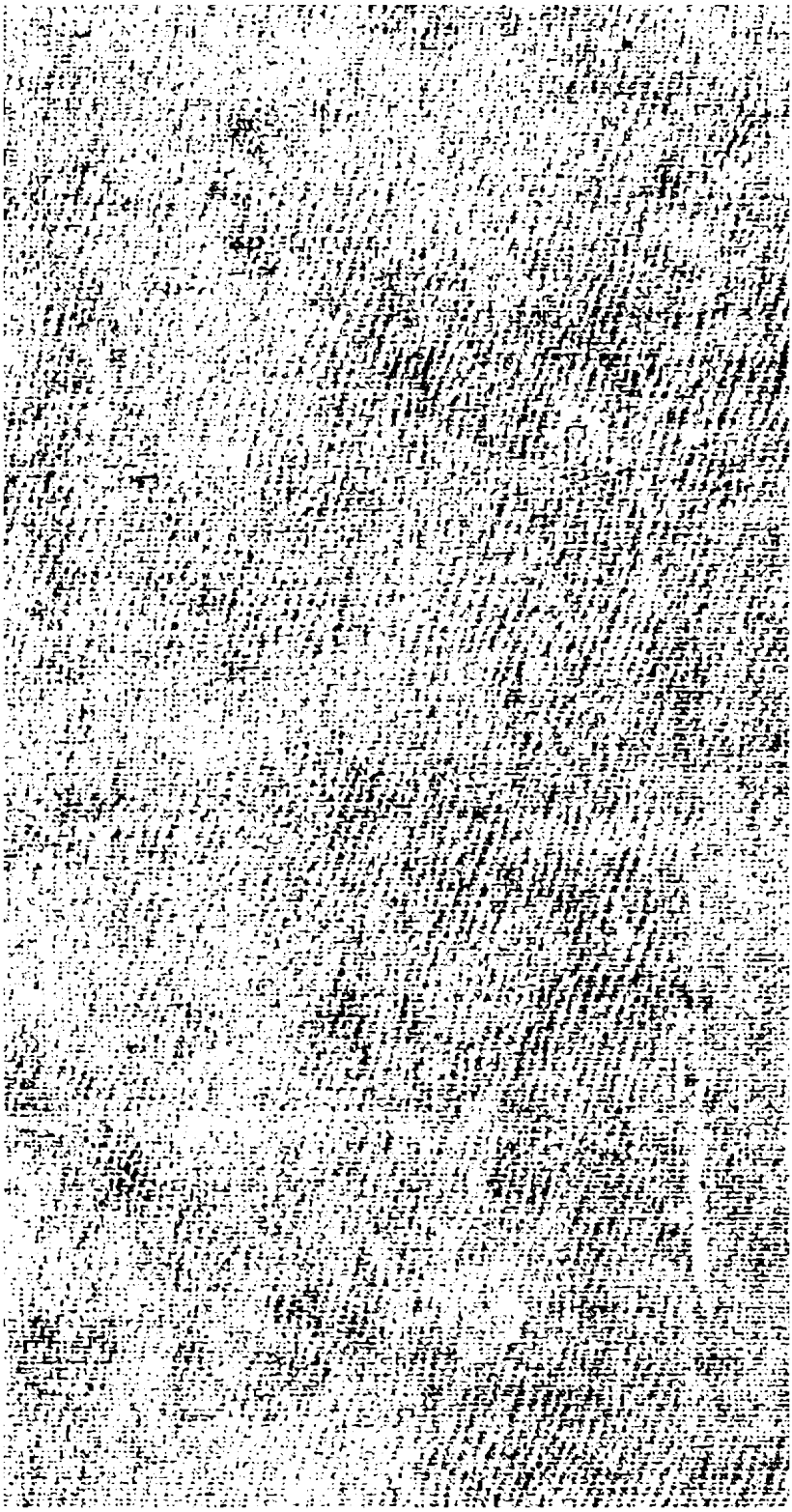

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MILITARY ENGINEERING.

(PART I.)

FIELD DEFENCES.

GENERAL STAFF, WAR OFFICE, 1908.

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WAR OFFICE,
5th June, 1908.

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MILITARY ENGINEERING.

PART I.—FIELD DEFENCES.

SECTION 1.—GENERAL PRINCIPLES OF FORTIFICATION.

Definition of Fortification.

1. The science of fortification deals with all the material means by the use of which it is sought to obtain an advantage for troops in the combat.

Its main object is that of enabling a commander to economize his defensive force, in order to increase that available for offensive action, by which alone decisive results can be obtained.

Fortification is usually divided into the following three branches :—

a. *Permanent Fortification*, which implies defences of the most complete kind. Such works must of necessity be constructed in time of peace, and are employed to protect important centres or to bar lines of advance. Permanent fortification.

b. *Provisional Fortification*, in which the works of defence are constructed during, or in immediate anticipation of war. It is used to supplement the deficiencies of permanent defences, or to create an extemporized fortress at some point of which the strategic importance has increased in consequence of the developments of a campaign. Works of this class are frequently described as "semi-permanent," but it must be remembered that the question of permanency does not decide the class to which a work belongs. Provisional fortifications may require several weeks for their construction; civil labour and resources will frequently be employed. Provisional fortification.

c. *Field Fortification*. Under this heading are included all measures taken to strengthen ground which it is intended to hold only for a time. Works of this kind are executed either in face of the enemy, or in expectation of his immediate approach. Field fortification.

General Principles regarding the use of Field Defences.

2. All measures of fortification must be regulated in accordance with tactical considerations. This is particularly true in the case of field defences, which must be constantly modified to suit the new conditions brought about by the improvement in firearms.

In order, therefore, to obtain the greatest advantage from field defences, the general principles of defence as set forth in "Combined Training" must be carefully studied. It should be borne in mind that a force awaiting the attack of its adversary must at some time resort to the offensive if it is to gain a decisive victory, and that the greater the economy of strength obtained by field defences of suitable design, the larger will be the force at the disposal of the commander for such offensive action.

3. It is a first principle in the application of field defences that they should be so constructed as to conform to the tactical plan of operations. They must be considered only as a means to an end, and never as an end in themselves. They should enable fire to be delivered under the most favourable conditions to the defence, but, except in the case of a passive defence, should not interfere with freedom of movement for a counter-attack.

When a purely passive defence is contemplated with a view to checking a hostile advance or holding some important point until assistance arrives, or protecting defiles, bridgeheads, and posts on the line of communications, the delivery of a counter-attack becomes of secondary importance, and obstacles and intrenchments should be constructed solely with a view to delaying the enemy.

4. The factors to be taken into account in selecting a position for defensive action are discussed in "Combined Training." No precise rules can be laid down as to the manner in which a defensive position is to be occupied or intrenched, as so much depends on the character of the operations, the physical features of the ground, and the composition of the troops engaged. The only reliable guides are a thorough knowledge of the effects of fire and a practised eye for ground.

The introduction of smokeless powder has vastly increased the element of concealment in field defences. For not only does it enable a force acting on the defensive to fire without disclosing its position, but it also robs the adversary to some extent of the advantages of the long range and great accuracy of modern weapons. It is, therefore, essential that in the construction of works of defence the greatest precautions should be taken to ensure their concealment. If this principle be carefully observed, the enemy may be betrayed into a rash and premature attack, or may even be exposed to the demoralization of a complete surprise.

Until the enemy has disclosed his line of advance, it will not always be possible for a commander to decide fully on the location and extent of the defensive works which will be necessary, but this will not prevent him taking preliminary

measures for defence, which will usually consist in strengthening weak points, both to the front and flanks, by the construction of small works and obstacles, the intervening spaces, when necessary, being protected by hastily-constructed trenches.

5. The use of intrenchments is not, however, confined to the defensive, for they constitute an important factor in all offensive operations. All important points gained should at once be put in a state of defence, so that attempts on the part of the enemy to recapture them may be defeated. Moreover, an assailant brought to a standstill by the fire of the defenders will often be obliged to have recourse to intrenchment to enable him to cope with the hostile fire; such protection will admit of economy of force, as in the case of the defensive, and will possibly free troops to act elsewhere with decisive effect.

SECTION 2.—ARMS AND PROJECTILES.

Influence of arms on defences.

6. The power and nature of the arms employed affect Field Fortification in two ways:—

1st. Their penetration, searching power, and destructive effect govern the amount and disposition of the cover necessary for security.

2nd. Their range and rate of fire influence the siting of works, and regulate the positions as well as the scale of the obstacles required.

Classification of fire.

7. Fire is termed frontal, oblique, enfilade, or reverse, according to its direction relative to the object fired at.

It is called:—

Frontal, when the line of fire is perpendicular to the front of the target.

Oblique, when the line of fire is inclined to the front of the target.

Enfilade, when it sweeps a line of troops or defences from a flank.

Reverse, when the rear instead of the front of the target is fired at. A line of troops or defences thus attacked is said to be "taken in reverse."

As regards the angle of descent of the projectile, fire is said to be

High angle, when it is delivered from guns or howitzers at any angle of elevation exceeding 25°.

8. Laying may be either "direct" or "indirect." In "direct" laying, the gun is laid by looking over or through the sights at the target; any other method of laying is termed "indirect."

Nature of arms.

9. The weapons employed by regular armies, which have to be reckoned with in designing works of defence, are rifles, machine guns, mountain and quick-firing field guns, guns of heavy artillery, and field and medium howitzers.

As regards the above weapons, the points which have to be considered by the engineer when designing field works are their range, penetration, searching power, destructive effect, and rate of fire. So far as their effect on field works is concerned, there is no great difference between our own weapons and those of other civilized armies; for practical purposes our own may be taken as a guide.

Service rifle.

10. The service rifle is the Lee-Enfield. It is universal for all arms. Length, 3 ft. $8\frac{1}{2}$ in. Mean muzzle velocity about 2,000 f.s. Its calibre is ·303-in.

Slopes of descent of bullets.

11. The slopes of descent of the bullet at various ranges are roughly :—

At 1,000 yards	..	..	..	1	in	30
„ 1,500 „	..	..	..	1	„	12
„ 2,000 „	..	..	..	1	„	6·5
„ 2,500 „	..	..	..	1	„	3
„ 2,800 „	..	..	..	1	„	2·5

Thickness of various materials proof against bullets.

12. The following table gives the thickness, in various materials, proof against a bullet from the short Lee-Enfield Service Rifle at 30 yards range. The bullets of some continental armies have, however, greater penetration.

Material.	Thickness proof.	Remarks.
Clay	5′	Varies greatly. This is maximum for greasy clay.
Earth free from stones (unrammed)	3′	Ramming earth reduces its resisting power.
Sand	2′ 6″	Rather more than enough. Very high velocity bullets have less penetration in sand at short than at medium ranges.
Sand between boards ..	18″	
Brickwork	9″	If well built.
Soft wood, *e.g.*, fir	48″	24″ proof at 500 yards.
Hard wood, *e.g.*, oak ..	27″	15″ proof at 500 yards.
Wrought iron, or mild steel	$\frac{1}{2}$′	
Hardened steel plate ..	$\frac{1}{4}$″	$\frac{1}{10}$″ proof at 600 yards.
Special hard steel	$\frac{1}{8}$″	
Shingle	6″	
Coal (steam)	2 6″	
Chalk	1′	When freshly excavated.

13. The service machine gun is the 0·303-in. Maxim which fires the ordinary rifle cartridge. It will deliver a stream of bullets at the rate of 600 rounds a minute. The height of parapet over which it can fire depends on the type of carriage or tripod on which it is mounted. The latest pattern carriage admits of the gun firing over a height of about 42 in., whilst when mounted on Mark I tripod it can fire over a height of 31½ ins.; Mark II, 42 ins.; Mark III, 30 ins.; Mark IV, any height from 14½ ins. to 30 ins. Machine gun.

In order to get the best results from the gun it should be given as large a field of fire as possible. It is particularly effective for delivering flanking fire.

14. The 1·457-in. Vickers-Maxim gun (pom-pom), which may be taken as an example of light quick-firing gun, fires a 1 lb. common shell, with a bursting charge of 340 grains of black powder. Its penetration into wrought iron is 2·25 ins. at the muzzle. The bursting charge of the shell is so small that its effect against earthworks is insignificant. Light Q.F. guns.

The slope of descent is 7° 57′ at 2,000 yards, 17° 19′ at 3,000 yards, and 45° 24′ at 4,500 yards. The muzzle velocity is 1,757 ft. secs., and the remaining velocity at 4,500 yards is 501 ft. secs.

This gun has now been withdrawn from the units of the Field Army, but similar guns form part of the armament of some Continental armies.

Quick-firing guns of larger calibre may be met with; none of them can have much effect upon an earth parapet. But all classes of light gun will be found effective for destroying loopholes at short range.

15. Horse and field artillery fire shrapnel shell of about 12 and 18 lbs. weight, with time and percussion fuzes. At short and medium ranges these light projectiles, owing to their high velocity, are easily deflected by very small parapets. At longer ranges their penetration, before burst, is slight. Field gun shells therefore, used against troops behind earthworks, depend for their effect chiefly upon their searching power when burst in the air. Field guns.

The principal use of common shell, which is used with a percussion fuze, is for ranging. It may also be used for the destruction of field magazines and earthworks, and for the attack of buildings. The small amount of bursting charge in the common shell of field guns reduces the possibility of good effect against earthworks, while as a man-killing projectile it is very inferior to shrapnel. Common shell.

Percussion shrapnel is used for ranging, and against troops in buildings or behind cover such as walls. The fire of percussion shrapnel will be effective against troops defending any ordinary building. Shrapnel.

Time shrapnel is employed against troops under all con-

ditions other than the above. The present fuze is effective up to about 6,000 yards.

Angle of cone of dispersion of bullets.

16. The angle of the cone of dispersion of the bullets (generally called the angle of opening) is about 20°. The angle increases slightly with the range, because the forward velocity of the shell decreases more rapidly than the velocity of rotation, so that the influence of the latter increases. In estimating the front covered by the spread of the bullets, it may be taken as from 35 to 40 per cent. of the distance at which the shell is burst short of the target.

The searching power of a bullet varies directly as the angle of its descent. To find approximately the greatest searching power of a shrapnel, half the angle of opening should be added to the slope of descent of the shell. The slope of descent of the shell is :—

At 1,500 yards ..	..	about 1 in	20
„ 2,000 „ ..	..	„ 1 „	13
„ 3,000 „ ..	..	„ 1 „	7
„ 4,000 „ ..	..	„ 1 „	4

Splinters of common shell.

17. The splinters of common shell from guns, even of those with high explosive bursting charges, all go forward, whether burst in the air with time fuze, or on impact with percussion fuze. If burst in the air, their searching power is much greater than that of shrapnel, but it is very difficult, even under peace conditions, to burst the shell in exactly the right place over a trench.

Field gun shells not intended to destroy earth cover.

18. Field gun shells are not intended to destroy earthworks. Against deep trenches, with low, flat parapets, field artillery has but little effect. The tendency of the shell to glance on striking an earth parapet is specially marked in the case where the latter is composed of sand and light soil. Such soil falls back into the craters formed, and thus little impression can be made on good earth cover at moderately long ranges.

Heavy artillery.

19. The 60-pr. B.L. and 4·7-in. Q.F. are examples of heavy artillery guns. Their range is longer than that of field artillery, and their shrapnel bullets are heavier ; their searching power is, however, little greater, and their shells are equally liable to be deflected by a very slight bank of earth.

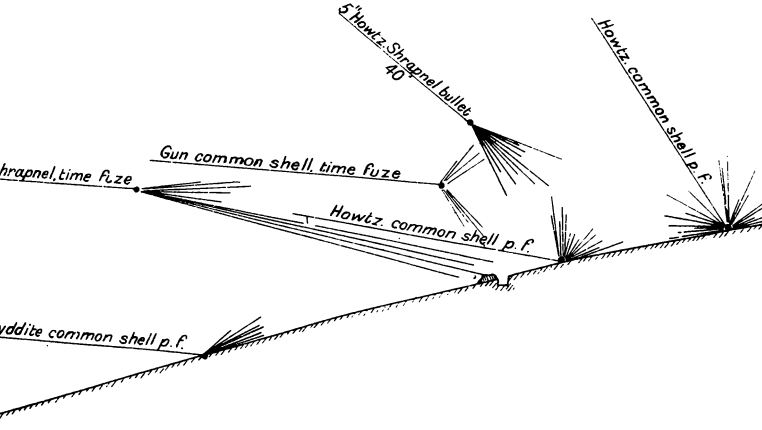
These guns can best be employed against trenches or other earthworks by bringing an oblique or enfilade fire to bear. Their long range frequently enables them thus to sweep the enemy's position whilst keeping out of range of his rifle fire.

Field howitzers.

20. Field howitzers have been introduced into the British as well as into several foreign armies. They produce results otherwise unobtainable, since their high angle fire will search out troops behind cover which would render field artillery harmless. They are also used to attack closed works, overhead cover villages, fire trenches, &c.

ARTILLERY ATTACK ON EARTHWORKS.

Shewing the action on bursting of various natures of Shell.



The 5-in. shell of 50 lbs. weight, with bursting charge of 9 lbs. 15 ozs. of high explosive, is especially effective against troops crowded together in such works as field redoubts, or in buildings or villages. Shrapnel shell with field howitzers can be used effectively at ranges up to about 5,000 yards; the angle of descent of the bullets may be anything up to $\frac{1}{7}$.

Action of projectiles.

21. Pl. I gives an idea of the action of various kinds of projectiles. It will be observed that practically the only one which has any backward effect after burst is the howitzer common shell, fired at a high angle of elevation.

This question is one which should be carefully studied by all officers, since it is impossible to design field defences properly without a clear and accurate conception of the effects of artillery projectiles.

For more detailed information as to the action of shells, see "Field Artillery Training."

SECTION 3.—FIELD LEVEL, AND FIELD GEOMETRY.

Designating slopes.

22. Slopes are usually described in field works by fractions, in which the numerator expresses the height, and the denominator the base of the slope. Thus a slope described as $\frac{1}{4}$ (or verbally as *four in one*) is one in which the vertical height is four times the base (see Pl. II, Fig. 1); whilst that expressed by $\frac{1}{6}$ (or verbally, as *one in six*) is, on the contrary, one in which the base is six times the vertical height (Fig. 2).

To convert slopes, given in degrees, into slopes as used in field works, a rough rule is to divide 60 by the number of degrees in the slope. Thus 6°=1 in 10 roughly. This rule should not be used for angles greater than 30°.

Field Level.

Field Level.

In laying out field defences certain simple geometrical operations may be necessary. The only special instrument employed for the purpose is the field level, which is used for setting off angles on the ground, and for gauging slopes.

The level is shown on Plates III and IV.

The limb C, which contains the spirit level, must be opened out first, and afterwards the limb, B; these are then joined at *a* by a catch.

The level is used in the following ways:—

(*a*) As an ordinary spirit level. For this purpose it need not be opened (Fig. 5).

(*b*) As a square for setting off right angles. The limbs B and C form the right angle.

(*c*) As a protractor, for laying out an angle from a given point on a given line. The limb A is made to coincide with the line, the point of the arrow head being at the given point. The required angle can then be laid out by stretching a tape from the arrow head over the angle as numbered on limb B or limb C.

(*d*) For setting off any slopes from the horizontal to the vertical. For this purpose the plumb-bob, kept in a recess of limb C, is required. The plumb-bob must be suspended from the brass socket in limb C (near the end remote from the spirit level), and allowed to swing freely, and the level moved until the string coincides with the required angle $\frac{1}{4}$, &c.; the edge of the limb A will then be at the required slope.

It may be noted that one edge of the level is graduated in feet and inches.

Field Geometry; Laying out Angles, &c.

Field geometry.

23. The following simple applications of geometry frequently occur in laying out field defences and require the aid of no special instrument:—

To lay off a right angle.

(*a.*) To lay off a right angle.—Let X be a point in a given straight line A B (Pl. II, Fig. 3), from which it is required to set off a right angle.

1st method.—Take any point C in A B, and drive in pickets at C and X. Take any convenient length of tape C D X, and make loops at either end, and find its centre D by doubling it. Now place the two loops over C and X, and stretch the tape taut into the position C D X. Take D X off the picket at X and turn it round till it comes into the position D E, in prolongation of C D. Join E X, which gives the right angle required. This method is founded on the fact that every angle in a semi-circle is a right angle.

2nd method.—From X, measure off a distance of 4 units X C along A B (Fig. 4). Take a piece of line or tape 8 units long and apply one end to the point X and the other to the point C; find a point in the tape 3 units from X, and seizing it at this point, draw the bight out to D, till the line is taut: then C X D is a right angle. This method is founded on the fact that in any triangle whose sides are in the proportion of 3, 4, and 5, the angle contained between the two shorter sides is a right angle. The first method is the one more usually employed.

To trace a perpendicular to a given line, from a point outside.

(*b.*) To trace a perpendicular to a given line from a point outside it—Let X be the point outside the line A B (Fig. 5), from which it is required to draw a perpendicular to that line. Take a tape or cord rather longer than the perpendicular will be; fix one end at X, and, stretching the tape taut, swing it

FIELD GEOMETRY.

Fig. 1.

Fig. 2.

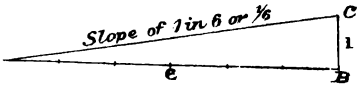


Fig. 4.

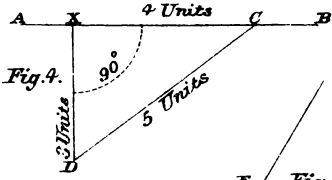


Fig. 3.

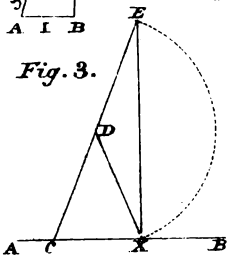


Fig. 6.

Fig. 7.

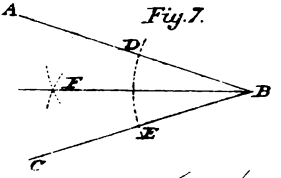


Fig. 5.

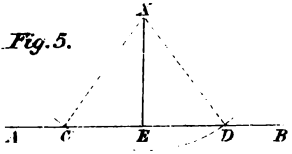


Fig. 8.

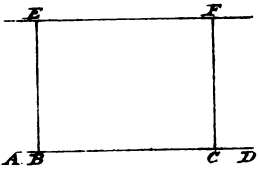
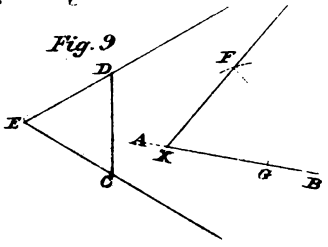


Fig. 9



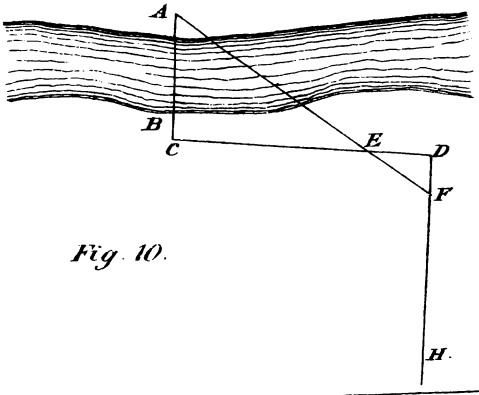


Fig. 10.

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To face page 10

FIELD LEVEL.

Setting off Slopes

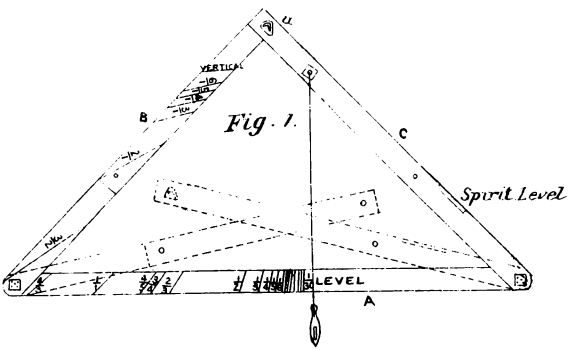


Fig. 1.

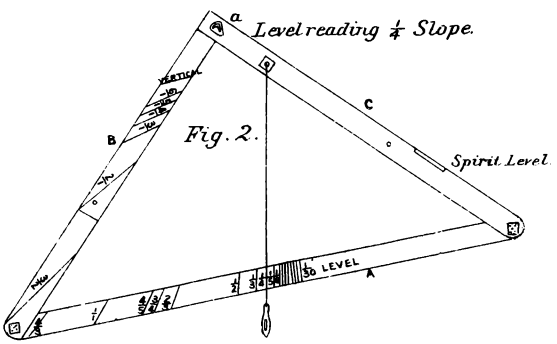
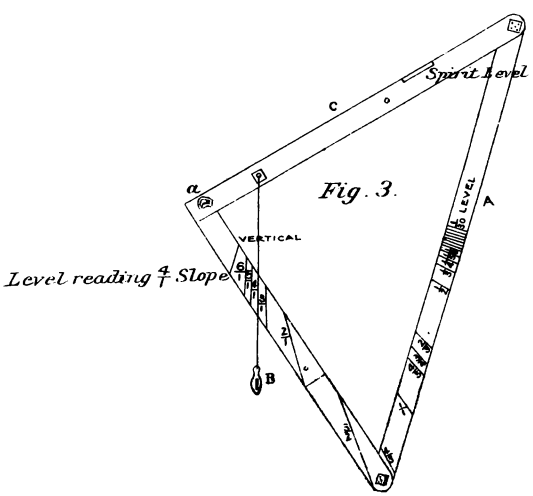


Fig. 2.



Level reading ¼ Slope

Fig. 3.

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To follow pl II

FIELD LEVEL (Cont.d)

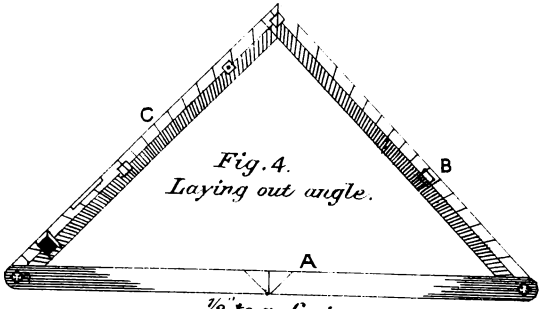
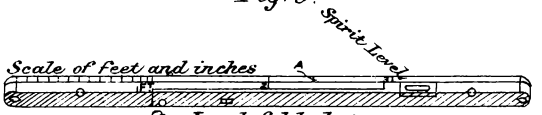


Fig. 4.
Laying out angle.

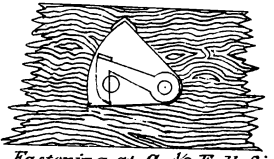
½" to a foot.

Fig. 5.



Level folded up.

Fig. 6.



Fastening at a, ½ Full Size

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round so that the other end will cut the line A B at the points C and D, Z C being equal to X D. Find E the middle point between C and D. Join X E. Then X E is at right angles to A B.

To lay off angles of 60° or 120°.

(*c.*) To lay off an angle at 60° or 120°.—Let X be the point in the line A B (Fig. 6), from which it is required to lay off an angle of 60°. Take any point C in A B at a convenient distance from X and towards that end of the line with which the angle of 60° is desired to be drawn. Take a tape or cord twice the length of X C, and fasten the ends to X and C. Seize it by the middle point and draw the bight out taut to E. Then the angle E X C is 60° and A X E is 120°.

To bisect a given angle.

(*d.*) To bisect a given angle.—Let A B C be the angle which it is required to bisect (Fig. 7). On B A and B C mark points D and E at equal distances from B. Find by means of a tape or cord a point F equidistant from D and E. Join B F. Then B F bisects the angle A B C.

To trace a line parallel to and at a given distance from a given line.

(*e.*) To trace a line parallel to and at a given distance from a given line.—Let A D be the given line; from C and B, any two points on A D (Fig. 8), erect two perpendiculars (Problem *a*). On these perpendiculars set off C F and B E equal to the distance at which the lines are to be apart. Join E F; then E F is parallel to A B.

To lay out an angle equal to a given angle.

(*f.*) To lay out an angle equal to a given angle.—Let X be the point in the straight line A B (Fig. 9) from which it is desired to lay off an angle equal to the angle D E C. Fix the points D and C at any convenient distance from E, and from the point X measure X G equal to E C. Then from the point X as centre, and a distance equal to E D as radius, and from the point G as centre, and a distance equal to C D as radius, describe arcs intersecting at F. Join X F. The angle F X G is equal to the angle D E C.

To find the distance between two points when it cannot be measured directly.

(*g.*) To find the distance between any two points A and B when it cannot be measured directly.—Select a point C in continuation of the line A B at any convenient distance from B (Fig. 10). From C lay off the line C D at any convenient angle, D being at any convenient measured distance. In C D select a point E so that C E is some multiple of E D, *e.g.*, divide C D into four equal parts; then C E is three times E D. From D lay off the angle C D H equal to the angle B C D (*see* (*f*)) and on the opposite side of C D. Make D F of such length that the point F is in line with A and E.

Then A C : C E :: F D : D E

$$\text{or A C} = \frac{\text{C E} \times \text{F D}}{\text{D E}}$$

If C E is three times E D as above, then A C = three times F D.

Measure B C and deduct its value from A C.

This gives the length A B which is required.

SECTION 4.—INTRENCHING TOOLS AND THE EXECUTION OF EARTHWORKS.

Intrenching Tools.

Definition of intrenching tools.

24. Under the heading of intrenching tools are included pickaxes, shovels, spades and crowbars. The light intrenching tool will also be included as soon as it is issued to the army.

Pickaxes.

25. The latest pattern of pickaxe has a 4½-lb. steel head, and a wooden helve with a steel ferrule to fit the head. The object of this ferrule is to strengthen the helve at the weakest point, and to make it easily detachable from the head. Fig. 1, Pl. V.

A pickaxe with an 8 lb. head can be obtained from Ordnance Store if heavy work be expected.

The word "pickaxe" is usually abbreviated into "pick."

R.E. shovel.

26. The R.E. shovel is a commercial pattern of shovel weighing about 5 lbs. Fig. 2, Pl. V.

G.S. shovel.

The G.S. shovel is a shovel similar to the above, but weighing only 3½ lbs., and having a much smaller blade. Fig. 3, Pl. V.

Spades.

27. Only a very small proportion of spades are carried, as they are of little use in the field. They are employed for cutting sods, for working in clay, and for digging generally when a pickaxe is not required. Fig. 4.

Crowbars.

Crowbars also are carried only in small numbers. They are of use for loosening rocks, making holes for pickets in hard ground, &c. Fig. 5.

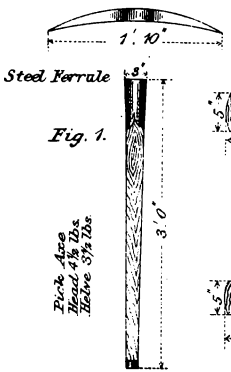
Use of Tools.

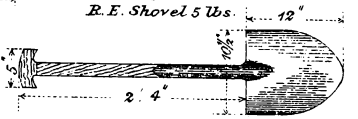
Use of tools.

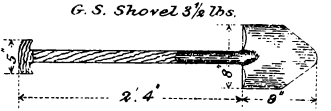
28. Careful instruction and practice in the use of intrenching tools are essential to good and rapid work.

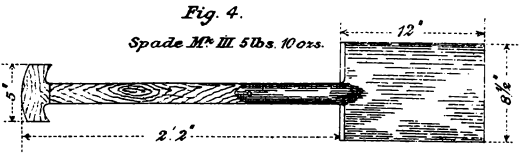
When using the full-sized tools, each digger is usually provided with a pick and a shovel. The shovel should be used only for shovelling up earth already loosened by the pick, except in particularly soft earth, where the pick may sometimes be dispensed with. Men should be practised so as to shovel equally well with either the right or left-hand on the T-head. When throwing earth horizontally, the shovel should be brought smartly forward in the required direction until the hands are level with the shoulder, both hands retaining their hold of the tool, which should, however, be allowed to slide easily through the hand which grasps the helve. Anything in the nature of a jerk should be avoided. Earth thrown properly from a shovel should all fall in a compact mass. Beginners

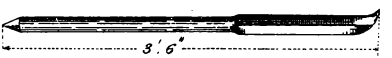
INTRENCHING TOOLS











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To face page 12

generally try to take up too much earth in the shovel. Navvies make great use of the thigh in thrusting the shovel under the loosened earth.

The pick is used for loosening the earth previous to shovelling. Too much earth should not be loosened at once, as it gets under the digger's feet, and is difficult to shovel. Men using the pick are not allowed under ordinary circumstances to work sideways in their task, but only to the front and rear, so as to avoid the risk of striking their neighbours. This risk becomes especially great in the dark.

The pointed end of the pick is for use in stony ground; the chisel-end is for cutting off the top sods, and, in soft soil, for loosening large pieces. Men using the pick should always endeavour to get a vertical face to their work. Before striking the pick into the ground, it should be raised well above the digger's head by both hands. In bringing it down, the helve should slide through the hand nearest to the head of the pick, and the weight of the tool should be employed to help in the work. Where picks are much used, a small forge should be at hand, to allow of their constantly being sharpened or re-steeled.

For work in clay, spades are better than shovels. Where possible, water should be provided to wet the blades.

29. Intrenching and cutting tools are carried by cavalry, artillery, engineers (field companies and field troops), and infantry. The detail of the tools carried is given in the Field Service Manuals of the various arms. Intrenching and cutting tools.

Reliefs and Tasks.

30. In digging intrenchments, for all except the smallest works, the working parties are not kept continuously at work, but are changed at intervals, thus dividing the total time into periods called *reliefs*. Reliefs.

The length of *reliefs* depends a great deal upon the nature of the work, the total time it will take, and the climate, also on the question whether the work has to be hurried through and whether it can be carried on by night as well as by day. Short reliefs are best, and as a rule it will be found that a four hours' relief (actual digging) is quite long enough for the infantry soldier. Six hour reliefs may occasionally be resorted to. A relief, when no time is specified, means four hours' work. When the soil is heavy, it is better to increase the number of reliefs rather than the length of them; the amount of work to be done in each is thus decreased, and the chance lessened of leaving unfinished tasks to succeeding reliefs.

Great care should be taken in the preliminary detailing of working parties, so that they may arrive at the site of their work ready provided with tools, their tasks clearly defined, and the men in such formation as will admit of their ready distribution on the work. Detail of working parties.

Delay and noise are thus avoided, and the chance of confusion during night-work is reduced to a minimum.

Tasks.

31. A task is the amount of work a man has to do in one relief. The amount of work to be expected from troops varies greatly. It depends on the nature of the soil, the amount of training in the use of their tools which the men have had, and on the class of tools used.

The estimates given below, of the amount of work to be expected from troops, are for guidance under average conditions, and serve for working out probable times, &c.

The figures must be altered to suit local conditions.

The conditions assumed are those of easy soil and untrained soldiers.

Rates of work.

32. For one hour a man can dig at the rate of 30 cub. ft. per hour. Up to four hours a man can dig at the average rate of 20 cub. ft. per hour, or excavate about 80 ft. in a four hours' relief.*

Organisation of Working Parties.

Length of tasks.

33. For all intrenchments the normal distances apart at which the men are spaced for work is two paces (5 ft.). This can be reduced if necessary to 4 ft., but to do so rather cramps the diggers, especially with heavy tools. It can be increased up to 10 ft.

Task work.

34. Task work is better than working for a fixed time, and each unit should be allowed to knock off work when the task is done.

In arranging tasks it is better to under-estimate than to over-estimate the men's power of excavating, in order to avoid uncompleted tasks.

Trenches.

35. The method of extending men for work on trenches is laid down in "Infantry Training," 1905.

The working parties will nearly always be infantry. Only half as many picks as shovels are carried by the infantry, therefore in cases where a company is only able to use its own tools, each digger cannot have both a shovel and a pick. Every two diggers must share a pick, or else pick-men must be told off, one to each pair of diggers.

If the party be large, and the work of a complicated nature, as in the construction of a redoubt, the men should be divided into detachments, each under a superintendent, corresponding to definite portions of the work. They should be formed in

* In very easy soils increase the rates by 50 per cent. In very hard soils decrease the rates by 30 per cent. Specially trained men can be reckoned to be able to do 50 per cent. more work.

These rates hold up to a maximum throw of 12 feet, and a lift out of a trench 4 feet deep.

column at some distance from the site, and successively extended along the tracing tapes, driving in their picks on the left of their tasks, and laying down their shovels along the front. It is sometimes advisable, in order to save time in extending, to keep a separate detachment to be distributed on the excavations at the angles.

Superintendence.

36. Shelter trenches and cover for guns will usually be constructed by the units which are to occupy them, under the superintendence of their own officers, but for more elaborate works military working parties will generally be superintended by the Royal Engineers. Civilian workmen should be employed in gangs under their own gangers, supervised by soldiers. In order to ensure continuity of the work, supervisors should not be relieved at the same hours as the working parties.

Tools.

37. Tools will be collected near the work and so arranged that the working parties can be marched on them and take them up with the least possible delay. A convenient plan is to place picks and shovels in two separate heaps about 10 paces apart.

Diggers and shovellers.

38. For excavating ditches, trenches, &c., where the throw does not exceed 12 ft. horizontally and 4 ft. vertically, or 9 ft. vertically from the ground on which the men stand, the working parties will consist of "diggers" only, each man having a pick and shovel.

39. When the distance is so great that the diggers cannot deposit the earth in its final position with a single throw, 'shovellers" must be told off as well.

The shovellers each have a shovel only, and their duty is to pass on the earth already excavated. The strongest men should be selected, and each unit, especially for task work, should have its proper proportion of shovellers, since men work more readily for their own company or regiment than for strangers.

The proportion of shovellers to diggers may vary according to the circumstances; it will be from one to two shovellers for every three diggers.

40. In any case the ordinary rates of work cannot be expected when the vertical lift is more than 4 ft.

Reserve.

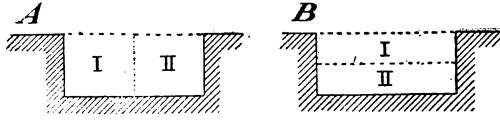
41. In addition to diggers and shovellers, it is advisable to provide a small reserve for general duties to each working party in order to ensure the completion of all tasks by the end of the relief. This reserve may be taken at about 10 per cent. of the diggers and shovellers together, and each unit should provide its own reserve upon which to draw for the purpose of assisting weak men, &c. The reserve should be provided with tools additional to those of the working party.

Reliefs.

42. In arranging reliefs the following rules should, if possible, be adhered to:—

(*a*) The second and succeeding reliefs should have less earth to excavate than the first, as the diggers have further to throw.

(*b*) *If possible*, each relief should leave a vertical face of earth for the next relief to commence upon. For instance, in figs. below, the dividing line should be as in A, and not as in B.



Method of executing Tasks.

Fire trenches.

43. When constructing fire trenches, the men should try to get cover as soon as possible. Sods and lumps of earth should be used for revetting the interior slope, which must be made as nearly vertical as possible, the revetting being carried up with the parapet.

No gaps should be left between tasks.

When separate pick-men are told off, each pick-man should change rounds with his two diggers at intervals.

Larger works.

44. In task work care should be taken that the men work to the exact dimensions.

Diggers must commence on the left of their tasks, in order to incommode each other as little as possible. Where there are both diggers and shovellers, the tendency is for the shovellers to move too close up to the diggers. This requires constant correction. The shovellers, where the excavation is shallow, should not be closer than 10 ft. to the cutting line. This distance can be decreased in the case of deep ditches, where the lift must be taken into account. Diggers must always throw the earth so that the shovellers can easily pass it on. Shovellers must pass the earth on as fast as they get it, and allow no accumulations.

Where the section of the ditch is of importance and has to be adhered to, the excess of excavated earth is got rid of by spreading it about. When the ditch is dug purely to obtain earth, the section does not matter, and can be reduced at the salients, where an excess usually occurs.

Double manning tools.

45. When time is short and plenty of men are available, it is possible to get the work done in about two-thirds of the normal time by detailing two men to each task.

As a rule only one row of diggers are employed to throw the earth in any one direction. With trained men, such as sappers, two rows of diggers may sometimes be employed to save time. One row should commence on the left and one on the right of their tasks, or the tasks be arranged to break joint. Special care in the use of the pick is required to prevent accidents.

Excavation of V-shaped ditches.

46. In the exceptional case of a deep V-shaped ditch, the sloping sides cannot be formed at once without great loss of time. It is usual, therefore, to commence by cutting out the sides in steps, which are subsequently cut to the required slope either in the same or in a subsequent relief.

Revetting interior slope.

47. There is often some difficulty in carrying on the revetment of the interior slope concurrently with the growth of the parapet, especially where the earth is obtained from a trench, but it should be done as far as possible.

Working in clay.

48. For work in stiff clay as many spades as possible should be used by the diggers, and buckets of water should be provided in which the men can dip their spades.

Water.

49. Drinking-water should be provided, mixed with oatmeal when possible, but the men must be warned against drinking much.

Balancing Parapet and Excavation.

50. In works larger than shelter trenches it will be necessary to balance the parapet and excavation. Under average conditions (see para. 32) a man can excavate 80 cub. ft. in a relief, and as the interval between diggers is 5 ft. (see para. 33), the sectional area of each man's excavation will be 16 sq. ft.

The earth required for the parapet is obtained from the rear trench, or from rear trench and front ditch combined. Earth, when newly excavated, especially in stiff soils, occupies more space than it did before excavation by about one-seventh to one-tenth of its volume. It is, however, not worth while to allow for this in calculation, as the surplus can always be either used in some way, or disposed of. It will be sufficient to take a section at right angles to the line of the parapet, and make the area of the excavation equal to the area of the parapet.

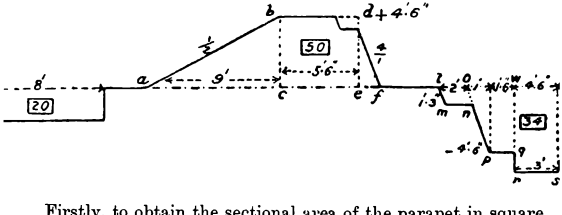
51. In most field works it may be assumed that local circumstances fix the dimensions of the parapet. The rear trench having to fulfil certain conditions as to cover, must also to a certain extent, be of fixed size, but its dimensions may be somewhat varied to assist in balancing, provided always that the trench affords sufficient cover.

In many cases it will be found that sufficient earth for the parapet cannot be obtained from the rear trench, without

making it too large; a ditch must then be added to provide the earth still required. This will not be a disadvantage, as it will permit of a second line of diggers, and so hasten the execution of the work. Should the sectional area of the ditch be less than 16 sq. ft., the interval between the diggers may be increased beyond 5 ft., in order to bring their tasks up to about 80 cub. ft.

52. In cases where the command is low, and the rear trench is consequently deep, the excavation will probably exceed the parapet in area; the surplus earth may either be used to thicken the parapet, or to form a parados, or it may be spread in rear.

53. The following example shows the method of balancing parapet and excavation, the section taken being that given on Pl. XXIX (Section through Parapet):—



Firstly, to obtain the sectional area of the parapet in square feet:—

Area of triangle *abc*	$= \frac{1}{2} \times 9 \times 4\frac{1}{2}$	$= 20\frac{1}{4}$	sq. ft.
,, rectangle *bced*	$= 5\frac{1}{2} \times 4\frac{1}{2}$	$= 24\frac{3}{4}$	,,
,, triangle *def*	$= \frac{1}{2} \times 4\frac{1}{2} \times 1\frac{1}{8}$	$= 2\frac{5}{8}$	,,
Add for loopholes, say	$2\frac{1}{2} \times 1\frac{1}{2}$	$= 3\frac{3}{4}$	,,
		$51\frac{1}{4}$	,,
Subtract area of elbow-rest,	$1\frac{1}{2} \times \frac{3}{4}$	$= 1\frac{1}{8}$	,,
Area of parapet		$= 50\frac{1}{8}$,	say 50 sq. ft.

The area of the trench is obtained in the same manner:—

Area of figure *wrst*	$= 6 \times \frac{1}{2} (4\frac{1}{2} + 3)$ ..	$= 22\frac{1}{2}$	sq. ft.
,, ,, *opqw*	$= 4\frac{1}{2} \times \frac{1}{2} (2\frac{1}{2} + 1\frac{1}{2})$	$= 9$	,,
,, ,, *lmno*	$= 2 \times 1\frac{1}{4}$	$= 2\frac{1}{2}$	,,
Sectional Area of trench		$= 34$	,,

Of this, about 4 sq. ft. is required for the overhead cover shown in Plate XXIX, which leaves 30 sq. ft. for the parapet. But the sectional area of the parapet is 50 sq. feet.

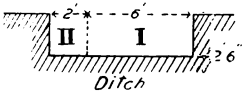
Therefore the sectional area of the ditch must be 50 − 30 = 20 sq. ft.

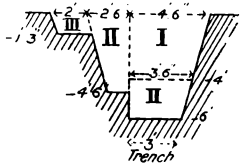
The ditch as a rule may be shallow, so that 8 ft. broad and 2½ ft. deep will give the required amount of earth.

54. On drawings, the area in square feet is shown thus **20**, the contents in cubic feet thus (80).

All heights above the ground level are marked with a "plus" sign +, those below with a "minus" sign −.

55. An arrangement of the reliefs necessary to execute the above work is shown below, in order to illustrate the usual method employed: -





Trench.

I.	1st relief, task	=	16 sq. ft.	×	5 ft.	=	80 cub. ft.
II.	2nd „	„	= 15½ „	×	5 „	=	77½ „
III.	3rd „	„	= 2½ „	×	5 „	=	12½ „

Ditch.

1st relief, task	=	15 sq. ft.	×	5 ft.	=	75 cub. ft.
2nd „	„	= 5 „	×	5 „	=	25 „

In the trench the first relief has been put at the back of the excavation in order to give the revetters and shovellers a platform sufficiently wide to work upon. The second relief should excavate the upright portion of their task first; half of the bottom portion should be deposited upon the reverse side of the trench, whence it can be shovelled on to the top of the overhead cover when that is ready for it. The third relief should first excavate their task, also throwing the earth to the reverse side; they should then erect the overhead cover. In addition to those actually digging, the following men should be allowed:— In the first relief for the trench, 1 man to every 2 diggers for revetting and shovelling (the revetting materials being on the spot); in the second relief the same; in the third relief 1 man should be allowed to every digger to assist in putting up the overhead cover.

For the ditch, in the first relief 1 shoveller should be allowed for every 3 diggers; in the second relief 1 man to every digger in order to assist in filling sandbags and forming the loopholes (which will have to be left to the latter half of the relief).

Tracing.

Tracing.

56. Tracing a work consists in laying out so much of its plan on the ground as is necessary to guide the distribution of the working parties. This is usually done by laying down lines or tapes, or by cutting a groove in the ground with pick or shovel (spitlocking).

The service tracing tapes are white, 1½ in. wide, and wound on pickets in 50 yard lengths.

A tracing party consists of one officer, one N.C.O., and three men. One man at the starting point drops the ball of tape at his feet, and lets the tape run through his hands, the officer drawing out the other end in the required direction. A second man measures the distance with a box tape or measuring rod, and the third drives pickets at any angle round which the tape is passed. The N.C.O. assists.

Order of tracing.

57. The crest line is traced first, and from this the edges of the various tasks, known as "cutting edges," are laid down according to the section. The tape is then taken up from the crest line (which is either spit-locked or marked with pickets), since this is not a cutting line.

Every tape or line left down indicates a cutting line, and implies that a working party is to be distributed along it.

Tools, &c.

58. The tools and materials required for a tracing party are :—

Mallet	1
Field level	1
5-foot rod	1
Measuring tape	1

Pickets, as necessary.
Tracing tapes, as necessary.

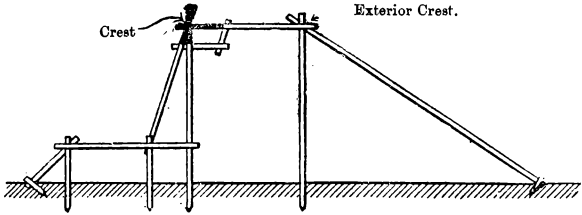
59. Simple works are, as a rule, constructed without being traced.

Profiling.

Profiles.

60. The work having been traced, *profiles* showing the various dimensions and slopes of the parapet are put up at right angles to the direction of the tracing lines. Profiles should be made of wood battens 1½ in. to 3 in. wide by ¾ in. thick; but string or tape may be used for all parts except the verticals. Two at least should be put up on each face near the angles, to serve as

guides in forming the parapet. Where the faces are long, more profiles are required, the usual proportion being one to every 30 ft.



Profile not exceeding 6 feet in height.

Erecting profiles.

61. In setting up a profile, the starting point is the firing line or crest. This is the intersection of the interior slope with the top of the parapet. The crest becomes an imaginary line after the elbow rest is formed. When the parapet has a low enough command for the level of the crest to be easily reached, battens or rods are driven vertically into the ground at points representing the base of the exterior slope, the crest and exterior crest lines, the edges of the banquette, and the toe of its slope. These points are then marked at the correct height on their respective uprights, and the profile is outlined by battens joining the points, and nailed or lashed to the uprights. The outer edges of these profiling battens mark the surface of the earth, except where a slope is to be revetted, when the inner edge of the batten should be used for that particular slope, in order that the profile may not interfere with the building of the revetment. On uneven ground the height of the crest should be fixed first, and the other slopes set off by means of a field level.

When the parapet has a considerable command (more than 6 feet) it is better to drive square-headed pickets into the ground at the position of the verticals, their tops projecting about 2 ft. above the ground. Battens of the exact height of the different points are then laid on the ground touching their respective pickets and at right angles to the line of the section, and their tops are connected by other battens to represent the different slopes; the whole is then raised and is fixed to the pickets by two or more nails, or by lashing, the profile being supported by side stays if required.

The profiles necessarily show sharp angles at the intersections of slopes or faces, but in working to them it is advisable to round off all such angles, so as to show no sharp lines towards the enemy.

It is very desirable that the profiles should be put up before the work is commenced, but, when time presses, the commencement should not be delayed for this reason, since the profiles can be erected during the progress of the work. Under such circumstances it may suffice merely to drive posts into the ground with their tops at the levels of the crest and exterior crest respectively.

Tools.

62. The tools required for a profiling party are:—

Crowbar	1	Mallet	1
Hammer, claw ..	1	Field level.. ..	1
Hand axe	1	6 ft. rod	1
Hand saw	1	Measuring tape ..	1

Materials.

63. The materials required are:—

Pickets, made up into bundles
Battens, $\frac{3}{4}$ in. by 3 in., long enough to make up the profile
Nails, cut, 2 in.

} all in quantities depending on the extent of the work.

If large profiles have to be erected, scantlings 3 in. by 4 in. and 2 in. by 3 in., of various lengths, are necessary; the profiling strips may also be of stouter material.

Where elbow rests are given, it is best to make the full profile first and then shape the elbow rest.

The part shown black in the diagram may be sawn off before the parapet is finished.

64. In the case of simple works profiling is not necessary.

Design of redoubts.

65. In the case of an important work such as a redoubt, its site and garrison will, as a rule, first be decided, and the design will then be worked out on the spot.

The design, organization of work, and actual construction having to be carried out more or less at the same time, the following is the order in which the successive steps should be undertaken, previous to the distribution of working parties.

(*a*) Arrange a trace to give fire in the necessary directions, the length of the crest line being proportioned to the allotted garrison.

(*b*) Detail tracing parties, and trace the firing line.

(*c*) Detail profile parties, and determine the command at the various profiles for fire and screening effect, modifying the trace where necessary. Commence drainage.

(*d*) Spitlock the trace or crest line.

(*e*) Determine the positions of the excavations, and trace with tapes ready for the extension of the working parties.

Organization of Working Parties.

66. In the preceding paragraphs of this section, the organization of working parties for earthworks has been

alluded to. The following rules are for the guidance of officers in detailing parties for all classes of work. (*a*) It is not always necessary to use short reliefs for works other than those which involve great and constant physical exertions, such as is entailed by digging. For example, in works such as bridge building it is generally best to work the whole party together, right through the hours of daylight, breaking off only for meals. Where work at night is possible, reliefs should be arranged to admit of each man getting his fair share of sleep. (*b*) Men must have good rests on a long job, and if the work will take some days, and is being carried on night and day, each man should have two reliefs off to one on. (*c*) It is best to keep units as far as possible unbroken. (*d*) It is always desirable to under-estimate rather than to over-estimate the work a man can do, therefore, calculate as well as you can by the aid of books and the exercise of common sense what amount of work a man can do, and then reduce this amount by 25 per cent. (*e*) In requisitioning for a working party a good plan is to demand 10 per cent. more men than you actually estimate you require. This allows a margin in case of emergencies. The same applies to materials. (*f*) In drawing up schemes for works, it is necessary clearly to indicate the working parties, tools, &c., required, also the time and place at which the working parties are to parade. This can conveniently be done in tabular form. Specimen headings are given below :—

No. of Men.		Where at Work.	Nature of Work.	Task per Man.	Total length executed.	Tools and Materials.	Remarks.
Inf.	R.E.						

SECTION 5.—MATERIALS AND TOOLS OTHER THAN FOR INTRENCHING.

For Table of Tools carried in the field, see the Field Service Manuals of the various arms.

Earth.

Earth.

67. Of all the materials used in the construction of field defences, earth is the most valuable as well as the most generally available. It can be dealt with by unskilled labour, and in combination with wood, iron, or masonry can be turned to account in a variety of ways, both for obtaining cover and for creating obstacles. No other material resists projectiles so effectually.

For the purposes of field fortification, earth is usually procured from trenches dug as near as possible to the place at which it is to be used. As a rule, therefore, it has not to be carried far, and shovelling only is required in its distribution. Where greater distances occur, earth is carried in baskets, barrows, or carts. Barrows and carts are occasionally procurable in the field by requisition from the civil population, and in England may be counted upon to a considerable extent.

Weight of earth.

68. The weight per cubic yard of earth of various kinds is as follows:—

Sand and gravel	about	30 cwt.
Ordinary soil	,,	26 ,,
Clay	,,	31 ,,

A barrow holds about 2 cubic feet; an ordinary two-wheeled cart, $1\frac{2}{3}$ cubic yards.

Slopes.

69. The *steepest* slopes at which thrown-up earths of different quality will stand are:—

Dry sand	38°
Gravel	40°
Compact earth..	50°
Clay (drained)..	45°

Sods.

Sods.

70. *Sods* are used for revetments, and also in special cases to form walls.

They should, when possible, be cut from meadows growing thick grass, which have been previously mown and watered, so that the earth may adhere firmly to the roots. Each sod should be about 18 in. long, 9 in. broad, and not more than $4\frac{1}{2}$ in. thick.

In cutting sods, spades should be used, specially sharpened with a file or grindstone. A convenient rule to remember is that the sods should be two spade-breadths long, one broad and one-half thick.

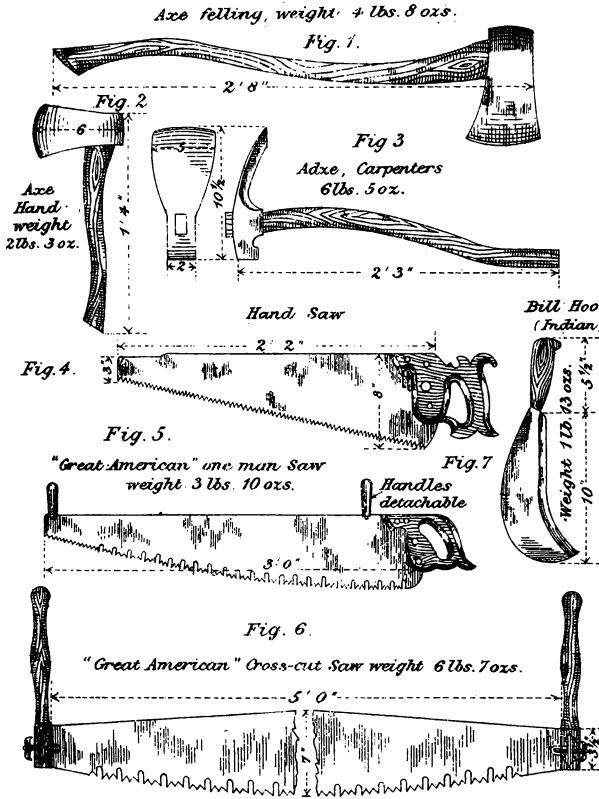
Three men will cut one hundred sods per hour.

Timber.

Timber, uses to which applied.

71. Timber is used for bridges, railway sleepers, huts, temporary bomb-proofs, splinter proofs, magazines, gun plat-

CUTTING TOOLS.



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forms, mining frames, stockades, palisades, abatis, barriers, and for numberless other engineering purposes in connection with an army in the field.

Felling timber.

72. The tools employed for felling timber are the *felling axe* (Pl. VI, Fig. 1), the *hand axe* (Fig. 2), the *cross-cut saw* (Fig. 6), and the *hand saw* (Fig. 4). Of these the felling axe is generally used, and, in the hands of an experienced workman, is the best of all. The hand axe is only suitable for felling small trees not exceeding 12 to 15 in. in diameter, but it may be employed with advantage when men practised in the use of the felling axe are not available, since it requires comparatively little skill in handling.

The cross-cut saw or the hand saw may also be used (the latter with small trees only) provided that measures are taken, by wedging or otherwise, to prevent the weight of the tree from jamming and breaking the saw. Unpractised men can use the cross-cut saw more easily and safely than the axe, and can cut more quickly with it. When convenient, it is best to fell a tree in the direction of its natural inclination. In using the felling axe the tree should be first attacked on the side on which it is required to fall, a rope being employed, if necessary, to pull it over, as, for instance, when the natural inclination is not in the required direction. When the tree has been cut into as far as the centre, or a little beyond, the workman should change over to the opposite side and commence again about 4 or 5 inches above the former cut, until the tree falls. The cuts should be as shown in Pl. VII, Fig. 5, where the arrow indicates the direction in which the tree is required to fall. With beginners, or when it is not important to save timber, and when there is no objection to leaving the cover which high stumps afford, the point *a* should be at the height of the hip, *b c* should be horizontal, *a c* inclined, and the distance *a b* should be about $\frac{3}{4}$ the diameter of the tree.

It may sometimes be convenient to employ both the saw and the axe to cut down a tree. In such cases the axe should be used on the side towards which the tree is to fall, and the saw on the opposite side.

The teeth of all saws used for cutting green timber should be *set* wide.

Rate of felling timber.

73. In a working day of 8 hours, two practised men can fell a tree of hard wood 5 ft. in diameter, or one man can fell a tree 3 ft. 6 in. in diameter, or two or more smaller trees. Soft wood trees, 2 ft. to 3 ft. in diameter, can be felled by four unpractised men in from 15 to 30 minutes with the axe and from 10 to 20 minutes with the cross-cut saw, and trees 1 foot in diameter, in about half that time. They can be cross-cut into three lengths in from 20 to 30 minutes more. Care should be taken to select soldiers who have been accustomed to the use of cutting tools.

The following table, showing the time actually taken by inexperienced men in felling trees of different kinds and sizes, is given for reference.

Nature of Trees.	Diameter where cut.	Kind of Tool.	Number of Men R.E.	Trades.	Time Taken to Cut Down each.
	feet.				hr. mins.
Oak ..	2·7	Cross-cut saw ..	4	Masons ..	1 20
Oak ..	2·0	Felling axe ..	2	Masons ..	1 30
Oak ..	0·9	Felling axe ..	2	Labourers ..	0 9
Oak ..	0·8	Cross-cut saw ..	2	Labourers ..	0 2¾
Oak ..	0·5	Felling axe ..	2	Masons ..	0 2
Elm ..	1·5	Felling axe ..	4	Masons ..	0 15
Birch ..	0·7	Cross-cut saw ..	2	Labourers ..	0 1¾
Beech ..	0·6	Felling axe ..	2	Labourers ..	0 3
Beech ..	0·6	Cross-cut saw ..	2	Labourers ..	0 2¾
Larch ..	0·8	Felling axe ..	2	Labourers ..	0 5
Larch ..	0·5	Cross-cut saw ..	2	Labourers ..	0 1½
Larch ..	0·5	Felling axe ..	2	Labourers ..	0 3
Chestnut ..	0·3	Cross-cut saw ..	2	Masons ..	0 1
Chestnut ..	0·3	Felling axe ..	2	Masons ..	0 1
Oak ..	0·9	Hand axe ..	1	Carpenter ..	0 7
Oak ..	0·9	Hand axe ..	1	Labourer ..	0 10
Oak ..	1·0	2 hand axes ..	2	Carpenters..	0 6
Oak ..	0·9	Hand saw ..	1	Carpenter ..	0 3½
Oak ..	1·3	Hand saw ..	2	Carpenters..	0 9
Oak ..	1·2	Hand saw and felling axe	1	Carpenter ..	0 5½

A good rough rule for time of felling trees up to 12 in. diameter, is that one man with a felling axe will take a minute for every inch of diameter.

Above 12 in. diameter the time, in hours, is approximately one-fifth of the diameter in feet, cubed.

One man with a felling axe will do the work of two men with hand axes. With saws half the time may be allowed.

A trained sapper can in one hour fell and trim about four fir trees of 4 to 6 in. diameter, or two of 10 in.

A trained sapper can clear about 250 square yards of fir plantation in ten hours, leaving the trees where they fall, the trees ranging from about 12 in. diameter at the butt, down to brushwood.

Trees when felled should, for facility of transport, be cut into logs of convenient size on the spot; or they may be carried as explained in para. 143.

In clearing tracts in forests, &c., fires are sometimes made round the trunks of trees, which are then burnt down to save the labour of cutting.

SAW PITS. &c

Fig. 1

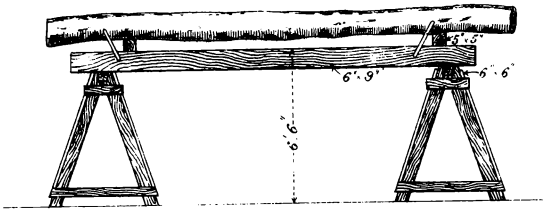


Fig. 2.

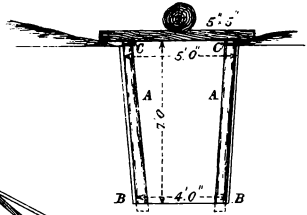


Fig. 3.

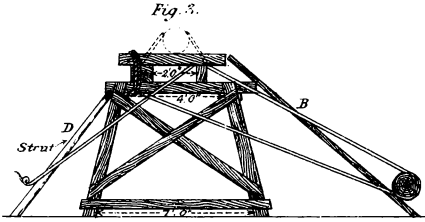
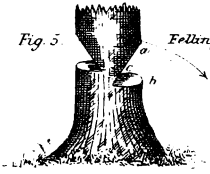
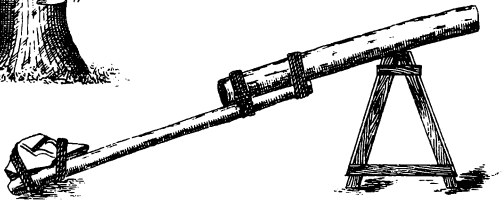


Fig. 5



Felling Trees

Fig. 4.



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In estimating the amount of tools and labour required for clearing average woods, a rough rule is to assume that a tree of 12 in. diameter is standing at every ten yards.

Sawn timber can occasionally be obtained in the field from houses and fences, or from timber yards in towns, as well as in the form of railway sleepers.

74. The following tools are generally required by a party of 100 men, employed in felling and removing timber :— Tools for felling timber.

Axes, felling, 4½ lbs.	60	Cant-hooks, iron	10
Axes, hand, 2 lbs.	12	Saws, hand, 26 in.	12
Handspikes, common, 6 ft.	12	Stones, grind, F.S., 18 in.	4
Chains, 1¼ in., 5 fathoms, with hooks at end	4	Tapes, measuring, 50 feet	2
		*Gyn, triangle, and tackle	1

75. An experienced lumberer can square and shape timber with the axe alone, but army artificers require the tools shown in Pl. VI. Converting timber.

In special cases, as, for instance, in a siege, steam machinery for converting timber may be available in the workshops; otherwise saw pits must be used.

76. The usual dimensions of saw pits are those given in Pl. VII, Fig. 2, the length being 10 ft. to 15 ft. The excavation in ordinary soil can be accomplished in eight hours, using two reliefs of diggers. Two or three of the props (A, A) are set up on each side, with their feet on groundsills (B, B), and topsills (C, C) are trenailed to them. The topsills support cross pieces which carry the log. Plank, fascine or hurdle revetment (see Section 6) can, if necessary, be used to line the sides of the pit. The top and bottom faces of the log to be cut up are roughly flatted with the axe, or adze; or, which is quicker, two slabs are sawn off to start with, the log being meanwhile steadied by dogs alone. It can then be sawn up into planks in the ordinary way. Saw pits.

When pits cannot be dug, the arrangement shown in Figs. 1 and 3 is used. The log to be cut up is got into position by parbuckling it up beams (B) into its place as shown in Fig. 3. It is then secured by dogs to the topsills or to the beams resting on them. During raising it may be necessary to prop up the trestles by temporary struts at D.

A short log may be cut up by resting one end on a four-legged trestle (Fig. 4), the other being secured to an additional length of timber, the lower end of which is weighted and rests on the ground. As the saw works through the log, the latter is pushed up the trestle as required.

Eight dogs are allowed for each pit; two should be twisted right-handed, two left-handed, and four should be straight.

* For heavy timber only.

Rate of pit sawing.

77. Two good sawyers require an hour to cut through 20 feet of a 12-in. squared fir log, including setting out the work. Hard woods, such as oak, elm, ash, and beech, take about twice as long as fir. If the saws be out of order, or the timber green, more time must be allowed. When trestles are used, some time is taken in getting the timbers on to them.

Tools for preparing timber.

78. The following tools are required by a party of 100 men in preparing timber:—

Axes, broad, carpenters'	40	Axes, pick } for saw-pit	8
Adzes, carpenters'	16	Shovels } for saw-pit	8
Saws: cross-cut, 5 ft.	8	Line, chalk	8
Saws: pit, 7 ft.	2	Wedges, iron, 6 in.	12
Saws: hand, 26 in.	24	Chisels, socket, 2 in.	16
Sets, saw: pit or cross-cut	4	Mallets, carpenters'	8
Sets, saw: hand	2	Squares, iron, 24 in.	8
Hammer, sledge, 9½ lbs.	4	Tapes, measuring, 50 ft.	4
Grease, lbs.	20	Rules, 4-fold, 2 ft.	8
Dogs, iron, ¾ in. round and 24 in. long	16	Rods, measuring, 6 ft.	8
Files, saw: cross-cut, 7 in.	16	Stones: grind, 18 in.	2
Files, saw: pit, 5 in.	12	Stones: rub, 12 in.	2
Files, saw: hand, 5 in.	24	Stones: rag or whet	2

Iron and Steel.

Iron and steel.

79. Iron and steel bars, rails, corrugated and sheet iron, tin boxes, &c., are often available, and can be usefully employed in various defence works.

Rails.

If rails are used for overhead cover, they should be left bare and made to slope downwards from the front, so as to cause ricochet.

Sap-shields.

80. The present pattern of steel sap-shield is made of specially hardened steel, $\frac{3}{16}$ in. thick. It is rectangular 2 ft. 6 in. by 2 ft., has two detachable legs, and a loophole with cover plate. The pattern has not yet been finally decided on.

Steel loophole plates.

81. Special steel loophole plates are now articles of store. Dimensions 24 in. by 12 in. by ¼ in. Loophole 5 in. by 3 in., but the dimensions may be altered.

Pl. XXI, Figs. 1 and 2, show how they should be built into sand-bag parapets.

Sacks and Sandbags.

Sacks.

82. On service, sacks of various kinds are usually obtainable in large numbers. They can be used for revetments, walls of blockhouses, loopholes, &c.

Sand-bags.

83. The service sand-bag is made of canvas, not proofed. For ordinary work 1 cubic yard of earth fills about 60 sand-bags.

BRUSHWOOD.

Method of binding Brushwood

Fig. 1.

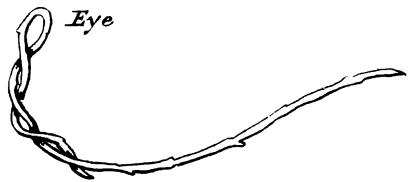
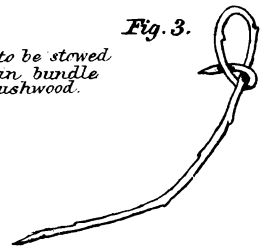


Fig. 3.



End to be stowed away in bundle of brushwood.

Withe twisted into a knot

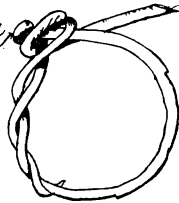


Fig. 2.

Fig. 5.

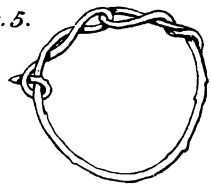
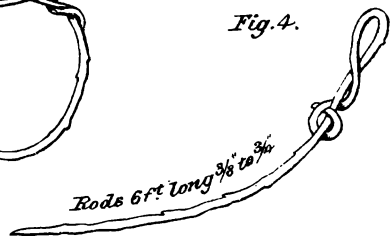


Fig. 4.



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Service sand-bags are packed in bales of 100, weighing 62 lbs. Fifteen bales of sand-bags measure 35 cubic feet.

Their dimensions are, when empty, 2 ft. 9 ins. by 1 ft. 2 ins., when filled usually 20 ins. by 10 ins. by 5 ins., but these may be varied as required.

Brushwood.

Brushwood, uses to which applied.

84. Brushwood is used for making gabions, fascines, and hurdles; also for wattling, &c. Willow, birch, ash, Spanish chestnut, and hazel are most generally suitable, and should, if possible, be cut when the leaf is off. The rods should not exceed $\frac{3}{4}$ in. in diameter for gabions and similar work, or $2\frac{1}{2}$ in. for fascines and pickets.

Best age for military purposes.

No definite age can be laid down at which it is best to cut brushwood for military purposes, much depending on the nature of the soil, climate, &c. As a general rule, however, for gabions and similar work, brushwood should not be more than six, and for fascines not more than ten years old. An acre of brushwood six years old produces an average of 440 bundles of about 50 lbs. to the bundle, or say three G.S. wagon loads to 1000 square yards.

How cut and bound.

Brushwood is usually cut with a billhook (Pl. VI, Fig. 7), and made up into bundles each weighing about 50 lbs. The bundles are bound in two places by pliable rods called *withes* (see para. 88) of about $\frac{1}{2}$ or $\frac{3}{4}$ in. in diameter, one being fastened near the butts—which are all placed at the same end—and the other a little beyond the centre of the bundle. A loop is made at the small end of the binding rod by twisting the rod, for a sufficient distance, to form an eye large enough to allow the butt end to pass easily through, and also to permit two or three turns to be taken round the standing part (Pl. VIII, Fig. 1).

The binding rods should first be laid on the ground at the proper distance apart, and as soon as sufficient brushwood has been laid over them, the butt end of each rod should be passed through the eye and hauled up taut, the eye being pressed down with the foot. The butt end is then twisted, a slight strain being kept upon it. After several turns have been given it will be found, on taking off the strain, that the rod will curl round the eye in such a manner as to prevent it running through (Fig. 2). The end should then be stowed away in the bundle.

A man can cut about 100 square yards of five-year old brushwood in four hours. Binding takes about an equal time.

The same man may cut and bind, but this is not desirable. A good arrangement is to tell off the men in parties of 25, under a non-commissioned officer. A cutting party should be spaced at four yards apart, when each man should cut 25 yards to his front in four hours making altogether 2,500 square yards or about half-an-acre, for the party.

A second party of equal strength should follow, to collect, sort, and bind.

If it be necessary to carry the brushwood to any distance, a third party must be employed, whose strength will vary according to the distance.

Men, tools, &c., for cutting and carting brushwood.

85. The following table gives an estimate of the men and tools required for cutting and carting an acre (4,840 square yards) of brushwood (a full day's work): —

For felling and binding.

Men	N.C.O.'s	infantry	2	Grindstones		1
	privates	infantry	50	Gloves, hedgers', pairs ..		50
	sappers		2	Billhooks		50
Axes	felling		2	Rag, rub, or whetstones		5
	hand		4			

and 4 men at the grindstones to keep up a supply of sharpened tools.

For loading and carting.

N.C.O.'s	infantry ..	1	Wagons, G.S.	14
Privates	infantry ..	15	Ropes, 1½ in. ..	fms. 100

In cutting down hedges, a proportion of hand saws will be required, as well as billhooks or hand-axes.

Fascines.

Description of fascines.

86. Fascines are bundles of brushwood of special dimensions, used in revetments, to form foundations for roads in marshy sites, and for many other purposes. The ordinary fascine is 18 ft. long and 9 in. in diameter, and its average weight, when the wood has been cut some weeks, is 140 lbs.

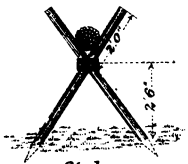
Construction of fascines.

Fascines are made in a *cradle* composed of 5 pairs of trestles, each consisting of two stakes about 6½ ft. long and 3 in. in diameter, driven obliquely into the ground, crossing at right angles, and tied to each other. The centre of the cross should be about 2 ft. 6 in. from the ground (Pl. IX, Fig. 1). The two end trestles are first placed 16 ft. apart (Fig. 4), and a line is strained between them where the stakes cross. The remaining three trestles are then inserted at intervals of 4 ft., care being taken that all the trestles touch the line, otherwise the fascines will be irregular in form. When the trestles are fixed, straight rods of brushwood, from 1 to 2½ in. in diameter, and trimmed if possible, are laid over them, projecting about 1 ft. 6 in. beyond the extreme trestles. The stouter rods must be laid on the outside with the thick and thin ends alternating, and the smaller stuff near the centre, until the cradle is nearly full, care being taken that the fascine is equally stiff

BRUSHWOOD. Cont^d

FASCINES.

Fig. 1.
Fascine Trestle



Stakes about 6ft long

Fig. 2.

Fascine Choker.

Fig 3

31" long *Hoop iron Band for binding Fascines*

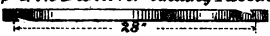
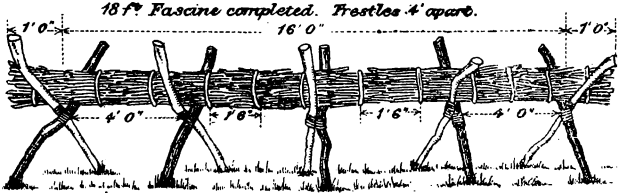


Fig. 4.

18 ft. Fascine completed. Trestles 4' apart.



H. & C. GRAHAM LTD. LITH^RS. LONDON, S.E.

throughout its length. The diameter of the fascine is then proved with the *fascine-choker*, and more stuff added where required. Any very crooked rods should be cut half through, so as to make them lie evenly.

Choking and binding fascines.

87. The *fascine-choker* consists of two wooden levers 4 ft. long, of 2 in. by $1\frac{3}{4}$ in. ash, with the edges rounded, coupled together by a chain 4 ft. long fastened to iron sockets at a distance of 1 ft. 6 in. from the ends of the levers (Pl. IX, Fig. 2). Two small rings are fixed on the chain 28 in. from each other, and equidistant from the centre, as a gauge for the circumference of a fascine. Two men, standing one on each side, *choke* the fascine, by placing the centre of the chain under the brushwood on the trestle, the short ends of the levers being upwards, handing the levers to each other over the fascine with the short ends down, and then bearing down on the long ends of the levers till the gauge rings meet. The fascine is then bound close to the choker. The bindings should be about 18 in. apart and about 9 in. from each end. Fig. 5, Pl. VIII, and Fig. 3, Pl. IX, show a withe and a hoop iron binding.

Preparation of withes.

88. Fascines are bound with spun yarn, wire, hoop iron, or withes.

The best rods for withes are hazel; they should be 6 to 7 ft. long, and between $\frac{1}{2}$ in. and $\frac{3}{4}$ in. in diameter, neatly trimmed, leaving about $\frac{1}{8}$ in. of each branch on the rod. In making a withe, the thin end of the rod is placed under the left foot, and the rod twisted with the hands, taking care to avoid kinks. When the rod is well twisted at the small end, and moderately so towards the centre, a loop about 9 in. long is made at the small end, by taking a half hitch with the end of the rod round the standing part (Pl. VIII, Fig. 3); the loop is then given a couple of twists in the contrary direction, so as to plait the double part of the rod and form a secure loop (Fig. 4); the other end is then pointed, and the withe is complete. As the streugth of the fascine depends upon the withes, they must be properly selected and well twisted, particularly at the eyes. In frosty weather the rods, before being twisted, should be warmed at a fire till the sap sweats through the bark.

Twister.

89. If the rod be stiff a *twister* must be used. This may be made of a stick about 1 ft. long, with some 3 ft. of spun yarn made fast to it in the centre by a clove hitch. Fasten the stick to the rod with a stopper hitch in the spun yarn, and it will serve as a lever to twist the rod.

Men, time, tools, &c., for making fascines.

90. A squad of four men will, after a little practice, make a fascine in an hour. Two select the wood and choke, two place the wood on the trestles and bind. For tools, see table, on page 38.

Pickets.

Pickets.

91. *Pickets* for gabions, fascines, fascine cradles, tracing, entanglements, sod work, &c., are made up in bundles of 25, tied together with a withe or piece of spun-yarn. They are of the following dimensions:—

Description of Picket.	Length.	Diameter.	
		From	To
	ft. in.	in.	in.
Hurdles and continuous revetment ..	3 6	1	2
Gabions..	3 6	$\frac{3}{4}$	1
Fascines	2 6	$1\frac{1}{4}$	$1\frac{3}{4}$
Fascine cradle	6 6	3	4
Tracing..	1 6	1	$1\frac{1}{4}$
High wire entanglement	5 0	$1\frac{1}{2}$	2
Low „ „	2 6	1	$1\frac{1}{2}$
Sodwork	1 6	$\frac{1}{4}$	$\frac{3}{4}$

Pickets should be finished off with blunt heads and sharp pointed ends.

Gabions.

Gabions.

92. Gabions are cylinders open at both ends, which, when standing on one end and filled with earth, make a strong revetment. Their usual dimensions are 2 ft. exterior diameter and 2 ft. 9 in. in length. They may be made of almost any material capable of being bent or woven into a cylindrical form, such as brushwood, Willesden paper, canvas, sheet iron, wire-netting, &c. In former wars, they have been very much used in field works, especially for revetment, but are not likely to be so much used in the future. The reason for this is that revetments now are not as a rule so high, and therefore simpler forms of support will suffice.

Continuous hurdle work, for instance, requires less labour and less material than wicker gabions. It has not the stiffness of the latter, but is quite good enough for ordinary parapets.

The cylinder has certain special advantages, such as stiffness and stability, so that occasions may still arise for its use.

Construction of wicker gabions.

93. In wicker gabions, the method of interlacing brushwood around pickets, to form what is called the *web*, is known as *waling*.

To make this gabion, a circle of $10\frac{1}{2}$ in. radius is traced on the ground. The circumference is then divided into as many equal parts as there are pickets, the number being usually 10; but if the brushwood be very small, 12, or 14, may be used.

The pickets (which should be 3 ft. 6 in. long, and from $\frac{3}{4}$ in.

BRUSHWOOD. Cont^d

GABIONS.

Sewn with wire or spun yarn.

Fig. 1.

Commencement of Waling.

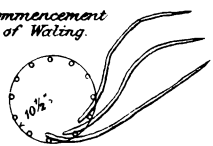


Fig. 2.

Waling.

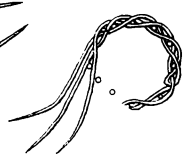


Fig. 3.

Pairing.

Fig. 4.

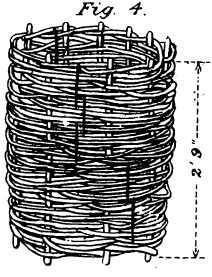


Fig. 5.

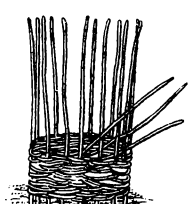


Fig. 6.

Fig. 7.

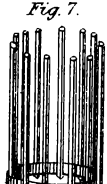


Fig. 8.

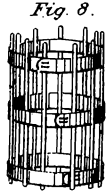


Fig. 9.

to 1 in. in diameter, straight and free from branches) are driven into the ground touching the *inside* of the circumference of the traced circle at the points marked, the thick and thin ends alternately downwards.

Waling.

The rods for the web must be entirely stripped of leaves and twigs, no part of any rod being used double. The waling is commenced by placing three rods, none of which should be more than 1 in. in diameter at the butt, with their butts inside three adjacent pickets, as shown in Pl. X, Fig. 1. The first rod is taken up and passed over the other two, outside the two adjacent pickets, and inside the third. The second rod is taken up and passed outside two pickets and inside one; then the third rod in the same way; then the first again, and so on (Fig. 2). Particular attention must be paid to the uniformity and closeness of the web, and small rods only should be used for the first 6 in. or 8 in. of height. The web should from time to time be pressed down with the foot or a mallet, the diameter should be frequently gauged, and the proper distance between the pickets maintained throughout. When introducing a fresh rod, to take the place of one that is coming to an end, the two must be laid together for a few inches and worked as a single rod. The waling is continued till the web is about 2 ft. 6 in. high, when two rods about 9 ft. long, called *pairing rods*, are put on at each end in order to strengthen the gabion. These rods should be well twisted and their butts driven down into the web on either side of one gabion picket. If one side of the web be lower than the other, the difference may be adjusted by driving in the butts of the pairing rods at the lowest part of the web. These rods are then (Fig. 3) passed alternately over and under each other, and inside and outside the pickets, twisting each pairing rod well with the hand during the operation; the ends of the rods are then driven down into the web on either side of the picket next beyond that at which the pairing was commenced.

Pairing rods.

Sewing of wicker gabions.

To prevent the pairing rods from slipping off, they are sewn down to the web, usually with wire or spunyarn, sometimes with withes. The gabion should be sewn at four places top and bottom. Pl. X, Fig. 4, shows the method adopted.

The small twigs are trimmed off, and the pickets cut to a length of 3 ft., with blunt points at the ends. Lastly, a *carrying picket* is driven through the gabion, near the centre of its height, and 9 in. from one side of the web. When the gabion is to be used at once, the sewing may be dispensed with, hooked pickets from 12 to 18 in. in length being driven down through the web at the points where the sewing would otherwise come. The short end of the hook should be inside the gabion, and must be beaten firmly down over the pairing rods.

Time and men for making wicker gabions.

94. Three men can make a wicker gabion with sewing of withes in about two hours, one man preparing the rods and withes, one waling, and the third holding the pickets and preserving the gauge. For tools, see table, page 38. Without pairing rods, and when wire is used for sewing, they can finish the gabion in about $1\frac{1}{4}$ hours.

Weight of wicker gabion.

The weight of a wicker gabion varies from 36 to 56 lbs., according to the size and dryness of the brushwood from which it is made.

Willesden paper gabions.

95. Willesden paper band gabions are articles of store.* Each gabion consists of ten bands, 3 in. wide, fastened at the ends by two brass clips. (Pl. X, Figs. 7, 8, and 9.)

To make it, lay a band on the ground ready fastened in the form of a circle. Drive the pickets, ten in number, round the band alternately inside and outside it, slip a second band over the tops of the pickets, alternating with the first band, and press it half way down to keep the pickets steady until the third band is on; the three may then be pressed down to the bottom, and the remaining seven bands put on. The joints in the bands should all be on the same side of the gabion, but no two joints should come together (*see* Fig. 9). A thin carrying picket can be driven through the web. The top and bottom bands should be nailed to the pickets.

Two men can make a paper gabion in ten minutes. Its weight will be 13 lbs.

Other forms of gabions.

96. Gabions of galvanized iron *wire net* have been proposed. Netting formed of 19 S.W.G. wire (galvanized), the meshes being $1\frac{1}{2}$ in. square, or hexagonal, in lengths 2 ft. wide, weighing about 2 lbs. per square yard, is suitable. If the soil be light or sandy, these gabions must be lined with felt or other material.

Wire netting can be carried in rolls of 56 lbs. weight, the lengths being cut off as required.

A wire net gabion is commenced with well trimmed pickets, of a size that will pass easily through the netting; wicker waling is carried up about 6 in., and then paired at the top. Each picket is passed three or four times through the netting, which should be cut into lengths of about 6 ft. 3 in. This makes up the height of the gabion to about 2 ft. 3 in.: two pairing rods are added, and the gabion is finished off with another 6 in. of waling, paired at the top.

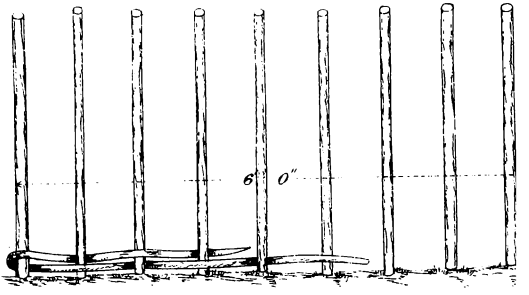
The gabion is stitched at both ends, the netting being included in the stitching. If the mesh be too small to allow the pickets to pass through, the netting can be placed inside the pickets and tied to them. These gabions are stiff, and suitable for flying trenchwork. A wire net gabion can be made by three men in an hour, and weighs from 16 to 20 lbs.

* Jones' steel band gabions are still articles of store, but no more will be made.

BRUSHWOOD. Cont^d

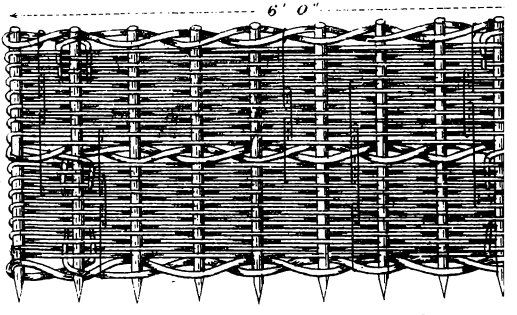
Hurdles.

Fig. 1.



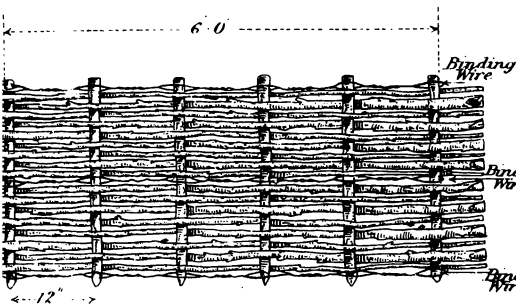
Commencement of a 6ft Hurdle

Fig. 2.

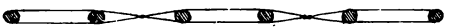


1 to 2 Bundles of Brushwood
Weight 56 lbs.

ROUGH HURDLE.



Elevation.



Plan.

(Showing pickets & bindingwire).

97. As a substitute for netting, three sand-bags can be ripped open and used, each picket being passed through three slits in the canvas, which must also be tied both to the top and bottom waling. Strips of carpet, canvas, or felt, &c., 1 ft. 9 in. wide, dry hay or straw rope, when procurable, may be used to replace or supplement other materials. Straw rope can be most conveniently used as in pairing. Each square foot of surface requires about 1 lb. of straw, that is to say, from 10 to 12 lbs. are required for a gabion.

Hurdles.

Hurdles.

98. *Hurdles* are used for revetting and hutting, and for the roadway of hasty bridges. An ordinary size is 6 ft. long, and 2 ft. 9 in. high, but when employed for revetments the web can of course be made of any height necessary. Hurdles can be made in lengths up to 18 or 20 ft. when required for special purposes. For bridging they are usually from 7 to 10 ft. long. An even number of pickets must be used; for a 6 ft. hurdle it is generally ten. The pickets should be from 1 in. to 2 in. diameter; the rods for the web must be of about the same size as for gabions, and as long and pliant as can be obtained.

Construction of 6 feet hurdles.

A line 6 ft. long is marked on the ground, and divided into nine equal parts. A picket is then driven at each division (Pl. XI, Fig. 1), stouter and longer pickets being chosen for the ends, in order to support the hurdle.

Two men work at the web, one holding the pickets, the other *randing* with a single rod, commencing at the bottom from the centre. The thick end of the rod is placed between two of the pickets, the other being taken alternately in and out between the other pickets, until it reaches the outside picket, round which it is twisted, turned, and woven back to the centre. Care must be taken that the joints are evenly distributed over the hurdle.

With stiff rods, the fibres must be twisted beforehand where they have to go round the outside pickets. When a new rod is introduced, it should be laid alongside the last rod for a length of two or three picket intervals. At the centre of the hurdle a course is *paired* with two rods, and pairing rods are also put on at the top and bottom when the rendering is finished. To put on these pairing rods, their thick ends are driven down into the web, one on either side of the last picket but one. The rod furthest from the end of the hurdle is then taken round the outside picket, and being brought back again is paired with the other rod, as in gabion making. The rods are finally finished off at the other end of the hurdle, *i.e.*, at the end opposite to the one round which the first turn was taken, in order to ensure uniformity in the height of the hurdle. If the hurdle be intended for immediate use

it need not be sewn; otherwise it is sewn in three places at top and bottom, the stitches being the same as for gabions. Pl. XI, Fig. 2, shows a hurdle completed. Hurdles intended for hutting or bridging should be so randed that all the ends of the rods are cut off on one side, which should be the outside for huts and the underside for roadway or flooring. When hurdles are intended for any of the above purposes, the pickets should be driven with their butts and tips alternately in the ground, thus making the hurdles of equal strength throughout. When finished and ready for use, the ends of the picket should be cut off nearly flush with the web. Hurdles intended for roadway or flooring should be sewn with iron wire.

Time, men, &c.

Three men can make a hurdle 6 ft. long and 2 ft. 9 in. high in $2\frac{1}{2}$ hours, two forming the web, and the third preparing the rods. A hurdle weighs about 56 lbs., and requires from 1 to $1\frac{1}{2}$ bundles of brushwood. For tools, see table, page 38. A little time may be saved, when the material is good, by omitting the centre course of pairing rods.

Rough hurdles can, however, be made very much more quickly, and are just as efficient for all ordinary purposes. Pl. XIA shows this pattern hurdle. Three men are required for their construction. The hurdles can be made to any required length up to about 10 feet to 12 feet as a maximum. Pickets should be driven into the ground about one foot apart, but when the material for weaving the hurdle is short and stiff this distance can be increased to 18 inches. The rods for the web are roughly trimmed, and placed in and out between the pickets as for *randing* in ordinary hurdle work. They are not, however, turned at the ends, but are cut off about six inches beyond the outer pickets. Care must be taken to vary the position of the butts of the rods in the web in order to keep the hurdle of a uniform strength. The pickets are tied together with binding wire in the middle, and at the top and bottom, the wire being double, and tightened up with a Spanish windlass. Three men should make one of these hurdles in 20 minutes.

Continuous hurdle work.

99. Continuous hurdles may be used for revetting long lines of parapet.* In such cases they must be made in the position they are to occupy. The pickets, which should be from 1 in. to 2 in. in diameter, and from 12 in. to 18 in. apart, according to their size, are driven about one foot into the ground, as close to the parapet as possible, sufficient space, about 3 in., being left between the pickets and the base of the parapet to allow of the randing of the web. Continuous hurdlework of untrimmed brushwood forms a good temporary revetment. By using untrimmed rods, and working three or four together, the work can be carried on much more quickly than if the revetment be made of trimmed rods, randed one by one.

* See para. 108.

Such a revetment can be completed to a height of 4 ft. 6 in. and anchored to the parapet, by unskilled men, under the direction of sappers, in from $\frac{1}{2}$ to $\frac{3}{4}$ of an hour. The men work in pairs, each pair having a task of 10 to 12 ft. of revetment, which must be worked in at the ends with that of the next pair. If commenced simultaneously with the parapet the revetment can more quickly be made than if added to an existing parapet. The inner face of the hurdle revetment may afterwards be trimmed, the top paired, and a course of sods laid over it. Time, men, &c.

On hard ground, crowbars or short hard wood stakes are required to make holes for the pickets. Extra time must be allowed for this.

100. Hurdles in the form of a *sector* can be made of brushwood, so as to form the floors of bell tents or circular huts. Hurdle sectors.

Four pickets, about $\frac{3}{4}$ in. at the butt and 7 ft. long, are driven 3 or 4 in. into the ground at equal intervals, the outer ones being 2 ft. 9 in. apart. The tops of the pickets are drawn together till they touch each other at 6 ft. 6 in. above the ground, a stick being tied across them to keep them together. Fine brushwood rods are then randed in, as in hurdle work, commencing at the bottom, and taking care to let all waste ends come out on what will be the underside of the hurdle. When the randing is done, the pickets are pulled up, their ends cut off, and both ends of the hurdle sector are paired and sewn.

About 16 hurdles of this form can be laid round the pole of an ordinary bell tent 14 ft. in diameter.

Each sector weighs about 20 lb. when green, and can be made by two men in 3 or 4 hours. For tools, see table, page 38. Time, men, &c.

101. The table on page 38 gives a complete detail of men, tools, and materials required in making fascines, gabions, &c.

Bamboo.

102. Bamboo is a material well worth studying, and wherever it is available troops should be trained in its use. The following are some of the principal uses to which it can be put in connection with field defences :— Uses of bamboo.

Stockades and palisades.
Fascines.
Gabions.
Framework of huts, including roofs and floors.
Matting.
Lashings.
Screens.
Ladders.
Field Telegraph Poles.

TABLE SHOWING TIME, LABOUR AND MATERIALS REQUIRED FOR BRUSHWOOD WORK AND GABIONS.

Nature of Article.	Men, Expert.	Time.	Bands.	Billhooks.	Brushwood, Bundles of.	Chokers, Fascine.	Gauges. 1 ft. 6 in. long.	Gauges. 3 ft. 6 in. long.	Knives, Gabion.	Lashings for Trestles.	Line, piece of, 20 ft. long.	Mallets, Wood.	Pickets Saws or Cleft. 3 ft. × 1½ in. × ¾ in.	Rods, measuring, 5 feet.	Saws, hand, 26-inch.	Stakes for Trestles, Pairs.	Stones.* Grind.	Stones.* Whet.	Wire, Iron, 14 S.W.G., feet.†	Pliers, side cutting.	Weight of completed articles, lbs.	Fasteners.	REMARKS.
Fascine	¼	1 hour	—	3	4	1	1	—	2	5	1	1	—	1	1	5	1*	3*	60	1	140	—	15 men, if the fascines are bound with withes.
Gabion, wicker	3	2 hours	—	1	1½	—	—	1	2	—	—	1	—	1	—	—	1*	3*	40	1	36 to 56	—	
,, Willesden paper...	2	10 minutes	10	—	—	—	—	—	—	—	—	1	10	—	—	—	—	—	—	—	13	20	NOTE.—If the men have been previously instructed in the manufacture of the different articles, 1 non-commissioned officer to 25 men should be allowed; if not previously instructed, a larger proportion is desirable.
Hurdle	3	2½ hours	—	2	1½	—	—	1	2	—	1	1	—	1	—	—	1*	3*	—	—	56	—	
Hurdle Sector	2	3 hours	—	1	⅝	—	—	—	1	—	1	1	—	1	—	—	1*	3*	40	1	20	—	
Fascine pickets, bundle ...	1	1 hour	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	30	—	
Tracing ,, ,, ...	1	1 hour	—	1	⅕	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.7	—	

* To every 25 men.

† The wire to be annealed by being made red hot and allowed to cool slowly.

REVETMENTS.

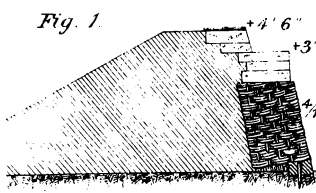
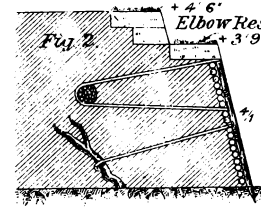
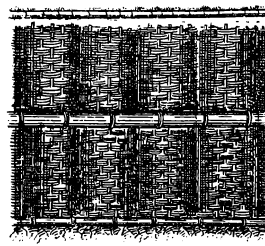


Fig. 1.
+4'6"
+3'9"
4/1


BRUSHWOOD
+4'6"
Elbow Rest
Fig. 2.
+3'9"
4/1


GABIONS
Fig. 3.

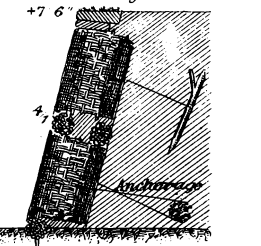
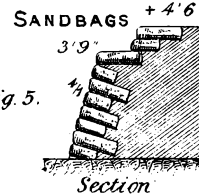
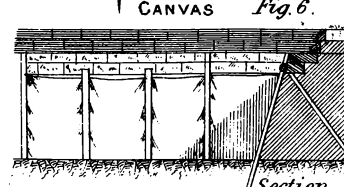
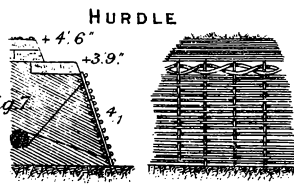
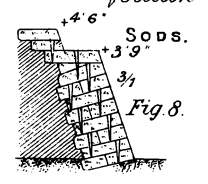


Fig. 4.
+7 6"
4/1
Anchorage


SANDBAGS
+4'6"
3'9"
4/1
Fig. 5.
Section


CANVAS
Fig. 6.
Section


HURDLE
+4'6"
+3.9"
Fig. 7.
4/1


+4'6"
SODS.
+3'9"
3/1
Fig. 8.

SECTION 6.—REVETMENTS.

Materials for revetment.

103. The term *revetment* is applied to any artificial material used for retaining earth at a steeper slope than that which it would naturally assume. The materials generally used for revetments, in connection with field defences, are gabions, fascines, sand-bags, sods, hurdles or continuous hurdle-work, strips of canvas, and occasionally casks, planking, &c.

Gabion revetment.

104. When a considerable height of parapet has to be dealt with, a *gabion revetment* is one of the best that can be used. It is usual to place the gabion at an angle of about $\frac{1}{4}$. A course of fascines is laid along the ground at the base of the slope to be revetted, a shallow trench about 3 inches deep being cut for their reception. The fascines are kept in position by 5 or 6 pickets, driven through each vertically into the ground. A tier of gabions is then placed in position, tilted forward so as to rest at a slope of $\frac{1}{4}$, partly on the fascines and partly on the ground. The gabions are then filled. This brings the revetment up to a height of 3 ft. 6 in. When the height to be revetted is 7 ft. or more, a course consisting of two fascines is laid on the tops of the gabions, picketted, and backed up with earth. A second row of gabions is placed upon the fascines, any additional height required being made up with sods, &c. (Pl. XII, Fig. 4). Fascines should never be used for crowning any parapet likely to be subjected to artillery fire, as the effect of a shell striking them is to carry away a whole length of 18 ft., bringing with it a corresponding portion of the parapet. For a breast high parapet, gabions are extravagant of material, but are useful in certain cases, as, for example, in siege trenches. Gabions in one tier need not be supported by fascines; they may be tilted to the required slope when half filled.

The stability of a parapet may be much increased by the employment of anchor fascines or logs of wood; these must be buried in the parapet about 4 ft. from the gabions, and connected to them by rope or wire passed round both gabion and anchor (Fig. 4).

Fascine revetment.

105. *Fascines* make a poor revetment when used by themselves. Even when well anchored, they give but little support to earth. They are specially adapted for revetting steps in earthworks, two being usually employed to form the *riser* of each step.

Sand-bag revetment.

106. *Sand-bags* used for revetments should be built up in *English bond*, one course *headers* with the choked ends in the parapet, and the next course *stretchers*, the long sides being

parallel to the face, and the seams towards the parapet. The stretchers may be in one row only, as in Pl. XII, Fig. 5. Each course is so laid as to be in section at right angles to the slope, and care should be taken that no two vertical joints in contiguous courses fall one over the other. The top course should be headers.

Two *builders* work together and are supplied by *carriers* with sand-bags, which are filled and tied by *fillers*. Care should be taken that the sand-bags are not more than three-quarters full, otherwise they will not form a solid and compact revetment. The parapet must be built up simultaneously with the revetment, the sand-bags being well bedded, and beaten to the required shape and slope with mallets; the earth should be carefully rammed in behind them.

Time and men.

Two builders, if well supplied, can lay about 70 sand-bags per hour. Three fillers can fill and tie this number in the same time; one man filling, two holding and tying. Carriers are required in numbers proportionate to the distance from the work at which the bags are filled.

Sod revetment.

107. *Sods*, when used for revetments, will seldom stand at a steeper slope than $\frac{3}{1}$, and require time and labour to build properly. It is advisable that sods should not be laid when wet. Sods so laid will shrink in dry weather, the joints will open, and the stability of the revetment will be endangered. If built when moderately dry, however, the revetment will remain solid.

Sods are usually 18 in. long, 9 in. wide, and not more than than $4\frac{1}{2}$ in. thick. For superior work the underside should be trimmed until the roots are well exposed. (See also para. 70).

They are laid with the grass downwards, and built in English bond, that is to say in alternate courses of headers and stretchers. Each course of stretchers consists of two rows, laid side by side. The top course, however, should be headers, laid horizontally, grass side upwards, care being taken that no two vertical joints in contiguous courses fall one over the other (Pl. XII, Fig. 8). The courses should be laid at right angles to the slope, as they thus resist the outward thrust better than if laid horizontally. The sods should be bedded and backed with fine earth well rammed, the revetment being carried up at the same time as the parapet. When completed the whole should be neatly cut and trimmed to the required slope with a sharp spade.

For superior work each sod should be secured to the rows beneath by a cleft peg driven through it, about 12 in. long and $\frac{3}{4}$ inch in diameter. The revetment when completed can be sown with grass seed.

Time, &c.

Two builders, if well supplied with sods, should lay 100 per hour if no pegs are used, or 70 per hour with pegs. Three men

with spades can keep the two builders supplied, and a proportion of carriers, depending upon the distance from the cutting ground to the parapet, is required in addition.

When hasty intrenchments are made in ground covered with turf, it should be cut into rough sods which can be either reserved to cover the surface of the parapet, or built into the interior slope, instead of being thrown promiscuously into the parapet. To cover the parapet with sods is one of the simplest methods of rendering a work inconspicuous. Rough sod-work.

108. *Hurdles* form some of the most useful revetments for parapets (Pl. XII, Fig. 7). They are placed touching each other along the line of revetment to be executed; the pickets being driven into the ground so that the hurdle inclines towards the parapet at a slightly gentler slope ($\frac{5}{1}$) than that at which it is required to stand ($\frac{4}{1}$). Each hurdle must be anchored to the parapet. Hurdle revetment.

When continuous hurdles are used they should be made in position along the parapet, as described in para. 99. The anchoring is perhaps the most important part of a hurdle revetment; unless securely anchored the revetment will not stand. Logs or fascines, with iron wire ties attached, are buried in the parapet as it is being made, or, in the case of an existing parapet, are sunk into holes dug for the purpose. After the completion of the ranging, the ties are secured to the heads of every second or third hurdle picket, that is at intervals of from 3 ft. to 4 ft. 6 in. If the pickets be weak they may also be anchored in half-way up, or strong stakes may be driven into the banquette, pressing tightly against the hurdle so as to support it; the heads of these stakes are anchored to the parapet.

It is advisable to finish off the crest with one or two courses of sods, or with well-rammed earth, so as to prevent the heads of the pickets from interfering with men firing over them.

For time, men, &c., see para. 99. Time, men, &c.

109. The interior slope of a work can be roughly revetted by driving stakes, 2 in. in diameter, about 1 ft. into the ground, at intervals of about 12 in., cutting them off a few inches below the interior crest of the parapet, and placing rods and small branches between them and the earth as the parapet is thrown up. The stakes must be driven in with a greater inclination towards the parapet than that at which the revetment is required to stand, and they should be anchored into the parapet as described in the preceding paragraph. Brushwood revetment.

Canvas, not proofed, in long strips about 3 ft. wide is now an article of store. It makes a useful revetment. Stout pickets should be driven from 1 ft. to 1½ ft. apart, and anchored as in the case of hurdles, para. 108. The canvas is stretched between these and the parapet, being laced with wire to the top and Canvas.

bottom of every fourth or fifth picket, that is to say, at about 6 ft. intervals. When secured in this way the revetment stands better than when the pickets are passed through slits in the canvas. (See Pl. XII, Fig. 6.)

Staves, &c. The staves of casks, wooden planking, &c., may also be used for revetments, their lower ends being let into the ground at the foot of the slope, and the upper ends anchored to the parapet.

Casks. Casks can be used standing on their ends like gabions.

Planks or logs. Planks can be utilized by being laid between the parapet and strung pickets; these pickets are driven into the ground and anchored to the parapet. In a timber country logs can be built up to form a revetment in the same manner. Short logs can also be used, the lower ends being buried in the ground, the upper sloped forward against the parapet and anchored.

Long planks are objectionable as revetments where they may be exposed to the fire of high explosive shell.

Stone. Dry stone walls can be used under special circumstances, but are always undesirable in the case of parapets exposed to artillery fire, since the stones are apt to fly about.

Wire netting. In soils which are not too sandy, wire netting forms a useful revetment. It is held up by pickets passed in and out of the meshes, driven into the ground and anchored.

Heather. Heather, or scrub, made into bundles and built like sandbags, makes a fair revetment.

Comparison of revetments. 110. *Continuous hurdle work*, where the materials can be obtained, is probably the most useful revetment for all-round purposes. *Gabions with fascines* are very good for high parapets, as being the most durable. Moreover, they need not be made on the spot, and therefore, no special revetting party is needed; the usual working party can build the revetment. *Fascines* give but little support to earth, and are only useful for short heights such as the *riser* of steps, &c. Many other kinds of revetment can be improvised. Sacks and sandbags are useful for the repair of parapets and traverses, but sandbags should be used sparingly for new work, on account of the time and labour required for filling and building; the supply, moreover, is not unlimited. *Sods*, though very durable, take a long time to build into a revetment, and do not stand at such a steep slope as either gabions or sandbags. As, however, they are generally to be found where a parapet has to be thrown up, they can frequently be utilized, care being taken that they are cut into proper shape when the working parties commence their excavations. *Canvas* makes a good revetment, and is easily fixed.

Materials for 100 superficial feet. To revet 100 superficial feet by the methods above specified, the quantity of materials required is roughly:—

Gabion revetment, 7 ft. 6 in. high, 14 gabions and 3 fascines.

Sandbag, 200 sandbags.
Sod, 450. (Average size of rods, 1 ft. 6 in. × 9 in. × 4 in.)
Sods laid flat, for covering slopes, 90.
Hurdle, 9 bundles brushwood.

On the data given above, it is easy to calculate roughly the amount of material required for revetting a slope of given height and length.

SECTION 7.—APPLICATION OF FIELD DEFENCES.

(N.B.—Some of the drawings show, for the sake of clearness, the slopes of parapets intersecting at sharp angles. In practice they would be rounded off.)

Characteristics of Earthworks.

General principles of earthworks.

111. When two forces armed with modern weapons are opposing each other in the field, the object of intrenchments, which may be used by either side or by both, is to give cover from the enemy's fire, rather than to offer an obstacle to his assault. This marked characteristic of modern earthworks, as opposed to those of, say, a century ago, has its origin in several considerations, all tending in the same direction.

(*a*) Earthworks cannot form an obstacle to assaulting infantry unless they are of considerable profile. The rapidity with which modern armies manœuvre seldom allows time for the execution of works of this kind.

(*b*) The defence of modern intrenchments depends on fire; if troops can get through the fire of the defence they are not likely to be stopped at close quarters by so slight an obstacle as an earthwork.

(*c*) In the days of short range muskets and guns, an assailant had comparatively little power of searching with dropping fire the unseen ground behind a parapet. It was therefore possible, with a moderate command, to make the whole interior of a redoubt reasonably safe for the movement of troops. This very important consideration made it worth while to throw up high parapets, which gave protection at once from view and from fire over a large area behind them. In providing the necessary quantity of earth, it was convenient to dig a corresponding ditch immediately outside the parapet, which ditch would also offer an obstacle to assault; hence arose the custom of making cover and obstacle in one. Now, however, against shrapnel from guns and howitzers, we can only give protection

to troops immediately behind the parapet, or in shelter casemates. This protection can be most readily got by sinking a trench behind the parapet, and therefore the value of the old-fashioned parapets with from $6\frac{1}{2}$ ft. to 10 ft. command is much diminished.

(*d*) As concealment is now of primary importance, earthworks must be made as inconspicuous as possible. This object is most readily obtained by making the parapet low. A low parapet needs a deep trench behind it, and hence no earth is required from the front.

112. It is not intended by the above remarks to imply that obstacles are not required in connection with intrenchments. On the contrary, they are of the greatest use in checking the enemy's rush, and giving the defender an opportunity for pouring in a hot fire at a critical moment. But they should no longer be treated as an integral part of the protecting parapet. It will sometimes happen, owing to accidents of the ground, that a really difficult obstacle can be extemporised in immediate connection with the parapet; at other times, the obstacle may best be 50 yards or more away. In every case the shelter and the obstacle must be considered as separate elements, though closely dependent on each other.

113. In the attack of trenches the object of modern artillery is not to breach the parapet with the projectile itself, but to bring such a heavy fire on the crest line of the trench that the defenders will be unable to use their rifles effectively against the advancing infantry. The fire of the attackers' artillery will be most effective where it is oblique or enfilade. When designing trenches the aim of the engineer should be to prevent oblique or enfilade fire being brought to bear with effect.

114. The maximum slope of descent of effective shrapnel bullets from guns may be taken as about 1 in 3; from howitzers angles up to 1 in 1 may be expected, but their fire will possibly not be so accurate as that from guns.

Against high explosive shell from howitzers, if burst in the right place, it is practically impossible to give protection in the field. The use of any parapet capable of keeping out such shells would be precluded by its size. Unless the parapet be strong enough to completely resist the explosion, the effect of a shell will be no worse on a thin parapet than on a thick one; it is therefore inadvisable to spend time and labour on building heavy parapets.

All types of earthwork are therefore designed with the main object of giving cover from shrapnel and rifle bullets, and only differ in the amount of protection given to the firer by means of head-cover, overhead-cover, depth of trench, traverses, &c.

Above all it must be remembered that against fire of every class, concealment is of the greatest importance.

Types of Earthworks.

115. *Earthworks* may be classified generally under two heads, viz., *Trenches* and *Redoubts.* Classification of earthworks.

Trenches are further distinguished as "*fire trenches*" and "*cover trenches*," according as they are for the firing line or merely to cover troops not actually engaged; see Pl. XXIV, Fig. 1. Trenches.

116. The defence of an extended position will consist mainly of trenches. According to the nature of the ground these may be either in a continuous line, or in groups with their intervals defended by the fire of the adjacent trenches.

117. Redoubts are used principally for isolated positions, such as posts on lines of communication. Redoubts.

118. The degree of protection afforded by earthworks will generally be a question of opportunity and of the time available. From the moment when defences are commenced, every effort should be used to make them strong enough to give efficient protection to all the troops that will be under fire. Degree of shelter and protection.

119. When only two or three hours are available, the earthworks of the defence cannot be more than slight open trenches, and the correct siting of these, from a tactical point of view, becomes of the utmost importance. Cases will, however, frequently occur where the attack is limited by the nature of the ground to one line of advance, and it will then be possible for the defence to select a position across that line several days or weeks beforehand, and to develop its field defences at leisure.

The holding power of modern firearms is so great that an attack on a position even lightly entrenched will often extend over several days provided the flanks are secured. In such cases there will be opportunity for improving the most important trenches at night. Such improvement should consist in deepening and perhaps widening them, so that men may move about freely without being seen, and with fair protection against artillery; head cover and overhead cover should be added in places where the defenders are suffering from the fire of the attack, and fresh communications can be provided for the supports and reserves, in order to facilitate reinforcement at threatened points.

Earthworks in Attack.

120. An attacking force under certain circumstances may utilize the advantages conferred by intrenchments. For instance, when the defender's fire is so effective as to prevent Intrenchments in attack.

an attacking line from advancing beyond a certain point, the line may intrench itself, and thus secure the ground already gained until the attainment of a superiority of fire or the arrival of fresh troops makes a further advance possible. In constructing such cover men will be under heavy fire, they will therefore be obliged to intrench themselves as far as possible whilst lying down, making such hasty cover as will enable them to hold on to their ground till an opportunity arrives, as with nightfall it probably will, of making proper intrenchments with secure communications to the rear. Such cover affords protection against counter attack.

121. In broken, enclosed, or undulating ground, it will often be possible during an attack for supporting troops to intrench a position a little in rear of the attacking line; this may even be practicable by daylight. Should the troops in the front line be driven back, they will then have a line to rally on.

Parallels.

122. A systematic approach on the above lines is common in siege warfare. As a rule the trenches (termed in siege warfare "parallels") and their approaches must be dug at night, the obtaining of cover being hastened by the use of gabions, steel shields, hurdles, or anything portable that will support the earth dug out. When owing to the hostile fire even this method is impracticable, resort must be had to the process known as "sapping" (Pl. XIII).

Sapping.

123. Sapping is usually executed by engineers, and consists in constantly advancing a trench in the direction of its length by a party who work standing on the bottom of the trench, and, by throwing up a parapet on the exposed flank and end of the trench, keep themselves under cover.

Possibility of sapping.

Progress by sapping has been rendered much more difficult by the introduction of small quick-firing and machine guns, which cannot easily be silenced and are very effective against sap heads. It will rarely be possible to work at a sap except by night. False saps may be started if it be found that the defenders are prepared to waste ammunition upon them.

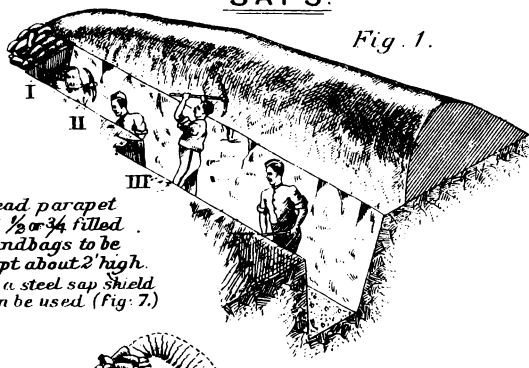
Right and left-handed saps.

124. Saps are usually "zigzagged" in direction to avoid enfilade. They are designated as right or left-handed, according to the direction in which they run; if to the right when facing the objective, the sap is called right-handed, and the sappers use their tools in the ordinary way that a right-handed man does, viz., with the right hand on the T-head of the shovel; if to the left, the sap is called left-handed; the sappers must hold the T-heads of their shovels in their left hands.

For extension of working parties, *see* "Infantry Training," 1905.

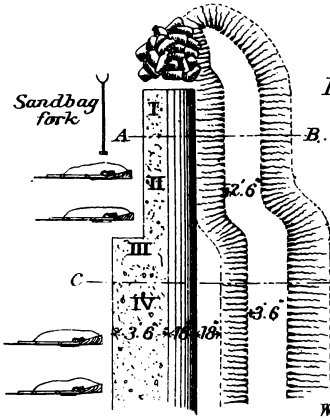
SAPS.

Fig. 1.



Head parapet of ½ or ¾ filled sandbags to be kept about 2' high. or a steel sap shield can be used (Fig: 7.)

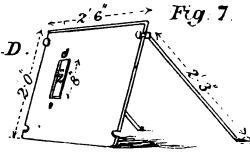
Fig. 2.



Rate of advance 2 to 4 feet per hour.

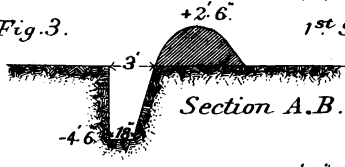
SAP SHIELD.

Fig. 7.



Weight { Sap Shield 40 lbs. 8 ozs.
2 Standards 3 lbs. 12 ozs.
Loophole Cover 3 lbs. 8 ozs.

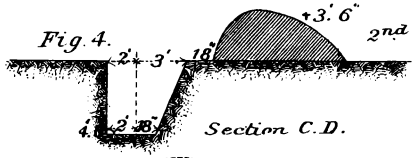
Fig. 3.



1st Stage.

Section A.B.

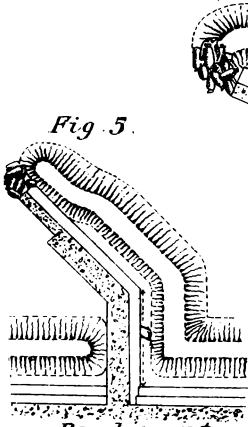
Fig. 4.



2nd Stage.

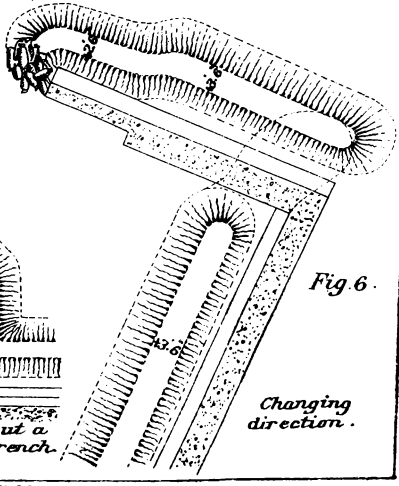
Section C.D.

Fig. 5.



Breaking out a sap from a trench.

Fig. 6.



Changing direction.

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Earthworks in Defence.

125. The advantages to be derived from field fortification are twofold: it enables fire to be delivered under conditions favourable to the defence, and by means of obstacles it limits the freedom of the attack. Advantages.

In order to realize these advantages, the following principles must be observed as far as possible :— General principles.

(*a*) The position to be defended must be choson with due regard to tactical requirements, and with a view to economizing men; its strong and weak points must be carefully studied.

(*b*) The enemy should during his advance be exposed as much as possible to the fire of the defenders. To this end the foreground may require more or less clearing.

(*c*) Every endeavour must be made to deceive the enemy as to the strength and dispositions of the troops in the defence, and as to the character of the defensive works.

(*d*) The defenders should be sheltered from the enemy's fire, and as far as possible screened from his view, by natural or artificial cover, so arranged as to permit the greatest possible development of rifle fire.

(*e*) The free movement of the attacking troops should be hindered by leaving or creating obstacles to detain them under fire, and to break their order of attack.

(*f*) The free movement of the defenders should be assisted by improving communication within their position and clearing the way for counter-attack.

Briefly stated, these principles involve the following considerations, the relative importance of each depending on the requirements of the situation :—

(*a*) Choice of ground.
(*b*) Clearance of foreground.
(*c*) Concealment.
(*d*) Provision of cover.
(*e*) Creation of obstacles.
(*f*) Improvement of communications.

In many cases the clearance of the foreground and creation of obstacles will proceed simultaneously.

126. The relative importance of the above principles must obviously vary according to the object with which the position is being fortified. A defence may be either "active" or "passive." An active defence implies vigorous counter-attacks and even pursuit, for which freedom of movement on the part of the defenders is essential; to this end it may be necessary to sacrifice to some extent both cover and obstacles. Nature of defence.

A passive defence, on the other hand, has in view no object beyond the repulse of the attack, and works may be multiplied to the utmost. But a purely passive defence should only occur under special circumstances, as, for example, in the case of great numerical inferiority on the part of the defenders, or when it is merely necessary to gain time.

In order that officers may be trained to select the best positions for defence and to construct suitable intrenchments, it is necessary that they should have ample practice in doing so on the ground; it is also advisable that they should study the use of intrenchments in past campaigns. The American Civil War, the Russo-Turkish war, the Boer wars, and the Russo-Japanese war furnish good examples.

SECTION 8.—TRENCHES.

Siting of Trenches.

Ideal site.

127. The ideal site for trenches is one from which the best fire effect can be obtained, in combination with complete concealment of the trenches, and of the movements of supports and reserves. As such positions will rarely be found, the best compromise must be sought for. The longest field of fire may not be the best if other advantages have to be sacrificed. A good grazing fire over a range of 600 yards may be more effective than a fire over twice the range which is not grazing. In most European countries long, unobstructed ranges are rarely met with; this is especially the case in England.

High and low ground.

128. There is a natural tendency to place the firing line upon high ground. Such ground is not always the most suitable.

The advantages of high ground are, that the defenders instinctively feel greater confidence, that communications are more easily concealed, and that a better view of the enemy is obtained.

The disadvantages are, that the defenders' fire is more plunging than grazing, that the position of the trenches can be more easily located by the attack when at a distance, and that the assault of the infantry can be supported by the attackers' guns until a later moment. Moreover, troops who have to fire down a steep slope are liable to expose themselves to the enemy's artillery.

Convex and concave slopes.

129. It is rare to find a uniform slope of any extent; almost all irregularities of the ground present either a convex or concave surface.

With regard to trenches on convex slopes it should be borne in mind that owing to the curvature of the slope, the field of fire from any point will be limited, but that the extent of country from which this point is visible will also be limited.

On concave slopes the field of fire is not limited by the curvature, but the visibility of trenches is correspondingly increased.

Site on hillside.

130. Most hills are convex at the top and concave at the bottom, the reason being that the soil is washed off the crest and deposited at the foot of the slopes. The soil thus washed down almost invariably assumes a concave surface; the line where the concavity merges into convexity marks its upper limit. Above this line the hillside, since it has resisted the weather, will probably be found harder to dig than below the line.

Trenches placed at the upper limit of the concavity should therefore have the advantages of easy soil and a good field of fire. But since the firing line is some distance down the hillside, it can be reinforced over the top of the hill only with great difficulty. Hence, it follows that when such a position is adopted on open ground, it will most likely be necessary to construct covered communications, either down or round the hill, from the supports and reserves to the firing line.

Site on reverse slope.

131. It may sometimes be advisable when the slope of a hill is easy on the defender's side, to place the trenches for the firing line some distance on that side of the crest. The ground in front of the trenches will, under these conditions, rise slightly towards the enemy; the crest of the hill should screen the trenches from the view of the hostile artillery, but such a position has the disadvantage of limiting the field of fire of the defending infantry, and requires great steadiness and good discipline on their part.

132. The siting of trenches must be governed largely by the nature of the attack to be expected. When the enemy is well provided with quick-firing artillery, the trenches must be either effectually concealed, or be provided with over-head cover against shrapnel. Under a concentrated shrapnel fire the defenders of an open trench will find it difficult to use their rifles with effect.

When time admits of good cover being provided against shrapnel, concealment becomes of less importance than when, owing to lack of time, only open trenches can be constructed.

From the point of view of concealment, the worst position for earthworks is on the sky-line, or with a distant background, when seen from the attackers' artillery position. It must be borne in mind that trenches placed well down the slope of a hill will sometimes be found to be on the sky-line when viewed from the enemy's position.

When it is not possible to conceal earthworks, much may be done by placing them so that it is difficult for the enemy to observe the burst of his shells. For instance, the firing line might be placed on a low ridge, with depressions to front and rear, the ridge being on the same level as the surrounding country. The depressions will render it difficult for the enemy to see where his shells fall.

Trace of Trenches.

Use of pits or trenches.

133. Troops highly trained as skirmishers, who can be relied on for individual action, may use broken ground to the greatest advantage by occupying separate shelters or pits; but for ordinary regular troops trenches are as a rule necessary. The continuous trench enables the officers to circulate among their men, allows of the distribution of ammunition, removal of wounded, &c., and also makes a local counter-attack by the firing line much more possible than it would be for men dispersed among rifle pits. The protection against oblique or enfilade fire given by pits can be equally well given to continuous trenches by frequent traverses and recesses. At well-defined salients the trenches will be specially liable to enfilade.

Arrangement of trenches.

134. The arrangement of trenches should be simple. There should be one main line of defence. Several tiers of trenches may sometimes be useful, in order to increase the volume of the defenders' fire, and to deceive the attack as to the actual position of the defence, but there should be no idea of using these trenches as *successive* lines of defence. The defenders should understand clearly which is the *main* line of defence, and to what they must hold on when the assault is pushed home.

The main line should not, as a rule, be continuous. If *echelonned* in suitable lengths, say for companies or even for smaller units, it will be more difficult for the enemy's artillery to get the range, but this division of trenches will entail more labour in making communications. Long, straight lines should be avoided.

Groups.

135. The form of the ground will usually entail the trenches of the main line being broken up into groups, between which unoccupied intervals must be left. The trenches on the flanks of each group should be arranged so as to deliver a cross fire over the intervals. In hilly ground it is frequently possible to place trenches so that the works on one spur flank those on the next.

Preparation of the Foreground.

General principles.

136. The selection of positions for defence should always be made with a view to securing a good natural field of fire, but other factors have to be considered, so that in many cases a certain amount of artificial clearing of the ground is required.

Before commencing the preparation of a foreground, the time and tools available should be taken into account. It is usually desirable first to take in hand a belt along the immediate front of the whole position to be defended; this belt can be widened later, should time permit.

The object should be to give the defenders the full use of their weapons within decisive range, while at the same time improving, or leaving intact, all natural obstacles which may impede the free employment of the weapons of the enemy, and obstruct or break up his attack.

Natural obstacles.

137. Obstacles left standing may therefore be intended to play one of two distinct parts: either to check an enemy's attack at points where the fire of the defence will be specially effective, or, by mere passive obstruction, to force the attack, in avoiding the obstacles, to choose certain lines of advance. In the first case it is essential that the obstacle shall be clearly seen and under heavy fire at decisive ranges from the defenders' position. In the second case the value of the obstacles depends almost entirely upon their power of passive obstruction, and their presence in front of any part of a position may justify a weakening of the fire defence in their vicinity. They clearly define the enemy's possible lines of attack, and on these lines defenders can secure for themselves every advantage.

Screens.

138. When clearing the foreground it is frequently of advantage to leave a natural screen, concealing some portion of the position from the enemy's view. For instance, a line of trees may be left standing when clearing a wood; these will obstruct the enemy's view, whilst offering very little hindrance to the fire of the defenders. Such screens will greatly assist in misleading the enemy as to the dispositions for defence, and, by preventing accurate observation of the burst of his shells, will render his artillery fire largely ineffective. Those portions of the line of defence which are intended to take the attack in flank should, when possible, be concealed; the effect of flanking fire is greatly enhanced when it is opened suddenly from an unexpected quarter.

Hollows.

139. Hollows which would give an enemy's troops shelter at points dangerously near the defender's position, may be filled up by abatis, felled timber, or the *débris* of walls and buildings. If, however, such hollows can be approached in security by the attackers, it will evidently be useless to provide them with any obstacle which can be rapidly destroyed or removed.

Hedges.

140. Thick hedges parallel to the front of a position, and capable of screening the advance of an enemy or of providing him with effective cover, should be cut down. Thin hedges, affording no cover against fire, will be no disadvantage where the

command of the defenders' position is such that the ground beyond them is thoroughly seen, and under effective fire.

Hedges perpendicular to the general line of defence may sometimes be left standing, as they serve to divide the attack and thus to assist a counter movement on the part of the defence. Such hedges must not, however, mask or interfere with essential flank fire.

Time, men, &c., for clearing away hedges.

A strong, thick, quick-set hedge, with wood from $\frac{1}{2}$ to $2\frac{1}{2}$ in. in diameter, can be cut down by men at two-pace intervals in from 6 to 18 minutes: if very bushy, a pole and ropes may be used to expose the lower branches to the axe (Pl. XIV, Fig. 1).

In place of clearing away a hedge altogether, it may be formed into an obstacle by cutting the main branches nearly through at the ground level, and bending and fastening them down towards the enemy. For this purpose the hedge must be strong and well grown.

Trees.

141. Large scattered trees give less cover when standing than when cut down, and may sometimes be useful as range marks. Unless they can be removed, it will generally be useless to cut them down. If felled, they should be cut off near to the ground, in order that the stumps may not give cover. On the other hand, smaller trees standing close together can be converted into a formidable obstacle by felling.

Brushwood.

142. Thick brushwood, especially in the case of some tropical growths, forms a very effective obstacle. In place of entering upon a general clearance, portions may frequently be left with advantage. It is thus possible to deny special points to an enemy, to break up his attack, and to compel him to adopt particular lines of advance.

Thin brushwood, however, unless cut and entangled, can generally be easily traversed by infantry without great loss of order, and if left standing may serve to screen an advance.

Clearing timber, &c.

143. For the method of felling trees, cutting down brushwood, &c., see Section 5.

Improvised devil-carts.

Timber felled in making clearings has often to be removed. Any kind of wagon can be employed for carrying small trees and brushwood, but for heavy logs *devil-carts* are more convenient (Pl. XIV, Figs. 2 and 3). These can readily be improvised by fixing poles to wheels and axles obtained from country carts.

Walls.

144. Walls must be dealt with on the same principles as those laid down in the case of hedges. When it is required to demolish them, they can frequently be knocked down by a party of a dozen or more men using a trunk of a tree, or a rail, as a battering ram. Low buildings may be similarly treated. Strong walls and substantial buildings must generally be blown down with explosives; as, however, the quantities of explosives

CLEARING GROUND.

Fig. 1.

DEVIL CART.

for moving large timber.

Fig. 2.

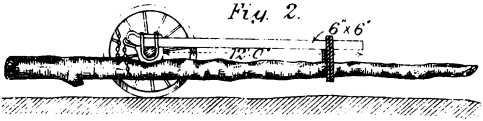
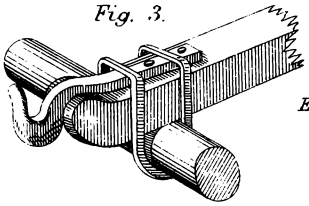


Fig. 3.



End of pole enlarged

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carried in the field is limited, economy must be exercised in their employment. The ruins should be so levelled as not to give effective cover. For hasty demolitions by means of gun-cotton, gunpowder, and other explosives, see M. E., Part IV.

High grass.

145. High grass, standing corn or reeds, if not required as a screen to any portion of the defenders' position, can be trampled down or possibly burnt, but care must be taken not to indicate thereby the line which the defenders have occupied.

Concealment.

Concealment.

146. Earthworks may be of the greatest value in providing cover for the defenders, but unless they are concealed from the enemy's view, a large proportion of their advantages will be lost. If a trench be clearly visible to the enemy it will certainly be subjected to an accurate fire of shrapnel, both from guns and howitzers. This shrapnel fire may do little damage to troops in good trenches with overhead cover, but it must have a certain moral effect on them, and will tend to keep them under cover whilst the attacking infantry approach.

147. The importance of the concealment of trenches cannot be overestimated. Should the enemy be unable to locate them he may be betrayed into making rash and unsuitable dispositions and be surprised by fire to which he will find it difficult to reply; moreover, his artillery will be unable to afford effective support to the firing line which is so essential to the success of the latter.

How obtained.

148. Concealment may be obtained:—

(*a.*) By judicious siting.

(*b.*) By assimilation to surroundings and keeping the parapet as low as possible.

The siting of trenches has been dealt with in paras. 127 to 132.

Assimilation to surroundings.

149. As regards assimilation of the trenches to their surroundings, it is important to remember that well-marked accidents of the ground, such as isolated hedgerows and lines of road, the dividing lines between cultivation and pasture, and, in some lights, sharp changes of gradient or anything which casts a shadow, are much more visible at long ranges than the trenches themselves. The neighbourhood of such objects may therefore serve to define the position of the trenches.

150. On most kinds of surface freshly turned earth is conspicuous. On pasture land the parapet should be smoothly sodded. On plough land the ridge and furrow effect should be imitated on the parapet. In scrub, branches should be planted here and there on the parapet and in front of it, care being taken to imitate the natural growth. The outline of the parapet

high parapet) should be from 1 ft. 6 in. to 3 ft. wide, the narrow step being only admissible when it can be revetted, or in stiff soil.

Principles of design.

161. Trenches should as a rule be designed for fire standing, but limitations of time and labour may necessitate a trench for fire kneeling or sitting.

The heights over which an average man can fire on level ground are:—

Lying down, 9 in. to 1 ft.
Kneeling or sitting, 3 ft.
Standing, 4 ft. 6 in.

Fire standing.

162. For fire standing, the height from the firing step to the elbow rest should be about 3 ft. 9 in., which with 9 in. added in front gives a total height of cover of 4 ft. 6 in. For firing down a steep slope, the total height should be 4 ft. 3 in., and the elbow rest only 6 in. below top of parapet, and for firing up-hill, the total height should be 4 ft. 9 in. and the elbow rest 12 in. below top of parapet. These heights will suit most men, but the soldier should of course learn to adjust his cover to suit himself. If the interior slope be nearly vertical, a tall man can fire over a parapet 5 ft. 3 in. above the firing step, and may as well have the advantage of the extra cover.

These dimensions apply also to loopholed parapets, and to stockade or blockhouse walls with plank elbow rests.

When no elbow rest is provided, the height over which men can fire down hill is reduced by from 3 to 6 in.

Width of trench.

163. The bottom of the trench should be 3 ft. wide when there is no firing step, so as to give a man room to sit down with his back to the parapet, and to allow of men passing behind the firing line. When there is a step, the trench behind it should be 1 ft. 6 in. wide or more.

Depth of trench important.

164. When time presses, the depth of a trench should be increased, rather than the width. The width can never be less than 2 ft., which is the minimum space in which a man can conveniently work. This should be increased as soon as possible.

When the trench is narrow at the bottom, recesses cut in the interior slope are very useful; these can be used to hold ammunition, water, &c.

Narrow trenches are bad.

165. Narrow trenches undercut at the bottom are rarely advisable. They allow of no movement in the trench for purposes of command, distribution of supplies, removal of wounded, &c.; the additional protection they give against artillery fire is not great. The undercut section is more difficult to excavate than the section with vertical sides, and will only stand in stiff soil.

DRAINAGE

Fig. 1.

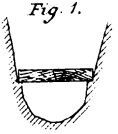


Fig. 2.

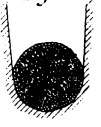


Fig. 3.

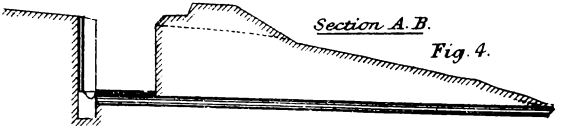
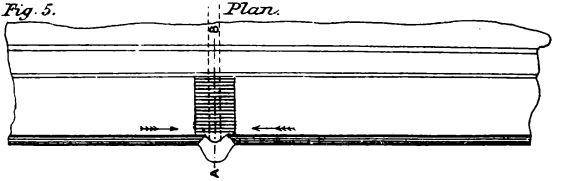


Fig. 4.

Fig. 5.



Cover for Outposts

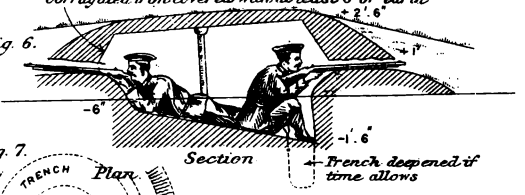


Fig. 6.

Fig. 7.

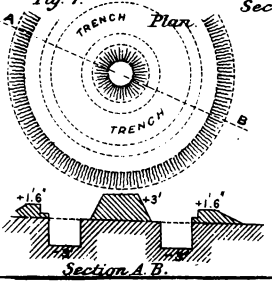
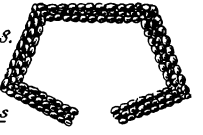


Fig. 8.



Stone Shelters

Transverse covering entrance (least exposed face)

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To face page 57.

Open Fire Trenches.

166. The simplest form of fire trench is that in which the amount of cover necessary is gained by the combination of parapet and excavation, without more than is necessary of either. The trench shown in Pl. XIX, Fig. 1. fulfils these conditions, and is a useful general type. Simplest form of fire trench.

Fig. 3 gives another type. It illustrates a case where the ground in front can be seen without any command, and where, for purposes of concealment, it is desired to dispense with a parapet. In this case the whole of the cover is given by the excavation, and the earth must be scattered, or removed to form a dummy parapet. Since the whole of the cover has to be obtained by digging, a trench of this type entails the maximum of labour before protection can be obtained. Fig. 4, gives a modified type, for use when time is limited.

The cover given by each of these trenches can be much improved by widening and deepening them at the back. Fig. 2 shows an example of this.

167. Pl. XVI, Figs. 3 and 4, show how cover can be quickly obtained for men lying down. This type takes about half an hour to dig. If time permit the trenches can be deepened to give cover for men standing, and may be connected to each other as shown by the dotted lines. Cover for men lying down.

Drainage of Trenches.

168. The drainage of trenches is of the first importance. It should be commenced at the same time as the excavation of the trenches. Drainage.

The best plan is to cut a duct to the nearest ground which is lower than the bottom of the trench. When this duct passes under the parapet, and has to be filled in, a fascine or some large stones may be placed at the bottom, or it may be roofed in with boards, brushwood, flat stones or anything else suitable. The duct should be of good size (say about half a square foot sectional area for an open drain, and twice as much for a French drain), with sufficient fall to let the water run away rapidly. The open drain covered in is the best form, as the others soon get choked with mud. Pl. XV, Figs. 1, 2, 3, 4 and 5.

169. The whole section of the drain should be below the level of the bottom of the lowest part of the trench; a collecting pit should be made at the mouth, which may be kept open by a small gabion. Collecting pit.

170. Where lower ground is not easily accessible, soak pits may be made at intervals along the trench; these can be baled Soak pits.

or pumped out when full. Their sides should be revetted with gabions or long pickets. If the bottom of the soak pit can be carried down to a porous stratum it will be a great advantage.

Shallow gutters should be made along the trenches, leading to the pits, and the bottom of the trench should be slightly sloped to these.

In fixing the position of drains, it should be remembered that the bottom of the trench will be approximately parallel to the surface of the ground.

171. Trenches made for instructional purposes should always be drained.

Protection against Enfilade, &c.

Traverses.

172. When trenches and parapets may be exposed to enfilade or oblique fire, they should be traversed and recessed. *Traversing* is the simplest means of gaining protection against enfilade fire, and also of localising the effect of high explosive shell bursting in the trench. An irregular line of trench will answer the same purpose when the ground is suitable.

Recesses.

Against *shrapnel bullets* coming obliquely or in enfilade, traverses will not suffice, on account of the steep angle of descent of the bullets. Recesses made in the parapet, large enough to hold one or two men, give the best protection against these. See Pls. XVII and XVIII. Such recesses may be made after the trench is excavated.

Such a traversed or recessed trench has, however, the great disadvantage of reducing very considerably the volume of fire that can be delivered from the trench. The traversed trench shown in plan in Plate XVI, Fig. 3, obviates this disadvantage to a certain extent. In this form of trench recesses need not be constructed, as by reducing the distances apart of the traverses, the trench forms practically a series of recesses.

For concealment, the sharp angles of the recesses should be broken by tufts of long grass, &c., so arranged as to make the parapet, when seen from the front, appear of one general height. But the view of the men in the trench must not be impeded.

Disconnected lengths useful.

173. When trenches are made at night on irregular ground, there is danger of losing the proper direction, so that parts of them may be liable to enfilade. In such a case it will be a good plan to make them in short disconnected lengths of say 10 ft., with 5 ft. intervals, and to connect these lengths afterwards.

Pl. XVI, Figs. 1 and 2, show one method of doing this. In this case a narrow trench is cut continuously in rear of the short lengths at first excavated, thus leaving traverses 3 ft

TRAVERSED FIRE TRENCH.

(Fig. 2 is an enlargement of a portion of Fig. 1)

Fig. 1.

Fig. 2.

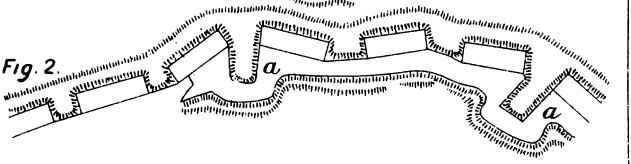
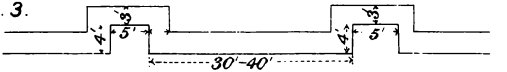


Fig. 3.



COVER-LYING DOWN

Fig. 4.

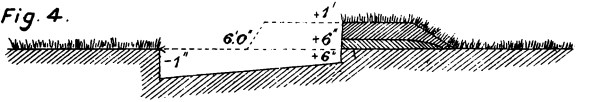
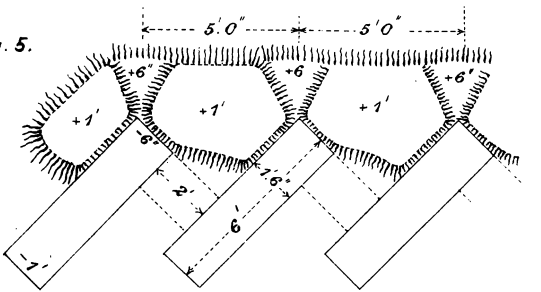


Fig. 5.



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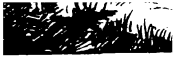
FIRE TRENCH RECESSED AND TRAVERSED

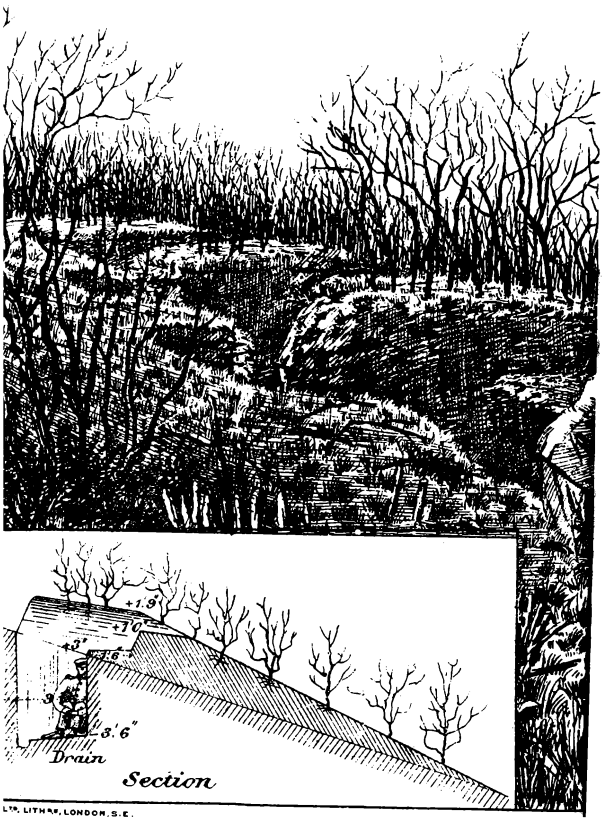
TIME REQUIRED 3 HRS. IN EASY SOIL.



To follow pl. XVI.

TRAVERSED FIRE TRE

TIME REQUIRED 1½ TO



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H WITH LOW COMMAND.

IOURS IN EASY SOIL.

To follow pl. XXVII.

long to protect the front part of the trench from enfilade. Here and there the traverses may be left, as shown at *a*, *a*, to extend right across the rear portion of the trench.

Revetted traverse.

174. Should it be necessary to protect an existing trench against enfilade, a revetted traverse not less than 2 ft. thick at the top may be built across the trench, communication being made round the rear of the traverse.

Head Cover and Loopholes.

Head cover.

175. Head cover tends to diminish the number of rifles that can be put in line, and to reduce the field of view. It renders the work more conspicuous, but is of undoubted advantage for protection, especially against shrapnel. Careful arrangement is required, so as to ensure the maximum of fire effect and invisibility with the minimum of exposure. This will usually be obtained by making depressions in the parapet for the rifle or by loopholes.

Loopholes.

176. Loopholes can be made of sandbags, sods, biscuit boxes, or any similar materials available on the spot. The size of the openings is governed by the extent of ground which must be covered by fire, and can best be regulated by testing with a rifle from which the bolt has been removed. By placing his rifle in the loophole, and looking both over the sights and through the barrel, a soldier can ensure that neither the line of sight nor line of fire is obstructed. The minimum depth of opening for a loophole in a parapet 2 ft. 6 in. thick, on level ground, using the new service rifle at 2,000 yards range, is for the inside 6 in. and the outside 4 in.

Loopholes made with earth or sandbags may have the larger opening either inside or outside. If the larger opening be inside, the loophole is very much less conspicuous, which is sometimes a point of great importance. A compromise between the two above forms is shown in Pl. XXII, Figs. 1 and 2.

If the larger opening be outside, a defender can fire with much greater ease, since he can cover the whole arc without moving his position.

The choice must depend upon local circumstances.

Loopholes made with hard material, such as stone, must have the larger opening inside to prevent ricochet.

A very good form of loophole is a slit all round the work, continuous except for the supports of the material above, see Pl. XX. This form has, however, the disadvantage of being extremely difficult to conceal.

Steel loophole plates.

177. Pl. XXI, Figs. 1 and 2, show how steel loophole plates may be utilized. These are articles of store.

Revetted loopholes.

178. Useful loopholes can be made with earth alone, supported by sticks. They can be much improved by revetting with sods.

Blinding loopholes against skyline.

179. The enemy must never be able to see light through the loopholes. Unless the nature of the background makes the loopholes inconspicuous as seen from the front, they must be blinded with pieces of canvas or opened sand bags hung behind them. In places where concealment is essential, the front of the loophole may be masked with branches or long grass, arranged so as not to obstruct the view. Cover should not be given at the expense of field of fire.

Overhead Cover.

180. Overhead cover gives the best protection against shrapnel both from guns and howitzers. It is especially useful against oblique fire, and if skilfully made enables the defenders of a trench to use their rifles effectively when exposed to shrapnel fire.

Overhead cover is difficult to combine with concealment, unless special material, such as steel plate, be available.

Nine to twelve inches of earth, or say 3 ins. of shingle, supported by brushwood or other suitable material, will stop a shrapnel bullet.

Pls. XX and XXII give types of overhead cover for trenches.

Pls. XXVIII and XXIX show types of cover separate from the parapet.

Such shelters are easily and quickly made after the work is completed, but they require a great deal of material. Pl. XXIV, Fig. 1, would take about six G.S. wagon loads of brushwood for 100 ft. of trench, and the other types would require more.

Protection against shrapnel.

181. Two sheets of corrugated iron, sloping to the rear at about ¼, afford good protection against shrapnel. The corrugations should be parallel to the line of fire. Pl. XXII, Fig. 3.

A row of heavy steel rails arranged in the same way as the corrugated iron, has been found to be practically proof against 6-in. howitzer shells filled with high explosive.

Splinter proofs.

Splinter proof partitions should be added at intervals of 10 or 12 ft. These are of great use in localizing the effect of a shell bursting in the trench. They may be made of hurdling and earth.

Protection from weather.

Even if time or material be not available for making over head shelter against fire, protection from weather is desirable. This can be obtained by the use of canvas, corrugated iron, or branches.

Lookouts.

Protected lookouts.

182. Protected lookouts should be made at occasional intervals in the parapet. Pl. XIX, Fig. 5, shows one with overhead cover. The sides of the opening should be splayed to the

FIRE TRENCHES.

Fig. 1.

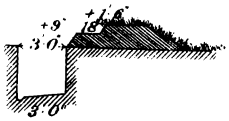


Fig. 3.

Fig. 2.

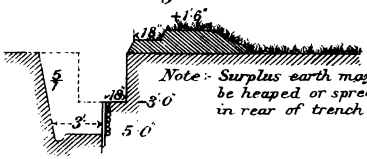
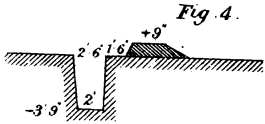
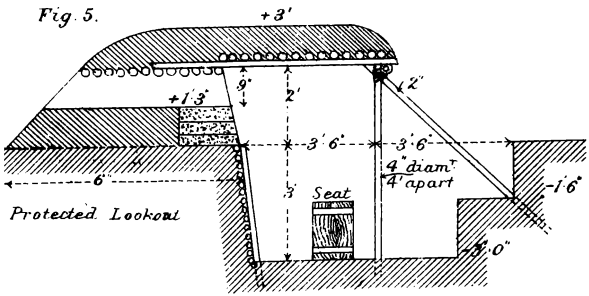


Fig. 4.



LOOKOUT.

Fig. 5.



ADAM & CO. LITH. LONDON S.E.

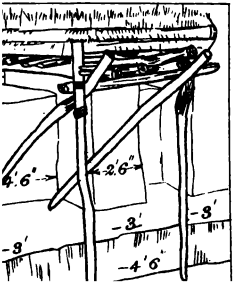
To face page 60.

FIRE AND COVER

FIRE TRENCH DEEPENED AND OVERHEAD COVER AD

RENCH COMBINED.

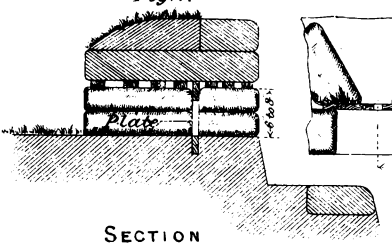
TIME REQUIRED IN EASY SOIL 4 TO 6 HOURS.



HEAD COVER

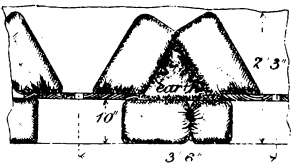
Sandbag Loophole with Loophole Plates on Level ground

Fig. 1.



SECTION

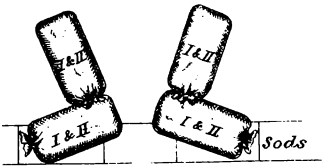
Fig 2.



PLAN

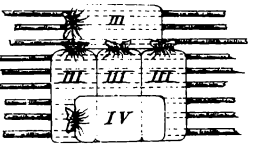
SANDBAG LOOPHOLE

Fig. 3.



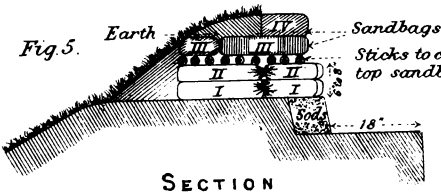
PLAN OF *I* & *II* COURSES

Fig. 4.



PLAN OF *III* & *IV* COURSES

Fig. 5.



SECTION

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To follow pl. XX

SOD LOOPHOLE

Fig. 1.

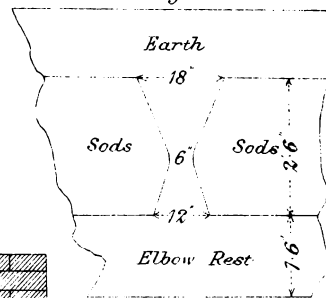
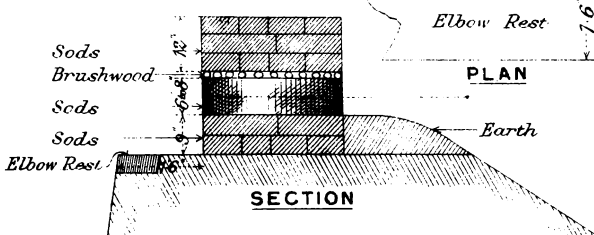


Fig. 2.



OVERHEAD COVER.

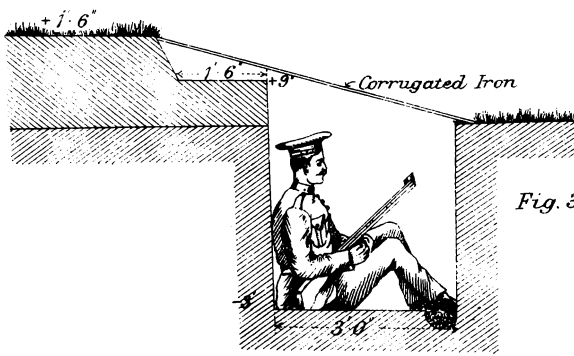


Fig. 3.

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To follow pl. XXI.

front so as to give a wide view of the foreground, and the inner opening should be only just large enough to look through.

A lookout may with advantage be recessed into the parapet.

In very exposed positions, a simple arrangement of looking-glasses will enable the lookout man to observe the whole of the foreground, whilst himself remaining under cover.

Cover Trenches.

Cover. trenches.

183. Troops in support of the firing line may have to be given cover in trenches.

These trenches can sometimes be used as alternative or reinforcing firing lines. In such cases types of trench can be used similar to those in the firing line.

Where overhead cover is required Pl. XXIV, Fig. 1, would be suitable, or when more time is available, Pl. XXVIII or Pl. XXX.

The object of banking the earth as at *a*, in Pl. XXVIII, is to intercept a flat trajectory shell, which might otherwise strike the roof of the casemate; by this arrangement the thickness of earth on the roof is reduced, and much weight is taken off the supports.

Cover for Reserves.

Cover on reverse slopes.

184. Troops in immediate reserve can usually find cover on the reverse slopes of the position.

But these slopes are liable to be swept by indirect fire, and artificial cover may even here be necessary.

Communication Trenches.

Communication trenches.

185. When time admits, covered communications should be provided from the firing line to the rear. These will enable the defenders to move unseen by the enemy, and, should a bombardment become very severe, it may be possible to withdraw the troops in the front line until the development of the infantry attack. A trench similar to Pl. XXIV, Fig. 1, will suffice.

It may be necessary to make long lines of such communications, but every possible use should be made of the ground in order to reduce the amount of labour required.

A parapet may be necessary on both sides of a communication trench, in order to give concealment from every point.

Cover for Guns.

Gun epaulments.

186. As a general rule, artillery construct cover for their own guns.

The simplest form of cover for field guns provided with shields is an epaulment or pit, as shown in Pl. XXIII. The

trace should, however, be modified when necessary to suit the ground. In the case of guns not provided with shields, the parapet will be run round in front of the gun.

The epaulments and pits may be connected by trenches.

In the construction of cover for guns, concealment is of the first importance, for if they offer a target in the least degree conspicuous, the guns run the risk of being overwhelmed by hostile artillery fire.

Gun pits.

187. When the gun is sunk in a pit, cover can be more quickly obtained than when an epaulment is thrown up. But it is generally unadvisable to break the hard surface of the ground. The advantages conferred by smokeless powder may be lost if light and dry earth is piled up near the gun, owing to the dust thrown up on discharge. Such earth should be well watered or have raw hides, &c., pegged down over it. In addition, brushwood or canvas screens will often be necessary to hide the flash of the gun.

188. If the artillery position is on a narrow ridge, the reverse slope may be scarped and the excavated earth thrown up on the flanks of the guns.

189. When there are very few guns defending an extended position, it may be well to provide two or three alternative epaulments or pits for each gun.

Ammunition recess.

190. An ammunition shelf must be provided close to the gun, and cover for one or more ammunition wagons near the emplacement is desirable. When time is available, covered communication between the gun emplacement and the wagons should be constructed. Parapets should be bullet and splinter proof.

191. Howitzers will, as a rule, be placed in concealed positions where they can only be reached by high angle fire. If they are likely to remain for some time in one position, as, for instance, in siege operations, they can be surrounded by splinter proof walls.

192. Heavy artillery may be provided with cover similar to that for field guns, the height of the parapet being made up to whatever the gun can fire over.

Gun banks.

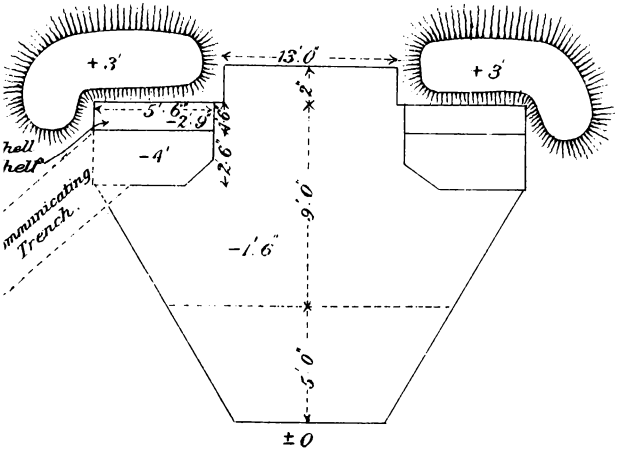
193. Should artillery be required to fire from a work of high command, a gun bank may be necessary to raise the gun high enough to fire over the parapet. The size of the gun bank depends on the mounting. A field gun or a Maxim will require a bank about 10 ft. × 6 ft. in plan.

Cover for Outposts.

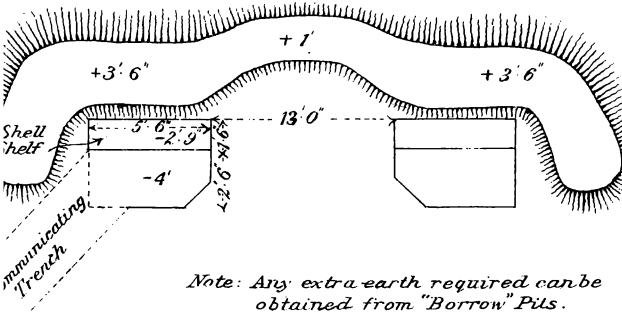
Outposts should be intrenched.

194. Where no natural cover exists, outposts should be intrenched. The guiding principles in the design of cover for

GUN PIT FOR SHIELDED GUN.



GUN EPAULMENT FOR SHIELDED GUN.



Note: Any extra earth required can be obtained from "Borrow" Pits.

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outposts should be the provision of an all-round field of fire, and the protection of the garrison from reverse fire. Pl. XV, Figs. 6, 7, and 8, show various types of cover suitable for outposts. Such works should, whenever possible, be surrounded with obstacles.

SECTION 9.—REDOUBTS.

Field redoubts.

195. Field redoubts are works entirely enclosed by defensible parapets.

They are not so well suited for the general defence of an extended position as are groups of trenches, because they cannot be so well adapted to the ground, their garrisons are more confined, and if their position be discovered by the enemy, it is possible that they may be made untenable in a short time by the fire of field howitzers. At the same time they have in certain cases greater value than trenches, because of the moral support afforded by them to the defenders. Inside enclosed works men know that their flanks are secure, and the fact that they are enclosed is proof of a determination on the part of their commander to hold the point they occupy to the last.

196. Field redoubts may be used under the following different conditions—

(*a*) To strengthen important points in the front line of a position.
(*b*) As rallying points in rear of the front line.
(*c*) For isolated posts.

Redoubts in front line of a position.

197. Redoubts can with advantage be used in the front line of a position at any point which may need strengthening, either because it is specially vulnerable, or because it commands the adjacent trenches. In the latter case the capture of the trenches will depend on the fate of the redoubt. Even should the defenders be driven from their trenches, the attacker will be unable to establish himself there until he has captured the redoubt.

198. Invisibility is one of the first requirements of a redoubt in the front line; otherwise the enemy will certainly subject it to a heavy artillery fire. The parapet should not be more conspicuous than those of the neighbouring trenches. Plates XXIV, XXV and XXVI show a redoubt designed with this object. Such a work should not draw more fire on account of its visibility than the trenches in its vicinity.

Since there may be no need for the defenders of the redoubts to take an active part in the early stages of the fight, positions

for the redoubts may often be found where they will be screened from the view of the enemy's artillery, but whence they can bring an effective fire to bear in the later stages of the attack.

Redoubts in rear of the front line.

199. Redoubts may be useful in rear of the front line. They may check a successful assault, and act as rallying points behind which retiring troops may be reformed and counter-attacks organized. A well-placed trench, or group of trenches, might, however, answer the same purpose.

At some distance in rear of the front line it will be easier to find positions secure from the enemy's artillery, and therefore the questions of invisibility and command of parapets will not present the same difficulties.

Redoubts for protection of isolated posts.

200. *Redoubts for the protection of isolated posts will occur especially on lines of communication. Every small body of troops liable to be surrounded should have either a redoubt capable of containing the whole force, or a number of small redoubts, connected by lines of obstacles and trenches. These are especially necessary for protection against night attacks, which may come to close quarters suddenly; to guard against these all the defenders must be near their posts.

The existence of these redoubts does not prevent the force from occupying by day more suitable fire positions.

201. When it is possible, there should be no ground higher than the site of the redoubt within about 2,000 yards of it, and the greater part of the interior should be defiladed from view. Invisibility is of less importance in the case of an isolated post than in that of a defensive position.

202. Arrangements for cooking and sanitation must be made within the enclosure. An isolated redoubt will often have a ditch in which the latrines can be placed, with a covered passage to them under the parapet.

203. Types of parapet and shelter suitable for redoubts of high command are given in Pls. XXVII, XXVIII, XXIX, and XXX. The parapets may be strengthened to resist common shell if necessary by flattening the exterior slopes a little more.

Trace of Redoubts.

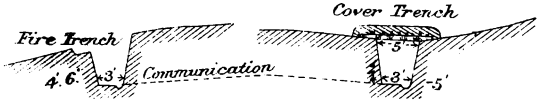
Trace of redoubts.

204. The trace of a work will depend first of all on the proposed garrison. This should always consist of one or more tactical units. A redoubt for two companies is a convenient size. Isolated works may be larger. The proportion of garrison to size of work should be from 1 to 1½ men per yard of parapet.

* See also Section 17 on Defence of Posts.

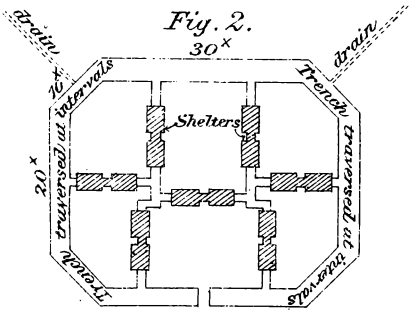
COVER TRENCHES.

Fig. 1.



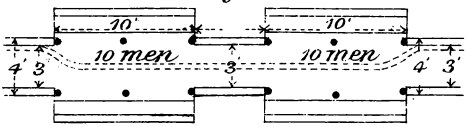
REDOUBT (LOW COMMAND)

Fig. 2.



General Plan.

Fig. 3.



Plan of Shelters.

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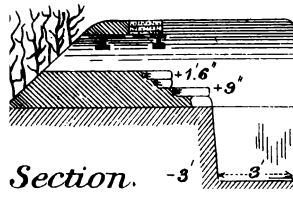
To face page 64

PORTION OF LOW

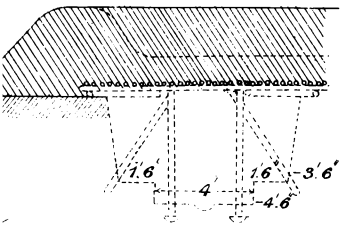
WITH HEAD CO



Section.

ND REDOUBT.

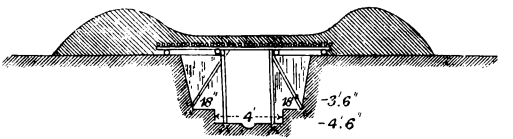
AVERSES.



To follow pl. XXIV.

HASTY REDOUBT.

BLINDAGE IN REAR OF FIRE TRENCH.



Section thro' Blindage.

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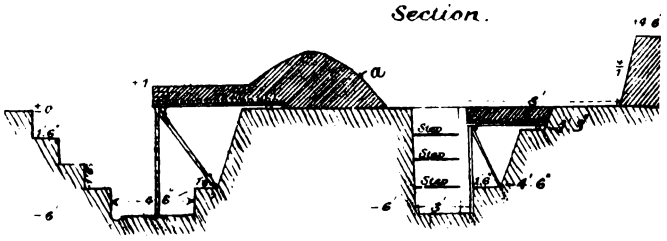
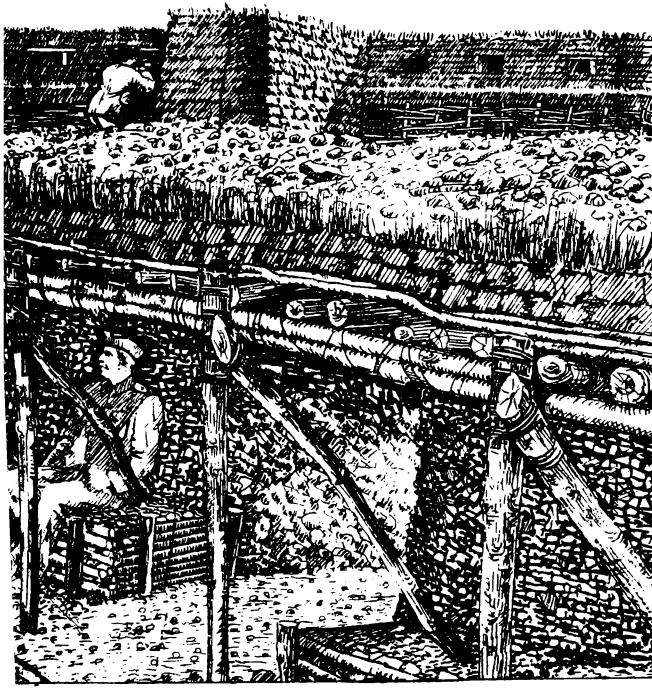
To follow pl.XXV.


Section.
a
+1
+0
-6'
-6'
-6'
Step
Step
Step
4'6"
4'6"

GH COMMAND REDOUBT.

COVER FOR SUPPORTS.



To follow pl. XVII.

HIGH COMMA

WITH TRAVERSES, HEADC

LOOPHOLES BLINDED WITH CANVAS

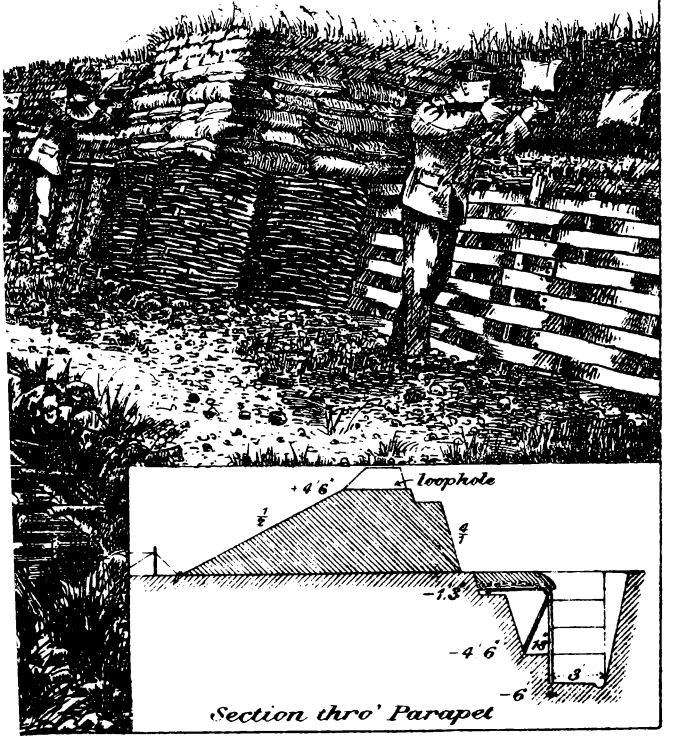
SHOWING AGAINST THE SKY, & SI

WITH TUFTS

REDOUBT

R. & OVERHEAD COVER

SIDE TO PREVENT THEM
BE SCREENED ON OUTSIDE
ASS &c

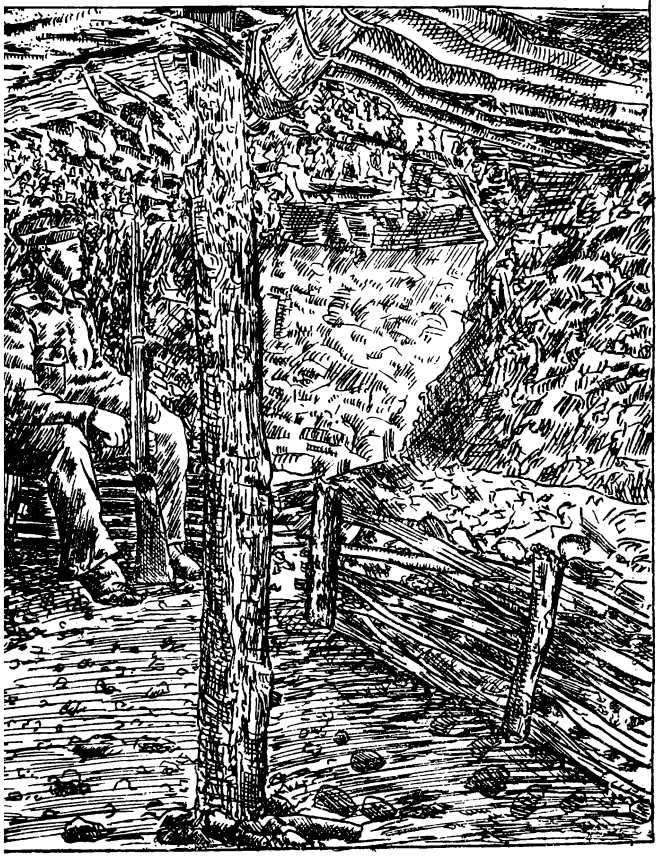


Section thro' Parapet

To follow pl XXVIII

SHELTER.

IN HIGH COMMAND REDOUBT.



To follow pl. XXIX.

Regularity of trace is of no importance. The disposition of the faces will be governed entirely by considerations of fire effect. There should be no dead angles, except when the nature of the ground in front of them precludes assault, and the longest faces should be arranged to fire on the enemy's best lines of attack.

205. It will generally be a very difficult matter to obtain a good field of fire for all faces of a redoubt of moderate size.

On a smooth level site a rectangle with all its angles well blunted is the best shape.

It will often be convenient to use curved faces. Where good fire effect is required, these should be struck with a radius of not less than 20 yards. A complete circle should as a rule be avoided, since it does not give a strong fire in any direction.

Collateral support.

When it is necessary to place a redoubt on the top of a slope too steep to be defended by the rifle fire of its own garrison, its foreground may be defended by flanking fire from neighbouring works. This fire cannot be so effective as that of the redoubt itself, especially at night; the obstacles must therefore be made specially strong, and be provided with some means by which they can be lighted up at night.

Entrances, Drainage, and Latrines.

Entrances.

206. Entrances will, in most cases, be simple cuts in the parapet, ramped down to the trench on the least exposed side. Occasionally it may be desirable to place a traverse across the entrance either inside or outside the redoubt. There will be a corresponding opening in the obstacle, which may be closed at night by stretching wire across it. This opening should not run straight through the obstacle; it should wind with a view to confusing an enemy trying to force his way in.

Should it be desired to bring guns or wagons into the redoubt, the slope of the ramp at the entrance must not exceed $\frac{1}{4}$.

Drainage.

The drainage of the redoubt and trenches must always be provided for, and should be put in hand as soon as the work is commenced. Soak pits will seldom suffice for this purpose; as a rule, the drains should be led out of the redoubt to lower ground.

Latrines, &c.

When a redoubt is to be occupied for more than a few hours, latrines and cooking-places should be provided within it.

SECTION 10.—IMPROVING EXISTING COVER.

207. Existing cover generally consists of hedges, walls, embankments, cuttings, roads, &c., which can be more or less prepared for defence according to the time available. The

same general principles apply to the improvement of existing cover, as are laid down in Section 8 for the preparation of artificial cover.

Defensible Hedges.

Hedges.

208. Strong hedges form one of the best obstacles that can be found, and with comparatively little labour can be made to afford good cover.

Even when they have no ditch or bank the concealment they afford is very useful for troops using smokeless powder; when time is available to improve them, the ordinary principles of trench work should be followed, care being taken that no excavated earth is visible on the enemy's side of the hedge.

In utilizing hedges as firing positions it is essential to see that the top of the bank on which a hedge stands is thick enough to keep out rifle bullets; if not, it must be made up to the proper thickness.

Head cover can be readily provided by cutting notches in the bank; through these the defenders can fire.

Hedges sometimes form very good screens for field guns. It will generally be advisable for the guns to come into action some distance, say 150 to 300 yards, behind the hedge, as it will then be more difficult for the enemy to obtain the range.

Defensible Walls.

Walls.

209. The defence of walls occurs chiefly in village fighting, or in the defence of farms, country houses, &c. In such cases, unless carefully prepared, walls restrict the movements of the defenders.

Brick walls.

Brick walls 9 in. thick and less may possibly be penetrated through the joints by small-bore bullets. Generally speaking, however, any fairly well-built wall, of which the mortar joints are not too thick, will give good cover against musketry.

Rubble walls.

Stones may be employed to form rough walls in places where digging is difficult or impossible. A well-built rubble wall, about 12 or 18 ins. thick, will keep out bullets, this thickness being necessary to avoid having any "through" joints.

Two rubble walls about 10 ft. apart afford good protection against artillery fire, the outer wall, which should be at least 2 ft. thick, serving to burst the shell.

Field gun shrapnel shell, with percussion faze, will penetrate any ordinary wall before bursting, and the splinters from the wall increase the destructive effect of the shell. Walls cannot therefore be occupied under effective artillery fire; but if they are in a good position for resisting the infantry attack, they may be prepared for defence, and the defenders can be withdrawn behind neighbouring cover during the bombardment.

HEDGES.

Fig. 1.

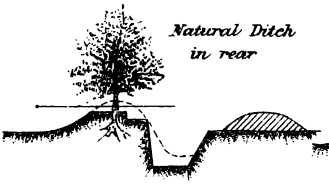
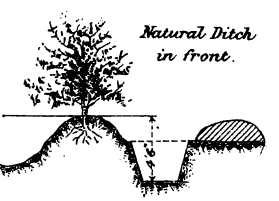


Fig. 2.



WALLS.

Fig. 3.

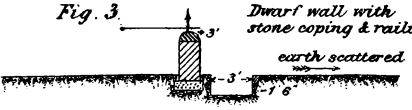


Fig. 4. Elevation of Fig. 3.

Fig. 5.

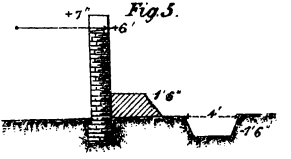


Fig. 6.

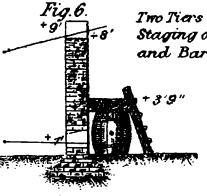
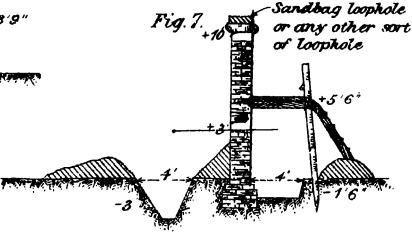


Fig. 7.



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The method of preparing a wall for defence will depend on its height, thickness, and structure, as well as upon the lie of the ground in front. In any case it should be so arranged that if the defenders be driven from the wall, the enemy cannot make use of the loopholes to his own advantage.

When the wall is only 4 ft. 6 in. high, the defenders can fire over the top. A trench in rear will improve the cover.

If the height be greater than 4 ft. 6 in., it will be necessary to make either notches or loopholes to fire through, or to provide a raised platform on which the defenders can stand. By notching or loopholing, head cover against rifle and shrapnel bullets is obtained.

Notching.

210. If walls be very thick, or strongly built of rough rubble, they cannot easily be loopholed, and must be notched by means of crowbars, mason's chisels and hammers, or picks. It is desirable to make the opening on the outside as small as possible, viz., about 3 or 4 inches wide, in order to lessen the chance of the entry of bullets, which, striking the sides or "cheeks" of the opening, may splash or ricochet through. The splay of the sides is regulated by the extent of arc which individual rifles are required to sweep. Where fire over only a small arc is required, a narrow notch is permissible. In place of laying down definite rules, it is sufficient to say that by holding a rifle in the required position the form and height of the notches can at once be arrived at.

Loopholes.

The above principles apply equally to loopholes. The opening should be smallest on the enemy's side, except in thick walls, when the narrowest part of the opening should be at the centre of the wall. For long range fire the height of the loopholes should be about 8 in. both inside and out. For fire at short range and more or less horizontal a height of 3 or 4 in. may suffice for the opening on the outside, though it must be greater on the inside.

The interval between loopholes should not be less than 3 ft., and will usually be 4 or 5 ft., in order to give men ample room to use their rifles.

One practised man, with a pick or crowbar, can make a loophole in a 14-in. brick wall (Pl. XXXI, Figs. 6 and 7) in about 15 minutes, and a notch or cut in about 5 minutes It is better in calculations to allow half an hour for a loophole, and 10 minutes for a notch. In the case of notches additional head cover can be obtained by using sandbags or large stones.

When sufficient fire cannot be obtained from a single tier of loopholes, a second tier must be provided, as shown in Pl. XXXI, Figs. 6 and 7.

Flanking lines of wall.

211. In cases where the number of troops available for the defence is not adequate to the extent of the position, so that the direct frontal fire is relatively weak, long lines of wall may be

flanked by making tambours (para. 248). Machine guns may be employed for bringing a cross and flanking fire on the ground in front. Structures formed to give flank defence should be strong and well protected. They will only be required at the last moment of an assault, after the defences have been subjected for some time to a heavy fire.

Embankments, Cuttings, Roads, &c.

Embankments.

212. Embankments are not as a rule good positions for a firing line, because they offer a distinct mark to the enemy's artillery. When an embankment in front of a position lies parallel to the line of defence it will generally be necessary to hold the embankment, lest the enemy should establish himself on the far side; but when the embankment is included in the position, it may be better to put the firing line well to the front, and to use the embankment as cover for supports or reserves.

Under artillery fire, infantry could only hold the top of the bank if posted in very well-made fire trenches. Either the rear or front edge of the bank may be held, as shown in Pl. XXXII, Figs. 1 and 2. The front edge gives the best command of the ground in front, but cover can be obtained with much less labour at the rear edge. Should time permit the front edge might be prepared for the firing line and the rear edge for the supports. Approaches to connect the two lines should be cut across the top of the bank, and the rear slope should be stepped in places.

Cuttings.

213. Cuttings parallel to the front also afford cover for supports and reserves. If occupied by the firing line, one of the two methods shown in Pl. XXXII, Fig. 3 may be employed. The method A may be employed by an active defence, supposing the troops to be strong enough to clear their front by a charge when the enemy gets close. If the defenders are not strong enough for this, they should generally be posted behind the cutting, as at B.

Roads.

214. A road cut on the side of the hill will generally be visible to the attack from a long distance, and therefore should not be held unless it offers special facilities for defence.

Drains.

Road drains and other small ditches can often be used as fire trenches or to cover supports.

Palings and fences.

215. Wooden palings can be used as screens or revetments.

Standing corn.

High standing corn may be useful as a screen along the firing line, in which case a narrow belt of it can be left standing and the rest trodden down.

A very effective screen may be formed by sticking bushes into the ground in front of a firing line, but care must be taken not to interfere with the defenders' fire.

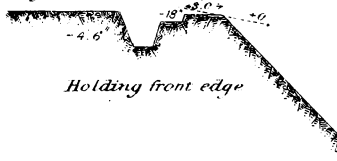
CUTTINGS & EMBANKMENTS.

EMBANKMENTS

Fig. 1.

Holding rear edge

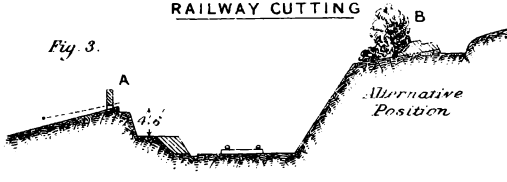
Fig. 2.



Holding front edge

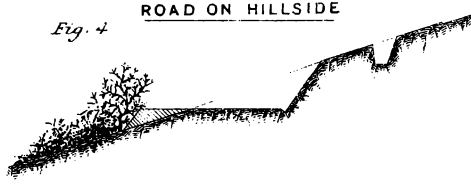
RAILWAY CUTTING

Fig. 3.



ROAD ON HILLSIDE

Fig. 4



SECTION 11.—OBSTACLES.

Principles of their use.

216. Obstacles are generally used in conjunction with defensive works, but may also be employed in the open to impede an advance of troops, or to increase the difficulties of a night attack. Obstacles.

Their main object is to delay the enemy whilst under the closest fire of the defenders. They are specially valuable when the field of fire is so limited that the enemy, in attacking, has only a short distance to traverse under fire; they are also useful in front of points where the fire is necessarily weak, as at salients. They may also serve to restrict the lines along which an attacking force can advance, and thus enable the defenders to make their dispositions with some degree of certainty as to where the attack will come. Although obstacles in the field can rarely be rendered insurmountable, yet they will fulfil their objects if they retard the progress of troops advancing to an assault, break the formation of the attack, and detain the enemy under the defenders' close rifle fire.

Natural features of the ground may sometimes be converted into serious obstacles with very little labour. Steep slopes may be scarped; in shallow water deep cuts or holes may be dug; wet ditches or inundations may be artificially formed.

Wire, or other materials or making obstacles, can only be carried in very limited quantities, and no large amount of transport of heavy materials (such as felled trees) can be undertaken. Obstacles can, as a rule, only be made where the materials are found on the spot. Clearances in woods usually furnish materials for obstacles.

217. The five general conditions which obstacles should fulfil are as follows:— Conditions to be fulfilled.

(*a.*) They should be under the close rifle fire of the defenders. For small posts and redoubts, they should be quite close, from 10 to 50 yards away from the rifles, so that they may be effectively defended at night. But they must not be so close that an enemy can throw explosives over them into the works which they protect.

(*b.*) They should not afford cover to the enemy. This condition is sometimes difficult to fulfil, but is very important.

(*c.*) They should not be liable to serious damage from the enemy's artillery. Against entanglements and abatis, artillery fire has very little effect. If it be

desired to give cover to an obstacle of any kind, care must be taken that whatever protects the obstacle will not at the same time give cover to the enemy's troops, and allow these to destroy the obstacle at their leisure.

(*d.*) They should be difficult to remove, and if possible should require special tools for that purpose.

(*e.*) They should be so placed that their exact position may be unknown to the attacking force.

As obstacles may interfere with a counter attack, they should not be constructed without the authority of the superior commander present.

Abatis.

Abatis.

218. An abatis is formed of stout limbs of trees 12 to 15 ft. long, laid side by side as close together as possible, with the branches towards the enemy. In order to make the obstacle more formidable, there should be several such rows, one behind the other.

The labour of dragging the trees from a distance being very heavy, the construction of an abatis should seldom be attempted unless suitable material grows near at hand. Sometimes, as in positions in or near woods, the material may be obtained in clearing the field of fire.

Abatis is much used in the defence of woods, farms, and villages. It is useful for closing intervals between works and for filling up hollows. When employed to protect a field redoubt it is usually placed in advance of the ditch, should one exist. If possible, the abatis should be in a shallow excavation which screens it from view and partially protects it from artillery fire (Pl. XXXIII, Figs. 1 to 3). The shape of the excavation depends on the nature of the trees. If the small branches project well from the stem the form in Fig. 2 may be adopted; if otherwise the form in Fig. 1 is best. The earth thrown up in front should not afford cover to the enemy.

Hard and tough woods are the best, and pine the worst, as the latter is easily broken up and burns readily even when freshly cut.

The fire of field guns makes very little impression upon abatis, and even that of heavier guns will only destroy it with a considerable expenditure of ammunition.

Details.

219. To prevent their removal, the butts of the trees should be firmly secured, either by burying them in the earth, by securing them to stout stakes driven into the ground, or by laying logs of timber across several butts.

When time permits, the large branches should be pointed, and the small branches and leaves removed.

The obstacle can be made more formidable by interlacing wire between the boughs.

OBSTACLES.

ABATIS.

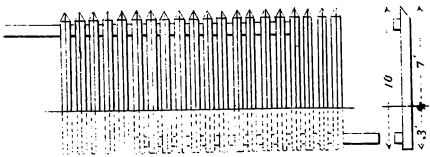
Fig 1.

Fig 2

Fig 3.

PALISADES.

Fig 1



Plan of Palisade.

When the abatis is laid in the open, as is very generally the case, the branches should be trimmed to within 3 or 4 ft. of the surface of the ground, so as not to interfere with the defenders' view of the enemy.

The method of forming an abatis with small branches is shown in Pl. XXXIII, Fig. 3. Several rows are used, the excavated earth being replaced after the branches are secured in position. If the stuff is straight grown it should point well upwards.

220. To make abatis carefully, at least six hours and a strong working party are required, so that very little of it can be undertaken in hastily fortified positions.

Time, men, tools, &c.

Twenty men can make an abatis in two rows, 30 yards long, in six hours, provided the trees be small and close at hand. One half of the party fell, point branches, and drag the trees into position; the other half fix the trees and picket down the butts.

The tools required are—6 felling axes, 2 hand axes, 6 billhooks, 2 hand saws, 2 mallets, 4 picks, 4 shovels, and a fair number of drag ropes.

A belt 5 yards wide of young oak trees 3 to $6\frac{1}{2}$ in. in diameter, the trees being already felled and on the spot, was constructed at Chatham in $1\frac{1}{2}$ hours by a party numbering 1 man to every 2 yards of front. Wire was laced through the branches. Two trees were required to every foot of front.

Rough abatis.

A very effective abatis may, however, be made much more rapidly by using the trees where they are felled, no excavation being made for them, and the branches being only roughly trimmed.

In Austria a regiment, using its own tools, in a wood where the trees averaged 7 or 8 in. in diameter, is reported to have constructed an abatis of this kind 50 yards broad in 3 hours, the men being distributed at 1 man to 2 yards of front.

Tree Entanglements.

Entanglement from trees, &c.

221. A *tree entanglement* may be formed by cutting trees, brushwood, &c., nearly through, about 3 ft. or less above the ground, bringing the upper parts down to the ground, and interlacing and securing them by pickets. Large trees thus treated form almost insurmountable obstacles, specially useful for blocking roads or defending the edge of a wood. The ends of thick branches should be pointed, and all weak places strengthened by ordinary abatis. Vines or hops woven together, with their tops picketed to the ground, form good entanglements.

The tools and time required for this class of obstacle vary according to the material of which it is formed. Axes, saws, billhooks, mallets, and ropes, are generally necessary.

Zareba.

222. In any country the materials most commonly found will suggest the class of obstacle which can be most easily improvised, for example, in the Soudan the "*zareba*," an enclosure made with mimosa thorn, is the commonest form of defence.

Panjies.

223. Panjies are bamboo spikes 9 in. to 1 ft. long, with one end sharpened to a point, and charred to hardness, and the other roughly sharpened to go into the ground. Panjies make a good obstacle in grass.

Wire Entanglements.

Wire entanglements.

224. Wire may be used in many ways, of which the following are a few.

(*a.*) As a trip wire, stretched just above the ground, or fastened in loose coils to short pickets.

When stretched it may be hung with bells, though this is not always a good plan, as straying animals may cause alarms. Or it may be connected with alarm guns or land mines; the latter course is not recommended for ordinary field use, as land mines are always dangerous to the defender. See also para. 230.

(*b.*) As a simple fence which may cause delay and confusion at night.

(*c.*) As a concealed obstacle in a ford.

(*d.*) As an adjunct to tree and brushwood entanglements.

(*e.*) As a wire entanglement.

Wire entanglement is the best of all obstacles, because it is easily and quickly made, difficult to destroy, and offers no obstruction to view. The materials are portable and are often found on the site.

Various forms of wire entanglement are described below.

Low wire entanglement.

225. A low wire entanglement is formed by stout stakes driven into the ground, about 6 ft. apart, in rows arranged chequerwise, their heads being connected by strong wires twisted round them and crossing diagonally about 1 ft. or 18 in. above the ground (Pl. XXXIV, Fig. 3). The outside stakes should be anchored so as to take the strain. No. 13 S.W.G. wire, weighing about 125 lbs. to the mile, or 14 S.W.G. wire, weighing about 90 lbs. to the mile, is well adapted for the purpose, but barbed wire, weighing about 16 lbs. per 100 yards, is better. One mile of wire will make an entanglement of about 5,000 square feet, or roughly, 1 ft. of wire is required for each square foot.

Except against mounted troops, a low wire entanglement is not a good obstacle unless concealed amongst brushwood, or long grass. It is especially effective in the bed of a river.

Roughly, one man can construct, with plain wire, 10 square yards in one hour. When barbed wire is used, twice this time must be allowed for construction. For every 10 men 3 billhooks, 1 mallet, and 2 pliers are required.

OBSTACLES.

HIGH WIRE ENTANGLEMENT.

Fig 1.

Horizontal wires omitted.

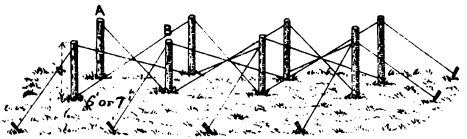


Fig 2. BARBED WIRE ENTANGLEMENT.

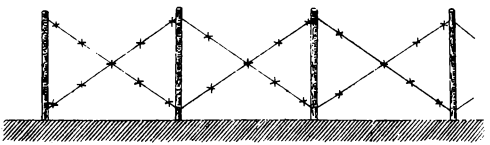


Fig 3. LOW WIRE ENTANGLEMENT.

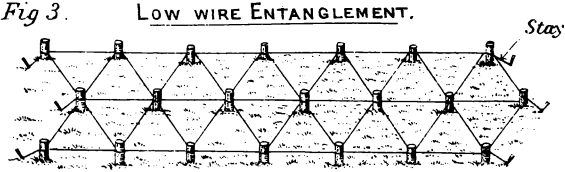
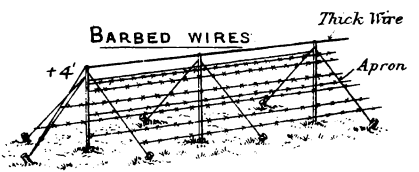


Fig. 4.



To face page 72.

226. A type of high wire entanglement is shown in Pl. XXXIV, Figs. 1 and 2. The stakes in this case are 4 ft. above ground, and 6 to 7 ft. apart, the head of each stake being connected by stout wire with the foot of the one diagonally opposite. These diagonal wires are again connected by other horizontal wires, thus forming a network exceedingly difficult to cross. The stakes should be firmly driven and stayed, in order to prevent the entanglement being dragged away by the enemy. High wire entanglement.

227. A high wire entanglement requires about three times as much wire as does a low entanglement, and also thrice the time for construction, that is to say, 3 ft. of wire are required for every square foot of entanglement, and 3 men will build, using plain wire, 10 square yards in one hour. Time, &c.

As in the case of the low type, when using barbed wire the time required is double that taken with plain wire.

On account of the material required and labour involved, very little high wire entanglement can be constructed for the hasty defence of positions, though a high wire entanglement, of a good breadth, and backed by a well-loopholed parapet, is a most formidable obstacle.

High wire entanglement can also be made with the pickets arranged chequerwise, about 6 ft. apart. This form is perhaps more difficult to cross by means of planks, hurdles, &c.

Another type readily adapted to an existing fence is shown in Pl. XXXIV, Fig. 4. It is not so good an obstacle as those described above, but is more easily and rapidly made.

228. When a trip wire, with bells or other alarm signals, is used in conjunction with an entanglement, it should be placed just within the front edge and fastened to pickets, distinct from those of the entanglement, in such a manner that it cannot be touched except by any one actually trying to cross the obstacle. This will prevent false alarms being caused by cattle, &c. Trip wire.

*Illumination of Obstacles and Foreground.**

229. The lighting up of the foreground and obstacles at night is of great importance. Illumination of obstacles and foreground.

The lights should be arranged so that they can be put in action instantaneously when the enemy approaches the obstacle; they must illuminate the whole of the obstacles and the foreground, whilst leaving the defenders in shadow.

Bonfires are effective when fuel is to be had. They may be built close to the line of the obstacle, with screens behind them, as shown in Pl. LII. Bonfires.

A bonfire should be so built that it cannot easily be pulled down by the enemy. A stout post may be fixed upright in the

* *See* also Section 17, Defence of Posts.

ground, and the fuel built up round it in the form of a cone. Or three posts may be erected, three or four feet apart, with sticks nailed to them horizontally so as to form a cage, and the fuel piled inside. A heap of shavings or dry leaves should be placed at the bottom, and means of lighting arranged in connection with it. For this purpose a length of instantaneous fuze may be used, with one end in a small bag of gunpowder, under the heap of shavings, and the other inside the work. But the fuze must be kept in thoroughly good condition. Friction tubes form an excellent means of ignition. They can be fired by the release of a weight which is attached by wire to the eye of the pin. The tubes must be rigidly fixed, and strong wire used for suspending the weight. The blast from a friction tube being considerable, the end of the instantaneous fuze nearest the tube should be one inch away from it. Both ends of the fuze may be packed with quickmatch to insure ignition. Another method is to arrange a match under the shavings so that by a pull on a cord the match will be rubbed against an igniting surface. The shavings must be enough to make a bright flame at once, and petroleum or pitch should be added to them if available. Materials for renewing the bonfire should be kept at hand. Small pieces of canvas should be fixed over the firing arrangements to protect them from weather.

Acetylene flares.

Acetylene flares, of which there are several commercial patterns, have been found to be fairly effective for illuminating obstacles.

Lights, illuminating wreck.

Lights, illuminating wreck are articles of store. They can be lit with either instantaneous or safety fuze. Instantaneous fuze should be stripped at the end to ensure good contact with the light. They illuminate a circle of about 100 yards diameter and burn for about 20 minutes.

Star shell.

Star shell, though they are apt to light up the defence as well as the foreground and do not last long, have often a good moral effect against savages; the firing of them at intervals through the night has been known to prevent an intended attack.

Search lights.

Search lights are the only really efficient means of illuminating the foreground, and will probably be largely used; they are most effective both for lighting up the ground and for blinding the attack.

Alarms and flares.

230. Where night attacks may be expected, automatic alarms and flare lights are useful adjuncts. They are usually combined with the obstacle. One of the simplest alarms is a row of tin pots, each containing a pebble, hung on a wire fence so as to rattle when the latter is disturbed. A piece of tin 2 in. to 3 in. in diameter, such as the top of a jam pot may be bent round the wire and will answer the same purpose. Trip wires can be arranged to fire a rifle, or to fire a cartridge which in its turn will ignite a flare. (See Pl. XXXV.)

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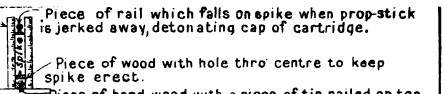
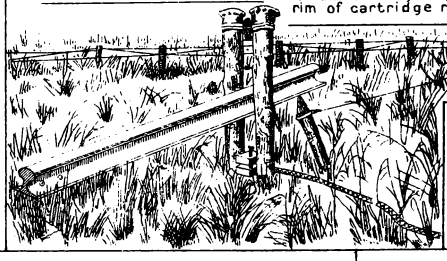
CARTRIDGE ALARM.

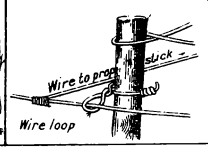


TO PRODUCE A FLARE.

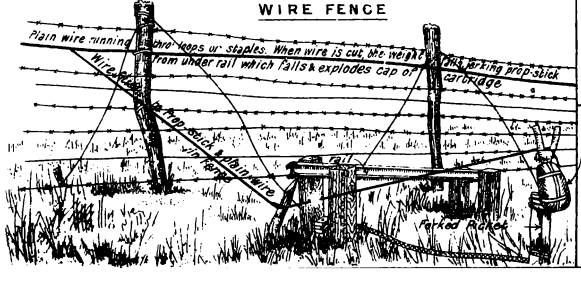
One end of a piece of instantaneous fuze is inserted into an empty cartridge case and pushed well up to cap. The mouth of the case is pinched to keep fuze in position. The other end of the fuze is bound up with loose cordite or flaked guncotton, a little dry tow is then arranged around it and then inserted in tow, straw, dry grass, shavings, etc, which should be saturated with oil.

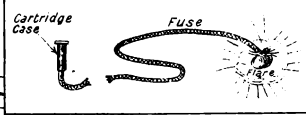
LOW WIRE ENTANGLEMENT.

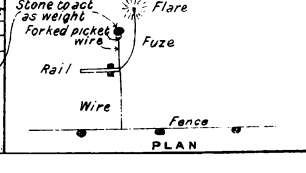




WIRE FENCE







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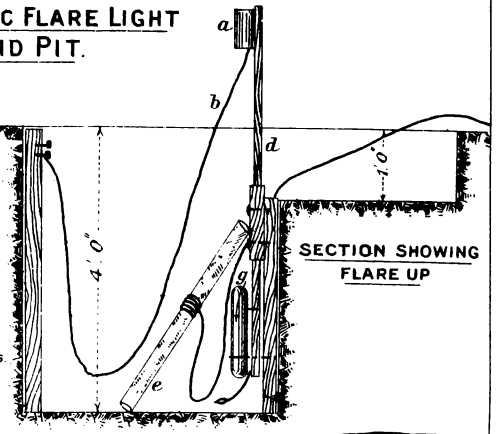
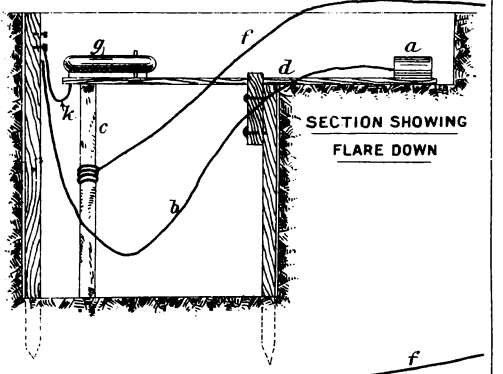
AUTOMATIC FLARE LIGHT AND PIT.

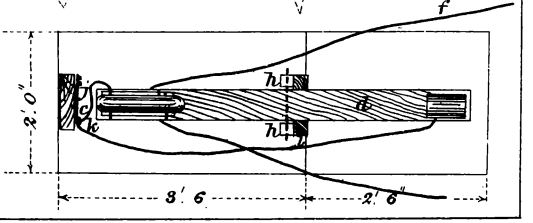
a. Flare, composed of nitrate of potash sulphur and orpiment.
b. Instantaneous fuze from flare to friction tube
c. Friction tube.
d. Balanced plank carrying flare and weights.
e. Prop stick connected to trip wires.
f. Trip wires.
g. Weights.
h. Lugs.
i. 3/8" round bolt to form hinge.
j. Quick match around friction tube.
k. Pliable wire to fire friction tube



SECTION SHOWING FLARE UP



SECTION SHOWING FLARE DOWN



PLAN

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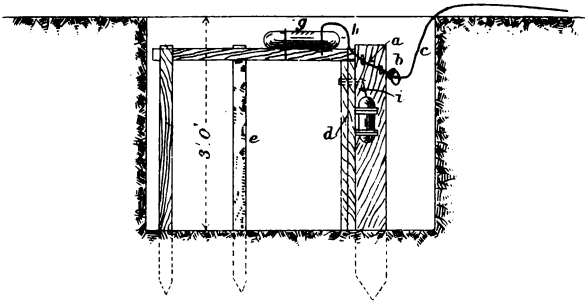
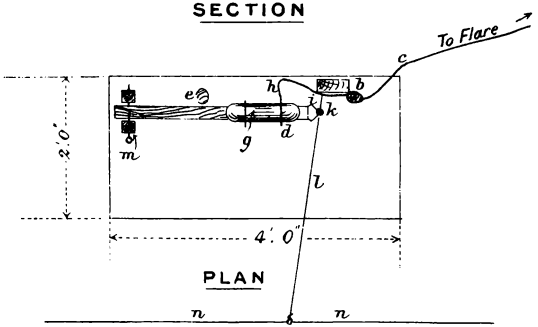
To follow pl XXXV

FLARE PIT.



SECTION



PLAN

a Fricton tube placed so that pull comes at a right angle.
b Quick-match.
c Instantaneous fuze to flare.
d Prop stick.
e Guide stake.
f Pivotted arm 2'6" x 2" x 2"
g Weight attached to arm and connected by flexible wire or spun yarn to friction tube.
h Flexible wire or spun yarn.
i Flexible wire or spun yarn from prop-stick to weight.
k Weight connected by flexible wire or spun yarn to prop stick and thence to wire "l"
l Wire connected to "cut" of "trip" wire.
m Wire pin thro' two uprights and acting as pivot for arm on which weight "g" rests.
n "Cut" or "trip" wire.

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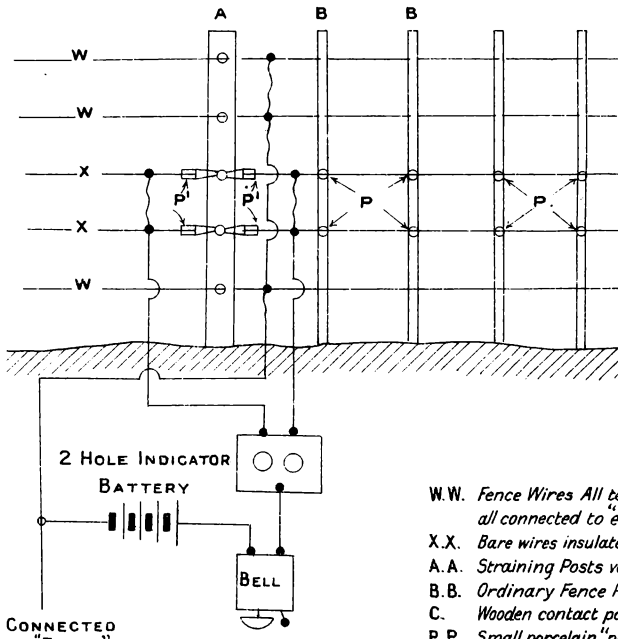
To follow Pl. XXXVA

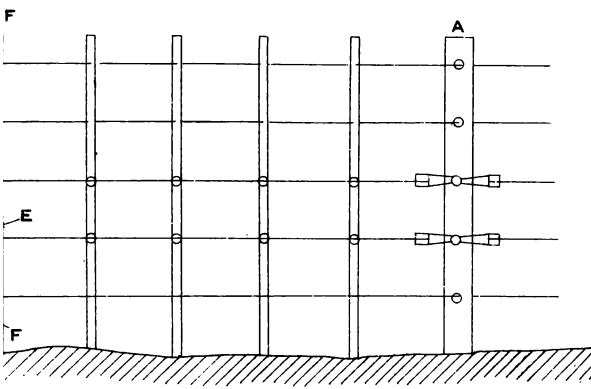
DIAGRAM ILLUSTRATING SIM



CIRCUIT IN BLOCKHOUSE

W.W. *Fence Wires All ter*
all connected to "ea
X.X. *Bare wires insulatea*
A.A. *Straining Posts ver*
B.B. *Ordinary Fence Po*
C. *Wooden contact pos*
P. P. *Small porcelain "pul*
P' P' *"Pulley" insulators*
D. D. *Contact pieces sec*
E. E. *Contact strips con*
F. F. *Insulated contact*
The wires W do no
with the strips E.

LECTRIC ALARM CIRCUIT.



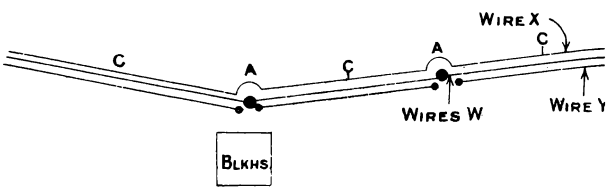
t Straining Posts. All free to run past other posts, and

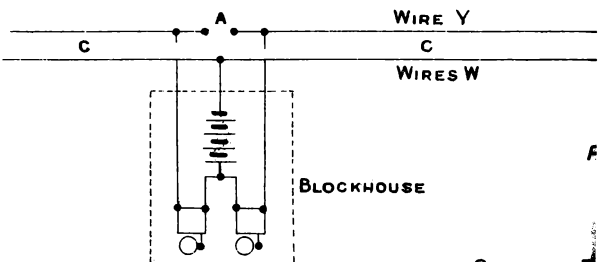
in insulators. Divided into sections at Straining Posts.
fixed. One at each Blockhouse and one between Blockhouses.

ery 200 yards.
tors through which the wires XX run.
ackles for subdividing XX into sections.
: various wires.
arthed" wires W.
nected to insulated wires X.
ntact with the strips F nor do the wires X make contact

To follow pl. XXV.

GENERAL ARRANGEMENT OF





SIMPLE

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E COMPLICATED CIRCUIT

Plate XXXVII.

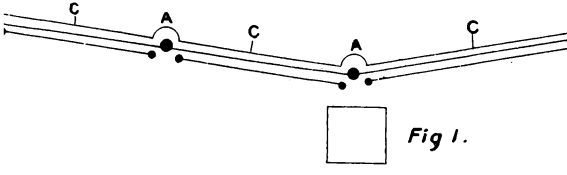
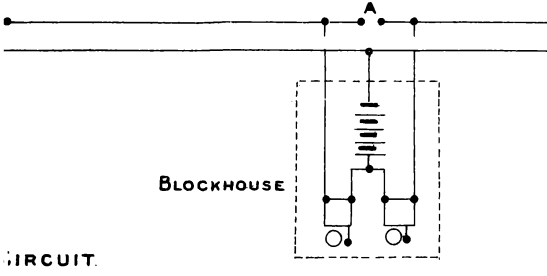


Fig 1.



IRCUIT.

To follow pl. XXXVI.

It must be borne in mind that flares lighted within a few yards of the perimeter of a camp, or close to a parapet, are difficult to screen effectively and are likely to be a source of greater danger to the defence than to the attack; they should therefore be used with great caution. At night troops have a tendency to concentrate their fire on any brilliantly illuminated area. A number of flares capable of burning from two to five minutes are preferable to one or two bonfires; a better effect is obtained from flares by placing them at some height above the ground. Convenient trees may be used for this purpose.

Arrangements for automatic alarm signals, in connection with entanglements or intermediate fences, generally have to be improvised on the spot with whatever materials are available.

A trip flare that has been found to work satisfactorily consists of a balanced board fixed in a trench having at one end the flare and at the other a heavy weight which is temporarily supported. The trip wire having been pulled, the support beneath the weight is withdrawn, and the end of the beam falls. By this means the flare appears above ground, and the jerk given to the beam fires a friction tube attached to the flare by instantaneous fuze and so lights the flare. (See Pl. XXXVA.)

The flare is composed of a mixture of nitrate of potash, sulphur and orpiment (Lights G.S. long, Mark III).

Pl. XXXVB shows a similar device for the firing of a mine or bonfire outside the pit. A bonfire composed of straw, dry wood, &c., is readily set on fire by a small one-ounce cartridge composed of 5 parts white sugar and 4 parts chlorate of potash enclosed in grease-proof paper fired by either instantaneous fuze or electrically by No. 14 Fuze, with metal cap with the meal powder removed.

The spring gun shown in sketch, Pl. XLIX, Fig. 2, is reliable and easily fixed. Spring gun.

Electrical fence contacts were devised during the South African War for intermediate fences between blockhouses. They may be classed under two headings. In the simpler form the contacts are fixed on one of the fence posts, or on a post erected for the purpose on the line of the fence. This simpler form will give a signal whether one or all of the fence wires are cut or pulled. Fig. 1, Pl. XXXVI gives a suggestion for an alarm circuit of this type. In the more complicated form the contacts are mounted upon a suitable carrier, which is secured to the fence wires more or less midway between two fence posts. With this arrangement, since the contact makers are "floating," a signal will only be given when there is relative movement between one or more wires. Pls. XXXVII, XXXVIII, XXXIX, and XL refer to an example of this type, employed to some extent in South Africa. The circuit may be arranged as a simple bell alarm circuit, as shown in Electrical contact.

Pl. XXXVII, or the alarm circuit may be combined with a mine-firing or flare-igniting circuit, as shown in Pls. XXXVIII, XXXIX, and XL. With the latter arrangement the mine or flare may be fired either by an exploder, or automatically by a battery of sufficient strength. Unless automatic firing is desired, it is important to remember that the bell battery must not be strong enough to fire the fuze or detonator. The action is as follows:—

The galvanized iron wire Y (normally insulated from the fence wires by the porcelain insulators) may be put in contact with the fence wires *either* if it be tied up to one of the fence wires, *or* by the relative horizontal movement of the wires, causing either of the wires D to make contact with the brass contact-piece. In either case the bell circuit is completed *viâ* the insulated copper wire X and mine (or flare) circuit.

Lest there should be a failure of the lighting arrangements, it will in any case be a sound precaution to have a second slight obstacle immediately in front of the parapet. See Pl. LII.

Grass fires.

231. *Grass fires* may be made to serve various purposes in countries where the grass is high, and when it is dry enough to be burnt. For instance, by burning the grass in front of a position much cover is destroyed which might be of value to an attacker. The fire will also act as an obstacle to an advance, whilst the smoke may screen the movement of troops before a counter-attack.

Barricades.

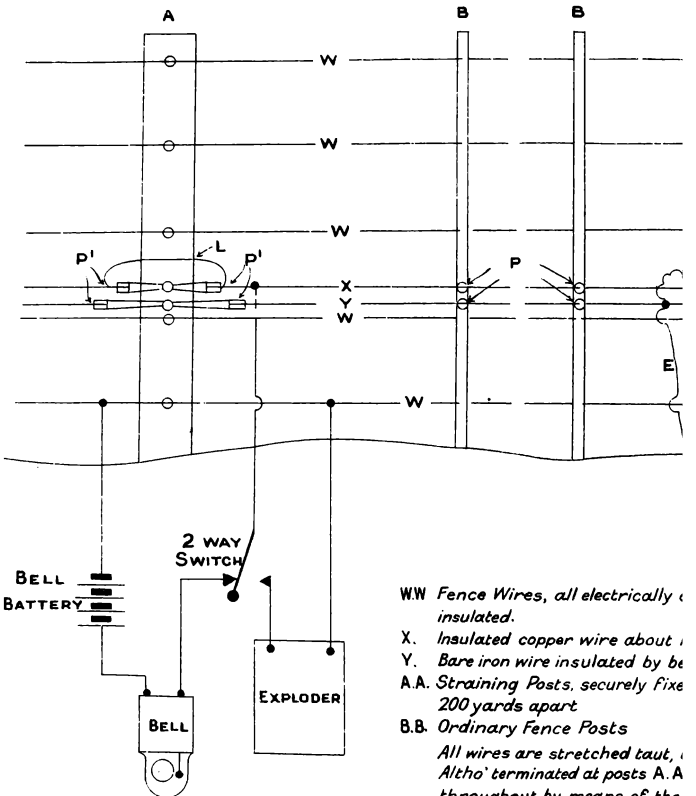
232. *Barricades* are used for the defence of streets, roads, bridges, &c., and may be made of almost any materials that happen to be at hand. Furniture, vehicles either overturned or with the wheels taken off, carts filled with earth, timber, heaps of stones, rubbish, iron railings, bales of goods, &c., can all be made available (Pl. XLI, Figs. 1, 2, 3). Earth should always be used, however, where the barricade is exposed to artillery fire. When trees grow alongside a road, a barricade can be rapidly made by felling them across it, or, more effectively, by entangling them as explained in para. 218.

In the case of a barricade for the defence of a street, it should be so constructed that fire can be delivered from it, and should, in addition, be flanked from loopholes in the adjacent houses or walls. The loopholes should as far as possible be arranged so as not to fire into each other; the defenders on being posted should be cautioned as to the direction of their fire.

On each side of a barricade the doors and windows on the ground floor which look into the street should be blocked up. The enemy will be thereby prevented from forcing an entrance and driving out the flanking parties.

Passages are generally required through barricades, to allow of the advance or retreat of outposts, but from the front these

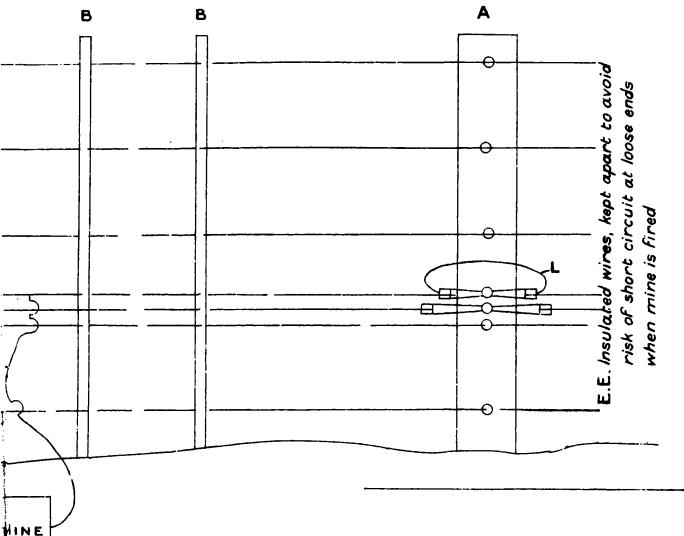
Diagram Illustrating more Com



Circuit in Blockhouse
(Firing by Exploder)

W.W *Fence Wires, all electrically*
insulated.
X. *Insulated copper wire about*
Y. *Bare iron wire insulated by be*
A.A. *Straining Posts, securely fixe*
200 yards apart
B.B. *Ordinary Fence Posts*
All wires are stretched taut,
Altho' terminated at posts A.A
throughout by means of the
sections at Posts A.A.
C. *Contact carrier, fixed to Fen*
two posts A.A.
D.D. *Bare copper wires fixed to Fe*
any other wires.

TED ELECTRIC ALARM CIRCUIT.



HINE
OR
LARE

together, but not purposely "earthed" or

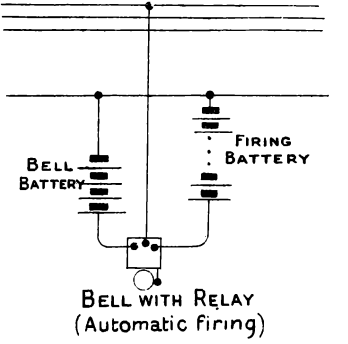
G.

rted on porcelain pulley insulators p' p.'
all wires terminated, about

run freely past the fence posts,
X is made electrically continuous
The wire Y is divided into

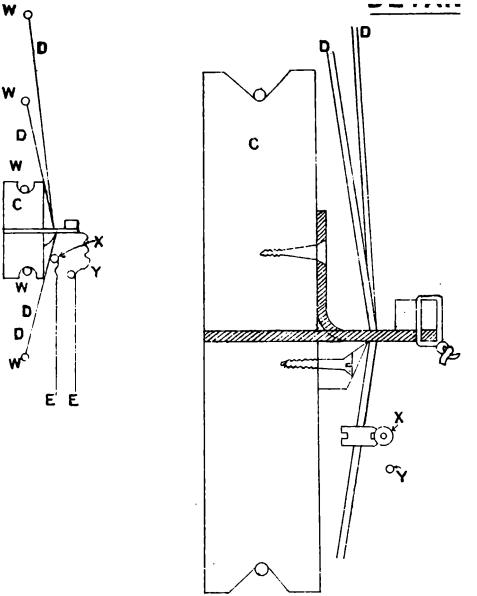
he contact carrier between every

as shown, but not touching



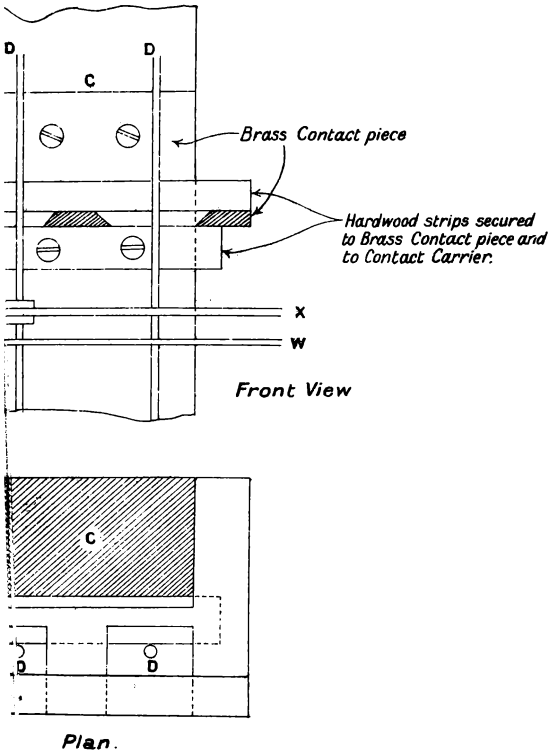
BELL WITH RELAY
(Automatic firing)

To follow pl. XXXVII.



Side View.

ʳING" CONTACT



To face page 76.

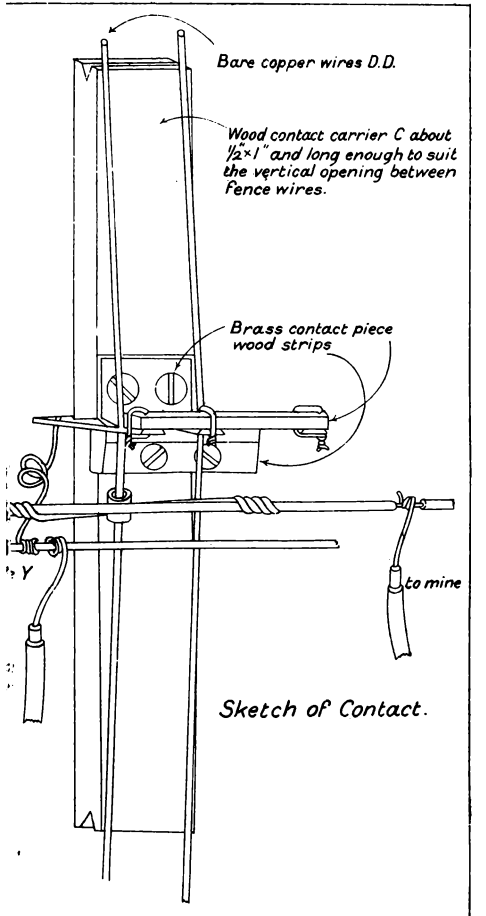
ELECTRIC ALARM

BLOCKHOUSE BELL RINGING CIRCUIT.

From Battery in Blockhouse to fence wire – any fence wire or the electric wire being cut the fence contact to bare g. i. wire thro' mine the covered electric wire X, to bell and back to other pole of battery.

Insulated copper wire, mechanically attached one of the bare copper wires D.

Bare



Sketch of Contact.

OBSTACLES.

BARRICADES

Fig. 1

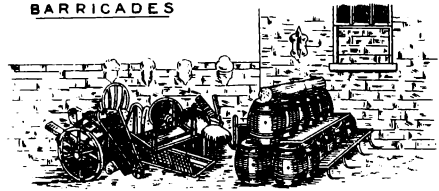
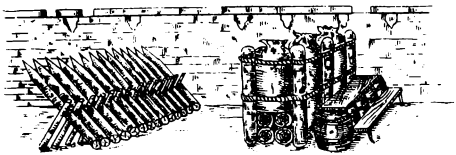


Fig. 2.



PASSAGES ROUND BARRICADES

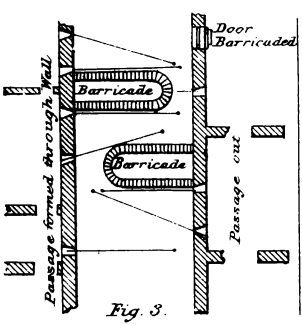


Fig. 3.

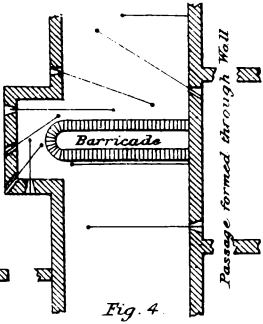


Fig. 4.

Fig. 5. LADDER FOR CROSSING OBSTACLES

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To follow pl. XI

passages must not appear as openings. This can be arranged by making the barricade in two or more parts, overlapping each other, as shown in Pl. XLI, Fig. 3. By placing the barricade at a sharp bend in the road, or where a house stands back from the general line of building, a passage can be arranged round the end of the barricade. One or two lengths of chevaux-de-frise, or wagons made bullet proof, may be kept at hand to close up the openings.

House defence.

233. A house to house defence will usually be arranged in connection with street barricades. The house immediately in advance of the barricade should be held. The best way to stop the enemy's attempt at systematic advance through the houses, is to loophole the party-walls of one house and to block the one next to it on the enemy's side; this may be done either by blowing down with guncotton the floors and ceilings above the lowest storey, or by sawing through the joists and letting the wreck of floors and ceilings remain where it falls. If this cannot be done, the party-walls should at all events be loopholed, and barricades of furniture should be arranged so as to make it difficult for the enemy to attack the defended walls with explosives.

Inundations.

234. When a position is occupied near a stream, the water may sometimes be retained by dams, so as to form an *inundation* in front of the line. When the inundation is to be shallow, ditches of sufficient depth to prevent wading should be cut chequerwise through the ground to be inundated, before damming up the stream. Harrows, &c., may be scattered about, and deep pits dug. The most favourable positions for forming inundations are those where the bed of the stream has only a slight fall, the sides of the valley being regular, and rising rather rapidly; where these features do not exist the work is generally too extensive to be undertaken.

Dams.

In making an inundation the portions of the dam on either side of the stream should be completed first. The soil of which the dam is composed should be impervious to water, otherwise a wall of puddled clay* must be constructed inside it. If there are to be two or more inundations, the materials for each dam should be taken from the lower side, so as to increase the depth of the inundation next below it. The earth forming the dam should be carefully rammed. The chief difficulty is the construction of the part across the bed of the stream; this part must be built as rapidly as possible, since when once the stream is dammed up the construction of the dam must keep pace with the rise of the water. Materials should be collected below the dam on each side of the stream, and as large a working party as possible employed. A bank of earth is first made across the

* Clay is puddled by being well kneaded with a small quantity of water.

opening between the two finished portions of the dam, so as to enable the foundations of the remainder to be put in The thickness of the dam at top should be made equal to the depth of water retained; the slope of the up-stream side is usually made $\frac{1}{2}$, and of the lower side $\frac{1}{1}$.

Waste weir.

235. Unless the surface of an earthen dam be protected, it will soon be washed away by any water flowing over it; a *waste weir* should therefore be made, large enough to carry off the water of the stream. A channel for a waste weir should if possible be cut through the solid ground, clear of the dam, otherwise it must be formed in the dam itself. Such a channel can be made of fascines or hurdles, if planks and timber cannot be procured. The bank near a weir must be well revetted, the revetment extending beyond the foot of the dam on the lower side, so as to protect it from the rush of water over the weir. A double layer of fascines, securely picketted, forms a good revetment. The surface of the weir should be 2 or 3 ft. below the top of the dam, according to the liability to floods. Dams and waste weirs may be constructed of timbers roughly framed together, and covered with a layer of clay (Pl. XLII, Figs. 2 and 3). Sluice gates are occasionally required to drain the inundations.

236. An inundation may sometimes be formed by damming up the arches of a bridge or culvert, as, for instance, where an embankment crosses a valley. But this is very likely to endanger the stability of the bridge or embankment.

Ditches of field works.

The ditches of field works, if sufficiently deep, form a considerable obstacle when flooded. Flooding may be effected by damming up the natural course of a stream and diverting it through the ditches, or by cutting a channel and leading the water into them. This should often be feasible in the case of bridge heads.

Fougasses.

237. *Fougasses* are not, strictly speaking, obstacles, but are generally described in connection with them.

A fougasse proper is a land mine loaded with stones, bricks, &c., and arranged so that when it is fired the force of the charge is expended in driving the stones in a given direction.

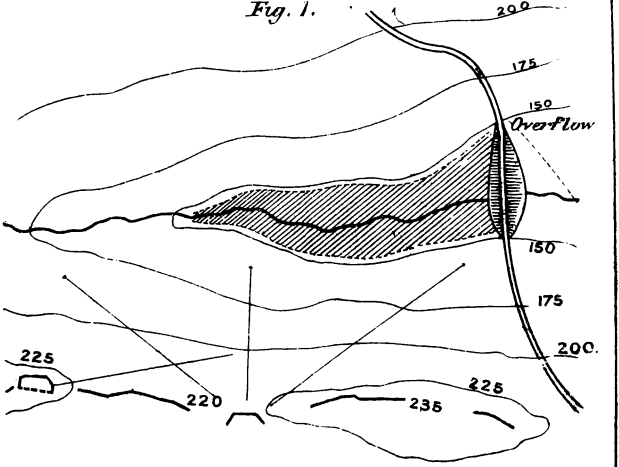
Fougasses may be arranged so that they are automatically fired by the enemy on his approach, but a more reliable system is to fire them by observation. Their moral effect is considerable, and they may be especially useful against troops attacking on a narrow front, as will be the case in a defile. But it must not be forgotten that every explosion of a fougasse will leave a crater that may serve as cover to the attacking troops.

For a stone fougasse an excavation is made in the form of the frustrum of a cone or pyramid, a box of powder is placed in a recess at the bottom, and on the box a wooden platform or

OBSTACLES.

INUNDATIONS.

Fig. 1.



DAMS

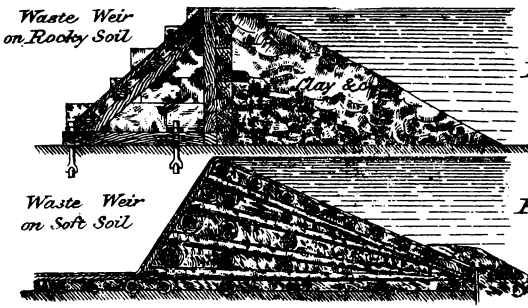


Fig. 2.

Fig. 3

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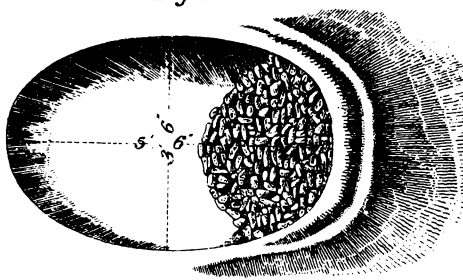
To face page 78.

OBSTACLES

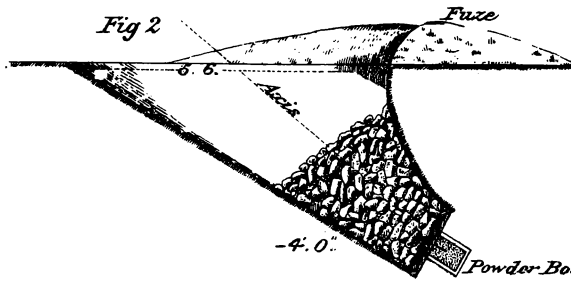
FOUGASSES.

Fig. 1.



Time to dig and load,
2 men 4 hours

Fig 2



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shield 3 or 4 in. thick, over which the stones, &c., are piled. The axis of the cone should be inclined at about 40° to the horizon, varying a little more or less as the ground in front is ascending or descending; the sides should form an angle of about 12° with the axis.

Fougasses may be fired by electricity, or by fuze or powder hose passed through a hole in the box, a groove to receive the wires or fuze being cut in the back of the excavation; this groove will protect the fuze from injury during the operation of loading, which should be performed with great care. Caution is specially necessary when powder hose is used, since this is liable to be fired during the loading of the mine.

A fougasse of the form shown in Pl. XLIII, if charged with 80 lbs. of powder, should throw 5 tons of bricks and stones over a surface about 160 yards long by 120 yards wide.

The *line of least resistance* must be so arranged that by placing the excavated earth on the back edge of the fougasse, at *a*, the powder will act in the direction of the axis, and not vertically.

In easy soil two untrained men can dig out a fougasse (about 350 cub. ft.) in 8 hours—in hard soil in 10 to 12 hours.

A smaller fougasse may be dug out by two men in two hours. With a charge of 30 lbs. of powder and $\frac{3}{4}$ ton of flints or stones such a fougasse has covered by its explosion a space to its front of about 200 yards long and 90 yards wide, the bulk of the missiles lying in an area of 115 yards by 40 yards; with 25 lbs of powder it covered a space about 140 yards long and 90 yards wide.

Land mines are small charges of powder, guncotton, or other explosives, placed on or near the surface of the ground, and fired either automatically or by observation. Their moral effect is great, but they should only be laid and worked by officers having a thorough knowledge of explosives. They possess the same objection as fougasses in forming possible cover for the attack. Land mines.

Passage of Obstacles.

238. Before trying to pass obstacles, such of them as can be injured by artillery fire should be thoroughly shelled, supposing that their positions can be ascertained; if used in sufficient quantity high explosive and large calibre shells may destroy obstacles, but wire entanglements and abatis do not suffer much from field artillery, except that the last named may sometimes be set on fire if the wood is dry or resinous. Destruction by artillery.

An obstacle may be passed either by cutting through or by climbing over it. Cutting through entails a fairly long halt on the part of the attackers, and losses may be heavier than if the obstacle were passed over. But a passage, once it has been cleared, enables the supporting troops to advance more rapidly.

Obstacles of the nature of abatis are difficult to cut through. The trees and bushes composing them must be dragged to one side.

Wire entanglements can be cut through with axes or with wire-cutters

Explosives thrown by hand. Good effect is sometimes, though not always, produced by explosives thrown by hand. Guncotton, on account of the security with which it may be carried under fire, is specially suitable. It should be made up in bundles of 4 or 5 slabs, with the holes for primers vertically over one another. A 1-oz. primer with a No. 8 detonator (see M.E. Part IV) is arranged so that the top of the detonator is below the top of the guncotton. The slabs are securely tied together. The detonator is thus protected from any accidental blow which might cause premature explosion. A charge of 6 lbs. (four $1\frac{1}{2}$-lb. slabs) has completely cleared the wires between four pickets of high wire entanglement.

Ladders. Rough ladders with broad steps made out of pieces of board (Pl. XLI, Fig. 5) are useful for general purposes. They can be used to bridge small ditches, or to surmount escarps, palisades, chevaux-de-frise, wire entanglements, and even abatis. If thrown on high wire entanglements their weight crushes down the wires, the effect being greatly increased if at the same time a few of the pickets are cut through by hand axes. One man can carry a 12 ft. or 15 ft. ladder; but in order to allow for casualties, and to have spare men for meeting unforeseen difficulties, it is well to tell off three men to every ladder (one at each end and one in the centre) and to arm at least the centre man with a hand axe.

Grapnels. Grapnels have been used for pulling down entanglements, but are not very effective.

Selvagees and iron hoops. Spunyarn selvagees, or even iron hoops off barrels, will assist men in passing over palisading where the horizontal bar of the palisading is near the top. The selvagees or hoops are looped over the uprights of the palisade, and act as stirrups for men climbing over.

Straw. Straw makes a good passage, but is too bulky and heavy to bring up in large quantities, and when once used cannot be taken up and carried forward to a second line of obstacles. It should be made up in long bundles not too heavy for a man to carry easily.

Light bridges. When there is plenty of time for preparation, and when it is possible to effect a surprise, light bridges may be used for crossing ditches, &c.

SECTION 12.—COMMUNICATIONS IN CONNECTION WITH DEFENSIVE POSITIONS.

General principles.

239. In preparing a defensive position, the provision of good communications is a most essential point.

Tactical communications, considered specially in connection with defence, should fulfil, as far as possible, the following general conditions:—

(*a.*) *They should be available for use under all circumstances.*

All risks from torrents, inundations, landslips, falling timber, sand, &c., must be foreseen and provided for.

(*b.*) *They should be specially arranged for convenience and rapidity of MILITARY movements.*

Communications between the firing line and the troops in rear should be as direct as is possible without undue exposure.

Provision should be made for free lateral movement of troops along the firing line, or close in rear of it.

Troops should be so posted that when taking up their positions, or when re-inforcing, they shall not cross the line of march of any other body of men.

(*c.*) *They should provide for movement in both directions.*

The width of existing roads and bridges cannot as a rule be quickly increased; all that can be done is to improve the road surface, and to provide crossing-places on roads which are not wide enough for traffic in both directions. In new works, such as causeways over marshes, or clearances through woods and hedges, allowance should be made for movements of troops on as broad a front as possible. The exits from a bridge should always be made wider than the bridge itself.

(*d.*) *They should be concealed from the enemy's observation.*

By using communications concealed from the view of the enemy, a defender both protects his own troops and confuses the attacker. But it may be preferable to have a short portion of the communications exposed to fire, rather than to lose time by making a wide detour. Much may be done by a judicious selection of the routes for communications, taking advantage of folds in the ground, belts of trees,

cuttings, embankments, &c. Exposed portions may be covered from view by screens of bushes or tall corn.

(e.) They should be easily identified and their destination must be unmistakable.

At every road junction, sign-posts should be put up on which are written directions and information as to distances. Rough sketches, drawn on planed wood and showing neighbouring villages, are most useful. Tough paper such as the Willesden paper used in surveying, may with advantage be nailed to sign-posts or trees; on this paper staff officers can write any occasional instructions which may be wanted.

In woods, indistinct tracks should be marked by "blazing" trees. A regular system of blazing must be adopted throughout; for instance, if only those trees are blazed which are on the right of a track when advancing, a man can then at once ascertain in which direction he is going, by noticing on which side of the track are the blazed trees. From each blazed tree it must always be possible plainly to see the next one.

Requirements for infantry.

240. Infantry can cross a ford 3 ft. deep, but it is undesirable that they should be required to wade through water; a number of narrow and light bridges, or even stepping-stones, will obviate this necessity. Troops should if possible be spared the exhaustion entailed by struggling through deep mud, sand or snow, or through reeds, cane brakes, or brush-wood. In marshy places a thin layer of hurdles, fascines, &c., will enable them to pass; in the absence of undergrowth, forest trees do not impede them. Infantry moving on a front of one company require a passage about 40 yards wide.

Requirements for cavalry.

241. Cavalry can cross a ford 4 ft. deep. It requires broader and heavier bridges than infantry, and will founder in soft ground where infantry can pass; causeways across marshes need most careful preparation when they are to carry cavalry.

Since a horse requires more room for movement than a man, cavalry are relatively more impeded by woods than are infantry. On the other hand, since cavalry can make a dash through a narrow defile, such defiles check the advance of cavalry less than that of infantry.

Requirements for pack animals.

Pack animals in general conform to the same conditions as cavalry, but cannot cross so deep a ford. They can be employed where wheeled transport is impracticable.

Requirements for artillery and train.

242. Guns and wagons require a hard surface not less than 8 ft. wide; they can cross fords 2 ft. 4 in. deep. Bridges to

carry them must be very solidly constructed, partly on account of the heavy load, and partly because it may be necessary for guns to cross rapidly.

During a long engagement ammunition wagons and carts will have to return in order to refill, and every precaution must be taken along the roads which they will use, so as to ensure that there shall be no blocking of traffic. On narrow roads extensive crossing-places should be prepared. Although a single vehicle only requires a width of 8 ft., still, when two or more have to pass each other or move abreast, a width of 9 to 12 ft. should be allowed for each.

Railways.

243. Railways can rarely be used tactically for the movement of troops, but a position astride a railway, or in its neighbourhood, has the great advantage that it can be supplied, without much labour and with a fair degree of certainty, with provisions and stores of all kinds, especially when branch lines or tramways can be carried from the main line to minor depôts.

Existing communications.

244. In the case of a position deliberately occupied for defence, existing communications can generally be materially improved; roads can be repaired, bridges strengthened, and wide clearances can be made throughout.

Obstruction of communications to the front.

A force acting on the offensive is confined to the existing lines of approach, or to such routes as can be hastily cleared.

An important part of the preparations for defence consists, therefore, in obstructing existing approaches; at the same time their possible use for an offensive movement must be kept in view. Under no circumstances must any important works, such as railways, bridges, or river walls, be destroyed without the orders of the commander of the defence.

Particular attention should be given to such lines of approach as favour turning movements on the part of the attack. Approaches can be most effectively blocked by the removal or demolition of bridges (see M.E., Part IV) at points where they are least easily replaced, and where there is no other means of passage. In low-lying country the cutting of sea walls or dykes will often render large tracts impassable.

Communications along the front.

245. Communications along the front of a deliberately occupied position will often have to be excavated. In some cases it may be impossible to move troops except along the fire trenches, which for this purpose will have to be made wider than usual.

Telephones.

246. It is desirable to establish a system of telephones between the various commanders, in order to obviate the necessity for sending messengers under fire, and to save time in obtaining information.

SECTION 13.—STOCKADES AND BLOCKHOUSES.

Stockades.

Stockades.

247. Stockades are improvised defensible walls, which, in addition to affording cover to their defenders, form a fair obstacle to an assault. They are only suitable for defences of a purely passive character, and can only be used where not exposed to artillery fire, in country where timber is plentiful, or where railway plant is close at hand. In village fighting, they may be used to barricade narrow openings, but they require time and a comparatively large working party for their construction.

Stockades were formerly most often made of timber alone, and against an enemy armed with a rifle of low penetration, such stockades may still be used.

Against a modern rifle bullet, no practicable quantity of timber, by itself, will make a bullet-proof stockade. The commonest form of stockade consists of earth, gravel or broken stone, between two upright revetments. The necessary thickness will be obtained from the table in para. 12. See Pl. XLIV, Figs. 1 and 2.

Railway metals or iron plates, if available, are useful materials. Types of stockades made of railway metals are shown on Pl. XLIV, Figs. 2 and 3.

It must be remembered that the loopholes through which the defenders deliver their fire should be so arranged that the enemy, if he succeeds in closing with the stockade, will not be able to use the loopholes in his turn. For this purpose it is sufficient that the loopholes shall be 6 ft. above the ground on the enemy's side of the stockade.

Loopholes may be formed of sand bags, or by inserting a plank box in the earth, gravel, &c., taking care to give some splay to the rear in order to admit of lateral range. They should be from 3 to 5 ft. apart, and blinded if necessary. See para. 179.

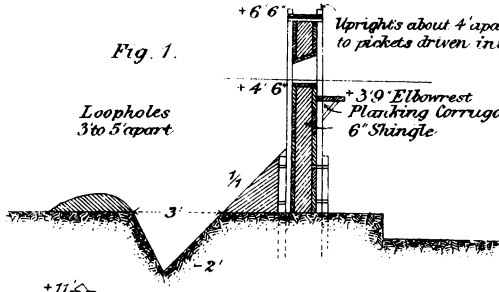
If required, two tiers of fire can be obtained in a rail stockade by arranging a staging of sleepers for the upper rank to stand on, leaving sufficient head room underneath the staging for the lower rank standing on the ground level. In this case there should be a ditch in front as in Pl. XLIV, Fig. 1.

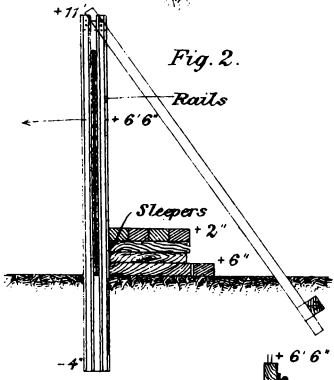
Tambours.

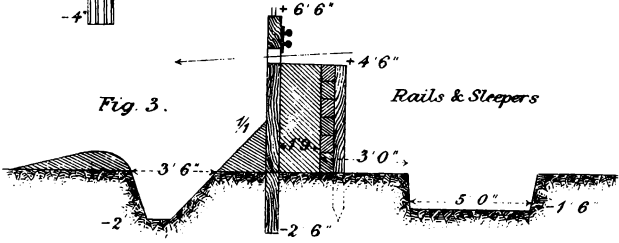
248. In order to flank stockades and walls, projections of stockading, triangular or rectangular in shape, called tambours, are sometimes employed.

Tambours can be arranged for either one or two tiers of fire. One tier is, however, generally sufficient, the loopholes being placed as close as possible, provided that there is room

STOCKADES.

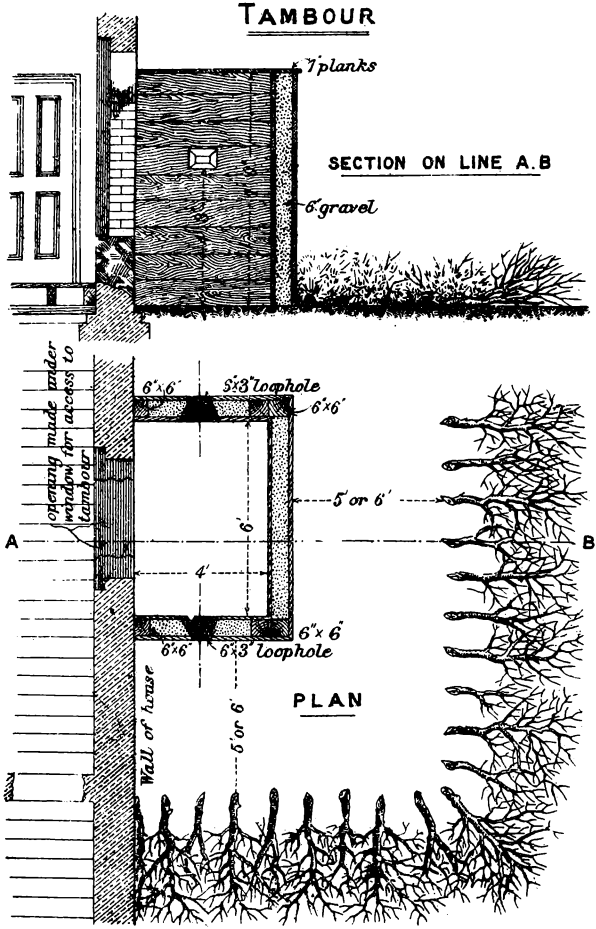






R. I. GRAHAM & SMITH, LONDON E.1

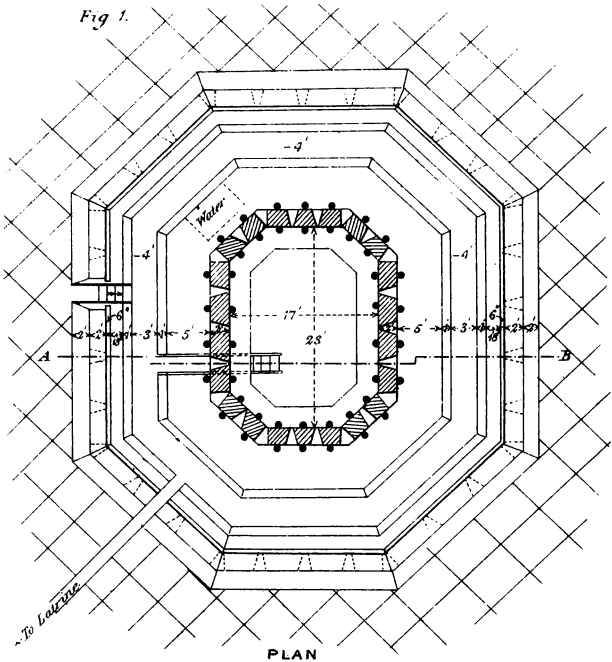
To face page 84



& C. GRAHAM LTD, LITH RS, LONDON, S.E.

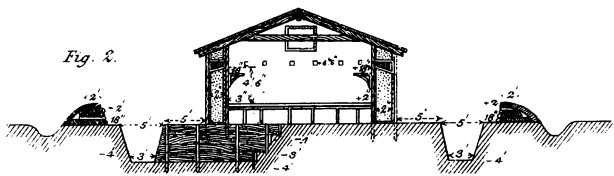
BLOCKHOUSES.

Fig 1.



PLAN

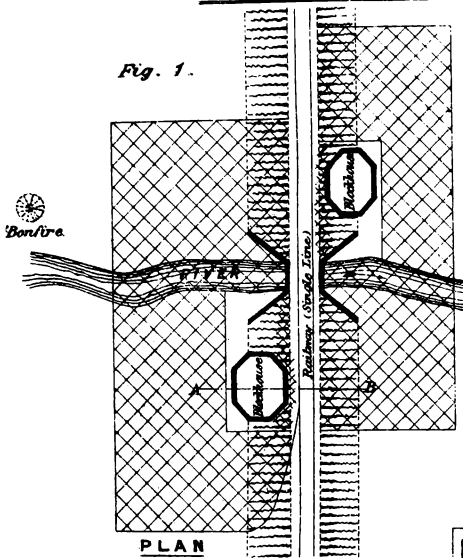
Fig. 2.



SECTION A. B.

BLOCKHOUSES

Fig. 1.



PLAN

Fig. 3.

Fig 4.

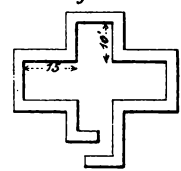
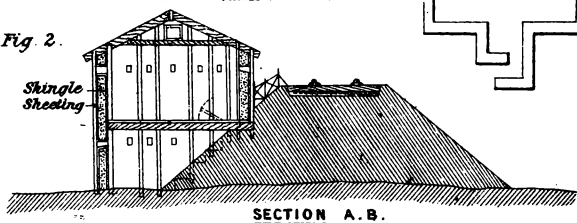
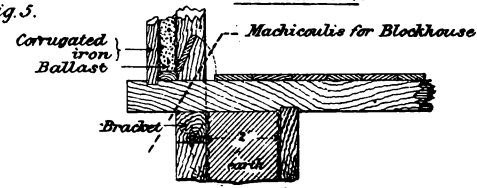


Fig. 2.



SECTION A.B.

Fig. 5.



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To follow pl. XLVI.

to use the rifle. It will be desirable to provide them with a rough roof. They can be advantageously placed so as to flank the passages or entrances leading through walls or stockades.

Pl. XLV gives an example of a rectangular tambour of the smallest size, to take two men.

Blockhouses.

249. Blockhouses are defensible buildings designed to give both shelter and protection to small posts. It is impossible, with the resources ordinarily available in the field, to make them capable of resisting artillery, but they may be very useful against infantry, or against cavalry without artillery. They should, therefore, be buildings whose roofs give shelter from the weather, and whose walls, up to the necessary height, give protection against rifle bullets. It will sometimes be necessary to give overhead cover against descending bullets. For this purpose a ceiling of 3-in. planking might be provided. Blockhouses.

Blockhouses may be used for the protection of picquets guarding mountain roads, bridges, or fords, where guns are not likely to be employed against them. If good fire trenches are used in conjunction with them, they may be held even against guns.

Pl. XLVI, Figs. 1 and 2, shows a blockhouse for about 30 men; the walls are made bullet proof with planks and earth. The trench shown outside supplies the earth for the walls, and will be occupied by the defenders when exposed to artillery fire.

Pl. XLVII, Figs. 1 and 2, shows an arrangement of two blockhouses protecting a culvert on a railway. These are for picquets of about 12 men each. In this case the walls might be of steel plates or iron rails, or of ballast between boards. Blockhouses protecting a culvert.

A wooden hut may quickly be made defensible by building up sand-bags either within or without the walls.

Pl. XLVII, Fig. 5, is a section of a machicoulis arrangement for defending the ground floor of a blockhouse. Machicoulis for blockhouse.

Stone blockhouses are much used in the Balkans. Some of the smaller ones are simply round or rectangular enclosures, for 8 or 10 men, consisting of dry stone walls without roofs. The large ones, for as many as 60 men, are sometimes in the form of a cross. Their walls are built with mortar, they have roofs and sometimes two stories. See Pl. XLVII, Figs. 3 and 4. Stone blockhouses.

250. Blockhouses should be protected by a good obstacle. A barbed wire entanglement is most suitable since it does not obstruct the view of the defenders. Bonfires or flares should be provided for lighting up the foreground. Obstacles and bonfires.

Blockhouses should be well stored with ammunition, water, provisions; there should also be a sunken latrine outside, with a trench leading to it.

A. Pattern.

251. Large numbers of circular blockhouses were erected in South Africa, for the protection of the railways during the war of 1899–1902; they gave entire satisfaction. They were built of sheets of corrugated iron 6 in. apart, fastened to a wooden framework; the space between the sheets was packed with small stones. The loopholes were frames of sheet iron built into the walls. The entrance consisted of a small hole covered by a movable screen of corrugated iron and stones. See Pls. XLVIII, XLIX, and LVII.

In order to obtain a maximum fire effect in any direction, the blockhouse was surrounded by a fire trench. The blockhouse itself was only allowed to be used for close defence. The fire trench served also as a protection for the sentry.

The whole structure could be sent to the required site by train and erected by half-a-dozen men (carpenters and fitters) in a couple of days.

Suggestions for design of stockades and blockhouses.

252. In the construction of stockades and blockhouses, good hints as to design may, in the case of a war against savages, be got from the enemy, who in the course of inter-tribal warfare will most likely have evolved the types of defence best suited for local materials, and for resisting the weapons and form of attack which he will employ against us. Such types, when improved by the light of our own knowledge, modified to suit our weapons, and executed with the aid of good tools and engineering skill, will, as a rule, be suitable for our own use.

On the N.W. frontier of India stone sangars are the rule; in the Lushai Expedition of 1889 bamboo stockades were made; in the Soudan, breastworks of sand and thorn zerebas.

Where railway stations need protection, it can be given by blockhouses, stockades and splinter proofs made of rails; in the case of a bridge the piers and girders can often, with a little ingenuity, be made into good cover.

For types of such defences, see Pls. L to LIV.

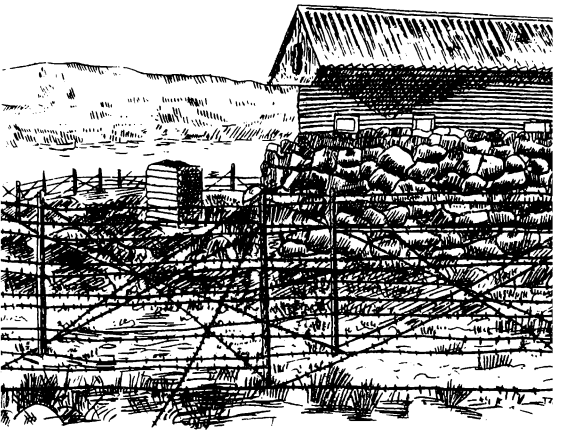
SECTION 14.—DEFENCE OF BUILDINGS.

General Principles.

Effect of field artillery.

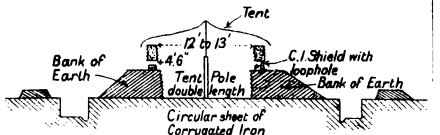
253. Houses, and other buildings standing alone, give very little protection against artillery fire to troops posted inside them; field gun shells can penetrate the thickest walls of ordinary buildings; their fuzes are set in action by striking the wall, and the contents of one shrapnel or common shell may disable all the occupants of the room in which it bursts.

CORRUGATED I

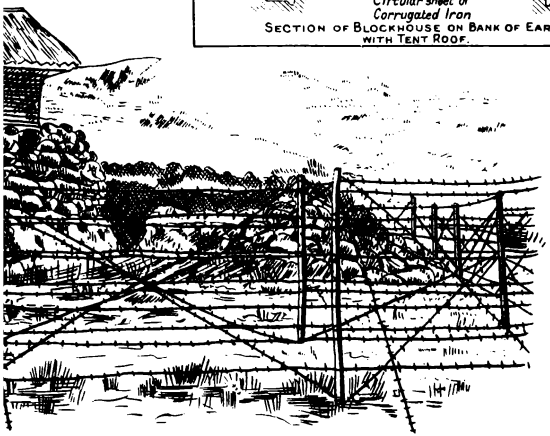


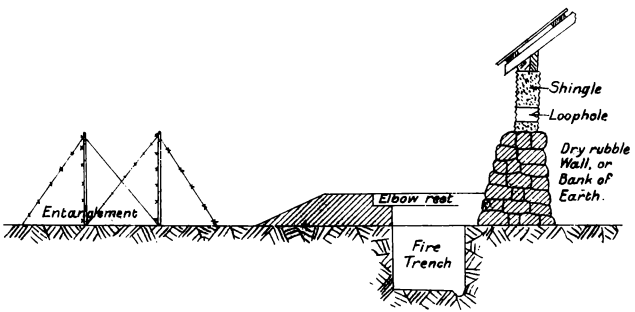
Rubble dwarf wall, or bank of earth. This wall, or bank, supp two corrugated iron skins 4" to 6" apart, packed with hard shin loopholes being provided as shown. Roof of corrugated iron or t the whole structure supported on a wooden frame. Care must b that any of the woodwork frame exposed to fire is adequately pr by shingle. Entrance partly underground, protected by traverse.

LOCK HOUSE.



SECTION OF BLOCKHOUSE ON BANK OF EARTH WITH TENT ROOF.

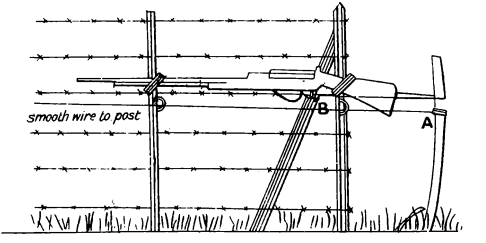




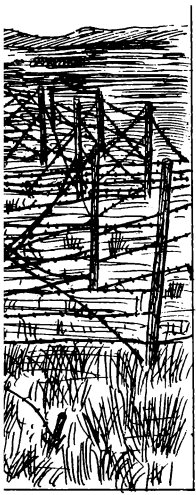
SECTION THROUGH WALL AND TRENCH.

To face page 86.

Corrugated Iron Blo



SIDE ELEVATION



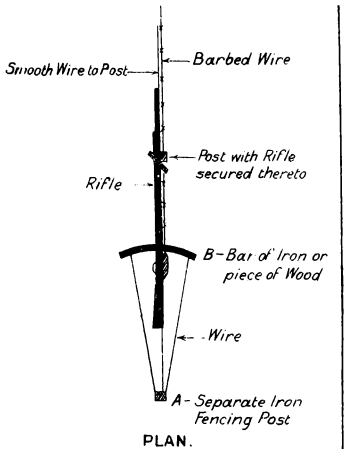


Fig. 2.

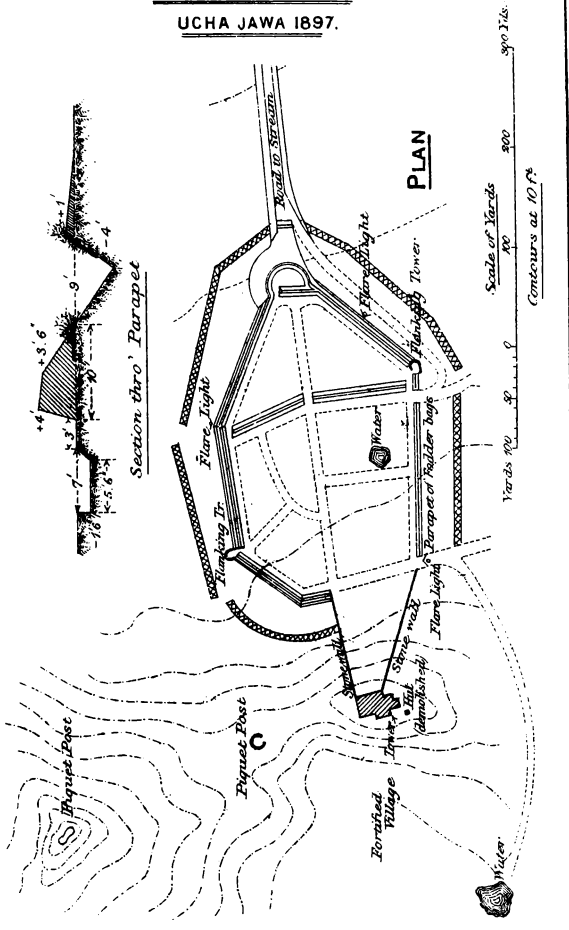
SPRING GUN FIXED TO A WIRE FENCE.

A smooth wire is strained tight to a seperate iron fencing post A. When this wire is cut the post flies back. and acting on the bar B. pulls the trigger.

To follow pl. XLVIII.

DEFENSIBLE POST

UCHA JAWA 1897.



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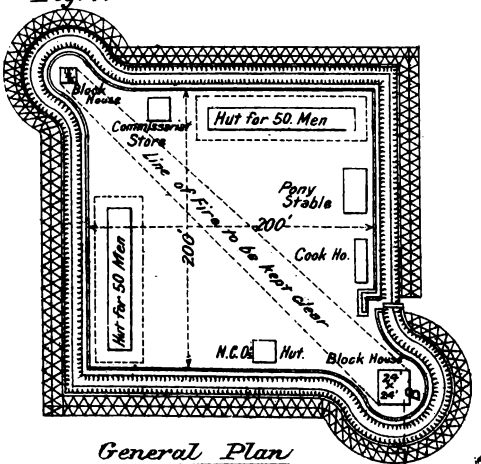
To follow pl XLIX

DEFENSIBLE POST.

BURMA

Fig. 1.



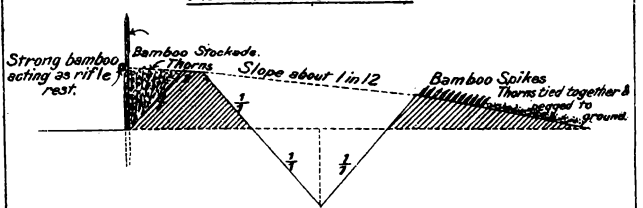
General Plan

Fig. 2.

Section A.B.

Fig. 3.

PROFILE OF STOCKADE



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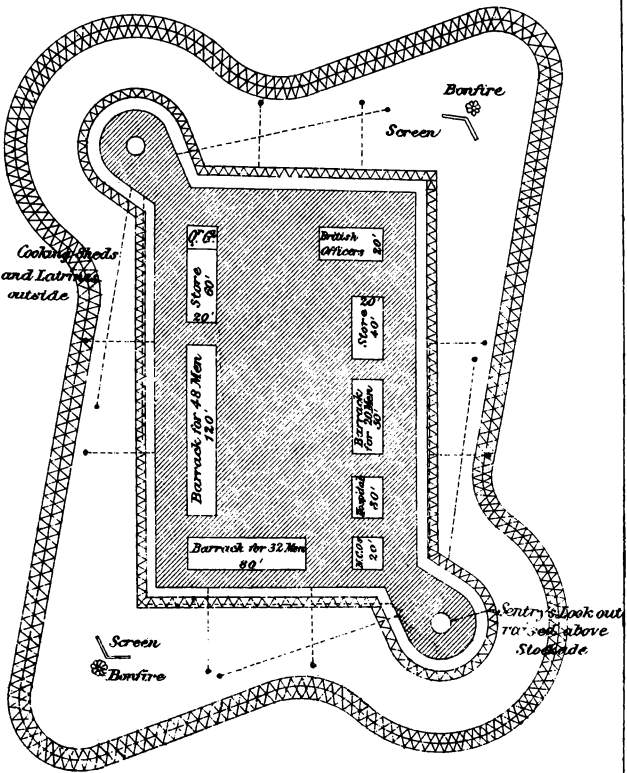
To follow pl L.

DEFENSIBLE POST.

LUSHAI 1889.

For Section, see plate XXXV. *Fig. 1.*



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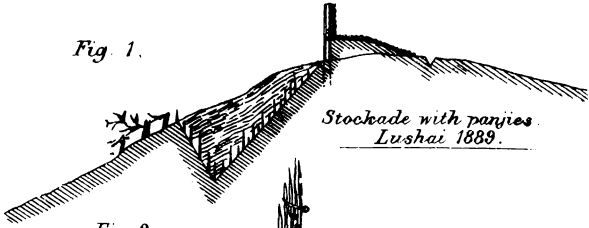
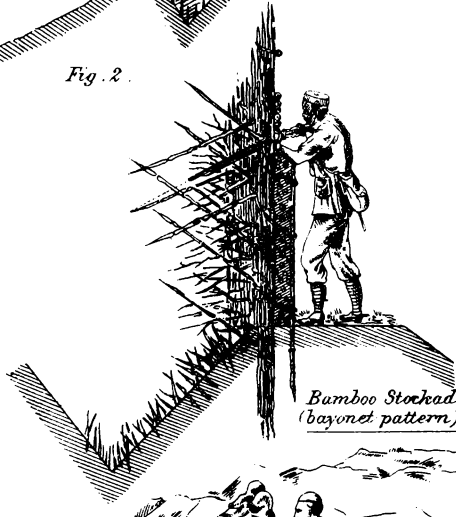
To follow pl. LI.

Fig. 1.



Stockade with panjies.
Lushai 1889.

Fig. 2.



Bamboo Stockade
(bayonet pattern) Lushai '89.

Fig. 3.

Afghan sangar.

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To follow pl: LII.

SANGAR

WITH HEAD COVER

(The men should fire obliquely, so as to get cover from frontal fire)

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To follow pl. LIII.

Men in the back rooms of a large house will have protection for a time, but as soon as breaches are made in the front wall, shells will begin to pass through the breaches and to penetrate the inner walls. In very large houses with many interior walls, troops in the back rooms will be fairly safe, but in such a position they can be of little use.

Field howitzer common shell will make the whole interior of a building untenable from the first. **Effect of field howitzers.**

254. Therefore, when buildings stand alone, in positions where they are exposed to artillery fire, it will seldom be worth while to spend time and labour in preparing them for defence, for during a bombardment they will not be tenable, and after it, the defensive arrangements will for the most part be found destroyed. **Not worth while to prepare exposed buildings.**

It is not, therefore, proposed to consider the defence of buildings against artillery. Houses, farms, &c., standing in a defensive line where they are liable to be attacked by all arms, will still have a certain value, both because they may give cover to troops posted behind them, and because they may have surrounding them walls and other enclosures which will be easily defensible. Again, it will sometimes be possible for troops to occupy them to advantage after the enemy's artillery fire has ceased. When time and labour are available, they may be prepared with this end in view.

Sometimes, on the other hand, it will be best to destroy buildings or to set them on fire, so that they may not be of use to the enemy, but to ensure this result the débris must be carefully scattered, a proceeding which will often involve more time and labour than are available.

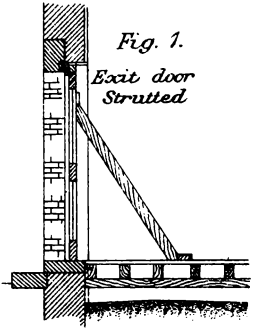
255. When buildings are screened by their position from the enemy's artillery, and are occupied by detached bodies of troops, they may be put into a state of defence, as their value in withstanding close attack is considerable. **Buildings not exposed to artillery fire.**

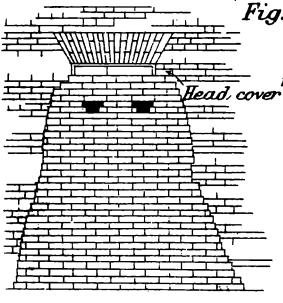
The defence in this case has to take account of only three methods of attack, viz., musketry fire, direct assaults on the openings in the walls, and the lodgment of explosives against the walls. To meet the first it is necessary to clear the foreground, so that the enemy may have little chance of establishing a superior fire against the loopholes. The second must be met by obstacles, by barricades, and, if possible, by flanking fire. The third method will not be commonly employed, as the attacking party will not often be provided with the necessary explosives. It must be met by obstacles and by flanking fire. When flanking fire is impossible, a more extensive use of obstacles becomes necessary, in order to give greater value to the frontal fire.

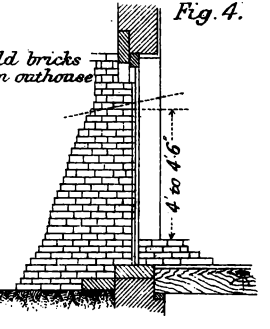
256. The danger of a house being set on fire by shells varies according to the class of building. In a modern fire-proof **Fire.**

DEFENCE OF A HOUSE.

DOORS.







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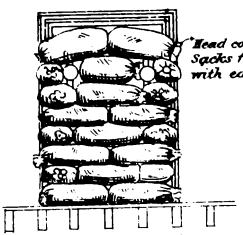
To face page 8

DEFENCE OF A HOUSE.

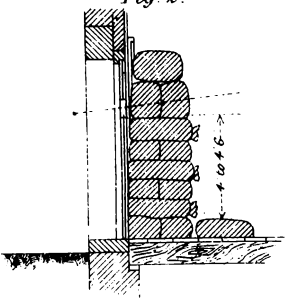
DOORS.

Fig. 1.



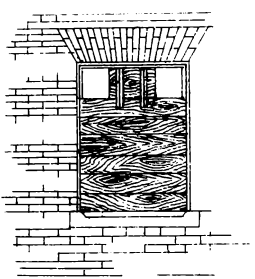
Internal Elevation

Fig. 2.



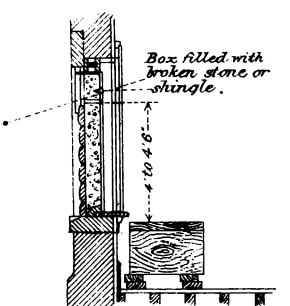
WINDOWS

Fig 3



Planks nailed on outside & inside of Window frame, with shingle, gravel, or broken stone between.

Fig. 4.



C. GRAHAM L^TD LITHO^RS LONDON S.E.

Whilst the details of the defence are being settled, work can be started by collecting gravel and stones from paths and roads, taking up a quantity of floor boards from points where the want of them will least inconvenience the defence, and starting to clear the foreground with a view to collecting materials for obstacles.

When very little time is available, as much as possible must be done in the following directions :— Hasty defence.

(*a*) Clear the field of fire.
(*b*) Barricade the entrances.
(*c*) Provide loopholes.

These measures are all equally important, and should be put in hand together.

Details of Defence.

258. *Doors* may be defended in the following ways (Pls. LV and LVI):— Barricading doors.

(*a.*) Struts or bars which can be removed at will from the inside (Pl. LV, Fig. 1), may be employed to prevent the door from being forced open. Otherwise a cupboard, or wardrobe, or a couple of chests, filled with earth or bricks (Fig. 2) and placed on rollers, may be used to secure the door from being fired through, or burst open. It will not be possible to render the door bullet-proof, and at the same time admit of its opening, unless it can be plated with iron or steel.

(*b.*) A door can be barricaded by placing flagstones or by building a wall of bricks against it on the inside; inside this barricade, and supporting it, place one of the inner doors of the house taken off its hinges, and either strut it, or, if there be a passage leading to the door, secure it by strong bars passed through holes in the walls of the passage. Or bricks may be built up into a rough wall, not less than 1 ft. 6 in. thick, outside the door, as shown in Figs. 3 and 4.

(*c.*) Timbers may be laid horizontally upon one another across the inside of the door; they must be spiked to vertical ribands held at the foot by blocks nailed to the floor, and at the top by struts. The space between the timbers and the door should be filled with stones or shingle.

Other methods, such as that shown in Pl. LVI, Figs. 1 and 2, can be employed according to the material available, care being taken that sufficient thickness is given to ensure the work being bullet proof.

Any door which is reserved for use and not barricaded, should if possible be in a re-entering angle of the building, or so situated that it cannot be fired into from outside. Door reserved for use.

259. *Windows* may be barricaded in a similar manner to doors. Shutters are often of assistance. Barricading windows.

Upper floors. Bedding not bullet proof.

The windows on the upper floors generally require only to be made bullet proof up to a height sufficient to cover men's heads. Bedding was formerly used for this purpose, but is not proof against modern rifle bullets.

Other methods of defending windows, more particularly those on the ground floor, are given in Pl. LVI, Figs. 3 and 4; these show a method which is often feasible, and which can be rapidly carried out, the intervals between the planks being filled with shingle, gravel, or macadam off the surface of the roads. Shields made of two sheets of corrugated iron kept 6 inches apart, prepared with loopholes and filled with broken stone, can easily be adapted to fit most openings in a house.

Loopholes.

260. *Loopholes* should, if practicable, be arranged so as to allow as much lateral range as possible to the fire from the lower floor, and as much depression as possible to the fire from the upper floor. The number and situation of the loopholes will depend on the amount and direction of the fire required. It will be advisable to provide a liberal number of loopholes round the building, even if the available garrison be insufficient to man all sides at the same time. The fire can then be increased in any direction according to circumstances.

The minimum distance apart of loopholes depends on the thickness of the walls and their strength. The ordinary interval is 4 ft., or 6 ft. in the case of thick walls loosely built. In good 9-in. brick walls, it may be reduced to 3 ft. if desirable. Very thick walls, such as those of churches, cannot always be loopholed; the fire must be delivered from the windows and doors, or from the roof. It is desirable that loopholes for frontal fire should not be less than 6 ft. above the ground outside, but flanking loopholes may often be advantageously made near the ground level, so as to avoid undefended space. The floor must be broken away inside so as to allow of men using these low loopholes. Banquettes, which may be necessary on the ground floor, can generally be made with furniture and planks, but must be firm and steady. A commanding line of fire may often be obtained with very little labour by removing tiles or slates just above the eaves of the roof, so that the men may fire over the top of the wall.

Ventilation.

Ventilation and light should be provided by leaving openings at the tops of the windows when barricading them, by making smoke-escape holes through the walls of the top storeys, close under the ceilings, or, in buildings with only one floor, by removing tiles or slates, and breaking the ceiling away if one exists.

Chimneys.

When the building is likely to come under artillery fire, high chimneys should be removed and the bricks made use of elsewhere.

Flank defence.

A good obstacle is generally to be preferred to flank defence,

when the choice lies between them, but a combination of both is always desirable. If it be considered advisable to create flank defence where the plan of the building does not lend itself to the purpose, tambours may be constructed. (See Pl. XLV.)

Existing openings should if possible be used to communicate with tambours. When, however, a tambour is constructed at the corner of a building, an opening must be made in the wall for communication between the building and the tambour.

Machicoulis.

261. In some cases machicoulis galleries may be employed as a substitute for flank defence. They consist of galleries from which fire can be directed vertically downwards, which object is usually attained by loopholing the floor; loopholes so placed have the advantage that they cannot be fired into by an enemy at a distance. They are easily arranged by making the parapets of balconies rifle-proof by hearthstones, bags full of earth, &c. When there are no balconies, a window can be adapted to form a machicoulis gallery, the wall below it being cut away to the floor level. Two beams or strong poles are laid on the floor so as to project 3 or 4 ft. through the window opening, the inner ends being firmly lashed or spiked to the floor joists. Planks are laid on the beams to act as a floor, and a bullet-proof parapet is built round the platform thus formed. One or two men sitting or kneeling on the floor, and protected in front by the parapet, can fire downwards.

Obstacles.

In the defence of buildings, obstacles are always advantageous, especially at night. When suitable material is available, an abatis can be quickly constructed; wire entanglements, palisades, &c., may be employed; existing objects, such as fences, pieces of water, shrubberies, &c., should be turned to account and improved. Small ditches dug outside the doors and windows, being almost useless as obstacles, are rarely worth the labour of excavation.

Ditches of little value.

Passage through obstacles.

The approach through the obstacles to the door reserved for use, should not be easy or direct and should, if possible, be brought under a cross fire.

Line of obstacles to be continuous.

The line of obstacles should be continuous in front of the weaker parts of the building, and should be connected at its ends with the walls of the building, in order that it may not be turned. Obstacles should also be so arranged that the enemy, should he succeed in penetrating to the building at any point, shall be unable to extend close to the walls underneath the line of the defenders' fire.

SECTION 15.—DEFENCE OF VILLAGES AND SUBURBS.

General considerations.

262. Villages have always possessed considerable tactical importance, from the fact that in many cases they can be obstinately defended, even without previous preparation. Their presence in a defensive position is not always to be desired, as they have defects in proportion to their advantages; they require a large number of men for effective defence, and the garrisons are necessarily scattered, so that there is a difficulty in exercising effective command. At the same time, in a civilized country, a village or two will generally be found in or near a defensive position of any extent; since they are difficult to demolish, and on account of the above-mentioned defensive qualities, they should not, as a rule, be resigned to the enemy, it will often be necessary to hold them.

They have in most cases the following advantages. They conceal the strength and dispositions of their garrisons, and of reserves posted in rear of them. They provide shelter from weather for their garrisons, which is valuable in proportion to the time which precedes attack. Their enclosures, such as walls and hedges, will generally offer good positions for infantry defence. Large buildings or groups of buildings in rear of the village, which by their position are not much exposed to artillery fire, can readily be prepared for obstinate defence as a second line of resistance.

When a village has an adequate garrison, it will be useless for the enemy to assault it without previous preparation by artillery. The effect of such preparation will vary according to the class of projectile which the enemy can employ.

Field howitzer shell will soon make a small village untenable, but in a large village this need not be the case. As the splinters are very easily stopped, the damage must chiefly be confined to the points where shells burst. A considerable number of shells are required to destroy any large number of houses, and it must be remembered that the number of available howitzers and the quantity of ammunition will always be limited.

The question of the occupation or non-occupation of a village is one of tactics. Should the village be situated in or near the general line of battle, it will, as a rule, be absolutely necessary to occupy it. If the village be very badly situated for defence, it may be best to throw the line in front of it.

Suitability.

263. The suitability of villages for defence depends upon:—

a. The form and nature of the ground on which they are situated.—The form and nature of the ground should be such

that only a small amount of labour is required in providing a good field of fire, and in assisting freedom of movement for counter-attack.

b. The shape of the village, and nature of the houses, enclosures, &c.—Straggling hamlets lying end-on to the enemy are weak if they project far in front of the general line.

It will often be necessary to abandon the more advanced portions of such a village, and to reduce as much as possible, by burning and other means, any cover that the enemy might utilise.

The question of cover for the defenders is affected as regards amount of protection afforded, ease in preparation, and liability to catch fire, by the construction of the houses, and the materials of which they are built.

The suitability of the enclosures for defence is also a matter of great importance.

General Arrangements for Defence.

General arrangements for defence.

264. In holding villages, whether in the main line or as supporting points in rear of it, every advantage should be taken of the opportunity they offer for obstinate defence. A village remaining in the hands of the defenders, after the line on either side of it has been forced back, is a great help towards the re-capture of the position. Similarly, one or two specially strong points in the village itself may be prepared. They are generally spoken of as "keeps," and will greatly facilitate the re-capture of the village by preventing the enemy from establishing himself firmly. Their garrisons will, as a rule, have orders to hold out to the last.

265. The disposition of the defending troops will entirely depend on the nature and shape of the village. This should be divided up into well-defined sections, each held by a company or companies, half-battalion or battalion, according to size, and each having its own responsible commander, acting under the commander of the whole. The boundaries of the sections should be well marked.

Each section can have two lines of defence, the main line holding the outer enclosures and a second or inner line holding enclosures or groups of buildings nearer the centre of the village.

Under the commander of the village, there will also be a reserve. This may be posted in the village or in rear of it, or part of it inside and part outside, as may suit the form of village and plan of the fight. The reserve must be in readiness to make local counter attacks round the flanks of the village, or to reinforce any section which is hard pressed. The garrison of the keep, if any, will be furnished from the reserve.

Strength of garrison.

266. It is difficult to estimate the exact strength of the garrison, as it will depend upon the form of the village, the time available, and the nature of defence required.

It is most important to prevent the enemy from obtaining a foothold at any point inside the village, since he at once begins to meet the defenders on even terms. To this end the main line of defence must be very strongly held, special attention being directed towards the repulse of any attempt at turning the flanks of the village.

Preparations for Defence.

Organization of defence.

267. In preparing a village for defence the following steps should be taken :—

a. Organize the sections of defence and allot the troops to them.
b. Provide loopholes, if required, for the outer line.
c. Clear the field of fire.
d. Provide for free communication within the sections.
e. Improve cover for outer line.
f. Make obstacles, and barricade the roads. This can be partly done whilst clearing the field of fire.
g. Prepare retrenchments and keeps.

The cover for the outer line, as already explained, will consist mainly of defensible hedges, garden walls, and fences, cover for the supports being provided immediately in rear. The irregularity of form of such enclosures frequently enables certain points in the line to be used as caponiers ; from these a flanking fire can be brought to bear on the assailants should they endeavour to break the line. The first requisite, however, is a powerful *frontal fire* on the principal lines of approach. Trenches with obstacles in front will be used to supplement the enclosures, in accordance with the principles laid down in Section 8.

During the artillery attack, and whilst the enemy's infantry is still beyond effective rifle range, the first line should be kept well under cover. If in trenches, they will be fairly well protected, but behind walls it may be desirable to provide either splinter-proofs or deep trenches, a few sentries being left on the front line to give warning of the enemy's advance.

Obstacles.

Obstacles should be plentifully employed to strengthen weak points. The roads should be blocked within effective range, and barricaded at their entrance to the village, the houses on either side of the entrance being prepared so as to flank the barricades.

Guns.

268. It is generally inadvisable to place guns in a village, because it impairs their mobility. They should be on the flanks, so as to bring an effective fire to bear on the field of attack, and to command the roads and approaches, or they may be placed in rear.

Partial penetration of first line.

269. To make additional provision against the partial penetration of the first line by small bodies of the enemy, short lengths of wall, hedge, &c., which run perpendicularly to, and in rear of, the first line, may be prepared for defence in order to prevent any assailants who may have forced their way in from spreading along the line. Any walls which form the boundaries between sections of the defence should be prepared in this manner.

Nature of second line or retrenchments.

270. The cover for the second or subsequent lines of defence will usually consist of an irregular line of loopholed walls and houses made as impenetrable as possible, roads crossing this line being barricaded. Houses close in front of the second line should be demolished, or their use denied to the enemy by cutting away the floors, clearing the window openings down to the ground, and so forth.

Keeps.

Buildings selected as keeps must be loopholed and barricaded all round.

Communications.

271. The interior communications of the position are of the utmost importance. Communications through the buildings should be arranged, and easy movement along the front of the various defensive sections is essential. Free radial communication is also necessary for the rapid advance of supports and reserves. Finger-posts should be freely provided to prevent mistakes. No communication should pass through the keep.

Fires.

272. If the enemy's projectiles are of a nature likely to cause fires, a party should be told off in each section to extinguish them, water being kept ready at hand for the purpose. In the more important buildings, water and earth should be provided on each floor. Buckets, garden hose, wet blankets, and bags partly filled with earth, should be collected at central positions; if a fire engine be available it should be kept in a sheltered spot.

Machine guns.

273. Machine guns may be advantageously placed behind barricades, to sweep long broad streets. They should be kept at hand, under cover, so as not to be exposed to the enemy's artillery fire during the early stages of the attack.

Hospital.

274. A building selected on account of its strength and sheltered situation should be prepared for use as a hospital.

Time.

275. With adequate working parties, from 12 to 18 hours will generally suffice to place a village in an effective state of defence, but the first line may be organised for a more or less effective resistance in two or three hours, according to the nature of the boundary. Even during the course of a fight, a village may be seized and turned to good account by well-trained troops.

Defence of Suburbs.

General considerations.

276. Owing to the dense population of many countries, it will sometimes happen that lines of defence must run through large suburbs and townships. The conditions here will be found very different from those governing the defence of villages.

Against a village the assailant has the power of concentrating his artillery, but a suburb offers such a wide target that no force can afford the expenditure of ammunition necessary to inflict severe injury.

To hold the outer edge of a suburb will merely bring about the ordinary conditions of village defence, in which, so far as concentration of artillery fire is concerned, the advantage lies with the assailant. It will therefore, be better, in most cases, to hold a line across the centre of the suburb, clearing the houses to the front to a distance of perhaps sixty feet. The field of fire is thus very much restricted, but the enemy will find it difficult to get the range of such a clearing, amidst the mass of roofs which presents itself as a target. By a judicious use of obstacles, and by arranging certain buildings as caponiers to flank the clearing, it should be possible to prevent any of the attackers from coming to close quarters with the garrison. The houses on the enemy's side should have their window openings cut down to the ground, and be as far as possible rendered useless as cover. The assailants may attempt to bring up guns to their side of the clearing, in order to drive out the defenders at point blank range, but the advantage in such a contest should lie with the defence, whose communications and facilities for concealment will be the better.

SECTION 16.—DEFENCE OF WOODS.

General principles.

277. Woods vary so much in character that it is impossible to give instructions for their defence suitable to all cases. A wood may consist in parts of large trees without any undergrowth, and in other parts of tangled brushwood impassable for infantry. With these varieties of natural growth, the ordinary variations of surface must also be taken into account. The ground may have the smooth, even surface that is often found in pine woods, or it may be broken, rocky, and intersected with ravines. It is obvious that under these various conditions the style of defence which is suited to one wood may not be suitable to another.

The protection afforded by woods against hostile fire is not great, but the concealment which they give to troops occupying them is of considerable value, especially to the defence. In all wood fighting, whether in attack or defence, the movement of troops is much hindered by the undergrowth and by the difficulty of maintaining direction, whilst the very limited view makes the exercise of command a matter of the greatest difficulty, and hampers combination of action. In an attack through a wood of average density great confusion is bound to occur, and it will be necessary to rely for success on the individual efforts of subordinate commanders.

Position to the front of a wood.

278. Where the line of defence of necessity follows the general direction of a wood or copse, the firing trenches should if possible be thrown out fifty to one hundred and fifty yards towards the enemy, for the sharply defined edge of a wood is easy for artillery to range on, and the noise of bullets and shell crashing through the branches overhead has a most unsteadying effect. But a wood frequently has a boundary which can with very little labour be made into a good fire trench, and must for this reason be selected as a position.

When the number of the defenders is limited, much can be done towards the defence of a wood by holding some portions of the boundary and entangling the rest.

Position in the interior of a wood.

279. Intrenchments and breastworks in the interior of a wood involve great labour, on account of the interlacing roots.

If no clearing be made in their vicinity, however, fortifications inside a wood will be quite invisible to the enemy's artillery, and under such conditions a strong defence should be made by blockhouses or breastworks. They may be constructed of rough hurdling inside and outside, with 2 ft. 6 in. of earth between, and should be loopholed. Abatis or entanglements must be used to assist them.

280. When time admits of a broad clearing being made across a wood, the defenders' edge of the clearing can be so traced as to enable a small force well entrenched, to sweep the clearing with a flanking fire. This can be readily effected by cutting the edge into a succession of flat bastions. The trees felled in making the clearing can be formed into abatis, and, with the help of machine guns, the defence should be able to prevent any of the attackers crossing a clearing fifty yards wide. The enemy's artillery will find great difficulty in getting the range of such a position.

281. When holding a position in front, or in the interior, of a wood, it will generally be better, supposing time to be limited, to improve the cover and communications of the firing line, rather than to multiply obstacles. A signpost showing the reserves the way to the front may be of more use than a wire entanglement.

Position in rear of a wood.

282. The rear edge of a wood will very seldom be a good line to hold. If the defence of the rear of a wood be more convenient than the front, the best arrangement will be to entangle the rear edge, and to take up a defensive position commanding it and some distance behind it.

283. Another expedient is to cut the rear edge of a wood so as to leave well-defined salients. This will induce the attackers to crowd into these salients, and so make a good target.

284. When holding a position in rear of a wood, the approaches through it must be blocked, and every effort made, by using obstacles, to break up the cohesion of the attack.

Effect of artillery on woods.

285. No reliable data are available as to the action of modern artillery on woods. Concealment apart, the question as to whether troops are better posted in a wood than in the open largely depends upon their fighting qualities. They will suffer to some extent from splinters of wood and from falling branches, but these mostly give slight wounds. A certain number of shrapnel bullets will be stopped by tree trunks and branches. As for high explosive shell, their effect will presumably be no worse in a wood than out of it, though here and there a tree may be brought down; a large number of splinters will be stopped, and the concussion will be somewhat modified.

Felling of large trees.

286. When clearing the field of fire, it must be remembered that no tree should be felled which is too large to admit of removal. Such trees give more cover when down than when standing.

SECTION 17.—DEFENCE OF POSTS AND CAMPS.

Use of fortified posts.

287. A campaign usually entails a line of communication in a country which may be hostile. This line is extremely liable to raids, and must be protected by fortified posts at intervals along its length.

Conditions affecting defence of posts.

288. Two conditions differentiate the defence of such posts from that of an ordinary position:—

(a) It is not always possible to select the position of a fortified post. In many cases it has to be established at some point of importance, even though the ground at that point be unsuitable for defence. For instance the bridges and junctions of railways must be protected, no matter how unsuitable their positions.

(*b*) Every man employed to guard the line of communication is a loss to the field army, consequently the garrisons of posts must be kept as small as possible. Owing to the small numbers of the garrison, the defence of a post must, as a rule, be entirely passive; as many rifles as possible should be in the firing line, and in no case can there be more than a very small reserve.

As regards obstacles, clearance of foreground, &c., the same steps should be taken for the defence of a post as for that of any other position, but the conditions are modified by the above limitations as to choice of ground and strength of garrison. For instance, where a counter-attack is not contemplated, obstacles can be multiplied to the utmost.

Classes of post.

289. A fortified post on a line of communication may be designed to serve either of two purposes:—

(*a*) To protect a definite point such as a bridge or signalling station.

(*b*) To protect a comparatively large area of ground, as must be the case at posts where there is an advanced depôt, a railway junction, or a halting place for convoys; the area protected must be large enough to ensure the safety of the animals, rolling stock, or supplies, which may be collected at the post.

Type of work.

290. The type of work varies with the class of attack to be expected, but always provides for an all-round defence. Against badly armed savages, stockaded enclosures, laagers, or zarebas are sufficient. But against a civilized enemy provided with artillery, it may be necessary to use low command redoubts and deep trenches, with sunken living quarters for the garrisons. Towards the end of the South African war, when the enemy was without artillery and invisibility became of little importance, blockhouses were almost exclusively employed.

Preparation for defence.

As a rule there is ample time for the preparation of a post on the line of communication, and the garrison can be made both comfortable and secure. Since they may have to stand a short siege, provision must be made for a reserve of water, ammunition and supplies; special sanitary arrangements are necessary, to be used when the works are under fire. In these respects each work must be self-contained and independent.

Unless a fortified post be unusually large, the works composing it will be liable to enfilade and reverse fire; dispositions must be made accordingly.

Obstacles, alarms, &c.

291. A good obstacle is one of the most important items in a fortified post. Automatic alarms and flares may also be most useful in case the enemy attempt a surprise by night. See para. 230.

Loophole shields.

Since the fighting may be at very short range, it is advisable to have the more exposed loopholes protected by steel shields. See Pl. XXI, Figs. 1 and 2.

Rifle rests.

On a dark night accurate aiming is out of the question, and it is even difficult to ensure that the men's rifles are pointed in the right direction. In the South African war fixed rifle rests were employed for works flanking an obstacle. By the arrangement shown in Pl. LIX, a number of rifles can be kept permanently pointed at the right spot; only one man, who can keep under cover, is required to load and fire them. A device which answers fairly well is to fasten a wooden bar across the loopholes, so as to prevent men from pointing their rifles too high. When the night is not too dark, it may be possible for men to aim at wooden pickets; these should be painted white on the defender's side, and placed on the correct line of fire at a short distance from the work.

Post protecting a bridge.

292. When a post is intended merely for the protection of a point such as a bridge, the number of works composing it may be very small. In some cases one will be enough. Pls. XLVII, LVII and LVIII show arrangements for defending a railway bridge.

In such posts, since the enemy may approach from any direction, the garrisons live inside the works they have to defend.

Post protecting convoys, &c.

293. A post intended for the protection of convoys, &c., consists of a ring of closed works surrounding the area to be protected.

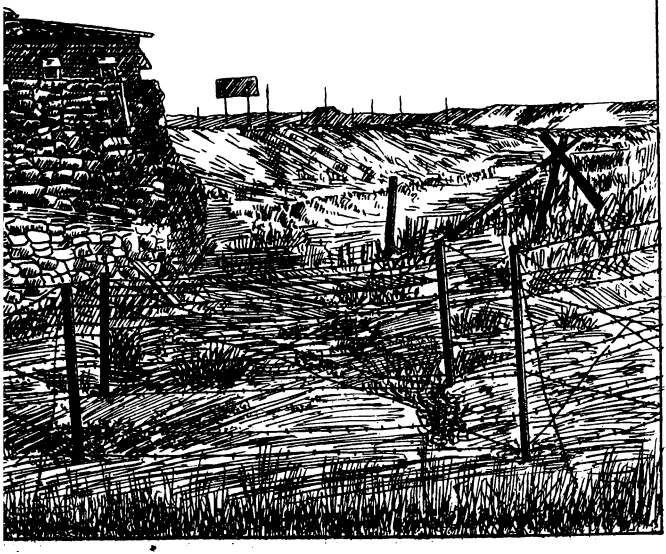
The garrison being of necessity limited, it is not possible to occupy a continuous line of defence, therefore the works composing the post are placed in the best positions for defence, and the intervals between them are, as far as possible, closed by obstacles. The works flank the obstacle with their fire, and at the same time support each other.

The distance of the works from the centre of the protected area should be such that the enemy cannot establish himself in any position whence he can bring an effective fire to bear over that area. But it is generally impossible to prevent long-range firing by individuals at night.

Since the enemy can only approach from outside the ring of defences, it may not be necessary for the garrisons to live actually inside the works, but they must live close by. In the confusion of a sudden night attack, it is rarely possible to reinforce, consequently the works and garrisons must be capable of holding out by themselves, even should the enemy break through the line of obstacles at night and obtain a foothold inside the post. Unless he can capture the works, his position is not likely to be tenable by daylight.

DEFENCE OF

LWAY BRIDGE.



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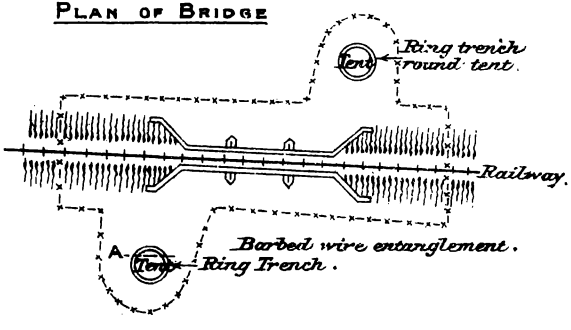
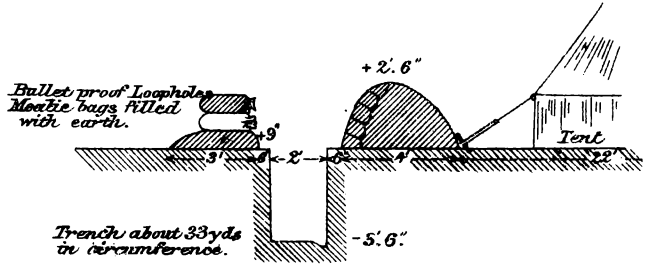
DEFENCE OF A RAILWAY BRIDGE.
S.A. WAR, 1899.





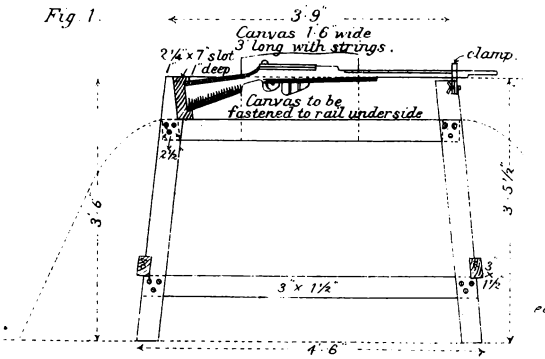
SECTION THROUGH A.

H. & C. GRAHAM LTD. LITH RS. LONDON S.E.

To follow pl. LVII.

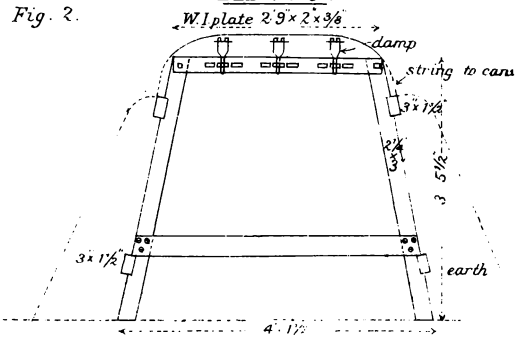
FIXED RIFLE BATTERIES.

Fig 1.



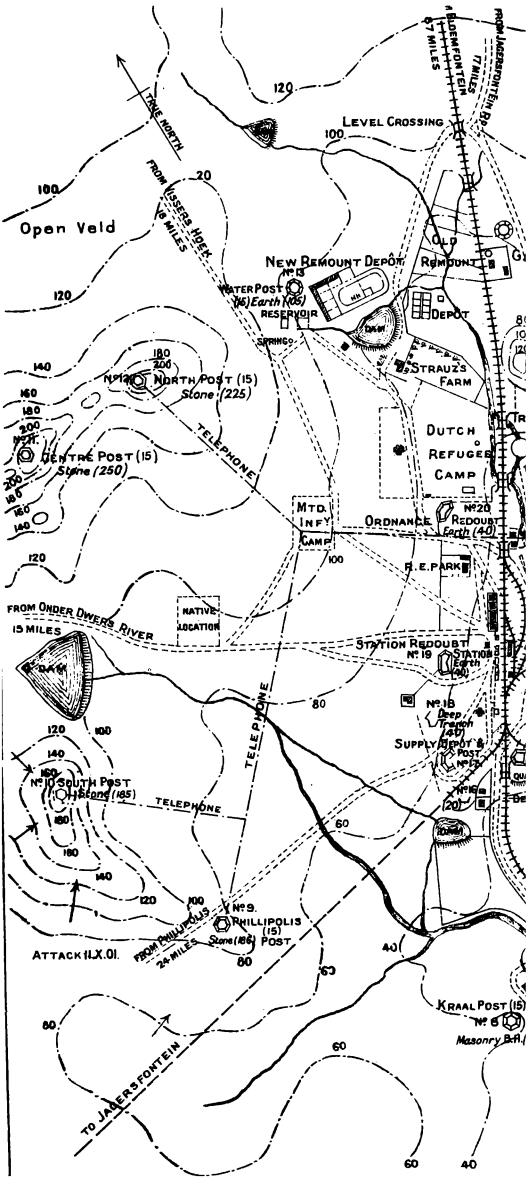
ELEVATION.

Fig. 2.



END ELEVATION.

To follow pl. LVIII.


TRUE NORTH
Open Veld
FROM VISSERS HOEK 18 MILES
120
100
20
LEVEL CROSSING
17 MILES BLOEMFONTEIN
FROM INNERSFONTEIN
NEW REMOUNT DEPOT
WATER POST No 25
(16) Earth (185)
RESERVOIR
SPRINGS
OLD REMOUNT DEPOT
STRAUSS FARM
No 12
NORTH POST (15)
Stone (225)
CENTRE POST (15)
Stone (250)
TELEPHONE
DUTCH REFUGEE CAMP
MTD. INF'Y CAMP
ORDNANCE
No 20 REDOUBT
Earth (40)
R.E. PARK
NATIVE LOCATION
FROM ONDER DWERS RIVER
15 MILES
STATION REDOUBT No 19
STATION
Earth (40)
No 18
Deep Trench (60)
SUPPLY DEPOT & POST No 22
No 16
(20)
No 10 SOUTH POST
Stone (185)
No 9.
PHILLIPOLIS (15) POST.
Stone (185)
FROM PHILLIPOLIS 24 MILES
ATTACK H.X.01.
KRAAL POST (15)
No 6
Masonry B.A.
TO JAGERSFONTEIN
140
160
180
200
220
240
80
60
40

It may be advisable to provide an inner ring of works; these need not be so elaborate as those in the outer ring. They may consist of fortified houses, garden, enclosures, &c., arranged so as to sweep the defended area, and to render it impossible for an enemy to maintain himself there.

A good telephone system should be organized throughout the post.

Defence of Camps.

294. When operating against an enemy who is accustomed to make night attacks, the defence of camps is a most important question. Essentials for camp defence.

There are two essentials for camp defence: the first is a well-defined firing line for the defenders, and the second is a good obstacle in connection with it.

For a small force the first thing to be done on arrival in camp is to mark out the positions to be taken up to repel a night attack. Even if there be only time to do this with a line of stones, it will give the defenders a definite line of defence and something to which they can hold on.

For convenience in camping, troops should generally occupy the same relative positions each night; but this convenience may have to be sacrificed, as it is very important that units should camp close to the ground which they would have to hold in case of attack.

In selecting a camp, regard must, of course, be had to the position of the water supply. This should always be under effective rifle fire, but it must be remembered that a good position against night attacks is the first consideration.

(As to prices in brackets, see top of page 2.)

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WAR OFFICE LIST, AND ADMINISTRATIVE DIRECTORY FOR THE BRITISH ARMY. 1914. *Sold by Harrison & Sons, 45, Pall Mall.* 5*s. net.* (*Under revision*)

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