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MANUAL

OF

MILITARY ENGINEERING.

GENERAL STAFF, WAR OFFICE.

LONDON:
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BY HARRISON AND SONS, ST. MARTIN'S LANE,
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1905.
Price One Shilling.

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H. Buchanan.

This Manual is issued by command of the Army Council for the guidance of all concerned.

E W D Ward

WAR OFFICE,
8th August, 1905.

CONTENTS.

MANUAL OF MILITARY ENGINEERING.

(This book is divided into two parts. Officers should be thoroughly acquainted with the matter dealt with in Part I. Part II contains information useful for reference.

The types of the various works described will vary according to the conditions of time, labour, and material.

Officers and Non-commissioned Officers in charge of works should, while bearing the principles in mind, learn to modify the types according to local conditions.)

CHAPTER I.—PRELIMINARY.

(*See also* "COMBINED TRAINING," 1905, Section 123, and following sections.)

1. The object of fortification is to strengthen ground, and by thus economising the numbers of the defenders, to swell the force available for offensive movements, by which alone decisive results can be obtained. This object is secured by fulfilling, as far as possible, the following conditions :— Objects of fortification.

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

(*b*) The enemy in attacking should be exposed as much as possible to the fire of the defenders during the advance. 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 or to break their order of attack.

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

Shortly stated these principles in order of importance are :—

(a) Choice of ground.

(b) Clearance of foreground.

(c) Concealment.

(d) Provision of cover.

(e) Creation of obstacles.

(f) Improvement of communications.

The above are dealt with in detail in subsequent chapters.

2. A thorough knowledge of the fire effect of all arms is necessary, in order to design good defence works.

Rifle fire.

3. Modern military rifles are sighted to about 2,800 yards. The slope of descent of the bullet varies from about $\frac{1}{30}$ at 1,000 yards to $\frac{1}{2.5}$ at 2,800 yards.

Height of line of fire.

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

Lying down	1′ 0″
Kneeling	3′ 0″
Standing	4′ 3″ to 4′ 6″

These heights must be adjusted to suit different men and varying inclinations of ground.

4. The following table gives the thickness in various materials proof against modern rifle bullets at *point blank* range :—

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

5. The usual projectiles for field artillery are shrapnel from field guns, and shrapnel and common shell filled with high explosive from field howitzers. Field artillery.

Shrapnel can be used from field guns at ranges up to about 6,000 yards.

The slope of descent of the projectiles of field guns varies from $\frac{1}{20}$ at 1,500 yards to $\frac{1}{4}$ at 4,000 yards, but howitzer projectiles have angles of descent up to $\frac{1}{1}$.

6. The penetration of shrapnel balls is considerably less than that of small-bore rifle bullets, but shrapnel with percussion fuzes can be used with considerable effect against troops behind walls. Penetration of artillery projectiles.

Several foreign nations have introduced common shell filled with some high explosive for use with field guns. The special feature of such shell is that, on bursting, they break up into a very large number of fragments which are driven in all directions. They are not so effective as well burst shrapnel.

Field howitzers. 7. Field howitzers, firing common shell and shrapnel, have now been introduced into the service of most nations. They are light pieces of artillery, firing comparatively heavy shell, with low charges at high elevation, and in consequence possess good searching power.

No practicable amount of extemporised cover, except as in Sec. 73, will keep out a howitzer common shell. The effect of the burst is very powerful, not merely from the fragments of the shell, but also from the blast and the fumes of the explosive; but this effect is very local, and slight cover will suffice against the splinters.

Heavy guns. 8. Heavy guns up to 6-inch have been used in the field and will probably be met with in future. They are long-ranging, but their searching power is little greater than that of field guns.

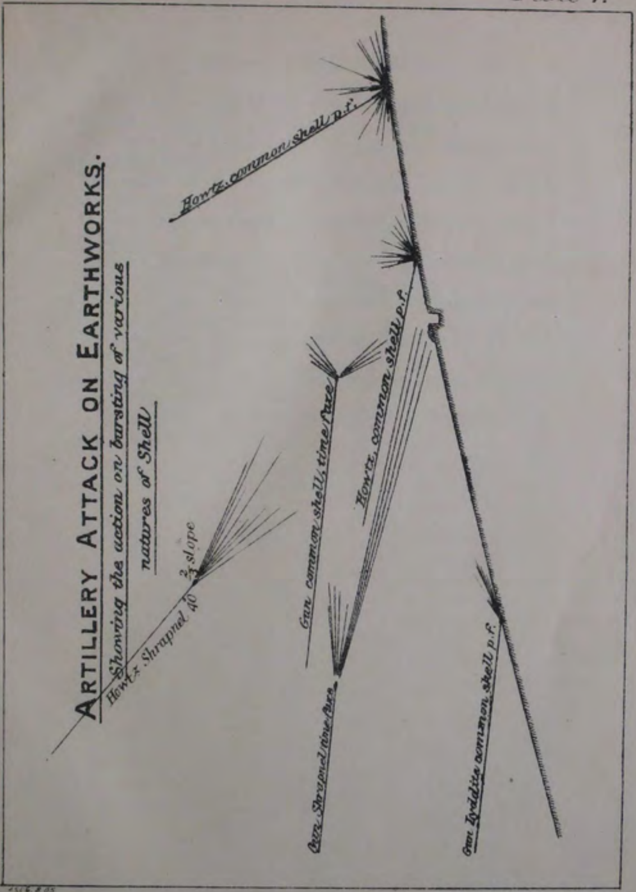
Modern artillery. 9. The object of modern artillery is to reach the defenders of a parapet by means of fragments of projectiles burst in the right position, and not by breeching the parapet with the projectile itself. An occasional shell may strike and penetrate the parapet, but in the case of a shrapnel shell the damage to the parapet will be trifling, while in the case of a howitzer shell filled with high explosive, the effect will be no worse on a thin parapet than on a thick one. Thus it is useless to spend time and labour on making a thick parapet to keep out the actual shell. Against such fire, concealment is of greatest importance.

Plate 1 gives some idea of the effect of bursting shells.

Ranges. 10. The following table (taken from "Combined Training," 1905) gives the various ranges of the different weapons :—

Terms applied to ranges.	Rifle.	Field Artillery.	Heavy Artillery.
	Yards.	Yards.	Yards.
Distant	2,800-2,000	6,000-4,500	10,000-6,000
Long	2,000-1,400	4,500-3,500	6,000-4,000
Effective	1,400-600	3,500-2,000	4,000-2,500
Decisive	600 and under.	2,000 and under.	2,500 and under.

Plate 1.



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Opposite page 8.

The extreme width of the area of ground struck by the bullets of an effective shrapnel is about 25 yards.

The limit of the forward effect of shrapnel at effective range is about 300 yards.

The radius of the explosion of a high explosive shell is about 25 yards.

11. The following terms are used with reference to artillery and rifle fire :— Natures of Fire.

High Angle Fire.—Fire from guns and howitzers at all angles of elevation exceeding 25°.

Frontal Fire.—When the line of fire is perpendicular to the front of the target.

Oblique Fire.—When the line of fire is inclined to the front of the target.

Enfilade Fire.—Fire which sweeps a line of troops or defences from a flank.

Reverse Fire.—When the rear instead of the front of the target is fired at.

CHAPTER II.—FIELD GEOMETRY.

12. Before proceeding to the more technical portion of military engineering, it is as well to understand some of the simplest applications of geometry to the laying out of field defences.

Slopes.

Slopes are usually described by fractions, in which the numerator expresses the height, and the denominator the base of the slope.

Thus, in Fig. 2, Pl. 2, the vertical height, B C, is $\frac{1}{6}$ of the horizontal distance, A B. The slope A C would, therefore, be called a slope of $\frac{1}{6}$ (verbally, one in six).

In Fig. 1, the vertical height B C is four times as great as the horizontal distance A B. The slope A C is called $\frac{4}{1}$ (verbally, four in one, or four over one).

Slopes are sometimes expressed in degrees. A good rough rule for converting degrees of slopes into fractions, or the reverse, is to divide 60 by the number of degrees expressing the slope, the result gives the denominator of the fraction whose numerator is 1, *e.g.*, 5° slope $= \frac{1}{12}$, or 1 in 12 slope.

N.B.—This formula should not be used for slopes steeper than 30°.

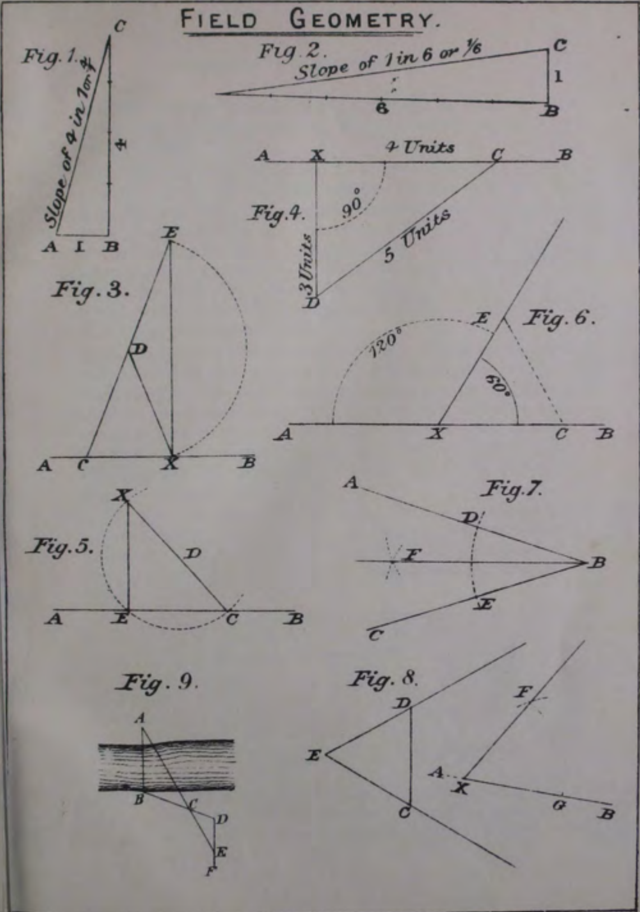
To lay out a right angle.

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

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.

2*nd 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 taught, then C X D is a right angle. This method is founded on the

FIELD GEOMETRY.



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Opposite page 10

fact that in any triangle whose sides are in proportion of 3, 4 and 5, the angle contained between the two shorter sides is a right angle.

To trace perpendicular from a point outside a given line.

14. To trace a perpendicular to a given line from a point outside. 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 longer than the perpendicular will be; fix one end at X, and stretching it taut, swing it round so that the other end shall cut A B in C. Drive in a peg at C, find D, the middle point of C X. With D as centre, swing D X or D C round to the position D E, cutting A B in E. Join X E, then X E is at right angles to A B.

To lay off angles of 60° or 120°.

15. To lay off an angle of 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 from 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.

16. 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 lay out an angle equal to a given angle.

17. To lay out an angle equal to a given angle. Let X be the point in the straight line A B (Fig. 8), 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 given angle D E C.

To find the distance between any two

18. To find the distance between any two points A and B when it cannot be measured directly. From B (Fig. 9) lay off the line B D at any convenient angle, D being at any conpoints when it cannot be measured directly.

venient distance. In B D select a point C so that B C is some multiple of C D. From D lay off the angle B D F equal to the angle A B D, and on the opposite side of the line B D. Make D E of such a length that the point E is in line with A and C.

$$\text{Then } AB : BC :: DE : CD,$$

$$\text{or } AB = \frac{BC \times DE}{CD}$$

as shown in Pl. 2.

CHAPTER III.—INTRENCHING TOOLS.

Tools.

19. The service intrenching and cutting tools are shown on Plates 3 and 4. It is well to note the dimensions, as they are useful in laying out and executing work.

A heavy pick with an 8-lb. head has been sealed, and can be obtained from Ordnance Store if heavy work is expected.

Only a small proportion of spades are carried, as they are of little use in the field. They are employed for cutting sods, and for digging generally when a pick-axe is not required.

Use of tools.

20. For safety the pick must be used working front and rear, and never sideways.

Before striking the pick into the ground it should be raised well above the head with both hands. In bringing it down, the helve should slide through the hand nearest to the head, and the weight of the pick should be employed to help in the work.

The shovel is used right or left handed. Navvies make great use of the thigh in thrusting the shovel under the loosened earth.

In throwing earth from the shovel there should be no jerk, the left (or right) hand must be allowed to slide freely up the handle, otherwise the earth will scatter.

INTRENCHING TOOLS

Fig. 1.

Pick Axe
Head 4½ lbs.
Helve 3½ lbs.

Fig. 2.

R.E. Shovel 5 lbs.

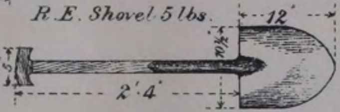


Fig. 3.

G.S. Shovel 3½ lbs.

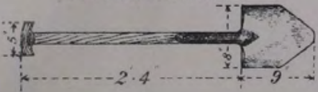


Fig. 4.

Spade Mk III 5 lbs. 10 ozs.

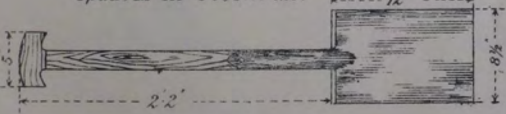
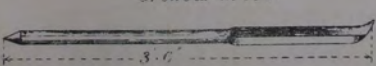


Fig. 5.

Crowbar 12 lbs.



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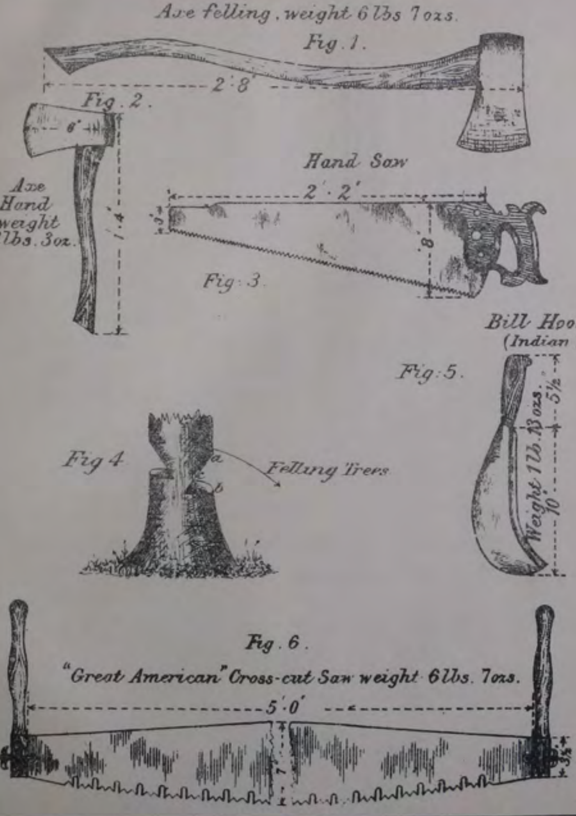
CUTTING TOOLS.



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To follow plate 3.

The following tools will probably be carried in the field by regimental transport, but *see* Field Service Manuals :— Intrenching and cutting tools.

Tools.	Cavalry Regiment.	Field Artillery Brigade.	Horse Artillery Brigade.	Field Artillery Battery.	Horse Artillery Battery.	Royal Engineers.		Infantry.	
						Field Company.	Field Troop.	Battalion.	Battalion, Mounted.
(a) Intrenching Tools.									
Shovels	80	144	98	36	36	100	32	222	220
Spades	—	—	—	—	—	—	2	—	—
Axes, pick	40	55	49	18	18	100	36	148	110
(b) Cutting Tools.									
Axes, felling	32	19	13	6	6	39	22	18	20
" hand	3	—	—	—	—	28	14	12	—
Bill-hooks	48	55	49	18	18	27	16	40	44
Saws, hand	—	54	36	12	12	14	18	2	2
" cross-cut	—	—	—	—	—	4	2	1	1
Reaping hooks	33	12	8	4	4	—	—	20	64
(c) Miscellaneous.									
Crowbars	11	1	1	—	—	8	6	12	8
Guncotton (including primers) lbs.	148½	—	—	—	—	606¼	320¾	—	—

The above numbers do not include wagon equipments.

NOTE.—G.S. wagon with headquarters of an Infantry Brigade carries :—

Picks	80
Shovels	120
Crowbars	12

CHAPTER IV.—WORKING PARTIES AND EXECUTION OF INTRENCHMENTS.

Reliefs. **21.** 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. As regards the length of *reliefs* a great deal depends upon the nature of the work, the total time it will take, and the climate. Also the question must be considered as to 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 hours* reliefs may occasionally be resorted to.

Tasks. A task is the amount of work a man has to do in one relief.

Detail of working parties. Too much pains cannot be taken in the preliminary details 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. Delay and noise is thus avoided, and the chance of confusion during night work reduced to a minimum.

Size of tasks. In ordinary easy soil the average untrained soldier should excavate with service tools (*see* Pl. 3, Figs. 1 and 3) 30 cubic feet in one hour, or 80 cubic feet in a four-hour relief.

If the soil is very easy these rates may be increased, and *vice versâ*; in hard stony ground it may be reduced by 50 per cent.

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

Balancing parapet and excavations. 22. As the earth required for the parapet of a large field work is obtained from the excavations (ditch and trench), the areas of the sections across the parapet and excavation must be roughly balanced.

Pl. 5, Fig. 1, gives an example of a section of a parapet with high command, the successive reliefs (with their tasks) necessary for the execution of the work being shown.

Figures shown thus $\boxed{36}$ denote the area of the excavation or parapet in square feet.

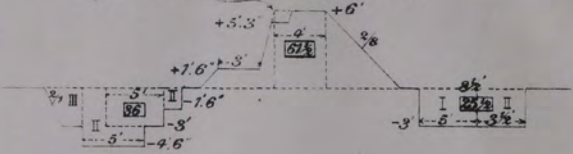
HASTY REDOUBT

BLINDAGE IN REAR OF FIRE TRENCH.

Section thro' Blindage.

BALANCING PARAPET & EXCAVATION.

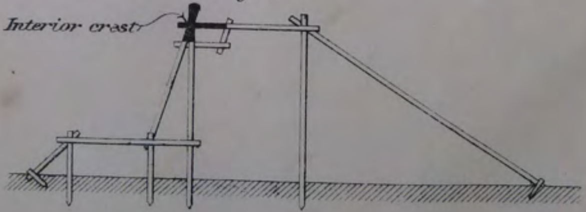
Fig. 1. Crest (for tracing purposes.)



TASKS	TASKS
I *Relief* 75 *cubic feet*	I *Relief* 75 *cubic feet*
II ... ,, ... 71¼	II ... ,, ... 52½ ... ,, ... ,, ...
III ... ,, ... 33¾ ,, ... ,, ...	

PROFILING

Fig. 2.



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23. 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 may be done by a mark on the ground, or by tapes. Tracing.

In hasty defence work tracing with a tape is usually only necessary for night work.

24. When making works of high command, profiles should be put up to guide the construction of the parapet. (*See* Pl. 5.) Profiling.

For high profiles it is best to drive stout pickets into the ground at the position of the verticals, construct the profile bodily to a straight line, lying flat on the ground, and then up-end it, and nail it to the pickets on a level line.

Profiles are laid out at right angles to the crest line. They should be placed at intervals of about 30 feet, two at least being required for each face near the angles.

High profiles should be secured by stays or light guys, or they are liable to be blown down.

25. For all intrenchments the normal distance apart at which the men are spaced for work is two paces (5 feet). This can be reduced, if necessary, to 4 feet, but it cramps the diggers. Organisation of working parties.

Task work is better than working for a fixed time. In arranging tasks it is better to under estimate the men's powers in order to avoid incomplete tasks.

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

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

(2) *If possible*, each relief should leave a vertical face of earth for the next relief to commence upon. For instance, in Pl. 5, Fig. 1, the dividing line between the reliefs is vertical and not horizontal.

26. A party of the necessary strength for the work in hand, including a reserve of one-tenth, having been demanded, should be detailed from a company, battalion, brigade, or division, and not formed of detachments from different companies and corps. Detailing working parties.

The party is then marched to the tool depôt to get their tools, which should be ready laid out, according to the detail of the several parties, either in rows or in heaps, the men in the former case filing on the rows and taking up a pick in the left hand and a shovel in the right, or filing between the heaps and receiving the tools in the same order in passing.

For extending men for work, *see* "Infantry Training," 1905, p. 96.

If the party be large and the work of a complicated nature, such as a redoubt, the men should be divided into detachments, each under a superintendent, corresponding to definite portions of the work, formed in column at some distance from the site, and successively extended along the line, 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 for distributing on the excavations at the angles.

No work must be commenced till the distribution of the whole is complete, as it is difficult to remedy mistakes when work has once begun, the subsequent shifting of men invariably tending to confusion and possibly loss of tools, clothing and accoutrements.

Double manning tools.

When the men available greatly exceed the tools in number, it may be advisable to tell off two men to each set of tools, and so complete the work in about two-thirds of the ordinary time.

Superintendents should be relieved at alternate hours to the working parties, to ensure continuity in work.

When the distance that the earth has to be thrown is too great for the diggers to deposit it in its final position in one throw, shovellers will be necessary as well as diggers.

Methods of executing tasks.

27. Diggers should commence on the *left* of their tasks, in order to incommode each other as little as possible.

In excavating V-shaped ditches the slopes should not be formed until the last relief, rectangular portions being taken out first.

If not under fire the earth first excavated should be furthest thrown.

In making *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 on with the parapet.

CHAPTER V.—MATERIALS.

For approximate time required for carrying out work referred to in this chapter, with labour and tools, see table, p. 120.

28. The materials, which are mostly available for the construction of field defences are earth, stones, timber and brushwood, while railway plant, iron sheeting, wire barbed and plain, &c., may often be obtained. Of these materials earth is the most valuable as well as the most generally used. **Earth.**

For the purpose of field fortification, earth is usually procured from the trenches dug as near as possible to the place where it is to be used.

The steepest slopes at which thrown-up earth will stand is about 45° or $\frac{1}{1}$.

29. Sods are used for revetments and also to form walls in special cases. They should, if possible, be cut from meadows growing thick grass. Each sod should be about 18 inches long, 9 inches broad (these dimensions depending, however, on the width of the spade) and $4\frac{1}{2}$ inches thick. **Sods.**

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

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

31. Timber is used in the construction of bridges, huts, splinter-proofs, stockades, abatis, &c. **Timber.**

Felling Timber.

32. The tools employed for felling timber are the *felling axe*, the *hand axe*, the *cross-cut saw* and the *hand saw* (Pl. 4). Of these the felling axe in the hands of an experienced workman is, probably, the best of all. The hand axe is only suitable for felling small trees not exceeding 12 inches to 15 inches in diameter, but it may be employed with advantage when men practised in the use of the felling axe are not available, as it requires little or no 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. Inexperienced 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 it, the workman should change over to the opposite side and commence cutting about 4 or 5 inches above the former cut until the tree falls. The cuts should be as shown in Fig. 4, Pl. 4, 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 the height of the hip, *b c* should be about three-fourths 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 down timber should be *set* wide.

Cutting brushwood.

33. Brushwood is much used in military engineering for roadmaking and revetting purposes, and for the construction of gabions, fascines, hurdles, &c.

Willow, birch, ash, Spanish chestnut and hazel are the most suitable kinds, and work best if cut when the leaf is off.

BRUSHWOOD.

Method of binding Brushwood

Fig. 1.

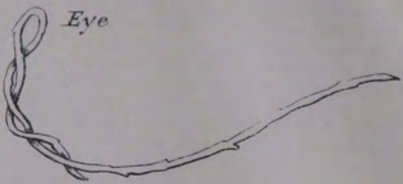


Fig. 3.

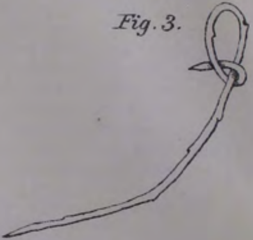


Fig. 2.

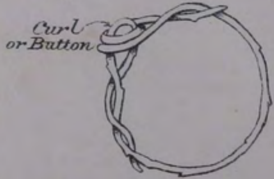


Fig. 5.

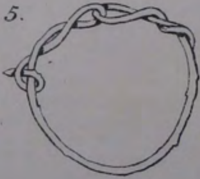
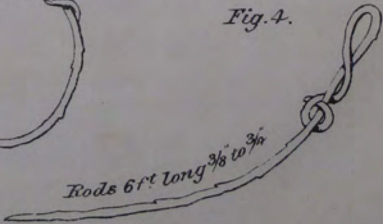


Fig. 4.



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Opposite page 19.

As a rough rule it may be taken that 1,000 square yards of brushwood, 6 years old, make up three G.S. wagon loads.

34. Withes, for binding purposes, in lieu of wire spun yarn, &c., are made of pliable wood, such as willow and hazel. They should be 6 feet to 7 feet long, ¾ inch in diameter, and made pliable by being well twisted, the thin end being placed under the left foot, and the rod twisted with the hands, avoiding kinks. If the rod is stiff a small piece of stick, lashed across the butt, will be of use in twisting it (Pl. 6). Withes.

35. A fascine is a long faggot tightly packed and carefully bound, used in revetments, for foundations of roads in marshy sites, and for many other purposes. The usual dimensions are 18 feet long and 9 inches in diameter. It is made in a cradle of trestles placed at a uniform level (Pl. 7, Figs. 6 and 9). The brushwood, trimmed if possible, is laid in the cradle, projecting about 1 foot 6 inches beyond the outside trestles, and adjusted so that there may be no weak place. Crooked rods must be half sawn through and straightened. Fascines.

The fascine is then gauged with the choker (Fig. 7), which consists of two wooden levers, 4 feet long, connected at 18 inches from their ends by a chain 4 feet long, provided with two gauge rings, 28 inches apart, corresponding to the circumference of the fascine. Choker.

To use it, two men, standing one on each side, place the centre of the chain under the fascine with the short ends of the levers uppermost, cross the levers to each other over the fascine with the short ends down, and bear down on the long ends until the gauge rings meet.

Binding must be commenced at one end. The first binding (of wire, spun yarn hoops or withes) is put on 3 inches beyond the outside trestle, and the remainder (12 in all) at intervals of about 18 inches. This admits of the fascine being cut, if required, into 9 feet or 6 feet lengths. The ends of the fascine are sawn off 9 inches beyond the outside bindings. Binding.

In all cases the fascine must be choked close up to the position of the binding while the latter is being put on.

With withes an eye is formed at the tip, the withe put on under the fascine, the ends brought up, the butt passed through the eye, turned back and twisted round itself (Fig. 5). With withes.

With spun yarn the centre is found and laid on the fascine, and the yarn is then passed twice round the fascine, hauled taut, and fastened off with a reef knot.

Both withes and yarn are apt to perish.

Wire is laid on like the yarn, passed twice round, hauled taut, the ends twisted together and tucked in; 14 gauge is a convenient size.

A piece of hoop iron may be used for binding. It should be 31 inches long, with notches cut at opposite sides, and 28 inches apart. The iron is passed round the fascine, and the notches hitched together (Fig. 8).

Pickets.

36. Pickets are made from brushwood for various purposes. The following dimensions are useful for reference :—

	Length. feet	ins.	Diameter. ins.	ins.
For gabions	3	6	$\frac{3}{4}$	to 1
,, fascines	2	6	$1\frac{1}{4}$	,, $1\frac{3}{4}$
,, fascine cradles	6	6	3	,, 4
,, hurdles	3	6	1	,, 2
,, tracing	1	6	1	,, $1\frac{1}{2}$
,, high wire entanglement ..	5	0	$1\frac{1}{2}$	,, 2
,, low wire entanglement ..	2	6	1	,, $1\frac{1}{2}$
,, sodwork	1	6	$\frac{1}{2}$	,, $\frac{3}{4}$

Gabions.

37. Gabions are cylinders open at both ends, which, when standing on one end and filled with earth, make a strong revetment.

For dimensions *see* Pl. 8.

They may be made of almost any material capable of being bent or woven into a cylindrical form, such as brushwood, canvas, sheet iron, wire netting, &c. Their employment in the future is likely to be more limited than in the past, as revetments are as a rule lower, and so simpler forms of support will suffice.

Brushwood gabion.

38. To make a brushwood gabion, a circle of $10\frac{1}{2}$ inches radius is traced on level ground, and an even number of pickets, usually 10 or 12, driven at equal intervals round the *inside* of the circumference (*see* Fig. 1).

The pickets are 3 feet 6 inches high, $\frac{3}{4}$ inch to 1 inch in diameter, and must be driven with the thick and thin end alternately downwards.

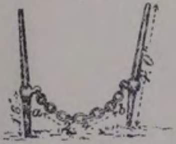
BRUSHWOOD.

FASCINES

Fig. 6.
Fascine Trestle

Stakes
about 6ft long

Fig. 7.



Fascine Choker.

Fig. 8.
31" long Hoop iron Band for binding Fascines

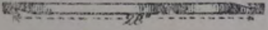
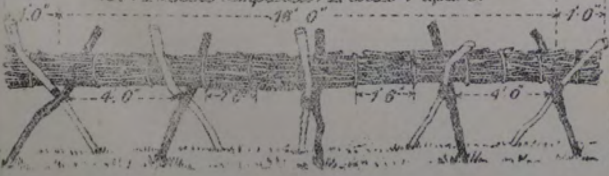


Fig. 9.
18 ft Fascine completed. Trestles 4' apart.



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Opposite page 20.

Plate 8.

BRUSHWOOD.

GABIONS.

Sewn with wire or spun yarn

Fig. 1.

Fig. 2.

Waling

Fig 3.

Pairing

Fig. 4.

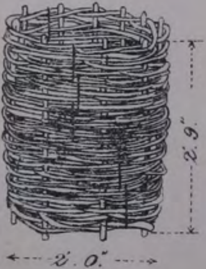


Fig. 5.

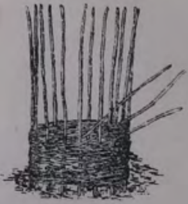


Fig. 6.

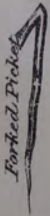
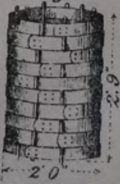


Fig. 7.

Fig. 8.

Fig. 9.



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Opposite page 21.

The web is constructed by a process called waling, as follows:— Waling.

Three rods well trimmed are placed with their butt ends inside three adjacent pickets (Fig. 1). The first rod is passed over the other two, outside the two adjacent pickets, and inside the third, the second and third rods are similarly treated, and the process continued. When introducing a fresh rod in place of one that is coming to an end, the two must be laid together for a few inches and worked as one rod.

The web must be close, even and well pressed down, the dimensions strictly maintained by frequent gauging, and the pickets kept upright and in their proper places, otherwise the gabion will become either crooked or funnel-shaped.

When the web has reached a height of 2 feet 6 inches, two pairing rods are put on as follows:—The rods must be 9 feet long, well twisted (like withes) and pointed at the butt ends, which are driven down into the web at its lowest point on either side of one of the pickets, the rods are then passed alternately over and under each other, and inside and outside the pickets (being well twisted during the operation), and finished off and driven down the web on either side of the picket next beyond that at which the pairing was commenced. Pairing.

The pairing rods are then sewn down to the web at four equal intervals, either with wire, spun yarn, or withes. If the latter are used they should be about 6 feet long and well twisted. The first sewing is placed where the pairing rods are double, the butt end is passed through the web from the outside 7 inches below the top and turned down inside; the withe brought over the top, down inside, through the web above the old place, down outside, through the web again 7 inches lower down, back through the web, clasping the butt end in passing down outside, back through the web another 7 inches down, and finished off with two half hitches round the butt end above the clasping. Sewing.

The gabion is then reversed, pairing rods put on at the bottom and sewn in four places, the sewings alternating with those already put on. A carrying picket must then be driven through the web.

Forked pickets (Fig. 6) driven well down into the web may sometimes be used instead of sewing.

Willesden paper gabions.

39. Willesden paper band gabions are an article of store. Each gabion consists of 10 bands, 3 inches wide, fastened at the ends by two copper clips. (Pl. 8, Figs. 8 and 9.)

To make it, lay a band ready fastened in the form of a circle on the ground. Drive the pickets, 10 in number, round it alternately inside and outside, 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, when they may be pressed down to the bottom, and the remaining seven bands put on. All the joints should be kept *behind* two adjacent pickets. A thin carrying picket can be driven through the web. The top and bottom bands should be nailed to the pickets.

Jones' gabions.

Jones' steel band gabions are still articles of store, but no more will be made. They are made up similarly to Willesden paper gabions.

Hurdles.

40. Hurdles, unless for a special object, are usually made 6 feet long and 2 feet 9 inches high in the web, thus corresponding to the height of a gabion (*see* Pl. 9).

They are useful for revetments, huts and temporary roadways.

A line 6 feet long is marked on the ground, and divided into nine equal parts, and a picket (about 3 feet 6 inches long and from 1 inch to 2 inches in diameter) driven in at each division, the two outside ones being somewhat stouter and longer; the web is then constructed by *randing*.

Randing.

Randing is worked with single rods, and is commenced in the centre (*see* Fig. 1). The rod is taken alternate sides of the pickets, twisted round the end pickets, and woven back to the centre. A fresh rod must overlap by several pickets the one which it supplants.

Pairing rods are used in the centre and at both ends of the web, which is usually sewn top and bottom in three places.

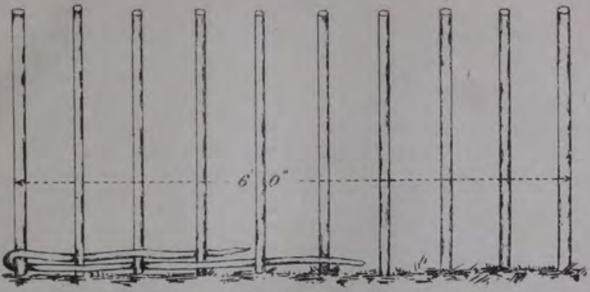
Slewing.

The operation of slewing is the same as randing, two or three rods being worked simultaneously; it makes weaker work than randing.

BRUSHWOOD.

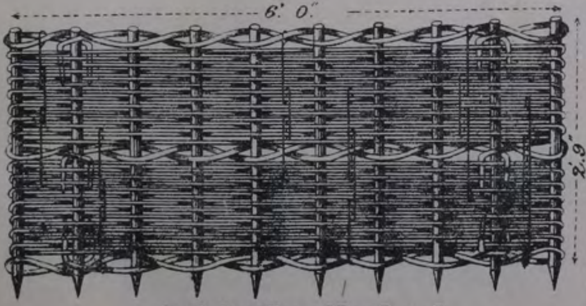
Hurdles.

Fig. 1.



Commencement of a 6ft Hurdle.

Fig. 2.



1 to 2 Bundles of Brushwood
Weight 56 lbs.

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Opposite page 22.

CHAPTER VI.—REVETMENTS.

41. A revetment is a retaining wall used for supporting earth at a steeper slope than that at which it would naturally stand.

The following are the revetments most in use in the field :—

Gabion revetment.

42. *Gabion.*—This is one of the best that can be used when a considerable height of parapet has to be dealt with, but for breastworks gabions are extravagant of material. They are usually placed at a slope of $\frac{4}{1}$. This tilt may be obtained by resting their outer edges on a fascine sunk 3 inches into the ground (Pl. 10, Fig. 1), or in any other way.

For high parapets two fascines are generally interpolated between the rows of gabions, and in this case it is advisable to anchor the gabions with wire to stakes, fascines, or logs buried in the parapet. (Figs. 3 and 4.)

Fascine revetment.

43. *Fascines.*—Fascines make a poor revetment by themselves, and their use is generally confined to revetting steps. They should be well picketed down.

Hurdle revetment.

44. *Hurdles.*—Hurdles form some of the most useful forms of revetment, either in the form of ready-made hurdles, or continuous hurdle revetment constructed simultaneously with the parapet. In either case the slope is built at $\frac{3}{1}$, and frequent anchoring is essential. Stretching of fastenings, &c., due to weight of earth in the parapet, will bring the hurdle to a slope of $\frac{4}{1}$, as shown in Pl. 10, Fig. 7. In continuous hurdlework the web is formed by *randing* or *slewing*, each pair of men having 10 feet or 12 feet of revetment as their task time, $\frac{1}{2}$ to $\frac{3}{4}$ of an hour. They must work in their rods with the men on either side. (Fig. 7.)

Brushwood revetment.

45. *Brushwood.*—This is a rapidly made and useful revetment. Stakes are driven in at a slope of about $\frac{3}{1}$, at from 1 foot to 2 feet apart, and anchored back. As the parapet rises, loose brushwood (or ferns, reeds, straw, &c.) is filled in between the stakes and the parapet. (Fig. 2.)

Sandbag revetment.

46. *Sandbag* revetment is made at a slope of $\frac{4}{1}$ with alternate rows of headers and stretchers (the former with the chokes, the latter with the seams turned into the parapet), breaking joint (Fig. 5). The bags must be laid *at right angles to the*

CHAPTER VII.—CLEARING THE FOREGROUND.

For estimate of time and labour required, see table, p. 120.

51. In most cases a certain amount of clearing will have to be done in front of a defensive position. The object should be to secure for the defenders the full use of their weapons within effective range, while at the same time leaving intact or improving all existing obstacles which would impede the free employment of the weapons of the enemy and obstruct or break up his attack. When an active defence is contemplated (which would be the general rule) the obstacles left should be such as not to interfere with counter-attack. In clearing the foreground, the value of leaving screens to hide the defenders' movements must be considered (*see* Chap. VIII, Sec. 63). **General principles.** **Screens.**

It is difficult to make exact estimates of time required to clear ground, as difficulties cannot be foreseen. The table on p. 120 can only be taken as a rough guide for estimating working parties.

It will be advisable to start the clearing from the position and work forward as time permits.

Hollows and unseen ground, which would give an enemy's troops shelter at points dangerously near the position, may be filled up with abatis, or *debris* of walls, &c.

Large scattered trees give less cover when standing than if cut down, and may sometimes be useful as range marks.

Thick brushwood, especially in the case of some tropical growths, forms a very effective obstacle, which should only be cleared away in accordance with the principles above laid down. Thus, in place of making a general clearance, portions may frequently be left with advantage, both to deny special points to an enemy and to break up his attack, or to compel the adoption of particular lines of advance (the portions cut down may often be formed into an obstacle among the parts left standing).

52. Hedges which interfere with the defenders' fire or screen the attack, must be removed. **Hedges.**

The clearance of those perpendicular to the front is of less importance than that of those parallel to the front.

Walls and buildings.

53. Walls can be knocked down by a part of men using a trunk of a tree or a railway iron as a battering ram. Low buildings may be similarly treated. If high, they must be blown down and the ruins levelled, as far as possible, so as not to give cover.

CHAPTER VIII.—IMPROVEMENT OF EXISTING COVER, STOCKADES, &c.

For time and labour required, see table, p. 120.

Walls.

54. Brick walls 9 inches thick, if badly built, are liable to be penetrated through the joints by small-bore bullets, and can be cut through by short range volleys directed on the same spot. Practically, however, any fairly well built wall will give good cover against musketry. Walls alone cannot be occupied, as a rule, under effective artillery fire, but may, nevertheless, be utilised for defence, after artillery fire has ceased.

A wall between 4 feet and 4 feet 6 inches high can be used as it stands. If a wall is less than 4 feet high, a small trench can be sunk on the inside to gain additional cover.

Between 5 feet and 6 feet in height a wall can be notched. (Pl. 11, Fig. 4.)

Above 6 feet in height, a step must be raised inside, to enable men to either fire over the wall, or through notches, or else the wall must be loopholed (Fig. 5).

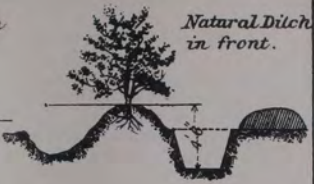
Loopholes.

55. Loopholes should not be closer together than 3 feet from centre to centre, and can be made by means of crowbars or picks. It is desirable to make the opening on the outside as small as possible, to lessen the chance of the entry of the bullets. In a moderately thick brick wall the loophole may be commenced by knocking out a "header" from the outside of the wall, the interior dimensions of the loophole being afterwards varied with the direction in which fire is to be delivered. In actual warfare a rough hole only can generally be formed,

HEDGES.

Fig. 1.

Fig. 2.



WALLS

Fig. 3.

Fig. 4. Elevation of Fig. 3.

Fig. 5.

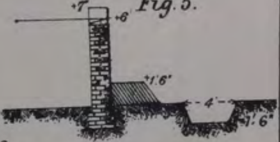


Fig. 6.

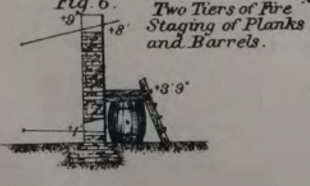
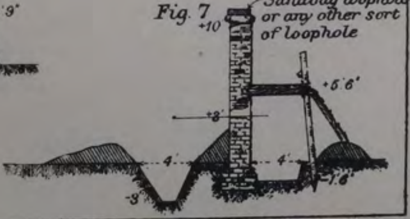


Fig. 7



which should, nevertheless, conform to the conditions above laid down as far as possible.

Figs. 6 and 7 suggest methods for preparing walls for a double tier of fire, which might be used for flanking purposes.

56. In preparing hedges for defence, weak places should be made up with boughs, stakes, wire, &c., and if a ditch is on the defenders' side, little else requires to be done. If not on the defenders' side, something in the nature of a shelter trench may be dug, and the earth thrown up breast high against it when such command is necessary, and if the hedge is strong enough to support it. Hedges.

In no case should excavated earth be thrown in front of the hedge, so as to indicate its occupation.

The time required to excavate such trenches is longer than for ordinary trenches on account of the presence of roots, and the work required to strengthen the hedge.

In preparing a hedge for defence, if the top of the bank on which it stands is not thick enough to keep out bullets, it must be made so.

Hedges sometimes form very good screens for field guns. It would generally be advisable for the guns to be in action about 150 to 300 yards behind the hedge.

57. Embankments are not as a rule good positions for a firing line, because they offer such a good mark to the enemy's artillery, but nevertheless embankments in front of a position and parallel to it, will generally have to be held. Embankments.

Embankments can be defended by occupying the nearer edge, as in Fig. 1, Pl. 12, or the further edge, as in Fig. 2.

The front edge gives the best command of the ground in front, but cover can be obtained with less labour at the rear edge.

58. Either side of a cutting can be defended, according to circumstances (Fig. 3). The rear side gives the best obstacle; the front side is best for a subsequent advance, and secures good shelter for supports. Cuttings.

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

Fig. 4 shows a method of defending a road, the fence or hedge on one side being converted into an obstacle, and that on the other used as cover.

Woods.

Woods.

59. Woods vary so much in character that it is impossible to give general instructions for their defence suitable to all cases. Those which reach down towards the enemy are very dangerous and require special consideration.

The two most important attributes of woods, which are common to nearly all, are the obstacle which they make to the passage of troops, whether in defence or attack, and the concealment they offer. As to the obstacle it is the defenders' business to arrange that it shall cause the least inconvenience to his own, and the greatest inconvenience to the enemy's troops. The concealment afforded should be so utilised as to be almost entirely in favour of the defence.

The front edge of a wood very often has a boundary capable of being easily made into a good shelter, while the materials for abatis are at hand: In order to economise troops, especially if the edge of the wood is indented, portions may be defended while the remainder is entangled; the portions to be defended being those whence the most fire can be developed. The edge of a wood, however, often offers a good mark for the enemy's artillery; for this reason it is sometimes desirable to place the firing line some distance in advance.

Entrenchments and breastworks in the interior of a wood involve great labour and should seldom be used. Where the ground is favourable, clearances in front of interior positions may be made, and the wood cut down made into abatis.

Log breastworks.

Log breastworks, especially of hard wood, will, of course, give a good deal of protection against bullets, even if it is not complete.

If the defence of the rear of the wood is more convenient than that of the front, the best arrangement will be to entangle the rear edge and take up a position commanding it and some distance behind it. The rear edge may be cut so as to leave well defined salients. This will induce the attackers to crowd into these salients and so make a good target.

CUTTINGS & EMBANKMENTS.

EMBANKMENTS.

Fig. 1.

Fig. 2.

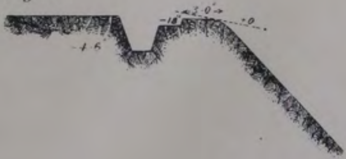
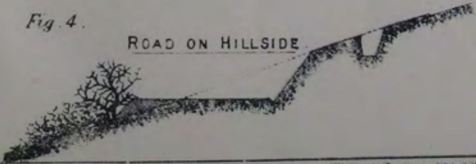


Fig. 3.

RAILWAY CUTTING.

Fig. 4.

ROAD ON HILLSIDE.



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Opposite page 28

DEFENCE OF A HOUSE.

DOORS.

Fig. 1.

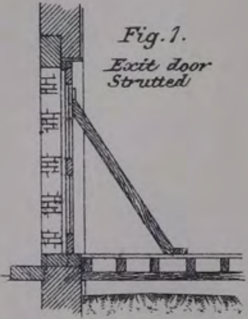

Fig. 2.

Fig. 3.

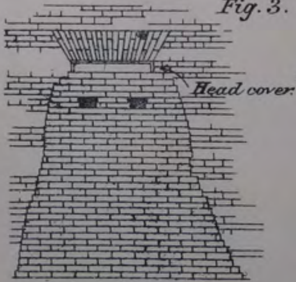

Fig. 4.

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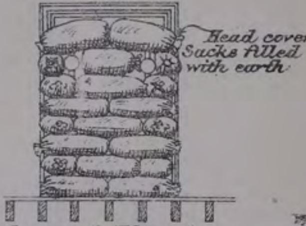
Opposite page 29.

DEFENCE OF A HOUSE

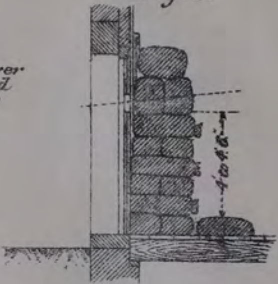
DOORS.

Fig. 1.



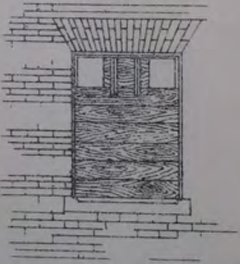
Internal Elevation

Fig. 2.



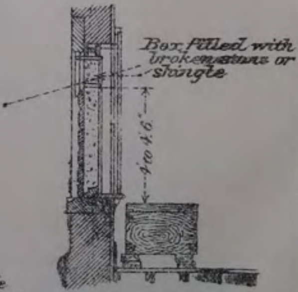
WINDOWS.

Fig. 3.



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

Fig. 4.



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Follows plate 13

Communications through the wood should be improved, if the front is to be held; if the position is in the rear of the wood and the latter is merely to serve as an obstacle, they should be blocked.

In making clearances, large trees should not be felled. Much can be done by judicious thinning.

With limited time, it will generally be best to occupy it in improving the communications rather than in multiplying obstacles.

Defence of Buildings.

60. Buildings can seldom be held under artillery fire. When time and labour are available they may, however, be prepared for defence. When screened from artillery fire they are of great value. Buildings.

The principles for defence of buildings are the same as those laid down in Chap. I, Sec. 1, but the following special points must be dealt with :—

- Barricading of doors and windows (*see* Pls. 13 and 14). (One door should be available for use and must be specially dealt with.) Arrangements for ventilation (usually by upper windows); for storing ammunition, provisions and water; for a hospital and for latrines; and precautions must be taken against fire.
- Any neighbouring buildings which are not to be occupied, should be made useless to the enemy.
- If the building is large and strongly built, and it is intended to make a determined defence, arrange for interior defence by loopholing partition walls and upper floors, and providing movable barricades to cover the retreat from one part of the building to the other.

Stockades.

61. Stockades are improvised defensible walls, which, in addition to affording cover to their defenders, form a fair obstacle to assault. They are only suitable for defences of a purely passive character, where not exposed to artillery fire. Stockades.

The commonest forms of stockade consist of earth, gravel or broken stones, &c., between two upright revetments The necessary thickness will be obtained from the table in Chap. I, Sec. 4 (*see* Pl. 15, Fig. 1).

Rails or iron plates, if available, are useful materials: Types of stockades of rails and sleepers are shown on Pl. 15, Figs. 2 and 3.

62. It must be remembered that the loopholes through which the defenders deliver their fire should be so arranged that the enemy, if he succeed in closing with the obstacle, will not be able to use the loopholes in his turn.

Loopholes may be formed of sandbags or by inserting a plank box in the earth, gravel, &c., taking care to give some splay to the rear to admit of lateral range. They should be from 3 to 5 feet apart.

Loopholes may with advantage be blinded when not in use by an old sandbag or piece of sacking in situations where the nature of the back ground would indicate their position clearly to the enemy.

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.

Screens. **63.** In these days of smokeless powder the value of screens, both for attack and defence, cannot be over-estimated. Much can be done in a close country by judicious thinning or leaving of woods, trees and hedgerows. Where no natural screens exist they can be made. Smoke sometimes forms valuable cover for working parties, especially against search lights.

Sacks filled rather tightly with straw, left open at each end and slit to allow the escape of the smoke, form simple and portable smoke producers. They should be lit in the centre of the straw, so as to burn outwards.

STOCKADES.

Fig. 1.

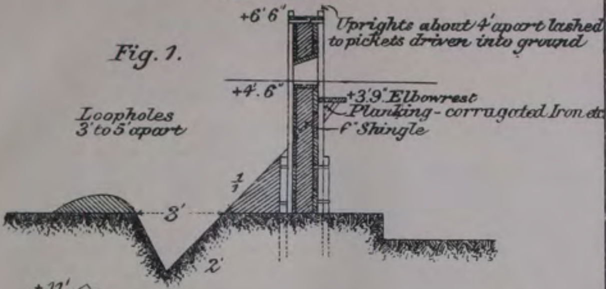


Fig. 2.

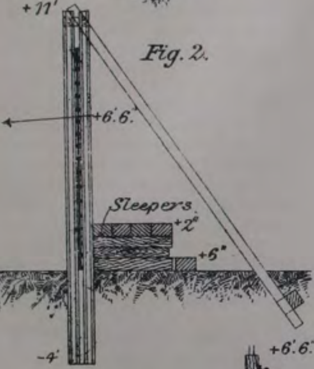
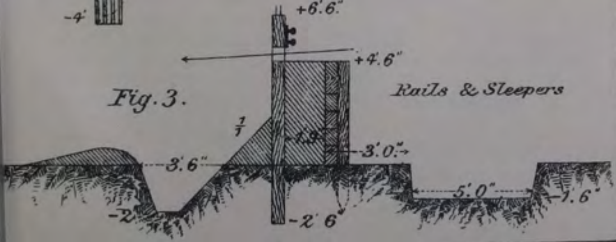


Fig. 3.



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Opposite page 30.

CHAPTER IX.—EARTHWORKS.

64. Earthworks may be classed generally under two heads, viz. :—*Trenches* and *Redoubts*. **Earthworks.**

The defences of an extended position will usually be trenches. They may be disposed in irregular lines arranged mainly for frontal fire, as may be best suited to the ground, or in groups with intervals. The ground sometimes permits of these groups being arranged so as to provide flanking fire for the intervals and front of other groups. In laying out such trenches the danger of enfilade fire must be considered. **Trenches.**

Redoubts will be used principally for isolated positions, such as posts on lines of communication, or a chain of advanced posts watching a long line of front. When placed as supports to the front line of an extended position they must be carefully withdrawn or concealed from view. **Redoubts.**

With all intrenchments invisibility is of the utmost importance, and is almost of as much value as the cover itself. **Invisibility.**

65. Every effort should be made to utilise and improve existing cover in order to save labour and time. On the defensive there will generally be time to make a trench before the attack commences. In attacking across open ground, under fire, men will not, as a rule, be able to stand up and dig. When brought to a halt, they will have to make such cover as they can while lying down, but no opportunity should be lost of entrenching ground that has been gained. **Existing Cover.** **Attack.**

SITING OF TRENCHES—(*See* also "Combined Training," 1905, Section 126).

66. The following points must be considered :— **Siting of trenches.**

A good field of fire; this is most important and should not be sacrificed to any other consideration.

As much concealment as possible, particularly from the enemy's artillery.

Ground in rear suitable for reserves.

When the position includes commanding ground the firing line need not necessarily be on it; it should be in the best position for fire effect. It will often be a good plan to place the firing line at or near the foot of a slope, so as to obtain a grazing fire, with the artillery on the high ground above.

The advantage of high ground for a defensive position is often over-estimated. It need only be high enough to conceal and shelter the defenders' reserves and their movements, and to expose the movements of the enemy.

Arrangement of trenches.

67. The arrangement of trenches should be simple. There should be one main line of defence. Several tiers of trenches may sometimes be useful, to increase the volume of defenders' fire, and also 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 what it is that they must hold on to 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 smaller units, it will be more difficult for the enemy's artillery to get the range.

In tracing a trench attention should be paid to probable enfilade fire.

Every artifice should be used to mislead the enemy as to the positions of the trenches, *e.g.*, conspicuous dummy trenches to draw his fire.

Invisibility.

Invisibility.

68. Every effort should be made to conceal the trench.

Concealment may be gained by (*a*) careful siting, *i.e.*, position. (*b*) Assimilation to surrounding ground. When possible a position should be studied both before and after the construction of trenches from the front, and especially from the enemy's artillery positions. Well-marked features of the ground, such as isolated hedge-rows, lines of road, sharp changes of gradient, or anything which casts a shadow are, at long ranges, more visible than the trenches themselves.

The neighbourhood of such objects forms a target, especially for artillery fire, and should when possible be avoided.

FIRE TRENCHES.

Fig. 1

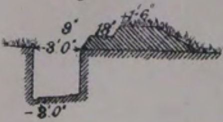


Fig. 3

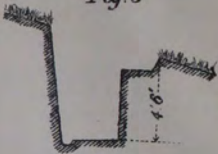


Fig. 2

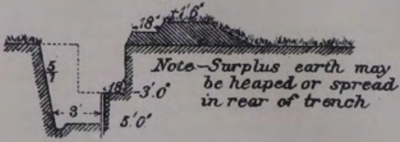
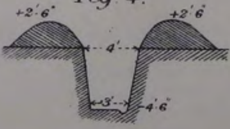


Fig. 4.



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Opposite page 33.

The front of the parapet may be covered with sods or branches, or whatever will make them look like the surrounding ground. Sharp lines must be avoided and attention must be paid to back ground.

If the parapet is on the skyline, spare earth may be piled up behind the trench to make a back ground for the defenders' heads. As a rule, however, a sky line is to be avoided.

The parapet should be kept as low as possible consistent with fire effect; in some cases no parapet is required.

Trenches.

69. Trenches are distinguished as "fire trenches" and "cover trenches," according as they are for the firing line or merely to cover troops not actually engaged. Trenches.

Fire Trenches.

70. The design of the trench will depend on the time and labour available, on the soil and on the siting, but the following points are important:— Fire trenches.

(1) The parapet should be bullet proof at the top; 2 feet 6 inches to 3 feet will usually suffice. But *see* Sec. 4.
(2) The trench should be as invisible as possible.
(3) The interior slope should be as steep as possible.
(4) The bottom of the trench (unless there is a step) should be wide enough to allow men to sit in it.
(5) The interior should be protected, as far as possible, against oblique and enfilade fire, and sometimes from reverse fire.
(6) Drainage should be attended to.

71. Types of fire trench are given in Pls. 16 and 17, but *see* Sec. 3.

Fig. 1 gives good cover against frontal artillery fire, and allows room for the supernumerary rank to pass behind the firing line.

To excavate the normal length of 2 paces of this trench will take an untrained man about $1\frac{1}{2}$ hours, in moderately easy ground.

In specially difficult soil the width may be reduced to 2 feet.

Should time be available, the cover and the facility of communication may be much improved by deepening and widening the trench, as shown on Pl. 16, Fig. 2.

Should a higher command than 1 foot 6 inches be required, to enable the defenders to see the ground in front, the parapet must be heightened with earth obtained from widening and deepening the trench. A firing step, at least $1\frac{1}{2}$ feet wide, is necessary $4\frac{1}{2}$ feet below the top of the parapet, the interior slope of which must be revetted.

Pl. 16, Fig. 3, is a case where the ground in front can be seen without any command, and it is desired to dispense with a parapet for the sake of concealment. The excavated earth must be scattered or removed to form a dummy parapet.

Pl. 44 shows how fairly good cover can be rapidly obtained for men lying down; the trenches can be connected up as shown by the dotted lines.

An elbow rest is a useful feature in a parapet. It increases cover considerably, gives support to the men while firing, and is convenient for ammunition. It should be 9 inches below the crest and 18 inches wide.

Earth thrown up should not be rammed.

Head Cover and Loopholes.

Head cover. **72.** Head cover tends to diminish the number of rifles that can be put in line and reduce the field of view and fire, and generally makes the work more conspicuous, but is of undoubted advantage for protection, especially against shrapnel.

It requires careful arrangement so as to ensure the maximum of fire effect and of invisibility with the minimum of exposure.

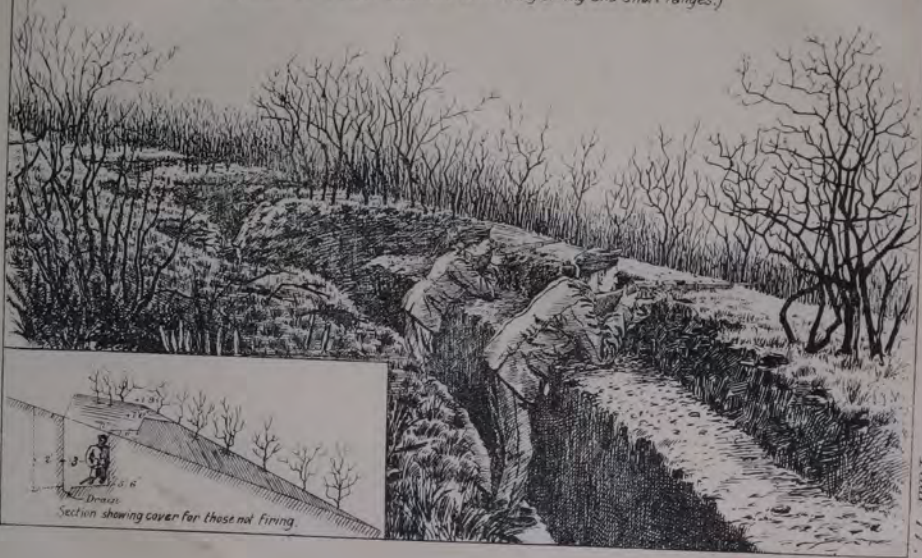
It will usually be obtained by making notches in the parapet for the rifle, or by loopholes.

Loopholes. Loopholes can be made of sandbags, sods, or other materials available on the spot, such as biscuit boxes or sacks filled with

TRAVERSED FIRE TRENCH WITH LOW COMMAND.

TIME REQUIRED $1\frac{1}{2}$ TO 3 HOURS IN EASY SOIL.

(Figures show cover obtainable when firing at long and short ranges.)



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Opposite page 34.

Plate 17.

Head Cover

Sandbag Loophole with Loophole Plates on level ground.

Fig. 1.

Section

Fig. 2.

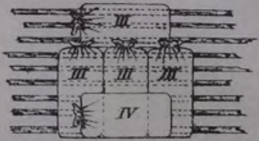
Plan

Sandbag Loophole

Fig. 3.

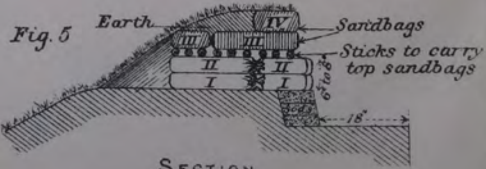
Plan of I & II Courses

Fig. 4



Plan of III & IV Courses

Fig. 5



Section

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Opposite page 35

earth. The size of the openings must be governed by the ground to be covered by fire,* and can best be regulated by testing with a rifle with the bolt removed to ensure that neither line of sight nor line of fire are obstructed.

Sandbag loopholes, as shown in Pl. 18, Figs. 3 and 4, can be made in a continuous line as close as 3 feet 3 inches from centre to centre. **Sandbag loophole.**

Sandbags sag a good deal unless well supported.

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 often a point of great importance.

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 the requirements of the place.

A compromise between the two above methods is shown in Pl. 19, Fig. 1.

A very good form of loophole which has the advantage of giving a wide field of view, is a slit all round the work, continuous, except for the supports of the material above (*see* Pl. 25). **Continuous loophole.**

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

Steel loophole plates, *see* Figs. 1 and 2, Pl. 18, are articles of store. They make the best head cover, but cannot, as a rule, be provided for hasty defence work. **Steel loophole plates.**

Loopholes should never show against the skyline, but should be blinded, say, by canvas hung behind them. The front of the loophole may be masked with branches, long grass, &c.

OVERHEAD COVER.

73. Overhead cover gives the best protection against shrapnel from guns and howitzers. It is especially useful

* The minimum depth of openings for a parapet 2 feet 6 inches thick *on level ground*, using the new service rifle at 2,000 yards range, is, for the inside, six inches; for the outside, four inches.

against oblique fire; 9 to 12 inches of earth, or say 3 inches of shingle, supported by brushwood or other suitable material, will suffice. (Pl. 20.)

Two sheets of corrugated iron sloping to the rear at about $\frac{1}{4}$, afford good protection against shrapnel (*see* Pl. 19.) The corrugations must be parallel to the line of fire.

Overhead cover of above natures will not keep out a common shell, but the effect of a burst in the trench can be localised (*see* below).

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

Overhead cover against weather may be made with branches, corrugated iron, canvas, or any other covering available.

See also Sec. 88.

TRAVERSES.

Traverses. **74.** Open trenches and parapets which may be exposed to enfilade fire and to the oblique fire of artillery, should be traversed and recessed. Traverses are simple means of gaining protection against enfilading shell, and also of localising the effect of a shell bursting in the trench. They are also effective against rifle bullets, on account of their flat trajectory. An irregular line of trench will answer the same purpose, when it suits the ground.

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* Pl. 21. Such recesses are best made after the trench is excavated.

75. Traverses to localise bursts may consist of two walls of brushwood, with about 1 foot of earth between.

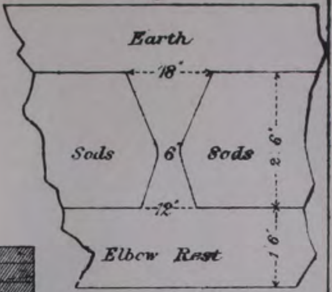
PROTECTED LOOK-OUT.

Look-out. **76.** In all trenches some sort of protected look-out is useful. It should not be distinguishable from the front.

A well-made loophole may suffice for this purpose.

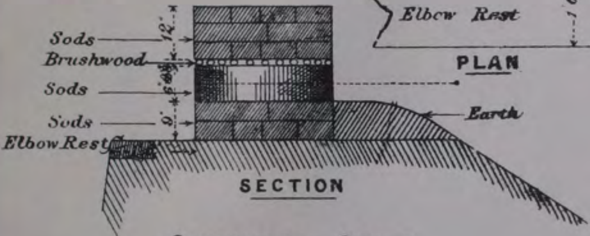
SOD LOOPHOLE

Fig. 1.



PLAN

Fig. 2.



SECTION

OVERHEAD COVER.

Fig. 3.

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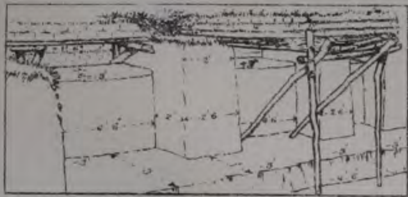
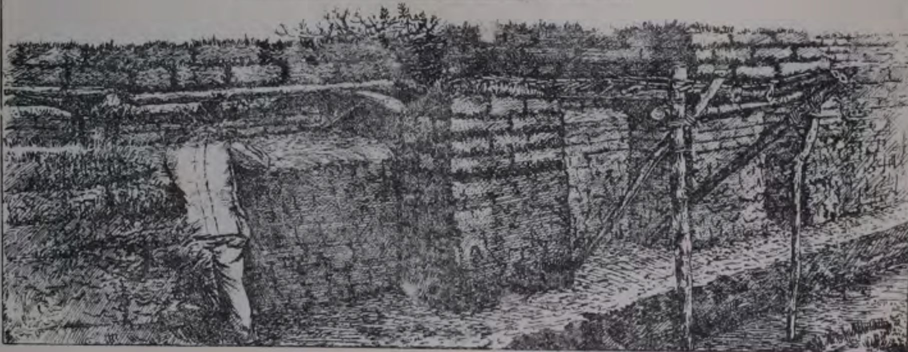
Opposite page 36.

Plate 20.

FIRE AND COVER TRENCH COMBINED

FIRE TRENCH DEEPENED AND OVERHEAD COVER ADDED. TIME REQUIRED IN EASY SOIL 4 TO 6 HOURS





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To follow plate 19.

FIRE TRENCH RECESSED AND TRAVERSED

TIME REQUIRED 3 HRS. IN EASY SOIL.

(Figures show cover obtainable when firing at long and short ranges.)

Plate 21.

To follow plate 20.

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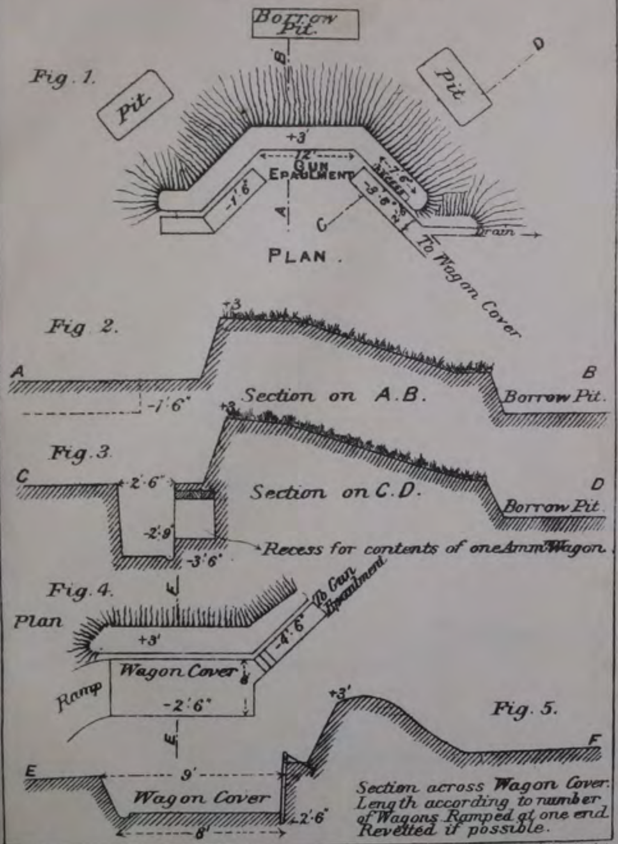
GUN EPAULMENT.



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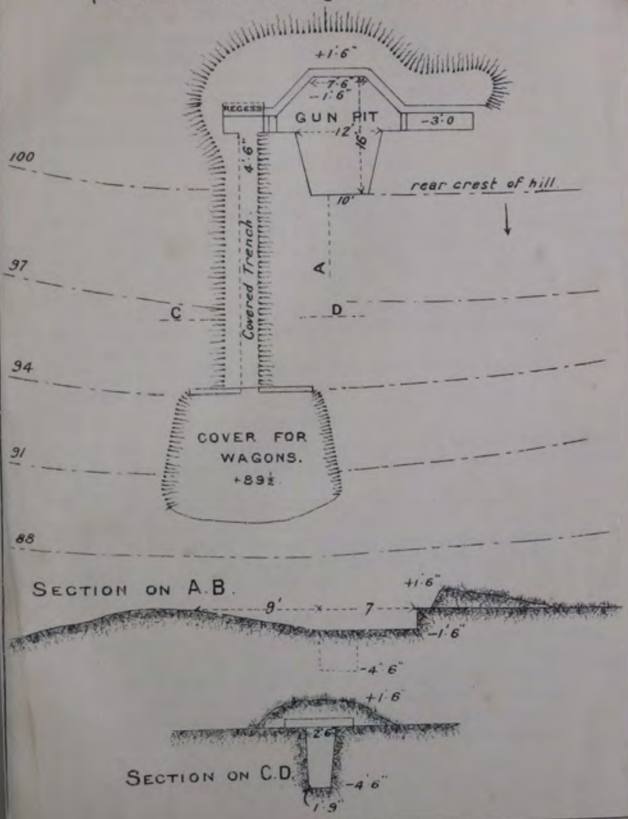
To follow plate 21.

GUN PIT.

(On rear crest with wagon cover in rear).



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To follow plate 22.

Drainage of Trenches.

77. This is an important point, and should be attended to from the outset. A gutter should be formed in the trench, usually at the back, and the bottom of the trench sloped to it. Any water collecting in it should, where possible, be led off to lower ground, otherwise into soak pits, which may be about 2 feet or 3 feet in diameter and 3 feet deep. Drainage.

Communication Trenches.

78. If time admits covered communications should be arranged behind the firing line. These, while concealing the movements of the defenders, will also permit of the firing line being withdrawn altogether while the artillery bombardment is going on. A trench similar to Pl. 16, Fig. 4, will usually suffice. Communication trenches.

It may be necessary to make long lines of such approaches, but every possible use should be made of the ground to minimise labour on them.

They may require parapets on both sides, and where much exposed may be given overhead cover.

Cover Trenches.

79. Cover trenches (*see* Pl. 24, Fig. 1) are useful to protect the firing line during a bombardment, and for troops not actually engaged. Cover trenches.

The section of these trenches may be as in that figure, or, if more time and material be available, as in Pls. 28 and 29. When time is limited and materials are not at hand, a section similar to Pl. 16, Fig. 1, might be employed, but with slightly higher parapet and no elbow rest.

Cover for Artillery.

80. Cover for field guns will take the form of epaulments, or pits, as shown in Pls. 22 and 23. An ammunition recess must be provided close to the gun, and cover for one or more ammunition wagons near the emplacement is also desirable. There should be covered communication between the gun emplacement and the wagons. Parapets to be bullet and splinter Cover for artillery.

proof. The height of the parapet should be regulated by the site and range. Three feet is suitable for medium and long ranges. Howitzers will, as a rule, be in concealed positions, where they can only be reached by high angle fire. If they are likely to be for some time in one position, *e.g.*, in siege operations, they can be surrounded by splinter-proof walls (*see* Traverses).

Field Redoubts.

Field redoubts. Definition. **81.** Field redoubts are works entirely enclosed by defensible parapets. Their dimensions should, as a rule, be such that they could be constructed in from 12 hours to 24 hours.

Employment. It may be generally laid down that redoubts in defensive positions must not, under ordinary conditions, be used on sites where they can be recognised as redoubts by the enemy: This will, as a rule, prevent their employment in the front line, although irregularities of the ground, &c., may shelter certain portions of this line where redoubts may find place. A redoubt has greater resisting power against infantry than a group of trenches.

As supporting points in rear of the front line, redoubts will more often be employed. In such retired positions there will generally be sites which, while commanding the foreground, will not be exposed to view from a distance.

It should be remembered that a redoubt does not necessarily need a high or thick parapet; a fire trench parapet may suffice.

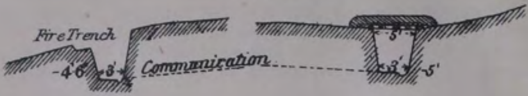
Detached posts. **82.** Redoubts may have to be used for detached posts, and posts in lines of communication. Such works will often have to be a refuge, shelter and depôt for passing troops, and room inside must be given. It will hardly be possible to make these works invisible, as it is essential that the parapets should conceal the interior from view. Plenty of splinter-proof cover should be provided, and a good obstacle near the parapet is essential.

Trace. **83.** The plan or trace of a redoubt will depend on—

(*a*) Fire effect required from it.
(*b*) Configuration of the ground.
(*c*) Proposed garrison.

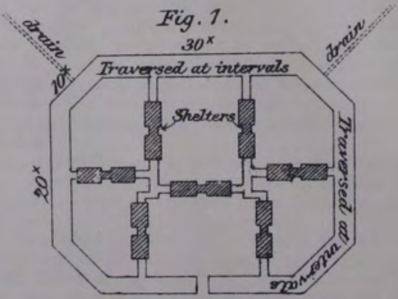
COVER TRENCHES

Fig 1.



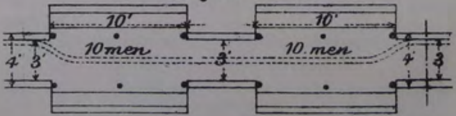
REDOUBT (LOW COMMAND)

Fig. 1.



General Plan

Fig. 2.



Plan of Shelters.

PORTION OF LOW COMMAND REDOUBT

WITH HEAD COVER AND TRAVERSES.

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To follow plate 2

84. The site should be such that the surrounding foreground may be well swept by the fire from the parapet, and the work should be so disposed as to give the strongest possible fire on the enemy's best lines of attack. There must be no dead angles. Site.

A redoubt may be of any shape that suits the ground and provides good firing lines. There is no necessity for symmetry in the design, although it has advantages. On a level site a rectangle with blunted angles would be suitable.

All faces should be long enough to give an effective fire. Those making a considerable angle with neighbouring faces, as in a rectangle, should not be less than 20 yards long, and the short faces which blunt the angles should be at least 10 yards.

It is often convenient to use curved faces. These, as a rule, should be struck with a radius of not less than 20 yards. A complete circle should be avoided, except for very small posts, as its fire is weak in every direction.

85. The garrison should always consist of one or more units of command. The proportion of defenders, including supports and local reserves, to size of work should be from 1 to 1½ men per yard of parapet, but the proportion of parapet to men may have to be much larger. Garrison.

86. In a redoubt in front line exposed to artillery fire invisibility is the first consideration. This will entail in most cases a low command, about the same as that of the neighbouring fire trenches. This should be combined, when time permits, with a deep trench in rear, both to increase the cover and to afford cover to troops not actually engaged. A redoubt of this type is shown on Pls. 24 and 25. Low command redoubt.

87. For a work placed as a supporting point behind the front line, the question of invisibility is not generally so urgent. In this case a high command has four advantages :— High command redoubt.

(1) It has a better command of its field of fire than a low redoubt.
(2) It has a better moral effect on its defenders.
(3) It conceals the whole of the interior of the redoubt from view.
(4) It can be easily combined with a good obstacle.

The disadvantages lie in the extra labour and time entailed in making the large parapet.

In the case of a detached post, which may be surrounded, invisibility is of much less importance than that the defenders should be able to move freely about the whole interior of the work without being seen.

A type of parapet with high command is shown in Pl. 26.

Reverse fire.

Since a redoubt is intended for all round defence, precautions must be taken to prevent the defenders suffering from reverse fire.

Overhead cover.

88. Overhead cover for a redoubt should consist of about 9 to 12 inches of earth supported on brushwood or other material.

Various forms of these shelters are shown on Pls. 26, 27, 28, and 29. They all require a great deal of material. They should always be given transverse partitions, at intervals of from 10 feet to 12 feet, to localise the effect of shell.

A fairly bomb-proof roof can be made with rails sloping down from line of fire (*see* Chap. IX, p. 36).

Shelters for the flanks, when artillery attack is expected from the front only, may be given in trenches roughly parallel to the front faces; some of these may be continued with advantage across the whole redoubt, for purposes of communication.

When the artillery attack may come from any direction, as with some detached posts, the shelters must be arranged to meet this by facing various directions.

Entrances.

89. The entrance to a redoubt used in civilised war may be a gap left in the face least exposed to attack, and covered by a traverse, inside or out as may be most convenient. The entrance should be wide enough to admit a wagon, *see* Chap. XXII.

Drainage.

90. 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, and, as a rule, the drains should be led out of the redoubt to lower ground if possible.

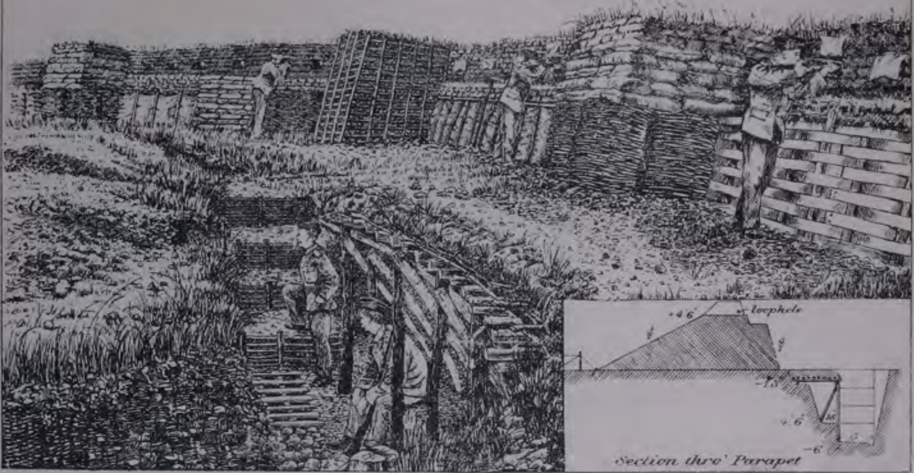
Latrines, &c.

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

HIGH COMMAND REDOUBT

WITH TRAVERSES, HEADCOVER, & OVERHEAD COVER

LOOPHOLES BLINDED IN CANVAS ON INSIDE TO PREVENT THEM SHOWING AGAINST THE SKY, & SHOULD BE SCREENED ON OUTSIDE WITH TUFTS OF GRASS &c



Section thro' Parapet

Plate 26

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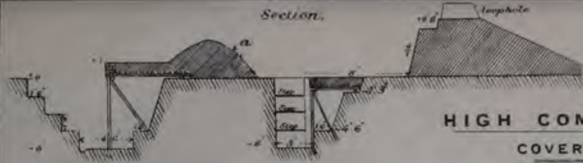
Opposite page 40

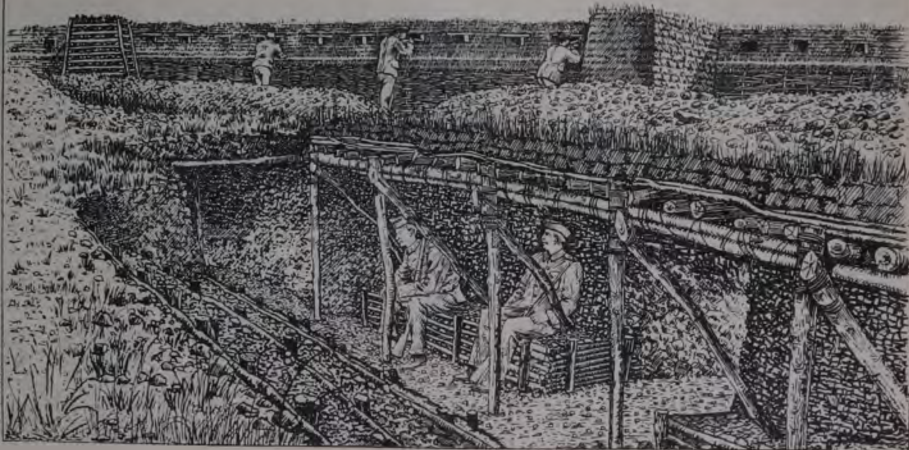
Plate 27.

Section.



HIGH COMMAND REDOUBT.

COVER FOR SUPPORTS.



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To follow plate 26.

SHELTER.

IN HIGH COMMAND REDOUBT

Section

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To follow plate27

92. Obstacles should always be provided in connection with redoubts. They must not mark the position of the redoubts. Obstacles.

The nearer the obstacle is to the parapet the less labour and material will be required, and the more effective will be the defence, especially at night.

CHAPTER X.—OBSTACLES.

For time, labour, tools and material required, see table, p. 120.

93. Obstacles judiciously placed add very much to the strength of a defensive position, and are especially useful as a protection against night attacks. The following conditions should be observed :— General conditions

- (*a*) They should be under the close rifle fire of the defender. For small posts or redoubts they should be *quite close*, so that they may be effectively defended at night. They should afford the enemy no cover, and, if possible, be sheltered from his artillery fire.
- (*b*) They should be difficult to remove or surmount, and will be most effective if special appliances, not usually carried by troops, are required for their removal.
- (*c*) They should, if possible, be so placed that their exact position may be unknown to the attacking force.
- (*d*) Except where the purely defensive is inevitable, they should be arranged so as not to impede counter attacks.
- (*e*) As obstacles on a large scale may interfere with an advance, they should not be constructed without authority. Caution.

For the protection of small posts at night some sort of automatic alarm is desirable, such as tins hung on a wire, rifles fired by trip wire, &c., *see* p. 47.

Abatis.

94. Abatis formed of limbs of trees firmly picketed down and interlaced, with the branches turned towards the enemy and pointed, form a very efficient obstacle (Pl. 30).

Figs. 1 and 2 show method of covering abatis from artillery fire.

Fig. 3.—The method of forming an abatis from small branches. Several rows are used, the excavated earth being replaced after the branches are secured. To make abatis carefully, at least a relief of six hours and a strong working party are required, so that very little of it can be undertaken in hastily-fortified positions. A very effective abatis may, however, be made much more rapidly when the trees can be utilised where they are felled, no excavation being made for them and the branches being only roughly trimmed.

Strands of wire interlaced between the branches are a useful adjunct to abatis.

Tree entanglements.

95. Tree entanglements (Fig. 4, Pl. 30) are formed by cutting trees, brushwood, &c., nearly through at a height of about 3 feet, and interlacing or securing the branches by pickets to the ground. They make a formidable obstacle at the edges of woods and orchards, and for blocking roads, and can often be formed whilst clearing the foreground.

Wire entanglements. Low.

96. A low wire entanglement is formed by stout stakes driven into the ground about 6 feet apart, in rows arranged chequerwise, their heads being connected by strong wires twisted round them and crossing diagonally about 1 foot or 18 inches above the ground (Fig. 3, Pl. 31).

The outside pickets should have wire stays, as shown in Fig. 3.

It is not a good obstacle unless constructed amongst brushwood, small bushes, or long grass, which conceal it, when it may be of great use against mounted troops. It is especially effective in the bed of a river.

High.

97. High wire entanglements form effective obstacles, especially if barbed wire be used. Pl. 31, Figs. 1 and 4, give two different types. Fig. 4 shows a method of improving a wire fence, but is not so efficient an obstacle as that shown in

OBSTACLES.

ABATIS.

Fig. 1.

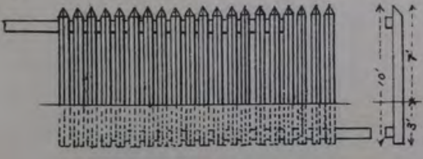
Fig. 2.

Fig. 3.

Fig. 4.

PALISADES.

Fig. 5.



Plan of Palisade

4808 5·08.
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Opposite page 42.

OBSTACLES.

HIGH WIRE ENTANGLEMENT

Fig. 1.

Diagonal wires should be connected by horizontal wires omitted in Fig. 1 for sake of clearness.

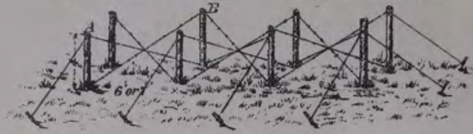
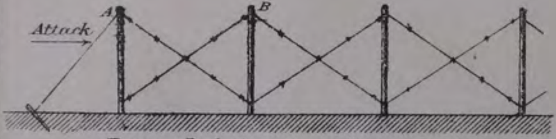


Fig. 2.



Diagonal Section across 3 rows showing where the horizontal wires are attached.

Fig. 3. **LOW WIRE ENTANGLEMENT.**

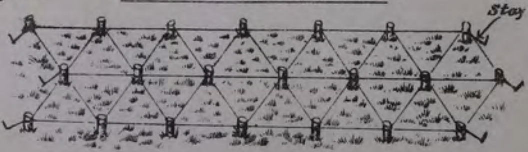
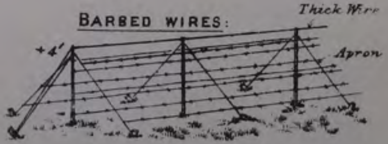


Fig 4.

BARBED WIRES:



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Opposite page 43.

Fig. 1. The pickets should be about 4 or 5 feet high, driven firmly into the ground and stayed as in the low wire entanglement.

Where two wires cross they should be fastened together with fine wire or string. Where materials are available the obstacle should be two or three rows deep.

98. Palisades are occasionally used for the defence of ditches, and for closing the rear or gorges of partially enclosed works. They would principally be employed in savage warfare. They are made of timbers about 10 feet long, arranged so as to form a stout open paling, and pointed or spiked at the top. The timbers may be round, split, or sawn to a rectangular or triangular section; they should be 6 inches to 8 inches wide, and are placed upright about 4 inches apart, and spiked to two ribands about 1 foot from either end, the butt ends being sunk 3 feet or 4 feet into the ground. The top riband should be on the defenders' side of the palisade. They are most conveniently made and placed in lengths of 10 feet or 12 feet, the ribands being arranged so as to overlap. (Pl. 30, Fig. 5.) **Palisades.**

99. Fraises are palisades placed horizontally, or nearly so. They should point downwards if placed on the defenders' side of the ditch and upwards if on the enemy's side. Both ribands are buried, the one nearest the points being placed underneath, the other on top. The points should, if possible, be at least 7 feet above the bottom of a ditch. **Fraises.**

100. Barricades, used to close streets, roads and bridges, can be made of any materials at hand. They should not, as a rule, completely close the road to traffic, but be made in two overlapping portions, or be placed where a house standing back from the general line of building allows a passage round the barricade. **Barricades.**

The defenders should be able to fire over them, and, if placed in a street, they should be flanked both in front and rear by the fire from adjacent houses.

101. Fougasses and land mines (*see* "Instruction in Military Engineering," Part I) are a useful adjunct to the defence. They should only be laid by officers who have a thorough knowledge of explosives. **Fougasses and land mines.**

Inundations. **102.** Inundations can be made by damming up a stream. A bridge is a good place to select for the purpose.

If the inundation is likely to be very shallow, the ground should be first prepared by digging irregular trenches and holes, the existence of which will render the passage of even a shallow inundation a difficult matter.

Passage of obstacles. **103.** Obstacles may be crossed by using hurdles, planks, fascines, bundles of straw, &c., or by rough ladders with steps made of pieces of plank about 9 inches wide and a pace apart. Handsaws, axes, bill-hooks and cutting pliers should always be carried by a party removing obstacles. Ropes, grapnels, hedgers' gloves and guncotton may also be useful.

Illumination of obstacles. **104.** For illumination of obstacles *see* page 47.

CHAPTER XI.—DEFENCE OF POSTS AND VILLAGES.

Organisation for Defence of Large Positions.

(*See also* "Combined Training," 1905, Section 123 and following Sections.)

General. **105.** Campaigns of the present time often entail a long line of communications in a more or less hostile country. Even when protected by a field army this is, if the enemy is strong in mounted troops, very liable to raids and must therefore be protected by fortified posts. These posts may involve (*a*) the protection of a comparatively large area of ground or of villages containing supply depôts, and will, in the case of a road, have to afford protection to the convoys and transport animals which are working along it, or, if on a railway, to protect rolling stock, station buildings, telegraph stations, &c.; or (*b*) may only have to protect a very limited area, *e.g.*, bridges, signalling stations.

Choice of ground. **106.** For strategic or other reasons the choice of ground for a post may be limited. Tactically the ground to be defended will not always be of the best, and the art of the field engineer will be taxed to the utmost. Water may not be readily obtainable, and may have to be stored; to insure that this and all other supplies are easily accessible, much forethought is required.

107. Every man employed on communications is in a sense wasted, therefore the garrisons of such posts must be kept as low as possible, and every effort made by the skilful use of ground and field fortifications to economise men. Scheme of defence, garrisons, &c.

The main principles to bear in mind are as follows :—

(*a*) Organisation of defence.
(*b*) Defenders to be close to the ground they have to defend.
(*c*) Storage of ammunition, water and supplies. Strong obstacles (automatic alarms if possible).
(*d*) Clear field of fire, adequate cover, good communications, including telephones, telegraphs, or a well organised system of signalling.

Plenty of time is usually available for the organisation of the defence, and in these days of rapid fire, given adequate supplies of ammunition, food, water and material, small posts can be made practically impregnable against raid attacks, even though the invaders be accompanied by a few guns; while larger posts can be so held that, even should the enemy be able to penetrate under cover of darkness, the risk and loss involved would be hardly worth the attempt.

Owing to the paucity of troops the defence will usually be entirely passive, and except for a small reserve to meet emergencies, every man will have his post assigned to him, and every rifle will be in the first line. Works and picquets suddenly attacked at night cannot, as a rule, be reinforced from a distance, and for this reason it is essential that the garrisons told off for the defence of such works should live quite close to them.

108. The defence of a post of class (*a*) (Sec. 105) will consist of a ring of closed works supporting each other; the number and distance from the centre will depend on the ground and troops available; the intervals will be closed by a strong obstacle, which latter must be flanked by a fire from the works. The works themselves, in view of a night attack, must be surrounded by an efficient obstacle at a very close range, say 20 to 50 yards. The field of fire must, of course, be cleared as much as possible. In most cases an inner line of defences will also be required, and possibly a " keep." Detail.

This ring of defences will not be of as elaborate a pattern as those of the outer line, described in the paragraph following, and will generally consist of fortified houses, garden enclosures, small blockhouses, &c., placed in the immediate outskirts of the village or depôt, and arranged so as to sweep all approaches and internal communications.

The posts of class (*b*) will consist of only one or two of the above works, and their garrisons may vary from say 6 to 50 men.

Type of work.

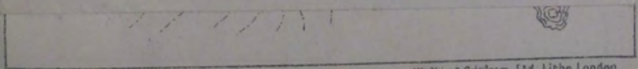
109. The types of works will necessarily depend on the nature of the probable attack. If the enemy is provided with artillery deep trenches and splinter proof cover must be provided (unless the ground affords adequate cover close at hand); against rifles only, walls or blockhouses may suffice. Against badly armed savages stockaded enclosures are good enough.

Invisibility is not essential, but every effort must be taken, with due regard to effective rifle fire, to protect the defenders. To this end head cover is necessary, and overhead cover often desirable, while, since the attack is likely to come from every direction, enfilade and reverse fire must be considered. Each of these closed works must be self-contained, the storage of reserve ammunition and water is imperative.

Design construction of works.

110. The construction of the works will mainly depend on the materials locally available. South Africa produced corrugated iron and shingle blockhouses surrounded by barbed wire; on the north-west 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 have to be protected, blockhouses, stockades and splinter proofs made of rails and loopholed buildings will predominate, while for a bridge the piers and girders can often, with a little ingenuity, be made into good cover for a small post.

In savage warfare the best hints as to designs may generally be got from the enemy, who, in the course of intertribal warfare, will most likely have evolved the types of defence best suited for local materials, and to resist the same form of attack and weapons which he will employ against us. Such types, when improved by the light of our own knowledge, modified to



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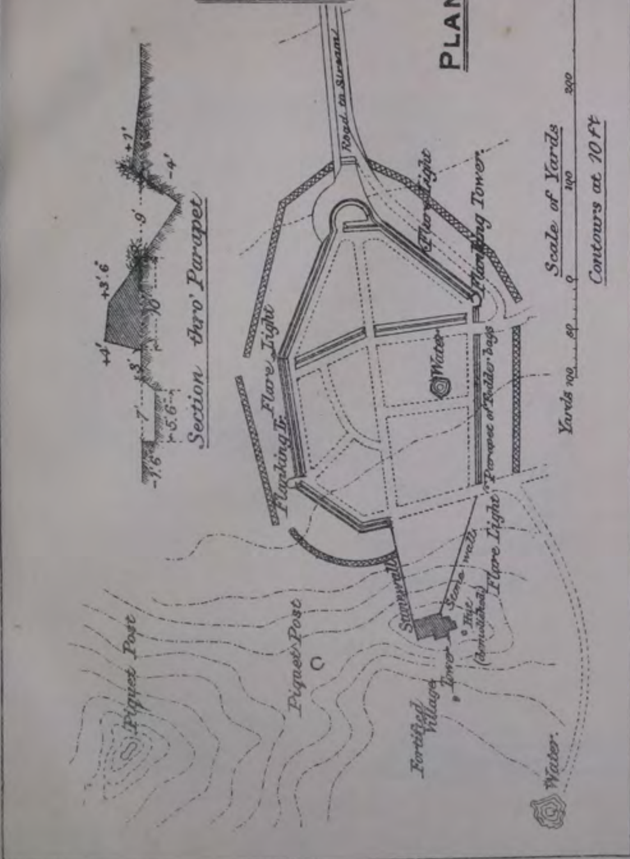
To follow plate 32.

DEFENSIBLE POST
UCHA JAWA 1897.



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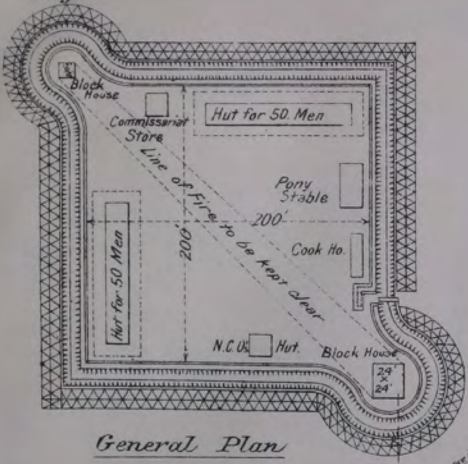
To follow plate 32.

DEFENSIBLE POST.

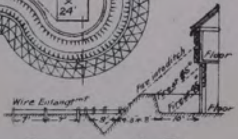
BURMA

Fig. 1.



General Plan

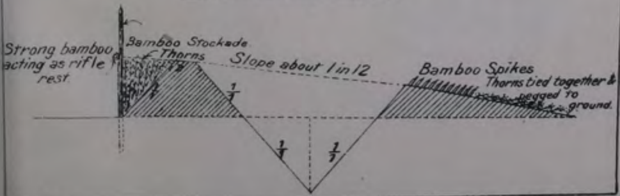
Fig. 2.



Section A.B.

Fig. 3.

PROFILE OF STOCKADE



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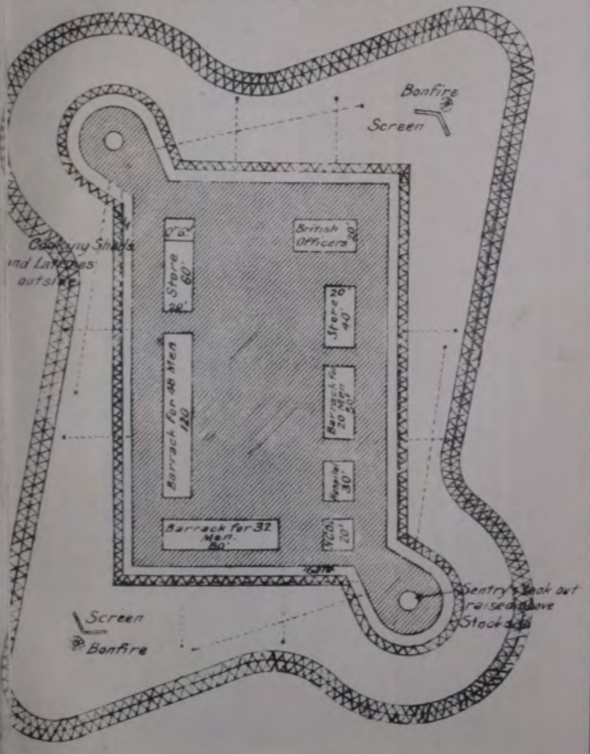
To follow plate 33.

DEFENSIBLE POST.

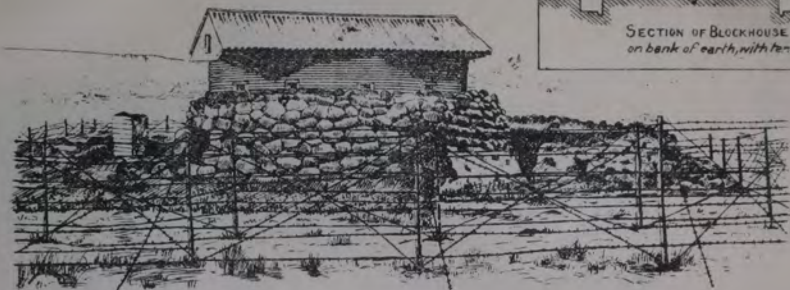
LUSHAI 1889.

(For section across Stockade, see Plate 42.)



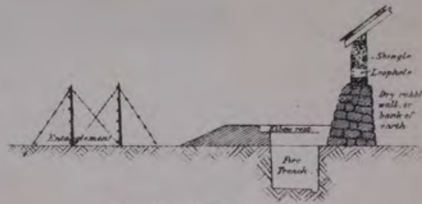
To follow plate 34

CORRUGATED IRON BLOCK HOUSE.



SECTION OF BLOCKHOUSE on bank of earth, with tent roof

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



SECTION THROUGH WALL AND TRENCH.

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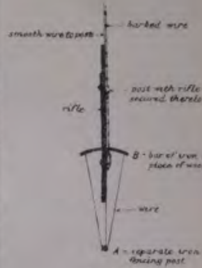
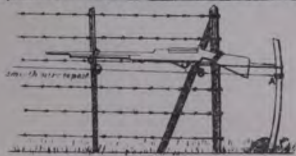
To follow plate 35.

Corrugated Iron Block House.



PLAN



SIDE ELEVATION

Fig 2

Spring Gun fixed to a Wire Fence

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

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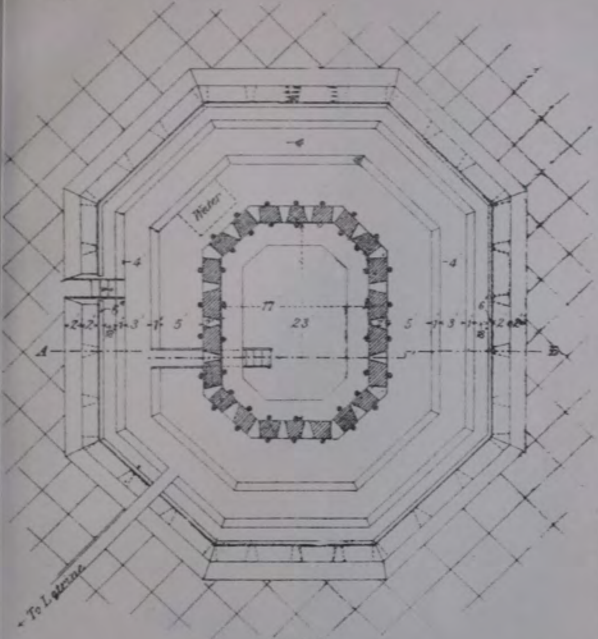
To follow plate 36.

BLOCKHOUSES.

Fig. 1.



PLAN

Fig. 2.

SECTION A.B.

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To follow plate 37

Plate 39.

DEFENCE OF A RAILWAY BRIDGE.

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To follow plate 38.

SANGAR

WITH HEAD COVER

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To follow plate 39.

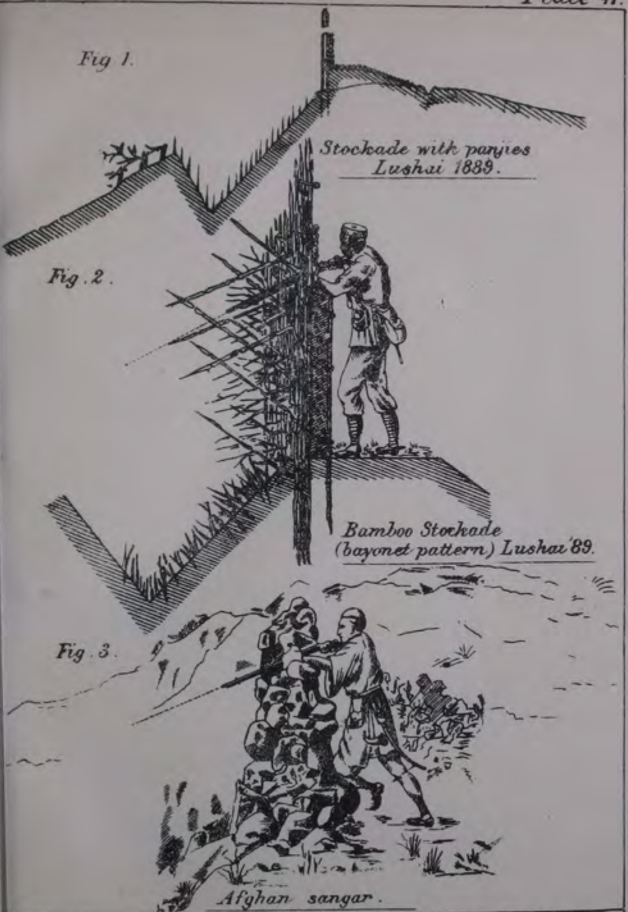

Fig. 1.

Stockade with panjies Lushai 1889.

Fig. 2.

Bamboo Stockade (bayonet pattern) Lushai '89.

Fig. 3.

Afghan sangar.

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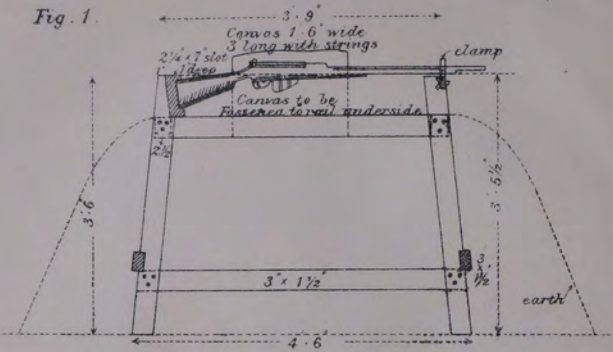
To follow plate 40.

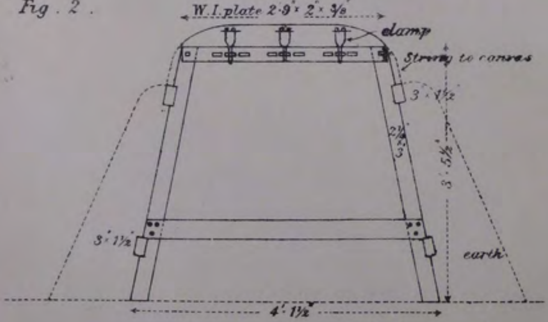
FIXED RIFLE BATTERIES.

Fig. 1.



ELEVATION.

Fig. 2.



END ELEVATION.

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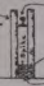
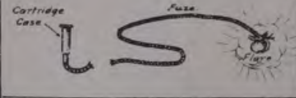
Opposite page 47.

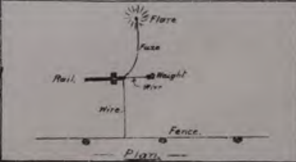
CARTRIDGE ALARM.



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..





To follow Plate 42

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suit our weapons, and executed with the aid of good tools and engineering skill, will, as a rule, be suitable for our own use. For types of such defence, *see* Pls. 32 to 41.

111. Automatic alarms and flare lights, worked mechanically or by electricity, are useful where night attacks may be expected. They are usually combined with obstacles. 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 inches to 3 inches in diameter, *e.g.*, the top of a tin pot, bent round the wires answers 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. 43). **Alarms and flares.**

For electric alarms, *see* Part 1, I.M.E.

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

112. The spring gun shown in sketch (Pl. 37) is simple to fix and is reliable in its action; another mechanical device is shown in Pl. 43. **Mechanical alarms.**

113. Means of temporarily illuminating the foreground will suggest themselves according to the material available. The illumination must be arranged so as to leave the defenders in shadow. **Illumination of foreground.**

A "flare" made of tow and oil is described on Pl. 43. A special illuminant is made in the Ordnance Factories under the name of "Lights, illuminating, wreck." This can be lit with a match or with either instantaneous or safety fuze. The instantaneous fuze should be stripped to ensure good contact. The light will illuminate a circle up to about 100 yards diameter and will burn for 20 minutes.

114. On a dark night it is difficult to ensure the men's rifles being aimed in the required direction. Any device to assist them in this matter is useful. In the South African war of 1899–1902 "fixed rifle rests" were employed to fire along the obstacle. By the arrangement shown in Pl. 42, a number of rifles can be clamped in the required direction and elevation, while only one man, who can be practically under cover, is required to load them; failing this, some such device as a wooden bar can be arranged across the loopholes, to prevent **Fixed rifle rest.**

a man raising his rifle barrel too high. Posts painted white on the defenders' side make a good aiming mark, if the night is not too dark.

Steel loop-holes. **115.** Loopholes made of sandbags, sods, &c., unless very carefully made, do not afford a good field of view and fire combined with adequate protection. To meet this objection a steel loophole plate has been introduced into the service. It would be specially useful for detached posts. (*See* Pl. 18, Figs. 1 and 2.)

Entrances. **116.** The entrances to closed works must be carefully attended to. They may be closed by a gate, barbed wire or other obstacle. When wire is used, a good plan is to construct an intricate winding approach, making access by night difficult. In all cases entrances must be covered by the fire of the defence. Entrances to admit artillery require a width of 7 feet.

Defence of Villages.

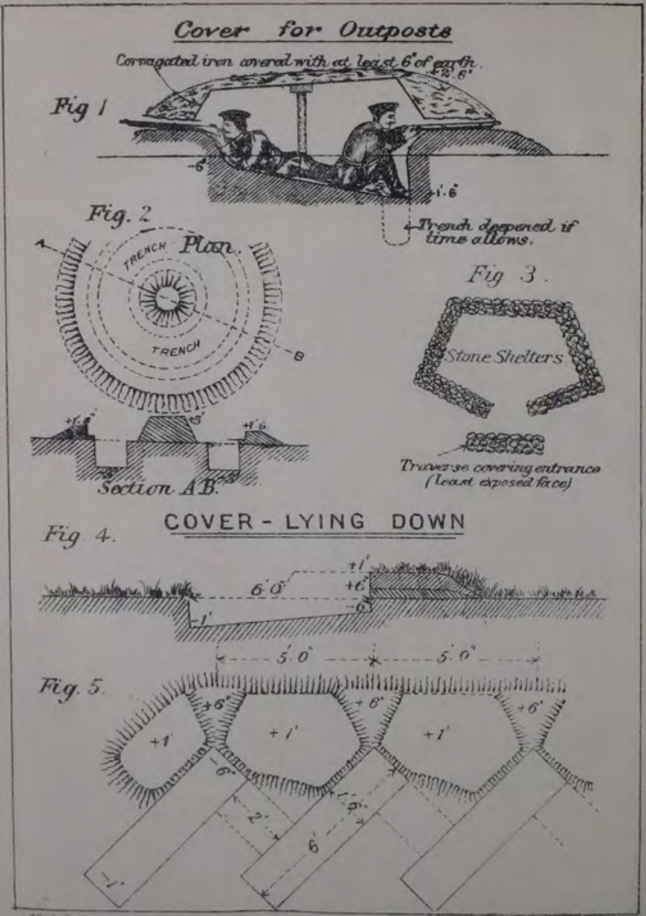
Villages. **117.** Villages will very often occur in or near a defensive position, and although they are unsatisfactory for defence they must generally be occupied, rather than be left to the enemy. They conceal the disposition and strength of their garrisons, and afford a shelter from the weather, but they take up a large number of men who are necessarily scattered.

A village should be divided up into well defined sections, each held by a tactical unit. Each section might have two lines of defence. There will be a general reserve for the whole under the commander of the village, to reinforce a hard pressed section, make local counter attacks, and furnish the garrison of the central keep of the village, if any.

118. The arrangements of the defence might therefore be as follows :—

(1) Clearing field of fire.
(2) Making communications.
(3) Providing or improving cover for first line along hedges, garden walls, &c., loopholing walls of houses as a second line.
(4) Placing obstacles. This would be partly done at the same time as (1).
(5) Preparing keeps.

Plate 44.



Opposite page 49.

DEFENCE OF CAMPS.

119. When operating against an enemy who is accustomed to make night attacks, the defence of camps is a most important question. 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. Camps.

For a small force the first thing to be done on arrival in camp is to mark out the positions to be taken up in order to repel a night attack. If there is only time to do this with a line of stones, it will give the defenders a definite line of defence and something to hold on to.

For convenience in camping, troops should generally occupy the same relative positions each night, but this convenience must be sacrificed to the arrangements necessary for defence, 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 probable night attacks is one of the first considerations.

COVER FOR OUTPOSTS.

120. Where no natural cover exists, outposts should be entrenched. Outposts

The guiding principles in the design of the defences should be :—

The provision of an all-round field of fire and the protection of the garrison from reverse fire.

Plate 44, shows various types of cover suitable for outposts. Such works should, whenever possible, be surrounded with obstacles.

Organisation for Defence of Large Positions.

Defensive positions.

121. In order to ensure a good system of command and organisation, defensive positions should be divided into well-defined sections, each under a separate commander, to whom should be allotted a distinct force, *e.g.*, a division, brigade, etc. (*see* "Combined Training").

Each section commander will be responsible for the occupation and preparation for defence of his section in accordance with the orders received. He will either indent on the service or department concerned, or may make arrangements by hire, contract, or requisition with the local civil authorities, according to the circumstances of the case, for such extra labour, tools or materials, as may be required.

For Tables, giving roughly time required for various works and form for working parties, which will be found useful in connection with the above, *see* pp. 120 and 136A.

CHAPTER XII.—TEMPORARY ROADS.

122. Temporary communications by road are usually required:— **Temporary communications.**

(*a*) In connection with a defensive position to enable troops to be readily moved from one portion to another.

(*b*) For the movement across country of detached columns.

In both cases provision will generally have to be made for wheeled vehicles, while simple means to enable the infantry to pass dryshod over water should not be neglected. The provision or improvement of such communications can, as a rule, be carried out by unskilled labour. For more permanent work *see* Chap. XXII, Part II.

Communications inside a position will consist in repairing existing roads, filling up soft places, cutting ramps in steep ground, cutting gaps through fences and clearing roads or paths through woods.

The points to be kept in mind are: That troops should be able to move on as broad a front as possible, and that troops and messengers should be guided to their destination by sign-posts, by "blazing" trees or other means.

The work in connection with detached columns will generally consist in repairing existing tracks or fords and making boggy or soft ground fit for wheeled transport.

Since soft ground, even though passable, is very trying to draft animals and causes delay, a little labour, well applied, will be amply repaid.

123. The best foundation for a temporary road over boggy ground is a layer or layers of fascines placed touching one another; the top row must lie across the direction of the traffic, but when time is not available or suitable material not at hand, much can be done by throwing down brushwood, heather, or even straw or grass, care being taken that this, like the fascines, is laid across the road. **Temporary roads over boggy ground.**

If there is much wheeled transport, a reserve of material should be collected to replace any that gets worn through.

In very wet ground it may be necessary to dig a drain on each side of the road (*see* Pl. 82, Fig. 3).

Corduroy road.

124. Where timber is available and heavy traffic is expected, a "corduroy" road may be made. This is constructed by felling trees, cutting them to the required lengths and laying them across the road at right angles to its direction, ribands being spiked to them at either end; or the logs may be held together by interlacing with rope or wire.

The interstices between fascines, brushwood, logs, &c., may be filled with small stones and earth to make a better surface.

CHAPTER XIII.—KNOTTING AND LASHINGS.

Knots and hitches.

125. The following are the most useful knots for bridging and lashing spars, and their principal uses :—

(*a*) To make a knot on a rope, or to prevent the end from unfraying, or to prevent its slipping through a block; the *thumb knot* (Fig. 1, Pl. 45) or the *figure of* 8 (Fig. 2).

(*b*) To *bend* or join two ropes together. The *reef knot* (Fig. 3) for dry ropes of the same size; the *single sheet bend* (Fig. 4) for dry ropes of different sizes; the *double sheet bend* (Fig. 5) for great security or for wet ropes of different sizes, and the *hawser bend* (Fig. 6) for joining large cables.

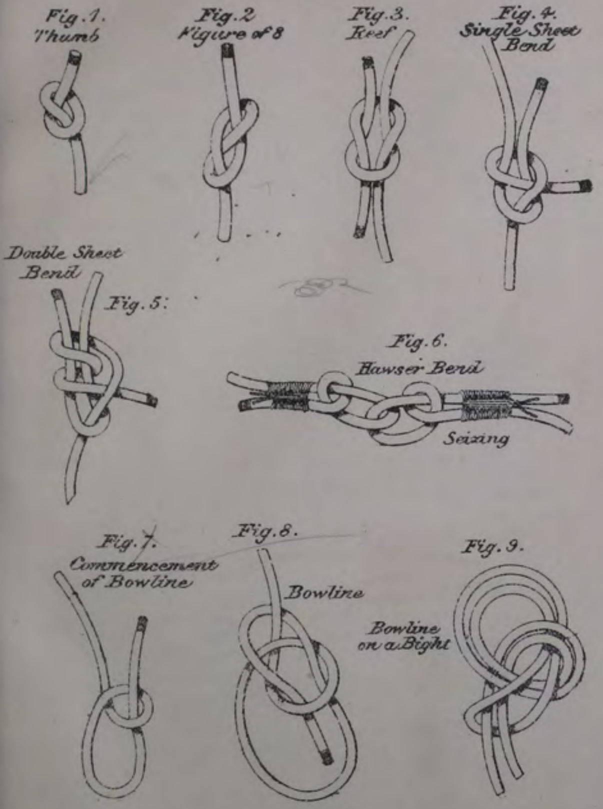
(*c*) To form a loop or *bight* on a rope which will not slip. The *bowline* (Figs. 7 and 8) for a loop at the end of a rope, the *bowline on a bight* (Fig. 9) for a loop in the middle, with a double of the rope.

(*d*) To secure the ends of ropes to spars, pickets, &c., or to other ropes.

Half hitch (Fig. 4, Pl. 46) for securing the loose ends of lashings, &c.

Clove hitch (Figs. 1 and 2, Pl. 46) (two half hitches) generally used for the commencement and finish of lashings.

KNOTS.



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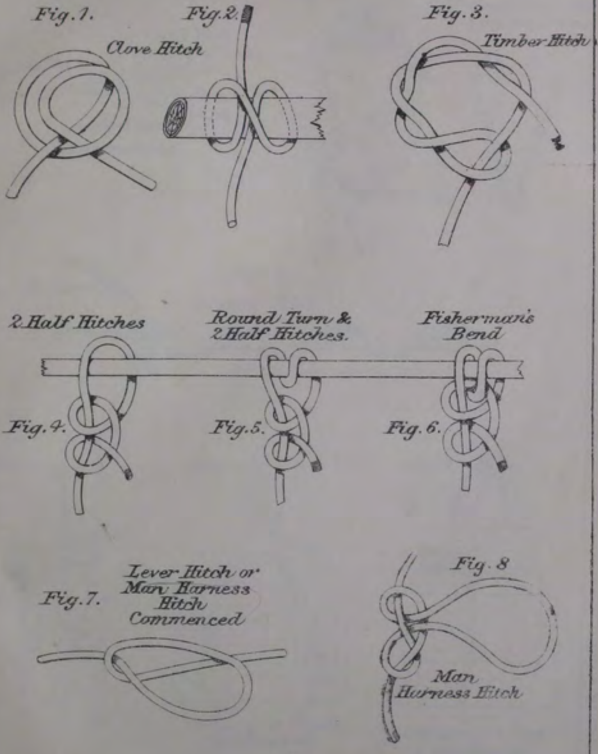
KNOTS.



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To follow plate 45

Timber hitch (Fig. 3) for catching hold of timber, &c., where the weight will keep the hitch taut.

Round turn and two half hitches (*or rolling bend*) (Fig. 5) for *belaying* (or making fast) a rope so that the strain on the rope shall not jamb the hitches.

This will be used for making fast a rope to a bollard or anchorage. Should the running end be inconveniently long, a bight of it should be used to form the half hitches.

Fishermen's bend (Fig. 6), for making fast when there is a give-and-take motion, *e.g.*, for bending a cable to an anchor.

(*e*) To fix a spar or stick across a rope.

Lever hitch (Fig. 7), for drawing pickets by a lever and fulcrum, fixing the rounds of a rope ladder, fixing bars to dragropes, &c.

(*f*) For forming a loop on dragropes.

Man's harness hitch (Figs. 7 and 8), the loop being of a size to pass over a man's shoulder.

(*g*) To fix a rope with a weight on it rapidly to a block.

Catspaw at the end (Figs. 1 and 2, Pl. 47) or in the middle of a rope (Fig. 3), for hooking on a block.

Blackwall hitch (Fig. 5), a simple hitch (with a pliant rope) which will only hold as long as the weight is applied.

(*h*) To transfer the strain on one rope to another.

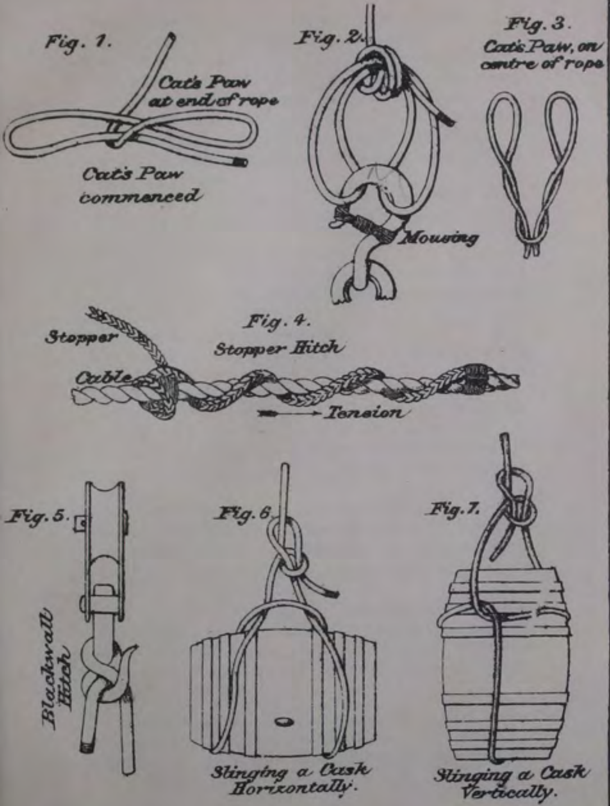
Stopper hitch (Fig. 4), for use on occasions when it is necessary to shift the strain off a rope temporarily.

126. To sling a cask horizontally. Make a long bight with a bowline and apply as shown in Fig. 6. **Slinging casks.**

To sling a cask vertically (Fig. 7). Place the cask in a bight at the end of the rope, and with the running end make a thumb knot round the standing part of the rope. Open out the thumb knot and slip it down the sides of the cask. Secure with a bowline.

127. A rack lashing, an article of store, consists of a length of $1\frac{1}{2}$-inch rope, with a pointed stick at one end. Used for fastening down ribands at the edge of the roadway of bridges. **Rack lashing.**

KNOTS.



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To follow plate 46.

Commenced with a thumb knot at *a*, Fig. 1, Pl. 48, the end twisted in the bight. The stick is then put into the bight, twisted against the hands of the clock till all is taut, and finally jammed in from right to left between the lashing and the outside of the riband. A rack lashing is readily improvised (Figs. 1 and 2, Pl. 48).

Belaying. **128.** To belay a cable to belaying cleats. First take a round turn with the standing part of the cable on the belaying cleats, then as many figure of 8 turns as necessary. Half hitches are on no account to be used in belaying any rope which is likely to have to be cast off quickly.

Lashings.

Square or transom lashing. **129.** To lash one spar square across another, commence by a clove hitch on spar *a* below *b*, Pl. 48, and twist ends together, carry at least four times round the spars, as shown in figure, keeping outside previous turns on one spar and inside on the other; two or more frapping or cross turns are then taken, the corners of the lashings being well "beaten in" during the process, and finished off with two half hitches round the most convenient spar (Figs. 3 and 4, Pl. 48).

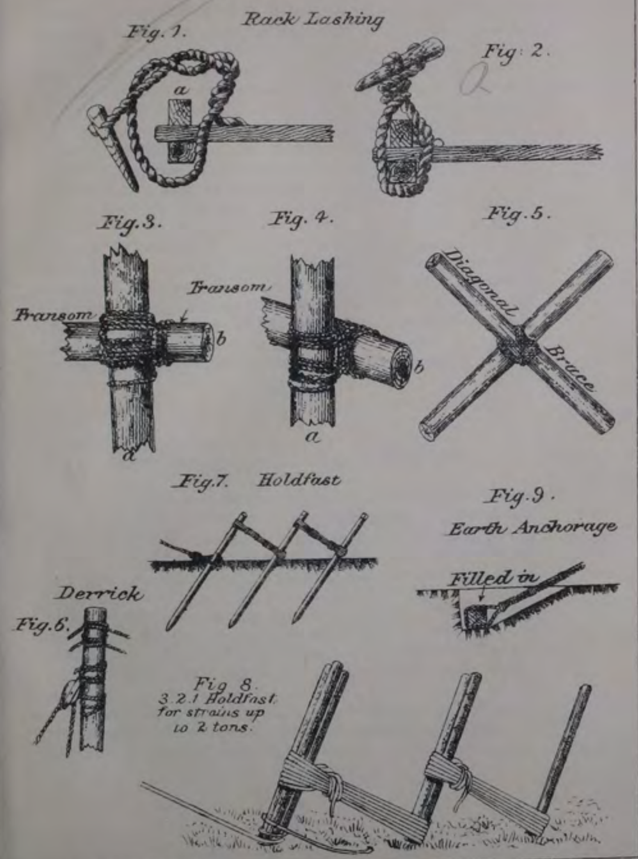
When the spars are the leg and transom of a trestle or frame, the clove hitches should be on the leg below the transom, and the lashings should be finished off on the transom outside the leg.

Diagonal lashing. **130.** To lash two spars together that tend to spring apart. Begin with a timber hitch or running bowline round both spars and draw them together, then take three or four turns across each fork and finish with frapping turns and two half hitches. (Fig. 5).

Wedges with well rounded points are often useful for tightening lashings. They are generally used by builders in scaffolding, and should be driven in at the top of the lashings.

Lashing block. **131.** To lash a block to a spar.—The back of the hook is laid against the spar, a clove hitch is taken round the spar above the hook, then several turns round the hook and spar, and finished off with two half hitches round the spar below the hook (Fig. 6).

LASHINGS.



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132. The hook of a block is *moused* by taking some turns round it with spun yarn or very light lashing, commencing with a clove hitch on the back of the hook and finishing off with one or two frapping turns and a reef knot (Fig. 2, Pl. 47). Mousing a block.

133. The end of a rope is *seized* to the standing part with spun yarn or string, by forming a clove hitch round one of the ropes with the spun yarn near its centre, taking each part round both ropes in opposite directions, leaving one end long enough to take two frapping turns between the ropes, and connecting the two ends with a reef knot (Fig. 6, Pl. 45). Seizing.

134. A picket used as a holdfast must be driven into the ground at a slope to meet the strain. If the latter is great and the pickets small, additional strength is gained by the methods shown in Figs. 7 and 8, Pl. 48. In using heavy rope, three or more pickets can be driven in a cluster to form a bollard. If a large piece of timber is used as a bollard, its corners must be rounded off. Fig. 9, Pl. 48, shows a method of using a log for large strains. Holdfasts or anchorages.

135. For strength of rope, wire and lashings, *see* Part II.

CHAPTER XIV.—MILITARY BRIDGES.

136. The approximate site for a bridge will usually be decided by the tactical requirements in selecting the exact position over a river, and regard must be had to the following points, most of which must also be considered when an existing bridge has to be repaired, viz.: The nature of the banks and approaches, the nature of the bed, width to be bridged, depth of water, strength of current, and the probability and extent of floods. If a tidal river, the rise and fall of the tide should be ascertained. A note should be made of any material near the proposed site which would help in the construction of the bridge. Site.

137. The approaches on both sides of a bridge are of the utmost importance, marshy banks should be avoided, if ramps are required the gradients should be easy. Banks and approaches.

Easy access and a difficult exit is sure to cause a crowding on the bridge.

Strength of current. **138.** The simplest plan for measuring the velocity of a stream is to use a light rod weighted at one end so as to float nearly vertically, with its tip above water. Note the distance it floats in a given number of seconds; then seven-tenths the mean number of feet a second gives the number of miles an hour, in which terms the velocity should be stated.

Materials. **139.** The materials usually available in the field are timber of all sorts and sizes, railway plant, hemp or wire rope and floating material.

The different parts can be fastened together with rope or wire, iron bolts and nuts, spikes and dogs, iron straps, &c.

The simplest construction consists of round spars lashed together with rope or wire, but squared timbers, *e.g.*, timber as used in the construction of houses, and iron fastenings, are often more easily obtained than spars and rope. Iron fastenings, however, necessitate a few carpenter's tools.

Form of bridge. **140.** The form of bridge will vary according to the materials available, the traffic expected and the nature, breadth, depth, &c., of the span to be bridged.

When bottom can be touched throughout, a trestle bridge (Pl. 49, Fig. 1), or some form akin to it, will generally be the most economical in material and the easiest to make. The method of constructing it should be thoroughly understood. When there is no available bottom the bridge becomes more complicated. Simple bridges for small spans are the single lock bridge, the double lock bridge, and the cantilever bridge (numbers used in the North of India). These are described in Part II. Where floating material is available and depth of water and current are suitable, a floating bridge will be the quickest and simplest to make. For long spans where bottom cannot be touched, tension or suspension bridges, or some form of girder bridge, may be suitable, but their construction requires skilled labour and will not be dealt with here.

Fig. 3 shows a combination of frame and trestle, Fig. 4 of floating piers and trestle—the depth of the gap in each case necessitating some support other than trestle.

TYPES OF BRIDGES.

Fig. 1.

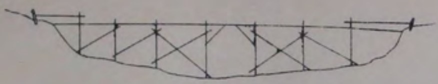


Fig. 2.

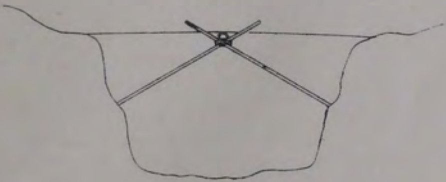


Fig. 3.

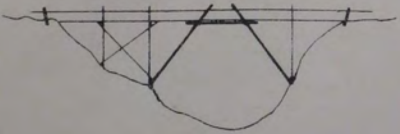
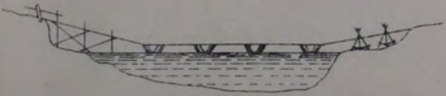


Fig. 4.



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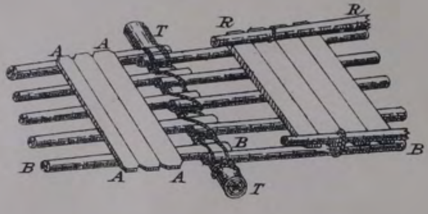
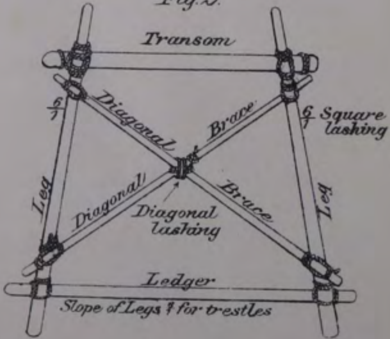
BRIDGES

Fig. 1.



Lashed Spar Trestle

Fig. 2.



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141. The same nature of roadway can be applied to each type of bridge, and its usual form is shown in Pl. 50, Fig. 1. Construction of roadway.

The planks or *chesses*, A, A, placed across the width of roadway are supported on longitudinal *baulks* or *road-bearers*, B, B, which in their turn rest on transverse *transoms*, T, T, and the method of supporting these last depends on the type of bridge. The chesses are kept steady by two *ribands*, R, R, which are secured to the outside baulks either by *rack lashings* or by lacing, or the chesses may be simply nailed down.

142. A width of 8 feet *in the clear—i.e.*, the clear space between the ribands—suffices for infantry in fours, for military vehicles in one direction, and for cavalry in *half-sections—i.e.*, two abreast; but 9 feet in the clear is a better width, especially when there is likely to be a sway on the roadway, as frequently happens in the case of floating and suspension bridges. Width of roadway.

The " normal " width of bridge is 9 feet in the clear.

Six feet will take infantry in file, cavalry in single file, and field guns passed over by hand; 1½ feet to 3 feet will take infantry in single file.

143. Planks 1½ inches to 2 inches thick are sufficient for ordinary traffic. Chesses.

For continuous or heavy wheeled traffic additional chesses should be laid longitudinally, to form wheel tracks.

Chesses can be economised, if they are longer than the width of the bridge, by placing them diagonally.

Hurdles, short fascines, corrugated iron, &c., can be used in lieu of planks, but are not good for horse traffic.

When material is available, chesses may be laid on the ground on the banks on each side for a short distance, to allow horses to become accustomed to the noise before actually getting on to the bridge.

144. A handrail should be provided, especially for horse traffic. They must be strongly built. Screens on either side are desirable for passing animals over a bridge, especially over running water. Handrail and screens.

145. In most bridges the ribands should be fairly pliant, in order that the rack lashings may press them tightly down on the chesses throughout. In suspension and floating bridges, however, stiff ribands are desirable, as they tend to stiffen the bridge. Ribands.

Rack lashings should be applied at intervals of 4 feet or 5 feet.

Baulks. **146.** The number of baulks depends upon the size of the timber available. They should be sufficiently close together to support the chesses.

Bays. **147.** The distance bridged by one set of baulks, *i.e.*, the distance between any two *transoms*, is called a *bay*.

The length of bays depends chiefly upon the size of available baulks; 10 feet to 15 feet is a convenient length.

When the trestles are large, material and labour should be economised by making the bay as wide as the length and strength of the available road-bearers will allow.

Strength of bridges. **148.** Whatever arm of the service it is constructed to carry, a bridge should be capable of supporting it when *crowded* in the formation for which it is intended. Thus a bridge intended to carry infantry in fours should be strong enough to take infantry in fours when crowded.

A bridge that will carry infantry in fours crowded at a check will carry field guns and 5-inch howitzers and most of the ordinary wagons that accompany an army in the field.

Timbers of bridges for carrying heavier weights, *e.g.*, guns of position, should be calculated (*see* Part II.).

The following approximate dimensions for spars of *unselected* timber are necessary for carrying infantry in fours crowded:—

For bays of 15 feet—Road-bearing transoms, mean diameter, 10 inches. Baulks (six), mean diameter, 7 inches.

For bays of 12 feet—1 inch less than above will suffice.

Other timbers not affected by length of bay:—

Ledgers and handrails, mean diameter, 4 inches to 6 inches.

Braces and ribands, 3 inches at tip.

Legs, trestle, mean diameter, 6 inches.

These dimensions are calculated for spars of rather weak wood, such as larch, and allow for a factor of safety of three. Five road-bearers are enough for selected spars.

Camber. **149.** The roadway is generally constructed with a slight rise towards the centre of the bridge to allow of subsequent settlement; this is technically called the camber, and should be about $\frac{1}{60}$ of the span.

150. Regulations for the passage of troops over field bridges are laid down in "Combined Training," 1905, Sec. 27. Precautions to be used in passage of bridges.

With the officer in charge rests the responsibility of no physical obstacles occurring to cause checks or crowding on the bridge itself.

The passage of troops *off* a bridge should be always expedited, their passage on to it carefully regulated, and, when necessary, checked by material obstacles.

The officer superintending the construction of a bridge is responsible that it is strong enough to support the weight it is intended to carry. To prevent it being over-strained he should place a signboard at either end, stating the greatest permissible load, thus :—

"Bridge to carry infantry in fours."

"Bridge to carry infantry in file."

"Bridge to carry guns not heavier than 13-pr."

TRESTLE BRIDGES.

151. Trestles made of spars lashed together with rope or wire may be of three kinds—two, three, or four-legged. Lashed spar trestles.

The ordinary form of two-legged trestles is shown in Pl. 50, Fig. 2.

152. To make trestles for a particular bridge the centre line of the bridge should be marked out on either side of the gap, and a section of the gap laid out on flat ground showing the depth of the gap at each trestle (two sections, if the depth on one side of the bridge is different to that on the other). For each trestle the position of the lashing on the *transom* is dependent on the width of the roadway, and the lashing on the *leg* dependent on the depth of the gap allowing an outward splay of $\frac{6}{1}$. The *ledgers* are usually lashed on about 1 foot from the bottom of the leg, parallel to the transom, their point of lashing depending on the length and splay of the leg. For a muddy bottom Order of work.

the ledgers should be close to the butts, so as to take the mud; for a rocky bottom they should be high enough up not to touch.

Square lashings (*see* Sec. 129) must be used. The braces are put on the frame with both butts and one tip on the same side, the second tip on the reverse side; their butts can be lashed simultaneously with the ledger and transom. The frame must then be *squared* by testing the diagonals, measuring from the centre of the ledger lashing to the centre of the transom lashing on the opposite leg, and the frame must be adjusted till these measurements are equal. The braces can then be lashed at the tips and crossing point.

If the timber is weak both legs and transom can be doubled. Ledgers and diagonal braces can be of light material, as little strain is brought upon them, but they should be well lashed.

Placing and bracing trestles.

When the water is very shallow the trestles can be carried out and placed by men working in the water. When the water is too deep for this they can be carried on to the bridge and lowered feet first down inclined spars to their final position, or taken out on rafts and by means of guys taken to shore tipped up into position.

Two-legged trestles are kept upright by lashing the road-bearers to the transoms and by cross-bracing from each trestle to its neighbour (*see* Pl. 49, Fig. 1), the nearest trestles to the banks on either side being rigidly connected thereto by light spars lashed to the tips of the legs and to bollards on the bank.

These light spars are put on before the trestle is launched, and help to get it into position, they also serve as handrails when the roadway is placed.

Three-legged or tripod trestles.

153. Pl. 51. Fig. 1, shows three-legged trestles, two of which are required for the support of a single transom: to make them, it is best to lash two legs together by a sheer lashing, open them out, and then add the third leg or prypole (*see* Fig. 2); the trestle must then be up-ended, the feet placed on the angles of an equilateral triangle with sides of about half the height, and three light ledgers attached.

The advantages of tripod trestles are that they utilise light material, will stand without bracing, and admit of more ready adjustment, raising or lowering, of the roadway than either

TRESTLES.

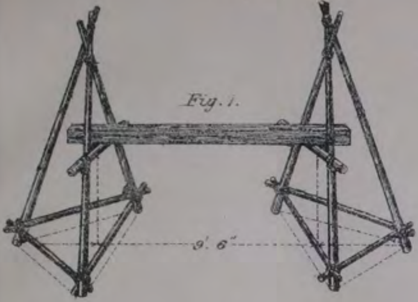

Fig. 1.

Fig. 2.

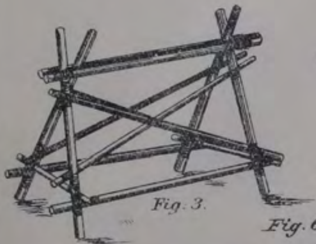

Fig. 3.

Fig. 5.

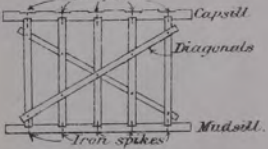

Fig. 6.

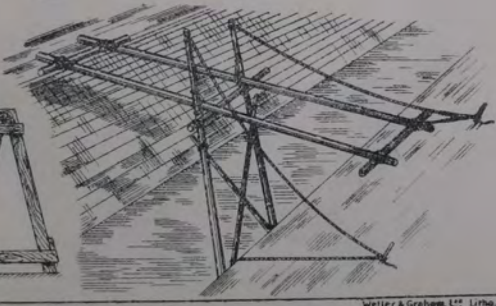

Fig. 4.

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Opposite page 60.

BRIDGING EXPEDIENTS.

Fig. 1.

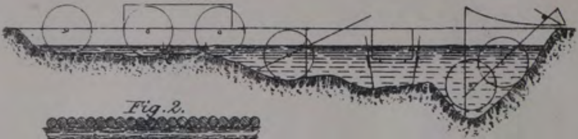


Fig. 2.

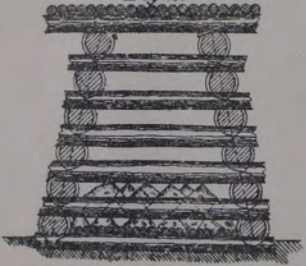


Fig. 3.

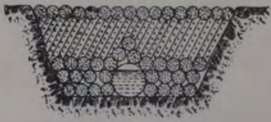
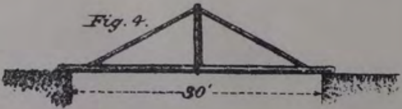


Fig. 4.



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Opposite page 61.

of the other forms; they are, however, unsuitable for an uneven bottom, and extremely difficult to place, excepting by actually carrying them into position. They are usually placed from rafts when working over water, and their legs must be weighted.

154. Fig. 3 shows a four-legged trestle; it is made of two frames similar to two-legged trestles, locked at the transoms, and connected by short ledgers at the feet. One frame must therefore be made narrower than the other. The inclination of the legs should be such that the breadth of the base on which the trestle stands should not be less than half the height. The legs must also have an outwards splay of $\frac{6}{1}$. **Four-legged trestles.**

Four-legged trestles can be made of fairly light material, and will stand without bracing. They are consequently useful for small bridges of two bays, requiring one central support, and as occasional steadying points in a long bridge of two-legged trestles.

When a carpenter's tools are available, trestles may be made with iron fastenings; they are more durable than those made with rope. Figs. 4 and 5, Pl. 51 are examples. Fig. 5 is especially useful when only light timber is available.

155. Communication may be rapidly established across a gap by the method shown in Pl. 51, Fig. 6. In Fig. 6 two spars are rested about their centres on the transom of a narrow light trestle and launched across. The transom should be lashed at such a height that when the trestle is inclined forward so as to land the tips of the spars on the opposite bank, the transom will be on a level with the two banks. Planks can then be laid on the spars to form a foot bridge. **Bridging expedients.**

156. In Pl. 52 are shown various expedients which can take the place of regularly constructed trestle bridges. Fig. 1, a roadway laid on carts. **Substitutes for trestle bridges.**

Fig. 2, piers of *crib work*. This is a specially useful form of pier when timber is plentiful and other stores deficient. If used in water a tray should be formed in the bottom of the crib, which latter can be towed into position, weighted with stones and sunk.

Fig. 3, small gaps crossed by means of brushwood, in the form of gabions or fascines.

Fig. 4 shows a method of roughly trussing a log, frequently used in Canada.

Floating Bridges.

157. In selecting a site for a floating bridge it should be remembered that the bed of the river should afford good holding ground for anchors if required.

The use that can be made of islands to economise material should be noted.

Roadway. **158.** The roadway of floating bridges is similar to that already described in Sec. 141; wide roadways are preferable to narrow ones, on account of their great steadiness.

Buoyancy. **159.** Each pier must have enough available buoyancy to support the heaviest load that can be brought on to one bay of the bridge. No extra allowance need be made if the load is live.

The length of the piers should be at least twice the breadth of the roadway for the sake of steadiness, and they may be connected together at their ends by *tie baulks* or lashings.

The *waterway* between the piers should never be less, and should if possible be more, than the width of those piers.

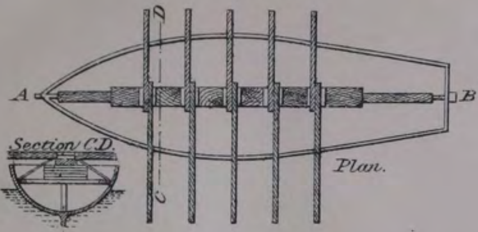
Floating piers may be made from specially constructed pontoons, boats, casks, or timber rafts; inflated skins, or anything that will float, may have to be resorted to on emergency.

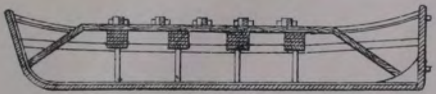
Boats. **160.** Open boats should not, except in sluggish water, be immersed deeper than within 1 foot of the gunwale, and a still larger limit of safety will be required in rough water or a violent current. They should be placed in bridge "bow on" to the current, and slightly down as the stern; or if the river is tidal they must be placed alternately bow and stern.

If the boats be not each buoyant enough to form a pier, they may be used in pairs (Fig. 2, Pl. 53). The sterns are lashed together, and the spars AA_1 BB_1 are held over the side; four 2-inch ropes at AB, CD, C_1D_1, A_1B_1, are passed under the boats and secured to the poles, and four double ropes are passed round the latter at the same points and cross over the boats; these ropes are racked up tight. Crosspieces, MM, are then lashed to the poles and thwarts, and blocks on the thwarts

BOAT PIERS

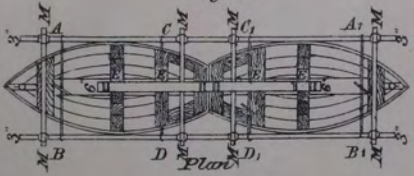
Fig. 1.





Section A.B.

Fig. 2.



Cross Section

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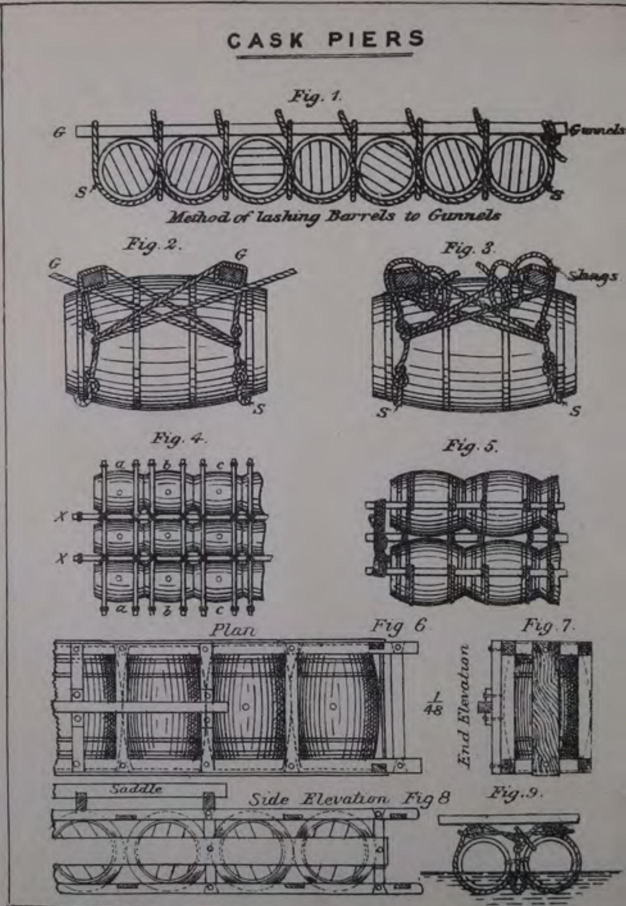
Plate 54.



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Opposite page

at EE support the saddle beam, which is lashed to the thwarts and to the stern rings of the boats.

Few boats, with the exception of heavy barges, are strong enough to allow of the baulks resting on their gunwales. A central transom should be improvised, which can generally be done by resting a transom on the thwarts, and blocking them up from underneath, thus bringing the weight directly on to the kelson. This arrangement is shown in Fig. 1, Pl. 53.

161. The available buoyancy of a boat may be (most simply) determined by loading it with unarmed men to such a depth as is considered safe, usually within 6 inches of the gunwale in sluggish streams and 1 foot in rapid, and multiplying this number by 160. The result gives the available buoyancy in pounds. **Buoyancy of boats.**

162. The usual method of forming a number of large casks into a pier is shown in Figs. 1, 2, and 3, Pl. 54. The casks are laid bung uppermost, and lined, two baulks technically known as gunnels (GG) are placed over the ends, and the slings (SS) are secured under the ends of the casks to the gunnels. Between each pair of casks, on each side, a brace is secured on the sling, and is then led round the gunnel; the opposite braces are crossed and secured again on their own side. **Piers of casks.**

A knot must be made as shown near the standing end of the braces to prevent the crossed parts slipping. Care must be taken that the braces are pulled taut; this is best done by rocking the barrels, at the same time hauling in the slack. For large piers the sling should be $2\frac{1}{2}$-inch to 3-inch rope, the braces can be of $1\frac{1}{2}$-inch rope. (For a detailed description of this method, *see* Part II.).

163. Fig. 4 suggests a method useful for smaller casks. Small piers of three or more casks, *aa*, *bb*, *cc*, being made as above described, and subsequently united by two large gunnels, X, X.

164. Figs. 5 and 9, show another method useful for medium-sized casks. The braces are first fastened to a gunnel and stretched out perpendicularly to it; the casks are then placed in two rows, end to end, on each side of the baulk and over their own braces. On the casks are laid two gunnels, loosely lashed together at the ends and at one or two intermediate points, the distance between them being less than a bung diameter, the braces are then secured to the gunnels by two round turns and two half-hitches; the lashings connecting the gunnels are then racked up, and finally the two at the ends are secured to the underneath baulk by lashings, which are also racked up taut. Other methods can be readily devised according to the material available, *e.g.*, the cask can be completely enclosed in a wooden framework, the parts of which are lashed or nailed together (*see* Figs. 6, 7, and 8.

Tie baulks. **165.** Piers of casks when in bridge should always be rigidly connected to each other at their ends by *tie baulks*, which must be lashed to *both* gunnels of each pier; the roadway baulks can then be laid, without lashing if rectangular; they should rest on *both* gunnels of each pier.

If, however, the baulks are round, or there is likely to be much sway on the bridge, and especially for animal traffic, it gives additional security to lash, at any rate, some of the baulks both to each other and their overlap, and also to the gunnels. Headless casks must be enclosed vertically in a specially prepared framework.

To form a raft. **166.** To form a raft, the logs should be placed side by side, thick and thin ends alternating; they should then be strongly secured with rope, and, if possible, by cross and diagonal pieces of timber fastened by spikes or wooden trenails; or the logs can themselves be connected by dogs.

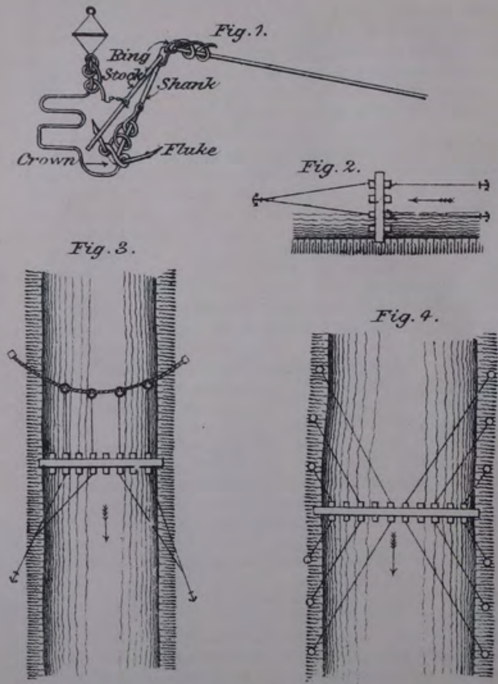
If a raft is to be used as a pier in a bridge, it will frequently be necessary to place the logs in two layers, to avoid obstructing the waterway. A central raised transom must be used. The up-stream end of the raft may, with advantage, be slightly convex.

Rafts are most easily put together and manipulated in the water.

Anchoring of bridges. **167.** Anchors are of various weights. For ordinary bridge work 56-lb. anchors, with a reserve of 112-lb. anchors, will generally suffice for moderate streams.

The cables are generally of 3-inch rope. The length of cable "out" should be ten times the depth of the stream, and rarely less than 30 yards. The cable is attached to the ring of the anchor (Pl. 55, Fig. 1) by a fisherman's bend; a buoy should

ANCHORS.



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Opposite page 65.

be attached to the anchor by a buoyline of 1-inch rope, fastened to a ring of the buoy by a fisherman's bend, and round the crown of the anchor, with a clove hitch split by the shank, and two half-hitches round the shank. The use of the buoy is to mark the position of the anchor and serve as a means of raising it.

As a rule there should be an up-stream and down-stream anchor to every second pier of a floating bridge.

If anchors are scarce, one may be made to serve for two piers by attaching two cables to it on the down-stream side of the bridge, as shown in Fig. 2.

Care must be taken before *heaving* an anchor overboard to see that it is carefully *stocked*.

Timber rafts and cask piers being, as a rule, a greater strain on anchors than boats or pontoons.

In a very rapid current, anchors can seldom be trusted. The bridge must then be secured to a hawser stretched across the river "up-stream." Wire rope is convenient for the purpose (Fig. 3). Short bridges can be kept steady by cables stretched from the piers to the banks, up and down stream (Fig. 4).

168. The following are substitutes for anchors :— Makeshift anchors.

Two or more pickaxes lashed together.

Heavy weights, such as large stones or railway irons; the latter are best when bent.

Nets filled with stones—remarkably effective on rocky bottoms.

Methods of forming floating bridges. Booming out.

169. A bridge can be formed by *booming out*, *i.e.*, the head of the bridge already constructed is continually pushed out into the stream, fresh materials being added at the tail. This method economises the distance the materials have to be carried, but necessitates a certain number of men working in the water, and cannot be used when the banks are steep, and there is deep water close in shore, as for instance, in the case of a wharf wall.

Forming up.

In *forming up*, material is continually added to the head of the bridge, the tail being stationary. This method is uninfluenced by the nature of the banks, no men being required to work in the water. Its only drawback is the distance the roadway materials have to be carried.

Rafting. In rafting, the bridge is put together in different portions or *rafts* along the shore, each raft consisting of two or more piers, which rafts are successively warped, rowed, or towed into their proper positions in bridge.

This method has the advantage that a large number of men can be employed simultaneously; and if secrecy be an object, the various portions can be constructed at some distance from the eventual site of the bridge, and a favourable opportunity seized for its construction.

Swinging. In swinging, an entire bridge is constructed alongshore, and then swung across with the stream.

A long bridge can be constructed by a combination of two or more of the above methods.

Forming cuts. If a bridge has to remain down for some time, arrangements must be made for the passage of the river traffic, which can be done by having two or more rafts, at the centre of the bridge, arranged for "forming cut" as required; or the two halves of the bridge may be swung, to afford the requisite passage.

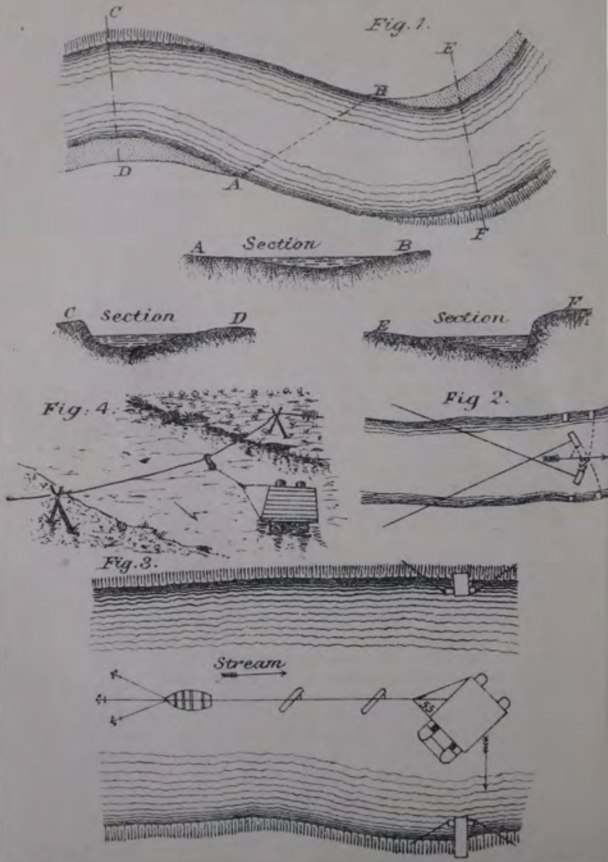
Protection of floating bridges. **170.** Arrangements must always be made, up-stream, for the protection of a bridge from damage by floating substances, either by a boat patrol or by stretching a net or some intercepting obstacle across the stream.

Passage of heavy artillery. **171.** If heavy siege artillery has to be passed over a broad river it will generally be most economical of material to construct the bridge of only sufficient strength for the ordinary traffic, and to warp the guns across on rafts constructed of sufficient strength for the purpose.

Passage of arms and ammunition. **172.** To keep rifles and ammunition dry when men swim across a river, small rafts can be made of waterproof kitbags filled with straw, blown-out masaks (water-skins), cooking kettles or any similar vessels, which should be placed mouth downwards.

Ferries and flying bridges. The simplest form of permanent ferry consists of ropes stretched across the river by means of which rafts can be sheered or hauled backwards and forwards from bank to bank. If it be not convenient, for the sake of traffic or other reasons, to stretch a rope across the stream, recourse may be had, if the current is rapid and regular, to a *flying* bridge, which is one in which the action of the current is made to move a boat or

FORDS & FLYING BRIDGES



raft across the stream by acting obliquely against its side, which should be kept at an angle of about 55° with the current. (Pl. 56, Fig. 3.)

Long narrow deep boats with vertical sides, to which lee boards can be attached, are the best for the purpose, and straight reaches the most suitable places, as they are generally free from irregularities of current or backwaters.

The cable, which should, if possible, float, such as coir rope, can either be anchored in mid-stream, in which case the raft can swing between two landing piers; or two cables may be used, one anchored on either bank, as shown in Fig. 2. This method requires less skill in manipulation, but necessitates two cables and four piers.

The length of a swinging cable should be one and a half to two times the breadth of the river, and it will work better if supported on intermediate buoys or floats to prevent it from dragging in the water.

Telegraph wire, buoyed up as above, on meat tins, makes a good swinging cable. Another way is to stretch a wire cable across the river, and arrange the raft so as to travel along it (*see* Fig. 4, Pl. 56).

173. The following depths are fordable :— Fords.

For infantry, 3 feet.
For cavalry, 4 feet.
Artillery, 2 feet 4 inches.

Gravelly bottoms are best, sandy bottoms are bad, as the sand gets stirred up, and the depth of water thus increases.

Fords should be clearly marked by long pickets driven into the river bed above and below the ford, their heads being connected by a strong rope. It is well to mark the pickets in order that any rise of the water may be at once evident.

The depth of a river is generally most uniform in straight parts; at bends the depth will generally be greater at the concave bank and less at the convex. Thus, in Pl. 56, Fig. 1, the depth will probably be above the average at C and F, and there will be shallow spits at D and E.

For this reason a river which is not anywhere fordable straight across may be found passable in a slanting direction between two bends, as at A B, Fig. 1.

CHAPTER XV.—CAMPING ARRANGEMENTS.

Cooking.

Field kitchens.

174. To cook for a large party, the most economical method is to dig or build up a long trench for the fire, place the kettles on it (its width not being sufficient to allow them to drop into it), and cover up between them with stones and clay, that the fire, fed from the windward end, may draw right through. A chimney can be built at the other end to increase the draught.

The section of a typical trench for this purpose is shown in Fig. 1, Pl. 57.

The chimney can be built of sods, and is supported where it passes over the trenches, by flat stones, slates, wood covered with clay, &c. The inside of the trenches and of the chimney may be plastered with clay, which makes them last longer. Several such trenches may be combined, as shown in Fig. 2, to form what is known as the *parallel* or rectangular kitchen, or three trenches may converge to one flue, as shown in Fig. 3, forming what is known as the *broad arrow* kitchen.

175. The gridiron kitchen (Aldershot pattern) is shown in Pl. 58.

Covered kitchen.

176. Pl. 57, figs. 4 and 5, gives details of a covered kitchen, suitable for standing camps. The roof may be covered with tarpaulins, or in the manner described in Section 193.

Expedients.

177. For a small party the cooking may be done by digging a shallow trench, in the direction of the wind, to contain the fuel. Small pieces of iron will be found very useful to support the kettle. Another way is not to excavate the ground at all but to build up two rough walls of stones on the top of which the kettle is placed.

Kettles.

The simplest and best arrangement for cooking in the field for any party over 20, especially if the stay in camp is only for one night, is to place a porportion of the kettles on the ground in two parallel rows about 9 inches apart, handles outwards, block the leeward end of the trench so formed with another kettle, lay the fire and place over it one or two rows of kettles resting on those already placed in position (*see* Pl. 59).

KITCHENS.

Fig. 1.

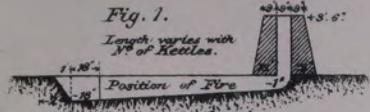


Fig. 2
RECTANGULAR

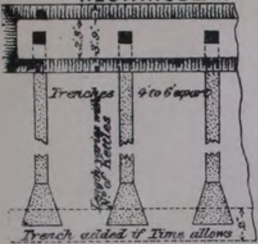
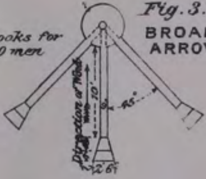


Fig. 3.
BROAD
ARROW



COVERED KITCHEN

Fig. 4.

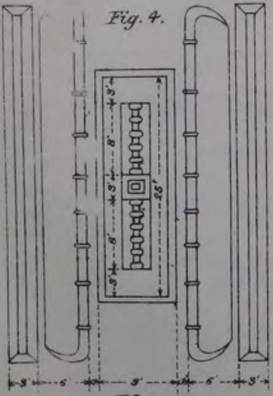


Fig. 5.

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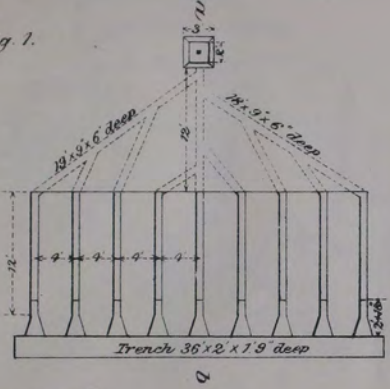
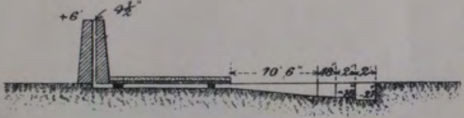
GRIDIRON KITCHEN

Fig. 1.

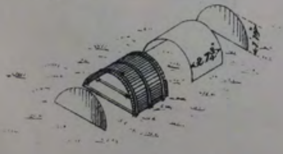


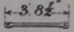


Section a. b.

ALDERSHOT OVEN

Fig. 2.





Bar

Fig. 3.

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To follow plate 57.

COOKING IN THE FIELD.

Fig. 1.

Fig. 2.

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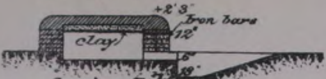
To follow plate 58

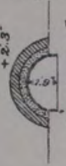
FIELD OVENS.

Fig. 1.



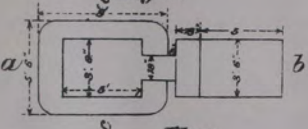
Section a.b.

Fig. 4.



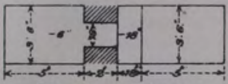
Section c.d.

Fig. 2.



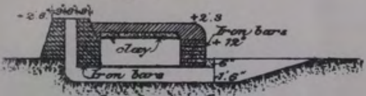
Plan

Fig. 3.



Tracing Lines

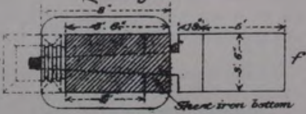
Fig. 5.



Section e.f.

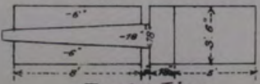
Fig. 6.

Section g.h



Plan

Fig. 7.



Tracing Lines

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To follow plate 59.

Mess tins can be arranged similarly, but in their case not more than eight should be used together. Mess tins.

178. The simplest form of a field oven consists of a hearth sunk below the ground surface, with an arch formed by a hurdle or sheet iron (*see* Pl. 60). The two gable ends are formed with sods. The whole of the interior of the oven is well plastered with cowdung and clay. The hurdle, well plastered on the outside with cowdung and clay so as to leave an arch when it burns away, is covered with earth from the excavation. The entrance to the oven is closed either by a hurdle plastered with clay or simply by sods. Field ovens.

This oven is specially suitable for making bread, and will bake for about 150 men at a time.

Figs. 5, 6, and 7 show an oven with a flue underneath an iron hearth. The oven is first heated by lighting a fire inside it, and this is afterwards raked out and pushed into the flue below to maintain the heat. It is a very useful oven for baking or keeping men's dinners warm. The service oven, Aldershot pattern, should be fixed up without the flue, but placed on a prepared flattened site.

Latrines.

179. Latrines should be made as soon as troops arrive on the ground; a small shallow trench will suffice for one night; and should be invariably filled-in in the morning, before the troops march off. In standing camps latrines may be made with seats, the seat being a pole (*see* Figs. 1 and 2, Pl. 61); additional comfort may be given by adding a top pole to form a back, as shown. Other forms are shown in Figs. 6 and 7. Latrines.

In order to keep out flies latrines, where practicable, should be closed in and made as dark as possible.

Latrines should be constructed to seat if possible at least 5 per cent. of the troops, 1 yard per man being allowed. The trenches must be narrow and deep to prevent the contents being blown about. When natives are employed special latrines for them are necessary.

It is very important that a couple of inches of the driest earth obtainable should be thrown over the soil twice daily; this, if carefully done, will prevent all smell and tend to prevent flies collecting. The earth may be dried by piling it close to the trenches of the field kitchens. Lime or charcoal may also be used to deodorise the soil in the trenches.

On leaving camp the site of latrines should be carefully marked.

Too much care cannot be bestowed in selecting the site of the latrines; since flies are very active agents in propagating diseases, latrines must be placed well away from cook-houses. Care must be taken that no filtration from them may reach the water supply.

Water Supply.

Water supply, quantity required.

180. Each man requires for drinking about 3 to 4 pints per diem; for drinking and cooking, 3 to 4 quarts; for drinking, cooking, and washing, 3 to 4 gallons.

Each horse requires for drinking 5 to 10 gallons, according to work and climate, soft water being the best; for cleaning, 6 to 8 quarts (which may be salt). Each mule or ox drinks 6 to 8 gallons; each sheep or pig 6 to 8 pints. These are minimum quantities.

Horses drink about $1\frac{1}{2}$ gallons at a time.

In calculating troughing, allow each horse five minutes at the trough.

N.B.—*See also* "Combined Training," 1905, Sec. 43.

One cubic foot of water = $6\frac{1}{4}$ gallons (a gallon = 10 lbs.).

Measurement of yield.

181. The rough average yield of a stream may be measured as follows:—Select some 12 yards or 15 yards of the stream where the channel is fairly uniform, and there are no eddies. Take the breadth and average depth in feet in three or four places. Drop in a chip of wood and find the time it takes to travel, say, 30 feet. Thus obtain the surface velocity in feet per second. Four-fifths of this will give the mean velocity, and this multiplied by the sectional area in square feet will give the yield per second in cubic feet of water.

LATRINES

Fig 1.

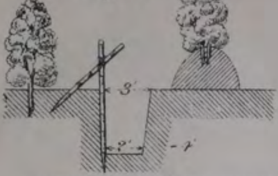


Fig. 2

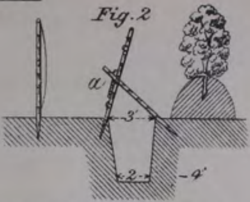
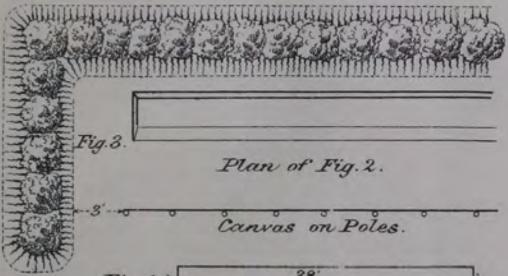


Fig. 3.



Plan of Fig. 2.

Canvas on Poles.

Fig. 4.

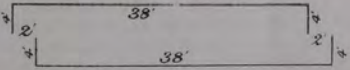


Fig. 5.

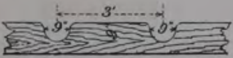
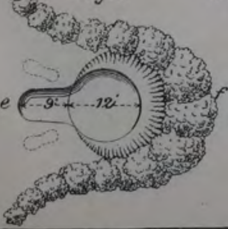
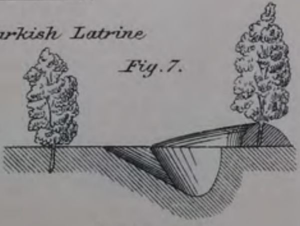


Fig. 6.



Turkish Latrine

Fig. 7.



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The source of the water supply should be carefully investigated, and measures taken to prevent the pollution of the water *en route* to the drinking supply. Source.

182. In the field the supply is usually obtained from sources which are at once available, such as streams, ponds, or existing wells. In default of these it may be necessary to sink wells and make reservoirs.

Surface springs should be sought for in hollows, at the foot of hills, where the earth is moist or where the grass is unusually green, where the thickest mists rise in the mornings or evenings, &c. Surface springs.

183. If the supply be from a lake, pond, or stream, separate watering-places for men and animals must be marked out and sentries posted. Stagnant water, as in a pond, is apt to be contaminated by large numbers of animals going in to drink; and even in a stream, when many animals are drinking, those below get foul water. If possible, therefore, the water should be drawn from the source and run into drinking troughs; these are best made of canvas or of boards; but trenches lined with puddled clay answer the purpose. Protection of the supply.

184. The overflow from the troughs must be carried off with the surface drainage. The sites of the troughs should, if possible, be paved and drained for a width of 10 feet, and should be so arranged that the animals may move to and from them without confusion or crowding, arriving from one direction and leaving in another.

Each horse occupies laterally 4 feet; if possible, all the horses in a camp should be able to be watered in an hour.

When troughs cannot be made, the banks should be cut down, and a hard bottom formed on the ramp to prevent the animal from sinking in. A barrier may be placed in the pond to prevent them from going out too far. The water should not be less than 5 inches or 6 inches deep where beasts are to drink.

185. In a stream the men should draw water above the place for the animals; while washing, &c., should be done below, and drainage should enter below the others as far down stream as possible. Supply from streams.

Barrels sunk in the bed of a small stream afford convenient dipping places.

Supply from springs.

186. If the supply be from springs, each springhead should be opened up and surrounded by a low puddled wall to keep out surface water. Casks or cylinders made of brushwood, like gabions, make good linings for springs. After they are placed, puddled clay may be worked down between the banks and the cask or cylinders. The overflow may be received into a succession of casks or half barrels (which may with advantage have their insides charred) let into the ground close together, the overflow from the first passing into the second, and so on; or deep narrow tanks with puddled sides may be constructed to catch the overflow.

Water from small ponds and shallow wells should be avoided, if there be a choice.

Pumps.

187. The lift and force pump is in most general use in the service. It is worked by two men. It can lift water from a depth of 20 feet to 28 feet, and force the water to a height of 60 feet from its former level, delivering 12 gallons per minute.

Purifying Water.

Boiling.

188. The best method of purifying water is by boiling. It gets rid of temporary hardness, renders dissolved organic matter harmless, and when carried out effectually practically destroys all micro-organisms. The water should be kept at the boil for at least five minutes.

Boiled water should be aërated before use. This can be done by passing through a sieve. Improvised methods can be arranged according to the means at disposal. Empty biscuit tins pierced with small holes suspended over a storage tank do very well for this purpose.

Care is necessary to prevent the addition of fresh impurities during aëration and distribution.

Filtration.

189. As it is not always possible to provide means of boiling water on a large scale, filtration must be resorted to.

Formerly mechanical filtration only was attempted and a clear sparkling water was considered good. Efforts are now directed to remove mechanical and chemical impurities as well as micro-organisms. Several filters have been brought before the public, all claiming to effect these purposes. The type most familiar is the "Berkefeld" filter. These filters, if treated with care and strict attention to detail, work satisfactorily. Their chief defect is a very slow delivery when water containing a large percentage of suspended matter is used. The porcelain candles become almost impervious when coated with fine mud and constant cleaning is necessary. This, however, is an easy process.

Dirty water should be strained before filtering. A good method is to tack a sheet on to a wooden frame so as to form a bag or basin; put a couple of handfuls of wood ashes in the bottom, and then pour on the water, allowing it to percolate into a receptacle beneath.

190. Chemicals are sometimes added either: (*a*) to precipitate suspended matters; (*b*) to remove hardness or; (*c*) to oxidise organic impurities. (*a*) Muddy water may be cleared by adding alum. Six grains of crystallised alum per gallon is sufficient. It should be added some hours before the water is required. (*b*) Water can be softened by the addition of limewater for drinking and carbonate of soda for washing purposes. The latter is unsuitable for drinking water as it gives an unpleasant taste. (*c*) Permanganate of potash (Condy's fluid) removes offensive smell from water and to some extent oxidises dissolved organic matter. It should be added until a faint tint remains permanent. It has not a disagreeable taste. Addition of chemicals.

Shelters and Huts.

191. Bivouacs are but seldom resorted to except in the neighbourhood of an enemy, when military rather than sanitary considerations are of primary importance. The following are the chief points to borne in mind in determining the sites for bivouacs:— Bivouacs.

In the presence of an enemy, tactical considerations, *e.g.*, favourable ground for defence in the event of attack, conceal- Choice of ground ment, facilities of protection, and consequently, economy in outposts are of the first importance. The comfort of the troops, in conjunction with sanitary conditions, is the next consideration.

A good water supply is essential, but considerations of safety may necessitate a camp or bivouac being placed at some distance from it. Other points to be considered are the facilities which a site offers for obtaining shelter, fuel, forage and straw.

The site for a camp or bivouac should be dry, and on grass if possible. Steep slopes should be avoided. Large woods with undergrowth, low meadows, and newly turned soil are apt to be unhealthy. Clay is usually damp. Ravines and watercourses are dangerous sites, as a sudden fall of rain may convert them into streams.

If the occupation is to be of a permanent nature, as in investment warfare and the defence of strategical points, the men ought to be hutted.

Temporary shelters.

192. Pl. 62 suggests methods of forming simple shelters. Fig. 1. Two forked sticks driven into the ground with a pole resting on them; branches are then laid resting on the pole, thick end uppermost, at an angle of about 45°, and the screen made good with smaller branches, ferns, &c.

A hurdle may be supported and treated in a similar way.

Fig. 2. A waterproof sheet, blanket, or piece of canvas secured by poles and string.

Fig. 3. A *tent d'abri* for four men, formed with two blankets or waterproof sheets laced together at the ridge, the remaining two blankets being available for cover inside.

Fig. 4. A wall of straw or reeds nipped between two pairs of sticks, tied together at intervals.

Figs. 5 and 7. Sentry box for standing camps.

When no other materials than earth and brushwood are available, a comfortable bivouac for 12 men can be formed by excavating a circle with a diameter of 18 feet, or thereabouts, and piling up the earth to form a wall 2 feet or 3 feet high. The men lie down, like the spokes of a wheel, with their feet towards the centre. Branches of trees, or brushwood stuck into the wall, improve the shelter.

BIVOUACS.

Fig. 1.

Fig. 2.

Shelter Tent

Fig. 3.

Fig. 4.

SENTRY BOXES.

Fig. 5.
Front

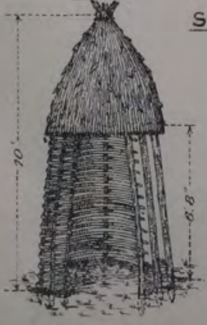

Fig. 6.

Fig. 7.

Front of round Box

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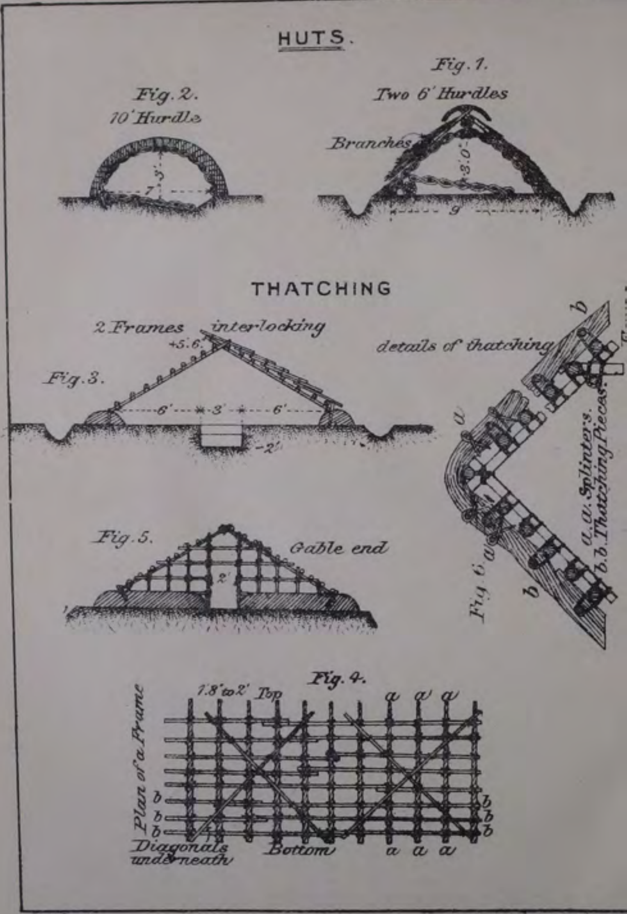

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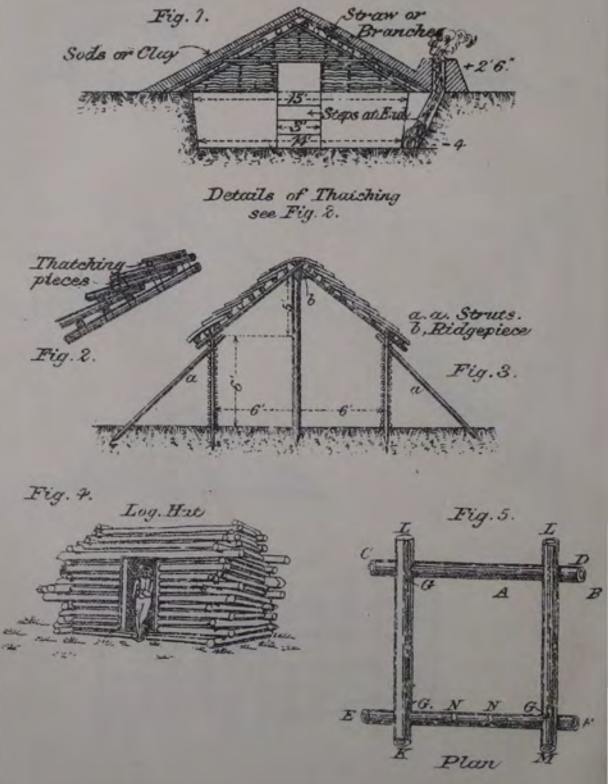
HUTS.



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To follow plate 6

193. The materials of which huts are made depend upon the resources of the locality, and are principally brushwood, logs, straw, reeds, clay, turf, and stones. Huts.

The best form of hut is generally rectangular in plan, with sufficient width for two rows of beds, and a passage down the centre, but, where the material available is of small size, one row of beds may be provided, or the hut may be made of circular form. A width of at least 6 feet should be allowed for each row of beds, and the passage may be from 2 feet to 4 feet wide. Plan.

The accommodation may be calculated on active service at one man per foot in length of the hut, when there are two rows of beds, and one man to every 2 feet when only one row on beds. Accommodation.

Fig. 1, Pl. 63, shows how the ordinary 6-foot hurdles may be arranged to form a hut. A fascine at the ridge, with thatching of straw, reeds, &c., may be used as roofing.

Hurdles may be made of special dimensions for hutting purposes. Fig. 2 shows how a hurdle 10 feet long (measured on the curve) may be made into a hut. The hurdle is constructed on a curve slightly flatter than that it is intended to have, so that it is necessary to spring it together to get it into position. It is then secured with pickets, and covered with sods, or daubed with clay in the manner described in Sec. 195. The ground forming the floor of the hut may be sloped as shown before putting on the hurdles. Hurdles.

Hurdles for hutting purposes should have the ends of the pickets cut off as close to the web as possible, so as to leave no gaps between them.

194. When brushwood of 2 inches or 3 inches diameter and 14 feet or 15 feet long is available, a hut for a double row of beds may be made as in Figs. 3 and 5. Brushwood.

The section of the hut being decided on, is laid out on the ground; from this the length of the rafters is obtained. Each side of the roof is then made separately on the ground as follows:—

Poles of 2 inches to 3 inches diameter are laid on the ground parallel to each other, from 18 inches to 2 feet apart, as *aa*, in Fig. 4, Pl. 63. These form the rafters. On the slope of the rafters, and at right angles to them, light rods or *laths*, *bb*. from ½ inch to ¾ inch thick are laid, the uppermost one being at such a distance from the bottom of the poles as will allow the frames, when made, to lock at the desired height above the ground, the lowermost one being within a few inches of the bottom, and the interval between being divided according to the length of the thatching or covering material. The distance apart of these laths should be slightly less than half the length of the covering material, so that the latter may be supported at three points. With good wheaten straw the interval may be from 12 inches to 1½ feet. At each point of crossing the laths and rafters are secured by a short length of one strand of spun yarn, and the frame thus made is afterwards stiffened by diagonals lashed underneath.

Roofing material. The roofing material, which may be unbroken straw, rushes, long ferns, &c., is now put on. Commencing at the bottom, a layer 4 inches or 5 inches thick is equally laid over the three lowest laths, ears or tops downwards; it is here secured by a light rod or *thatching piece* tied with spun yarn at intervals of 2 feet or 3 feet to the second lath from the bottom. A second layer is now put on one lath higher up, and is secured in a similar way to the third lath from the bottom, and so on until the top is reached; the last layer projecting over the top lath, so that when the frames are locked the ends may be twisted together to keep out wet (Fig. 6, Pl. 63). When both frames are ready they are raised and locked, as in Fig. 3. Forked uprights and a ridge piece may be added to stiffen the roof.

Each side of the roof may be made in one piece, or if large and inconvenient to move, in two sections. The ends of the laths should project about 2 feet beyond the extreme rafters and are supported by the framework forming the Gable ends Fig. 5. The latter are made and thatched in a similar way to the roof, and simultaneously with it, an opening being left for a door.

Passages. In order to give additional headway, the passage may be sunk as in Fig. 3, with steps at each end, the earth being thrown to the eaves as additional protection, and to give more head room when lying down. In very cold weather the whole interior of the hut may be excavated, fireplaces constructed as in Fig. 1, Pl. 64, and, if the rafters be strong, some of the excavated earth may be thrown on to the top of the roof, a collar tie being added to strengthen it.

Huts may also be thatched by forming the straw or grass into *panels*. The straw in moderately thick layers is doubled and nipped near the centre between two rods, one above and one below, which are tied tightly together at the ends and at intervals of about 6 inches. Panels.

The panels formed thus are tied on to the roof, being placed so as to overlap like large slates.

195. Walls may be constructed of *wattle and daub*, *i.e.*, continuous hurdle work daubed over on one or both sides with clay, in which is a proportion of any fibrous substance, such as straw, grass, horse hair, &c., chopped into short lengths to prevent the clay cracking and opening as it dries. This mixture, which should be kneaded into the consistency of a stiff paste, should be worked in with the hands. The sides should be strutted at intervals to resist wind, and the roof may be carried on a ridge pole, which may be strengthened by uprights in the centre, Fig. 3, Pl. 64. Wattle and daub huts.

196. When timber is abundant, log huts may be constructed as shown in Fig. 4, Pl. 64. No fastenings are required beyond some *trenails* (wooden pegs) to secure the rafters to the top logs. The roof may be made as already described, or the covering material may be of slabs of wood, bark of trees, &c. Log huts.

Bark may be got off trees in large strips by cutting round the tree with a knife at intervals, say, of 4 feet; then cut off width required, and beat with a flat piece of wood to detach the bark from the tree.

197. When straw is issued for the troops to lie upon, it may be made up into mats in the manner shown in Pls. 65 and 66. Straw mats.

To make the mat shown on Fig. 1, pickets are driven into the ground, the outside pickets being at a distance apart about 6 inches less than the width of the required mat. A crossbar, AB, is fixed about 2 feet from the ground. Several lengths of spun yarn are then taken and made fast, about their middle, to the crossbar, AB, at a distance of 5 inches or 6 inches apart, and their ends made fast to the bar, CD, and to the other pickets, as shown in the figure. Handfuls of straw rather longer than the width of the mat are taken and pushed in between the yarns, and the bar, CD, being alternately raised waist high and depressed to the ground, and passed inside and outside the end pickets, so as to form a hitch. Finally, the sides of the mat are trimmed to the right size by a sharp pair of scissors or a knife, and the yarns finished off at either end with reef knots.

Straw ropes.

The mat shown in Figs. 2 and 3 is formed by making straw ropes and interlacing them on pickets driven into the ground. If the straw ropes are carefully made, this makes a more durable mat than the previous one. (Pl. 67.)

CHAPTER XVI.—HASTY DEMOLITIONS WITH EXPLOSIVES.

Explosives.

Explosives carried in the field.

198. The service explosives available for hasty demolitions in the field are guncotton, gunpowder, cordite; guncotton being specially carried for this purpose. Dynamite may also sometimes be obtained locally.

Comparison of explosives. Guncotton and powder.

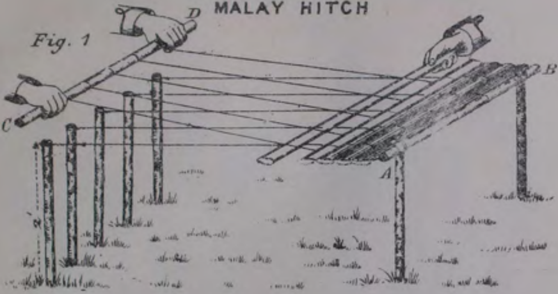
For hasty demolitions guncotton is by far the best of the service explosives. Its chief advantages over gunpowder are that for equivalent effects a guncotton charge takes up much less room, and does not require the same amount of tamping*; it is therefore much more easily and quickly placed and fired, which is an important point in hasty demolitions.

* "Tamping" is covering the charge over with earth or other material so as to confine the gases at the commencement of the explosion, and thus develop their force more fully.

STRAW MATS

MALAY HITCH

Fig. 1



STRAW ROPE MATS

Fig. 2

Pickets 6' apart

Fig. 3.

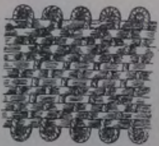


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Plate 66.

MAKING STRAW MATS

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To follow plate 65

MAKING STRAW ROPE

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To follow plate 66

Guncotton is also safer in transport and handling.

Cordite and dynamite are nearly as powerful as guncotton, and have the above advantages over gunpowder, but are not so safe in transport. *Cordite and dynamite.*

Where a lifting and shaking effect is required, gunpowder is best.

Where a cutting or shattering effect is required, which is most likely in hasty demolitions, guncotton, cordite or dynamite are best.

Guncotton.

199. Guncotton, if steeped in water, will absorb about 30 per cent. of its weight. *Properties of wet guncotton.*

Wet guncotton does not ignite easily, and requires the explosion of a very large amount of detonating substance, such as fulminate of mercury, in contact with it to detonate it.

Dry guncotton will not detonate in the open in small quantities if a light be set to it, nor if a bullet strikes it when not heated. *Properties of dry guncotton.*

It will detonate if it is struck between two hard substances.

If dry guncotton, especially when finely divided in the shape of fluff, becomes heated in any way (through friction or the heat of the sun) it is much more sensitive to percussion. *Sensitive when heated.*

If a small quantity of detonating substance such as fulminate of mercury be exploded in contact with dry guncotton, it will detonate with great violence, and also cause the complete detonation of any wet or dry guncotton with which it is in contact. *Means of detonating wet guncotton.*

The explosive force of wet guncotton is slightly greater than that of dry.

So that for safety in transport, &c., in the field, the bulk of guncotton is carried and used wet in the shape of "*slabs.*" For detonating this, dry guncotton is also carried in the shape of small discs called "*primers.*" The following table gives the dimensions of the slabs and primers for land service :— *Carried wet. Primers.*

Slabs are issued in two sizes, about 6 inches square, weighing $1\frac{3}{4}$ and $1\frac{1}{2}$ lbs. respectively.

Primers are also issued in two sizes, weighing 1 oz and 2 ozs. respectively.

The slabs have two holes in them, one to fit the 1 oz. primer and the other the 2 oz. primer.

Cavalry pioneers carry special 1 lb. slabs.

Primers are carried dry in airtight tin cylinders.

Use of wet and dry guncotton. For auger holes and for necklaces round timber, dry guncotton primers form the charge. Otherwise the charge is always of wet slabs.

Details. The slabs can be cut without danger with a sharp knife or saw, care being taken to press the guncotton between boards whilst it is being cut to prevent it flaking away. There is a special clamp in the R.E. equipment for doing this. The guncotton should be kept damp.

Means of detonation. A charge of wet guncotton is detonated by means of the explosion of a dry primer in close contact with it. The primer is exploded by means of a "detonator," the detonator is detonated by means of either "safety" or "instantaneous fuze," which is lit by a fusee or other means. (For details of detonators, fuzes, see Sec. 205 and onward.)

Improvised primer. If dry primers are not available, a piece of wet guncotton can be dried *by exposure to the sun*, and used instead.

Connecting up for detonation. **200.** A charge is connected up for detonation as follows :—

The fuze (safety alone or safety with instantaneous) is cut to the required length. The end to be ignited is cut on a slant to expose as much of the composition as possible.

The end to be inserted in the detonator is cut straight across.

The straight cut end is then gently inserted into the open end of No. 8 detonator, from which the paper cap has been torn. This end of the detonator is then slightly bent (or with new-pattern detonator, pinched) to make it grip on the fuze and so prevent its being withdrawn.

(Cavalry pioneers carry detonators with a short length of safety fuze ready fixed, the fuze having a piece of quickmatch added to the end to facilitate lighting.)

The primer having been placed in *close contact* with one of the slabs of the charge, either in one of the holes or tied to a slab (see that the primer is dry), the small end of the detonator is gently inserted into it so as to fill the entire length of the hole. If the hole is too large, a piece of paper or grass must be wrapped round the detonator to make it fit tight; if too small, it must be enlarged with the rectifier* or piece of wood, but not with the detonator. **Rectifiers.**

The charge must be in close contact with the object to be demolished, and all the slabs must be touching each other. **Arrangement of charge.**

Where the charge is a very long one, more than one detonator should be used.

The charge must extend across the whole length of the object to be cut. **Placing of charge.**

Arrangements must be made to prevent sparks from the fuze falling on it and so setting it alight instead of detonating it.

For calculation of charge, *see* Chapter XXI. **Amount of charge.**

GUNPOWDER.

201. Gunpowder is not so suitable for hasty demolitions as guncotton, and the larger the grain of the gunpowder the less suitable it is, owing to its slow burning. **Details.**

Except the larger grained prism and moulded powders, which are packed in cases, it is usually carried in barrels, the powder being contained in a waterproof bag inside the barrels.

Powder is usually fired by safety or instantaneous fuze. **Ignition.**

A gunpowder charge should be made up in as compact a form as possible, and if sandbags filled with earth are used to tamp it, the charge should be of the same shape as the sand bags. **Making up the charge.**

A service sandbag will hold about 40 lbs. of gunpowder, which is about as much as a man can carry conveniently. When a charge has to be placed under fire, and the amount is greater than this, it should be divided amongst several bags, as required, rather than put into one large one. In this case only one bag need be fuzed.

* Rectifiers are boxwood implements supplied for enlarging the perforations in guncotton primers so as to take the shanks of detonators.

Connecting up with means of ignition.

A gunpowder charge should not, as a rule, be spread evenly along the whole breadth of the object to be destroyed, but should be divided up into portions, which may generally be at a distance apart of twice the thickness of the object. The several portions must be fired simultaneously.

In the case of a stockade or fort gate, one concentrated charge will make a breach wide enough to admit of easy entrance.

Amount of charge.

For the amount of charges suitable, *see* Chapter XXI.

Cordite.

Supply.

202. Cordite can be used instead of guncotton or dynamite. It may be obtained from gun cartridges, and would only be used where no other explosive is available.

Making up charge.

It must be detonated with a guncotton primer, and the cordite should be tied up in a tight bundle with the primer in the centre.

The primer being connected up with No. 8 detonator and fuze as described for guncotton.

Its successful detonation is rather uncertain.

Placing charge.

As with guncotton, the charge must be in *close contact* with the object to be demolished.

The cordite must be covered up with fresh grass or leaves to prevent the sparks from the fuze setting it alight, which happens very easily.

Amount of charge.

As for guncotton, *see* table, Chapter XXI.

Dynamite.

Supply.

203. Dynamite, where procurable, can be used instead of guncotton.

For military purposes the only advantage that dynamite has over guncotton is, that being plastic it is easier to fit into narrow and irregular holes such as are used for blasting rock.

For demolishing masonry it is not so good as guncotton, as its action is even more local.

It cannot be used after exposure to wet, which separates the nitro-glycerine and makes it dangerous. General properties.

It freezes at 40° F., and remains frozen at higher temperatures. Frozen dynamite can be distinguished by being harder than unfrozen, by being more brittle than plastic, and being of a slightly lighter colour.

Frozen dynamite should if possible be thawed before use. It cannot be used when frozen as it will not detonate readily, though it will explode by simple ignition.

IT MUST NOT BE THAWED NEAR A FIRE, but by the warmth of warm water, in some apparatus like a common glue pot, where the dynamite can be kept dry while surrounded by warm water not hotter than the wrist can bear.

It is usually obtained in 2 oz. cartridges wrapped in parchment paper. Supply.

It can be detonated by fuze and No. 8 detonator, or by fuze and cap. Detonation.

No. 8 detonator is unnecessarily strong.

When cold weather is likely, dynamite should be buried a foot or two underground. Storage.

Dynamite Charges.

204. If a No. 8 detonator be used, this is connected up with fuze, as described for guncotton, and the end inserted into one of the cartridges for about 2 inches and tied in. Connecting up with means of detonation.

If a commercial cap is used, the straight cut end of the fuze having been gently inserted into the mouth of the cap till it touches the fulminate, the mouth of the cap is squeezed to hold the fuze in place.

The cap, with the fuze attached, is then inserted into one of the dynamite cartridges almost as far as its length, and tied into position.

Arrangement of charge. Boreholes. For a bore hole for blasting, or an auger hole in timber, as many cartridges as necessary are inserted, and each squeezed in separately with a wooden rammer (*see* Fig. 7, Pl. 68). Iron must not be used to ram with, and the ramming should be gently done.

The cartridge with detonator or cap for firing should be the last.

Placing charges. For other charges the dynamite should be tied up in as compact a parcel as possible, and placed *tight* against the object, the means of detonation being in one cartridge.

All the cartridges of a charge must be in contact.

Hole for cap. Holes for detonators or caps must be made with the rectifier or a piece of wood.

Tamping. The tamping of a bore hole may be sand, clay, or water, but in the latter case the cap must be kept dry.

Cheddite. A new explosive called cheddite is coming into use; it has about the same explosive effect as dynamite, and has the advantage of not freezing at so high a temperature. It would be useful in blasting work.

Use under water. For use under water dynamite and similar explosives should be tied in a waterproof bag (*see* Pl. 68, Fig. 8).

Means of Detonation and Ignition.

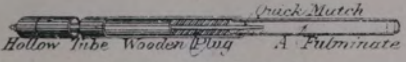
Detonators.

Detonators for guncotton. **205.** There are two kinds of *detonators* in the service for detonating guncotton; only one will be here described, viz., that called "Detonator No. 8 for safety fuze"; the other, which requires electrical firing apparatus, being beyond the scope of this manual.

No. 8 detonator. Fig. 1, Pl. 68, gives a section of this detonator. It consists of a brass tube painted red, the small end of which, A, contains

HASTY DEMOLITIONS.

Fig. 1.



Section of No 8 Detonator.

Fig. 2.

Fig. 9.

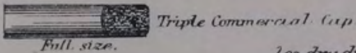


Fig. 5.

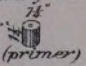


Fig. 3.

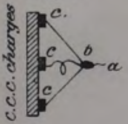


Fig. 4.

Fig. 6.

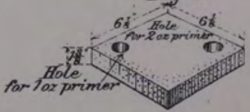


Fig. 7.

Fig. 8.

Tying up a dynamite cartridge in a waterproof bag when used under water

the detonating compound (fulminate of mercury); above this is a wooden plug with a hole in it, through which passes a piece of quickmatch. The upper end of the tube is empty, for the insertion of the fuze, and is closed by a small paper cap. These detonators are packed in tin sealed cylinders painted red, which contain 25. A new pattern No. 8, with a short shank, will shortly be introduced.

No. 8 detonator will detonate dry guncotton, but it will *not* detonate wet guncotton or cordite without a primer. Both safety and instantaneous fuze can be connected to it.

Commercial caps. Where dynamite is obtained a smaller kind of detonator used in civil works will often be available and should be used in preference to No 8 detonators as being more economical. This is the "commercial cap," which is made of copper, and contains less fulminate than the No. 8 service detonator, *see* Fig. 9, Pl. 68.

These caps vary slightly in size and strength. To detonate dynamite, trebles are used as a rule. The weaker sorts cannot be counted on to detonate guncotton primers, but "sextuples" are strong enough.

They can be connected up to safety or instantaneous fuze.

Storage. Detonators must be stored apart from explosives; when attack is likely they should be protected from bullets.

Fuzes.

Safety fuze. **206.** The present pattern of safety fuze is known as "Safety, No. 9."

This consists of a train of fine gunpowder enclosed in jute yarn, covered with guttapercha and waterproof tape. It is packed in tin cylinders containing 8, 24, or 50 fathoms.

It is coloured BLACK.

Burning under water. Safety fuze will burn under water.

Rate of burning. For practical work the rate of burning can be taken as 3 to 4 feet per minute.

Old fuze. Old fuze should have its rate of burning tested before being used. Fuze which has been more than six months or so in a tropical climate should be very carefully examined.

Lighting. It is difficult to light safety fuze with a match or flame. A portfire or vesuvian (fusee) is best, but in the absence of such means of ignition, the head of a match inserted in the fuze and lit by another match, forms a good method of lighting. A glowing cigar, cigarette or pipe is also good for the purpose.

Instantaneous Fuze.

Instantaneous fuze. **207.** Consists of two strands of quick match enclosed in flax and several layers of guttapercha and waterproof tape.

It burns at the rate of 30 yards a second, or practically instantaneously; it is packed in sealed tins holding 100 yards.

It is coloured ORANGE.

It can be distinguished in the dark from safety fuze by feeling the open crossed thread snaking outside it.

Joining Fuzes.

Joining fuses. **208.** In firing charges with instantaneous fuze, a piece of safety fuze should be joined on for lighting, in order to allow time for getting away, except in special cases where the instantaneous fuze used is long enough to admit of being lit from a safe place.

Joining safety and instantaneous fuze. To join safety and instantaneous fuze, cut the instantaneous fuze on the slant so as to expose the quickmatch for a short length, also the safety fuze in the same way, taking care that the composition is well laid open.

Join these two surfaces together and bind up tight. A small piece of wood is useful as a splint, and if handy, a little powder or quickmatch can be put between the two fuzes (Fig. 2, Pl. 68).

Joining two lengths of instantaneous fuze. To join two lengths of instantaneous fuze, slit the outer covering of each piece of instantaneous fuze at the end, it can then be turned to expose the quickmatch; the strands are then twisted together, the outer covering made to overlap the joint, and firmly fixed with twine.

Joints in fuze can be made waterproof by wrapping them round tight with indiarubber tape smeared with indiarubber solution, which are articles of R.E. equipment. Ordinary tape and tallow would do for a short time against damp. Waterproofing joints.

Simultaneous Charges.

209. Charges are best fired simultaneously by electricity. When this is not available, it may be done as shown in Fig. 3, Pl. 68, by using equal lengths of instantaneous fuze, "*bc*," which are ignited at "*b*" by a length of safety fuze, "*ab*." Simultaneous charges.

The joint at "*b*" can be made with a small bag or box of gunpowder, into which the end of the piece of safety fuze and the ends of the instantaneous fuze are led, the quickmatch in the latter being exposed.

Care must be taken that the *lengths of instantaneous fuze are equal*, irrespective of the distance from the powder box to the charges.

SUBSTITUTES FOR SERVICE FUZES.

210. When service fuzes are not available, means of firing must be improvised.

"Mealed powder" (which is very fine), moistened, or ordinary gunpowder ground into a fine paste with water between two pieces of wood, can be pressed into a tube and used instead of safety fuze. Mealed powder.

This burns at the rate of 2 feet per minute, or slower, depending on the dampness of the powder.

Powder hose, made up by filling tubes of strong linen with fine powder, can be used instead of instantaneous fuze. Powder hose.

The tubes can be from ½ inch to 1 inch in diameter, made from one strip of stuff; they are loaded in lengths up to 20 feet through a funnel. The lengths can afterwards be joined.

It burns at the rate of from 10 feet to 20 feet per second.

PRECAUTIONS.

211. For amount of explosive required, *see* Chapter XXI. General rules.

For cordite and dynamite use slightly more than is required for guncotton.

When possible, tamp all charges. If guncotton charges are tamped, one-half the charges given in the table are sufficient.

For demolitions in the presence of the enemy, increase the calculated charges by 50 per cent.

Storage of detonators in camp.

Detonators should be buried to prevent being exploded by stray bullets.

Connecting up detonators.

When connecting up No. 8 detonators with fuze, the detonating ends of the fuze should not be pointed at anybody.

When carried out under fire, take every precaution against a possible failure; detail spare men to carry the stores to replace casualties, and see that every man with the party has the means of lighting the charge.

For large charges of all sorts which cannot easily be got at after tamping, and for demolition work where certainty and rapidity are essential, it is a good rule to insert two fuzes (and detonators if required) in the charge in case one should prove faulty.

Connecting up caps.

When pinching or bending the mouth of a detonator or cap to grip the fuze, care should be taken not to squeeze the detonating end.

Protection to detonator for tamping.

When tamping a guncotton charge with earth, stones, &c., the detonator should be protected from being knocked.

Make arrangements to prevent sparks from the fuze causing premature explosion of gunpowder charges, or setting fire to guncotton.

Brickwork and Masonry.

General.

212. For the demolition of brickwork or masonry with guncotton, the charges worked out by the formulæ in the table will sometimes be too small to allow the whole length of the breach to be cut, being covered with whole slabs touching each other. In such a case :—

(*a*) If guncotton is available, do not divide slabs, but add extra slabs till the whole length to be cut is covered by slabs touching each other.

(*b*) If plenty of guncotton is not available, cut some of the slabs so as to make the charge stretch right across. Smaller pieces than thirds of slabs should not be used.

PREPARING CHARGES.

Fig. 1.

Fig. 2.

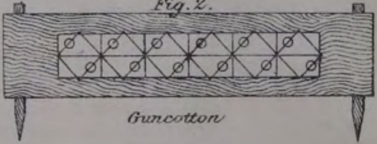


Fig. 3.

Fig. 4.

Fig. 5.

N.B. 1 Sandbag holds about 50 lbs of Gunpowder.

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Opposite page 8

213. Where there is a series of arches, as in a viaduct, the best *result* is got by cutting the piers and so bringing down two arches for each charge, but in hasty demolitions this can only be done when the piers are thin and high. Brick and masonry arch bridges.

214. The best explosive to use for this purpose is guncotton. The charge should be placed where the section of the pier is smallest, and if possible a groove should be cut in the pier to place the charge in; this reduces "T" and also to some extent tamps the charge. Otherwise the charge should be tied in a continuous strip along a board, and this fixed on to the pier with the guncotton next it (Pl. 70, Fig. 1, and Pl. 69, Figs. 1 and 2). High and thin piers. Gun-cotton.

215. The piers cannot be satisfactorily demolished with gunpowder in haste, as the speediest method of placing the charge would take some time; it would generally be better to attack the arches. Gun-powder.

The following is the quickest way of attacking piers:— Divide the whole charge into two or three parts, and as the chambers cannot be cut in the pier, place the charges in pits dug in the ground close alongside each pier. Tamp with earth and fire simultaneously. If the piers are in water the above cannot be done.

216. The amount of guncotton and gunpowder for cutting short and thick piers is prohibitive, and the arches should be attacked. The best method of doing this is to place a charge at *each* "haunch" of the arch. This ensures a much larger gap being made than if only one charge were placed at the "crown." Short and thick piers.

217. If guncotton be used, a trench must be dug down to the back of the arch ring at each haunch. Then the slabs (tied to a board if possible) should be laid all along the trench on the back of the arch ring. If it is desired to economise the explosive, tamping may be used, but it is not essential (Pl. 70, Fig. 4). Gun-cotton.

218. If gunpowder be employed, the charge for each haunch should be divided into equal parts, which should be placed about twice the thickness of the arch-ring apart from each other, the outside ones being placed twice the thickness of the arch-ring from the side walls, to avoid the charges blowing out through the side walls. A pit must be dug for each portion of the charge down to the back of the arch, and tamping is necessary equal to twice the thickness of the arch. Gun-powder.

In all cases the charges at *both* haunches should be fired simultaneously.

When there is not enough time to reach the haunches, the crown (*a*) may be attacked in a similar way, but the result is not so satisfactory (Pl. 70, Fig. 4).

Gun-cotton under arch.

219. Where time presses, small arches can be cut by guncotton at the crown without digging through the roadway. The charge to cut through the arch can be tied in a continuous strip along a plank, and this held up underneath the arch by ropes from the parapet at the crown, with the guncotton next the arch. These ropes should be windlassed up tight so as to ensure contact between the guncotton and the arch.

The plank should be supported or trussed to prevent sagging in the middle.

Walls.

Gun-cotton.

220. To demolish a wall by guncotton, a groove should be cut, if possible, for the charge in the wall; if not possible, the charge should be laid against the wall. (*See* Pl. 70, Figs. 2 and 3.)

Gun-powder.

With gunpowder the total charge should be divided up into parts, each part being placed from the next a distance equal to twice the thickness of the wall. Earth tamping should be used.

To bring down the top of a wall, the length of the breach cut must be not less than the height of the wall.

Houses and huts.

221. For weakly-built houses, place a charge in the centre of each room, shutting all doors and windows. If possible, fire charges simultaneously by electricity. The amount of explosive required depends on the size of the rooms and the nature of the walls. Mud huts up to 18 ft. square, with walls 2 feet thick at the bottom, have been destroyed by about 4 lbs. of guncotton placed inside the hut in one corner, all openings being closed; 6 to 12 lbs. of guncotton will probably destroy a four-roomed cottage. For strongly-built buildings it may be necessary to attack the walls.

Towers of stone and mud.

222. Towers such as those in the North-West Frontier of India are usually 15 feet to 20 feet square in plan, with walls 3 feet or 4 feet thick, solid up to a height of 15 feet to 20 feet.

Gun-cotton.

The walls consist of stone and mud, with layers of brushwood. To blow down one of these, a tunnel should be made into the centre of the tower under a layer of brushwood (which keeps

HASTY DEMOLITIONS.

Fig. 1.

Fig. 2.

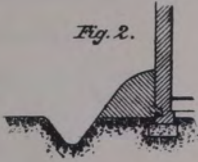

Fig. 3.

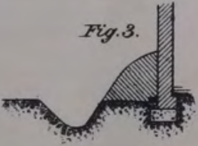

Fig. 4.

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Opposite page 90.

the roof from falling in), and guncotton charges placed at the ends of the tunnel, the whole being tamped.

223. Charge for a tower with a solid base of 15 feet side is about 16 lbs. Charges.

Charge for a tower with a solid base of 25 feet side is about 24 lbs.

For hollow towers charges of 6 lbs. of guncotton placed inside the tower at one corner, and in the centres of two adjacent sides, fired simultaneously, will generally be effective.

Timber.

224. It is more economical to destroy baulks of timber by cutting them down or burning them than by explosives, which would only be used when time presses. Timber uprights.

225. Of explosives guncotton is the best, and is most economically used when placed in auger holes bored horizontally at the required height for cutting. For baulks up to 18 inches diameter one auger hole will suffice, bored to just beyond the centre, the centre of the charge being in the centre of the timber (Pl. 68, Fig. 4). Guncotton in auger holes.

For larger baulks two or more holes will be needed, bored alongside each other, the intervening portion of wood being cut away.

The whole charge should consist of primers: 2-oz. primers in a 2-inch auger hole, or 1-oz. primers in a 1½-inch auger hole, earth or clay being used for tamping. The fuze may be hung on a nail or splinter to take the weight off the detonator.

226. Dynamite can be used in a similar manner. It must be carefully and gently rammed to fit the auger hole. Dynamite.

227. To save the wood rom being splintered, or where great haste is necessary, the demolition can be done with a necklace of guncotton primers; but this method is very wasteful of explosive, and can only be used for small timbers, and is not even certain then. Necklace of guncotton primers.

Sufficient primers, threaded on a string, to reach all round the timber, *each primer touching the next and the timber*, are hung on nails. The detonator may be inserted in one of these or in an extra primer tied to one of the others.

Timber may also be blown down by a charge of guncotton in slabs. In this case a niche may be cut for it to decrease "T."

Timber may be made to fall in any required direction by getting a strain on it beforehand with a rope.

Timber or timber and earth stockades.

Gun-cotton.

228. The most convenient way to place a guncotton charge against a stockade, so as to ensure contact between the slabs, is to tie them beforehand on to a board, and to carry this up with the guncotton attached; a hole must be cut in the board for the detonator and fuze (Pl. 69, Figs. 1 and 2).

The board is placed with the guncotton next the stockade, and two pickets can be driven into the ground to keep it there, or a couple of nails driven into the stockade, to which the charge may be hung.

The length of the board and the charge must equal the breadth of the breech to be made.

Gun-powder.

229. A gunpowder charge can be made up as follows (Pl. 69, Figs. 3, 4, and 5) :—

Making up the charge.

Connecting up with means of ignition.

The powder should be placed in a well tarred sandbag, or failing that, in one sandbag inside a second one. About half the powder is first poured into the bag, and then the safety fuze, knotted round a stick to prevent its being pulled out, is inserted, a piece of stout wire or a withe being also attached to the stick, to help to support the fuze after it leaves the mouth of the bag. The rest of the powder is then poured into the bag, and the mouth is secured with spun yarn as shown, so as to make it more easy to carry, a last seizing of the spun yarn being made round the fuze so that any pull on it will fall on the spun yarn and not on the fuze iteslf.

The fuze will almost invariably ignite the charge by burning through its wrapping as soon as it reaches the powder. The necessary lengths of fuze should therefore be measured from outside the mouth of the bag.

Instantaneous fuze in addition to safety fuze should not be used where there is only one charge, as it increases the liability to missfire.

Placing the charge.

230. To place a bag against a gate or stockade, the precautions mentioned in Sec. 211 should be observed, and, in addition, the men carrying the tamping bags should be thoroughly drilled as to how the charge and tamping is to be placed. The man carrying the powder bag on his shoulder leads the way, and placing the bag, fuze down-wind, and so that the fuze does not curl up against the charge, against the stockade, prepares to light. The other men, each carrying a bag in the same way, successively drop them so as to place them as shown in Fig. 5, Pl. 69. The fuze is then lighted, and all get away as quickly as possible.

For a gap 5 feet to 6 feet wide, a charge of 60 lbs. to 80 lbs.. roughly tamped with sandbags, as shown in Fig. 5, Pl. 69, will suffice.

231. The gate of a fort may be treated as a very strong stockade. As the thickness cannot usually be known, a good margin in the amount of the charge should be allowed. Fort gate.

For guncotton 50 lbs. will usually be enough, either placed on the ground or hung to the gate on a nail carried for the purpose and driven in. Gun-cotton.

For gunpowder a charge of 200 lbs., tamped with sandbags, should suffice. Gun-powder.

Railways.

232. On railways, the easiest parts to attack in hasty demolitions are the bridges. Bridges.

233. Masonry arch bridges should be attacked as described already. Masonry bridges.

234. Iron and steel bridges can be destroyed with small expenditure of explosive. Iron and steel bridges.

The girders *may* be destroyed by placing charges of gunpowder or guncotton beneath the ends at the supports; but by far the quickest may is to actually cut the girders themselves with guncotton. Gun-cotton.

Nearly all girders consist of a top and a bottom "*flange*" or "*boom*," connected by a "*web*," which may either consist of continuous plating or of open cross bracing. Girders.

All girder bridges have at least two main girders which carry the flooring and go right across the span, and these main girders alone need be attacked. Usual arrangement of girder bridges.

As a rule the best effect will be produced by cutting a girder near a point of support, and this course will be economical of explosive, as the flanges are usually slighter at the ends than at the centre. In the case of a girder continuous over several spans, the point selected should be in the first or last span, at the end away from the shore. Position of charge.

If there is any doubt about the effect of one charge, the girder should be cut at each end of a span.

In the case of girders built on the arch principal, two charges should always be employed, with the object of blowing away a segment of the arch. (Pl. 71, Fig. 5.) In girders with an open web, the top and bottom flanges should be cut. In girders with a plate web (unless this is very thin relatively to the flanges) both flanges and web should be cut. When there is a lack of explosive, the bottom flange is the most important to cut.

Charges. The arrangement of the charges will depend on the section of the girder; to simplify the firing arrangements, they should be divided up as little as possible. The charge for the top flange will generally be placed on the top, and that for the bottom flange underneath. In each case they will be most easily fixed if fastened to a board. The charge for the web, if any, should be tied to a board, the ends of which can be wedged up between the flanges.

Where there is a choice between masonry and iron girder bridges, the girder bridge ought, as a rule, to be attacked, as the demolition of the girder bridge will be much quicker, and will save guncotton (*see* Pl. 71).

Rails. **235.** Two-thirds of a lb. of guncotton is necessary to destroy heavy rails. Two-thirds of a lb. is most conveniently got by cutting a $1\frac{3}{4}$-lb. slab into thirds, as this size fits into the web of the ordinary sized rail.

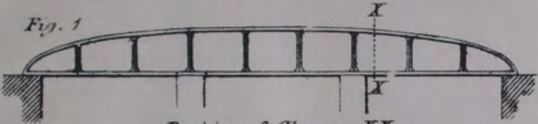
Six 2-oz. primers (with the detonator in one of them) will also do, but is not so convenient to fix. Where the charge can be wedged between the rails at points or a crossing, a less charge will do this, as this tamps it.

On the straight line the slab should be tied tight into the web of a rail close to a chair on the same side as the key. Lead strips are provided for fixing the slabs to the rail, but string suffices (Pl. 72, Figs, 2 and 3), or the key may be removed and the charge put in its place. In the hasty demolition of a railway line care must be taken that the break is sufficiently broad, or the rails displaced, so as to ensure the stopping of traffic.

An effective way of damaging a railway line is by firing

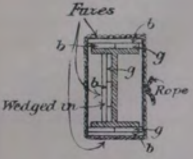
GIRDER BRIDGES.

Fig. 1



Position of Charges XX

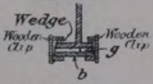
Fig. 2.



g - guncotton
b - boards

Fig. 3.

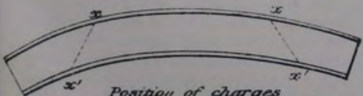
Alternative Method



Girder with plate web

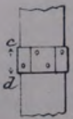
Fig. 4.

Fig. 5.



Position of charges in case of girder upon arch principle shown by dotted line x . x.

Fig. 6



Charge in direction c. d. not to be longer than one slab

Plan of girder

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charges under the rail joints. This will bulge the rails vertically and make traffic impossible. This method however requires a large amount of explosive. If alternate joints are attacked every rail will be damaged.

236. Blowing in tunnels is a very good way of stopping traffic, but to be effective requires a large quantity of explosive. Tunnels.

Gunpowder is best for this. Gunpowder.

The points attacked should be some distance within the tunnels, and it is better to blow down one long tunnel in several places than several tunnels in one place only.

The crown or the haunches should be attacked as in cutting arches, and the lining should be brought down for some distance along the length of the tunnel.

In hard soil it will not do much harm to cut the lining only, as very little of the soil may fall.

The charges should be placed as far back from the interior surface of the arch as time and explosive available will allow, and twice as far from each other as from the surface. Placing charges.

For calculating the charge, T should be taken as the total distance from the surface of the lining to the charge. Amount of charges.

The charges should be in chambers branching off the gallery dug in from the surface of the tunnel.

Instructions for the Destruction of Guns.

237. (1.) A shell having been loaded in the ordinary way, the guncotton charge necessary for the destruction of the gun should be packed in behind it so as to be in close contact with the shell and with the sides of the chamber. After the insertion of the primer, sods, earth, paper or other material that may be at hand should be used to keep the guncotton in position. Field and siege guns

(2.) The breech block should then be swung to as far as possible, just allowing room for the safety fuze or electric leads for igniting the charge.

(3.) The charges required for guns from 3-inch to 6-inch calibre are given by the following rule :—

"For a 3-inch gun use 2 lbs., and double the charge for every inch increase in calibre, *e.g.*, for a 4-inch gun use 4 lbs., and for a 5-inch, 8 lbs."

(4.) A shell is not absolutely necessary for destroying a gun by the above method, but, if available, its use increases the effect.

(For B.L. guns, if a crowbar or heavy hammer is available, much damage can be done by opening the breechblock and smashing the block and screw threads in the breech, thus saving explosive.)

Heavy M.L. guns can be demolished by placing 4 lbs. of guncotton at the bottom of the bore and tamping with sand or water.

CHAPTER XVII.—HASTY DEMOLITION OF RAILWAYS AND TELEGRAPHS WITHOUT EXPLOSIVES.

Railways.

Demolition of railways.

238. When a demolition is contemplated, all unnecessary rolling stock should first be withdrawn. Simultaneously with this, all reserves of railway plant and the most important technical tools should be removed from the station, as well as all individuals entrusted with the working of the railway; and the signals, first the electric and then the visual, should be destroyed. The permanent way should be attacked, and either destroyed or removed altogether, the most important item being the destruction of as many points and crossings as possible; and the engineering works, such as the bridges, tunnels, embankments, and cuttings, would also be important items in the demolition if the abandoned line could be of use to the enemy alone.

Stations, buildings, &c.

239. Buildings not being indispensable to the traffic, are seldom worth destroying.

The different workshop fittings should be taken away altogether, telegraphic apparatus and batteries removed and handed over to the Director of Telegraphs, and stationary engines made unserviceable by taking out the piston, &c.

HASTY DEMOLITIONS

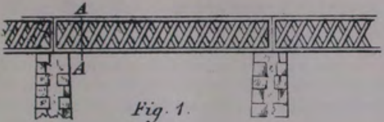


Fig. 1.

Fig. 2.

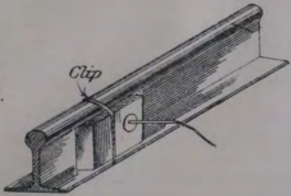


Fig. 3.

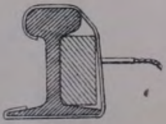
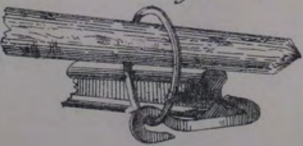


Fig. 4.

Safety fuze prepared with Quick Match

Fig. 5.



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The water supply of a line should invariably be attacked, and the more complete the destruction of tanks and pumps the better. **Water supply.**

240. The rolling stock, if it cannot be removed to the rear, may be rendered unserviceable by burning; or trains may be run against each other at full speed on the same line, or they may be run over an embankment by turning a rail. **Rolling stock.**

Locomotives may be rendered useless, but still repairable, by taking off the injector, or the connecting rods on each side of the engine, or the piston or safety valve.

In carriages the springs may be removed so as to let the body of the carriage fall on the wheels and axles, or the axles themselves may be cut through by guncotton.

241. The method in which the permanent way is attacked must depend greatly on the extent of damage desired, the time at disposal of the demolishing party, and the strength of that party. **Permanent way.**

A simple method, when explosives are not used, is to remove portions of the line at intervals, especially at curves, remove switches, &c., and carry them away. To remove the rails, unscrew the fish-plate nuts with a spanner, if available, if not, they may generally be broken off by hammering. The enemy will find considerable difficulty in fitting in rails of the right length in the demolished portions, but if this method is adopted on a double line, at least one line of rails must be entirely removed, and the other partially so, otherwise an adversary might renounce the advantages of a double line for a time, and employ the material from one line of way to complete the partially destroyed one.

242. A second method, used where many men are available, and where the time is short, and the plant not required elsewhere, is to attack the line at several point at once, tear up the permanent way and render it useless on the spot.

Labourers are employed in preparing sleepers in piles for burning, placing rails upon them, and then twisting them. If the rails are only bent they can be bent back and used again, but if twisted they must be sent to regular workshops to be re-rolled before they can be utilised. The chairs should be broken by a sledge hammer. A variety of this style of demolition is to lift up and turn over whole portions of the railway, together with the attached sleepers. This method is specially useful on high embankments. The men are formed along a rail in single rank, outside of it and facing inwards, the rails at both flanks are disconnected and at a signal they seize the rail, lift it up with the sleepers attached, and turn it over. Of course the ballast must be previously removed. Teams of horses or oxen can be hooked on to the rails and used in like manner.

243. Another method is to divide the destroying party into squads of ten men each, and to equip each party with two iron hooks (Fig. 5, Pl. 72), two axes, and two ropes, each six yards long and two levers. The irons are then fixed as shown. The ropes attached to the ends of the levers are hauled on, the rails twisted and the chairs destroyed, one end of the rail being previously disconnected. Each rail requires about five minutes' work, so that in one hour a squad can destroy twelve lengths of rail.

244. A fourth method of demolition is to take up the permanent way and remove it bodily in wagons. Where there is a double line, the first line is removed by packing it into the wagons which are alongside on the other line; but the second line has to be packed into wagons which have been run up close to the end of the second line itself. This is the most satisfactory of all styles of demolition, but requires much time, and careful arrangement of the necessarily large working parties.

Telegraphs.

Demolition of telegraphs.

245. The amount of damage that can be done in a short time to a line of telegraph depends chiefly on the number of separate wires running parallel to each other on the same poles in the case of an aërial line, or the number of separate cables contained in the same set of pipes in a subterranean line. These forms are by far the most likely to be encountered on service. The case of a subaqueous line, which may sometimes be met with, will be discussed later.

246. It is assumed that the line to be destroyed lies in a country occupied by the enemy, to which access has been obtained for a short time by a raid; since if any part of the line lay in a part of a country from which the enemy had been expelled it would be of course easy either to disconnect the wires and appropriate them, or, leaving the lines intact, to interpose instruments, and thereby read any messages sent by the enemy.

247. The poles can be readily cut or blown down, the easiest and safest poles to attack being those that have stays. Destruction of aërial line.

A rope should first be fixed to the top of the pole or thrown over the wires in order to put on a strain tending to overthrow the pole.

The pole should then be partly cut through at about 4 feet from the ground. All hands should then commence to strain on the rope, except one man, who should cut the stay through with a file or pliers. The men on the rope must be sufficiently far from the pole to be well clear of the wires when they fall.

The destructive effect will be increased by previously cutting partly through the adjacent poles on each side, and, if several adjacent poles are also stayed, cutting their stay at the same time.

Cast iron poles can easily be broken with a sledge hammer.

Having brought down as much as possible of the line in this way, the wires should be cut at each end as far as can be reached, and twisted up so as to be rendered useless. The insulators should also be broken.

Any damage of this sort, however, can be quickly repaired by the enemy using cable, and even the complete restoration of poles and wires will not take very long to accomplish.

248. Probably an equal amount of delay could be occasioned with less trouble by skilfully placing what are known as "faults" on the line. Faults.

Faults consist of "disconnections," "leaks," and "contacts."

"Disconnections" are partial or complete breaks in the continuity of the conductor.

"Leaks" are partial or complete connections of the conductor to earth. A complete connection is known as "dead earth."

"Contacts" are formed by one wire touching another or being put in connection with it by some conductor. They are very troublesome faults, since they affect two lines, and cannot be overcome, as other partial faults can be, by increasing the battery power.

Damage done to an office.

All artificial faults, however, to be successful as causes of delay require to be skilfully made, and the description of the methods of making them is too technical to be suitable for inclusion in this book.

249. If possession can be obtained of an office, wires can be disconnected. Any papers connected with the working of the line and, if possible, the instruments, should be sent to the officer in charge of the field telegraphs.

Records of messages should be sent at once to the Head-quarters.

Destruction of subterranean line.

250. A subterranean line is naturally more difficult to discover than an aërial one; for this reason among others they are now extensively employed in countries liable to invasion. In England they are rarely met with except in large towns, where overhead wires are dangerous.

The existence of such a line being known or suspected, marks should be searched for at equal distances apart, indicating the position of test boxes.

These marks are usually about 100 yards apart, and generally consist of blocks of wood or stone numbered in succession. They would very probably, however, have been removed by the enemy.

If not to be found where the line is known to exist, a cross-trench should be dug at right angles to the probable direction of the line, about 2 feet deep, and in this way the pipes may be discovered. These can then be dug up as far as possible, and bent or otherwise destroyed if means are available, the wire being pulled out and cut to pieces.

If possible the trench should be carefully filled in and all traces removed.

Destruction of subaqueous line.

251. A subaqueous line is rarely employed except for crossing seas or big rivers, but in time of war they may be laid along the course of the rivers to connect towns on their banks, as was done at Paris in the Franco-German war.

To destroy such a line it should be grappled for with a grapnel, and when caught as large a piece as possible cut out of it; the piece should then be cut into smaller pieces and thrown into deep water.

PART II.

CHAPTER XVIII.—STRENGTH OF MATERIALS AND BUOYANCY.

Cordage.

252. The word "rope" is now officially used to denote steel or iron wire rope, while hemp and fibre ropes are termed "cordage." Colloquially "rope" is still used to denote both classes. Ropes and cordage.

The size of a rope is denoted by its circumference in inches, and its length is given in fathoms. (A fathom is 6 feet.) Cordage is usually issued in coils of 113 fathoms, and steel wire ropes in coils of 100 fathoms.

253. The breaking strain of ordinary sound cordage is obtained with fair accuracy from the formula $\frac{C^2}{3}$ tons, where C is the circumference in inches. Strength of cordage.

For field purposes C^2 cwts. has been laid down as the safe working load for all cordage, but this may be increased, for good cordage in good condition, to a maximum of $2C^2$ cwts.

254. The strength of wire varies greatly: as a very rough rule it may be taken that the breaking weight in pounds equals three times the weight per mile in pounds. This rule holds good for iron and hard drawn copper wire, while steel wire may be taken as about twice as strong as iron wire. Strength of wire.

The breaking strain in tons of iron wire rope is about equal to the square of the circumference in inches. Steel wire rope Strength of wire rope.

is from 2 to $2\frac{1}{2}$ times as strong as iron wire rope. Wire rope can be worked, for field service, up to half its breaking strain.

Strength of chain.

255. The following table gives the strength and weight of ordinary crane chain, obtained chiefly by experiment (ordinary commercial iron chain is not very reliable) :—

Diameter of iron.	Mean breaking weight.	Test load.	Weight per fathom.
inches.	tons.	tons.	lbs.
$\frac{3}{16}$	0·84	0·42	2·1
$\frac{1}{4}$	1·5	0·75	4·88
$\frac{3}{8}$	3·35	1·625	10·57
$\frac{1}{2}$	6·0	3·0	16
$\frac{3}{4}$	13·5	6·75	36
1	24·0	12·0	63·5
$1\frac{1}{2}$	54·0	27·0	144
2	96·0	48·0	256

256. The strength of a lashing may be taken as $\frac{4}{5}$ of the number of returns from the object lashed. *e.g.*, a square lashing with four turns has a holding power of $\frac{4}{5} \times 16 \times$ strength of rope; in the case of a hook lashed to a spar with four turns it is $\frac{4}{5} \times 8 \times$ strength of rope.

When using wire in lashings, multiply by $\frac{3}{5}$ instead of $\frac{4}{5}$.

Timbers of Bridges.

Strength of bridges.

257. The following are the maximum weights, which are brought on by the passage of troops in marching order, per lineal foot of bridge :—

Infantry, in file, crowded at a check, $2\frac{1}{2}$ cwts.
,, in fours ,, ,, 5 ,,
Cavalry, in single file, crowded at a check, $1\frac{3}{4}$ cwts.
,, in half-sections ,, ,, $3\frac{1}{3}$,,

258. Maximum weight brought on a bridge by howitzers, guns of position, &c. :—

5-inch B.L. howitzer and R.A. ammunition wagons, Mark II with limber. Maximum concentrated weight in one bay = 30 cwts.

4·7-inch Q.F. guns of position with limber, on travelling carriage. Maximum distributed weight = 85 ,,

259. A bridge that will carry infantry in fours crowded at a check will carry any of the field guns and most of the ordinary wagons that accompany an army in the field.

260. A good rough formula for calculating the necessary sizes for road bearers and transoms is given below. The formula includes a factor of $1\frac{1}{2}$ for live load, and gives a factor of safety of 3; it also allows for the weight of superstructure. **Formula for rectangular beams.**

Unselected rectangular beams—

$$W = \frac{bd^2}{L} \times K \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (A)$$

Where W = actual distributed weight in cwts. (superstructure *not* to be included).

b = breadth of beam in inches.

d = depth of beam in inches.

L = length of span in feet.

K = a variable quantity for different timbers (*see* below).

261. Unselected round spars— **Formula for round spars.**

$$W = \tfrac{6}{10} \times \frac{d^3}{L} \times K \quad . \quad . \quad . \quad . \quad . \quad . \quad (B)$$

The symbols being the same as for formula (A), b and d being here equal, and round spars being only about $\frac{6}{10}$ as strong as square beams of the same depth.

262. For larch and cedar .. .. .. $K = 1$ **Values of K.**
„ Baltic fir .. .. $K = \frac{5}{4}$
„ American yellow pine .. .. $K = \frac{6}{4}$
„ beech and English oak .. .. $K = \frac{7}{4}$

In the above formula, W is the *distributed* weight, such as that of troops, on any span.

263. If it is wished to use these formulæ for a *concentrated* weight, such as a gun, the actual weight on the gun wheels must be multiplied by two to reduce it to the equivalent *distributed* load, when it can be substituted for W. When, as in the case of a transom, there are concentrated loads at more than four points along the span, it will be sufficient to take the total as being distributed. **Concentrated loads.** **Transoms.**

264. With several baulks under a roadway, the two outer ones can be assumed as taking only half as much of the weight as the inner ones. **Baulks.**

Thus, with five baulks, the outer baulks each bear $\frac{1}{8}$ total weight, the inner baulks each bear $\frac{1}{4}$ total weight. (In calculating, the greater weight must be worked to.)

Rectangular beams are stronger on edge than on the flat, and should be always used on edge.

Arrangements of baulks.

265. In calculating the strength of a tapering spar when used as a baulk, d is to be taken at the centre of the spar.

Experiment has proved that such baulks, when supported at both ends and overloaded, will break in the centre, and not at the small end.

Knowing b, d and L, from formula (A) or (B) we can find W, the safe distributed load, for these data. Knowing W, and choosing L, a convenient length, we can find b and d, the necessary section of the beam.

Formula for cantilever bridge.

266. A rough formula for strength of cantilevers is as follows :—

$$W = \tfrac{1}{8}\,\frac{bd^2}{L} \times K \text{ for square timbers.}$$

$W =$ the total live load which can be brought to bear on the end of the cantilever in cwts.

$L =$ the length of the cantilever in feet.

$\left.\begin{aligned} b &= \text{breadth} \\ d &= \text{depth} \end{aligned}\right\}$ in inches.

$K =$ a variable quantity according to the tree for values, *see* Sec. 262.

Formula for round spars.

For round spars :—

$$W = \tfrac{1}{8} \cdot \tfrac{6}{10} \cdot \frac{d^3}{L} \times K.$$

These formulæ give an allowance for superstructure and a factor of safety of 3.

Weight of water.

267. *Useful facts*—

One cubic foot of water = $6\frac{1}{4}$ gallons.

One gallon weighs 10 lbs.

Buoyancy.

Buoyancy of casks.

268. In using closed vessels like casks for floating piers, the safe buoyancy for bridging purposes may be taken at $\frac{9}{10}$ the actual buoyancy.

269. The buoyancy of closed vessels can be determined by the following methods :— Closed vessels.

(*a*) When the contents are known—

Multiply the contents, in gallons, by 10, and take $\frac{9}{10}$ of this, which will give safe buoyancy in pounds.

(*b*) For casks, when the contents are not known— Collins' rule.

$$\textit{Actual}\text{ buoyancy} = 5C^2L - W \text{ lbs.}$$
$$\text{Safe buoyancy} = \tfrac{9}{10}\{5C^2L - W\} \text{ lbs.}$$

Where C is the circumference of the cask, in FEET, halfway between the bung and the extreme end ; L is the extreme length, exclusive of projections along the curve, in FEET ; W is the weight of the barrels in pounds.

270. The following are the dimensions, weight and buoyancy of certain casks :— Table of casks.

Name of cask.		Gallons.	Bung diameter.	Length along the cask.	Circumference at ¼ length.	Weight empty.	Actual buoyancy.
			ins.	ft.	ft.	lbs.	lbs.
Used in the trades	leager	170	38·5	4·52	9·33	252	1,736
	butt	108	33·3	3·97	8·09	174	1,125
	puncheon	72	30·7	3·20	7·57	140	773
	hogshead	54	28·6	2·76	7·05	119	567
	barrel	36	25·3	2·42	6·23	88	382
	half hogshead	26	22·7	2·12	5·61	65	269
	kilderkin	18	20·3	1·81	5·02	49	185
	small cask	14	18·3	1·76	4·49	32	146
	,, ...	6	13·8	1·37	3·40	20	69
Powder barrels	whole barrel... ...	—	17·5	1·58	4·26	28·5	115
	quarter ,, ...	—	14	1·07	2·93	8·5	39
Commissariat vats	ton	—	40	3·2	9·96	95	1,477
	¾-ton	—	32	3·2	8·69	74	1,134
	½-ton	—	31	3·3	7·75	67	903
	¼-ton	—	27	2·5	6·61	51	499
Water cask		—	—	—	—	—	50

Buoyancy of timber.

271. The buoyancy of a log can be obtained by multiplying its cubic content by the difference between its weight per cubic foot and that of a cubic foot of water, viz., $62\frac{1}{2}$ lbs.

The actual flotation then of the log given below, if it were pine, would be :—

$$95 \times (62\tfrac{1}{2} - 40)$$
$$\text{or } 95 \times 22\tfrac{1}{2}$$
$$= 2{,}137\tfrac{1}{2} \text{ lbs.}$$

As, however, timber absorbs a great deal of water, only $\frac{5}{6}$ of the above can be safely relied upon.

This available buoyancy will then be—

$$\tfrac{5}{6} \times 2{,}137\tfrac{1}{2} = 1{,}781 \text{ lbs.}$$

Bridges of rafts of timber.

272. The contents in cubic feet of an unsquared log of timber can be found by the following rule :—

$$\frac{L}{4}(D^2 + Dd + d^2).$$

Where L = length of log in feet,
D, d = diameter at ends.

Thus, if the log is 3 feet and 2 feet in diameter at the ends and 20 feet long—

$$\text{the cubic contents} = \frac{20}{4}(9 + 6 + 4).$$
$$= 95 \text{ c.f.}$$

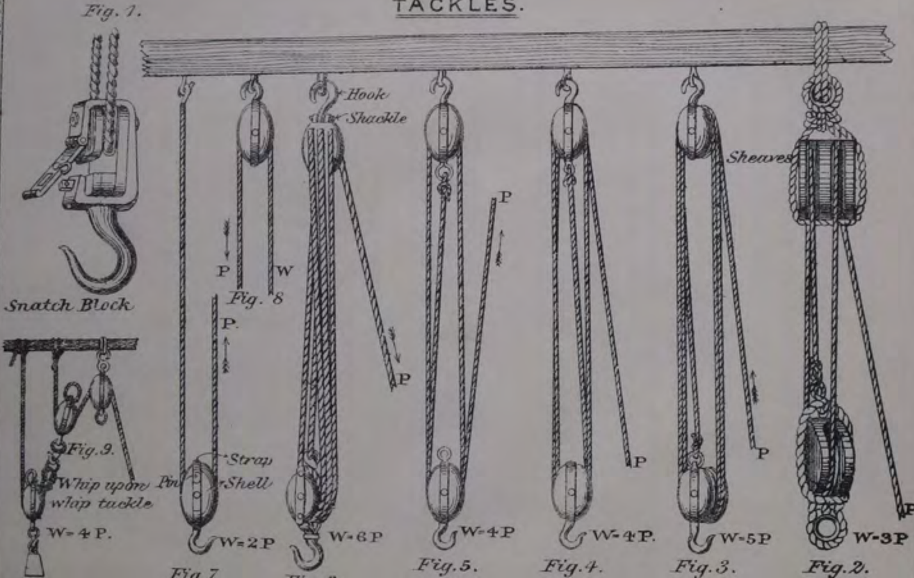
Weight of timber.

273. The following are approximately the weights per cubic foot of different kinds of timber :—

Ash, English ..	46 lbs.	Pine	40 lbs.
Beech	43 ,,	Poplar ..	27 ,,
Chestnut ..	41 ,,	Sycamore ..	36 ,,
Elm	37 ,,	Teak, Indian ..	51 ,,
Fir	33 ,,	,, African ..	61 ,,
Larch	33 ,,	Yew	41 ,,
Maple	32 ,,	Walnut ..	38 ,,
Oak, English ..	57 ,,	Blue Gum ..	63 ,,

Willow .. .. 25 lbs.

TACKLES.



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CHAPTER XIX.—BLOCKS AND TACKLES—USE OF SPARS.

274. Blocks are used for the purpose of changing the direction of ropes or of gaining power. **Blocks and tackles.**

They are called single, double, treble, &c., according to the number of sheaves, which are of metal or hard wood, and revolve on the pin, which should be kept well lubricated.

Snatch blocks, Fig. 1, Pl. 73, are single blocks with an opening in the shell and strap on one side, to admit a rope without passing its end through.

The rope with which tackles are *rove* is called a *fall*. To *overhaul* is to separate the blocks. To *round in* is to bring them closer together. When brought together the blocks are said to be *chock*.

275. A tackle is rove by two men, back to back, 6 feet apart; the blocks should be on their sides between the men's feet, hooks to their fronts, and the coil of rope to the right of the block at which there are to be the greater number of returns. Beginning with the lowest sheaf of this block, the end of the fall which is to be the standing end is passed successively through the sheaves from right to left and then made fast. **Reeving.**

276. In using tackle great care must be taken to prevent the tackle from twisting. The best method is to place a handspike between the returns, close to the movable block, with a rope to each end, by means of which it can be steadied. New rope must be uncoiled and stretched before using it as a "fall." **Precautions with tackles.**

Crane chain, when used as a fall, should be thoroughly soaked in oil. **Crane chain.**

277. Various tackles are shown in Pl. 73. The power necessary to raise a weight W is W $\div$ number of returns at the movable block + about 10 per cent. per sheaf for friction. **Power.**

278. The fall, in lifting heavy weights, can rarely be worked by hand, but has to be "led" to either a capstan or winch, by which power is gained and a steady pull ensured. **Machines.**

Carrying spars.

279. In carrying spars, the party should be equally divided on either side of the spars, facing it, and sized from one end. The spar should then be lifted, in two motions, on to the inner shoulders, the party facing one way. In lowering a spar, the party should slowly face inwards, and lower the butt end first to the ground, and afterwards the tip.

Derricks.

280. A derrick (Fig. 6, Pl. 48) is a single spar set up with four guys, secured with clove hitches. A tackle is lashed to the head, and the derrick can be used for raising and swinging a weight into any position within its reach, which is about one-fifth of its height. The anchorages for the guys should be at a distance from the foot of the derrick equal to twice its height. The foot should be let into a hole in the ground to prevent its slipping.

In Fig. 6, Pl. 74, a derrick is shown in the act of raising a pair of sheers.

Fig. 8 shows a swinging derrick.

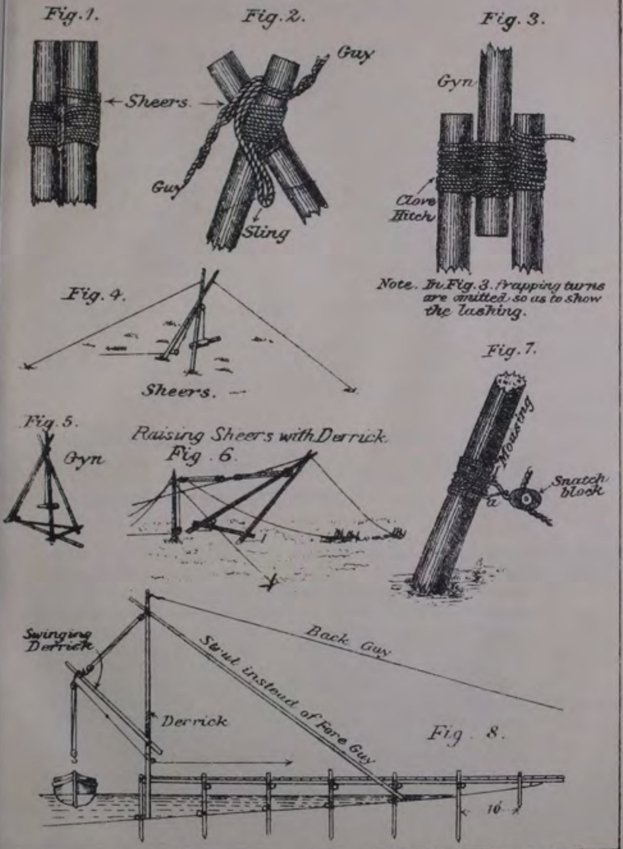
Sheers.

281. Sheers (Fig. 4) require only two guys—a "fore" and "back" guy. They should be fastened to the legs above the crutch by clove hitches, the back guy to the fore spar, and *vice versâ*, so that their action may tend to draw the spars closer together and not strain the lashing. The minimum distance of the anchorages should be double the height. The upper block of the tackle is hooked to a sling of rope or chain passed over the crutch. Sheers can, as a rule, be used for heavier weights than derricks, but can only move them in a vertical plane passing between the legs. The feet of sheers must be secured or let into holes in the ground. The distance apart of the legs should not be more than one-third the length of the leg up to the crutch, and the sheers not to be heeled over more than one-fifth of their height.

Sheer lashing.

282. The legs of the sheers are laid side by side on a skid, and kept 2 inches apart by a wedge. The lashing is commenced with a clove hitch on one spar, carried six or more times upwards round both spars without riding, then two frapping turns, and finished off with two half hitches round the other spar. (Figs. 1 and 2, Pl. 74.)

USE OF SPARS.



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283. Gyns, Fig. 5, require no guys, and are good for a vertical lift, such as dismounting guns. Gyns.

The three legs of the gyn are placed as shown in Fig. 3, resting on a skid, and 2 inches apart. The lashing is commenced with a clove hitch on an outside spar, and carried upwards over and under loosely and without riding six times. Two frapping turns are taken in each interval, and the whole finished off with two half hitches round one of the spars.

Iron chain is better than rope for these lashings, as it admits of fewer turns, which allows the legs to be more easily opened.

284. In using tackles with sheers, gyns, or derricks, the running end of the fall should always be led through a "leading block," lashed, as a rule, to one of the spars a few feet above the ground; a snatch block is most convenient for the purpose. (Fig. 7, Pl. 74.) Leading blocks.

CHAPTER XX.—CANTILEVER BRIDGES, FRAME BRIDGES, FRAMED TRESTLES, SUSPENSION BRIDGES, AND CASK PIERS.

285. Pls. 75 and 76 show various types of cantilever bridges as used in Northern India. Cantilever bridges.

From the smallest to the largest span the method of construction is practically identical. A site is chosen where a large rock or rocks rise out of the stream or a pier is constructed of dry stone work and wooden bindings. On the top of these are laid a number of stout beams, *aa*, projecting over the stream, with the projecting end somewhat higher than the shore-ends. The number of beams, their length and amount of projection depend on the span. The shore-ends of each row of cantilevers should be covered with planks or like material. Stones are then packed round these ends, and the whole weighted down. It is also desirable to lash the top layers to the bottom ones as shown in Figs. 5 and 6.

Supposing that the central span is too large for available timbers, then more rows of cantilevers are placed on the first row *aa*, two more transoms *tt* are placed near the projecting ends and the roadbearers *rr* are placed in position. There are generally more cantilevers in the bottom row than in the row above and so on. Figs. 5 and 6.

The step from top row of cantilevers to top of central roadbearers can be avoided by lashing the top transom underneath the ends of the top row of cantilevers instead of placing it on the top, or an extra row of roadbearers may be added above the top row of cantilevers. In the case of a long bridge a few wire ties are a great improvement, as they stiffen the bridge greatly. Fig. 7.

Frame bridges.

286. The following are simple types of frame bridges :—

(*a*) *Single Lock.*—Supporting one central transom, and sufficing for a span up to 30 feet.

(*b*) *Double Lock.*—Furnishing two transoms, span up to 45 feet.

They are not so generally useful as trestle bridges.

The span of a frame bridge is the horizontal distance between the footings of the frames, and is independent of any increase of span due to sloping banks or bays of trestles.

Single-lock bridge.

287. A single-lock bridge (Pl. 77) consists of two frames locking together; one frame must therefore be narrower than the other.

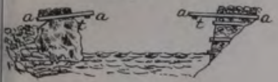
Double-lock bridge.

288. A double-lock bridge (Pl. 77) consists of two frames held apart by distance pieces. The frames must therefore be the same width.

The frames are nearly identical with two-legged trestles (Fig. 2. Pl. 50), but the slope of the legs is not so great, $\frac{20}{1}$ generally sufficing, and the transom and ledger are lashed on on opposite sides of the legs, transom on the shore side so as to bear on the legs, ledger on the outer side so as not to interfere with the footings. Before lowering the frames into their places footings must be prepared, holdfasts driven, fore and back guys attached to the top of each leg, and foot ropes attached to each leg below the ledger. The frames are then

CANTILEVER BRIDGES.

Fig. 1.



Elevation

Fig. 2.

Plan

Fig. 3.

Fig. 4.

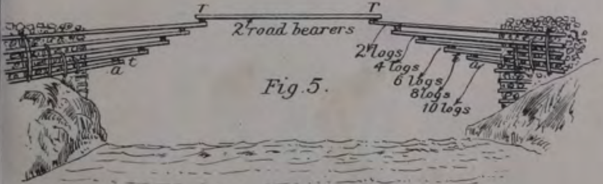


Fig. 5.

Fig. 6.

Fig. 7.

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To face page 110.

Plate 76.

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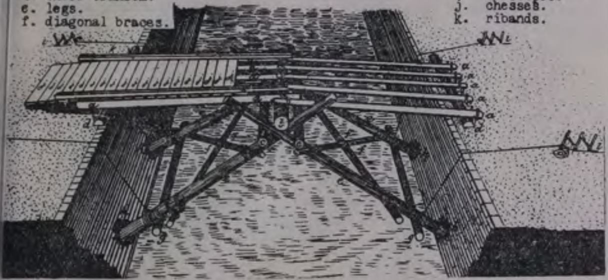
To follow plate 75

LOCK BRIDGES.

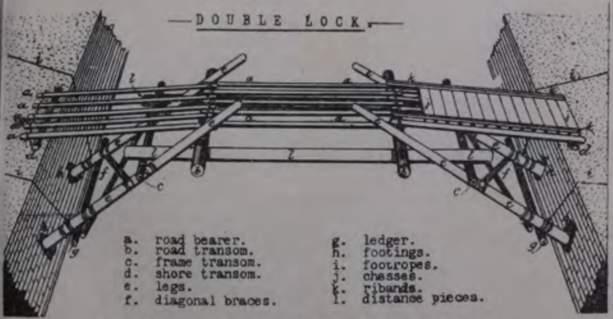
a. road bearers.
b. fork transom.
c. frame transom.
d. shore transom.
e. legs.
f. diagonal braces.

— SINGLE LOCK. —

g. ledger.
h. footings.
i. anchorage for footropes.
j. chesses.
k. ribands.



— DOUBLE LOCK. —



a. road bearer.
b. road transom.
c. frame transom.
d. shore transom.
e. legs.
f. diagonal braces.
g. ledger.
h. footings.
i. footropes.
j. chesses.
k. ribands.
l. distance pieces.

Note. Footropes are removed after frames are locked.

866. 8. 05

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To follow Plate 76.

lowered, and if a single-lock bridge, locked; if a double-lock bridge, held back by the guys a little higher than their ultimate position. A single-lock bridge is then completed with the usual roadway: for a double-lock bridge two distance pieces must be placed across the ends of the frame transoms, as shown in the diagram and the road-bearing transoms lashed across, as shown. The back guys can now be eased, and the bridge allowed to lock. The roadway is completed as usual.

In order that the parts of frame bridges may fit together, considerable accuracy is necessary in taking the measurements and marking the positions for the lashings. To this end a section of the gap and proposed bridge should be marked out on the ground, allowing for camber. The spars for the legs must now be laid on this section in the exact positions they will occupy when in bridge, and marked to show proper positions for lashing on ledgers and transoms.

289. The following approximate dimensions of timbers for single and double lock bridges are necessary for carrying infantry in fours crowded:— Dimensions of timbers.

Legs	7 inches at tip.
Frame transoms, mean diameter ..	6 inches.
Distance pieces ,, ,, ..	11 inches.

Other spars as for trestle bridges.

290. Plates 78, 79 and 80 show examples of heavy trestles made of timbers framed together and fastened by iron dogs, spikes, bolts, etc. They are specially useful for hasty railway bridges (*see also* Chap. XXIII) and for road bridges where heavy traffic is expected. Skilled labour is required for their construction. Framed trestles.

These trestles usually consist of groundsills, capsills, uprights, struts, and diagonal braces and stringers connecting the trestles in the line of the bridge.

The uprights should be as far as possible arranged under the road-bearers, so as to support the weight directly. When they can be got of sufficient length, it is best to make the trestles in one tier only, however high the bridge, taking care of course that they are properly braced both ways to prevent buckling (Pl. 78, Fig. 1 and Pl. 79, Fig. 1).

When the material is not long enough, the trestles must be made in two or more tiers. In this case the upper tiers must not be made too heavy, or they will be very difficult to hoist into position. The groundsills of the lower tier must be strong enough to support and distribute the weight of the uprights. Where the soil is firm and can be levelled to an even bed, no other foundation than the groundsill is necessary; where the soil is soft a low crib pier may be made to distribute the weight.

The adjoining capsill and groundsill, where one trestle rests on another, need not be very strong. A 3-inch plank will suffice for each, and may be spiked to the uprights. In this case the uprights may be fixed in position with cleats, and dogged to each other (Pl. 78, Fig. 2).

Struts. **291.** The inclination of the struts depend to some extent on the height, width and length of the bridge. They are not essential for wide bridges of no great height.

Struts for railway bridges must have a greater inclination than for ordinary bridges to provide for wind pressure on the side of the train tending to overturn the whole structure. This is especially the case when the bridge is high and long.

Bracing. **292.** For the arrangement of the diagonal bracing, *see* Plates 78 and 79.

The ends of struts should not be notched into uprights unless the latter have a considerable margin of strength and stiffness. Uprights and struts should be notched into groundsills and capsills when possible; but when time presses and few carpenters are available, a careful arrangement of dogs will suffice, without notching.

Corbel. **293.** Pl. 78, Fig. 4, shows a corbel, an arrangement for giving a wider bearing at the top of a trestle; and Fig. 5 an alternative method, which also helps to fix the capsill.

Fastenings. **294.** Dogs, spikes and bolts are the most useful fastenings for framed trestles. The position of each dog should always be considered with a definite object of preventing a possible distortion of the frame. They should be on both sides of the trestle. Dogs should not be driven within 3 inches of the edge of a timber, or within 4 inches of its end.

Spikes, when used in pairs, should be driven inclining towards each other. They run 5 inches to 10 inches in length.

FRAMED TRESTLE

Fig. 1 — SQUARED TIMBER

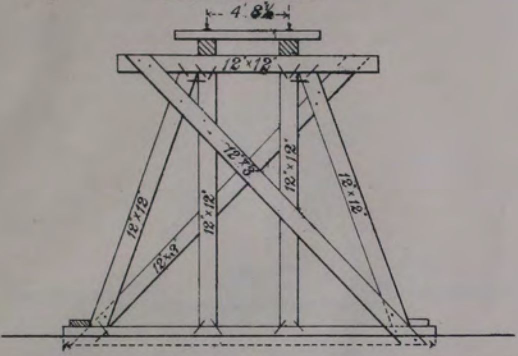


Fig. 2.

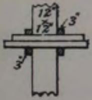
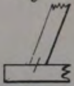


Fig. 3

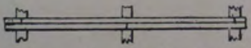


wrong position for dog.

Fig. 5

Fig. 4.

Fig. 6.



Composite roadbearers with planks (breaking Joint

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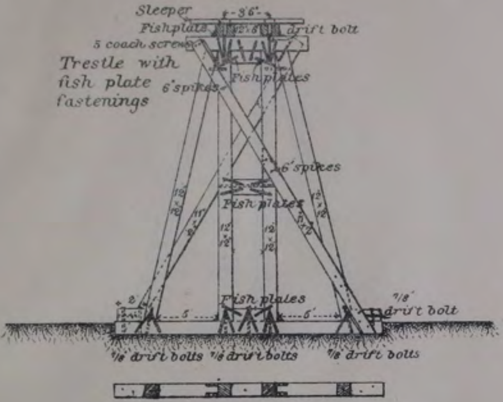
Opposite page 112.

FRAMED TRESTLES

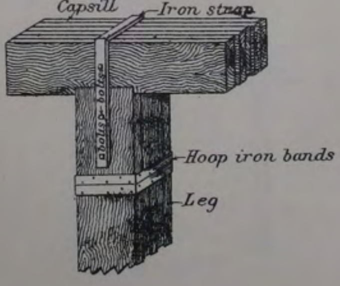
Fig. 1.



Plan

Fig. 2.

Trestle of Planks



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To follow plate 78.

FRAMED TRESTLE.

ROUND TIMBERS

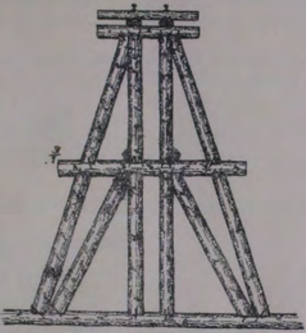
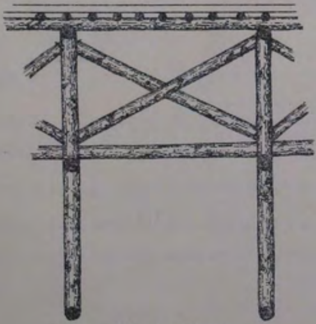


Fig. 2.



Elevation

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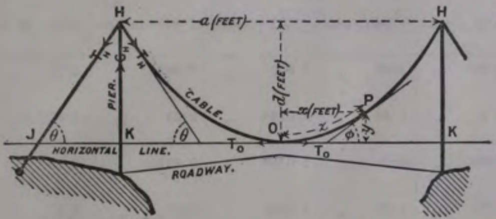
To follow plate 79.

295. When round timbers are used the groundsills and capsills must be adzed to give a square bearing surface for the uprights. Framed trestles of round timber.

When there are two or more tiers, it will be best for the upper tiers not to have groundsills. The uprights may rest directly on the capsills of the tier below (*see* Pl. 80. They should be wedged up after fixing; to keep the trestle together while it is being raised, a light timber or board may be spiked to the sides of the uprights near their feet.

296. FORMULÆ FOR USE IN SUSPENSION BRIDGES. Suspension bridges.



Length of cable between piers $= a + \dfrac{8\,d^2}{3\,a}$

Tension in cable, T_o $= \dfrac{W\,a^2}{8\,d}$

Tension at piers, T_H $= W\dfrac{a}{2}\sqrt{1 + \left(\dfrac{a}{4\,d}\right)^2}$

Pressure on piers $= W\,a$

W = uniform dead load on cables per foot run of bridge.

Height of frame $d = + 5'$ (length of centre sling) + camber (1 in 30).

For a concentrated load, such as that brought by a traveller, without roadway, safe load on the cable $= \dfrac{4d}{a} \times$ working strength of cable.

297. The following table will be found useful for calculating stresse[s] due to uniform loads on suspension bridges; in it the load is $W \times a$:—

1. Dip.	2. Tension at lowest point.	3. Tension at highest point.	4. Length of cable.	5. Depression at centre due to an elongation of cable of 1 inch.	6. Value of JK.
$\frac{a}{10}$	1·25 × load	1·346 × load	1·027 × span	1·875 inches	2·5 HK
$\frac{a}{11}$	1·375 "	1·49 "	1·022 "	2·0625 "	2·75 "
$\frac{a}{12}$	1·5 "	1·58 "	1·0185 "	2·25 "	3·0 "
$\frac{a}{13}$	1·625 "	1·7 "	1·0158 "	2·4375 "	3·25 "
$\frac{a}{14}$	1·75 "	1·82 "	1·0136 "	2·65 "	3·5 "
$\frac{a}{15}$	1·85 "	1·94 "	1·012 "	2·815 "	3·75 "

298. For length of slings $y = \frac{4d}{a^2} x^2$.

a = span.
d = dip.
y = length of sling,
x = distance from lowest point in fee.

Anchorage.

299. Pull on anchorage = tension in cables at piers.
Strength of log anchorage (Fig. 9, Pl. 48) = holding powe[r] of the anchor face, and can be obtained from the following

table, showing the holding power of dry loam at various depths and inclinations of cable :—

Mean depth of Face of Anchorage below Surface.	Inclination of the force drawing the anchorage (in a direction perpendicular to its face), and corresponding ultimate resistance in lbs. per square foot of anchor face.			
	1/1	1/2	1/3	1/4
2 feet	2,700	3,880	4,032	4,370
3 "	4,400	5,860	6,160	6,750
4 "	8,000	10,660	11,200	12,260
5 "	22,000	29,330	30,800	33,730

300.

Nature of Soil.	Relative Holding Power.
Compact loam, rammed (dry)	1
Hard compact gravel, rammed (dry)	0·9
Wet river clay (below subsoil water level), rammed	0·5
Incoherent river sand, not rammed (damp)	0·5

301. A 3. 2. 1. holdfast, made of 5 feet park pickets, driven 2 feet 6 inches to 3 feet in the ground, should stand a strain of 2 tons (*vide* Pl. 48).

302. The following detail shows the most convenient way of making cask piers with large casks, *see* Pl. 54. Cask piers.

The *gunnels* should, for a pier of the size shown in the figure (the casks used being *butts*), be 21 feet by 4 inches by 5 inches. Gunnels.

The *slings* of 2½-inch rope, 6 fathoms long, with an eye splice 1 foot long at one end. Slings.

Braces. *Braces* of $1\frac{1}{2}$-inch rope, 3 fathoms long, a small eye splice at one end, and a figure of 8 knot 1 foot 5 inches from the eye.

Ways. The pier being made, is launched into the water by means of a sledge called the *ways*.

Forming piers. To make a pier the number of men required is two more than double the number of casks, or $2n + 2$, where n is the number of casks.

Four men stand at the ends of the gunnels, the remainder opposite the intervals between the casks on either side. The gunnels being in position, the gunnel men at one end place the eyes of the slings over the gunnels; the gunnel men at the other end secure the slings to their ends of the gunnels with a round turn and two half hitches. The brace men keep the slings under the casks with their feet, and as soon as they are secured adjust the braces as follows, the men working simultaneously by word of command.

The eye of the brace is passed under the sling in the centre of the interval between two casks, the end passed through the eye and hauled taut, the sling being kept steady with the left foot. The brace is then brought up outside the gunnel immediately over the eye, and a turn round the gunnel taken *to the left*, the foot is removed from the sling, and each man then hauls up the standing part of his brace with the left hand, holding on to the turn with the right; as soon as the brace is taut the turn is held fast with the heel of the left hand, and the remainder of the brace, in a coil, is placed on the cask *to the left*. Each man then takes his opposite neighbour's brace from the cask on the right, and passes it between the standing part of his brace and the cask *on his left*, then back between his brace and the cask on his right, keeping the bight so formed *below* the figure of 8 knot on his own brace, and placing the end on the cask to his right. Each man then takes back his own brace from the cask on his left, passes it under the gunnel *to the left* of the standing part, places his foot against the gunnel, and hauls taut. The pier is then rocked backwards and forwards, all the brace men taking in the slack of their braces and hauling taut until the word *steady* is given, when they take a round turn round the gunnel *to the left* of the previous turns, and make fast with two half-hitches round the two parts of their own brace close to the gunnel, drawing the two parts close together and placing the spare ends of their brace between the casks. The pier is then turned up on one side, and the sling adjusted below the third hoop of the casks, and a breast line attached to the slings at each end : it is then lowered and turned up on the other side, the other sling adjusted, the *ways* brought up into position, and the pier lowered on to them ready for launching.

CHAPTER XXI.—DEMOLITION FORMULÆ.

CHARGES FOR HASTY DEMOLITIONS.

NOTE.—The charge is in lbs. B = length to be demolished in FEET.
T = thickness to be demolished in FEET.
t = thickness to be demolished in INCHES (in the case of iron plate only).

In the presence of the enemy increase the charges by 50 per cent.

GUNPOWDER (Tamped).

Object attacked.	lbs.	Remarks.
Brick arch—one haunch ..	$\frac{3}{2}BT^2$	Total amount divided into charges placed apart about twice the thickness of brick-work.
Brick arch—crown	$\frac{3}{2}BT^2$	
Brick wall	$\frac{3}{2}BT^2$	
Wood stockade—hard wood	40 to 100	One charge. Soft wood half this.
Stockade of earth between timber up to 3 ft. 6 in. thick	60 to 80 per 5 ft.	One charge.
Fort gate	200	One charge.
Tunnels	$\frac{2}{3}T^3$	Where T = total distance from the surface of the lining to the charge.

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In the presence of the enemy increase the charges by 50 per cent.

GUNCOTTON (Untamped).

If the charge is tamped, decrease by one half.

Object attacked.	lbs.	Remarks.
Brick arch—haunch or crown..	$\frac{3}{4}BT^2$	Continuous charges.
Brick wall—up to 2 ft. thick ..	2 per foot	Length of breech B not to be less than the height of the wall to be brought down.
Brick wall—over 2 ft. thick ..	$\frac{1}{2}BT^2$	
Brick pier	$\frac{2}{3}BT^2$	
Hard wood—stockade or single	$3BT^2$	In a single charge outside. For a round timber charge = $3T^3$. (Soft wood half this.)
Hard wood—necklace	$3BT^2$	Trees up to 12 ins. diameter. For a round timber charge = $3T^3$. (Soft wood half this.)
Hard wood—auger hole ..	$\frac{3}{8}T^2$	Where the timber is not round, T = smaller axis. (Soft wood half this.)
Stockade of earth between timber up to 3 ft. 6 ins. thick	4 per foot	Single charge.
Heavy rail stockade	7 per foot	
Fort gate	50	
Breechloading guns	—	For 3-inch gun use 2 lbs. Double the charge for every inch increase in calibre. To be placed in breech. The gun should be loaded with a shell if possible.
First class rail	—	A third of a $1\frac{3}{4}$-lb. slab against the web near a chair if those are used.
Iron plate	$\frac{3}{8}Bt^2$	t is in INCHES.
Iron girders	$\frac{3}{8}Bt^2$	Calculate as for iron plate, given thickness of flange to be measured where it joins the web.
Frontier tower, stone and mud	16 to 30	In one charge in centre of tower.
Wire cable	$\frac{C^2}{24}$	"C" being the circumference in inches.

Nature of Work.	Dimensions.	No. of Men.	Time.
1. Felling trees	Up to 1 ft. diameter	1 man	1 minute per of diamete
2. Cutting brushwood	Up to about 1½″ diameter	"	4 hours
3. Clearing plantation of brushwood, with trees up to 12 in. diameter; sorting, binding, carting	100 yds. × 40 yds.	1 company (100 men)	"
4. Cutting hedge	Wood, ½″ to 2″ diameter	1 man	6 minutes t minutes
5. Making fascines	18′ long, 9″ diameter	5 men	1 hour
6. Gabions	2′ 9″ high, 2′ external diameter	3 "	2 hours
7. Band gabions	2′ 9″ high, 2′ diameter	2 "	10 minute
8. Hurdles	6′ long, 2′ 9″ high	3 "	2½ hours
9. Cutting sods	18″ × 9″ × 4½″	3 "	1 hour
10. Loophole in wall, two bricks thick	—	1 man	½ "
11. Notch, two bricks thick... ..	—	"	10 minute
12. Abatis, roughly constructed ...	50 yds. deep	"	1 relief
13. Low wire entanglement... ..	—	10 men	1 hour
14. High " "	—	5 "	4 hours

N.B.—Gabion revetments, 7′ 6″ high, requires 14 gabions, 3 fascines p
Hurdles or brushwood, 2′ 9″ high, requires 9 bundles brushwoo
Sandbag revetment requires 200 sandbags per 100 sup. feet.
For constructing head cover, sandbags and sods, on earth parapet

Amount.	Tools.	Remarks.
—	Felling axes; hand axes; saws, cross-cut; saws, hand	For larger trees the diameter in inches cubed and divided by 144 will give the number of minutes. With the hand axe allow 2 minutes per inch of diameter for trees up to 1 foot; for trees over 1 foot twice the calculated amount.
100 sq. yds. or 9 to 10 bundles of 50 lbs. each	Billhooks, lashing or wire; a small portion of felling axes, hand axes and saws; a grindstone and a few whet stones	Men opened at 4 yds. interval should cut 25 yds. to their front in 4 hours.
About 300 bundles of 50 lbs. each		40 men cutting; 40 men sorting and binding; 20 men carting.
2 paces	Billhooks and hand axes	If very bushy a pole and ropes can be used to expose their lower branches to the axe.
1	1 measuring rod; 1 choker; 3 billhooks; 2 knives; 1 maul; 1 hand saw; 1 pair of pliers	Materials: 4 bundles brushwood, 60 ft. of wire or spun yarn if withes are not used. Weight about 140 lbs.
1	1 billhook; 1 mallet; 2 knives; 1 measuring rod	One and a half bundles of brushwood. Weight complete about 50 lbs.
1	—	10 bands, 10 pickets. Weight complete, 13 lbs.
1	2 billhooks; 2 knives; 1 mallet; 1 pair of pliers (if sewn with wire)	
100	Sharpened spades or sod cutter	
	Crowbar or pick	
1	" "	
2 paces	—	Trees used where felled.
100 sq. yds.	3 billhooks; 1 maul; 2 pairs of pliers	1 sq. ft. of entanglement takes 1 ft. of wire.
20 yds. length.	2 billhooks; 2 mauls; 2 pairs of pliers, 1 hand saw	1 sq. ft. takes 3 ft. of wire. Entanglement built with 3 rows of pickets, each 2 yds. apart.

100 sup. ft.
wire and stakes for anchoring per 100 sup. ft.

allow ½ hour to 1 hour in addition to the calculated task.

Boning at ....

1. Stations (*see* Fig. 3).	2. Horizontal distances.	3. Height of Back Station.	4. Height of Forward Station.	5. Rise +	6. Fall −	7. Above or below datum.	8. Remarks.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	
A and B ..	5 0	Datum line (or starting line).					Height of boning rod 3′.
C	10 6	3 0	5 1	—	− 2 1	− 2 1	
D	8 2	5 1	6 2	—	− 1 1	− 3 2	
E	7 10	6 2	3 10	+ 2 4	—	− 0 10	
Totals ..	31 6	14 3	15 1	2 4	3 2	—	

(Date) (Signature)

CHAPTER XXII.—ROADS—BONING AND LEVELLING.

Roads.

303. A roadway 10 feet wide (8 feet minimum) will take a single line of wagons* passing in one direction, or infantry in fours; 12 feet is better as allowing horsemen to pass without difficulty; for each additional line of vehicles 10 feet should be added to the width of the road. Width of roadway.

Where there is little traffic, a width of 10 feet may suffice for wagons both going and coming, provided sidings are made at intervals, into which one wagon may go to allow another to pass.

A width of 6 feet is sufficient for infantry in file or pack animals moving in one direction.

304. The gradient for a short distance, such as a ramp leading on to a bridge, may be $\frac{1}{3}$, or even $\frac{1}{2}$ for infantry, $\frac{1}{7}$ for artillery, but for animals or wheeled traffic slopes steeper than $\frac{1}{10}$ are inconvenient, and if the incline be long it is still more desirable to reduce them. Traction engines will, on good roads, draw a load equal to their own weight up $\frac{1}{10}$, twice their own weight up $\frac{1}{20}$, and three times their own weight on the level, or up slopes not exceeding $\frac{1}{33}$, which is the maximum gradient in first-class roads. Gradients.

305. When a new road has to be constructed it should be made as straight as is consistent with the extreme gradient permissible. Laying out a new road.

In laying it out the centre line should be marked by pickets, *spitlocking* (*i.e.*, marking out the line with the point of a pick), &c.

If the road passes through a wood, it will be well to cut down a line of trees in the required direction. The space occupied

* The ordinary width of the wheel track of W.D. carriages is 5 feet 2 inches from out to out, except that of the pontoon wagons, which is 5 feet 10 inches.

The points of the axletree arms project about $6\frac{1}{2}$ inches beyond the wheel track on each side.

by the road should then be cleared of all irregularities, and th tree roots grubbed up.

Metalled road.

306. Fig. 1, Pl. 81, gives a section of a metalled road on lev ground, or only slightly inclined in the direction of the widt of the road.

Side drains must be cut where necessary, and communication made underneath the road at intervals to allow the wate to escape. The earth from these side drains, when well rammec may be employed to give a shape to the road if metallin is afterwards to be put on to it, otherwise it is better scatterec In applying the metalling large stones should be spread as foundation, and above this should come a layer of broke stones some 3 inches or 4 inches thick. A thin top layer c gravel or other binding material is an advantage. This shoul be rolled or rammed, a plentiful supply of water being usec The surface of the road should slope from the centre to th side at about $\frac{1}{30}$, to allow the water to drain off.

Sometimes only one layer of stone of the smaller size is usec

In many situations gravel is the only available material it should contain a portion of loam, sand, or other small stu to bind the pebbles together.

Where metal is not obtainable, such growths as reeds, heathe or long grass, laid thickly across the road are better tha nothing.

Road on side of hill.

307. When on the side of a hill the road will be partly cuttin and partly embankment (Fig. 2), unless the hill is very steep when it may be all cutting as in Fig. 2, Pl. 82.

The ground on which the embankment rests should b stepped, to prevent slipping, and a retaining wall of dry stone (Fig 2, Pl. 81) or logs, fascines (Fig. 1, Pl. 82), or sods, &c., ma sometimes be required. The surface of the road should slop inwards towards the hill, the water being got rid of at interval by drains passing under the road. If no drain pipes be available *French* drains may be constructed by digging a trench and fillin it with large stones fitted loosely, so as to allow the wate to pass through, the top being covered with brushwood, whic carries the roadway. Serviceable drains may also be mad with barrels or planks.

When ascending a hill by means of zig-zags the road shoul be made as level as possible at each angle, and half as wid

METALLED ROADS.

Fig. 1.

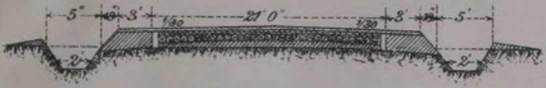

Fig. 2.

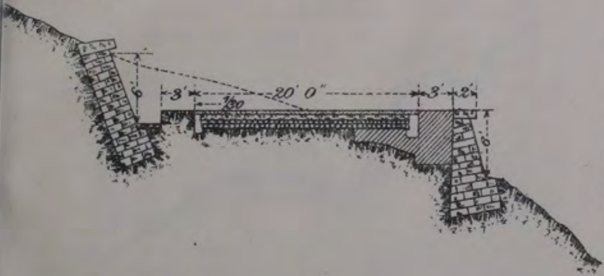

Fig. 3.

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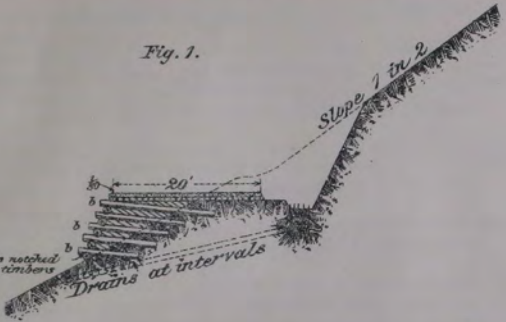
Opposite page 124.

TEMPORARY ROADS

Fig. 1.



Road on side of very steep Hill entirely cut out

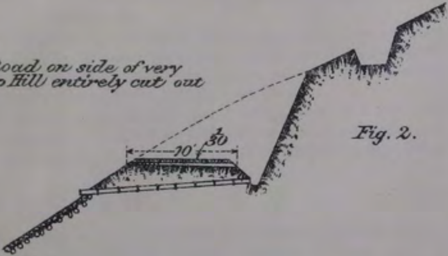
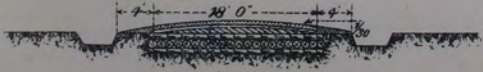


Fig. 2.

Fig. 3.

Road over Wet or Marshy Ground built on Fascines.



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To follow plate 81.

again as in the straight portions. Short zig-zags should be avoided.

308. When a road passes over very wet or marshy ground, and brushwood is available, it should be made up into fascines or hurdles, or even laid loose across the road (though this plan is not so good as if made up) as foundation for the road material. Roads across marshes.

309. When fascines are used there may be one, two, or more layers (Fig. 3, Pl. 82), according to the requirements of the case, the top row being always at right angles to the direction of the road. Fascine road.

310. With hurdles their length should be equal to the width of the road, and there should not be less than two layers across the road, the layers breaking joint. Hurdles.

When the road is a permanent one it is considered advisable to place the brushwood at such a depth below the surface as will ensure it always being damp, as when it is alternately wet and dry it soon rots.

Four inches to six inches of broken stone or gravel are then laid on top, or, if these materials be not available, the earth excavated from the trenches on either side is thrown there, the surface being sloped as already described.

311. The trenches should be cut about 3 feet or 4 feet from the brushwood on either side, and outlets should be made from them at intervals, to allow the water to discharge into lower ground. Trenches.

312. *See* Chapter XII. Corduroy roads.

313. Roads which are exposed to the traffic of heavy military vehicles require constant repair. Parties of men under a N.C.O. should therefore be told off to every 3 or 4 miles of road to keep it in order, and depôts for road metalling should be formed at short intervals from which the material is distributed along the road as required. The material used may be either broken stone (of a size to pass through a $1\frac{1}{2}$-inch ring), broken furnace slag, brick or gravel, which should be applied in thin layers, the surface of the road being first loosened by scoring it with the pick. Repair of roads.

Tools.—Shovels, picks, rammers, measuring rods, levels, &c.; also, to break up the metalling, stone hammers 3 lbs. Tools.

in weight, with handles $2\frac{1}{2}$ feet long, so as to work standing, or of $1\frac{1}{2}$ lbs. weight, with handles 18 inches to 2 feet long, to work sitting.

Boning and Levelling.

Levelling by means of Boning Rods.

Definition. **314.** It is often necessary in the field to make a rough section of a piece of ground or parapet, so as to calculate the amount of work to be carried out, or to lay out short lengths of ground at a given slope, as in road-making, drainage, &c. For such purposes levelling by means of boning rods may be employed.

Tools. **315.** The tools required for boning are a field level (or a mason's level, or a spirit level with a straightedge), a mallet, pickets, measuring tape, a set of three boning rods, and where great differences of level are met with, a long rod graduated to read feet and inches.

Mason's level. The mason's level is shown in Fig. 1, Pl. 83, and can be made by any ordinary carpenter, where a field level is not available.

Boning rods. Boning rods are usually made of deal, 3 inches wide and $\frac{3}{4}$ inch thick, and consist each of a long arm, with a head dovetailed on at right angles to it (Fig. 2, Pl. 83). Care must be taken that all of a set are of exactly the same length.

316. To make a section with such rods, it is usual to select the highest point of the section and there drive in a picket flush with the ground, driving in a second picket on the line of the section with its top carefully levelled to the top of the first picket (by means of the field, mason's, or spirit level), and as far away from the first picket as the length of the level or straightedge will allow (*see* A, B, Fig. 3, Pl. 83). It is evident then by looking over the tops of the two pickets (A, B), the depth below the line of sight of any other points (C, D), on the section could be determined by holding up a measuring rod at those points, and the horizontal distance apart of the various points being also measured, a rough section could be made. To avoid the obvious difficulty of getting one's eye down to the top of the first two pickets (A, B), boning rods are set up on them, and a third boning rod (or the long rod) is set up at the different

BONING & LEVELLING

Fig. 1.

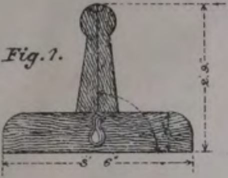


Fig. 2.

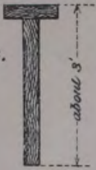


Fig. 3.

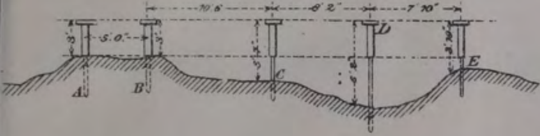


Fig. 4.

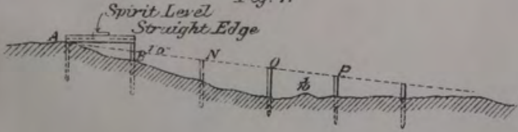
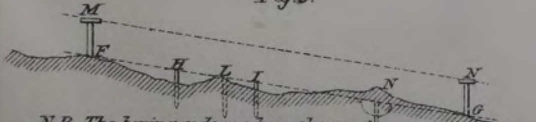


Fig. 5.



N.B. The boning rods are here shewn at right angles to their proper position

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Opposite page 126.

FIELD LEVEL

Fig. 1.

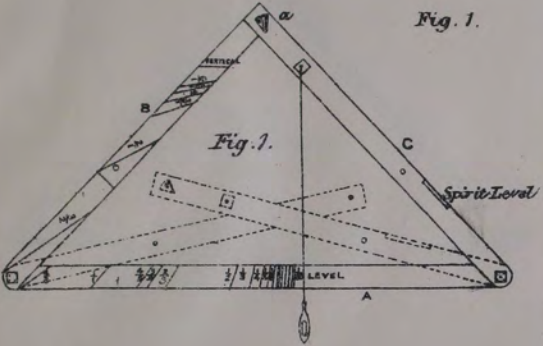

Fig. 2.

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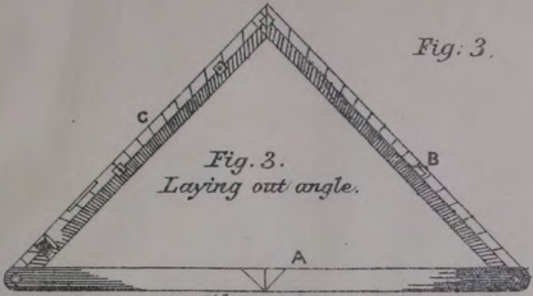
To follow plate 83

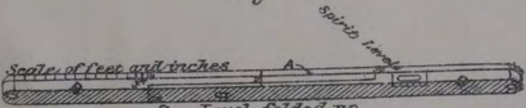
FIELD LEVEL (Cont^{d}.)

Fig: 3.



½" to a foot.

Fig. 4.



a Level folded up.

Fig. 5.

Fastening at a, ½ Full Size.

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To follow plate 84.

FIELD LEVEL.

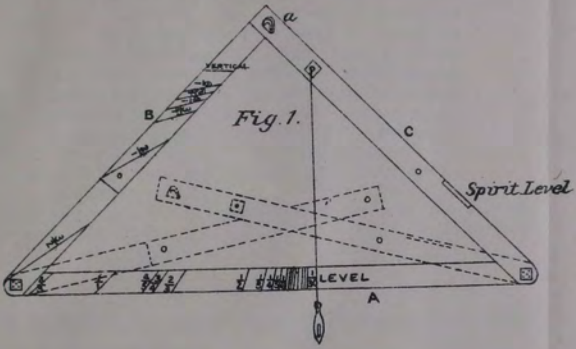

Fig. 1.

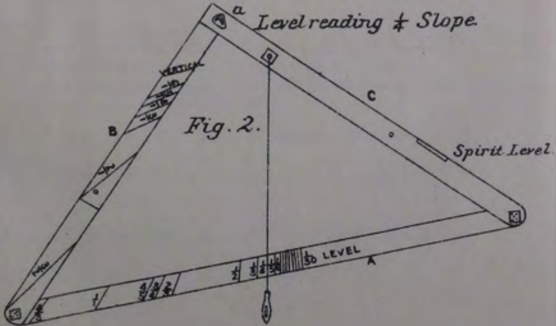

Fig. 2.

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points (C, D, E) whose level is required to be known. The boning rods being all of the same length, give by their tops a horizontal line parallel to the first line of sight, but 3 feet (or thereabouts) above it. In the same way a given slope (say $\frac{1}{10}$) can be set out (Fig. 4) by arranging the tops of the first two pickets at the required slope (level A and B, 10 feet apart, and then cut 1 foot off B), setting up two boning rods on them, and by means of the third boning rod driving in pickets to show the top of the slope at any required points, N, O, P. Again, a continuous slope between any two points can be laid out with pickets, as in Fig. 5, by putting the first boning rod at F, the second at G, and with the third rod setting up the intermediate pickets.

317. In taking a section it is usual to enter the levels, &c., in a book (*see* page 122). Taking a section.

Field Level.

318. The field level is shown in Plates 84, 85, and 86.

It can be used when closed—

(1) As an ordinary spirit level for boning, levelling, &c., the spirit level being on the edge of the limb C. (Fig. 1, Pl. 84.)

When open—

(2) As a square for setting off right angles. (Fig. 1.)
(3) As a protractor for setting off angles. (Fig. 2.)
(4) For setting off slopes of all grades, and as a mason's level with plumb bob. (Fig. 1.)

In all cases place the limb A against the slope to be measured.

The dotted lines in Fig. 1 show how the instrument is closed.

N.B.—One edge of the level is graduated in feet and inches.

CHAPTER XXIII.—RAILWAYS AND TELEGRAPHS.

Railways.

319. The duties likely to be required of troops in the field with regard to railways (apart from large railway schemes, for which special arrangements would be necessary) may be considered as either temporary repairs, or the laying of short lengths of line to join up breaks, the construction of additional works such as platforms, &c., to adapt the line for military use, or the demolition of an existing line.

Formation. **320.** The formation includes the whole of the earthwork necessary to complete the line to "formation level" and secure the required width of way together with "side" and "catchwater" drains, and any "retaining walls" or protective works to secure the bank against floods. Tunnels are included under the head "Formation."

Formation level. **321.** *Formation level* means the level of the completed surface before the ballast is put on. On rapidly constructed military lines, where ballast is possibly not available, the formation level would be the depth of the rail and sleeper below the rail level. The formation level is not absolutely horizontal transversely, as it should slope slightly downwards from the centre line towards the sides of the bank or cutting for purposes of drainage.

Width of railway. **322.** The width of the railroad depends on the gauge, the width of the rails, the clear space outside the rails and the space necessary for drainage.

Gauge. **323.** The *gauge* is the shortest distance between the inside edges of the upper surfaces of the rails, and is $\frac{3}{4}$ to 1 inch greater than the distance between the flanges of a pair of wheels.

In Great Britain, and most of the European countries, the ordinary gauge is 4 feet $8\frac{1}{2}$ inches; in Ireland, it is 5 feet 3 inches; in Russia, 5 feet; in British India, 5 feet 6 inches (mètre, 3 feet $3\frac{3}{8}$ inches) and 2 feet 6 inches.

For a 4-feet $8\frac{1}{2}$-inch gauge, single line, the minimum width of banks and of cuttings at formation level should not be less than 12 feet and 16 feet respectively. These dimensions might be taken for gauges of 3 feet 6 inches, or mètre gauge (3 feet $3\frac{3}{8}$ inches). For a 2-feet 6-inch gauge these minimum dimensions might be reduced by 2 feet. For every additional line of rail it is necessary to add the gauge plus two rail-heads, plus a way between the tracks such that two vehicles can clear each other with their doors open and a little to spare—say 11 feet for the 4-feet $8\frac{1}{2}$-inch gauge.

324. General type of first-class English railway:— Permanent way.

Rails.—Steel, *double-headed*, weight 80 to 90 lbs. per yard.

Sleepers.—Baltic fir, 9 feet by 10 inches by 5 inches (Pl. 87, Fig. 2), weight 140 lbs.; laid 3 feet apart centre to centre, 2 feet 2 inches at rail joints.

Chairs.—Cast-iron; width 6 inches or 8 inches; weight 45 lbs. each; secured by two steel spikes and two screws. (Fig. 4.)

Keys.—Compressed oak, 6 inches long. (Fig. 4.)

Fishplates.—Steel; weight 54 lbs. per pair; secured by four steel bolts $\frac{3}{4}$ inch diameter. (Fig. 7.)

Ballast.—Screened cinders, broken granite or slag, size not exceeding $1\frac{1}{2}$ inches cube, nor more than 10 per cent. to pass $\frac{1}{2}$-inch mesh. Rounded gravel, if used, to be mixed with sand or broken stone to prevent it from working out from under sleepers.

In most foreign countries, however, the *flatfooted* or Vignoles rail is used. This does not need chairs, and is spiked direct to the sleepers, sometimes with a bearing-plate between if the timber is of a soft description.

325. Two of the many different kinds of rails in use are shown on Plate 87, Figs. 5 and 6, the double-headed and the flat-bottomed rails are usually made in lengths of from 15 to 30 feet, or even 60 feet, and weigh up to 110 lbs. per yard for permanent lines intended for heavy traffic. Rails.

326. The rails are connected together by two fishplates of wrought iron or steel, each with four bolts with nuts and washers. The sleepers on each side of the joint are brought closer together so as to reduce the bearing to about 2 feet. Rail joints.

Sleepers.

327. Sleepers are bearers, whether of wood or of steel, used to distribute the weight on the rails over the ballast or roadway, and in the case of cross-sleepers as a connection between the two rails to preserve the gauge.

Each mile of railway requires 1,850 to 2,000 sleepers.

Chairs.

328. *Chairs* are used to connect the rails to the sleepers, when necessary owing to the sectional form of the rail, and to distribute the weight over a greater bearing area on the sleeper than is obtained by the rail resting on it.

Connection between chairs and sleepers.

329. Chairs are fastened down to sleepers by spikes and trenails.

Trenails are wooden spikes, so compressed by machinery as to expel all moisture from them. When they have been driven into the sleepers their tendency is to absorb moisture and swell, and so to grip the sleeper more tightly. They must not be employed alone, but where they are used there should be at least one iron fastening to each chair, for, although the trenail is a firm means of holding down the chair to the sleeper, it is liable to rupture from a shearing stress. For this reason, oak trenails with iron spikes driven into them (Pl. 87, Fig. 3) are often used.

In the case of flat-footed rails with good bearing area and exposed to moderate axle loads, the rails may be spiked direct to the sleepers without chairs or bearing-plates.

Connection of rails with chairs.

330. The double-headed and also the bull-headed rail is held in its chair by a *key* or small block of wood, compressed by machinery (Fig. 4). This key is slightly wedge-shaped, and is driven firmly into the gap in the chair at the side of the rail. Rails may be keyed on the outside or inside.

Connection between rails and sleepers.

331. Flat-footed rails are generally connected directly with the sleepers by dog-spikes, or with the intervention of *bearing-plates*.

Ballast.

332. *Ballast* is broken stone or other suitable material placed on the formation level, on which the sleepers rest, and with which they are "packed" to the proper level or inclination.

The objects of ballast are:—

i. To distribute the pressure imparted to it by the sleepers over a larger area.

RAILWAYS

Fig. 1.

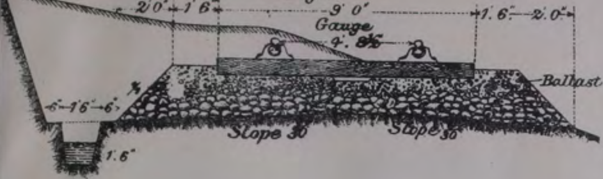


Fig. 3.

Fig. 2.

Sleepers 9' 0" × 10' 0"

Chair for
Double-headed Rail

Fig. 4.

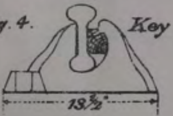


Fig. 5.

Fig. 6.

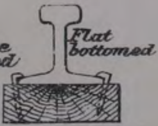
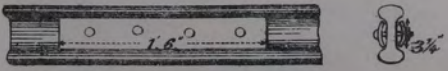


Fig. 7.



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Opposite page 130

RAILWAYS

Fig. 1. POINTS OF SWITCHES

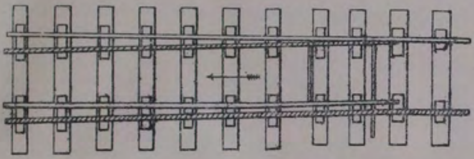


Fig. 2. CROSS OVER ROAD

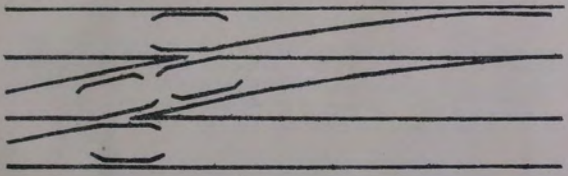
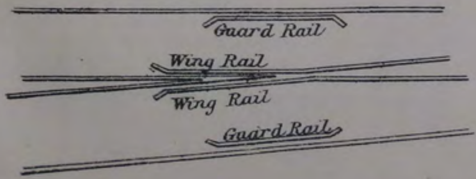


Fig. 3. CROSSING



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To follow plate 87.

ii. To keep the sleepers dry, by affording a permeable mass for rainwater to pass through, and thus prevent their decay.

iii. To afford facilities for packing under the sleepers when they have sunk.

The ballast is usually laid to a thickness of about 1 foot, or 18 inches in very wet places; the permanent way is then laid on it, and its thickness is afterwards increased to the height of the bottom of the rail. The two layers are called the bottom ballast and the top ballast or boxing.

In field railways the bottom ballast may be required for drainage, but the top ballast could be omitted. As a temporary measure ballast could be dispensed with altogether.

333. Any railway tools or materials found along the line must be handed over to the officers in charge of repair, and not on any account appropriated by troops. Railway tools and materials.

Railway Repair and Reconstruction.

334. The main principles on which the work of repair and reconstruction is carried out are:— General principles for repair of railways.

(1) To make the speediest temporary repairs possible, (*e.g.*, deviations and low-level bridges) in order to get a line of some sort through with the least possible delay.

(2) Simultaneously to commence high-level trestle bridges on concrete foundations where required in order to do away with the disadvantage of long deviations with steep gradients and sharp curves.

(3) To commence, without any delay, all permanent repairs, viz., rebuilding the masonry, repairing the girders, or replacing them with new ones in order that the line should be as soon as possible restored to its former position and entirely safe against floods.

335. The best system to adopt whereby to carry out rapid repairs is to establish "*Construction Trains.*" The reconstruction staff live in these trains, which gradually advance along the line as it is being repaired, conveying also the necessary material. Construction trains.

Labour.

336. For railway work of any magnitude large gangs of unskilled labour are required, and this is especially true of temporary repairs to be executed rapidly.

The proportion of unskilled to skilled labour on temporary repairs is as 7 to 1; on semi-permanent and permanent repairs as 3 to 1.

Material depôts.

337. An *advance depôt* for railway material and stores must invariably be formed at some place within 50 miles of the starting point for repairs, and that before work begins.

Wagon transport at rail-head.

338. Sufficient wagon transport to carry 60 tons should, if possible, be available at railhead to allow an advanced party to move on, repairing minor breaks. Much time is thus saved.

Night work.

339. Provided that the arrangements for lighting works at night are good, an equal amount of work can be done by day and night shifts, and when repairs are being pressed, day and night shifts are essential. The only class of work which cannot well be carried on by night is platelaying, which requires plenty of light along the track.

Flares, oil, or acetylene, are easily manipulated and give good light for working parties.

Temporary bridges.

340. Up to 18 feet height. Crib piers of sleepers make satisfactory bridges, which are rapidly built, as a large number of men can be employed to handle materials.

Between 18 and 25 feet, the speed at which such bridges can be built decreases rapidly, not only on account of the additional height, but because more material is used.

Water supply.

341. Damages to water supply by the enemy is apt to cause much difficulty. Troops must not use railway water supplies without special authority. A steam pump and boiler carried on a truck is a useful adjunct. Lift and force pumps worked by manual power, each with several lengths of hose, should also be carried. Engines can then make shift with temporary watering arrangements.

Temporary platforms.

342. To provide for entraining or detraining animals, vehicles and guns, extra siding and platform accommodation will become necessary at various points.

The *sidings* would be in extension of existing sidings, or branch from the main line, according to circumstances.

The *platforms* would, as a rule, be most conveniently placed alongside a siding of sufficient length to allow of the train being shifted so as to bring different vehicles alongside in succession.

Almost any available material may be used, but perhaps the most rapid method of construction is to make a crib work of sleepers (or similar baulks) and rails, or of sleepers only, decked with sleepers, or planking of sufficient thickness to carry the anticipated loads.

The edge of the platform must be just sufficiently far from the rails to allow trucks and carriages to pass, and the top should be level with the truck floor. No over-hang need be given. The decking should usually be held down by ribands along the edges.

One or more inclined ramps will be needed at the back or ends, according to length.

TELEGRAPHS.

(The term *Telegraphs* includes also *Telephones.*)

343. Special troops are usually employed in the construction of telegraph lines, but it is as well that all should have a slight knowledge of the principles of construction, if only with a view to producing the greatest possible damage to the lines when demolishing them. Line.

344. For the transmission of messages by electric telegraph it is necessary to have a *continuous insulated* conductor connecting the various stations in communication.

345. By a conductor is here meant a metallic substance for conveying the current. For this purpose galvanised iron, copper, or bronze wire is generally used, either as a single wire or a smaller number of wires twisted into a strand, as in a rope. Conductor.

346. By "continuous" is meant that the conductor must not have the smallest break in its metallic continuity. The wire is necessarily supplied in coils of convenient weight, as it would be too heavy to manipulate if in one length. In the joints however, metallic continuity is ensured by soldering. Continuous.

347. By "insulated" is meant that the bare conductor must not be allowed to touch the earth, or any neighbouring wires, or any substance of a conducting nature which may be in Insulated.

connection with the earth or other wires. This is effected usually either by "aërial lines" or by "cables."

Aërial line.

348. An aërial line consists of a wire suspended on insulators of porcelain or glass, supported on poles placed at about 60-yard or 80-yard intervals. The poles should be of such height as will keep the wire clear of obstacles and traffic, and safe from malicious damage. No wire should be less than 12 feet from the ground.

Insulators.

349. The insulators are shaped like inverted cups having one or more grooves round them. Porcelain insulators are usually fixed to the pole or arm by means of iron bolts, the cups being provided with an internal screw thread to fit the top of the bolt (Pl. 89, Fig. 2).

Wiring.

350. In erecting the line the wire is first stretched conveniently tight over several poles. It is then placed in one of the grooves of the insulators and "bound in" securely with a piece of smaller wire or tape binder; thus at ordinary insulators there is no break in the continuity of the wire.

Wires for telegraph circuits are invariably run *straight*, that is to say, their insulators occupy similar positions on each pole. On the other hand, important telephone circuits require two wires, each of which revolves or twists round the other, though of course they are kept well apart.

Poles.

351. The poles may be of iron or wood, usually the latter. They should be buried in the ground to one-fifth their length, and their tops protected by a piece of galvanised sheet iron termed a "pole roof."

Arms.

352. Where more than one wire is carried on the same line of poles, the wires are attached to insulators fixed on wooden or iron arms, let into the pole, and at right angles to it (Pl. 89. Fig. 1). The length of the arm depends on the number of wires to be carried. When more than one arm is required they are usually placed at vertical intervals of 1 foot.

Earth wires.

353. Wooden poles, except in dry rocky ground, should be provided with earth wires, consisting of a piece of iron wire running down the pole, under the head of each arm-bolt, to the butt, where it is stapled in the form of a small spiral; this ensures the earth wire being well under ground. Each of the arms is wired, and a turn of the wire is taken round the arm

TELEGRAPHS.

Fig. 1.

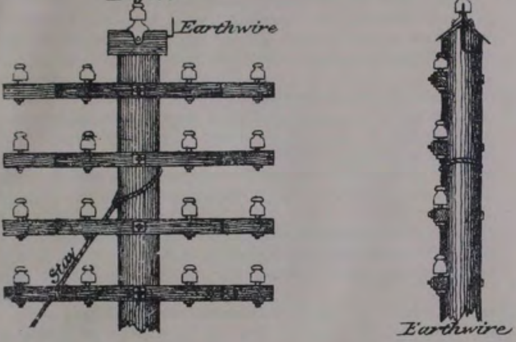


Fig. 2.

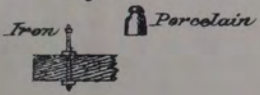


Fig. 3.

Pole brackets.

5186.8.05.
Welter & Graham, L^d Litho. London.
To face page 134

between each pair of insulators. This wire is also brought under the nut of the bolt which secures the arm to the pole.

Earth wires serve a dual purpose; they protect the poles against lightning, and prevent the current from a faulty wire leaking to other circuits, the current being conveyed by the earth wire direct to earth.

354. Where, from the pull of the wires, wind pressure, and other causes, the poles are likely to be forced out of the vertical, they should be *stayed*. Stays are formed of stranded iron wire firmly anchored in the ground and attached to the pole about 2 feet from the top. When the pole carries a great number of wires a second stay may be required, in which case it is added below the first. Stays and struts.

In situations where it may not be convenient to fix a stay, a *strut* can be erected in a similar position, but on the other side of the pole. Struts are usually about two-thirds the diameter of the poles they support.

355. Insulators are sometimes fixed on *angle brackets* attached to chimneys, or *wall brackets* driven into the masonry. Where arms are not used, *pole brackets* (Fig. 3) may be employed to support the insulators. Brackets.

Brackets are not usually earth wired.

356. The insulation of a conductor may also be effected by surrounding it throughout its length with indiarubber, gutta-percha, or other non-conducting substance. When this insulating material is protected from injury by a coating of plaited hemp, tape, or wire, it forms what is known as a *cable*. A cable may contain one or more insulated conductors. Cables.

Cables are employed for :—

(*a*) Under water lines.

(*b*) Under ground lines.

(*c*) Lines on the surface of the ground.

357. When a cable is to be laid in the water it should be strongly protected with a sheathing of steel wires, otherwise the conductor is liable to be damaged by the anchors of vessels, or by the motion of the water. Under water.

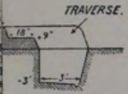
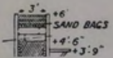
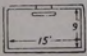
358. A similar kind of cable may be employed for under ground lines, but it is generally more economical to lay a line of iron pipes into which the unprotected insulated conductors Under ground.

can be drawn in convenient lengths. Joint boxes should be provided in the line of pipes at about 100 yards intervals to enable the lengths of wires to be connected. After the joints are made they are covered over with indiarubber tape or gutta-percha to insulate them. The position of these under ground boxes are marked so as to render them accessible when desired for testing the wires or other purposes.

On the surface of the ground.

359. For very rapidly establishing telegraphic communication in the field, a light single core cable is often employed. This consists of a stranded steel conductor, moderately insulated with indiarubber, and covered with plaited hemp; thus considerable tensile strength is obtained with a minimum weight. The cable is laid out on the surface of the ground temporarily; if the communication is required for any length of time an aërial line is constructed, and then the cable is removed.

Section, | **ES.** DATE, 30*th May*, 1904.

No. of Men. Infantry.	R.E.	Whe	REMARKS. ld contain sufficiently full and clear information for the Officer, N.-C. Officer or other on who has to execute the work, to be able to carry on without hesitation.			
50	4	Redoubt I of DUN	renches and redoubt.	Section blockhouse, uprights bound together with wire. Loop-holes 3 ft. 6 in. interval, splayed inwards.	Blockhouse.	1st relief.
95	2	Trench I, chalk BURST C			 Door 3 ft. high by 2 ft., faced by bank.	8–12 1st day, 225 Infantry employed.
25	2	Trench II orchard on pit,			Field. Redoubt.	
50	2	Trench I 200 yds 150 yds				
25	6					

which a gun is fired.

GLOSSARY OF TERMS.

Abatis.—An obstacle formed of trees or branches of trees picketed to the ground, with their points towards the enemy.

Banquette.—A bank upon which men stand to fire over a parapet.

Berm.—A small space left between the parapet and excavations of a work.

Bivouac.—An encampment without tents or huts.

Bomb-proof.—A shelter, proof against the penetration of shells.

Calibre.—The diameter of the bore of a gun.

Caponier.—A small chamber formed in the ditch of a work projecting from the escarp to give fire down the ditch.

Casemate.—A shell-proof chamber constructed for the accommodation of the garrison of a work or position.

Chess.—A plank forming a portion of the flooring of a bridge.

Command.—The vertical height of the crest of a work above the natural surface of the ground.

Counterscarp.—The slope of the ditch of a work furthest from the parapet.

Crest.—The intersection of the interior and superior slopes of a parapet.

Crib-pier.—A support for a bridge formed of layers of baulks of wood laid alternately at right angles to each other.

Dead ground.—Ground which cannot be covered by the defenders' fire.

Defilade.—The adjustment of the levels of the crest and interior portions of a work with a view to obtain cover for the defenders or to screen them from view.

Derrick.—A single spar held up by four guys, used for lifting or moving weights.

Embrasure.—A channel through the parapet of a work through which a gun is fired.

Enfilade fire.—Fire which sweeps a line of troops or defences from a flank.

Epaulment.—A small parapet to give cover to a gun and detachment in action.

Escarp.—The slope of a ditch nearest the parapet.

Exterior slope.—The outside slope of a parapet extending downwards from the superior slope.

Fascine.—A long bundle of brushwood, tied up tightly, used for revetting, &c.

Flèche.—A work consisting of two faces, forming a salient angle towards the enemy.

Fougasse.—A small mine filled with stones which are projected towards the enemy on the mine being fired.

Fraise.—A palisade fixed horizontally in a slope.

Gabion.—An open cylinder of brushwood, sheet iron, &c., used for revetting.

Glacis.—The ground round a work outside the ditch. This is sometimes made up artificially.

Gorge.—The face of a work furthest from the enemy.

Guy.—A rope fastened to the tip of a spar or frame, to support, raise or lower it.

Gyn.—A tripod constructed with three spars, used for raising weights.

Interior slope.—The inside slope of a parapet (seen in section), extending from the crest to the banquette.

Keep or Réduit.—A separate enclosure within another work to enable the defenders to resist after the outer line of defence has been carried.

Lunette.—A work consisting of four faces, the two centre ones forming an obtuse salient, the two side ones affording fire to the flanks.

Lunette, blunted.—A work consisting of five faces (otherwise similar to a lunette).

Machicoulis gallery.—A balcony with a musket-proof parapet in front, loopholed in the floor, to afford fire in a downward direction.

Parados.—A traverse to give cover from reverse fire.

Profile.—The section of a parapet at right angles to the crest.

Redan.—A work consisting of two faces, forming a salient angle towards the enemy.

Redan, blunted.—A work consisting of three faces, the centre one firing to the front, the others to the flanks.

Redoubt.—A field work entirely enclosed by a defensible parapet.

Relief.—The length of time that men have to work before being relieved.

Revetment.—Any method of making earth stand at a steeper slope than the natural slope.

Reverse fire.—Fire directed on the backs of a line of defenders.

Riband.—A baulk fastened down on each side of a roadway to keep the chesses in place.

Sap.—A trench formed by constantly extending the end.

Sheers.—Two spars lashed together at the tip and raised to rest on their butts, which are separated. They are used to lift and move weights in one plane.

Splinter-proof.—A shelter, proof against splinters of shell.

Superior slope.—The top of a parapet (seen in section).

Tackle.—Any system of blocks and ropes by which power is gained at the expense of time (*i.e.*, more power—less speed).

Tambour.—A projecting chamber or stockaded enclosure, constructed so as to flank the walls of a building.

Terreplein.—The surface of the ground inside a work.

Trace.—The outline of a work in plan.

Traverse.—A bank of earth erected to give cover against enfilade fire, and to localise the bursts of shells.

Wattle.—Continuous brushwood hurdle work.

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