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NOTES ON THE CONSTRUCTION AND EQUIPMENT OF TRENCHES

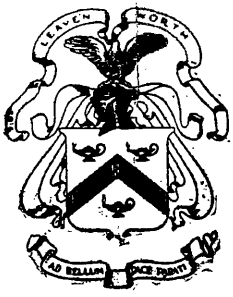
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APRIL, 1917

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WAR DEPARTMENT,

DOCUMENT NO. 592.

Office of The Adjutant General.

WAR DEPARTMENT,
WASHINGTON, *May 16, 1917.*

The following Notes on the Construction and Equipment of Trenches are published for the information of all concerned.

[2602979, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

TASKER H. BLISS,
Major General, Acting Chief of Staff.

OFFICIAL:

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The Adjutant General.

CONTENTS.

	Paragraphs.
Trench terminology	1–8
Modern developments	1–3
Intrenched zone, description and details	4–19
Supporting points described and illustrated, Plates I and II	20–24
Additional intrenched zones	25
Selection of site, including preparation	26–35
Profiles, firing, communicating and approach trenches	36–40
Traverses, classes, advantages and disadvantages in trenches	41–42
Head cover, definition and method of securing	43
Overhead cover, classes and description, including cave shelters	44–49
Revetments, necessity for, and methods	50–57
Drainage of trenches and shelters	58–60
Latrines, location and systems	61–62
Obstacles, tactical use, requisites, kinds, and construction methods, including obstacles in approach trenches	63–72
Defense of buildings, advantages and methods of preparation	73
Construction of trenches, under fire, at night, details	74–81
Employment of engineers	82
Training in field fortifications, necessity for, of troops to occupy the trenches	83
Equipment and maintenance field fortifications, requisites and provision for	84–105
Notes on field defenses	pp. 55–64
Appendix I. Consolidation of trenches	pp. 65–95
Appendix II. Wire entanglements	pp. 97–102
Plates I to V	pp. 103–108

NOTES ON THE CONSTRUCTION AND EQUIPMENT OF TRENCHES.

MODERN DEVELOPMENTS.

1. The name field fortification was originally applied to that class of measures taken for the defense of positions intended to be held temporarily. In the present European war, however, temporary positions have often been occupied for such long periods that their fortification has acquired many of the characteristics of permanent works or siege works, resulting in a development of the art which we seek to describe by the term "trench warfare" or "position warfare."

The principles of field fortification or field intrenchment have not changed, but many extensions, adaptations, and new applications of existing principles have been developed in the European war.

2. The developments to be noted are due to the following main causes:

(*a*) Improvement in artillery; longer ranges; heavier projectiles; high explosive shells; special use of shell and shrapnel in demolishing earthworks and cutting wire entanglements; vast number of guns and enormous expenditure of ammunition; skillful indirect fire.

(*b*) Improved methods of observation and communication; balloons, airplanes; photography from aircraft; telephones; wireless telegraphy; motor transportation.

(*c*) Continuous intrenched positions with unassailable flanks.

(*d*) Long continued occupancy of field works at all seasons of the year.

(*e*) The construction of intrenched positions in localities of great diversity as to topography, character of soil, geology, vegetable growth, and drainage.

(*f*) The close proximity of the opposing lines of trenches.

(*g*) The use of new devices and methods of attack such as grenades, trench mortars, poisonous gases, inflammable liquids, intense artillery bombardment, barrier fire, machine guns in great numbers, and many accessories developed as the result of the continual reaction between the attack and the defense.

3. The most conspicuous changes that have resulted in field fortification are:

(*a*) Less extensive field of fire.

(*b*) Greater importance and corresponding greater difficulty of concealment, involving use of screens, dummy trenches, hidden emplacements, and covered approaches.

(*c*) Deeper and narrower trenches.

(*d*) Greater use of traverses and parados in firing trenches.

(*e*) The use of many support and cover trenches generally parallel to the firing trench and not very distant therefrom.

(*f*) More numerous communicating and approach trenches, screened and defiladed, forming with the firing, cover, support, intermediate, and reserve trenches a labyrinth of trench work known as the "first intrenched zone."

(*g*) Increased use of cover.

(*h*) Provision of shelter for men in cover, support, intermediate, and reserve trenches, and in deep underground bombproofs or "cave shelters," safe against powerful artillery fire; less elaborate shelters in the walls of the cover and support trenches and sometimes in the firing trenches.

(*i*) Extensive use of strong points and supporting points in the first intrenched zone.

(*k*) Provision for the defense of the communicating and approach trenches against flank attack by hostile forces that may have broken through the front lines.

(*l*) A second intrenched zone some 2 or 3 miles in rear of the first zone, generally on the reverse slope of a crest or ridge, and connected with the first-zone trenches by sheltered approaches, natural or artificial.

(*m*) Intrenched zones still further to the rear for possible occupancy in case of defeat or retirement.

(*n*) Increased use of obstacles, especially barbed-wire entanglements.

(*o*) Increased use of mines and countermines.

(*p*) Accessory special measures to prevent surprise and to resist special methods of attack.

(*q*) Systematic measures to prevent confusion and going astray of troops moving in the maze of trenches, by day and by night, such as guideposts, lights, maps, names of approaches, and shelters.

(*r*) Routine measures of maintenance, convenience, and comfort due to the long-continued occupancy of the trenches, such as revetment, drainage, heating, food supply, water supply, ammunition supply, and sanitation.

GENERAL DESCRIPTION OF AN INTRENCHED ZONE.

4. The "first intrenched zone" includes the foremost firing trenches and the cover, support, intermediate, and reserve trenches. An obstacle, continuous except for narrow passages for patrols, is in front of the firing, support, intermediate, and reserve trenches, and between strong and supporting points and approaches.

The trenches may be entirely in excavation, partly in excavation with a parapet, or the necessary cover may be provided entirely above ground level by a high parapet. The second is the usual combination with low parapet about 12 inches high. Wet ground or poor drainage may require the third type.

The front line consists usually of two parts, the firing trench and the cover and communicating trench.

5. The *firing trench* may either be a continuous trench of irregular or indented trace, traversed at suitable intervals to give protection from enfilade fire and to localize the effect of shell bursts, or it may consist of firing bays, T shaped or L shaped in plan, jutting forward from the cover or communicating trench. The latter is a continuous trench, affording easy lateral communication close behind the firing positions and connected with them at frequent intervals.

6. The *support trenches* accommodate the support to the garrison of the firing and cover trenches, the support being ready for immediate reinforcement of the garrison. They are provided with numerous shelters. The cover trenches have numerous small shelters and furnish cover to the bulk of the garrison of the firing trench when temporarily withdrawn during a bombardment, or for rest during the daylight hours when there is not much danger of an attack by the enemy. The support trenches are usually continuous in each supporting point and should be a second line of resistance protected in front by an obstacle, arranged so as not to interfere with the rapid reinforcement of the firing trench. They should be connected with adjacent supporting points by communicating trenches. To escape artillery fire directed on the front trenches, the support trenches should be not less than 50 yards to the rear, and preferably about 100 to 200 yards. Support trenches are connected with the front line by frequent approach trenches. Cover, support, intermediate, communicating, and reserve trenches may be prepared for firing at certain points for use in case the enemy breaks the front line and makes a flank attack.

7. Behind the support trenches and also connected with them by approach trenches lie the *reserve trenches*, which may consist of a line of trenches and of bombproofs, or cave shelters, often formed by

improving the cover of some natural features. The reserve trenches and shelters are to accommodate the battalion reserve, whose function is to make the local counter attack. The reserve line may be 400 to 600 yards in rear of the front line.

8. The intrenched zone may also include *local trenches*, such as the bombing trench, dug behind the firing trench within easy grenade-throwing distance of it, its purpose being to drive out by grenades an emeny who may have captured the front line. A slit trench is a very narrow trench dug off the communicating trenches for the accommodation of men during a bombardment; slit trenches are 1 or 2 feet wide and 7 feet deep.

9. An intrenched zone is also usually provided with a series of works prepared for all-round defense and surrounded with a continuous obstacle, known in our service as *strong points*, or supporting points. Their object is to break up a hostile attack that has penetrated the front line, prevent its further development, and thus facilitate counter attack. They must come as a surprise to the enemy and should be concealed as much as possible. The number on a given front will depend on the facilities offered by the ground for their concealment. The garrison must hold out to the last, whatever happens to the rest of the line. Adjacent works of this kind should, if possible, afford mutual support to one another.

10. *Approach trenches* lead to the first intrenched zone from points on roads that can be reached without too much exposure to view.

Communicating trenches and approaches have the usual zigzag trace to limit the effect of enfilade fire. They are also arranged to be used as defensive trenches and to serve as starting points for counter attacks in case the first-line trenches have been temporarily lost. They have a firing banquette at intervals from which a flank fire can be brought to bear upon the enemy if he endeavors to pass over the open ground in rear of the first line of firing trenches. At intervals along these trenches are placed supplies of obstacles to be quickly pulled into the trench to obstruct the advance of an enemy by this route. At intervals sortie steps are built to permit the defenders to debouch and launch a counter attack. A further defensive feature is the occasional elevated platform across the trench at an angle, where one or two men with hand grenades can conveniently oppose an advance along the trench.

Latrines are provided in all trenches and must be in positions easy of access and protected from fire. They are usually made in T heads at the ends of short trenches leading off from the approach, communicating, cover, or support trench.

11. *Assembly points* are former firing trenches which have been organized for a stay of several days, or they are short trench elements dug especially to hold companies during short stays, and in which the men can only sit down. Even the latter should contain water barrels and latrines, also a command post sheltered from rain, where the captain can make a light, open his map, and confer with his platoon leaders.

12. *Strong points and supporting points.*—In every intrenched zone there will be a certain number of points whose loss or occupation by the enemy will endanger seriously the rest of the line or weaken the defender's hold upon it. Other points particularly favorable for defense will also occur. Such points should receive special treatment so as to develop to the utmost their capabilities for defense and to enable the troops to hold them even after the neighboring portions of the line have been lost. If the intervals between these points are great, there should be small intermediate works. These works should be clearly designed to offer a protracted resistance, unsupported if necessary, to hostile attack from any direction, flank and rear as well as front.

The importance of the point to be strengthened, its position, and its nature generally determine the area to be inclosed. A large defended work offers a less concentrated target to hostile guns and is therefore less vulnerable, but it requires a large garrison. It is usually garrisoned by a battalion or regiment and is then called a *supporting point.* (Pls. I, II, and IV are for foreign units with companies of 200 men.)

13. The small intermediate works above referred to are generally arranged for an all-round defense. Such a work is designed to be held by a company or a half company and is called a *strong point.* This type of work should be carefully concealed and strongly constructed, or it will become a shell trap. Good bombproof cover for the garrison should be provided within the work. The garrison should be kept small and the defense provided by machine guns to as great an extent as possible.

14. The larger *supporting points* are better defended by a system of trenches covering a more extended area. The edges of such a center should be provided with defenses against attacks from any direction, these defenses consisting either of a continuous firing trench or of isolated lengths of firing trench covering every possible line of approach and connected with one another and with the works in the interior of the locality by communicating and approach trenches. Small strong points such as are described above might

well form an element of the defenses of the larger supporting point. Within the defended perimeter should be shelters for the garrison and a series of cover, support, and reserve trenches, and communicating and approach trenches, many of them prepared for firing.

In this way the interior is cut up into compartments, and the scheme of defense is so organized that even if the enemy succeeds in establishing himself at some point in the perimeter an unbroken front can still be presented to him and the defender's hold on the locality is practically undisturbed.

Machine guns play an important part in the defense, and alternative emplacements should be numerous. The siting of the emplacements should be very carefully considered, so as to disperse the guns laterally and in depth, and will largely govern the general design of the defenses. A supporting point should not offer a concentrated artillery target, and its reduction by bombardment should be a difficult and lengthy operation entailing a vast expenditure of ammunition.

15. *Villages* of masonry construction placed in a state of defense make the best kind of supporting point. (Pl. IV.) If the defense is properly organized their capture has usually proved a long and costly operation. Cellars with their roofs shored up and reinforced form excellent shelters, and good communications entirely underground can be made by breaking through from cellar to cellar. The organization of the defense of a village is similar to that described for a supporting point. The field of fire for interior lines of resistance must be improved wherever necessary by the thorough demolition of buildings and the removal or spreading of débris.

16. These strong points and supporting points should always have a continuous obstacle around them. In addition, any interior trench which may under the scheme of defense become a line of resistance should also be covered by a wire entanglement.

17. Unity of command is an important thing in the defense of one of these works, and for this reason they should be designed for a garrison of a complete unit.

18. The supporting points must be within supporting distance of each other; that is, effective infantry fire must be able to reach the middle of the interval between adjacent centers of resistance. The intervals are closed by dummy trenches so as to deceive both the aerial observers and the assaulting troops of the enemy. The attacking force will ultimately push into the intervals and may surround the supporting points, but it is necessary to capture the latter before the attack can pass on. It is stated that the power of the defense

under present conditions does not consist in holding the firing trenches or even the support trenches but lies in the ability to organize and launch the counter attack. The attack and capture of the firing trenches is not so difficult with efficient artillery preparation, but the holding of the captured trenches against a powerful counter attack from the line of trenches next further back is the key of success.

19. The commanders of sectors do not count on holding their firing trenches in case of violent attack, but always have arrangements made in every detail for a counter attack. If the counter attack fails the final resistance is made in the strong points that form the reserve trenches of the supporting point. Supporting points have been usually the cause of failure of attacks on intrenched lines in the present war. They are considered absolutely essential.

20. In the sketches illustrating supporting points the features to be especially noted are:

PLATE I.

Two companies in the firing line, one in support, and one in reserve. Double line of trenches in front line; double line of trenches in support; communicating and cover trenches behind the firing trenches of first line, support lines, and in strong points; two distinct lines of wire entanglement in front of first line; the whole supporting point divided into two longitudinal sections, each protected in flank by wire; each longitudinal section divided transversely into three parts, viz, the firing trenches, the support trenches, and the reserve trenches, each in turn completely surrounded by wire and each protected with trenches arranged for firing faced to the rear as well as to the front and flanks; passages through the wire of the first line made continuous through the two lines, but always in the reentrants.

Listening posts in front of each firing trench of the first line, placed between the two systems of wire.

Machine guns of the first line in reentrants. Those on the flanks to sweep the intervals between this center of resistance and those adjacent to it.

Communicating and approach trenches provided with firing parapets mostly facing outward toward the wire of each section of the supporting point.

PLATE II.

21. Three companies in the firing line, each with one-half in support; one company in reserve.

Wire surrounds at least two distinct portions of each company front.

Wire protects the two flanks of each communicating trench.

Wire divides the supporting point into three distinct portions.

Passages through the wire in the front line are all in the reentrants.

The supporting point is prepared for all-round defense.

The emplacements for the machine guns of the front line are in reentrants to sweep the front of the wire.

The communicating and approach trenches are arranged for firing throughout a large portion of their length.

Communicating and cover trenches extend behind nearly all of the firing trenches.

The railroad cut and fill are not prepared for defense because, for one reason, they are too well located on the general map in possession of the enemy.

22. Arrangements must be made for reconnaisance parties and for attacking columns to debouch conveniently through openings in the line of defense protected by movable obstacle. These openings must be under the fire of the support trenches.

Support trenches are from 100 to 200 yards in rear of the front-line defenses. They are not continuous as a rule. Their purpose is to limit the retreat of a fraction which may have been thrust back temporarily from the front line and to give time for the reserves to arrive and counter attack.

23. Farther to the rear is a line of strong points garrisoned by local reserves supporting the firing trenches and the support trenches and sweeping with its fire all the ground in rear of the forward lines. These strong points are less numerous and less developed than those forward and are surrounded by obstacles. The intervals between strong points are filled with obstacles arranged to allow passages for the debouching of troops in reserve when used in counter attacks; these counter attacks may be made by the garrison of the reserve trenches of a battalion supporting point or by the regimental reserves; the passages are properly covered by fire. About half the crests are furnished with loopholes and the other half with uncovered parapets, which permit at the moment of assault the most rapid fire. Machine guns and light artillery may also be used advantageously when available. It is important to direct the axis of the loopholes so that

there is no danger of firing into the adjacent supporting or strong points.

24. The reason for breaking a front or indenting a line to provide flanking fire, is that a rifleman fires ordinarily at right angles to the crest of his trench or not more than 30° on each side of such direction. Do not count too much on oblique fire, especially to the right oblique, as the latter requires a displacement of the usual position of the soldier.

25. Intrenched zones in rear of the first zone. These may consist of an intrenched zone 2 to 3 miles in rear of the first zone, usually behind a protecting ridge or crest and connected with the first zone by artificial or natural communications that furnish fairly good concealment from the enemy's view and artillery. A *more elaborate defense* may cover a zone in rear 4 to 5 miles deep in which every *point of tactical importance is fortified by supporting points as already described.* Troops occupying these points can break up the attack of a hostile force that may have penetrated the front system, delay the further advance and facilitate counter attack. They also furnish a framework on which by digging trenches connecting the supporting points a new line can be quickly constructed to hold against vigorous attack.

One or more similar zones may be constructed farther to the rear.

SELECTION OF SITE.

26. The following general rules should be borne in mind:

(*a*) Study the strong and weak points of the position and locate the line of the firing trench with due regard to the tactical requirements and the economy of men.

(*b*)The field of fire should be such as to expose an attacking enemy to the fire of the defenders in the last 200 or 300 yards of their advance. To insure this the foreground may require clearing. The experience of the present war indicates that the above width of the exposed foreground is ample and even a narrower belt is often considered sufficient with trained troops, provided it is clearly commanded from the firing points and is strengthened by a good obstacle which should also be well screened from the distant view of the enemy.

(*c*) concealment of the works and dispositions is of the greatest importance.

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

(*e*) The foreground should have obstacles to detain the attacking troops under fire and to break up their formations, but these obstacles should not afford cover for the attacker.

(*f*) Good communications should be provided within the position and over ground that may be used for counter attacks.

27. *First step.*—The first step in the preparations is to improve the field of fire, both by clearing the foreground and by taking ranges to all prominent objects. Special range marks may also be placed if time is available, and the troops should become familiar with features in front and their ranges.

Objects in or near the position that might assist the enemy in estimating ranges should be removed or altered in appearance, so as to make them less conspicuous.

The line of trenches should not be placed too near unalterable features that reveal the position of the lines or furnish good range marks for the enemy.

The stronger points in the line, that is, those more readily defended, may be villages, solid buildings, patches of timber, hills, knolls, or broken ground. These should be specially prepared for defense, as described hereafter.

28. *Firing trenches.*—The firing trenches constitute the principal defense of a position, and they are laid out in irregular lines or in groups, with intervals, according to the character of the ground. The increased importance of screening defense works from view and fire of the enemy's artillery tends to the selection of sites for firing trenches behind rather than in front of the crest of a slight ridge, provided a sufficiently clear field of fire can be obtained against hostile infantry advancing in force. The main advantage of this retired position is that it affords greater security against hostile artillery fire. It must be remembered, however, that security against artillery fire is almost entirely at the present time a matter of concealment; that is, security against observation. If the enemy has hilltops in his possession or can establish an artillery observer with telescope and telephone on high ground from which he can overlook the ridge or crest in front of our trenches, the back or retired position of the firing trench loses much of its advantage. Location of trenches in rear of crest lines should therefore include as an important circumstance the denial of dominating ground to the enemy.

Trenches on the crest or forward slope are certainly exposed to view and bombardment, but the occupation of high ground gives a feeling of superiority to the troops and acts favorably on their morale.

The forward position has also the advantage, if not too far down the slope, that the support and communicating trenches and the works in which most of the garrison live are fairly well concealed behind the crest. In offensive action the forward position offers greater facilities for observation and for the assembly of troops for the assault close to the front line and unobserved.

Special conditions may justify the deliberate choice of the retired position behind the crest. If adopted, arrangements must be made to deny the enemy access to the crest of the hill and to secure it for ourselves. The firing trench must not be too far down the reverse slope; 50 to 100 yards from the crest line will usually be far enough and gives a sufficient field of fire if machine guns are numerous and well located, and there must be an ample number of saps forward to the top to allow of continuous observation of the forward slope. With these precautions and readiness to deliver an immediate and vigorous counter attack on the enemy if he appears on the crest, the retired position may sometimes be taken up when conditions impose a temporarily defensive attitude and local superiority in artillery is with the enemy. But if the two lines remain facing each other on the same ground for a protracted period it will be impossible to prevent the enemy from ultimately establishing himself on the crest unless it is included in our line. The location selected should be such as to conceal and shelter the defender's reserves and communications.

29. The soldier, in attack, first learns to make use of existing cover and then to improve same when there is time. Where he has to advance over ground devoid of cover and is halted by the enemy's fire he will have to make for himself individual cover as rapidly as possible, using his intrenching tool. With this he may make a shallow rifle pit in which he can lie, the earth thrown up in front protecting his head and shoulders while firing.

If compelled to hold the line where he has been halted, he may improve this rifle pit to a kneeling, sitting, or standing trench. These individual shelters may be then connected and finally an intrenched zone develops from the first series of simple pits. Some of the first positions in the western Europe arena were thus occupied, and by successive efforts of each side to get better ground they were gradually altered until an equilibrium was fairly established and the more permanent lines elaborated.

The location is often determined under these circumstances by the line at which the troops are forced to halt by the enemy's fire and to dig themselves in.

This line may in some cases be a hostile trench captured in the course of the attack.

Small adjustments of position may be made by the officers with a view to getting the best line possible under the circumstances, but the men as a rule start at once to get what cover they can with the intrenching tool. Officers with the front lines should study the ground ahead of them at every opportunity and endeavor to recognize the minor features of real tactical importance. Generally, if the check is merely temporary and it is intended to resume the advance at the earliest possible moment, all ground gained should be held except for very minor adjustments, unless some portion is clearly untenable against counter attack; if, however, strategic or tactical considerations require a temporary abandonment of the forward movement and the construction of a defensive line to be held for some time, the decision will be governed to a great extent by the same considerations as already discussed in taking up a line deliberately, and it may be advisable to give up ground on some parts of the front.

The siting and construction of a trench in the presence of the enemy and under fire is influenced by factors which are absent in the deliberate and undisturbed choice that can be made when preparing a rearward line. The two problems are quite distinct and call for different methods.

30. For deliberate location a careful reconnaissance is made first to determine the general line of defense and the points or localities having special importance and calling for special treatment, and then in more detail to decide the form of the works to be constructed for the defense of the tactical features and localities laid down in the general scheme and the method of treating the intervals between these strong points and localities. As a result of this detailed reconnaissance, large-scale plans are made showing the exact siting and construction detail of the essential works.

Flanks.—If the flanks of an intrenched position do not rest on impassable obstacles, they may be turned by an active enemy unless special defensive arrangements are made. The best method is to refuse the flanks gradually by trenches in echelon until some supporting point is reached. The flanking trenches should not be turned obliquely to the main front, as this exposes them to enfilade and does not seriously increase the circuit of a turning movement.

31. *Trace.*—A common tendency is to make the trace too straight. An irregular line with frequent salients and reentrants gives greater facilities for concentration of fire over any desired area and for the

most effective employment of machine guns. Such a trace will expose short lengths of trench to enfilade fire, but the effect can be reduced by proper traverses. The enemy's line will also be in salients and reentrants and will be equally exposed to enfilade from our side.

Minor irregularity of trace is essential and should always be obtained. The creation of large salients to include an important tactical point will depend upon the following important conditions:

(*a*) Whether the possession of the point in question by us will facilitate future offensive action without unduly weakening our line.

(*b*) Whether its possession by the enemy will seriously threaten the security of our trenches.

32. The permissible traces for communicating and approach trenches are the indented line, easy to dispute in case of attack, and the zigzag, which gives better defilade. The litters evacuating wounded move more readily in the latter trace.

The best type is the winding one, but the curves must be sufficiently pronounced to give real protection against enfilade fire. If traverses are used in communicating and approach trenches the best kind is the island traverse with the trench going round it on both sides.

33. *Concealment.*—Aerial reconnaissance makes concealment of a position impossible, but isolated works and gun emplacements can be hidden and trenches in woods may escape observation if clearing is not overdone. Airplane photographs show clearly every trench and traverse in open country and even wire entanglements. Nevertheless every effort should be made to make the work inconspicuous, to deceive the observers by dummy trenches, to avoid paths or tracks that call attention to works otherwise well hidden, and to avoid the construction of fresh trenches immediately before an attack which would reveal the fact that an attack was intended. Work done on buildings themselves is easily concealed from air observers, but the existence of trenches around or leading to a building gives a clear indication of its occupation.

34. *Buildings.*—Substantial buildings found close to the line of defense may be demolished or they may be occupied. The decision depends generally on two points, whether they have cellars which can be improved into good cover and whether it is possible to demolish them. Buildings draw artillery fire and unless good cover can be constructed in connection with them they are nothing but shell traps. Solid blocks of buildings with cellars can be made into good

cover as a rule and had better be occupied. A building without cellars may be left out of the line if it can be so effectively demolished as to afford no cover to the enemy.

35. *Woods.*—A position from 30 to 50 yards inside the edge of the wood will afford concealment from observation and accurate artillery fire and will deny the edge of the wood to the enemy. The front edge should under no circumstances be occupied as it furnishes an excellent range mark for the hostile artillery. (Differs from par. 23, Part V, E. F. M.)

If a wood has to be left unoccupied in the immediate front of an intrenched line special arrangements must be made for the concentration of fire on the near edge of the wood and on the ground between it and the front trench.

PROFILES.

36. A narrow trench is desirable as it presents a smaller target. There must, however, be enough width to permit the construction of a firing banquette and of a certain deeper space at the rear part of the trench to allow men to pass behind the firing line. Also enough slope must be given the walls and the embankment work to prevent crumbling.

Unrevetted trenches even with side slopes as flat as 1 on 1 are sure to cave in. A good berm 12 inches wide and revetment are therefore essential. The minimum width at the bottom is 2 feet 6 inches, or better 3 feet, but 3 feet should seldom be exceeded; greater width reduces the protection too much. Revetted sides should have a slope of 4 on 1 or 3 on 1 and not be cut vertical. The depth from the top of the parapet to the floor board or bottom of the trench should be not less than 7 feet if possible. Height of parapet will depend on the site and the depth of the ditches for drainage.

37. *Firing trenches.*—The figures given on plate III are typical sections such as can be excavated in good soil when time is available. In actual practice they will be rougher and more irregular, with slopes depending on the consistency of the soil and the time at the disposal of the troops, but an effort should always be made to follow the prescribed lines of excavation as accurately as possible. Smooth and even slopes and crests of visible earth embankments and parapets should be avoided. Rough sod, grass, bushes or clods of earth should be used to break the continuity of straight lines and to make them merge into the surrounding features. It will be noted that the firing banquette is 5 feet below the interior crest instead of 4½ feet as given in the Engineer Field Manual and Field Service Regulations with the idea that the men who occupy them will build up the

banquette or notch or loophole the parapet when they take position in them.

It is both an advantage and a standing rule that if done by military labor, riflemen should themselves construct the trenches they are to hold.

The best type appears to be a trench with a firing banquette, for five or six rifles in each bay, between two traverses each 6 feet thick, and with the back part of the excavation formed into a communicating trench for observation and manning of parapets. This trench is somewhat deeper and 3 feet 3 inches wide.

Another type of firing trench has a minimum width of 28 inches, in order to afford the firer better protection; 15 to 20 yards in rear there is a second trench which permits communication and contains the shelters. The essential point in training is that one of these types should be adopted as the normal type suited to the local conditions, and the troops should be thoroughly trained in its construction.

38. Every firing trench should fulfill the following essential conditions:

(*a*) The parapet must be bullet proof.

(*b*) Every man must be able to fire over the parapet with proper effect; that is, so he can hit the bottom of his own wire entanglement.

(*c*) Traverses must be adequate.

(*d*) A parados must be provided to give protection against the back blast of high-explosive shell.

(*e*) The trace of the trench should be irregular to provide flanking fire.

(*f*) And if the trench is to be held for any length of time, the sides must be revetted and the bottom of the trench must be floored and drained.

The narrower the trench the better the cover, but if too narrow it may hamper the movement of troops too much. Therefore, a firing trench is usually made broad enough to allow of movement behind the line of men manning the parapet. Every man must be able to use his rifle over the parapet, and the men moving behind must not have to stoop down low in order to get their heads under cover.

The resulting section is, therefore, with a banquette or firing step 18 inches wide and 4 feet 6 inches (or 5 feet if we allow for a small notch or hollow to hold the rifle) below the crest of the parapet, and behind this a deeper portion from 18 to 30 inches wide at the

bottom, and from 6 to 7 feet below the crest line of the parapet. The firing step must have a level surface to give a firm foothold. It may consist of an earth step revetted with planks held in place by stakes.

Quotations from Solano's Field Entrenchments, page 43: "The rifleman must not expect to obtain bullet-proof cover of any value at close range in less than 35 to 45 minutes' work at hasty intrenching under fire. The mere fact, however, of obtaining concealment for the head and shoulders is of some moral value, even though the mound of earth forms for a time a better target to aim at than did the body alone. But once the rifleman has obtained good fire cover the value of his fire, the chances of his survival to use the bayonet, and the difficulties of driving him back by fear or panic increase so greatly that his eventual success in attack is almost a certainty, provided he does not cease to press forward to the attack with courage and determination, remembering that his spade is only a means to enable him to use his bayonet as quickly and effectively as possible."

39. *Communicating and approach trenches.*—Less emphasis is laid on the firing trenches than on the communicating trenches, because in case of necessity resistance can be made in any kind of a trench, while in a communicating trench out of repair or badly made it is impossible to move freely and promptly. This does not justify inferior firing trenches when time permits of good work. They should be of clear-cut design and well made and kept in the best repair possible. (Pl. III.)

Types are now becoming fixed and in France the following seem to be the normal: Communicating and approach trenches well to the rear are 6 feet wide, those farther forward 3 feet wide, and both types 6 feet deep. A communicating trench less than 3 feet wide at the bottom is sure to become blocked. This is the minimum to be allowed, and the work should be commenced with a width of not less than 3 feet 8 inches at the top, so as to get 3 feet at the bottom according to the stiffness of the soil. Trenches for light railways may be as much as 10 feet deep and 8 feet wide.

Berms of 1 foot on each side of a sap or trench where earth is piled up are considered indispensable. They prevent sliding of earth, and furnish a little shelf on which to place tools, bags, guns, and other articles, in case troops want to pass the occupants; the double berm also makes it possible for infantry to leap out of a trench when the emergency requires.

40. Earthworks built entirely or largely above ground are used only when wet, ill drained, or rocky ground compels. They afford good cover and if the parapets are about 10 feet thick at the top, with gentle front slope, and have had time to consolidate and dry out, they are said not to suffer much more from heavy artillery bombardment than do the usual types of trenches with low parapets.

They are, however, very conspicuous, especially when new, and require great time and labor to build. They are much more comfortable for the troops sheltered behind them. The ditch excavation in front may be used as an obstacle and filled with wire. There should be at least a 2-foot berm at the foot of the exterior slope so that this is not likely to fall into the ditch. Parapets of sandbags exclusively are much more vulnerable than those of earth, and are of expensive material; they should be avoided except for minor works, such as blocking a trench toward the enemy, barricading a road and the like. They may be used in emergency in the first zone if haste or silence is paramount importance.

TRAVERSES.

41. Traverses are solid masses of earth extending from the front wall of the firing trench or sometimes from the rear wall dividing the trench into a series of compartments whose purpose is to decrease the exposure of the men to enfilade fire and to localize the effect of a shell bursting in the trench. Traverses must be strong and solid and when possible should consist of the undisturbed earth. They should be from 2 to 4 yards thick and should overlap the width of the trench by at least 1 yard, and should be well revetted. The clear distance between traverses is that necessary to accommodate a small number of rifles, say those of a squad of 5 to 8 men; the distance therefore is from 5 to 8 yards. (Pl. III.)

Traverses in a trench facilitate bombing attacks along its length by an enemy who may have entered it as grenades can be thrown from under cover of a traverse into the second compartment beyond. A longer compartment to prevent this may be occasionally placed in the line of the trench. This long bay should be straight, and the traverses on either end should be loopholed for fire into it. Bombing trenches or pits behind the front line are also useful to stop this form of attack.

Where traverses have to be built in a completed trench insufficiently traversed, they must be made in embankment using the earth excavated to form the passage round the traverse and supplementing it with sandbags or other revetting material.

42. For approach trenches the best type is the "*island traverse*" with the trench going round it on both sides. Sections of trench subject to special exposure are sometimes protected with "bridge traverses," built across the top of the trench on supports of timber or steel. (Pl. III.)

HEAD COVER.

43. *Head cover* is the term applied to any horizontal cover which may be provided above the plane of fire. It is obtained by notching or loopholing the top of the parapet.

Notches.—When the relief of the trench is too great for a man to fire standing, or when the height of the parapet is more than 1 foot above the level of the ground, notches should be made in the parapet. The simplest way to make these and give support to their sides and make them the least visible is to arrange sand bags on top of the parapet.

Loopholes.—When overhead cover is used, loopholes are necessary. They may be collective or individual (Pl. III), constructed of sandbags, wood, steel, hurdles, or other material. They should be concealed by using grass, brush, canvas, or empty sandbags. The sky as a background should be avoided by raising the parados or placing a canvas curtain behind them, and closing the opening with a metal cover which can be removed when the loophole is in use.

In addition to their visibility, loopholes have the disadvantage that they cause a pause in the fire of the defender when the attack reaches the most deadly zones of fire, because the defenders have to withdraw their rifles to prepare for bayonet fighting. It is therefore necessary to arrange for fire over the parapet. For this purpose banquettes can be constructed of sod, stones, logs, or scaffolding between the loopholes. In all firing trenches, however, a few loopholes are desirable for the use of snipers, and there may be one or two between each two traverses. All night firing is over the parapet.

In some sectors the loopholes should have their axes inclined to the normal to secure flanking fire. Every loophole intended for observation should be placed obliquely in the parapet in order to be protected against shots from the front. The bottom of a loophole must be in the plane of fire that sweeps the ground in front.

OVERHEAD COVER.

44. The defenders of a trench must have shelter against bombardment by high-explosive shells and against the weather.

This is secured by traverse, narrow trenches, and shelters. (Pl. III.) Shelters are classified as splinter proofs of bombproofs accord-

ing as they are designed to afford protection against the splinters of shells burst over or near them or against shells hitting them direct and bursting on impact. Distinction between the two is important.

45. Shelters in the front wall of the firing trench under the parapet made by undercutting are objectionable. Even if carefully shored up they weaken the resistance to the burst of a high-explosive shell. A certain amount of splinter-proof cover should be provided in the front line, and it will also serve as protection against the weather. The best place for it is in the walls of the cover trench. It may also be placed behind the parados.

46. Bombproof shelters safe against heavy high-explosive shell have to be dug very deep and entered by a narrow opening and steps. This means delay for the men in getting out of the bombproof, and every moment is important in a well-planned attack, as the enemy will make a sudden assault almost at the moment the artillery lifts its range. Deep cover shelters are therefore inadmissible in the front line except for the protection of machine guns (for which special lifts may be provided) and their detachments and for company command posts. They are also dangerous in an attack by gas. They are generally confined to the position of the battalion reserves and to the strong points that may form a part of the front system. They may be used elsewhere, however, if the soil and natural features are favorable to their construction and arrangements can be made to get the men out of them quickly.

The entrances must be covered to keep out splinters. They are, therefore, masked either by a turn in the approach trench or by a traverse or splinter proof of gabions or sand bags. Each shelter should be provided with two entrances, of which one may consist of a simple exit without head cover, with a little stairway to be used in case the main entrance is obstructed.

The shelters which are generally large enough for 25 men at most should be constructed so that they will contain the men not on guard, half of them seated and half of them lying down.

The roof may be built as follows: First a layer of poles 6 to 8 inches thick, then a layer of earth 8 to 12 inches thick, a second layer of poles at right angles to the first, then a second layer of earth 12 inches thick.

The water-tightness of the roof is secured by sheets of corrugated iron on the top layer of poles or by tar paper placed on the surface of the earth, in which case the ground should be well tamped. It is well to place brush or straw between the sheet iron and the earth above, also to place branches on the first layer of poles.

The rails or beams must have a good margin of strength beyond that necessary to support the load above them, so as to stand the shock of the explosion. It will be seen that this roof is fully 6 feet thick. Hence, the shelter will require to be at least 10 feet deep if its position is not to be too conspicuous.

For types of shelters with bills of material, see Plate V.

Following is a description ot a type of dugout construction.

Dugouts.—The construction of the dugouts has been carefully studied and designed to withstand shell fire. There is first a lower roof made of curved corrugated iron cover with two or three layers of sandbags, and above this is an air space of not less than 18 inches, over which is placed steel 6-inch I beams; then another air space and layer of curved corrugated iron, upon which are sand bags, steel 6-inch I beams and earth, and on top of all a detonating surface made of broken brick or stone, the idea being to have the shells detonate on top of upper roof at the surface of the ground and not penetrate through air space into lower roof before exploding.

47. The extended use and effectiveness of artillery fire demands an increase in the number and strength of shelters provided for the men. The light splinter-proofs are replaced by shelters with strong roofs. This is possible because the great depth of the trenches furnishes earth for a thicker roof which is further strengthened by layers of resisting materials such as steel rails or beams, timbers, plate iron, concrete, or brick.

The shelters under the parapet are frequently divided into two stories by an intermediate floor or platform leaving in each story only sufficient head room to accommodate men lying down. This arrangement enables a larger number to be placed in relatively stronger shelters.

Underground or cave shelters (Pl. III) have become deeper and now are made with 25 to 35 feet of solid earth as cover with never less than two entrances which are curved or broken to keep out splinters. Communicating trenches and approaches between firing and cover trenches are generally blinded throughout their whole length.

48. "Slit" trenches, or very narrow trenches 1 or 2 feet wide and 7 feet deep dug at right angles to approach trenches, form good protection against hostile bombardment. They must be braced near the top to prevent caving in. They should be long enough for 10 or 12 men. Control of the men is more easy than in the cave shelters.

49. *General principles.*—Every deep cave shelter must have two or more separate exits to facilitate rapid egress and to prevent a blockade by the destruction of one exit.

Roof timbers must always have *three* or *four* times the strength necessary to support merely the load due to the thickness of the roof. This allows for the shock of the shell as well as for the contingency that a new garrison may pile 2 or 3 feet more of earth on top of the existing roof.

A rectangular timber will support more weight if set on its edge than if set flat.

The ends of timber should never be supported on sandbag walls or even direct on solid ground. A strong timber frame should always be used on two opposite sides of the shelter to support the ends of roof timbers.

A "burster" layer of 6 inches to 12 inches of brick or stone should always be provided near the top surface of the roof. Over this burster layer should be a layer of not less than 6 inches of earth to decrease danger from the scattering of the stone or brick by the burst of the shell. As the object of the burster layer is to explode the shell near the surface, it will be to a large extent defeated if the layer of earth above it is made more than 12 inches thick.

Cave shelters must be ventilated and the ventilator may be utilized for a periscope.

Splinter-proof cover is afforded by a layer of logs or beams 6 inches or more in depth covered over with not less than 12 inches of earth. (Differs from par. 14, Part V, E. F. M.) The following forms a roof proof against a 6-inch high-explosive shell: A layer of rails or beams, 18 inches of earth, a layer of brick, 2½ feet of earth, another layer of brick 6 to 12 inches thick, and over all 6 inches of earth.

REVETMENTS.

50. The deep firing, cover, support, reserve, communicating, and approach trenches now considered necessary require careful consideration of suitable revetments, especially where the soil does not weather well. To keep the men comfortable and the trenches clean and dry requires something more substantial than the usual temporary revetment, such as brush, sod, and sandbags. Some soils are apparently firm and stand at a steep slope when first excavated, but under the action of the weather the side walls soon slough off, obstruct the trenches, and make them muddy in rainy weather. In case of long continued occupancy of the trenches, revetments of timber and plank will gradually replace the lighter forms, and boards and gratings will be used to floor the bottom of the trenches.

In regions near cement mills and where gravel, sand, ruined walls and houses, or other suitable materials can be found, concrete blocks

or concrete molded in place may be used for revetments and for flooring the trenches.

A convenient size of side wall blocks is 10 by 8 inches by 6 inches thick, and for floor blocks 30 by 20 inches by 4 inches thick. Side-wall blocks should have two projecting wire loops to serve as handles in carrying the blocks through the trenches and in anchoring them in place. These blocks afford a neat and substantial revetment which contributes materially to cleanliness. They are also useful for building small covered observation stations along the parapets.

51. Some of the forms of temporary revetments are:

Sandbag.
Brushwood hurdle.
Wire-netting hurdle.
Continuous hurdle work.
Expanded metal.
Rabbit wire.

52. *Sandbags* are laid as headers; i. e., the length of the bag at right angles to the face of the revetment or as stretchers; i. e., the length of the bag in the plane of the face of the revetment. The revetment should slope at an angle of 4 to 1, and therefore the ground on which the bottom layer or course is laid should be at a slope of 1 to 4. The sandbages must be bonded, i. e., the bags of each course must break joint with the bags of the courses above and below. A certain number of headers must be used to tie the revetment into the bank. It is usual to lay sandbags with one header to every two stretchers.

When filling sandbags the bottom corners must be well tucked in and it helps if the mouth of the bag is turned over for about 3 inches. The bag then stays open more easily. Bags should be three-fourths filled and care must be taken to obtain uniformity in this, for unless the bags are all the same size they will not build up readily. A sandbag when filled should measure 20 by 10 by 5 inches.

The line of revetment must be prepared by digging a notch with the bottom at a slope of 1 to 4 and broad enough to take a header. Since the header is 20 inches long the back of the notch should be 5 inches below the front. If the face of the revetment is kept at right angles to the bottom of this notch the required slope of 4 to 1 will be obtained.

In laying the bags the mouths of the bag should be folded over underneath the bags. The mouths of the headers and the seams of the stretchers should be turned in toward the back so that if the bag becomes untied or the seams burst the earth will not fall into the

trench. The bags should be beaten with a spade, maul, or shovel into a rectangular shape, otherwise the bags do not get a firm seating. The face of the revetment should be quite smooth and not lumpy. Unless it is certain that the revetment is not to be extended, the ends should be left irregular so that any extension will be bonded to the existing revetment. It is best to finish off the parapet of a firing trench with a row of headers.

53. *Brushwood hurdles* are usually made 6 feet long and of the required height. The pickets should project 18 inches below the brushwood and be sharpened for driving into the ground. They should be about 3 inches in diameter and should be spaced approximately 2 feet apart; that is, four pickets to a hurdle. Actually the two outer pickets should be about 6 inches from the ends of the hurdle. The pickets are therefore 1 foot 8 inches apart. The brushwood should be 1 inch to 1½ inches in diameter and of ash, willow, or other pliable wood.

To construct the hurdle, drive the pickets into the ground firmly, and 18 inches from the bottom of the pickets run two strands of plain wire along the pickets, taking a turn round each picket. Twist these wires together until they are quite tight, then weave the brushwood in and out of the pickets, beginning at the bottom and keeping it pressed firmly down on the wire. Each length of brushwood should pass alternately in front of and behind the pickets and if a piece of brushwood is behind the picket the piece next on top should be in front of it, and so on. If the brushwood is not long enough to reach the length of the hurdle, twist another piece to it or tie a piece to it with wire. It is seldom possible to bend a piece of brushwood round the end picket and take it back along the hurdle, so let it project about 6 inches and cut it off. Continue until half way up, then put in a couple of strands of wire twisted as before. Complete the hurdle and finish in the same way with wire along the top. Then sew the hurdle in three or four places from top to bottom with plain wire. This construction differs from that mentioned in paragraphs 30 and 31, Part V, E. F. M.

In placing the hurdle, the bank should be cut away to a slope a little flatter than 4 to 1. The hurdle should be laid against the bank and the pickets driven into the ground 18 inches. The top of each picket should be anchored back by 6 to 8 strands of plain wire to a stout anchor picket driven firmly at a good slant. The anchor picket should be about 3 feet long and driven in 2 feet. It should never be less than 10 feet from the revetment even in good ground, and may be as much as 30 feet away in bad holding ground.

If the holding power of the ground is good all four pickets of a hurdle may be anchored back to one anchor picket. If very bad, each picket may require its own anchor. The anchor wires should be windlassed up tight. The anchor wires should be fastened to the anchor picket at ground level and to the hurdle just above the brushwood.

54. *Rabbit-wire hurdles.*—The following is perhaps the best way of using rabbit wire or poultry netting:

Three pickets, each 6 feet long and of 3 by 2 inch timber are laid on the ground parallel to each other and spaced 3 feet apart. A 5 by 1 inch plank is nailed to all three 6 inches from one end. Another plank is nailed to all three 18 inches from the other end and a third plank dividing the gap between the other two. Diagonals are then added from the top of each outer picket to the bottom of the middle picket. Each diagonal is of two strands of plain wire windlassed up tight. The rabbit wire is laid on top of all, stretched tight and fastened to planks and pickets with nails and staples. The ends of the pickets projecting 18 inches are sharpened for driving. The anchor wires are put on the pickets close to the top plank and another 5-inch plank is then nailed on flush with the tops of the pickets.

55. *Continuous hurdle work.*—In this case the bank is cut back to a slope of 4 to 1, stout 8-foot pickets are driven in every 2 feet 6 inches or 3 feet, with their feet 4 to 6 inches from the bank and driven in 18 inches. These pickets should be driven at a slope of 4 to 1. The brushwood is then woven in and out of the pickets. The brushwood is bent around the corners. The pickets are anchored back in the usual way. The revetment is finished off with two or three strands of plain wire twisted together tightly to prevent the brushwood from coming off the top of the pickets.

56. *Expanded metal* is made out of thin sheets of metal slit and then pulled out to form a mesh. The sheets are usually 6 by 3 feet. They are quite light and one man can carry three sheets. This material makes a good revetment. It is best to carry it up to the trenches already made up into panels.

Put two sheets of metal edge to edge and overlapping to such an extent that the sheets together make up the requisite height of the revetment. The overlap should not be less than 6 inches. Sew the two sheets together strongly with plain wire. Take three light poles 1½ to 2 inches in diameter and lay them on the metal parallel to the long edge of the sheets, one near the top, one near the bottom, and one in the middle. Sew these poles to the metal with plain wire,

starting and finishing 9 inches from the edge of the metal, thus leaving a length of 9 inches at each end of each pole not attached to the metal. The panel can then be rolled up and carried into the trench.

To construct the revetment, cut the bank back to a slope of 4 to 1. Lay the panel against the bank, the poles horizontal, the panels overlapping; that is, the edge of the metal of one panel is slipped in between the poles and metal of the next panel. The poles will then overlap 9 inches and the metal will overlap 9 inches behind them. Take good 8-foot pickets 4 inches in diameter and drive them on a slope of 4 to 1 tight against the panels, one at each overlap and one between the overlaps. Anchor back in the usual way.

In getting round traverses the horizontal poles must be omitted and the panels cut vertically from the top about three-fourths of the way down. One-half is then allowed to slide behind the other, thus keeping the slope of 4 to 1.

57. *Continuous rabbit-wire revetment.*—Use slightly lighter pickets 2½ to 3 inches in diameter. Cut the bank back to 4 to 1. At intervals of 2 feet or 2 feet 6 inches, cut vertical grooves in the bank big enough to take a picket. Drive a picket with its foot in the bottom of each groove. Do not drive in more than 6 inches and let the picket stand a few inches clear of the bank.

Then at the bottom, half way up and about 6 inches below the top of each picket, run two or three strands of plain wire, twisted up taut. The bottom strands should be put on first, then the middle, then the top, so as to avoid loosening the wires already put on by overtwisting the next ones. Then run diagonals of similarly twisted wire from the top of each picket to the bottoms of the pickets on both sides. Where the diagonals and horizontal wires cross in the middle of the panels, join them together with a short piece of plain wire. This gives a framework to hold the rabbit wire.

Run the rabbit wire behind the framework; that is, between the framework and the bank. Pull it as tight as possible and attach it to the framework in many places with short lengths of plain wire. Put on the anchor wires and draw the poles up against the bank. Then drive the poles tight home. Tighten up the anchor wires so as to draw the poles into the grooves. The rabbit wire is then brought tight against the bank.

Angle irons may be used for anchor pickets. Anchor pickets and wires should be buried.

DRAINAGE.

58. *Drainage* is essential to the preservation of the trenches and the health and comfort of the troops. In deliberate works it is well to study the drainage question in detail and to dig special ditches of ample capacity before work on the trenches proper is begun. Of course this can not be done in the presence of the enemy. About the only remedy in that case is the collection of water into pits, the use of constant pumping, and the construction of floors or gratings. The bottom of the trench should slope toward the back, where the water may be run to a pit in a drain. Where the soil is impermeable an endeavor should be made to reach a permeable layer by boring with an earth auger. In hilly terrain the water may be drained off by pipes placed under the parapet. (Pl. III.) If a permeable layer can not be reached, the drainage pits must be emptied with buckets or pumps.

59. The drainage and flooring of *approach and communicating* trenches constantly used is specially important, and should be considered in their location. When timber for flooring is not available, drains filled with broken stone should be constructed in the bottom of the trench. A good form of floor grating is in lengths of 6 feet, 18 to 24 inches wide, made of cross pieces of ¾ by 4 inch boards nailed to two longitudinal pieces of timber about 3 by 4 inches set on edge.

60. In *shelters* provision should be made for the drainage of water which runs through the entrance or seeps through the walls. A drainage pit should be constructed near the entrance and the floor of the shelter should be sloped toward it; the pit must be emptied when necessary. (Pl. III.) The roofs of shelters should be made waterproof by using roofing paper, corrugated iron, tin or zinc, linoleum, canvas or tiles.

LATRINES.

61. *Latrine* accommodation should be ample; seats should be based on at least 2 per cent of the troops using them. Urine receptacles should be based on the same scale. The best location for latrines and urinals for the firing line is behind the cover trench in T-heads at the end of short branches leading off from it. (Pl. III.) Latrines should be provided for all trenches and shelters which have to be occupied even for short periods by troops.

62. The following are some of the various kinds:

(*a*) Deep trench with box on top or "box latrine."

(*b*) Buckets.

(*c*) Short trench system.

Box latrine.—This consists of a pit 15 feet long by 2 feet wide by 6 feet deep. A square box or boxes are placed on top. The sides should be boarded all round so that the boards project over the sides of the pit. The height of the box should be 17 inches. Two holes are made in it and a lid provided. If deep enough it does not smell. It is most suitable for trenches, provided the ground is dry. Box latrines are not suitable for positions that are to be occupied a long time.

If there are frequent approach trenches, say one every 100 yards, a good position is just off the approach trench. This may not be suitable, depending on the trench; in some cases a suitable site is at the corner of a traverse.

Bucket system.—If the ground is wet and deep trenches can not be dug, the bucket system is most suitable for trenches. Any metal receptacle will act as a bucket. The excreta must be covered with earth. It is very important that every officer, noncommissioned officer, and man shall make it a habit to cover the excreta every time before he leaves the latrines. Officers and men are apt to forget this and in five minutes excreta will be covered with flies. The buckets are removed and emptied at night. They should be emptied into a deep pit somewhat in rear of the support trenches. This pit should be covered, screened from flies, and burned out at intervals.

The short trench system is suitable only on the line of march when a halt is made for a night or two. These should be dug 3 feet long by 2 feet wide by 1 foot deep with 4 feet 6 inches interval between latrines, so that when the first lot are full and covered in, fresh ones can be dug between, leaving a margin of 9 inches on each side of the hole of solid and not foul ground.

Every latrine should have a separate pit dug for a urinal. The following are the various kinds:

(1) *Pit with tin can on top.*—The purpose will be served by any pit 3 feet deep and 3 feet in diameter, with stones in the bottom, covered over with a tin can perforated at its bottom placed on the stones.

(2) *Trough system.*—This is more elaborate and suitable for a permanent camp. A trough slightly inclined, 2 feet long, made of wood lined with zinc. Oil can at one end out on the ground, placed to catch flow from the trough.

(3) *Pipe system.*—This consists simply of an oil can, with a pipe soldered on, conducting the flow to a pit 3 feet deep. This is clean and simple.

(4) In trenches it is sometimes impossible to dig a pit and an ordinary oil can placed in a suitable position as container can be used.

Disinfectants.—Bleaching powder (chloride of lime) should be freely used at every latrine and urinal. All ground which has been used for latrines should always be marked "foul ground."

OBSTACLES.

63. *Tactical use.*—The use of an obstacle is to check a hostile rush and delay the enemy under the close fire of the defense. An obstacle should be at such distance from the parapet that it is difficult for hostile bombers to crawl up to it and then throw bombs into the trench. On the other hand the obstacle should be under close observation and under close fire of the defense. If the front edge of the wire is 40 yards from the trench these conditions are fulfilled.

64. *Concealment.*—The value of an obstacle will be increased and its liability to injury by fire decreased if the obstacle is concealed. If it is possible to place the obstacle in a fold in the ground so much the better. It is sometimes possible to place the obstacle in a broad shallow ditch. In that case the deepest part of the ditch should be toward the enemy. The earth should be carried back and placed in the parapet.

65. *Construction.*—The obstacles should be made in such a way that the following conditions are fulfilled:

(1) The working party constructing it should be extended and never bunched together.

(2) Silence must be preserved. Therefore everyone must know exactly what he has to do.

(3) Speed is necessary. The work must therefore be methodical, each man having a specific task.

(4) The working party must never have an obstacle between it and the trench.

(5) The obstacle should be one that can be improved and thickened up easily and quickly.

(6) The obstacle should be of a type that will suffer as little as possible from hostile gun and small arm fire and from rifle and machine-gun fire of the defense.

The following pages show how obstacles can be constructed to fulfill as many of these conditions as possible:

66. *Low wire.*—The party should consist of 32 workers, if possible, exclusive of noncommissioned officers. Form the party in two ranks and number them in threes both front and rear rank. The left file

is not numbered. For the sake of explanation, letters are given to these parties of three as follows:

O O O	O O O	O O O	O O O	O O O
B	D	F	H	K
O O O	O O O	O O O	O O O	O O O
A	C	E	G	I

Assume that two bays of low wire are to be built.

Description of obstacles.—The obstacle consists of 3 foot 6 inch pickets driven about 1 foot into the ground. At the end of each row of pickets is a short anchor picket sloping back away from the line of the entanglement and about 3 feet from the end pickets. The rows are 3 yards apart and the pickets in each row are 3 yards apart. The pickets are placed in quincunx order; that is, those of the middle row divide the gaps between those of the outer rows. A taut strand of barbed wire is run along each row at knee height, being made fast with a round turn to each picket. Between the middle row and each of the outer rows is a diagonal wire, taut and at knee height, running from the first outer row picket to the second center row picket, the second outer row picket and so on.

Resting on the diagonal and halfway between the rows of pickets are laid two wires, one on each side of the center row, quite loose so that they loop about on the ground. These loose wires are fastened to the diagonals by twisting the loose and diagonal wires together in every other place that they cross.

Duties of parties.—Parties A and B go out almost simultaneously. Party A drives the first row of pickets, and so needs a maul. The maul man should be tall. One man mauls, one supplies the pickets, one paces the three yards and holds the pickets for driving. Keeping close up so as not to lose the pickets comes party B with a coil of barbed wire, a pair of wirecutters, and two pairs of hedging gloves. All wire parties carry similar equipment.

Starting at the anchor picket, party B runs out the first straight wire, one man holding and uncoiling the wire, the other two taking round turns, each taking the turns on alternate pickets.

About 6 yards behind is party C, a picket party which drives the second row of pickets, one man again mauling, one holding and pacing, one supplying pickets. This party measures the position of each picket from the front row by going to each picket in the front row, pacing 1½ yards along the line, turning at right angles and pacing 3 yards and then planting the picket. This eliminates cumulative errors.

Starting 6 yards behind C comes party D, which works on the same system as B and puts on the diagonal, keeping behind its own wire. Care must be taken to make real round turns.

Party E runs out the first loose wire, starting about 12 yards behind D. One man holds the coil and unwinds it. One man places the wire in position on the diagonal. The third man clips the loose wire to the diagonal.

Party F comes 15 yards behind E and runs out the second straight wire. Party G drives the third row of pickets, measuring the position of each from those of the second row. Party H starts 6 yards behind G and puts on the second diagonal. Party I starts 12 yards behind H and runs the second loose wire. Party K starts 15 yards behind I and completes the bay with the third straight wire.

The direction is kept by the men of the left file who provide themselves with a piece of string or tape, equal in length to the distance from the parapet to the front edge of the wire. They go out with party A. One man places himself at the foot of the parapet with one end of the string in his hand. The other runs the string out until it is taut. The man on the parapet keeps the string always perpendicular to the general line of the parapet. The other man keeps it taut and moves along with party A. Work can be done with parties of two men, but if one is hit the work is disorganized.

If there are fewer parties the same party may have to do two or more parts of the work. Thus if there are only six parties A will also do G's work, B will do H's, C will do I's, D will do K's. The pickets must be driven in far enough in the first instance. If they have to be driven after the wire is on, the wire will be too low. Mauls should be muffled with sandbags nailed on.

Advantages of this form of obstacle.—Easily thickened; quick to build; easy to conceal; not easily destroyed by hostile fire or by friendly fire which will pass over it; the men are always behind the wire; easy to mend. This entanglement requires one picket and 11 yards of barbed wire for each yard of front.

67. The high wire entanglement is similar in a general way to the low entanglement, but is 4 to 6 feet in height. It usually consists of three to five rows of stakes connected by barbed wire. In addition to the horizontal wires connecting the tops of the stakes it has diagonal wires running from the top of each stake to the bottoms of all adjacent stakes. The side toward the enemy should be completed as an ordinary wire fence. Slight irregularities in height of stakes and arrangement of wires add to the value of the obstacle.

68. *French wire.*—This consists of a continuous spiral of plain wire 3 feet 6 inches in diameter, each turn of wire being clipped to the

turns on both sides in five places. When closed up it looks very much like a coil of plain wire, but when pulled out it makes a cylinder of wire mesh. Each small coil pulls out to a length of 20 yards. A big coil consists of five small coils.

Advantages and disadvantages.—It can be easily crushed down by throwing a weight on the top and must therefore be supported by pickets and barbed wire. It is easily carried and quickly put up. It is held in place by iron staples 5 inches long. The number of men required for a party is 26. Two men keep the direction with a string as for low wire and the remaining 24 are divided into parties of 3 as for low wire.

Description of obstacle.—The obstacle consists of two rows of French wire. Each small coil is stapled down in five places, that is at each end, one-fourth, one-half, and three-fourths of the way along. Where two coils meet the same staple fastens down both coils.

Pickets 5 feet long are driven into the center of the coils in five places as for the staples. These pickets should be driven in at least a foot. A strand of barbed wire is run along the top of each row of French wire. These strands of barbed wire are pulled as taut as possible and are twisted on the French wire with a staple, peg, or pair of wire cutters, close to each picket and in several places between the pickets. This barbed wire supports the French wire.

The two rows of French wire are tied together by a diagonal strand of barbed wire running from the tops of the pickets of one row to the tops of the pickets of the other row.

In addition a strand of barbed wire is run along the front of the front row of French wire and twisted to it. This is partly to hold up people trying to crawl through and partly to hold the French wire together, should it come loose from its fastenings. This wire is usually called the "apron wire."

After this more apron wire can be added or loose wires may be inserted between the two rows. The two rows of French wire are just far enough apart for a man to pass between them.

Duties of wiring party.—Party A, first French wiring party.

A 1 holds end of wire and staples it down.

A 2 pulls wire out for 20 yards.

A 3 shakes wire clear of obstructions and puts in staples one-fourth, one-half, and three-fourths way along.

A 1 gets another coil and butts it against A 2's end of the first coil and staples both ends together.

A 2 and A 3 proceed as before and so on until the first row is complete. A 1, 2, and 3 carry 15 to 20 staples slung on a cord over the shoulder. As soon as party A is clear, party B comes out.

B 1 mauls in the anchor picket and the long pickets through the center of the coil every 5 yards along the line.

B 2 measures distance and holds pickets for driving.

B 3 supplies pickets.

B 1 should be a tall man. Where coils butt up against each other they are crossed and the picket is driven through both coils holding them together. As soon as party B is clear party C comes out.

C 1 uncoils barbed wire.

C 2 makes fast end to anchor picket and then takes a round turn with the barbed wire around every picket about 6 inches above the French wire.

C 3 twists the barbed wire to the French wire close to each picket and in three or four places between. He carries pegs or staples for this purpose.

As soon as C is clear party D comes out.

D 1 has a coil of barbed wire and runs it out up against the front of the French wire about halfway up.

D 2 and 3 twist it to the French wire every 2 or 3 yards, thus forming the apron.

Next come parties E, F, and G, who run out a second row of French wire behind the first row at such a distance that a man can just pass between the two rows. Their duties are identical with those of parties A, B, and C.

Next comes party H.

H 1 has a coil of barbed wire and moves between the two rows, uncoiling the barbed wire.

H 2 and 3 move on either side of the entanglement and make this barbed wire fast to the pickets. H 1 holding the coils in such a way as to enable H 2 and 3 to reach it. This forms the diagonal.

NOTE.—It is impossible to keep the men always on the home side of the entanglement. The obstacle can be quickly put up, but it is liable to be badly cut up by artillery and small-arm fire and is difficult to mend.

69. The maintenance of a wire obstacle requires constant care. It should be inspected every night and a few men should be detailed in each company as a permanent wiring party for the repair and improvement of the obstacle.

70. Where opposing trench lines are very close together, stakes can not be driven for the usual form of wire entanglement on account of the noise of driving which would draw fire. If not too close to the enemy iron rods with a screw end may be used in lieu of stakes; these may be three-fourths inch diameter with one or two loops in their length to which to fasten the wire. In ordinary ground such rods can

be screwed into a firm hold without noise. When the enemy is too close for this, various forms of portable obstacles in the nature of chevaux de frise are employed. These are made up at the depots, brought forward through the trenches and simply tossed out in front, by day or by night.

Several forms are used, such as the regular chevaux de frise, the elongated sawbuck, and the tripod or hollow cube formed of steel angle rods or plain rods. These obstacles are covered with barbed wire. Boards filled with nails are also used.

71. When the enemy's bombers get into the approach trenches they attempt to work down then under cover of the zigzags, curves, or traverses to attack one of the rear lines and provision should be made by the defense to check such advance. It is best accomplished by making the rear 40 yards of any approach trench straight and providing for machine gun and rifle fire down the straight portion. An alternative arrangement is to provide enfilade fire down one or more of the zigzags from loopholes in the parapet of a trench in rear cutting the necessary sloping channels to fire through. Provision must also be made for blocking the rearmost 40 yards of the approach trench at both ends of the stretch by means of movable obstacles, such as chevaux de frise or other forms mentioned above, kept in a corner of the trench whence they can be readily pulled down into position by the last man to retire.

72. Openings for the passage of troops through wire entanglements are generally about 10 yards wide and are placed so that two belts of wire overlap the openings. (Pls. I, II, and IV.) The continuity of the obstacle may be preserved by using gates or barriers that can be quickly opened and closed.

The best place for the openings is at the flanks of the supporting points between the wire entanglements around the supporting points, and those in the intervals. If these openings must be placed in the intervals on account of the terrain, they must be covered by the close fire of sections of trench placed immediately in rear.

DEFENSE OF BUILDINGS.

73. It is often advisable to include substantial buildings in the firing line. Experience shows it to be very hard to dislodge a determined defender from a properly organized building. On the other hand, buildings in or near the front invariably draw much artillery fire. For this reason a building should not normally be occupied by day unless it has cellars which can be improved to provide good bombproof cover, or similar cover can be made quite

close to the house and connected with it by communicating approach trenches. Otherwise if the building has been put into a state of defense a garrison should be detailed which will occupy it only at the last moment in case of attack. A building is strongest for defense when it has been knocked about a bit. The defensive arrangements should be concentrated on the first floor and cellars; time spent on the upper stories is sure to be wasted. In the building itself the work to be done is:

(*a*) Reinforce the cellar roof if possible with concrete; it must be well shored up to enable it to carry the extra protection and also the débris which subsequent shelling will bring down upon it.

(*b*) Loophole the walls for rifle or machine gun fire; the nearer the loopholes are to the ground the better the protection afforded, but there is a risk of falling débris blocking them.

(*c*) Thicken walls up to the height of the loopholes. This thickening may be done by throwing earth up against the outside of the building, or making a wall of gabions filled with earth or of earth between hurdles, 3 feet clear of the wall of the building to serve as a shell burster. Building up inside with brick rubble or earth in sandbags is better, as loopholes near the ground level and cellar windows for machine guns can then be used.

(*d*) Block up and loophole ground floor doors and windows.

(*e*) Erect overhead cover over firing positions. This should be in the form of a false roof, preferably of concrete, otherwise of heavy rails or very stout timbers on very substantial timber supports or on rails and girders. This roof will protect the firers from falling débris, and the more the house is knocked about the stronger will the cover become.

In connection with the defense of the building there may also be firing trenches in front of it and on either flank, communicating by trenches with one another and with the building, the whole forming practically a small strong point of which the house is the keep. "Slit" trenches situated close behind the house and connected with it by an approach trench form a useful adjunct to the defensive arrangements.

CONSTRUCTION OF TRENCHES.

74. *Under fire.*—The first object is to get some sort of cover as quickly as possible for the firing line. The individual men start to dig pits for themselves just where they are stopped by the enemy's fire. As soon as may be these pits are then joined to form a continuous firing trench. This trench may form the ultimate front firing trench and the cover trench be subsequently dug back of it,

or it may become the cover trench and new firing trenches may be dug in front by pushing forward at intervals. The question of proper traverses for the final trench should be considered in the spacing of the first constructed pits and in joining them up to form a trench. It is desirable to have traverses formed out of the original undisturbed ground.

If the first dug trench is to form the cover trench the next step after completing it is to push forward T-heads to the front to form the firing bays.

The work of digging the individual firing pits will be begun by the infantry troops generally with their intrenching tools. Troops should, therefore, be well practiced in digging themselves in by night or day with these tools.

Heavier more effective tools should be brought up to the firing line as soon as possible and every plan for an advance should provide for a certain number of digging tools in addition to the intrenching tools accompanying the attack, and this number should be supplemented as early as possible by every pick and shovel available.

It may be necessary to wait until dark before a large number of tools can be brought up and serious work attempted, but it is sometimes possible under the covering fire of artillery to dig a continuous trench by day. In any case every effort must be made to get good trenches dug as soon as possible and one of the first things to do is to get some wire entanglement in front of the trench, as this gives a feeling of security to the workers.

During the first day or two the new line will be bombarded heavily and probably counter attacked. If the front trench is constructed in the first instance very close to the enemy's line it is particularly vulnerable to counter attack, and if the enemy succeeds in breaking through the line at a time when there are no defenses prepared behind it he may force a retirement on a large front. The construction of support trenches 100 to 200 yards in rear of the front line and of reserve trenches should therefore be proceeded with simultaneously.

75. *At night.*—If the offensive open attack has to be given up temporarily and the enemy is found in a prepared fortified line a more gradual and concealed method of approach has to be adopted. A line of trenches is constructed in the first place at quite a distance, say 500 to 600 yards or even more, from the enemy's front trench, the exact distance depending on the ground and the facilities for cover. This line is made fairly strong and complete before any further advance is attempted. Then under cover of darkness or fog and perhaps of a heavy bombardment of the enemy's front line a new trench is constructed at a distance of 200 to 300 yards from the enemy.

From this line further advance is usually made by sap. The advantage of this method is that before any attempt is made to dig a line within easy reach of small counter attacks, there is a completed line ready behind the new line, to stop further progress by the enemy if the new line is counter attacked and broken.

76. In order to get within assaulting distance of the enemy trenches, it is necessary to push out saps from the firing trenches, at intervals of perhaps 20 yards, and the heads of these saps must then be connected by a continuous trench called the *parallel of departure*. The construction of this parallel is a difficult task and can not be expected to be accomplished in a single night. The enemy's fire and hand grenades compel it to be built as a sap. One of the difficulties is maintaining the proper alignment. The tendency is to dig in a broken or wavy line like that of the firing trench. This trace is excellent for the latter on account of its facilities for flanking fire, but the prime condition of the several short elements composing the parallel of departure is to face the objective, for the assaulting troops who start from it will go instinctively straight forward.

Careful adjustment with the use of tape and compass is necessary to get good results. The azimuth of the general direction of attack is given to all who have compasses for use when dust, night, or fog obscure the objective, and the trace of the parallel of departure must bear 90° from this general direction.

The profile of the parallel of departure must be that of a narrow trench with banquette somewhat raised, continuous and without traverses. In this type only can the assaulting wave start in line with the men at one pace interval.

To keep the parallel clear of the dead or wounded, there must be arranged in saps and other trenches some niches in which the disabled can be placed temporarily.

77. The construction of trenches should be preceded by careful staking out of lines and tasks assigned by measurement. This results in an economy of time and prevention of confusion among the working parties. Otherwise parties will be digging at random and system will be lost.

New work must be given at once its full depth. The improvement of a long trench unequally begun on its different sections gives an opportunity for laziness and loss of time. In daylight the officer should show the chief of each working party in minute detail, the work assigned to his party, have him mark it out himself and determine the men needed; then at night form them and send them up in succession. The men should have eaten before starting, for the arrival of a meal at night is an unfailing pretext for leaving the work.

78. *Placing the workers and executing the work.*—The men are divided into working groups composed of those who are to work at a common task. Group tasks are laid off at such intervals up to 5 feet as may be determined by conditions affecting the work as time available, tools, character of the work and the soil. In easy ground one pick to two shovels should be furnished; in hard ground one pick to one shovel.

Distribution of tools.—The picks are placed in one pile and the shovels in two piles if there are three men to the group; picks in one pile and shovels in one pile if there are two men per group. The men formed in two or three ranks march by these piles. All those of the same rank each take a tool from the same pile.

79. Mark out the direction of the trench by means of tape or withes, or of markers sitting or lying down indicating points where the direction changes, and where ground should be left unchanged for traverses. The column of workers in single file, groups formed together, arrives at one end of the trace and deploys along the line established by the markers at proper intervals. For special work, splinter proofs and traverses the width of task for a group is proportionately reduced.

Begin work by digging downward so as to cover oneself from the front as rapidly as possible. Commence the parapet in such a way as to make rapidly a mask with a steep slope on the side of the workers. Work under fire is done at night. The men must keep absolute silence, lie down immediately on the ground when rockets appear, and resume their work when the light has disappeared. (See E. F. M., par. 39, Part V for placing relief on work when tasks are individual, not group tasks.)

80. *Shaping bottom of trenches.*—The digger left to his own devices will make the bottom of the communicating trench concave; the mud will then settle to the center which the men's feet will soften and gradually wear down. When the trench is cleaned the mud will be taken out in a series of holes along the center, making walking very difficult. This is a detail that should be insisted on when work is going at a high rate in the first line and a shift of workers is on every night. It has been reported that more men are injured by sprains than by hand grenades and bombs, and a sprain lays a man up for a month. The bottom of the trench should therefore be made convex or rounded upward just like the cross section of a good road. No other form should be allowed.

81. *Stairs or steps* from the bottom of communicating trenches to the ground level, are important at all crossings where possible, and bridges over lateral trenches will furnish practically a roadway

parallel to the main communicating trenches for use at night or during an intermission in the artillery bombardment.

An effort should be made to draw the hostile artillery fire upon dummy trenches in which case 12 inches is sufficient depth. Well defined edges should be made so that airplane photographs of them will look like the regular works.

82. *Employment of engineers.*—The numerical insufficiency of engineers both during the preparation of the terrain and during the combat has developed in more than one case during the European war.

As soon as the first wave of the assault starts, engineer units (or other troops) posted previously should connect the parallel of departure with the enemy's first-line trench. When this part of the terrain has been crossed by approach trenches there will be covered approaches right into the enemy lines. It is not sufficient to give general orders about this matter; the attack order must specify accurately that such and such approach trenches will at once be prolonged to the conquered trench, so that every one will know in advance and make use of them the first day. These could well be used by artillery observers who must personally follow closely infantry attack, and then come back through these trenches and telephone instructions or information to their batteries in regard to the points reached by the infantry.

TRAINING IN FIELD FORTIFICATION.

83. Infantry must be capable of the construction, repair, and maintenance (par. 102) of all forms of trenches (pars. 37–39), shelters (pars. 45–48), and barbed-wire entanglements. Constant practice in digging (pars. 29, 37–39, 41, 74–76, 80) and making entanglements at night is necessary. Officers and men must be well trained in the method of marking out works to be dug at night (pars. 31, 77) and in extending a party silently on a task in darkness (pars. 78, 79). Troops should be trained to dig fully equipped except for their packs. It will be useful to have a certain number of men in each company specially trained under engineer supervision in the construction of obstacles (pars. 63–72), loopholes (par. 43), revetments (pars. 50–57), and drains (pars. 58–60).

The output of work is much greater when the workers have been systematically trained and when they are correctly distributed to their several tasks and directed by competent noncommissioned officers.

The elementary training need take only two or three weeks, but what is learned should be learned with great thoroughness, so that each man in actual operations will know exactly what he has to do and what to expect of his neighbors. This instruction can be given from the Engineer Field Manual, Part V, and should include the use of the different tools listed in the Unit Equipment Manual, the most effective way of handling them, systematic distribution of tools and tasks, cooperation so that men will not get in each others way, and knowledge of the adopted sections and types of construction.

The types of construction are few in number, and the men should be trained to build without hesitation the normal or usual type of firing trench, communicating trench, machine-gun emplacement, covered shelter (Pl. III), and to break out and work a sap as described in the Engineer Field Manual. Special constructions beyond the above list can be given later to those best qualified to receive it or in cases of special emergency.

Instruction of troops should prepare them to take their places immediately among the combatants when they go to the front as reinforcements. For their own sake they must know all the latest methods of combat, both defense and attack.

It has been noted that in training the reserves and troops in depots in some of the European armies not enough attention is given to grenade instruction, sapping, rules for life in cantonments, duties in the trenches, actual assaults, and combats in a labyrinth of communicating trenches and barricades.

All depots should have on hand a sufficient number of tools, sandbags, and unloaded but primed grenades, without which training for trench work is purposeless and futile. Combats with blank cartridges should be carried out daily in lines of entrenchments copied after those of some known and tested field of battle. The men in reserve need instruction for the work they will take up at the front and should have full course in work, discipline, and life in the trenches.

EQUIPMENT AND MAINTENANCE OF FIELD FORTIFICATIONS.

84. *Observation.*—The observation of the enemy is of first importance in position warfare. It should give complete knowledge of all the elements of the hostile line and prompt information of any movement of the enemy. It is effected by observation from the ground and observation by aircraft.

Observation from the ground is divided into three echelons:

(1) Observation in front of the firing line from small posts and listening posts.

(2) Observation on the firing line by sentinels and lookouts.

(3) Observation in rear of the firing line by artillery observers, sentinels, and lookouts of the shelters.

It is effected by the infantry and artillery.

Observation in front of the firing line is effected by small posts or listening posts of from one to eight men placed in rifleman's pits, shot holes, organized shell craters, or in short semicircular elements of trench connected with the firing line by sap or low mine gallery. Their protection is assured by their invisibility. The retreat of the observers is protected by a system of branch galleries whose entrance into the main gallery can be closed rapidly, or by a barbed-wire protection placed over the sap. The lookouts in small posts are placed in very short trenches, which are provided with loopholes. Protection at short range against grenades is secured by a network of wire.

Observation on the firing line is effected by lookout posts organized preferably at the salients where the view is more extended. (Pls. I and III.) These posts give a view over the enemy's firing line; they are provided with periscopes, range finders, and large scale maps. They should be concealed by all possible means; observation is carried out under good conditions only when it is done without the knowledge of the enemy. The posts should preferably be constructed on the right of a traverse and in an excavation in front of the trench wall.

The observation posts, even of the infantry, are not necessarily in the firing line or in the listening posts. Often in rear, points will be found which will give an excellent view and will not attract the enemy's attention. The term "observatory" is often employed for this kind of observation post. The observatories generally have a more extended view than the lookout post; they are protected and have means of communication such as telephone, heliograph, messenger, carrier pigeons, wireless. They may belong to the infantry, the artillery, or higher commands. The observatory may be occupied by the commander himself or by an observer who represents him. In any case the observatory is near the command post. (Pl. III.) It must have a low parapet, be defiladed from view, and proof against large projectiles.

The location of the lookout posts and observatories must be determined in accordance with a complete plan for each supporting point

or sector of defense. No part of the hostile front should be free from observation and the parts of the front favorable for the attack of the enemy should be specially watched. An observatory should be located near the command posts of the commanders of strong points, supporting points, and sectors. Those of the last two must have extended views over the whole of the terrain.

85. *Illumination of the battlefield.*—In position warfare it is necessary:

(*a*) To discover and keep in touch with the movement of the enemy during the night.

(*b*) To seek out and illuminate hostile objectives so as to fire upon them.

(*c*) To blind the enemy.

These results are obtained with searchlights. The smaller ones, about 12 inches, are only acetylene or incandescent electric, and have a short range of 300 to 1,000 yards. The larger, 24 to 36 inches, are of the electric arc type and have a range of 2,000 to 5,000 yards. They can also be used for signaling. They are placed in shelters similar to those for machine guns, located so as to flank the line of fire. (Pl. III.)

86. *Lines of information.*—During a bombardment, the maintenance of lines of information becomes very difficult, but it must be accomplished by all possible methods, such as:

(*a*) Installing telephones under strong shelters.

(*b*) Using lead-covered cable, buried 6 feet deep, especially for the lines connecting the regimental, brigade, division, and corps headquarters.

(*c*) Placing rockets in all shelters and observatories where officers or noncommissioned officers are posted.

(*d*) Preparing posts for visual signaling, safe from bombardment and defiladed from view of the enemy. These posts are constructed in shelters similar to those for searchlights and are provided with horizontal loopholes with openings to the flank or rear.

The problem of the telephone is one of the most important and has yet to be satisfactorily worked out. The allowance of apparatus must be greatly increased and systematic organization of men and matériel is urgently demanded. All persons along the line, passers-by, guards, and the like, must have an interest in maintaining the lines and keeping clear of the wire. Every noncommissioned officer should have a few staples or long hooks in his pocket so as to place a fallen wire temporarily out of reach of passing troops. Artillery wires should be placed on one side of the trench and infantry wires

on the other; they must be high enough to clear men passing at night, loaded and weary, and at trench crossings they must be carefully protected. Constant supervision and repair of the lines is necessary. Lines with too many phones in series should be avoided. Multiply the centrals and reduce the phones on the same line to three or four.

87. *Depots for material and ammunition.*—These consist of galleries of variable dimensions, opened in the walls of the trenches and approaches, and usually lined with timber like mine casings. The entrance should be closed with a strong door. They are used to store water, rations, ammunition, grenades, pioneer tools, portable searchlights, field glasses, maps, range finders, periscopes, lighting pistols, and rockets. Depots for engineer material are usually installed in the angles of the approaches. Depots for water, rations, tools, and sandbags are usually established about 20 yards to the right of the company command post (par. 90). Depots for arms, ammunition, bombs, grenades, and rockets are about 20 yards to the left of the same post. An inventory of the material should be kept up to date at the company command post. (Pl. III.)

88. *Machine guns.*—The general principles of their employment are:

(1) The personnel and matériel should be protected from fire as much as possible.

(2) In order that they may be available at the moment of attack, it is indispensable that they survive the bombardment. Their protection must therefore be specially provided for by employing all of the following means:

(*a*) Placing them under shelter.

(*b*) Making their emplacements invisible.

(*c*) Dispersing them laterally and arranging them in echelon.

(3) Casemates must be used only when they can not be seen by the enemy, such as on the reverse slope or in woods or villages. (Pl. III.)

(4) The great importance of making them invisible necessitates the construction of firing emplacements outside the shelters, but close enough so that the guns can be put in action with the least possible delay.

(5) The firing emplacement may be protected by a light roof with very slight height (Pl. III), or it may be entirely without overhead protection. The emplacement may consist simply of a pit in the open field, situated in front or in rear of the parapet, and connected with the shelter by an underground passage. The

machine gun should be placed in action at the last moment. It may be simply placed on the edge of the pit without any protection, but preferably should be covered by a light shield, or a low parapet joining the natural slope of the ground with a gentle slope. The pit should be carefully hidden and will not usually be discovered by the enemy. Emplacements of this nature are frequently employed in rear of the firing line.

(6) When the firing trench is situated on the reverse slope, machine guns should be emplaced in concealed pits in front of the trench, and connected with it by underground passage.

(7) The requirement of invisibility makes it necessary to conceal all the approaches to the firing emplacements by making them underground, and to increase the number of emplacements so that it will not be necessary to fire daily from those to be used in case of an attack.

(8) The emplacement of too many machine guns in the first line is dangerous; in order to stop an attack they should be echeloned to the rear. In favorable terrain, flank fire should be provided, to mow down the attacking lines as they push forward. Therefore, the available machine guns should be distributed between the firing trench and the terrain in rear, with each emplacement prepared in a manner suitable to the terrain and object in view.

89. *Emplacements and shelters for trench weapons.*—In trench warfare, batteries of light mortars and other trench weapons are generally situated between the cover and support trenches. (Pl. III). Like machine-gun emplacements they are of two types, viz, with and without overhead cover. Whenever overhead cover is used, if practicable alternate emplacements should be constructed near by. The emplacements should be concealed as much as possible, and for this reason the command should not be greater than that of the adjacent trench. The guns should be dispersed laterally and in depth as indicated for machine guns.

90. *Command posts.*—For every 100 to 150 yards of new trench constructed there should be a command post for the company (Pl. III), or battalion commander, the brain center of the new organization of trench world thus created. These command posts may be the vital points of some future battlefield. They should be placed conveniently near some main communicating trench and should be numerous enough for all uses during an action. Each command post must have a specific identifying letter or number, the series not to be repeated where there would be danger of confusion, so that when an officer comes to take possession he can immediately record

his address without the least danger of mistake. These posts will be marked by big signboards and on the map or plan by a clearly legible conventional sign.

Command posts if located and marked as described will thus form definite spots in the terrain, known to every one and used as the origin of coordinates for indicating other near-by points. For this reason the necessary supplies that troops in the vicinity may need in an emergency should be collected at some point definitely located with reference to a command post. The command post of every captain should therefore have at 20 yards to the right a depot for water, food, and sand bags; at 20 yards to the left a water-tight shelter for cartridges, grenades, and rockets. When these are needed urgently by troops in front they can be found and furnished. This coordination of the supply depots with the command posts of the captains must be regulated and insisted upon by the higher commanders.

The command posts being thus important centers and not the mere shelter for the company commander, they must be uniformly and positively supplied with certain articles as follows: A table, a water barrel, a lamp, oil and candles, a periscope, simple box or pigeonholes, a gas mask, an oiled cloth, and a curtain. All this material must be placed in the post when it is built and not distributed the day before an attack to the company commanders. In each command post there is a pad or book of printed forms for orders, requisition for supplies, and other necessary papers.

The command posts may also be used advantageously as material depots where the supplies for the troops will be continually collected and inventoried.

91. *First-aid stations.*—These are connected with the cover or firing trench by a communicating or approach trench wide enough to carry a litter. They are constructed like other shelters. The walls are covered with straw or hurdle work, which must be frequently changed. They should be at least 8 by 12 feet in size. Two cots should be placed against one wall and a bench for the wounded to sit on against the other. (Pl. III.)

92. *Kitchens.*—These should be constructed in shelters. (Pl. III.) The stovepipes should project somewhat above the top of the shelter to secure good draft. In addition, numerous ventilating holes must be made. The shelters should be large enough to accommodate the rolling kitchens. Small fires built of dry wood in the bottom of deep trenches do not betray the position of the trenches.

93. *Lavatories.*—These are improvised of tin or wood so as to form a number of basins in a row, with holes in the bottom, placed

above a wooden trough which receives and carries off the water to a drainage pit. There should be a grating for the men to stand on. They should be constructed in a branch trench, covered if practicable. The floor of the trench should have a decided slope for drainage.

94. *Shower baths.*—These should be installed in a deep shelter or in a cave shelter. A simple arrangement is to provide one or two kettles for heating water, tubs or casks for storing water, placed about 9 feet above the ceiling of the shelter. The tubs or casks should be connected with a pipe fitted with sprinklers, properly spaced. There should be a grating on the floor, and the bottom of the approach should have a fairly steep slope toward a drainage pit.

95. *Water supply.*—This usually consists of several large casks, filled by pipes, if practicable; otherwise the water is carried to them. There should be an interval of at least 10 yards between casks to avoid crowding and mud puddles. (Pl. III.)

96. *Sign posting the approach and communicating trenches.*—At all crossings two solid signboards must be set into the berm, beyond the reach of involuntary blows of passers-by. Their position is important. Whoever sets them must put himself in the position of both the passer-by coming from the front and the one coming from the rear and then arrange the signboards so that no one can mistake them.

Often the big approach trenches are named and marked only up to a parallel, beyond which they are doubled or quadrupled by others which absorb them into their special system of notation. This is a mistake. The approach trench must keep its name up to the parallel of departure, because it forms an important known feature or avenue in the trench system and the terrain.

97. Besides the sign posting, a simple rule prevents confusion between an approach trench and all those connected with it; that is, wherever there is a crossing or a fork, to keep the bottom of the principal approach trench at 12 to 16 inches below that of the offshoot trench. It is thus clear that if one takes a step up he is leaving the principal approach trench. In the same way at a right-angle turn a few blows of a pick will form a small arc of a circle and suggest the continuity of the main trench. These small efforts will save many an error and much confusion.

98. It is desirable to have traffic in one direction only in an approach trench, so one set is built for bringing troops up from the rear and another generally parallel for evacuation or moving to the rear. Movement in the contrary direction should be allowed only by special order.

99. An approach trench should merely cross a parallel (such as a support trench) and should not use even a small portion of the parallel for the movement of men to the front or rear. The objections are that men may make a wrong turn, right or left, into the parallel, and that the presence of troops in the parallel will interfere greatly with the movement to front and rear. The rate of flow of the movement through an approach trench is that of its most difficult point; for example an underground passage, tunnel, or a hole full of water. Therefore, every effort should be made to improve these choking points.

Everything that hinders movement in approach and communicating trenches must be rigidly suppressed. Shelters and niches must be so placed that they can not interfere with the use of the trenchs as free corridors.

100. *Daily upkeep of approach and communicating trenches.*—The difficulties are to fix the responsibility for the upkeep of the several parts and to order only such work as can be done. An exact and measured plan of the approach and communicating trenches is here of inestimable value. The method by task work should be used, tasks being assigned to small squads, distant 100 to 300 feet from each other, and all beginning work at the same hour on the entire length of trench. When 25 men are put together at the beginning of a trench they fall over each other and never finish their job.

101. *Command posts*, telephone stations, first-aid stations, trench depots, kitchens, the supply of drinking water, latrines, lavatories should generally be constructed in short covered trenches at the angles in the approaches. For equipment, drinking water, rations, and lanterns lighting signposts, niches of various sizes are constructed in the parapet, or recesses, lined with timber, are constructed in the walls of the trenches.

102. *Maintenence.*—Order and sanitary conditions must be rigidly exacted in the trenches or they will soon become untenable or very unhealthful.

The trenches after prolonged use deteriorate, not only from the fire of the enemy, but also from the effects of the weather. They must constantly be repaired. Walls which break down must be revetted. Firing banquettes must be constantly repaired with planks, fascines, or other revetting material. Damaged parapets must be repaired. Berms must be kept at proper width. Drainage pits must be watched carefully and kept cleaned out. It requires constant work to keep trenches clean and sanitary. Any commander who tolerates lack of work or poor work, under any pretext, is wanting in the first duty of a commanding officer.

When parts of trenches are captured, steps must be taken immediately to clear them of insects which swarm in them and transmit disease germs, particularly typhus. Straw should be burned in the trenches and shelters, and all wood should be whitewashed.

103. *Protection against asphyxiating gas.*—All occupants of the trenches must be provided with gas masks. In the shelters thorough ventilation must be provided by boring vertical or inclined holes with an earth auger through the roof. (Pl. III.) These can also be used for periscopes. Against asphyxiating gas it is necessary to seal hermetically the shelter as soon as the alarm is given. For this purpose two curtains of canvas or blankets are placed at the entrance, a short distance apart. There must always be a barrel of a solution of hyposulphite of soda in the shelter, which should be sprayed into the air.

104. *Protection against bombs and grenades* is secured by a grill of wire netting placed in front of the trench. The top of the grill should be so placed that a bomb passing over it will clear the trench.

105. *Trip and alarm wires* should be provided at important points. These may be arranged to light a flare or give some other signal to disclose the advance of the enemy. Lookouts should be provided with some means of giving a special alarm at the approach of asphyxiating gas.

NOTES ON FIELD DEFENSES.

[September, 1916.]

DUGOUTS.

1. *Number required.*—Sufficient deep dugouts must be provided in each sector of the front for its garrison. The garrison should be calculated at one man per yard of front, including brigade and battalion reserves. In addition, dugouts must be provided for machine-gun and trench-mortar detachments.

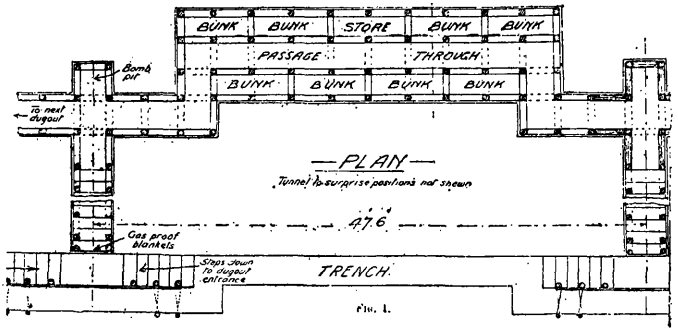


FIG. 1.

2. *Grouping.*—Dugouts should be constructed in groups, each dugout of a group being joined to the other.

3. *Sentry posts.*—Each dugout will be connected by a speaking tube to a sentry post, which should be given as much protection as possible. The sentry should be able to see No Man's Land, or the ground in front of the dugout, either direct or through a periscope.

4. *Depth.*—The minimum overhead cover for all dugouts should be 20 feet.

5. *Exits.*—All dugouts must have at least two entrances. It is also desirable to construct an alternative exit behind the parados to a surprise position for a machine gun, or so that bombers may

be able to get out to bomb the front trench if captured by the enemy, or for the garrison to get out to counter attack across the open.

The surprise position behind the parados and the exit must be most carefully hidden from view.

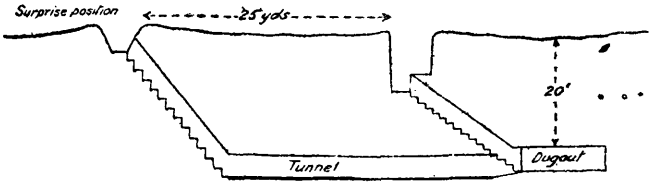


FIG. 2.

6. *Notes on construction.*—In the construction of dugouts the following points are to be observed:

(*a*) *Entrances.*—They should be well concealed and have not less than 5 feet of headcover with a bursting course. The best protection is usually obtained by well strutting the trench opposite the entrance.

Antigas blankets must be fitted to all entrances.

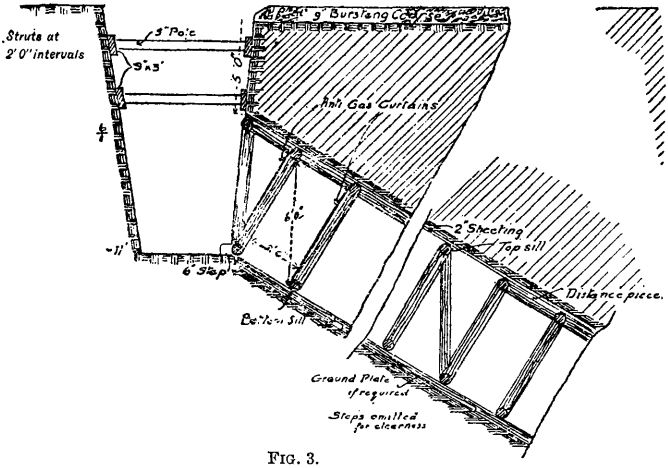


FIG. 3.

(*b*) *Galleries.*—Galleries leading to dugouts should have an incline of 45° except in the case of dressing stations, when it should be 30°.

Internal dimensions of galleries to be 2 feet 6 inches wide and 6 feet high. This involves using frames 2 feet 6 inches by 4 feet 6 inches.

Frames of standard dimensions will be supplied from corps or division parks; they are not to be made on the site.

Frames will be made of not less than 6-inch roughly squared timber; they will consist of a top sill and bottom sill and two posts, properly shouldered and fitted.

Frames must be put in at right angles to the slope of the gallery and be strengthened by distance pieces at the top or single diagonal struts from top to bottom; these should be secured by nailing.

In treacherous soil these frames should rest on ground plates.

Wooden steps to be provided, 1 foot tread 1 foot rise.

Frames should be spaced not more than 2 feet 6 inches in the clear. (See fig. 3.)

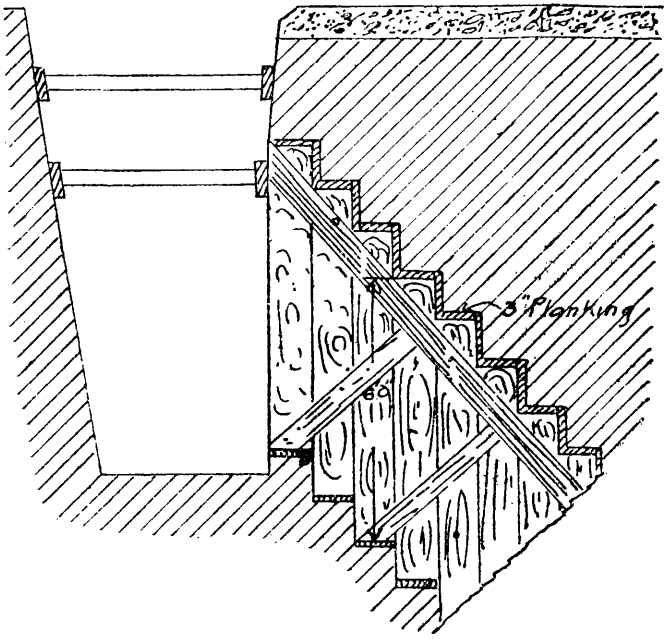


FIG. 4.

When material is available, galleries may also be made of mine cases. These must be made of 3-inch planks, and be prepared and fitted in the parks.

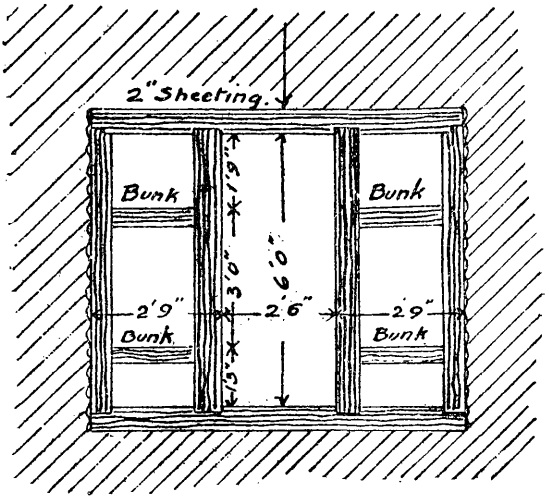


FIG. 5.

(*c*) *Interior of dugouts.*—These will be made of a standard section 6 feet high by 8 feet, to allow for bunks on either side.

Frames of standard dimensions will be supplied from corps park or division park. They are not to be made on the site.

Frames are to be made of not less than 6-inch roughly squared timber, with a top and bottom sill, properly framed to four uprights. They are to be spaced not more than 2 feet 9 inches in clear. (See fig. 5.)

(*d*) *Lining.*—Two-inch close sheeting will be used for roofs of both galleries and dugouts. For the sides 1½-inch sheeting or corrugated iron may be used. Sheeting should be cut into 3 feet 6 inch lengths and one end beveled at the parks.

(*e*) *Bomb traps.*—Inclined galleries are not to lead direct into dugouts; they should be entered by a short passage about 3 feet long from the gallery. (See fig. 6.)

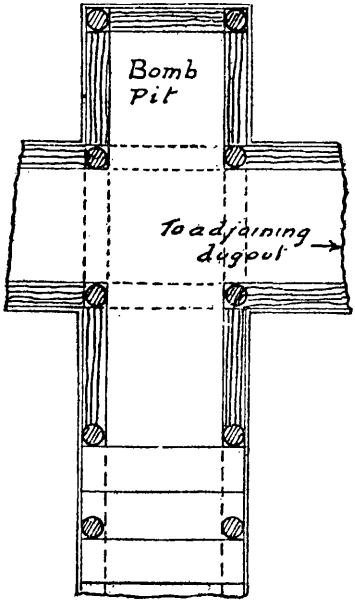


FIG. 6.

The gallery should be continued down about 3 feet below passage to dugout to form a trap for bombs.

7. *Emergency tools.*—Two picks and two shovels should be kept in each dugout.

BLOCKING GATE FOR COMMUNICATION TRENCH.

Placed at junction of communication and support-line trenches.

The gate "A" is made of expanded metal double sheets. It is an ordinary "shut-to" gate which is closed by two iron rails which slip into iron hooks on the doorposts.

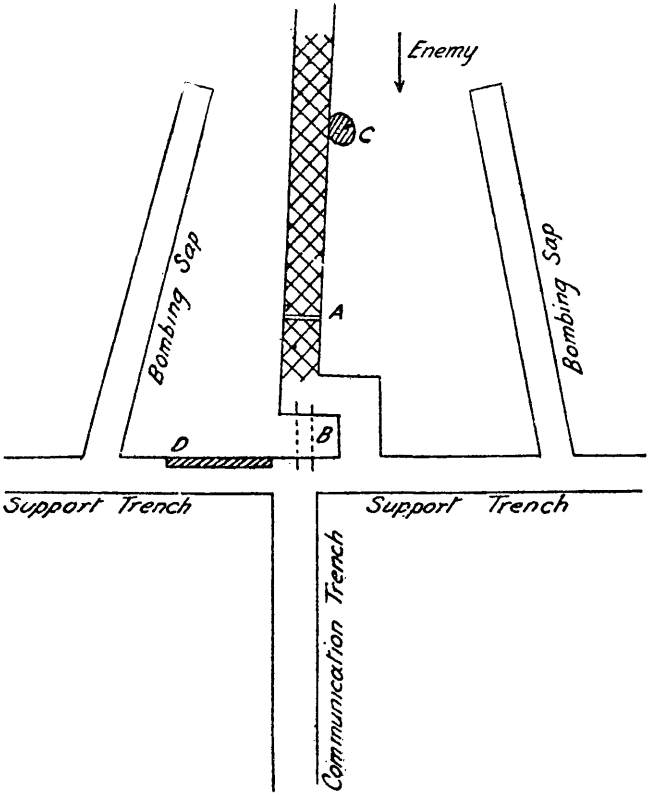


FIG. 7.

At the gate the trench is wired over, close enough to stop a grenade from being thrown out of the trench.

At "C" there is a barbed-wire knife rest, which can be pulled into the trench to form an additional obstacle.

Bombing can be carried out from the saps on either side, and from fire step at "D."

There are two loopholes in the traverse at "B," which cover the gate and trench beyond it.

REVETMENTS.

1. *Local conditions.*—Different natures of soil require different revetments.

The following notes apply to revetments suitable to the soil on the present front of this corps. In Flanders, where the clay is soluble, modifications would be necessary.

2. *Slopes requiring revetment.*—Front parapets and sides of communication trenches usually require revetment. The back wall of fire trenches should not be revetted unless they will not otherwise stand, or unless they have been blown down by shell fire and require rebuilding.

3. *Revetments.*—If the fire step is not a wooden one, as is preferable, the best revetments in order of suitability are planking, hurdles, corrugated iron, expanded metal, or three thicknesses of rabbit-wire netting nailed on frames.

Above the fire step, brushwood is the best revetment, as the stakes, being loose, do not impede repair work in the event of the trench being blown in.

4. *Notes on revetments.*—The following are a few points with regard to various kinds of revetments:

(*i*) *Brushwood.*—To make a brushwood revetment, stakes should be driven into the ground from 1 to 2 feet apart along the line of parapet, the brushwood laid behind, and the whole anchored to the parapet.

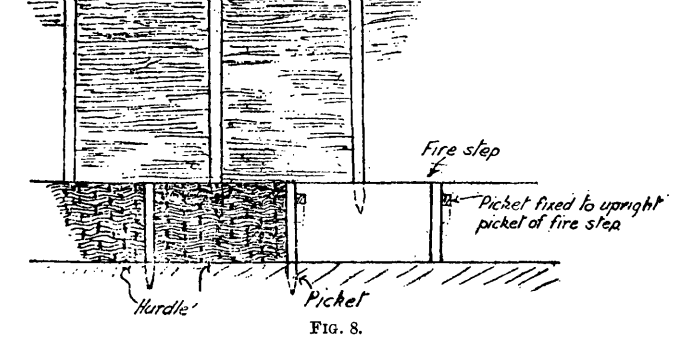
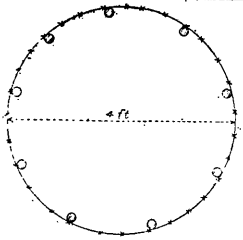
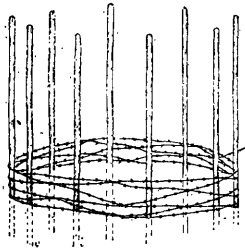


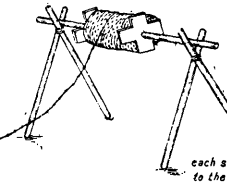
FIG. 8.

CONCERTINA BARBED WIRE.



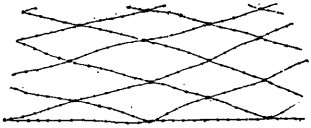
Nine pickets are arranged in a circle 4 ft in diameter.



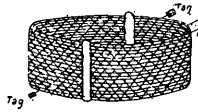


Four men sit round the circle and one guides the wire, uncoiling it off the drum, till the whole coil is bound round the outside of the nine pickets.

Pieces of pliable wire about five inches long having been prepared, each strand of barbed wire is bound to the next strand above it in the centre of every second space between the pickets.

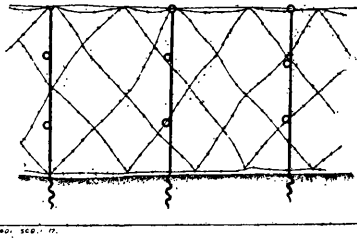


There being an odd number of pickets, the result is a diamond pattern when the coil is stretched out.



When the coil is expended and bound with pliable wire, it can be lifted off the pickets. It is then secured by wire and tags are fastened to the two outside circles to enable them to be found with ease at night.
The coils are now ready to be carried to the site.

TO ERECT THE ENTANGLEMENT.



Erect a row of pickets at three to four feet interval. See that they are perpendicular and firmly fixed. Extend the Concertina and drop it over the pickets. Run a line of strong plain wire through the top loop of each picket; if screw pickets are used and thro' Concertina, giving the wire a double turn round the loop, so that if one bay is cut, the next will stand up. If other posts are used the plain wire should be twisted round top of each picket.

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FIG. 9.

(*ii*) *Hurdles.*—Hurdles are made and sent up to the trenches in two sizes, viz, 6 feet long by 3 feet high, and 6 feet long by 1 foot 6 inches high.

To use hurdles for revetment, the ends of the stakes are driven into the ground; stout pickets must then be driven in in front of the hurdles and the whole well anchored back to the parapet.

Hurdles, especially the larger size, should not be used above the fire step in trenches which are liable to be continuously blown in, as they make the work of clearing a trench difficult.

(*iii*) *Rabbit netting.*—Single rabbit netting is not strong enough to support clay or chalky soil in bad weather. Netting should be double or treble. It should be strongly nailed to stout frames.

(*iv*) *Expanded metal.*—Expanded metal is a good strong revetting material, but neither this nor rabbit netting should be used in trenches which are particularly liable to be blown in, as, when buried, it greatly impedes the work of digging out a trench.

(*v*) *Sandbags.*—Sandbags are one of the most useful and common forms of revetment. Their great disadvantage is their short life; but, if laid properly, they should last a considerable time, especially when filled with chalk, as this hardens and forms a sort of brick.

Great attention should be paid to the way in which sandbags are laid. They must be laid at least at right angles to the slope of the parapet. Everything depends on the bottom row being laid at the correct angle. This can be done by preparing the ground and giving it the correct slope.

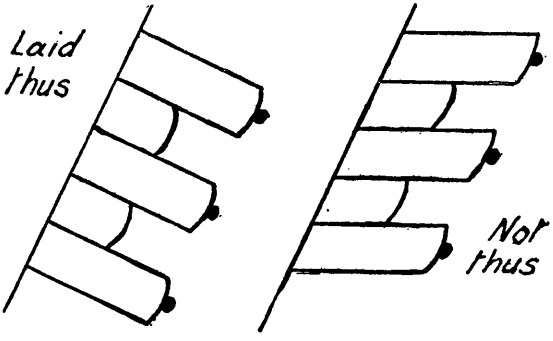


FIG. 10.

5. *Anchoring of revetments.*—The proper anchoring of revetments is most important, as without this no revetment will stand. Brushwood, hurdles, wire, and expanded metal must all be anchored back

to the parapet. The method of doing this is practically the same in all cases. Tne difficulty is to place the anchors in position if the parapet has been laid, and it often means that the parapet has to be pulled down to enable the anchor to be put out. This may, however, sometimes be avoided by the use of an iron needle. This can be pushed through the parapet, the wire put through the loop and pulled back into the trench. These iron needles can be made in any workshop.

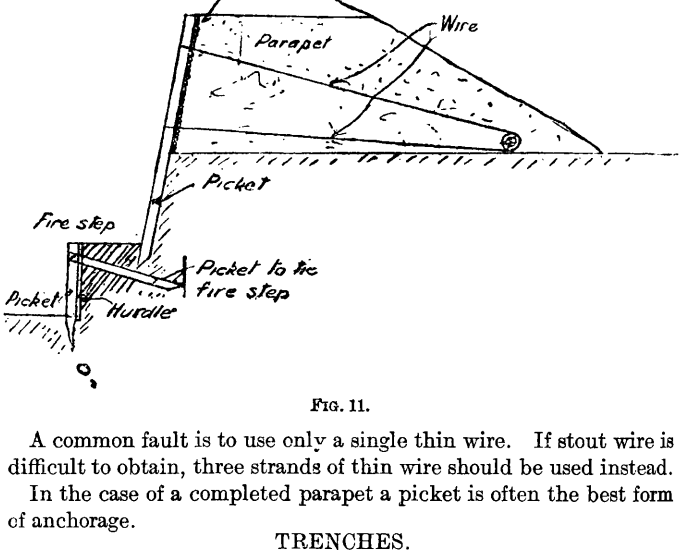


FIG. 11.

A common fault is to use only a single thin wire. If stout wire is difficult to obtain, three strands of thin wire should be used instead.

In the case of a completed parapet a picket is often the best form of anchorage.

TRENCHES.

A broad, deep, well traversed trench, with unrevetted sides, is the best, as it is less likely to get blocked, and the danger of men being buried is reduced. The dimensions recommended are: Fire trench—breadth at bottom, 2 feet; breadth of fire step, 1 foot 6 inches; amount of cover, 7 feet; slope of sides of trench, 4 to 1. Communication trench—breadth at bottom, 3 feet; amount of cover, 7 feet; slope of sides of trench, 4 to 1. *A berm at least 1 foot wide must always be left on both parapet and parados.* Time should not be wasted in rebuilding and revetting narrow trenches so as to keep them narrow. They should be reconstructed as broad trenches

APPENDIX I.

CONSOLIDATION OF TRENCHES AND LOCALITIES AFTER ASSAULT AND CAPTURE.

1. CONSOLIDATION OF A CAPTURED SYSTEM OF TRENCHES.

The capture of a system of hostile trenches is an easy matter compared with the difficulty of retaining it. A thorough knowledge of the principles, a careful study and correct use of the natural features of the ground, and a detailed preparation and organization of the work, are necessary; but success will only result if there is also an absolute determination on the part of all ranks to get the work done promptly at all costs.

The principles of the consolidation of captured trenches are, briefly, as follows:

(*a*) To establish a series of strong points or supporting points, wired all around and mutually supporting each other according to the ground. These points should be provided with machine or Lewis guns at once.

(*b*) To provide good communication to the rear from these points.

(*c*) To fill in all hostile trenches within bombing distance of the points occupied.

(*d*) To establish, if possible, simultaneously with the consolidation of strong points in the front line, a number of supporting points in rear. These points should, if the ground is favorable, be placed to cover the intervals between the works in the front line.

(*e*) The strong points can later be connected to form a continuous front line.

The above principles must be applied with due regard to the natural tactical features of the ground. The satisfactory siting and consolidation of a position will largely depend on the power possessed by the officers on the spot to recognize during the various stages of a battle the minor features of real tactical importance. This ability is only acquired by previous training, and is a quality which every officer must study to possess. The size and trace of the "strong points," as well as the intervals between them, will vary

according to the lay of the ground and the plan of the hostile trenches captured. During the process of consolidation concealment from artillery observation is of importance.

The first essential is speed in rendering the captured position strong enough to resist the first counter attacks. It is therefore necessary that a definite plan should be decided on beforehand as to which points first require attention. This can be done, in the majority of cases, with great accuracy from maps and aeroplane photographs and from a study of the ground from any point in our lines which commands a view of it. In the case of craters the forecast of the tunneling officers must be obtained.

Although it is usually advisable that assaulting troops should be relieved as soon as possible, this must not to be taken to imply that the duty of securing ground gained is the task only of the relieving troops. It is an unsound principle for troops to *expect* to be relieved immediately after an attack, as it wastes valuable time at a critical period when speed in work is essential. It must be understood that troops which take a position must commence the work of consolidation at once.

The distribution of engineer detachments requires to be carefully considered beforehand. In all cases of an assault or advance, where it is intended to secure the ground gained, the troops destined for the purpose should include a detachment of engineers, the commander of which should be detailed previously and attached to the staff of the unit or formation concerned.

Garrisons must hold on to their ground; they have nothing to fear from being outflanked.

2. CONSOLIDATION OF LOCALITIES.

During an advance, when it becomes necessary to consolidate some locality of tactical importance, such as a village or wood, the same general principles hold good as in the consolidation of a system of trenches. Some notes on the particular points that require attention in the case of villages and woods are appended.

Villages.—Enlargements from even small scale maps give very accurate plans of most villages and make it possible to plan the defense in sufficient detail beforehand. It is essential that subordinate commanders should be provided with such plans, in order that the general idea of the defense may be quickly and properly understood.

The principles of the defense of a village are laid down in Infantry Training, section 143. The order of urgency of work is as follows:

(*a*) Barricade and picket all exits. Establish strong points near exits to cover approaches or any streams or tracks which might serve to guide a counter attack. Commence work on keep, preferably at village crossroads. Barricade roads.

(*b*) Reconnoiter for cellars.

(*c*) Establish communications, giving cover from view, radiating from keep to outer strong points, and from keep to the rear.

(*d*) Construct bombproofs in cellars at strong points and keep, false roofs to cellars, etc.

(*e*) Complete keep.

(*f*) Improve communications at (*c*) above, to give cover from fire.

(*g*) Make lateral lines of communication between strong points.

Strong points should be established (if it is possible to do so) to the flank of conspicuous buildings likely to afford good targets for hostile artillery fire. In the case of keeps in villages, this is often impossible owing to the presence of church spires. It is, however, preferable to have a keep, even with this disadvantage, that is central, accessible, and strong against infantry assault. It should be remembered in this connection that by the time hostile infantry can assault a village keep hostile artillery fire will necessarily have ceased.

Woods.—As in the case of villages, plans should be prepared of the locality.

There has been much discussion in the past as to what part of a wood should be occupied. Experience has proved that, owing to the great advantages afforded by cover from view, the position to take up in a wood is just so far within the outer edge as will permit of good view into the open. In this connection it should be remembered that in course of time shell and rifle fire thins out the edges of woods considerably. It is therefore advantageous in the first instance to take up positions slightly in rear of those which may appear at the moment to be most advantageous.

If, as is often the case, the wood is surrounded by a hedge, there is a natural tendency to make trenches against this hedge. This is to be avoided. A hedge forms a very good obstacle against assault, with the addition of a little wire. If it screens the view it can be quickly thinned.

The order or urgency of work is as follows:

(*a*) Establish strong points for all-round defense at the corners and salients of the wood. These are the points which are most liable to counter attack.

Establish central reserve, reconnoiter, blaze, and clear communications.

The defense of a wood should be very active, and counter attacks must be launched against any hostile troops that may reach the edge of the wood in order to prevent a lodgment that places the enemy on equal terms.

(*b*) Establish intermediate strong points and lateral communication.

(*c*) Establish central keep at junction of roads, or on near edge of clearing.

In the case of large woods and forests, where the general line of defense runs through a wood, a line of strong points should be established across the wood, if possible behind a road or other clearing. The near edge of the clearing should be entangled, and the intervals between the "points" should be swept by fire. As time permits "rays" should be cleared, radiating from the strong points and crossing similar "rays" from adjoining centers, so as to add to the depth of the field of fire.

These rays should be wired and obstacles arranged so as to break up an attack and force the attackers into the openings.

A line of intermediate strong points, communications, etc., should also be established, as indicated in (*b*) above.

3. OCCUPATION OF CRATERS.

I. The occupation and consolidation of mine craters presents many difficulties, and all ranks should understand the principles to be acted upon in the event of the explosion of mines on their front.

II. Craters are usually formed as a result of one of the following mining operations:

(*a*) An attack by us on the enemy's trenches.

(*b*) An attack by the enemy on our trenches.

(*c*) Underground fighting.

III. The possession of crater offers the following advantages:

(*a*) It can be turned into a strong point capable of holding a small garrison.

(*b*) It gives command of the ground in the vicinity.

(*c*) It forms a considerable obstacle.

IV. (*a*) When mines are exploded by us in connection with an attack on the enemy's trenches, our object should be to seize and hold the whole of the mine crater or craters, or a line in front of them. The latter plan is usually the best, and the craters in rear can then be turned into strong points.

(*b*) When craters are formed as the result of an attack by the enemy on our trenches, or in the course of underground fighting, our object will usually be to seize and hold the near "lip" of the crater.

Parties must be rushed out at once to seize the lip. It may be impossible to open up communication to these parties till after dark. They should, therefore, take sufficient grenades, water, etc., and must be prepared to hold on though isolated.

V. Before the explosion of a mine a forecast should be made of the state of affairs to be expected after the explosion, and all details of probable requirements should be worked out. These would include:

(*a*) The formation of dumps of engineer materials as close up as possible.

(*b*) The organization of working and carrying parties.

Work should start immediately after the explosion of the mine, and no time should be lost in turning into account the quiet interval which usually follows the explosion.

The personnel of engineer field companies should be freely used for this work under instructions given through the general staff.

VI. The following are the main points to be attended to in the actual consolidation of the craters:

(*a*) All trenches should be strutted as they are constructed. Special frames for this purpose must be made beforehand.

(*b*) All works on a crater, whether inside or outside the "lip," should be provided with a parados.

(*c*) Dugouts should be made by tunnelling into the sides and not at the bottom of a crater.

(*d*) At least two communication trenches should be constructed leading into each crater.

Entrances to craters should be made at the sides and not through the rear "lip."

(*e*) All trenches leading up to a crater from the enemy's line should be straightened or filled in for a distance of at least 40 yards from the position of the defenders, so as to keep the enemy bombers at a distance.

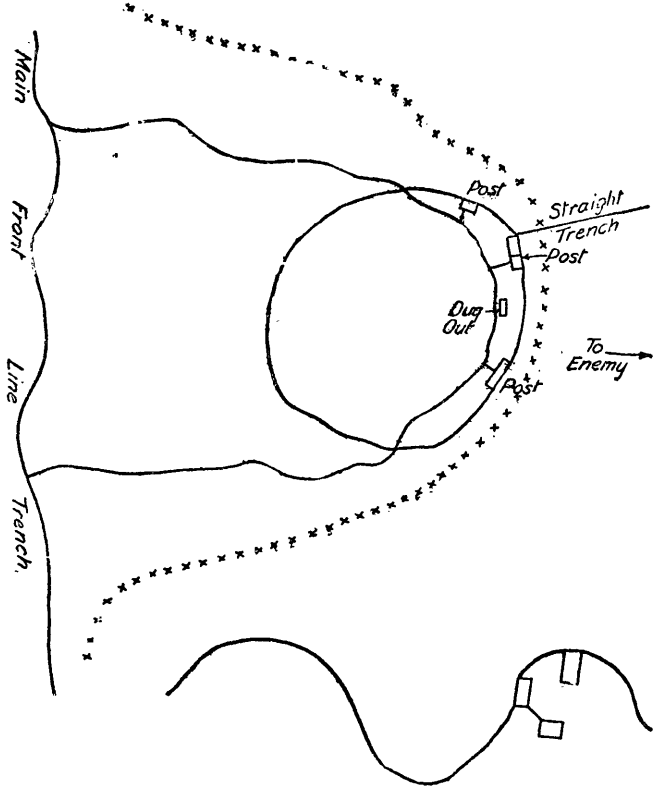
This work can usually be carried out with the least difficulty immediately after the explosion.

(*f*) Collapsible knife rests, French wire and other forms of portable wire entanglement, should be brought up in large quantities and thrown over the "lip" of a crater.

VII. There are two main methods of holding craters:

(*a*) *Method 1.*—(See sketch below and pl. A).

This method should usually be employed after the explosion by us of a mine in the enemy trenches or in the area where it is known that the enemy is not engaged in mining.



The front "lip" of the crater is held by means of several posts. Two communication trenches lead into the crater, one on each side, and give lateral communication between the posts. One or two dugouts are constructed in the sides of the crater.

(*b*) *Method B.*—(See sketch below and pl. B.)

This method should usually be employed when the enemy has exploded a mine in or near our trenches, or when we have exploded a defensive mine close to our own trenches.

The rear "lip" of the crater is held. Wire is thrown inside the crater. One or two loopholes are cut through the rear "lip" so as to command the inside of the crater.

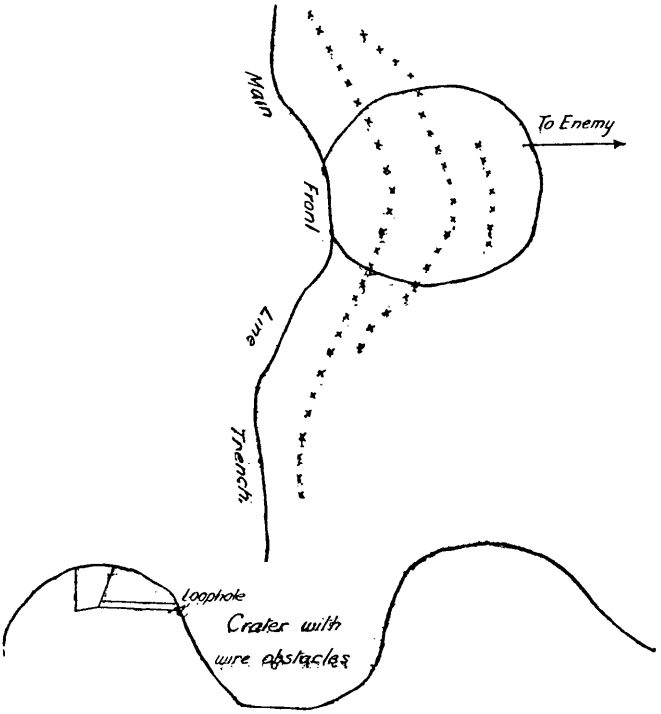


Plate C shows a scheme for converting the area behind the lips of a series of craters, which have been occupied, into a strong post.

The importance of rendering the means of access to the lip secure from bombing attack is not always recognized.

VIII. Work should be carried out in the following order:

(*a*) Construction of one or two posts in the "lip" of the crater.

(*b*) Wiring the front of posts and filling in or straightening trenches leading from it toward the enemy.

(*c*) Digging of communication trenches up to the crater.

And, if far lip has been occupied:

(*d*) Digging trench for lateral communication inside the crater.

(*e*) Completion of wiring front of crater and construction of further posts in far "lip."

(*f*) Construction of dugouts.

(*g*) Improvements to the above.

It should usually be possible to do (*a*), (*b*), and (*c*) together.

4. NOTES ON RAPID WIRE ENTANGLEMENTS.

One of the first requirements in consolidating a position is to get some wire out in front of it.

The following general principles regarding the construction of wire entanglements should be observed:

(*i*) The rear edge of the entanglement should be about 20 yards from the trench; if the trace of the entanglement is irregular and does not follow the trace of the trench, it will make the task of the hostile artillery more difficult.

(*ii*) The depth of the entanglement should be as great as possible, and at least 30 feet. The wire available should be expended in forming a deep entanglement rather than a "heavy" one (i. e., one with a large amount of wire between each set of posts). The construction of two belts with an interval between them, rather than one belt of twice the depth, gives the hostile artillery a deeper target to destroy, without increasing the material required for constructing the entanglement, except by one row of pickets.

(*iii*) There will seldom be time in rapid wiring to "dig in" the wire for concealment. Every advantage should be taken, however, of natural folds in the ground, long grass, or brushwood, or other means of concealment.

(*iv*) Wire entanglements should be 2 feet 6 inches to 3 feet high.

(*v*) The posts in a row should be about 6 feet from each other, and the rows about 6 feet apart. If wooden posts are used they must be strong; light posts are useless.

(*vi*) The difficulties of crossing an entanglement are increased if it is not too regular, e. g., if the heights of the posts above ground and the distances between them are varied. For rapid wiring drill, however, a regular entanglement is easier to construct.

To insure that an obstacle can be erected with rapidity and in silence, every one of the working party must know what he has to do and work so that he does not get in the way of the others.

This necessitates some form of *drill*. There are a large number in use, of which a selection is given below. The following notes and rules will be found useful in carrying out any form of drill for constructing wire entanglements:

(*i*) The party should, as far as possible, work so that the obstacle is always between them and the enemy. Each wiring party should have a double sentry lying down about 30 or 40 yards toward the enemy to prevent patrols sniping or bombing the party. If circumstances necessitate it, a special covering party should be provided.

(*ii*) The party should work extended and not bunched together.

(*iii*) Large parties, in which each group of men has only one operation or duty to perform, will erect entanglements quicker than a small party, in which each man has several duties to perform in succession, unless latter is very well drilled.

(*iv*) The best *unit* of entanglement is about 40 or 50 yards long. Its construction can then be controlled from one point. This distance is also a convenient interval to leave small gaps for patrols.

(*v*) A line of posts is best laid out at night by putting down a tape or string with the intervals of the posts marked by bits of rag or sandbag tied on to it.

(*vi*) The end of a coil of barbed wire will be found secured on the drum tucked under the standing part. In the dark it is very hard to find and release. Coils should, therefore, be prepared by daylight. A good method is to attach a piece of string to the end, uncoil the roll half a turn, re-coil it on a piece of old sandbag, and fasten it up by the string. The end of the wire can then be readily found in the dark. The pieces of tin on the wooden drums should be removed to prevent noise. It may be found convenient, to make carrying easier, to re-coil the barbed wire in smaller coils on a stout stake.

(*vii*) Pickets should be made up into bundles of one-man loads. They should be firmly tied with plain wire or brought up in sandbags. The latter is the surer way of keeping them together; at any rate, with small wooden pickets. A drum of barbed wire is best carried over the shoulder, with a stout stake passed through it, which also serves for uncoiling the wire. Pickets and wire should be dumped by the carrying party outside the trench behind the center of the length to be wired.

(*viii*) Mauls, if used, should be muffled by nailing on a leather face or with sandbags. About eight thicknesses of sandbag material are necessary to be of any use.

(*ix*) Equipment should not, unless necessary, be worn by wiring parties, as it is liable to cause noise.

(*x*) *Stays and holdfasts.*—(See fig. 1.) Forward stays are not absolutely necessary if the entanglement posts are well driven in. They are usually required with iron screw posts, which are not very stiff unless driven in up to the bottom eye. Forward stays can not be put on, without great loss of time, until the fence on the first row of posts has been completed, for they would interfere with the fence wires being looped over the posts.

Back stays should invariably be provided and anchored well back, so as to resist any attempt to pull the entanglement away by grapnels.

Side stays at the ends of separate lengths of entanglement are usually desirable.

Pickets used as holdfasts for stays should be "staggered," i. e., not driven in vertically, but inclined away from the post that they stay.

(*xi*) When stringing horizontal wires for an apron on a stay or diagonal, the latter should be given a kink or bend at the places of crossing, so that there will be less chance of the wires slipping down. The horizontal wires may be secured by binding wire, or by taking a bight and looping it around the stay. The coil should not be passed over and under, as this is a slow process.

NOTES WITH REFERENCE TO IRON SCREW POSTS AND PICKETS.

(*a*) The posts are 5 feet long with four eyes, the pickets are 3 feet 6 inches long with two eyes, or 15 inches long with a loop at the end. If the ground is soft, the posts can be screwed in 2 feet deep or more.[1]

(*b*) In rapid work the wire can simply be placed in the eye by forming a loop in the wire and slipping it over the post. It is not intended that the wire should be threaded through the eye. If time allows, the horizontal wires can be put on slack, and when the fence is strung the post can be given a complete turn, so as to prevent the wire slipping out should it be cut; or the barbed wire may be twisted round the posts, through an eye, as it is put on; or it may be secured to the eyes by binding wire.

(*c*) To permit of the loops being slipped over the posts, it is obvious that the lowest wire in a fence must be put on first, and no forward or back stays can be fixed until the fence has been completed.

[1] Angle-iron posts are 5 feet 10 inches and 3 feet 6 inches long

(*d*) Care must be taken that all the posts are originally screwed in so that the eyes point the same way, otherwise delays will occur in the wiring.

(*e*) Loose bundles of iron screw posts and pickets cannot be carried noiselessly. It is advisable, therefore, to wrap them round with a sandbag, secured by a light turn of wire with the ends twisted together. Enough end to this wire should be left so that it can be untwisted by hand without pliers.

(*f*) Short stakes or bats must be provided to fit the top eye of the posts in order to screw them in. The helves of the entrenching implement serve the purpose.

EXAMPLES OF WIRE DRILLS.

Picket is used to mean a short picket used as a holdfast.

Post is used to mean a longer upright.

Fence is used to mean a series of wires on a row of posts.

The conventional signs used in the diagrams are explained in figure 2.

In all the drills given, unless otherwise stated, it is assumed that:

(*a*) The length to be erected is 50 yards.

(*b*) The stores required are collected at a point behind the center of the length in a convenient order.

(*c*) The line of the fence has been marked or indicated.

(*d*) The drums of wire are opened and the ends ready.

(*e*) Bars or sticks are run through the drums, so that the wire can be uncoiled readily.

(*f*) Short sticks for screwing in the pickets are carried by the men requiring them (or mauls if wooden or angle iron pickets are used).

(*g*) All wirers have hedging gloves and wire cutters; and have their legs protected by gaiters or sandbags.

(*h*) Each number consists of two men who work together, and the numbers commence work in succession at a suitable interval (say 4 posts apart). Thus Nos. 2 move off as soon as Nos. 1 have the desired start, Nos. 3 at the same interval behind Nos. 2.

(*i*) All work is commenced on the left.

(*j*) The men who put the top wire on a fence stay the end post to short pickets.

(*k*) On completion of each operation or "duty" detailed in the drill, all men should return to a fixed place, in order to prevent confusion, if some work faster than others.

(*l*) Spare men are at hand to replace any casualties.

The drills are primarily intended for use with iron screw posts, but can be used for wooden or angle iron posts with slight modifica-

tions. If the soil permits of posts being screwed in to the bottom eye, no stays are necessary, and three horizontal wires in the fence, instead of four, will be sufficient.

No estimates of stores required are given, as the distance apart of the posts and the amount of wire used must depend on what is available.

Drill No. 1.—Double Apron Entanglement.

(See fig. 3.)

Working party, 12 men exclusive of noncommissioned officers.

First duty:

Nos. 1. Lay posts in position on ground A.

Nos. 2. { Front rank—assists Nos. 1.
Rear rank—holds up posts for Nos. 3 to screw in.

Nos. 3. Screw in posts, separately.

Nos. 4. Lay front and rear pickets in position.

Nos. 5. Screw in front pickets B.

Nos. 6. Screw in rear pickets C.

Second duty:

Nos. 1. Bottom wire of fence A.

Nos. 2. Second wire of fence A.

Nos. 3. Third wire of fence A.

Nos. 4. Top wire of fence A.

Nos. 5. Front diagonal between A and B.

Nos. 6. Rear diagonal between A and C.

Third duty:

Nos. 1. Top horizontal wire on front diagonals A B.

Nos. 2. Second horizontal wire on front diagonals A B.

Nos. 3. Bottom horizontal wire on front diagonals A B.

Nos. 4. Top horizontal wire on back diagonal A C.

Nos. 5. Second horizontal wire on back diagonal A C.

Nos. 6. Bottom horizontal wire on back diagonal A C.

This drill involves Nos. 5 in "second duty," and Nos. 1, 2, and 3 in "third duty," working in front of the fence.

In the "first duty" No. 2 rear rank holds up a post for No. 3 front rank to screw in until it gets a bite in the ground. He then holds up a post for No. 3 rear rank, etc.

This obstacle and others of the same nature can be deepened by adding similar bays behind it. The posts in successive bays should cover the intervals between those in front of them. (See fig. 4.)

If two bays are made, the obstacle can be increased by tossing loose wire into the valley between the posts.

DRILL NO. 2.—TRIP, FENCE, AND APRON.

(See fig. 5.)

Working party, 10 men exclusive of noncommissioned officers.

First duty:

Nos. 1. Lay posts in position A.
Nos. 2. Hold up posts.
Nos. 3. Screw in posts.
Nos. 4. Bring up and screw in front pickets B.
Nos. 5. Bring up and screw in rear pickets C.

Second duty:

Nos. 1. Front trip wire on pickets B.
Nos. 2. Bottom wire on fence A.
Nos. 3. Second wire on fence A.
Nos. 4. Third wire on fence A.
Nos. 5. Top wire on fence A.

Third duty:

Nos. 1. Front diagonal between A and B.
Nos. 2. Back diagonal between A and C.
Nos. 3. Top horizontal wire on the diagonals A C.
Nos. 4. Second horizontal wire on the diagonals A C.
Nos. 5. Bottom horizontal wire on the diagonals A C.
Nos. 1 have to work in front of the fence in "third duty."

DRILL NO. 3.—TRIP AND FENCE.

(See fig. 6.)

Working party, 16 men exclusive of noncommissioned officers.

First duty:

Nos. 1. Screw in posts 6 feet apart, A.
Nos. 2. Screw in pickets B and C; B first.
Nos. 3. Trip wire B.
Nos. 4. Bottom wire of fence A.
Nos. 5. Second wire of fence A.
Nos. 6. Third wire of fence A.
Nos. 7. Top wire of fence A.
Nos. 8. Diagonal wire between A and C.

Second duty:

Nos. 1. Diagonal wire between A and B.
Nos. 2. Trip wire C.
Nos. 3. Uncoil loose wire.
Nos. 4. Uncoil loose wire.

Second duty:

Nos. 5. Toss in loose wire uncoiled.

Nos. 6. Toss in loose wire uncoiled.

Nos. 7. Fasten loose wire.

Nos. 8. Fasten loose wire.

In the "second duty," Nos. 1 have to work in front of the fence.

Nos. 3 and 4 uncoil the loose barbed wire on the ground well clear of the entanglement. Six coils for each 25 yards.

Nos. 5 and 6 with large wooden pickets lift the loose wire and toss it on to the entanglement.

Nos. 7 and 8 spread the loose wire out and fasten it by twisting a bight at intervals to the diagonals and fence wires.

DRILL NO. 4.—FENCE, WITH CROSSED DIAGONALS AND TRIPS.

(See fig. 7.)

Working party, 14 men exclusive of noncommissioned officers.

The pickets are placed opposite the posts.

This drill involves four men working on the enemy's side of the fence.

First duty:

Nos. 1. Screw in posts A.

Nos. 2. Screw in pickets, B first, then C.

Nos. 3. Trip wire B.

Nos. 4. Bottom wire of fence A.

Nos. 5. Second wire of fence A.

Nos. 6. Third wire of fence A.

Nos. 7. Top wire of fence A.

Second Duty:

Nos. 1. } Prepare posts in next length.
Nos. 2. }

Nos. 3. Front diagonal between A and B, commencing at picket B, B_1, then to A_2, B_3, etc.

Nos. 4. Front diagonal between A and B, commencing at top of post A_1, then to B_2, A_3.

Nos. 5. Back diagonal between A and C, commencing at picket C_1, then to A_2, C_3, A_4, etc.

Nos. 6. } Back diagonal between A and C, commencing at top of
Nos. 7. } post A_1, then to C_2, A_3, etc.

DRILL NO. 5.—SUCCESSIVE ROWS OF FENCES.

(See fig. 8.)

Working party, 12 men, divided into four groups of 3 each, W, X, Y, Z.

The posts must be prepared by attaching binding wire to the bottom eye; to this the vertical diagonals between the fences are made fast.

First duty:

Group W Lay out posts in row B.
Group X. Screw in above.
Group Y. Lay out pickets in row A.
Group Z. Screw in above.

Second duty:

Group W. Lay out posts in row C.
Group X. Screw in above.
Group Y. Bottom wire of fence B.
Group Z. Trip wire on row A.

Third duty:

Group W. Second wire on fence B.
Group X. Third wire on fence B.
Group Y. Top wire on fence B.
Group Z. Front diagonal between A and B.

Fourth duty:

Group W. Bottom wire of fence C.
Group X. Second wire of fence C.
Group Y. Third wire of fence C.
Group Z. Top wire of fence C.

Fifth duty:

Group W. Diagonal between B and C, bottom of C_1 to top of B_1, bottom of C_2, etc.

Group X. Second diagonal between B and C, top of C_1, to bottom of B_1, top of C_2, etc.

Group Y. Lay out and screw in pickets D. } or { lay out row of posts D, if the fences are to be continued.

Group Z. Diagonal between C and D. } or { screw in above, etc.

In "third duty," Z, and in "fifth duty," W and X, work on enemy's side of fence.

In "fifth duty," W and X loop the diagonals over top of pickets and make them fast to the bottom eye by binding wire.

Instead of putting the crisscross diagonals between fences B and C as above, which involves binding wire and takes some little

time, it would be sufficient, if time presses, to stay the pickets merely by connecting the heads. (See fig. 9.) "Gooseberries," etc., can be thrown into the space between B and C.

Another variation is to put loose wire or French wire between fences B and C and crisscross plain wire to connect the tops of the pickets. (See fig. 10.)

A further variation can be introduced by placing the posts so as to form squares instead of triangles. (See fig. 11.)

Drill No. 6.—Double Fence.

(See fig. 12.)

Working party, 28 men exclusive of noncommissioned officers.

This entanglement is designed for stout wooden posts well driven in, or screw posts screwed in down to the bottom eye; no holdfast pickets are then required.

The drill only requires one duty from each pair of men.

The apron is of a different pattern to those previously given; the wires miss alternate pickets.

Three horizontal wires can be used for the fence instead of the "gate" pattern shown.

ORDER OF WORK.

(1) Under superintendence of two noncommissioned officers all hands carry up and place the posts on the ground.

(2) Nos. 1. Drive or screw in posts in front fence A.
Nos. 2. Drive or screw in posts in back fence B.
Nos. 3. Bottom wire 3 of fence A.
Nos. 4. Diagonal wire 4 of fence A.
Nos. 5. Diagonal wire 5 of fence A.
Nos. 6. Top wire 6 of fence A.
Nos. 7. Bottom wire 3 of fence B.
Nos. 8. Diagonal wire 4 of fence B.
Nos. 9. Diagonal wire 5 of fence B.
Nos. 10. Top wire 6 of fence B.
Nos. 11. Apron wire 11.
Nos. 12. Apron wire 12.
Nos. 13. Apron wire 13.
Nos. 14. Festooned wire 14.

Drill No. 7.—Ordinary Low Entanglement.[1]

(See fig. 13.)

Working party, 30 men in 10 groups, with a noncommissioned officer.

Group A, front row of pickets A.
Group B, straight wire A row of pickets.
Group C, second row of pickets C.
Group D, zigzag wire A_1, C_1, A_2, C_2, etc.
Group E, loose wire on zigzag A_1, C_1, A_2, C_2, etc
Group F, straight wire on C row of pickets.
Group G, third row of pickets G.
Group H, zigzag wire G_1, C_1, G_2, C_2, etc.
Group J, loose wire on zigzag G_1, C_1, G_2, C_2, etc.
Group K, straight wire on G row of pickets.
Pickets may be 12 to 18 inches out of the ground and 3 feet apart.

Drill No. 8—French Wire Obstacle.

(See fig. 14.)

The obstacle consists of two rows of French wire, placed just far enough apart for a man to pass between them. Each coil is stapled down in five places—at each end, and at one-fourth, one-half, and three-fourths of its length. When two coils meet, the same staple fastens down both coils.

Posts, 5 feet long, are driven through the center of the coils in five places, as in the case of the staples; the ends of adjoining coils are interlaced a little so that the post will go through both.

A strand of barbed wire is run along the top of each row and fastened to the posts with a round turn. It is pulled as taut as possible and twisted on to the French wire, by a staple, peg or wire cutters, close to each post, and in several places between the posts.

One or more strands of barbed wire are run along to the front as an "apron."

Diagonal wires are run from the tops of posts of the front row to tops of posts of second row.

[1] A low entanglement is not, as a rule, sufficient by itself, but may be combined with a high entanglement. (See figs. 15, 16, 17, 18.)

Working party, 24 men in three parties, with noncommissioned officers.

Front row:

Party A. No. 1. Holds end of French wire and staples it down.
2. Pulls wire out 20 yards.
3. Shakes wire clear of obstructions and puts in staples one-fourth, one-half, and three-fourths way along.

Party B. No. 1. Mauls in anchorage pickets and posts.
2. Holds posts.
3. Supplies posts.

Party C. No. 1. Uncoils barbed wire.
2. Makes fast end to anchorage and twists wire round tops of pickets.
3. twists barbed wire on to the French wire.

Party D. No. 1. Runs coil of barbed wire along the front.
2. } Twist it on to the front of the French wire.
3. }

Back row:

Party E. Same as A.

Party F. Same as B.

Party G. Same as C.

Party H. No. 1. With coil of barbed wire, moves between the two rows, uncoiling the wire.
2. } Move on either side of the entanglement and
3. } make this barbed wire fast to the posts as the diagonal, while H_1 holds the coil so that H_2 and H_3 can reach it.

The obstacles described above can be combined in various ways either by placing one behind the others (see figs. 15 and 16), or by placing a high wire entanglement over a low one (see figs. 17 and 18)

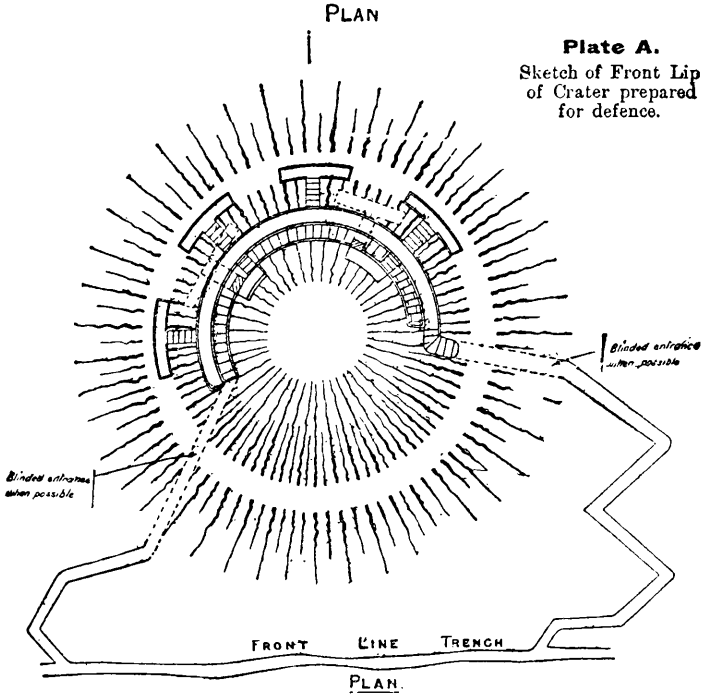


Plate A.
Sketch of Front Lip of Crater prepared for defence.

ELEVATION PLATE A.

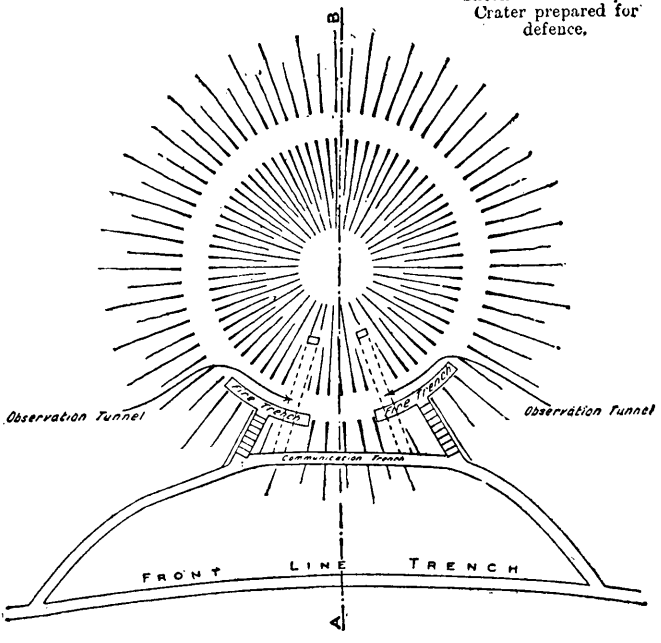
Approx. Scale 1″ = 12′.

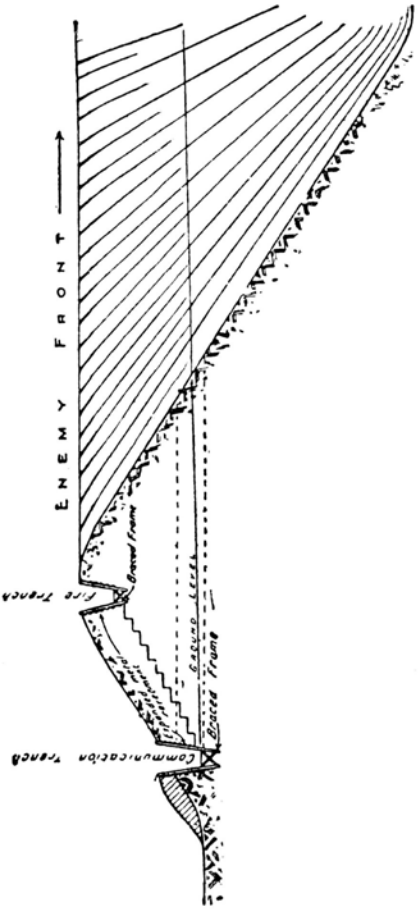
Enemy Front.

PLAN

Plate B.

Sketch of Rear Lip of Crater prepared for defence.





Sectional Elevation on A. B.

Approx. Scale 1″=24′.

Plate C.

SKETCH PLAN.

Shewing proposed system of defence by bombing trenches behind craters where no field of fire can be obtained.

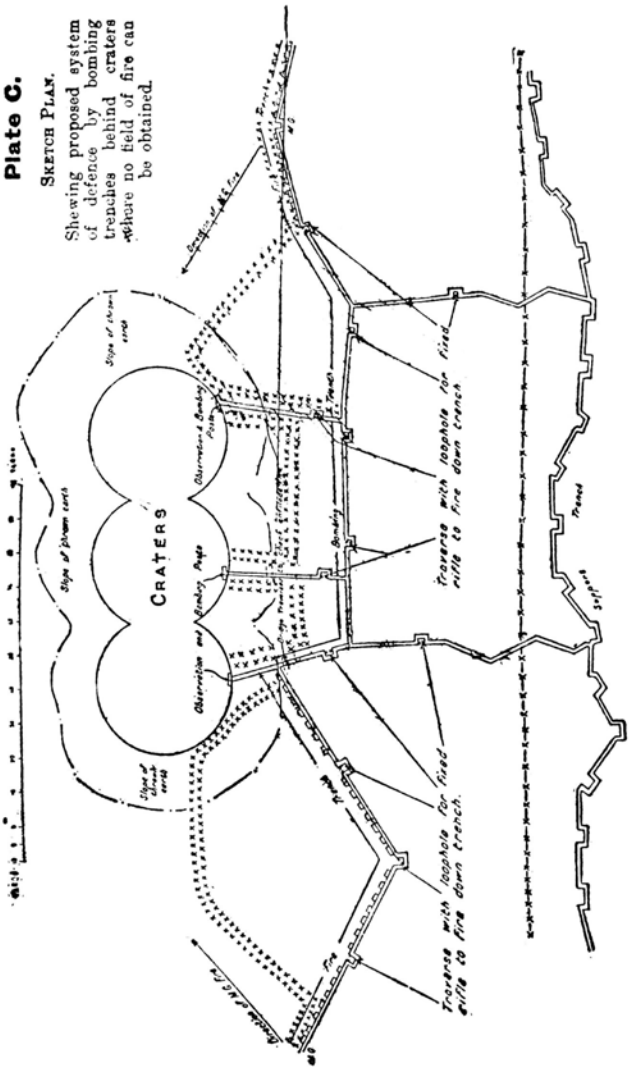
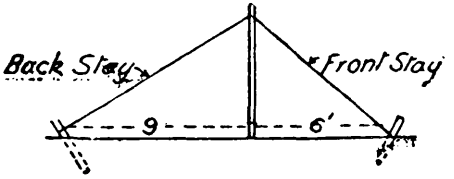
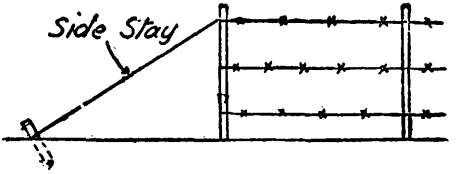

SCALE.
CRATERS
Traverse with loophole for rifle to fire down trench.
Traverse with loophole for rifle to fire down trench.
Observation and Bombing Posts
Bombing Posts
Slope of Crater earth
Slope of Crater earth
Slope of Crater earth

Fig. 1.



SECTION.



ELEVATION.

Fig. 2.

CONVENTIONAL SIGNS USED IN PLATES.

PLAN. ELEVATION.

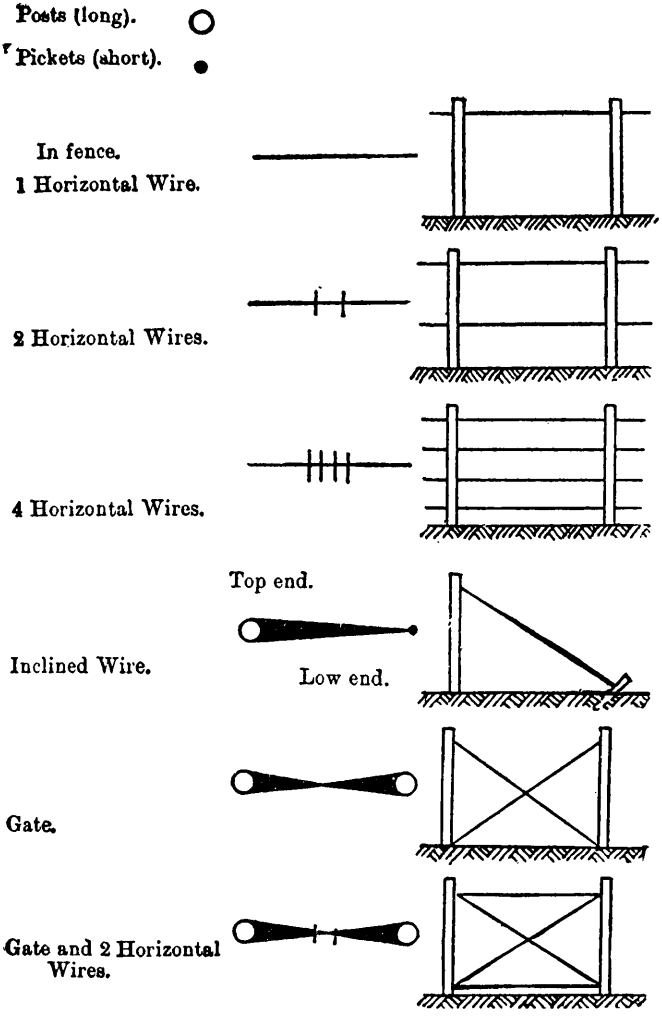


Fig. 3.

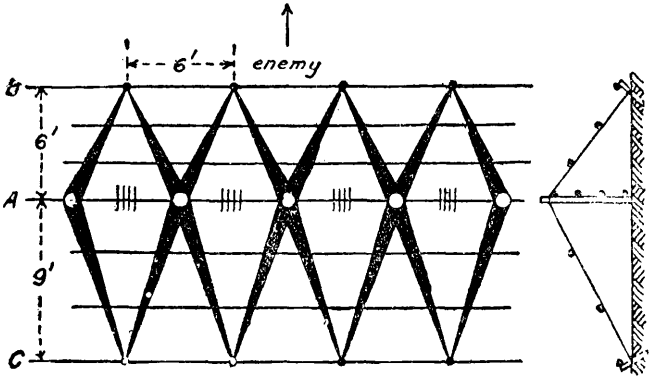


Fig. 4.

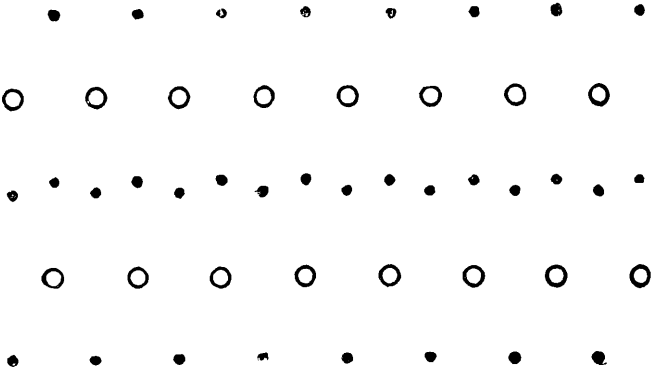


Fig. 5.

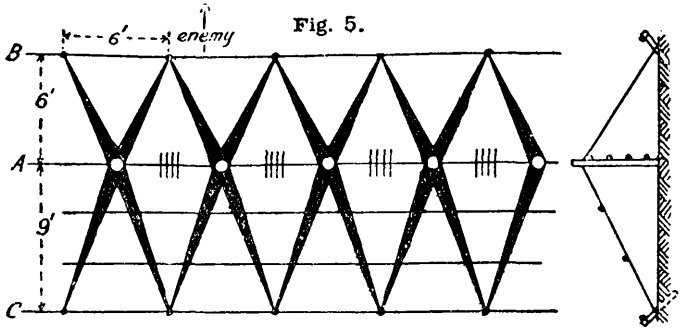


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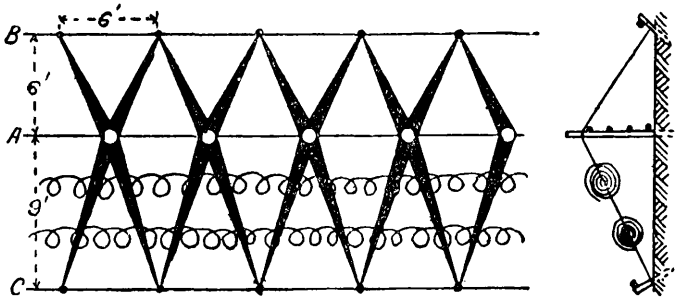


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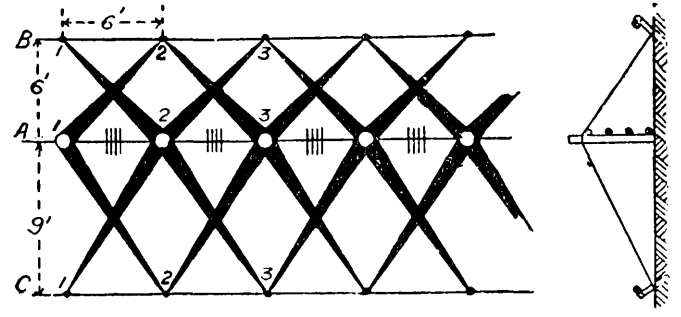


Fig. 8.

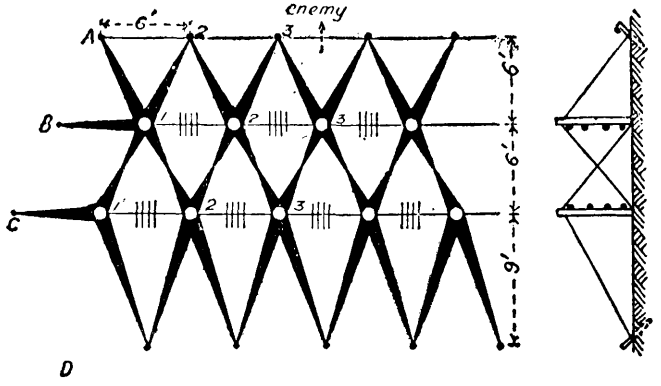


Fig. 9.

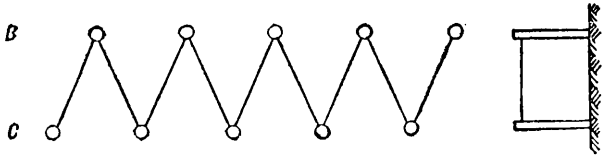


Fig. 10.

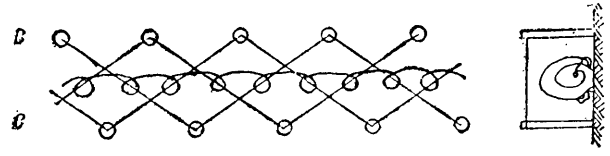


Fig. 11.

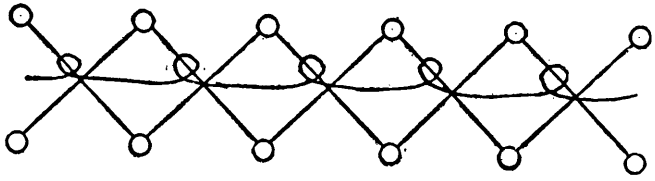
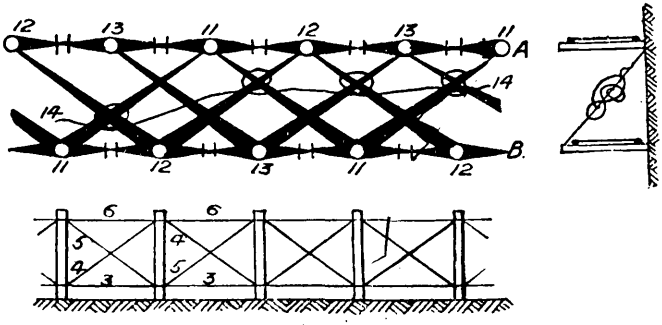


Fig 12.



ELEVATION OF A AND B.

Fig. 13.

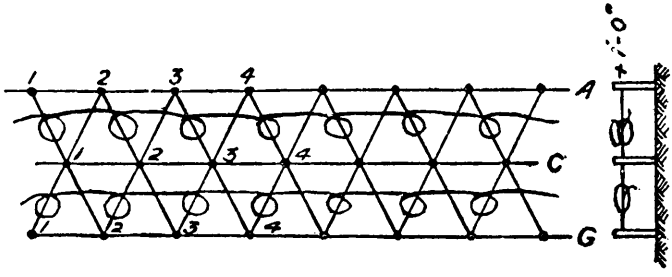


Fig. 14.

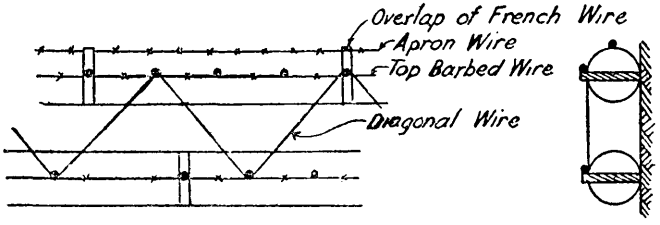


Fig. 15.

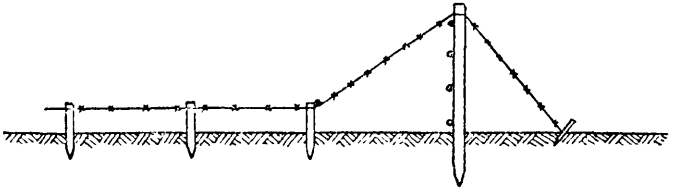
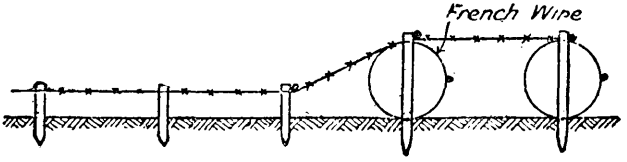


Fig. 16.



COMBINED HIGH AND LOW ENTANGLEMENTS.

Fig. 17.

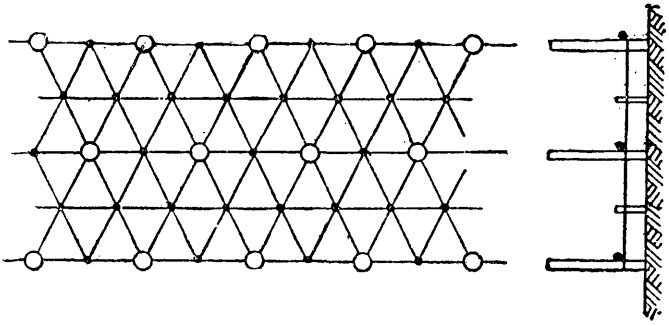
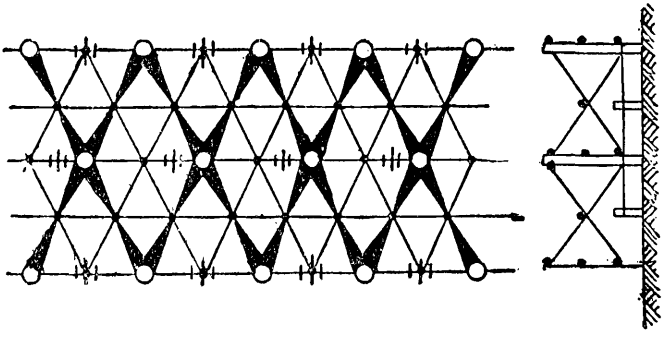


Fig. 18



APPENDIX II.

NOTES ON WIRE ENTANGLEMENTS WITH SCREWPOSTS AND PICKETS.

The screwposts are 5 feet long.

The pickets are approximately 15 inches long, with a loop at the end.

If the ground is very soft, posts can be screwed in 2 feet deep.

The barbed wire should be twisted round the post through an eye and not simply laid in the eye; but in order to enable this to be done, the posts should be screwed in so that the loops face the enemy. The simplest form of entanglement is made by running a line of pickets at 6-foot intervals along the front and one or more lines of screwposts behind them, thus:

A	...	...	...	...	Pickets.
B	...	...	...	...	Posts.
C	...	...	...	...	Posts.

Line A represents the front line of pickets.

Lines B, C, etc., represent the line of posts.

The wiring is carried out as follows:

(*a*) Four horizontal strands on B.

(*b*) Diagonal front stays A1—top B1—A2—top B2, and so on.

(*c*) Two or three horizontal wires along front stays.

(*d*) Diagonal stay top C1—bottom B1—top C2—bottom B2, and so on.

(*e*) Diagonal stay bottom C1—top B1—bottom C2—top B2, and so on.

(*f*) Loose coils between lines B and C.

(*g*) Four horizontal wires on C line.

Care should be taken to carry out the work in this order. The diagonal staying as at (*d*) is not easy owing to the difficulty in attaching the wire to the bottom of the post; but if the lowest loop is used it is simplified.

Line after line can thus be erected one behind the other. The following has been found a simple procedure:

Lay out line with tracing tape.

Each man to carry three posts and three pickets—lay them out on line.

Twelve men are divided into four parties—W, X, Y, Z. W1, X1, Y1, and Z1 each to carry a hard wood spindle which can be used for screwing in the posts and for carrying the barbed wire.

Having screwed in posts by parties, 1 and 2 of each party rolls out a coil superintended by 3, who attaches it to posts.

Party W starts on the bottom horizontal, X follows behind, and so on, one party after the other.

On completion, W and X parties work toward each other on front diagonal stay from each end; Y and Z work on diagonal stays, as at (*d*) and (*e*); Y goes ahead of Z, care being taken that the stays as at (*d*) keep ahead of those as at (*e*), otherwise some difficulty will be experienced.

The work will then be repeated. Much time will be saved if all the wire fastenings on the barbed wire coils are cut by daylight, the end of the wire being then attached to a piece of string and then uncoiled half a turn and recoiled on a piece of an old sandbag, the string being then made fast; the end of the wire can then be readily found in the dark.

The entanglement should be made entirely of barbed wire.

DRILL FOR PUTTING UP WIRE ENTANGLEMENTS.

The following is a drill for putting up a wire fence with a double apron. Each post has two side stays to obviate having to cut short lengths of wire for this purpose. The fence can be improved by adding horizontal wires along the apron. Angle iron pickets or screw pickets can be used. The principle of the drill is the same, whatever type of picket is used.

The party is divided into three squads—the long picket squad, the short picket squad, and the wiring squad. The long picket squad consists of two men, with one maul or sledge hammer if ordinary pickets are used, or two short pieces of wood for screwing the posts if screw pickets are available. The officer or noncommissioned officer in charge of the party goes with the long picket squad and shows them the line along which the fence is to run. The men then fix the pickets between 4 and 5 yards apart.

The short picket squad consists of four men, two working either side of the long pickets, and they fix the short pickets opposite the long pickets and two paces away from them.

The wiring squad is divided into four groups—A, B, C, D, of two men each. Group A starts by fixing the end of a coil of wire near

the bottom of the first post. One man of this group then walks away with the coil, allowing it to unroll on a stick while the other forms loops in the wire, which he slips over each long picket as he comes to it, and pulls the wire sufficiently taut.

When group A has advanced about 20 yards, group B starts and fixes the second wire up from the ground on the long pickets in a similar way.

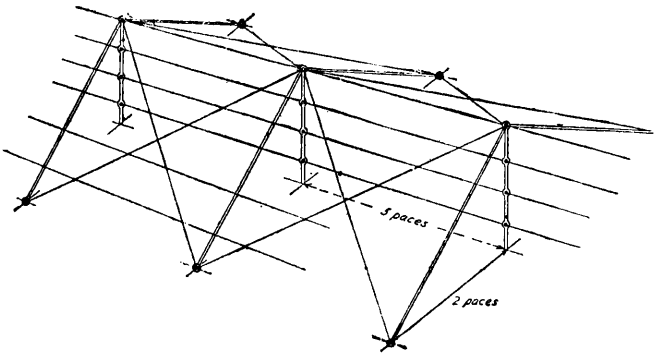
Groups C and D follow in their turn.

When all the wires on the long pickets are finished, groups A and B work on the apron on the enemy's side, and C and D on the rear side. A starts on a short picket and goes diagonally up to the next long picket—down to the short picket and so on. B works along the opposite diagonal. A's wire is shown by arrows on the sketch.

This completes the fence, but it can be improved by adding horizontal wires as shown in the sketch.

Each squad requires a party to keep it fed in the material; the strength of this party depends entirely on the distance away of the dump of material.

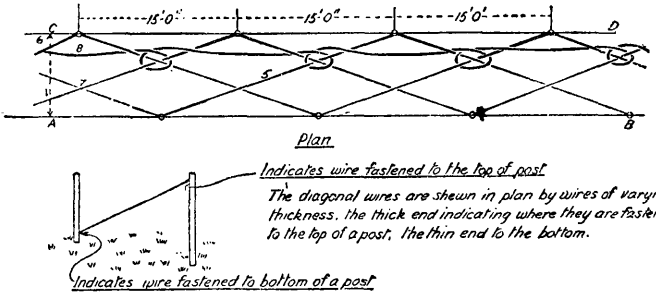
Total number of men required (irrespective of carrying parties): 1 noncommissioned officer, 14 men; time required, 15 minutes per 100 paces run; stores, 20 long pickets, 40 short pickets, 1,400 paces wire per 100 paces run.



Perspective view of wire fence.

RAPID WIRE ENTANGLEMENT.

Not to Scale.



Elevation of A.B. and of C.D.

ORDER OF WORK.

Two men place the posts on the ground (one on each side) with the wires as carriers.

Four men drive in the posts (two on each side).

Two men put on wire 1 of front row.

Two men put on wire 2 of front row.

Two men put on wire 3 of front row.

Two men put on wire 4 of front row.

Two men put on wire 5 (diagonal wire).

Two men put on wire 6 (diagonal wire).

Two men put on wire 7 (diagonal wire).

Two men put on wire 8 (looped wire).

Two men put on wire 1 of back row.

ENTANGLEMENT DRILL FOR APRON FENCE WITH SCREW PICKETS.

Party required, 16 men; rate of speed, 20 yards in 15 minutes.

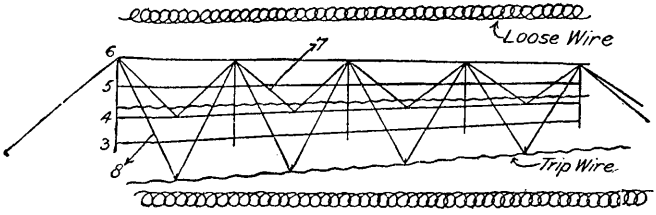


Fig. 1. *General View.*

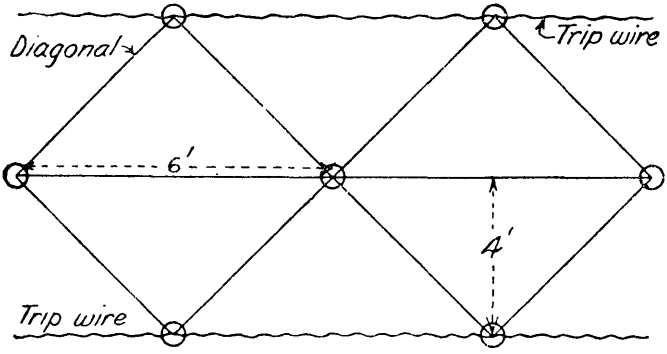


Fig. 2, *Plan.*

1. The men work in pairs, each pair having two duties, as shown in attached table. The second and subsequent pairs commence as soon as the pair in front have got a short distance ahead.

2. Pair No. 1 puts in the big screw pickets 2 yards apart. As soon as these have commenced, pair No. 2 puts in small pickets in the center of the spaces between the big pickets and at a distance of 4 feet from them. (See fig. 2.)

3. Pairs Nos. 3, 4, 5, and 6 then put on the horizontal wires on the big pickets, starting at the bottom. The wires are slipped through the loops fairly loosely. The pair taking the top wire give the picket one complete turn to prevent the wire slipping out should a strand be cut.

4. Pairs Nos. 7 and 8 put on the diagonal wires between the big and small pickets. This completes the first part.

5. After a suitable distance, say 50 yards, has been done, the pairs as they finish return to the starting point and work as follows:

Pairs 1 and 2 lay down the trip wires.

Pairs 3 and 4 uncoil the loose barbed wire on the ground on either side well clear of the entanglement, 6 coils going to 20 yards.

Pairs 5 and 6 with large wood pickets lift the wire and toss it into the entanglement.

Pairs 7 and 8 spread it out and fasten the wire by taking a turn at intervals to the diagonals and fence wires.

6. It is necessary when the work requires to be done at any speed to have a carrying party carrying stores to dump at 50–100 yards' interval.

7. Stores required for 50 yards:

Barbed wire	coils..	25
Screw pickets, large	number..	25
Screw pickets, small	do....	52

N. B.—Care should be taken that spikes on top of the pickets are all pointing the same way, otherwise when passing the wire through loops the turn has sometimes to be made with running end and sometimes with standing part.

TABLE.

Pair.	First duty.	Second duty.
1	Screw in big screw pickets 6 feet apart..	Trip wire nearest enemy.
2	Screw in small screw pickets both sides..	Trip wire farthest from enemy.
3	Bottom fence wire marked "1" on diagram.	Uncoil loose wire side nearest enemy.
4	Second fence wire from bottom marked "2" on diagram.	Uncoil loose wire side farthest from enemy.
5	Third fence wire from bottom marked "3" on diagram.	Toss in loose wire uncoiled by third pair.
6	Top fence wire marked "4" on diagram will give pickets one complete turn.	Toss in loose wire uncoiled by fourth pair.
7	Diagonal wire side nearest enemy marked "5."	Fasten loose wire.
8	Diagonal wire side farthest from enemy marked "6."	Do.

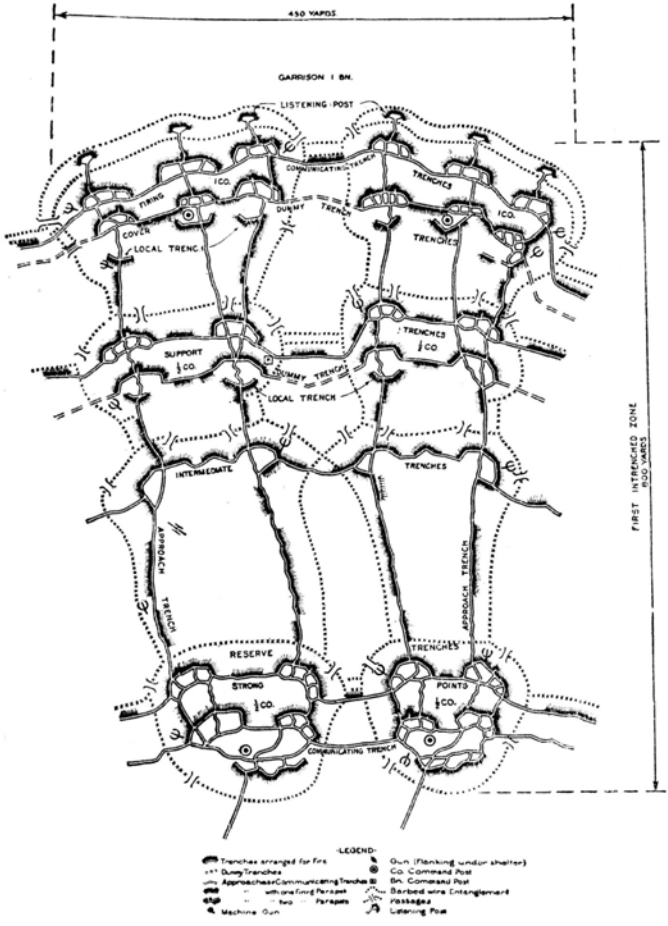

450 YARDS
GARRISON 1 BN.
LISTENING POST
FIRING
COVER
LOCAL TRENCH
DUMMY TRENCH
SUPPORT
INTERMEDIATE
APPROACH TRENCH
RESERVE
STRONG
POINTS
TRENCHES
FIRST ENTRENCHED ZONE
1000 YARDS
LEGEND
Trenches arranged for fire
Dummy Trenches
Approaches Communicating Trenches
with one Firing Parapet
two Parapets
Machine Gun
Gun (Flanking under shelter)
Co. Command Post
Bn. Command Post
Barbed wire Entanglement
Passages
Listening Post

PLATE I

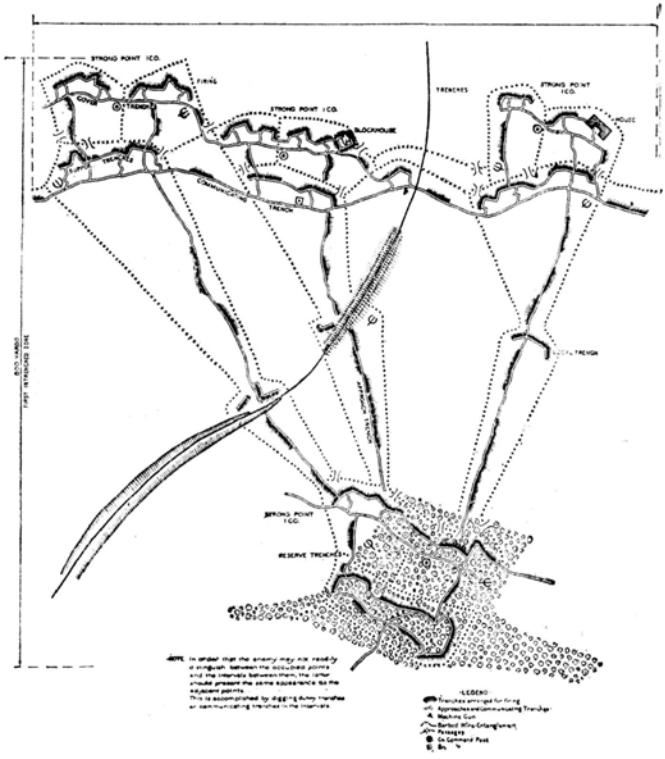

STRONG POINT (CO.
FIRING
TRENCH
STRONG POINT (CO.
BLOCKHOUSE
TRENCHES
STRONG POINT
(CO.
TRENCH
TRENCH
STRONG POINT
(CO.
RESERVE TRENCH
NOTE. In order that the enemy may not readily distinguish between the occupied points and the intervals between them, the latter should present the same appearance as the adjacent points.
This is accomplished by digging dummy trenches or communicating trenches in the intervals.
KEY
Trenches arranged for firing
Approaches and communicating Trenches
Machine Gun
Barbed Wire Entanglement
Passages
Co. Command Post
Bn.

PLATE II.

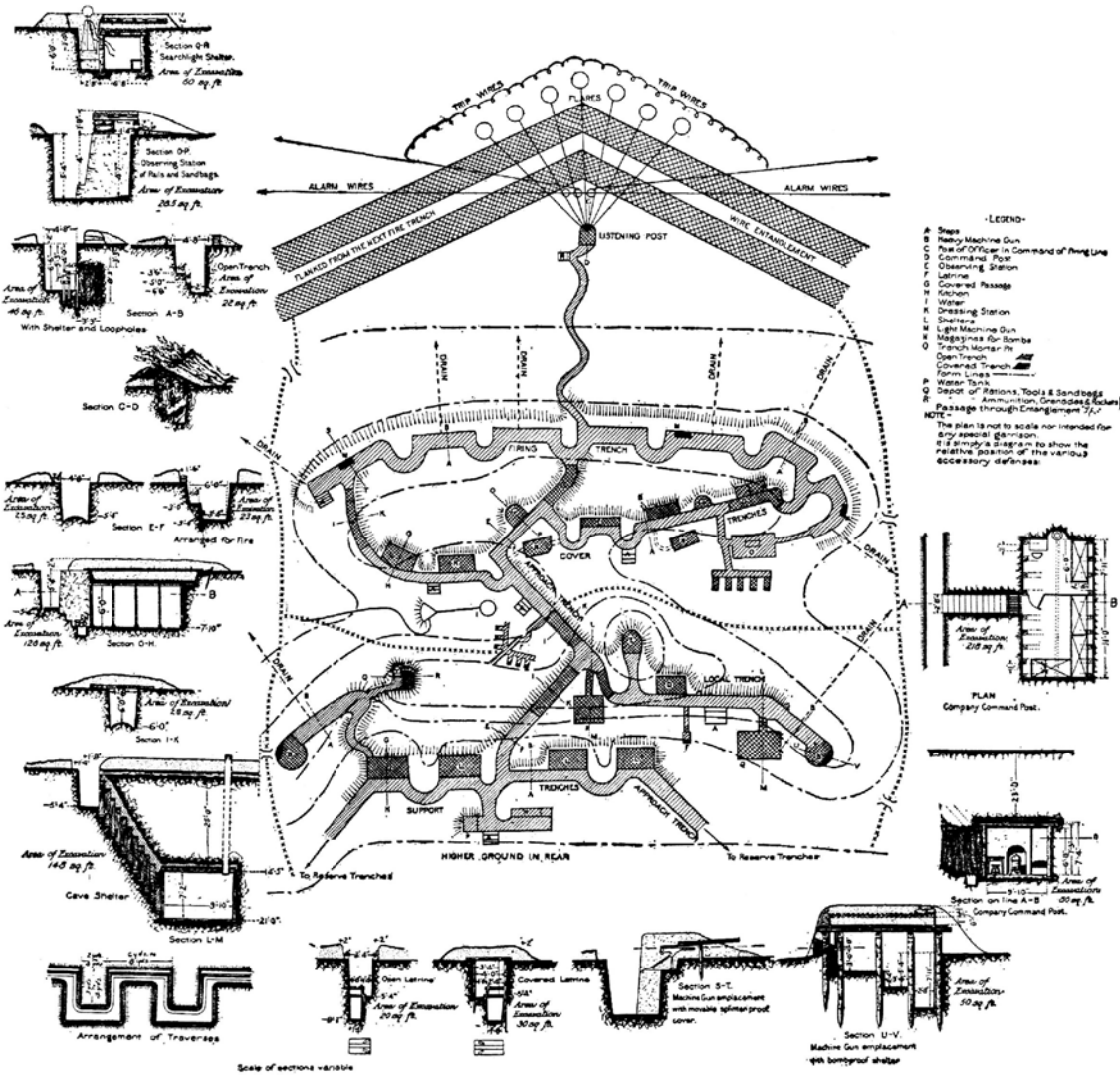


PLATE III.

99454°—17. (To face page 104.) No. 1

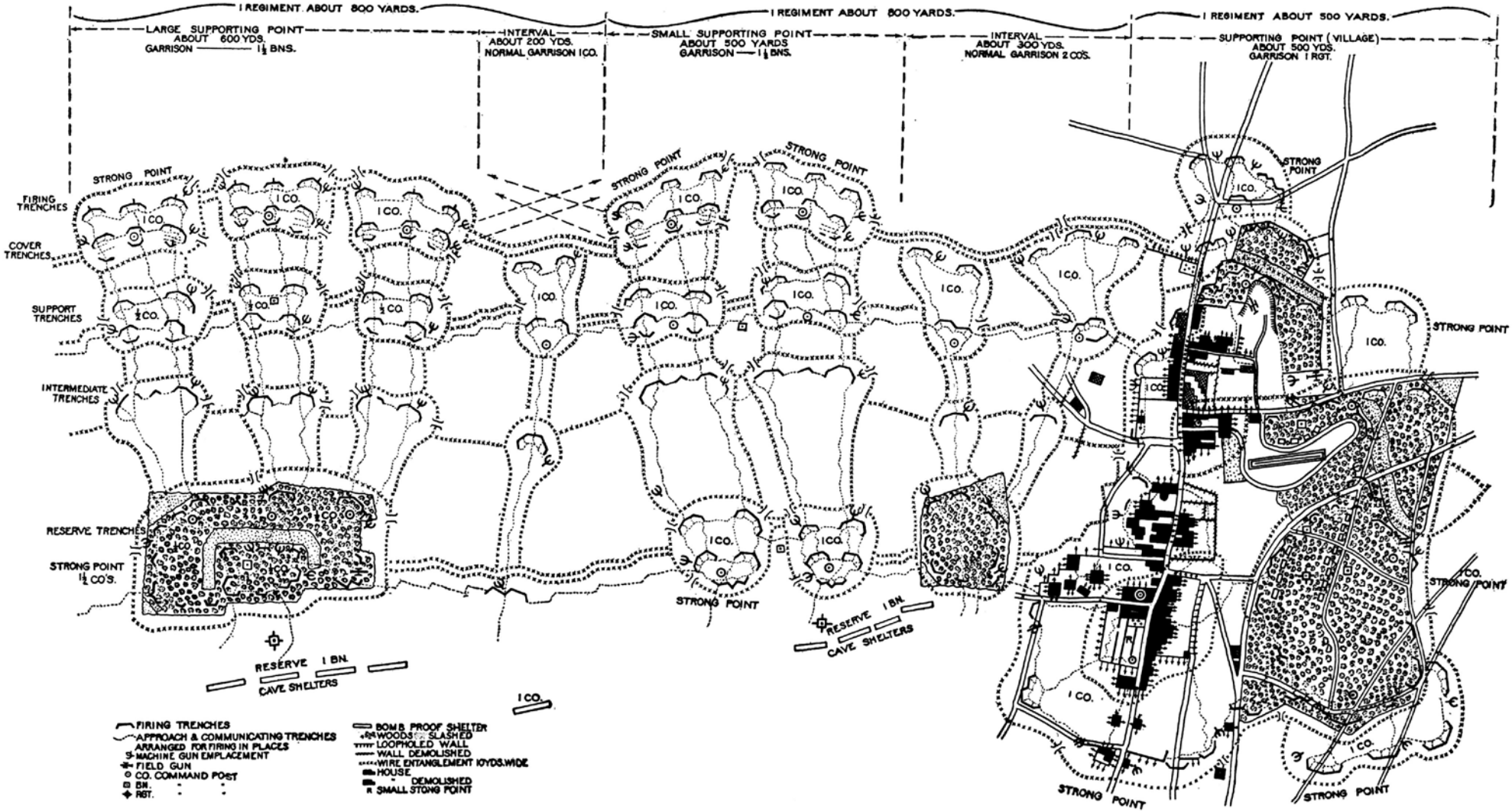
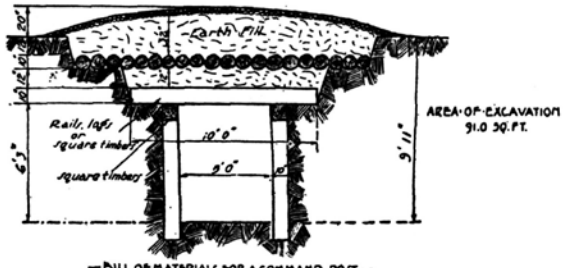

1 REGIMENT ABOUT 800 YARDS.
LARGE SUPPORTING POINT ABOUT 600 YDS. GARRISON — 1½ BNS.
INTERVAL ABOUT 200 YDS. NORMAL GARRISON 1 CO.
1 REGIMENT ABOUT 800 YARDS.
SMALL SUPPORTING POINT ABOUT 500 YARDS GARRISON — 1½ BNS.
INTERVAL ABOUT 300 YDS. NORMAL GARRISON 2 COS.
1 REGIMENT ABOUT 500 YARDS.
SUPPORTING POINT (VILLAGE) ABOUT 500 YDS. GARRISON 1 RGT.
FIRING TRENCHES
COVER TRENCHES
SUPPORT TRENCHES
INTERMEDIATE TRENCHES
RESERVE TRENCHES
STRONG POINT 1½ CO'S.
STRONG POINT
1 CO.
½ CO.
RESERVE 1 BN. CAVE SHELTERS
FIRING TRENCHES
APPROACH & COMMUNICATING TRENCHES ARRANGED FOR FIRING IN PLACES
MACHINE GUN EMPLACEMENT
FIELD GUN
CO. COMMAND POST
BN. " "
RGT. " "
BOMB PROOF SHELTER
WOODS SLASHED
LOOPHOLED WALL
WALL DEMOLISHED
WIRE ENTANGLEMENT 10YDS. WIDE
HOUSE
" DEMOLISHED
R SMALL STONG POINT

PLATE IV.

PLATE V

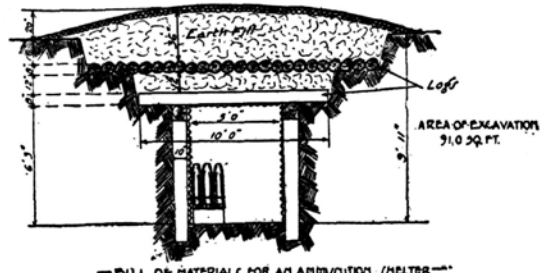
COMMAND POST



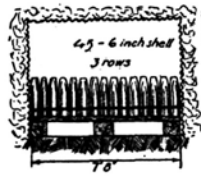
— BILL OF MATERIALS FOR A COMMAND POST —
- 2 ROOMS -
5' X 8'4"

48 steel rails, 13.3 lbs. per ft. 10 feet long.
24 pieces of square or round timber, 10 ins. x 10 ins. 10 ft. long
45 logs at least 10 ins. in diameter, 10 ft. long.
300 spikes. 8 ins. long.
48 sq. yds. corrugated iron.
328 linear ft. of boards 1" x 12" x 14" for revetment,
60 pieces of square timber, 10 x 10 ins. 10 ft. long for posts and sills.
4.6 lbs. of 40d. wire nails.
22 lbs. of 12d. wire nails.

SHELTER FOR AMMUNITION

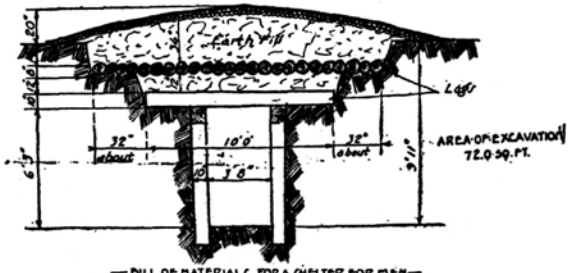


— BILL OF MATERIALS FOR AN AMMUNITION SHELTER —
5' x 8'4"



56 logs at least 7 in. in diameter and 10 ft. long.
200 spikes, 8 inches long.
24 sq. yds. corrugated iron.
220 lin. ft. boards 1" x 12" x 14" for the revetment of the entrance.
20 pieces of square timber, 10 x 10 ins., 10 ft. long for framing.
15 lbs. of 40d wire nails.
7 lbs. of 12d wire nails.
3 planks 10 ins. x 3 ins. 10 ft. long to support the ammunition.

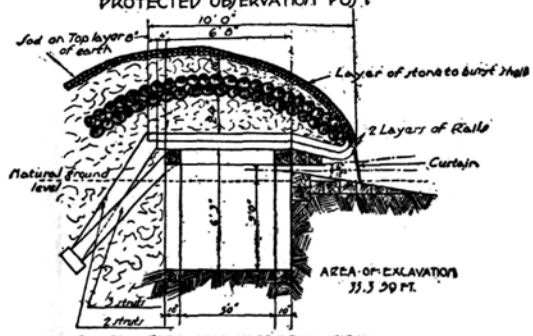
SHELTER FOR MEN



— BILL OF MATERIALS FOR A SHELTER FOR MEN —
5'4" by 3'0"

9 pieces of square or round timber 10" x 10 ins. 10 ft. long.
30 logs at least 7 ins. in diameter and 10 ft. long.
200 spikes, 8 ins. long.
11 square yards corrugated iron.
375 lin. ft. of boards 1" x 12" x 14" for revetment.
20 pieces of square timber, 10 x 10 ins., 10 ft. long for framing.
15 pounds of 40 d. wire nails.
7 pounds of 12 d. wire nails.

PROTECTED OBSERVATION POST



— BILL OF MATERIALS FOR AN OBSERVING STATION —
5' x 6'0"

48 steel rails, 13.3 lbs. per ft. 10 ft. long, curved at one end if possible as shown.
30 pieces of timber, 10 x 10 in. 10 ft. long (10 are used to form loopholes).
140 logs at least 7 in. in diameter, 10 ft. long.
260 spikes, 8 in. long.
4.5 yds. of smooth wire, 1/8 in.
3 lbs. of 40d. wire nails.
7 lbs. of 12d. wire nails.
220 lin. ft. of boards 1" x 12" x 14" for revetment.
7 sq. yds. corrugated iron.

— SCALE —
3 0 3 FEET

PREPARED AT ARMY WAR COLLEGE FROM LATEST AVAILABLE INFORMATION APRIL 1917.

PLATE V.

99454°—17. (To face page 104.) No. 3

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