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MANUAL

FOR

ENGINEER TROOPS;

CONSISTING OF

Part I.—**Ponton Drill.**
Part II.—**Rules for Conducting a Siege.**
Part III.—**School of the Sap.**
Part IV.—**Military Mining.**
Part V.—**Construction of Batteries.**

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PREFACE.

The following Manual is a compilation from English, French, and Austrian Military Authors, with such alterations, as appeared necessary to adapt the work to our service.

In the instruction for the Pontonier, it has been attempted to devise a drill applicable to the various Ponton Trains now in use in our Army.

The first part of the instruction for the Sapper is, with a few alterations, a reprint of General Pasley's Rules for conducting the Practical Operations of a Siege. The second is a translation of the French Sapper Manual.

That part which relates to Military Mining is taken from the English and French Aides Memoire.

PONTON DRILL

PART I.

PONTON DRILL.

CHAPTER I.

PASSAGE OF RIVERS.

When an army in the field finds its march interrupted by a river, it may effect the passage of this obstacle either by fording, by ferrying in boats, rafts or flying bridges, or by military bridges.

The selection of the place and means of crossing a river, is determined by a reconnoissance, which should be as detailed and extensive as circumstances will permit.

Fords.

A river with a moderate current may be forded by infantry when its depth does not exceed three feet, and by cavalry and carriages when its depth is about four feet.

The requisites for a good ford are, that the banks are low but not marshy, that the water obtains its greater depth gradually, the current moderate, the stream not subject to freshets, and that the bottom is even, hard and tenacious.

In mountainous countries, the bottom is frequently covered with large stones, rendering the passage of carriages nearly or quite impracticable.

In level countries, the case is often still worse, the bottom being either of mud or quicksand, rendering it impassable for both men and carriages. Sometimes the bottom is composed of fine sand, which is hard enough, but by the action of the hoofs of animals is stirred up and washed away, increasing the depth until it is unfordable.

The best bottom is coarse gravel.

Fords are usually found in the wider and more rapid parts of the river.

Their position may be determined by sending a number of mounted men across wherever there is a probability of the river being shallow enough.

The most certain method is to float down the stream in a boat, keeping it in the swiftest part of the current, where the stream is usually the deepest. Over the stern a sounding line of the proper length is hung; when this touches bottom the river is sounded across.

When the ford is discovered, the remarkable objects on the shore should be noted, that the ford may be easily recognized, and a picket planted at the water's edge, in order that any variation in the height of the water may be ascertained.

Rivers which are not fordable may sometimes be rendered so, when the only obstacle is a too great depth of water over an extent of eight or ten yards, by filling in this portion of their bed with fascines loaded with stones, or with stone and gravel.

When the water is sluggish, or muddy, a ford may be improved by covering the bottom with bundles of coarse grass, rushes or twigs.

There have been instances of rivers rendered fordable by diverting a portion of the water from its natural course.

When the river is wide and rapid, the ford must first be carefully examined and staked out. The troops pass in column of platoons, with sufficient interval to avoid choking the current.

When boats are to be had, a few should be stationed below the ford, to assist those who may be carried down by the current.

When boats are wanting, this duty may be performed by mounted men, or a life-line may be stretched across, supported on casks or other floats. The force of the current may be broken in a measure by stationing cavalry in the stream above the ford.

After a freshet, the ford should be re-examined, lest some alteration may have taken place in the bed of the river.

In marching in retreat, it is frequently advisable to destroy a ford after having used it. This may be effected by digging trenches across it, or filling in the deepest part with harrows, teeth up, plank filled with spikes, crow's feet, &c.

Ice.

In high latitudes, during the winter, rivers are frequently covered with ice of sufficient thickness to sustain the heaviest loads. This means of communication should be used with great circumspection. A change of temperature may not only suddenly destroy this natural bridge, but render the river impassable by any method for a considerable time, in consequence of the floating ice.

The thickness of ice should be, to allow the passage of infantry in single file, on a line of planks and two yards apart—two inches; cavalry, or light guns, with intervals, four inches; 12-pounder field-pieces, unlimbered and on sleds, five inches; 12-pounder field-pieces, limbered and drawn by horses, with intervals between pieces, six to seven inches. Ice when ten to twelve inches thick, bears the heaviest loads.

Two tracks of planks laid on the ice, for the carriage-wheels to run on, may be employed when there is any doubt as to its strength, or the wagons may be transformed into a sort of sled by fastening two planks under the wheels.

The thickness of the ice may be increased, when the temperature is low enough, by throwing water on it.

When the river is frozen on each side, but open in the middle in consequence of the velocity of the current, a boom stretched across the open space will often check the velocity sufficiently to cause the ice to freeze.

Passage on Boats, Rafts, &c., &c.

The point of passage being selected, all the boats that can be procured will be collected—in default of a sufficient number of boats, lumber, casks and other material suitable for rafts—and the rafts constructed without delay. The banks, if too steep, will be cut down; the landing on the opposite shore should be further down the stream than the point of embarkation, as the loaded boats will drift with the current. The boats will be arranged along the shore according to size, and numbered; the rafts moored below the boats.

The infantry will be divided into sections, depending in size upon the capacity of the boats in which they are to embark; each section is provided with the number of its boat; great care must be taken not to overload the boats or to crowd the boatmen.

The soldiers will enter the boats one by one, alternately against the right and left gunwale; they will be cautioned not to stir from the places assigned them, and above all, not to spring up when the boat lurches; they will disembark in the same order, *i. e.*, one by one.

When the river is shallow near the shore, the boat must not approach the bank near enough to ground as it fills with men.

In the passage of artillery, it is usually necessary to dismount the piece.

Cavalry are not often passed over in boats. When boats of sufficient size can be obtained, their bottoms must be covered over with plank, the horses placed crosswise, facing alternately up and down stream, otherwise they may be thrown down by the rolling of the boat.

The passage of all arms may be facilitated by constructing a floating bridge formed of two boats, covered with a platform constructed as follows:

From five to seven beams of the same thickness are laid across the two boats, the interval between the beams equal, and such that the covering plank extends one foot beyond the extreme beams.

The interval between the boats allows the beams to extend two feet beyond the outer gunwales. The beams are lashed to the boats; the covering planks are kept in place by two side-rails laid directly over the outer beams, and lashed down to them; the extreme planks are nailed down.

The size of the beams is regulated by the load, and interval between the boats. With seven beams 27′ long and 5″ square, and covering plank $1\frac{1}{2}$″ thick, a 24-pounder may be carried.

Not only artillery and cavalry may be transported by this means, but infantry may be, in much greater numbers than by using the boats separately.

The raft can be manœuvred by oars with nearly the same facility as a boat.

The same rules apply to the passage of troops on rafts as in boats, attention being paid to the following circumstances: that rafts drift more than boats, consequently the landing on the opposite shore will be further down stream; and as the embarkation is easier, there is more danger of overloading the raft, and of confusion in embarking. Infantry enter by the flank, and occupy first the middle of the raft, through its entire length; a rank is then added alternately on the up and down stream side, until the raft is loaded.

Artillery and heavy carriages are placed in the centre, and cavalry as in the boats.

Rafts possess these advantages, viz.: the embarkation and landing of all arms is easier.

They carry large numbers at each trip.

They are not easily injured by the fire of the enemy.

They draw little water.

They cannot, however, be navigated with the same facility as boats, and move much more slowly through the water, thus keeping the troops a longer time under fire when in presence of an enemy.

They cannot be directed with certainty on a fixed point, when the stream is rapid, and in this case it is often impossible to bring them back against the current to the starting point.

Finally, the length of time required for their construction forbids their use when the passage is to be effected secretly.

When the material is limited in quantity, the passage will be executed more readily by means of the rope ferry, trail or flying bridge.

The first, which is used in streams with sluggish currents, consists of a floating support, either raft, floating bridge (as described above) or a wide scow. This support is provided with two forked uprights, one near each end of the up-stream side. The forks support a strong rope, stretched across the stream, and securely fixed at each bank. The raft is caused to traverse the stream by men on its deck hauling on the cable.

The trail bridge is employed on streams of not more than one hundred and fifty yards in width, and with a current whose velocity is not less than one yard per second. The rope must be maintained above the surface of the water, consequently must be drawn very tight by means of windlass, blocks and falls, or similar expedients, also raised at each bank some distance above the water.

The raft or boat is attached to a pulley which runs on a sheer line, and by means of a rudder, is given such a position that its side makes an angle of about 55° with the direction of the current.

The force of the current exerted on the side of the float may be divided into two components, one perpendicular to the sheer line, which is destroyed by the resistance of this line, the other parallel to it, which causes the float to cross the stream with a velocity depending on the strength of the current.

The most suitable float for the purpose, is one composed of two long narrow and deep boats, with the sides nearly vertical, the interval between the boats, such that the current shall act on the sides of both through their entire length, when they form the proper angle with it.

When timber rafts are used, they should have the form of a lozenge, whose acute angle is 55°. When two sides are parallel to the current, the up-stream side will be in the most favorable position for the passage.

When the river is more than one hundred and fifty yards in width, the strain on the sheer-line would be very great; it is therefore usually replaced by a cable, one end of which is attached to the float, the other anchored in the stream, thus forming a flying bridge.

The cable is supported by several floats, either small boats, barrels, logs, &c.

When an anchor is used, the first float should be as near it as possible, without danger of tripping it; the others should be so arranged as to maintain the cable above the water. The cable is anchored in the middle of the stream, when the current is stronger there; but when stronger near one shore, it must be anchored nearer the other. If no floats for the cable are used, it must be passed over a gallows-frame on the raft to keep it from dragging in the water.

This bridge is manœuvred in the same manner as the trail bridge. The rope-ferry, trail or flying bridge, furnish the means of passing any stream, and may be advantageously employed in many cases. They may be established without difficulty in a short time with limited material, and such as can often be found in the vicinity. They permit the passage of all arms, and the heaviest loads.

They are not liable to injury from floating bodies, and the flying bridge does not interrupt navigation.

Bridges.

When a river is more than four feet in depth, or when its bottom is of mud or quicksand, recourse must be had either to ferrying, by means of boats, rafts, &c., or to military bridges. The latter method is always to be preferred, when circumstances will permit their establishment.

Military bridges are composed of a road-way and its supports; the first consists of beams, or balks, reaching across the adjacent supports, and covered with plank, called chess.

The supports, from which the bridge takes its name, may be either fixed, as trestles, gabions, carriages, piles; or floating, as pontons, boats of commerce, rafts, &c.

Ponton bridges are preferable to all others when the passage by main force or surprise is to be undertaken.

They may be constructed on any stream of sufficient depth.

Pontons may be replaced by rafts, when the velocity of the stream does not exceed 6′ per second. In swifter currents, rafts are unmanageable, drag their anchors, and are liable to destruction from floating bodies.

Trestle bridges may be constructed in rivers whose depth does not exceed 9′, and whose velocity is not more than 6′.

They may be employed with advantage in rivers of moderate depth and gentle current, with hard even bottoms; when the bed of the river is uneven, the adjustment of the trestles to the bottom is very tedious, and when the current is rapid, almost impossible; when the bed is of mud or fine sand, the settlement of the legs is liable to be irregular.

Gabion bridges are used over marshes and shallow streams; they consist of gabions constructed in the ordinary way, and of a height necessary to give a level road. These are placed in rows perpendicular to the axis of the bridge, filled with stones or gravel, and capped with a piece of timber, on which the balks rest.

Pile bridges are superior, in point of stability, to all other military bridges, but require much labor and time in their construction, and are usually employed in securing the communication in rear of the army.

Military bridges being merely temporary expedients, the same solidity is not required in them, as in permanent bridges. It is sufficient to give them the strength required to support the weight of the heaviest loads which accompany an army, and to resist the action of the current, which has a tendency to tear away the supports.

The first requisite is attained by giving sufficient volume to the supports, if they are floating, vertical strength if fixed, and using balks and chess of the proper dimensions, taken in connection with their length between bearings.

To resist the action of the current; a good system of anchorage, the greatest possible distance between supports, and by placing these supports exactly in the direction of the current.

An intimate connection between the parts of the road-way, and between the road-way and its supports, is also a great assistance in resisting the current; sufficient play must however, be left, to allow the bridge to accommodate itself to the action of a heavy load passing over it, and the action of the waves when the water is rough, otherwise, however firm the fastenings may be, they will soon work loose.

The interval between the supports is regulated not only by the length of the balks, but by the cross section and the buoyant power of the support. The duties of an officer charged with the construction of a bridge are, to discover and collect all the material disposable for the purpose; to examine carefully the position chosen for the bridge, ascertain the width and velocity of the stream, and the nature of its bottom and banks. He can then determine the composition of the bridge, calculating so as to reserve sufficient material to repair damages, and lengthen the bridge in case of a rise in the water. He will then divide his force into detachments, assign to each its task, and require each to labor at its own task without attempting to interrupt or assist that of any other.

During the progress of the work, he will not allow any unnecessary person to approach the working parties, or step upon the bridge.

CHAPTER II.

CONSTRUCTION OF PONTON AND TRESTLE BRIDGES.

There are four methods of constructing a bridge when pontons or boats of commerce are employed.

1st. By successive boats.

2d. By rafts.

3d. By parts.

4th. By conversion.

The Modified French Bridge Equipage,

Plate 1,

Consists of 34 Ponton Wagons, each loaded as follows, viz.:

7 long balks; 1 ponton, inside of which are placed 12 balk lashings; 7 rack lashings; 7 rack-sticks; 6 row-locks; 2 spring-lines; 5 oars; 2 boat-hooks; under the rear axle is lashed 1 anchor.

22 Chess wagons; load of each, 41 chess; 2 cables.

4 Trestle wagons; load of each, 2 trestle caps; 4 legs; 4 shoes; 4 chains; 14 short, or claw balks.

4 Abutment wagons; load of each, 2 abutment sills; 1 trestle cap; 2 legs; 2 shoes; 2 chains; 14 short balks.

4 Tool wagons; loaded with carpenter's and intrenching tools, spare cordage, &c.; 2 travelling forges.

Recapitulation of Equipage.

Ponton wagons	34	Pumps	5
Chess "	22	Buckets	10
Trestle "	8	Pickets	24
Tool "	4	Rack-sticks	240
Forge "	2	" collars	48
Trestles complete	12	Cordage.	
Balks, long	238	Cables	44
" short (claw)	118	Spring-lines	128
Chess	902	Lashing balk	720
Sills (abutment)	8	" side-rail	360
Row-locks	200	Sheer-lines	2
Oars	192	Sets double blocks, large	6
Boat-hooks	100	" " " small	6
Scoops	70		

Discharge of Material.

The ponton is removed from the wagon by twenty men. The wagon is brought near the river bank, the pole toward the stream, and unlimbered. A double row of chess is laid from the carriage to the water. The lashings are removed, and the boat is allowed to slide gently into the water. The balks are piled on the left of the entrance to the bridge. Two balks are laid on the ground parallel and 18 feet apart; on these is a layer of balks nearly in contact with each other, then two more directly over the first set. Then a second course, &c., until the pile is about 5 feet high.

The chess are piled on the right of the bridge, as follows: three balks are laid on the ground parallel, and 5 feet apart; on these a course of ten chess not quite in contact; on these a second course of ten chess, &c., until the pile is 5 feet high. Other articles, as trestles, cables, &c., are in separate piles on the right of the chess.

Construction of Trestle Bridge over Dry Ravine.

Plate 4.

Sections. No. of	Duty.	Non-Com. Officers.	Men.	
1st.	Abutment Section	1	8	Construct abutments, &c.
2d.	Trestle Carriers' "	1	8	Bring first trestle, then go for another.
3d.	" Builders' "	1	8	Erect the trestle and adjust the balks upon the caps.
4th.	Balk "	1	10	Carry balks by right side to end of bridge, front men give ends to trestle builders, take rear ends and assist in placing. Go back for more by left of bridge.
5th.	Chess "	1	24	22 carry chess by right of bridge to other two who place them. Return by left.
6th.	Side-rails "	1	8	Bring side-rails, and lash them down.

Dismantled by reverse process.

The pontoniers are divided into detachments, in which each rank is numbered from the right, so that the front and rear rank men of each file have the same number.

The first section is composed of one non-commissioned officer and eight men, whose duty is to prepare a convenient entrance to, and exit from the bridge, and to place the abutment sill.

For the latter purpose there will be required picks, shovels, a maul, one sill and pickets, the number and size depending on the nature of the soil.

A trench one foot in depth is excavated to receive the sill, which is placed in a direction exactly perpendicular to that of the bridge, and firmly fixed in position by pickets eight inches from each end in front and rear; as soon as the balks are in place, a chess is arranged against their ends, its upper surface coinciding with that of the chess forming the roadway, and retained by pickets.

The approach to the bridge is then rendered easy by cutting down and levelling the bank, if necessary; the abutment for the other extremity of the bridge is then arranged in the same manner.

Trestle Carriers.

2d Section.—1 chief of section and 8 men. Nos. 1 and 1 and Nos. 2 and 2 carry the cap, passing rack-sticks through the suspension rings; Nos. 3 and 3 the legs and false legs; Nos. 4 and 4 the chains, shoes and wedges. The section is then formed and marched back to the trestle depot.

To Construct the Trestle.

3d Section.—1 C. S. and 8 men. No. 1 inserts the leg in the cap and adjusts the chain; No. 2 the false leg and wedge; No. 3 the shoe. No. 4 is stationed at the foot, to prevent it slipping.

The C. S. lays off the distance from the sill or last trestle, at which the new trestle is to be placed; he also measures the height the cap is to be above the ground, and from this estimates the distance the legs are to be thrust through the caps.

Nos. 1, 2 and 3 raise the trestle. No. 4 prevents the foot from slipping. Nos. 3 and 4 hold the trestle erect, whilst Nos. 1 and 2 adjust the balk which they receive from the balk carriers.

When the cap is so high that it cannot be reached from the ground, the manœuvre is performed as indicated in plate 4.

Balk Carriers.

4th Section.—1 C. S. and 10 men. C. S. commands "lay hold," "raise," "shoulder," "forward;" each file seizes a balk, raises it; the front rank to the right, and the rear rank to the left shoulder. The section marches in line to the entrance of the bridge, the balk carriers on each flank then precede the others, all keeping as close as possible to the right-hand side of the bridge; on arriving at the bridge head they come into line, the front rank pass their end of the balks to the trestle section, step back and relieve the rear rank, and assist in placing the balks. The section is then formed in two ranks on the left side of the bridge, and marched off by the flank.

Chess.

5th Section.—1 C. S. and 24 men (22 carriers and 2 coverers). 22 carry chess; each man carries a chess under the right arm, the forward end raised well up in the air; he marches on the right side of the bridge, delivers the chess to the coverers, then passes back to the pile of chess, by the left side of the bridge. The coverers stand on the balks to be covered (one on the 1st and 2d, the other on the 4th and 5th balks), facing to the rear; they receive the chess and place them.

Side-Rails.

6th Section.—1 C. S. and 8 men. Nos. 1 and 1 carry side-rails for up-stream, Nos. 2 and 2 for down-stream side of bridge. They are carried in the same manner as balks, and one laid on each bay as soon as the coverers have left it. Nos. 3 and 3 lash up-stream, Nos. 4 and 4 down-stream rails.

The side-rails are placed immediately over the outer balks, and lashed by passing a rope around the balk and rail, tying it loosely, then twisting it up tight with a rack-stick; three lashings are placed on each rail.

Remarks.—The greatest attention should be given to placing the abutment.

The stability of the bridge depends, in a great measure, on that of the abutment sill.

When, after raising a trestle, the cap is found not to be on proper level, it is better to lower the trestle to the ground to correct the error, than to attempt doing so whilst it is standing.

To Dismantle Bridge.

The sections remain the same as in the construction, operating in an inverse order—6th section remove the side-rails; 5th section the chess; 4th section the balks; 2d and 3d sections overturn, dismember, and carry off the trestles; 1st section remove the abutments.

Construction of Trestle and French Ponton Bridge by successive Pontons over Watercourse.—Summary.

Plates 6 and 7.

No. of Sections.	Duty.	Non-com. Officers.	Men.	
1st.	Abutment Section,	2	8	Construct first abutment, take material for second across river and construct it.
2d.	Trestle,	2	8	Construct raft of two pontons, load it with separate trestles, caps and legs, &c., take raft to its place, put trestle together, right it, put claws of balks to caps, haul on cables, drop legs, disengage raft.
3d.	Up-Stream Anchor,	2	8	Two half-sections. Boats with up-stream anchors are above abutment, two half-sections enter two boats, row to place for anchor, cast it, drop boat to place in bridge and go ashore for another boat. If boat is to be moored, down-stream anchor is also placed in stern.
4th.	Down-Stream Anchor	2	8	Two half-sections. First with boat take anchor from boat already in bridge, drop down and cast it; second half-section bring pontons with no anchors into bridge and give them to balk lashers.
5th.	Balk Carriers,	1	10	Bring balks by right side of bridge, pass front end to trestle men or ponton lashers, men at front ends take rear ends and assist in placing them for a ponton, the balk carriers push it off and give their end to lashers, all go for more.
6th.	Balk Lashers,	2	17	Four men alternate by twos in fixing spring-lines; two attend up-stream cable, one down-stream; in placing ponton, ten (five in alternate pontons) receive balks and lash them down.
7th.	Chess,	1	22	Twenty men bring chesses by right of bridge to other two, who face to rear and place them.
8th.	Side-Rails,	1	8	Bring side-rails and lash them down.

When more than seventeen boats are employed, the 3d and 4th sections should be doubled.

When the current is very rapid, the 3d section must be increased.

When the bridge is composed of twenty bays or more, there should be two sections for balks alternating; the same for the chess.

To Construct a Bridge over a Watercourse.

Plate 5.

The axis of the bridge should be as nearly as possible perpendicular to the direction of the current of the stream. This direction is determined by throwing a floating body into the stream where the current is the strongest, and as it floats down, mark (with two boat-hooks) a line as nearly perpendicular to this as can be determined by the eye. The wagons are unloaded as has already been described; the pontons launched.

At the command "*Construct the Bridge*"—

1st Section construct the first abutment, as in the previous chapter; then embark in a ponton with the material for second abutment; pass over the river, determine its position by sighting at the two boat-hooks marking the axis; construct this abutment and the road leading from it. If no trestles were used, they would plant pickets thirty paces above and below, and three and one-half paces above and two and one-half below—the 1st for anchoring cables, the 2d for spring-lines.

2d Section construct a raft (Plate 5) with two pontons, (I) two balks, (*bb*) lashed firmly to the gunwales; a deck is formed of chess (*hh*) covering part of first ponton, and the interval between the two.

The different members of the trestles are embarked, the caps and legs are laid alternately on the balks over the second ponton, the chains on deck over the first, the false legs and shoes in the bow and stern of first ponton; the raft is brought opposite the abutment.

The corresponding files in front and rear rank of the section have the same numbers. The rear rank performs the same operations for the down-stream part of the bridge that the front rank does for the up-stream side; No. 4 holds the raft in position by the guys or shore lines until they receive cables from the anchor detachment; Nos. 1, 1 and 2, 2 bring forward a sill, lay it on its side, the bottom toward shore; Nos. 1, 1 introduce the legs in the mortices of the sill, Nos. 2, 2 the false legs and chains, Nos. 3, 3 place and secure the shoes.

The C. S. commands—"*raise*," the trestle is *righted*; Nos. 1, 1 step on the trestle and hold the legs to keep them from sliding down. Nos. 2, 2 adjust the ends of the balks, which are passed to them by balk carriers; the raft is then pushed off by the balk carriers pushing on the shore end of the balks until the proper distance is attained.

The Nos. 4, 4 are directed by the C. S. to haul or slacken their cables as circumstances may require, until the trestle is in its true position. Nos. 1, 1 then thrust down the legs, pressing them firmly into the bottom of the river; Nos. 2, 2 hook the chains, Nos. 3, 3 drive in the wedges; C. S. commands—"*disengage*." All lift on the cap of the trestle just placed, in order to sink the ponton sufficiently to disengage the balks (*bb*) from under this cap.

3d Section is divided into two half sections, for casting up-stream anchors. The pontons which are to receive up-stream anchors are moored above the abutment. If the ponton is to be anchored down stream, a second anchor and cable are placed in the stern. Each half-section embarks in a ponton with an anchor. The anchor is placed in the bow, the flukes projecting over, the cable coiled immediately behind it. No. 1 front rank attends the cable; No. 1 rear rank steers; Nos. 2, 2 row. The line on which the anchors are to be cast is marked by two boat-hooks, placed about twenty paces apart, on shore. Arriving on this line, and opposite the position which the ponton is to have in the bridge, the C. S. commands—"*cast anchor.*" No. 1 throws over the anchor and pays out the cable until the boat arrives at its place in the bridge, the cable is made fast, and the ponton brought, with the boat-hook and oar, along the bridge head; the short balks, supports, block and sill are arranged, and turned over to the cable detachment, the anchor detachment passing to the shore by the bridge after another ponton.

The distance of the anchors above the bridge should be at least ten times the depth of the stream, otherwise, when a strain is brought on the cables, the anchors will trip.

In ordinary circumstances, an up-stream anchor is required for the alternate pontons, and an anchor down-stream for every fourth ponton.

When the river is not over seventy or eighty yards wide, or the current is gentle, a sheer-line may be used in place of anchors.

The sheer-line is a cable stretched across the river sixteen or twenty yards above the bridge, to which the pontons are attached by lines. As the strain on this line is generally very great, the points of attachment on the shore must be secured with great care. An arrangement similar to the abutment sill may be used, or if the soil is firm, an anchor buried in the ground.

4th Section.—Two half-sections. First half-section cast down-stream anchor; half section embark in a ponton moored below the bridge; proceed to the first ponton in the line of the bridge, which has an anchor on it. No. 1 holds the two pontons together, whilst Nos. 2, 2 remove the anchor and cable to the anchor boat, having previously made the end of the cable fast to the ponton. The anchor boat is then allowed to float down to the line of anchors, No. 1 paying out the cable. The anchor is then cast, and the boat hauled back to the bridge by means of the cable of the anchor just cast.

The boat proceeds to the next boat having a down-stream anchor. Second half-section brings into line those pontons which are not provided with anchors.

These pontons are brought into their proper places and held alongside the nearest ponton between them and the bridge, until the cable men are ready to take charge. The detachment then passes ashore by the bridge.

5th Section—Balk Carriers. Duty the same as 4th section in chapter 2d, except that the front rank push off the ponton before giving the balks to the balk lashers.

6th Section.—Balk Lashers. When the French train is used, an additional section is required to lash the balks to the gunwales of the ponton.

This section is composed of two non-commissioned officers and seventeen men.

Four men alternate, two and two, in fixing the spring-lines, which connect the pontons bow and stern, and are made fast to the mooring-posts ; three men at the cables—two for the up-stream and one for the down-stream cable; ten balk lashers. The five front-rank men enter the first ponton, station themselves opposite the lashing hooks, facing down stream. They receive the ends of the balks from the balk carriers, lay them in their places on the outer gunwale, and overlapping it by six inches. They then throw their weight on the balks to keep them in place whilst the boat is being pushed off. In the mean while, the rear rank lash the shore ends of the balks to the abutment sill, if claw balks are not used, and pass over into the second ponton. When the second ponton is pushed off, the lashers in the first ponton receive the ends of the second set of balks from the carriers, place them on the gunwales of the ponton in contact with the first set, and overlapping the inner gunwale six inches, lash them firmly to both gunwales, then pass over to the third ponton.

7th Section.—Chess Carriers. The same as 5th section, chapter 2d.

8th Section.—Side-Rail Carriers. The same as 6th section, chapter 2d.

Dismantling Bridge over Watercourse.

8th Section—Remove the side-rails.

7th Section—Remove the chess.

6th Section—Act on spring-lines and cast them off, tend cables, and unlash balks.

5th Section—Remove the balks.

4th Section—Two half-sections remove the pontons without anchors; take up the down-stream anchors; the anchor boat is brought up to the ponton; sufficient cable is taken into the boat to allow it to drop down the stream to the line of anchors; the anchor is raised, and the anchor boat hauled back to the bridge. This operation is repeated until three anchors are weighed, when the anchor boat returns to the shore. If the cable to the up-stream anchor is long enough, the readiest way is to allow the ponton to drop down stream by this cable, coiling the down-stream cable until the ponton arrives at the lower anchor line; the anchor is then weighed, and the ponton hauled by the up-stream cable to the upper line of anchors; when the upper anchor is weighed, the anchor boat is then dispensed with.

3d Section—Weigh the up-stream anchors, and take the boats to the second shore. The section is divided into two half-sections, which enter the first two pontons. When the boat is anchored up stream, it is hauled up to trip its anchor by its cable. Boats are taken to shore below bridge.

2d Section—Take up trestles by the reverse of the process used in placing them.

1st Section—Take up the abutments.

Construction of a Bridge by Parts.

Plate 8.

The parts are composed of two or three pontons.

If the velocity of the stream is less than two yards per second, they are constructed above the abutment; if greater, below.

The abutment and each bay is formed as in the case of successive pontons, and at the same time. The parts are formed by sections of one C. S. and twelve men, each part as follows:—a ponton is moored bow and stern to the shore; a second ponton (No. 2) is brought alongside; chess are laid from the shore to No. 1, for the pontoniers to walk on; seven balks are brought; five are placed as for an ordinary bridge, one on the bow and stern; No. 2 is pushed off; a third ponton is brought alongside of No. 2, and is treated in the same manner.

The construction is indicated in the plate.

m m, crossed spring-lines; *f f*, balks; *d d*, chess to form the junction with the next part.

When the part is above the bridge, it is conducted to the line of up-stream anchors, drops its anchor, then floats down to its place in the bridge; a line is thrown to the bridge; it is hauled up to the head of the bridge; the balks are put in place, and the part pushed off, the chess and side-rails lashed. If the construction is from below, the part is towed to its place, where it receives one or two cables of up-stream anchors, as may be necessary, from another boat.

To Dismantle by Parts.

1st Section—Take up the abutment from the shore of departure, and the balks, chess, &c., of the first bay, and pile the material on the first part. The 2d section take up the balks, chess, &c., uniting the first and second parts, pile them on the second part, and the same for the other section;

as soon as the parts are disconnected, the down-stream cables are attached to a buoy and cast adrift; each part is then hauled up by the up-stream cables, the upper anchors weighed, and the parts rowed or poled ashore and dismantled. If necessary, the up-stream anchors may be buoyed.

Construction by Rafts.

Plate 9.

Abutment is constructed as in the previous case, each part as follows:

No. 1 ponton is brought up and moored bow and stern; chess are laid to it from shore. No. 2 ponton brought alongside; five balks are laid resting on both gunwales of each ponton, lashed and covered with chess; ponton No. 3 brought alongside No. 2, and treated in the same manner; side-rails laid and lashed; cross spring-lines; two spare balks are carried on each part; the parts are conducted to their places as in previous case. The parts are united by lashing the adjacent pontons bow and stern, and laying the spare balks over the joint formed by two adjacent side-rails, lashing these balks firmly, either with rope or rack collars. The extreme chess in each part should be nailed to the balks.

Dismantling.

The parts are disconnected by removing the lashings and balks that unite the different parts. The parts are then brought ashore and dismantled as in the bridge constructed by parts.

Bridge by Conversion.

Plate 10.

The position of the bridge having been determined, and the width of the stream accurately measured, a suitable place at some distance above the position of the abutment is selected for the construction of the bridge. The place of construction may be at a considerable distance from that which the bridge is to occupy, and is frequently on some tributary of the stream to be bridged, out of sight of the enemy's shore.

The bridge is constructed parallel to the shore, side-rails are lashed on all except the extreme bays. The balks, chess, &c., for the abutment bay, are embarked on the next to the last bay of the bridge; a ponton is lashed to the last ponton in the bridge; this contains, in addition to the articles necessary for constructing the abutment, two strong pickets. The up-stream anchors are deposited in the bows of the boats on the wheeling flank, ten or fifteen yards of their cables coiled, the remainder stretched along the bridge. Two strong lines are extended and lashed, the one over the bows, the other over the sterns of all the pontons; these lines should be considerably longer than the bridge, and the ends coiled on the platform. The bridge is then allowed to float down to within fifteen yards of the first abutment.

The material for the first abutment and bay is brought down in a ponton, two strong pickets are planted at A and B to fasten the spring-lines, and one to fasten the line which is coiled on the next to the last ponton.

The wheeling flank is pushed off, men are stationed in the bow and stern of each ponton with oars and boat-hooks to increase or retard the progress of the ponton, as may be necessary. A detachment is stationed at the first abutment to manœuvre the spring-lines, another to prevent the pivot flank from touching shore; a turn of the shore line is taken around the mooring-bar of the ponton, and this line is eased off, as the case may require. The anchors are cast as the pontons in which they are carried come in the proper places, and their cables are brought to the pontons to which they are attached. The progress of the bridge is checked when it arrives opposite the abutments, which should be constructed during the conversion of the bridge, if the force is strong enough. The down-stream anchors are cast by the spare pontons, as in the bridge of successive pontons.

Dismantle by Conversion.

This manœuvre is rarely executed except by an army in retreat, closely followed by the enemy.

The abutment bays are dismantled, the spring-lines are fastened to A and B; buoys are attached to the down-stream cables, which are cut off, the up-stream cables are lengthened out with spare cables. A strong line is passed from the next to the last ponton to the shore. The bridge is allowed to swing around, the up-stream cables are eased off, also the upper spring-line. When about half the wheel has been completed, the pontons form such an angle with the current that the tendency of the bridge is no longer toward the required direction, but to move obliquely toward the other shore. The strain on the lower spring-line is very great, and the shore line must be used to haul in.

After the wheel has been effected, the bridge is floated down stream behind an island, or to some other place sheltered from the enemy's fire, and then dismantled.

Advance-Guard Bridge Equipage,

Plate 11,

Consists of—

29 Ponton Wagons. Load of each—7 claw-balks, 1 trestle complete, 1 canvas ponton, 4 oars, 2 boat-hooks,

15 Chess Wagons. 41 chess, $12' \times 12'' \times 1\frac{1}{2}''$, 1 anchor and cable.

1 Abutment—4 abutment sills, 7 balks, 2 anchors and cables.

1 Wagon—1 sheer-line, 6 anchors and cables, spare cordage.

1 Wagon—7 anchors and cables, windlass, blocks and falls.

1 Wagon—Carpenter's tools and picks, shovels, &c.

The pontons are of the Russian pattern (plate 11), viz.: two side-frames, twenty-one feet long, and two feet four inches deep. These are connected by movable transoms. The whole made of four-inch pine scantling.

To equip the ponton, the transoms are inserted in the side frames, and then firmly united by rack-lashings. A canvas cover is then stretched over the frame and secured by lashings.

When employed in the bridge, the balks may be lashed to both gunwales, as in the French bridge, or the trestle cap may be placed in the axis of the boat, with its upper surface six inches above the gunwales. It is supported in this position by two transoms let into the stanchions of the side frames, about five feet from the bow and stern. The claw-balks rest on this cap, as in the Austrian bridge.

As the number of trestles in this train is equal to the number of boats, either of these classes of supports may be used to the exclusion of the other; in either case forming a bridge about two hundred yards in length.

Construction of the Bridge by Successive Pontons when the Balks are not Lashed.

	N. C. Officers.	*Men.*	
1st.	2	8	Abutment.—Construct the abutment, drive the shore-line pickets, attach the shore lines, embark with second abutment.
2d.	2	8	Raft.—Construct a raft, embark trestles, caps, legs, &c. Construct trestles.
3d.	2	8	Boat.—Up-stream divided into half-sections, which alternate in bringing up-stream boats and casting anchors.
4th.	2	8	Boat.—Down-stream—two half-sections—first half-section brings down-stream boats, second cast down-stream anchors.
5th.	1	10	Balk Carriers.—Bring the five balks for each bay.
6th.	1	22	Chess Carriers.—Twenty bring chess, two receive and place the chess.
7th.	1	8	Side-Rails.—Two half-sections; first bring side-rails—second lash side-rails.

When more than seventeen boats are employed, the 3d and 4th sections should be doubled.

When the current is very rapid, the 3d section must be increased.

When the bridge is composed of twenty bays or more, there should be two sections of balk carriers, alternating. The same for the chess.

CHAPTER III.

FLYING BRIDGES—BRIDGES OF RAFTS—TRESTLES AND BOATS—PRESERVATION OF BRIDGES.

Flying Bridge.

Plate 12.

THIS term is applied to any floating support anchored to a fixed point (usually in the stream), and driven from shore to shore by the oblique action of the current on its sides.

Although these bridges do not afford a continuous communication, yet they possess some decided advantages, viz.:

They are readily established over even the most rapid streams.

They require but little material for their construction.

They may be worked by very few men.

They permit the passage of troops of all arms, and the heaviest carriages.

The entrance to and exit from them is easy.

They do not interrupt navigation, and are not liable to be injured by floating bodies which, either by accident or design, are carried down stream by the current.

The current should not be less than one yard per second.

Construction.

The raft is formed of six pontons (plate 12). Two pontons *a a*, are lashed stern to stern, and to these a third *b*, breaking joints. A second set similar to the above, are placed at a distance from the first, of twenty-six feet from set to set. The two sets are connected by six balks *c*, over which four courses *d*, are lashed. Then fifteen balks *e*, in a manner suitable for receiving the chess. The extreme chess are nailed down, and the outer courses secured by side-rails.

The length of the cable should be at least one and a half times the width of the river. One, two or three anchors are used, depending on the strength of the current.

The cable is supported by pontons.

The boat nearest the anchor is the largest; the distance between the boats should be such that the cable shall not touch the water between the first boat and the raft; each boat is fitted with a staging, composed of two short balks and a supporting block, on which the cable rests, and to which it is lashed.

The cable is also connected with the bow of the boat by a line of such length that the boat is allowed to turn just enough to keep parallel with the raft.

After the raft is attached to the cable, it is passed from shore to shore once or twice, until the anchors are firmly imbedded, and the cable stretched; the two abutments are then constructed; these do not differ from the first bay of the ordinary bridge.

If the strongest current is nearer one of the shores, the anchor must not be cast in the middle of the stream, but nearer the other shore.

The proper angle of the axis of the boat with the current is about 55°.

This angle is gradually increased on nearing the shore, until the way of the raft is diminished sufficiently to prevent it from striking the abutment with a shock.

The raft should be provided with spare cables and anchors ready to cast, in case the cable by which it is moored should part.

When the river is not more than one hundred yards wide, a sheer-line may be used in place of the anchor and cable; the sheer-line must be taut enough to keep above the water. See plate 16.

If the banks are not high enough, the sheer-line should be elevated at each shore by passing it over a frame formed of three poles, arranged like an artillery gin. A capstan, or blocks, will be required to tighten the line from time to time as it stretches. Upon this line a pulley is fixed, so that it can run freely from shore to shore; through the eye of the pulley block a line is passed, one end of which is attached to the bow of the first, and the other to the bow of the second boat forming the raft. This is a trail bridge.

The raft is manœuvred as in the case of the flying bridge, or two pulleys may be used on the sheer line; a line from one is attached to the bow of the first boat; a line from the second pulley is passed through a pulley block fastened to the stern of the same boat.

The required direction may be given to the raft by hauling in, or slacking the stern line.

Rhine Flying Bridge.

Two boats are required; they should be long, narrow, and deep, that they may expose as much surface as possible to the action of the current. Those in use on the Rhine are usually ninety feet long, twelve feet wide, and five feet six inches deep. Each boat is provided with a trestle, formed of a bottom sill resting on the ribs directly over the keel. Stanchions connect this with a cap sill, which should be on the same level as the gunwales.

The boats are connected by a series of balks, whose number and size depend on the load to be carried. These balks should be long enough to give such an interval between the boats, that both may be freely acted upon by the current.

The beams are spiked to the trestle and gunwales. The flooring planks are nailed on.

The platform extends over the waists of the boats, and a small forward after-deck is formed between the boats for the accommodation of the crew.

Each boat is provided with a mast, passing through the deck and firmly stepped.

The masts are connected by two horizontal beams, the lower being the stronger, between which a block pierced with a hole slides freely.

The whole frame is stayed by guys. This frame is placed about one-third of the length of the boats from the bows, and is from twenty to thirty feet high.

A beam is fastened across the bows of the boats, to prevent the cable from catching under them.

Each boat is provided with a rudder, the tillers of which are coupled by a bar, so that both may be worked by one man.

The cable, after passing through the cat, is made fast to a windlass.

The cable should be, in length, about one and a half times the width of the river.

The cable is attached to one or more anchors.

With boats of the size above stated, the best arrangement is to cast a large anchor about five hundred pounds weight, with its shank in the direction of the current; two others of about half this weight are cast, with their shanks in the direction which the cable takes when the bridge is at either shore.

The cables of the three anchors are united near the first supporting boat.

The cable is supported by small boats.

The first, which should be the largest, must be at a distance from the anchors, at least three times the depth of the stream.

The remaining boats should be near enough to prevent the cable from dragging in the water—their number increasing with the length of the cable, and diminishing with the strength of the current. Near the bow of each boat is a short mast, forked at the top to receive the cable; a short line or bridle connecting the cable with the bow, prevents the boat from turning too far. The length of the bridle is regulated so as to allow the boat to take position parallel to that of the boats in the raft.

Any floating body may be, in accordance with the above principles, used as a flying bridge; rafts of timber, casks, or wagon bodies, are frequently employed.

When plank can be obtained, a scow either with or without ribs, may be constructed by any of the troops who are at all accustomed to the use of carpenters' tools. When plank cannot be found, a rough frame of poles covered with stout cotton canvas may be employed. When a single boat or raft is used the position of the bridge is regulated by a stern line attached to the cable, instead of a rudder.

When the river is less than one hundred yards wide, a sheer line may be employed, as in the flying bridges, composed of pontons.

When the velocity of the current is not sufficient to work the boat or raft as a flying bridge, it may be propelled as follows:

On the up-stream side near the bow and stern, standards are erected, the tops of which are forked to receive a sheer line which is stretched across the river, and the boat is caused to pass from shore to shore, by men hauling on the cable.

Bridges Constructed of Boats of Commerce.

The same principles are applicable in this case as in that of ponton bridges.

The following precautions, however, must be observed.

As the boats are not usually of a uniform size, the length of the balks for each bay should be so arranged with reference to the capacity of the boat that sustains them, that the bridge will not be endangered, even when the bay is covered with as many men as can be crowded on it.

The boat next to each abutment to be strong and large.

The boats selected for the strongest part of the current, to be large, so that they may be as much separated as possible.

The bridge will then offer less obstruction to the current; and will also be in less danger from floating bodies.

The intermediate boats should increase or diminish in size, gradually, to avoid a sudden change in the level of the roadway.

The gunwales of the boats should be brought to the same level, or as nearly so as possible. This is effected by cutting down the larger boats, or loading them until they are sufficiently deep in the water.

This latter expedient increases the strain on the cable, and should not be resorted to in a strong current.

In the smaller boats the gunwales must be raised,

Or a trestle, composed of a bottom and cap sill, united by stanchions of the proper length, is placed in the axis of the boat, and kept vertical by braces.

The balks, when timber of sufficient dimensions can be procured, should be lashed over both gunwales of the two boats on which they rest. If the timber is not sufficiently long to admit of this arrangement, the following course is adopted. The balks of the first bay rest on both gunwales of the first boat; in the second bay the odd-numbered balks rest on both gunwales of the first, and on one gunwale of the second; the even-numbered balks on one gunwale of the first, and on both of the second boat; the odd numbers of the third bay on both gunwales of the second, and one of the third boat, &c.

If the bridge is subject to the action of the waves, the oscillating motion produced will soon loosen the balk-lashings and destroy the bridge. In this case, it will be necessary to make use of a sill and short balks, as in the ponton bridge. When anchors of sufficient size can be procured, the anchoring of this species of bridge does not differ from that of the ponton bridge.

When this is not the case, some of the following expedients may be resorted to:

First—Anchoring paniers (Plate 3). These are conical gabions, closed at both ends, a pole passing through the axis, and a hole in the side of the cone. Through this hole the panier is filled with stones; the hole is then closed with twigs, a cable is attached to the end of the pole furthest from the panier. It is cast in the same way as an ordinary anchor.

A strong box filled with stones or gravel may be employed. A common harrow loaded with stones forms a good anchor. The best anchorage is formed by driving a row of piles above the bridge. This method possesses the advantage of bringing a horizontal instead of a downward strain on the cable, and protecting the bridge from injury by floating bodies.

Timber Rafts.

Plate 14.

The buoyancy of a raft depends on the volume and specific gravity of the timber employed.

The volume may be found approximately, by the following formula: $V = 0.785\ C^2 L$. $V =$ Volume. $C =$ circumference at middle of log, $L =$ length. To find the specific gravity, take a piece of the timber of convenient length and of uniform even section, stand it vertically in the water, retaining it in this position by three stakes so driven as to allow it to float freely; mark the depth to which it sinks.

Let l = the length of the part above the surface of the water; L = the whole length of the stick; then

$\frac{L-l}{L.} \times 62\frac{1}{2}\ lbs.$ = weight of a cubic foot of the timber, and

$\frac{l}{L} 62\frac{1}{2}$ = weight which a cubic foot will sustain in the water, in addition to its own weight, or the buoyant power of the log, $= V\frac{l}{L}62\frac{1}{2}$.

In the calculation due allowance must be made for the loss of buoyancy which the logs will sustain after immersion, from absorption. This loss will depend on the kind of timber used, being least in resinous varieties, such as pine, and may be retained by smearing the ends of the logs with *pitch.*

To Construct a Raft.

Plates 13 and 14.

Select the longest and largest timber; each stick must be at least thirty-five feet long. The timber is thrown into the water and moored to the shore at a suitable place for building the raft, and where the current is not rapid. After the position which the stick naturally assumes in the water has been ascertained, the end which is to be up stream when in the raft is drawn up on the shore, and the lower side bevelled in a whistle shape, so as to present less obstruction to the action of the current.

The timber is then arranged in the position it is to have in the raft—the butts alternately up and down stream—the up-stream ends forming a right angle, salient up stream.

Employ the largest and longest timber, giving at least thirty-five feet length to the raft. Shorter than this, it will not have sufficient stability, but will be subject to dangerous oscillations, especially in a rapid stream.

Squaring the timber will be worse than useless. Any irregularities, such as branches and knots, should be trimmed off. The raft must be built in the water. Select a place where there is little current, and where the bank slopes gently to the water.

Take the case of a raft, to be composed of twenty logs forty-seven feet long and averaging twelve inches in diameter.

The first log is brought alongside the shore, and the end of a plank or small trunk of a tree (*a a*) is spiked to it about 3′ from each end; it is pushed off a little, and a second log is brought up under the transoms, and in close contact with the first.

The second log is spiked as the first, and so for each of the remaining logs, care being taken to alternate the butts, placing the whistle ends up stream, with the bevel underneath, and to spike the transoms perpendicularly to the logs. When the current of the river in which the raft is to be used is very gentle, the up-stream ends may be on a line parallel to the transom; but if rapid, they should form a right angle salient up stream, the vertex being in the middle log.

When the bank is too steep to admit of this construction, the trees may be floated into their proper positions, lashed together, and the transoms spiked on; if the logs are nearly of the same size, the centre of gravity will be near the centre of the raft.

Two additional traverses are spiked at equal distances from the centre of gravity of the raft, and at a distance apart equal to the width of the roadway or platform.

The traverse should be about 8″ wide by 6″ high. If square timber cannot be had, saplings 7″ or 8″ in diameter may be used.

They should have a bearing on all the logs forming the raft. To effect this the larger logs should be cut down with an adze, and those too small be blocked up to the traverse.

The four traverses may be fastened to the logs either with spikes or wooden pins, or each log may be lashed by passing a rope around it and the traverse and twisting it tight with a rack-stick.

When a platform is to be constructed on the raft, intermediate transoms are laid, and at a distance apart depending on the strength of the planking.

The size of this platform must be regulated by the buoyant power of the raft. A single course of logs will not have sufficient power to sustain troops enough to cover its whole surface.

When this is required, several courses of timber are employed, each perpendicular to that below it, the whole firmly united with pins as lashing.

When the raft is to be used in a bridge, the two intermediate transoms are separated by a distance a little less than the length of the chess, and at equal distances from a point somewhat astern of the centre of gravity of the raft, in order to correct the downward action of the cable on the bow.

On these traverses, three supports *d d d*, are spiked to receive the balks. A piece of plank *f*, is nailed on the bow to prevent the cable from getting entangled in the raft.

When the logs are less than thirty-five feet in length, the following construction is employed. See plate 14.

The small ends of half the trees are bevelled; then a raft is formed with the butts all down stream; in other respects similar to that described above.

The remaining trees are then brought butt to butt with those in the raft, and fastened to them with iron clamps or dogs, or by spiking a piece of plank across the two. A traverse *c* is spiked on the stern. The traverses *h* and *L* as in the preceding example. The traverse *g* a little forward of the centre of gravity of the partial raft A, and the traverse *k* a little astern of the centre of gravity of the partial raft *C*. Two strong timbers *d d*, extend over the four interior traverses. These timbers support the balks and diffuse the load ever the entire raft, without tending to disunite the partial rafts.

For use as support in a bridge, a raft should be able to sustain at least fifteen thousand pounds. The same expedients are employed for the anchorage of rafts as for boats. It must, however, be borne in mind, that a raft offers a much greater obstruction to the current than a boat, and that the strain on the cables is proportionally greater.

Rafts are sometimes constructed for flying bridges, in the form of a lozenge, the acute angle being about 55°, so that when two of the sides are parallel to the direction of the current, the up-stream side, which in this form is the only one acted on by the current, is in the most favorable position.

A raft of casks may be constructed, by forming a frame of timber to contain the casks. See plate 15.

The frame consists of four longitudinal pieces, halved into four transoms. The long pieces must be at least twenty feet long; their distance apart a little less than the head diameter of the casks. The under edges are bevelled so as to give them a good bearing on the casks.

In default of square timber, poles may be used in the construction of the frame. The string pieces and transoms may be spiked or lashed at their intersection.

The four exterior casks in the raft should be lashed to the frame, otherwise they may be carried off by the current when the raft lurches.

Trestles.

Plate 15.

A trestle is composed of a cap about $15' \times 9'' \times 9''$, four legs, two lower and two upper traverses, four braces.

The cap is notched 18″ from the end, to receive the legs; the notch is five inches wide and one inch deep.

The legs should be from five to six inches square; a shoulder is made to fit the notch in the cap; the spread is quarter the height. The inclination in the other direction about one-sixteenth. The leg is spiked, pinned or bolted to the cap. The lower traverse is $5'' \times 1\frac{1}{2}''$, dovetailed into the legs at about one-quarter their height from the ground.

The upper traverse, which is nailed on the inside of the legs and against the cap, is six inches wide, five inches thick.

The braces are four inches wide, one and a half inches thick, spiked to the cap and legs.

The above dimensions, and method of construction, are not absolute, but given as a guide to be followed as closely as circumstances will permit.

The trestle may be made of round timber, care being taken to level the upper surface of the cap.

When the trestles are to be placed on a soft bottom, a flat sill may be spiked under the legs of each side.

Trestle Bridge.

Plate 15.

When the water is less than four feet deep, the trestles may be carried to their places, by men wading in the stream; an abutment is formed as for an ordinary bridge; the trestles are placed with their caps parallel to the abutment sill, and about 13′ apart.

But when the water is too deep or too cold to allow this method to be pursued, the bridge may be constructed as follows:

The abutment sill being placed, the first trestle can usually be placed by hand; the balks are laid and covered with chess to within one foot of the trestle; a roller is laid on the bridge, on this are laid two beams from 30′ to 40′ long, and 6″ or 7″ square. The trestle is placed upright with its cap resting on these beams, to which it is firmly lashed. The pontoniers bear down on the other ends of the beams, at the same time pushing until the trestle is rolled out to the proper distance, they then suddenly let up on the beams, dropping the trestle into its place.

If the trestle does not stand firmly, or if the caps are too much inclined in consequence of the unevenness of the bottom of the stream, a man must walk out on the beams, and sound with a pole the depth of water where each leg is to be placed; having thus determined the required length of the legs, the trestle is hauled on to the bridge, the legs cut down to the proper length, and the trestle replaced. The flooring balks are slid out on the two beams, adjusted, and covered with chess.

When a boat or raft can be procured, the trestles are placed with much less labor.

The boat is brought alongside the last trestle placed, two balks are laid from the bridge, and resting on the outer gunwale of the boat, the trestle is laid on the balks, its legs extending over the outer gunwale of the boat. The boat is pushed off by means of the balks, until it arrives at the proper position for placing the trestle.

The trestle is righted. If it has not a good bearing on the bottom, it is hauled into the boat, and the legs cut to the proper length.

The bridge may be entirely built of round timber.

The caps should be from 10″ to 12″ inches in diameter, the legs at least 6″. The balks 7″ or 8″ inches, and faced on the lower side, where they rest on the trestles, so as to bring their upper surfaces on the same plane.

The covering may be of strong hurdles.

Preservation of Bridges.

When the current is rapid, the bridge is protected from the shock of floating bodies by establishing a guard of observation above the bridge, to arrest these bodies; by placing a stockade obliquely across the stream, or by constructing the bridge by rafts, and withdrawing that part of the bridge which is menaced, and allowing the body to float past.

The guard of observation is stationed about one thousand yards above the bridge. It is provided with boats containing cables, anchors, grapnels, hammers, &c. These boats are stationed at different points across the stream.

As soon as a floating body is observed that may endanger the bridge, a boat hastens toward it, fastens the end of a line to it, and endeavors to tow it ashore. If unable to do so, the line is made fast to an anchor, which should be so cast that the first strain on the cable will be in an oblique direction with the current. The body will then swing around and lose part of its momentum, thus relieving the cable of a portion of the strain.

The boats should also be provided with chains and grapnels, to tow burning bodies.

The floating stockade is constructed of trees united by chains, and forming a continuous barrier to floating objects. Its direction should form an angle of about 20° with the current, which will require its length to be 2½ the width of the river.

Each piece is formed of one, two, or three trunks lashed together.

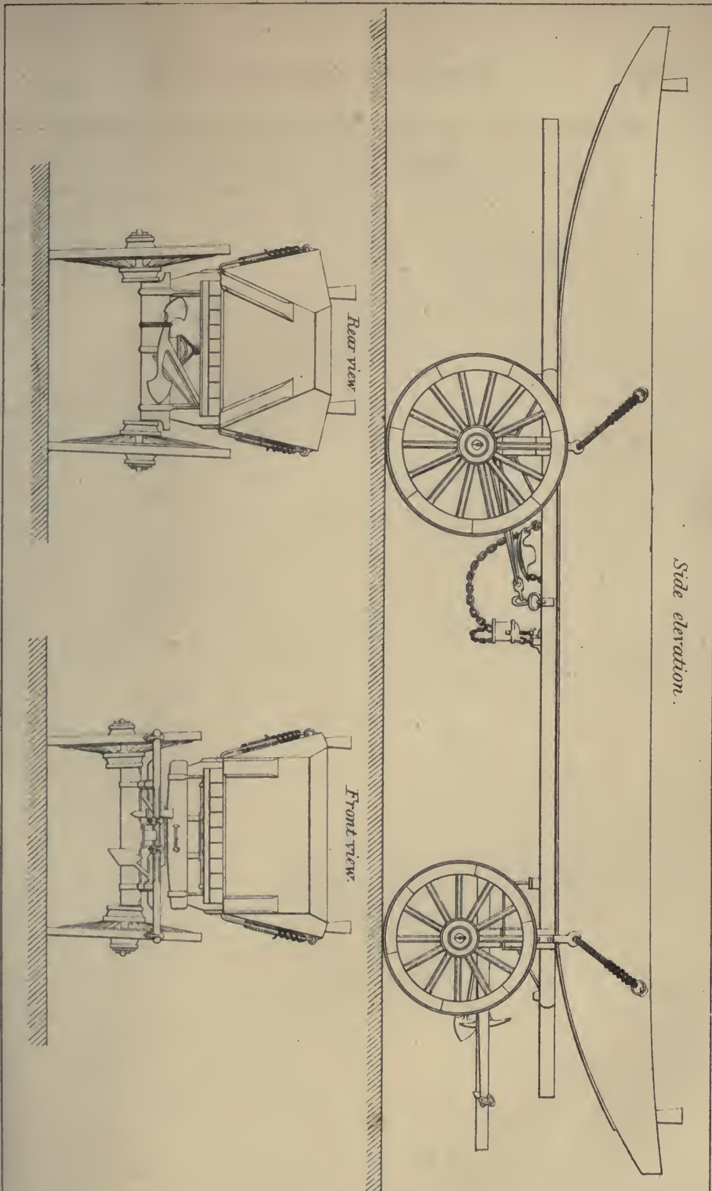
As a stockade is not a reliable protection, it should be established some distance above the bridge.

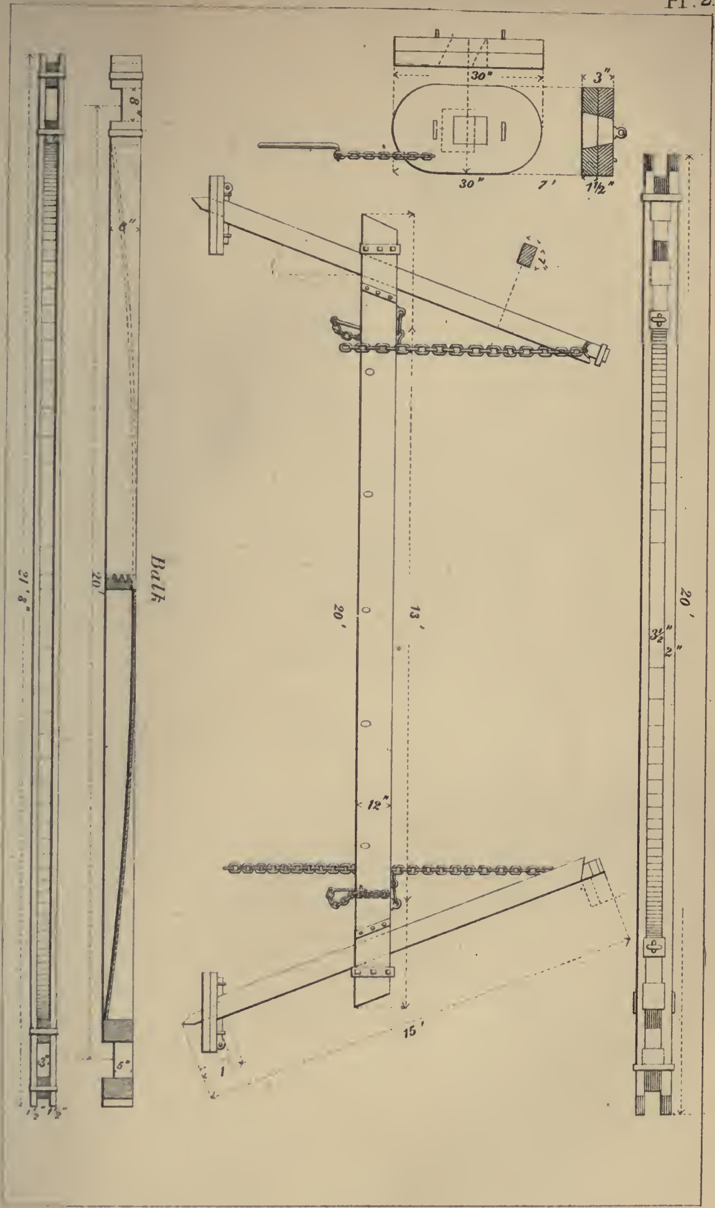
A guard should be at the bridge, from which a sentinel is posted at each extremity; and, if the bridge is long, at intermediate points.

These sentinels should turn out the guard when the bridge is in danger from any cause. They will see that the troops march at the route step; that the cavalry dismount; that the troops and carriages halt when the bridge commences to oscillate dangerously; that two heavily loaded carriages do not enter the bridge; that not more than five or six head of cattle enter at the same time.

The officer in charge of the bridge will frequently inspect the cables to see that they are not chafing, and that the anchors do not drag. He will cause the rack lashings to be tightened when they work loose, and the pontons that have leaked or shipped water to be bailed.

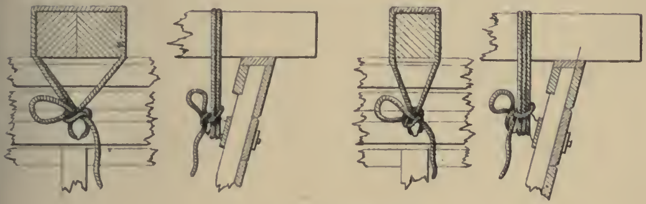
There should be formed on the shore, near the entrance to the bridge, a depot of spare balks, chess, cordage, &c., by means of which any injury the bridge may sustain can be promptly repaired.


Rear view.
Front view.
Side elevation.

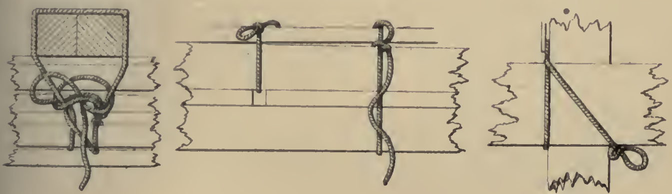

Balk
30"
3"
30"
7'
1½"
21' 8"
20'
13'
12"
15'
3½"
2"

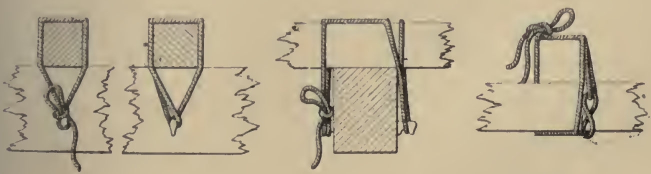
Anchoring pannier

Balk lashing

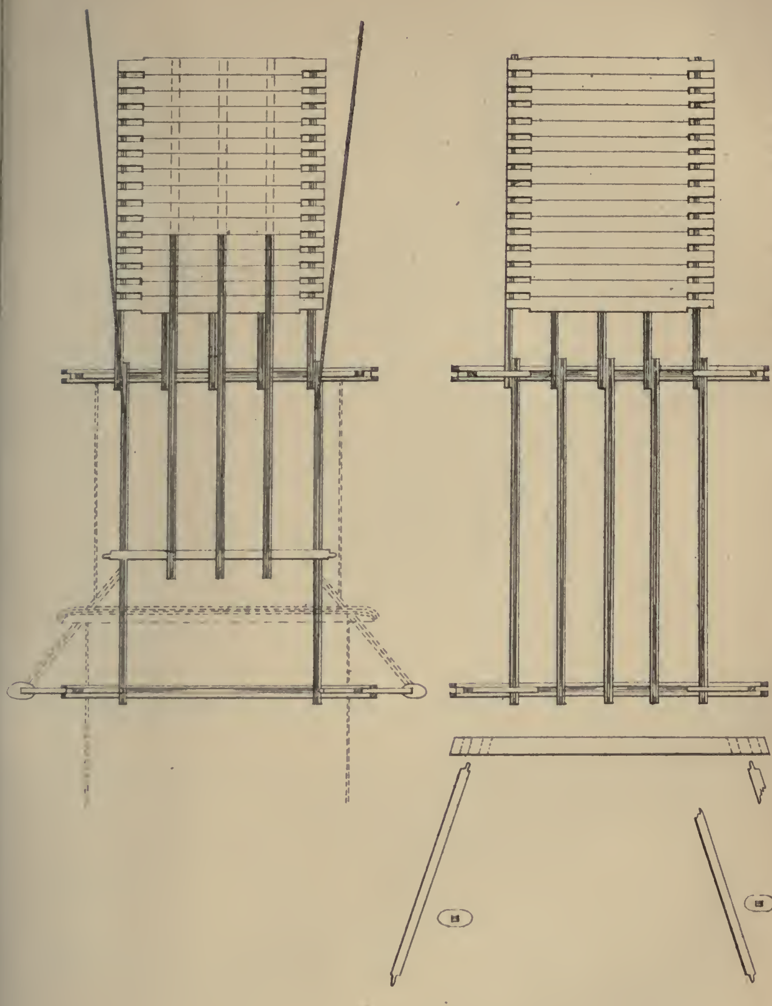


Rack lashing

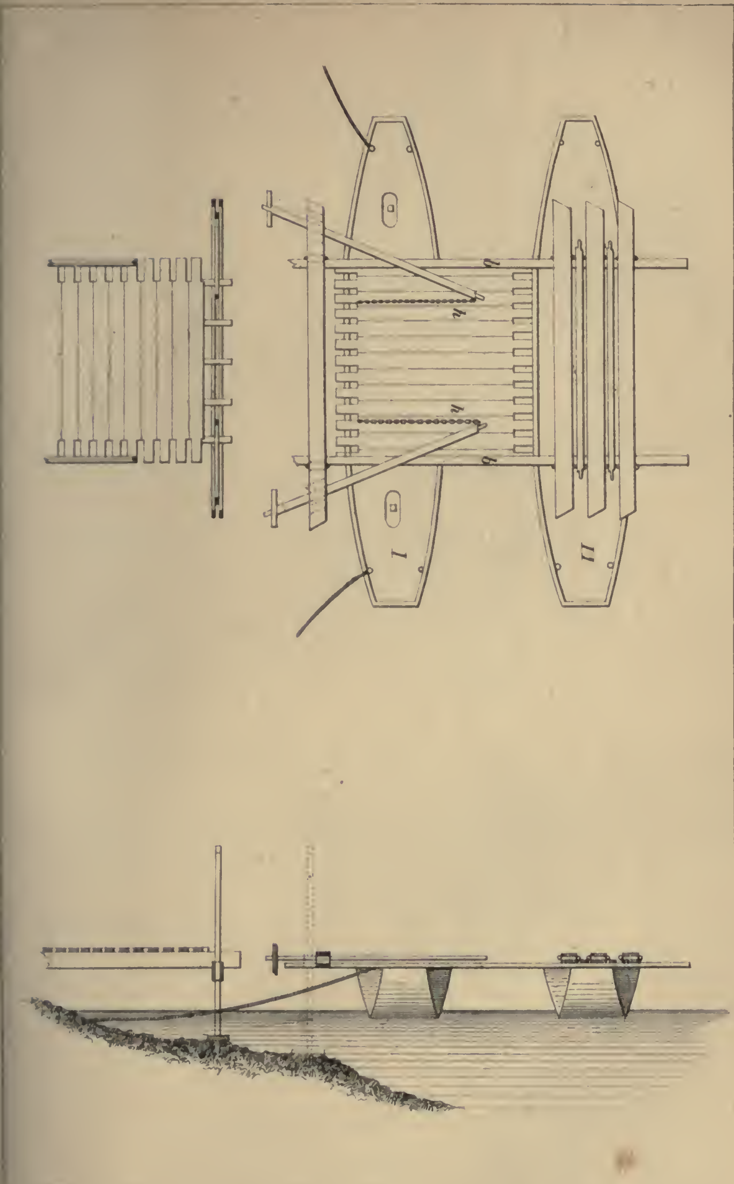


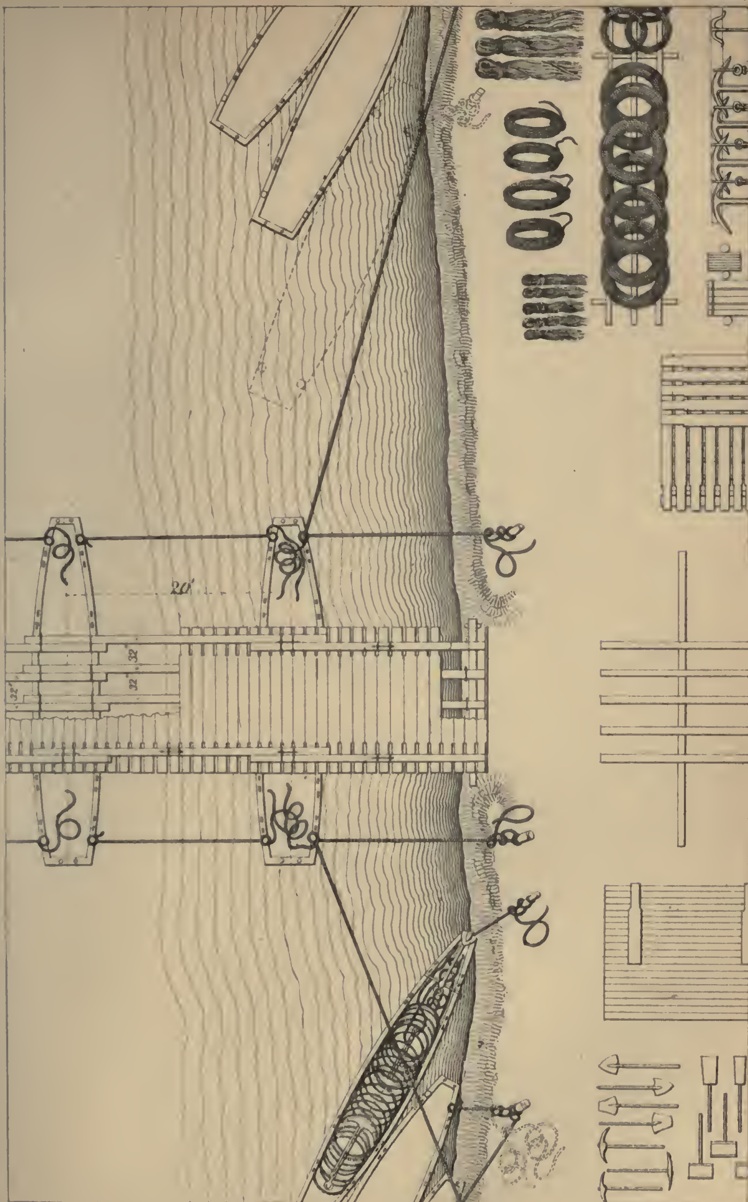


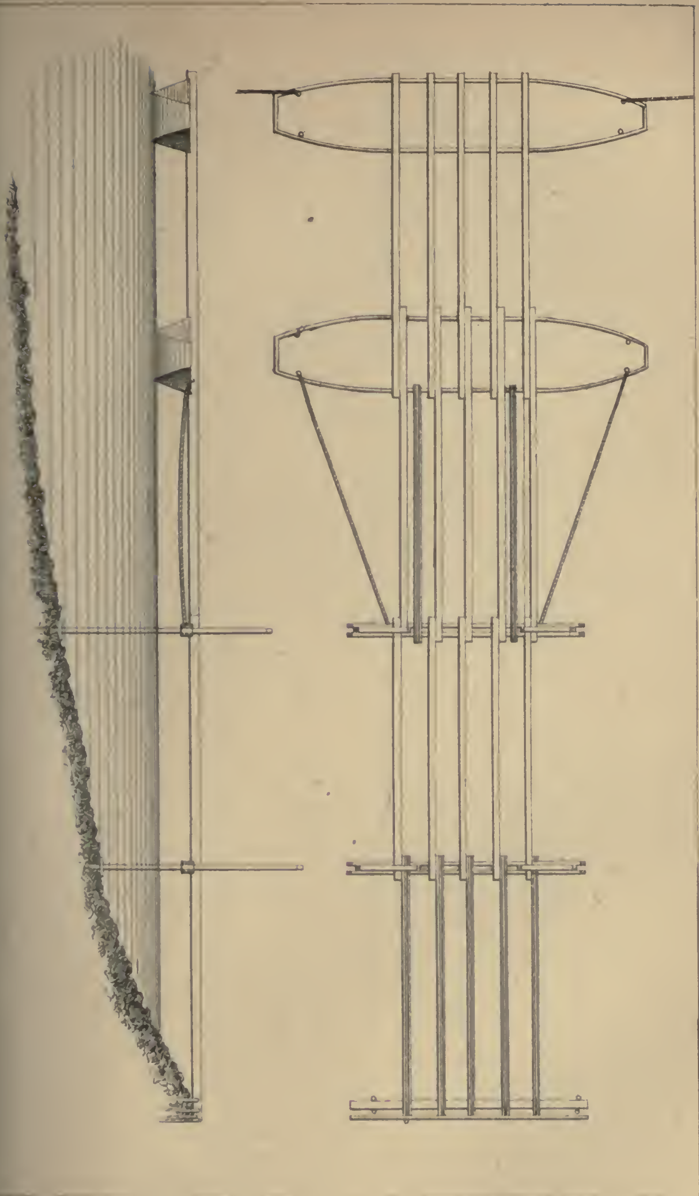
Trestle Bridge over dry ravine.



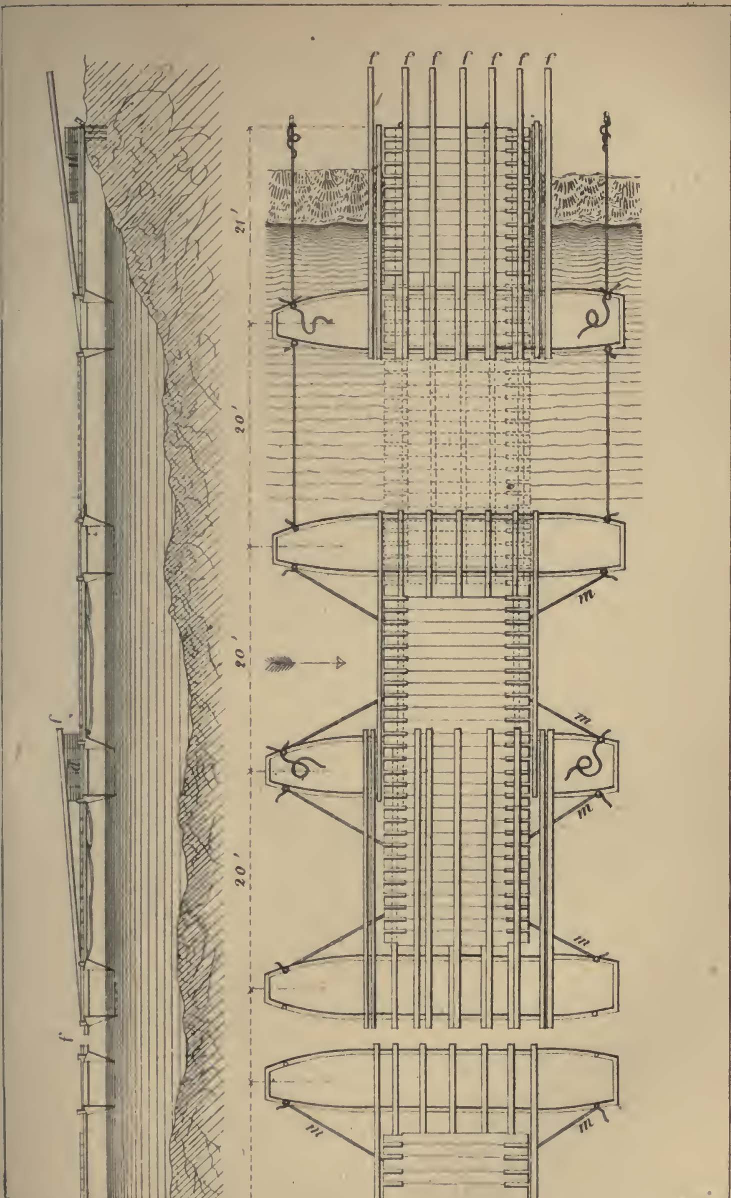
Trestle Bridge over Water course. Pl. 5.



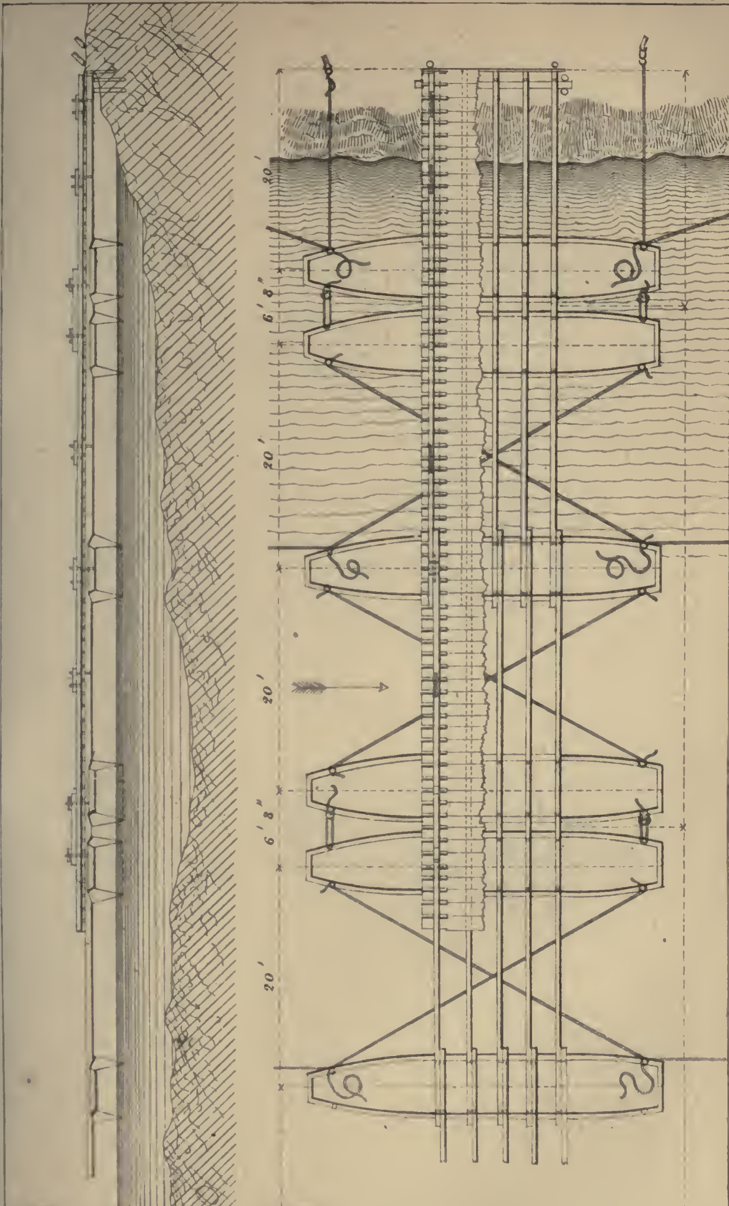

20'
32'
32'
32'



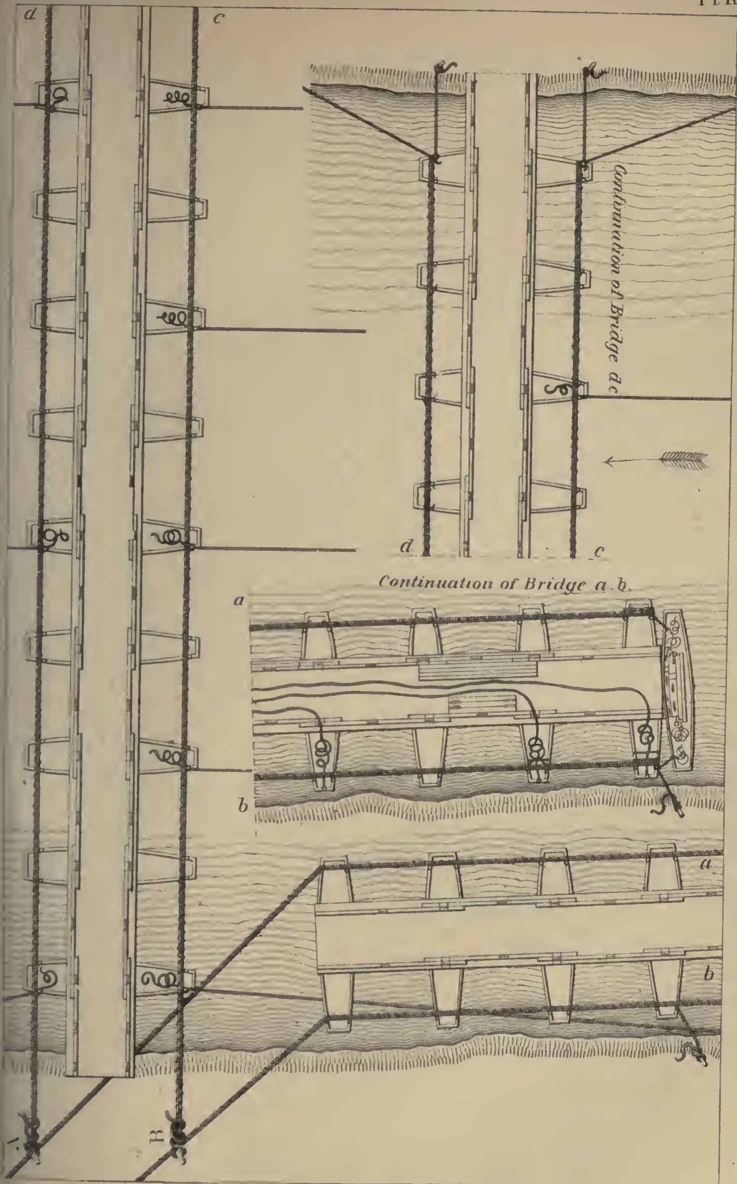
Bridge constructed by parts.

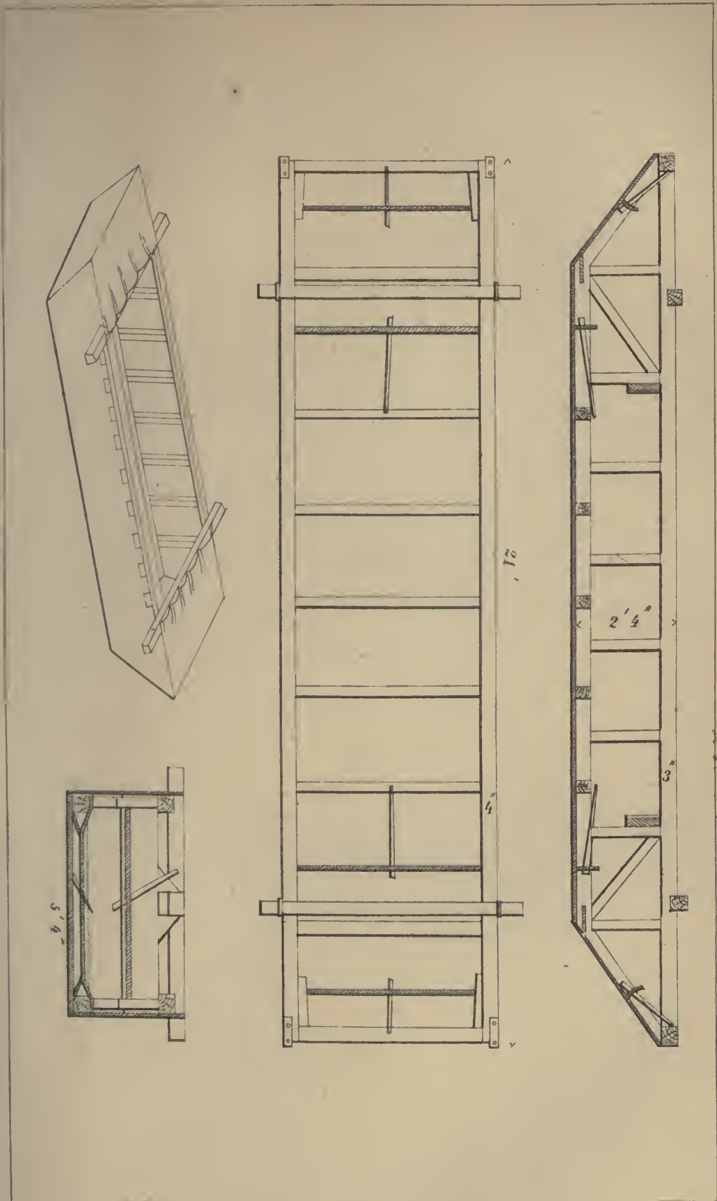


Bridge constructed by Rafts.

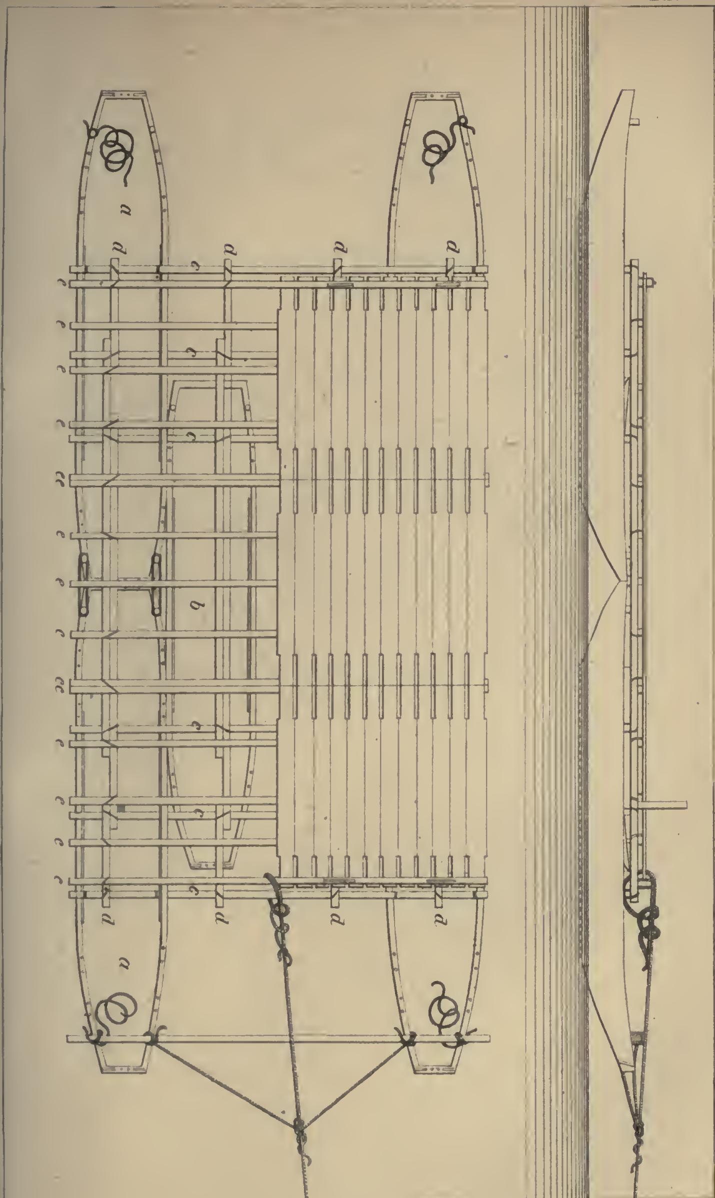


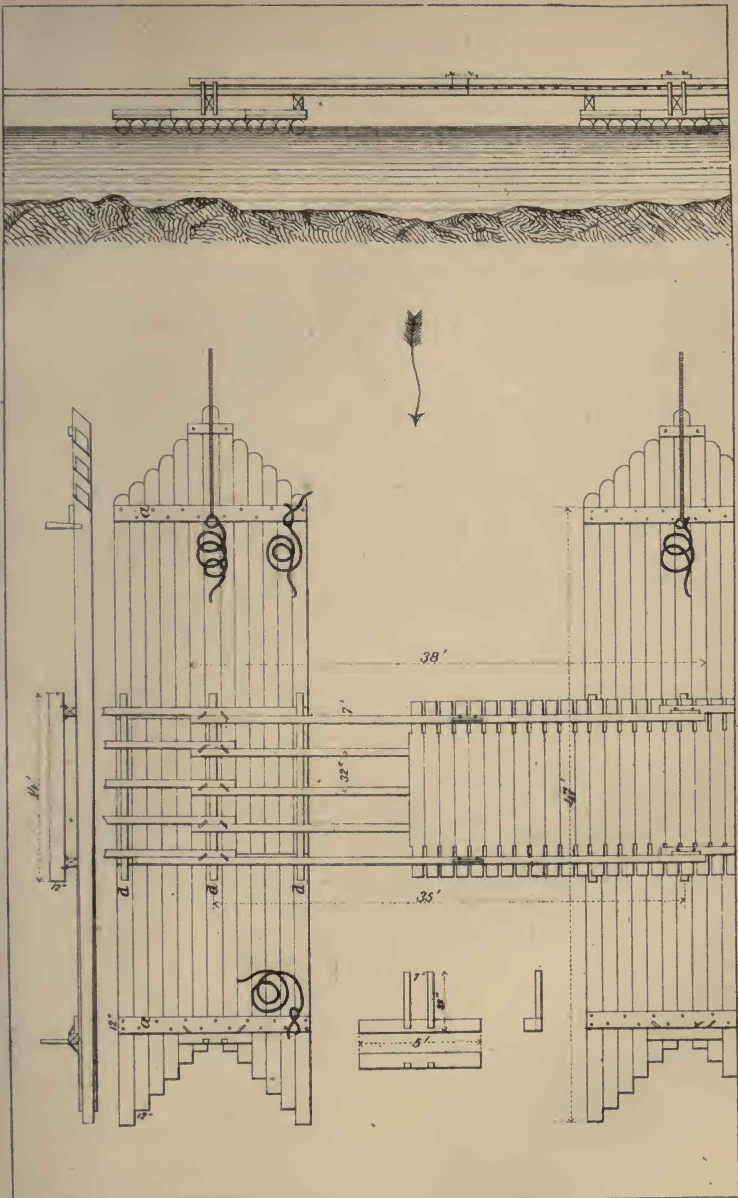
Bridge by Conversion



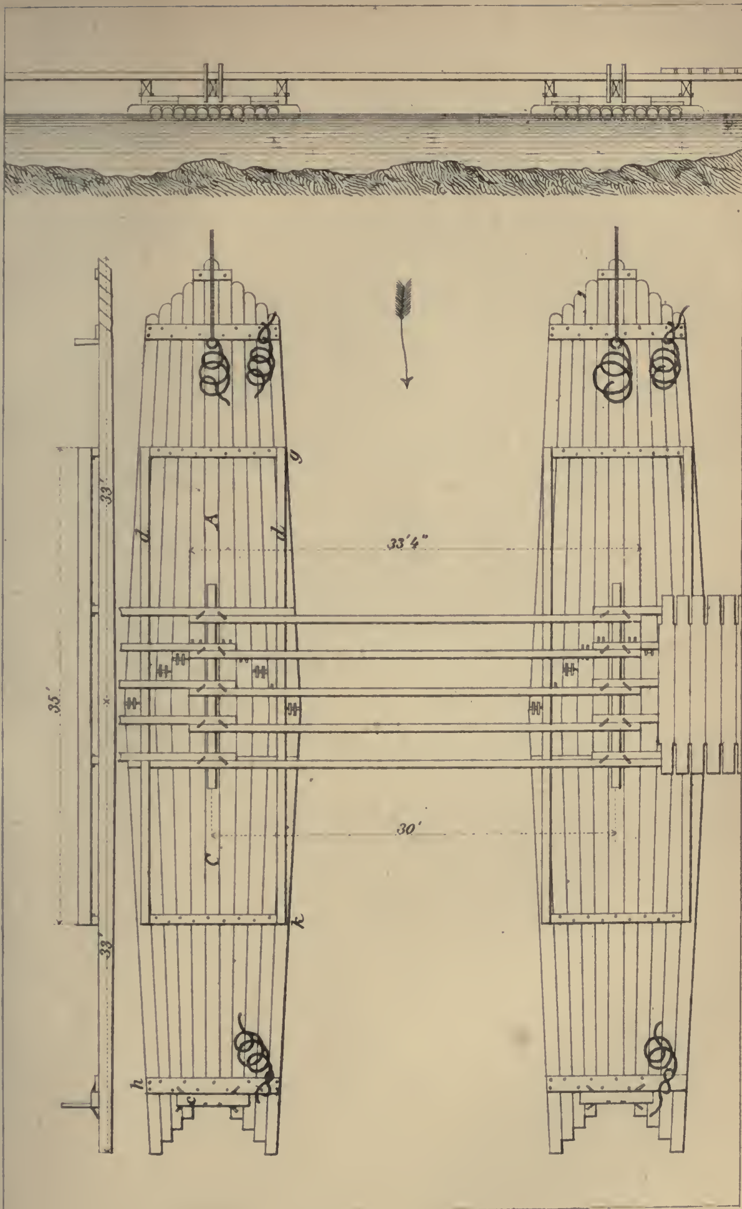

21'
4"
2' 4"
3"
5' 4"

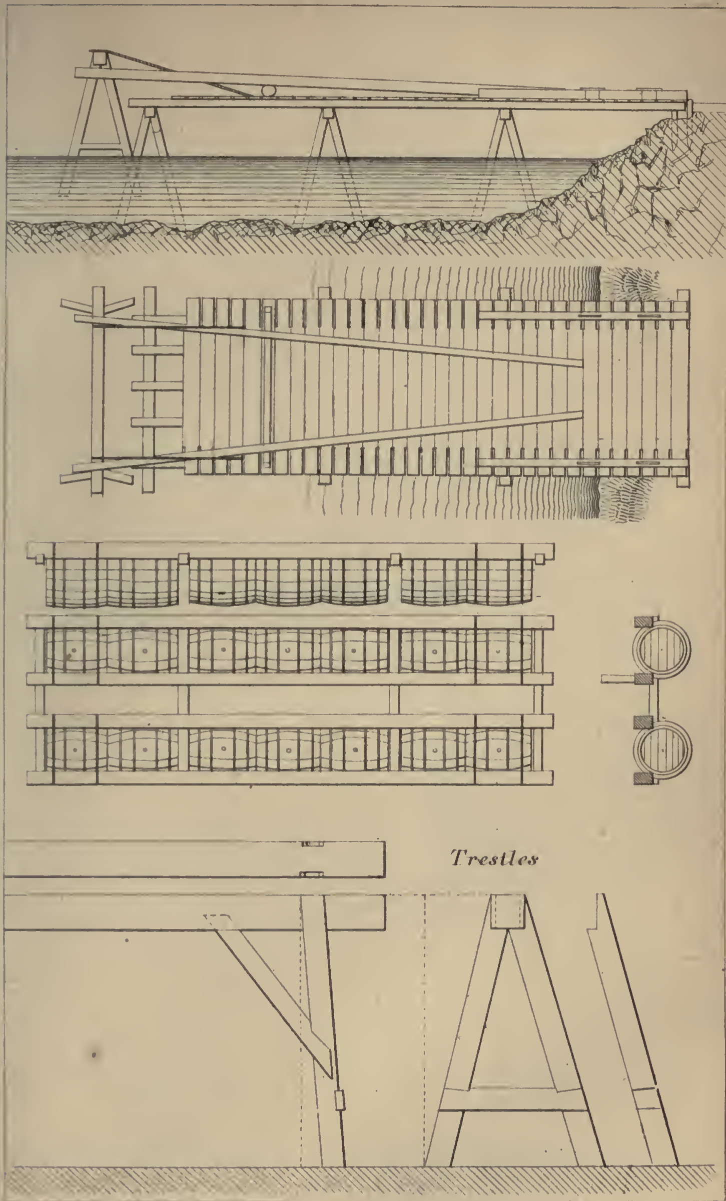
Flying Bridge. Pl. 12.

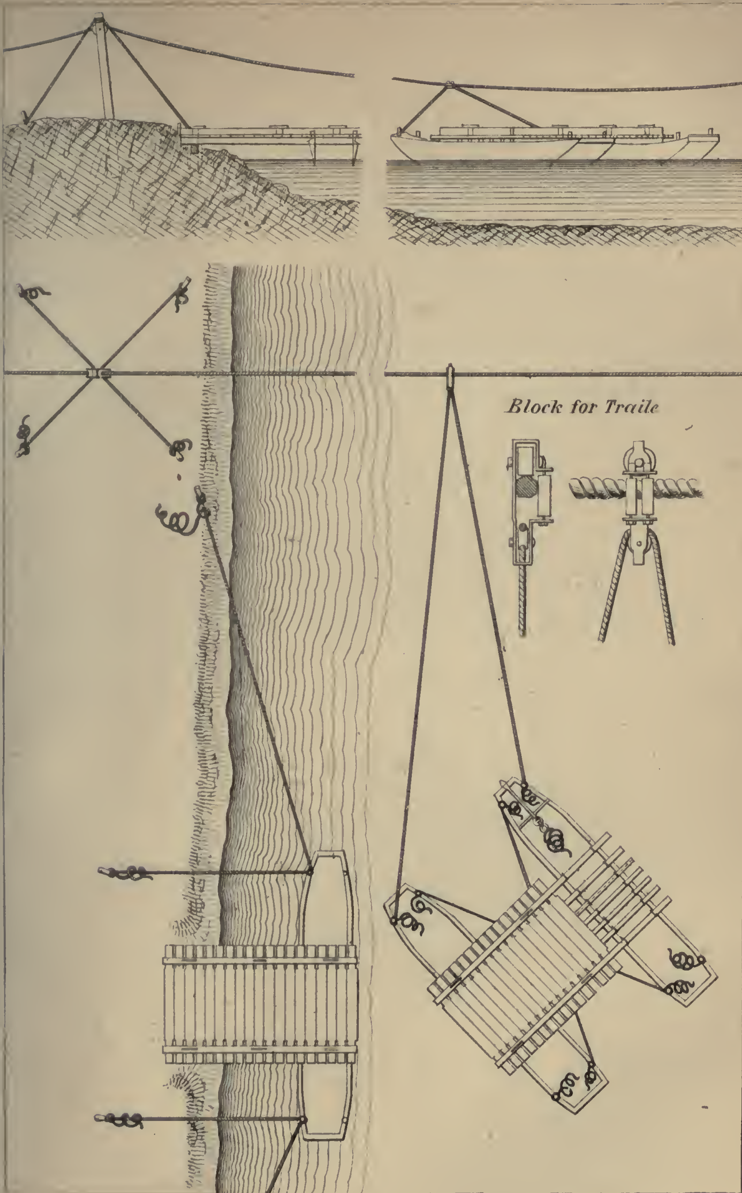



38'
7'
32"
14'
47'
12"
a
d
35'
12"
5'

Timber Rafts No. 2.




Trestles


Block for Traile

RULES FOR CONDUCTING

THE

PRACTICAL OPERATIONS OF A SIEGE

PASLEY.

PRACTICAL OPERATIONS, ETC.

I. Of Preparing Timber and Brushwood for Military Purposes.

1. OF THE LARGE TIMBER REQUIRED IN A SIEGE OR CAMPAIGN.

In the siege of a fortress situated on the sea-coast, platforms, timbers for powder-magazines, mine-cases, &c., may be forwarded by sea; but in inland operations, it is often necessary to cut materials for those purposes in some adjacent wood, if they cannot otherwise be obtained. In a campaign, abatis, stockades, palisades and chevaux-de-frise, are often required to strengthen positions, and temporary powder-magazines and bridges are also necessary for field-works. Bridges of trestles, or even floating bridges, as a substitute for pontons, may likewise be necessary in the field. All these services require large timber, or young trees; the former to be cut into regular scantling and planks, the latter either to be well squared, roughly squared, split down the middle or left round, according to circumstances.

2. OF THE TOOLS, ETC., REQUIRED FOR CUTTING TIMBER FOR MILITARY PURPOSES.

The felling axe for cutting down large trees.

The cross-cut saw is necessary for cutting large trees transversely, after being felled; the handsaw is more convenient for small ones.

The pitsaw is of indispensable necessity for preparing large trees into scantling and planks, fit for platforms, bridges, mine-cases, sheeting, &c.; also for sawing them down the middle, if considered larger than necessary, for stockades or palisading. Dogs, iron implements for securing the trees while being sawed, and cant-hooks, for turning over, or dragging them, are useful.

The carpenter's broadaxe is the most useful tool for rough squaring. The adze may answer the same purpose, but it is more particularly adapted for cutting concave curves, when necessary.

Wherever saws are used, setters are necessary; one to each saw, if detached, one to several saws, when working together. One kind of setter is used for the pit and cross-cut saw. Another, of a smaller size, for the handsaw; and to every individual saw files are required, in a proportion not less than a dozen to each, even for the shortest service.

Where cutting tools are used, a grindstone is necessary, to which a proportion of rubstones may be added. The latter may serve in lieu of a grindstone, but not so conveniently. Ragstones (or whetstones) are also necessary.

Recapitulation of tools for cutting and preparing large timber into scantling and planks.

Felling axes.	Cross-cut saws.
Topping axes.	Files for ditto, dozens of.
Pitsaws.	Setters for ditto.
Files for ditto, dozens of.	Handsaws.
Setters for ditto.	Files for ditto, dozens of.
Chalk lines and chalk.	Setters for ditto.
Plumb bobs.	Carpenters' broadaxes.
Squares, iron, 2-feet (divided).	Adzes.
Compasses, 6-inch.	A grindstone.
Dogs.	Rubstones.
Cant-hooks.	Ragstones, or whetstones.

Pickaxes and shovels are necessary for forming sawpits in the field. Ropes or chains would also be required for moving the trees. Handspikes, rollers and wedges, may be cut in the wood. If you should wish to raise your timber on trestles in sawing it, in preference to making a pit, two-inch socket chisels and mallets, with half-inch spike bits, and spikes, will be required for making the trestles, in addition to the carpenter's tools before mentioned.

3. OF THE SMALL TIMBER, OR BRUSHWOOD, REQUIRED IN A SIEGE OR CAMPAIGN.

A great number of fascines, gabions and pickets, are indispensable in a siege, and are often necessary in field-works.

For this purpose, brushwood, not exceeding from one and a half to two inches in diameter at the butt end, is most suitable. The thicker pieces are usually called poles. The smaller ones are called rods.

When brushwood is not to be had, branches of trees may be used for the same purpose: and the pickets in particular may always be split out of large timber.

4. TOOLS, ETC., REQUIRED FOR CUTTING BRUSHWOOD.

For this purpose no tool is so efficient as the hand-hatchet,* with which the great body of men employed on this duty ought to be supplied. A very small proportion (say one in ten) of topping axes may be used for the larger poles, or young trees, when such are required.

A grindstone or rubstones, and ragstones or whetstones, are, of course, absolutely necessary.

* Formerly a two-edged bill-hook was used in the service, calculated to act both as a hand-hatchet and bill, or to chop as well as cut. Recently this complex and less efficient instrument has been abolished, and a bill-hook of the Kentish pattern, a large curved knife, with the edge on the concave side, has been adopted in lieu of it. In making hurdles, woodmen sometimes use a block-bill for chopping pickets, which has a straight edge, with a small hook at the back: but, by a little management, the common bill will chop as well as cut, and it is not worth while to use two tools for military purposes.

RECAPITULATION OF TOOLS, ETC., FOR CUTTING BRUSH-WOOD.

Bill-hooks.	A grindstone.	Ragstones or whetstones.	
Topping axes.	Rubstones.	Gloves.	Hatchets.

5. DETAIL OF MEN FOR CUTTING BRUSHWOOD.

When troops are ordered for this duty, it will be most convenient to tell them off in divisions of twenty-five men each. These must be subdivided into squads, in proportion to the number of non-commissioned officers present, each of whom will be responsible for the work of his own squad, but corporals, as rank and file, are not exempted from their share of personal labor, unless it should be considered that they may be more usefully employed in superintending. The men must be drawn up in single rank, and in extended order, not less than three yards apart; and if there be not room for the whole of the divisions employed, to work in one line, they may either commence in several parallel lines, at intervals of about thirty yards apart, or on different sides of the wood. The brushwood must be made up into bundles, loosely bound together by withes; the size and weight of each to be such as a man can conveniently carry to the rear. In wood that has attained the proper age, a bundle may contain from twenty to forty rods. The average weight of those made by military working parties will scarcely exceed forty pounds. On commencing the work, all the men should cut; afterward a few should be told off to bind and carry. After the first day's work, the whole may be tasked to clear a certain extent of ground.

If the men have to march four miles to the wood, a task involving five hours' labor on the spot, will probably be sufficient for each relief or party of men. If the wood should be nearer to the camp, their task may be increased.

II. Rules for Making Fascines.

6. FASCINES DESCRIBED.

FASCINES are a superior kind of fagot, which being built in courses, with a moderate slope, and secured by pickets driven into an earthen parapet, form a revetment useful in field-works.

A Fascine, when the term is used without further specification, implies one about eighteen feet long and nine inches in diameter, such as is used in reveting batteries, &c., and which can be cut to any shorter length, as may be required, during the execution of the field-work in which it is used. To make fascines thicker than the above dimension would be a waste of materials.

Trench Fascines, six feet long, are used for crowning a line of gabions in a sap. These are formed by merely sawing the common long fascine, or *Battery Fascine*, into three parts.

In like manner, nine-feet fascines, which are useful for covering blinded galleries, and for other purposes, are formed by sawing the common long fascine into two equal parts.

7. DETAIL OF MEN.

The men employed in making fascines must be divided into squads of five men each, besides which there must be spare men in the proportion of one to every three or four squads, to prepare pickets. One private in each squad is appointed to direct, but not without taking his share of the labor. One non-commissioned officer has the charge of several squads.

8. TOOLS, ETC., FOR EACH SQUAD.

5 Pairs of stakes for trestles, or more if the brushwood be bad.
5 Lashings, or withes, for ditto.
1 Fascine choker. 1 Fid of hard wood.

1 Maul.
1 Handsaw.
1 Six-feet rod.
1 Gauge for the bands.
3 Bill-hooks, } at the rate of one cutting tool per
2 Gabion knives, } man.

For the spare Men making Pickets.

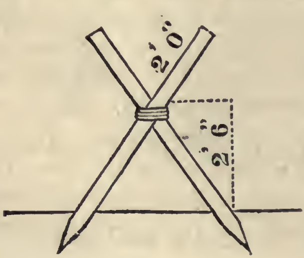
1 Bill-hook, } for each man.
1 Chopping block, }

For several Squads.

1 Grindstone, or several rubstones.
Ragstones, or whetstones.

REMARKS.—The size of the common handsaw is convenient, but its teeth are rather too large for sawing brushwood expeditiously. If regular six-feet rods cannot be issued to every squad, let a rod eight-feet long, cut out of the brushwood, be used as a measure for each squad that is deficient. Two lengths of this rod will mark the distance between the extreme trestles. The fids of hard wood should be about nine inches long, one inch in diameter, and pointed at one end. The gauges are pieces of wood about fifteen and a half inches long, also cut out of the brushwood. Chopping blocks it is needless to describe; but if large timber is not to be had, stout stakes driven into the ground, and standing about two feet above the surface, will answer the purpose. If a lower block be used, the man must work kneeling.

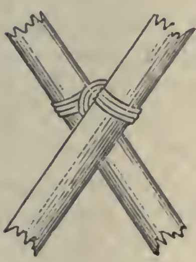
9. METHOD OF PREPARING FASCINE TRESTLES.



Fascines are made in a cradle composed of a certain number of trestles, placed at intervals not exceeding four feet apart.

Each trestle consists of a couple of stakes about six and a half feet long, and not less than from two and a half to three inches in diameter, driven obliquely into the ground, touching each other, and crossing at right angles, or nearly so, in the form of a St. Andrew's cross. The upper part of the cross should stand at the perpendicular height of about two feet six inches above the ground, with the ends of the stakes projecting obliquely about two feet beyond it, as in the foregoing figure.

At the centre of the cross, the trestle may be secured by a lashing six feet long, consisting of a piece of spun-yarn or tarred line, of the size of tracing line, or a very little larger. This is done by applying the middle of the lashing



to the two stakes, and passing the ends horizontally round both until some three or four turns are taken. The ends are then crossed vertically round the centre of those turns, in the space between the two stakes, and hauled taut; and after taking two or three turns in this new direction, as shown in the annexed figure, the ends are tied together with a reef-knot. The turns last taken are technically termed frapping turns, and by straining the first part of the lashing, keep every thing tight. A withe or twisted rod may answer the same purpose when lashings cannot be procured.

When one trestle is thus fixed, another is always placed at the distance of sixteen feet from it. The intermediate trestles, which may be three in number when the brushwood is good, making five in all, are then placed at equal intervals of four feet apart, between these two. When the brushwood is bad, that interval will be too great, and therefore six or even seven trestles may be used instead of five. The head of the squad directs the placing of the trestles, assisted by two men of his party, whilst the others collect brushwood. After the first two trestles are properly fixed, he aligns the others by the eye, looking along the upper side of each stake, on the same principle as in profiling.

REMARK.—At this establishment we sometimes use stakes of fir, of regular scantling, about two and a quarter by three inches square, shod at bottom and hooped at top with iron, like small piles, and connecting each pair by an oak pin passing through holes cut for the purpose in the centre of the cross. Although these make very good fascine trestles, one would scarcely recommend using them on service.

10. FASCINE MAKING DESCRIBED.

When the trestles are fixed, straight rods and branches, not exceeding about one and three-quarter inches in diameter, are laid over them, with their ends projecting about seventeen or eighteen inches on each side, beyond the extreme trestles. The leaves must be stripped off entirely, as well as the refuse ends of the thin branches. When the branches grow out of the stem, with irregular or clumsy bendings, they should be first separated by the bill-hook, as all very crooked parts injure the fascine; but straight and flexible branches may be laid in along with the stem, cutting them half through or not, as may appear necessary. The men piling the brushwood should endeavor to lay the stouter rods outside, and the smaller stuff near the heart of the bundle. When the cradle is nearly full of brushwood, it will be time to prove the diameter of the proposed fascine, in several places, which is done by the fascine choker; and more stuff is added in those parts which require it. The fascine is then finished by binding it with withes prepared for the purpose. This is done by four men, two of whom choke, or compress the brushwood near the spot where the other two bind. The first band is applied near the extreme end of the fascine, about six inches from the first trestle. The second is applied about fifteen and one-half inches from the first, and others are successively added at the same central intervals, until the whole number of thirteen bands are completed. The fascine is then removed from the trestle, and the rough ends sawed off. It is to be observed that these ends should be laid as regular as possible in piling the brushwood, and no more should be cut away than is necessary, although the length of the finished fascine should, in this case, prove to exceed the standard of eighteen feet. In regulating the central distance from band to band, the gauge-rod is used as a measure. If the brushwood be very bad, or withes of the desirable length cannot be obtained, the intervals may be diminished to twelve inches, which will increase the number of bands to seventeen, and in this case a twelve-inch gauge must of course be used.

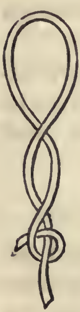
Strictly speaking, four men are sufficient for making a fascine, when all the materials are at hand, but the fifth may be usefully employed in preparing withes, which is the most difficult part of the work.

11. METHOD OF PREPARING AND USING THE WITHES.

For *Withes* (or *Gads* as they are also called) to bind fascines, very straight rods must be selected, which when afterward cut to the proper length of about five feet, should not be less than about three-eighths of an inch in diameter, nor greater, if possible, than about three-fourths or seven-eighths of an inch at the big end. In choosing them, therefore, let no part be smaller than your little finger, or much thicker than your thumb. All the small branches must be lopped off, not close to, or cutting in upon the stem, but so as to leave a small stump projecting about one-eighth of an inch above it; otherwise the rod will be liable to break at each knot.

In preparing them for use, you must put the thick end under your left foot, and twist the rod with your hands, from the top downward, with your right hand toward the end of the rod, which you will move in the same manner, nearly, as if working at a winch, so as to turn the rod in the direction technically called "with the sun."* Great care must be taken to avoid making kinks in the wood, which unpractised persons are apt to do, as these spoil the withe.

After the rod is well twisted at the small end, and moderately so downward, you will form a loop about nine inches long, near the small end of it, by taking a half-hitch with the end of the rod round the body, or standing part of it, as in the foregoing figure.



You will then give the loop a couple of twists in the contrary direction, so as to plait the double part of the rod, and form an eye, or smaller loop at the top of it, as in the second annexed figure. At the part where this eye is formed, the rod should not be less than half an inch in diameter.

Lastly, the end of the rod must be pointed, after which it will be ready for the use of the fascine makers. In this state it should be at least four feet long, which, after preparing one or two, a man may easily judge of by the eye.

In binding the fascine, two men assist, standing on opposite sides. They pass the withe under the brushwood, then bring the ends together above it, and pass the big end of the rod through the eye. One man sets his foot upon the eye, and forces it home, it being at this time some inches lower than the top of the fascine. At the same time he hauls upon the end of the rod, turning it with his hands, until the part within the eye is more completely twisted, but, of course, in the same direction of the fibres as before. He then hands

* "With the sun," and "against the sun," are in reference to the apparent motion of the sun, as observed by a man standing in the northern hemisphere and looking toward the south.

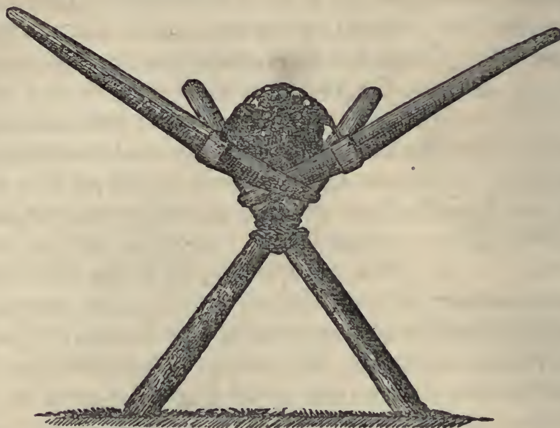
over the end of the rod thus twisted to his comrade, who bends it back, so as to form a new loop engaged within the former, like two links of a chain, after which he (the second

man) passes the end of the rod from left to right, under the standing part on his own side, over it again, and then under it a second time; whilst the first man assists with the fid, in disengaging the standing part, which at this time is, of course, jammed close to the body of the fascine. After the second turn, the superfluous part of the rod is cut off; and then the two ends appear exactly alike, excepting that the thicker part has not got a half-hitch at the extremity of it, like the other part. The band when finished according to this process, is represented in the foregoing figure, in which the fascine supposed to be embraced by it, is omitted.

12. METHOD OF CHOKING A FASCINE.

The instrument called a fascine-choker, consists of a stout chain, attached to a couple of ashen levers, each of which is four feet long, and cut out of one and three-quarters by two-inch scantling, the section of the wood being an oval. The chain is four feet long, between the levers, which it embraces by means of a couple of iron sockets. It is fixed at the distance of eighteen inches from one end of each lever, from whence they taper to both ends. There are two small rings attached to the chain, one on each side of the centre, at the distance of twenty-eight and two-sevenths inches apart, which corresponds with the circumference of a nine-inch fascine. In choking the bundle of brushwood, which is done by two men standing on contrary sides of it, the centre of the chain is first brought under the brushwood, and then the ends of it, together with the levers, are brought over and crossed;

the men handing over the opposite levers to each other, with the long ends uppermost.



The levers and chain will then appear as in the annexed figure, in which the chain is supposed to have made rather more than one complete turn round the fascine. The small rings are also represented, which do not yet meet, as the chain is supposed to be slack. The short ends of the levers press against the contrary sides of the fascine. Commencing at this position, the two men press down the long ends of their respective levers, and thus by degrees tighten the chain, until the brushwood is choked, or compressed into as small a space as possible, when it assumes the form of a perfect circle, or nearly so. At this period the long ends of the levers should be depressed below the horizontal line,* and the two rings, which at first were several inches apart, ought to meet at the top of the fascine.

* Hence, if fascines were made of different thicknesses, the length of the chain of the fascine-choker used, should vary according to the diameter of the proposed fascine. Five and a half times the diameter is a good proportion.

As soon as each band is finished, the men employed in choking disengage their levers and chain, and commence at a new place. If any part of the fascine has been pinched in choking, it may be turned over when finished, and the bands or fascine beat with a picket, to render the latter quite cylindrical.

13. REMARKS.—In making fascines, the officers and non-commissioned officers superintending, must be very strict, in regard to dimensions and neatness; more especially in seeing that the withes are properly selected, well twisted, particularly at the eyes, and in every respect made according to rule, for upon these, the strength of the fascine almost entirely depends.*

When good withes cannot be had, spun-yarn may be used in lieu of them, which must be cut into lengths of six feet. In binding with spun-yarn, the centre of the piece of rope is laid upon the fascine, and the ends are passed under, so as to make one complete round turn; they are then hauled taut, by the two binders pulling against each other; after which they are brought together at top, and crossed so as to form the first part of a reef-knot. The two men again haul taut, by pulling in contrary directions, after which one man presses down the joint of the spun-yarn with his finger, until the other has taken the necessary turns, for completing

* We tried experiments with green willow cut a month before it was used, to ascertain the strength of fascine bands of different kinds, by applying progressive weights, until the withes broke. Eyes formed according to rule, at a part of the rod not exceeding half an inch in diameter, required an average weight of more than four cwt. to break them; but in some few instances, the standing part broke before the eye. Under the supposition of such eyes being the weakest part, another method of forming a fascine band was suggested, in which the thick end of the rod was not passed through the eye, but round it, on the principle of what is called the midshipman's hitch in knotting with ropes; but on trial the round turn thus taken with the thick end, unexpectedly proved to be the weakest part, and invariably broke under an average weight of two cwt. only.

the reef-knot. Thus the band passes twice round the fascine, before the knot is tied.

If proper chokers are not to be had, a couple of stout stakes, and a rope doubled by splicing, or rather by tying the ends together, will answer the same purpose. The length of the rope must be equal to that of the chain and sockets, in lieu of which it serves. After the rope is passed round the fascine, and crossed, the ends of the levers are pushed through the bights of the rope, and the operation of choking is then performed in the usual manner.

14. TIME REQUIRED FOR MAKING FASCINES, WEIGHTS, ETC.

Every squad of five men may finish fascines at the rate of one in an hour, after a few days' practice.* The average weight of an eighteen-feet fascine, is one and a quarter cwt., or one hundred and forty pounds, after the wood has been cut some weeks.

15. OF FASCINE PICKETS.

The men employed in cutting pickets must provide them in the proportion of six or seven to each fascine, and should make them up in bundles of twenty-five. They should not be less than three feet six inches long, including the points, but four feet is better. A sharp triangular point is considered the best way of finishing the picket, and this form penetrates a stout fascine with great ease. The top should also be pointed, but very obtusely, as in the annexed figure; for if it be cut perpendicularly across, so as to form a plane surface, the picket will be liable to split, in driving. All the branches must be cut off quite close to the stem.

Fascine pickets should not exceed one and three-quarter

* Expert men may make fascines much quicker when tasked, but it would not be prudent to calculate on making greater progress, with the common military working parties in a siege.

inches in diameter at the thick end, but from one and a quarter to one and a half inch is a better proportion. After a little practice, a man's eye is the best guide for judging of the proper thickness. When the stuff much exceeds two inches in diameter, pickets must be formed by splitting it into two or more parts, according to its size.

16. TIME REQUIRED FOR MAKING FASCINE PICKETS, WEIGHT, ETC.

After a few days' practice, a man may cut and make up fascine pickets into bundles, at the rate of one bundle (or twenty-five pickets) in an hour.

A couple of withes, or of pieces of spun-yarn, must be used for binding each bundle.

The average weight of a bundle of well-sized pickets, three and a half feet long, is about thirty pounds, after the wood has been some weeks cut.

17. OF TRACING-FASCINES.

The tracing-fascines, five or six feet long, recommended in all the elementary writers on the attack of fortresses, being of no use whatever, except to measure the task of each workman, in opening the trenches in a siege; and it being evident, that almost every other mode of effecting this measurement, that can be suggested, would be simpler than the above, the use of tracing-fascines has been abolished; they were made four inches in diameter, in order to waste as little brushwood as possible.

18. OF COVERING-FASCINES.

Covering-fascines are those made of stout picket stuff, not less than one inch thick, without any mixture of small brushwood. They may be used in place of planks for the superstructure of wooden bridges; and may also be used, if no stout planks or spars are to be had, for the roofs of field powder-magazines. They may be made of the usual diameter of nine inches. Their length will depend upon the special purpose for which they are intended. The withes should be particularly good.*

19. OF SAP FAGOTS.

A sap fagot is a short but very strong fascine, about three feet long, and nine inches in diameter, composed also of stout picket stuff; which may be used, instead of sand-bags, for filling the interstices between the gabions, at the head of a sap. One picket usually projects five or six inches from the end of the sap fagot, and is driven into the ground to keep it steady, when set upright, in which position it is always placed. Sap fagots are also sometimes used for filling the gabions themselves, to hasten the progress of a sap, under peculiar circumstances.

20. OF TRACING-PICKETS.

These are short pickets eighteen inches long, and about one inch in diameter, which are useful in marking out the details of field-works. When they are to be used in the dark, the bark should previously be stripped off.

They may be made rather more expeditiously than fascine pickets, and should be tied up in bundles of twenty-five each. Every bundle weighs about eight pounds when the wood is dry.

* A covering-fascine, made of willow, twelve feet long and nine inches diameter, was found by experiment to be equal to the calculated strength of a piece of Riga fir, about two inches and nine-tenths square. Consequently covering-fascines, although strong enough to bear the weight of any military carriage or wagon, if supported by proper beams, not more than four feet apart, are not quite so strong as common three-inch planks. The strength of a common fascine of the same diameter, was about five-eighths of that of the covering-fascine.

III. Rules for Making Gabions and Hurdles.

21. OF GABIONS.

Gabions are cylindrical hampers, open at top and bottom, which, being filled with earth, form a revetment useful in field-works, but more especially in a siege, in the construction of batteries, and in the operations called the regular and flying sap.

Light gabions are a species of basket-work, and it requires greater skill and care to make them than is necessary in making heavier ones, which may be compared to hurdle work.

22. DESCRIPTION AND DIMENSIONS OF GABIONS.

For many years past we have made all our gabions of the same size, namely, two feet in exterior diameter, and two feet nine inches high in the web, but averaging three feet in height when used for the revetment of a trench or field-work, in consequence of the projecting ends of the pickets. Hence when the term GABION is used, without further specification, it implies one of the above dimensions, and no other.

To make larger gabions than the above would be useless, for we ascertained by repeated experiments, that two-feet gabions formed as strong and durable a revetment as those of greater diameter; which result was the more conclusive, having been contrary to our expectations; and we also found that there was no advantage in using smaller ones.*

The batteries being of greater importance than most of the other works of a siege, it is proper to finish them in the most substantial manner, and therefore we use the strongest and heaviest gabions, made of the thickest brushwood, for

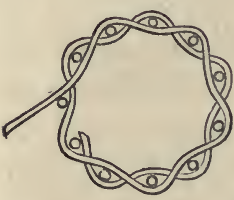
* At one time we used not only two-feet gabions, as above described, but also twenty-one inch gabions. The latter, being employed exclusively for the regular sap, were called *sap-gabions*, to distinguish them.

this purpose. In other respects there is no difference between *Battery-Gabions* and *Trench-Gabions.*

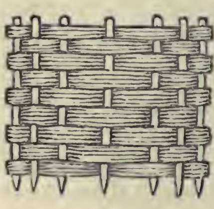
23. BASKET-WORK DESCRIBED.

Before we describe the method of making gabions, a few technical terms and observations on basket-work will be introduced.

The upright parts are called *Stakes* or *Pickets.* The *Watling*, or *Web*, is composed of *Rods*, the thick end of which is the *Butt*, the small end is the *Tip.* It is a rule that the rods shall always be a little smaller than the pickets.



In working with a single rod, which is called *randing*, an odd number of pickets must always be used. The rod is alternately passed round one picket, and within the next, and thus commencing at the bottom, it goes round in a kind of spiral, until the body of the basket or gabion is finished, as in the annexed figure, which represents the plan of the commencement of the work, the pickets being denoted by small circles.



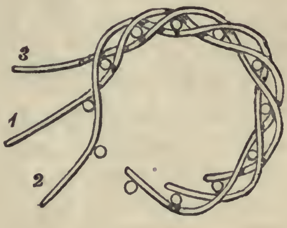
Sometimes two or three rods are worked round together, precisely in the manner above described, and still using an odd number of pickets.

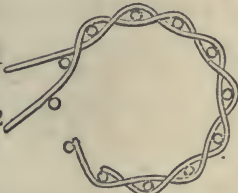
This is called *slueing.* The appearance of the work so finished is shown in elevation, in the annexed figure.

Neither randing nor slueing ought ever to be allowed in making gabions. They are both very weak, especially the latter; so that the strength of baskets made in this manner, depends entirely upon the top and bottom, which are always finished with greater care.

Working with two rods together, when braided or plaited, is called *pairing*.

In this case, the two rods are separated by one picket. That which is to the rear is passed over the other rod, round one picket, and within the next. The second rod, which is now to the rear, is passed over the first rod, and also round one picket, and within the next.





Thus the two rods cross each other alternately, over and under, as in the annexed figure. In this, and in all the succeeding methods, it is of no consequence whether the number of pickets be odd or even.*

Working with more rods than two is called *waling*.

In waling with three rods, they are first placed with the butts inward, and tips outward, each being separated by one picket, as in the annexed figure. Then the first rod, which is to the rear, is passed over the other two rods, round two pickets and within one. The second rod, which will then be to the rear, is also passed over the other two rods, round two pickets, and within one. The third rod is next treated in the same manner. Hence each rod will alternately come to the front in its turn, and they will always be separated

* This is the method usually practised in our service.

from each other by one picket, as in the second annexed figure; and thus in winding spirally round the pickets, the rods will be braided into the form of a three-stranded rope.

Basket-makers sometimes wale also with four or five rods, in a manner which I forbear to describe, as it is not applicable to military purposes.*

In passing a rod from the outside round the inside of any picket, and out again, the basket-maker does not move it all round by the top, in the way that an inexperienced person would naturally do. Holding the rod in his left hand, with the tip pointing upward, he passes the fore-finger and thumb of his right hand into the inside of the gabion, between those two pickets, through which the end is to come out, after making the required turn, and with these bent backward, he grasps the middle of the rod, and pulls it out with a jerk, between the said pickets.

In circular waling, the rods should always pass round more pickets outside than inside.† In straight work, with the same number of rods, this is not necessary.

When the rods for basket-work, or for withes, are to be used any length of time after they have been cut, they must previously be steeped in water to restore their flexibility.‡

The only basket-maker's tool applicable to gabion making, is the knife; which, for gabions, ought to be like a stout pruning-knife. The *Iron*, used by basket-makers for beating down their rods, may be superseded by a common picket, and the *Cleaver*, a steel instrument for cleaving a rod into

* The best method for a young officer to learn waling, is to provide some wires as pickets, which he may fix on a large pincushion, using pieces of the small round cord called bobbin, as a substitute for the rods. In this way very neat models of gabions may be made.

† Because it is desirable that the inside of a gabion, or basket, shall be as nearly circular as possible. But if several pickets be passed inside by each rod, the interior outline will assume the form of a small polygon.

‡ It has also been recommended to heat green withes over a fire, before twisting them.

three parts, may be dispensed with altogether; for, in the process of gabion making, if any of the rods should be considered too large, it will be sufficient to split them into two parts, instead of three, which may be done by the bill-hook.

24. DETAIL OF MEN FOR GABION MAKING.

The men employed in making gabions may be divided into squads of three men each, of whom one prepares pickets, rods and withes, whilst the others level the ground, and afterward work at the gabion. In some cases two men may suffice. One private has charge of each squad, under the non-commissioned officers, who superintend several.

25. TOOLS FOR EACH SQUAD.

1 Bill-hook.
2 Gabion knives.
1 Four-feet rod, or three sticks cut as gauges, one for the height, and one for the diameter of the proposed gabion, and one for the length of the pickets.
1 Chopping block, or stake.
1 Piece of line, about three feet long.

The following tools are useful when heavy gabions are to be made, otherwise they may be dispensed with:

1 Handsaw.* 1 Mallet.

Implements for several squads.

1 Grindstone, or several rubstones. Whetstones.

When a party of men are sent to make gabions, pickaxes and shovels should be taken to the ground, if necessary.

When wooden bottoms are used in gabion making, the proportion is one per squad.

26. METHOD OF MAKING LIGHT GABIONS.

The pickets must be from three feet four to three feet six

* Even in making heavy gabions, the handsaw may be dispensed with, if the men are expert at the bill-hook.

inches long; and their proper thickness is from five-eighths to seven-eighths of an inch.

The rods for the web should be from five-sixteenths or three-eighths, to three-quarters of an inch in diameter. Those for the withes should be a little thicker, and the most perfect that can be selected.

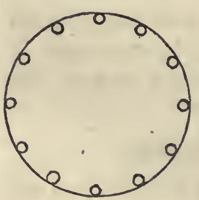
The number of pickets used in working with brushwood of the above description should not be less than fourteen.

Gabions are usually made by driving the pickets into the ground, and therefore in hard or rocky soil small pits about two and a half feet in diameter, and nine inches deep, must be dug at proper intervals, and filled with loose earth, excluding stones and large gravel.

A circle of the proper diameter must then be traced, with a piece of string made fast to two short pickets, one fixed into the ground as a centre, the other moving round to mark the circumference.

The diameter of the circle thus traced should be one inch less than that of the proposed gabion. Hence the proper radius for a two-feet gabion is eleven and a half inches.

When this is done, the circumference must be divided into as many equal parts as there are pickets to be used in the proposed gabion. When twelve pickets are to be used, the best way is to divide it first into four equal parts, and afterward to subdivide these portions into three each. A small piece of stick may be used as a measure.



All the pickets must next be driven, so as to touch the internal circumference, as shown in the annexed figure, and it is proper to place them alternately with the large and small ends upward.

The rods prepared for the web must be entirely stripped of leaves and twigs; no part of any one single rod being used double, although in joining a new rod to the tip of one that is coming to an end, these two may be laid together for a few inches.

The most approved method of forming the web of light gabions, is by waling with three rods, as described in the foregoing observations; but it will be best not to place all the butts, or thick ends, the same way.

If the stuff be larger than usual, pairing with two rods may be allowed, but this method must be confined to the body of the gabion only. Five or six inches of the bottom, and as much of the top, must always be waled with three rods.

Very thin short rods should not, in any case, be used at the top or bottom of a gabion; for, unless these portions of the work are finished with more than usual care, they are liable to separate from the remainder of the web, whilst the gabions are carried or thrown about. These portions may be formed of twisted withes, instead of common rods.*

In making the gabion, the web must continually be pressed down with the foot or hand, or beat with a stout picket; and the greatest care must be taken to preserve the proper diameter, for which purpose a couple of rods may be cut as gauges, which may be placed transversely across the finished part and inside of it, pressing against two opposite pairs of pickets.

27. METHOD OF FINISHING GABIONS.

When the web is completed to the proper height of two

* Twisted withes, braided or plaited, are used in preference to common rods, for all very open wicker-work, as they are less liable to separate from, or slip up and down the pickets with which they are connected. In gabions this is not absolutely necessary.

Iron wire may be substituted for withes in the construction of fascines and gabions. This material is superior both in strength and durability to the withe. When used, a pair of pincers must be added to the list of tools for each party. The wire should be annealed, by heating it red-hot.

feet nine inches, it must be bound from top to bottom, with withes, previously well twisted, in four distinct places, and these should be applied, so as to secure the ends of the extreme rods, in preference to the middle of them.

The centre of the withe being laid over the top of the web, the ends are passed through it, in contrary directions, a few inches from the top; near to each other, but not between the same two rods. Two men haul upon them, till they are quite taut. They then pass them again through the web, a few inches lower down, in contrary directións, and haul taut a second time; and thus they proceed by double stitches, as they may be called, like those of shoemakers, until the ends of the withe arrive at the middle of the web. The gabion, being thus secured by four withes from the top downward, disposed at equal distances apart, is pulled out of the ground, and turned upside down; and an equal number of withes are used, to bind the remaining part of the web, in the same manner, so that the two sets of withes used shall meet, or cross each other, about the centre of the gabion. The ends must be neatly secured, but in what manner is of little consequence. The stitches of these bands should be rather close, but not so as to embrace fewer than two spirals, of the original waling of the web.

Before the gabion is pulled out of the ground, the tops of all the pickets must be cut off about an inch above the web. This is usually done by a handsaw, but the expert woodman cuts off the heads of pickets by his bill-hook, introducing a stout stake between two of the pickets, which he uses as a movable chopping block, in striking at one of the two.

After the gabion is turned upside down, the points which originally stood in the ground may also be cut off, according to the same rule, if judged necessary; we always leave them, which appears to be rather an advantage than otherwise.

28. METHOD OF MAKING GABIONS OF VERY SMALL BRUSHWOOD.

Lighter gabions than those described in the preceding article are not to be recommended, otherwise than as a matter of necessity on service; or of economy, where very small brushwood is often used, in order that nothing may be wasted.

For example, when none of the brushwood runs larger than about five-eighths or three-quarters of an inch, the pickets will not of course exceed from one-half to three-quarters of an inch, and the rods may vary from one-quarter of an inch, or even less, to about one-half, or at the utmost, five-eighths of an inch.

In this case, the number of pickets used must be increased from fourteen to sixteen, or even twenty, using the greatest number to the smallest brushwood; and the making of gabions with such very light materials, requires more than usual dexterity and attention. In other respects the method is the same as in making the common gabion before described.

In gabions made of very small brushwood, the ends of the pickets should always be cut off, after drawing them out of the ground; otherwise they are liable to break. This is done by the gabion knife, not by the saw or bill-hook.

After finishing one gabion, and drawing it out of the ground, the same picket holes will answer for commencing a second gabion, without describing a new circle.

29. OF WOODEN CIRCLES FOR GABION MAKING.

In making gabions, wooden circles are sometimes used, consisting of plank ledged together so as to form a circle like the head of a cask. Notches are cut on the circumference to receive the stakes. The circle is laid on the ground, the stakes driven around it and in the notches, the circle raised a foot, and the stakes bound firmly into the notches by means of a rope and rack-stick. The gabion is then wattled above the circle, and withed, turned over the circle removed, and the remaining portion wattled. I am informed that this facilitates the operation, and saves time, when inexperienced men are employed; but I conceive that no extra implements of this description that can possibly be dispensed with, ought to be used on service.

30. METHOD OF MAKING GABIONS OF THICK BRUSHWOOD.

Sometimes thicker brushwood than usual must be employed for making gabions, as a matter of necessity. Sometimes stronger gabions may be desired for some special purpose, such as reveting the embrasures of a battery, or for the interior of a field powder-magazine, in which case the thickest parts of the brushwood are selected.

The pickets for strong two-feet gabions, need not exceed from seven-eighths to one inch, or, at the utmost, one and a quarter inch in extreme thickness. The rods for the web should not be less than one-half or five-eighths of an inch, and need not exceed one inch in thickness, the best being selected for the withes.

On account of the greater strength of the brushwood used, the pickets may be reduced to eight or ten for gabions of the above diameter;* and the whole of the web may be formed, by pairing with two rods only. In other respects, the same method is followed, as in working with smaller brushwood.

METHOD OF MAKING IRON GABIONS.

Describe a circle two feet in diameter on a wooden platform. Divide the circumference into six or eight equal

* The proper number of pickets for gabions made of strong brushwood, is in the proportion of one picket to every two and a half or three inches of diameter.

parts (half the number of stakes to be used in the gabion); at each of these points insert wooden pins about five inches long. Wrap the hoop iron tightly around the pins, thus forming a polygonal hoop. The point where this hoop is to be riveted must be marked before it is removed from the form, so that all the hoops may be of the same size. The hoop is then punched and riveted. As the iron used is usually one inch wide, thirty-three of these hoops will be required for a gabion.

The stakes are usually made from pine plank one inch thick; their cross section being a triangle, with three or four inches base and one inch altitude.

This is the best form, although round stakes may be used.

To set up the gabion, place a hoop on the ground, and a second directly over it, the first as represented by the dotted, the second by the full lines in the figure. Insert a stake in each of the triangular spaces, then place the remaining hoops alternately over the first and second. Drive nails in four of the stakes over the exterior hoops to keep them from coming off. This gabion is much stronger and more durable than those made of brushwood, and is peculiarly adapted to the construction of the cheeks of embrasures, as it is not injured by the blast of the piece.

CORRUGATED IRON GABIONS.

For this purpose, the corrugated sheet should be six feet long, thirty-three inches wide, and of iron weighing three-quarters of a pound to the square foot.

The corrugations running transversely, the sheet is easily bent into a cylindrical form, in which it is retained by two clamps, the holes for which are punched near the corners of the sheet.

The chief advantage claimed for the corrugated over the hoop gabion is, the readiness with which it can be put together on the field. It is also rather more portable, and stakes are dispensed with; but it is inferior to the latter in stiffness.

31. TIME REQUIRED, WEIGHT, ETC.

The time required for making gabions, by common military working parties, after some days' previous practice, may safely be estimated as follows, observing that it increases in direct proportion to the number of pickets and smallness of the rods used.

TIME.—Three men will finish a gabion, with eight or ten pickets, and of large brushwood, in two hours: they will finish a common gabion, of fourteen pickets, and of smaller brushwood, in three hours; but they cannot finish properly a very light gabion, of from sixteen to twenty pickets, and of the smallest brushwood that can be used, in less than from four to five hours.*

WEIGHT.—The average weight of gabions may be estimated at thirty-six pounds, and they scarcely much exceed forty pounds, even when made of large brushwood.

32. OF SAP-ROLLERS.

Finding, by experiment, that a stuffed gabion, six feet long and four feet in diameter, if filled with small brushwood, was not musket-proof; but that, if filled with pickets, it was perfectly unmanageable; the sap roller was adopted by us in preference.

The sap-roller is a hollow cylinder, formed by making two concentric gabions, each six feet long, one of four feet

* In 1839, the men of the eighth company, who had learned gabion making the year before, finished their gabions in three and a half hours.

in diameter, but the other about two feet six inches in diameter only, so as to leave a clear interval of nearly eight inches all round between these two, which is afterward stuffed with strong six-feet fascines of a diameter suited to the above interval, and with rods not less than about one inch in thickness. The larger gabion of these two should have more than the usual number of withe-bands, in proportion to its diameter.

As we found it difficult to procure pickets of brushwood long enough, and at the same time perfectly straight, for our sap-rollers, we have often used pickets split out of deal, and about an inch by an inch and a half square. For the larger gabion of the sap-roller, we generally used twenty such pickets, and for the smaller gabion, fourteen.

Sap-rollers serve as a substitute for mantlets. In the single sap one sap-roller is used. In the serpentine double sap, two sap-rollers of the ordinary size are used, with one of a smaller size. The latter may be only three and a half feet long, and rather less than four feet in diameter. In the direct double sap, three ordinary sap-rollers and two short ones are required.

To prevent the sap-rollers from losing their shape, at one time we introduced internal wheels made of plank; but recently we have adopted the simpler expedient of driving three pairs of strong pickets, not less than about an inch and a half thick, through the large sap-roller, and two pairs of such pickets through the small one, arranging every two pickets at right angles to each other, and cutting off the ends flush with the external surface of the roller.

33. TIME, WEIGHT, ETC.

To make the inner gabion of a large sap-roller requires about six hours, and to make the outer one, nine hours; to which must be added about two hours for stuffing and combining them into a finished roller.

The average weight of the large sap-rollers now used by us at this establishment, and stuffed with fascines and pickets, is six and a quarter cwt. When the wood was green they must have weighed more: and it must be evident that if they were of any other form than round, such a weight would be perfectly unmanageable.

The small, or rather the short sap-roller before described may be finished in about two-thirds of the above time, and weighs nearly two-thirds of the former; their respective lengths being nearly as two to three, and all other particulars the same.

34. OF HURDLES.

Hurdles consist of strong wicker-work, of a rectangular form, and as they may occasionally be useful in a siege, the mode of making them shall be described.

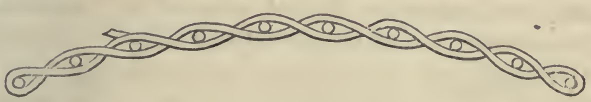
The best size for military purposes is six feet long, and two feet nine inches high. The same kind of pickets will therefore answer, as in making very strong gabions; and, generally speaking, the rods for hurdles should not be much less than an inch in diameter. An even number of pickets must always be used: and I consider ten a good proportion for a six-feet hurdle, although the woodmen in this neighborhood generally employ only eight for a hurdle of that length.*

In preparing to make a hurdle, it is necessary to describe an arc of a circle on the ground, with a radius of about eight feet, making the length of the arc six feet. This space must be divided into nine equal parts. A picket is then driven into the ground at each end of it, and others into every intermediate point of division, making ten in all. Then the watling is begun, on the same principle nearly as

* The hurdles made by the Kentish woodmen are either eight feet long, with ten pickets, or six feet long, with eight pickets, and are usually three feet high.

in gabion making, excepting that you do not work round a circle, but in a continued line; and therefore when you come to one of the extreme pickets at either end, you must twist part of your rod like a withe, and bend it round the picket, after which you must work in the contrary direction.

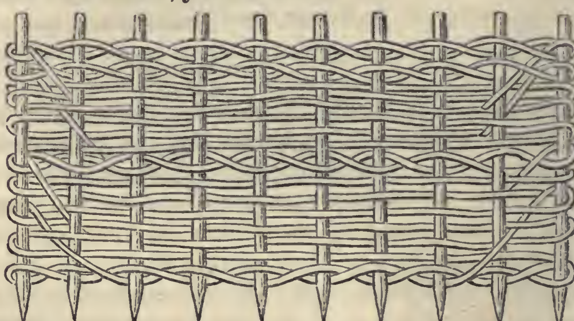
The woodmen assert that hurdles intended to be straight must always be made curved in the first instance, as above directed, in order to prevent them from being crooked when pulled out of the ground, which they say that those made in a straight line invariably become. And in hurdle making they use a wooden sleeper, moderately curved, with holes for the pickets on its upper surface, which they lay flush with the level of the ground; but it would not be worth while to make use of such sleepers in the field. The annexed figure is the plan of a hurdle made in a curve, according to the above rule.



In commencing a hurdle, the men work from the bottom upward, as in gabion making, but the first rod is not pressed down close to the ground, excepting in the centre. Both its ends are raised about nine inches above the ground, and there bent round the extreme pickets by twisting. Thus the first rods used form an arc of a circle, concave on the upper side. The second and third rods are bent round the extreme pickets, as close to the ground as possible, at each end of the hurdle, but in the centre they rise higher than the first rods used; and thus the first three or four rods, or rather courses of rods, composing the web of the hurdle, are interlaced in such a manner, by crossing each other toward the centre, as to prevent the separation of that part of the web from the pickets.

The ends of the rods are kept in their places, by pressing against a picket, which jams them, and they are cut off about an inch in rear of it. It is not good workmanship to commence or finish with a rod, by cutting it off in this manner, close to either of the extreme pickets, as the twisted joint formed by bending the middle of a rod round those pickets, evidently gives greater firmness to the work.

After having commenced as described, the remainder of the web is worked up in parallel horizontal courses, until it reaches the top of the pickets; and at this part one or two of the uppermost rods, after being twisted round the extreme pickets, are passed diagonally downward in an oblique direction, toward the centre of the hurdle, passing through and between one or two of the pickets. This arrangement, which is also sometimes adopted about half-way up, as well as at the top, prevents the upper part of the web from separating from the pickets. The annexed figure represents a hurdle in elevation, just finished.



In making hurdles for civil purposes, it is usual to work by randing, or with single rods only, for the thick brushwood generally used in this process is so stiff, that it requires an effort to separate it from the pickets. But as military hurdles would be exposed to greater strains than those used in husbandry, it is better to pair the rods in making them, which may either be done throughout the whole of the web, from the bottom upward, or at least for several courses at the bottom, middle, and top; for this undoubtedly gives greater firmness to the work. But the precautions before described for interlacing the lowest, and finishing the uppermost courses of the web, render it unnecessary to use vertical withes for binding it, as in gabion making.*

35. NUMBER OF MEN, TOOLS, TIME AND WEIGHT.

The men and tools to be nearly the same as for gabion making, but with more bill-hooks and knives, and with a line ten feet long.

The probable time for making a six-feet hurdle would be about three hours; I do not speak with certainty, having made very few; and it weighs about fifty pounds when the wood is dry.

IV. Rules for Tracing and Commencing the First Parallel, and the Approaches Connected with it.

36. METHOD OF TRACING THE WORK.

In opening the trenches in a siege, the workmen should be drawn up in single rank, and each ought to have a task assigned him, which should be six feet in length. Hence if the line marked out be divided into portions of fifty yards each, a working party of twenty-five men may be allotted to each portion.

The trenches in a siege are traced by pieces of white tape, previously rolled up into balls, the above color being chosen

* The following method has been advantageously employed in constructing hurdles, viz.: a stick about seven feet long and five inches in diameter is notched at intervals, corresponding with the spaces between the hurdle stakes. This stick is laid on the ground, and the stakes driven opposite each notch; it is then raised horizontally about eighteen inches, and the stakes lashed firmly into the notches, and are thus retained in place, whilst the upper half is wattled. The hurdle is then reversed, the stick removed and the remaining half finished.

as the most conspicuous by night. Each tape is one hundred and fifty feet in length, and is marked at intervals of six feet by pieces of the same sort of white tape sewed to it,* which should not be less than six inches long; besides which it has a short piece of tracing line added at each end, for the purpose of making it fast to the pickets or otherwise.

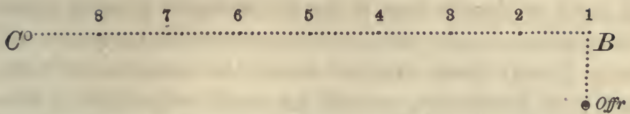
When the proposed trenches are extensive, they may be traced in several portions, and by several engineer officers.

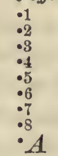
When two officers are employed in tracing a parallel, they may commence from the same central point, and work outward. The mode of proceeding is as follows: each officer will draw up the sappers who are to assist him, in single rank, and will number them from right to left. Every man is to be prepared with a ball of tape, and a white picket. One or two supernumerary men may act as orderlies; a sergeant will assist.

In tracing part of a parallel, the officer, followed by his party marching in file, will advance upon a point therein previously fixed, where he will order the leading man to halt, and will take his tape from him, and march on with it, in the alignment of the proposed parallel, previously turning to the right or left, as may be necessary. The other men will follow the officer. As soon as this tape is expended, the second tape-bearer will halt at the end of it, and deliver over the end of his own tape to the officer, who will march on with it as before, in continuation of the proposed parallel. When this is expended, the third tape-bearer will halt, and deliver the end of his own tape to the officer, who will proceed in the same manner until all the tapes are expended.

The annexed figure represents this movement, in which the party first advance upon the parallel, in the direction A B, by filing in single rank. On arriving at the point B, in the proposed parallel, they distribute themselves from

* This improvement was suggested by Captain Jebb, when adjutant.





thence along the proper alignment B C, in regular succession, and in extended order. The portion of parallel represented in the figure is supposed to be four hundred yards in length, and to have been traced by eight tapes. In this operation every tape-bearer, after halting and delivering the end of his tape to the officer, drops the ball on the ground, and lets the tape slip through his fingers. Both parties must keep the tape near to the ground in windy weather, and take care that it be not pulled entirely away from the tape-bearer, when nearly expended. The ends of adjoining tapes must be tied together. The tape-bearers, who are now to act as markers, will place themselves on that side of the white line which is nearest to the fortress, and will face toward the point from which the tracing commenced, as soon as they have taken post opposite to their respective marks; and if the ground be soft enough, they will fix their pickets into it without knocking, and make fast the ends of the small line to the pickets. They are not to move on any account, before the working parties are properly distributed along the whole line.

37. METHOD OF ARRANGING THE WORKING PARTY, AND COMMENCING THE PARALLEL.

Whilst one engineer officer is tracing, another must direct the working party, who will assemble at the engineers' depot, at least one hour and a half before sunset, and form in close column, of divisions of twenty-five men, drawn up in single rank.

If the extension is to be made to the left of the first point marked in the proposed parallel, the column must be drawn up right in front; but if the extension is to take place to the right of that point, the column must be drawn up left in front. Each division should be commanded by a captain or lieutenant, assisted by a due proportion of officers and non-commissioned officers; and every battalion furnishing the working parties should also send superior officers in proportion, one to command the whole, others to superintend several divisions.

After having formed in single rank, a non-commissioned officer or private of sappers, with a six-feet rod, will be placed on the reverse flank of every division, who is afterward to assist in extending it; and every man of the working party will now take up or receive a shovel, which he is to carry in his right hand, and a pickaxe, which he must carry in his left hand.

To expedite this arrangement, a fatigue party should previously lay out the tools in such order as to suit the column; the several sets of tools being placed in successive lines of twenty-five pairs each, at the clear distance of about four feet apart, so as to allow room for the men of each division, when in single rank, to form in rear of their respective tools for the purpose of taking them up.

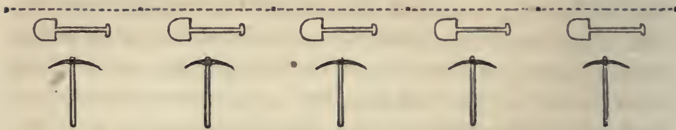
The divisions of the working party, formed as above directed, must be regularly numbered, and when all the men are provided with tools, each division must successively be marched off by files from its own right, if the column was formed right in front, or from its own left, if the formation was left in front.

Whilst this movement is in progress, the remaining divisions are to wait until each preceding division has moved on in the aforesaid order. As every division is successively faced to the right or left, and put in motion, the sapper on the reverse flank of it will lead. The engineer officer must be at the head of the first division, to guide the working party to that point in the parallel where the first marker is stationed, and from which the proposed extension is to begin. On reaching this point, the whole of the working party must be made to form line to the left or right, in extended order, in rear of the white tape, each man's place being regulated by the non-commissioned officer or private of sappers who marched with the division. In so doing, the sapper will be in front of the white tape, that is to say, on that side of it which is nearest to the fortress, and will see that the first man of the working party grounds his shovel parallel to and in rear of the tape, placing the centre of the shovel opposite to the centre of the first six-feet portion marked upon it. He will then see that the second man does the same, opposite to the second six-feet portion of the tape, and thus he will proceed until he shall have arranged all the twenty-five men of whom his division was composed; who will form up into their proper places behind the white tape, in regular succession, each man marking the centre of his own task by his shovel, when it comes to his turn.

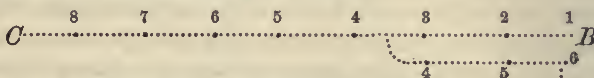
The engineer officer superintending is to watch over the whole of this measurement and extension with the greatest care, in order to prevent confusion. He must not allow any man of the working party to take post behind the white tape, until the sapper is ready for him; and he must also see that the latter does not move on until each successive workman is properly posted.

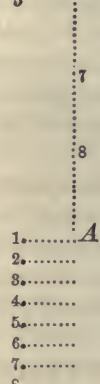
As soon as each workman has grounded his shovel in the manner before directed, he must lay his pickaxe in rear of it, and opposite to the centre of it, with the iron to the front. He will then sit or lie down behind his own tools, so as to be in readiness for work, and waiting the order to begin, in perfect silence.

The following figure shows the manner in which the tools are arranged in rear of the white tape, which is represented by a dotted line. The large dots show the marks upon the tape by which the tasks of the workmen are regulated.



As soon as the last division is extended on the reverse flank of the whole line, the men belonging to it will be ordered to commence work, and this movement must immediately be taken up by the other divisions with all possible dispatch; the commander of each, as well as the sappers attached to it, being on the alert, to watch the movements of the adjoining ones; and every commander ordering his own men to rise as soon as he observes the men of the next party on his reverse flank in motion.





The annexed figure represents the operation that has been described. The working party are supposed first to be formed in close column in single rank, at A, right in front. From thence they are supposed to move forward by filing from the right of divisions to the point B, when the first division begins to form up into line in extended order, in the direction B C, marked by the white tape, the other divisions successively wheeling to the left as they reach the point B, until it also comes to their turn to form up in the same manner. Every division commences its formation as soon as the head of it reaches its own marker. In the figure the first two divisions are supposed to be properly formed: the third is represented in the act of forming. The remaining divisions are coming up by files, in single rank.

If the working parties understand what they have to do, the above extension may be executed with precision and without hurry, at the rate of one division in a minute and a quarter, or of one hundred men in five minutes. Thus it will not require more than twenty minutes to extend four hundred men. It is not desirable that a greater number should be extended from the same point, in the same direction; but in extending from a central point, two distinct working parties may be made to file up together, under two different engineer officers, and in this case the total number employed may be greater, and they will of course advance in double files until they reach the point from whence the extension is to take place.

It is to be remarked that the extension of the working parties, after the tape is once laid down, is comparatively easy, but that the proper tracing of an extensive parallel the first night that the ground is to be broken before a fortress, may be attended with very great difficulty, and therefore the officers who are ordered for this duty cannot take too many precautions to avoid error.

When the working party begins to break ground, each man will seize his pickaxe and cut a hole in rear of and exactly opposite to the centre of his own shovel, which he will then take up, and throw the loosened earth over the white tape, until the whole shall form a continued trench of the dimensions prescribed for the first night's task in a siege, which is usually three feet deep, and in that case should be at least five feet wide, measuring from front to rear. The original pickets, driven in to mark the task of every division, should be carefully preserved; and the officer of infantry commanding it should be held responsible for finishing his trench, according to the prescribed dimensions, throughout the whole extent of the hundred and fifty feet thus marked out. The field officer commanding the working party furnished by each battalion, should enforce the proper execution of the work laid out for the whole of the divisions under his command, he himself being held responsible for the same by the general officer on duty in the trenches. The engineers superintending, and the sappers attached to divisions, will only be responsible for tracing and directing the work, and for measuring it when reported to be finished according to order; but not for the diligence of the men, which must entirely depend upon their own good-will and the zeal and attention of their regimental officers. The sappers will assist in working when they are not more usefully employed.

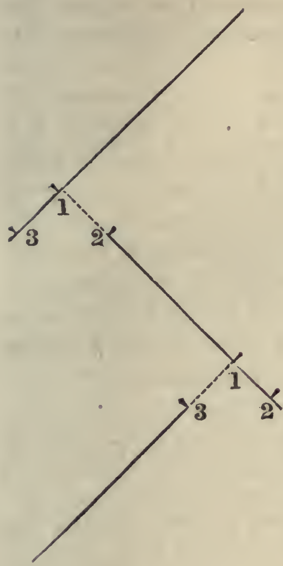
38. METHOD OF TRACING THE FIRST APPROACHES, OR THOSE CONNECTED WITH THE FIRST PARALLEL.

In tracing approaches, the same principle must be acted upon. One engineer officer must be employed to lay down the white tape, and to arrange the markers.

When any of the angular points of the zigzags does not coincide with the end of a tape, a spare marker must be placed there with three pickets, one of which he will plant at the angle; and in order to prevent the tape from moving, it must be passed round this picket, or made fast to it, after which he will cut off about fifteen feet of the tape, from the head of the branch immediately in rear of the angle, and extend it in continuation of the adjoining branch in front of it produced toward the rear. The remaining pickets must serve to mark the extremities of the ends of the tape after the angular part has thus been cut.*

This arrangement, which is represented in the annexed figure, serves to mark the returns, which are necessary at all the angles of the zigzags. The dotted lines show the first positions of the small portions of the tape, that are afterward cut off and moved in the manner that has been

* In our practice at this establishment, the tapes are not to be cut, as on service.



described. The figures 1, 1, represent the positions of the original pickets, which mark the angles. 2 and 3, are the pickets afterward driven to mark the extremities of the branches, after the returns, 1 3, 1 3, shall have been traced.

39. METHOD OF ARRANGING THE WORKING PARTY, AND COMMENCING THE FIRST APPROACHES.

Another engineer officer will guide the men of the working party, who will advance by files in single rank, as before directed, until the head of the leading division reaches the tail of the proposed approaches, on the reverse side of the white tape, that is, on the side farthest from the fortress. The men will then be made to form up in extended order, along the white tape, a non-commissioned officer or private of sappers placing them as before directed.

As soon as they reach the end of the first branch, which is marked by the point 2 in the foregoing figure, the engineer who superintends this measurement will lead the next man to the extremity 3, of the return of the branch immediately in front of it; and will cause him and the men who follow, to extend along the reverse side of the white tape, which marks the second branch of the approaches, in the same manner as before directed, but with this difference, that if in extending along the first branch, they formed up to their right, they must now necessarily form up to their left, and *vice versa;* and at each succeeding angle of the zigzags the formation must be reversed in the same manner.

40. GENERAL REMARKS ON THE ABOVE OPERATIONS.

It appears essential toward the proper tracing of a first parallel, that the front of attack of the fortress to be besieged shall be well reconnoitred beforehand, and the distances of certain points, from the most advanced works, accurately ascertained, by day; from which fixed points the engineers who are to trace a parallel should measure forward toward the place, until they reach the exact position of the intended parallel, by means of a chain or tape, being the most accurate method, and as expeditious as any other; unless they have confidence in their own accuracy of pacing. If it be possible to obtain a correct plan of the place, it will of course be of the greatest service, as fortresses are usually surrounded by objects, such as roads intersecting each other, buildings, &c., which cannot be destroyed in such a manner but that traces marking their original position must remain.* Whatever be the reputation of these plans, they should however be verified by actual observation, instead of trusting to them implicitly. If correct, the fixed objects before alluded to furnish the most satisfactory data for determining, on the ground, the proper position of the first parallel and of the approaches connected with it.

It appears of the most essential importance, that the tracing shall be executed before it is dark. Therefore unless the night chosen for opening the trenches is foreseen to be a moonlight night, it is absolutely necessary to commence early, and to have the tracing finished before the end of twilight. If there should be no moon, and a foggy or

* At the siege of Copenhagen, we obtained a Danish plan of extreme accuracy.

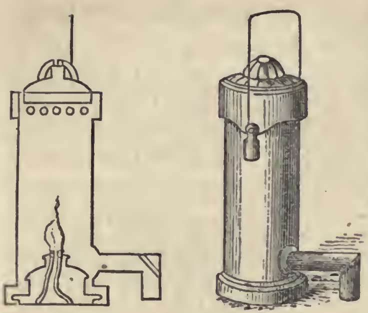
cloudy night, this operation may be attended with the greatest difficulty and confusion, as has been found by experience. The arrangement of the men, on the contrary, as was before observed, is by no means difficult, after once the white line is marked on the ground; that is to say, provided that they themselves are well inclined, and attentive to the directions of the engineers.

As soon as the trench and parapet are well defined, which will take place in about an hour after the work has been commenced, the sappers should carefully roll up and take care of the several tapes used in the tracing; but the pickets for marking out the work on the ground should not be removed, and it would be useful for those sappers to provide themselves beforehand, with white banderols, or with bundles of straw or other light-colored objects to be used as such, which should be planted on the reverse of the trench, opposite to the original boundary pickets, for the purpose of preserving the task of each party perfectly distinct in the dark; and such marks would be very useful even after daybreak.

41. METHOD OF COMMENCING THE TRACING OF A PARALLEL BY THE COMPASS. PRECAUTION USEFUL IN A FOG.

As the bearing by compass of an intended parallel may always be ascertained beforehand, it appeared desirable to use this instrument for the purpose of tracing in a dark night; but we had found by previous experience that the common dark lantern could not be employed so as to give light in this operation without being seen from the fortress. Lieutenant Frome* therefore suggested a reading lantern, on the principle of those used in observatories, which is represented in elevation and in section in the two figures an-

* Then superintendent of the Course of Surveying and Practical Astronomy, at the Royal Engineer establishment.



nexed, having air-holes at top and bottom, screened so as not to be seen from the outside, and having its lens inclosed in a tube, which being first horizontal and then bent vertically downward, with an oblique reflector at the angle, throws a strong circle of light upon any object placed below it. Thus the officer in charge of the tracing is enabled to read the bearing of a compass fixed in the middle of a six feet or ten feet rod, which rod being thereby laid in the proper direction of the proposed parallel, the white tape is applied to the side of it, and thus the tracing is commenced, and may afterward be verified, from time to time, so long as the direction is to remain unaltered, by applying the rod to the tape, and again using the lantern, to see if the same bearing has been preserved. The best sperm oil must be used.

It has also been found useful in a fog for the officer employed to place three men upon the tape facing toward him, and at a short distance from each other, after he has commenced his tracing, and then to move on himself as long as he can distinguish them clearly, taking care that he guides his own movement by seeing that they always cover each other. When this is no longer practicable he halts with his foot on the tape, and causes them to advance toward him, preserving their distance from each other, and not deviating from the tape, which will enable him to proceed again with his tracing in the same manner, after the first man shall have reached him. It may be advantageous to have these men dressed in white.

42. RULES FOR ARRANGING THE SECOND AND THIRD RELIEFS OF WORKMEN, FOR A FIRST PARALLEL, AND THE APPROACHES CONNECTED WITH IT.

The engineer will give directions, that after every party of twenty-five men shall have finished their task, each individual shall lay down his own shovel and pickaxe, close together, in rear of the spot where he worked, on the reverse of the trench, and near to the brink of it. Thus the tools being arranged by pairs, at intervals of six feet apart, or nearly so, will save the trouble of marking out the tasks of individuals a second time. The sappers will take care to preserve the original pickets at the end of every one hundred and fifty feet, and if the tools should not be arranged quite regularly, one of them, who is to remain on the spot, may employ himself in laying them out better, whilst the other goes to meet and conduct a new party to the same ground.

The second relief of men of the line will parade at the engineers' depot, at such hour as may have been previously fixed. There a part of the engineer officers on duty, and one sapper from each portion of the trenches, will be assembled to receive them. The engineer will tell off one sapper to each division of twenty-five men, as before; and the whole will be marched by divisions, the sapper of each party leading it, until they reach the ground allotted for the task of that party.

Preparatory to this arrangement, the several parties being drawn up at the engineers' depot in column, let them be numbered from rear to front, so that the rear division shall now be No. 1, and the front division, if there be sixteen in all, shall be No. 16.

In this order let them be made to file off, not in a body, but by divisions, singly, and successively, with an interval of some yards between the rear of one division and the head of another, to prevent confusion; and let each sapper, acting as guide, lead his division straight up to that picket, which marks the extreme boundary of the task allotted for it. The stationary sappers will remain at those same pickets, ready to assist in distributing the workmen, as soon as they shall arrive, and as the head of each division approaches them, they will each call out their respective numbers, that the officer commanding the division, as well as the sapper who acts as guide to it, may know whether it is to be halted there or not; which halt will of course take place, as soon as the number of the division shall correspond with that announced by the stationary sapper.

When thus halted and fronted, which orders should be given at the same time, the men of each division will be made to extend over the whole space of fifty yards, allotted as their respective task, by forming them in single rank, if that should not have been done before, and by causing each man, after facing the whole to the rear if necessary, to extend until every pair of tools laid out on the reverse of the trench shall be covered by a workman.

In this second formation, each party of twenty-five men will begin to work independently, as soon as they shall be extended on their own ground, without waiting for the others.

It may perhaps appear almost superfluous to observe, that if there should be more reliefs than two required, to complete the parallel, the third relief must be formed precisely in the same manner that has just been described.

If, under peculiar circumstances, any strong reason should exist against leaving the tools in the trenches, the stationary sapper will have time enough to mark out each man's task with tracing pickets, during the interval that must elapse between the quitting of one relief and the arrival of the next; or, if such pickets are not at hand, the new working party may be made to extend themselves between the extreme points with sufficient accuracy, without subdividing the space into six-feet portions at all.

43. TIME OF PARADING THE SECOND AND THIRD RELIEFS OF WORKMEN, FOR A FIRST PARALLEL, AND THE APPROACHES CONNECTED WITH IT.

In opening the trenches it is absolutely necessary to commence at dusk, as the men, having no cover, would be too much exposed to the enemy's fire, if such a thing were attempted by daylight. No such necessity, however, exists in respect to the second relief of workmen. If therefore a siege should be conducted, in any country, at a season when the nights are ten hours long or upward, the second relief should be ordered to parade at the engineers' depot, at such time as will admit of all the necessary arrangements being got through, just before daylight, in order that they may commence filing into the trenches with the dawn; for, considering the number of men usually required at this period, in a siege of any importance, and the great extent of ground they are to cover, it appears next to impossible to form the second relief of workmen properly in the dark. Indeed the attempt might lead to inextricable confusion, and it is altogether unnecessary; for after cover is once obtained, the work of half a day, even in the short winter days of temperate climates, is better than that of a whole night. Let it therefore be laid down as a rule, that in the formation of parallels and approaches, the second relief of workmen shall never enter the trenches until at or after daybreak: and that the third relief, when three are employed, shall enter them at noon.

Hence, in the long summer days of northern climates, the periods of relieving the working parties in the course of every twenty-four hours, may always be at equal intervals of eight hours, not otherwise.

V. Rules for Tracing and Commencing the Second Parallel, and the Approaches connected with it, by the Flying Sap.

44. OF THE TRACING.

In commencing the second parallel, one engineer officer must be employed in tracing each portion of it, and another in arranging the workmen on the principle before explained in treating of the first parallel; but there are several variations in the details of the duty; and in the first place it may be remarked that the tracing of the second parallel, and of the approaches connected with it, is a much easier task than that of the first parallel and its approaches.

For example, if we suppose the first parallel finished, and that the second parallel is to be established at any average given distance in front of it, such as three hundred yards, it is obvious that the engineers employed in tracing may mark a certain number of equidistant points in the first parallel, at any intervals apart they may judge most convenient, from each of which they may sally out at dusk and measure three hundred yards straight toward the fortress. This will give them an equal number of points in the proposed second parallel, from which they may detach tape-bearers to the right and left, in sufficient number to overlap each other a little when they go to the full extent of their tapes. If they do not meet, let the officer superintending the tracing move backward or forward, when arrived at the extremity of one party thus detached, and he will be sure to find the end of the corresponding tape, which was intended to have been connected with it. Then let him cause one of the parties to move their own tape forward, and the other to move their tape backward, until they meet, and the error will be corrected; and the tapes for marking the second parallel may thus be laid out with sufficient accuracy for all practical purposes.

If the second parallel should not be intended to be exactly parallel to the first, it will be obvious that it may be laid out correctly enough, after consulting the plan of attack fixed upon, by measuring unequal distances toward the fortress instead of equal ones, from the points of departure taken up in the first parallel.

In pushing out approaches from a first parallel, the point from whence any branch is to commence, as well as the proper alignment of it, may be marked or ascertained in the day time, and such approaches may be traced with white tape at dusk, whilst it is too dark for the enemy to discover this operation, but not dark enough to prevent persons outside from distinguishing the outline of the extreme works of the fortress, from which the proposed approaches are to be defiladed.

When the approaches are pushed forward in front of the first parallel, as far as the intended position of the second parallel, previously to the commencement of the latter, which arrangement is very common in a siege, the tracing of the second parallel is of course much facilitated. For in this case all that is to be done will be to connect the heads of the approaches with each other by a line of white tapes, the proper direction of which may be ascertained beforehand, in the day time.

45. OF ARRANGING THE WORKING PARTY, AND COMMENCING A SECOND PARALLEL BY THE FLYING SAP.

When a parallel is said to be commenced by sap, it merely implies that gabions are used. The peculiar arrangements and manner of working with them described in this article constitute what is called the FLYING SAP.

The workmen ordered for the duty of commencing, or, as it is also termed, of opening the second parallel, will parade at the engineers' depot to receive their tools and gabions, in divisions of twenty-five men, who must be formed in column in single rank.

Every man is to carry a couple of two-feet gabions, holding them under his arms, by means of a picket two feet nine inches long, driven transversely through each of them, about fifteen inches from the top, which pickets he grasps in his hands.

In one of these gabions he also carries a pickaxe, and in the other a shovel, as shown in the foregoing figure. The iron part of the shovel and likewise of the pickaxe, rest on the top of their respective gabions, and are secured from falling, by passing them beyond the picket ends, which project above the web, whilst their helves hang down inside. In carrying these tools in the gabions, they should be as near to the man's sides as possible. The pickaxe may therefore come entirely under one of his arms, but the shovel iron standing too high to be carried in this position, must be a little to the rear of his other arm. The transverse pickets must not be driven through the centre of each gabion, but nearer to one side of it, namely, that which will touch the man's thighs after he takes it up. (See the more correct figure, afterward given in Article 53.).

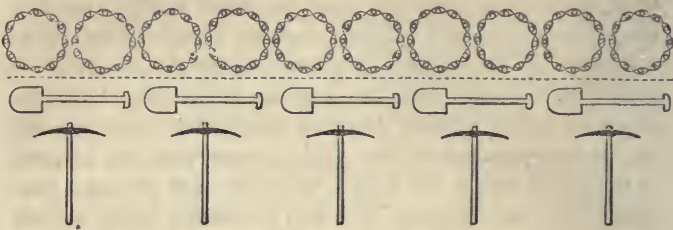
The implements necessary for each division, consisting of fifty gabions, with their transverse pickets, and a shovel and pickaxe fixed in each alternate gabion, must be previously laid out at the engineers' depot, in successive parallel lines, at central intervals of about six feet apart, so as to suit the formation of the column. The sappers employed in this duty must be well acquainted with the proper mode of arranging the pickets and tools, and strictly cautioned to do so with the greatest care, for which purpose they should be ordered to lift up each pair of gabions in succession, by way of trial, after the pickets and tools shall be fixed, shifting them, if inconveniently placed. If the working party should be so numerous as to occupy an inconveniently great extent of ground in this order, the depth of the column may be diminished, by laying out one hundred gabions in each parallel line, in two portions of fifty gabions each, with an interval of about ten feet in the centre, between each adjacent portion. This arrangement will suit a working party drawn up in grand divisions, instead of single divisions as before explained.

After receiving their tools and gabions, the whole working party must advance by files, in single rank, to the point from whence they are to extend; on reaching which they will be formed along the line of white tape, previously laid, as before directed in Article 37, excepting that no marks on the tape are necessary in the flying sap; for the two gabions carried by each workman measure his task.

As they come up into their proper places on the reverse side of the white tape, the men will successively put down their gabions close together in front of the line, so as to clear it by two or three inches.

The sapper who assists in superintending the extension, is to correct the position of every successive pair of gabions, which it is difficult for the workman himself to place properly on setting them down. The engineer officer directing will take care to enforce accuracy, and to prevent hurry and confusion. As soon as each workman has got his gabions placed by assistance of the sapper, he will disengage his tools and pickets, as it is useless to waste the latter by leaving them in the gabions. They may be laid down in rear of, and close to the gabions. The tools must be laid down behind the two gabions, which mark each man's task, in the manner before described in treating of the first parallel.

The following figure represents this arrangement, showing



the position in which the gabions and tools of five workmen are placed, the former in front, the latter in rear of the white tape.

Whilst the extension of the whole working party is thus going on progressively, the men first posted will sit down behind their own gabions and tools, as soon as the latter are properly laid out, and will wait in perfect silence for the order to commence work, which will be passed on from the extreme points of the parallel, as soon as the whole operation shall be completed.

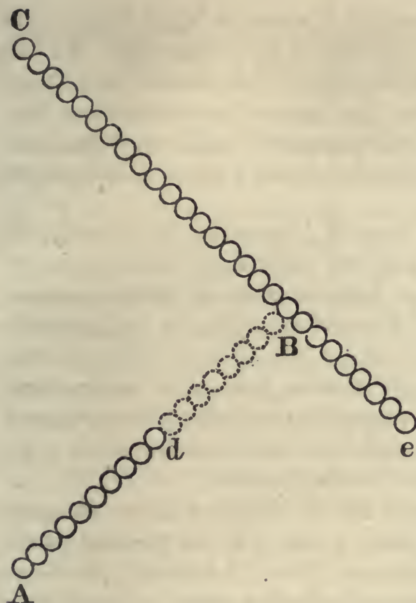
Every man will then commence digging in rear of his own two gabions, which he will fill with all expedition, patting the earth well down before he throws any part of it over.

46. OF TRACING AND COMMENCING APPROACHES BY THE FLYING SAP.

The approaches in front of the second parallel, and sometimes even those immediately in rear of it, are commenced by the flying sap.

The method of tracing them is precisely the same as if no gabions were used, and has already been explained in Article 39. The method of extending the workmen, and of commencing approaches by the flying sap, is the same as in commencing the second parallel.

In tracing approaches, which are to be executed by the



flying sap, it is unnecessary to cut the tape for the purpose of forming a return. Instead of which, let four pairs of gabions be moved from the head of each branch adjoining to an angle, and placed in prolongation of the next branch in front of it.

Thus, for example, in the foregoing figure, if A B and B C be the original form of an angle of the zigzags, as traced by the white tape, the four pairs of gabions originally placed at the head of the branch A B, are removed from the position *d* B to B *e*, where they are placed in prolongation of the advanced branch B C, produced toward the rear, and thus they form the return, at the angle B.

47. OF THE PROPER TIME FOR PARADING THE SEVERAL RELIEFS OF WORKMEN FOR THE SECOND PARALLEL, AND THE APPROACHES CONNECTED WITH IT.

The proper periods for the relief of the workmen must be regulated precisely on the same principle as those of the first parallel.

I before named at least an hour and a half before sunset as the parade time of the first relief at the engineers' depot. It is possible that the necessary arrangements may be made in rather less than this time, but I have doubts on the subject;

and one thing is certain, that it would be better for the working parties to be kept waiting an hour longer than the time actually required in those preparations, than that they should be ten minutes too late; for if the dark should surprise them before the necessary arrangements are fully completed, the whole night's work may be lost in a scene of inextricable confusion.*

It is of the most essential importance that every thing shall be completely prepared beforehand at the engineers' depot, so that whatever materials and tools shall be assigned to each individual of the working party to carry, shall be put together and laid out for him, in good order, without giving him any trouble in what belongs to arrangement. Unless this system be adopted for facilitating the commencement of the work, it might take the whole afternoon to get through the preliminary arrangements.

For the reason before stated (Article 43), the formation and distribution of the second relief of the working parties of men employed in the execution of a second parallel, or of the approaches connected with it, should not be attempted till daylight, when it will be comparatively easy.

Let it be understood that the same necessity does not exist for waiting till daylight before the second relief are set to work in the other operations of the siege, in which, when the nature of them shall come to be explained, it will be evident that there is much less risk of confusion, for the men are either more concentrated on particular spots, as in the construction of batteries, or more subdivided, at the same time that fewer are employed, as in the execution of the final operations of a siege, most of which are commenced by the regular sap, or by mining.

* At the siege of Flushing, when I was the executive engineer on duty of the first relief, with my brigade, a night's work of about five hundred men was entirely thrown away from this cause, to my extreme mortification.

48. REMARKS ON THE ABOVE ARRANGEMENTS FOR COMMENCING THE SECOND PARALLEL, ETC.

To carry two gabions, with their whole weight, as well as that of the pickaxe and shovel, resting entirely on the hands, may be acknowledged to be rather fatiguing, but there is no means of obviating this inconvenience, except by having shoulder boards and slings, such as are used with milk-pails. But to provide such articles for so temporary a service as the commencement of the second parallel, would not be worth while; and therefore it is best that the working parties employed in this operation should submit to the inconvenience for a short time, which cannot bear hard upon robust, able-bodied men like the British infantry.

49. OBJECTIONS TO CROWDING THE WORKMEN IN COMMENCING A SECOND PARALLEL.

If to consult the ease of the workmen in marching from the depot of gabions to the position marked out for the second parallel, each man should be required to carry one gabion only, a much greater evil would follow. As every gabion in the flying sap occupies only two feet, it would be absolutely impossible for the whole number of men who carried the gabions to work together properly. Hence one-half of them must either be sent back to the camp after having deposited their gabions, or must get out of the way and remain idle, thus uselessly harassing or exposing to the enemy's fire double the number of men that can work to advantage; for it has been found in field-works, whenever a line of excavators has been crowded into a smaller space than four feet per man, which we consider the minimum pace that ought to be allowed, that instead of expediting the work, it has retarded it; for, being in each other's way, and in danger of being wounded by each other's tools, which has occasionally happened even in working by daylight, a part of the men have necessarily stood still, and much confusion has ensued, which would of course have been considerably aggravated had men thus crowded been employed in the dark, and before an enemy.

50. MODE OF CARRYING ONE GABION ONLY, WITH TOOLS.

Excepting, however, those employed in the commencement of a second parallel, or of the approaches connected with it by the flying sap, who should carry two gabions, it may not always be necessary to require the workmen in a siege to carry more than one gabion with their tools. In this case the gabion is carried on the left shoulder, with the pickaxe previously attached to it in the manner before described; or, for greater security, with the point of the iron passed between two parts of the web, near the top of the gabion, which must always be to the rear; for this being naturally carried a little higher than the front, prevents the pickaxe from dropping out. The shovel is carried in the right hand, at the trail, with the iron to the front, as shown in the foregoing figure.

VI. Of Arming the Working Parties in a Siege.

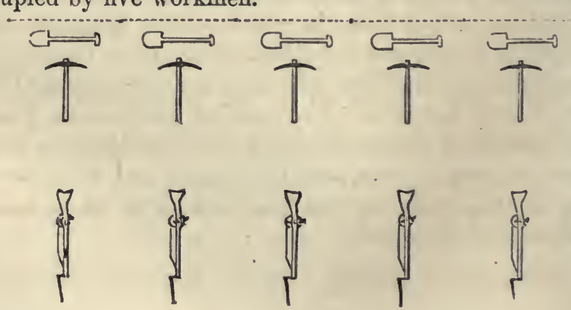
51. WHETHER WORKING PARTIES IN A SIEGE SHOULD BE ARMED OR NOT.

It appears to me that the working parties employed in opening the trenches on the first night of a siege, ought not to carry their arms with them. They must necessarily be protected by strong covering parties, destined for the special duty of repulsing sorties. To call upon the working parties also to assist in this service, would only create confusion without adequate benefit; for they are spread over so great an extent of ground, that they could scarcely collect their arms, and form in sufficient time to be of much use; and if once formed as a military body, no more work could be expected from them. In the event of sorties, therefore, they should remain at their post, if sufficiently protected by the covering parties. If not, let them be ordered to take up their tools, form by divisions, and in that order file independently to the rear, each division being always collected as an organized body, under its own officers, ready to return to its post in the trenches, on receiving orders to that effect.

This remark applies chiefly to the first parallel, and to the approaches in rear of or near to it. But when the operations are more advanced, as in the second parallel, and in other parts usually commenced by the flying sap, the working parties being now much nearer to the fortress, may be allowed to take their arms in order to give them confidence; but they should carry the musket and bayonet only, without accoutrements, because it is impossible for men to work with their accoutrements on; and if they take them off, they could not put them on again and adjust them in proper time, in the event of a sudden sortie; besides which, the men of the working parties, if provided with accoutrements, could not be distinguished from the guards of the trenches; and thus lazy or ill-disposed individuals might often have an opportunity of skulking from their work for a great part of the night, without detection. The working parties when armed should therefore only carry a few ball cartridges in their pockets or foraging caps, and they should not even be allowed to take their bayonet scabbards with them, which might be liable to be lost.

52. METHOD OF ARRANGING WORKING PARTIES WITH ARMS, WHEN THEY COMMENCE A PARALLEL OR APPROACH WITHOUT GABIONS.

In all cases when working parties are to carry their arms, they should sling them behind their backs, after the fashion of the old British grenadiers, that is, with the sling all to the front of the body over the right shoulder, and under the left arm, and with the firelock behind, the butt downward and muzzle upward; and as accoutrements are not to be carried, the bayonet should previously be fixed in reverse, or pointing downward. In this order they will march to the engineers' depot and receive their tools, which they will be able to carry with ease, as both their hands are at liberty. As soon as the extension shall be made behind the line of white tape, which must be done precisely in the same manner, whether arms are carried or not, and which was before described in Articles 37 and 38, each workman, after laying down his tools in their proper position behind the white tape, will unsling his firelock, and fix his bayonet properly, and afterward, when the ground behind him shall be clear, in consequence of the remainder of the working party having moved on, he will face about and march three full paces to the rear, and ground his arms, in the manner shown in the annexed figure, in which the dotted line represents so much of the line of white tape as is sufficient to mark the ground occupied by five workmen.



53. METHOD OF ARRANGING WORKING PARTIES WITH ARMS, WHEN THEY ARE TO WORK AT A PARALLEL OR APPROACH, COMMENCED BY THE FLYING SAP.

Case I. When the men are to carry two gabions each, as well as tools.

In this case the tools and gabions are to be arranged beforehand, by pairs, in the manner before described in Article 45, a picket being driven through each gabion to carry it by.

The men of the working party, having their arms slung behind their backs, with bayonets fixed the reverse way, will carry their gabions and tools as shown in the annexed figure, and they will place the former and lay down the latter, after being extended, in the manner explained in Article 45; and when this is done, each man will unsling his firelock and fix his bayonet properly, and afterward ground his arms three full paces in rear of his own tools, as directed in Article 52.

Case II. When the men are to carry one gabion and their tools, which applies only to the continuation of the work.

The firelock will be slung and the bayonet fixed, as in the two preceding articles, whilst the gabion and pickaxe attached to it will be carried on the left shoulder, and the shovel trailed in the right hand, as explained in Article 50.

54. FURTHER REMARKS ON THE ARMING OF WORKING PARTIES.

It was before stated, that the working parties who open the trenches on the first night of a siege, should not be allowed to take their arms, considering the very extended order in which they are formed for work, and also their distance from the fortress. It is to be remarked, however, that the chief objection to taking their arms is the former circumstance, of their being so much dispersed. But if a greater number of men be concentrated on one spot, as in the construction of large batteries, redoubts, or intrenchments, the working parties may be allowed to take their arms; for in this case a considerable body of men may be speedily formed to repulse a sudden attack, who might afterward resume their work without much confusion, as they would probably be able to maintain their ground, without retiring to the rear.

The propriety of this arrangement will be obvious, by considering that a ten-gun battery alone might give employment to nearly two hundred men, within a space of about eighty yards, whereas in a first parallel the same number of men would be spread over an extent of four hundred yards.

Even in this case, accoutrements and bayonet scabbards ought not to be taken, for the reasons before assigned.

VII. Rules for Executing the First Parallel, and the Approaches Connected with it.

The methods of arranging and distributing the workmen, in commencing the first and second parallels, and the approaches connected with them, in a siege, having now been fully discussed, it remains to explain the nature and execution of those works in detail, which will form the subject of the present and of the following section.

55. OF THE PROFILE PROPER FOR A FIRST PARALLEL.*

The profile usually adopted by us of late consists of a

* This profile is illustrated by the figure afterward given in Article 59.

trench eleven and a half feet wide at bottom, three feet deep in front, and three and a half feet in rear, with a reverse slope having a base of three and a half feet, being equal to its height, and with a step of made earth, one and a half feet wide at bottom and one and a half feet high, added to the front of the original trench when half finished, which therefore reduces the net width of the sole of the trench from eleven and a half to ten feet.

The earth of the trench, being thrown forward toward the fortress attacked, forms the parapet of the parallel, which is not rammed.

A berm of one and half feet is left between the front of the trench and the base of the interior slope of the parapet, which serves as a banquette, to fire over the parapet, which on being left to take its own form usually proves to be about five feet high, after the trench is finished. The inside of the parapet should then be smoothed, the berm widened if necessary, and any unseemly irregularity in the height of the parapet should be removed, but it is not worth while to cut it generally lower than the form which it may naturally assume; and if therefore its height should be too great to fire over conveniently, let a small narrow step be cut on the interior slope a little higher than the berm, for a man to stand upon whilst firing.

A regular banquette, like that of more permanent works, is considered unnecessary.

56. GENERAL REMARKS ON THE TASKING OF MILITARY WORKING PARTIES, IN THE FORMATION OF A FIRST PARALLEL.

By repeated experiments at Chatham, tried with the utmost care, it was found that a portion of parallel of the dimensions above stated, which involves two hundred and sixty-one cubic feet, or nine and two-thirds cubic yards of excavation, may be completed in an average of five hours per man, in soft soil, which requires little or no picking, and an average of nine and a quarter hours per man, in hard soil.

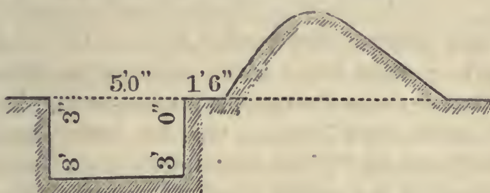
The most difficult soil that we could possibly find in this neighborhood, which consisted of a concretion of flint-gravel, sand and clay, required an average of ten and a half hours. In all those experiments, the task of each man was two yards in length; and we are of opinion, that a shorter portion of trench work ought in no case to be allotted to individual workmen, on the night of opening the trenches in a siege. For, as was before observed, if men be crowded in too small a space, they are liable to wound each other with their pickaxes, and finding that they are in each other's way, a part of them will be tempted to stand still; and thus by increasing their numbers beyond a certain proportion, the casualties from the enemy's fire will of course be increased, without obtaining a proportional increase in the quantity of work performed.

The sappers employed in those experiments were generally artificers, not previously inured to labor, with the pickaxe and shovel, until they joined this establishment, and not by any means more robust men than the British infantry usually are. It is evident, that many intermediate qualities of soil may occur on service, between the soft soil, which required only an average of five hours' labor, and the very hard soil, that required ten and a half; and of course, in employing workmen of the same physical powers and dexterity, the time for completing a parallel might vary, between the minimum average of five hours and the maximum of ten and a half hours. In those experiments, the men were tasked individually, and in all cases some got through their task in nearly half the time of others; but in the very worst soil, the time of the slowest workman did not exceed thirteen and one quarter hours.

In tasking a working party of the line on service, the task of fifty yards for each party of twenty-five men ought to be general, not individual; for although a good workman may do twice as much as a bad one in the same time, yet if both do their best, it will be no greater exertion to the one than to the other; and when a whole party of soldiers are jointly responsible, they will scarcely allow any one man to evade his due share of work.

57. FIRST TASK IN EXECUTING A FIRST PARALLEL BY THREE RELIEFS.

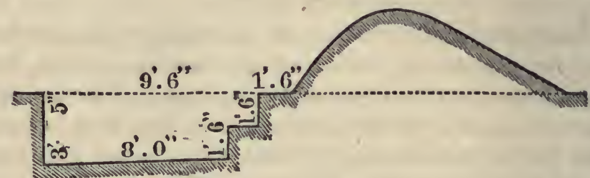
Considering that the first relief of workmen are more harassed by preliminary arrangements than the others who succeed them, whilst they cut their trench to the standard length of six feet, let them make it three feet deep in front, three feet three inches deep in rear, and five feet wide from front to rear, as shown in the annexed figure.



The above will amount to ninety-three and three-quarters cubic feet, which is nearly but not quite equal to three and a half cubic yards of excavation, which may be executed by able-bodied men, with moderate exertion, in from one hour and three-quarters to three hours and a half, or four hours at the utmost. It really would be trifling with the service, to allot a smaller task than the above to any set of men deserving of the name.

58. SECOND TASK IN EXECUTING A FIRST PARALLEL BY THREE RELIEFS.

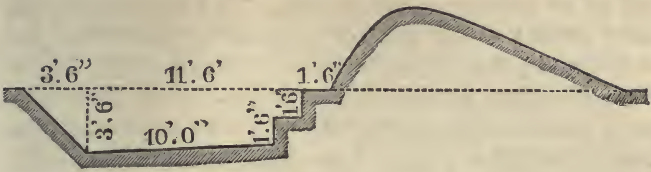
In this task, an equal number of men being employed at the standard rate of six feet to each man, as before, let the trench be widened by cutting it four feet six inches more to the rear, which would make it nine feet six inches wide in all, but for a step of eighteen inches in width in front of the trench, which is formed by this set of men, and which reduces the net width of excavation at the sole of the trench, to eight feet, as represented in the annexed figure. The depth in rear must be increased to three feet five inches.



This task involves ninety cubic feet, or three and a half yards of excavation, being a little less than the former, but the distance to throw the earth is greater, and on the whole it is somewhat more laborious than the former task, and is made purposely so for the reason before implied, namely, that the men of the second relief are exempted from those preliminary arrangements that fall to the lot of the first working party.

59. GENERAL DESCRIPTION OF THE THIRD TASK IN EXECUTING A FIRST PARALLEL BY THREE RELIEFS.

In this task, an equal number of men being still employed, at the standard rate of six feet to each man, as before, let the trench be widened by cutting two feet more to the rear, which will complete the sole of the trench, making it three feet six inches in extreme depth. This being done, let the reverse slope of the trench be formed at an angle of forty-five degrees, making the base of the slope three feet six inches, being equal to its depth.



The quantity of excavation in this task amounts to about seventy-eight and a quarter cubic feet, which is equal to two and eight-ninths cubic yards only, but owing to the great distance that the earth must be thrown to clear the parapet, which cannot be done at one heave, as in the first task throughout, and in part of the second task, and owing also to the necessity of causing this party to make a complete finish of the work, by putting every thing in order, trimming the parapet, widening the berm, forming a small step as a banquette on a higher level if required, besides making cesspools and drains to secure the trench against rain, as will be described in the next article; I conceive that this task will probably require rather more time than either of the two former tasks to bring it to a conclusion, but it is not a more trying operation, as the men have the advantage of being well covered when they begin. The foregoing figure represents the profile of a finished parallel, such as has been described.

60. REMARKS ON PRESERVING THE TRENCHES DRY. THAT THE WORK NECESSARY FOR EFFECTING THIS OBJECT MAY SOMETIMES REQUIRE A SPECIAL WORKING PARTY.

When the ground is marshy, it must of course be exceedingly difficult to preserve the trenches dry in a siege; but when the evil only arises from heavy and continued rains, the following measures must be adopted, in order to effect that object.

Let drains be cut from the reverse of the trenches into all valleys or hollows, which, by being on a lower level, can carry off the water, and let cesspools of about two feet square, and a foot or two lower than the sole of the trench, be made in the reverse thereof, at intervals of about fifty yards; not however making such cesspools exactly equi-distant, but in all low points, where the rain-water shows a tendency to stagnate. They must be cut entirely in rear of the trench, so as not to diminish its regular width, and the sides sloped, if necessary, to prevent the earth from falling in.

Cesspools of this description will keep the trenches as dry as can be expected; but in excessive rains it may be necessary to bale out the water occasionally, for which purpose shovels will answer.

In short the rule to keep a trench dry in rainy weather is, to take such measures as to prevent it from becoming a drain to the neighboring ground which would from time to time convert it into the channel of a torrent.

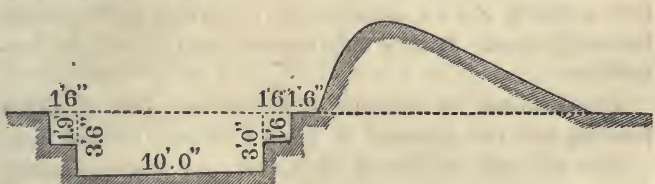
Nothing therefore but the rain which falls vertically down upon the trench itself should be admitted, and this surface water, which cannot be excluded, will never annoy the troops in any considerable degree, provided that the above mentioned precautions, of cutting cesspools at intervals and of occasional baling, be resorted to. The rear of the sole of the trench may also be cut in the form of a small drain, from cesspool to cesspool.

The arrangements described in this article must generally be made a part of the task of the third or last relief of men, employed in finishing any portion of the trenches, excepting when necessity requires any part of them to be carried into effect at an earlier period. The formation of a drain leading into a valley may sometimes require a special working party destined for this object exclusively.

61. FURTHER REMARKS ON THE EXECUTION OF PARALLELS. THAT EACH RELIEF OF WORKMEN SHOULD BE ALLOWED TO QUIT THE TRENCHES, ON FINISHING THEIR TASK TO THE SATISFACTION OF THE ENGINEERS ON DUTY.

As a matter of mere labor, it would evidently be better to cut the front step of the trench out of the solid ground, instead of forming it afterward, with loose earth from the rear; but as the first working parties have to work in the dark, often exposed and always expecting to be exposed to fire, it is of importance to simplify their task as much as possible, which cannot be more effectually done than by the arrangement of leaving the step to be formed afterward, by the second relief, who at this period will have the advantage of working by daylight.

Sometimes we have formed our parallels, with a reverse step, instead of a slope in rear, making this step eighteen inches in width, and equal in height to one foot nine inches, or to one half of the extreme depth of the trench, as shown in the annexed figure.



This construction, which diminishes the labor of the third task by twenty-one cubic feet, or seven-ninths of a cubic yard, is quite as good as the former, excepting for the passage of carriages, which enter into or issue out of a trench, more conveniently by means of a slope, than by steps.

When the working parties have a given task allotted to each relief, which in the construction of parallels and approaches is the best arrangement, or rather indispensably necessary; each party of twenty-five men should be allowed to quit the trenches as soon as they shall have finished their task to the satisfaction of the engineer on duty, who must of course previously ascertain this point by actual measurement, in which he will be assisted by the sappers of the division; and in so doing he should be very strict, rather measuring over than under; for as all the tasks are easy, it would not be fair to throw any part of the labor of the first upon the second, or of the second upon the third relief of workmen.

In case of any gratuity being promised to the working parties by the general commanding, for the execution of a particular work, it should never be granted without a certificate in writing from the engineer on duty in the trenches, that they finished their task to his satisfaction.*

62. ON THE EXECUTION OF THE APPROACHES CONNECTED WITH THE FIRST PARALLEL.

The rules for tracing the approaches connected with the first parallel, and for commencing the work, have already been explained. It now only remains to treat of the execution.

The profile of an approach so nearly resembles that of a parallel, and the quantity of labor necessary for the completion of both differs so little, that, generally speaking, the same rules as to the number of reliefs, and the proportioning of the task of each, may be followed in both cases.

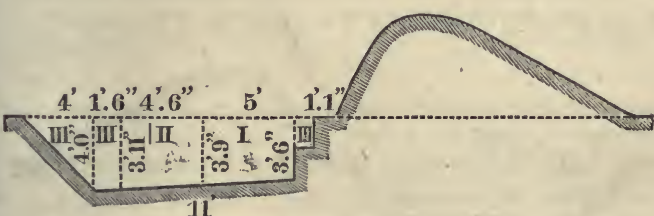
The only difference in the practice of this establishment is, that we have made our approaches generally a little deeper than our parallels, and we have usually made the

* This rule has generally been followed in our sieges, in which an extra allowance of grog or wine has sometimes been ordered to each man of the military working parties as a gratuity.

front steps and berm narrower, a banquette not being so essential in the former as in the latter. We have also usually made the parapets of our approaches a little higher than those of our parallels.

The reason is, that approaches, being laid out obliquely, require more relief than a parallel, in order to enable them to afford equal protection to the besiegers; for in the former, a man in the trench is covered by a distant point of the parapet, in an oblique direction, whereas, in the latter, he is covered by that part of the parapet which is near to and perpendicularly in front of him.

The subjoined figure represents the profile usually adopted by us, in which the trench is eleven feet wide at bottom, three feet six inches deep in front, and four feet deep in rear. The berm and front step are only one foot wide. The latter, instead of being formed with made earth, was cut out of the solid.



In the above figure the tasks of the three reliefs, as represented by the Roman numerals, I, II, and III, are as follows:

Each task being six feet in length, the first relief are to cut a trench (I) five feet wide, three feet six inches deep in front, and three feet nine inches deep in rear, which involves one hundred and eight and three-quarters cubic feet, or about four cubic yards of excavation.

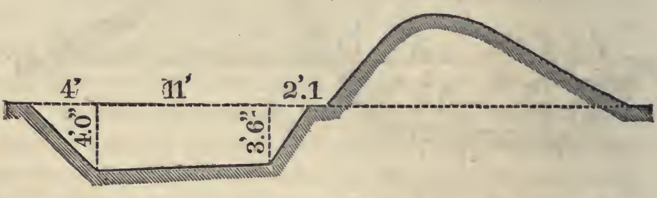
The second relief are to cut the trench four feet six inches wider, and two inches deeper in rear, which involves a task

(II) of ninety-nine cubic feet, being equal to three and two-thirds cubic yards of excavation.

The third relief are to cut the trench one foot six inches wider, and one inch deeper, which increases the total width of the approach to eleven feet. They will then cut the reverse slope, giving to it a base of four feet, which is equal to the extreme depth of the trench in rear. This being done, they will cut the front step, making it one foot wide, and one foot nine inches high, or one-half of the depth of the trench in front. These three portions (each marked III, III, III,) amount in all to eighty-five and three-eighths cubic feet, being nearly three and one-sixth cubic yards of excavation.

The whole of these tasks added together involve two hundred and ninety-three and one-eighth cubic feet, or very nearly ten and five-sixths cubic yards of excavation.

Sometimes an approach is made with slopes only, without having any steps in front, as shown in the annexed figure, which arrangement, however, can make little or no difference in the quantity of labor, or in the tasking of the men.



63. THAT ALL TRENCHES OR DITCHES SHOULD BE COMMENCED BY VERTICAL EXCAVATIONS, FINISHING THE SLOPES LAST.

Whenever an approach is formed with slopes in front and rear, as represented in the foregoing figure, the body of the trench is completed first, and both the slopes are cut afterward. And let it be understood that this is a rule which we have invariably followed, not only in forming the trenches of parallels and approaches, but in respect to the ditches of elevated batteries, and other excavations generally, in field fortification. We always commenced with vertical cuts of a rectangular section, until the great mass of excavation was finished, doing the slopes last of all. In executing these, the crest of each slope should first be marked out on the ground, after which small sections should be cut here and there, according to the proper form of the finished profile. Finally the intermediate earth should be cut away between these small sections, which answer the same purpose of insuring regularity in an excavation that wooden profiles erected at intervals do in the formation of a parapet.

If, on the contrary, the slopes be commenced from the first without these precautions, the men will either lose time in attempting accuracy, or will cut them at random, and thereby either disfigure the work or injure its stability.

VIII. Of the Execution of the Second Parallel, and the Approaches connected with it.

64. RULES FOR EXECUTING A SECOND PARALLEL COMMENCED BY THE FLYING SAP.

The method of arranging the workmen with their tools behind the line of gabions, so that the space covered shall be at the rate of two gabions, or about four feet per man, has already been explained. In this order the men are rather more crowded than one could desire, but the use of gabions, the size of which is necessarily limited, leaves no alternative.

When the order is given to commence work, every man will begin digging in the rear of his own two gabions, which he will fill with all expedition, striking the sides of the gabions from time to time with his shovel, and afterward patting the earth at the top, to shake it down and make it compact, before he throws any of it over. When filled, which may be done by good workmen in from seven to fifteen minutes, the line of gabions will be musket-proof everywhere, excepting at the intervals between the adjacent ones. The engineer officers superintending, and the sappers attached to divisions, will take care to instruct the men to force their gabions forward at top, whilst the work is in progress, in order to give them a slope of about one-fourth of their height, which is necessary to their stability, and which may be judged of, with sufficient accuracy, by the eye. This arrangement may be aided by introducing sods under the back of each gabion. The usual berm of eighteen inches must be left behind the line of gabions.

The parapet of a second parallel may be crowned with one or more rows of fascines laid over the gabions, with which it is reveted interiorly. In other respects it does not differ from that of a first parallel, and the trenches of both are exactly alike.

When fascines are used to crown the gabions in a second parallel, which arrangement however can scarcely be necessary under ordinary circumstances, the second and third reliefs of men ought to take them out with them, each man carrying a six-feet fascine, and two or three pickets. If more fascines and pickets should be required at this period, and generally speaking on any other occasion, when the regular working parties cannot carry a sufficient quantity of materials for their own use, the guards of the trenches may be ordered to call at the engineers' depot for the purpose of receiving materials, which they will deposit on the reverse of the trenches, in such situations as shall be deemed most convenient.

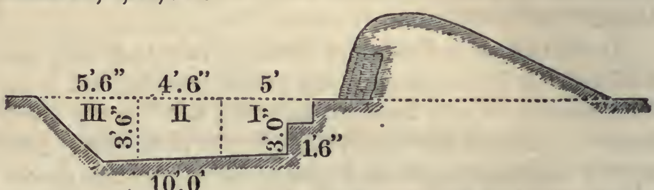
65. PECULIAR ARRANGEMENTS FOR CONTINUING AND FINISHING A SECOND PARALLEL, BY THE SECOND AND THIRD RELIEFS OF WORKMEN, AT SIX RUNNING FEET OF TRENCH-WORK PER MAN.

Though the workmen who commence the second parallel by the flying sap, are extended at the rate of only four feet per man, the same necessity does not exist for thus crowding the workmen of the second and third reliefs, employed in continuing and finishing the same parallel, who should each be required to execute a task of six running feet per man. Hence the number of workmen demanded for the second and third reliefs should only be two-thirds of the number previously employed in commencing the second parallel. Owing to this change in the arrangements, the workmen in the first relief, after finishing their task, must carry all their tools back with them to the engineers' depot, instead of leaving them in the parallel, as suggested in Article 42, which applied to different circumstances. The second relief must therefore bring their tools out with them.

As the task of a division of twenty-five men is only one hundred feet in commencing the second parallel, but is to be increased to one hundred and fifty feet for the same number of men of the second relief, it will be necessary previously to divide the whole extent of the parallel into spaces of one hundred and fifty feet, which must be marked by pickets or banderols, at their extremities, including seventy-five gabions between each pair of such pickets. This must be done by sappers under the direction of the engineers, and when the space allotted for the task of each division of the second relief is marked out, a sapper must be stationed at each picket or banderol, on reaching whom each division of the working party must be halted and fronted, in the manner before explained in Article 42. When this is done, the men composing each division must be extended over their respective spaces, until the whole of the gabions are covered by a line of men posted behind every third gabion, placing the first man behind the second gabion, the second man behind the fifth, the third behind the eighth, and so on until the whole extension is completed. Every man will then be set to work, each preserving his proper place, and continuing the excavation of the trench to the rear, along the whole space occupied by his own three gabions.

If the commanding engineer should deem it convenient, the men of the second relief, before they quit the trenches, may be directed to leave their tools behind every third gabion, to mark the proper position and at the same time the extent of task of the men of the third relief, who are to work in equal numbers along the same extent of ground, and may use the same tools.

The annexed figure is a section of a second parallel, finished with gabions only, not crowned by fascines, in which the tasks of the three reliefs are marked by the Roman numerals, I, II, III.



The task of the first relief includes also the excavation of the space now occupied by the front step, which is supposed to have been added afterward by the second relief. The clear width at the sole of the trench is supposed to be ten feet, being the same as in the first parallel, with which it likewise agrees in all its other dimensions, as was before stated.

66. STATEMENT, BOTH IN CUBIC FEET AND IN CUBIC YARDS, OF THE QUANTITY OF EXCAVATION IN A FIRST PARALLEL, FINISHED IN THREE TASKS, AT SIX RUNNING FEET OF TRENCH-WORK PER MAN, AS COMPARED WITH THAT OF A SECOND PARALLEL COMMENCED BY THE FLYING SAP, AT FOUR RUNNING FEET ONLY PER MAN, IN THE FIRST TASK, ALL OTHER PARTICULARS BEING THE SAME IN BOTH.—(*Compare the foregoing figure with that in Article* 59).

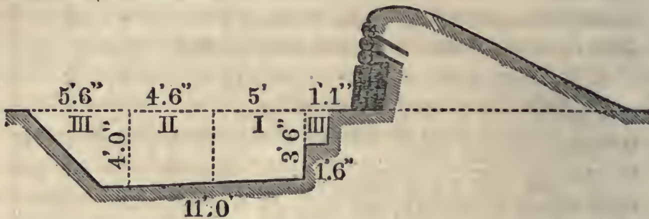
COMPARATIVE EXCAVATION.	1st. Parallel.		2d. Parallel.	
	Cubic Feet.	Cubic Yds.	Cubic Feet.	Cubic Yds.
1st Task (1) 5 feet wide, 3 feet deep in front, 3 feet 3 inches deep in rear	$93\frac{3}{4}$	$3\frac{1}{2}$	$62\frac{1}{2}$	$2\frac{1}{3}$
2d Task (II) 4 feet 6 inches wider, 3 feet 3 inches deep in front, 3 feet 5 inches deep in rear	90	$3\frac{1}{3}$	90	$3\frac{1}{3}$
3d Task (III) 2 feet wider at bottom, which completes the sole of the Trench, making it 3 feet 6 inches deep in rear, and a reverse slope, having a base of 3 feet 6 inches, equal to its height.	$78\frac{1}{4}$	$2\frac{8}{9}$	$78\frac{1}{4}$	$2\frac{8}{9}$
Total . .	262	$9\frac{2}{3}$		

67. RULES FOR EXECUTING THE APPROACHES CONNECTED WITH THE SECOND PARALLEL, AND COMMENCED BY THE FLYING SAP.

These also differ from the first approaches, only in having their parapets reveted with gabions, or with gabions and fascines. In the execution no further difference occurs than what must necessarily arise from the use of gabions, the tasks of the several reliefs of men employed being alike in profile, and proportional to each other, in the ratio of two to three, in the first reliefs of each, in consequence of the men, who commence by the flying sap, being drawn up at intervals of four feet apart, instead of six feet; but in the second and third reliefs, the tasks are equal, each man having six feet of trench-work to execute.

The subjoined figure is the section of an approach of this description, having its gabions crowned by three courses of fascines, which should be laid at the same slope of one-fourth which was before prescribed in placing the gabions.

These fascines must be secured by pickets driven through them obliquely downward into the earth, at an angle of about forty-five degrees. There should be two such pickets to a six-feet fascine.



It was before explained in Article 62, that approaches usually require more relief than a parallel; and for this reason it may sometimes be expedient to crown the parapets of approaches commenced by the flying sap, with several courses of fascines, as shown in the above figure; whereas this precaution might be entirely dispensed with, in a second parallel, situated at the same distance from a fortress of equal command.

The want of cover in the trenches of approaches is more felt at the angles of the zigzags, than anywhere else; and therefore it may sometimes be expedient, even in the approaches in rear of the first parallel, which are generally left unreveted, to revet their parapets, for about ten or twelve feet, at each angle of the zigzags only. It may also be proper for the same reason, to cover out those angles by raising not only their own parapets, but also certain portions of the parapets of the trenches in front of them, and at some distance from them, one or more feet higher than the general level of the adjoining parapets.

Portions of the parapets thus raised, although for a different purpose, partake of the nature of trench cavaliers, so far as the construction alone is concerned: and therefore when more than usual height is required, it might be preferable to use a couple of tiers of gabions, with one inter mediate row of fascines, instead of gaining the whole height necessary, by crowning one course of gabions entirely with fascines, in the manner represented in the foregoing figure. But as well reveted parapets, which are always essential in gun batteries and trench cavaliers, are only required occasionally in approaches, I shall not enlarge further upon the construction of such revetments at present.

When small portions only of a set of approaches are to be reveted, or when small portions only of the parapets of the trenches are to be raised, it is better to employ extra men for the purpose of executing such details, than to make them a part of the task of any of the regular working parties.

68. STATEMENT, BOTH IN CUBIC FEET AND IN CUBIC YARDS, OF THE QUANTITY OF EXCAVATION IN THE FIRST APPROACHES, FINISHED IN THREE TASKS, AT SIX RUNNING FEET OF TRENCH-WORK PER MAN, AS COMPARED WITH THE MORE ADVANCED APPROACHES AFTERWARD COMMENCED BY THE FLYING SAP, AT FOUR RUNNING FEET OF TRENCH-WORK PER MAN, IN THE FIRST TASK, BUT AT SIX RUNNING FEET PER MAN, IN THE OTHERS.—(*Compare the foregoing figure with the first figure in Article* 62).

COMPARATIVE EXCAVATION.	First Approaches.		Advanced Approaches.	
	Cubic Feet.	Cubic Yds.	Cubic Feet.	Cubic Yds.
1st Task, 5 feet wide, 3 feet 6 inches deep in front, and 3 feet 9 inches deep in rear	$108\frac{3}{4}$	4	$72\frac{1}{2}$	$2\frac{2}{3}$
2d Task, 4 feet 6 inches wider, 3 feet 9 inches deep in front, and 3 feet 11 inches deep in rear	99	$3\frac{2}{3}$	99	$3\frac{2}{3}$
3d Task, 1 foot 6 inches wider at bottom, and 4 feet extreme depth, besides a reverse slope of 4 feet base, and a front step of 1 foot wide, and 1 foot 9 inches deep	$85\frac{1}{3}$	$3\frac{1}{6}$	$85\frac{3}{8}$	$3\frac{1}{6}$
Total . .	$293\frac{1}{8}$	$10\frac{5}{6}$		

69. THAT TWO RELIEFS OF WORKMEN MAY BE SUFFICIENT FOR FINISHING PARALLELS AND APPROACHES IN EASY SOIL.

Having kept records of the various periods of time employed by every individual of successive parties under instruction, in finishing parallels and approaches at Chatham, in all varieties of soil, from the easiest, which required very little picking, to the most difficult, which demanded the constant use of the pickaxe, I shall subjoin an abstract of two of these reports of parallels, one of which was finished in the shortest time known at this establishment, and the other in nine and a half hours, in as difficult soil as can be expected to occur anywhere, without coming under the definition of rock. On one occasion, as noticed in article 56, one hour more was occupied in finishing a parallel in the same sort of difficult soil by another party of men, but the report of this latter experiment was not entered in the record book in sufficient detail to make use of it.

ABSTRACT OF TIME, ETC., IN MAKING A FIRST PARALLEL.

Date, No. of men employed and Soil.	Tasks, No. of.	Cubic Feet.	Time of Individuals. Shortest.		Time of Individuals. Longest.		Average Time of all the men.	
			Hours.	Min.	Hours.	Min.	Hours.	Min.
Mar. 11th and 12th, 1828. 20 men. Very difficult soil.	First . . .	$93\frac{3}{4}$	1	10	3	10	2	17
	Second . .	90	2	25	4	0	3	23
	Third . . .	$78\frac{1}{4}$	2	35	4	30	3	50
	The whole Parallel.	262	6	12	11	55	9	30
October 12th and 13th, 1828. 30 men. Very easy soil.	First . . .	$93\frac{3}{4}$	0	16	1	30	0	44
	Second . .	90	1	5	2	40	1	36
	Third . . .	$78\frac{1}{4}$	4	0	4	0	2	34
	The whole Parallel.	262	2	41	8	4	4	54

In the various records, it was observed that the individual who was the most expeditious in performing the first task, was sometimes slower than other men, in executing the second and third, and *vice versa;* but as the whole of the parallel in very easy soil in one of these examples was finished by one very active and zealous workman in two hours and forty-one minutes,* and by the worst workman out of thirty men, in eight hours and four minutes, and as it was executed by the average labor of the whole party in four hours fifty-four minutes, it will be evident, that the number of tasks proper for finishing a parallel in such soil may be diminished from three to two; but the details of executing a parallel by two reliefs of men only will afterward be explained. A working party of men of the line might not perhaps finish quite so soon, but even if entirely unaccustomed to labor, it is not likely that in completing the same task, they would require more than one-third of additional time, over and above the periods stated in the above table; and even if one-half more, making an average of seven hours twenty-one minutes in all, should be required for finishing the parallel: to do this in two tasks only would not involve a greater personal exertion, than able-bodied men are capable of undergoing without over-fatigue.

70. OF FLANKING BOYAUS, OR SUCH PORTIONS OF THE APPROACHES, IN A SIEGE, AS PARTAKE ALSO OF THE NATURE OF PARALLELS.

When a set of approaches are on the extreme right, or on the extreme left of the trenches, in a siege, those branches of them which have their parapets facing outward, are termed flanking boyaus, and may be made to answer the

* Private Hugh Lanyon, since promoted to the rank of serjeant, after having been employed for several successive years with a party of R. sappers and miners, at the R. M. College, Sandhurst, in making field-works for the instruction of the gentlemen cadets.

double purpose of acting also as places of arms, or parallels, for containing the troops destined to repulse the sorties made by the besieged, if such sorties should be attempted, as is most frequently the case, on the flanks of the trenches.

Thus, for example, if we suppose the first and second parallels, and the approaches from the rear to the second parallel in a siege to be finished, and that an enemy makes a sortie at this period, it will be evident, that if he advances in front, the troops in the parallels will oppose him by a direct fire; but if he should attempt to penetrate in rear of the second or first parallel by either flank, troops placed in flanking boyaus, will be more conveniently situated than those in either of the two parallels for defeating this object.

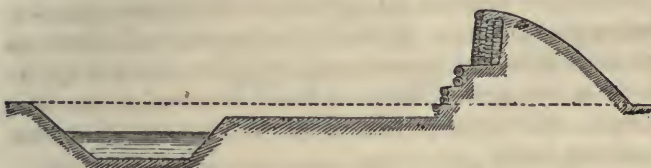
Flanking boyaus, therefore, should never be finished with a front slope, as shown in figure 2, Article 62, nor with narrow steps; but with broad steps and a banquette, like a parallel. In other respects, they need not differ from common approaches.

IX. Modifications in the Construction of Parallels and Approaches that may Become Necessary, from Circumstances.

In the above rules and examples, we have supposed the fortress to be situated on a plain, and to have only that moderate degree of command over the country to which the foregoing profiles are suited, and we have also supposed the soil to be favorable for the works of the besiegers. If the soil were unfavorable, it might be necessary to alter the profiles both of parallels and approaches in the manner about to be explained.

71. MODIFICATIONS THAT MIGHT BE REQUIRED IN MARSHY OR ROCKY SOIL.

First, supposing water to be found a few feet below the surface, as in Holland and other marshy countries, it would not always be practicable to excavate the trenches, in which the troops are to be posted, to the extreme depth of three or four feet as before supposed, without inundating, and thereby rendering them unserviceable. Hence it may be necessary to make shallower and wider trenches, and even to cut a ditch in rear of such trenches and below the usual water level, in order to supply earth for the parapet which in such soil must be raised much higher above the ground, than in dry soil. The subjoined figure represents the sort of profile now alluded to.



Secondly, supposing rock to be found one or two feet below the surface, it would in this case also be necessary to make a shallower trench, and a parapet much higher above the natural ground, than in the regular profile suited to deeper soil, and it might perhaps also be necessary to carry earth from the rear, in sand-bags or otherwise, instead of throwing it all forward by shovels.

Under both of these suppositions, whether of water or of rock below and near to the surface, it may be expedient, in working by night, to obtain earth not only from the rear, but also from the front; and more gabions, fascines, and other materials, will be required than under ordinary circumstances.

In making the trenches alluded to, in proportion as the depth is diminished the width necessary for the task of the first relief of men should be increased; and in the second and third reliefs the number of men may also be increased to more than the number proper for more favorable soil: but I would not generally recommend employing more men than usual in the first relief, because it might produce confusion.

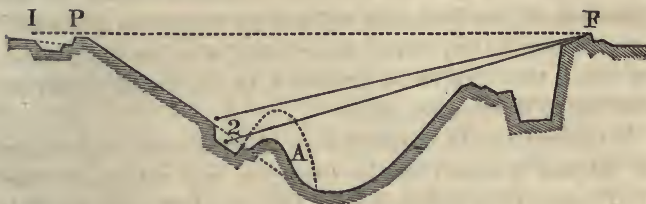
72. CONSIDERATIONS TO BE KEPT IN MIND IN RESPECT TO PARALLELS AND APPROACHES ON IRREGULAR GROUND. THAT APPROACHES SHOULD NOT BE MADE DOWN HILL.

First, if the fortress should be situated on a very commanding eminence, it is obvious that the trenches must be cut deeper and the parapets raised higher than the profiles before described, which apply to ordinary circumstances, that is, supposing the parallels or approaches of the besiegers to be constructed on level ground.

But if we suppose the ground on which these parallels and approaches must be made to slope regularly down on all sides, from the commanding eminence crowned by the fortress, this ground being naturally defiladed, is not unfavorable, and may not require deeper trenches or higher parapets than usual.

Secondly, supposing that there are heights opposite to the fortress, and divided from it by an intervening ravine, at the distance of from five or six hundred yards or upward, these heights should be occupied by the besiegers, as they will be favorable for the construction of parallels or batteries; but approaches should not be made from thence down the declivity, because they will be seen and plunged into by the guns of the fortress.

The reason is, that every branch of an approach being always very oblique, in reference to some part of the works of a fortress of any magnitude, the men in the reverse of the trench are not covered by that part of the parapet of the same branch, which is perpendicularly in front of them, but by some distant part of it, which may be thirty or forty, or even so much as sixty feet lower down the slope. Hence, if we suppose the ground to dip at the rate of one foot in five, the part where the reverse of a descending approach would require to be excavated, may be six or eight, or even twelve feet higher than the other part of the same ground, where the parapet that ought to cover it from some of the guns of the fortress would be situated. Hence, instead of a total relief of about eight feet, which is sufficient for the parapet of an approach against a fortress situated on a plain, which agrees with the profiles before given in articles 62 and 67, it might require the parapet to have a relief of fourteen or sixteen, or even twenty feet, to cover every part of the trench of an approach so situated.



These particulars are exemplified in the foregoing figure, in which the parapet of the parallel P, crowning the summit of a height opposite to the fortress F, from which it is divided by a ravine, affords good protection against the shot, 1, fired from the fortress; but the parapet of the approach A, on the ground below, sloping toward the fortress, affords no protection to the men behind it, against the shot, 2, of the fortress, nor could it possibly afford such protection unless it were raised to the very inconvenient, or one may say impracticable height, shown by the dotted outline above it.

In short, approaches should never be carried down the slope of a hill occupied by the besiegers, but should be carried round from the rear of the hill, so as to turn the flank of it, which I believe may always be done.*

* For example, in the attack of Burgos, supposing the hornwork to be taken by the besiegers, the high ground on which it is situated ought to be occupied by a portion of parallel with approaches from the rear, as well as by gun and mortar batteries; but instead of carrying approaches from thence down the slope of the hill, I would recommend the turning of that

I do not think that there is any example of a fortress being situated in a hollow at the extreme bottom of a descending slope; and therefore, except to draw attention to a principle, it may be deemed scarcely worth while to observe, that it would be less objectionable to make approaches down hill against such a fortress. In fact, whenever the path of the shot fired point blank from the guns of a fortress, is parallel to the surface of the ground outside, the approaches of the besiegers will not be subject to inconvenience, or require any extraordinary relief, whether the ground, on which they are to be executed, be horizontal, or an ascending or descending plane.

To return to the consideration of our former supposition of heights occupied by the besiegers, and separated from the fortress by a valley, it may be remarked, that parallels on the descending slope immediately below such heights are also objectionable, from their requiring a deeper trench and higher parapet than would suffice on level ground, but not in so great a degree as approaches, because, as was before stated in article 62, the men in the reverse of the trench of a parallel are protected by those parts of the parapet which are either perpendicularly opposite to them or nearly so, not exceeding about twenty feet at the utmost. Even this, however, would evidently be a very great inconvenience, if the slope were steep.

To investigate the farther modifications in the outline or profile of parallels or approaches, that might be required by other varieties of irregular ground not yet noticed, would be superfluous in a treatise of this kind, because the expedients necessary for overcoming or evading the difficulties thereby occasioned, will readily suggest themselves to an intelligent officer, on the scene of action.

height by going round it, without attempting any direct communication from thence to whatever works might afterward be executed in front of it, on the ascending slope opposite.

X. Of the Arrangements and Regulations Proper for Military Working Parties in a Siege.

73. OF THE BEST MODE OF SUPERINTENDING THEM. THAT THE REGIMENTAL OFFICERS OF THE WORKING PARTIES SHOULD BE HELD STRICTLY RESPONSIBLE, FOR THE EXECUTION OF THE QUANTITY OF WORK ORDERED TO BE DONE. THAT MIXED WORKING PARTIES, COMPOSED OF MEN OF DIFFERENT CORPS, OUGHT NOT TO BE EMPLOYED.

The subject of this article is of such importance, that it appears proper to treat of it in some detail, although the general principle about to be developed, might have been inferred from some observations to the same effect, previously made.

It has already been implied, that the engineers on duty should only be responsible for marking out the several works, for supplying materials and tools, and for making such arrangements and giving such directions, as will enable the working parties of the line to execute their tasks to proper advantage. If the soldiers of the working parties do not exert themselves as they ought to do, let the engineers make their representation to the general or field officers on duty in the trenches.

The regimental officers of the corps which furnish the working parties, should be held solely and most strictly responsible, for the diligence and exertions of the men under their command. The captains, subaltern officers and sergeants, attached to each division of the working parties should move about continually, to encourage the diligent, and reprove the idle; and the field officers in charge of several divisions should in like manner move about the whole line of workmen under their charge, to see that the men are diligent, and that the officers and sergeants* are

* It was before mentioned that corporals, as rank and file, take their share of the work in the British service.

doing their duty. These field officers should be held responsible for the diligence of the working parties under their command, by the general officer or officers, on duty in the trenches; and the latter should be responsible for the proper execution of the operations of each period of twenty-four hours, to the general officer in command of the besieging army.

It is of the most vital importance to the success of a siege, that this system of responsibility, from the regimental officers of working parties to the general officers on duty in the trenches, shall be established, and fully understood, and inflexibly adhered to; for which reason the commanding engineer ought to apply to the commander of the forces, to issue a general order to this effect, previously to the opening of the trenches; for if this precaution be neglected, it is but too likely that many officers of the working parties will remain perfectly inert, and leave every thing to the engineers, who cannot be expected to keep the workmen diligent, when the latter see that their own regimental officers, who have more influence over them than any others, are either asleep, or grouped together in some corner, in conversation, in a state of apparent indifference to the progress of the work. Such an order is also necessary, to counteract a pernicious and unreasonable prejudice, which appeared to prevail amongst the officers of some regiments of the line, at the commencement of the late interesting wars with France, against being employed on working parties at all. Too much pains cannot be taken to prevent the recurrence of a feeling so radically opposed to the success of all siege operations.

To carry this subject further, it may be considered of great importance in the execution of a parallel, and the same remark may generally apply to other works of a siege, that the praise of diligence, and the disgrace of failure shall not be frittered away by employing mixed working parties; but that one particular division of the army shall have the whole of the operations of the first twenty-four hours, whether the men be relieved three times or only twice within that period• and that each brigade and battalion of this division shall have its own distinct portion of the work, which no men of any other corps shall meddle with. Thus, if the whole of the work directed to be done in the twenty-four hours should be well executed, the whole division generally will have the credit of it. If the whole should be badly executed, or incomplete, the disgrace will attach to the division as a body; but if part only should fail, the disgrace will attach to the particular regiment, which either neglected or proved incompetent to its share of the duty.

In the construction of the first batteries, which are usually commenced the second night, the same system should be followed with a second division of the besieging army, each battalion of which might have its own distinct battery allotted to it; and by pursuing this system, both regimental officers and men would take a strong interest in siege operations, and would feel their own honor and reputation involved in them, which beneficial feeling, by all accounts, has hitherto scarcely ever prevailed amongst the troops in general, in any of the sieges carried on by the British army. Indeed the operations of those sieges, as recorded by Colonel Jones,* in his able and useful work, speak for themselves. When we find that in the sieges of the Peninsula a task of no more than four feet in length, three feet in depth, and three and a half feet in width, being only forty-two cubic feet, or about one and half cubic yards, of excavation, was only executed by each individual of the military working parties as their first night's work, which task we know by experience may be finished by an able-bodied man, with very moderate ex-

* Now Major-General Sir John T. Jones, K. C. B.

ertion, in twenty minutes,* in easy soil, that requires little or no picking; and in less than one hour in the hardest and most difficult soil that does not exactly come under the definition of rock; one cannot but feel mortified and ashamed that the exertions of the British army, on such occasions, should have fallen so miserably short of their brilliant exploits in the field.† It was not so in the royal navy, where officers and men equally disdained to skulk from useful labor as to shrink from danger; and where the watering of Nelson's fleet on the coast of Barbary, in an extraordinarily short space of time, just before he proceeded to the West Indies, was regarded with almost as much pride as the memorable victory of Trafalgar, that was gained not many months afterward.

I attach so much importance to having the duty of working parties done by regular divisions, brigades, battalions, and companies, that I am confident that any number of workmen furnished according to this system, will do as much as twice their number of mixed working parties, each composed of officers and soldiers of different regiments, furnished according to the roster: a system which, in our service, has been too often carried from the garrison guard-mounting‡ into the camp of the besieging army, and which,

* Sergeant Lanyon finished his first task of a parallel, nearly one hundred and nine cubic feet, in sixteen minutes, in easy soil (see the note to article 69). At this rate, an active workman might have finished his first night's task in the British sieges in Spain, in seven minutes.

† Always, however, making an honorable exception in favor of the working parties furnished by his majesty's foot-guards, who did as much as officers and men could do, so that I really do not think that their exertions in making batteries, &c., on service, have been exceeded in our practice at this establishment. I speak to this fact not only from my own observation, but from that of Colonel (now Major-General) Sir John F. Burgoyne, K.C.B., and other brother officers of much greater experience than myself.

‡ In garrisons in which the duty is regulated by roster each corps furnishing a daily detail in proportion to its number, nothing is more com-

in all cases, more or less injures that organization upon which discipline depends, and to a certain degree converts an army into a mob.

74. OF THE NUMBER OF TIMES THAT THE WORKING PARTIES, GUARDS OF THE TRENCHES, ETC., OUGHT TO BE RELIEVED IN THE TWENTY-FOUR HOURS.

It must be evident, on a little reflection, that the marching ing backward and forward between the trenches and their camp or cantonments may occasion considerable fatigue to the troops of a besieging army, besides occupying a good deal of time. Hence, if the total number of reliefs or changes of men be limited, which is always the case, it follows that the oftener they are relieved in the twenty-four hours, the more harassing it must be to those men, who might, even by increasing the number of times they were sent on duty within that period, be kept in almost constant movement, or preparation for movement, without due time for rest.

For this reason the guards of the trenches, who, unless the enemy makes a sortie, are usually in a state of rest, with the exception of pickets or sentinels, or men employed as sharpshooters, are not relieved oftener than once in twenty-four hours; and the same system is followed in relieving the artillery, whose exertions are not generally of a very labori-

mon than to see a guard composed of an officer of one regiment, non-commissioned officers of another, and privates of two or three others. Hence no one regiment or corps can drill to advantage, for no regiment is ever off guard in a body. Thus the discipline of all suffers, and if the duties of such mixed guards involved any serious exertions or responsibility, it is my opinion that the service would be much more likely to suffer through neglect than under the more salutary system of causing each guard to be furnished by officers, non-commissioned officers, and privates of one and the same corps. At the same time I admit that the roster system in garrisons, if only used occasionally, does good, by destroying a prejudice, which young soldiers are apt to entertain, that they ought only to be commanded by their own regimental officers.

ous nature, because the ordnance in a siege is not fired frequently and incessantly, as in battle.

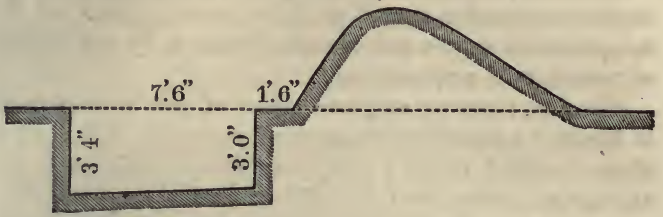
The working parties, on the contrary, must necessarily be relieved oftener; for a man cannot work for more than eight hours, without being exhausted; and if he be stimulated by taskwork four, five, or six hours, at the utmost, of actual exertion will be quite sufficient.

On the other hand, it may be observed, that to bring a body of men into the trenches, to execute any task involving much less than four or five hours' labor, would really be trifling with the duties of a siege. Now if the soil be of any easy description, requiring little or no picking, and if the whole parallel be divided into three tasks or portions, such as were before described, each party might finish their respective tasks in less than two hours.

In case therefore of very hard soil, it is proper to divide the execution of a parallel or parallels into three tasks, to be executed by three reliefs of men, the first relief to commence their work at dusk, as explained in Article 37, the second at daylight next morning, and the third at noon. But in very soft soil, as was before implied in Article 69, it will be better and less harassing to the troops, to divide the work into two tasks only, and consequently to have no more than two reliefs of workmen in twenty-four hours. We shall now consider the details of this arrangement as applied to a first parallel.

75. FIRST TASK, IN EXECUTING A FIRST PARALLEL BY TWO RELIEFS, IN EASY SOIL.

Being drawn up at the usual rate of one man to every six feet of trench-work as before, each man must cut his portion of trench to the width of seven feet six inches from front to rear, making it three feet deep in front, and three feet four inches in rear, which amounts to about one hundred and forty-two cubic feet, or rather more than five and a quarter cubic yards of excavation.



76. SECOND TASK, IN EXECUTING A FIRST PARALLEL BY TWO RELIEFS, IN EASY SOIL.

The second relief of men should be marched into the trenches at daylight, and should make the front step, and add four feet to the width of the original trench, which will increase it to the width of ten clear feet at bottom, over and above the base of the said step, and to the extreme depth of three feet six inches in rear; after which they must finish the trench, either with a reverse slope, having its base equal to its height, according to the profile before represented in the figure in Article 59; or with steps in rear, according to the figure given in Article 61.

When the parallel is finished with a reverse slope, the task of the second relief amounts to about one hundred and twenty cubic feet, or to four and a half cubic yards nearly; but when it is finished with reverse steps, the task of the second relief amounts only to about ninty-nine cubic feet, or to three and two-thirds cubic yards.

In either case, after completing the excavation according to the profile prescribed, the second relief of workmen must make a perfect finish of the parapet, and cut cesspools, &c., to secure the trench against the effects of rain, as before directed, which will not be a difficult task, as the men have the whole day before them to execute, what would scarcely require more than from two and a half to three hours of active exertion at the utmost.

The same principle may be applied to the execution of the first approaches, as well as of the second parallel and of the advanced approaches connected with it, by two reliefs of men only, in very easy soil.

Whether three or only two reliefs of men be employed in finishing a parallel or an approach, according to the tasks above specified, the first party may always complete their excavation sooner than the others, after they shall have been fairly set to work; but the loss of time in preliminary arrangements and the unfavorable circumstance of commencing by night, will counterbalance this advantage, and tend to equalize the trouble of all.

77. OF THE TOTAL NUMBER OF TROOPS NECESSARY IN A SIEGE, TO FURNISH MEN FOR EVERY OPERATION, IN REFERENCE TO THE NUMBER OF RELIEFS EMPLOYED IN EACH, IN THE TWENTY-FOUR HOURS.

When soldiers are employed in military duties, in the trenches or batteries, in a siege, and are relieved only once in the twenty-four hours, three changes of men may suffice, and even when they are relieved twice in the twenty-four hours the same proportion may regulate the total number of men necessary.

Thus, for example, six thousand infantry, and one thousand and two hundred artillery, might supply daily two thousand men for guards of the trenches, and four hundred gunners to man the batteries in a siege; as troops employed in the former duty are only relieved once in the twenty-four hours, and the artillery are seldom relieved oftener.

In respect to the working parties, as these would generally be relieved three times in the twenty-four hours, it is desirable that there should be four changes of men in all, by which means each relief would only be on duty once in thirty-two hours, which would allow ample time for rest, whilst this arrangement would prevent the same men from always coming on duty at night, which must necessarily be the case if there were only three changes of men to supply all the three reliefs. If therefore the average number of workmen wanted for constant duty day and night, at the commencement of a siege, should be estimated at one thousand and two hundred, it would require four thousand and eight hundred infantry to supply this number in four reliefs, three of which only should be employed within the space of twenty-four hours. This number, added to the two thousand before mentioned, would require six thousand and eight hundred men, for all the infantry duties of the siege.

In estimating the number of officers and soldiers of the engineer department necessary for a siege, the same rule should be observed which applies to working parties of the line. Hence the number of reliefs would be the same for both, but it has been considered best to relieve the engineers at intermediate periods between the hours of relieving the workmen, in order that the former may get perfectly acquainted with every thing necessary before the arrangement of the new working parties, which always occasions some difficulty, shall be thrown upon them. This was the system usually followed in the sieges in the Spanish Peninsula. In respect to the proportion which engineers ought to bear to the working parties of the line, one to twelve appears to me to be desirable, in order to insure proper superintendence and efficiency.

It is evident that over and above the number of soldiers wanted for the daily operations of siege, a certain proportion would also be required on account of casualties, to replace men killed or wounded by the enemy, or disabled by sickness, and also to furnish men for the necessary duties of drawing rations, cooking, and for various other little details, which always engross a much greater number of men than one would suppose on a hasty view of the subject. But it is not my intention to enlarge further at present, on the mode of calculating the proper strength of a besieging army. I shall therefore conclude this article by observing that such estimates should always be made in reference to the number of effective rank and file that can be spared daily for duty, exclusive of soldiers necessarily employed in the various details before alluded to.

SCHOOL OF THE SAP.

PART III.

THE FULL SAP.

The approaches may be carried on by the flying sap until they arrive within close range of small arms from the covered way, after which the full sap must be employed.

This is a path executed by sappers, who advance foot by foot, covering themselves from the fire of the place by gabions, which are placed and filled in succession, and by a sap-roller placed at the head of the sap. The sap is called *simple* when, the fire coming from one direction only, but one gabionade or parapet is required. It is *double* when the fire, coming in two different directions, requires a gabionade on each side of the trench, which is effected by conducting two simple saps side by side, whose parapets mutually protect each other.

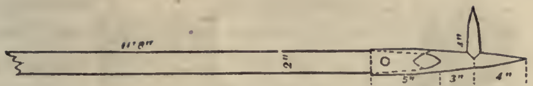
The simple full sap is executed by a brigade of eight sappers, four of whom are especially designated sappers, and are numbered 1st, 2d, 3d and 4th sappers, and four termed assistants, who are also numbered from one to four. The duty of the former is to excavate the trench, that of the latter to perfect the work and prepare material. During the operation the men composing the brigade frequently change places, so that every man shall in succession occupy every position.

Sapper No. 1 is placed at the head of the sap. He works kneeling, making an excavation 20″ deep and 20″ wide at the top, and leaves a berme of 12″, giving the side of the excavation toward the gabionade a slope of $\frac{1}{4}$ in ordinary earth. The opposite side should be vertical, so that the width at bottom may be 15″. The earth thus obtained is sufficient to fill the gabions. In ordinary earth this sapper should fill two gabions before being relieved. The second sapper follows, two gabions and a half in rear of the first; he also works kneeling. He increases the depth and width of the sap by seven inches, taking the earth from the reverse, and continuing the slope on the other side; this will leave his form 27″ wide at top, 20″ at bottom, and 27″ deep. The quantity of earth excavated by No. 2 is nearly the same as that by No. 1. The third sapper is also two gabions and a half in rear of the second (5′ 6″). He works on his feet, but stooping. He widens and deepens the sap 7″, leaving it 34″ deep, 34″ wide at top and 25″ at bottom. The fourth sapper, the same distance in rear of the third, widens and deepens the sap 6″; it is then 40″ deep, 40″ wide at top and 30″ at bottom. The excavation in this state, at which it does not arrive until eight gabions are placed, is completed, as a sap. Its parapet, even when formed of earth, which increases considerably in bulk from its movement, is only about 7′ 8″ thick at base, including the gabion, and 2′ 8″ high. It is then turned over to the ordinary workmen to be enlarged, and disposed for the reception of the guards of the trenches or for a communication.

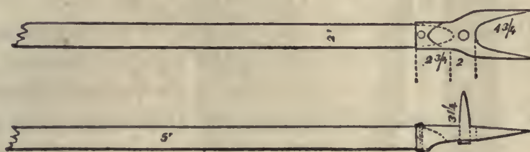
TOOLS.

Each of the eight sappers should be furnished with a pick and shovel, and each head of sap with two hooks, two forks and one or two drags.

The sap-hook has two prongs at right angles to each other, each 4″ long; the entire length of the fork is 1′, of which 4″

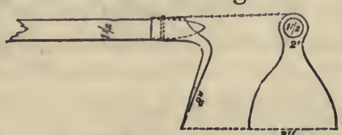


is for the point, $3\frac{1}{4}''$ for the body and $4\frac{3}{4}''$ for the socket; the handle is 11′ 8″ long, and is fastened in the socket with a rivet; to the other end is attached a ring $1\frac{1}{4}''$ or $1\frac{1}{2}''$ in diameter. The weight of the entire fork is about 13 lbs.



The sap-fork has three points, the two extreme, parallel and 4″ apart, the middle at right angles to the plane of the other two, the length of the iron part is 10″, of the handle 5′, the weight 11 lbs.

The drag is 8″ high, 8″ wide at the edge and 2″ at the eye; the handle is 3′ 4″ or 6′ 8″ long.

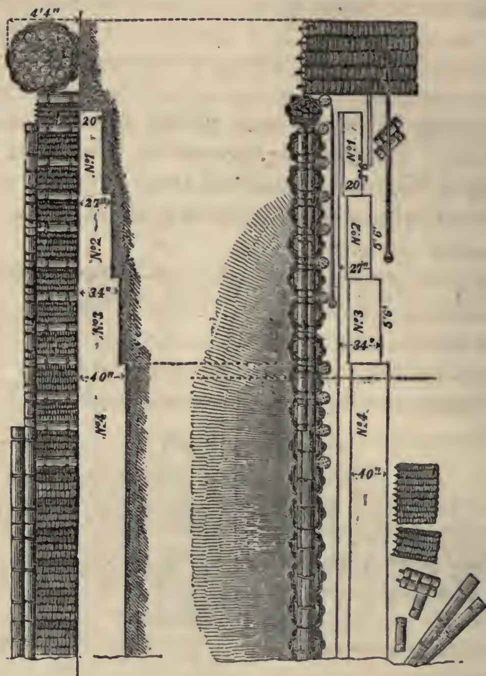


Each head of sap should be provided with 1 sap-roller, about 30 sap-fagots, and as many crowning fascines, ordinary gabions and fascines, levers 10′ or 12′ long, 4″ × 4″ crowbars, sand-bags, wool-sacks 20″ or 26″ in diameter and 30″ or 40″ high.

EXECUTION OF THE FULL SAP.

The following figure represents a sap in the course of construction.

The four sappers, having the positions indicated, work at



their respective forms. All the gabions opposite these forms, except the last-placed (which the first sapper is engaged in filling), are crowned with temporary crowning fascines. The joints of the gabion are closed with sap-fagots, as well as that of the last gabion and sap-roller. The latter is placed at the head, and perpendicular to the direction of the sap, in such a manner as to cover at least one foot of the first gabion. The picks and shovels which are not in use are placed on the berme, close to the gabions. One of the hooks is also on the berme, the other, on the reverse, is fixed in the roller, about two-thirds of the height of the roller, above the ground, and 1′ from the end; it is held in position by a picket driven through its ring into the ground; a sap-fork lies on the reverse near the first sapper, also two crowning fascines. The assistants are occupied with replacing the temporary crowning fascines with ordinary fascines, and supplying the head of the sap with all the necessary material. They are furnished with two sap-forks, which are placed on the berme, as well as their picks and shovels, which, in case of need, may supply the place of those broken at the head of the sap.

The sappers and their assistants have neither swords nor cartridge-boxes, their muskets are placed on the reverse, perpendicular to the trench, locks up, opposite their respective forms. The chief of sap, stationed a little in rear of the fourth sapper, directs the operation; the non-commissioned officer has charge of the assistants.

TO PLACE A NEW GABION.

When the last gabion placed is filled and crowned with two small fascines, and the first sapper's form has arrived opposite the middle of the gabion, he warns the chief by crying "*Halt.*" The latter examines the work, and if he is satisfied with it, gives successively the following commands:

1. "Attention."
2. "Gabion."
3. "Hooks."
4. "Forward."
5. "Enough."
6. "Fagot."
7. "Commence working."

At the first command the four sappers cease working, place the tools on the berme, and hold themselves in readiness to execute the manœuvres which the chief is about to command. At the second, sapper No. 1 removes the fagot from the joint of the last gabion and sap-roller, and places it a little in rear on the berme. The second sapper moves, if necessary, the handle of the hook on the reverse, to allow the passage of the new gabion. The fourth sapper receives a gabion from the assistants, rolls it along the reverse, holding it by the points of its stakes; it is passed successively to Nos. 3, 2 and 1. The latter places it on its base in the joint of the last gabion and sap-roller.

At the command "*Hooks*," sapper No. 2 takes the berme-hook and fixes it in the roller at about half the height of the top of the latter from the ground, and as near the parapet as possible. No. 3 seizes the other hook, and replaces it about the same height from the ground as the first. No. 4 aids No. 2, and the first assistant No. 3, and all prepare to push forward the roller. In this state of things the first and second sappers should be kneeling, and leaning against the berme. Nos. 3 and 1 assist on the side of the reverse, and stooping as much as possible.

At the command "*Forward*," the four sappers armed with the hooks push the roller forcibly but steadily forward, without abandoning it or deranging its perpendicular direction with respect to the sap. As the roller advances, No. 1 pushes the new gabion in the interval left between it and the last gabion, moving it by means of the fork. He indicates by the words "*more*," "*too much*," and "*enough*," what the sappers at the hooks must do to bring the roller into the proper position. In the mean while the chief of sap indicates to No. 1 whether the gabion is to be pushed nearer the place attacked or driven back, by the words "*out*" or "*in*."

At the command "*Enough*," the sap-roller is drawn back forcibly against the newly-placed gabion. No. 2 disengages his hook, and places it on the berme; No. 3 leaves his engaged, fastening it in its position by driving a picket through the ring with his pick. No. 1 takes the sap-fagot which he placed on the berme, and replaces it in the joint between the first and second gabions, striking the head of the central picket with the flat of the blade of his pick.

At the command "*Fagot*," which follows the last immediately, the assistants pass a fagot to No. 4, who passes it through Nos. 3 and 2 to No. 1; the latter places it in the joint of the first gabion and roller by means of his fork. The assistants also pass to No. 2 two crowning fascines, which he lays on the reverse near the roller.

At the command "*Commence working*," all the sappers resume the excavation, No. 1 keeping close to the berme, throwing back the opposite shoulder, throwing the earth carefully into the new gabion. When it is filled he crowns it with the two small fascines by means of the fork. The other sappers throw the earth in rear of the gabions, and as near to them as possible—the second being careful to throw it opposite the joints of the gabions of his own form.

CROWNING THE GABIONADE WITH FASCINES.

The object of crowning the gabions with the small fascines, is to increase the cover of the sappers engaged in the excavation, but as they only give the parapet a height of 44″, and do not bind the gabions together, they are replaced by ordinary fascines, which accomplish the latter object and procure a height of 52″ to the parapet. To effect this, as soon as there are in rear of the fourth sapper three gabions not crowned, the chief of sap commands, "*Fascines*." The first and second assistants, each provided with a fork, draw the temporary crowning fascines from these gabions down upon the berme; the third deposits them on the reverse; the fourth brings forward three ordinary fascines; the first and second take one and place it on the berme, raise it with their forks, and place it on the rear of the top of the gabions, joining it as closely as possible with the preceding, and strike it several blows, to engage it in the points of the gabion stakes. A second is placed in advance of this, and a third on top, and in the joint of the first and second.

TO CHANGE THE POSTS OF THE SAPPERS.

When the first sapper has terminated his task, which is, ordinarily, filling two gabions, the chief of sap commands, "*Attention*," then "*Change*." Each sapper falls back one form; the first assistant takes his musket and passes to the head of the sap, going between the sappers and the reverse. This assistant becomes the first sapper; the first becomes the second, the second the third, and the third becomes the fourth, the fourth passes to the rear of the brigade, and is fourth assistant. Each of the other assistants advances one number.

A wounded sapper is replaced by the first assistant; if he is badly wounded or killed, the sappers in rear deliver him to the assistants, who carry him off, and the work is immediately resumed.

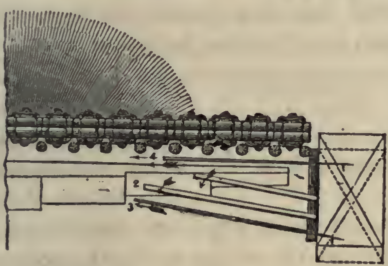
Each brigade should have a reserve, to replace those removed by accidents. A sapper taken from this reserve becomes fourth assistant.

TIME REQUIRED FOR EXECUTING THE FULL SAP.

In the schools of practice, when the full sap is executed in ordinary earth, about 15 m. are required to place and fill one gabion, consequently in one hour of uninterrupted labor the sap advances 8′ 10″. A brigade should be relieved after eight hours' labor; when this time is exceeded the men become too much fatigued to push the sap forward with the necessary rapidity. Experience has proved that although the excavations of the four sappers differ in volume they can be accomplished in the same time, which may be accounted for by comparing their tasks with the more or less cramped positions in which they work. But if from any cause one of the three last sappers is retarded, the chief of sap should push him on, and cause him to keep within two and a half gabions of the preceding, as the velocity of the sap should be regulated by the first sapper, and should experience a retardation from him only.

OBSERVATIONS RELATIVE TO INCLINED SOIL.

When the ground over which the sap passes is inclined in any sense whatever, it often happens that gabions placed on their bases simply, have not sufficient stability. The first sapper must endeavor to place them in the most favorable positions. The slope may be so great as to require the gabion to be propped with a fagot, sand-bag or sods.



When the ground is inclined toward the interior of the sap, the roller frequently descends by degrees in the same direction—finally no longer covering the gabionade, and leaving a dangerous opening. To bring the roller into its true position, the chief of sap gives the following commands:

1. "Levers. Fagots."
2. "Hooks."
3. "Replace the sap-roller."

At the first command the assistants pass from hand to hand to the first sapper, a well-bound sap-fagot, which he places on the ground parallel to the roller, opposite its middle and near its line of contact with the ground. Nos. 1 and 2 receive each a lever, which they engage under the roller, about 1′ each side of its middle, resting on the fagot as a fulcrum, and inclining toward the berme.

At the second command No. 3 takes the reverse and No. 4 the berme-hook, the former being fixed in the roller. The first assistant aids No. 3 and the second No. 4.

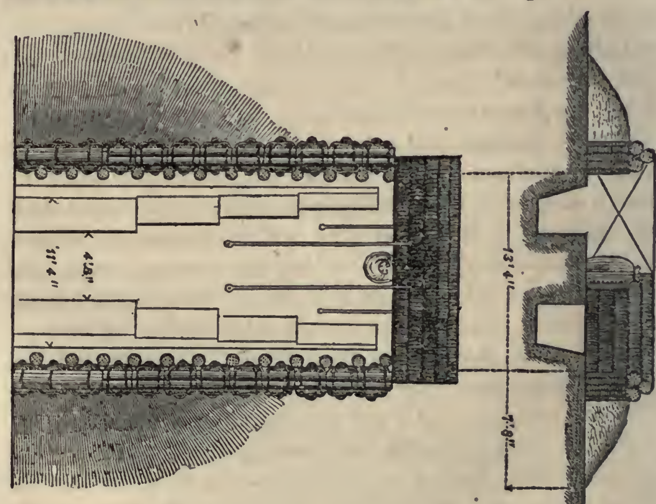
At the third command Nos. 1 and 2 weigh down on the levers, bearing them toward the reverse, thus moving the roller in the opposite direction. They should act by successive and sudden impulses, the sappers at the forks pulling strongly to prevent the roller from moving in advance.

This manœuvre may be facilitated by first running the roller a little forward by means of the hooks, then engaging the levers and drawing the roller back upon them. As it does not then rest upon the ground, it can more easily be moved in the direction required.

If there is reason to fear that the sappers will not be sufficiently covered during this operation by the crowning fascines, sand-bags may be placed on the fascines.

HALF-FULL SAP.

When the sappers have only a flank fire (coming in a direction nearly perpendicular to that of the sap) to fear, the sap-roller may be dispensed with. The first sapper then covers himself by the last-filled gabion whilst placing and filling the new one. This species of sap, to which application is sometimes found, is called the half-full sap.



DOUBLE SAP.

The details of the double sap are similar to those of the simple. The gabionades which form the two parapets, are 13′ 4″ apart in the clear, taking from this 2′ for the two beams, 6′ 8″ for the width of the saps at top, there remains a bank of earth 4′ 8″ thick in the middle, which is to be removed by the ordinary workmen. When this is accomplished, the double sap is 9′ 6″ wide at the bottom. The depth is usually 40″, but when the nature of the ground will permit, it may be greater, in order to facilitate the defilement.

The head of the double sap is covered by two rollers, placed end to end, each covering one of the lateral gabionades; it is well to engage the fascine with which one is filled, with those of the other; when this is not the case, their joint is masked with a wool-sack, which the two leading sappers push forward with their forks, after having placed their sap-fagots in the gabionade, keeping the joint always closed. The two brigades execute at the same time the commands of the chief of sap, who stations himself in that one in which he judges his presence most necessary.

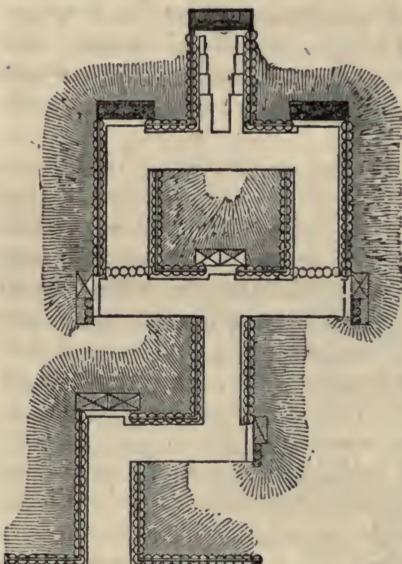
The two heads of sap should always be in the same state of advancement. The chief of sap should not give the command "*Attention*" until the sappers at the head of each have cried "*Halt.*" The sapper who first fills his gabion continues to enlarge his form until the other is ready.

This necessity of awaiting for the slowest sapper causes the double sap to advance with less rapidity than the simple. About one-fifth more time is required for the former, that is, eighteen minutes to a gabion.

When the double sap is pushed directly on the place, *traverses* must be formed from distance to distance to guard against enfilade fire.

These traverses are said to be "en cremaillères" when placed alternately on the right and left of the sap, "tournantes" (winding) when left in the middle of the sap, which surrounds them entirely.

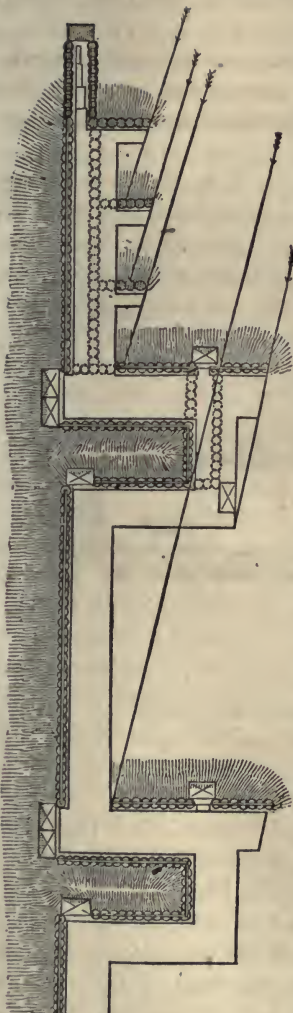
The position of the traverses and returns should be so situated that a man standing in any part of the sap cannot be seen from the place, and that projectiles cannot ricochet on the bottom.



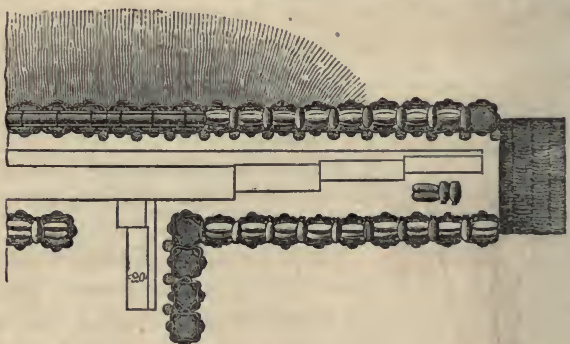
It therefore varies with the command of the place over the ground on which the sap is constructed, and as the ground is more or less favorable to ricochet. The construction of these traverses involves that of debouches, which will be treated of hereafter.

The inconveniences of the double sap are, 1st, length of time required in its construction. 2d, the parapets have not sufficient thickness. 3d, the guard and workmen are too much crowded. 4th, it affords less facilities than the simple sap, to be pushed forward by the flying sap, when a favorable opportunity offers. 5th, its direction exposed to plunging, enfilade and reverse fire. 6th, the head of the sap has no lateral protection against sorties.

HALF DOUBLE SAP.



Frequently the double sap is traced over ground so much inclined, that one sap is exposed to fire passing over the parapet of the other; this frequently occurs in the crowning of the covered way. In this case, when cover cannot be obtained by increasing the depth by a few inches, the half double sap is resorted to. This sap is executed by a single brigade of sappers; it has on the side of the berme the ordinary parapet, and on the reverse a provisional parapet, formed of gabions filled with sand-bags. The two parapets, which are 5′ 8″ apart, are formed at the same time by the first sapper. At the command "*Gabion*," the assistants pass forward two gabions, to No. 1, who places the first on the reverse against the rollers, and the second on the berme in the ordinary way. At the command "*Forward*," he first places the gabion on the berme, as in the simple sap, then that on the reverse in such a manner that one half of it shall be covered by the roller. After the command "*Enough*," the chief of sap, instead of simply giving the command "*Fagot*," commands, "*Bags and fagots.*" Two fagots are passed to No. 1, who places them in the angles of the gabionades and roller. He then receives on his shovel from No. 2 a sand-bag, which he throws into the gabion on the reverse; he proceeds in this manner until the gabion is filled and the joint with the preceding well closed; this usually requires ten sand-bags. To avoid having too great a variety of material at the head of the sap, it is better to use sand-bags for crowning the true parapet in the place of small fascines; four sand-bags are required to crown one gabion. The assistants will therefore pass forward fourteen, which are arranged on the reverse opposite the first sapper form.



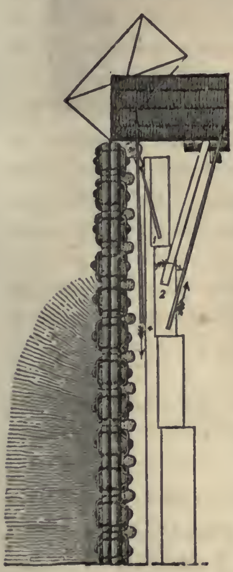
The time required to advance this sap one gabion, is about twenty minutes in the place of fifteen employed in the simple and eighteen in the double sap. As soon as the sap has advanced so far that twelve provisionary gabions are found in rear of No. 1, the chief of sap causes a small trench to be commenced, perpendicular to the sap, whose parapet shall form a traverse, high enough to cover the sap in rear.

This trench is but 40″ wide, and is executed in the half-full sap by the reserve; this allows the provisionary gabionade in rear to be removed, leaving the head of the sap only encased by two gabionades; the part in rear can then receive the proper enlargement. Finally, the small traverses are themselves destroyed, after the construction of the large ones, destined to guard against enfilade and reverse fire, both of artillery and musketry.

CHANGE OF DIRECTION OF THE FULL SAP.

All the changes of direction of the full sap, both simple and double, are comprised in the following list:

1. Obliquing to the right or left.
2. Debouching by the simple or double sap from the end of simple sap whilst in course of construction.
3. Debouching by the simple sap, from one or both sides of the double sap, in course of construction.
4. Uniting in one double sap two simple saps meeting each other.
5. Debouching by the simple or double sap from a sap not enlarged.



6. Debouching by the simple or double sap from a trench of the ordinary dimensions.

Before describing these different debouches, it is well to observe that the sap should be well supplied with sand-bags and wool-sacks, and that the chief of sap should conduct the operation with the greatest order and celerity.

TO CHANGE DIRECTION TO THE RIGHT OR LEFT.

This change of direction reduces itself to turning the sap-roller until it becomes perpendicular to the new direction to be given the sap. We will suppose the direction is to be changed to the left, the chief of sap first warns the brigade by the command, "*Prepare to change direction.*" Then

1. "Levers. Fagots."
2. "Hooks."
3. "Change direction."

At the first command the assistants pass to the first sapper two sap-fagots and a wool-sack. No. 1 places one fagot perpendicular to the roller and near its interior extremity, the other on the first, near and parallel to the roller, inclining toward the sap. He then replaces the fagot in the joint of the gabionade and roller by the wool-sack, which he fixes in its position by means of the sap-fork. No. 2 receives a lever 12′ long, one end of which he introduces between the roller and fagot just placed.

At the second command No. 3 takes the reverse-hook and fixes it in the roller, in such a manner as to be able to push the roller. No. 4 fixes the berme-hook in such a way as to be able to pull it. The first and second assistants aid respectively sappers No. 3 and 4.

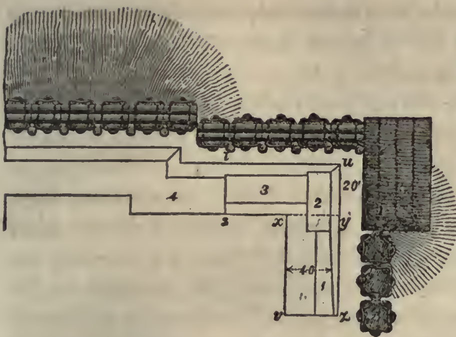
At the third command No. 4 holds the roller against the last-placed gabion, whilst No. 3 pushes the opposite extremity, No. 2 favoring the motion of the roller by weighing down on the lever as the roller advances. No. 1 pushes up the fagot (which is used as a fulcrum for the lever) in order to give No. 2 a better purchase.

In this way, the direction of the roller may be changed 50° or 60° in about fifteen minutes, even on ground ascending toward the place.

TO DEBOUCH BY THE SIMPLE OR DOUBLE SAP FROM THE EXTREMITY OF THE SIMPLE SAP IN COURSE OF CONSTRUCTION.

FIRST CASE.—BY THE SIMPLE SAP.

When but five gabions remain to be placed before arriving at the point at which the change of direction is to be



made, the chief of sap causes an off-set to be made in the gabionade and berme, so that the last five gabions shall form a line parallel to that of the others, and 13″ within it. The object of this arrangement will be seen hereafter.

When the fifth gabion is placed, the chief of sap warns No. 1 to arrest his form within 20″ of the roller, instead of advancing to the middle of the last gabion. When this is filled, the following commands are given.

1. "Prepare the debouch."
2. "Prepare to debouch."
3. "Debouch."

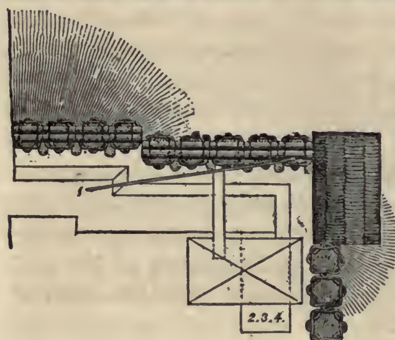
At the first command No. 1 commences a form parallel to the roller on the reverse; this form is also 20″ wide and deep, but a berme of 20″ is left between it and the roller. When he arrives nearly opposite the extremity of the sap-roller he places in its prolongation, by the half-full sap, three gabions, in order to prolong the epaulement necessary to cover the manœuvre of debouching. He arrests his form opposite the middle of the third gabion. The other sappers follow, enlarging their forms as usual.

No. 2 throws his earth in rear of the roller and the first gabion in its prolongation, the others throw the earth behind the gabions in rear of the crochet.

The sap being now in the situation indicated in the above figure, Nos. 1 and 2 commence excavating the retreat, v, x, y, z; making it 40″ wide and 40″ deep at x, y, and 24″ at v, z, they throw their earth in rear of the three last-placed gabions. Nos. 3 and 4 also enlarge the extremity of the sap, *s*, *t*, *u*, *y*, until it is 40″ wide and deep, throwing the earth in rear of the fifth and sixth gabions.

At the same time the assistants bring forward a sap-roller, and the fascines necessary to stuff it, also a piece of scantling or plank 7′ long.

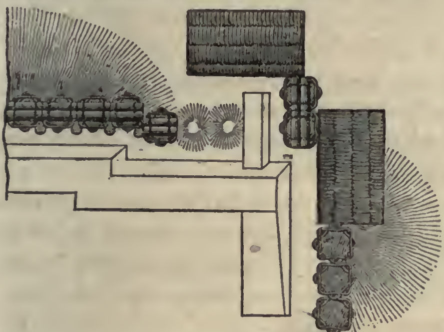
When Nos. 3 and 4 have finished their excavation, they lay the plank across the sap opposite the joint of the third and fourth gabions, one end on the berme, the other on the reverse. Then, aided by the assistants, they place the roller upon it, and against the parapet of the sap, its extremity 6″ from the first roller; they then stuff it with the fascines, which operation should be completed about the same time that Nos. 1 and 2 finish their excavation (*x*, *y*, *v*, *z*).



At the second command, Nos. 2, 3 and 4 place themselves in the retreat, *x*, *y*, *v*, *z*; furnished with two forks and two hooks, they draw the new roller toward them, away from the gabionade; they place a wool-sack under it to protect their legs from the shot which might pass under the roller after the gabions are removed. No. 1 having a sap-hook, places himself a little in rear of the fifth gabion, in the re-entrant formed in the berme at this point, and holds himself in readiness to overturn the gabions, the first assistant aiding him.

At the third command No. 1 overturns into the sap the first four gabions, the fascines or sand-bags with which they are crowned and the sap-fagots closing their joints; he drags them to the rear with his hook, or ranges them on the bottom of the sap in such a manner as not to interfere with the advance of the new roller, and without displacing the plank over which it is to pass.

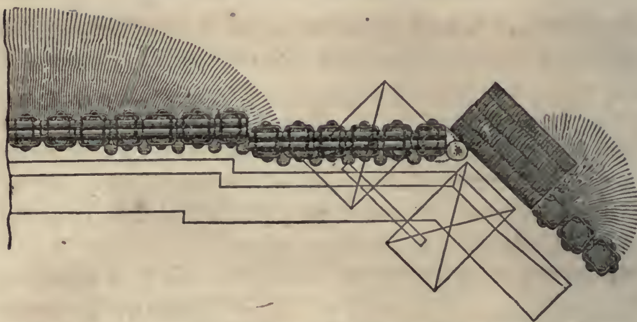
This being accomplished, Nos. 2, 3 and 4 push forward the roller, causing it to pass through the opening thus formed, notwithstanding the mounds of earth left on the berme by the overturned gabions. They effect this first by using the forks, afterward the hooks.



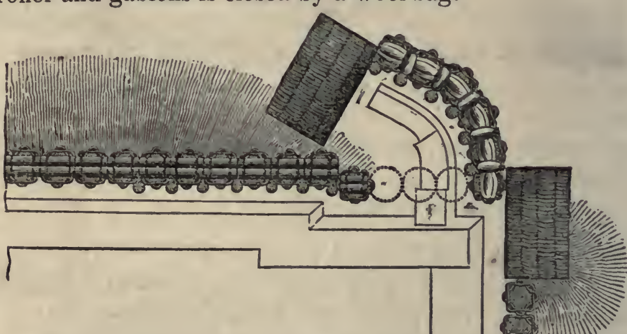
No. 1 then repairs to the angle formed by the two rollers, where he places a gabion in the position of the first one, which was overturned; if the earth left by the latter on the berme impedes the operation, it can be removed with the drag; after this the sap is executed in the ordinary manner. In ordinary ground this debouche can be executed in an hour and a quarter, from the command "*Prepare to debouch*" to the placing of the first gabion of the new sap. The time required for the different operations is as follows, viz.:

Executing the form of No. 1 along the first roller, and filling the three gabions of the epaulement,	30 min.
Completing the sap, placing and filling the roller,	34 "
Overturning the four gabions, - - - -	8 "
Advancing the roller, - - - - -	1 "
Replacing the first gabion, - - - - -	2 "
	1 h. 15 min.

To debouch obliquely from the sap of departure, it is necessary to give the first roller a parallel direction to that

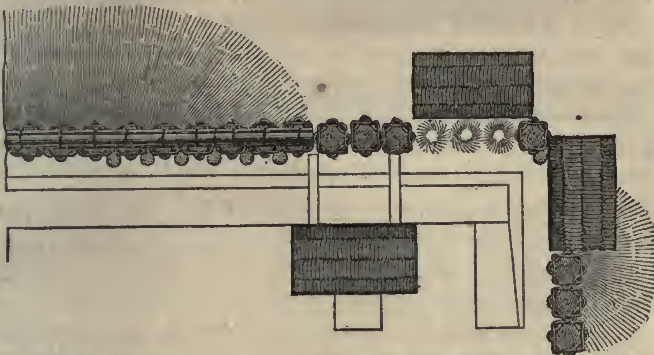


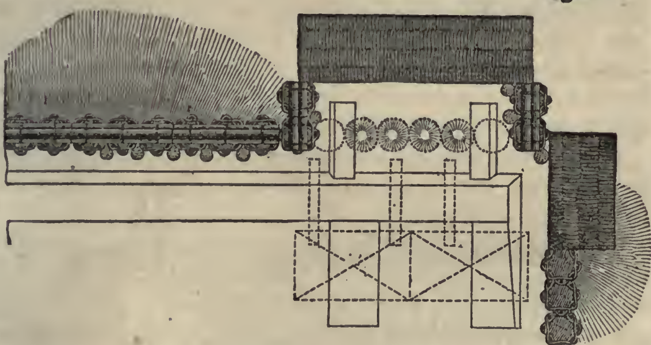
which the new sap is to have, the retreat is then made parallel to this, and the new roller placed perpendicular to the new direction. The number of gabions to be overturned will depend on the angle made by the two saps. These gabions are not all overturned at the same time, but in proportion as the roller advances, filling the opening left by those first pulled down. Any opening that may occur between the roller and gabions is closed by a wool-bag.



An oblique debouche may also be effected by first executing the perpendicular from the sap of departure, then, by successive changes of direction of the roller, obtaining the required direction. This is perhaps the most expeditious method; but it may happen, that the portion of the new sap which is perpendicular to the sap of departure, is exposed to reverse fire, in which case it will be necessary to make use of the half double sap for this portion.

SECOND CASE.—DEBOUCHING BY THE DOUBLE SAP.





Having arrived at the position from which the debouche is to be made, the chief of sap cautions the sappers to throw no earth in rear of the last eight gabions, which are to be overturned, in order to allow a passage for the new rollers. In most cases these last gabions can be placed in the same line with those of the gabionade preceding them, dispensing with the crochet used in the former example.

The head of the sap having arrived at the last gabion, the chief of sap commands, "*Prepare to debouch by the double sap.*" The sappers then execute all that has been indicated at the analogous command in the simple sap, and in addition, the first and second assistants of the brigade, or two sappers of the new brigade (necessary to execute the double full sap, excavate a second retreat in the reverse similar to the first, and opposite the 6th and half of the 7th gabion.

Two sap-rollers are then placed on the planks that have previously been laid across the sap. The rollers should be so situated that their outer extremities should be opposite the first and eighth gabions to be overturned. The sap-rollers are moved back on to the reverse.

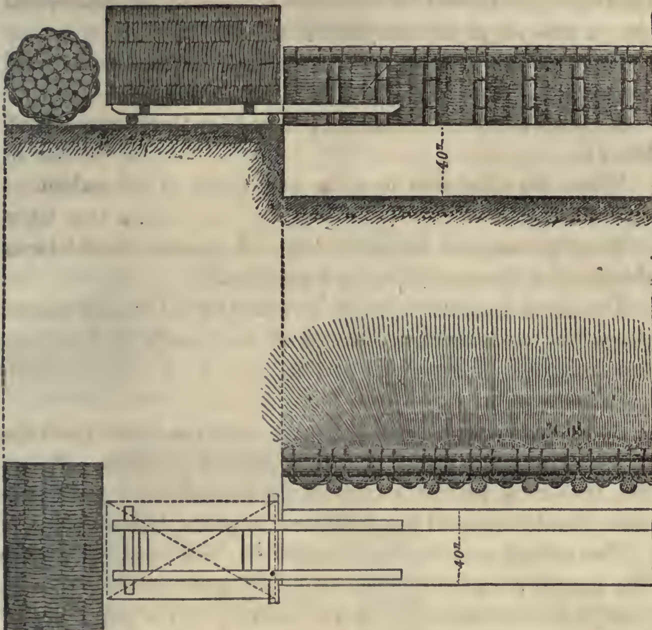
The chief of the double sap then causes the first brigade to debouch, replace the first gabion and fill it, then retire.

The second brigade then advance, debouch with their sap in similar manner, and replace and refill the eighth gabion. The double sap is then conducted by the ordinary commands. It may happen that after the debouche, the two rollers are not in contact; in this case the opening must be masked with a wool-sack, and the rollers brought together with the levers.

It requires about one hour and a half to execute the debouche, from the command "*Prepare to debouch*" until the first gabion of the double sap is replaced.

The following method for debouching from a sap in course of construction, appears to be both of simple and easy execution. A frame is provided, having been previously prepared to receive the new roller, also three rollers 4″ in diameter and 40″ long, and a plank 7′ long.

The sap having received its full depth, and the berme being cleared off, the chief of sap commands, "*Prepare to debouch.*" No. 1 places a roller across the trench. No. 2 places the plank also across the trench and opposite the third gabion. These two sappers then pass to the rear and receive from the other sappers the frame, which they lay with one end on the small roller, the handles on the plank.



2d. "*Sap-roller.*"

At this command an empty roller is passed to the head of the sap by the assistants, placed by the sappers on the frame and against the first roller, then stuffed.

3d. "*Prepare to advance.*"

Nos. 1 and 2 leave the sap; crawl on their bellies along the sap-roller; No. 1 is charged with pushing the first sap-roller, renewing the rollers under the frame, and giving warning by the words "more" or "too much" of the progress of the new roller which No. 2 holds upon the frame. Nos. 3 and 4, with a sap-hook passing between the gabionade and new roller, hold themselves in readiness to push the first sap-roller forward. The first assistant places himself under the new

8

sap-roller, the second between the handles of the frame, and the 3d and 4th at the extremities of these handles.

The chief of sap then glides behind the new roller and commands, "*Forward.*"

All push (in silence, that they may hear the commands of No. 1).

When the chief sees that the new roller is unmasked he commands, "*Halt.*"

No. 3 disengages the sap-hook, and places a wool-sack in the joint of the new roller and gabionade.

The second assistant yields his place to the first as soon as the roller has arrived at the end of the trench, and goes to the assistance of sappers 1 and 2.

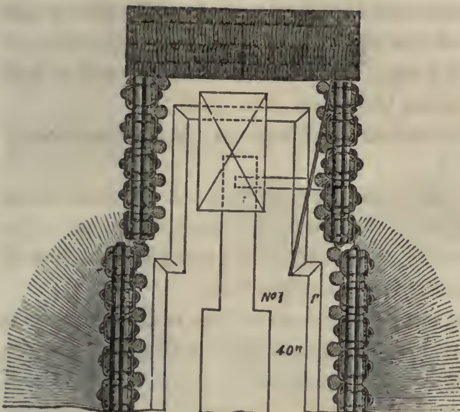
"*Forward.*"

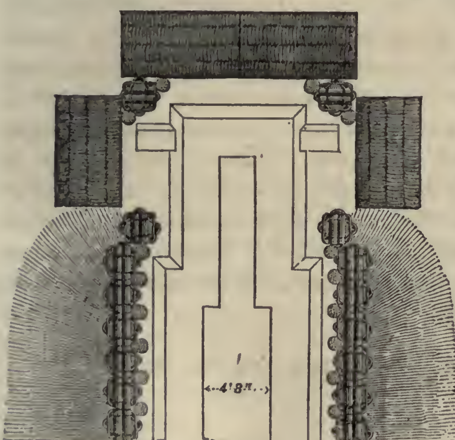
At this command, Nos. 1, 2, and second assistant push the new roller of the frame into the required position. To effect this they should lie flat on the ground, and push with their shoulders, until the command is given, "*Enough.*"

The second assistant then passes the wool-sack to sapper No 1, who places it in the joint of the two rollers. The operation is terminated by the command, "*To your posts.*" Each sapper retakes his place, the frame and small rollers are carried to the rear by the assistant. This method requires not more than five or six minutes, not including excavating the sap to the full depth and stuffing the new roller. It would therefore appear that the process, with some slight modification, would be equally safe and much more expeditious than that now in use.

TO DEBOUCH BY THE SIMPLE SAP FROM ONE OR BOTH SIDES OF THE DOUBLE SAP.

When the debouche is to be made on both sides of the double sap, the chief of sap will cause the last five gabions of each parapet, to be placed 1′ within the lines, and the form of each of the first sappers to stop within 20″ of the rollers,





when in their permanent position. He will then command, "*Prepare to debouch by the simple sap.*"

Each No. 1 will then fix his sap roller with pickets. Then turning their forms at right angles, they will move toward each other, making their excavations 40″ wide and deep, the preceding portions of the sap are also enlarged to the same dimensions. They will all avoid throwing the earth against any of the gabions that are to be overturned.

The brigade that first completes this task (that on the right for example) will bring forward an empty roller, place and stuff it, as in the preceding cases. The chief will then command:

2. "*Left brigade retire. Right brigade prepare to debouch.*"
3. "*Debouch.*"

At the second command the left brigade will retire to the rear of the sap, and the right will execute the debouche on the right side of the sap. When they have replaced and refilled their first gabion, the chief commands:

4. "*Right brigade retire. Left brigade prepare to debouch.*"

5. "*Debouch.*"

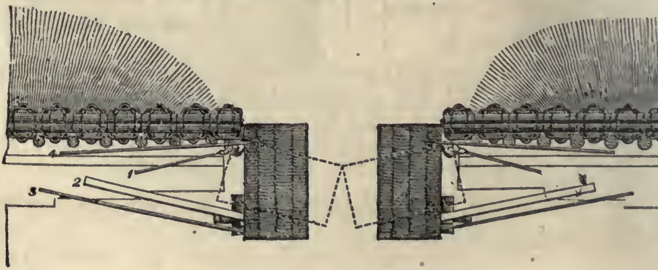
The right then retire and the left brigade execute the debouche from the left side of the sap, in a similar manner; when they have refilled their first gabion, the chief will command:

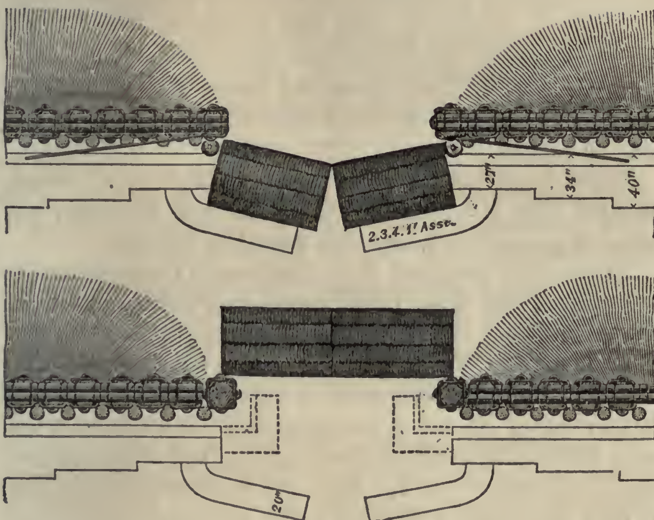
6. "*Right brigade, to your posts.*"

The two saps will then proceed in the ordinary manner. About one hour is required to execute the double debouche, which is composed of two successive debouches. If the debouche is to be executed on one side only, but forty minutes will be required.

The processes described in the three preceding articles consume one or two sap-rollers, which remain in their places. As these rollers are of difficult construction, it may be desirable to withdraw them from these positions to use elsewhere. To effect this, earth is thrown in rear of the roller to be removed, until a parapet is formed 40″ high; two beams are then laid in front of the roller, upon which it is rolled down into the trench, the position which it occupied is then immediately supplied by three or four ordinary gabions, which are filled and crowned.

TO UNITE TWO SIMPLE SAPS INTO ONE DOUBLE SAP.





When the gabionades of the two saps to be united have approached to within 13′ 6″ of each other, the chief of the double sap causes their junction by the following commands:

1. "Prepare to unite in the double sap."
2. "Lever. Fagots."
3. "Hooks."
4. "Change direction."
5. "Halt."
6. "Commence working."
7. "Forward."

At the first command each brigade prepares to execute simultaneously the manœuvres which will here be described for one of them. Nos. 1, 2 and 3 enlarge their forms, making them 7″ wider and 40″ deep. No. 1 must not pass beyond the middle of the first gabion, or throw earth behind this gabion.

The second, third and fourth commands are executed in the same manner as the same commands in the simple change of direction of the sap, with this exception, Nos. 1 and 4 draw toward the interior of the sap, the end of the roller on the berme; by these means the direction of the roller is changed 70° or 80°; it should then be entirely within the line of gabions.

The fifth command is given when the direction is so much changed that No. 2 can no longer act with his lever; the lever, fagots and forks are then passed to the rear.

At the sixth command No. 1 commences a form 20″ wide and deep in rear of the roller, and as near it as possible; he works kneeling, and is followed closely by No. 2, who deepens it 12″. The earth is thrown on the reverse.

When No. 1 has excavated to within 12″ or 16″ of the further end of the roller, he retires, and when the form has been sufficiently enlarged, Nos. 2, 3, 4, and first assistant enter it, provided with two forks and two hooks, taking care to keep themselves perfectly covered by stooping.

At the seventh command these sappers push forward the rollers with their hooks and forks, causing them to enter the interval left between the gabionades. The two brigades will so concert their movements that the two rollers shall be exactly joined, forming thus one roller whose direction is parallel to the sap.

In the mean while No. 1, stationed at the head of the sap, directs the motion of the roller by warning the sappers who are pushing, and if he perceives that the motion of the roller is hindered by the last gabion of the gabionade (as is almost always the case), he, aided by the second assistant, overturns it in the trench with a sap-hook, and supplies its place with a wool-sack, using a fork to place it.

Finally, when the two rollers have entered the opening, the chief commands, "*Gabions;*" the two gabions that were overturned are replaced, and the double sap is continued by the ordinary commands.

In ordinary ground the time occupied in this manœuvre is as follows:

Enlarging the two saps about to be united,	25 minutes.
Changing direction of sap-rollers 70° or 80°,	15 "
Excavating forms in rear of sap-rollers,	25 "
Advancing the rollers, overturning the extreme gabions of the two saps, and replacing them, - - -	15 "
Total - - -	1 hr. 20 minutes.

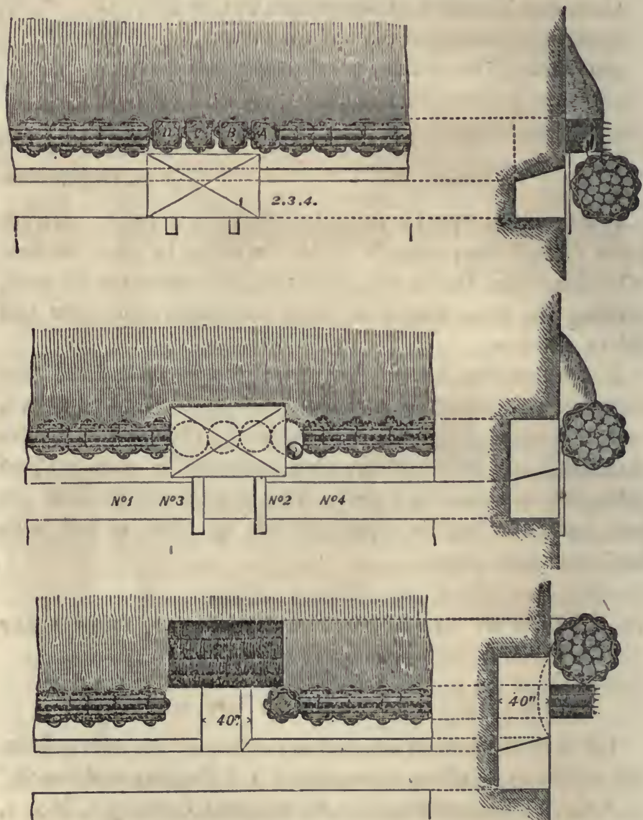
It must, however, be remarked that No. 1 has to turn his form around the replaced gabion, in order to take the new direction of the double sap, which employs about ten minutes, making the total length of time consumed one hour and thirty minutes.

If the two simple saps are merely to be *united* the two rollers which are to form the parapet are united as above, and, if necessary, may be withdrawn by the process before described. In this case the first command is changed into "*Prepare to unite the saps.*" The overturned gabions are not replaced, but the openings left by them closed with fagots or sand-bags.

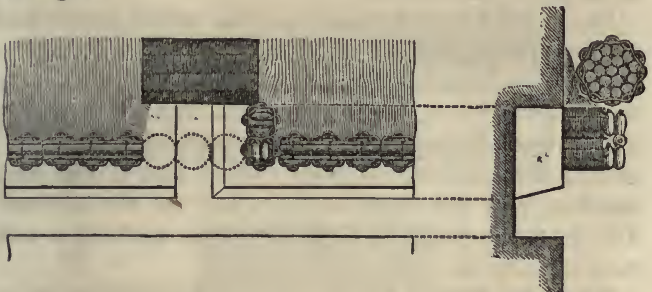
TO DEBOUCH BY THE DOUBLE OR SIMPLE SAP, FROM A SAP NOT ENLARGED.

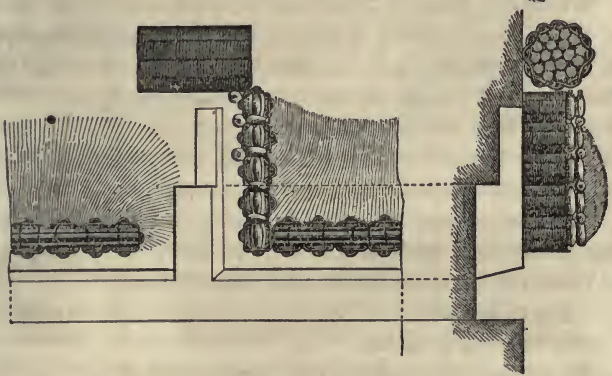
FIRST CASE.—TO DEBOUCH BY THE SIMPLE SAP.

Let A be the gabion selected as the first of the new gabionade. The chief of sap commands: 1. "*Prepare to debouch.*" 2. "*Commence working.*" At the first command, No. 1, directed by the chief, traces on the berme and slope of the sap a form 12″ to the left of gabion A, 40″ wide and deep. He is provided with a pick and shovel. No. 2 places across the sap on each side of this form a plank, one end resting on the berme, the other on the reverse. He is furnished with two drags, one having a handle 3′ and the other 6′ long. The 3d and 4th sappers pull down the crowning fascines from gabions A, B, C, and D, with their forks.



The assistants bring forward an empty roller, place it on the planks against the four gabions to be removed, one end opposite the middle of A, and prepare to stuff it. At the 2d command No. 1, kneeling under the roller, commences to excavate his form. No. 2 draws the earth thus obtained along the bottom of the sap (and to the right), with his drag. Nos. 3 and 4 throw it over the parapet. During this time the assistants stuff the roller and adjust the crowning of the gabions adjacent to the debouche, if they have been disarranged.





As soon as No. 1 has advanced 16″ or 20″, No. 3 also passes under the roller, on the side opposite No. 2, and drags away a portion of the earth excavated by No. 1. The first assistant throws this over the parapet.

No. 1 pushes his form until he has passed the line of gabions passing under C and B; he then drags the earth out of these gabions into his form, pulls the gabions themselves through the opening into the trench, overturns gabions A and D, and drags them also into the sap, clears away the earth which might impede the progress of the roller with his drag. During this operation he is covered from the fire of the place by the mask of earth (about 32″ high), which remains in advance of the roller.

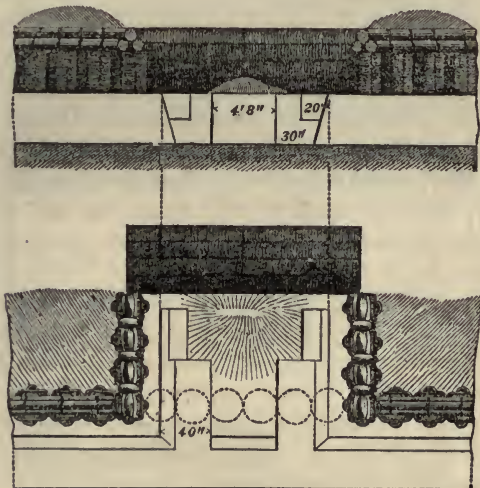
Nos. 2 and 3 move forward the roller until it rests against this mask, closing the openings that may be dangerous between the roller and gabionade with sand-bags, wool-sacks, fagots, &c. No. 1, under the roller, which is gradually moved forward, continues his form (40″ wide and deep), passing the earth to the rear. Nos. 2 and 3, who work standing, pass this earth to No. 4 and the first assistant. The gabion A should be replaced as soon as there is sufficient space for it.

When the form of No. 1 has attained a length of about 5′ 4″, a second gabion is placed, and the work is continued as in the ordinary sap. It must, however, be remarked that the places of the 2d, 3d and 4th gabions must be prepared with the drag previous to setting them, and that the roller has to be forced over a small mound of earth, the remains of the parapet which has been cut through.

The time necessary for this debouche, including the crowning of the third gabion, is about two hours and a half, viz.:

From the commencement until the overturning of gabions, - - -	30 minutes.
Overturning gabions, - -	17 "
To advance the roller to the outer surface of gabionade, - - -	6 "
The roller entirely engaged in the gabionade,	32 "
First gabion filled, - - -	35 "
Second " " - - -	10 "
Third " " crowned, and No. 1 form reaches the middle, - - -	20 "
Total, - - -	2 hrs. 30 minutes.

In the case of an oblique debouche the roller is placed perpendicular to the new direction, and No. 1 excavates in this direction. The operation is similar to that just described, but longer. It is therefore generally preferable to debouch perpendicularly first, and then change the direction, if necessary.



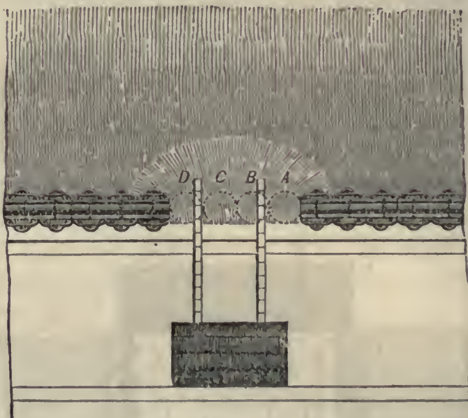
SECOND CASE.—TO DEBOUCH BY THE DOUBLE SAP.

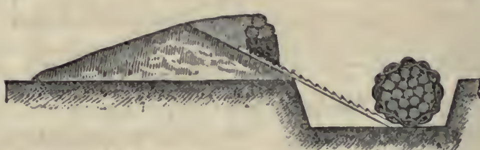
Two gabions of the gabionade 13′ 4″ apart, are chosen as the first of the double sap. The chief commands, 1. "*Prepare to debouch by the double sap.*" 2. "*Commence working.*"

Each brigade executes all that has been prescribed above for these commands. The assistants, in stuffing the rollers, should bind them together, causing the fascines of one to project into the other. The earth, in this case, can only be drawn away on one side of the sap, instead of both, as in the preceding case, which renders the execution somewhat longer.

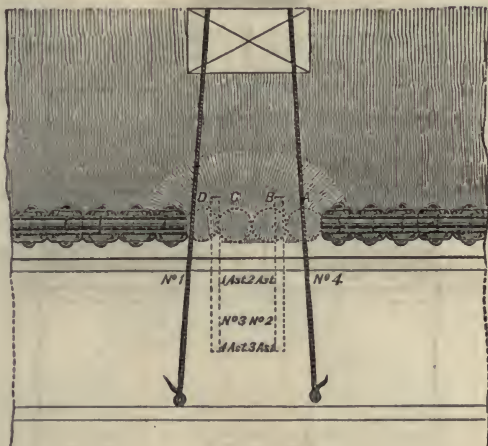
TO DEBOUCH BY THE SIMPLE OR DOUBLE SAP, FROM A TRENCH OF THE ORDINARY WIDTH.

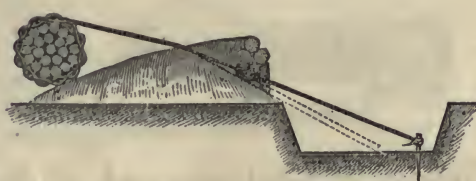
FIRST CASE.—TO DEBOUCH BY SIMPLE SAP.



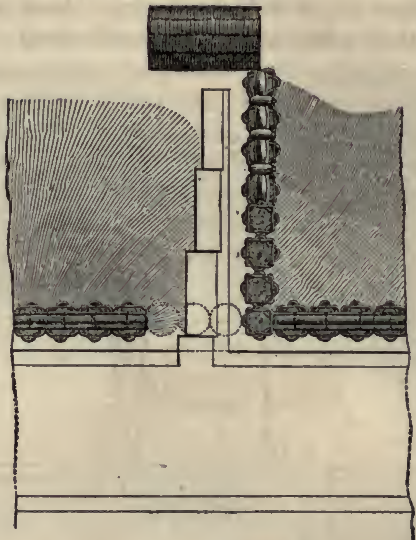


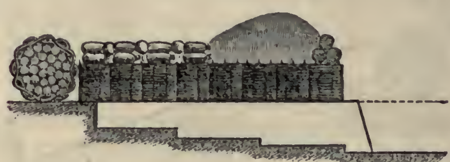
Let A be the gabion chosen as the first of the new gabionade (on the right of the new sap). The chief commands, 1. "*Prepare to debouch.*" 2. "*Ready.*" 3. "*Debouch.*" 4. "*Halt.*" At the first command, the assistants bring forward a sap-roller, place it against the reverse, in the trench, and opposite the gabions A, B, C, and D, and if not already filled, fill it. Nos. 1, 2, 3 and 4 are provided with two sap-hooks, two forks, two beams, 10′ 6″ long, and notched on one side, two ropes 30′ or 40′ long, having a hook at one extremity of each, a long and a short handle drag.





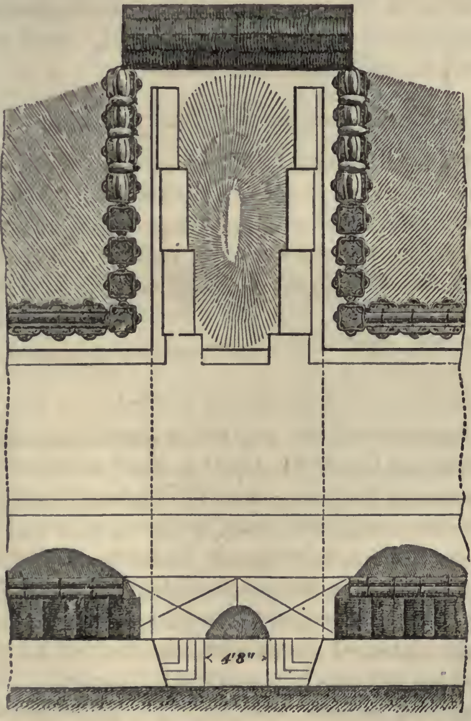
At the second command, Nos. 1 and 4, each taking a fork, place themselves opposite A, B, C, D (the first on the right), and first take down the crowning fascine, then overturn the gabions into the trench. The same sappers place the beam, engaging one end under the roller, and about 12″ from its extremity, the other on the parapet, which has been previously formed into a ramp, by dragging the earth inward with a hoe. Nos. 2 and 3 lay two hooks on the reverse, opposite and perpendicular to the roller, fasten the hooks of the ropes in roller, and plant two strong stakes on each side of it.





The assistants are placed two on each side the 1 and 2, provided with forks. At the third command the roller is pushed up to the top of the parapet, first by hand, then with forks; the sappers having the following positions—Nos. 2 and 3 assistants near the right beam, acting with the same hook; Nos. 3 and 4 assistants do the same on the opposite end; the first and second assistants opposite the middle of the roller, pushing with the forks, and prevent it from rolling back when the hooks are disengaged to take a new hold; Nos. 1 and 4 at each end of the roller, and outside the beams, also pushing, and in case of need assisting at the hooks.

When the roller arrives at the crest of the parapet, it is still pushed with the hooks, but the first and second assistants taking the ropes, give them a turn around the pickets (in the bottom of the trench), allow the roller to roll gradually down the exterior slope of the parapet, keeping it parallel to its first position. At the fourth command, which the chief gives when he judges the roller has nearly reached the foot of the parapet, the ropes are made fast to the pickets, and the beams, hooks, &c., taken away and laid on the reverse and berme. The sap is then commenced with the usual command, "*Gabion*," &c.



It should be remarked, first, That the new gabionade should be so directed that, arriving at the sap-roller, the last-placed gabion shall be at least half covered by it.

Second, That No. 1, being perfectly covered by the parapet, having cleared away the earth of the parapet, places the first two gabions on the natural ground, and then commences his form in the usual manner, throwing the earth to the rear; the sappers in the rear fill these two gabions; No. 1 fills the following one, throwing the excess of earth to the rear.

Third. Any accidental openings are closed immediately with wool-sacks. The time required to execute this debouche, from the command "*Prepare to debouch*," until seven gabions are placed, is about four hours.

SECOND CASE.—TO DEBOUCH BY THE DOUBLE SAP.

This case is executed in the same manner as the preceding. The assistants, in placing the two rollers, take care to bind them well together, that they may not separate in the manœuvre. That portion of the earth of the parapet between the two saps which does not crumble into the forms, is allowed to remain until the trench is turned over to the ordinary workmen.

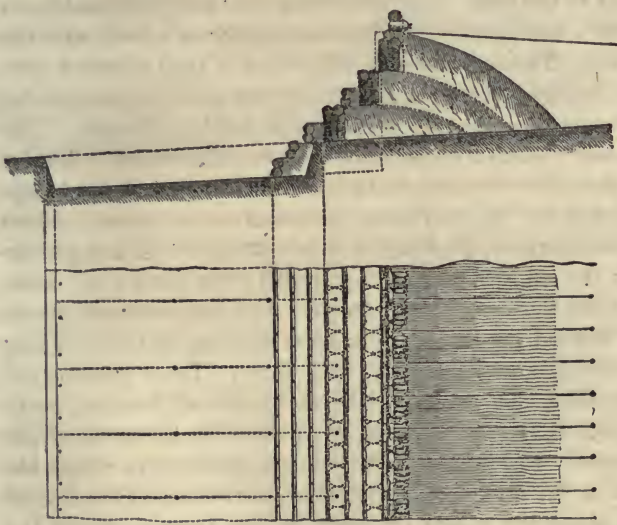
TRENCH CAVALIER.

The trench cavalier is a mass of earth surmounted by a parapet erected just beyond the range of the hand grenades of the besieged, for the purpose of obtaining a plunging fire over the salient places of arms of the covered way.

This construction is ordinarily traced by the full sap. It is included between the prolongation of the branches of these salients, and as nearly perpendicular to them as the sally of the collateral works will permit. To its extremities are added small flanks to cover it from enfilade.

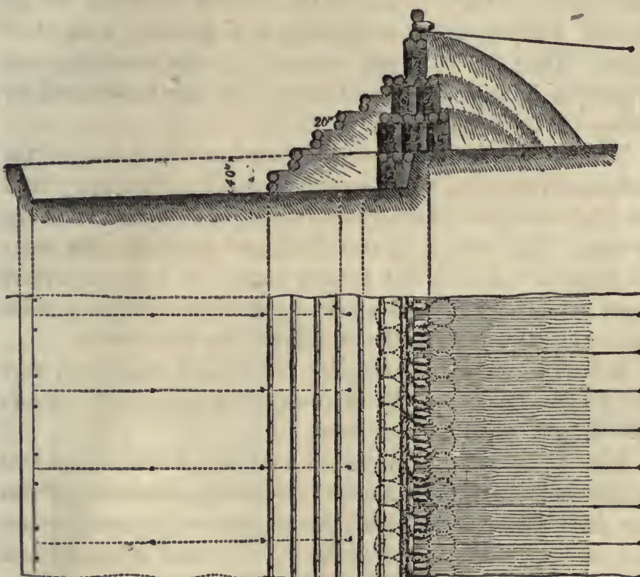
The mass of earth is sustained by several courses of gabions, against the interior of which steps are arranged to ascend to the upper course, which serves as a parapet. The number of these courses is determined by the condition that the cavalier shall command the crest of the covered way at least 4′ 4″, so that as each course of gabions crowned with two fascines gives a height of 40″; there will be as many courses plus one required as the difference between the level of this crest and the site of the cavalier contains this numbering.

The following is the process for constructing a cavalier three courses high, in an easy soil:



After having traced the cavalier and its return by the full sap, and crowned the gabionade with two fascines, the width of the sap is increased by 6′ 8″, in order to increase the thickness of the parapet and form a step at the foot of the berme 20″ high, and extending 6′ within the gabionade, for the cavalier, and 4′ for the flanks. The sappers mount this step, and with crooked handle-drags equalize the earth of the parapet, thus forming a horizontal platform to receive the second course of gabions. The width of this platform (including the gabionade) should be 6′ for the cavalier, 4′ 4″ for the flanks. The sappers then, standing on the step or kneeling on the berme, and stooping to keep themselves well covered, place the second course of gabions 44″ from the first for the cavalier, and 24″ for the flanks. They are placed in position with sap-forks, and filled with earth, which has previously been thrown in the bottom of the trench at the foot of the step. A second step is then made, leaving 20″ tread to the first. The latter step has also a rise and tread of 20″; its upper surface is consequently on a level with the berme. The second course of gabions is then crowned with two fascines, and earth thrown in rear until the parapet has sufficient thickness to receive the third gabionade. The necessary earth is obtained by widening the trench. A relay of shovellers is stationed on the second step. A third step, also with 20″ rise and tread, is formed on the berme. Aided by this step, and kneeling on the crowning of the first gabionade, the sappers prepare a platform for a third, 4′ 4″ wide, both for the cavalier and flanks. The last course is placed 24″ beyond the second, by sappers kneeling on the crowning of the first, and provided with forks. These gabions are then filled and crowned with three rows of fascines; earth is thrown in rear of them to increase the thickness of the parapet. For this purpose men are stationed in relays, the first on the first course of gabions, the second at the foot of the steps, the others 12′ apart, to the reverse, where the necessary earth is excavated. When the parapet has attained the required thickness, which must be at least 40″ at the summit, it is crowned with sand-bags, so arranged as to form loop-holes, and a step is formed between the first and second courses of gabions, to allow the troops to mount the latter.

The preceding method has the advantage of consuming the least possible number of gabions. It may be employed when the earth of the glacis is easily worked, and when the fire of the place is not too hot to prevent the sappers uncovering themselves sufficiently to place each course of gabions 40″ in advance of the preceding. But in case the fire is very active, or the ground difficult, the following method must be resorted to, which, although much slower than the preceding, gives a more solid construction.



1st. The cavalier is traced by the ordinary full sap, the gabionade crowned with two fascines, and the trench enlarged in width by 40″, to thicken the parapet.

2d. A course of gabions is placed in the bottom of the trench, at the foot of the slope of the berme, which are crowned with two fascines, and earth added if necessary, until the top has attained the level of the berme. Earth is also thrown against this gabionade, in order that the earth which acquires considerable consistency by the tread of the workmen, may afford it some support.

3d. A third course of gabions is placed on the berme, in contact with the first. These are filled and crowned in such a manner that the crowning of the two shall be in the same horizontal plane.

4th. A fourth course is placed over the joints of the first and third. This is effected by sappers kneeling on the second course, and manœuvring the gabions with their forks. They are filled and crowned like the preceding, and a parapet formed in rear of them, with earth obtained by enlarging the trench.

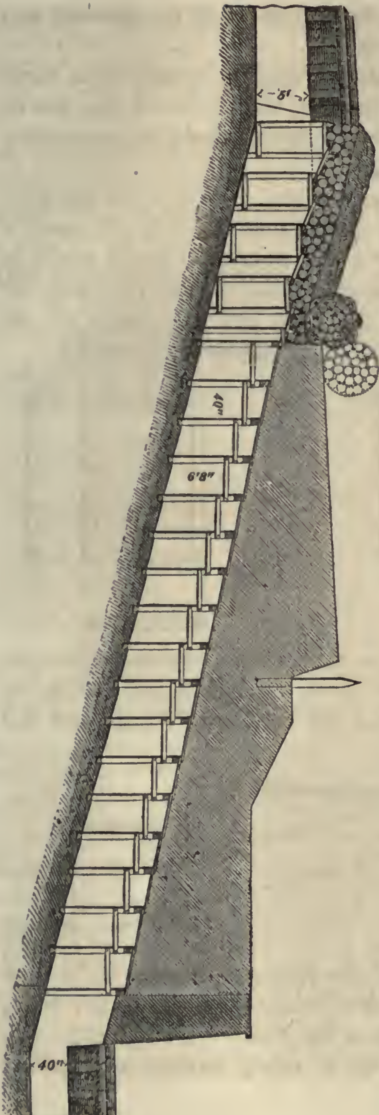
5th. When the parapet is elevated to the height of the last-placed gabions, a fifth course is placed against the course on the berme, and consequently on top of those placed in the trench. This course is also filled and crowned. In order to support the first and second course of gabions, a fresh mass of earth is formed against the interior side of these gabionades, as high as the middle of the first course.

6th. A sixth row is placed in the second stage, and over the joints of the two interior rows of the first stage. These are likewise filled and crowned.

7th. A seventh row is placed over the joints of the two of the second stage, by means of the fork, as before. These are filled and crowned with three fascines, and the parapet is increased until it reaches the level of this crowning and has acquired a sufficient thickness.

Finally, loop-holes are formed by placing sand-bags on this parapet, and the interior is arranged with steps, that the troops may conveniently mount to the upper stage.

A cavalier composed of three stages, each stage twelve gabions or 26′ in length, with flanks 15′ or 20′, can be constructed in twenty-four hours, not including the time re-



quired to trace it with the full sap. The number of workmen required, in ground where one pick is required for each shovel, is from 25 to 30 for the first twelve hours, and 30 to 36 for the following twelve.

The shovellers are arranged in files opposite every third gabion, and composed of as many men as there are relays from the reverse of the trench to the summit of the parapet. Each row of gabions can be placed in one minute, and filled in twenty, allowing one man to two gabions.

At the commencement of the work, and while the steps are being constructed, a part of the workmen are employed in preparing material.

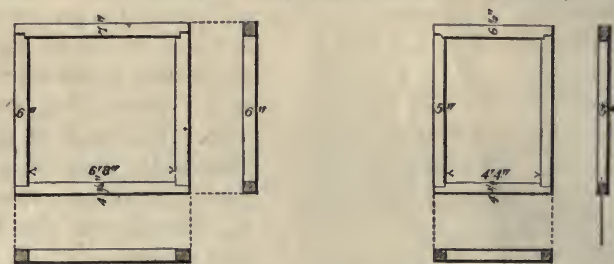
THE DESCENT INTO THE DITCH.

The descent into the ditch is effected by a subterranean gallery, when the counterscarp has sufficient height to allow a mass of earth at least 40″

deep to be left between the terreplein of the covered way and the roof of the gallery.

This thickness is considered requisite by miners, in earth of ordinary consistency, in order that the work may not be of too difficult construction. It is also useful as a protection against vertical projectiles.

The height of the descent is from 6′ to 6′ 8″ in the clear. Its width varies with the difficulty of the soil. In earth of ordinary consistency the width should be about 6′ 8″; in light sandy soil it is prudent to limit it to 4′ 4″. The following figures indicate the form and dimensions of the frames used in the two cases (oak timber being used.)



It will be perceived from these dimensions that the height of the excavation must be about 7′ 6″, giving 10′ 10″ as the minimum distance between the surface of the ground and the floor of the gallery.

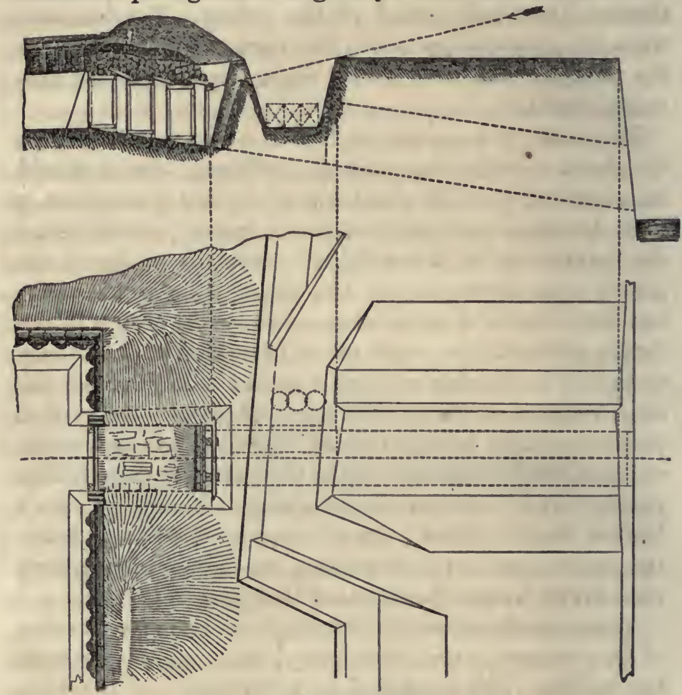
The point of arrival of the descent is ordinarily fixed at 40″ below the bottom of the ditch, in the case of a dry ditch, and 16″ above the surface of the water in the contrary case.

The direction should be as nearly straight as possible, since a change is of difficult execution, and renders the communication incommodious. The slope should not be greater than $\frac{1}{4}''$, but it is not indispensable that it should be uniform through the whole extent of the gallery. For instance, when the counterscarp is low, that portion which is beneath the terreplein can have a very slight slope, while the proceding part has $\frac{1}{4}''$.

The point of departure is fixed in a trench executed in the glacis, to fulfil the preceding conditions. But it should be remarked that the condition of having throughout a mass 40″ thick over the roof of the gallery, would oblige the entrance to be placed 10′ 10″ below the surface if the gallery were commenced at this point. Considerable time and labor would be required to excavate the trench to this depth, particularly as earth rarely has sufficient consistency to sustain itself when excavated to such a depth, with the slope required in the present case. Moreover, the vertical projectiles of the besieged would, by falling into such an excavation, render the approach to the gallery extremely dangerous. It is therefore advantageous to commence with a blinded descent, whose point of departure is 20″ only below the surface, and not to commence the subterranean gallery until the excavation has attained the depth of 10′ 10″.

When the ditch has little depth, advantage may be taken of the traverses in the covered way, under which to execute the gallery. This is effected by debouching into the defile of the traverse (by the blinded gallery) 40″ below the terreplein, and entering the profile of the traverse with the subterranean gallery. In this case the sap-roller employed to cover the head of the work, as will be seen hereafter, becomes superfluous from the depth of the excavation.

It may also be observed that the debouche is only covered by the profile of the traverse from direct fire, and may be subject to a flank fire. It is therefore advisable, when near the debouche, to first enter the defile by a small opening similar to a branch gallery, and to place a mask of gabions crowned with fascines in the defile, which may cover the passage into the gallery under the traverse.



It may also be remarked that the above process gives the means of "descending into the covered way," since having once descended into the defile of the traverse, a debouche by the sap can be effected into the terreplein of this work, in order to establish lodgements.

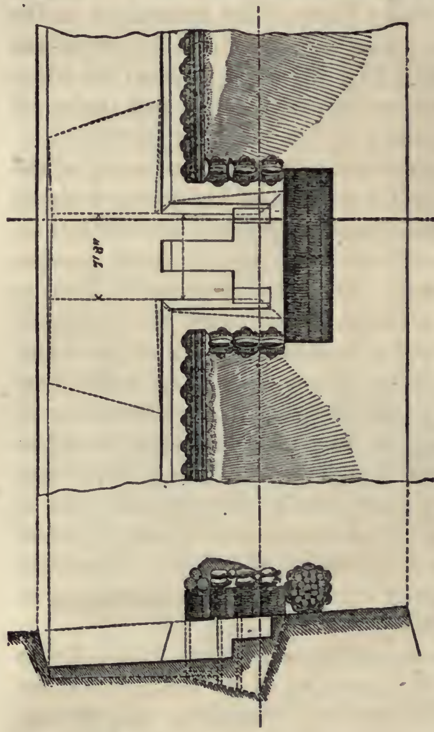
One hour is required to execute 40″ of a subterranean descent, 6′ × 6′ 8″ in ordinary soil. The miners employed should be relieved every six hours.

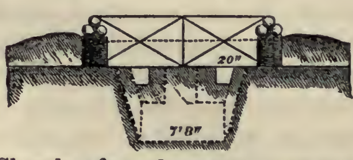
BLINDED DESCENT

Consists of a deep sap, which is covered as it advances with fascines supported by blinds. The dimensions of the latter are so regulated that the width and height in the clear of the descent shall be 6′ 8″, which requires the width of the sap at the bottom to be 7′ 6″, in order that the lateral blinds may be easily placed.

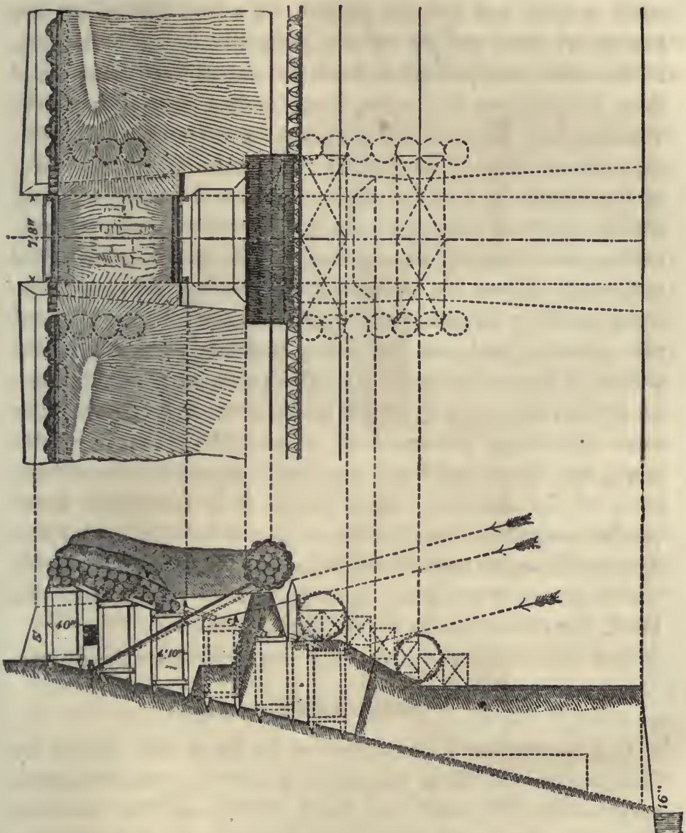
The point of departure is usually in the crowning of the covered way, 5′ below the surface of the glacis, a depth which allows the requisite mass of fascines and earth to be heaped on the blinds without projecting above the parapet of the adjacent trenches. The point of arrival is fixed as for the subterranean descent, at 40″ below the bottom of the ditch when dry, and 16″ above the level of the water when wet. The direction of the descent between these two points should be a right line, and the inclination should not exceed $\frac{1}{4}$. In case the maximum inclination would be insufficient to cause the descent to debouch at the proper level, the point of departure must be lowered. But this is seldom necessary, since blinded descents are only employed when the depth of the ditch is less than 10′ 10″. This depth permitting, as has already been stated, the construction of a subterranean gallery.

The construction is as follows: a debouche by the double sap is executed from the crowning of the covered way, according to the method previously described, with the exception that bermes 2′ in width are left, in order to reduce the width of the trench (when completed) at bottom to 7′ 8″. This course is pursued until the sap-rollers have nearly cleared the parapet of the trench from which the debouche has been effected, which will require the placing of four gabions, if care has been taken to enlarge the sap forming the crowning, and to throw no earth in rear of the gabions to be overturned in debouching. The required depth for the descent is then attained; the slope given to the sides should be as steep as the nature of the ground will permit ($\frac{1}{3}$ or $\frac{1}{4}$ for example). At the same time a landing is formed in the crowning sap at the point of departure of the descent, having the same depth as the latter. This landing is united with the bottom of the trench by slopes. A vertical blind is then placed on each side, and connected by a strong batten passing across the trench. A horizontal blind is then placed, one side resting on the two vertical blinds, the other on two false stanchions placed in advance. Two or three of the vertical blinds are placed when the excavation has sufficiently advanced. The whole is then covered with fascines and the hides of newly-killed cattle.





Shortly after the commencement of the descent a very delicate operation has to be executed, viz.: causing the sap-rollers to descend the interior slope of the covered way.



In order that this operation may be successful, it is essential that previous to debouching the two rollers should be securely fastened together. Then, if there are no palisades in the covered way, or if the palisading, torn by the cannon of the besiegers, has little sally above the crest of the glacis, the rollers may be pushed forward with the sap-hooks and allowed to fall on the banquette, a rope or chain being fastened to each end and the middle, by which the rollers are prevented from rolling off the banquette to the terreplein. If, however, the palisades have preserved their points and then sally above the crest, these points engaging in the watling may impede the progress of the rollers. In this case the rollers may be slightly raised with levers, and three or four planks slid under their middle and extremities, and placed, one end resting on the glacis, the other on the palisading, thus forming a ramp over which they may be rolled untill they fall on the banquette. The same end may be accomplished by throwing sand-bags into the interval between the palisades and interior slope, heaping them above the points of the palisades. In every case great attention must be paid to the ropes by which the rollers are retained. The same precaution is necessary in descending the banquette slope, lest the roller move too far in advance to cover the head of the descent. If, however, it is sometimes found too far in advance, it will suffice to suspend across the descent, against the upper part of the last-placed blinds, a thick plank, which serves to mask the interior. As to the head of the work, the roller always covers it sufficiently.

The execution of the descent comprises two operations,

EXCAVATING AND BLINDING.

The excavation is accomplished by the double sap, as before mentioned. It is executed by two sappers, who excavate to the full width and depth of the descent, throwing the earth in rear of the lateral gabions. If, however, the depth is to be greater than 80″, the leading sappers only dig to this depth, and are followed by two others, who complete the excavation, leaving for the first a banquette 40″ wide, and throwing the earth into wheelbarrows, in which it is transported to the rear and thrown on the parapet of the crowning by the remaining sappers. In case the soil is too loose to allow the excavation to be carried to the depth of 80″, leaving a slope of $\frac{1}{3}$; the leading sappers dig as deep as the nature of the soil will permit, giving the sides a slope of $\frac{1}{4}$ or $\frac{1}{3}$.

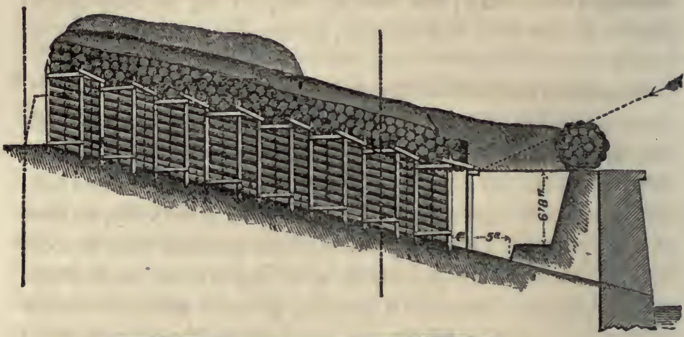
When the head of the descent has attained a depth of 80″, the leading sappers are sufficiently covered to dispense with the lateral gabionades. They still continue, however, to form parapets, by throwing the earth to the right and left, taking care to move the rollers forward gradually, so that at each partial advance a portion of the parapet thus formed shall fall forward against them, affording a cover to the sappers. On such occasions a quantity of loose earth should be kept in readiness to fill up the gaps formed by the advance of the rollers, as soon as they are made. Finally, as soon as the lateral parapets have acquired sufficient thickness to protect the head of the work, earth is thrown to the rear, on the fascines forming the roof of the blindage, to protect it from the fireworks of the besieged.

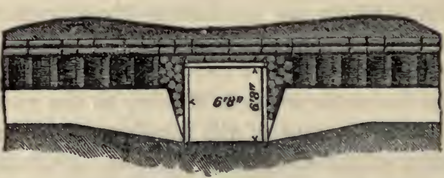
As the excavation advances, pickets are driven at intervals of 40″, to aid in determining the direction and inclination.

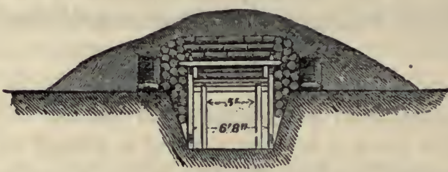
BLINDAGE.

When the excavation has advanced 24″ or 28″ beyond the last vertical blind, a horizontal blind is placed on the latter, and sustained in front by two "*false stanchions.*" These are placed on each side, and about 30″ from the axis of the descent; the foot of each is buried a few inches in the ground, and their height is such as to raise the anterior of the horizontal blind from 4″ to 6″ above its true position.

A new lateral blind is introduced when the excavation has advanced 5′ from the last-placed vertical blind; for this purpose two holes are made on each side, in the alignment of the lateral blinds, to receive the feet of the new ones, the one 14″ deep and 20″ from the nearest stanchion of the last blind, the other 4″ deep and 40″ from the first (in the case where the inclination is $\frac{1}{4}$). The lateral blinds are then







placed, their tops engaged under the horizontal blind, and the false stanchion removed.

It may be remarked that the lateral blinds should be placed as nearly vertical and in the same alignment as possible, but an attempt to place them with great accuracy would delay the work unnecessarily; it is sufficient to place the two first on each side carefully to guide the position of the following.

When the blinds are in position they are covered with blinding fascines, which are 9′ long, and 9″ in diameter. The two sappers at the head of the work are charged with this operation. They seize the fascines (one at each end), cast them up on the blinds, and arrange them with their forks; three or four courses are thus placed and covered with raw hides.

The spaces between the lateral blinds and slopes of the excavation are then filled with fascines, for this purpose a great number of fascines from 3′ to 5′ long and 9″ in diameter will be acquired.

TIME.

In ordinary soil, and with a counterscarp 11′ high, about 13″ of the descent may be executed in one hour. Ten sappers are employed; the two at the head of the work should be frequently relieved; they are provided with all the tools necessary for the double sap, as well as those required in executing an ordinary attack by the mine.

UNCOVERED DESCENT.

The sap by means of which the descent into a ditch of little depth is effected, without employing a blindage, is termed an uncovered descent. From the difficulty of defiling them, they usually require to be very narrow, and much deeper than the ordinary sap; otherwise there is nothing peculiar in their construction, except the difficulty in firmly placing the gabions on the slope of the descent.

DESCENT INTO THE COVERED WAY.

This is nothing more than a blinded descent executed by the process already described—usually placed opposite a traverse, as previously remarked, and indicated in the figure. When not exposed to a plunging fire, the "uncovered descent" may be employed for this purpose.

PASSAGE OF THE DITCH.

When the ditch is dry, the passage merely consists of a sap connecting the debouche of the descent with the foot of the breach. But in the wet ditch, a bridge must be constructed, which, under musketry and artillery fire of the place, is ordinarily a very difficult operation. The greater part of the experiments in this operation in the schools of practice have led to no satisfactory results. The following is the process given by Vauban in his "*Traité de l'attaque des places.*"

PASSAGE OF THE MAIN DITCH.

When the ditch is wet, from 100 to 120 men (according to circumstances) are stationed in line, two paces apart, with their backs to the parapet; they pass fascines from hand to hand to the head of the bridge; they are there received by a sapper, who forms an epaulement with them, by piling them on his right or left, as the case may require; he then advances a few paces and commences the construction of the bridge, by casting the fascines obliquely downward and beneath the water. This operation is continued until the mass arrives at the surface; he then lays a course of fascines crosswise, and covers them with sufficient earth to sink them. The same operation is repeated until a firm passage is formed, whose top is a few feet above the surface of the water, and from 12′ to 14′ wide. During this manœuvre the epaulement is carried on by placing fascines a little in advance, with a fork, and arranging by the most convenient means. The epaulement should receive a considerable height, as the fascines always settle a good deal.

When it is perceived that the fascines touch the bottom of the ditch, and the epaulement has sufficient solidity, it is revetted with fascines bound together and picketed.

NOTE.—When the debouche is exposed to a plunging fire from the bastion, the passage must be commenced by forming a "*mountain*" of fascines, from 8′ to 10′ high, the sappers keeping close to this work at the epaulement and gallery, continually pushing forward the mountain until out of range of the plunging fire. The fascines of which it is constructed are then withdrawn by degrees and used for the bridge and epaulement, continuing to push forward the passage until it arrives at the foot of the breach, which I suppose by this time to be far advanced.

To guard against this plunging fire, the mountain of fascines alone will not be sufficient; a good strong gallery must also be employed, which is constructed under shelter of the mountain, as above stated, and continued until beyond the range of this fire.

When the water in the ditch is deep and has a rapid current, or can be given one, it must be acknowledged that the passage is by far the most difficult operation of the siege, especially when the current can be neither turned nor weakened from without. The utmost care and address will hardly secure success, unless the fire of the place is totally extinguished; even after that of the faces, flanks, curtain and tenailles is silenced, the work will be very much annoyed by mortars and stone-mortars.

When all these dangers can be avoided, the operations are carried on in the ditch as elsewhere. But it is extremely difficult to avoid even a part of them, and the danger of the execution is still very great; the workmen are very badly covered. From the constant danger of being seen a great loss of time and life ensues.

Let us suppose a place surrounded by a ditch, through which the water passes with considerable velocity, and is supplied either by a river or by a reservoir, from which the water is distributed from time to time through the ditches by means of sluices, giving whatever velocity may be required, as is the case in many of our places. In either case, as there will be either a continuous current, strong or feeble, or one repeated from time to time, the only method of effecting the passage will be by means of a heavy dike across the ditch, having sufficient strength to withstand the current, and a height at least two feet above the level of the water when at its greatest height.

For this purpose a mass of fascines well loaded with stones, sods, and earth, must be formed, that they may sink immediately to the bottom. Great width must be given to it, the earth rammed, and stakes driven through into the bottom of the ditch.

In a word, every means must be taken to render it solid, until it arrives within 20′ or 24′ of the foot of the revetment. The current then becomes very troublesome, and it will be necessary to make use of various expedients to complete the passage, such as rolling in large gabions and barrels filled with stones, which filling up the interval will still leave a passage for the water; trestles loaded with stones, earth and fascines, sinking boats (if any are to be obtained). All this should be accomplished before opening the breaching batteries. After by all these expedients the dike has arrived within 12′ or 18′ of the scarp, its head well secured, and its upper surface above that of the highest water, the guns of the breaching batteries should commence a lively fire against the foot of the scarp, which being overturned into the ditch, will probably fill up the interval.

If this is not completely effected, it will be necessary to attach a miner to the portion of the scarp still standing to drive the mine well in advance and opposite the head of the dike, if this does not succeed, workmen must be detached to form a lodgement at the foot of the breach, and working from that side of the ditch contribute to the completion of the dike.

There is another method which is excellent, but only applicable in narrow ditches with high revetments, which is, to attach two miners, the one to the scarp the other to the counterscarp, directly opposite each other.

If the mines are sufficiently deep and heavily charged, the ditch may be choked at one blow, particularly if the water has not more than 5′ or 6′ head.

It is thus we contemplated passing the ditch at the "*porte* *d'Auzin*," at Valenciennes, if the place had resisted long enough to compel us to go thus far.

SAPS CONSTRUCTED WITH SAND-BAGS.

These saps are principally employed when the ground passed over cannot be excavated, either in consequence of the presence of rock or water.

The bags are filled at some convenient place near the position where they are to be used, and out of view of the place attacked.

The working parties for this purpose are divided into squads, composed of two shovellers, one holder, two tiers, and as many men provided with picks as the nature of the soil may require. Each squad should fill 150 bags per hour.

The flying sap is constructed as follows:

A path from the depot of sand-bags to the trench should be selected, and distinctly marked, advantage being taken of the inequalities of the ground to obtain as much cover as possible. The carriers march along this path in single file, each carrying a filled bag on his shoulder; on arriving at the head of the sap he delivers the sand-bag to the sapper and returns for another.

Two sappers receive the bags from the carriers and form with them the 1st course of the parapet. The bags are all laid (*i. e.*, headers) perpendicular to the direction of the trench and with their mouths alternately out and in.

When twelve bags have been laid, a second course is commenced, by a second couple of sappers, supplied by a second set of carriers. This course is laid directly over and in the same manner as the first.

The succeeding courses are added in the same manner until the parapet has attained the required height. When a trench of the usual depth can be dug in the rear of this parapet, six or seven courses of bags will be sufficient. If the trench is but half the ordinary depth, nine or ten courses will be required; and if no excavation can be made, the parapet must be 6′ 8″ or fourteen bags higher.

This parapet is executed as follows: the 1st sapper, kneeling, places the first four courses (1), the second, also kneeling or stooping, lays the four courses No. 2.

Sappers Nos. 3, 4, and 5, lay the courses marked 3, 4, and 5; No. 6 lays the portion marked 6, No. 7 standing on the banquette and passing the bags up to him.

By a combination of gabions and sand-bags, the parapet may be constructed with greater rapidity and a less number of bags.

The gabions are placed as in the ordinary flying sap, and filled with sand-bags by a party of carriers. The bags for this purpose should not be quite full, in order that they may lie closer in the gabion. The sand-bags for increasing the height and thickness of the parapet are laid in a manner similar to the preceding case.

To give greater stability to the parapet, two rows of gabions may be employed, and the thickness afterward increased by either throwing earth over, joining the mound represented by the dotted lines, or increasing from the interior by courses of sand-bags.

MILITARY MINING.

PART IV.

PRACTICAL OPERATIONS IN MINING.

The essential difference between civil and military mining is, that in the former the works are, for the most part, carried on at greater depths below the surface of the earth, and in solid rock; whereas, military mining is what may be termed superficial, and consequently the miner works through the more recent formations of earths and sands, which, from their little tenacity, he has to support, as he advances, with wooden linings. It is in the adjustment and fittings of these linings that the chief art of the military miner consists.

The excavations made by military miners are, when vertical, called shafts; when horizontal, or when slightly inclined, and exceeding in dimensions three feet by four feet, galleries; when under these dimensions, branches. When galleries or branches are inclined, they are called ascending or descending, according to the direction of their inclination.

The galleries or branches of a system of mines, forming part of the defences of a fortress, are usually reveted with masonry. Their construction and detail will not be included in this part of the subject.

The following table gives the names and dimensions of galleries and branches employed in mining operations:

Name. Description of Gallery or Branch.	Dimensions in the clear.	Scantling of Frames.		
		Ground-sill.	Stanchions.	Cap-sill.
	Height. Width. Ft. Ins. Ft. Ins.	Inches.	Inches.	Inches.
1. Great Gallery,	6 6 × 7 0	6 × 3	6 × 6	6 × 8½
2. Principal Gallery,	6 6 × 3 6	5½ × 3	5½ × 5½	5½ × 8
3. Common Gallery,	4 6 × 3 0	"	5 × 5	5 × 6½
4. Great Branch,	3 6 × 2 9	4 × 3	4 × 4	4 × 5
5. Small Branch,	2 6 × 2 0	3 × 2	3 × 3	3 × 4

1. Those galleries used for descent into ditches and the passage of cannon.

2. Those used for descent into ditches and the passage of troops, two deep.

3. Sufficiently large for all the general purposes of attack; and as it allows the miner a free change of posture, either to work kneeling on both knees or on one knee, with the right or left foot advanced, he works without feeling cramped, and executes this size more rapidly than any other.

4 and 5. Too small to work in for a greater distance than ten or twelve feet.

TOOLS REQUIRED FOR MINING OPERATIONS.

Pickaxe (common),
do. (short-handled),
Shovel (common),
do. (short-handled),
Push-pick,
Rake,
Canvas bucket,
Windlass and rope,
Rope-ladder,
Wooden wedges and pins,
do. pickets,
Miners' wagon,
Wheelbarrow,
Handsaw,
Mallet,
Hammer (claw),
Rough plane (¼-inch),
Chisel,
Gimlet,
Two-foot rule,
Plumb-bob,
Boring-rods,
Five-foot rod,
Bellows (miners),
Ventilating tube,
Flexible joints,

Iron candlestick,
Lamp (miners),
Lantern,
Oil-can,
Measuring-tape,
Compass,
Universal level,
Needles, threads, and scissors,
Calico for hose,
Hatchet,
Tin funnel (for fitting hose),
Rammers (short-handled),
Helves (spare),
Sand-bags.

WOODEN LININGS.

It has already been stated that the military miner, from the loose or made soil in which he generally works, has, as he advances, to support with wooden linings the top and sides of his excavation. In some soils, the earth is of sufficient tenacity to require only, that in driving galleries in it, their top should be supported. But in sinking shafts, it is always advisable, unless their depth should be very little, to line them with boarding throughout, or, at least, partially.

In describing the process of driving a gallery, the soil is supposed to be of that nature which renders close casing desirable.

There are two methods adopted for lining shafts and galleries. The first is with mine-frames, which, in appearance, are similar to door-frames, being cut out of scantling, and placed upright or horizontally at certain intervals in the gallery or shaft, as the case may be, and which serve as supports to planks, called sheeting-planks, or sheds, which are placed all around between the frames and sides of the excavation. The second is with cases, which, instead of being made from scantling, are formed out of plank, about two inches thick and one foot wide; these are placed close together, and serve at once for frames or sheeting. The advantage of this latter method in saving excavation, and consequently expediting the work, is at once obvious. Besides which, the facility of fixing them up is much greater.

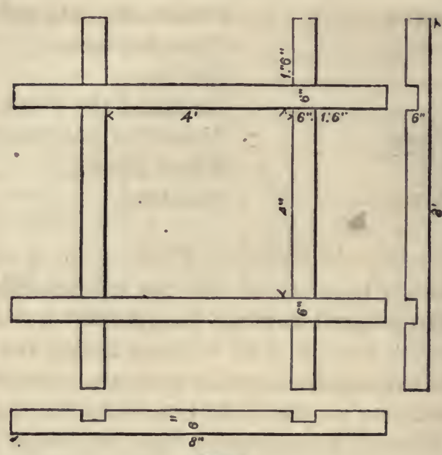


Fig. 1.

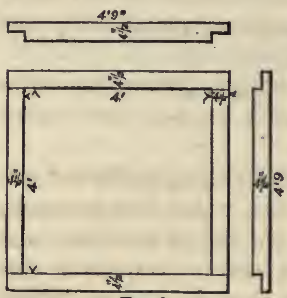


Fig. 2.

Shaft frames are composed of four pieces halved together. The top frame has the same dimensions in the clear as the other, but the ends project about one foot in each direction.

The sheeting for shafts should be of plank, from 1″ to $1\frac{1}{2}$″ thick. The planks are usually chamfered at one end, to admit of their being more easily pushed forward. Their length will depend on the distances at which the frames are placed, which, on an average, may be assumed to be four feet; the planks may therefore be cut in lengths of five feet, which will allow the necessary overlap.

MEN AND TOOLS REQUIRED FOR SINKING A SHAFT.

It has been found that one man can work in a shaft not less than four feet in depth, and throw out earth until it is eight or nine feet deep; after which the earth is drawn up in a canvas bag, or bucket, by two men at the top, by means of ropes attached to each of its handles. Should the depth become great, a windlass and bucket must be substituted.

MEN.		TOOLS.													
		Picks.		Shovels.											
N. C. Officers.	Privates.	Short.	Push.	Long.	Short.	Line.	Level.	Measuring-rod.	Mallet.	Canvas bag.	Rope-ladder.	Wheelbarrows.	Windlass.	Miners' trucks.	Ventilating apparatus.
1	9	1	1	2	2	1	1	1	1	1	1	2	1	2	1

The disposition of the workmen is as follows:

One man excavates and fills the bag.

Two men haul up, or work the windlass.

One man fills the wheelbarrow.

One man wheels.

One man spreads, to prevent an accumulation, which might attract observation. Two gauges or rods for the extreme dimension of the rectangle of excavation are to be provided. These two rods must exceed respectively the true exterior dimensions of the shaft-frame in length by about six inches (three inches on each side), in order to admit of two thicknesses of sheeting planks being introduced all around, between the frame and sides of the excavation.

The top shaft-frame having, when placed, only one thickness of sheeting planks around it, the rectangle of excavation must be marked on the ground rather less than the dimensions of the gauges. When the shaft is intended to be sunk with a view to the commencement of a gallery, care must be taken that the scores on the sides of this rectangle shall agree with the direction of the proposed gallery.

The distance at which the floor of the gallery is to be placed below the surface of the ground being given, the first thing to be done is to determine the distance to be left between the frames. To find this, let us suppose that a common gallery, four feet six inches high in the clear, is to be driven from the bottom of a shaft twenty-five feet deep.

Then the height of the gallery, from the floor to the top

of the cap-sill being . . .	5 ft. 1 in.
Thickness of top sheeting, . .	0 " 2 "
Free space for introduction of sheeting, .	0 " 2 "
Thickness of shaft frame next above the gallery,	0 " $4\frac{1}{2}$ "
Total, ...	5 ft. $9\frac{1}{2}$ in.

The top, therefore, of the frame above the gallery must then be five feet nine and one-half inches from the bottom of the shaft. Subtract this from the total depth of twenty-five feet, there remain nineteen feet two and one-half inches. There would then be required four intervals of four feet each, and one of three feet two and one-half inches for the last interval. To find the length of the last set of sheeting planks, the thickness of one frame and one overlap of two inches must be added to $5' \, 9\frac{1}{2}''$, making $6' \, 4''$.

An excavation of the size of the rectangle previously marked must then be cut vertically down to the depth of two or three feet; after which, one of the top-shaft frames, before described, is placed directly over the excavation, the projecting pieces preventing it from falling down. This frame is generally placed flush with the surface of the ground. The excavation is then continued to the depth of four feet, when a common frame is put together, and laid horizontally at the bottom of the shaft, with its corresponding sides vertically under those of the upper frame. The excavation at this level must be fully equal to the dimensions indicated by the gauge-rods. A plumb-bob is necessary to preserve the verticality of the excavation, as well as for the adjustment of the successive shaft-frames by means of the notches before noticed. As soon as the second frame is placed, the first set of planks are pushed vertically downward, with their pointed ends foremost, between the earth on each side and the top frame.

At top, each of these planks is pressed home close to the top frame, but at the bottom it is kept out from the lower frame by wedges rather thicker than the plank itself. The two frames are then connected by four ties of wood, which are thin laths, about two inches wide, extending vertically from one frame to the other, being nailed to each. Sometimes rope is used, in which case it is made to pass through holes bored in the frames; and a knot in the rope, or a picket between the strands, immediately under the lower frame, prevents it from falling.

After the first two shaft frames and one set of sheeting planks are thus placed, and the frames connected, the excavation is continued about four feet deeper, when another frame is placed with the same care. A second set of planks is then introduced between the first set and the second frame, after removing the wedges which were before inserted, in order to preserve room for them. These new planks are pushed down to the bottom of the shaft, and are there separated from the lower shaft frame by wedges, as before described. Thus the work goes on until the miner arrives near the level of the top of the proposed gallery, when the last shaft frame must be placed at the calculated interval. This being attended to, the excavation is continued down to the bottom of the intended gallery, when another shaft-frame is placed so as to have its upper surface on a level with the floor of the gallery. Three sides only of this part of the shaft must now be sheeted, and without wedging out the planks which are to rest against the bottom frames. The fourth side of the shaft being left clear for the entrance of the gallery on this side, the outline of the gallery is traced.

DRIVING GALLERIES WITH MINE FRAMES.

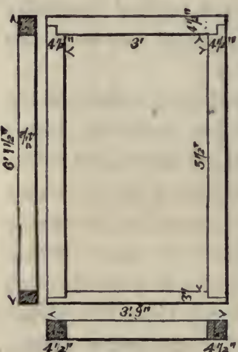


FIG. 3.

Fig. 3 represents a gallery-frame. The uprights are called stanchions; the top piece, cap-sill; the bottom piece is the ground-sill. The two latter pieces are scored at the middle point.

The scantling for the stanchions of a branch may be 4″; for a gallery three or four feet wide, $5\frac{1}{2}$″ or 6″. The cap-sill is usually made of the same width as the stanchions, but somewhat deeper, for the sake of strength, the chief pressure being vertical. In branches and small galleries an excess of about one-fourth will be sufficient; in the wider galleries, the excess may amount to one-third, or even one-half. The side sheeting of galleries may be of 1″ or $1\frac{1}{2}$″ plank; for the top sheeting it should be from 2″ to $2\frac{1}{2}$″. Great gallery frames have their stanchions of scantling $5\frac{1}{2}$″ or 6″ square, and their cap-sills 8″ by $5\frac{1}{2}$″, or 8″ by 6″.

We shall now proceed to describe the method of driving the gallery from the bottom of a shaft; and we shall consider the ground to be such as to render it necessary to sheet the sides as well as the top. The first thing necessary is, to prepare two rods as gauges for regulating the height and width of the excavation. The gauge for the height must allow, beyond the extreme dimensions, for two thicknesses of plank, and that for the breadth for four thicknesses of plank—two on each side of the frame; and the latter, i. e., the gauge, must be notched, or otherwise conspicuously marked, in the centre. It was stated before,

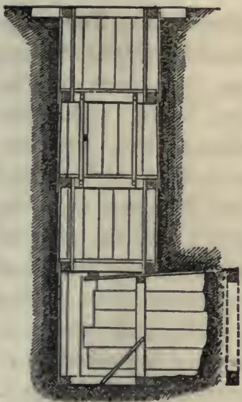


FIG. 4.

that in sinking a shaft the scores on the frames must correspond with the direction of the gallery intended to be driven from the bottom. If this has been carefully attended to, the direction of the gallery will be at once obtained by dropping plumb-lines along the scores, and marking these points at the bottom of the shaft with pickets; or, the notches on the bottom frames, if accurately laid, will be sufficient. In commencing the gallery, the excavation may be carried forward about one or two feet before the first frame is placed. The entrance made in the first instance should be less, both in width and height, by the thickness of one set of planks—that is, by $1\frac{1}{2}''$ on each side and $2''$ on the top. The exact position of the first frame being determined, the ground-sill is imbedded in the ground, outside and against the lower shaft frame. The stanchions are inserted, and the cap-sill set, and the whole frame squared by means of a plumb-bob, and temporarily secured in place by battens. This being completed, the excavation is continued for a distance of four feet, when another frame is set up. The ground-sill is first placed exactly perpendicular to, and its score in, the axis of the gallery. If the gallery is to be horizontal, the position of this sill will be verified by a spirit-level and straight-edge. If inclined, a slope-block is used in connection with the above implements. This is a block whose thickness is equal to the rise or fall of the floor of the gallery, in a distance equal to one interval.

The stanchions are then set up, their lower ends inserted in the notches in the ground-sill. The cap-sill is placed, and its position verified by plumbings from its score to that in the

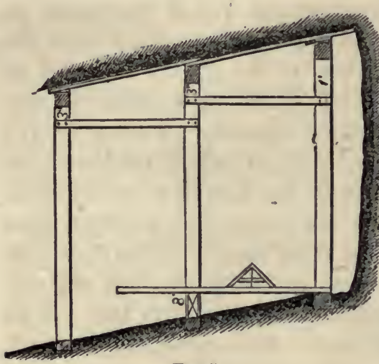


Fig. 5.

ground-sill. The top-sheeting planks having been introduced over the first frame, with their pointed ends foremost, are now pushed forward until they rest upon the cap-sill of the second frame. Wedges are then introduced, as in sinking a shaft, and the side sheeting is pushed on in an exactly similar manner.

MEN AND TOOLS REQUIRED FOR DRIVING A GALLERY FROM THE BOTTOM OF A SHAFT.

MEN.		TOOLS.										
		Picks.		Shovels.								
N. C. Officer.	Privates.	Short.	Push.	Long.	Short.	Line.	Level.	Measuring-rod.	Mallet.	Canvas bag.	Rope ladder.	Wheelbarrows.
1	6	1	1	2	1	1	1	1	1	1	1	2

The disposition of the workmen is as follows:

1 man picks.

1 " fills the truck.

1 " wheels.

1 " fills the bucket at the bottom of the shaft, or attaches the truck to the windlass.

Five men are employed at the top of the shaft, as stated before.

For every fifty feet driven, an additional man and truck become necessary, recesses being cut at the sides to receive the empty truck while the loaded one passes. One additional man will also be required at top, to work the ventilating apparatus. Instead of using a bucket for hoisting up the earth, it is found to be a more expeditious plan to attach the full truck to the windlass. Where the gallery is unconnected with a shaft, the two men working the windlass might be struck off. In great galleries the earth may be removed in wheelbarrows.

Whenever there appears to be any risk of the soil falling in, it is proper, after placing each successive frame and excavating one or two feet beyond it, to remove the wedges, and to introduce the next set of top-sheeting planks, as far as they will go, without waiting for another frame, and to push them forward as the excavating proceeds. Thus the man excavating will always work under cover of these planks.

INCLINED GALLERIES.

When the depth required to be reached is not great, it will generally be found more convenient to obtain this object by making a descending gallery in preference to striking out from the bottom of a shaft. A gallery is never made to descend more than 1 foot in 2. A descending gallery may be commenced from behind some bank or natural cover, or from behind a parapet; as for example, from one of the most advanced parallels or lodgements in a siege. It may not always be convenient to commence a gallery, when required in a siege, from one of the regular parallels or lodgements; in such cases a small parallel may be made for the purpose, and connected with the nearest trenches by a boyau. When a descending gallery is commenced from a parallel, the trench of the parallel must be deepened at the spot chosen for the entrance of the gallery as much as may be necessary to allow the top of the excavation of the gallery to be two and a half or three feet below the original surface of the ground. The execution of the gallery is to all intents the same as that of a horizontal one, except that the frames are

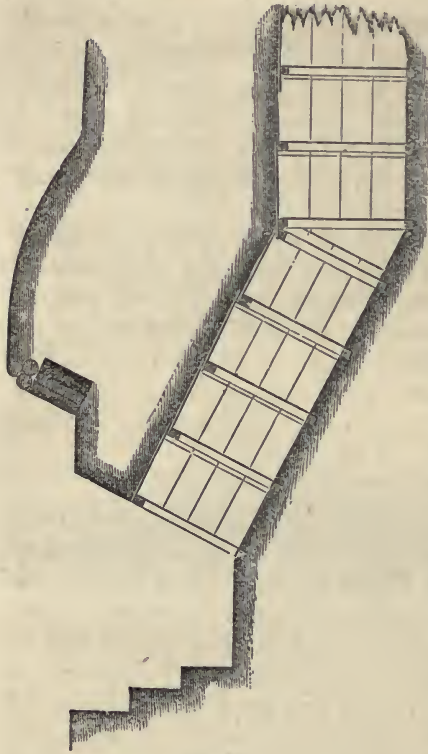


FIG. 6.

set up perpendicular to the slope, and the distance between any two must be measured along it. This being attended to, the same sheeting will answer whether the gallery is inclined or horizontal. The first frame of an inclined gallery ought, as nearly as possible, to be under the terreplein of the banquette. It is to be observed that the pressure of loose earth acting upon the roof of a gallery will always tend to overset the mine-frames, unless the latter are placed in a direction perpendicular to the floor of the gallery, or nearly so.

In changing from a descending direction to a horizontal one, it is necessary to change also from oblique frames to vertical ones, and it becomes also necessary to support the first vertical frame by struts placed parallel to the stanchions of the oblique frames in rear of it. Thus the cap-sill of the first vertical frame is as it were supported by two pairs of stanchions, one pair vertical and the other oblique, in order to resist the double action of the loose earth immediately above it, which presses vertically upon the top sheeting of the first horizontal bay, but obliquely upon the top sheeting of the last inclined bay of the gallery.

SINKING A SHAFT IN BAD SOIL.

In soil which has little tenacity, it may be necessary to provide an intermediate support for the sheeting, during the operation of sinking the interval.

For this purpose a false frame is employed; this differs from the ordinary shaft frame, in being a little larger from out to out, and being made of rather smaller scantling.

It is used as follows, after the excavation has been carried about two feet below the frame last placed: the sheeting having been driven down as fast as the excavation advanced, the false frame is placed in the same manner as the ordinary frame; with the exception that no wedges are driven between it and the sheeting, it is connected by battens with the frame above. The excavation is then continued until the full depth of the interval is attained, when an ordinary frame is placed, the wedges driven, and the false frame removed.

When a common, or branch gallery is to be driven from the bottom of the shaft, the only precaution to be taken in making the last interval, will be to use somewhat thicker sheeting. But when the gallery is to be grand, or principal, the sheeting must be driven on all four sides, instead of three, and an additional frame placed three feet above the bottom.

To commence the gallery, set up the first frame and secure it in place by battens, then drive down the sheeting that is opposite the cap-sill until sufficient space is gained to enter the top sheeting of the gallery. As soon as this sheeting is entered, in order to prevent the pressure of the earth from forcing down the forward ends, a piece of plank is laid over the rear ends and engaged under the shaft-frame directly above. (See fig. 4.)

Then force down the shaft sheeting above mentioned, one foot further, drive the top sheeting as far as it will go, and enter the upper course of side sheeting. It may be necessary to brace the opposite plank of this sheeting apart, at their inner ends, to counteract the pressure of the earth at their other extremities. Continue to introduce the side sheeting by pairs, forcing down for this purpose the shaft sheeting one foot at a time on reaching the intermediate shaft frame, knock out the side which is against the gallery, and remove the sheeting resting against it, insert all the side sheeting, and push the excavation forward, always driving the sheeting in advance of the excavation. Two feet in advance of the first frame, the false frame (fig. 7) is set up. This consists of a ground-sill, two stanchions, and a cap-sill, united by mortice and tenons, the cap is rounded on top, the height is the same as the gallery frame, the width two inches greater. It is placed in the axis of the gallery, and in such a manner that the cap-sill shall be 2″ higher than those of the ordinary frames. In driving the sheeting around it no wedges are used. The excavation is then pushed on, until the place for the second gallery-frame is reached; this is set up and the wedges driven in the usual manner, and the false frame is removed.

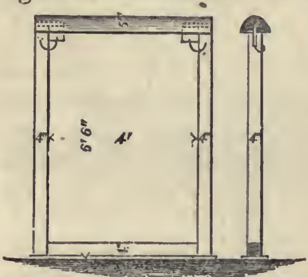


FIG. 7.

When the soil is very bad, a mask is employed to prevent the earth, above and in front from caving into the gallery. The process is as follows: as soon as the top sheeting is entered and the shaft sheeting forced down 1′ as above described, a piece of plank, equal in length to the width of the gallery, is placed directly under the top sheeting and against the earth to be excavated; this plank

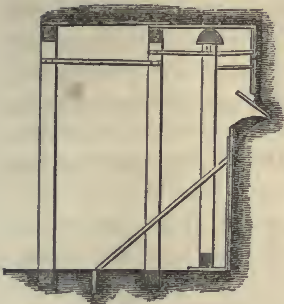


FIG. 8.

is held in place by braces on each side to the frame in rear. In the same way the remaining planks of the shield are added in succession, and as soon as the shaft sheeting is lowered enough to receive them, until the entire front is covered, then the top plank of the shield is removed, and the earth excavated until it can be replaced 8″ or 10″ in advance, after which each plank is removed in succession, the earth excavated, and the plank replaced; as each partial excavation advances, the sheeting is driven forward.

BRANCHES.

In a system of military mines the branches are merely smaller galleries than usual, branching out from the common galleries, hence their name. As the construction of both is so much alike, it is only necessary to notice the circumstances under which a branch proceeding from a gallery may be commenced.

1. A branch may be excavated in the same direction and in continuation of the gallery itself. In this case the first branch frame must be placed immediately beyond the last gallery frame and close to it; or, if there be room, it may be placed exactly within it, the centre of both coinciding as in the annexed figure.

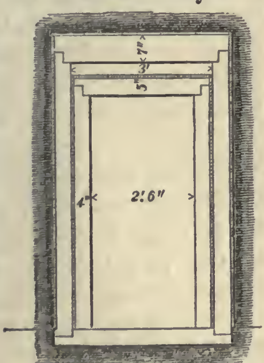


FIG. 9.

2. A branch may be cut at right angles to the gallery from whence it proceeds. In this case the mode of commencing is the same as ex-

cavating a gallery from the lower part of one side of a shaft, it being understood that the floor of the branch always commences from the bottom of the gallery. The entrance of the branch is of course cut half way between two adjacent gallery frames.

3. A branch may be commenced obliquely from the side of a gallery.

In this case, if the soil be good and not wanting much support, the first branch frame is placed as near to the side (see fig. 10) of the gallery as possible, but at right angles to the direction of the intended new branch. Hence, one stanchion only of the first branch frame can agree with the side of the gallery; the other side will be more or less distant from it in proportion to the degree of obliquity.

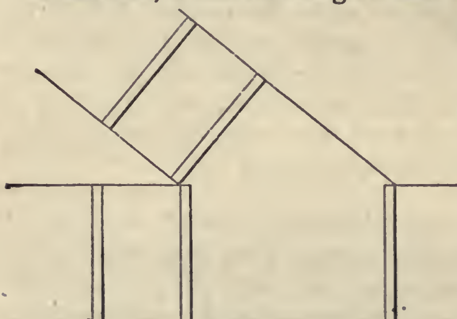


Fig. 10.

If, on the contrary, the ground cannot be trusted the first branch frame must be placed so as to line with the side of the gallery itself (see fig. 11), and consequently a longer cap-sill than the ordinary ones will be necessary.

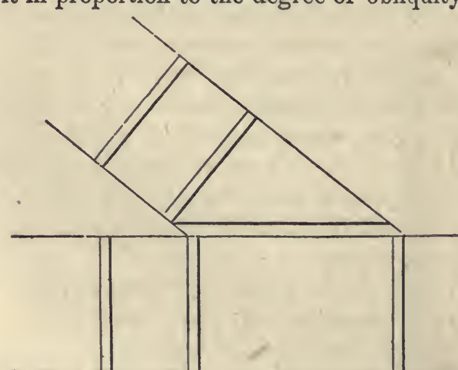


Fig. 11.

MINING WITH CASES.

Having described the method of mining with frames and sheeting, it remains now to point out the difference when mine-cases alone are used. These descriptions of cases have long been known under the name of Dutch cases; these consist of four pieces—two stanchions, a cap-sill, and ground-sill. For ordinary work they are made out of two-inch deal, and have a three-eighths of an inch round iron bolt driven transversely through the middle thickness of the wood of each piece, about four and a half inches from each end, to prevent them from splitting. The stanchions have tenons 2″ long by 3″ wide at each end, and mortices of corresponding dimensions are cut in the ends of the cap-sill and ground-sill to receive the tenons; the most convenient width for the piece would be twelve inches, but this is not a matter of consequence, and they may be made of whatever sized planks, not less than two inches thick, that can most readily be procured. In great galleries which require stronger materials, the stanchions may be four inches thick, the ground-sill three inches and the cap-sill five inches; notches, as shown in the figure, are cut in the stanchions for the purpose of rendering them more manageable, both in putting them up and taking them down; they also serve for places in which to drive pickets to support the case in a descending gallery. The size in the clear of cases, both for shafts and galleries, is the same as that of frames, and the same precautions and arrangements in their adjustments are necessary.

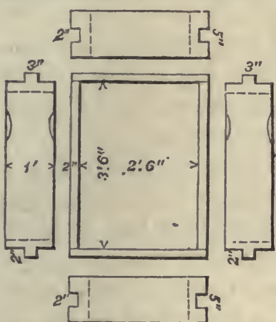


Fig. 12.

In sinking shafts when the excavation has advanced about one foot in depth, it becomes necessary to fix the first case, which is done in the following manner: One of the short pieces is first placed in its proper position into the excavation; the tenons of the two long pieces are then fitted into the mortises of this, and then the mortise at one end of the fourth side is fitted on its tenon; but to adjust the corresponding mortise and tenon, it will be necessary to push back either this short piece or the long one full two inches, in order to bring the mortise and tenon together; and whichever plan is adopted, as little earth as possible should be cut away. The first case being placed the excavation is proceeded with, and the second case is placed close under the first, and in a similar manner, and so on to the bottom of the shaft. This is the mode of proceeding when the soil is so bad as to require close casing; under ordinary circumstances, however, it will be sufficient to introduce a case at every three or four feet; and when this is done, it is usual to cut out the earth to the thickness of the plank, so as to admit of the case being placed flush with the sides of the excavation.

When it is intended to push a gallery from the bottom of a close-cased shaft, it is evident, before proceeding, it will be necessary to remove one side of the casing; and to do this without causing the adjacent sides to collapse, and the casing to tumble in, a frame somewhat similar to a door frame must be introduced—its ground-sill being ad-

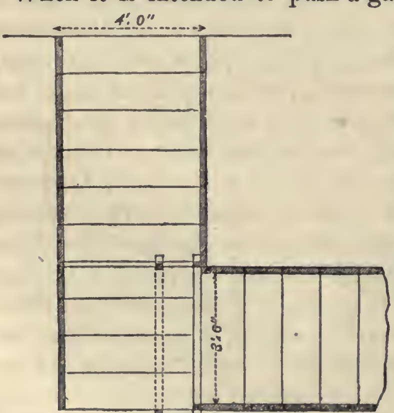


FIG. 18.

justed so that its upper side may be on a level with the floor of the intended gallery; the exterior dimensions of the frame must exactly correspond with the width of the shaft, and the interior dimensions may be exactly those of the gallery, or exceed them by an inch or two. When this frame is first put up it should be made to stand about one foot from the side of the casing which is to be removed; and when this is effected, it must be forced up against that side. These details having been attended to, the casing on the side from which the gallery is to start may be removed, commencing with the side of the lowest case; to remove which will be a work of some difficulty, as the earth must be picked away from behind it in order to admit of its being pushed back to clear it of its tenon. It will be necessary, in the first instance, to excavate the ground underneath it in order to admit of the introduction of the pick and push-pick, but the removal of each successive side will be easier. In driving the gallery, the mode of using the cases is as nearly similar as possible to that described for shafts, making allowance for the difference of direction; the ground-sill is first placed next the stanchions, and to fix the cap-sill the same mode of proceeding is to be adopted as has already been described for fixing the fourth side of the shaft case; the space which is necessarily left between the earth and the top of the cap-sill should be filled in before proceeding to place the next case. Close casing will seldom be required in a gallery, but the roofing should in most cases be supported; this can easily be effected by using pieces of the cases as top sheeting, extending from the top sides of the cases which it may be found necessary to use.

Great gallery cases are somewhat different from other cases. In order to give greater strength, the stanchions are made without tenons at their lower ends, which are kept in their places by cleats two inches thick nailed on to the sill; the mortises in the cap-sills need not be more than two inches deep. In driving great galleries in loose soil, after setting up the first frame it becomes necessary to support the top-sill, whilst the miner excavates the ground for the ground-sill and stanchions. For this purpose two upright

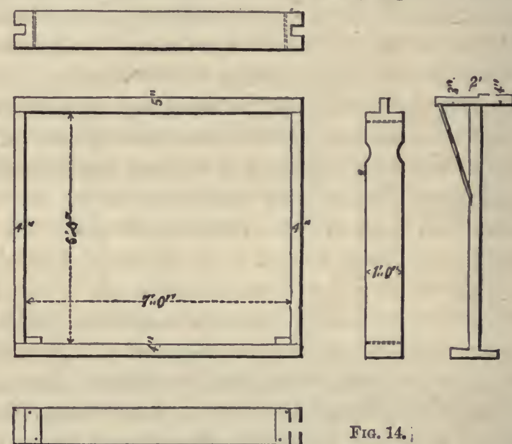


Fig. 14.

pieces of timber, carrying each a cross-piece, as represented in the annexed figure, are made use of. The upright part rests on the sill of the frame already placed, and is steadied by being wedged up. The cross-piece is two feet long, and the part that projects in advance, as will be seen from the figure, is made an inch higher than the rear part, to support the top-sill somewhat higher than its final level.

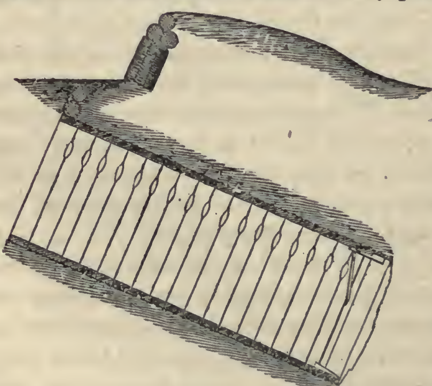


Fig. 15

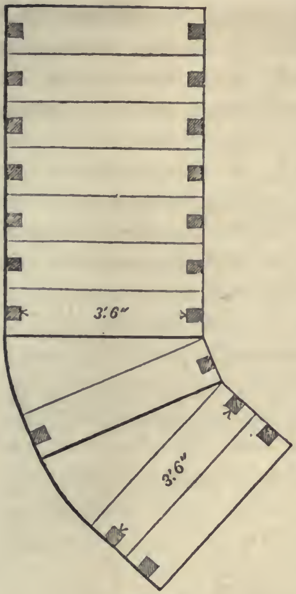


FIG. 16.

The rear part of the cross-piece is braced by a piece of iron to the upright. These are called crutches, and the materials of which they are made should be as light as a due regard to strength will admit.

In working with cases, the direction of a gallery may be easily and gradually changed, as shown in fig. 16.

If the soil is good, the intervals which occur between the cases may be left open; if bad, they may be filled up with small pieces of wood. When it is necessary to break out from the side of a gallery in a direction perpendicular or oblique to it, the requisite number of cases must be removed, and the roof of the interval lined with pieces of board extending across and supported on the extreme cases, as in fig. 17.

If the soil is very bad, the stanchions only from the side whence the new gallery is to proceed need be removed, and the intervening cap-sills can be supported as in fig. 18. But this method has the inconvenience of lowering the headway, a serious objection.

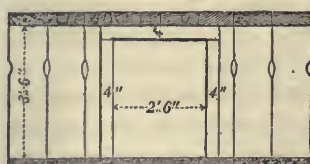


FIG. 17.

When a gallery branches from another in an oblique direction, it will be better to obtain the obliquity gradually, than by introducing an oblique case, like the frame indicated in fig. 16.

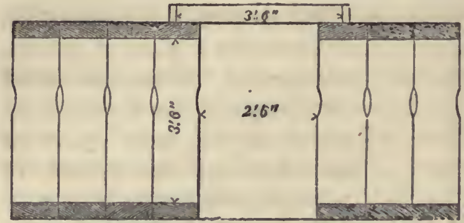


FIG. 18.

When cases are used, the work will advance at nearly double the rate it would with frames and sheeting, viz.: great galleries and shafts about one foot an hour; common galleries one foot and a half per hour.

CHARGING OF MINES.

The receptacle for the powder is called the chamber, and is usually at the extremity of a branch, either in its prolongation or on the flank.

When the charge does not exceed one hundred pounds, the ordinary powder-barrel may be used to contain it. When it is greater a cubical box is constructed in such a manner as to be readily put together in the excavation for the chamber. When the charge is very large, the lining of the chamber is formed with the ordinary mining-frames and sheeting or with mining-cases. When the weight of the charge is given, the size of the box may be determined by allowing thirty cubic inches to the pound.

TAMPING MINES.

The tamping of mines consists in filling up the gallery with solid material for a certain distance from the chamber, with the view of preventing the force of the explosion from expending itself in the gallery, rather than in the direction in which the mine is required to act.

The tamping should extend from the charge for a distance equal at least to 1½ times the line of least resistance; and if the material used for forming the tamping be not heavy, o·

otherwise but loosely packed, this distance should be double that line.

The materials usually employed in tamping consist of earth which has been excavated in the formation of the gallery, sods, sand-bags, or indeed, of any heavy substance which may be at hand. If the soil be argillaceous, it may be roughly moulded into bricks, which form an excellent material, and one with which the operation proceeds quickly. The most expeditious mode of tamping is, however, generally considered to be with sand-bags.

Split or cleft timber, in lengths of four or five feet, and of about 9 inches girt, jammed together in the gallery, is also very applicable, and when mixed with common earth at intervals of 10 or 12 feet, forms a good tamping. Indeed, in the demolition of revetments, by an arrangement of mines in an escarp gallery, it would be found sufficient if both extremities of the gallery were tamped with cleft timber. In tamping wholly with common earth, it is desirable to strengthen the mass by pieces of scantling crossing each other, and placed diagonally in the gallery. These pieces of scantling must be secured in their position by letting their ends into the sides of the gallery, or by simply jamming them.

In a permanent system of countermines, it is usual to leave grooves in the walls of the galleries, for the purpose of receiving the ends of the scantling above alluded to.

In a common gallery ($4\frac{1}{2}$ by 3 feet), the tamping, when executed with common earth and well rammed, will not be completed at a greater rate than from 2 to 3 feet per hour.

In proportion as the charge is increased, the value of the tamping diminishes. Experiments were made by Mouzé for the purpose of determining in what ratio the charge must be increased to produce the same effect with a diminished tamping; and he concluded that when the tamping is diminished by $\frac{1}{3}$, the charge should be increased $\frac{1}{4}$; when the tamping is diminished by $\frac{2}{3}$, the charge should be increased $\frac{1}{2}$; and when the mine is not tamped, the charge should be doubled.

FIRING MINES.

Mines are usually fired, or, as it is technically termed, sprung, by a powder-hose, or by Bickford's fuze.

The powder-hose consists of a tube of strong linen, reaching from the chamber to the outside of the tamping. To protect the hose, it is enclosed in a hollow wooden case represented in profile as follows:  the exterior dimensions of the case being 3 inches, and the interior $1\frac{1}{2}$ inch. The case is fastened to the side of the shaft or gallery by wooden pegs; and in galleries and branches, after it has been secured, it is usually covered with earth, to prevent accidents during the operation of tamping. The mine is fired by a piece of port-fire inserted into the end of the powder-hose, of such length as will give time to the man who fires it to escape before the explosion takes place. The port-fire is then covered all round with moist clay, well kneaded with the hands; and earth is applied around all, so as to render it impossible for any fire to communicate with the powder-hose till the port-fire shall have burnt out. When it is desired that several mines should explode simultaneously, being fired from one point, it is necessary that equal lengths of powder-hose should extend from the focus or point of ignition to all the mines.

To effect this object, the hose of the mines nearer to the focus must be bent more frequently than those leading to the more distant ones, as in the annexed diagram (fig. 19).

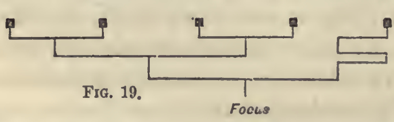


FIG. 19.

The bendings of the hose retard the progress of ignition, but only in a small degree, so small as to be safely neglected.

Bickford's fuze consists of a train of gunpowder enveloped in the strands of a rope which has been steeped in a peculiar composition, and the rope protected by a coat of pitch; it is not injured by damp, and will burn under water; it burns at the rate of 12 feet in five minutes.

The Voltaic battery is a means which may be resorted to for igniting mines; but the care and attention required to isolate the wires, and the difficulty of arranging securely so great a length of them, render this application of the battery, however desirable, hardly available for military purposes.

The rocket is also employed to fire the charge. Like the powder-hose, it requires a case or hose-trough. Wherever a change of direction takes place in the case, care must be taken that it is not made too quickly. At each angle it is usual to place a fresh rocket, with its quick-match secured round a nail; the first rocket, arriving at the point where the second is placed, fires it. In order better to secure the first rocket firing the second, a quantity of powder should be strewed about the match of the latter, protected by a triangular slip of deal, nailed to the bottom of the trough; the first rocket then ignites the powder, and so fires the second, which its rapid motion might otherwise fail to do.

When by the explosion of a charge of powder in a mine, a conical excavation or crater is formed in the ground. The radius at the surface is called the radius of the crater. The distance from the centre of the charge to the surface is the line of least resistance. The slant height of the cone is the radius of explosion. When the crater radius is equal to the line of least resistance, it is called a one-lined crater, when double a two-lined crater, &c.

When the crater is two-lined, the mine is called a common mine, when less an undercharged, and when greater an overcharged mine, or globe of compression.

The charge of powder necessary to produce these craters will of course depend on the nature of the soil as well as the depth of the charge below the surface.

In ordinary soil, the charge to produce a common mine may be found by cubing the line of least resistance taken in feet; this number divided by ten will give the charge in pounds. For the other classes of mines the charge has not as yet been well determined.

The following table has been derived from the most reliable experiments.

$LLR^3 \times \frac{1}{30}$	gave	1-lined	crater.	
$LLR^3 \times \frac{1}{20}$	"	$1\frac{1}{2}$	"	"
$LLR^3 \times \frac{1}{10}$	"	2	"	"
$LLR^3 \times \frac{1}{4}$	"	3	"	"
$LLR^3 \times 2\frac{1}{2}$	"	5	"	"
$LLR \times 4$	"	6	"	"

The following general rules will give approximate results

Subtract the given line of least resistance from the radius of crater; multiply this difference by ,85. Add this product to the given line of least resistance; the result will give the L L R of a common mine, requiring the same charge as the globe of compression, which may be determined as before stated by cubing the line of least resistance, and dividing by ten.

The effect of the explosion of the charge in a mine, is not confined to the formation of a crater. The earth in every direction within certain limits, called the radii of rupture, is pulverized and compressed to such a degree as to destroy any gallery that may be within the sphere of action. As one of the principal objects of offensive mines is the destruction of the enemy's galleries, it is important to ascertain the lengths of the radii for different charges.

When the charge placed at A is insufficient to form a crater, the effect is, to produce a spherical compression M N O, whose radius will depend on the charge and nature of the soil. This sphere is termed a camouflet.

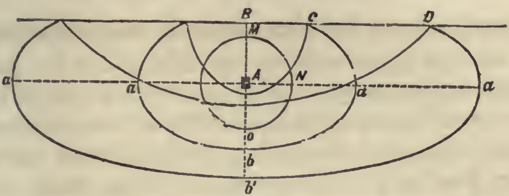


FIG. 20.

When the charge is sufficient to produce a crater, the solid of rupture becomes an elipsoid, *a b c*.

When A B = B C, or the mine is a "common" one, *a* A will be = 1.7 A B, and A *b* = 1.3 A B.

In the globe of compression, although the crater radius cannot be increased much beyond three times the line of least resistance A B, yet the radius of rupture may be, almost indefinitely, by increasing the charge.

In the case of a six-lined crater, the transverse axis A a'= $4\frac{1}{2}$ A B, and the vertical axis A b'=$1\frac{1}{2}$ A B. It will be observed that the radius of rupture increases much more rapidly in the horizontal than in the vertical direction, with the increase of charge.

VENTILATION.

Great attention must be paid to ventilation in driving extensive galleries, as the gases generated by the explosion of gunpowder or contained in the soil, have sometimes suffocated the miner before the extinction of his light have warned him of its presence, and even under ordinary circumstances, the air becomes so much vitiated by the presence of the workmen alone, that branches cannot be safely driven more than about 60 feet; beyond this distance apertures should therefore be bored, if possible, up to the surface of the ground at intervals, taking care to conceal their position from the enemy. Communications may also be made with adjacent galleries to create a draught.

Mechanical means are sometimes employed to produce a circulation, so as to substitute fresh air for that which is impure; for this purpose tubes are laid along the galleries through which fresh air may be forced in, or bad air extracted. As there may be a large quantity of noxious gas in the soil, ready to supply the place of that extracted, the system of forcing air in is to be preferred. The tubes used for ventilation have ordinarily been made of wood or tin, but vulcanized india-rubber would probably answer the purpose better.

For forcing the air through the tubes, the fan-blower, such as is used in reverberatory furnaces and forges has been employed advantageously. The ordinary blacksmith's bellows may be used where the length of the tube is not great.

ATTACK AND DEFENCE OF A SYSTEM OF COUNTERMINES.

When the besieger arrives in the vicinity of the glacis of a countermined fortress, he is obliged to move slowly, and dares not advance on the surface of the ground further than what he may be master of below. He then commences to excavate the earth, in order to try to discover the galleries of the besieged, and to seize them, or else he endeavors to blow them in by firing mines. To accomplish this, in the middle of his third parallel he sinks shafts from sixteen to twenty-one feet deep, he then pushes forward a gallery, taking care to stop working at intervals, to listen if the enemy is coming to meet him.

Often the besieged, especially when his galleries extend to a great distance, drives a branch almost under the third parallel, and fires one or more mines. The besieger, under this supposition, ought to make a lodgement on the edge of the crater, and sink a shaft, in his own lodgement. This shaft is not sunk from the bottom of the crater, because it would be the reservoir of all projectiles thrown from the place. Care must be taken, however, at the same time, to clear away the excavation caused by the globe of compression, in order to discover the direction of the branch which joins it, and which necessarily communicates with a main gallery.

While the besieger is sinking the shaft, he ought frequently to listen, for there is not a doubt that he is now in the vicinity of the mines of the besieged; and when he arrives at the depth of eighteen or twenty feet, he commences a branch, breaking out on that side where he imagines the enemy's gallery to be situated.

When the besieger finds himself sufficiently near to the gallery of the place, and is in danger of being forestalled, he hastens to dig a chamber at the extremity of his branch, in which he places a certain quantity of powder. He then tamps as fast as possible, and endeavors to fire his mine before the besieged can find time to establish one to destroy his works.

The besieged, on their side, directly they cease to hear the sound of the pickaxe, work with the greatest possible diligence, because they suppose from that instant their enemy is engaged in tamping their mine. If they have the good fortune to fall in with the mine, they endeavor to seize the powder, or else to saturate it by an inundation of water. If, on the contrary, they discover a part of the branch already excavated, they ought, without delay, to inundate it, in order to destroy the hose, and so prevent the powder from exploding. These artifices are made use of in like manner by the besieger.

It sometimes happens that two miners, who are working to meet each other, are only separated by a slight partition of earth. This is an occasion seized upon to give the "camouflet," which is performed in this manner: The most active of the two pierces a hole on the side of his enemy, with borers of different diameter, in order to enlarge it gradually, and to give it a diameter of six inches. He digs this hole as deep as he can—from six to eight feet, for instance. He then introduces a large cartridge of the same size, containing from twelve to twenty pounds of powder. He drives in this species of mine with a plug of wood, which he fixes and props up strongly with a piece of wood across the branch. Finally, he fires this little mine, by means of a fuze which goes through the middle of the plug.

If the gallery of the enemy is but four or five feet from the head of this cartridge, he may be sure that it will be driven in by the explosion.

To produce the same effect, two or three shells, fixed together, are sometimes employed. But this method requires a great deal of care and attention, in order that one's own labor be not exposed to destruction.

In subterranean warfare, when two miners are working to meet each other, they take care to try the ground frequently with a borer, to find out exactly what distance they are off. In such a case, he who sees the end of his enemy's borer appearing, keeps a strict watch on the moment it is drawn back. He then introduces quickly into the hole it leaves a pistol loaded with ball, and fires it the moment he imagines the hole is clear. This ought to be followed by three or four more; after which a probe is pushed into the opening, to clear it, and prevent the enemy coming through on that side.

Vauban recommends the following articles to be provided, in attacks of this description:

1st. A frame of wood, like a shield, 3″ or 4″ thick, with a bolt in the middle to manage it with, and to place it against the hole perforated by the probe.

2d. Smoke balls. They are pushed in through the same hole, when lighted, and care is taken to stop the hole on one's own side, so that all the smoke goes into the enemy's gallery, by which means their miner is driven away for some time. During his absence the mine is charged and fired, which, by blowing in the gallery, prevents the return of the enemy. If the opening is wide enough, a shell or port-fires, to suffocate, or grenades, may be introduced. The shell is to be preferred, when it can be used, because it destroys the part of the gallery where it falls. When a thin partition of earth divides the combatants, a petard is used to blow it in.

Such are a great part of the artifices made use of by miners. To avoid them the besieger should, as soon as he can, fire a mine to blow in the branches, and even the galleries, of the besieged, if within reach. He is sure, by this means, of driving him away for some days. It is well known that the firing of a mine shakes the ground to a considerable distance, so that if a gallery be within this limit, the gases of the powder penetrate and poison the air with such effect that no one can breathe it. This is not so much felt by the besieger, as he has more air, not being obliged to use such long galleries.

CONSTRUCTION OF BATTERIES.

PART V.

CONSTRUCTION OF BATTERIES.

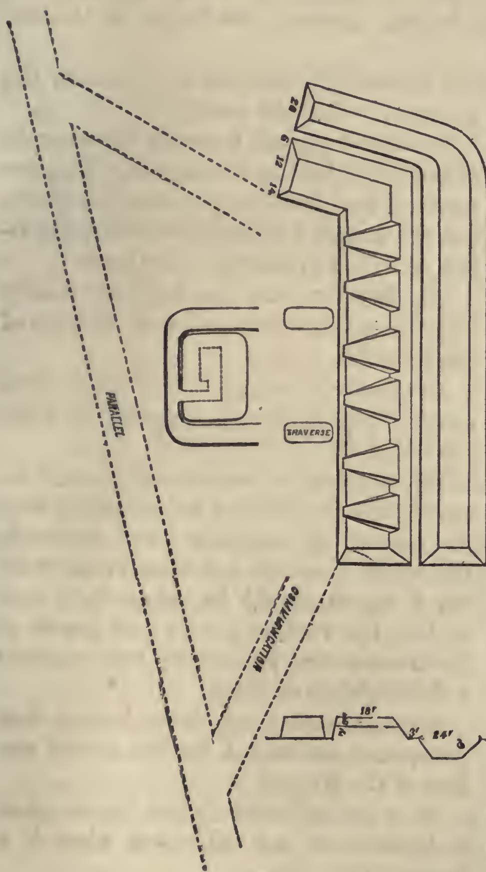


Fig. 1.

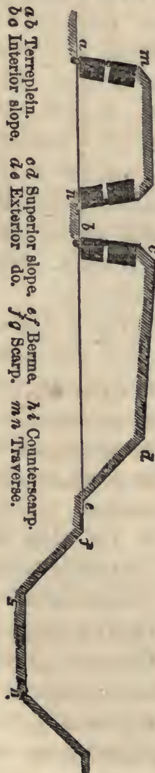
In the following pages the term battery is applied to those positions prepared for the reception of artillery in such a manner as to cover the pieces and cannoniers from the enemy's fire.

Fig. 1 represents the plan of a battery for six pieces. The covering mass in front is the parapet. That at the side is the epaulement. The earth for the construction of these embankments is generally furnished from an exterior excavation or ditch. In batteries the different slopes of the parapet, ditch, &c., are designated in the same manner as the corresponding surfaces in field fortifications.

Embrasures are openings in the parapet through which the pieces are fired.

The lower surface is termed the sole, the sides the checks, and the interior openings the throat of the embrasure.

In the interior of the battery the floor, or surface of the ground, is called the terreplein.



ab Terreplein. *cd* Superior slope. *ef* Berme. *hi* Counterscarp.
bc Interior slope. *de* Exterior do. *fg* Scarp. *mn* Traverse.

FIG. 2.

The splinter-proof traverses are mounds of earth sustained by revetments. They are usually placed alternately between the pieces, and are intended to limit the destructive effect of a shell exploding in the battery.

The first batteries in a siege are usually situated about thirty yards in advance of the parallels.

The nature of the ground, or danger from sorties, may render it necessary to place them behind or in the parallel.

Whatever their position may be, it is essential that they should be connected with the parallel by well covered and commodious communications, and when in the parallel, a trench should be cut in their rear, so that the working parties and guards of the trenches may pass around and not make a thoroughfare of them.

Batteries are termed elevated when their terrepleins are formed by the natural surface of the ground.

They are half-sunken when the terreplein is lowered 2′, and full-sunken when it is lowered three feet.

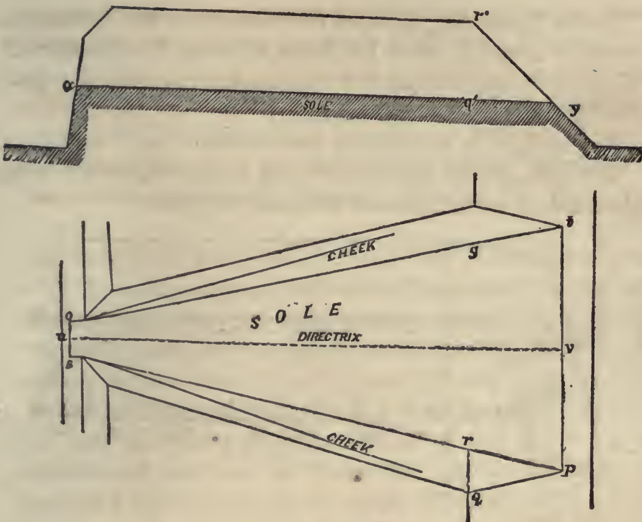


FIG. 8.

$cstp$ Sole of embrasure.
sqp — Cheek.
$pt = \frac{1}{2} uv$.
Horizontal distance $rq = \frac{1}{2}$ vertical distance $r'q'$.

In the first form the fire of the guns is less liable to be obstructed by accidents of the ground in front, and the terreplein is more easily drained. In the latter classes the parapet has more stability, and their construction is more rapid, as a greater number of workmen can be employed at the same time.

THE TRACING OF BATTERIES.

The ground on which a battery is to be constructed, should be carefully examined, and if possible the direction of the parapet traced before dark. Whenever it is practicable, the parapets of direct batteries should be parallel, and of enfilade batteries perpendicular, to the faces they are to attack.

Before proceeding to trace the battery on the ground, an accurate drawing must be made, showing the direction of the parapet, epaulement and communications, also the position of the traverses and magazine.

The tracing on the ground must be made after dark.

We will suppose that an elevated six-gun battery is to be constructed, with traverses between the guns.

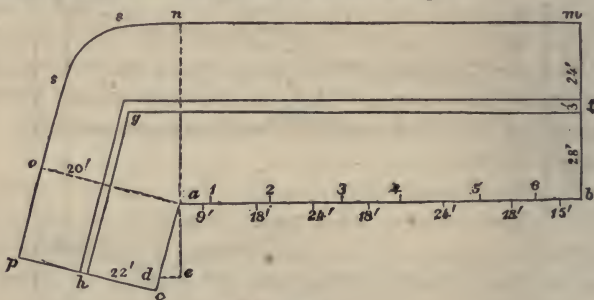


FIG. 4.

Let a b represent the foot of the interior slope of the parapet, a c that of the epaulement. Lay off a, $1=9'$, 1, $2=18'$. 1 and 2 will give the positions of the first and second embrasures. The next interval is 24′ as a traverse which will occupy six feet, will come between the second and third gun. The other intervals are laid off in a similar manner, 15′ being allowed for the extreme merlon on the side where there is no epaulement. The object of the epaulement being to screen the interior of the battery from oblique fire, the length and direction of the line a c will be dependent on the direction of this fire. The angle c a b having been previously determined, may be laid off either with a field level, or by constructing the triangle a e d.

By inspecting figure 1, the thickness of the parapet at its base will be found 28′ and that of the epaulement 20 feet. These distances must be laid off on the perpendiculars, b m, a n, and a o, c p. Stout pickets are driven at c, a, b, m, n, s, *s*, *o*, and *p*, and tracing-tape or white cord stretched around them, thus enclosing the ground to be covered by the parapet.

The ditch is marked out in a similar manner, giving it a width of 24′ in front of the parapet and 20′ for the epaulements, and leaving a space of three or four feet from the foot of the exterior slope for the berme.

DISTRIBUTION OF THE WORKING PARTY.

The working party, provided with tools and reveting material, are conducted to the site of the proposed battery, as soon as it is dark enough to avoid being seen by the besieged.

The line representing the foot of the exterior slope is divided into intervals of six feet; for each interval two excavators are placed in the ditch, one shoveller on the berme, one on the parapet, to level and ram the earth thrown in, and one sapper to level the terreplein and prepare the ground for receiving the platform.

When earth has been thrown into the parapet to the depth of two feet, the revetment of the interior slope is commenced; for this purpose five sappers for each one-gun portion of the battery are required.

FIG. 5.—FIRST NIGHT'S WORK.

During the first night the terreplein should be prepared, the parapet and revetment carried to the height of the sole of the embrasures, the traverses commenced, and the communications finished; the latter are constructed by the flying

FIG. 6.—WORK AT END OF FIRST DAY.

sap. As the excavation of the ditch is the most fatiguing part of the work, the men thus engaged change places with those on the berme and parapet every two hours.

The working party for the day arrive, just before dawn, bringing with them gabions, fascines, &c. The working party for the ditch is the same as before, the excavation being deep enough to cover them from the fire of the place.

They continue the excavation, throwing the earth on the berme, until no more can be piled there, then dig back toward the counterscarp, throwing the earth against the scarp ready to be passed up as soon as the berme is cleared on the following night. The shovellers and rammers will be prevented from working on the parapet by the fire of the besieged. They will be employed in finishing the communications, and the excavations for the magazine commenced on the previous night, and bringing up the timber for the platforms. The sappers will continue the revetment if the fire is not too heavy, and work at the magazine.

The working party for the second night arrive at dusk; they are distributed as on the first night—the shovellers throwing in the earth accumulated during the day on the berme. The sappers finish the revetment, the platforms are laid, if they have not been during the day, and the battery armed.

CONSTRUCTION.

The excavation is commenced 3′ from the line marking the crest of the scarp, and is carried down to the depth of 3′, then toward the counterscarp; as the ditch is intended merely to furnish earth for the scarp, and not as a defensive work, its form is immaterial. That indicated in fig. 5 is generally found most convenient, the step furnishing a platform on which the earth from the outer part of the ditch is thrown, and from thence into the parapet by a relay of shovellers. The steps are removed when the parapet is nearly finished.

REVETMENT WITH FASCINES.

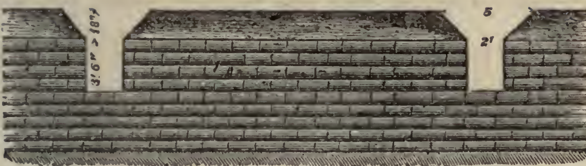


FIG. 7.

The line of the foot of the interior slope is levelled and a trench five inches deep is excavated to receive the first course of fascines for the revetment of the parapet. (The epaulement is not reveted.) The fascines are then laid, aligned, and fastened down with three pickets, one driven through the middle and one 18″ from each end of every fascine. The earth of the parapet is levelled up to the top of this course and rammed. The second course is laid, breaking joints with the first and picketed, the stakes passing through both courses. The other courses are laid in the same way, the earth always being brought up to the level of the top of each course before another is laid. In order to give uniformity to the slope of the revetment, it will be convenient to drive guide-stakes having the *proper inclination* in front of the first course (as soon as they are laid). The withes of the fascines should have their knots toward the parapet.

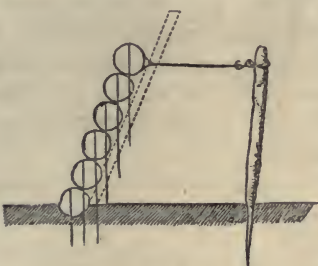


FIG. 8.

The fifth course brings the revetment to the height of the sole of the embrasure; these fascines must be anchored. This is effected by making one end of a piece of wire, rope, or withe fast to the fascine, and with the other taking two or three turns around a stake driven vertically into the parapet, and three feet from the revetment; each fascine of this course should have at least two anchoring pickets.

EMBRASURES REVETED WITH FASCINES.

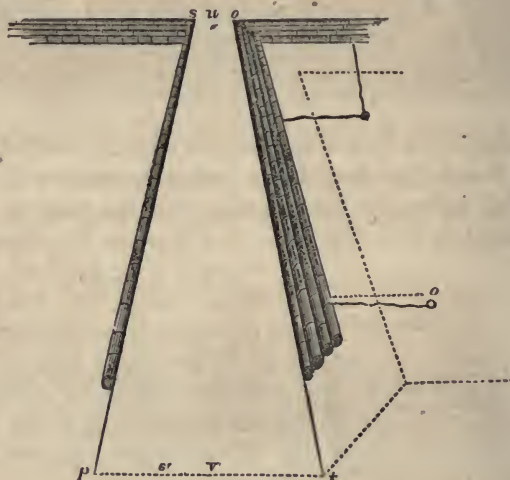


FIG. 9.

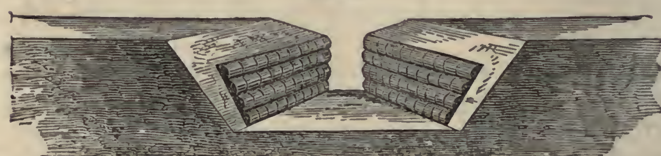


FIG. 10.

The sole of the embrasure is an inclined plane, falling about one foot toward the exterior. To trace the sole, mark the directrix by a cord, $u\,v$ (fig. 9), lay off $u\,o$, and $u\,s = 1'$, $v\,t = v\,p = 6'$, $o\,p\,s\,t$, is the sole. Along the lines $o\,t$ and $s\,p$ excavate a trench about $5''$ deep to receive the first course of fascines for the revetment of the cheeks; three pickets are driven through each of these fascines. The three remaining courses, which are required to finish this revetment, are laid so that the cheeks shall be vertical at the throat, and have a slope of one-third on the exterior. Each fascine should be anchored twice, the anchoring pickets being driven 3′ within the merlon; the fascines forming the interior slope overlap those of the embrasures. The revetment is usually terminated 18″ below the superior slope, and is connected with it by a slope of 45°. The fascines for the embrasures should be bound with wire instead of withes, and the ends toward the throat strengthened by additional bands.

SPLINTER-PROOF TRAVERSES.

These are rectangular, they are 16′ × 6′ at the base, and 14′ × 4′ at top, a passage 2′ wide is left next to the parapet. The first course of fascines is half imbedded in the ground and secured by pickets, the earth filled in and rammed. The other courses are laid in a similar manner. In every second or third course the opposite fascines of the long sides are tied together with wire or rope, those of the short sides are anchored.

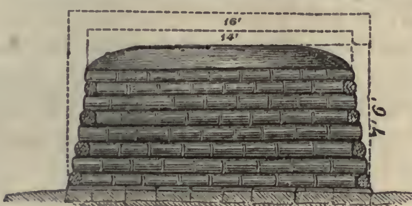


FIG. 11.

FIG. 12.

The method of arranging the courses is shown in the figure.

REVETMENT WITH GABIONS.

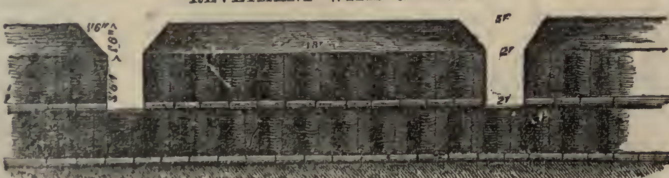


FIG. 13.

The interior slope is commenced by imbedding a course of fascines and securing it by pickets, as in the previous case. The first course of gabions is placed with the points of the stakes up, and the inner edge of the bases resting on the fascines just laid, the ground having been previously prepared so as to give the gabions the proper slope. Earth is thrown into and in front of the gabions, and well rammed. When nearly full every second gabion should be anchored to a stake, driven 3′ in front of it in the parapet.

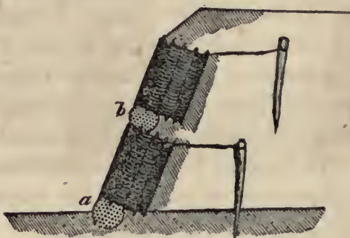


FIG. 14.

When the gabions are full, a second course of fascines (*b*) is laid on their inner edges, and driven down with a maul until it is firmly engaged on the points of the stakes.

The second course of gabions is placed so that the axis of each gabion coincides with that of one of the lower course. The points of the stakes are down, and driven into the fascines of the course (*b*). The gabions are anchored as in the first course.

The throats of the embrasures are formed by omitting a gabion and sawing out the corresponding portion of the upper course of fascines.

TRAVERSES.

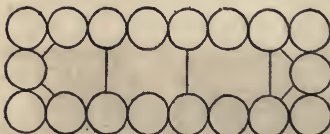


FIG. 15.

A course of fascines is employed to form the base of the revetment, as in the previous case.

The arrangement of the first course of gabions is shown in the figure. When nearly filled, the opposite rows should be tied together and across

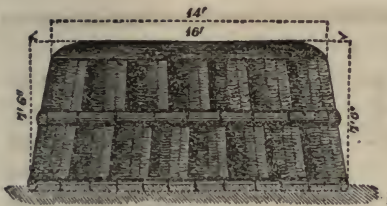


FIG. 16.

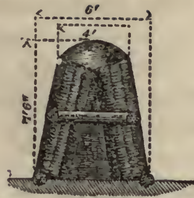


FIG. 17.

the corners, with wire or rope; when filled they are crowned with fascines. In the second course there is one less gabion on each side than in the first. The two rows meet at top, where they are tied together. The earth is rounded over the top to the depth of 18″.

EMBRASURES REVETED WITH GABIONS.

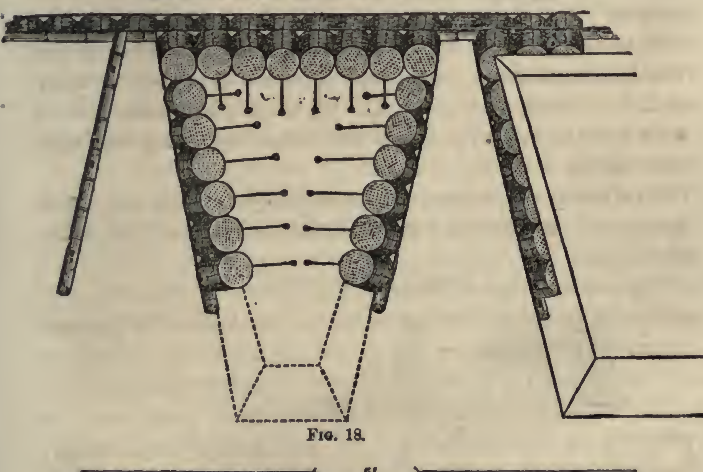


FIG. 18.

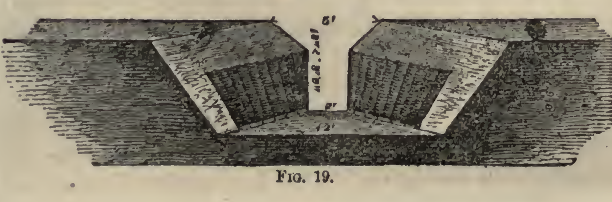


FIG. 19.

The sole is prepared and one course of fascines laid, as in the fascine embrasure.

The revetment of each cheek is formed as follows: commencing at the throat, six gabions are placed in a line, and resting on the fascine above mentioned. The first gabion is vertical, the last has an inclination given it of $\frac{1}{3}$, from the directrix. In these positions they are filled and secured, and the intermediate gabions aligned on them at top and bottom.

All the gabions are securely anchored to pickets driven 3′ within the merlon.

The strongest gabions should be selected for this part of the revetment. Those of hoop iron, make the most substantial embrasure. Although it is essential that the embrasure gabion should be well anchored, they should never be tied to each other. The independence of the parts in this revetment, renders the gabion superior to any other material, for the upper portion of the battery; as one portion may be torn away by a shot without endangering the adjacent parts.

The merlon is carried about 18″ higher than the revetment, and its superior slope united to it by a slope of 45°.

SAND-BAG BATTERIES.

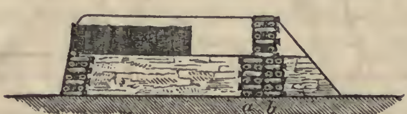


Fig. 20.

When the presence of rock, water, or other obstacle renders excavation on the site of the battery impossible, the work is executed by means of earth brought forward in sand-bags, some of which are built into, and others emptied on the parapet.

The bags are filled before dark and are brought as near the proposed battery as possible without attracting the observation of the besieged.

The battery is traced after dark, the surface to be covered by the parapet is marked by tracing-tape,

The working party is divided as follows:

For each one-gun portion—twenty-five men to fill and tie, and forty to carry bags; eight sappers to lay the bags, and two to level and ram the earth.

The carriers pass from the depot to the battery in single file, each carrying a filled bag on his shoulder. These are received by the sappers, who immediately commence forming a mask or wall of bags (*a b*) extending the whole length of the battery. The lower part of the mask is 40″ thick, the remainder 20″. The bags are laid alternately, headers and stretchers. The usual height is 6′ 6″, but this may be increased, if it does not afford sufficient protection. It may also be found necessary to carry the mask round into the epaulement.

The revetment of the interior slope, which is carried on at the same time, is formed of sand-bags laid in alternate courses of headers and stretchers. The tie of the bag is kept in the parapet. From time to time bags should be anchored by passing a rope around them and making it fast to a stake driven within the parapet.

Whilst the revetment is going on, a second party of carriers bring up untied bags of sand, which they empty between the mask and revetment to form the parapet and outside the mask to form the exterior slope.

The embrasures should be reveted with gabions or fascines, if possible. When sand-bags are employed they must be covered with raw hides, or hurdles, otherwise they are soon destroyed by the blast of the piece.

About twelve hundred sand-bags are required per gun, for the revetment and mask, and four thousand bags of sand to form the parapet.

This battery may be constructed in a single night.

In consequence of the celerity and safety with which the work is executed, this method may often be employed with advantage, even when the soil will permit the use of the ordinary form.

HALF-SUNKEN BATTERIES.

Fig. 21.

This term is applied to those batteries in which the earth to form the parapet is derived partly from a ditch in front, and partly from the excavation of the terreplein.

To trace the battery, first mark out the base of the parapet and epaulement. Then a line 20′ in rear of and parallel to the parapet, which will give the position of the foot of the reverse slope of the terreplein.

The construction is as follows: taking the case where the terreplein is to be lowered 2′.

For each one-gun portion, six excavators are placed in the ditch, and six sappers commence the interior revetment by half imbedding a fascine at the foot of the interior slope. Parallel to this they commence excavating a trench 2′ deep and 3′ wide, leaving a berme of 18″ on the side next the parapet. At the same time, six men are employed excavating along the rear line of the terreplein, throwing the earth toward the revetters, who pass it into the parapet, where it is levelled and rammed by two sappers, assisted by two workmen.

The terreplein has an inclination to the rear, where it is finished with a trench to carry off the rain-water. If there is no low ground in the vicinity to which this trench can be conducted, it should terminate in a cesspool.

The revetment of the interior slope is carried up to the level of the sole of the embrasure with fascines. It may be finished either with fascines or gabions.

The method above described is only applicable when the soil is sufficiently firm to stand without revetment in the excavated portion of the interior slope. When this is not the case, a trench is dug at the foot of the interior slope, and to the full depth of the terreplein. At the bottom of this trench the revetment is commenced and carried up, as in the elevated battery.

Under ordinary circumstances, this battery may be constructed in eleven hours.

FIG. 22.

FULL-SUNKEN BATTERIES.

In full-sunken batteries the terreplein is lowered 3′. Sufficient earth is thus furnished for the parapet, and no ditch is required.

There are two methods employed in their construction: The first is the same as for half-sunken batteries, the whole of the interior slope usually being reveted, and the ditch omitted.

The second consists in first constructing a trench by the flying sap, 10′ in advance and parallel to the interior crest of the proposed battery. The terreplein is traced 20′ wide, taking the foot of the interior slope 10′ from the gabionade (*c*).

The working party is distributed along the trench, and commences excavating from the reverse (*a b*), throwing the earth against *e d*. When the trench has been carried back 3′ or 4′, the revetment (*i k*) is commenced. This is executed as in the elevated battery. The embrasures are laid out, and the revetment of the cheeks carried as far as the gabionade (*c*), which is allowed to remain until the parapet has attained its full height, when it is overturned, and the embrasure finished. These batteries may be constructed in a parallel, instead of making a trench especially for the purpose.

In this case, a trench must be cut around, and thirty yards in rear of, the battery, to replace the portion of the parallel thus occupied.

There is still another method of changing a trench into a sunken battery, which will be described under the head of "Breaching Batteries."

MORTAR BATTERIES.

As mortars are fired at an angle of elevation of at least 30°, greater latitude is allowed in the selection of the position of their batteries, than for those of guns and howitzers. The least exposed position is on the capitals of the works attacked. Frequently the labor in their construction may be very much abridged, by taking advantage of the irregularities of the ground. Thus the greater part of the parapet may often be formed by a natural ridge.

Under ordinary circumstances they are placed in rear of the second parallel.

Unless the nature of the soil is unfavorable, these batteries are always sunken. They are without embrasures, and unless the soil is very light, are not reveted.

TO CONSTRUCT A BATTERY FOR FOUR MORTARS.

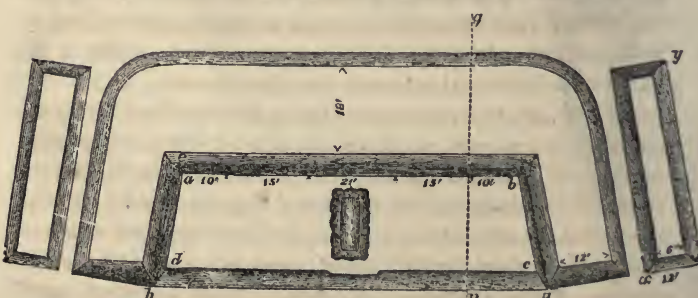


FIG. 28.

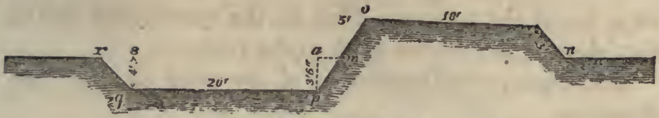


FIG. 24.—SECTION ON *pq*.

The intervals between the axes of the mortars should be 15′. Six feet is added to the interval in which the traverse occurs. A space of 10′ is allowed between the axes of the extreme mortars and the epaulement. The width of the terreplein is 20′ at bottom; its depth, in front, 3′ 6″, and in rear, 4′.

TRACE.

Mark on the ground the line representing the foot of the interior slope, and lay off on this line 71′ (the sum of the intervals). From each extremity lay off the epaulements; their direction will depend on that of the enemy's fire. Parallel to the first line, and 20′ from it, lay off the foot of the reverse slope. Then mark, with tracing-tape, the lines, *h*, *e*, *g*, *f*, 30″ outside the lines first laid out. These lines will be the intersection of the interior slopes of the parapet and epaulements with the natural surface of the ground.

The excavation is commenced on the line (*a b*), by sinking a trench 40″ deep and 4′ wide. The earth is thrown into the parapet, and passed forward by a relay of shovellers, to form the exterior slope. When the trench is finished, the excavation is carried back toward the reverse.

As soon as the parapet has attained its full height on the exterior, the sappers commence building the interior slope (*e*, *m*), which will be one of $\frac{2}{3}$ in ordinary soil. The earth required for this purpose is thrown on the berme. When the excavation of the terreplein has been carried back to the line (*r q*), the step (*a m p*) is cut away, and the earth thrown on the parapet. The earth obtained from the excavation of the terreplein is about sufficient for the construction of the parapet. That for the epaulements will be furnished by the ditches (x y) on the exterior.

The splinter-proof traverse is of the usual form and construction.

When the soil is of such a character as to require the interior slope to be sustained, the usual revetments of gabions, fascines, or sand-bags, may be employed. The working party is distributed as follows:

For each one-mortar portion, 4 picks, 4 shovels, 2 rammers.

For each epaulement, 9 picks, 7 shovels, 4 rammers.

For each traverse, two picks, two shovels, two revetters.

Or, for the four-mortar battery, ninety men, four being added for the increased interval opposite the traverse.

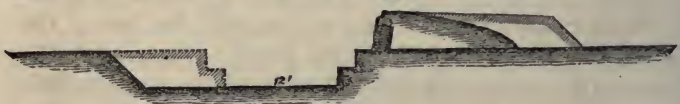


FIG. 25.

Portions of a trench or parallel are frequently converted into mortar batteries. To effect this it is only necessary to increase the width of the trench to 20′. The earth thus furnished is thrown in front of the parapet, thus giving it the requisite thickness.

BREACHING AND COUNTER BATTERIES.

The crowning of the covered way is a trench constructed by the full sap, the crest of the parapet being parallel to and 14′ from that of the covered way. In this trench, the breaching and counter batteries are constructed.

The traverses employed for the defilement of the trench, are usually far enough apart to allow the introduction of two pieces between them. The intervals between the pieces may be reduced to 14′. The line of fire in the breaching battery should be as nearly perpendicular to the scarp to be breached as possible; if the angle is less than 30° the shot will ricochet and the breach cannot be effected.

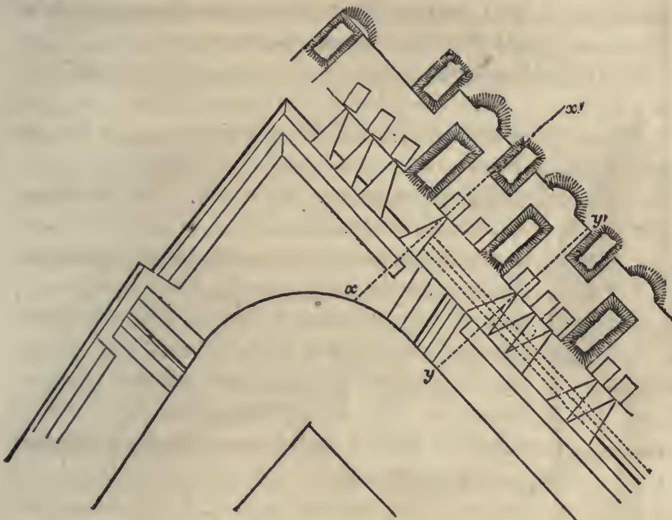


FIG. 26.

The profile of the scarp to be breached, and the ditch and covered way in front should be ascertained. This will determine the position of the directrices, and inclinations of the soles of the embrasures.

The parapets of breaching batteries are 14′ thick and 8′ high. Those of counter batteries, have the same height, but should be five or six feet thicker, as they are more exposed to the enemy's fire. In each the terreplein is 27′ wide.

CONSTRUCTION OF BREACHING BATTERIES.

During the day all the necessary material is collected, the terreplein excavated and the platforms laid.

If the trench has been well constructed, and the soil is good, the revetment of the trench may be retained for that of the battery, otherwise a new revetment is formed, similar to those described under the head of full-sunken batteries,

Fig. 27.

with this exception, that the upper course of gabions must be crowned with three fascines to bring the parapet to the required height.

The line marking the reverse of the terreplein is laid out parallel to and 27′ from the interior slope.

The directrices of the embrasures are determined and four pickets driven to mark the position and height of the corners of the platforms. The excavation of the terreplein is commenced, part of the earth thus furnished is used in forming the foundation of the platforms, the remainder in increasing the height of the adjacent traverses. The figure shows the necessary alterations, from a trench to a breaching battery.

To construct the embrasure, a double row of gabions filled with fascines, is formed along the exterior crest of the parapet, as a mask, or protection against musketry.

A gabion of the revetment of the interior slope is removed, to form the throat; into this opening a sapper enters, and commences the excavation of the embrasure, throwing the earth on the merlons, until he has formed a seat for the second pair of gabions of the cheek, which he places, and is then relieved by two sappers, who continue the excavation, throwing the earth into the gabions just placed, until they are full, then on the merlons; they each place a gabion, forming the third pair in the embrasure. In the same way a third relief places the fourth pair, &c., until six pairs are placed. During this operation, the direction of the cheek and inclination of the sole, are indicated to the workmen by a straight-edge resting on the heads of two pickets, one in the throat of the embrasure the other in the terreplein.

After the embrasure is finished, the mask is either removed by drawing the gabions into the battery, with sap-hooks, or is left to be blown out by the first discharge of the piece.

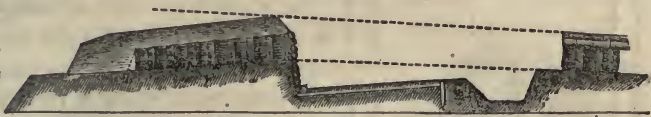


FIG. 28.—SECTION ON $x x'$.

The parapet of the counter-battery being five or six feet thicker than that of the trench, which increase is gained on the inside, it will always be necessary to renew the interior revetment. In other respects the construction does not differ from that of breaching batteries.

MAGAZINES

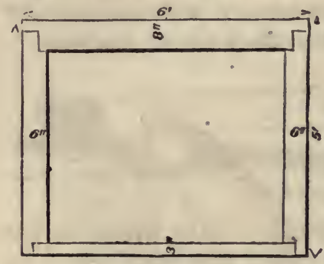
Are usually built fifteen yards in rear of the parapet of the battery or communication, sometimes at the end of the battery parapet or in that of the communication.

The figure represents a rectangular magazine in rear of the parapet. An excavation 4′ deep receives the five mining frames, each composed of a cap-sill 6′×8″×6″, two stanchions 4′ 6″×6″×6″, and one ground-sill 5′ 6″×6″×3″. The intervals between the frames are 2′ 6″. The ground-sills are brought to the same level, and surrounded with sheeting one inch thick, and covered with timber or plank at least 6″ thick. The frames for the communication may be of somewhat smaller scantling, that of six inches square will answer for the cap-sills. These frames are 2′ 6″ wide in the clear, and of the same height as those in the magazine. The sheeting is also the same.

The roof may be still further strengthened by layers of timber or fascines. The whole must be covered with earth to the depth of 7′.

As a precaution against moisture, a mound of earth is raised over the magazine, in the form of a roof, and about 2′

high in the middle, over which a tarpaulin is laid and the remainder of the earth thrown on.



The earth for this covering is partly furnished by the excavation for the magazine, and the remainder from a trench cut around it, leaving a sufficient berme to prevent the embankment caving in.

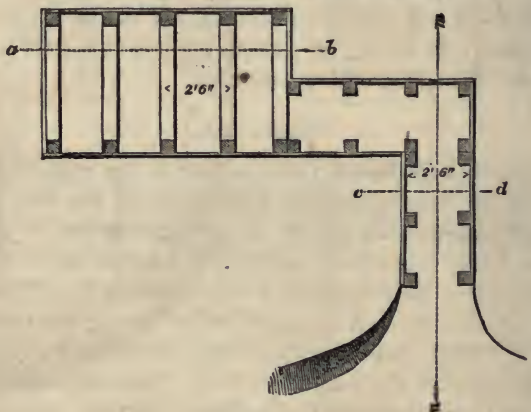


FIG. 29.

When the soil is favorable the magazine may with advantage be sunk two or three feet lower.

The magazine is connected with the battery, by a trench 4′ wide, and 3′ 6″ deep, whose direction is such as to avoid being enfiladed.

The entrance to the covered passage should be turned from the enemy. The passage having a return or change of direction, so that there may be no danger of fragments of shell finding their way into the magazine.

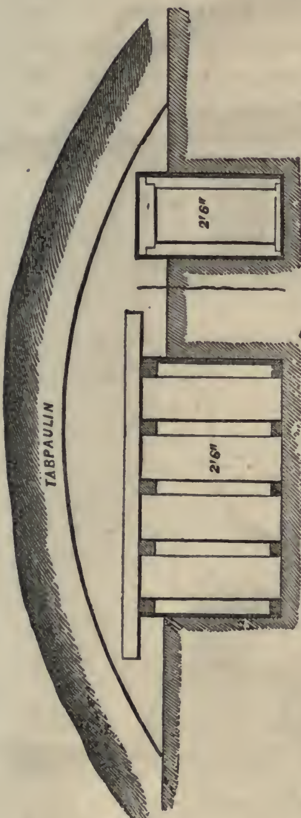


FIG. 30.—SECTION ON *ab. cd.*

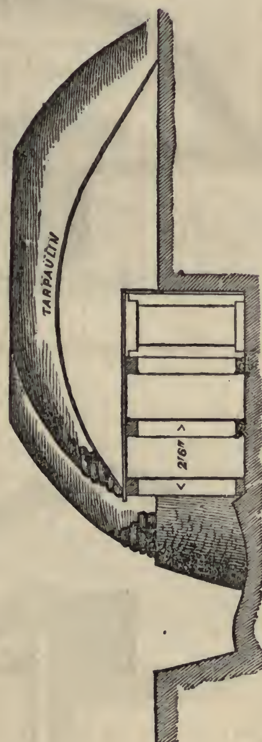


FIG. 31.—SECTION ON *nm.*

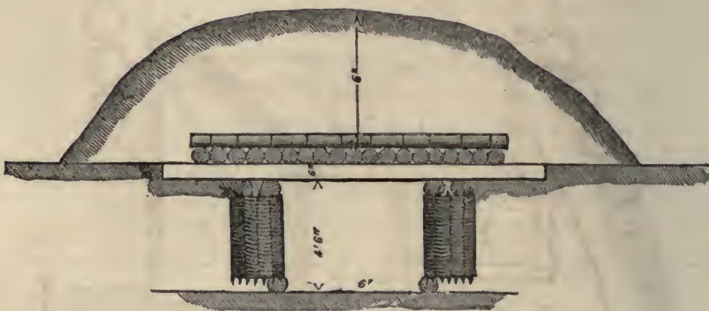


FIG. 32.

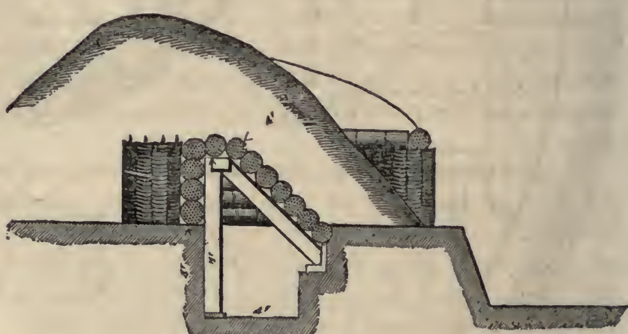


FIG. 33.

When suitable timber cannot be obtained for the above construction, those shown in the following figure may be used, in which the interior revetment is principally of fascines and gabions.

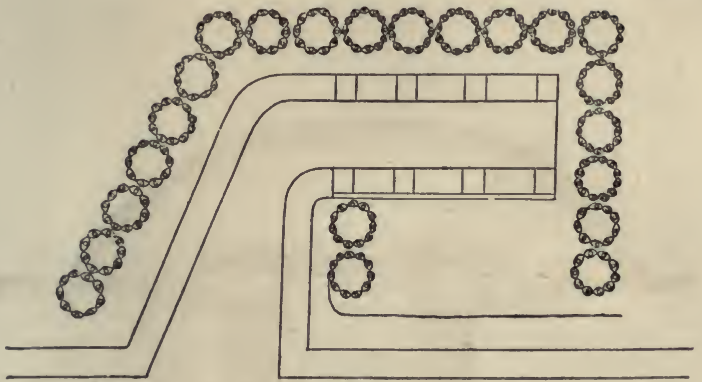


FIG. 84.

REMARKS.

The dimensions given for the preceding constructions are not invariable.

In ordinary soil, the thickness of parapet and covering of the magazine, are a sufficient protection against the artillery usually employed in the défence of a work. In the case however, of a light soil, or when the enemy is provided with very heavy ordnance, as in the siege of Sebastopol, this thickness may frequently require an addition of six or eight feet.

The throats of the embrasures must also correspond with the pieces which are to be fired through them. For howitzers the width should be 2′ 6″, and when pieces are intended for ricochet firing only, an embrasure of peculiar form may be employed, the sole having a reverse slope, and but two gabions being used in the revetment of each cheek.

The subject of siege platforms is fully treated in a work on heavy artillery, published by the war department, and is therefore omitted here.

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