, weighing 16 kilograms, can be compared to the 155 cast-steel projectile, and the bomb, weighing 40 kilograms, to the 220 projectile.

It should be remembered that the handling and installation of this matériel require skilled and well-trained personnel. The efficiency will vary 100 per cent with the degree of instruction acquired by the noncommissioned officers and men, which proves the absolute necessity for trench-artillery schools (one for each army and one at Bourges).

Considerable time is required to completely install a battery of trench artillery, as it must be placed close to the enemy, with great caution (platforms, shelters, etc.), in order to procure favorable firing conditions. In case of emergency it can be done more hurriedly, but its effectiveness will be decreased.

The following table shows the range, rate of fire, and time required to install:

Caliber.	Weight of bomb.	Weight of explosive.	Range.		Rate of fire per minute per gun.	Time for complete installation.
			Maximum.	Minimum.		
58 No. I bis	16 Kg.	4-6 Kg.	400 M.	80 M.	½	20 days.
58 No. II	18 Kg.	4-6 Kg.	650 M.	100 M.		
	18 Kg.	5 K, 350	1,000 M.	100 M.	½	20 days
	40 Kg.	10,500	450 M.	100 M.		
	35 Kg.	10 K.	600 M.	100 M.		
240 howitzer	87 K.	46 K.	1,000	500	⅙	20 days.
240 gun	81 K.	42 K.	2,150	600	⅙	20 days.
340	195 K.	93 K.	2,300	500	⅛	30 days.

THE GRID PLOTTER.

Description.—The board measures about 12 inches by 9 inches and has mounted on it a piece of xylonite marked in 20-yard squares on a scale of 1/2500, the center point representing the observer's clamping point. The shape of any target of considerable size can be drawn to scale on the xylonite in pencil, and the fall of the rounds measured with reference to any portion of the target. Surrounding the squared portion is a circle graduated in degrees from 0 to 180 right and left, the 0–180 line being vertically central on the board, and representing the line battery to observer's clamping point. Used in conjunction with the above are transparent pieces of celluloid, each engraved down the center lengthwise with a zero line and having lines representing degrees radiating on each side. The radiating center of these lines is not on the celluloid, but each strip represents a 600-yard section of such lines between varying ranges. The strips are in duplicate and cover all ranges from 400 to 3,000 and represent the observer's field of observation.

To prepare the instrument.—A suitable strip for each observer, according to his range from the clamping point, having been selected, each strip should be pinned down and clamped, with the clamps provided so that its zero line passes through the center of the squared portion of the xylonite, and makes an angle with the battery line, corresponding to the angle made at the clamping point between the observer's line and the battery line, as measured from a map. This angle can be measured by the circles drawn on the xylonite.

To use the instrument.—On a round being fired and observations having been received, the result is plotted, by means of the strips, onto the squared portion of the xylonite, and the distance R or L and plus or minus of the clamping or ranging point in yards is read off. The result is converted to minutes of G. E. and G. D. by means of two small circular slide rules provided on the board, which should have been set before opening fire in the necessary proportion found from the range table.

The instrument can be used at ranges outside those shown on the strips. If the distance from the observer to the target is greater than 3,000 yards (the longest distance shown on the sectors), the sector should be set at half the distance and the observations doubled before applying them. At certain ranges the strips when clamped fail to cover all the squared portion of the xylonite; under such circumstances the strips can be moved up or down 100 yards without practically impairing the efficiency of the results obtainable.

[Translation of a German document.]

THE EMPLOYMENT AND DUTIES OF THE ARTILLERY FLIGHTS IN TRENCH WARFARE.

A. General.

The great importance of the artillery flights to the artillery makes it essential that all artillery commanders should be thoroughly acquainted with the employment of these units and their capabilities. In this connection personal experience gained by taking part in flights is of particular value.

On the other hand, in order to obtain useful results it is essential that the artillery flights should have a general knowledge of the principles of the employment of artillery, of the tasks allotted to the various guns, and of the methods of fire of this arm; they must, in addition, be trained in observing from the air and possess a thorough knowledge of the wireless and photographic apparatus.

Intimate liaison between the artillery and artillery flights, mutual confidence, and practice in working together are absolutely essential to successful combined work.

B. Employment.

The artillery flights are army troops and will be attached by the army to some formation. For tactical purposes they will be under the orders of this formation.

The continual employment of the same artillery flight in a particular zone will secure that thorough knowledge of the country and of our own and the enemy's dispositions which is essential for successful work.

The size of the zone which can be reconnoitered and observed by one artillery flight depends on the extent of the tasks allotted to the flight, and particularly, therefore, on the strength of the enemy's artillery in the zone in question, as well as on the nature of the ground. As a rule, one artillery flight will be employed at first on a corps front.

The splitting up of artillery flights is not sound, as the flight commander is unable to make his influence felt in the matter of further training, judicious employment, and maintenance of matériel; it also leads to administrative difficulties. As occasional casualties in personnel and machines must be anticipated, the establishment of the complete flight is designed to provide a certain surplus to ordinary requirements, so that the flight may (at all events, if it is not split up) be capable of carrying out all its tasks even if casualties occur.

C. Command.

The artillery flight is an artillery reconnaissance and observation unit. It should, therefore, always be placed under the orders of an artillery commander. Which particular commander this should be will vary, owing to the different methods of artillery command obtaining in individual corps.

If there is a corps artillery commander, the flight should be placed under his orders. It will be advisable for the corps artillery commander to allot the artillery flight to the commander of the heavy artillery, should there exist in the corps organization an artillery battle group of heavy artillery specially intended for counter-battery work.

If there is no corps artillery commander or heavy artillery commander, the flight should be placed under the orders of the artillery commander of one division, who will, in consultation with the flight commander, meet the wishes of the artillery commander of the other division regarding the allotment of machines (pilots and observers should always be the same, as far as possible) and wireless receiving stations..

It will be best, if it can be arranged, for one artillery flight to observe for two independent divisions alongside each other.

In accordance with instructions received from the artillery commander under whose orders the flight is placed, the flight commander will allot the machines, pilots, observers, and wireless receiving stations to the artillery group commanders.

On principle, every endeavor must be made to detail the same observers for the observation of fire from any particular batteries, as the fact of having worked with one another before increases the probability of obtaining good results. (Cf. G. G. S. of Field Army No. 7248 r. par. iv.)

D. DUTIES.

The duties of the artillery flight consists of reconnaissance for the artillery and observation of artillery fire. Their employment for other purposes, e. g., for forming aeroplane barrages, means taking them away from their proper sphere of duty.

(*a*) *Reconnaissance.*—This comprises the location of all hidden targets, which it may be necessary to shell, and especially all concealed hostile artillery.

The closest cooperation is essential with all other reconnaissance units, etc., survey section, sound-ranging section, Reconnaissance Flight, captive balloon, and the corps staff officer (sec. IId), to whom all results of reconnaissances are forwarded (cf. C. G. S. of the field army, No. 7248 r, par. ii).

In particular, the photographs taken by the Reconnaissance Flights must be forwarded to the Artillery Flights.

Reports from the troops regarding suspected hostile artillery and knowledge of the information gained by other reconnaissance units, etc., will give the Artillery Flights indications as to particular areas which should be thoroughly examined and photographed with a view to locating hostile artillery.

In order to carry out their reconnaissances it is essential for the Artillery Flights to be equipped with photographic apparatus.

The most difficult task is that of determining whether known gun positions are occupied or not. The observations of the survey sections and sound-ranging sections will form a basis on which to work. The aeroplane observer should, however, always endeavor to see the flash of the gun himself. This will help to insure that dummy batteries are not shelled. In this connection it is a good plan to draw the enemy's artillery fire systematically; for instance, by shelling those portions of the enemy's position which usually draw retaliatory artillery fire. When observing for gun flashes the object of each flight should not be to observe for one particular gun flash only, but a lookout should be kept on a group of several neighboring batteries.

The Artillery Flight should always be notified of all firing which the artillery propose to carry out, even when aeroplane observation is not necessary, in order that the Artillery Flight may make use of it in connection with reconnaissance and observation, as well as for purposes of instruction.

Other reconnaissance duties are:

Observation of the general behavior of the enemy and determination of the roads (depressions) along which his main traffic (troops and vehicles) passes. This will form a basis for bombardments by flat trajectory heavy guns and for barrages behind the enemy's lines.

The location of parks, camps, railway constructional work, retired positions in course of preparation, etc.

As regards the quickest method of communicating the results of reconnaissances to the troops and the topographical section (Vermessungs-Abteilung), see C. G. S. of the field army No. 7248 r. par. ii.

(*b*) *Observation of artillery fire.*—The assistance given to the artillery when firing is connected principally with the registration of and firing for effect against the enemy's batteries which are known to be occupied, either on the strength of information obtained by the observer or by the orders of the artillery commander. Next in importance is the registration of and sometimes (depending on the extent of the target and the question of time) fire for effect against other targets (e. g., bridges, camps and villages, railway stations, ammunition and store depots, retired defensive lines).

When the artillery flight is carrying out reconnaissance flights a battery should be detailed to fire, when signaled by the observer, on good targets actually observed by the latter; this applies specially to the enemy's batteries observed to be in action. The method of describing the position of the target and of communicating it to the battery is given in section X, "F. T. Flieg." (Aeroplane Wireless Manual.)

E. Method of Carrying Out Artillery Observation.

I. GENERAL.

1. It is essential that the observer should have a thorough knowledge of the ground near the target, obtained by personal reconnaissance and from his own photographs as far as possible.

2. As a general rule it is not advisable to detail one machine to observe simultaneously for several batteries, but it is quite sound to allow one machine to observe consecutively for several batteries or for several shoots of the same battery against different targets.

(Registration and fire for effect.)

3. On principle, the battery commander must direct the fire of his battery. If he (the battery commander) does not himself observe from an aeroplane, the observer will only report his observations to the battery commander, not the necessary corrections.

It is essential that all reports should be absolutely reliable. If there are any doubts or difficulties in observation, firing should be stopped to prevent waste of ammunition.

II. PREPARATIONS.

1. Before carrying out a prepared shoot the battery commander should come to some agreement, verbally if possible, with the observer regarding the following points:

(*a*) Position, number of guns, and nature of the battery which is going to fire, position of the receiving station to which the observer is to signal, and its communications with the battery. In order to avoid lengthy telephone lines, the receiving station should be close to the battery commander; it is either permanently installed there or should be set up as required, a motor lorry being used for the purpose. The telephone circuit will be manned by the artillery. If it is not a special circuit it should be closed to all other traffic during the shoot. The receiving station will not communicate the actual signals to the battery, but only their signification; for instance, not "3 dots," but "fire."

(*b*) *Target.*—There must be no possibility of misunderstandings. Even the ground in the vicinity of the target must be thoroughly discussed. When targets are situated in high woods it may be advisable to fire the first few shots intentionally in more open ground near the target, in order to insure the possibility of observation. The procedure laid down in paragraph 179c, "Schiessvorschrift für die Fuss-Artillerie," will be followed when necessary. Picking up the target and subsequent observation will be facilitated if the observer marks on his map the line joining target and battery (without marking in the position of the latter) and compares it with the ground. Battery positions should only be marked on the maps which are taken out in the aeroplane when they are essential for observation purposes.

When it is intended to shell several targets consecutively it must be previously decided whether the targets are to be taken

in a particular order or whether the observer is to decide the order according to the results of his reconnaissance. (Code words to be arranged for each target.)

(*c*) Nature of ammunition, possibility of observing the bursts, and number of rounds intended. Change of ammunition should be avoided during a shoot.

(*d*) Time for opening fire.

(*e*) Intended procedure, single shots or salvos; the latter is often necessary for registration.

(*f*) Errors in the shooting of the guns, time of flight of the projectiles.

(*g*) Employment of lamp signals in case the wireless breaks down.

(*h*) Arrangement of visual signals, which will be given by means of linen sheets (Fliegertücher) displayed near the command post. For the regulation visual signals see Section X, Aeroplane Wireless Manual.

2. The batteries must also make all the necessary preparations for firing with aeroplane observation (aeroplane map and supplementary squared map), and the battery commander must have a thorough knowledge of the rules laid down in Section X, Aeroplane Wireless Manual.

3. When the fighting capabilities of the flight are not sufficient for the execution of special tasks protection by means of battle planes and antiaircraft guns should be applied for, through the Abteilung commander, to the field officer of the flying troops.

4. Wave lengths will be laid down by the last named.

III. METHOD OF CARRYING OUT THE FIRING.

1. The receiving station will inform the battery as soon as communication with the aeroplane has been established.

The battery will report "Ready for action" to the receiving station. The aeroplane observer will ask for each shot (or salvo).

The battery commander will wait for this request until "Fire for effect" is called for.

As regards designation of fire, intervals, reestablishment of "readiness for action," ceasing fire, landing for discussion, see Section X, Aeroplane Wireless Manual.

2. It must be left to the observer to decide the height at which he will work and the position from which he will signal his observations.

3. Whether the battery should cease fire or not on the approach of hostile aeroplanes depends on the importance of the task in hand, and each case, therefore, should be decided on its merits.

4. Rapidity of fire is necessary in order to lighten the observer's task.

5. Other batteries should not fire near the target.

6. The observer is only responsible for accurate observation, the battery commander for good shooting based on the results of the observation. Success can only be attained if the battery commander bases his corrections exclusively on the results of the aeroplane observation and not by correcting at one time according to his own observation or that of the survey section, at another by that of the aeroplane observer.

It is, however, quite sound to allow the survey section or balloon observers to observe simultaneously, both for practice and for the purpose of enabling a comparison of and a mutual check on the results to be effected after the firing is completed.

7. Registration which is not immediately followed by fire for effect can only be justified in special cases—for instance, when preparing to carry out an attack on a large scale.

8. When firing with time H. E. shell from the heavy field howitzer (15 centimeter) only the bursts on impact will be taken notice of when observing.

(*Note for those who are not trained in gunnery.*—When this method of fire is adopted the aim is to obtain a large number of bursts on impact and only a few bursts in air.)

IV. AFTER FIRING IS COMPLETED.

The hostile battery is, when possible, to be reconnoitered by aeroplane immediately after the firing is completed in order to ascertain the damage by means of photographs taken from vertically above the battery and by personal observation.

The details of the various observations will be discussed by the battery commander and the observer after the firing is completed in order to obtain an accurate picture of the whole of the firing and to gain fresh experience.

(Sd.) *v.* FALKENHAYN.

APPLICATION OF METEOROLOGICAL DATA IN GUNNERY.

1. *Barometer.*—Aneroids should be tested from time to time by comparison with certified mercury barometer.

The barometer pressure at the level of the gun is what is required by the B. C. The fact that the pressure decreases with the height (about $\frac{1}{10}$ inch per 100 feet) is allowed for in compiling the range tables.

2. *Air temperature.*—The thermometer should be hung in a shady but not inclosed place; *never* in the sun, nor inside any building.

The fact that the temperature usually decreases with height (at average rate of 1° F. per 300 feet) is allowed for in compiling the range tables, and although weather and seasons cause wide variations, from this average, the temperature of the air at the level of the battery is what is normally required by the B. C.

In the particular case of a cold night or morning in winter, with high barometer and settled weather, if the shell will reach above 500 feet, the temperature as read at the battery should be modified by adding to it two-thirds of the difference between it and the temperature that has generally been reached by day during the past few days; if no such allowance is made, the predicted range is likely to be 20 yards or more too great.

Humidity has very little effect on the density of the air. The maximum error likely to arise on this score is comparable with those arising from an error of 1° F. in the air temperature.

3. *Wind.*—Above 2,000 feet there is a comparatively steady and regular motion fairly uniform over whole districts.

The wind nearer the earth's surface, however, is much less regular, owing to irregularities of the ground and diurnal changes of temperature. These check its velocity, deflect its course, and cause gustiness.

The ground wind increases during the day and decreases during the night (though above 1,000 feet the wind shows the opposite effect). There is also a considerable change of direction

with height. On the average the wind veers 20° or 30° in the first 1,000 feet and is afterwards more steady.

Large errors may occur through not knowing what wind the shell will encounter; surface measurement of wind is not sufficient to insure accuracy. With high-angle fire particularly, the statistics of wind above are required.

In applying wind corrections it is best to use the wind direction and velocity at two-thirds of the maximum height of the trajectory (maximum height in feet equals four times the square of the time of flight).

The two best methods of determining the upper wind are:

(*a*) The practical method of sending up small pilot balloons 1 or 2 feet in diameter; this is done at three "meteor" stations along the British front.

(*b*) The theoretical method of calculating from the weather chart of the day; this is fairly accurate, except in the case of very light winds.

Meteor wind reports are sent out three times daily and are always in the same form. All bearings are true bearings; velocities are given, when possible, at 200, 500, 2,000, and 4,000 feet.

"Five hundred 35 at 260 a a a" means that at 500 feet the wind is 35 f. s. from true bearing 260°. Given that and "two thousand 50 at 275" one can interpolate that at 1,000 feet up the wind was 40 f. s. coming from true bearing 265°.

EXTRACT FROM A RECENT REPORT FROM AN OFFICER SERVING IN WESTERN EUROPE.

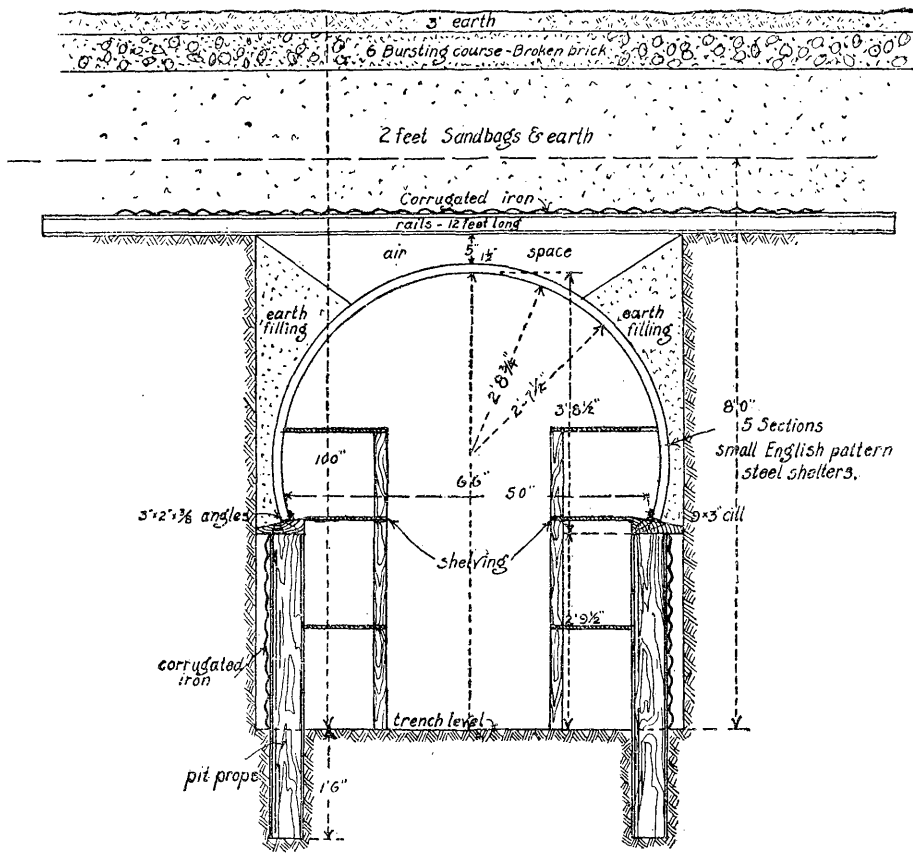
Gun pits.—All of the guns that I saw in action were heavy types, 6-inch howitzer, 8-inch howitzer, 9.2-inch howitzer, and 60-pounder gun. All of these were located in shallow pits, with a little sandbag protection erected on either side. They had no overhead protection whatever. In some, but not in all cases, a camouflage was used. This consisted generally of a hempen rope net with twigs or colored bits of canvas intertwined in the meshes of the net. The net was removed while the gun was being fired and replaced as soon as a series had been finished.

Rabbit wire instead of rope netting was suggested to me as far preferable for camouflage purposes. One officer preferred canvas, on the ground that canvas would serve to shelter the men from the weather; but the consensus of opinion was that canvas is unsuitable, since it flaps in the wind and is easily torn, leaving holes that show up as dark spots in an aeroplane photograph.

Dugouts are usually provided near each gun, but those gave only about 2 feet of overhead cover.

As for 18-pounder guns, the overhead cover provided depends upon the amount of time available. If the guns remain in one place for considerable periods, overhead cover is provided and continually strengthened. But for offensive concentration it is recommended that guns should be put in the open or in pits 2 feet 6 inches deep (to lower the general height) and camouflaged.

Shelter for gun detachments must be provided in narrow trenches sited as the situation indicates. They should be 8 feet deep and strutted at the top. Ammunition recesses can be cut in these trenches if time and material permit. Plate —, "Ammunition store," shows a shelter which may be constructed if ample time is available. In any case shelter against weather must be given for cartridges.



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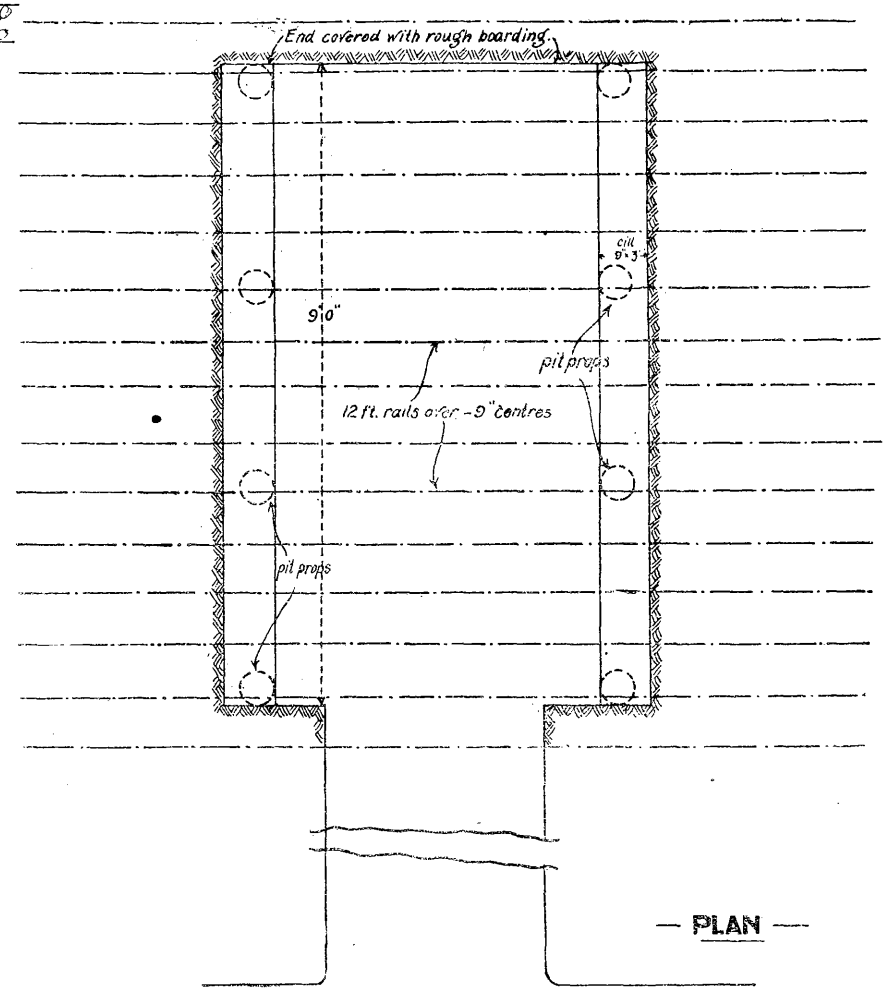


— PLAN —

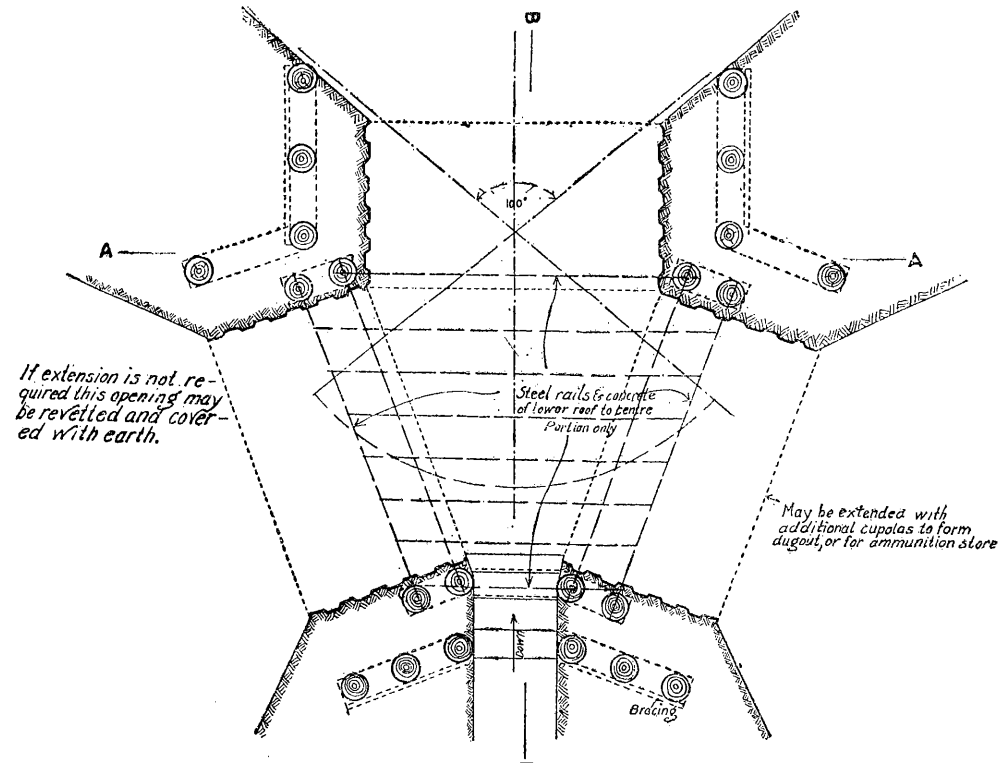
QUANTITIES:

5 double sections - small English steel shelters
15 steel rails - 12 ft. long
18 - 6 ft. sheets corrugated iron
2 steel angles 3"x2"x3/8 9 ft. long
2 - 9"x3" splayed cills - 9 ft. long
8 pit props - 4' - 3 1/2" long
1/2 Square - rough boarding
54 ft. run - shelving & bearers - widths as required
44 - 1/2" x 1 1/4" bolts & nuts
nails & dog spikes
broken brick
sandbags

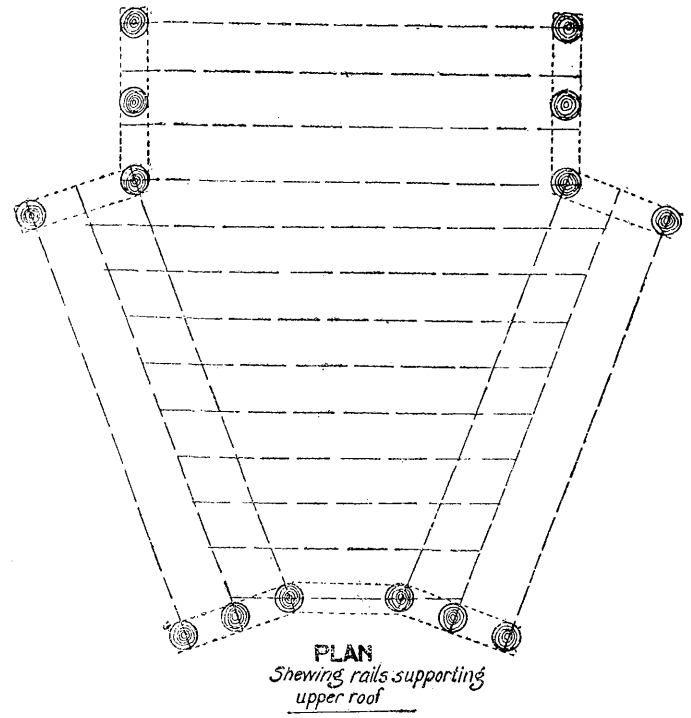
— Trench —
8 feet deep

Inches 12 9 6 3 0 1 2 3 4 5 10 feet

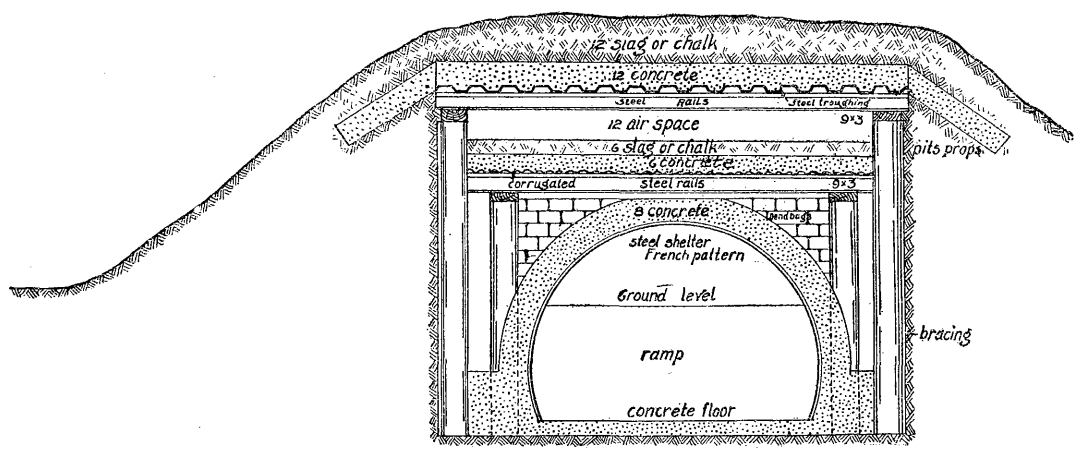
— Scale - 3/8" = 1 foot —



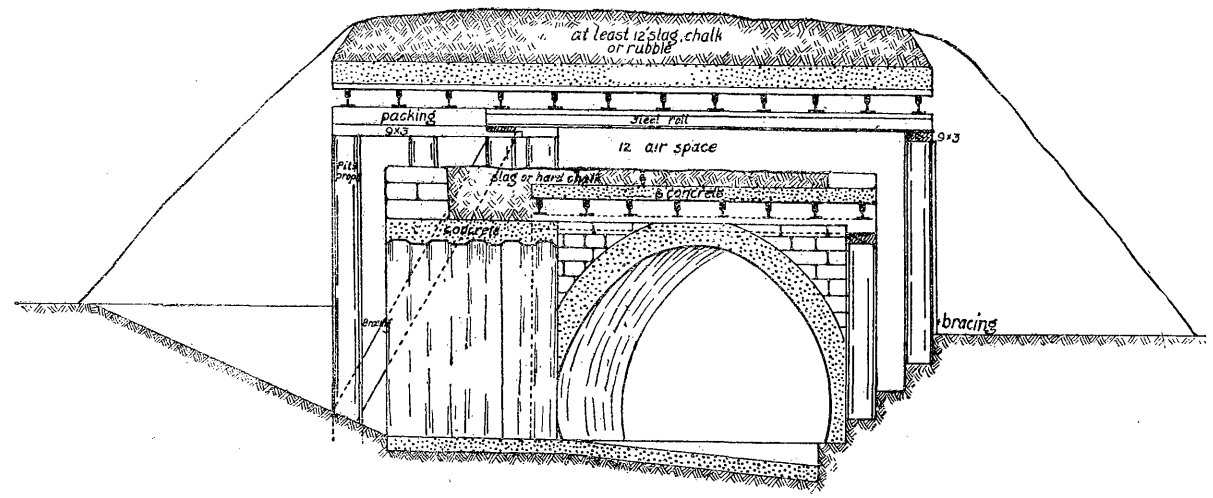
PLAN
Shewing rails supporting lower roof



PLAN
Shewing rails supporting upper roof



SECTION AA



SECTION BB

12 6 0 1 2 3 4 5 10 15 20 25 feet

Scale 1½ ft to 1 inch

Plate —, "Design for gun pit, Type C," gives details of a pit constructed when time is available and conditions necessitate considerable overhead cover.

Guns that expect to remain for any length of time in one locality must be given strong overhead cover at least for the gun detachments.