INTRODUCTORY ESSAY

TO THE

STUDY OF FORTIFICATION,

FOR

YOUNG OFFICERS OF THE ARMY.

BY

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PREFACE.

This little Essay is intended for Young Officers preparing for the Army. It treats chiefly of Field Fortification: but a few chapters are added on Permanent Works. And some instruction is given on the attack both of Field and of Regular Works.

But it must be thoroughly understood that, in order to obtain an intelligent knowledge of the whole subject, an officer must proceed to study larger and more elaborate works; and especially that he should make himself acquainted with the principles of the great arm of Artillery, without which, no enlarged conceptions can be formed of the powers either of attack or defence. It is Artillery combined with Musketry, that animates military works; and such is the present power of Artillery that it may be safely said to be double what it was when the great masters of the art, Vauban, Coëhorn, Bousmard, &c., wrote their able treatises on Fortification.

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FIELD FORTIFICATION.

CHAPTER I.

TRACING. PROFILES. FIELD-WORKS OPEN AT THE GORGE. ENCLOSED FIELD-WORKS. LINES. BRIDGE HEADS.

1. Fortification is the art of constructing military works, either for defensive or offensive purposes. These works are of two kinds, viz. *Permanent Fortification*, consisting of works of a permanent character for shutting in a piece of ground, or a city, in the most advantageous manner, in order to make the greatest possible resistance, with a garrison, proportioned to its size, against the attack of superior numbers.

2. *Field Fortification;* which has for its object the protecting or retrenching of camps, villages, houses, passages of rivers, and the construction of such works as may be required to aid the operations of troops in the field, either in the defence or attack of positions.

3. Preparatory to entering upon the subject, it is necessary to understand a few technical terms:—

A piece of ground to be fully fortified is supposed to be surrounded by a polygon, either regular or irregular: for example, see plate IV., fig. 103, which shows a portion of a town; say one half, enclosed by a figure 1, 6, 7, 8: if the other half were shown, enclosed by a similar figure; it would form a regular six-sided figure (or a hexagon) enclosing the whole space to be fortified. All the works constructed on any one of these enclosing sides is called *a front of fortification:* hence, the works shown by a succession of lines, 1, 2, 3, 4, 5, 6, is a front of fortification, being con-

structed on the side, 1, 6; and there are three fronts seen in figure 103.*

4. The succession of lines that show the figure of the works, and indicate the direction in which the defensive masses are laid out, is named the *outline* or *tracing;* and the general height to which the works are raised, is termed *the relief.* Should there be two or more ranges of works, protecting a certain space (such as 1, 2, 3, 4, 5, 6, and F, fig. 103), and that the inner one is raised higher than the outward one, the difference of level is termed *the command* of the one work over the other. Thus, in fig. 105, the height of the inner work or curtain, is 22 feet; of the ravelin, 19 feet; and of the glacis, 8 feet above the ground line; therefore, the curtain has a command of 3 feet over the ravelin, and of 14 feet over the crest of the glacis.

5. The general level of the ground, or ground line, upon which the works are constructed, is called the *plane of site,* whether that plane be horizontal or oblique to the horizon; as in Plate I., figs. 1 to 15, the planes of sight are horizontal: in fig. 17, *i h* is an oblique plane of site.

6. *A plane of defilade* is a plane supposed to pass through the summit or crest of a work and parallel to the plane of site. Thus in fig. 102, Plate III.; *z b* and *g y* are planes of defilade parallel to a plane of site, *c d k e.*

7. *A plan* shows the tracing (definition 4); also the horizontal lengths and breadths of the works, the thickness of the ramparts and parapets, the width of the ditches, &c.: it exhibits the extent, division, and distribution of the works; but the depth of the ditches and the height of the works are not represented in a plan. Thus fig. 103, Plate IV., is a plan of half a complete fortress: fig. 59, Plate II., is the plan of a square redoubt.

* All the strongly marked and shaded works in fig. 103 from U to T and inwards towards the bottom of the Plate, indicate the attack; and are explained in the Chapters devoted to the subject.

8. If a plane pass through a work in any direction, the cut made by it is a *section;* if the cut be vertical and perpendicular to the face of the work, it is a *profile.* If horizontal at the base of a work, it is a *ground plan.* Thus fig. 11, Plate I., shows the plan of a small parapet and ditch, and fig. 10, a section of the same.

9. *A parapet* is a covering mass of earth thrown up out of the ditch, and formed of the shape seen in fig. 8, Plate I., where the names of the various parts are given, which should be *familiarly known.* The height of the parapets varies from 6 to 12 feet, and their thickness from 3 to 12 feet, according to the purposes for which they are required, and the positions they may occupy. Suppose a man to stand upon the banquette, *b c,* and to fire over the superior slope, *d e,* the ball would pass along the line, *e l m;* this man could not fire into the ditch, *g h i k;* hence it is desirable to arrange or trace the parapets in such a way that the ditch of one part of a work shall be defended by the fire of some neighbouring parapet which can see into it; therefore,

10. When it is possible, parapets are arranged or traced as seen in fig. 103, Plate IV., as 1 2 3 4 5 6: this arrangement is called the *bastion* tracing: A and B being *bastions,* G and D, *half bastions;* the connecting part between two bastions as 3, 4, is called a *curtain:* the angle 6 is the flanked angle of the bastion; 5 the shoulder angle; 4 the curtain angle. By this means, the fire of the flank, 2, 3, defends the ditch before the face, 5, 6, and a reciprocal defence is produced throughout the works.

A work disposed so as to defend another by its fire, is said to be a flanking work, and the work thus defended is said to be flanked: this is a matter of great importance, and no work can be accounted strong that is not well flanked, so that an enemy in advancing to the attack shall be fully seen and fired upon.

11. It is known from experiment that the penetration of

missiles into a common bank of earth is as follows; which will require a thickness of parapet somewhat greater.

Penetration in feet at a mean range.	In the superior slope. Proper thickness of parapet in feet.	
Musket-ball $1\frac{1}{2}$	3	See figs. 8, 9, 10, 13, 14, 15, 16, 17, &c., Plate I.
6 pounder $3\frac{1}{2}$ to $4\frac{1}{2}$	6	
9 ditto $6\frac{1}{2}$ to 7	9	
12 ditto $8\frac{1}{2}$ to 10	12	
18 & 24 ditto $11\frac{1}{2}$ to 13 . . .	18	

But as 18 and 24-pounders rarely form part of a field equipment of artillery, a thickness of parapet beyond 14 feet is seldom necessary.

In the defence of villages, the walls and barricades to resist musketry must be of sufficient substance. A good 9-inch brick wall; 6 inches thick of stone; 12 inches thickness of fir; 4 or 5 inches of oak will do so.

The object of the ditch being to create an obstacle to an enemy's approach, and to obtain earth from it to construct the parapet or breast-work, its capacity chiefly depends on the demand for the latter. The obstacle can be increased by deepening and widening its dimensions; but to do so beyond its due limits, gives more earth than is required; to excavate and remove which takes time and labour.

The means usually available for the construction of field-works, will seldom admit of the ditches being made more than 12 feet in depth: and they generally vary from 6 to 12 feet. These means likewise affect the height and bulk of the masses of the parapets, which under ordinary circumstances, never exceed 12 feet in height.

The height of a parapet must be such as to give good cover to the defenders in its rear; and when the contending parties are on nearly the same level, nothing less than $7\frac{1}{2}$ feet can be considered as sufficient for this purpose.

But if a work be intended merely to cover a guard, or to hold out against a sudden assault, 6 feet high of parapet will, in many cases, be sufficient.

A difference of level in the ground, either within or without the work, will invariably affect the height of the parapet: if, for instance, the defensive position is on the brow of a hill, and the ground to be commanded be low, a parapet 5 or 6 feet high would probably answer every purpose; but if the work be in a hollow, or on low ground, the height of the parapet must be augmented to 8, 10, or 12 feet, according to circumstances, so as to screen the defenders from any commanding ground that an enemy may occupy.

In general, the banquette is assumed to be 4 feet 3 inches below the crest of the parapet; the tread is 3 or 4 feet wide, with a slope of 2 inches to the rear; and where the slope of the banquette would be too great to be made double its height, it is broken into steps from 9 to 12 inches rise, having a tread of 1 or $1\frac{1}{2}$ feet wide, with a little slope to the rear to carry off rain water: by this arrangement, the quantity of excavation is diminished, as well as interior space saved. The exterior slope is at 45°; the interior slope is 1 foot: the superior slope $\frac{1}{5}$ or $\frac{1}{6}$ of its thickness. See figs. 8, 9, 10, 13, 14, 15, &c., Plate I.

In some of these figures, the scarp, or front slope of the ditch, is represented as nearly one line from the foot of the superior slope of the parapet to the bottom of the ditch; and this construction, as in fig. 15, is assuredly more difficult for an enemy to overcome, than a parapet with a berm;* but this berm is of great use in the construction, as it gives a step or footing for the workmen; and should the work have to stand for any time, or should the soil be loose, the berm gives it greater stability; its advantages, therefore, are such as to induce engineers in many cases, to prefer it to the continued slope.

* A berm is a flat space or step, of a few feet in width, between the foot of the exterior slope of the parapet and the front slope of the ditch, as in figs. 8, 9, and 17.

These profiles, however, need not be adhered to; the nature of the soil, in some cases, requires great slopes to be given to the parapets and sides of the ditches. In the celebrated lines of Torres Vedras,* the profiles had generally a berm of two feet, and the sides of the ditches sometimes nearly met in an angle at the bottom, as fig. 9. This was a judicious construction, as the redoubts in these lines were rarely flanked, and thus anything like a settled formation of troops in the ditch was prevented. The defenders, on this occasion, were abundantly supplied with that most useful weapon, hand-grenades, to shower over the parapet into the ditch, to supply the want of a flanking defence.

In excavating and constructing a redoubt, &c., it is of great importance to secure its being well drained in the interior, especially if the terre-plein be sunk below the level of the ground; else it becomes a pool of water in continued rain.

Figs. 8, 13, and 14, are specimens of ordinary parapets. Fig. 9 was one of the redoubts in the lines of Torres Vedras. Should the face of a work occupy the summit of a hill, the depression of the superior slope of the parapet should be such as to command the whole ascent of the hill, as in figs. 16 and 17; and should the ground fall to the rear, as indicated in fig. 16, it affords excellent cover for the defenders: in most cases of this kind, a parapet 6 feet high will suffice to protect the troops. Figs. 13, 14, 15, 16, 17, 18, and 19, are specimens of profiles under the various circumstances indicated in these figures. From all which it may be seen, that although there are general principles to be followed as to height and thickness, yet that the application of these in detail, depends on the peculiar circumstances in which the works may be placed and the features of the ground on which they rest.

12. It is necessary on many occasions to excavate in rear

* Constructed by order of the Duke of Wellington, to cover Lisbon in 1810.

of the parapet, and to form a *trench* covered in front by the parapet. This is the usual figure of offensive works and batteries, as seen in figs. 1, 2, 3, 6, and 7: (in all cases, the amount of excavation from the ditch in front, or from the trench in rear, depends upon the quantity of earth required to construct the parapet:) the examination of these figures will show the kind of cover usually obtained for troops, from a mere screen to a substantial parapet, proof against 12-pounders. The usual depth of trenches is 3 feet, as it is easy to step in and out of them by means of a single step, as seen in fig. 3. These trenches should always slope to the rear, and, in case of wet weather, care must be taken to direct their soles or bottoms so as to fall into the natural ravines or hollows of the ground on which they are placed: besides which, cess-pools, one foot square or more in dimensions, should be made, as in fig. 2. Should the nature of the ground be such as to prevent the proper quantity of soil being obtained from the trench in rear, in consequence of its being either swampy or rocky, a small ditch must be dug in front, as in fig. 6.

13. *Tracing proper for field-works.* The tracing depends upon the situation and importance of the works; the number and species of the troops; and the quantity of artillery intended to occupy and defend them. It is usual to divide them into three classes:

First, works open at the gorge. Fig. 45 to 50, Plate II.

Second, works enclosed all round. Figs. 51 to 53, ditto.

Third, lines; connected. Figs. 54 to 57. Lines at intervals. Fig. 58.

Redan, ...	Fig. 45	are the names given to the various tracings of the first class, or open works.
Lunette, ...	„ 46	
Redan with flanks, . .	„ 47	
Double Redan, . . .	„ 48	
Tenaille-head, . . .	„ 49	
Bastion-head, . . .	„ 50	

Redoubt, ...	Fig. 51	are the names given to works under the second class, or closed works.
Star fort, ...	„ 52	
Bastioned fort, . . .	„ 53	

Indented lines (à crémaillère)	Fig. 54	are the names given to the works of the third class or lines.
Lines of redans, ...	„ 55	
Lines of tenailles, ...	„ 56	
Lines of bastions, ...	„ 57	
Lines at intervals, ...	„ 58	

14. The following maxims are necessary to be observed in the construction of field-works:

1st. That the works to be flanked are never to be beyond the range of the missiles of the works flanking them; that is, never out of the effective range of musketry, or from 140 to 180 yards. This flanking defence should be particularly attended to; that is, in attacking any portion of a work, the adjoining portion should be so disposed as to bring a cross fire upon the assailants, which coming upon his flank as he advances, is called a *flanking fire*. This remark extends to all defensive works, towns, villages, farms, outhouses, gardens, enclosures, &c. In occupying such places, the roads, streets, avenues, and approaches, should be seen in flank, so that an attack on one part shall be flanked or defended by neighbouring parts. For example: suppose, in fig. 23, Plate I., that an attack were made on the angle, *a*; the fire from the loop-holes, *m*, *m*, *m*, &c., would cross or flank the approaches to *a*: thus *a* becomes a *flanked* angle. The lines of fire, *f*, *f*, *f*, &c., from the loop-holes, *l*, *l*, *l*, and *m*, *m*, *m*, also cross or flank each other.

2nd. That the angles of defence should be about right angles.

3rd. That the salient angles of works should be as obtuse as circumstances will permit.

4th. That, although ditches cannot always be as fully flanked, as in permanent fortification, yet that partial flanking must be carried as far as possible.

5th. That in the construction of field-works, reference should not only be had to the direct and immediate obstacles that the work itself presents to the enemy, and the positive effects of fire on the approaches to it; but likewise the relative value of the work must be considered, as to the support it can give to, or receive from, other works.

6th. That the outline of a field-work should be proportioned to the number of men intended to defend it.

7th. The ground over which an enemy must pass to the attack should if possible, be seen both in front and flank.

15. *Redans* (fig. 45, Plate II.) are the simplest kind of trace for field-works; having two faces, forming a salient angle: they serve to cover bridges, causeways, avenues, &c., and being quite open at the gorge, are only suited for defence when resting their extremities on rivers, or obstacles which prevent their being turned; or else, when within the full sweeping fire of works in their rear, that an enemy may be deterred from any attempt to assault by the gorge. Redans in front of other works are generally mere cover for an advanced post: for example, if a strong redoubt occupies the commanding summit of a hill, as *c*, fig. 58, its elevation and position usually prevent the deep hollows and approaches, by the vallies being fully seen from its faces; redans or flèches, *a'* and *b'*, may then be advantageously constructed on the lower knolls, or under features of the hill, to see into all the hollows, while the fire of the main redoubt plunges into their interior.

When there is time, redans are provided with flanks, fig. 47, at about 50 or 60 yards (or half musket shot) from the flanked angle. These flanks should be 10 or 20 yards long, and perpendicular to their faces, and by their fire, flank the capital.

Redans have the defect of unflanked ditches; their profile should therefore be like that represented in fig. 9, Plate I., and the defenders should be provided with hand-grenades to throw over the parapet for the defence of the ditches.

To obtain a defence for the ditches of redans situated in front of other works, their extremities should be directed upon some of the faces in the rear, and sloped up (à la rampe) to receive a flanking defence.

Redans having flanks parallel to their capitals are called *lunettes*, fig. 46; the position and extent of these flanks depend upon the purpose for which they are made, and the ground that they have to flank, as a'', a''', fig. 58, Plate II.

Two redans joined together, as fig. 48, form a double redan; a shape and size that may, in some cases, be more convenient than the single redan; besides which, the re-entering faces mutually defend or flank each other: this double redan gets the name of *tête à queue d'hyronde*. The re-entering angle should be as near a right angle as possible; the front about 80 yards; the salient angles never less than 60°; and the flanks about 20 yards. Should the ground to be defended require more important and extended works than these, the bastion head should be used.

16. *Tenaille heads* are traced as fig. 49, the fronts 80 or 90 yards; but if the ground admits of, or requires, a greater extent of front, a *bastioned head* may be constructed, of dimensions suitable to the ground.

17. *Bastion heads.* See fig. 50. The length of the fronts depends upon the ground to be occupied, varying from 100 to 200 yards; beyond 220 yards, the line of defence for musketry becomes uncertain.

The application of works open at the gorge, is seen in fig. 62, Plate II., which represents a redan with flanks covering a bridge across a river: and also in fig. 58, which supposes the defence of a position by lines at intervals: the open works, a, a', a'', a''', b, b', b'', f, being placed in the first

line, having their interiors and ditches flanked by the fire of the closed works, *c*, *d*, D, *d'*, and *e*, on the second line.

The extremities of all works which have to be defended by works in their rear, as the open works in fig. 58, should have their ditches flanked by being sloped upwards, like a ramp from the bottom, in order that they may be seen and defended by the fire from the works in the rear: and in many cases it may be proper to close the gorges of such works by a good stout loop-holed stockade, to prevent their being carried by a rush in the rear.

18. *Redoubts* are works enclosed on all sides without flanks, of a square, polygonal, or circular figure: the latter form is rarely used, from the unsuitable nature of such an outline to ground in general; and the total impossibility of giving any flanking defence to its ditch.

Redoubts are commonly square or pentagonal figures in their trace, as each front can then furnish a steady strong fire perpendicular to its face, as in fig. 58. D, *d*, *d'*, *c*, *e*, are polygonal and irregular redoubts; traced according to the shape of the hill. Fig. 51, is a square redoubt, on a small scale; fig. 59, the same, on a larger scale.

19. Whether the outline be square or pentagonal, every endeavour should be made, in tracing a redoubt, to direct the faces upon ground either inaccessible or difficult for an enemy to possess; not only to guard against his enfilade fire, but, if possible to hinder him from approaching upon the angles, and compel him to advance upon the faces, from which comes the strongest fire.

20. There are several ways of remedying the want of fire upon the spaces before the angles: see fig 59. The first is by cutting off the vertex of the angle by a straight line, so as to obtain a fire of musketry from as many files as the banquette will hold; or by rounding it for the same purpose: second, by forming an embrasure or barbette on the capital: third, constructing the parapet en crémaillère, or

indenting it: that is, disposing the parapet in a succession of small salient and re-entering angles, alternately parallel and perpendicular to the capital, in order to obtain a musketry fire upon the ground before the angle. All these modes are good when properly and judiciously applied; the last is difficult in construction, and even when completed, it may be seen by the figure that the faces are deprived of their direct fire, from the portion occupied by the crémaillère.

Still, in square redoubts, the ditches remain unflanked; and unless the contrivances described in articles 29 and 30 be resorted to, it is advisable to form them of the profile of fig. 9, Plate I., and to furnish their defenders with an ample supply of hand-grenades.

A square redoubt having its side of 40 yards along the crest of the parapet, is capable of holding 4 pieces of artillery and 320 men; hence they are never made larger: as if it becomes necessary to construct a work for a greater body of troops, a superior tracing to that of an unflanked redoubt is adopted.

21. *Star forts,* represented in fig. 52, Plate II., were proposed to remedy the defects of redoubts, that have the ground before their angles undefended by a flanking fire: by this arrangement, a cross fire is brought upon the ground before the angles: but in consequence of the great exterior slopes necessarily given to field profiles, the lengths of these faces are greatly diminished, affording but a feeble quantity of fire from each; and for the ditches, the flanking defence amounts to almost nothing. Baron Jomini says, that "star forts are the very worst description of fortification; they cannot have flanks, and the re-entering angles take so much from the interior space, that it is impossible to place troops and artillery in them sufficient for their defence: they are especially exposed to be enfiladed from one end to the other, which precludes the possibility of their making a long defence." An opinion confirmed by the practice of Sir Richard

Fletcher and Sir John Jones, in the construction of the lines of Torres Vedras: where the trace of the redoubts was made subservient to the shape of the ground; to the object in view; and to the protecting of them, as much as possible, from the fire of the enemy's position.

22. *Bastioned forts.* Fig. 53, Plate II., shows the tracing and dimensions of a bastioned fort upon a square.

As bastioned forts are constructed only in cases of importance, where it is wished to present every obstacle to an enemy, and to hinder him from getting possession of the ground upon which they are placed; such works should have every possible labour and means expended on them, to make them as formidable as possible; and great care should be taken in the first construction to drain the interior thoroughly, by making drains of tiles, brushwood, &c. In small works, it is impossible to obtain good flanking defences for the ditches, from the want of interior capacity; but in great forts, which generally form the key of a position, the interior space lost by breaking the faces into flanks is more than compensated for by obtaining a good defence for the ditches. The experience gained in the Peninsular war has fully proved that field forts or redoubts, having unflanked ditches, cannot stand against determined and skilful attacks.

All the accessories, such as fougasses, abattis, trous-de-loup, fraises, palisades, &c. (to be described in Chapter II.), should be used to strengthen bastioned forts in the places considered most suitable for them.

Forts, with demi-bastions, as the right face of fig. 53, Plate II., are objectionable; for the ditch before the face of the demi-bastion is only obliquely and imperfectly defended from the long face: the curtain angle also is a dead angle. Demi-bastions are therefore only admissible at the extremities of works resting on obstacles.

Great latitude is given in the construction of bastioned

forts, as the exterior side may vary from 100 to 220 yards, and they are therefore suited for many situations.

23. On the lines of Torres Vedras, constructed by order of Lord Wellington, to cover Lisbon in 1810, Colonel Sir John Jones remarks on the *trace of several works:* "The redoubts were made of every capacity, from that of one, limited by want of space on the ground it occupied, for 50 men and 2 pieces of artillery, to one for 500 men and 6 pieces of artillery; the importance of the object being the only guide in forming the dimensions. Many of the redoubts first thrown up, even some of the smallest, were shaped like stars, under the idea of procuring a flank defence for the ditches; but this construction was latterly rejected, it being found to cut up the interior space, and to be almost fallacious with respect to flank defence, the breadth of the exterior slope being in some cases equal to the whole length of the flanks so obtained. Even when, from the greater size of the work, some flanking fire was gained, the angle formed by the faces was generally so obtuse, that it demanded more coolness in the defenders, than ought reasonably to be expected, to aim along the ditch of the opposite face; and further, this construction prevented the fire of the work being more powerful in front than in rear.

"In order to decide on the proper trace of a work, it is necessary to consider whether its object is to prevent an enemy establishing himself on the ground on which it is to be placed, or whether it be to insure a heavy fire of artillery on some other point in its vicinity. In the first case, every consideration should be sacrificed to that of adding to its powers of self-defence, by flanks or other expedients. In the second, its powers of resistance are secondary to the establishment of a powerful offensive fire, and its trace cannot be too simple. Latterly, the shape of the redoubts were invariably that most fitted to the ground, or such as best parried the enfilade fire or musketry plunge of neighbouring

heights; care being taken to present the front of fire deemed necessary towards the pass, or other object to be guarded; and such will generally be found to be the best rule of proceeding.

"This recommendation, however, is not intended to apply to isolated works of large dimensions, and more particularly to those considered the key of a position. No labour or expense should be spared to render such works capable of resisting the most furious assault, either by breaking the parapet into flanks, or forming a flank defence in the ditch; for the experience gained in the Peninsula shows that an unflanked work of even more than an ordinary field profile, if skilfully and determinedly assaulted, will generally be carried. Nor does the serious evil of curtailing the interior space, which renders any breaks in the outline to procure flanks so objectionable in small works, apply to works of large dimensions; for it must be recollected, that in similar figures, whilst the length of the outline increases only in the simple ratio of the double, triple, or quadruple, the interior space or surface increases as the square of their like sides."

24. *Lines.* Continued or connected lines are sometimes resorted to, in order to enclose the front of a position, or to connect important redoubts or forts together.

Fig. 55, Plate II., shows the most simple tracing of lines being redans connected together by curtains of parapets; but as the ground before the redans, and the ditches of the curtains, are only defended by an oblique fire from the portions of the faces of the redans that view them, it is proposed to remedy this partially, by breaking the curtains so as to form nearly right angles with the faces of the redans, as fig. 56; thus modified, they take the name of lines of tenailles.

Fig. 54 shows the tracing of indented lines; having long faces and flanks perpendicular to them, to defend their ditches: and when these long faces can be directed towards

inaccessible ground, or where an enemy cannot establish enfilading batteries, the construction is considered good.

These indented lines (en crémaillère) are also suitable for connecting important redoubts or large works together, as the long branches can then be directed upon the salients of the great works so as to be defiladed. The dimensions of those shown in fig. 54, in yards, may be used, or increased to double the quantity, according to the ground and to circumstances. Fig. 58, *f*, is a specimen of indented, or crémaillère lines, the long branches of which are directed on the hills *b'*, *b''*.

Bastioned lines, as shown in fig. 57, are the strongest trace that can be given to continued lines, when the ground admits of its being done. A perfectly regular trace, as seen in this figure, is only suited for level ground; but it may be applied with modifications to suit unequal ground.

In this construction, the ditches of the faces should be prolonged *en rampe* towards the adjoining flanks, that they may receive a flanking fire.

25. *Lines with intervals.* Fig. 58 shows the general trace of lines of this kind: the salient works should never be beyond the range of the musketry, or canister, of the re-entering works; and the angles of defence between the two lines of works should be as near right angles as possible: the ditches of the salient works should be formed *en rampe* to receive a flanking fire from the re-entering line of works.

The disposition of the works, in fig. 58, supposes ground, on which the redoubts, D, *d*, *d'*, *e*, *c*, occupy the most important features of the hills, and that they can see, and flank by artillery or musketry, the open works, *a a' a'' a''' b b' b'' f*, which are on lower ground (having their gorges closed by a stockade or good palisades).

The tracing and dimensions of the works composing these lines must always depend upon a great variety of circumstances; such as the shape of the ground; the means and

power of the army thus entrenched, to assume the offensive, &c. In the case seen in fig. 58, suppose the redoubts, D, *d*, *d'*, to occupy the most commanding knoll, say 200 feet high; the redoubts, *c*, *e*, on lower features 180 feet high; the lunettes and redans on ground 30 feet high; the indented lines, *f*, on the plain below.

It may be seen, in this figure, that the great redoubt D, is in fact composed of three redoubts connected together by parapets and ditches, all taking their shape or tracing from the nature of the ground; that the redoubts *d*, *d'*, are nearly cut off from the great redoubt D, as in the event of one being taken, the passages of communication to the others (usually slight plank bridges) can be removed: were not this precaution taken, of nearly isolating the different parts, the fall of one part would involve in it the possession of the whole, as the enemy could circulate all round when he got in at one part. The great redoubt D, *d*, *d'*, being the key of the position, is provided with 8 or 10 pieces of cannon to flank and defend all the ground and works around: the works open at the gorge are generally within easy musketry range of the redoubts. It might suffice in some cases, to give the redans and the indented lines, *f*, a trench profile, as in fig. 1, Plate I. The river in fig. 58 covers the whole position.

26. Sir John Jones observes, that to cover an extent of country with continued lines, as figs. 54, 55, 56, and 57, is a most injudicious and weak proceeding: all parts require equal guarding; for if forced at one point the whole is gained; the number of men also that are required to construct and to man so great a development of parapet, as the trace of all kinds of continued lines present, is so great as to demand great means and time; as well as to cramp the power of making any immediate and formidable offensive movement: and thus both defensive and offensive operations are marred by an army having its entire front covered by continual lines.

Sir John Jones, however, with his characteristic talent and judgment, remarks that "field defences are not to be indiscriminately condemned or rejected because they are continuous or systematic. In order to strengthen the front of an army with judgment, it is necessary to consider every feature and every portion of the ground separately, and arrange such mode of occupation as shall best combine its particular defence with the general defence of the position. Thus, in parts unfavourable for manœuvring, it may be advisable to form a continued line of considerable extent, covered with every nature of obstacle, and having none but the most confined outlets, on the principle that a range of difficult heights would be scarped, or low ground inundated, to lessen the number of men on those points, and have a superabundance of force for other points favourable for offensive movements. Again, since the employment of artillery in masses has been introduced, and that an irresistible fire, sometimes of hours' duration, now invariably precedes the advance of the columns of attack, it will frequently prove a good measure, in situations where natural cover cannot be found from a cannonade, to create it artificially between all the prominent defensive posts.* Thus each furlong of ground being duly considered, and the nature of defence best adapted to the locality being formed, the whole front of an army may occasionally be covered with lines of works, which, while they augment its defensive powers, leave its movements perfectly free."

27. *Bridge heads*, (as in fig. 62, Plate II.; and in fig. 98, Plate III.) are field works generally open at the gorge, rest-

* This might be effected by means of a sunken trench, like a parallel at a siege, made to connect the whole chain of redoubts. Such an expedient would cover infantry from the fire of guns without impeding their forward movements in line, and openings might be left for the advance of the cavalry and artillery, or they might act in masses on the flanks.

ing their flanks upon the banks of a river, in order to cover one or more bridges.

The magnitude and tracing of these works depend upon the importance attached to the bridges: whether they are intended to serve as a temporary or permanent passage during the campaign; whether the army, in retreating, is likely to be exposed to a serious attack in passing the river, &c.

The most favourable situation for a bridge head is in the re-entering sinuosity of a river; because the work can then, in some cases, conceal the bridge from the enemy's view; as also that, in such a position, the supporting batteries on the opposite side of the river are most favourably situated for aiding the defence and passage of the river. (See fig. 62.)

As têtes-de-pont, or bridge heads, are usually constructed for the specific object of aiding a retiring army to pass the river in order, and to check an enemy pressing upon it, the tracing and profile of the works must be such as to secure this double advantage as much as possible.

In the trace, a sufficient number of good openings should be left, as in fig. 98, Plate III., to permit the retiring divisions, with their guns, carriages, &c., to file through with ease; and parapets so disposed, as seen in this figure, to flank and defend these passages in every direction.

The various figures shown in figs. 45, 46, 47, 48, 49, 50, Plate II., may be used either singly or collectively as bridge heads, according to the importance of the passage: a simple redan with flanks may cover a passage of small importance across a narrow river, supported by a fire of artillery or musketry from parapets on the opposite side, as in fig. 62. If the river be wider, and the bridge of more importance, it may be covered by a series of fronts, and supported by batteries of artillery from the opposite side. Their profile should always be strong, as the pursuing party will not fail to employ masses of artillery to destroy their para-

pets and uncover the bridge; an interior range of parapets, or a stockade, or a redoubt, would be proper to secure the bridge as long as possible.

The bridge head, in fig. 96, Plate III., is within the musketry range of a line of hills (from which it is protected in the interior by traverses that will be more fully explained in Chapter IV). Two good redoubts are made on the opposite side of the river, not only to flank the redan head, but to enable the troops to hold out should it become necessary to dismantle the bridge, or in case of the redan being forced. Indeed, it would be advantageous on most occasions to have good redoubts to protect bridges in preference to open works.

Great têtes-de-pont are works constructed to defend the bridges which cross a river covering part of the frontiers of a state, in order to preserve the communications by which armies may advance into, or retreat from, an enemy's country. In such cases, space should always be left between the fortress and the river, where an army may form and rally, without being obliged to throw itself into the place, and thereby compromise its security.

When separated from an enemy by a river, (as in fig. 58) in which there are fords, it is necessary to watch them carefully. The points most likely for an enemy to attempt, are their own re-entering angles.

CHAPTER II.

CAPACITY OF FIELD WORKS. COUNTERSCARP GALLERY. COVERED CAPONIER. AMOUNT OF EXCAVATION. FIELD REVETMENTS. OBSTACLES.

28. The periphery of a work, and the number of men to defend it, should bear a just proportion to each other: for this purpose, three running feet of parapet is required for each man to use his arms freely; and if a file of men be told off to each running yard, the front and rear rank man changing places on the banquette as each fires, then the number of yards and the number of files for each face agree, and no difficulty occurs; for no deduction need be made for the space occupied by artillery; as the spare men arising therefrom will form a reserve to fill up casualties or to meet a sudden assault at any point. Should there be no artillery, a reserve of one-fourth or one-fifth of the whole may be provided.

It has been customary, in calculating the area of enclosed field works, to allow 10 square feet for each man, and 324 square feet for each gun and its stores; an estimate that need be attended to only in the case of the garrisons of the redoubts being always confined within the parapets: this is rarely necessary; for, during the day, their drill, amusement, and cooking, will be without; and in case of attack, in a system of works, the general formations of the troops will also be without, while the redoubts have only their parapets lined.* We therefore deem it unnecessary to follow the French authors upon this subject, who lay great stress upon

* Sir John Jones's work on the Lines of Torres Vedras.

the mathematical accuracy with which the capacity of the work is adapted to the number of men who are to occupy it, and generally furnish tables to regulate the dimensions to the number of men.

29. From what has already been stated of the usual trace of field works, it is evident that their ditches are rarely defended by a flanking fire: some contrivances have been proposed to remedy this defect; two of which will now be described.

One is the construction of a gallery behind the counterscarp, figs. 82 and 84, Plate II., having loop-holes looking into the ditch, to defend it by a reverse fire of musketry. In chalky soil, where galleries can be easily formed, this species of defence is most suitable, as the reverse gallery can be connected to the interior of the work by a gallery of communication underneath the ditch, as was the case in one of the redoubts in the lines of Torres Vedras; but where the soil does not favour this construction, the reverse gallery can be made without any such communication; as was done by the French in the defence of the lunette Picurina, at Badajoz, in 1811.

In fig. 82 the dotted space, behind the reverse slope of the ditch, has, underneath, a recess or gallery, as seen in section under the glacis, fig. 84: this section being taken on the line C D E of fig. 82, part of the ditch would be seen in elevation, with its loop-holes looking into the ditch, as represented in fig. 84 (looking under D): a drop, or small ditch, is made before the gallery to prevent an enemy closing with the loop-holes.

For the details of the construction of a reverse gallery, examine figs. 82 and 84: by the plan, it is seen that there is a flanking fire from the gallery at the angle for the ditches on two faces: the counterscarp (from the loop-holes to the bottom of this drop) is 7 feet, which is out of the reach of an assailant; the extremities of this drop, or ditch, are

supposed to be reveted perpendicularly: the gallery occupies a space which is determined by the prolongation of the foot of the exterior slope of the parapet (see fig. 82), and has a width of 4 feet throughout: its face is supported by strong timber uprights or stockade work bound firmly, as shown in the section. In order to communicate with this reverse gallery, a descent must be made into the ditch, as seen in figs. 81 to 83, by a regular gallery, closed with strong doors; or step-ladders may lead into the ditch from the regular opening into the redoubt.

30. To defend an unflanked ditch by means of a covered caponier, see figs. 81 and 83. The section shown in fig. 83 being taken on the capital, A B, of fig. 81, the dimensions of the slopes, in this oblique direction, are greater than when taken perpendicularly across the face. The floor of the caponier is 2 feet below the bottom of the ditch; the top of the roof, including the earth, is $7\frac{1}{2}$ feet above the bottom of the ditch; the nearest part of this caponier is 12 feet from the crest of the glacis, which is sufficient to defeat any attempt to cross the ditch over the roof of the caponier; but, if suspected of being too small to deter an enemy from such a proceeding, the floor may be sunk still more; and the ditch at the angle made 10 or 12 feet instead of 8 feet. This caponier is a double oblong stockade, strongly roofed in, the loop-holes being cut obliquely (see fig. 81) to enable the defenders to fire down the ditches: the interior breadth should be about 7 or 8 feet. A square redoubt requires two such caponiers on opposite angles; a gallery of communication (like a common gallery of mine) leads to this caponier, and is constructed on the first building of the redoubt; or it may be driven afterwards. The inspection of the figures will enable the reader to understand this work thoroughly. Should there be any fear of an enemy closing with the loop-holes, a drop or ditch could be made all round the caponier, of a form like that seen in fig. 30, Plate I., which is a

transverse section of a covered caponier. The roof is formed with fascines, dung, and fresh hides drawn over them, to prevent it being fired. Such a stockade, may, in a large deep ditch, be made into a temporary barrack, with a triangular roof: every precaution being taken to keep it dry and well ventilated, the timber being of a large scantling.

31. When a work is traced on the ground, strong pickets are driven at all the angles, and the lines joining them distinctly scored with a pickaxe or spade; two profiles should be set up on each line to show the workmen the form of the parapet, and to guide them in the execution of their task.

On long faces, three or more profiles should be set up. These profiles, when made with straight slips of deal or other wood, show with great accuracy the form of the parapet, &c. To set up a profile (see fig. 12, Plate I.), first drive in the square-headed pickets and nail firmly to them the upright slips, in order to obtain the proper shape of the parapet.

If profiles are set up showing the several angles formed by the parapet, they will be of great assistance to the workmen: the dimensions of these must be fixed by producing the faces of the work. Having set up the profiles, trace with a pickaxe the escarp and counterscarp lines. In constructing trenches and parapets for hasty cover, profiles are not used.

32. *Amount of excavation.* When the situation for a redoubt or field-work has been fixed upon, the slopes of the ground should be well examined, and drains prepared before the work is begun, especially in works enclosed on all sides, as redoubts, &c. Without this precaution, the interior of the works would become pools of water in heavy rains.

Before commencing the excavation of the ditches, it is desirable to know how deep they can be made: pits should therefore be sunk where the ditches are to be excavated, in order to ascertain the nature of the soil, and whether rock or

water will prevent the ditches going beyond a certain depth: the nature of the soil in these pits will enable the officer charged with the construction to determine upon the proper depth for the ditches. The reader is referred to *Appendix* [*A.*]* in order to become conversant with the mode of calculating the quantity of earth to be excavated in order to form the parapets, &c.; as well as the amount of work that ought to be done by the working parties, and other arrangements connected with the practical details of constructing field-works.

33. *Fascines* are usually made of good strong brushwood laid in a bed or cradle of tressels, as seen in fig. 33, Plate I., where the tressels are at about 4 feet apart: two levers united by a rope or chain about 4 feet in length (fig. 34), are used to choke the fascine, by being passed round it, and pressed by men on opposite sides, till the brushwood is about 9 inches in diameter: for which purpose there are two marks on the rope or chain, at 14 inches on each side of its centre (that is 28 inches apart), and the fascine is increased or diminished in substance till these marks meet in choking it closely: before the *choker* is removed, a strong withe or *binder* is passed round the place, where it is compressed and firmly fastened: these binders are at about 18 inches apart, and much of the goodness of the fascine depends on this fastening. A good 9-inch fascine, with a little earth outside of it, is proof against musket shot.

Fascines are made of various lengths and diameters, according to the required purposes; but the usual dimensions are 18 feet long, and 9 inches in diameter: such a fascine would weigh about 140 pounds, and can be made by 5 men in 1 hour, including the cutting of the material when at hand in a wood. With the fascines, bundles of strong pickets are prepared, in the proportion of 6 to each fascine: the pickets

* See the end of Field Fortification for Appendix A.

should be about 4 feet long, and one and a half inches in diameter: and are used to fix the fascines into the earth, and to each other, as they are built up to form a revetment. These fascine pickets are driven through the thickness of the fascine into the earth, in building up the parapet. (See fig. 38 for the section of a fascine revetment.)

Besides these long fascines (or, as they are often called, saucissons), there are shorter and smaller fascines used in carrying on the work of the trenches at a siege. These *trench-fascines* are about 4 or 5 feet long, and 6 inches thick; there are also thick fascines of 18 inches in diameter, and from 6 to 9 feet in length, called *water-fascines*, used to cover a wet surface: and in crossing wet ditches, they are sunk with stones in layers to form a causeway. A small kind of fascine is used in sapping, called a *sap-fagot;* they are usually 3 feet long and 9 inches thick, having a strong sharp-pointed stake through their middle to fix them into the ground.

In constructing a field-work, the number of fascines required to revet is readily found by the following rule:—

Divide the length of the work by the length of the fascines, and divide the height of the work by the thickness of the fascines; then multiply the two quotients together for the number required. Fascines will sustain slopes of earth with a base of one-fourth of their height: ten rows will be required to sustain the interior slope of a parapet $7\frac{1}{2}$ feet high without a banquette, and six rows with a banquette. See fig. 38.

34. *Gabions*, or cylindrical baskets, open at top and bottom. To construct these well, the men employed must be acquainted with basket-work in all its parts.

Gabions are of various dimensions, according to their intended use. When required to revet the steep interior slopes of batteries, two upright rows of them should equal the full height of the parapet; in this case the basket-work

is strongly and rather coarsely made; but in the sap-gabions the work is carefully *waled* and finished.

To construct a *sap-gabion*, as in figs. 35 and 36, a circle of 20 or 22 inches in diameter must be traced on a clean hard level piece of ground: each quarter of the circle is divided into four or five parts, and small holes, made at the points of division, to receive straight uprights of $3\frac{1}{2}$ feet in length, around which the withes of the basket-work are *waled*.

When finished, the gabion is 2 feet 9 inches or 3 feet high: the ends of the uprights are cut off, and the work is firmly stiched together from top to bottom in several parts. A sap-gabion carefully made and finished, generally weighs from 20 to 40 pounds, and occupies 4 men for 1 hour in making it. To revet an interior slope with gabions, see fig. 37: should there be no banquette, two rows of sap-gabions and two or three of fascines will be necessary to complete the slope, retained at one-fourth of its height. With a banquette, one row of gabions and one of fascines will complete the slope. *Casks* make good interior revetments for parapets.

35. The *sap-roller*, figs. 71, 72, 73, Plate II., consists of two large concentric gabions, each 6 feet long: the greater one has a diameter of 4 feet, and the lesser one of 2 feet 8 inches: both these gabions are very strongly made, and the interval between them is stuffed with pickets of hard wood, not less than one inch thick, which renders it musket-shot proof. It occupies 8 men for 12 hours to make such a sap-roller; or the sap-roller may be the larger gabion stuffed with hard fascines, so as to be musket-shot proof: the French practise this; but it is considered too heavy in the British service, where the two concentric gabions are preferred.

36. *Hurdles* are useful in temporary works, to retain earth at a steep slope for a short time, &c.: when thus used, anchoring pickets should be introduced to secure them. They are usually made 3 or 4 feet high, and from 6 to 9 feet

long: they are handy in the trenches, especially in wet weather, to form a firm footing, and enter into the construction of the passages of wet ditches. At the siege of the citadel of Antwerp, in the winter of 1832, the ground of the trenches was so inundated and rotten as to require layers of fascines and hurdles to give it solidity.

37. At page 192, vol. ii., of Sir John Jones's Sieges, the following judicious remark is made:—"No general rule for the size of materials and implements can be laid down: but in arranging the dimensions of fascines, gabions, splinter proofs, &c., for any service, it behoves a British officer to consider well the nature of the trees and shrubs to be found in the country where the army may be acting; or, otherwise, following the rules taught in books, he will find himself occasionally in a sad dilemma. For instance, in the early part of the war, it happened, in making the preparations for the attack of a post in the West Indies, the superior density of the wood peculiar to tropical climates not being adverted to, the fascines and gabions were prepared of the usual dimensions; and, in consequence, none of the original supply could be made available in the trenches from their great weight.

"Fascines and gabions made in summer will also weigh more than those made of similar boughs in winter.

"Where brushwood or other material is scarce, or difficult to be procured, it should be recollected that the content of fascines of equal lengths, being as the squares of the diameters, much will be saved by making them of small bulk."

38. *Sand-bags* are extremely useful for reveting the steep interior slope of field batteries, &c., figs. 39 and 40, Plate I.: they will retain earth at a slope of about one-fourth; and as they are intended for very temporary purposes, the canvass of which they are made may be very coarse. When the soil on which a lodgment is made is rocky and bare, bags of sand

are built up or thrown into gabions to give cover. These bags are usually made up in bales of about two hundred each: their dimensions are seen in fig. 40, where they are described. When full, they hold a bushel of earth, and are musket proof; and weigh about 60 lbs.

Sand-bags do not make a good lining for the cheeks of embrasures, as the bags burst from the explosion and take fire. There should always be a good supply of sand-bags for siege operations, both in the attack and defence, for obtaining cover rapidly, by sand-bag parapets, traverses, &c.; for loop-holes for a musketry fire; for tamping galleries of mines, &c.

Bales of cotton, woolpacks, bags of hay, &c., built up or stuffed into frames, or gabions, (as fig. 29) serve to obtain a temporary cover from a musketry fire; but these, as well as fascines, are apt to take fire when there is not a sufficient quantity of soil to fill and cover them: thus, in the attack upon the Havanna by the British in 1762, the same parapets of fascines were burnt twice.

39. When a parapet is constructed to furnish a close musketry fire against a work, and is therefore itself exposed to the same, it is customary for both parties to cover their men as much as possible, by forming loop-holes for them to fire through; this is done with sand-bags: two are placed so near as to leave a small opening between them, and a third on top resting its ends on two beneath. The two sand-bags are placed lengthways and perpendicularly to the crest of the parapet at 5 or 6 inches apart, and one transversely over them: being musket-shot proof, they form an excellent loop-hole. See figs. 20, 21, and 22.

40. *Sod revetments.* Fig. 41 gives the necessary information on this subject. The sods should be cut from meadows well provided with grass, previously mown; and, if possible, watered, that the earth may more firmly adhere to the roots of the grass.

The sod-work is laid with the grass downwards, alternately headers and stretchers, as in brick-work, so that the joints of no two rows fall immediately over one another. If the layers of sods are laid perpendicular to the slope, they will resist the thrust of the parapet better than if laid horizontally. Each sod should have two or three pegs driven through it to secure it to the work beneath. Sod-work can be made with great perfection and very durable. The size of the sods depends upon the nature of the soil and of the grass. In meadows, the sods may be 12 or 18 inches long, 12 inches wide, and 4 or 6 inches thick. In heath, having large roots, they may be 2 feet long, 12 or 18 inches wide, and 8 or 10 inches thick.

41. *Escarp revetments.* When the earth will not stand at a slope of one-third, as is very generally the case, the escarps of important works should, if possible, be made difficult to escalade. Trunks of trees form the best description of protection for escarps. They should be planted vertically, and touching each other, their ends sunk 3 or 4 feet into the earth. When the escarp is covered in this manner, it may have the natural slope of the earth; and the trunks of trees may be placed either at the foot of the slope, or, when a line of musketry fire is required, at 4 feet in front of it. In this case, loop-holes are pierced in the timber 3 feet apart, and it is called a *stockade.* The ditch must be made deeper in front than in rear of the stockade, to prevent the enemy closing on the loop-holes; and ready means of communication between the interior of the work and the ditch should be provided. But it is evident that this is not suited for a work, the ditch of which can be taken in flank. (See elevation of a stockade, fig. 24.)

When a field-work is of much importance, and it is desirable to revet the escarp, and to retain it at a slope of one-fourth of its height, then none of the methods described for interior revetments would be sufficient; and a revetment of

timber is the only one that would answer without resorting to masonry. This may be done by means of strong upright beams that hold in a series of horizontal planks: they are sunk $2\frac{1}{2}$ feet in the ground, and attached to horizontal beams, strongly bound and tied by others within, so as to resist the pressure of the earth against the planks: fig. 42 is a section and perspective view, and fig. 43 a front elevation of this construction. This arrangement, however, is of rare occurrence, and requires plenty of good timber, active carpenters, and time. The object could be better attained by the obstacles seen in figs. 13, 14, and 15. Interior revetments can, of course, be made in like manner, in forest or woody countries.

42. *Bridges of communication.* To communicate with the interior of a work, a bridge must be formed across the ditch. This bridge will generally consist of two parts, one standing or permanent, the other movable. (See fig. 59, Plate II.)

If the ditch be not more than 12 feet wide, the whole bridge may be made movable. Four or five sleepers laid across the ditch, if not less than 6 by 4 inches, are covered with planks; a piece of smaller scantling or ribband is laid on the top of the planks immediately above the exterior sleepers, to which it is secured with *rack-lashings*, notches being cut in the ends of two adjoining planks for their introduction. The rack-lashing consists of a piece of stout rope fastened to the thick end of a pointed stick: the rope is passed round the piece of timber to be secured, then twice round itself: the end of the stick is then put into the loose *gromet* so formed, and twisted round until the whole is firmly secured, when the stick is turned flat on the outer side of the ribband. (See fig. 67, B.)

When the ditch is more than 12 feet wide, a trestle or frame must be placed in the middle to support the sleepers of the bridge. The height of the frame will depend on the

depth of the ditch. The transom or upper piece should be 10 feet long, and the legs be wider apart below than above, in order to give steadiness to the bridge.

When a bridge is more than 24 feet long, two or more trestles must be placed in the ditch to support it. These supports should not be more than 12 feet apart. The sleepers should be from 7 to 8 inches square, and all except the last bay of the bridge may be permanently fastened; a piece of scantling or ribband being nailed over the planking on each side of the bridge, to prevent the wheels of carriages, &c., going too near the sides. When rough timber only can be procured, and no plank, a bridge may be formed much in the same manner as already described: stout straight limbs must be selected for the sleepers, which should have but short bearings; they may then be covered with strong hurdles, over which a layer of sods, and then a small quantity of gravel may be laid.

43. To determine the length of a traverse, $b\ b'$, fig. 59, required to cover a given passage through a parapet; draw on the same ground line, fig. 60, profiles both of the parapet and of the traverse, making their distance apart equal to that intended to be left (6 or 9 feet), between the bottom of the exterior slope of the traverse and slope of the banquette of the parapet. Make the width of the passage in the plan, fig. 59, 6 or 9 feet, as may be required. A man of ordinary stature fires at a height of a little less than $4\frac{1}{2}$ feet above the ground; suppose the profiles of the parapet and traverse, fig. 60, to be cut by a horizontal plane $a''\ b''$, at that height. Project on the plan of the parapet and traverse, the intersections of the line $a''\ b''$, with the interior and exterior slopes of the parapet of the redoubt. Through the points of the intersections of these lines, draw the lines, $a\ b$, $a'\ b'$, and make the traverse 4 feet longer at each end than b, b', in order to allow for the partial destruction of the sides of the passage and ends of the traverse, and to secure the interior.

This arrangement, however, gives very large traverses when the passages are wide, and so not only increases the labour but also takes up considerable of interior space. In most cases, it would be preferable to have a descending gallery *d f*, fig. 59 (similar to what is seen under the parapet in fig. 83), leading to the bottom of the ditch: the reverse slope of the ditch being ascended by a few wooden steps; or in case of artillery being used, by a sloping road, *g h*, or ramp (*d*, fig. 59, is a slope or ramp leading to the gallery from the inside of the redoubt).

44. The obstacles usually added to render the approaches to field-works and the possession of them, more difficult to the enemy, are as follows: palisades, stockades, barriers, abattis, trous-de-loup, or trap-holes, chevaux-de-frise, harrows, crows'-feet, fougasses, and inundations: some of these obstacles should be formed with great attention, as it greatly daunts the ardour of the best assailing troops to be checked, and to have their formation broken, under a near fire of musketry, without the power of immediately closing with their opponents.

45. *Palisades.* Sir John Jones, in the first volume of his "Sieges," page 471, says, "The French plant admirable palisades in the ditches and rear of their works: each palisade is the rough stem of a young tree, or the half of a larger tree fixed to a heavy beam 4 or 5 feet under ground. To cut through these palisades, in their usually confined situations, is the work of half an hour, and to force them out is impossible, so firmly are they planted. They are, therefore, an excellent defence when covered from cannon."

Palisades are fixed in ditches in the various ways shown in Plate I., figs. 13 and 15: those inclined as figs. 13 and 14 are called *fraises:* they are not much approved of. A good range of these on the escarp (nearly horizontal) served, in one instance, during the Peninsular war, to place the scaling ladders against, and to give the assailants a tolerable

footing before rushing over the parapet. In a scarp slope, a range of palisades at its foot forms a kind of revetment which may be made very formidable when the wood is of a large rough scantling: and on the other side of the ditch they are also useful and difficult to cut down, should the assailants attempt to descend the counterscarp. Square beams of timber, from 12 to 9 inches square, cut diagonally, are suited for palisades. Iron fraising in particular positions may be found very useful.

46. *Stockades* are strong timber walls; or palisades touching each other, and loop-holed for musketry. The timber should not be less than 9 inches square, with a height of 8 or 9 feet out of the ground, and sunk into a good trench 2 feet under ground. If made of young trees, the interstices may be filled in with half trees trimmed and made as high as the loop-holes, that is about 4 feet from the ground: in this case, a trench would be necessary about 3 feet in rear, in order to cover the troops within the stockade; and to keep an enemy from closing with the loop-holes of a stockade, as well as to protect the timber as much as possible from being battered, a ditch may be made in front, and the earth formed into a kind of parapet as high as the foot of the loop-holes, as is seen in fig. 24.

Fig. 23, *m*, *m*, *m*, represents the wall of a house; the door is at *b*; loop-holes for musketry are shown at the shaded parts *m*, *m*, *m*: the door is protected by a strong stockade (traced as a redan) pierced with loop-holes *l*, *l*, *l*: this stockade has a ditch in front of it, 6 feet wide, from 3 to 5 feet deep; the earth of which forms a little bank, covering the bottom of the stockade as high as the loop-holes (4 feet from the ground): a little bridge of planks leads across this ditch to a gate in the stockade. Fig. 24 is a section (and elevation of the stockade) taken on the line *a b* of fig. 23: *f f f* show the lines of fire. This work is sometimes called a *tambour*.

Stockades serve to bar up passages, streets, avenues, gorges of field or advanced works, and have been made very formidable defences in countries abounding with timber. Covered passages or caponiers, as seen in figure 30, are often made of a double stockade; and as in plan and section in figs. 81 and 83, Plate II. It is evident that this arrangement may be carried out on a great scale in making stockaded barracks and redoubts.

A native stockade of Donoobow, in Burmah, extended for nearly a mile along the sloping bank of the Irrawaddy. It was composed of solid teak beams, from 15 to 17 feet high, driven firmly into the earth, and placed as closely as possible to each other. Behind this wooden wall, the old brick ramparts of the place rose to a considerable height, strengthening the front defences by means of cross beams, and affording a firm and elevated footing to the defenders. Upwards of 150 guns and swivels were mounted on the works, and the garrison was protected from the shells of the besiegers by numerous well contrived traverses and excavations. A ditch of considerable magnitude and depth surrounded the defences; the passage of which was rendered more difficult by spikes, nails, holes, and other contrivances. Outside of the ditch were several rows of strong railing: and in front of all, an abattis, thirty yards broad. Against this formidable enclosure, heavy artillery was put in battery, and breached sufficiently to allow of its being stormed by the British troops, in 1826.

47. *Barrier gates*, to close in the entrances of field-works, should be very massive, and capable of resisting any sudden attack. They may be made of strong stockade or palisading, swept by the fire of a traverse, and are always placed on the least accessible side.

48. *Abattis* are lines of felled trees of a considerable size: their stems strongly bound together and picketed down, while their branches are spread towards the enemy, and in-

terlaced as much as possible: the small branches are cut away and the boughs well pointed.

Fig. 13, Plate I., is one instance of placing an abattis where it is covered by an advanced glacis that hides it from the view and the fire of the enemy's artillery: and in forcing this abattis, the assailant is exposed to the full fire of the parapet in the rear. See also figs. 15 and 19.

At page 360 of the third volume of Col. Napier's "History of the War in the Peninsula," in describing the lines of Torres Vedras, it is said: "Across a ravine on the left, a loose stone wall, sixteen feet thick and forty feet high, was raised: and across the valley of Aruda, a double line of abattis was drawn, not composed, as is usual, of the limbs of trees, but of full grown oaks and chestnuts, dug up with all their roots and branches, dragged by main force for several hundred yards, and then reset and crossed so that no human strength could break through. Breast-works, at convenient distances, to defend this line of trees, were cast up, &c."

Well disposed abattis make a formidable obstacle, and have always been highly esteemed and much used in ancient and modern warfare.

A good position for abattis is seen in fig. 84, Plate II. It is here intended to increase the difficulty of an enemy's approach to destroy the reverse gallery that defends the ditch of the square redoubt.

A striking illustration of their value and importance in retarding the advance of troops, was furnished in the Mahratta war of 1817 and 1818, in the case of a division of the British army with a siege train, employed in the capture of the Peishwa's fortresses in the Concan; a mountainous district peculiarly difficult for such movements. Forest trees were sometimes felled by the enemy, and so laid as to interlock immediately across valleys and ravines in the path of our army: not unfrequently supported by direct and flanking fire from matchlocks and iron rockets. Had these

very strong positions been at all adequately defended, they might have cost the advancing army dear to effect a passage, from the impossibility in many cases of moving the heavy artillery and stores by the flanks. And even when these had been turned by light troops, and the position gained with serious loss of life on both sides, the progress of the army was still further delayed until the gigantic abattis could be burnt down, the only practicable way of effecting a passage, thereby giving time to the retreating enemy the better to prepare their adjacent fortresses for a siege.

49. *Trous-de-loup*, or trap-holes, are rows of pits in the form of inverted cones or pyramids made before a work, and having a strong palisade or stake in the centre of each, as in fig. 83: these used to be about 6 feet deep, and 8 or 10 feet diameter at the top: but upon some occasions, during the Peninsular war, bold and active riflemen crept into them, and brought a destructive fire from them upon the defenders; to prevent which they should be made too deep or too shallow for the convenience of riflemen, as in fig. 83; where they are represented as 8 feet, and $2\frac{1}{2}$ feet deep. In tracing trap-holes, they should always be chequered to prevent an enemy passing them easily. In fig. 83, they are placed so as to increase the difficulty of approaching the angle of the redoubt, where there is a covered caponier for the defence of the ditch.

50. Farmers' harrows may be used with advantage a obstacles, strongly picketed down to the ground.

Crows'-feet are triangular pieces of iron, used as obstacles to the advance of troops, especially of cavalry.

CHAPTER III.

CONSTRUCTION OF BATTERIES. PLATFORMS. FIELD POWDER-MAGAZINES. SAPS.

51. *On the construction of batteries.* Batteries are of four kinds: 1*st*, *cavalier batteries;* 2*nd*, *elevated batteries;* 3*rd*, *sunken batteries;* and 4*th*, *half-sunken batteries.* The first has the platform for the gun-carriage above the level of the ground: this construction is rare, as it involves great labour, requiring a large excavation and many workmen to execute it. See Plate I., fig. 4.

An elevated battery is a complete parapet, the platform for the gun-carriage being laid on the level of the ground; it is in most general use, and in most cases, it is the easiest of construction. For the section of an elevated battery, see fig. 5, Plate I., and for the plan of such a battery, see fig. 44, Plate II.

A sunken battery has its level below the ground line, so that the gun can range just above it, as seen in fig. 7, Plate I. This construction is frequently used in turning the portion of a parallel into a battery, by increasing the width of the interior excavation of the trench so as to make room for the platforms of the guns. Great care must be taken that no rise in the ground before the battery obscures the view from the soles of the embrasures; for this purpose, the officer laying out the battery should lie down and look along the ground, in order to be sure that his guns can range freely from their embrasures, before he fixes his details for construction. When guns are fired with an elevation (as in the case of ricochet), this construction is approved of when the ground is favourable (that is, raised or

elevated ground), when the soil is sandy or gravelly, and when the weather is dry; otherwise the interior of a sunken battery becomes a pool of water. The depth of the excavation for the interior must depend on the height of the carriages upon which the guns are mounted: it should be deeper in rear than in front, that it may be drained.

A half-sunken battery has both an interior and exterior excavation to furnish earth for the parapet: that is, a trench in rear and a ditch in front of the parapet: see fig. 6. This kind of battery is suitable to rocky ground where there is only a thin layer of earth. The interior slopes of these batteries, and the cheeks of the embrasures, must be supported by field revetments of gabions, fascines, sand-bags, casks, or sods.

Half-sunken batteries are the most expeditiously constructed of any, as allowing double working parties to excavate and build the parapet; one set of men working in front and another in rear, of the parapet. But these, as well as sunken batteries, can only be constructed in the dark, for the security of the men who would be exposed to the enemy's fire whilst excavating in front of the parapet. In cases where securing cover expeditiously is of great importance, or where a shallow soil favours it, this double application of working parties has been found very useful, as it exactly *halves the time usually employed in raising cover* for troops, either in siege operations or in securing a post exposed to a severe and destructive fire from an adjacent enemy.

52. In the second volume of Sir John Jones's "Sieges," at page 170, there is an interesting and instructive memorandum as to the manner of carrying on the duty and performing the work at the sieges in Spain; in which he says, "It was found an excellent expedient to form the interior of the cheek of the embrasures, that is, the part of the opening next the gun, with very strong gabions, made larger than the ordinary size, and placed so close to each other, as only to admit the

muzzle of the gun between them. This, besides giving great strength to the interior angles, protected the gunners very much from the enemy's musketry.

" In fact, after a few hours of the quick firing, which is now practised from heavy iron guns, the embrasures become utterly shapeless beyond the muzzle of the piece, and all that can be hoped is to preserve two or three feet of tolerable cover next the interior of the battery. During these sieges, the embrasures of the several breaching batteries were fresh lined every night; and though every expedient was adopted to give them strength, still they were invariably found on the ensuing evening to have returned to a shapeless hole.

" Gabion revetments are preferable to fascines, not only for economy in materials, but also in time and labour. Raw bullock hides (doubled) should be stretched tightly over the neck and cheeks of the embrasures, to preserve the gabions in heavy firing.

" Most of the batteries at these sieges were thrown up in a solid mass, and the embrasures cut through when the guns were mounted, in consequence of the destructive fire to which they were exposed: but where the fire on a battery was moderate, it was found most expeditious to form the embrasures simultaneously with the parapet."

In the relation of the siege of the citadel of Antwerp, in 1832, published in the 52nd number of the *United Service Journal*, it is stated, " that in all the batteries not exposed to direct fire of cannon, the embrasures were furnished with thick musket-proof wooden shutters, opening vertically in their centre, and mounted on frames, with iron hinges and handles. These were opened to point and fire, and immediately closed on the recoil of the piece." (An excellent expedient when within range of the enemy's musketry.)

53. In batteries exposed to a heavy fire, especially of shells, it is necessary to provide as much cover as possible for the men serving in them: for this purpose, traverses are

usually placed between every two guns; and as these masses serve to protect the men from the splinters of the bursting shells, they are generally called *splinter-proof traverses.* To make these entirely of earth would require a greater space in the batteries than could be given; they are therefore reveted with gabions and fascines, enclosing a few feet of earth, as seen in section in figs. 70 and 75, Plate II.; (fig. 70 is the section of a splinter-proof traverse for an elevated battery, and fig. 75 for a sunken battery;) but if this be found insufficient, the lower tier may consist of three, and the upper tier of two rows of gabions. In the memorandum of Sir John Jones, quoted in the last article, he says "Between every two guns a splinter-proof traverse of sand-bags was built up; it was made perpendicular to the parapet, 10 feet long and 1 foot distant from it at the base, with a thickness of 2 feet at the top. To have ample room for these traverses, it is best to place the first two guns 18 feet from the epaulement; then leave a space of 22 feet, then 18 feet, and so on alternately, placing the traverse in the larger interval. These traverses in the batteries were of essential service, saving many lives, particularly at Rodrigo, where the number of shells thrown into the batteries was surprisingly great."

Fig. 44 shows this construction: the first gun, *a*, is at 14 feet from the epaulement, *o;* the second, *b*, is 18 feet from *a;* the third gun, *d*, is at 22 feet from *b*, and in this interval is the splinter-proof traverse, *e;* and so on: thus the length of the parapet, from epaulement, *o*, to epaulement, *p*, will depend upon the number of guns and traverses to be placed behind it: the traverses are not always engaged as *e*, but are sometimes unconnected, or disengaged, from the parapet, as *g*.

Fig. 44 shows the dimensions that should be given to the profile of a battery within point-blank range of an enemy's guns: and, if it has to be constructed within the range of musketry or grape, it becomes necessary, for the security of the workmen, to begin by placing a row of gabions, *k*, *k*,

along the front of the ditch, and to fill them immediately, so that the men proceed with an excavation behind this cover. See fig. 5, Plate I.

Should the battery be at a greater distance than 600 yards from the enemy's guns, the dimensions shown in fig. 44 may be decreased to 14 or 12 feet in the superior slope. The depth of the ditch should never exceed 6 feet in offensive works of this nature; as anything beyond this makes it very difficult to throw the soil up from the bottom of the excavation; indeed a less depth (5 feet) is more convenient: in which case, as well as for the additional earth required for the traverses, the breadth of ditch must be increased.

The height of the parapet of a battery requires to be either increased or diminished, in the cases of its being commanded by the hostile work; or the latter being commanded by it.

54. *Howitzer batteries* have usually the neck of their embrasures a little wider than long-gun batteries.

All short guns in batteries, such as the old howitzers and carronades, have the disadvantage of requiring wide necks for their embrasures, and thereby exposing the gunners. The flash, and expansion of the elastic fluid, on the explosion of the charge, taking place at the neck, soon ruins the embrasure. Howitzers being fired with a little elevation, (as well as guns for ricochet,) the soles of the embrasures may, in these cases, be made with a counterslope, that is, sloping inwards; which adds something to the general stability of the mass. Howitzers and ricochet batteries may sometimes be made without embrasures to cover the gunners better, the guns at 15 feet apart, and retired from the parapet so as to fire over it. A trench may be dug between the parapet and the guns, extending on both sides of the battery, in order to check the enemy's sorties. When howitzers are fired at considerable elevations, that is, 10° or 12°, this construction is best, and gives great strength to the parapet, which can then be countersloping at top, unless a fire of musketry is likely

to be required from it, in which case the superior slope must have the usual depression to the front.

55. *Mortar batteries* (see the right part of fig. 44, Plate II.) have no embrasures: if exposed to a heavy fire, their superior slope may be flat at top, or even have a counterslope.

Mortars are usually placed at 15 feet apart, and when fired at 45° of elevation, they are removed to a distance of 12 feet from the epaulement: as the angle of elevation is decreased, the pieces are proportionally removed to a greater distance from the epaulement. The right portion of the battery, fig. 44, shows two platforms prepared for mortars, placed at 12 feet from the parapet.

56. *Dimensions of an elevated battery reveted with gabions.* (Fig. 44, Plate II.)

	feet.	inch.
From the centre of embrasure *a*, to that of embrasure *b*, without a traverse (general dimensions)	18	0
Ditto from *b* to *d*, with a splinter-proof traverse, *e*,	22	0
From the centre of embrasure *a*, to the foot of the interior slope of the left epaulement *o*, without the magazine, *m*	6	0
Do. do. with the magazine *m*, (similar in construction to that shown in fig. 107 or 108, Plate III.)	14	0
Clear space between the platform *b*, to the foot of the interior slope of traverse *e*, (similar in construction to that shown in fig. 70.) . . .	3	0
Interior slope of the parapet ($\frac{1}{4}$ its height $\frac{7\frac{1}{2}}{4}$)	1	$10\frac{1}{2}$
Depression of the superior slope per foot $\frac{1}{12}$ . .		$1\frac{1}{2}$
Interior width of embrasures at the sill . . .	2	0
Exterior do. do. on the sole, measured at 12 feet from the sill	6	0
Slope of the cheeks of embrasures at the neck, per foot		1
Do. do. at the mouth do.:	3	0
Height of the sill; depending on the kind of guns' carriage; about	3	0

This battery, fig. 44, is supposed to be constructed at the extremity of a parallel, having a trench leading into it, the extremity of which has a ramp to communicate between the terre-plein of the battery, and the lower level of the trench and parallel. This battery is intended for 4 guns and 2 mortars, with traverses (one engaged as *e;* the other disengaged as *g*). The parapet is made 18 feet thick, and the epaulements 10 feet: there are two small magazines, one in each epaulement *y* and *m:* or a large rectangular one, M, in the rear. On the left flank of the battery, a sloping road or ramp, *s*, is made, to enable the workmen to pass safely into the ditch of the work. There is a *gabionade*, *k k*, outside of this ditch, in order to cover the workmen while excavating the earth, and throwing it up on the main parapet: this *gabionade* is afterwards removed when the guns are ready to open their fire. (The pupil should draw a plan and section of this battery and its details on a large scale.)

57. *To trace this battery* (probably at dusk on the second night of the siege): required 1 non-commissioned officer and 3 privates, 1 ground square, 1 measuring tape, 1 white tracing line or tape, 2 ten-feet rods, 1 bundle of pickets, 1 mallet. The tracing pickets and mallets to be carried in a sand-bag, and a few long pickets to mark the embrasures.

A line, *a x*, should be carefully laid down in the exact direction of the object against which the battery is to be erected: if for direct fire, this line should be perpendicular to the face of the work; if for enfilade, it should be exactly parallel to the prolongation of its crest, and 4 or 5 feet within it; this line, *a x*, may be about 60 feet long, and may be called the line of fire. Perpendicular to this line, *a x*, lay down the line *o p*, by means of the ground square, for the foot of the interior slope of the parapet; picket down this line, also the lines, *p m* and *o y*, in the required direction of the epaulements. Add together the breadths of the interior,

superior, and exterior slopes; of the berm, and of the front slope of the ditch, in this case (1 ft. 10 in.$+18'+5'\frac{1}{2}+3'+3'$.) say 31 feet, and picket the line, *f h*, and the lines *f l* and *h i*, at their proper distances, parallel to *p m* and *o y*. The calculation of the deblai having been previously made by the officer charged with the execution of the work, and the dimensions of the ditch fixed accordingly, the reverse slope of the ditch must be traced in like manner, and picketed off, as the workmen will begin here to form the rough epaulement or flying sap, *k k*. Pickets, 3 feet 6 inches long, are driven in along the line, *o p*, to mark the centre of each embrasure; and mark, also, the necks of the embrasures by driving in pickets at the distance of one foot on each side of these centre pickets: then measure off 12 feet from the sill of the embrasure perpendicular to *o p;* and on each side of the end of this 12 feet line, drive in pickets 3 feet 6 inches long, to mark the width at the mouth of the embrasure: this must be done for each embrasure.

As soon as the battery is traced, and the screen, *k*, finished, the diggers are placed at 4 feet apart in the ditch, and throw up the earth from the ditch upon the parapet forming the whole into a solid mass as high as the soles of the embrasures, that is, about 2 feet 9 inches, or 3 feet high; there will then be some cover behind this bank for the builders to arrange the revetment, and prepare the embrasures, traverses, &c.

58. *Working party: tools and materials required for each gun, mortar, traverse, and epaulement, in an elevated gabion battery.*

Men. On an average, from 9 to 12 men per gun (according to the nature of the soil,) to excavate the ditch, and to form the parapet, besides 2 sappers, and 2 assistants to revet the work.

For the extra parapet where there are mortars or traverses, one-third more than the number required for a gun.

Extra men for each traverse, 10.

For the epaulements and adjacent shoulders, twice as many as for a gun.

Tools and reveting materials, according to the nature and size of the battery.

To apply this to fig. 44 :—

4 guns at 15 men each, including builders	60 men
2 mortars at 17 do. do. . . .	34
For the two traverses, and for their extra portions of parapets, 20 to 26 . . .	44
For the epaulements, 30 men for each, do. .	60
	198 men

For the siege of Bayonne (in 1813) the Duke of Wellington allowed 20 men for each embrasure, to construct the battery, platforms, magazines, and traverses in one night : 40 pieces of artillery were to be put in battery ; total working party 800 men, to be relieved every six hours.

Tools. 9 pickaxes, 15 spades or shovels for every 18 feet ; for every two guns, 1 saw, 1 hatchet, 1 bill-hook, 1 field-service level, 1 six-feet rod, 3 mauls, and 3 rammers ; for every three guns, 1 lantern, 2 pounds of candles ; in all, for 4 guns and 2 mortars, as in fig. 44, with two epaulements, 74 picks, 130 shovels, 3 saws, 3 hatchets, 3 bill-hooks, 3 field-service levels, 6 six-feet rods, 9 mauls, 9 rammers, 2 lanterns, and 2 bundles of matches.

Reveting materials. For battery, fig. 44, 122 feet of parapet on *o p ;* 60 feet for the two epaulements,=182 feet ; now, if the gabions be 2 feet in diameter, and 3 feet high, two tiers of gabions will be required for every two feet (as in fig. 37), in all 182 gabions : allow three gabions for each cheek of an embrasure, in addition to the one at the neck ; then 4 embrasures$\times$6=24 gabions ; the gabionade, *k k*, on the front and epaulements, is equal to 265 feet, re-

quiring 133 gabions. Two traverses, each 18 feet long (of the profile shown in fig. 70) requiring each 9 gabions in two rows on each side: for the two traverses, 72 gabions. Fascines, 18 feet long, 24 for the parapet and the two traverses, and 8 for the 4 embrasures; fascine pickets, 1 bundle of 50 to 6 fascines; some spare bundles of gads, and a roll of measuring tape.*

59. It will be good practice for a pupil to calculate the exact quantity of earth required for this battery, by the process given in *Appendix* [*A*]; including the traverses, epaulements, &c., and deducting the embrasures: then to regulate the size of the ditch accordingly, supposing cases where the depth is to be 5, $5\frac{1}{2}$, and 6 feet, draw out the figures on a large scale with tables of material, number of men, and time required for the work.

60. *Sand-bag batteries and saps.* At the siege of Gerona by the French, in 1809, there was a remarkable instance of the rapidity with which a battery was formed by sand-bags. On the 2nd of July, during a night of rain, a battery for 20 guns was formed in eight hours upon a rocky ground, having a height of 7 feet 6 inches and a thickness of parapet of 16 feet 6 inches, the embrasures being at a distance of 19 feet 9 inches from centre to centre. 80,000 sand-bags had been filled beforehand, and arranged in five separate heaps of 16,000 each, placed in hollows hid or screened from the view of the place, at a distance from 100 yards to 50 yards from the site of the battery. Three thousand workmen were allotted to carry the bags, and divided between the five depôts. The operation commenced at 9 P.M.: the men felt the necessity of a prompt execution, and each carried two and even three bags: at 5 A.M. on the following morning,

* It is not always necessary to revet the epaulements of a battery; they may be left with their interior slope, having a base of one half or more of the height, as the soil may be found capable of standing for the time the battery may be required.

the 20 pieces, under cover of this beautiful battery, commenced their fire, to the astonishment of the besieged.

In the French siege of Constantine, in 1837, batteries and saps were formed of sand-bags, in consequence of the rocky nature of the soil, with even a greater rapidity than the like work could have been executed in the ordinary manner by gabions and fascines.

The works of a siege executed in sand-bags, has considerable advantage; for *it saves men and time.* There is no battery that cannot be commenced and finished in one night if the bags have been filled and prepared beforehand: and this can nearly always be done; because the batteries ought to be preceded and protected by saps, during the execution of which there is always time to fill the sand-bags. *A flying sap ought to be executed in a quarter of an hour*, so as to cover the workmen who may have to excavate the trench in rear, when the ground admits of it, and who have to raise and thicken the parapet. In order to employ sand-bags with the utmost efficiency, it is necessary that they should be made of strong canvass and tarred, of exactly the same dimensions; and that they may be easily and quickly laid for parapets, loop-holes, embrasures, &c., the sappers should be exercised in filling them; in forming themselves into squads, in order to work with the utmost despatch; in practising flying and full saps in sand-bags: upon the perfection of all which details the success of the operations may often depend.

On naked rocky ground, a deficiency in sand-bags will prove to be a serious detriment. In the attack of hill forts in India, a large supply of sand-bags should be provided: the author remembers that the most efficient battery against the hill fort of Singhur, in 1818, near Poonah, was of sand-bags, and beautifully made.

61. *Platforms for guns and mortars.* To enable a gun to be worked with ease, expedition, and accuracy, it must

be placed on a platform. In permanent fortification, platforms are sometimes made of stone, but in field-works they are always of timber: they are composed of beams or sleepers covered over with a flooring or deck. For guns, the platforms are laid with a slight rise to the rear (about half an inch to a foot); and as the platforms are usually 15 feet long there is a rise of $7\frac{1}{2}$ inches from front to rear.

See figs. 63,* 64, and 65, Plate II., Field Fortification, for the plan and sections of a gun or howitzer platform. Materials required, as follows (of fir):—

5 Sleepers, each 15 feet long; 5″ square . .	weight, depending on the nature of the wood, about 13¼ cwt.
20 Planks, each $10\frac{1}{2}$ feet long: 9″ broad & 2″ thick	
2 Ribbands, each 15 feet long and 4″ square .	
10 Rack-sticks and lashings	

The sleepers must be well embedded in cuts or trenches, and firmly fixed or pinned into the earth, then covered with the planks, and finally completed with the two ribbands and five rack-lashings on each side. It will be observed that the form of the platform is rectangular $15' \times 10\frac{1}{2}'$ in fig. 63: differing from that in permanent fortification, as seen in fig. 102 A., Plate III., at f', which spreads or splays to the rear: this latter form is best suited for traversing guns to the extreme opening of the embrasure: but if the field platform were made of this form, splaying to the rear, the planks would all differ from each other in length; and the sleepers underneath would also have to follow this form, and spread out fanlike, to sustain the planks. Now, as battery platforms in a siege are almost always laid at night by a very indistinct light, and sometimes under fire, such an arrangement would be very difficult, if not impracticable: but when of a rectangular form, as soon as the sleepers are properly laid, the boards

* The planking of the platform in fig. 63 is not complete; part is omitted in order to show the arrangement of the sleepers underneath the planks.

being all of the same size, the first that comes to hand will suit, and the platform is easily and quickly laid. Moreover, as guns in sieges have a specific duty to perform, and are placed in such a position as scarcely to require traversing right or left above two or three degrees, the rectangular form is as good as the other for all the purposes required.

The modes of fastening the flooring or deck to the sleepers, are by screws, spikes, or rack-lashings: the latter is the preferable of the three. It is evident that the rack-lashings must be arranged in their proper places when the two outer sleepers are first laid in their grooves or trenches in the earth.

For carrying this platform, 2 men are required for each sleeper, one for each plank and ribband. The non-commissioned officer carries the rack-lashings. This platform may be laid down in an hour by expert men, and may be dismantled in a few minutes.

For a mortar platform. (Figs. 66 and 67.) Materials required (of fir), to be laid perfectly horizontal.

7 Sleepers; 5 of which are laid longitudinally, and 2 transversely, underneath the 5; all well embedded in trenches in the ground; each sleeper 7 feet 6 inches long, and 6 in. square 8 Planks, 6 feet 6 inches long, $11\frac{1}{4}$ in. broad, and 4 inches thick . . . . . . 2 Ribbands, 7 ft. 6 inches long, and 4 in. square 10 Rack-sticks and lashings	weight depending on the nature of the wood, about 9 cwt.

As the recoil of a mortar fired at 45° of elevation is at this angle on the platform, it is necessary to make a mortar platform stronger than a gun platform; hence 7 sleepers are used, as stated above, instead of 5, and the scantling of the sleepers and flooring is greater in the mortar than in the gun platform.

1 non-commissioned officer and 17 men can carry the plat-

form. Time required for laying or dismantling, the same as a gun platform.

If rack-lashings be not used, screws are preferable to spikes, in order to fix the flooring to the sleepers. Spikes are difficult to withdraw, and greatly injure the wood; there is also much noise in driving them through the wood, and noise should always be avoided within the hearing of an enemy, as it draws his fire on the place. Screws are not so objectionable as spikenails on this account, but they injure the wood, and require more time to fix than rack-lashings; but the latter are the preferable fastenings, on account of the quietness and ease with which they are managed, and because these lashings do not injure the timber.

The Madras platform. (See figs. 68 and 68 A, for the plan and side elevation.) It consists of a strong frame-work; 2 side pieces, *a a*, are each 12 feet 6 inches long, 1 foot wide, and 4 inches thick.

1 Fore transom, *f*, 7 feet long, and 6 inches square.

2 Hind transoms, *h* and *i*, each 6 feet 6 inches long, 9 inches wide, and 3 inches thick.

1 Trail-piece, *b*, 12 feet long, 16 inches wide, and 4 inches thick.

3 Sleepers, *s*, *s*, *s*, (shaded in the plan) each 9 feet long, and 6 inches square.

2 Wedges for the rear, to run the wheels of the gun upon the side pieces.

8 Iron bolts, with nuts and screws, to fasten the transoms to the side pieces and the trail-piece.

The trail-piece is hollow in the centre, to receive and guide the trail of the carriage in recoiling, and thus keep the wheels in their places on the side pieces.

Weight of Madras platform, 8 cwt. 2 qrs. 16 lbs.

The front transom is fixed firmly at the foot of the parapet, and pinned down; the 3 sleepers are also pinned down, the centre and rear sleeper being out of the ground (and the last

one, under the trail, having a little mound of earth to give the whole platform a rise to the rear of 8 or 10 inches). The framed work is easily moved by handspikes so as to slide over the 3 fixed sleepers, and thus to traverse the gun as much as may be required. 24-pounders have been tried with success on the Madras platform.

62. *Barbette batteries.* Guns in embrasure are evidently limited in their range to the size of the embrasure, and any attempt to widen this opening beyond the fixed dimensions would weaken the merlons to an unsafe degree. Therefore when guns are required to range freely over all the surface of the country before them, there is a platform of earth raised in rear of the parapet, of sufficient height and breadth to permit the guns placed on it to be run out over the crest of the parapet, and to be pointed in any direction. Guns in this position are said to be "*en-barbette.*" In serving guns *en-barbette*, the gunners are exposed from the thighs upwards; and although this is a matter of less consequence while the enemy is beyond the range of musketry, and thus cannot reach them with this weapon, yet when he has sufficiently advanced his attack, to lodge his riflemen in trenches within such a distance as to enable them to pick off the gunners; the guns must then be sunk into embrasure to protect the gunners as much as possible.

The garrison carriage upon which the gun rests, runs on four small wheels or trucks; and when thus mounted the gun is usually about two feet six inches from the ground. In order to raise it up to enable it to fire over the crest of the parapet, there is a kind of frame-work, composed of two great sides or cheeks, upon which the carriage is placed, and on which its trucks run in groves; by being thus elevated upon a *traversing platform*, the gun can fire over the crest of the parapet without the construction of the barbette mass just spoken of: this platform has its name from traversing upon a pivot and trucks. Traversing platforms are made either of

wood or cast-iron, and are more used in permanent works than in field-works. Barbette masses of earth are usually constructed in field-works.

63. *Field powder-magazines.* In the memorandum by Sir John Jones, already quoted, there is the following remark on this subject: "Splinter proof* timber for magazines were cut 12 feet in length, and from 8 to 10 inches in breadth and thickness, and were placed against an epaulement, or parapet, at an angle, making the base equal to half the height. They were then covered with a tarpaulin, extending well over the top of the epaulements, upon which were laid one or two rows of filled sand-bags, so as to prevent the possibility of the tarpaulin being cut by splinters of shells. A second tarpaulin was usually thrown over the exterior in rainy weather. On this construction, the magazines were found to be perfectly dry, and sufficiently spacious, and of the strength no doubt can remain, as the sand-bag covering was frequently knocked off by large shells, and in no instance were the splinter-proofs broken."

"The best situations for magazines are on the flanks of the batteries. Nothing can be worse than to place them in rear of the centre of a battery, as then every cartridge has to be carried along the most exposed and dangerous part of the battery, and the number of accidents and casualties which arise therefrom is very great indeed. The artillery always preferred to have two magazines formed, rather than to have one exceeding ten or twelve feet in length: when two were made, they were placed, one on either flank, as *y*, *m*, fig. 44, Plate II.; a situation which was found to answer extremely well, for the magazines of batteries constructed in advance of a parallel, was at the extremity of a cut, made perpendicularly through the parapet of the communication from the

* This name is given, because the arrangement is merely intended to be proof against the splinters of bursting shells; a heavy shell falling upon the contrivances now referred to, would crush them in; but being very small objects, this evil rarely occurs.

parallel, at ten or twelve yards before arriving at the battery. The level of the floor of the magazine was then kept as nearly on the level of the approach as would admit of its being drained; and the foot of the splinter-proof timber was sunk twelve or fourteen inches under it. In this situation an accidental explosion of the magazine will not injure the battery." *

As it is customary to cover the flanks of batteries by epaulement, as *o*, *y*, *p*, *m*, fig. 44, and as these masses of earth are not in general exposed to so direct a fire as the parapet, they are not made so thick, nor is it always necessary to revet their interior slopes: it is these epaulements that Sir John Jones refers to, in the remarks just quoted, as the most suitable situations for magazines; the position is indicated by the shaded parts, *y*, and *m*.

Field powder-magazines are made of various shapes and dimensions. General Sir Charles Pasley's are of two kinds. 1st. A rectangular tracing, excavated to about $3\frac{1}{2}$ feet below the level of the ground, and having its interior space lined with timber, so as to form a dry chamber of triangular section. 2nd. A rectangular tracing similar to the first; the dimensions of which are 12′ 3″ by 6′ 3″; but instead of the section being triangular, it is rectangular. By thus gaining interior space the amount of labour is less, and the number of barrels of gunpowder that can be stowed away exceeds that for which there is room in the triangular section. The rectangular section, having a tracing of 12′ 3″ by 6′ 3″, will hold 44 barrels, or 3960 lbs. of gunpowder.

Again, the sides of the rectangular tracing may be supported by good strong gabions, with two or three layers of fascines, covered over by splinter-proof timbers and earth, thus giving a dry good space $4\frac{1}{2}$ feet high by any rectangular shape that may be most suitable for the splinter-proof timbers that are available.

* Jones's Sieges.

The traverses in batteries, especially on the crowning of the glacis, in a regular attack would, in most cases, be suitable for magazines, by merely using mining cases, and having a recess like a small gallery either in the side of the traverse, or at the end of the traverse. Let the shaded part of fig. 99, Plate III., above 2, 1, 4, 1, represent the end of a traverse; and the dotted part from *d* to *c* a perspective view of the side of a gabion traverse. A magazine could be made by mining cases (described in Chapter IV.) either from, A, running underneath the length of the traverse; or by entering from B, through the width of the traverse.

64. *Sapping* is a mode of constructing trenches and parapets under a *musketry* fire. The sappers, or engineer soldiers, must be well instructed in their business: it is a slow operation, as the work cannot proceed at a quicker rate than what one man can dig at a time. For this duty, the sappers are told off into squads or brigades of four men each: the man at the head of the squad is the first sapper, and they are numbered 1, 2, 3, 4. The head of the trench, which they dig, is covered by a sap-roller (article 35, and fig. 72, Plate II.): and on the flank whence the fire comes, the sappers are protected by a line of gabions filled with earth. Fig. 72, shows a plan and section of a single sap, with the work of each sapper numbered in the section: the sap-roller is pushed on by the head sapper, assisted by No. 2, by means of forks having long handles. The first sapper cuts the trench marked No. 1 in the section, making it 18 inches wide and 18 inches deep: No. 1 also places each successive gabion: he works on his knees, taking care to leave a banquette of 18 inches between his trench and the row of gabions: he works in a length of 5 feet, with which the following sapper does not interfere. No. 1 is very careful not to allow his body to pass the gabion last placed till he has filled it with earth, and placed a sap-fascine or a couple of sand-bags in the hollow between the two advanced gabions, so as to

have a musket-shot proof cover behind which to continue his work: the leading sapper thus occupies the most dangerous as well as the most laborious post, which each of the squad takes in succession.

No. 2 works on his knees, and excavates the trench marked II. in the section: to equalize the work, his trench is 20 inches wide and 18 inches deep, having a length of 5 feet.

No. 3 follows No. 2, deepening the trench to 3 feet, marked III. in fig. 72: and No. 4 completes the trench, by enlarging its breadth 10 inches, and deepening it to 3 feet, marked IV., in fig. 72: the earth excavated by the squad is first put into the gabions and afterwards thrown beyond them, so as to form the rough parapet seen in the plan and section. Working parties follow the sappers, and complete the trench to any dimensions that may be required. The sappers' work is marked 1, 2, 3, and 4, in the section.

In sapping, or in using gabions as a revetment, &c., they should always have a little slope outwards towards the parapet, of about one quarter their height; for, if placed quite upright, any swelling of the fresh earth of the parapet from rain, would throw them down inwards. By examining figs. 72, 71, and 73, the plan, section, and elevations of a single sap, the pupil will become fully acquainted with all its details: the sap fagots need only be used between the gabions where there is no earth beyond them.

The time occupied in constructing ten feet of sap, in the manner just described, is about one hour; but if, during the night, the fire from the place slackens, portions of sap may be pushed on more rapidly by placing several gabions at a time, and filling them simultaneously: when this is done, it is called the *flying sap*.

Approaches by sap are usually carried along the capitals of attacked works, in a zigzag direction; see fig. 103, Plate IV.: the direction of each successive zigzag is such as to be clear

of enfilade from the place, hence their parapets run obliquely to the place; but when the saps draw near, these zigzags become so multiplied, and the angles between them so acute that it saves time in many cases to carry on a double direct sap towards the place. Thus when 100 yards of zigzag does not carry the approaches so much as 32 yards in advance the double sap should be adopted. Two brigades of sappers are employed on it at a time, each covered in front by a sap-roller, fig. 80, Plate II.; the gabions of the two squads are usually 12 feet 6 inches asunder: the intervals between the sap-rollers (about two feet) being covered by a short sap-roller. This double sap is therefore a mode of advancing against a musketry fire in the front and on the flanks. Should the sap be liable to be enfiladed or raked, it must be traversed; that is, instead of being carried on in a straight line, the squads of sappers must work round solid dies of earth, as in fig. 80, which forms the traverses.

In the event of sapping under a commanding situation, it may become necessary to blind* the sap, as seen in fig. 74: that is, to set up strong frames to be covered at top with fascines, sand-bags, and earth; in such a case, the sap should be narrowed as much as possible.

65. Fig. 76, shows a plan and longitudinal section of a double sap with 4 sap-rollers in front, worked by 3 brigades of sappers. Sections and elevations of this sap taken on the lines CD, FE, and GH, are shown in figs. 77, 78, 79: the work of each brigade is the same as in the single sap: an inspection of these figures shows the progress of the sap and its details; the unshaded gabions, in the two traverses near the head of the sap, indicate that they are not filled with earth, and as they can be easily removed, will allow a sapper

* The terms blind, or blinding, a work, is hooding or covering it over. Thus guns and mortars are frequently covered over with strong timber or blind frames and earth. The splinter-proofs already described in article 63 may be called blinded cover.

to creep in to keep up a communication. As the three squads work steadily in advance, others following them lay out and complete the traverses, for which purpose, part of the excavated work must be filled in again: this is a loss of time, but it is more than compensated for by security and general expedition of the sap. In fig. 80, the sappers have to wheel the great unwieldy sap-rollers in working round a solid die of earth in order to form a traverse, which is a dangerous process, and so exposes the men that expert riflemen are sure to find fatal openings: but in fig. 76, the sap-rollers move steadily on in one line, and thus keep the men well covered at work. This sap was first proposed by Colonel Jebb, of the Royal Engineers, and has been greatly approved of in the Chatham Engineer Establishment.

Suppose the four sap-rollers of this sap to be thus passed over the parapet of the parallel, the three brigades of sappers then commence their respective work: the right brigade remove gabions 1 and 2, and No. 1 sapper proceeds with his excavation; the others complete the traverse P, assisted by the centre brigade, who have removed gabion 3; and No. 1 sapper of this brigade goes on with his excavation. The left brigade remove gabions 4 and 5, and proceed with their regular work; first clearing away the parapet of the parallel. Sappers of No. 3 and 4 of the right brigade, afterwards fill in the excavation of No. 1 with fascines, from *a* to *b*, to make a good footing for the gabions 1 and 2, which they replace, and complete traverse, P.

The right, centre, and left brigades work steadily and equally in advance: the gabions at 3 are removed, and the sap completed in this part.

Gabions 6, 7, 8, 9, 10, are placed so as to protect the workmen in the branches Q and O: these gabions are removed in due time as the sap proceeds. Similar cover is used in each successive branch N, M, L, K, &c. This is seen at the head of the sap, from the sap-rollers to the second traverse; those

in the rear being completed, have this centre line of gabions removed.

In addition to the three brigades of sappers, a working party from the line is required to clear the branches Q, O, N, &c., and throw the earth over the gabions for the exterior parapet.

Materials required. 28 feet from the centre of one traverse to the centre of the next, giving 28 gabions for the two sides, and for each traverse, 12 gabions.

Fascines. Two rows on each side, or about 6 fascines of 18 feet in length. Fascines for the traverses, about 4 fascines for each. Also fascines for filling in No. 1 sapper's work through the traverses. Four sap-rollers. Two or three dozen of sand-bags.

It may be observed that there is no banquette on the outer side of the traverses, so that an enemy penetrating from the front could not use the traverses as the defenders can from their banquettes.

Were it necessary to blind this sap, as shown in fig. 74, ten or eleven feet bearing between the uprights would suffice to do it.

CHAPTER IV.

MINES. DEFILADING. INUNDATIONS.

66. *Mines.* Charges of gunpowder exploded under an enemy's work are used to destroy it. In many cases it is a very desirable proceeding, when cover can be obtained sufficiently near to permit galleries being driven under the part to be destroyed or breached; and when the nature of the soil is such as to admit of galleries being constructed under ground.

In defending works, small mines placed under the path that an assailant must take in his attack, will do good service, if they can be fired when he is exactly over them; but there is great difficulty in managing this. They are liable to be fired too soon or too late, from haste or from delay. The hose or fuse from the point of firing to the charge takes some seconds to burn; and it may be easily conceived how the time may be miscalculated that an enemy will take (when seen advancing) to be exactly over the required point. It is desirable to have some obstacle requiring a certain time for an enemy to overcome, such as an abattis in a sunken unseen ditch, &c., and the mine under this (as in fig. 84, Plate II.), or a palisading, stockade, trap-holes, &c., so as not to fire the charge until he actually reaches the obstacle, and is occupied in forcing it.

The application of gunpowder in blowing open gateways, stockades, destroying buildings, walls, &c., may be successfully employed in the attack of villages, posts, and field-works: and when there is no time for the construction of

regular shafts and galleries, *large* charges laid against obstacles will succeed in doing mischief.

67. The common mode of proceeding is, to sink a square shaft or well to the necessary depth, and from the bottom of this shaft to drive out a gallery of the length required, so as to lodge a sufficient charge of gunpowder in a chamber at its extremity, which by its explosion will destroy the enemy's work.

Fig. 88, Plate III., is a vertical section of a shaft and gallery: *f d* is the shaft, and *d h* the gallery; *h* is the chamber to receive the charge of powder. This is seen also in plan in fig. 92, where the chamber, *h*, is shown on one side of the gallery, that when the explosion takes place, the force of the elastic fluid shall not be exerted immediately in the line of the gallery. In the plan, the top of the gallery is bared of the earth that would be above it, in order to show the pupil the arrangement of the gallery cases.

Shafts and galleries are lined with cases made of timber to prevent the soil from breaking in, and, when complete, the charge is lodged in the chamber *h;* a powder-hose (formed by sewing a tape, three-quarters of an inch wide together, along its whole length, and filled with fine gunpowder,) is enclosed in a trough, made of two battens of wood hollowed or grooved in their centre. Fig. 90, *a b*, shows this wooden case or trough (or *auget*, as the French call it): fig. 91 is a section of the case showing the hollow for the powder-hose: it is put together as in fig. 90, in pieces, tying it with twine at *c c*, &c. The hose, or train, thus prepared and protected by its wooden trough or case, is conveyed safely from the charge through the gallery and shaft to the point from which it is to be fired: as from *h* to *d* and *f*, fig. 88.

68. There is a substitute for the powder-hose, used in the service on some occasions: it is called *Bickford's patent fuze;* being a very small tube of gunpowder, *served* round with tarred twine, and the whole pitched over: it is pro-

cured in coils like small rope, and keeps very well; it is not injured by damp, and will even burn (when well made) under water. When it can be had, it should be used in preference to the powder-hose when the charges are not deeply buried in the earth: it burns regularly at the rate of 12 feet in 5 minutes: hence the chief objection to it is the time it takes to burn: and a serious objection this is, as in a gallery requiring 24 feet of this fuze, 10 minutes would elapse before the explosion after lighting the hose; whereas the common hose burns very rapidly. Bickford's fuse may be used with advantage in firing bags of gunpowder intended to burst open gates, barriers, stockades, &c.: 2 or 3 feet of it will give time for the man who lights it to escape.

69. In fig. 88, suppose the depth of the shaft, *f d*, to be 14 feet below the ground line, *f*, and that the gallery runs parallel to the surface of the ground: then the distance from the charge, *h*, to the *nearest* surface of the ground, is called *the line of least resistance.* The effect of the charge upon the surrounding ground depends upon the quantity of powder lodged in the chamber, and certain rules are given to guide officers in such cases, so that they may know what quantity of powder to use: the line of least resistance is generally expressed by the letters, L L R.

70. As soon as the charge is lodged in the chamber, the hose trough properly fixed, and the mining cases withdrawn, the chamber is blocked up with earth to a length equal to once and a half the line of least resistance, in order to prevent the effects of the explosion finding vent through the gallery: this blocking up is called *tamping.*

71. When the charge is exploded, the crater or funnel formed thereby depends upon the amount of the charge: if it be sufficient to form a moderate sized crater, having a diameter at top equal to twice the length of the line of least resistance, it is called a *two-lined charge*, and a *two-lined crater:* increased charges will give craters having diameters

equal to three, four, five, and six times the lines of least resistance.

72. A two-lined crater, in common soil, is generally produced by a charge of gunpowder found by cubing the line of least resistance, and dividing by 9 : thus, if the line of least resistance be 12 feet, then $12^3 = 1728 \div 9 = 191$ lbs. nearly.

73. There are two modes of arranging the timber supports for shafts and galleries: the old method is by placing square or rectangular frames at every 3 or 4 feet apart, and by lining the spaces between them with strong planks or *sheeting*. If the soil be loose, these planks are placed close to each other; if stiff, two planks on each side of the gallery or shaft will suffice, although the top of the gallery must always be lined throughout.

74. Another and more approved mode of lining the galleries and shafts, introduced by General Sir Charles Pasley, C.B., Royal Engineers, is by means of a succession of cases, formed and fixed as in fig. 85 and 86. Each case is composed of four pieces of plank, about 2 or 3 inches thick, and 10 or 12 inches wide : the two side pieces have tenons to fit into the mortises, made in the top and bottom pieces. To prevent these pieces of plank from splitting, an iron rivet of $\frac{3}{8}$ inch iron rod is driven through the middle thickness of the wood, at $4\frac{1}{2}$ inches from each end. The lengths of the different pieces of a case depend upon the size of the required shaft and gallery. Fig. 87 shows the different pieces of the case of fig. 86 fitted into each other (the dots are the heads of the iron rods): the thickness of the timber being seen in fig. 87, and the width of it in fig. 86. Let it be supposed in this figure, that the planks of the cases are 10 inches wide and 2 thick; that the shaft *f d*, fig. 88, is 14 feet deep, with an interior capacity of 4 feet square: also, that the gallery, *d h*, is 12 feet in length, and has a clear interior capacity of 5 feet by 3 feet 8 inches. If the soil be

loose in which the shaft is sunk, the cases are placed touching one another; but where it is stiff, they may be placed at intervals, as *a a a*. The same rule is extended to the gallery, except that the top space between cases at intervals must be boarded: as seen at *c c*, in figs. 88 and 92.

75. *To sink a shaft.* See figs. 85, 88, 92. This is a square shaft: each of the four pieces are 4′ 4″ long: the mortises and tenons are each 2″; hence there is a clear interior space of 4 feet when the pieces are fitted into each other. Let the planks be 10 inches wide and 2 inches thick.

To sink the shaft: excavate to the extent of the exterior size of the frame, and to a depth of 10 inches (or its breadth), and place the first case in it. In placing the second case under the first, excavate to the extent of the interior size of the case, and 10 inches in depth (but deeper in the middle of the shaft for the convenience of the man at work); then cut out a space equal to the thickness of one of the pieces having mortises, and fix it in its place; do the same with the other short mortised piece exactly opposite to the first, at the required distance of 4 feet; then prepare the place for a tenoned piece, in fixing which it becomes necessary to cut away an additional slope of earth at one end so as to push the end of the tenon beyond its proper position, and then to draw it back in order to get both tenons into the mortises. Thus a few inches of earth is cut away from one end beyond what is actually occupied by the case; and each side is thus adjusted.

Each successive case is thus fixed by separate pieces; case under case, until the required depth be obtained. In fig. 88 the soil at *a a a*, being firm, the cases are placed only at intervals of about every 2 feet.

76. *To drive a gallery with General Sir Charles Pasley's cases.* (See fig. 88.) When the shaft is completed, a frame composed of 4 pieces, like a door frame (fig. 89), is set up on that side of the shaft from whence the gallery is to be

commenced, having its sill sunk below the level of the floor of the proposed gallery. This frame is taken down the shaft in pieces, and put together so as just to fit in between the sides of the shaft: its height in the clear must give good space for the gallery.

The undermost end or side pieces of all the lowest cases must be removed from that side of the shaft against which this frame is set up, until the earth is laid bare to admit of the excavation for the proposed gallery. In this operation, the lowest piece of all must be first removed, then the next above it; the others may be taken away after the frame is fixed. This frame is to prevent the sides of the shaft collapsing after the pieces have been removed for driving the gallery. In fig. 88, *d*, there is a side view of the frame. The top and ground sills are shaded: in fig. 92, this frame is seen projecting a little into the plan of the shaft.

The work of the gallery now proceeds by excavating the quantity of earth required for each case in succession.

Suppose the gallery to be 5′ high by 3′ 8″ wide in the clear: the pieces of the cases are prepared exactly, as are those of the shaft (fig 86), and supposing them to be turned into each other, the mortises fitted into the tenons, fig. 87 would represent the front elevation of one of these cases.

To drive the gallery, *b*, *c*, figs. 88 and 92, the cases are set up in succession as the excavation proceeds, so that there is never more than 10 or 12 inches of unsupported earth opened at a time: the mortised pieces form the ground and cap sills; the tenoned pieces, the sides or stanchions. A little management is required in adjusting the cap or top sill on the stanchions; the mortise of one end of the cap must first be fitted to the tenon of the stanchion; after which it becomes necessary either to raise the other end of the cap, or to push out the end of the stanchion about two inches beyond its proper position, so as to fit

the tenon into the mortise: a little wedging behind the vacant part left after the fitting is desirable.

In using large cases, a pair of temporary props or crutches become necessary to support the cap while the case is under adjustment; it is best to lay the ground sill first, then the cap supported by the props (raised a couple of inches beyond its final position), and lastly the stanchions.

Thus the fixing of the cases proceeds safely and rapidly when the soil is sufficiently stiff for the purpose; and in almost every instance this arrangement will answer.

77. The cases are useful for a great variety of purposes, and are extremely handy: the gallery of descent into the ditch, indicated at *d f*, fig. 59, Plate II., and communicating with the covered caponier in figs. 81 and 83; also the reverse gallery in figs. 82 and 84, may all be made of these cases, the plank being more or less thick according to circumstances.

78. Shafts are chiefly used for hasty explosions; when it becomes necessary to lodge a charge at a given depth; to lead a hose from it; to tamp the shaft, and to explode the charge, for the purpose of creating a great crater and throwing down some obstacle, or crushing in some gallery within the sphere of the action of the gunpowder.

To drive a gallery from the bottom of the shaft, as seen in fig. 88, involves some danger to the miners at work, who cannot, in case of accident, or in the case of an enemy getting to the top of the shaft and throwing down shells, smoke-balls, &c., escape easily: whereas in a gallery driven obliquely, as in fig. 93, the miners can get out more readily than they can by the rope ladders of a shaft.

Shafts constructed for hasty explosions very rarely need to be lined with cases; and, if made circular, the soil stands better than when square or rectangular.

79. Figs. 93 and 94 show the section and plan of an oblique or descending gallery: the dimensions here given,

viz. 7′ wide by 6′ 6″ high, are those of great galleries sometimes used in important sieges, through which artillery can pass for operations to be carried on within the ditches. The timbers of the mining cases are in this great gallery made of larger dimensions, especially the cap sills, which should be at least 4″ thick, in order to sustain the great weight of earth above them.

These descending galleries (figs 93) have usually a base, A B, about four times greater than their depth, B C. The cases are here shown as perpendicular to the general slope, A C: this gives a smooth regular slope to the bottom of the gallery, as the ground sills are then all in the same line, and the cases are amply strong enough to sustain all the pressure upon them: were the cases made vertical, the bottom of the gallery would be in a succession of little steps; moreover, the required depression of the gallery is more correctly maintained in driving or forming it, when the cases are placed as in fig. 93; for if the three or four first cases be laid exactly in the proper line, the rest are readily adjusted, until a change of direction becomes necessary.

Fig. 94 shows the ground plan of fig. 93: the dotted lines indicate the position of the cases underneath the horizontal plane of the ground. In both these figures it may be seen that there is a long ramp or slope leading into the gallery, as well as sloping sides on each side of the ramp; for the gallery cases cannot be fixed until a sufficient depth is gained, so as to have a few feet of solid earth above the first cap sills (4 feet in fig. 93) in order to steady them.

The dimensions of the large ramp, with its slopes, as shown in these figures, are certainly objectionable: they should, if possible, be diminished, as indicated by the space, *p q r s*, fig. 94, and may be made in steps supported by good boards.

A very steep descending gallery or oblique shaft may be made, if necessary, as indicated by the dotted line, *f h*, fig.

88: the mining cases should be placed perpendicularly to the slope of the gallery.

80. *Ventilating and lighting galleries of mine.* In the field engineer department at Chatham, General Sir Charles Pasley introduced a method of ventilating galleries of any length, by forcing air from a pair of bellows, made of a cylinder of pliable leather, into a long pipe which is conveyed to the head of the gallery: the bellows is about a foot in diameter and a foot in depth, having a circular wooden top and bottom: the air enters by a valve in the wooden bottom, and is forced into a pipe attached to one side: to this pipe, others of leather, and from three to five feet in length, can be fixed on successively, having tin tubes at each end to fit tightly into each other: these pipes are about an inch and a half in diameter; and, being always led to the head of the gallery, fresh air is pumped in continually from the bellows, which is worked at the entrance of the gallery or shaft.

All mines require ventilation and light when in progress. Experience has shown that candles will not burn in small and confined galleries from the want of air, as it becomes exhausted by the miners breathing, unless it is supplied by artificial means.

As regards light, mirrors may be advantageously used in the day time to reflect a gleam of sunshine from the top of a shaft to a mirror at the bottom, which last again reflects it down the entire length of the gallery. But as mining work progresses by night as well as by day, and should be independent also of the state of the weather, candles are frequently necessary; and both with a view to their burning brightly and to the health and comfort of the miners, fresh air requires to be forced into the gallery: this, indeed, is so indispensable that no galleries could be extended without it, and the common double hand-bellows, used by smiths in India, have been found preferable in India to all other con-

trivances; because one man seated between two of these bellows on the ground, suffices to keep the gallery well ventilated, whilst hidden from observation. A bellows of this kind is always procurable in India from the native artificers accompanying the siege train; or it may be formed for temporary purposes, by taking a raw sheep's hide tied at the four feet, with two pieces of flat sticks secured along the opposite edges of the longitudinal cut along the belly, leaving the neck to be made fast to the tube or hose that conveys the air to the gallery. Two of such bellows should be simultaneously used, to be worked alternately by each hand. The leather skin should open as the hand is lifted up, and, as pressed down again, the hand should close it. In this simple way an abundant supply of pure air is constantly supplied to the very extremity of the gallery; care of course being taken that the hose or tube which conveys it be not trodden on or crushed; for which purpose it should be protected with casing along the corner of the shaft or gallery. If tin tubes are procurable, in lengths, they form excellent air tubes, and they should be added to extend the ventilation as the gallery advances.

It is proper to commence ventilation by bellows, when a gallery has attained the length of 50 feet; for although at that distance the lives of the miners are not exposed to any risk from foul air, yet the atmosphere, so far from the mouth of the gallery, is very impure.

There should be as few lights as possible in a mine, in order to avoid consuming the pure air; and, when practicable, they should be placed above the level of the heads of the men.

One candle should be at the head of the gallery, and the next at least 50 feet in rear of it, when the gallery is straight and of that length; and when the gallery is not straight, a light is required at every second angle or turn, placed so as to light both ways.

81. Most rigid rules are required to regulate the loading

of mines. It should be conducted entirely by the officer on duty. The size of the chamber, the dimensions of the powder-box, the length of hose, the quantity of powder necessary to fill it, the length of the casing-tube, the quantity of portfire and slow-match, the safety lantern, &c., should all receive his full attention. Too much care cannot be exercised in every detail. The powder-hose must be made of the best materials, most firmly stitched, so as not to allow any powder to escape, either in conveying it to the mine, or in laying it; otherwise the most fearful accidents may happen. Again, in placing the powder in the hose, the utmost care is necessary to fill it properly, so that, on the one hand, it shall not be made to contain so much powder as to render it liable to burst; or, on the other, that however handled and laid, there may be no part of the tube without its due proportion of powder.

All the persons employed in the loading to be without shoes, or they should have worsted shoes or stockings on; the lights to be all removed, and all the men ordered out of the gallery except those employed in loading.

The greatest attention is necessary to secure the end of the hose or fuze within the box or bag. If a box be used, the end of the hose should be passed though a hole on the top of the box, and a wooden skewer run through it, to prevent its being drawn out accidentally; the end of the hose should be sewed up to prevent its wasting powder. If the charge be conveyed in a truck, it should have copper fastenings; wooden wheels with copper rims. The non-commissioned officer of the mine should advance with the charge, followed by the officer, at a distance of 20 feet, carrying a strong reflecting lamp: on reaching the chamber the officer hands the lamp to his assistant, and proceeds to direct the placing of the charge and the laying of the hose: the latter must be secured in a casing-tube, the lid of which is pegged down, and immediately afterwards covered over

with 6 inches of mould: in doing this a copper shovel should be used.

82. In order to obtain materials for tamping the mines, branches may be driven right and left of the main gallery, and the earth required wheeled forward.

In tamping, half-dried mud bricks have been used: a very small gallery of this kind, of 25 feet in length, occupied 2 hours and 48 minutes in tamping. Two or three feet an hour is the full extent that can be performed in a common gallery when the earth is well rammed.

Should sand-bags be used in tamping, half-bushel bags are more handy and convenient than the ordinary bushel sand-bags.

The mode of arranging the working parties in mining operations at Chatham is very judicious. The parties work in three reliefs, beginning at 6 A.M. and leaving off at midnight; each party working 6 hours. The officers exchanged duties in each relief 2 hours before the men, thus keeping up the chain of information.

83. The voltaic battery is now so well understood, and has been so successfully used in exploding charges of gunpowder, both under water and under ground, that there can be no doubt of its being the best method of discharging mines, as it gives the means of making the explosion at the exact moment required.

84. In that most excellent work (Jones's Sieges in Spain) Sir John Jones says, that at the siege of Burgos, the inexperienced miners there were 108 hours piercing through 60 feet: practised miners would have done it in 72 hours, which would give 20 feet in 24 hours; but at page 314, of the first volume of his Sieges, in detailing this operation, he says, the gallery was 3 feet wide by 4 feet high, "*the soil stiff and standing well without support.*" Hence expert miners cannot work at the rate of more than from 14 to 18 feet in 24 hours, where the soil requires cases to sustain it.

At the siege of St. Sebastian in 1813, Sir John Jones details some of the mining operations, thus: "The soil being a loose sand, the whole of the interior was obliged to be sustained by framework; the frames were placed *two feet* asunder. Three days were passed before the miners (uninstructed men procured from the regiments of the line,) could acquire any degree of expertness in driving the gallery; but after that period they penetrated and completed 16 feet in 24 hours with ease, even when the gallery had extended to a length of eighty feet.

85. In the defence of field-works, small mines, called fougasses, are recommended. Mines are so called when placed at the bottom of small shafts from 9 to 12 feet deep. The powder is lodged in one of the sides of the shaft, and it is fired from a secure spot by means of a powder-hose or fuze brought up one side of the shaft.

86. *Defilading* is the proper arrangement of works, in order to parry the effects of commanding ground.

In field fortification, the limits for defilading are regulated by the range of musketry; that is, the horizontal limit is about 300 yards, and the vertical height above the top of the commanding hill, is about 8 feet; for 8 feet is considered the height of the crest of a parapet, over which the assailants fire.

A work defiladed from musketry will also be defiladed from artillery, if the parapets, &c., be made sufficiently thick.

In an enclosed work, the interior place is limited by the projection of the crests. Open works are generally defiladed to a distance of twenty yards in rear of their gorges.

In no case should the interior slopes of the parapets be discoverable from without; whence arises the necessity of traverses to protect the defenders from enfilade, slant, or reverse fire: when intended for the latter purpose, they are called *parados*.

To defilade from musketry. See fig. 95, Plate III. Let C represent the angle of a lunette which has to be defiladed

from the hill H, at 300 yards' distance; H being the summit of a pole 8 feet high, placed on the top of the hill: this would be the height of an ordinary parapet, should an enemy raise one on the surface of the hill, H. Upright poles are placed at all the angles of the lunette, and a line *m*, *n*, is tightly stretched between the poles marking the gorge of the work; then, at the distance in the rear at which it is wished to be covered, a straight edge or rod, *a b*, is fixed 8 feet above the ground; let the eye pass along this line, *a b*, and move *m n*, until the visual ray cuts the top of the pole, H, and at the same time intersects the poles at the shoulder angles, and at flanked angle, C, of the lunette: the points at which the visual rays cut these poles will fix the heights of the parapets, and lines connecting these parts of the poles together will give the crests of the faces and flanks. A plane parallel to the visual ray, B H, would be the plane of site (8 feet below the defilading plane) and tangential to the brow of the hill from the gorge lines of the ground. Should this arrangement give a greater elevation to any part of the parapets than 12 feet, it is desirable either to lower the parapet at the gorge from 8 to 6 feet, or to excavate the whole or part of the interior of the lunette, and thereby obtain cover for the troops. The labour of forming parapets more than 12 feet high is so great that it should, if possible, be avoided. If the distance, *a b*, to the rear be considerable, where it is desirable to be covered from a fire from the hill, it would probably be a saving of labour and time to form a traverse straight across the gorge, or even on the rear of it, which would allow a considerable diminution of the height of the parapets of the lunettes.

This arrangement, it will be observed, places the defiladed parapet precisely in the same position, with reference to the hill, that ordinary parapets are in when situated on level ground; the plane of site being a tangent to the ground; the defilading plane 8 feet above and parallel to the plane of site.

With the aid of a plane-table, the plane of site can be accurately and rapidly determined. Suppose the upper surface to be directed to the points of command, the intersections of that surface prolonged, with the poles planted at the angles, fix the heights of the plane of site.

If it were required to be defiladed from two or more heights, then the plane of site being at once tangent to two points of the surrounding ground, could not be made to pass through a given *line* at the gorge, as in the foregoing articles, but only through a *point* of that gorge: for example, a point near the centre of it; which point must be raised 8 feet above the plane of site.

Let H and N, fig. 95, be two heights, A F the gorge of a work to be defiladed. In the centre of the gorge of the work, or at the point most distant from the heights, plant a pole, standing 8 feet out of the ground. Before it place two others, A and F, and cause a straight edge or tightened cord to be moved up and down on them, until, when seen from the end of the 8-feet pole, it appears to touch at the same time both the points, H and N (the latter being poles each 8 feet high on the summit of the hills): this will be the defilading plane, and the parapets must be raised to meet, and even to exceed it by a foot or two.

It often happens that a single plane of defilade would give too great a relief; the left part of the work must then be defiladed from the height, H, and the right part from the height, N: and as this would expose the faces to be seen in reverse, it becomes necessary to construct a traverse of a height and thickness sufficient to screen the troops when on the banquettes from slant or reverse fire: the traverse is usually made on, or nearly on, the capital; it should not be less than 6 feet thick at top; and, unless reveted, its slopes should be at 45°.

A triangle, constructed of smooth laths (the ends halved into each other, so that the upper and under surfaces may be

parallel), and each side of about a yard in length, is convenient to use to find the plane of site.

If a line at the gorge be given, as *m n*, fig. 95, place one side of the triangle on this line, and move the apex until the surface of the triangle is a tangent to the pole on the commanding ground.

At the pole near the gorge of A F, fig. 95, place one of the angles of the triangle, and let the triangle revolve about that point until its surface is a tangent to the poles or H and N on the hills.

The most simple mode of determining a traverse is to assume the most convenient position for it, and then to give it a sufficient elevation to cover the men placed on the banquettes on each side of it. At the same time, the planes of defilade of the parapets should pass 8 feet (or 6½ feet at least) above the ground towards the centre of the traverse.

The above mode of defilading is only applicable to works that rest their extremities on a river, the opposite side of which is possessed by the defenders; or to ground where an enemy cannot turn the work or get to the rear of it: for if such a work were situated in a plain, and an enemy able to approach from the rear (even if the rear be closed by a common parapet or stockade), yet as the parapet is probably 10 feet high at the salient and 7 at the extremity of the flank, the crest between the 10 and 7 feet points being a connected oblique line, a considerable portion of the inside of the parapets would be seen from the plain in the rear, and the defenders on their banquettes would be exposed to an enfilading and reverse fire.

Therefore, in order to defilade enclosed works as redoubts, it is necessary to protect their interior, not only from the heights around but also from the fire of an enemy approaching from the plains. Fig. 96 shows a bridge covered by a redan with flanks on one side of the river, and two square redoubts on the opposite side; all commanded by a range of

neighbouring hills within the range of artillery and musketry. It is supposed that an enemy might find the means of crossing from the left to the right bank of the river, 70 yards wide, and attack from the plain as well as from the hills: the bridge has, therefore, on the right bank, a little redan, with a traverse, *t*, to protect it from the fire of the hills.

To defilade the works, the following arrangement might be made: a small increase of height at the salient of the great redan A, with interior traverses of the required height within the work, as shown by lines in the redan: one on the capital, spreading out into two, just before the bridge: as well as smaller traverses, *d d*, all intended to protect from the hills on the left bank, as well as from the plain on the right bank of the river.

The redoubts on the right bank of the river must be defiladed from the ground on both sides of the river. The redoubt, *c d*, fig. 96, is shown in section in fig. 97: this section is taken on the diagonal *c d*, of fig. 96: the shaded parts of the fig. 97, represent the elevations of the faces of the redoubt. The two faces of the redoubt forming the angle *d*, fig. 96, have their parapets of the usual height of $7\frac{1}{2}$ feet, as seen in section in fig. 97: they are shielded from the fire of the hills by the traverse that divides the redoubt into two parts perpendicularly to the diagonal, *c d*, fig. 96; which high traverse in the middle of the redoubt, is seen in section, fig. 97, and about 12 feet high: the salient of the redoubt next to the hill *c*, fig. 96, has an elevated or cavalier parapet, called a *bonette*, 12 feet high, to prevent the faces forming the angle *c*, from being enfiladed from the hills: this bonette is seen in section and elevation in fig. 97, about 12 feet high. The two faces forming the angle *c*, fig. 96, have sloping planes of site and defilade, as seen more clearly in fig. 97, so that the line of fire, *f f*, from the hills passing over the bonette may clear the heads of the defenders on these faces. If *d c*, fig. 97, be the original level of the ground, it often becomes de-

sirable and necessary to excavate below the ground line in some parts, in order that the plane of site, or the interior of the redoubt, may run parallel to the crest, and thereby give proper cover to the defenders. The shaded part sloping upwards underneath the traverse, indicates a passage (made with mining cases) in order to communicate between the two sides of the traverse : this passage may be covered by a little traverse in front. The other redoubt on the right of the bridge would be defiladed by some similar process, suited to its position. It will be observed that the faces of these two redoubts are so disposed as to flank the works on the left bank : and that the prolongations of these faces would fall clear of the hills. In tracing field-works near hills, the faces should, if possible, be so directed as to fall clear of the hills, that they may not unnecessarily be exposed to enfilade fire.

If a piece of ground be entirely surrounded by hills, it is impossible to defilade it completely: positions of the kind can only be defended under very peculiar circumstances.

87. *Inundations.* Whenever local circumstances permit the ditches to be filled with water to the depth of five or six feet, this means of defence should not be neglected; as not only the defects of dead angles will be greatly remedied, but the enemy will be forced to employ more than ordinary means to approach the work. If a small river or rivulet passes within musket range of the work, the difficulty of access to the latter may be increased by throwing up some dikes across the course of the river, thereby spreading an inundation over the adjacent ground. These dikes are so placed as to be enfiladed or flanked by the fire of the work; and when time and workmen are not wanting, the most exposed amongst them may be covered or supported by a small redan, to prevent the enemy from arriving at them, and draining off the waters of the inundation. Experience has proved that a good dike should not be higher than 9 or

10 feet: hence from one dike to another, when several are used, the difference of level between them should be only $4\frac{1}{2}$ or 5 feet, in order that the most shallow parts between two dikes shall not be fordable. Therefore, after fixing the place for the first dike, that of the others will depend upon the natural slope of the waters, which must be determined by levelling, or ascertained by information obtained from the neighbouring millers. The level of the second dike will be placed $4\frac{1}{2}$ or 5 feet lower than the first; the third as much lower than the second; and so on with the rest. Hence it follows that this kind of defence is inapplicable to a mountainous country, because the slopes are too great: it is equally so to a country where the bed of the river is not sufficiently confined, and has its borders too far apart; because the dikes in this case, would require too considerable a length, which would entail extraordinary labour in the construction and difficulty in the defence.

It is impossible to fix a limit for the length of the dyke, because its construction depends upon the means at disposal. In some cases, a dike one hundred yards long would be a prodigious undertaking: in other circumstances, the construction of such a dike would be sufficiently practicable. But as neither the profile of a dike, nor the length of its fall for the evacuation or running off of the superfluous water, are dependent upon its length, some details upon the subject may be given. When a dike is not liable to be battered by artillery, a thickness at top of $4\frac{1}{2}$ feet will suffice, supposing the dike to be made, as it most generally is, of earth. The earth may be taken from the lower or ebb side: if it be not sufficiently binding, and let the water filter through it, proper earth must be brought from the neighbouring country wherever it may be found. This will augment the trouble, but it is indispensable for the goodness of the work. The best way to prevent filtration is to line the inside of the dike with clay. When the dike is exposed to cannon, its

summit ought to be proof, that is about 10 feet thick. Its natural slope may be given to the earth on both side of the dike; but for greater perfection, the upper slope, that is, the one on the flood side, should be made the gentlest, by giving its base twice the length of the dike's height; to avoid the shock of the stream, and to diminish its pressure.

If, after constructing the dike with earth, according to the profile above indicated, the waters were allowed to rise above it and flow over the whole of its length, it would not be long before the whole dike must be destroyed, supposing the current were at all rapid. To avoid this inconvenience, a space is left 8 or 10 inches lower than the rest of the dike, and of sufficient breadth to allow a free passage to all the water of the stream. This part, forming a cavity on the top of the dike, and constructed more solidly than the rest, is called *the fall*, or *deservoir*. This fall is constructed with fascines, that is, after building the dike to a certain height, a double revetment of well picketed fascines is commenced; this revetment must not only cover the top of the fall and the ebb side, but must extend underneath, forming a bed to break the fall of the water, and prevent its undermining the foot of the dike. With respect to length, this bed is made to extend a little beyond each extremity of the fall, in order that it may more completely fulfil its object. To give greater solidity to the bed of fascines, the tops of the pickets, which are driven through the mass, may purposely be left a little above ground, and have hurdle-work interwoven round them. The pickets or stakes ought to be $4\frac{1}{2}$ feet long. The same hurdling might be made on the revetment of the fall; but if this should appear too laborious, the extremities of the fascines should at all events be secured by others placed cross-wise, and strongly picketed into the first. The cheeks of the fall are likewise reveted with fascines, which are placed at right angles with those of the top of the fall and picketed to them.

Inundations of the description and extent just mentioned, are rarely within the compass of field operations : to block up the arches of a bridge, so as to cause the water to rise upon the upper side of it and overflow its banks, is a ready and effective way of increasing the obstacles to an enemy's approach.

Let fig. 101, Plate III., represent a fortified village, having a small river covering one side of it, with a bridge across, as seen in this fig.; the stream running in the direction of the arrow : by examining the figure it will be seen that the banks above the river from *m*, *n*, up the stream, are low, while they are steep, rocky, and high from *m*, *n*, down the river. If the arches of the bridge be blocked up so as to allow only a small quantity of water to pass through, the low bank above *m*, *n*, would overflow, and cover the low ground with water, and thus serve to protect in a great measure the side of the village from *m* to *p*.

When any part of the ground round a work is low and marshy, but destitute of such currents of running water as would prevent an inundation to be formed, holes or trenches 5 or 6 feet deep, and as many wide, may be substituted. The holes and trenches will effectually stop the enemy, and he will be obliged to fill them up before he can arrive at the counterscarp which they cover. The above-mentioned breadth will be sufficient to render them impassible for men loaded with arms, ammunition, and knapsacks. The earth excavated must be carefully and evenly strewed about, both to prevent it forming small islands, which would assist the assailants, and because any rise of ground in the vicinity of a field-work may be detrimental, owing to the small relief usually given to the latter. If the localities be such as offer to the enemy the facility of draining the inundation, or sheet of water, the holes and trenches above-mentioned may be multiplied, as they will contain water, and be a serious obstacle even after the draining is effected.

CHAPTER V.

DEFENCE OF VILLAGES, HOUSES, &c., AND REMARKS ON MOUNTAIN RIDGES. BLOCKHOUSES. KEEPS.

88. In defensive warfare, it is often necessary to intrench towns and villages, either for the purpose of securing them from the incursions of small parties, or to serve as points of support for the movements of troops.

If a town or village be commanded on all sides, or even by great elevations on one side, if the houses be of wood and the roofs thatched, so as to be easily set on fire, such a position should be avoided as a place of defence to be intrenched. Neither should a detachment of troops occupy a town or village, the extent of which is beyond their means of defence; unless a part of the village can be easily cut off from the rest.

The first thing to be done is to clear the approaches to the town, by levelling houses, hedges, shrubberies, and whatever may not be of advantage to the defence, or whatever may favour the assailants. Trees and shrubs ought to be cut two feet from the ground, that it may serve to impede the advance of the enemy without masking the fire of the defenders. The hedges and walls that run towards the defence, and that can be raked or enfiladed on both sides, should be left standing, as they will separate the enemy's columns in their advance: but those walls and hedges that run parallel to the outline of the works should be levelled, as they would afford cover to the enemy. All wet ditches in the surrounding fields should be deepened and widened, if time admits of doing so; dry ditches should be filled up, that they may not give cover to an enemy.

The next object is to form or complete the enclosure round the town. For this purpose, advantage is taken of buildings, walls, and fences, applicable to the defence. The openings which remain must be closed by means of palisades, stockades, parapets, and ditches, strengthened by abattis. All streets leading directly out of the town must be barricaded: these barricades ought to be sufficiently thick to resist field artillery, and high enough not to be easily got over: they ought to be flanked by loop-holing the neighbouring houses. Fig. 101, Plate III., is the plan of a fortified village, with references attached to it.

The barricades may be constructed with palisades, or in stockade-work; or else a frame may first be made with uprights and planks, and then it may be filled in with earth or dung.

When pressed for time, such barricades may be formed by filling carts or waggons with earth or dung: the wheels are taken off (fig. 28, Plate I.), and, if trees be at hand, an abattis way be formed in their front. A barricade may also be made by a strong frame-work enclosing bales of wool, cotton, or even fascines, with a banquette in rear and a ditch in front, as in fig. 29, Plate I.

The slight fences and palisades, either of wood or iron, that are found in every village, may be turned into barricades by additional spurs and braces, and by building a wall of sand-bags behind them; always taking care that the loop-holes for the musketry are at least 8 feet from the ground without: planks would probably be required inside, raised high enough to form a banquette. The doors and windows of buildings that are occupied for defence should be blocked up with sand-bags, supported by frames of wood; but such as must be left open for communication, should, if possible, be covered with sheet iron $\frac{1}{4}$ of an inch thick.

Should a building have to be defended that has no projecting wings or porches, it will be necessary to make an

arrangement in order to obtain a flanking defence. This is done by a stockade-work. See figs. 23 and 24, Plate I. The fortified house, H, fig. 101, Plate III., has a good double tambour in front of the door.

If there be any drains or galleries under the town, they must be stopped by gratings or otherwise.

Advantage must be taken of the most salient points to establish flanking defences, whether by loop-holing the houses, constructing tambours, or any other field-works.

If there be artillery, it ought to be disposed so that it will fire upon the enemy in his advance, and protect those parts of the defences which are most liable to assault. It will generally be placed behind salient points of the line of defence, whether consisting of earthen works, tambours, or of old walls. In the latter, embrasures must of course be opened.*

It is proper to cut a ditch in front of the parts where the defence consists of buildings or enclosures; and if there be time or means it is desirable to continue this all round, and to increase the obstacles by palisades and abattis.

If a town be situated near a river or stream, by which any part of it can be covered by inundations, it should never be neglected.

If there should be any old castle, jail, or large substantial building inside of the town, it may be converted into a keep, by blocking up useless openings; by covering entrances or any unflanked portion of the wall with a tambour; by loop-holing the walls, and by surrounding them, if possible, by a ditch with palisades and abattis. K, is the keep in fig. 101.

Villages being generally surrounded by gardens enclosed by live hedges, these hedges may be made use of in forming

* Flat-roofed buildings are sometimes found strong enough to bear light artillery, whence a commanding view of the country may be had; ruined houses with strong walls have been filled up with earth and rubbish, so as to form a solid cavalier battery.

the line of defence. A small ditch may be dug in front of them, or else an abattis must be placed there as an obstacle. See fig. 31, Plate I.

That the communications in the interior may be free, all hedges and enclosures, which may in any way impede the movements of the defenders, must be levelled: thus *t*, *t*, *t*, *t*, (fig. 101, Plate III.) represents a free communication inside of the works, to enable the defenders to carry support rapidly to any point pressed by an enemy.

If there should only be troops sufficient to defend part of the village, then a part only must be intrenched, which must be separated from the rest of it by cuts and barricades.

In tracing the outworks of the village, advantage should be taken of the walls, hedges, and ditches, where they can be useful to the defence.

The hedges and walls preserved may serve as curtains to the principal intrenchments: sometimes they form the only defence, and then care should be taken to preserve those which flank each other. In examining fig. 101, it will be observed that the tracing gives a succession of bastions, or of salient and re-entering angles; some of the original garden-walls and good hedges form the curtains: the parapets of the bastions are of the common kind, or made of good casks, as *c*, forming a strong interior revetment; or of stockades, or barriers, &c., (as seen in figs. 26, 27, 28, 29, 31, Plate I.) The main streets are also barricaded, as *b*, *b*, and the keep, K, commands a considerable portion of the interior, as well as the bridge and the opposite side of the river: the bridge is covered with a double line of works, and flanked by artillery, *m*, *i*, and K, *i*. The enclosure is made complete all round the village. The development of the whole of these works is about 1300 yards: good abattis, *x*, *x*, *x*, cover the salients and parts most in advance.

The following means are to be employed to render hedges and walls serviceable to the defence:—

If the hedge be more than $6\frac{1}{2}$ feet high, cut off the branches to that height, and work in the parts so cut, to strengthen the remainder of the hedge: excavate a ditch in front, without being particular as to its dimensions or regularity of form, and let the earth be thrown over the hedge, or brought in by a gap within it, and laid against it, so as to form a kind of parapet of from 15 to 18 inches thick at the top; and with a portion of the earth a banquette may be made, to enable the defenders to fire over this parapet. See fig. 31, Plate I.

Sometimes there may not be time to make the arrangement above described; then dig a trench in the rear of the hedge, and form the parapet with the excavated earth.

If the hedge be planted on a steep slope, the earth should as in the preceding case, be taken from the rear.

Should the hedge not be $6\frac{1}{2}$ feet high, a small ditch should be made in front, the earth be thrown over the hedge, and a trench be dug in the rear to obtain cover behind the parapet. The earth of this trench, the depth of which must depend on the height of the parapet, may be used to give a greater thickness to that parapet and to make a banquette. Or a trench may be dug in the rear of the hedge, 2 feet deep, and 3 feet wide at the top, and the earth be thrown against the hedge to form a parapet 2 feet high, behind which cover may be obtained by stooping. This trench might easily be excavated in half an hour, and would be of great assistance to light infantry. The hedge thus prepared should not be clipped, in order that the men behind it may be concealed from the view of the enemy, and that it may oppose a greater resistance to the assailants when endeavouring to force it.

A strong hedge thus prepared is an excellent means of defence. A thin hedge is but a very slight obstacle, and should therefore be avoided. Neither should those hedges be occupied which can easily be enfiladed by the enemy's artillery.

A wall 4 feet high may, without any preparation, serve as a parapet; but if it be 6 feet or more, loop-holes should be pierced. See fig. 27, Plate I.

Loop-holes generally are of an irregular form, pierced roughly in the walls with crow-bars, chisels, hammers, &c.; and it rarely happens that there is time to make them in any other manner. They should then be made as small as possible.

To prevent an enemy closing on the loop-holes, a small ditch should be dug on the outside, 3 or 4 feet deep, and the earth be laid against the wall. The depth of this ditch being small, its slopes may be steep. If the wall be more than $4\frac{1}{2}$ feet high, but too low to admit of loop-holes being formed in it, a banquette should be made to enable the defenders to fire over the wall. Instead of making a banquette, the top of the wall may be cut down at intervals to form small embrasures 3 feet apart.

With lofty walls (see fig. 26,) two lines of fire may be obtained by forming a banquette of wood-work (the tread $4\frac{1}{4}$ feet below the crest of the wall), and piercing loop-holes on the level of the ground. The banquette may be planks, supported on trestles, casks, &c., and be ascended by ladders, or stairs, made by the tables, stools, or other furniture of the neighbouring houses. To enable the defenders to fire through the loop-holes, the external opening of which must be very small, pits should be excavated in rear, of about $3\frac{1}{2}$ or 4 feet deep, and 2 feet from the wall. In this case, no ditch must on any account be made in front of the wall, as it would serve for cover to the enemy, and enable him to reap an equal advantage with the defenders from the loop-holes.

Another arrangement consists in constructing over ill-flanked doors, a balcony or a gallery, *à machiacoulis*, entered from a window or opening made in the wall for that purpose, as in fig. 25.

These machiacoulis enable the defenders to throw down shells, grenades, or stones, on the assailants, and thus drive them from the doors, or foot of the wall. The machiacoulis were the principal defence for unflanked walls in ancient fortresses.

The machiacoulis gallery is made to project 4 or 5 feet from the wall, in the clear, and has a musket-proof stockade in front, and at the sides, about 6 feet high: the flooring is supported by brackets without the wall and bolted to the rafters within the wall. This gallery is loop-holed for musketry in front, at the sides, and in the floor.

In common window balconies, two rows of sand-bags placed on their ends (and therefore about 4 feet high) all round the exterior edges of the balcony, will give good cover: holes should be pierced through the floor of the balcony, in order to fire upon the foot of the wall. The glass of the windows should be broken, as the splinters would wound the defenders.

Fig. 32, Plate I., shows the wall of a house in section, with two tiers of loop-holes; a flat-roof from which also a fire may be given, if there be, as here represented, a little parapet wall.

In the defence of a village, the rule already referred to, of one file of men for every running yard of parapet, may serve as a general guide for the parts exposed to an enemy's attack. Such portions of parapet as may be covered by an inundation, or that may have obstacles that make it difficult for an enemy to advance to the attack in column or in good order, may be calculated to require one man to every yard, to every two yards, or to every three yards, according to circumstances; reserves being made at the time of attack, of the greatest number of the defenders that can be withdrawn from the unassailed sides.

Respecting the defence of single buildings, whether they are detached, or whether they form part of the general

outline of the defensive works, it will be sufficient to average one man for every 4 feet for the lower stories ; one man for every 6 feet of the second story; and for higher stories, one man for every 8 feet.

The solid buildings in almost every village in India, such as Pagodas, Mosques, Choultries, or Caravansaries, with their enclosing walls, afford most excellent means of forming very strong redoubts or keeps; and the formidable quickset and aloe hedges which abound in the villages of Asia are natural defences, and require but little art to render them inattackable to troops without artillery.

89. Extract from Captain Brown's able defence of the little fort of Kahun, in Beloochistan, in 1840.

(27th May.)—" Busy in clearing the ground of everything in the shape of trees or shrubs for 200 yards round the fort outside.

(29, 30, and 31.)—" Commenced digging deep trenches along the foot of the walls inside, planting sharp pointed stakes in them : pulled down all houses touching the walls, to prevent the enemy's landing, should they succeed in mounting the walls in overwhelming numbers. This gave them a drop leap of 25 feet on to a body of stakes."

It was an excellent measure thus to prevent any communication from the ramparts by houses, walls, &c., as well as render it difficult, if not impracticable, for an enemy to descend from the ramparts, even after succeeding so far as to get on them. Strong barriers across ramparts (having good gates), at intervals, are also useful: all to be raked from the interior defences.

Defences of the character thus resorted to, with a view to obstruct the assailants' progress, *after the outer works are carried*, require to be strongly flanked or commanded by the defenders from other points; and when thus completely scoured or fired down upon, such portions of the defences may obviously be left without other protection. For supposing

works thus as it were cut off from a ready retreat or support, to have defenders upon them at the moment of assault (except where there may be communications with other parts of the works), such defenders would, if overpowered, be completely sacrificed; and the very knowledge of this alternative would paralyse the energy of all but men driven to desperation. As a general rule, therefore, obstacles of the nature resorted to at Kahun, apply to peculiar positions; where, as in the case of that brave and honourable defence, the garrison is very small and incapable of manning the entire line of enceinte: when it is desirable to limit the points of defence to a few strong positions; cutting off, as it were, intermediate lines by obstructions like those so judiciously resorted to by Captain Brown, and concentrating upon such lines strong commanding fires, both direct and flanking. In such cases, obstacles, viz., ditches or trap-holes, with abattis or stockades, should be resorted to as much as possible exteriorly to the walls to be defended, as well as interiorly in the manner applied at Kahun.

As connected with such defences, it may not be irrelevant to observe, that were a line of mountain ridges required to be defended, it is possible a natural scarp on the interior side might occasionally favour the defence, even where the exterior might be easy of ascent. If the interior natural scarp is of a height precluding a safe descent, viz., beyond 35 feet (a height considered *beyond escalade*, from ordinary ladders breaking if loaded to that height), in this case, such portions of ridge should be cut off and effectually separated from the rest by ditches, &c., with the abovenamed additional obstacles to assault, and supported by flanking fire from each extremity.

A combination of exterior with such like interior defences, would prove the most expeditious, as well as the most effective mode of defending such lines of heights. For supposing the assailants to attempt to force a part of the

position thus cut off and flanked, they would find descent impracticable by wooden ladders, and they would be mown down by a destructive fire, raking the whole approach, as well as crossing and completely scouring the interior of the precipice.

This idea is thrown out with a view to economising the number of defenders of any lengthened line of works, and the principle may be applied to permanent as well as to temporary positions.

90. *Interior keeps, redoubts, blockhouses, &c.* The surest way to support the courage of the defenders, and consequently to increase the strength of a work, is to facilitate their means of retreat in case they should be overcome; and thus to procure for them a place of refuge, in which they may capitulate upon terms the more honourable in proportion as they have defended with gallantry the principal work. This may be accomplished by the construction of an interior redoubt, when the magnitude of the principal work will permit it. In forming such redoubts, care should be taken to dispose them in such manner that there shall not be a single point within the principal work undiscoverable by their fire; and their size must be adapted to the numbers for which they may be required to afford cover. If the principal work be one of a considerable extent, the redoubt may be made with earth, like an ordinary redoubt; but then a command must be given to it over the parapet of the exterior work, in order that the enemy, when standing upon the parapet of the latter, may be unable to see into the redoubt. In the fortified village, fig. 142, Plate IV., K is supposed to be a large substantial masonry building, surrounded by a good wall, *w*, *w*: this is made the keep of the village, and has a ditch separating it from the rest of the work. In the large redoubts in the Duke of Wellington's celebrated lines of Torres Vedras, the interior space was generally divided into several parts by parapets, so that if the

outer parapet was carried, the interior ones could prolong the defence; as seen at *d*, D, *d'*, fig. 58, Plate II. A good interior covered redoubt is called a blockhouse, or casemated redoubt, which we are next to describe.

Blockhouses are a species of retrenchment peculiarly adapted to woody countries: because the materials for their construction are found upon the spot; and as these countries are mostly mountainous, the enemy cannot without much difficulty transport his cannon with him. There is besides in such countries difficulty in finding a site whereon to construct a work of the ordinary uncovered kind, which may not be seen into and commanded by some neighbouring height. The plan of a blockhouse is usually that of a rectangle, eighteen or twenty-four feet wide in the inside: but when it is possible to give it greater dimensions, its plan is that of a cross, so that its fires flank one another mutually. The profile of the blockhouse will vary according as it may be liable to an attack of infantry merely, or of infantry with artillery. In the former case its sides may consist simply of rows of contiguous trunks with loop-holes made in them three feet asunder. In order that the enemy may not be able to set fire to the work, he must be kept off from it by a ditch, the earth of which is piled up against the work as high as the loop-holes, and is moreover employed to cover the roof, and form also a small glacis round the work. The only difference between a redoubt intended to resist artillery, and that which has been just described, is that, instead of a single row of contiguous trunks of trees or piles, the former is constructed of a double row; the interval between them being filled with well-rammed earth as high up as the loop-holes, the whole composing a wall three feet thick. This work being of a more important nature than the preceding one, its inside dimensions should be twenty-four feet, and the tie-beams, owing to their length, must be composed of two pieces scarfed in the

middle, and moreover supported by strong stanchions resting on a ground sill. These may become temporary barracks; the cots will serve as banquettes for firing through the loop-holes.

But this description of the mode of erecting blockhouses, being confined to the usual practice of European service, would be incomplete without some reference to the peculiar construction and employment of similar defences in the forest warfare of North America. By the universal expertness of the back-woodsmen of that country in the use of the axe, works of the kind are constructed with astonishing rapidity, and rendered capable of opposing a formidable resistance. The Americans build their blockhouses, like ordinary log-habitations in their new settlements, of thick horizontal trunks of trees, roughly squared; and several of these works, disposed like bastions at the angles of an area, in such order as to flank each other, and connected by a stockade, or curtain of close palisading of upright trunks of trees, loop-holed for musketry: this is a temporary field-fort of no despicable strength. Even when artillery can be brought against these works, their defenders, protected by interior traverses of earth, suffer little loss; while the blockhouses and stockades, being formed of green timber, do not easily admit of being breached; and may equally—as was proved in one instance, during the war of 1814, on the Canadian frontier,—defy any attempt to set them on fire with red-hot shot. Against mere musketry, or an open assault, it is evident that, if well defended, the nature of such enclosed and flanked buildings can leave a garrison little to fear. The American blockhouses have sometimes an upper story, projecting sufficiently over the lower to afford a plunging fire, through the loop-holed floor, upon the assailants at the foot of the walls.

CHAPTER VI.

ON THE ATTACK OF FIELD WORKS.

ATTACK BY SURPRISE. STORMING PARTIES, &c. ESCALADING LADDERS. REGULAR ATTACK BY OPEN FORCE.

91. THERE are two modes of attacking fortified posts or field-works: 1st, *by surprise;* 2nd, *by open force.* In both cases the assailant must have a thorough knowledge of the localities and defences: this can generally be obtained by spies, deserters, maps, and plans; also from the peasantry, especially such as may have been employed by the defenders as workmen or mechanics: all such information should, however, be taken with caution, and none fully relied upon that has not been confirmed by the personal observation of intelligent officers, or in small detachments of non-commissioned officers. A good telescope is an indispensable aid in obtaining information.

Should an officer charged with the duty of carrying an enemy's fortified post, be induced to attack it at night, his arrangements should be of the plainest and simplest character; for anything that is otherwise, is almost certain of failure from the confusion that darkness brings into all such operations.

92. An attack *by surprise.*—

The strongest and most formidable works have been carried by surprise and boldness, through the negligence and misconduct of the defenders: attempts of this kind will be regulated more by the latter consideration than the strength of the works.

1st. If the enemy has neglected the placing of piquets, videttes, sentinels, outside of his works, and other precautions, indicating a state of carelessness or want of professional intelligence.

2nd. Should it be ascertained that he has neglected interior arrangements for the defence of the works.

3rd. Should his troops be raw, undisciplined, or his officers slovenly, then a surprise may be successful; and with good troops, good arrangements, and a bold execution, it will probably be so.

To carry this service into effect, some such plan as the following must be adopted:—

1. Be perfectly *secret* in your intentions until the moment it becomes necessary to communicate to others what they have to do.

2. Determine whether your troops are to destroy or to hold the work; give orders and make clear arrangements accordingly.

3. Divide your party properly; some for the real attacks, some for false attacks, to be turned into real attacks if the opportunity offers. A party of picked men with axes, sledge-hammers, crow-bars, bags* of powder, of 20, 30, or 50 pounds each, with fuzes prepared, and with gimlets to attach them to barriers, stockades, covered caponiers, &c., or to lay them down against such obtacles. Each party should know *thoroughly* what is its duty and object: and there should be a conventional sign or badge.

Perhaps the best time for assaulting a work is early in the morning, or just before the moon rises; as the previous darkness covers all the preparatory arrangements. If the assault be made at night, it has been recommended to intrust a few

* These bags should be waterproof. A failure has lately occurred in the North of India, in consequence of continued rain and snow having made the powder so damp that a bag attached to the gate would not explode.

steady men with portfires, in order to light them in the event of the assaulting party having to penetrate dark passages. Cold rainy nights are favourable for such operations, as sentinels are apt to seek shelter and to become sleepy; and the noise of the wind and rain also prevents the advance of an assailant being heard.

93. In all assaults, whether by surprise or by open force, it is proper to divide the troops into—

1st. Storming parties.

2nd. Supports.

3rd. Firing parties.

The latter will seek cover as near the work as possible; and, on the appointed signal for the storming parties to advance, this firing party will spread itself out in extended order, to keep down the fire of the defenders; if possible, preventing any man showing his head above the parapet, and firing steadily into the embrasures, to slacken the service of the guns. If the attack be by surprise, the firing party may be small; and as this attempt would be made only in the event of the enemy being quite unprepared, no firing or noise of any kind should take place until the assailants are in the work and upon the enemy.

The assaulting parties must be followed by the supports, as soon as it is supposed that they have overcome the first obstacle: the supports should be ready at hand, not too soon in following; but above all *not too late*.

94. Should escalade be necessary (as it almost always is), as many ladders should be prepared as can possibly be carried and used by the storming parties. When it is considered how slow a process it is to bring up ladders to the counterscarp, in order to descend by them into the ditch, then to cross the ditch and to rear the ladders against the escarp, and to mount them, it is evident that success will, in a great measure, depend upon the number of men that can mount at the same moment; in other words, upon the number of ladders. Fraises

in the counterscarp, as in fig. 14, Plate I., are more troublesome to overcome than on the escarp, as in fig. 13. In one case, during the Peninsular war, the assault of *Fort Picurina, at Badajoz*, the fraises on the escarp served as a step between the ladders and the parapet, and greatly aided the British troops. Again, in the assault and capture of the French works covering the bridge over the Tagus, at Almarez, by the British division under Lord Hill, the 50th Regiment and one wing of the 71st Regiment escaladed the first slope of the ditch of Fort Napoleon at three points, and got upon a broad berm; drew up their ladders after them, and by this means ascended the long steep exterior slope of the parapet. Hence, parapets with berms are the most easy to escalade; and, when on them, the assailants can not only circulate around the work to get in at embrasures, but also, instead of rushing singly upon the defenders from the top of their ladders (as they must, in a bold profile without a berm), they can shelter themselves on a berm until a sufficient number of their comrades have joined them to carry weight and numbers with their assault.

A ladder beyond a certain length becomes unwieldy, and the rearing of it difficult. The distance from the foot of the ladders to the wall should be at least equal to one-fourth of their height. If the distance be greater, the ladders will be easily broken under the weight of the men mounting them; if much less, they will be so erect that the soldiers, as they ascend, must be continually in danger of falling headlong down. Ladders should always be at least one-eighth longer than the height of the wall to reach the top.

The scaling ladders introduced by General Sir Charles Pasley, used at the Engineer Depôt of Instruction at Chatham, are in pieces of 12′ 8″ and 7′ 6″ in length, fitting into each other with strong double iron sockets, and tied by stout ropes. These can be arranged for any length, and quickly adjusted. See figs. 100, *e f*, *g h*. Ladders made of long spars are awkward to carry;

especially if there be narrow sharp turnings in approaching the point of escalade: nor can long sound spars be always procured. It is desirable that ladders should be made of light tough wood: teak wood is too heavy. If a guy-rope be attached to each side of the ladder, they greatly assist in adjusting and fixing the ladder against the wall: the men told off for the guy-ropes should stand close to the wall, within the slope of the ladder: these guy-ropes should be fixed at 5 or 6 feet below the top of the ladder, to prevent their being cut by an enemy from the top of the walls. The total lengths of the ladders should exceed the height to be escaladed by 3 or 4 feet, in order that the men may step easily off the ladders on the parapet or wall. Many failures have occurred from ladders being too short. It is desirable to have a pair of stout lifting bars, 3 or 4 feet long, with hooks, for each ladder. When an escalade is to take place, *be sure* to practise the men intended for the service thoroughly in carrying, in fixing, in ascending, and descending the ladders (descending, for going down a counterscarp; ascending, for getting up an escarp.)

Always use as many ladders as possible: if there be a counterscarp to descend, leave half the ladders there, while the other half are used against the escarp, that no time may be lost. Ascend the ladders together, on as large a front as possible.

When an escalade is opposed by an enemy, take care that a good firing party covers the escalade, with especial directions to fire upon any work that may flank the ladders.

Avoid night attacks, except under peculiar circumstances; the example of gallant men is lost at night, whilst the timidity of some becomes infectious. Make all your arrangements under the cover of darkness, and assault as the day breaks.

The bamboo, which grows so abundantly in India, makes excellent scaling ladders. Those of the largest size, being

3 or 4 inches in diameter, sufficient for lofty escarps, are not always procurable in the required lengths; but two or more such bamboos may be bound together securely, with the step-bars not let into holes, but lashed on, either single or double, at intervals of 9 inches apart. The hollow bamboo being very light and portable (thus strengthened two or threefold,) make very good ladders, without being too heavy to be carried and raised.

It is doubtful whether any ladders could be manageable of a length suitable for an escarp of 35 feet (*i. e.* of about 40 feet of one continued length of ladder), of a strength capable of bearing the weight of a number of men crowding up, as is usual with storming parties: hence 35 feet of revetment has been assumed as beyond escalade height. Cases, however, doubtless, may occur, in which it may be necessary to carry such works by assault; and has not unfrequently been done in India, where, especially in hill forts, the escarp is considerable; and in such cases more particularly should the ladders be strengthened to the utmost consistency *with their being kept portable*, and every additional support in the way of prop-stays and guy-ropes, &c., should be supplied.

95. *Regular attack by open force.* In well flanked and formidable field-works defended by good troops properly commanded, it would be highly imprudent to attempt to carry them by storm; for until the flanking defences are greatly injured, and good openings made by artillery for the assailants to gain an entrance, it would be an unwarrantable waste of life to try to force such posts. (Of course we do not speak here of the assault of strong and fortified positions occupied by armies: such, we know, have been taken, or rendered useless, by the superior strategy of an assailant; but we speak of the minor operations of detached bodies of troops.) To proceed against a well fortified post, the principles of a regular attack must be partially followed.

These principles may be briefly explained by a reference to

Plate IV., fig. 103. A, B, are the bastions, C, the ravelin, to be attacked: a rough trench and parapet (of a section similar to that shown in fig. 1, Plate I.) must be thrown up on the first night of investment, called *the first parallel*, at a distance varying from four to six hundred yards from the place, according to the nature of the ground and other circumstances. This parallel is represented as continuous; but it need not always be so: it may be made in parts. Upon the parts where the prolongations of the crests of the defensive parapets fall, batteries, as I, II, III, IV, &c., are erected, to enfilade and subdue the defensive fire. When this is done, zigzag trenches are pushed on, and fresh parallels, or portions of parallels, are made to contain strong guards; the trenches are still advanced by saps, until they reach the counterscarp of the defensive ditches, where batteries, &c., are made to overwhelm the remaining defences, and make breaches fit to enter; the assaults being given under the protecting fire of those batteries. The principles and details of the attack are more fully described in Chapter X. The above will suffice to show, that works to be attacked must be enveloped, and raked along their faces, by an enfilading fire of shot and shells, in order to break down gun-carriages, lay open traverses, and subdue the enemy's fire, so as to allow the assailant to advance his work near enough to see and to destroy the flanking defences, and make openings or breaches in the works, in order to assault them with success.

In attacking redoubts, entrenched villages, &c., it is seldom necessary to push on a succession of parallels and trenches: it will suffice to silence the defensive artillery and the flanking defences, and then to win the place by a bold and overpowering attack by assault.

96. The attack of permanent works has been referred to, in order to show *the principle* upon which all well flanked formidable works, defended by good troops, should be attacked: namely, the construction of a succession of good

trenches, to contain strong guards to meet sorties and to reply to the musketry fire of the defences; of batteries of artillery, to enfilade and subdue the defensive artillery from a distance, to dismantle the parapets by a fire of shot and shell, and to sweep their terre-pleins; to establish breaching batteries, to make openings, fit to assault; and, finally, to blow in the counterscarp by mines, in order to join the rubbish upon the opposite sides of the ditches, as a path for the assaulting parties.

In most cases, however, these operations may be greatly abridged, although the principles must be adhered to. In nearly all fortified villages or posts, some of the walls or defensive stockades, &c., can be seen from a distance down to their very bottom, and therefore breaches can be made without advancing the batteries within the musketry range of the defences (for gunners suffer greatly from a good steady musketry fire into the embrasures).* Nor would it be necessary, in most cases, to carry forward the trenches or saps close to the walls; and as many walls and barriers are without ditches in front, and are open and seen from a distance, the breaches can be effected at from 400 to 800 yards, and can be reached by the storming parties advancing over the intervening space between the trenches and the breaches; provided this space is not too great, and that the defensive parapets are dismantled, so that the assaulting columns shall not be exposed to a heavy fire in advancing to carry the breaches. Their success depends on the breaches being quite accessible, their reaching them in perfect unbroken order, and their being well led on by able officers.

97. Take fig. 101, Plate III., as an example of an attack against the fortified village described in Chapter V. The figure shows at once that such attack has been expected and

* The breaching batteries at the taking of Barroda, in the early part of this century, suffered severely from this cause : nearly all the artillerymen were killed or wounded.

well provided against. The streets have been closed up with musket-proof parapets: the houses, in flanking positions, loop-holed: lower-doors and windows all built up; every aperture and opening into the village has been closed by parapets constructed of casks, *c*, *c*, *c*, and with ditches, *p*, *p*, *p*, and lines of stockades, *r*, *r*, *r*, and abattis, *x*, *x*, *x*, giving additional strength to the fronts that are most open to attack; the river and inundation covering the other sides. The bridge, it may be inferred, would be mined and ready for explosion after its covering lunettes are forced; and even, independently of this obstacle, so well flanked is the tête-de-pont by 4 pieces of artillery, that to carry the bridge might be expected to involve a heavy loss to the assailants, even if successful.

Suppose then that the possession of this village is considered necessary by a field detachment, limited to light troops, with one field battery of foot artillery, as at present armed with five 9-pounder brass guns, and one 24-pounder howitzer, and with an ample supply of reserve ammunition. The key to the whole position it will be seen, is the keep, K; and the readiest point from which to assail it appears to be along the left bank of the river, which accordingly is selected for the attack.

The field battery is opened at B, at 350 or 400 yards' distance; *i. e.*, beyond the effective range of musketry from the village, to lay open the flanked angle and destroy the flanking defences of the temporary bastion or redoubt, *c*; under cover of which fire, a running sap is thrown up by the troops, with a musketry-proof parapet only, D, D, and with a return capable of being converted into a field-piece battery, E, to which position the guns should be advanced during the night. The stockade, *r*, *r*, *r*, being breached, and the lower portion of the outer wall of the keep, *e*, *e*, well laid open to view, the artillery are then advanced to the battery, E, and a concentrated fire by salvos directed to the spot. Supposing

the wall to be of sun-burnt brick or mud, the usual kind found in Indian ghurries or village keeps, such as it is difficult to make an impression upon by round-shot alone, shells filled with gunpowder should be used, so soon as any impression could be made by their penetration. A few rounds would suffice to lay open the inner keep, against which the combined fire of the whole battery should be directed, and kept up until promising to be soon effectively breached: when, leaving four 9-pounders to complete the breach, the remaining two pieces, viz., one 9-pounder and one 24-pound howitzer, should then be removed to F, to scour the flanking defences by an enfilading fire during the advance of the assaulting column, A, which debouches from the protected line, D D, preceded by scaling ladders and pioneers, to make sure work of the breach, to overcome any unforseen obstacles, and covered in the advance by light infantry skirmishers, *s*, *s*.

The above presupposes that the defenders' guns in position have not been removed to support the defence of the keep, and that this post once carried decides the fate of the place. Should, however, the possession of the village be still further disputed, a lodgment must be effected in the keep, and a flying sap, *g*, *h*, should connect it with the breach; and from the keep the artillery would speedily subdue the rest of the defences.

This mode of attack would be preferable to a division of the artillery into small and comparatively ineffective batteries; and the use of shells, in the way proposed at such short ranges, is strongly recommended. From their lightness, they, of course, have not momentum sufficient to penetrate, at long ranges, into very hard and tenacious walls; but at close quarters their explosive effect in shattering a wall is hardly to be conceived; and in completing a breach they prove a formidable obstruction to any attempts to retrench the breach, from the incessant shower of splinters from the shells.

The reasons for selecting this particular point for attack are, that the river covers the left flank of the assaulting

columns; the stockades, *r*, *r*, *r*, on this side, are more easily breached than parapets; the concentrated fire of the guns will have silenced all opposition from the flanking defences that would fire upon the approaching columns, and cover their advance. It is presupposed that the keep, K, is the commanding position and key to the other defences; and it is therefore obviously desirable to concentrate all the available means and resources of the assailants, to its reduction, without throwing away fire unnecessarily on the other portions of the enceinte. The three breaches, *e*, *e'*, *e''*, are conveniently near each other; and, if requisite, the flying sap and trench, *g*, *h*, would effectually protect it from surprise after securing its possession.

Behind the trench, D, parallel to the river, the assaulting column, A, is formed, with its support, Z. The smaller false attacks have their firing parties in the two other fronts of the village, *s*, *s a*, *s a*.

98. Light troops should be accustomed to place themselves quickly under cover. On service they soon learn to take advantage of heaps of rubbish, stumps of trees, hollows, &c.; but, in the neighbourhood of a fortress, the ground around which is previously levelled, so as to afford no cover for an assailant, they must be taught to dig pits so as to lodge themselves as near as possible to the ramparts. Fig. 21, Plate I., is a plan: fig. 20 is a section taken longitudinally; and fig. 22 is a section taken transversely across the plan, of a pit, which light troops should be expert in making, and having good loop-holes of sand-bags, as seen in these figures. Finished dimensions of this kind, however, cannot be always attended to: the object is to get cover, and each man digs a hole for himself as rapidly as possible. Good light troops thus lodged around an attacked work, have a great effect in subduing the defensive artillery, by firing steadily into the embrasures.*

* "My turn of duty did not arrive until eight o'clock in the

99. If there should not be any artillery to destroy the flanking defences, such as caponiers, reverse galleries, &c., a bold attempt must be made by night to hang bags of powder against them, with long powder-hoses, or Bickford fuzes, in order to ruin them by the explosion. This can be done by active officers or non-commissioned officers approaching silently and in darkness, so as to place the charge against the object to be destroyed, or as near it as possible. In bold attacks by daylight, a pole may be fixed on the axletree of a light limber carriage, carrying a bag of powder at its extremity, manageable by a rope, which carriage can be run up to the counterscarp (having a shield of bags of hay or cotton), and the charge dropped upon the required part, and fired by a lock or by a hose.

Should there be an abattis, if possible get round its flank; if not, set it on fire with pitched fascines and howitzer shells, or haul portions of it away by night.

Trap-holes and small ditches must be filled in by bags of hay, bundles of fascines, light bales of cotton, &c.

Stockades, barriers, palisades, fraises, chevaux-de-frise, to be destroyed by an enfilading fire of howitzer shells; or in closing with them, by bags of powder.

To ensure success in all these matters, sufficient means, perfect arrangement, thorough explanation, boldness, and rapidity of execution, are indispensable.

evening, when I was ordered to take 30 men with shovels to dig holes for ourselves as near as possible to the wall, for the delectable amusement of firing at the embrasures for the remainder of the night. The enemy threw frequent fire-balls among us, to see where we were; but as we always lay snug until their blaze was extinguished, they were not much the wiser; except by finding, from having some one popt off from their guns every instant, that they had got some neighbours whom they would have been glad to get rid of." (*Siege of Ciudad Rodrigo.*) "*Adventures in the Rifle Brigade*," *by Captain Kincaid.*

Captain Kincaid also relates the effect of the same proceeding at the siege of Badajoz; which forced the French to close the necks of their embrasures with sand-bags.

APPENDIX TO FIELD FORTIFICATION.

A

[Referred to at page 25, Article 32.]

In square redoubts, or works having salient angles, it is to be observed that, if the areas of the sections of the parapet and ditch are made nearly equal, there will be too much earth; this is easily understood by referring to figs. 10 and 11, Plate I.: let the area of the profile of the parapet *a*, fig. 10, be 45·5, and of the ditch 40 square feet: let *a*, fig. 10, be the centre of gravity of the mass of the parapet and banquette: *b* the centre of gravity of the excavation. The solid contents of the portions shown in plan, in fig. 11, will be equal to the areas of these two sections multiplied into the distance traversed by their respective centres of gravity. Now, that of the parapet, a', a', a', is equal to $29\frac{1}{2}$ feet, and that of the ditch, b' b' b', is 44 feet; hence 45·5 feet $\times$ $29\frac{1}{2}$ feet $=1342$ cubic feet for the parapet: and $40\times44=1760$ cubic feet for the ditch: that is, the ditch gives 418 cubic feet more than is required for the parapet. Were the angle in fig. 11 a re-entering one, instead of a salient, the result would be reversed; and an officer charged with the construction of a work must calculate, before he begins his excavation, what should be its amount, in order that he may have neither too much nor too little earth for his parapet.

In the figures under consideration, we assume 8 feet as the depth of the ditch; what then should be the width, in

order to furnish the necessary quantity of earth required for the remblai? If 1342 cubic feet, the quantity needed, be divided by 44, the length of the path of the centre of gravity of the ditch, it will give 30·5 square feet as the proper area of the section of the ditch capable of yielding the necessary remblai: this section in fig. 10 is a triangle, and as the area of a triangle is equal to the base multiplied by half the perpendicular height, therefore $30{\cdot}5 \div 4 = 7{\cdot}62$ feet the breadth for the top. (This however is not exactly correct, for by narrowing the ditch at the top, the centre of gravity b' b' b', is brought in towards the parapet, and the line of its path is not quite 44 feet.) Should the figure of the ditch be of the usual form (as in fig. 8.) instead of a triangle, the mean breadth is found by dividing by the depth: the width at top and bottom being regulated according to the nature of the slopes. In calculations of this kind the depth is assumed, as it is nearly always most convenient to do so, leaving the width as the unknown quantity to be found by calculation.

The following process will serve to guide an officer in the construction of ordinary field-works, and will be easily understood by those who have a very moderate knowledge of mathematics. It is only an approximation; sufficiently correct, however, for common practical purposes: the reader is referred to treatises on mathematics for precise and perfect methods of determining the exact amount of excavations for constructions of this kind.

Whatever may be the form or tracing of a field-work, or any mass of regular dimensions, such as the usual parapets, the solid content is found by multiplying the area of the uniform section by the extent of the path of the centre of gravity. It matters not how many salient or re-entering angles or curves there may be in the tracing: this rule always holds good; that is, if the area of the section in fig. 62, Plate II., amounts to 103 square feet, the dotted line

G G G, represents the centre of gravity of the parapet; and if it be equal to 345 feet, then 103×345=the number of cubic feet contained in this solid body of parapet.*

Let fig. 61 represent the section of a parapet, ditch, and glacis, to be applied to fig. 62, which serves to cover a bridge, or for any other purpose. The areas of these sections must be calculated first: this is easily done by dividing them into rectangles and triangles: the content of a rectangle is equal to the base multiplied by its height; and of a triangle, the base multiplied by half the height (the areas, therefore, of the parapet and glacis will be those marked above fig. 61, the parapet being 103·5 and the glacis 12·375 square feet).

Now, what is required, is to know what width the ditch should have in order to furnish the required remblai, fixing the depth at 8 feet, and the slopes at a base of one-half the depth. The first process is to find a width for the ditch sufficiently near the truth to allow the plan, fig. 62, to be drawn. For which purpose, add the areas of the parapet and glacis together

$$103{\cdot}5 + 12{\cdot}375 = 115{\cdot}875,$$

which divide by the depth of the ditch,

$$115{\cdot}875 \div 8 = 14{\cdot}484 \text{ feet},$$

which will be the mean width of the ditch, or $z\,y$, fig. 61: then

$$14{\cdot}484 + 4 = 18{\cdot}484 = \text{width at the top; and}$$
$$14{\cdot}484 - 4 = 10{\cdot}484 = \text{width at bottom.}\dagger$$

But in considering fig. 62, we see that there are three salient, and only two re-entering angles, and that the path

* See Cape's Mathematics, vol. ii. "Mechanics," article 100.

† Or let x=the width of the ditch at the bottom in fig. 61

$8\,x + 32\ddagger = 115{\cdot}875.$
$8\,x \ldots\ldots = 83{\cdot}875.$
$x \ldots\ldots = 10{\cdot}484$ ft.

‡ This number 32 is the quantity of square feet contained in the two triangular portions of the ditch in fig. 61.

of the centre of gravity, H, of the ditch, exceeds that of the parapet, G: hence, as an approximation, the above dimensions for the width of the ditch may be diminished, and we may try what 16 feet wide at top and 8 at the bottom will give. Let figs. 61 and 62 be drawn with these dimensions. The centres of gravity of the parapet, ditch, and glacis, must now be respectively found; this may be done mechanically by cutting out a piece of clean deal board, or pasteboard, of equal thickness throughout, into three pieces of the dimensions of these three sections, with any convenient scale (the larger the better); then take one of the sections, say the parapet, hang it freely by any corner on a pin, from which pin suspend also a plumb-line, and mark where this line cuts the board:* then hang up the body by any other point, and where the plumb-line cuts the first line on the board, the intersection is the centre of gravity: this must be done with each piece: let G, in fig. 61, be the centre of gravity of the parapet: let a perpendicular from G meet the horizontal line Q S: let H be the centre of gravity of the ditch; and I in the glacis.

In Cape's Mathematics, vol. ii., article 75, "Mechanics," there is the following rule:—(Noting, however, in the first place, that in a right-angled triangle, a perpendicular let fall from the centre of gravity of the triangle on the base, cuts the base at one-third of its length from the right angle; in rectangles and squares, a similar perpendicular will bisect the base. Now as all the parapets and ditches can be reduced to these figures, there is no difficulty in finding the points required.) To find the centre of gravity of any body or system of bodies. Through Q, fig. 61, draw an horizontal plane, Q S; draw also vertical lines through the centre of gravity of each body, to meet the base, Q S; let the distance of these points be severally *Ql' Qe' Qf' Qd' Qc' Qb' Qa';*

* See Cape's Mathematics, vol. ii. "Mechanics," article 71.

then the distance of the common centre of gravity of all these bodies from Q, will be Q G.=

$$\frac{Ql\times l+Qe'\times e+Qf'\times f+Qd'\times d+Qc'\times c+Qb'\times b+Qa'\times a.}{l+e+f+d+c+d+a}$$

that is

$$\frac{4\times 18+10\frac{1}{2}\times 54+12\times 6{\cdot}75+15{\cdot}5\times 3+15{\cdot}33\times 2{\cdot}25+18\times 12+21{\cdot}66\times 7{\cdot}5}{18+54+6{\cdot}75+3+2{\cdot}25+12+7{\cdot}5}=\frac{1179{\cdot}5}{103{\cdot}5}=11{\cdot}4\text{ft.}$$

the centre of gravity, G, from the point Q.

Again for the glacis, to find the distance of the centre of gravity from the point O, by the same process.

$$\frac{Om'\times m+On'\times n}{m+n}=\frac{1{\cdot}125\times 1+11{\cdot}25\times 6{\cdot}5}{12{\cdot}375}\ or\ \frac{74{\cdot}25}{12{\cdot}375}=6\text{ft}\ or\ OI$$

The figure of the ditch being regular, the centre of gravity must be in the middle line. Thus the paths of the centres of gravity become marked on the plan, fig. 62, by the dotted lines G, H, I: in this case, let them be as follows: $G\ G\ G$=345 feet: $H\ H\ H$=440 feet: $I\ I\ I$=502 feet; then $345\times 103{\cdot}5$ =35707·5 cubic feet in parapet: $502\times 12{\cdot}375$=6212·25 cubic feet in glacis: hence

35707·5
6212·25

Total in parapet and glacis 41919·75 cubic feet.

Area of ditch, $(8\times 8)+(8\times 4)$=96 square feet$\times 440$=42240 cubic feet: that is, 321 cubic feet more than is required for the parapet.

A reduction of rather more than three square feet in the area would make the remblai and deblai balance each other.

The earth thrown up from the ditch will, at first, occupy a greater volume than it did before it was moved; calculated usually at $\frac{1}{15}$ or $\frac{1}{20}$ more bulk than in its compact original state: this increase of volume must be duly considered and calculated upon, in the event of the work being constructed to hold out for a few days or weeks only: but as the excavated earth settles down in a few weeks in a compact state; and as, in the careful construction of good parapets, it is well rammed down as it is thrown up, it would not then be ne-

cessary to reckon on the increased bulk in works intended to stand for months or years.

This simple process, however, requires that the path of the centre of gravity of the parapet, of the ditch, and of the glacis, should be known, which cannot be ascertained until the plan be drawn; hence the approximation first stated becomes necessary.

The foregoing method will answer for general purposes, and in carrying it out it is supposed that the constructor can always calculate on going to the depth that he requires in the ditch, and that the soil is of a tolerably uniform nature; which circumstances, it is well known, do not always hold true in practice; moreover, in planning field-works, which are usually placed on irregular sites, the slopes of the ground must be particularly examined and considered before beginning the excavation, that the interior of the work may be thoroughly drained, and in doing this it may often be necessary to cut away in some places, and to fill in in others, so that there may be earth to spare from the interior, to assist in the construction of the parapets, or otherwise; besides which, deductions may be made for embrasures, and additions for barbettes, traverses, &c.

In low ground, or even in elevated plains, care must be taken, particularly in the rainy season, by exact levelling, that the ditches of the works, the covered caponiers, the reverse galleries, and the posterns, are not below the general level of the water-courses and ponds around. Draining works well, should be particularly attended to.

A labourer can remove one cubic yard, or 27 cubic feet, in one hour in easy soil: and he can keep working at this rate for eight hours.

In the construction of field-works, trenches, and batteries, &c., the workmen are placed at 4 feet, $4\frac{1}{2}$ feet, or 6 feet apart, according to circumstances. At 4 feet, instead of 6 feet from each other, the time gained is not in proportion

to the lessened distance: for the men are then crowded, and cannot use their picks and shovels with ease, and without the danger of injuring each other, more especially at night. Suppose that in excavating a trench, as in fig. 2, Plate I., the men are placed at 6 feet apart, the calculation will be as follows:—the area of the excavation is 43 square feet, which multiplied by 6 feet=258 cubic feet; divide this by 27 cubic feet, it gives rather more than 9 hours for the time of excavating the trench in easy soil. If the soil, however, be difficult, the time may nearly be doubled, especially if the men are untrained. This is the profile usually given to the first approaches and parallels at a siege, which can rarely be finished on the first night. It may be commenced in general about eight o'clock at night, and the working party should be tasked to have at least one half of it excavated by daylight next morning, nor should they be relieved until this is done; for although it is customary in sieges to relieve the working parties every eight hours, this rule should not be acted upon if there be any want of activity in the workmen.*

The trench, according to figure 2, should be completed by the second relief of workmen, that is, by noon on the day after breaking ground, this is as much as can be expected even from good workmen well superintended, when it is remembered that half of it is done at night with interruptions from the enemy's fire: the rough parapet thrown up

* Working parties should not be furnished by details from different regiments; this old system of duty brings officers, non-commissioned officers, and soldiers together who know nothing of each other, and many evils arise. Whereas, with working parties from the same regiment, superintended by officers who know their men, and where there is an *esprit de corps*, good steady work may be expected. The idle hands should be kept on to finish their tasks, while the active men are permitted to return to their tents on completing their work. All duties, such as guard of the trenches, assaults, &c., should be (for the reasons stated) from one or two regiments, not from details and detachments of many regiments.

from this trench being at five or six hundred yards from the place, and of great extent, will be a sufficient screen for the assailants.

But if such a work had to be constructed by trained sappers, in daylight and in easy soil, it could be done with great ease in nine hours.

A change, however, takes place in these calculations when a regular parapet is formed by excavating a ditch in front of it, from which the soil is obtained. In defensive works, this ditch is made as formidable as possible, and its depth is considerably greater than the three-feet trench just spoken of; and the workmen have more labour in throwing up the soil. In the construction of regular field-works in daylight, the men in the ditch may be placed at 4 feet apart. Take an example: fig. 8, the area of the section of the ditch is 84 feet; then $84 \times 4 = 256 \div 27 = 9\frac{1}{2}$ hours: the depth of the ditch being 7 feet, able men can heave up the earth at one throw: and, even in difficult soil, this work may be completed in 18 or 20 hours.

But when the depths of the ditches reach their maximum, as in figs. 9, 14, and 15, scaffolding and stages of men will be required to throw up the earth, when the time required for forming the parapet will be very greatly increased, and when every 4 feet of work will probably require about 1 digger, 2 or 3 shovellers, 1 rammer, 1 builder, and 1 carrier, in all 7 men; and will take from 30 to 40 hours of daylight to complete.

With regard to batteries, especially offensive batteries at a siege, where the ditch is excavated for the purpose of obtaining earth for the parapet, rather than to serve as an obstacle, the depth is only made 4, 5, or 6 feet, from which the earth can conveniently be thrown up: hence the labour and time is less than in massive defensive works, and requires 10 or 12 men per gun: the solid parts of the parapets where there are traverses or mortars, as well as the epaule-

ments and the traverses also, require respectively 6, 20, and 10, additional men for each.

Regularly trained sappers at the Chatham establishment usually excavate, in easy soil, two cubic yards per man per hour ; and in difficult soil, one cubic yard in an hour. But such trained men are seldom to be had in ordinary cases, and it is best to calculate for what can be done by men of the line and common labourers, at the rate of one cubic yard per hour in easy soil, or in two hours in difficult soil.

Suppose the excavation to be equal to that in fig. 5, Plate I., and fig. 44, Plate II., which represent the section and plan of an elevated battery, the guns being at 18 feet asunder: the area of the section of the ditch=126 feet$\times$18 =2268 cubic feet, or 84 cubic yards, and suppose this is sufficient to complete the battery with its traverses and epaulements.

With capable sappers, allowing 4 diggers for every 18 feet, we have 84$\div$4=21 cubic yards per man; then 21$\div$2 cubic yards per hour=10$\frac{1}{2}$ hours, or the time taken in executing the work under *the most favourable circumstances of men and soil.*

But in unfavourable soil, with partially trained men, with interruptions from weather and an enemy's fire, double this time at least must be allowed; and it is as much as can be expected if an elevated battery, under these circumstances, be executed in twenty-four hours of work: very little work can be done during daylight in the first batteries of a siege, while the enemy's fire is still vigorous and unsubdued.

Let us now apply these remarks to a specific case :—

See fig. 98, Plate III. Let the pontoon bridge represented in this figure be 200 yards long (or, in other words, the river 200 yards wide at this place): and let this bridge be protected on the right bank by the works traced as on this figure. The outer line of works to consist of a good trench and parapet, as seen in fig. 2, Plate I.; the inner line to

be formed of a parapet and ditch, as seen in fig. 9, Plate I.; the ground being considered favourable for defensive works of this description. Four field-pieces and 700 men are allotted for the defence and for the construction of these works: the 4 guns and 50 men to be on the left bank; 650 men to construct and occupy the works on the right bank of the river.

Let the area of the section of the trench in fig. 2 be 43 square feet, and the length of the line traversed by the centre of gravity of *a b c*, fig. 98=1620 feet, the quantity of earth to be excavated for this work=1620×43=69,660 cubic feet, or 2580 cubic yards nearly.

Let the area of the section of the parapet of the upper line of works corresponding with the section in fig. 9,=126 square feet, and the path of the centre of gravity of *e d f*, fig. 98 = 780 feet, the quantity of earth to be excavated =780×126=98280 cubic feet: or 3640 cubic yards.

Of the detachment of 650 men for these works, let 50 men be required (as carpenters) to construct strong stockades to shut in all the openings, &c., and let 600 men be available as labourers for excavating, forming the parapets, &c.: let this detachment be divided into three working parties of 200 men each: and to work 6 hours each relief during daylight, which we will suppose to be 12 hours each day. Let 30 men of each relief be put on the outer line to excavate the earth from the trench, and throw it up so as to form a rough parapet about $4\frac{1}{2}$ feet high.

$$\left.\frac{\text{2580 cubic yards}}{\text{30 workmen}}\right\} = 86 \text{ cubic yards per man:}$$

and allowing the soil to be such, that one cubic yard can be excavated and thrown up by each man in one hour, and there being twelve hours of daylight, the period required to complete the trench work will be rather more than seven days.

For the larger or inner line of works there remains 170

workmen in each relief: divide this party into 57 diggers, 57 shovellers and rammers, and 56 builders and carriers: then 3640 cubic yards (the solid contents of *e d f*, fig. 109) divided by 57 diggers=64 cubic yards per man; the shovellers, builders, &c., throwing up the earth and forming the parapet: and if the soil be easy so as to permit each digger to excavate a cubic yard per hour, then 64 hours of daylight will be required, or rather more than 5 days.

While the works are in progress on the right bank, the batteries for the guns, or any light works required on the left bank, will be easily completed by the 50 men told off for these duties.

Hence, with plenty of tools and materials prepared—pick-axes, shovels, wheelbarrows, planks, stockade timber, &c., such works as are here referred to should be completed in 8 or 10 days.

For their defence, let the outer line of trench have a man for every 4 feet; this will require 400 men; while there is a reserve of 250 to man the interior work, into which the larger party of 400 would retire in case of their work being forced: or a smaller detail may be given to the outer line of works, and a larger to the inner, according to circumstances and the judgment of the officer commanding.

The construction of the outer line of works in the form of a trench would only be resorted to in cases where the ground favoured such a profile, as is shown in figs. 18 and 19, where the original slopes of the ground are seen by the dotted lines *d e f* and *a b c;* and where the inner line would have a good command over the outer one: but on level ground, the trench profile would be too weak to offer a good obstacle to a determined enemy; and would in that case require to be made of a good parapet and ditch before it.

When works are hastily thrown up, the vegetable mould, which is generally the best for forming the slopes, is covered by the inferior strata; when these latter are full of small

stones, as is often the case, the earth first excavated should be thrown into the interior of the work, to be afterwards used as a cover for the parapet. If this precaution were not taken, many casualties might occur, from the effect produced by the enemy's shot striking on the stony surface of the parapet.

In selecting the site of a work, rocky situations but slightly covered with earth should be avoided.

From the commencement of the work, attention should be paid to the draining of its interior, which otherwise might soon be overflowed. When the work is open at the gorge, a small trench may be formed at the lowest part of it, and the terre-plein be sloped towards it. In enclosed works, a drain covered with flat stones or wood should be made, to convey the water from the lowest point of the interior into the ditch, taking care to prolong this species of tunnel with planks or other means beyond the base of the escarp, so that the water may not wear away that slope. A couple of planks may be nailed together to form a gutter, which can be let into the escarp slope, and the drain be made to empty itself into the gutter, the bottom of which should rest on a few flat stones or ends of fascines. When practicable, the ditches of field-works should also be drained from partial floods, otherwise the escarp and counterscarp slopes will not stand long, unless they be reveted.

In all cases, work should be given either by task or at a certain sum per cubic yard of excavation, &c.; for men will do much more when tasked than when paid by the day. If peasantry are employed, it is much better and cheaper to pay a high price for measured work than to employ them by the day.

PERMANENT FORTIFICATION.

CHAPTER VII.

DEFINITIONS, &c. NECESSITY OF THICK EARTHERN RAMPARTS AND PARAPETS.

100. PERMANENT FORTIFICATION is the art of shutting in a piece of ground, or a city, of any form whatever, by defensive masses of earth and ditches, in a manner the most advantageous for making the greatest possible resistance, with a garrison proportioned to its size, against the attacks of superior numbers.

101. Every piece of ground to be fortified is supposed to be surrounded by a polygon, either regular or irregular, as the dotted lines, 1, 6, 7, 8, fig. 103, Plate IV., (which shows half of a town enclosed by three sides of a hexagon, or regular six-sided polygon), the lengths of the sides of which (as 1, 6 : 6, 7 : 7, 8 :) are generally regulated by the necessity of the works being mutually within the range of the defensive weapons : this original imaginary enclosure (1, 6, 7, 8, &c.,) is called the *polygon of fortification*. See article 3, page 1.

All the works constructed on one side of the polygon, is termed *a front of fortificatian :* thus, in fig. 103, Plate IV., all the works constructed on the side 1, 6, is a front of fortification. Here the first range of works, 1, 2, 3, 4, 5, 6, is the

enceinte, or *the body of the place*. All the works beyond this enceinte, and within the glacis, are *outworks*, as 9, F, 11, 12.

102. Should the polygon of fortification be quite regular, and all the works on each front correspond with each other, it would be *a regular fortification*.

But should the polygon be irregular, having its sides and angles varying in dimensions, and the works differing on the several fronts, it would be *an irregular fortification*. Irregularity, however, does not imply weakness.

103. The outline or figure of a fortification, is a succession of lines that form different angles with each other, (as 1, 2, 3, 4, 5, 6, &c., fig. 103,) on the good arrangement of which much of the strength of the fortress depends; and as this arrangement may vary almost indefinitely, it follows that there are a great many *methods or systems of fortification*.

104. The succession of lines that show the figure of the fortification, and that indicate the directions in which the defensive masses of earth are laid out, is named the *outline or tracing*; and the general height to which these defensive masses are raised is termed *the relief*. See article 4.

Two things are therefore to be considered in a fortress—the tracing and the relief: the tracing shows the manner in which the works should be laid out to obtain a proper defence; and the relief provides the requisite elevation for the artillery and musketry to ensure this defence.

105. The great mass of earth thrown up from the ditch inwards, in order to give the defenders a commanding surface for their cannon and musketry, is the *rampart* (as *c*, *q*, *y*, *p*, *s*, *f*, *d*, fig. 102, Plate III.); and the covering shot-proof mass of earth on the exterior edge of rampart is the *parapet*, that is, all above the line *p*, *s*, or the part *p*, *o*, *r*, *s*. This parapet is usually $7\frac{1}{2}$ feet high, that it may cover the defenders behind it; and a step of earth is raised at the foot of its interior

slope, sufficiently high to enable the defenders standing on it to fire over the crest of the parapet with ease: this step is the *banquette.*

106. Immediately without the ditches of the place, there is a road of communication all round the fortress, usually 30 feet wide; having on its exterior edge a covering mass of earth 8 feet high, which slopes off gently towards the country: this road is *the covered-way*, and the sloping mass *the glacis.* See fig. 102, Plate III.

107. *Advanced works* are such as are constructed beyond the covered-way and glacis, but within the range of the musketry of the main-works.

Detached works are those which it sometimes becomes necessary to construct beyond the range of the defensive musketry of the main-works; and as a constant and steady communication with them cannot be kept up during a siege, they are consequently left chiefly to their own resources; nevertheless, they ought to exercise a general influence on the defence of the place.

108. In permanent fortification, the sides of ditches are supported by walls of masonry or *revetments*, as in Plate IV., fig. 104: *t p* is a section, and *y* a plan of an escarp masonry revetment. These walls are strengthened interiorly by buttresses, at about 15 or 18 feet apart, called *counterforts (x, x, z, z.)* The side of a ditch next to the place is the *escarp*, and that next to the country is the *counterscarp.*

The top of the revetment is usually covered with a flat stone, to protect the masonry from being injured by rain: this stone projects about a foot beyond the rest of the masonry, and is called *the coping-stone, or cordon.*

In the actual construction of the works, the revetment is first built, and the measurements of the other parts of the works are calculated and laid out from the cordon, which thus becomes a guiding line; and in the tracing is called *the magistral, or master line.*

109. The general level of the ground upon which the works of a fortification are constructed, is called the *plane of site*, whether it be horizontal or oblique to the horizon, as on the general slope of a hill. It usually agrees with the terre-plein of the covered-way. See article 5.

A plan shows the tracing (articles 4 and 7): also the horizontal lengths and breadths of the works, the thickness of the parapets and ramparts, the widths of the ditches, &c. It exhibits the extent, division, and distribution of the works; but the depths of ditches, and heights of the works are not represented in the plan.

A plane of defilade is a plane supposed to pass through the summit or crest of a work, and parallel to the plane of site. See article 6.

If a plane pass through a work in any direction, the cut made by it is a *section:* if the cut be vertical and perpendicular to the face of the work, it is a *profile.* If horizontal at the base of the work, it is a *ground plan.* See article 8.

The elevation of a work shows its geometrical dimensions above the ground, in the direction in which it is viewed. See fig. 102, A, Plate III., for front and rear elevation of embrasures.

110. The explanation of the term relief having been given in its fullest extent, in article 4, it now remains to point out its more limited signification; the total height of any single work from the bottom of the ditch to the summit or crest of the work, is the *relief* of that work: for instance, in fig. 104, Plate IV., the height $p\ r$, is 44 feet, which is the relief of this work.

The *command* of a work is its superior height over the work before it; or, in the case of there being no work before it, its height over the country.

Command is divided into command of fire, and command of observation. In fig. 103, suppose the banquettes of the bastion, D, and the covered-way beyond its ditch, to be both

manned with musketry, and firing together to the foot of the glacis at the space 18, &c.; then, if the crest of the work in its rear, has a sufficient elevation to enable it to carry its fire to the same spot, without any injury to the defenders on the covered-way, clearing the crest of the glacis, the inner work is said to have a *command of fire* over the covered-way and glacis; but if the rear work be only high enough to look into the work before it, without both parties being able thus to carry their fire to the same point, the higher work has only a *command of observation* over the lower one.

111. The following are the names and general dimensions of a rampart and parapet. See fig. 102, Plate III.

The line *c*, *d*, *k*, *e*, is the plane of site: *c*, *q*, *p*, *s*, *f*, is the rampart: all above the line *p*, *s*, the parapet. Let it be supposed (in this fig.) that the relief, *a*, *b*, is 41½ feet; that is, that the depth of the ditch, *d*, *a*, below the level of the ground, is 22 feet; and the height of the rampart and parapet, *d*, *b*, above the ground, is 19½ feet.

c, *q*. *The interior slope of the rampart* has a base, *c v*, equal to its height, *v q*; in this case, *c v*, and *v q*, are each equal to 12 feet: this slope of 45° is the natural slope at which earth of common tenacity will stand; and it is thus formed, that it may remain stable without support or repair.*

q, *p*. *The terre-plein of the rampart.* It has already been shown that the platforms for guns occupy a length of 15 feet, and allowing from 10 to 25 feet (according to circumstances,) in their rear, for the free passage of the artillery and the defenders; the terre-plein will then have a width of from 25 to 40 feet.

* In many fortresses, this slope is cut away, and a perpendicular wall supports the rampart on the inside; this is done in places where the interior space of the fortress is limited, and when it is desirable to give the inhabitants as much room as possible.—See fig. 105, Plate IV., in the section of the curtain.

All terre-pleins have a slight slope or inclination to the rear, to keep them drained from rain-water.

o. *The interior slope of the parapet* has a base of one-fourth of its height; it is supported by a revetment of turf or sods; this steep slope is necessary in order that the guns may be run well out into the embrasures; and also that the musketry on the banquette may lean conveniently against it to fire over the parapet. The total height of the crest of the parapet above the terre-plein is $7\frac{1}{2}$ or 8 feet, that the men in its rear may be sufficiently covered and protected by it.

As guns in battery stand at 18 feet apart, the spaces between their platforms are sometimes occupied by banquettes; *the tread* or *terre-plein of the banquette* is raised to within 4 feet 3 inches of the crest of the parapet, that the defenders may fire along its superior slope with ease; it is from $4\frac{1}{2}$ feet to 5 feet in width, that there may be room upon it for two ranks of men: although more than one is rarely on it at a time: its slope to the rear is made gentle that the defenders may ascend and descend with facility.

r. *The superior slope of the parapet* has a base of 18 feet, that it may be shot-proof; its slope prolonged (the line of fire of its musketry) should cut the opposite counterscarp; this depression is usually at the rate of two inches per foot; a greater dip would weaken the crest by making too sharp an angle of earth, which could be easily beaten down.

s. *The exterior slope of the parapet* should have a natural slope to prevent its being worn away by the action of weather and time; and, as it is exposed to receive the shot of the assailants' guns, it is well to give it even a greater base than its height. In this figure the base cannot be less than 9 feet, where the perpendicular height of the revetment is 30 feet.

The thickness of the rampart is, from the above,

Interior slope, its base	12 feet
Terre-plein of the rampart (including the banquette)	25
Interior slope of the parapet	1½
Superior ditto	18
Exterior ditto	9
Total	65½

Some of these dimensions may in certain cases be reduced or augmented; hence ramparts may be said to average from 60 to 100 feet in thickness.

By the examination of figures 102, and 102 A, it will be seen what parts of the section, fig. 102, correspond with that of the plan, fig. 102 A, as they have the same letters: the pupil must be quite familiar with these. Fig. 102 A, likewise shows a front and rear elevation of the rampart, parapet, and embrasures, shown in the plan. There are three perpendicular *lines of fire*, f' 1, f'' 2, f''' 3, and one oblique line of fire, f'''' 4; the *necks* of the embrasures are 2 feet wide, the *mouths* 9 feet wide; and the slopes of the *cheeks* of ¼ of their height at the neck, and ½ of their height at the mouth: the platforms are 15 feet long, 9 feet wide at the head, or the hurter, and 14 feet wide in the rear, having a rise of 7 inches in the whole length.

In fig. 102, one side or cheek of an embrasure (shaded) is seen in elevation; the depression of the sole of the embrasure depends on the objects to be fired at. The pupil must strictly examine figs. 102 and 102 A, in all their details, and then turn to Plate IV., in order to examine fig. 103, and clearly to comprehend the sections taken on the lines, 16, 17; 17, 18, as seen in fig. 104: and also on the lines $x\ y$, $y\ z$; 13, 14, 15, as seen in fig. 105, so as to be able distinctly to understand the corresponding parts in plan and section.

112. In examining the outlines of a fortress, as fig. 103, Plate IV., it is seen that some angles point outwards towards the country, and others inwards towards the place; the former are *salient,* and the latter are *re-entering angles.*

113. A *bastion* is a work having two faces and two flanks, the angles being all salient; see fig. 103: the angle formed by the meeting of the two faces is the *flanked angle of the bastion;* that formed by the meeting of a face and a flank is *the shoulder angle;* and that formed by the flank and the curtain is *the curtain angle;* that formed by the meeting of the line of defence and the flank, is the *angle of defence.*

In standing in a bastion and looking towards the country, the face and flank on the right hand is called the right face and flank; and on the left hand, the left face and flank.

The mass of rampart and parapet follows the winding of the faces and flanks; leaving, in some cases, an interior space in the centre of the bastion, on the level of the ground: for example, in fig. 103, Plate IV., bastion G and D, all the space within is on the level of the ground: this construction is called a *hollow* or an *empty bastion.* In other cases, as in bastions A and B, the interior space is all filled up to the level of the terre-plein of the rampart; these are *full bastions.*

In a bastion, the distance between the inner extremities of the two flanks, is the *gorge* of the work; the prolongations of the adjoining lines or curtains, are the *demi-gorges.* When the demi-gorges and gorge are in the same line, and the former is half of the latter, the work is called a *flat bastion.*

The line of rampart that joins the flanks of two bastions together, is the *curtain,* as 3, 4, fig. 103.

114. *The ravelin or demi-lune* is a work having two faces, forming a salient angle, placed beyond the main-ditch

opposite to the curtain, and separated from the covered-way by a ditch that runs into the main-ditch, as F, fig. 103.

115. *Places of arms* are enlargements in the covered-way at the re-entering and salient angles of the counterscarp; hence the terms *re-entering places of arms* and *salient places of arms;* the latter space is formed simply by rounding the counterscarp, and the former by setting off demi-gorges of 30 yards, (more or less,) and making the faces form angles of 100° with the adjoining branches of the covered-way.

116. *Traverses* are portions of parapet thrown across the covered-way, on the prolongations of the faces of bastions and ravelins, and at the entrance of the re-entering places of arms; passages are cut into the glacis, to enable the defenders to circulate round the traverses.

117. *The tenaille* is a low work in the main-ditch, before the curtain and between the flanks of the half bastions of a front of fortification; it is usually 16 yards in thickness, and reveted with masonry all round. See fig. 103, 9.

118. *A citadel* is a small strong fort, constructed either within the place, or on the most inaccessible part of its general outline; it is intended as a refuge for the garrison, in which to prolong the defence after the place has fallen, or to hold out for the best terms of capitulation. Citadels are generally in positions that command the interior of the place, and are therefore useful in overawing a population that might otherwise strive to shorten the length of a siege, during which the inhabitants are always great sufferers.

119. *A cunette* is a small ditch in the middle of a dry ditch, in order to keep it drained.

120. *A caponier* is a parapet from $7\frac{1}{2}$ to 10 feet in height, having its superior slope terminating in a small glacis: it is placed in a dry ditch, in order to cover the defenders in passing across the ditch from one work to another, and has a banquette to furnish a fire of musketry upon the ditch (10, 10, fig. 103, Plate IV.)

121. *A batardeau* is a strong wall of masonry built across a ditch to sustain the pressure of the water, when one part is dry and the other wet; to prevent this wall being used as a passage across the ditch, it is built up to an angle at top, and armed with iron spikes; and to render the attempt to cross still more difficult, a tower of masonry is built on it: in the batardeau is the sluice, by the opening or closing of which the manœuvres of the water can be regulated.

The quantity of earth or soil contained in the mass of the rampart and parapet of a work is called the *remblai;* and the quantity excavated from the ditch the *deblai:* and, in general, the number of cubic yards contained in the remblai has been furnished by the deblai; so as to balance each other.

122. *Necessity for fortifying with the present thick earthen ramparts, parapets, &c.* Before the knowledge of gunpowder, which has rendered artillery so tremendous an engine in all kinds of modern warfare, but more especially so in the attack and defence of fortified places, the mode of fortifying was simple, but quite adapted for defence against the implements then in use; which however ingenious and formidable at that time, sink into insignificance when compared with the irresistible missiles now projected from guns and mortars, by the power generated from the explosion of gunpowder.

A thick wall flanked by towers, separated by a ditch from the country, constituted the whole of an ancient fortification.* The towers were within bowshot of each other, and raised one or two stages above their connecting walls,

* This rampart wall had, upon its exterior edge, a thin battlemented or loop-holed parapet, to serve as a cover for the archers, and to permit them to fire through. And in most cases this parapet was projected like a balcony, having loop-holes in its base, to enable the besieged to see and to defend the base of the rampart wall. This balcony was called machiacoulis, and forms the picturesque projection of old towers as seen at this day.

in order to preserve a command over the latter, should an enemy make himself master of them; as well as to obtain a height sufficient to contend with the great moving towers then used in the attack; these flanking towers were sometimes partially separated from the curtain walls by a cut, having a drawbridge: thus they answered as rallying posts and citadels which required to be attacked, even if the walls connecting them were carried; hence the attack was nearly always carried on against a tower in preference to the curtain wall.

To become master of such a place (after having reached the counterscarp or outer edge of the ditch), a portion of the ditch was filled in, and a good causeway made across it, to allow of the battering-rams being brought up to beat down the walls; while showers of stones and arrows were kept up from both sides.

It would be merely to swell the pages of this work to enter upon the details of attacks and defences conducted according to the science and machinery then known: history furnishes us with numerous and splendid instances of defences. Without going back to the siege of Troy, we find Tyre defended by a manufacturing and trading people, braving the power of Alexander for seven months; the great Camillus triumphed at Vieœ, only after a siege of several years; and Syracuse was sustained for two years, by the genius of Archimedes, against every effort of Marcellus. Besides these and other well-known instances, it is only necessary to peruse history from the earliest periods down to the invention of gunpowder to form long tables of extraordinary sieges, which, when contrasted with the brevity of modern ones, abundantly show how greatly superior the powers of the attack have been rendered by the use of modern artillery.

On the introduction of cannon, the shot projected from which can beat down masonry at a distance of many hundred

yards, the old high frowning battlemented walls no longer afforded security, as breaches or openings could be made in them without the necessity of bringing the breaching batteries (as with the battering rams, &c.) close up to the wall; and in the attack the great moving towers, and most of the other contrivances, were of necessity laid aside, as the shot from the defensive batteries could break them to pieces. A total change, therefore, became necessary in the construction of defensive works and in the mode of conducting the attack, in order to suit the new kind of artillery and its wonderful agent, gunpowder. This agent was discovered about the year 1320, although it was not till 1380 that its power was sufficiently ascertained and regulated, to make artillery so formidable as to create a necessity for an entire revolution in the defence and attack of fortified places.

In the advance of the mechanical arts, which have, of late, brought almost to perfection the manufactnre of gunpowder, the casting and boring of guns and mortars, the construction of carriages and implements necessary in the transport and use of artillery, the value of this arm has become proportionably greater, and its influence almost paramount in the branch of warfare of which we are now treating.

Hence the old narrow rampart wall has naturally given place to one of earth of greater breadth and less height: and although it is faced exteriorly with masonry, yet no part of the latter should be seen from the country: for in viewing a well-constructed place from without, the masonry ought to be so well covered, that an observer could see nothing but one shot-proof earthen parapet rising one over another. Hence the assailant is forced to bring his battering guns, by a toilsome and dangerous process, to the counterscarp of the ditch, in order to make a breach or opening in the scarp revetment.

The thin parapet of masonry that sufficed formerly to

cover the archers and slingers, could be immediately cut through by shot projected by gunpowder: and if it were sufficiently thickened to be shot-proof (8 feet), it is very undesirable to make it so; since the splinters detached from masonry walls by shot striking them, are at all times very dangerous, and do much execution amongst those who are near them. A parapet of earth has therefore superseded that of masonry; and as the shot from heavy guns can penetrate from 12 to 15 feet into a bank of earth, the thinnest part of the parapet at top is made 18 feet, and its base occupies from 25 to 30 feet.

123. By being placed behind a massive earthen parapet, the defenders are so far removed from the ditch before them, that it is impossible for them to see or to defend it: as in fig. 104, Plate IV., the superior slope of the parapet, fg, prolonged (the line of their fire) only cuts the top of the opposite counterscarp; such a defect as an undefended ditch, or piece of *dead ground*, must not, if possible, be permitted to exist within range of the defensive weapons, even outside of the place, but assuredly not in the ditches; in which an enemy may either collect in force, or employ his miners to penetrate the rampart and blow it up: it therefore becomes necessary to trace the works so as to obviate this defect.

The only way of doing this is to trace the works, as seen in fig. 103, Plate IV., that is, the bastion tracing 1, 2, 3, 4, 5, and 6: then the musketry placed on the flank 2, 3, can see and defend the bottom of the main-ditch from 10 up by 5 to 6; and that on the flank 4, 5, can see and defend from 10 up by 2 to 1; then the whole ditch is fully seen and defended by a musketry fire; and the ditches of the ravelin are seen and defended by the portions of the faces of the bastions that look into them.

This bastion tracing having been evidently contrived to defend ditches from behind thick parapets, there will be no

necessity to enter here upon what is sometimes called the history of the bastion system, which some engineers date as far back as the beginning of the fifteenth century; because thick ramparts and parapets must have followed immediately on the increased power arising from gunpowder artillery.

CHAPTER VIII.

ON THE PRINCIPLES OF THE TRACING OF VAUBAN'S FIRST SYSTEM; WITH REMARKS.

124. When the situations are considered and examined, in which fortresses are generally constructed, it will be found that the works usually rest upon irregular and unequal ground, or on ground presenting natural obstacles on some sides to the approach of an enemy. Fortresses usually cover commercial marts, dock-yards, harbours, &c., and their defensive properties may be, and generally are, increased from the navigable rivers, islands, marshes, or commanding positions, that are to be met with in such cases. When some sides of a place are inaccessible or very difficult of access, from these, or from other causes, it would be quite needless to present there a succession of fronts of bastions, ravelins, and covered-way; such sides require only to be enclosed by a single rampart with artillery in barbette or embrasure, to command the obstacle or the ground beyond it; while fronts liable to be attacked are protected by an accumulation of works and artificial difficulties: and for these reasons almost every existing fortress is irregular.

125. In examining the works of Vauban, it is found that, in the general outline, he used various lengths for the sides of his polygons of fortification, which have been accordingly classed into *great, mean, and small fortification;* and as some general principles are to be traced through the whole of his works, it will serve to illustrate the subject if

the investigation of his first method* be arranged under the following heads:—

1. The general outline and form of the works.
2. The lengths of the various lines and works.
3. The openings of the different angles of the works.

First. *On the general outline.* From the remarks in article 124, it follows that the assailable fronts of a fortress should be carefully and perfectly constructed, and that those covered by natural obstacles will suffice, if barely enclosed by a single line of works: accordingly, in examining most existing places, this is found to be the case; the general outline presenting some long simple fronts, either crowning heights, or covered by rivers, marshes, &c.: the fronts liable to attack are of a medium length, having a careful tracing and relief, with a regular system of outworks; and where advanced or detached works are thrown out, they are generally found constructed on short or contracted fronts: this has given rise to the classing of the fronts into *great*, *mean*, and *small:* the great fronts average from 370 yards to 500 yards; the mean from 340 yards to 370 yards; and the small from 200 yards to 340 yards. Viewing a fortress as ground enclosed by great, mean, or small fronts, according to circumstances, the general outline is a succession of salient and re-entering angles, affording each other a mutual defence.

126. Second. *The length of the various lines of works.* First, the reasons for fixing the lengths of mean fronts at about 360 yards: refer to fronts 1, 6: 6, 7: 7, 8: fig. 103, Plate IV., where all parts of the enceinte are within mutual range

* It is necessary to remark, that in this investigation the works are supposed to be constructed on a horizontal plain; inequalities of ground either on the site of a fortress or in the neighbourhood, form a separate subject. It is also to be noticed, that although the principles of Vauban's first system are explained, they are also discussed, and the opinions of approved modern engineers of experience on their properties, are given.

of musketry: now the longest range is the line of defence, that is, the line 3, 6, front 1, 6; for the defenders upon the flank, 2, 3, have to defend all the ditch before the face of the next bastion, A, up to 6, and even to the salient place of arms in front of it; therefore this length, 3, 6, ought not to exceed the effective range of the rampart muskets used upon the flank: and this is a long range, for it is 310 yards from 3 to 6. It will soon be seen that the lengths of the faces and flanks of the bastions, as well as of the curtains, are not arbitrary, but become so dependent upon fixed principles, as to force the tracing to be what it is in fig. 103, which brings the line of defence within the range of musketry; and the desired advantage of all parts of the enceinte within mutual musketry range. But if the exterior side 1, 6, were more than 370 yards, the length of the line of defence would exceed the effective range of rampart musketry, and the consequence would be, that the portion of the main-ditch about the flanked angle of the bastion would labour under the disadvantage of being undefended by a musketry fire: it appears, therefore, that the exterior side of the polygon of the mean class is made as long as it can be without sacrificing a mutual musketry defence throughout the enceinte.

127. As the length of the faces of the bastion depends greatly on that of the flank and curtain, it is necessary to show on what principles the lengths of the two latter works are determined: the flank, 2, 3, fig. 103, being armed with musketry and artillery, requires to be long enough to defend the main-ditch by its fire; and, as at the end of a siege it has also to contend with the enemy's counterbattery established on the crest of the glacis opposite to it (at XXVII.), where the assailant has a space equal to the width of the main-ditch at the salient angle (in the case of a dry ditch, it is 30 yards added to that of the covered-way, 10 yards, in all 40 yards), the flank 2, 3, should not be less than 40

yards long; but to give it a preponderance, it has a length of 54 yards, which enables the defenders to place more guns upon it than the enemy can in the only space (XXVII.,) from which he can directly counterbatter them.

128. In the front, 1, 6, fig. 103, the musketry defenders on the flanks, 2, 3, and 4, 5, have to defend the main-ditch, so that the fire from their muskets, depressed over the superior slope of their respective parapets, must meet at the bottom of the main-ditch, upon the perpendicular. Now supposing the superior slope of these parapets to have the usual depression, their prolongation should meet at the bottom of the ditch, near 10, 10; a slight consideration will show that the distance to which these flanks must be removed from each other (and this distance is the length of the curtain) must depend upon their relief. In the system now under discussion, when the relief of the enceinte is 44 feet, the length of the curtain is about 140 yards.

129. The lengths of the flanks, 2, 3, 4, 5, and curtain, 3, 4, being regulated in the manner just described, the remaining part of the lines of defence, 1, 2, and 5, 6, form the faces of bastions; and as these faces carry the most powerful batteries, it is desirable to have them as long as possible, consistent with a proper length of flank and curtain: here (fig. 103) they are about 102 yards each.

130. Thus the lengths of the exterior side, of the line of defence, of the face of the bastion, of the flanks and curtains, in a mean front, are all fixed by the rules just laid down; and a good bold relief of 44 feet with revetments 30 feet high, can be obtained by these arrangements: but if the length of the exterior side be less, and brought down, for example, to that of a small front of 240 yards, the consequence would be that, in maintaining a proper proportion between the lengths of the different lines of works, the relief of 44 feet must be much diminished, and reduced so that the ditches may be fully defended from the flanks.

Suppose, for a moment, in a small front, a curtain of 80 yards in length, instead of 140 (as in the mean front), and the relief of the flanks to be 44 feet, it is evident that a considerable portion of the main-ditch could not be seen from these high flanks, and that the flanks must be lowered, and the bottom of the ditch raised, until the musketry fire from the flanks would meet in the middle of the main-ditch. Hence, in proportion as the exterior sides of the polygon become short, a bold relief must yield to one of less height, which of course is disadvantageous, as it gives shallower ditches, lower revetments, and less formidable works.

The mean fronts give good sized bastions, and a bold relief. To reduce the fronts, the bastions are contracted, and their defensive powers greatly injured. Hence small fronts should be used only on restricted ground, where mean fronts could not be traced; or in field-works, where parapets alone, without ramparts, form the defensive masses.

Thus the width of the ditch and the length of the flank that defends it, operate mutually on each other; and when, from the above, or any other cause, it becomes necessary to shorten the flank that has to defend a ditch, the latter should be narrowed also; and the converse of this should likewise be kept in view, namely, that when it is necessary to widen a ditch, it should have a flank capable of defending it efficiently.

131. The ravelin or demi-lune (F, fig. 103, Plate IV.) has a capital (that is, the distance from the re-entering angle at its gorge to the salient angle) of 100 yards; and its faces are directed to points at 10 yards from the shoulder angles of the bastions in its rear: this makes the length of the faces of the ravelin about equal to those of the bastion; and considering that these lines have to defend and flank the ground before each other respectively by a cross fire, and that this mutual support is of equal importance to each, they have accordingly about an equal length of ram-

part in their faces: the ditch of the ravelin has its counterscarp parallel to its escarp, and receives a full flanking defence from those portions of the faces of the bastions that look into it, as seen in the right front of this figure.

132. The covered-way is formed by the crest of the glacis passing around in a succession of salient and re-entering angles, all within easy musket-shot of each other: it is traced at 10 yards parallel to the counterscarp of the ditches, that the defenders may have room enough for all necessary movements within the glacis; and the places of arms give space for the assembling of considerable bodies of troops when required.

133. Third. *The opening of the different angles of the works.* If the bastion A, fig. 103, Plate IV., stood alone and isolated, and the defenders on its faces were supposed to fire perpendicularly to the parapets behind which they are placed, there will be a great sectoral space before the salient angle, undefended by a direct fire; hence the line that leads to this angle is the least defended line, and the most proper for an assailant to select on which to approach the work from the country; now this sectoral space, undefended by a direct fire, becomes less and less in proportion as the salient angle of the work opens, and greater as it becomes more acute: in this respect, therefore, obtuse are preferable to acute angled works: besides which, there may be said to be two more reasons for the superiority of obtuse angled works: 1st, they give greater interior space, and thereby admit of larger bodies of troops and of more artillery being used in them; which, of course, increases their importance and power: the artillery too can be worked freely close up to an obtuse angle; whereas the gun-carriages on opposite faces near an acute angle will interfere with each other. 2nd, an acute angle, having less solidity that an obtuse one, is sooner injured by the action of time and the weather; as well as more readily beaten down by an enemy's artillery.

It has been considered as a principle that the salient angle of a work is never to be less than 60°.

Re-entering angles being, in most cases, angles of defence, their opening should be regulated with reference to the best situation in which artillery and musketry can be placed for the use of these weapons. For example, take the flank, 2, 3, fig. 103, Plate IV., front 1, 6; in the parapet of which embrasures are opened to permit the guns to defend the ditch; if the angle of defence, 2, 3, 5, be a right angle, the embrasures are then cut perpendicularly through the parapet, which would not be the case if the flank stood either at a greater or less angle than 90° to the line to be defended; but the embrasures would have to be oblique to the parapet, which should be avoided if possible.

134. The position of embrasures is more clearly seen in fig. 103, Plate III.: the lines of fire f' 1, f'' 2, f''' 3, are perpendicular to the crest of the parapet; but f'''' 4, is oblique. Suppose, in the latter case, that the crest of the parapet was straight, instead of being indented, as shown in this figure, and that a line joining h i, showed the foot of the interior slope of the parapet, or the hurter; w being the off-wheel, and w' the near-wheel of the gun-carriage: the gun placed on this carriage (where one wheel w' cannot be fully brought up to the hurter, h i, of the platform) cannot be run so far into the embrasure as a gun on a like carriage in either of the other embrasures, where both wheels can be fully run up to the hurter.

It therefore becomes necessary to turn the parapet out of its straight line and indent it, in the manner shown in h k, in order to allow the gun to be run out as far as possible into the embrasure. This indenting of the parapet lessens its thickness in the superior slope on one side of the embrasure, and therefore weakens it; moreover, the merlon * between

* The merlon is the solid portion of the parapet between two embrasures.

this oblique embrasure and the perpendicular one next to it, is considerably less in quantity than the other merlons, whereby it is also weakened, and yields sooner to a heavy fire from an enemy's battery.

Guns should be run out into embrasure as far as possible, in order to preserve the shape and stability of the embrasure : the flash and concussion from firing guns, shakes and injures the cheeks of the embrasures ; and as the cheeks are only two feet apart at the neck and then widen rapidly, it is evident that the further the muzzle of the gun is advanced, the less injury the cheeks will receive. Hence long guns are preferable to short ones, as far as preserving the cheeks of embrasures is concerned.

Those portions of the faces of the bastions that look upon and defend the ditches of the ravelins, are seldom or ever at right angles to the parts defended ; the embrasures are consequently oblique to their parapets (see fig. 104, Plate IV.) ; and this construction must be adopted unhesitatingly, whenever it becomes necessary.

135. In examining the tracing of the covered-way which is laid out to suit a musketry fire, the faces of the re-entering places of arms stand at an angle of 100° with the adjoining branches of the covered-way, and the reason why angles of defence for musketry are 10° more than those for cannon, is, that the latter are always regularly laid and pointed : whereas a man with a musket firing over a parapet in cases of darkness, fog, smoke, or confusion, is very likely to vary the inclination of his musket to the right or left, out of a line perpendicular to the parapet, which deviation may carry the fire upon his comrades in the work flanked : to prevent accidents of this kind, angles of defence for musketry are usually made with an opening of 100°.

CHAPTER IX.

ON THE USES OF THE VARIOUS WORKS IN A REGULAR FRONT OF FORTIFICATION. COMMUNICATIONS BETWEEN THE WORKS. RELIEF AND COMMAND. DITCHES.

136. It is now time to consider the uses of the various works of a regular front, according to Vauban's first system, the way in which they mutually flank and aid each other, and their respective properties: and, in examining each work, two things must be kept in view: the first is its intrinsic value; and the second is its relative value: the former includes the extent and power of fire that the work can bring upon the surrounding country; what obstacle it offers in itself to an enemy as to its inaccessibility of situation; its ditch; height of revetment; and its resources to prolong its defence to the utmost: the latter refers to the extent of influence that a work exerts upon the neighbouring ones, or they upon it, by its capability of giving or receiving assistance.

137. Before entering upon these details, it may be well to remark, that the two weapons to be brought into full operation upon all the ground over which an enemy must advance, are musketry and artillery: for the first (whose range is the shortest), there is provided a sheltered advanced position outside of the ditches (the covered-way), from which a fire can be kept up all round the fortress: this formidable line of musketry is supported by the faces of the bastions and ravelins or strong batteries of artillery, whose fires cross in every direction: so that every advantage to be derived from the defensive weapons is secured in the best manner by the

positions of the works: and viewing the field to be defended in this light, the most convenient mode of entering upon the merits of the works will be to begin with the covered-way or musketry position, and then pass on to the outworks and the body of the place.

138. The covered-way being 30 feet broad, and having a parapet or glacis on its exterior, the crest of which is from $7\frac{1}{2}$ to 9 feet in height, affords, in the first place (fig. 103, Plate IV.) a secure road of communication all round the fortress, outside of the ditches: here guards and sentinels are placed, which prevent all access to the counterscarp of the ditch, to reconnoitre and sound its state or dimensions; an evil against which it is difficult to find a remedy in fortresses unprovided with a covered-way, during dark and tempestuous nights: and as the banquette is but $4\frac{1}{2}$ feet lower than the crest of the glacis, a strong palisading is placed at the foot of the interior slope of the glacis, to prevent any attempt at forcing a passage into the covered-way.

2nd. From the covered-way, a close grazing fire of musketry is obtained upon the glacis and the surface of all the ground without.

3rd. Bodies of troops can be formed in the covered-way and its places of arms, to act defensively or offensively by sorties; although there is room in the covered-way for its defenders and all their operations, there would not be convenient space for the assembling of such bodies of men as are required for sorties, were it not for the places of arms. The re-entering places of arms also afford, by their position, a flanking fire upon the ground before the adjoining branches of the covered-way.

4th. The crest of the glacis being on an average about 8 feet above the level of the ground, the scarp revetments of the main works in its rear can thus be made 8 feet higher than would be possible if there were no glacis; for it has been already shown how necessary it is to hide all the revet-

ments from the fire of distant batteries; thus a most important result is obtained by the covered-way and glacis, in the increased height of the scarp revetment.

5th. The exterior part of the fortification, namely, the glacis, presents to an enemy an indestructible bank (for the slope is scarcely two inches to a yard in length), exposing its whole surface and all beyond it to the fire of works in the rear: up this glacis the assailant must work, and must reach its crest ere he can see the revetments of the place: here he is in a position exposed to the fire of all the remaining defences; and by its elevation, greatly interfering with, and masking the effects of, his own batteries in the rear.

6th. He cannot descend to establish his batteries in the covered-way, for it is only 30 feet broad; which, although quite wide enough for all the necessary movements of the defenders, is too narrow for the assailant to construct a parapet next to the counterscarp, and to work his guns behind it; for this would require a space of at least 44 feet: and as the crest of the glacis is but 30 feet from the counterscarp, there would remain 14 feet of glacis to cut away from the crest: a proceeding too long and too laborious to be contemplated in common cases. For the defenders, the covered-way is only a musketry position, aided occasionally with light artillery in the places of arms; but the assailant would fain make it an *emplacement* for his breaching batteries, if it were wide enough for the purpose.

The covered-way being a low work, it is subject to the disadvantage of being easily enfiladed and ricocheted by the enemy's batteries; and to lessen the effects of this destructive fire as much as possible, traverses are thrown across its breadth at intervals of about 40 yards: the traverses have their crests as high as the glacis, and are generally perpendicular to the covered-way: these masses of earth stop the shot projected from the enfilading batteries of attack: and to do so effectually, they should never be more than 40 yards

apart, that if a shot ricochets or bounds over one traverse it may be stopped by the next. Traverses are made on the prolongations of the parapets of the faces of the bastions and ravelins, since there is no direct fire on these spots from the parapets themselves; they are also always made at the entrance of the re-entering places of arms, in order to close in these important rallying posts to the covered-way. Traverses are made to face towards the salient places of arms, as they are intended to assist in disputing the possession of the covered-way with the assailant, who, in the general progress of the attack, enters the salient places of arms first, where a fire is brought upon him from the two traverses, right and left; and should the defenders be driven from them, they retire behind the next traverses, and continue to dispute the covered-way, till they reach the re-entering places of arms.* Traverses in the covered-way are palisaded to hinder an enemy forcing himself over them; and a barrier-gate connects the palisades of each traverse to those of the glacis.

In order to permit the defenders to circulate with ease around the covered-way, the crest of the glacis is indented, as seen in Plate IV. fig. 103.

Lastly, the covered-way being low and fully commanded by all the main-works in its rear, it may be even abandoned to a sudden and overpowering attack, in order that the whole fire of the other works may be brought upon the enemy within it: and when it is thus obliged to yield, there is always a hope of regaining possession of it under the fire of the more commanding works.

* As all the faces of the works (whose prolongations fall upon ground without, upon which an enemy can establish himself) are subject to be enfiladed, traverses are usually constructed on them between every two guns, to neutralize the effect of this otherwise destructive fire: these, however, are not made till the siege begins, and are merely passive mounds of earth, and not intended for defensive purposes, as in the covered-way.

139. With respect to the ravelin: the relief is sufficient to permit it to fire over the glacis with ease, and in general it is only from 3 to 6 feet lower than the body of the place: it is, therefore, well situated for flanking by its fire all the ground on either side of it, and thus effectually defending all approach on the capitals of the bastions, by a close and powerful fire. Moreover, its shape, spreading its faces to the rear, covers, in a great measure, the curtains and flanks of the bastions from the fire of an enemy's batteries on the crest of the glacis, as well as from his distant batteries.

The advantages of the ravelin may then be enumerated under the following heads:—

1. It screens in part the flanks and the curtains from the view of the distant batteries of the besiegers, and thus prevents these works being injured from the beginning of the siege.

2. It gives a near cross-fire upon the capitals of the bastions.

3. It closely flanks on both sides the glacis of the covered-way.

4. When sufficiently large, it prevents a breach being made through the trouée of the tenaille.*

5. When sufficiently large, it secures any retrenchment made in the shoulder of the bastion.

6. Large ravelins form great re-enterings before the salients of the bastions, into which it is impossible for the besiegers to penetrate, without being previously masters of the ravelins, which see these re-enterings in reverse and in rear.

* The trouée of the tenaille is the open space between the extremity of the tenaille and the flank of the bastion, as at 2, and 5, front 1, 6; fig. 103, Plate IV. By examining this figure it may be seen that, in the event of an enemy having reached the crest of the glacis of the re-entering places of arms, he could see through the trouées of the tenaille, and fire upon the curtain: an evil which is obviated when a front has a fine large ravelin.

The ravelin, then, is a work of great importance, not only from its positive but also from its relative value, and is indispensable to the efficiency of a front accessible to a regular attack. See fig. 105, Plate IV., for a section of the ravelin.

140. The tenaille is a work of more value from its passive and relative, than for its active, properties. Its crest is usually a few feet higher than the plane of site, that the artillery on the flanks of the bastions may be able to fire over it upon the main-ditch. It is made 48 feet thick, that there may be room on it for a regular parapet, with a useful terre-plein of 12 feet wide in its rear. Thus furnished, the tenaille can give a direct fire into the interior of the ravelin, after an enemy has taken it; as also an oblique fire upon the main-ditch and the covered-way. This low grazing fire into the ravelin, and also upon the bottom of the main-ditch, would be most formidable in the latter part of a siege. To these, its active properties, it adds the important advantage of hiding nearly all the revetment of the curtain and flanks of the bastions from the view of the enemy's batteries established on the crest of the glacis; or subsequently in the ravelin after its fall: therefore, a breach fit to assault cannot be made in these parts of the enceinte, and the revetment of the face of the bastion alone is sufficiently exposed to have a practicable breach made in it: thus, then, the enemy must assault that portion of the enceinte behind which the defenders have ample space for making the best defence possible. The relief of the tenaille is usually 23 or 24 feet (see fig. 105, Plate IV.): hence an enemy's battery, XXVII., fig. 103, could see over the tenaille, and beat down the upper part of the revetment of the flank, as well as part of its parapet; but this would not be sufficient to form an assailable breach: for this purpose it is necessary to see to the bottom, or nearly to the bottom, of the wall.

Again, the mass of the tenaille is no less useful in hiding

from the enemy's establishment on the covered-way the opening or door of a vaulted passage or postern of masonry, which postern is indicated by the dotted lines in the centre of the curtain (fig. 103, Plate IV.), that communicates from the interior slope of the rampart in the centre of the curtain to the main-ditch: a postern is also pierced through the tenaille itself, and a protected passage, the caponier, then leads to the gorge of the ravelin: thus a communication is kept up between the enceinte and the ravelin: a matter of the first importance in giving vigour to the defence of this latter work.

141. A caponier is placed in a dry ditch, for the purposes named in article 120: for instance, in fig. 103, Plate IV., there is a double caponier (10, 10,) at the bottom of the main-ditch, from the mouth of the postern in the tenaille to the staircase at the gorge of the ravelin. Caponiers are placed wherever they may be required. When a cunette is used, it is flanked by a caponier.

142. We now come to consider the uses and value of the various parts of the enceinte: the student is referred to articles 126 and 130, for principles of their construction, and for some of their uses; from which it may be gathered that the bastions are the most important parts of the enceinte, from their projection, position, and interior space.

The whole of this first enclosure, being the last permanent obstacle the enemy has to overcome, it is consequently the most formidable, having a broad ditch before it, with scarp revetments from 30 feet to 35 feet in height; massive ramparts and parapets carrying the heaviest artillery, the various lines of which mutually flank each other, and by their height, overlook all the works before them.

In fig. 103, Plate IV., it may be seen, by the position of the faces of the bastions, that they fully flank by their fire all the ground before the faces of the ravelins, and all the approaches by their capitals to their flanked angles, or weak

points: the ditches of the ravelins are also defended by the fire of those portions of the faces of the bastions that look upon them; and these must be silenced ere the enemy can pass the ditches thus flanked to assault the ravelin.

Each flank of a bastion can carry batteries of five or six pieces of artillery to defend the main-ditch; and as it has been already shown that the faces of the bastions are the only parts of the enceinte in which the assailant can make practicable breaches, it is quite necessary that the ditches, by which these breaches can be reached, should be fully swept by the fire of the flanks; and this is the case: now, in a regular attack, the passage of the main-ditch cannot be effected under the fire of so strong a battery, which has to be silenced before the attempt be made.

The curtain may be said to have more a passive than an active defence; it closes in the body of the place by joining the bastions to each other, and it overlooks the works before it; into which it can pour a strong fire after their fall into the hands of the assailant; as it has only a command of observation over the ravelin, its embrasures must be oblique to fire into the covered-way, or upon the country beyond it.

Thus, in the enceinte, the faces of the bastions may be said to have the most active duties to perform: the flanks are for a specific object, viz., the defence of the main-ditch; and the curtain is nearly a passive barrier till the end of the siege, when its fire tells strongly on the works before it.

143. In plan-drawing, it is customary to represent all the masonry work in red lines, and the earthen works in black; the cordon or master-line of the escarp is a thick red line, and all the crests of the parapets are in thick black lines. The tint of Indian ink, for shading, should be very light, and all slopes shaded down, from top to bottom, with a water-brush. To ornament the plan, the rays of light are supposed to enter from the upper left-hand corner of the

paper; and all slopes that face it are but lightly shaded, while those that recede from it are more strongly so. Dry ditches have usually a light flat tint of burnt sienna, or umber; and wet ditches a light flat tint of blue.

In a profile, the earthen works are shown by a tint of umber or sienna: the masonry, by a light flat shade of lake or light red: to finish profiles, there is a thick red line on the side of the masonry, furthest from the light.

144. *Communications.* The communications between the interior of the place and the country; between the various works; and those to facilitate the passage of artillery, &c., from one part to another, may be divided into—

1. Gateways.
2. Bridges.
3. Posterns.
4. Caponiers.
5. Staircases.
6. Ramps.

Of these, the two first may be considered as especially made for the convenience and use of the inhabitants in their intercourse with the country: and the four last more particularly for the use of the garrison.

145. Of the former, there should be as few as possible, since they entail extra duties on the garrison, requiring constant watching and repair. In places of a small size, and if possible in every place, two main passages should be made to suffice; the opposite fronts, having regular bridges of timber across the ditches; with passages through the ramparts and glacis, which lead to the main roads without: in the centre of the curtain, the rampart has a large vaulted passage, supported on each side by masonry, to form a road sufficiently wide for the passage of carriages, waggons, &c.; that is, from 18 to 24 feet wide and 12 feet high: this passes underneath an archway in the scarp revetment, and leads over a bridge, on the same level (that is, the plane of site,) to the tenaille: the passage is continued through the parapet of the tenaille, over a bridge connecting the tenaille with the gorge of the ravelin; in like manner, it proceeds through the

ravelin, its rampart, and across its ditch by a bridge, all on the plane of site, to the covered-way: a winding road is cut through the glacis (to prevent its being enfiladed), which leads to the main roads without. Here it may be observed that this road and the bridges it crosses are fully defended; the main bridge, leading from the body of the place to the ravelin, is placed between the batteries on the flanks of the two adjoining bastions; as well as exposed to the fire of the tenaille and curtain: the continuation of the road through the ravelin and across the bridge of its ditch, can be both enfiladed and flanked from the different parts of the enceinte that command it: in short, this road of communication is better protected in this situation than it could be if placed in any other part of the works.

The bridges are always broken by drawbridges, which can be raised on a moment of emergency; and are usually drawn up every night, by order of the governor of the place: guards are necessary in the covered-way, ravelin, and curtain, to protect and watch the bridges; and every precaution is constantly used to prevent an enemy getting any access to these passages, either by force or stratagem.

146. *Posterns* are vaulted passages of masonry constructed underneath the mass of the rampart, to communicate from the interior of a work into the ditch before it: in a dry ditch, the door at the mouth of the postern is about 6 feet from the level of the ditch, and the defenders pass up and down by temporary wooden steps, which are removed at pleasure; so that, if an enemy gets into the ditch, and is so powerful that the defenders must retire by the posterns, the wooden steps can be drawn into the mouth of the postern and the door shut, which, being loop-holed, permits a fire of musketry to be brought upon the assailants.

Posterns are usually from 5 to 9 feet wide, and from 6 to 7 feet high at the crown of the arch; they are closed at each extremity by doors, within which are recesses of masonry for

stores, &c.: although posterns are only intended as secure covered passages for men to pass from the inside to the outside of a work, yet when 9 feet wide they will admit of light artillery being taken through them and passed into the ditch on inclined planks; and, even when narrower, guns and their carriages can be passed through when taken to pieces.

In wet ditches, the posterns lead from the interior of the rampart to the level of the bridge that crosses the ditch; or, if the ditch be crossed by boats, to the level of the water.

Posterns are made on the first construction of the fortress wherever they may be required; the interior earthern slope of the rampart is suppressed, and masonry supports the sides of the passage leading into the postern; the vault of which passes through the whole thickness of the rampart, the masonry being, of course, made strong enough to resist the pressure that it has to support both laterally and vertically.

In a regular front, as fig. 103, Plate IV., the postern in the centre of the curtain is indicated by the dotted cross lines, issuing out into the main-ditch, behind the tenaille, where the defenders are in perfect security: they proceed through the mass of the tenaille by the postern (shown in its centre by the dotted cross lines), and then pass through the main-ditch covered by the caponier; either to ascend by the staircases at the gorge of the ravelin; or to proceed by the passages.

147. *Staircases* should always have a sufficient slope to make it easy to pass up and down quickly. Staircases are, in many cases, carried down within 6 feet of the bottom of the ditch, and temporary wooden steps are used to reach the bottom: these are removed at pleasure, to render it difficult for an enemy to enter a work by the gorge should he succeed in getting into the ditch. Staircases are objected to from the possibility of their being greatly injured or destroyed during a siege by shells falling and bursting upon them; which

likewise causes many splinters; and it is difficult to repair or restore the communication during the arduous occupations of a siege.

148. *Ramps*, being long, broad earthern slopes, constructed along the interior slopes of the ramparts, to facilitate the passage of artillery, they are most useful and convenient communications; easily repaired if injured by shells during a siege. As ramps are for the use and transport of artillery, &c., they should be sufficiently gentle and broad to permit the guns to be run up and down with ease and safety; and as this labour augments with an increase of height, ramps in high ramparts are proportionally longer than in low ramparts. The average length of ramps are at about ten times their height.

Ramps are made at the gorges of the ramparts of full bastions; in the flanks of empty bastions, and in the gorges of the ramparts of ravelins, as seen in fig. 103, Plate IV.: they are also made in the crest of the glacis for the exit of sorties; their tracing is such as to prevent their being enfiladed: they are usually 30 feet long, 12 feet broad, and are closed by barrier gates of palisades.

149. Lastly. Safe and assured communications between the different works, and especially between the enceinte and the outworks, are of the first importance. It is absolutely necessary, for the good defence of a work, that there should be the means of succouring it, by reinforcements, through safe and convenient passages; of relieving the troops on duty; of withdrawing them in safety when they can resist no longer, &c.: and this can only be done by a sufficient number of the communications described above: they are therefore indispensable; not only as they affect the actual means of resistance, but also from the influence they have on the moral feeling of the soldier; who performs his duty with a much greater degree of confidence and cheerfulness when assured of aid, or of a safe retreat if overpowered.

150. *On Relief and Command.* From articles 103 and 104, it follows, that however important it may be to dispose the tracing of the works of a fortification, so that their reciprocal defence may not interfere with their general effect upon the country; it is of no less importance to fix the relief which determines the proper elevations of the works, respectively, so as to ensure the full effect of their fire for all the purposes desired.

The relief is generally determined by means of profiles; and it is said that a place is well *profiled*, when the works cover and defend each other without injury to their particular command over the country.

In considering this subject, the pupil is reminded that the works are still supposed to be constructed on a horizontal plane: the intricacies of construction, in cases of irregular sites, or the neighbourhood of hills, are not explained in this introductory instruction.

In profiling the works of a fortress, the following principles should be kept in view:—

Firstly. That all parts of the surrounding country, within the range of the artillery, and musketry of the defences, should be seen and exposed to their fire.

Secondly. That an enemy from without should not be able to see any part of the interior of the works.

Thirdly. That no part of the revetments should be seen by an enemy till he has worked up to the crest of the glacis.

Fourthly. That all the works progressively increase in height as they approach the body of the place.

The first principle has been established in order that an enemy may not get cover from natural obstacles within range of the defensive weapons; to oblige him to begin the works for the siege at a considerable distance; and that he may be fully exposed to the fire of the place as he progresses towards it. The second principle shows that an enemy must not have it in his power, while yet at a distance, to drive the

defenders from their works. (Its application to works within the range of heights which an enemy can possess, forms the subject of defilading.) The third principle is to oblige the enemy to bring his battering train of guns to the crest of the glacis; as, till then, he cannot see the scarp revetments to form breaches fit for assault. The fourth shows that when an enemy gets possession of the works in succession, beginning with the outermost and lowest, those that remain, being more elevated, can bring a fire upon the captured works; either to drive an enemy out of, or to disturb his lodgment in, them. Moreover, that the low and high works may fire together, and that the most formidable works should be the last to be taken. The tenaille is an exception to this rule, for reasons stated in article 140.

In the application of these leading principles, they must be subservient to the promotion of the great objects of the tracing and the uses of the works, as stated from article 136 to 142; and also to ensure the full effect of the defensive weapons.

151. *Ditches.* Deep broad ditches are certainly more formidable obstacles for the assailant to overcome than the moderate ones spoken of in a regular front on a horizontal plain; but however deep and broad a ditch may be, it should be perfectly flanked, that the enemy's miner may not be able to attach himself to the walls, and destroy them by the explosion of mines; and, in no case, should the general good arrangement of the works be sacrificed to obtain a formidable ditch.

The next point to enter upon is, the kind of ditch best suited for defence: that is, the consideration of wet ditches; dry ditches; or those that, by well-managed currents of water, can be made wet or dry at pleasure.

If a ditch be permanently wet, it can only be crossed by bridges or boats; and so long as an enemy is at a distance, the communication between the place and the outworks can

be kept up with tolerable ease and security; but from the moment that he establishes himself on the crest of the glacis, his batteries will command all the ditches; the bridges are swept away by his fire; and every attempt to cross must be under his view by day, or within his hearing by night; thus the defenders are deprived of the means of succouring the outworks in the time of need; and the consequent effects upon their defence are so prejudicial, that some engineers object to permanently wet ditches, except in swampy ground (where it cannot be well avoided), or when a fortress, from having low or defective revetments, which may offer an inducement to the enterprise of an enemy to attempt to carry it by surprise and escalade; more particularly if the garrison be inefficient, either from the quality or number of the troops; in this case, a wet ditch serves to secure the place from a coup-de-main. Wet ditches also augment the labour of the besiegers in constructing bridges or causeways across them, at the end of the siege, to connect the breaches to the counterscarps.

If the ditches of a fortress be permanently dry, then the important object of a safe communication between the enceinte and the outworks is secured by means of posterns and caponiers; which gives vigour to the defence, and keeps the enemy from the main enclosure as long as possible. Mining operations also can be carried on in dry ditches to augment the duration of a siege.

If the situation of the fortress admits of the ditches being filled with water at pleasure, there is no doubt that a preference should be given to thus combining the advantages of the wet and dry ditch; and from what has been said (in article 124) on the general site of fortresses, this object can sometimes be secured; since the flowing and ebbing of the tide on the sea-coast, or its influence on the rivers on which fortifications are so generally constructed, renders such a means of defence available. The batardeaux (article

121) should be constructed in situations where the enemy's batteries cannot reach them; for, if exposed to his fire, these barriers and their sluices would be destroyed, and the ditches made either permanently wet; or, if affected by the tide, the enemy would always know when they were passable. But if the batardeaux and sluices remain uninjured, the besieged may keep the ditches dry as long as the outworks can be defended, and inundate them to increase the difficulty of the enemy's work in effecting a passage across; which work may also be swept away, or retarded, by well-managed currents of water.

A fortress situated on the sea-shore, or at the entrance of an harbour (as Portsmouth), possesses the advantage of being able to fill the ditches with water by sluice-gates, on the flowing of the tide; and either to retain the water in the ditches by the batardeaux, or permit it to flow off on the ebbing of the tide; fortifications on rivers, within the influence of the tides, have the same advantage.

CHAPTER X.

ON THE ATTACK OF FORTRESSES.

152. To enter upon the strategical movements of an army previous to undertaking a siege, would be quite out of place in a treatise of this kind; but it is necessary to observe that the forces about to undertake a siege must have the lead and superiority in the field; for the corps appointed to conduct the duties and details of the siege, as also the investing corps (or that which surrounds the whole place, and hems in the garrison on every side), ought not to be liable to have their operations disturbed and defeated by an army attempting to succour the place, or to raise the siege; and should the besieged thus have an army in the field, it becomes necessary for the assailants to have a corps of observation to watch it.

153. The army intended to *invest* a place, approaches it when least expected, and occupies positions simultaneously on every side, so as to cut off all its means of communication with the country. The positions thus occupied are strengthened by good field-works, and a sure communication is kept up between them.

It is absolutely necessary to *invest* the place to be attacked; that is, to surround it with troops; and if required by lines of field-works, so as to prevent the garrison holding any intercourse with the neighbouring country; for it is evident that if this precaution be not taken, the defenders may be able to draw fresh supplies of men, provisions, and ammunition from the country, and the assailants will labour under the disadvantage of attacking these renewed means on two or

three fronts of fortification, and thus waste their superiority, which chiefly consists in their capability of bringing up numbers and means of attack continually, while those of the besieged, however efficient at first, must in time diminish, and ultimately be rapidly expended. A place may be reduced by investment or blockade alone, and in some instances, where it is possible suddenly to blockade a place ill provisioned and filled with a numerous garrison and population, it may be the most ready and bloodless mode of proceeding. Indeed, many other circumstances may render it desirable to endeavour to reduce a place by blockade.

154. The *matériel for a siege* is brought up to the fortress from the depôts established in the rear to supply the expenditure. The siege may begin with a supply sufficient for the first week or ten days, when the train and animals employed in transporting the stores are sent back to the depôts for a fresh supply of all that is needed; they leave their burdens and return to the depôts for a fresh supply, and this goes on until the place is reduced.

A siege should not, however, be commenced, until all these depôts for the siege *matériel* are fully established, and ample means secured for supplying the expenditure in the most vigorous attack. The distance and position of these depôts must entirely depend upon the nature of the country, and the relation in which the besieging army stand with the government and inhabitants. To begin a siege without full means of reducing the place, would be a most injurious and improper measure.

155. When the defenders have been driven within their works, and the place invested, the ground before the fronts is well examined,* and the most suitable situations selected for

* Localities sometimes greatly favour the assailants; for example, in the second volume of the "Journals of Sieges," by Sir John Jones, it is stated, that, on the close investment of Bayonne by the Duke of

the park of artillery, and *the engineers' park:* the former to receive all the ordnance stores and ammunition; and the latter all the engineers' stores and materials to be used in the construction of the trenches and batteries, &c.: these parks should be removed beyond the general range of the artillery of the fortress, and placed behind the slopes of hills or in ravines, but with a ready access to the trenches and batteries of attack, for the use of which they are formed.

The trenches are generally opened at about a distance of 600 yards from the place: and as the engineers' park is usually at a distance of 1800 or 2000 yards, entrepots between these distances become necessary.

156. The pupil is referred to the preliminary observations on the attack of fortresses, by Sir John Jones, in the first volume of his "Journals of Sieges," part of which is quoted below:—

"The first operation of a besieger is to establish a force equal to cope with the garrison of the town about to be attacked, at the distance of six or seven hundred yards from its ramparts.

"This is effected by approaching the place secretly in the night with a body of men, part carrying entrenching tools, and the remainder armed. The former dig a trench in the ground parallel to the fortifications to be attacked, and with the earth that comes out of the trench raise a bank on the side next the enemy, whilst those with arms remain formed in a recumbent posture, in readiness to protect those at work

Wellington, in February, 1814, "a road forming almost a parallel to the new works, at two hundred and forty yards in their front, served as a communication along the centre of this line, and by means of traverses, walls, &c., was converted into a beautiful covered-way, along which, and the houses in its front, the pickets were lodged.

"The troops during the blockade bestowed considerable labour in strengthening these advanced parts; and although the garrison cannonaded them frequently, they never succeeded in dislodging a single picket."

should the garrison sally out. During the night, this trench and bank are made of sufficient depth and extent to cover from the missiles of the place the number of men requisite to cope with the garrison, and the besiegers remain in the trench throughout the following day, in despite of the fire or the sorties of the besieged. This trench is afterwards progressively widened and deepened, and the bank of earth raised till it forms a covered road, called a parallel, embracing all the fortifications to be attacked; and along this road, guns, waggons, and men, securely and conveniently move, equally sheltered from the view and the missiles of the garrison. Batteries of guns and mortars are then constructed on the side of the road next the garrison, to oppose the guns of the town, and in a short time, by superiority of fire, principally arising from situation, silence all those which bear on the works of the attack. After this ascendancy is attained, the same species of covered road is, by certain rules of art, carried forward, till it circumvents or passes over all the exterior defences of the place, and touches the main rampart wall, at a spot where it has been previously beaten down by the fire of batteries erected expressly for that purpose in the more advanced parts of the road.

"The besiegers' troops, being thus enabled to march in perfect security to the opening or breach in the walls of the town, assault it in strong columns; and being much more numerous than the garrison defending the breach, soon overcome them, and the more easily, as they are assisted by a fire of artillery and musketry directed on the garrison from portions of the road only a few yards from the breach; and which fire can, at that distance, be maintained on the defenders of the breach till the very instant of personal contention, without injury to the assailants. The first breach being carried, should the garrison have any interior works, the covered road is, by similar rules of art, pushed forward through the opening, and advanced batteries are erected in

it to overpower the remaining guns of the place; which effected, the road is again pushed forward, and the troops march in security to the assault of breaches, made in a similar manner in those interior works, and invariably carry them with little loss.

"To preserve the life of a single soldier is, however, always an object; therefore, when time is abundant, the loss of the few men attendant on the assault of the breaches under these favourable circumstances is avoided; as, by a small delay, the covered road can be equally well pushed up and through the breach, without giving the assault, as after the breach has been carried; and thus by art and persevering labour, the strongest and most multiplied defences frequently fall without any exertion of open force.

"From the foregoing description, it will readily be conceived, that the most important object at a siege is to carry forward the covered road to the walls of the place, and that all the other operations are secondary to, and in furtherance of, such an advance; and, consequently, that the efficiency of armies at sieges depends on their ability rapidly to complete the road, and at a small expense of life.

"To enable the general reader to form his own judgment on the means necessary for such efficiency, it should be stated, that the formation of the covered road is attended with different degrees of difficulty in proportion as it advances.

"At its commencent, being at the distance of 600 yards from the fortifications, and not straitened for space, the work can readily be performed by the ordinary soldiers of the army. The second period is, when the road arrives within a fair range of musketry, or 300 yards from the place; then it requires particular precautions, which, however, are not so difficult but that the work may be executed by soldiers who have had a little previous training. The third period is, when it approaches close to the place—when every bullet

takes effect—when to be seen is to be killed—when mine after mine blows up the head of the road, and with it every man and officer on the spot;—when the space becomes so restricted that little or no front of defence can be obtained, and the enemy's grenadiers sally forth every moment to attack the workmen, and deal out destruction to all less courageous or weaker than themselves.

"Then the work becomes truly hazardous, and can only be performed by selected brave men, who have acquired a difficult and most dangerous art, called sapping, from which they themselves are styled sappers.

"An indispensable auxiliary to the sapper is the miner; the exercise of whose art requires even a greater degree of skill, courage, and conduct, than that of his principal. The duty of a miner at a siege is to accompany the sapper to listen for, and discover the enemy's miner at work under ground, and prevent his blowing up the head of the road, either by sinking down and meeting him, when a subterraneous conflict ensues, or by running a gallery close to that of his opponent, and forcing him to quit his work by means of suffocating compositions, and a thousand arts of chicanery, the knowledge of which he has acquired from experience. Sappers would be unable of themselves, without the aid of skilful miners, to execute that part of the covered road forming the descent into the ditch; and in various other portions of the road, the assistance of the miner is indispensable to the sapper: indeed, without their joint labours, and steady co-operation, no besiegers' approaches ever reached the walls of a fortress.

"A siege scientifically prosecuted, though it calls for the greatest personal bravery, the greatest exertion, and extraordinary labour, in all employed, is beautifully certain in its progress and result. More or less skill or exertion in the contending parties will prolong or shorten in some degree its duration; but the sapper and the miner, skilfully directed and

adequately supported, will surely surmount every obstacle. On the contrary, the sieges of armies destitute of these capable and confident auxiliaries, are hazardous in the extreme. Their only chance of success is in scrutinizing the exterior of a fortress, to discover some spot from whence, in consequence of the irregularity of the ground or faults of construction, the main escarp wall can be seen at a distance sufficiently great for ordinary soldiers to approach with the covered road, and there establish batteries to form an opening through the wall into the place.

"That effected, the troops must advance to the assault of the breaches, as in the 16th century, losing the shelter of the covered road at the moment the fire of the place becomes most powerful and destructive; whereas, the fire of the besiegers' distant batteries being necessarily suspended to avoid killing their own storming party, the garrison can, with impunity, mount on their parapets, and use every kind of weapon and missile in their defence.

"Should the columns, under these disadvantages, arrive in good order at the brink of the ditch, they must descend into it, down a wall from fourteen to sixteen feet in depth, which cannot fail to break their order, and throw them into confusion. No fresh formation can be attempted, in a spot where death is incessantly showering down on the assailants, and they rush to the breach more like a rabble than a solid column.

"From this moment, success hinges on the individual and confident bravery of the officers and troops, and the unshrinking firmness of the commanding general in encouraging and supporting their efforts.

"These qualities, when united in a high degree, may obtain success at a considerable sacrifice of life; but whenever such nature of assault has been attempted under ordinary circumstances and feelings, in former or recent wars, repulse has invariably been the consequence."

157. The covered road spoken of in the foregoing article, is now the subject for consideration : its progress may be seen in Plate IV., where the three distinct periods alluded to, are marked by the trenches that run parallel to the general outline of the place, and hence their name *parallels.** (The place being fully invested, and the fronts to be attacked fixed upon.) At the time appointed, the working parties move to their allotted stations, in order to *break ground,* or open the first parallel, at a distance of about 600 yards from the salients of the covered-way of the place. This distance is previously fixed by the engineers, and all prepared before night-fall to commence operations; after dusk the working parties move silently to their posts, and lie down till the appointed signal is given to commence the excavation : they are protected in front by an armed covering party, having detached pickets, and chains of sentries, to repel any sortie which the garrison may attempt to make, in order to interrupt the work. Every endeavour is made, previously to breaking ground, to deceive the garrison as to the fronts selected for attack, by making a reconnoissance on all sides, and apparent preparations for opening the trenches : the besieging corps furnishes both the covering party and the workmen; all of whom are paraded in proper time by daylight, and told off for their respective duties. It is to be distinctly understood that, throughout the siege, the breaking of new ground is to be done at night, and the work completed on the following day; except in cases where the

* It does not however follow, that these trenches are always made parallel to the general outline of the works attacked. It often happens that local circumstances favour their being constructed in a different direction. Nor are the distances specified in Plate IV., or in the following details, meant to do more than give a general notion to a pupil of siege operations. The number and extent of the parallels, batteries, &c., will always vary with the nature of the works attacked, the localities, and the means at the disposal of the besieged and besiegers.

fire from the place is so subdued that some of the advanced saps can be pushed on during the day.

The experience gained in the sieges under the Duke of Wellington led to the following arrangements, detailed by Sir John Jones, in his "Memoranda relating to the Manner of carrying on the Duty and Performing the Work at the Sieges in Spain." Vol. ii., page 179.

Breaking ground. "A certain number of brigades of engineers were ordered for duty, and the working party being told off into a similar number of divisions, the tools were laid out in separate portions in the park, according to the strength of the several divisions of workmen. As soon as it became dusk, the commanding engineer, having previously well reconnoitred the ground, went with the officers of engineers for duty, attended by a few of their non-commissioned officers, and pointed out to them the line of the parallel and the returns of the approaches to it. The officers then divided the extent of the work between them, beginning at one end of the parallel, according to seniority; and each taking for his portion of it a certain number of yards, according to the number of men contained in his division of workmen. He then planted a picket at each end of his portion of work, and ran a white line from one end to the other; and that the pickets might be readily found when it became quite dark, he made one of his overseers lie down at each: and in like manner were all the returns of the approaches marked out. Whilst this was executing, the sub-officer of each brigade, after having well remarked the situation of his portion of the work, so as to be certain of finding it in the dark, returned to the place of assembly of the working party, and took charge of his division. The whole were then marched in one body to the place of breaking ground, either to the centre, right, or left of the intended parallel, as the country offered most facility for advancing. When that happened to be in the centre,

the workmen were filed in two parties to the right and left; but, to avoid confusion, they were, whenever practicable, filed along the whole length of the parallel, say from left to right. Then the officer with the leading section marched on till he arrived at the picket on the extreme right; the second officer halted his division when the head of it arrived at the right picket of his brigade; the third officer halted his at the right picket of the third brigade; and so on with the other divisions. Without this precaution of halting each division separately, as the men march in much closer order than they work, they would all be crowded together, and, in the dark, it is almost impossible to make men extend themselves into regular distances. Each man, on marching out of the park, carried a fascine four feet in length, which, on the division halting, he placed down parallel to the white line, at two feet in front of it; and as he afterwards only opened the ground to the white line, and threw the earth beyond the fascine, a space of two feet was left for the banquette.

158. "The workmen were placed four feet apart,* and were expected at that distance to complete, before the hour of being relieved, a trench 3 feet in depth by $3\frac{1}{2}$ feet wide at bottom, being something more than a cubic yard and a half of excavation. Frequently, however, they did not complete the allotted excavation; which could only arise from want of due exertion, for under a heavy fire they never failed to perform the same quantity of work in three hours. It would, therefore, be a desirable regulation to enforce, that, on breaking ground, no relief should take place till an assigned portion of work had been completed. The workmen under the present system of relieving them at a fixed hour, whether they have done much or little, feel assured that they shall quit the trenches before daylight, and are not interested that

* Six feet is a better distance; at four feet men are too close to each other, and cannot work with safety in the dark.

proper cover should be obtained against the fire of the place, which seldom opens with much effect till that period.

" With each division of workmen, a number of spare tools should be sent, as it will unavoidably happen that in some parts of the line, four or five men will be found working together with the same nature of tool; also in some parts the ground will prove soft, and require shovels only, and in some parts so hard as only to be moved with pickaxes. To attempt to change the men or tools in the dark, is productive of endless confusion; so that where the supply of tools will admit of it, each man should carry a shovel and a pickaxe.

159. "At the distance of the first parallel, or 600 yards from the covered-way, there is, in high latitudes, a considerable period of partial obscurity, during which the work may be seen to be traced, those so employed not being observable from the garrison; but in southern latitudes the day is so immediately succeeded by darkness that not a moment is to be lost in fixing the different points. After complete darkness, it is impossible to trace any line with certainty, for even the very bearing of the front to be attacked becomes doubtful; and, on such occasions, if men be not left lying down at the different points, or a white line used, the trace may remain undiscovered for the whole night.

" To enable the engineers to trace out the work in the dusk with security to themselves, it is desirable that the investing corps should, at sunset every evening, close upon the place, and that it should, even in the day time, hold all such advance posts as it can without loss of men. During the time of fixing the marks in the dusk, sentinels must be advanced in front of the officers so employed, and a strong support be posted near at hand, or a cavalry patrol might sweep the whole party into the place.

" Reconnoissances of other points of the fortress should be made daily during the investment, and more particularly

of those parts of which the garrison show a jealousy by much firing. It will frequently serve to prevent suspicion of the intended point of attack. At Badajoz, both in 1811 and 1812, officers were employed with much show to reconnoitre the south fronts, whose motions were jealously watched and interrupted by fire, men being even sent out of the place to occupy some ruins to prevent their near approach on that side; whilst underneath the castle the commanding engineer, attended by another officer, was actually pacing the intended parallel uninterruptedly, under the show of being officers regulating the advanced sentries. At one point this was done close to a French picket, which, by a sort of tacit agreement, quietly occupied in the day-time a house beyond the glacis, retiring from it every evening on the advance of the investing pickets, neither party ever firing on the other.

160. *Covering parties.* "The covering party preceded the working party, and was conducted by an officer of engineers, selected for that purpose from those who had accompanied the commanding engineer when he laid out the parallel in the dusk: and who, having made himself thoroughly acquainted with the roads, had returned to the place of assembly of the troops, which was usually at the engineers' park. In these sieges the covering party was always placed a few yards in front of the workmen; but of course the general officer of the day places it wherever he thinks proper, either in front or rear of them. It would, however, seem most advisable to place it in front, as the natural weapon of the British, and the most effectual in the dark, is the bayonet, and the order of the troops must necessarily be destroyed in crossing over the work and through the workmen to use it. Again, the covering party being in front of the workmen gives them a confidence, which is essentially necessary to their attending to their work. For the same reason it is better that the workmen should have their arms, for, when without them, they disperse on the slightest alarm, and it is

very difficult to collect them again; but such is the natural intrepidity of the English soldier, that, with his arms, he never thinks of moving off. The workmen carrying their arms, is admitted to be a great impediment to the work in many respects; but that is considered as being much overbalanced by the confidence it inspires amongst them, and the real security it affords.

"The battalions, as soon as posted, were made to lie down, having small platoons of men placed in their front, with advanced sentinels. The sentinels had positive orders not to fire on any account, and the squads were not to fire unless assured of a sortie advancing in force."

Besides the working party to execute the first parallel on the night of breaking ground, a detail is also told off to connect the parallel to the depôts in the rear, by means of trenches of communication. These zigzags of approach from the entrepots to the first parallel, will probably not be less than 800 or 1,000 yards. A profile, like fig. 1, Plate I., will suffice for these approaches. Any natural hollows or ravines which may be found in the required direction may afford the means of still further diminishing this profile, or altogether dispensing with a trench or parapet. Good epaulements should also be prepared behind the extremities of the first parallel, for the protection of cavalry, who may be required to act against sorties. See Plate IV.

161. The distance of 600 yards is selected as suitable for the first parallel, as here there is little to fear from musketry, grape, or cannister; but when the localities of the ground require that any portion of the parallel should be advanced or retired, in order to command the ground in front, it should be done. The distance of 600 yards also is too great for sorties from the place to hope for success, and to retire without great loss. The development of this parallel is usually so great, that the defenders would not think of expending ammunition upon it, unless it be to concentrate a

fire upon any suspected site of a battery, &c. Moreover, batteries in this parallel, are at a very good distance for ricochet practice.

The moment that the parallel affords cover, as well as room, for the workmen to continue their excavation, the main body of the covering party retire into it, leaving their pickets or sentinels in advance; but all are to be under cover by daylight next morning.

The parallel is widened and completed during the day after breaking ground, affording a covered post (of the dimensions shown in fig. 2, Plate I., "Field Fortification").

The parallel is intended as a place of arms, furnished with a guard to protect the further approaches against the efforts the garrison may make to retard or destroy them.

With respect to the extent of the first parallel, it depends on the nature of the works attacked, as well as the localities of the ground on which it is made. In Plate IV., where the ground around is supposed to be a plain, the first parallel is of great extent, viz., about 3,100 yards: this arises from the necessity of enfilading the right face of ravelin E, and the left face of ravelin F, the guns of which command the ground to be worked over; and the parallel is extended so as to embrace the prolongations of these faces, where the batteries No. I. and IX. are constructed. But should the localities prevent the parallel being thus extended, and oblige the assailant to terminate at H and I, the (dotted) battery, 40, would be made, in order to contend, by a direct fire, against the right face of ravelin E; and the battery, 41, against the left of ravelin F. These batteries, 40 and 41, would have to be armed with a greater quantity of artillery than No. I. and IX., nor would they even then be so efficient as the latter: for ricochet fire is superior to direct for subduing an enemy's defences. It is therefore best, if possible, to extend the parallel, in order to obtain a good position for the batteries for ricochet practice.

Should any rising ground (as seen on the right of the first parallel, Plate IV.) be on the prolongation of any of the works, it would be preferable to the level ground for the construction of the battery (as dotted on the rising ground): such a site offering itself either in front or in rear of the parallel, or even a little out of the prolongation of an enemy's work (provided it is on the inner side of the prolonged crest), should be taken advantage of.

Should the site of such a hill or rise be too rocky or hard for excavation, the construction of a sand-bag battery may perhaps be practicable, as described in article 60, Chapter III.

Should the fire of the faces of any of the works, the prolongations of which fall beyond the sphere of the first parallel, become troublesome, batteries for subduing these defensive works, by a direct fire, must be established: for instance, if the fire from the right face of bastion D, disturbed the offensive proceedings, battery, *z*, would be erected to act against it by a direct fire of heavy iron guns and a vertical fire from mortars.

162. On the morning after breaking ground, the engineers determine the positions in the parallel for the construction of the batteries to be raised to subdue the fire of the place: the situations for the ricochet and enfilade batteries are fixed at the spots where the prolongations of the faces of the various works (that command the ground to be passed over) fall into the first parallel; and those for direct fire are opposite to the faces to be counter-battered. See Plate IV.

It is of the utmost consequence to complete the batteries on the first parallel as soon as possible, that the fire of the defences may be checked and subdued by the combined efforts of the enfilade, ricochet, direct, and vertical fires, of the besiegers' batteries. It is impossible to push on the trenches of attack until the artillery fire of the place is subdued by the superior fire of the assailants' batteries on

the first parallel: hence every effort is made to effect this object. The first parallel then becomes the base on which all the batteries are constructed, as No. I., II., III., IV., V., VI., VII., VIII., IX., Plate IV. The reader is referred to articles 50 to 61, Chapter III, on "Field Fortification," where the construction of the offensive works in a siege is fully entered into. Articles 51 to 61 fully detail the different kinds of batteries suited for various purposes and sites. In Plate IV., the left of the first parallel passes over a slight rising ground: the soil of which is supposed to be a sandy gravel, and suited for sunken batteries. Hence battery VI. to enfilade the left face of ravelin C, battery VII. to enfilade the right face of ravelin F, and battery VIII. to enfilade the left face of bastion A, being on this rising ground, are all sunken batteries. The remainder of the batteries on this parallel (except No. III.) are elevated batteries.

Some of these batteries may subsequently have to be removed and placed further in advance; but it is most desirable that they should act efficiently against the defences from the first parallel, because at this distance they are, 1st, out of the range of the musketry of the defensive works, and the gunners are therefore liable to fewer casualties: 2nd, sorties are not likely to be successful against these distant batteries: 3rd, the guns and ammunition are more easily brought up.

163. While the arming and practice of the batteries is going on, the engineers prepare for pushing the trenches towards the place. These are constructed in a zigzag direction; so that, when prolonged, they shall fall clearly without all the defensive works, that they may not be enfiladed. These trenches cross the capitals of the ravelins and bastions alternately to the right and left. Here they are not exposed to the direct fire of the works, towards which they advance; and also, it may be observed (by examining the directions of the fires from the various batteries on the first parallel in

Plate IV.), that the zigzags are in situations where they interfere less with the fire of the batteries than if constructed anywhere else: the capitals of the defensive works also, are the shortest lines on which these zigzags can be advanced. The parapets of the zigzags being oblique to the general outline of the fortress, frequently require a greater height than those of parallels, in order to cover their trenches perfectly.

By examining the zigzags, it is seen that there is a return at the extremity of each of 25 or 30 feet in length, by which the troops in filing out of one zigzag into another are covered, not only in flank, but in front: this return also is useful for collecting tools, materials, &c.

As the zigzag trenches are merely intended as covered communications from one parallel to another, they are not always furnished with a banquette; and as they only present the parapets obliquely to the fire of the place, there is no necessity for a greater thickness than 12 feet to the whole parapet at the base.

The zigzags are pushed on till they arrive nearly within the reach of the musketry fire of the place, or within about 300 yards of the salients of the covered-way; but they are never constructed beyond the efficient range of the musketry of the place of arms, or parallel in their rear, that has to support them.

(In drawing a plan, the zigzags of approach between the first and second parallels are directed to points about 20 yards beyond the foot of the most advanced front of the glacis. Between the second and demi-parallels, they are directed to the foot of the most advanced glacis: and beyond the demi-parallels, half way up the glacis.)

One of the errors of the old method of attacking fortresses was, that of establishing the first parallel as just described, and pushing on the zigzags to the foot of the glacis, unsupported by parallels; in consequence of which the sorties

from the place had only to act against the guard and workmen that occupied the head of each approach, and were therefore generally successful in destroying the work, and greatly retarding its progress.

Vauban first introduced the enveloping parallels; the second within musketry range of the first; and the third and fourth between the second and the glacis; so as always to afford the approaches not only a good close fire, but a strong guard at hand, to repel any attempt made to interrupt the work by sorties. The assailant should always have a parallel, or a place of arms, nearer the head of his attack than the enemy, in order to give it support. Hence, in Plate VIII., it is to be observed that portions of parallel, N N, are constructed when the approaches have advanced about 150 yards; these portions of parallel, or places of arms, are to receive part of the guard of the trenches, in order to support the workmen efficiently.

When arrived within the range of the musketry of the place, it becomes necessary to construct the trenches with greater care and caution, and to proceed by sapping. See articles 62 to 64, Chapter III.

164. The execution of the second parallel is generally by the flying sap: its distance is within the extreme range of the musketry of the covered-way of the place, or 300 yards; Plate IV.

The tracing of the first parallel having been carefully made, the true distances from the salients of the place must be fixed; and it must embrace all parts of the fortress that look upon the march of attack; in tracing the second parallel, guided by the plan of attack, points on the first parallel are marked at equal distances from each other; engineers start from these points, walking upon some fixed objects till they have paced 300 yards; they then connect their positions by white tapes picketed down.

The working parties assemble at the engineers' depôt

before dusk, where their tools are arranged in columns, behind which the divisions file : each man carries 2 *light* gabions and his entrenching tools, a spade and pickaxe ; he afterwards works behind his pair of gabions : the working party is preceded by a covering party having an advanced chain of sentries : the whole supported by battalions in the most advanced zigzags or approaches : each engineer conducts his men (in the manner described in Sir John Jones's note), and sees their gabions placed close together at 2 feet beyond the white tape : the men then lie down till the engineers have ascertained that the whole is connected and ready ; when, at the appointed signal, the excavation begins : the gabions should be filled and musket-shot proof in fifteen minutes, after which the earth excavated is thrown beyond the gabions to form the parapet ; ample cover should be obtained by daylight next morning, as well as a respectable width of trench finished, as each has only the breadth of two gabions (about 4 feet) to excavate. (This process is called the flying sap).

The second parallel will probably be excavated on the fifth or sixth night.

The parapets of the second parallel, as well as those of all the other parallels nearer to the place, must have sufficient thickness to resist the fire of the artillery of the place : the first parallel from its great development is a mere screen and covered post, and an enemy would not waste his ammunition by attempting to destroy it : but were he to concentrate his fire upon some particular suspected spot of the second parallel, which is often much less than the first in its extent, and within 300 yards of his guns, the communication might be seriously interrupted ; consequently its parapet must be reveted interiorly and solidly, as seen in fig. 3, Plate I. On the night of constructing the second parallel, some zigzags of approach beyond it may be traced and executed by the flying sap : but, from the proximity of the place, few

opportunities will afterwards present themselves for this expeditious mode of construction, unless the fire be very slack indeed.

At page 208, vol. ii., Sir John Jones says, that "At St. Sebastian, the sappers, finding the fire from the place very slack, contrived to push on the approaches more rapidly than usual, by a mixed nature of flying and full sap; that is, the sappers advancing on their hands and knees, placed one empty gabion after another, till a small row was formed: then two or three sappers placed themselves behind the empty gabions at good distances from each other, and sitting at their work, each formed a small hole for himself, and with the earth from the excavation filled the gabions in his front; after this, the sappers severally worked towards each other, till the whole row of gabions was filled and a trench formed along their rear. This mode of proceeding would probably facilitate the reduction of a small detached work, the artillery and musketry of which was well kept under, but would not be generally found practicable under a smart fire."

The second parallel need not be of such an extent as the first; and it is customary to protect its extremities by forming redoubts to contain a few pieces of light artillery, and a strong detachment to repel sorties: the rear faces of such redoubts not being exposed to the fire of the place, need not be of so strong a profile as the front faces: Plate IV.

Instead of a redoubt, the extremity of the second parallel may be continued in a defiladed curve to the rear to join the first parallel, or joined by zigzags of approach, as seen in Plate IV.; which has the advantages of shutting in all the ground between the parallels, and of giving an additional trench of communication, which may prove of importance in reinforcing the troops in the second parallel, if attacked by a strong sortie.

If the defence be not very active, neither of these methods need be resorted to, but the extremities left *en l'air*, or

open; terminated at the points 43 and 46, so as to be clear of the fire of the batteries, No. II. and VIII.

165. If the ground between the first parallel and the place be level, the second parallel will not interfere with the fire of the ricochet batteries on the first parallel: for the guns being fired with an elevation, the second parallel will be nearly under the trajectory, or highest part of the curve described by the flight of the shot. But should the localities of the ground cause the second parallel to mask the fire from the batteries on the first, fresh batteries must be constructed in corresponding situations, and for like purposes, on the second parallel; and the guns removed into them. The dotted outlines marked 2, 4, 5, 5′ 6, and 7, indicate the positions of the new batteries to receive the ordnance from batteries II., IV., V., VI., and VIII. If necessary, the batteries for direct fire must also be removed to the second parallel, from which the practice will be much more powerful and correct. The second parallel being at 300 yards from the defensive works, it is probable that some of the short faces or flanks (the prolongations of which could not be distinctly seen from the first parallel,) may be discovered and their crest prolonged, and marked: such as the flanks of the bastions, the faces of redoubts, &c.; for example, in Plate IV., the right flank of bastion B and the left flank of bastion A, which have finally to be silenced by the counter-batteries XXVIII. and XX.), might each be enfiladed by an 8-inch howitzer from batteries 47 and 48 *in* the second parallel. It is true that short ramparts and parapets are difficult to enfilade; but as each of these flanks is 50 yards in length, an occasional shell bursting from batteries 47 and 48, against the defensive guns, would help materially to injure them, and aid in their final reduction.

Under all circumstances, the fire from the batteries must be unremitting, and amply sufficient to keep under the fire of the defences; for all the trenches beyond the second

parallel are formed by the sap, which cannot be conducted against the fire of artillery.

166. As the approaches draw nearer the attacked place, it becomes more and more difficult to defilade the branches of the zigzags, especially if the front of the enemy's works be extensive (or on a high polygon), without making the alternate angles inconveniently acute. It then becomes necessary to advance in a straight line by the *double sap*. Chapter III., articles 64 and 65.

The zigzag approaches, either by the flying or single sap, are pushed on from the second parallel, till they reach within 150 yards of the crest of the glacis of the place: here it becomes necessary to establish *demi-parallels*, or portions of parallels, to contain strong guards to protect the further progress of the work, and to answer the enemy's musketry, which is done through loop-holes, formed by sand-bags. These demi-parallels are either straight or formed in a curve, extending so as to embrace the prolongations of the covered-way before the attacked works; see Plate IV.: at each extremity of the demi-parallel there is a battery of one howitzer (battery X. to XV.) on the prolongations of the branches of the covered-way, in order to enfilade and ricochet them; and to keep down their fire as much as possible, by tearing up their traverses and clearing their banquettes, these howitzer batteries are sunken: that is, they are formed in the demi-parallels, in order that they may not mask the fire of the batteries in their rear. It may be observed, in Plate IV., that there are six branches of the covered-way crowned from T to U. In order to enable the assailants to do this, the defenders must be entirely driven out of the covered-way, and those howitzers at the extremities of the demi-parallels are for the purpose of completely clearing the terre-plein of the covered-way.

167. From the demi-parallels the sap is continued on the three capitals as far as it can be carried in a zig-zag direction;

but when the zigzags become too multiplied, the double sap must be resorted to, as seen in Plate IV.; when the saps on the three capitals have reached the foot of the glacis, they break into single saps, and deploy to the right and left to connect their work together, to form the *third parallel.* In all this work the guard of the trenches must follow close upon the sappers, and that in the demi-parallels and second parallel must be prepared to meet sorties that may now be expected to attempt to destroy or retard the work, so near to their covered-way. As soon as the third parallel is sufficiently advanced, batteries of small mortars or pierriers are placed in it wherever they may be required, in order to shower into them grape or hand-grenades (see Plate IV., batteries XVI. to XIX.): so that with the fire of the mortars and howitzers in the demi-parallels, and the batteries on the first parallel, the defenders may be quite overpowered. These batteries for $5\frac{1}{2}$-inch brass mortars are placed on the capitals of the re-entering places of arms, which places they are intended to shell, as well as the flanks of the bastion.

A strong guard occupies the third parallel, to keep under the musketry fire of the place and sustain the workmen.

The foot of the glacis being about 8 feet beneath its crest, 19 feet beneath the crest of the ravelin, and 22 feet below the crest of the enceinte, the third parallel will not mask the fire of the artillery behind it.

It now becomes necessary to seek for the defensive mines, for it will be needless and destructive to attempt to push on the sap, until the ground below has been secured.

168. *To advance by sap to crown the covered-way.* If the attack has been successfully carried on, and the weather has been such as not to fill the trenches with water and to delay the work, it is customary to calculate upon completing the third parallel about the *twelfth* night after opening the trenches: and if the safe process of sapping regularly up to the crest of the glacis be followed, instead of the attack *de vive force*, it

may begin about the twelfth or the thirteenth night, by striking out single saps, (Plate IV.,) about 30 yards on each side of the capitals of the two ravelins and the bastion attacked, and carrying them forward in the curved direction therein shown, so as to meet about 20 yards up the slope of the glacis; these *circular portions*, S, S, S, are defiladed from the fire of the place by their curved shape; and from them double and direct saps, with proper traverses, are carried forward, till they arrive within 20 feet of the crest of the glacis; double saps have also been pushed forward at the same time from the third parallel along the capitals of the re-entering places of arms, until they reach within 20 feet of the crest of the glacis: here all the double saps break into single saps, and proceed to connect their work together, and to extend their lodgement from T to U, forming traverses, as seen in the tracing, to shelter the trenches from reverse or enfilading fire. The length of these traverses depends on the projection of the neighbouring works still manned by the enemy.

Formerly, during the process of this advance from the third parallel to the crest of the glacis, the assailant constructed great elevated masses on the glacis, in order to obtain a musketry fire from a superior height to the covered-way: these masses were called *trench cavaliers*. They were made at 30 yards from the crest of the glacis, see the dotted circular portions 39, 39, fig. 79, Plate IV.: this distance of 30 yards, or 90 feet, being rather greater than men can throw hand-grenades.

A profile of a trench cavalier is seen in Plate II., fig. 69, where the second tier of gabions may be supposed to be above the level of the glacis, and the lower tier, below that level and occupying the original trench at the place of construction. Such an immense profile, having a total height of 12 feet, and requiring so great a quantity of gabions and fascines, and involving in it so much labour and time, as well

as serving as a conspicuous mark for an enemy, cannot be recommended. The defenders, however, must be driven out of the covered-way, ere the assailant can form his lodgment on the crest of the glacis; and the object of the trench cavaliers is to give so commanding a position as to enable an assailant to look into and drive the defenders out of the covered-way: but this can be done more effectually by the fire of artillery than by that of musketry. Each branch of a trench cavalier having usually a length of 36 feet, cannot give a stronger fire than 12 men from its crest; whereas an 8-inch howitzer, placed in a parallel or in a demi-parallel, in order to enfilade a branch of a covered-way, projects at each round a spherical case-shot, carrying 380 musket bullets. Moreover the branches of the whole of the covered-way, from T to U, Plate IV., having been enfiladed by the constant fire of the first batteries from their first establishment, and by a succession of common shells and spherical case, as well as being exposed to a vertical fire of shells, and subsequently from the demi-parallels, there can be no need of such works as trench cavaliers; which, in addition to all their other defects, would mask the artillery practice from the batteries in their rear.

As, soon, however, as the saps reach the crest of the glacis, the fire of the distant batteries must be very carefully conducted. The range of the shells from the mortars being accurately known, their fire can be carried on with little interruption: also from the whole of the ordnance of batteries, No. I., III., VII., and IX. But the rest of the guns must fire only according to their opportunities and circumstances.

169. *The counterbatteries*, XX., XXI., XXVII., XXVIII., Plate IV., are to counterbatter such of the remaining defences that may be still active upon the flanks; these flanks, however, will have previously suffered greatly from the enfilade fire of the guns, howitzers, and mortars from the various

parallels. It is absolutely necessary completely to overcome the flanking defences of the place that the ditches may be crossed in security. The traverses on the branches of the covered-way that mask the fire must be either cut or blown away, that the guns may have a free range. In those parts of the crowning of the covered-way, where it is necessary to place batteries of artillery, the trench in rear of the parapet should have a breadth at bottom of 24 feet, but elsewhere not more than 12 feet (unless earth be required to construct the parapet, which from the slope of the glacis to the rear is likely to be the case); and traverses must be constructed wherever it may be necessary, in order to cover its interior from flanking fire, or to afford shelter from bursting shells. When batteries XX. and XXVIII. have silenced the flanks against which they fire, and beaten down the defensive parapets (as indicated in fig. 103), their fire can be brought to bear upon any entrenchments in the bastions A and B, and aid in their reduction.

At the salient places of arms before the ravelins attacked, the counterbatteries XXIV. and XXV. are constructed to silence the defences that flank the ditch of the ravelin: thus the besiegers obtain a full command of the ditches on the fronts attacked, and by keeping the fire of the defensive works under, the operation of crossing the ditches and taking possession of the breaches becomes a comparatively safe proceeding. The batteries XXIV. and XXV. having obtained the superiority over the defences, become breaching batteries; and the ditch of the ravelin being entirely under their command, the besieger may descend into it, when it is dry, and sap along its bottom towards the breaches. The counterbatteries XX. and XXVIII. should take care to beat down the crest of the tenaille (between the bastions A and B), and ruin its parapet; else the defenders placed on this work would bring a powerful musketry fire into the ravelin and upon the main-ditch at the time of assaulting the breaches.

170. *Breaching batteries,* No. XXII., XXIII., and XXVI., are constructed on the crowning of the glacis opposite to such portions of the faces of the works as are selected for that purpose, in order to breach the revetments to make them fit either to assault or to carry the saps up their slopes. After breaching, should the soil of the rampart stand stiffly, large shells filled with powder, having long fuzes, thrown in, will act as fougasses and bring it down; the breaching batteries must be in action by night as well as day, to keep the enemy from stockading the breach, or rendering it impracticable.

When the lower part of the revetment cannot be seen sufficiently from the breaching battery on the crest of the glacis to make an effectual breach, it must be established upon the terre-plein of the covered-way.

The combined fire of these batteries on the crest of the glacis must uncover the interior of the enemy's works as much as possible, by destroying the parapets; and assisted by riflemen from loop-holed cover of sand-bags, &c., the enemy must be quite kept down. The defenders must have no rest; the unceasing, irresistible, and concentrated fire of fifty pieces of artillery from the first parallel, followed subsequently by the fire from the powerful howitzers on the demi-parallels, from the mortars on the third parallel, and, lastly, from the counter and breaching batteries upon the crest of the glacis, will effect this; this fire also will be aided by that of the extreme batteries on the first and second parallels, and by the fire of the howitzer and mortars on the demi-parallel and third parallel (but the fire from the ricochet batteries on the first and second parallels, will be greatly, if not entirely, masked by the crowning of the covered-way).* This combined fire is of a nature so overpowering, tearing up and destroying everything opposed to

* "In consequence of the establishment of the breaching and counter-batteries, and the boyaus of communication crowning the two glacis, it was necessary to stop the fire of several of the breaching

it, that the operation of seizing the other works will be far less destructive than is, at first sight, imagined.

It is calculated that by the *fifteenth* night the counter and breaching batteries can be finished and armed; and the descents into the ditches commenced opposite to the breaches.

171. *Descent into the ditch* (*i k*, *p r*, and *q t*, in Plate IV.) This is by a subterranean gallery, whenever the counterscarp is sufficiently elevated to preserve a covering of five feet between the top of the gallery and the terre-plein of the covered-way: miners deem this the least thickness necessary, overhead, in driving a gallery in ground of ordinary tenacity, that the soil may not break in and render the execution of the work too slow and difficult; besides which, it is necessary to protect the top of the gallery against vertical projectiles.

The dimensions of the *descending gallery* (see article 79, Chapter IV.) depend upon the use that is to be made of it: if artillery is to be used in reducing the inner works, the retrenchments, &c., and that guns have to be passed through this gallery, it must be large enough for the purpose, that is, 7 feet wide by 6 feet 6 inches high. If the gallery be only for the passing of troops to the assault of the breach, &c., less dimensions will suffice; viz., 6 feet high by 4 feet wide. The gallery usually opens at the bottom of a dry ditch, and at 15 or 16 inches above the highest level of the water in a wet ditch. It ought to be driven as much as possible in a straight line, since changes of direction are of slow and difficult construction, and render the communication less commodious: the base of the gallery should be at least equal to four times the height; but it is not indispensable that this slope be uniform in the whole extent of the descent. The commencement of the descending gallery is usually from

batteries in their rear, and to confine the discharge to that of mortars and howitzers."—"*Relation of the Siege of Antwerp*, in 1832." *Vide* "*United Service Journal*," No. 52.

some of the trenches or saps, a little in rear of the crowning of the covered-way; and to prevent the assailant from seeing the process, it is made behind a sap or traverse. In Plate IV. the beginning of the descent into the ditch of the ravelin, at *p*, is protected and covered by the traverse, *l*.

When, however, the fire of the defensive works has been fully subdued and is quite kept under, the parapets destroyed, and that it is intended to assault the breaches as soon as they can be made, instead of these laborious descending galleries, three or four shafts should be sunk in the terre-plein of the covered-way, immediately opposite to the breaches, and charges lodged in chambers at their bottoms; the explosion of these will throw in the counterscarp and join the rubbish to that of the breach in the escarp: the explosion being the signal for the storming parties to advance: *x*, *x*, *x*, *x*, Plate IV., is intended to embrace the space thrown down by the explosions.

Passage of a dry ditch. When the ditch is dry, this passage consists of an ordinary sap, pushed from the opening of the gallery of descent to the slope of the breach, as at *t*, bastion B, fig. 103, Plate IV., and, when necessary, it is carried on to crown the summit of the breach. In crossing a ditch protected by the fire of the counter and breaching batteries, the interruption to the work from the defences cannot be very vigorous, and a single sap will suffice, having its parapet on the exposed side. If it be intended to storm the breaches at once, no sap is required across the ditch.

If the ditch be full of water, and the locality favours the draining of it, every means must be used to break the batardeaux to cause the water to flow away, if not altogether, at least in part; and should none of the batteries on the crowning of the glacis, or those formed in the covered-way, be able to see the batardeaux, these sluices must be sought for and destroyed by large shells, or, if possible, galleries for

mining them must be driven from the nearest part of the establishment on the covered-way.

Should the ditches be subject to the ebbing and flowing of the tide, the destruction of the batardeaux will at least secure to the assailants the advantage of having the ditches dry, or nearly so, for the periods of low tide; and thus facilitate the means of crossing, either by permitting the storming party to assault the breach at low water: or, if the slower and surer mode of making a causeway across be followed, the foundation of it can be more securely laid.

If the assailant has not the means of arresting the current of the water, or of draining or turning it, it becomes necessary to construct either a bridge or a causeway, with a solidity amply sufficient to prevent it from being carried away. This operation is one of the most difficult in the siege; it is even impossible to execute it unless the defences of the enemy be totally ruined by a correct and well sustained fire from all the batteries.

The dyke or bridge, with its epaulement, is constructed with fascines, hurdles, joists, gabions, and sand-bags. When the water is stagnant, this work is conducted to the foot of the breach; but when it is running, or can be made so, an issue is left for it at the foot of the breach, of from 18 to 25 feet, across which a float of rafts is thrown to complete the passage; and openings are left in different parts of the work or causeway to allow the free flow of the water.

General Sir Charles Pasley's method of crossing a wet ditch. The following experiment was tried successfully at the Royal Engineer Establishment for Field Instruction at Chatham, by order of General Sir Charles Pasley, K.C.B., F.R.S, &c.:—Two hundred large casks were prepared; their heads taken out; they were lashed by fours, end to end, so as to form hollow piers, about 18 feet in length, and of unequal diameters, in consequence of the unequal diameters of the heads and bungs. Each pier was launched

in succession from a great gallery, representing that of the counterscarp in a regular siege. These piers had guys at each end, by which they were hauled round into their intended position, and there sunk by means of sand-bags. In this manner, a piece of water, representing a wet ditch, was bridged over by these hollow piers, with great ease and expedition. After which the intervals between the upper tiers of casks were filled with long fascines, where they rose above the surface, and others were laid over these at right angles, till a general level was obtained, when strong skids were laid over all, and a 24-pounder, on a travelling carriage, was dragged through the gallery and passed along these skids to the other side of the water. This experiment was afterwards tried with full success in the Mast Pond of Chatham Dockyard, where a very strong current was produced, much more so than could exist in the ditches of any fortified place. There was no perceptible depression in the bridge as the 24-pounder passed over.

The same experiment was tried with common gabions, lashed together, end to end, in the like manner; and forming hollow piers or cylinders, which being similarly sunk until they rose above the water, were covered with fascines and skids: this, also, bore a 24-pounder, causing a depression of more than six inches in the part over which the gun was passing. The gabions were very weak and old.

These piers of casks were fastened as follows: on being placed end to end, staples were driven into each cask, about ten inches from each end, in three equidistant parts of its circumference: strong spun-yarn, connecting these staples, lashed the four casks together. Six or eight bushel sand-bags were necessary to sink each pier with ease, yet without making it sink rapidly. To get them into the water, they were launched on ways made of planks. (Each cask weighed on an average 141 lbs.)

In making the gabion bridge, each pier consisted of four

gabions lashed endways together, as the casks, by spun-yarn, at three equidistant points of the circumference: these were not loaded to make them sink. It was found, from the irregularity of their surface, that the second pier merely forced the first out from the bank to make room for itself; the third the same, and so on, until tiers of gabions connect the two scarps floating on the surface. On rolling other piers on the top of them, the lower ones sunk to the bottom, and fascines and brushwood were laid in the bites of the gabions to form a level surface.

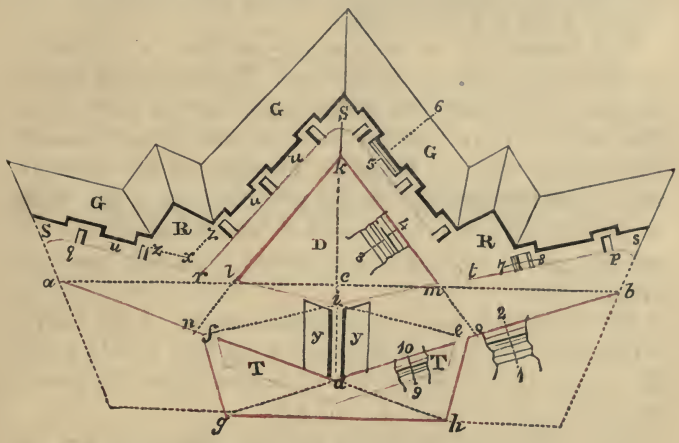
By the breaching experiments made at Metz, in 1833, the base of the rubbish, brought down by the batteries, measured from the foot of the escarp along the bottom of the ditch, never amounted *to twenty-five feet*, after every means had been resorted to, by a horizontal fire of shells, to render it as level as possible: the revetment was 21 feet high.

On the completion of the passage of the ditch, the breaching batteries render the breach as gentle and practicable as possible either by round shot or shells, as required; a few brave and intelligent sappers glide up the breach and reconnoitre the interior of the work, under vollies of uncharged shells, and blank cartridge. Officers or intelligent non-commissioned officers should fully and strictly examine the breaches, especially at night: their reports of the interior defences or retrenchments, will probably determine the officer in command as to whether it is proper to storm the breaches, or to proceed to crown them by the sap, and construct batteries within them against the retrenchments.

T. C. Johns, Printer, Wine Office Court, Fleet Street.

Appendix to MAJOR STRAITH'S *Introductory Essay to the Study of Fortification.*

ONE FRONT OF VAUBAN'S FIRST SYSTEM.



TO CONSTRUCT A FRONT OF VAUBAN'S FIRST SYSTEM.

Take a scale of equal parts, and use it as yards and feet.

Draw *a b*, is the exterior side .....360 yards.

c d, the perpendicular, divides *a b* into two parts ..... 60 do.

Draw *a d h* and *b d g*, the lines of defence.

Make *b e* and *a f*, faces of bastions, each.....103 do.

Place one leg of your compass at *a* as a centre, stretch the other to *e*, and carry it to *h*; do the same from *b* to *f*, in order to get *g*: *e h* and *f g* are the flanks of bastions. — The flanks are each about 54 yards in length.

Join *g h* for the curtain ..... about 140 yards in length.

This line of works *a f g h e b* is the enceinte or body of the place.

In order to get the main-ditch, take *a* as a centre, and with a radius of 30 yards describe an arc; then from *e* draw a tangent to this arc, which will give the line *e i l r q:* do the same on the other side, to get the line *f i m t p:* these lines form the counterscarp of the main-ditch.

Thus the enceinte, with its main-ditch, is complete.

Outworks. For the ravelin D, make the capital *i k* equal to 100 yards; direct the faces *k l* and *k m* to points *n* and *o* at 10 yards from the shoulder angles (*f* and *e*) of the bastions; the counterscarps *r s* and *t s* are parallel to the escarp *l k* and *m k*, at 20 yards.

The covered-way *u*, *u*, *u*, *u*, has its crest at 10 yards parallel to the counterscarp all round. The re-entering places of arms, R R, have demi-gorges, *x z*, *x z*, of 30 yards each. The faces of the re-entering places of arms form angles of 100 degrees with the adjoining branches of the covered-way. The traverses are on the prolongations of the faces of the bastions and ravelins, and at the entrance of the re-entering places of arms of the covered-way, with passages around them.

The tenaille T has its master-line, or top of the escarp revetment on the lines of defence (*a h* and *b g*); it is 16 yards thick; and its extremities are at 8 yards from the escarp revetments of the flanks (*f g* and *e h*).

The double caponier *y*, *y*, in the dry main-ditch, has its crest at 3 yards on each side of the perpendicular (*c d*), and the foot of its glacis parapet is 20 yards from its crest, with a passage of 9 feet from the gorge revetments of the ravelin.

Observations. The thick red lines indicate the top of the revetment or escarp walls; the thin red lines, the top of the counterscarp walls. The thick black lines indicate the crests of the parapets. Portions of ramparts and parapets are put in rear of the revetments of the face *b e* of the bastion; of the face *k m* of the ravelin; and of the right face of the tenaille: sections on 1, 2; 3, 4; 9, 10; taken across these lines, as also on the line 5, 6, are shown in fig. 105, Plate IV: a section on 7, 8; is that of a common parapet and banquette. as fig. 61, Plate II.

The principles upon which the front is constructed, are given in Chapters VIII. and IX.

Erratum. At page 137 of the Essay, line 16 from the top, for fig. 103, read fig. 102 A.

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