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NOTE ON THE CONSTRUCTION OF DEEP GALLERY SHELTERS

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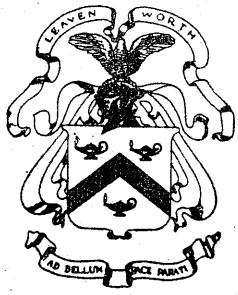
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WAR DEPARTMENT,
WASHINGTON, *October 20, 1917.*

The following pamphlet "Note on the Construction of Deep Gallery Shelters" is published for the information of all concerned.

(062.1 A. G. O.)

BY ORDER OF THE SECRETARY OF WAR:

TASKER H. BLISS,
General, Chief of Staff.

OFFICIAL:

H. P. McCAIN,
The Adjutant General.

WAR DEPARTMENT,
THE ADJUTANT GENERAL'S OFFICE,
Washington, June 19, 1917.

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By order of the Secretary of War:

H. P. McCAIN,
The Adjutant General.

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DOCUMENTS CONSULTED.

Instructions of December 21, 1915, on Fieldworks for the Use of Troops of All Arms.

Manual for Commanders of the Infantry Platoons (General Headquarters, Third Bureau, 1916).

School of Mines.

Various Army Notes on Deep Shelters.

Note on Deep Shelters by Col. Cernesson (Engineer Instruction Center of the Army Group of the Center).

Lecture on Shelters by Lieut. Col. Cazalas (Engineer Instruction Center of the Army Group of the Center).

Extract from the secret note of general headquarters, dated April 5, 1916, in regard to the information to be drawn from the Battle of Verdun.

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NOTE ON THE CONSTRUCTION OF DEEP GALLERY SHELTERS.

I. OBJECT.

With the increasing intensity of bombardments, the question of shelters has become one of capital importance in the organization of sectors both from the offensive and defensive points of view.

As bombardments are executed exclusively with artillery of medium and large caliber, it is necessary that the shelters be able to resist the systematic and regular fire of medium-caliber artillery or of single rounds from the large-caliber gun most frequently used, for example, the 21-centimeter mortar. In other words, the shelters in question should belong to the class of works defined as bombproof shelters by the Instructions of December 21, 1915, on field works for the use of troops of all arms. (See Instructions of Dec. 21, 1915, No. 89, p. 43.)

Experience has shown, on one hand, that the type of sunken shelters (see Instructions of Dec. 21, 1915, No. 128, p. 77) covered with a filling of earth concealing three layers of round logs was not proof against the projectiles with delay-action fuses of the German 21-centimeter mortars, even with a small charge of explosive (6.3 kilograms to 8 kilograms), and that on the other hand the type of shelter known as "deep shelter" (see Instructions of Dec. 21, 1915, No. 128, p. 77) was able to resist projectiles of large caliber if the untouched soil above it was of the proper thickness, which again depends on the nature of the terrain and the kind of projectiles used against it.

Consequently, among the sunken shelters described by the Instructions of December 21, 1915, under No. 128, only those constructed underground, at a suitable depth, are bombproof in the sense given to this term in the above-mentioned instructions.

It therefore follows that this shelter, generally known as a deep-gallery shelter, should be adopted to the exclusion of every other type, except in cases where a water-bearing stratum is encountered near the surface.

It appears from the above that the Engineer troops, to whom the construction of such shelters is intrusted, should be thoroughly acquainted with all details concerning the construction of these shelters. The Engineer troop depots of the interior must therefore lay great stress on that part of the instruction of sappers which deals with the construction of this type of shelters.

The object of the present note is only to facilitate the task of the officers of the above-mentioned depots by placing at their disposal a résumé of the principles and details of construction now used by the armies in constructing "deep gallery shelters."

II. DEFINITION.

By deep gallery shelters are understood shelters executed by subterranean, as distinguished from open-cut, excavation, the roof and walls of which are given a plank lining constructed according to the principles laid down by the School of Mines for the construction of mine galleries. (See School of Mines edition published Apr. 30, 1909.) The prescriptions of the School of Mines must be strictly followed, and, in particular, the precautions therein mentioned as regards strengthening the galleries must always be taken.

The casing is generally of wood. (Note: Some types of frames of reinforced cement, studied by the Technical Section of the Engineers, are now on trial.) In this case, according to the resources at hand, the frames may be either of the ordinary standard type or makeshift frames of roughly squared logs (see plate 5).

If on good terrain large frames of thick planks may be used for lining the entrance descents to the galleries (see plates 2 and 5).

III. ADVANTAGES.

Besides providing shelter against single rounds of the 21 centimeter gun with the means at hand in the field, the deep gallery shelter has the advantage of being easy to construct, and the enemy will suspect nothing if care is taken either to conceal the spoil or to unload it far enough away.

The one fault generally found with this type of shelter is that it is slow to construct. This is compensated, in a certain measure, by the fact that work may be carried on continuously as soon as the descents have attained a length of a few meters.

These descents then constitute shelters in themselves and are far superior to niches or temporary shelters.

IV. SUMMARY DESCRIPTION.

Deep gallery shelters are of two types—single and double. The former are especially appropriate for troops guarding the first-line trenches.

Generally speaking, the single shelters are the most used.

The type of shelter to be adopted depends on local tactical circumstances, but its choice is also subordinate to the nature of the subsoil and the contours of the terrain.

As to the nature of the subsoil and the situation of the emplacement, experience has shown that it is best to make a careful examination of the terrain before giving up the construction of deep shelters through fear of their being invaded by water. Simple solutions may often be found after a close study. For instance, in certain places where only shelters of no great depth had been undertaken the existence was discovered, at a varying depth, but fairly near the surface, of a layer of thick clay, compact, without fissures, and consequently waterproof. Deep gallery shelters were dug there, after the pervious upper layer had been previously drained and isolated within a certain radius by means of ditches dug deep into the clay strata, which insured the draining of the water.

SINGLE SHELTER.

The single shelter generally consists of a horizontal gallery, dug underground to a depth depending on the nature of the terrain, and chosen in consequence, according to the indications given in Paragraph V hereafter.

Access is obtained by *at least* two distinct descents, at sufficient distance from each other to prevent their being subject to the action of the same projectile.

The descents should be made as steep as possible, in order to diminish their length, in order, on the one hand, to reduce the amount of work required to construct them, and on the other to make them less vulnerable. Each descent generally debouches at one extremity of the main part of the shelter. The entrances to the descents constitute the most delicate part of deep shelters, as it is not possible with the means usually available to give them adequate protection. They open on a trench or on a portion of an open or covered boyau.

The protection of the entrances may be improved by keeping their sills at a fairly low level, by deepening the entrance boyau, and by reinforcing the covering of the armored portion of this boyau with layers of logs placed side by side and solidly joined together with wire or cramp irons. (See variation of sketch No. 6.) However, every precaution should be taken to prevent the entrance of water.

To enable the garrison of a shelter to leave it, even if the trench has fallen into the hands of the enemy, it is wise whenever the necessary time and personnel is available to provide an additional outlet easy of egress, debouching in the open country in rear or in front of the trench. This outlet should consist of a gallery with gentle slope so as to permit of rapid evacuation. To deceive the enemy, it would be well for the relative position of this third outlet not to be uniform with reference to the two others. Moreover, the exit should be concealed as well as possible. If there is no natural or artificial depression within convenient distance around the shelter, the exit gallery may be made to end in a sloping sap, debouching in a shell crater, real or simulated, if the terrain is already torn up. In this case care should be taken to disguise this sap to prevent its appearing on the aerial photographs. An easy and simple method consists in stretching a metal grating between the berms of the sap and covering it with a thin layer of grass, straw, rafia, or branches. It may also be covered with ordinary canvas or awning properly adjusted.

This supplementary exit on the open country is especially needed in shelters for troops guarding the first-line trenches.

It is also advisable to provide shelters of the latter class (shelters for first-line trenches) with *underground communication* connecting them *in front with the combat posts for machine guns or automatic riflemen, with the observing stations and listening posts. In the first positions,* where it is hardly possible to transport matériel and armor, these stations, also well disguised, are equipped with shields (of a light type that can be transported in the galleries) proof against perforating bullets and projectiles of small-caliber guns (37–47 millimeters). *In the second position* these posts or observing stations, also disguised, may be covered with cement and equipped with armored roofs.

On account of the many and various solutions which may be devised, the dimensions and arrangements of detail of the shel-

ters can not be strictly regulated. The types shown in the sketches attached to the present note are only given as an indication.

It should be noted, however, that each shelter should be constructed with a view to receiving a unit consisting of *at least* one-half a platoon, as a rule. A smaller unit should not be considered, for owing to the amount of work required by the construction of the descents to the deep shelters (which work is independent of the capacity of the shelters), the construction of shelters for a unit of less than one-half a platoon would require an amount of work out of all proportion to the object to be attained.

The capacity of the shelters is determined by the commanding officer in the orders relating to the organization of the sector.

As for the arrangement of details and the preparation of the interior of the shelters, it will be sufficient to call attention to the following points:

1. In each shelter there should be camp beds with two, and sometimes in exceptional cases, three berths above each other (made of boards or wire trellis work with wooden frame), for a fraction of the unit in occupation, and a certain number of seats, the proportion of each to be determined by the commanding officer.

2. Room for the camp beds may be obtained by giving to the horizontal gallery the profile of the grand gallery,[1] or else by opening on a transversal service passage (in the main gallery or in the great gallery) cells of varying length of the dimensions required for the installation of camp beds.[2] These cells are generally constructed in the grand gallery. The width to be obtained by this arrangement is, per tier of berths, either three places side by side,[3] or two places separated by a passage;[4] the latter installation should be reserved for cases when the cell must contain several rows of beds in depth.[4]

Two rows of beds of three tiers each are sometimes installed in the grand gallery, which with equal capacity gives more free space.

The cell system is often praised because it can be constructed progressively. It can be utilized as soon as the transversal gal-

[1] See sketches 1 and 3.
[2] See sketches 6, 7, 8, and 9.
[3] See sketches 7 and 8.
[4] See sketches 6 and 10.

lery is completed. It may then, according to requirements, be prepared immediately and definitely occupied, or the construction of the cells may be continued with the possibility of the work being interrupted at any time and rapidly utilized.

3. Whatever the arrangements for the shelters may be, care should be taken never to omit niches for hand grenades (to be properly isolated from the parts occupied by the men), infantry ammunition, Vermorel apparatus, solutions for protection against gas, and movable canvas panels for closing trench galleries (to be installed near the points where they are to be set up, see Par. VIII, line 7, p. 22), and also small store shelves for food and signal rockets.

4. A special small room with stool and cot should be provided for the commander of the platoon or one-half platoon.

5. Ventilation and smoke chimneys should be made at least for the shelters that are not in the very first line. These chimneys must be provided with a device by means of which they can be closed from below to exclude asphyxiating gases. It is advisable to make the chimneys in the form of shafts lined with tubes. (The central establishment for special engineer matériel issues for this purpose metal tubes of 15 centimeters in diameter). When the ground is not too hard the shaft may be bored from the outside with a boring bar (and widened by a string of petards) or from the inside with the Guillat-Genie drill, which gives the required diameter.

In important shelters it is often necessary to install ventilators and a *special lighting system* (electricity, acetylene, etc.).

6. When circumstances require—

(*a*) Insure the supervision of the approaches to the shelter by installing in its vicinity, at suitably chosen places, an *armored lookout* and a *periscope room.*

The lookout should be slightly raised and carefully disguised.

The periscope room is made as nearly bombproof as possible.[1]

These two places are connected to the shelter by underground passages.

(*b*) Organize the defense of the entrances. (See Par. VI.)

(*c*) Protect the interior of the shelter against grenades thrown from the entrances. (See Par. VII.)

7. Protect the shelters from asphyxiating gas. (See Par. VIII.)

[1] In drawing up plans, the dimensions of the periscopes supplied to the armies must be considered (all lengths, from meter to meter up to 6 meters; above 6 meters, but one type of 14 meters.)

Plates 1, 2, 3, 4, and 5 show the detailed arrangement of a type of single shelter for one-half a platoon, established by an army for the use of troops guarding first-line trenches.

Plate 6 contains plans of various single shelters with cells constructed to the front.

Plates 9 and 10 show a very complete type of single shelter, with cells, worked out for the same use as the type of plates 1 to 5 by the Engineer Instruction School of the Armies of the Army Group of the Center, and put into practice at the Melette camp. However, attention is directed to the rather complicated arrangement of this shelter, which makes it slower to construct. This type should only be considered as a school model to be followed as nearly as circumstances and available means permit.

GROUP OF SINGLE SHELTERS.

Several single shelters placed side by side and connected by an underground passage[1] form a regular underground barracks with numerous entrances, where units larger than one-half a platoon may be conveniently lodged without being broken up.

But it should be observed that this arrangement, which is especially adapted for reserves, is rarely to be used for lodging troops guarding first-line trenches, for their units are generally not grouped together, but are distributed on the front of the sector they are guarding.

DOUBLE SHELTER.

The double shelter *differs from the single shelter only in the addition to the latter of a second gallery*, identical with that forming the main body or service passage of this first shelter, and communicating with it by gallery passages. This second gallery may be established deeper underground than the first; it is then joined to it by sloping galleries forming descents.

All indications given in the preceding paragraph on the subject of installation of single shelters are applicable to double shelters.

The latter type, which permits several units to be grouped within a relatively small space, with satisfactory conditions of

[1] This underground passage should be constructed in the form of a gallery, in preference to the branch, the available surface of the passage is thus increased without increasing the amount of work in proportion.

safety, seems, as a result of this advantage, particularly designated for reserves.[1]

Sketches 7 and 8 show in detail a part of a group of double shelters. Sketch 7 contains, in addition, the diagram of the plan of this group.

UNDERGROUND BARRACKS.

An underground barracks may be obtained by building several of these shelters at a certain distance from each other and connecting them by gallery passages established between the successive bodies of the shelters on a same level. Storerooms are arranged in the galleries or near them for ammunition, food, etc., kitchens, ordinary rooms, rooms for the general use of the units.

An installation of this kind makes it easy to utilize electricity for lighting and ventilation, which, when it can be realized, greatly improves the conditions of the shelters and makes them more habitable.

It appears to be of great advantage to construct shelters of the above type whenever circumstances allow, for it has the threefold advantage:

1. Of sheltering the troops from bombardments.
2. Of facilitating their exit, even when several entrances have been obstructed.
3. Of giving the men the comfort which is becoming more and more necessary with the duration of hostilities.

V. FUNDAMENTAL PRINCIPLES TO BE OBSERVED IN THE CONSTRUCTION OF "DEEP GALLERY SHELTERS."

If a deep gallery shelter is to be made thoroughly proof against single projectiles of the German 21-centimeter mortar, with slow fuse and heavy charge,[2] it is absolutely necessary to follow *strictly* the directions given below, the first of which is common to all deep shelters, whatever may be the type of revetment adopted for their roof and walls.

(*a*) *Depth required.*—As a general rule, the thickness of the layer of virgin soil (vegetable mold not included) above the

[1] It should be pointed out, however, that there is an increasing tendency to quarter reserves in single shelters with cells. See sketch No. 6.

[2] 17.47 to 18 kilograms.

roof of the shelter should never be less than *6 meters in hard, compact chalk.*

The thickness of the virgin soil may be diminished, but only when serious reasons require it (presence of a water-bearing stratum, necessity of rapid construction, soft ground into which large-caliber projectiles with delayed-action fuse penetrate to a great depth). The insufficiency of protection resulting from this reduction must be compensated by establishing, on the surface of the ground, a *bursting layer* which must extend materially beyond the projection on the surface of the outline of the shelter.

However, a special examination is necessary in each case, for it may be found impossible to construct the layer owing to the difficulty of obtaining supplies and of transporting to the spot the large tonnage of necessary materials.

The bursting layers, which in any case must rest on virgin soil, may be constructed in different ways:

(1) *By a bed of logs* 15 to 20 centimeters in diameter, placed side by side and solidly joined together with wire bands.[1] If this bed is covered with about 1 meter of fill, the layer obtained in this way will be equal to about 1 meter of virgin soil.

(2) *By reinforced cement blocks* 50 by 50 by 10 centimeters, with a special device for joining them to insure the desired rigidity.

The details of one type of block are indicated in plate 11.

(3) *By bags of cement,* either immersed in fresh water for 6, or, better still, 10 minutes, or else sprinkled slowly during the same length of time (it is useless to prolong either operation for more than 10 minutes), and then placed side by side. The resistance to crushing with Portland cement is 150 kilograms per square centimeter at the end of a month, and at least 200 kilograms at the end of three months.

(4) *By bags filled with a mixture of gravel and cement* immersed and sprinkled as above; the resistance varies with the kind of gravel.

(5) By bags filled only with gravel. This method is not as good as the preceding one on account of the absence of binding elements.

(*b*) *Reinforcement of the galleries.*—The frames composing the structure must be very carefully braced parallel to the length of the gallery shelters, so as not only to maintain the

[1] Concerning arrangements to be made for these bands, refer to instructions of Dec. 21, No. 97, fig. 72, p. 52.

equal spacing in case of pressure from above, but also to prevent the sliding of the caps on the uprights.

The single set of mine battens ordinarily provided for this purpose by the regulations for the construction of galleries has been acknowledged to be insufficient; it is therefore necessary, in all gallery shelters, to apply the measures for reinforcement against pressure from above, described at the School of Mines as follows:

(1) Double the number of battens connecting the uprights.

(2) In each interval place four horizontal braces forced between two consecutive frames. Two of these braces are placed at the juncture of the cap and the uprights, the others at the juncture of these same uprights and the sill, for it is absolutely necessary for the braces in question to hold both the uprights and the caps and the uprights and the sills.

It is also necessary to reinforce the shelter against lateral pressure;[1] for this purpose the length of the intervals is reduced to 85 centimeters at the most in *horizontal galleries*, and the space between the axis of the framework *in the descents* should be reduced to 60 centimeters.

(*c*) *Special precautions in regard to entrances and descents.*—The framework (casing or ordinary framework) of the lower extremity of each descent must be solidly braced against the structure of the shelter itself, in order to prevent the shifting of the framework of the descents toward the interior of the shelter under the action of the concussion and pressure produced by the bursting of projectiles falling in the vicinity of the entrances.

These entrances are very easily obstructed on account of the projection and the falling earth resulting from the bombardment. It is not often possible to construct them solidly enough to make them proof against projectiles of 21 centimeters, consequently it is of the greatest importance that tools should be kept in the shelters (4 shovels, 6 picks, 50 sandbags), in order to enable the occupants to clear the entrances rapidly when circumstances require. For the same purpose each shelter should be provided with means for lighting in case of emergency (candles, electric lamps).

A rope (or a cable made of several strands of twisted wire) would be very useful as a handrail in the descent, to facilitate the exit in case of partial obstruction. Lastly, to complete these

[1] School of Mines, No. 112 (pp. 89, 90).

measures, a thick plank or a strong board should be nailed to the uprights and the sills in one of the lower angles of each of the descents, at an angle of 45°, so as to form a small triangular shaft through which air and even food may be let in to the shelter in case of total obstruction of the two entrances.

Special precautions should be taken in the construction of descents composed of a gallery with ordinary framework (see sketch 7) in order to prevent the caps from slipping on the uprights. These precautions, which are the same as those prescribed by the School of Mines,[1] consist of—

(1) The joining of the caps to the uprights by two braces nailed in the upper angles of the framework or by two battens nailed diagonally on each side.

(2) The connecting of the caps by two sets of battens, as is done for the uprights.

(3) The placing in each interval of diagonal braces between the foot of one frame and the juncture of the cap and corresponding upright of the next frame.

These measures may be supplemented with great advantage by a brace, placed by forcing, in each interval, between the corresponding angles of the two frames concerned, parallel to the direction of the descent, resting against the lower frame and having its highest part joined to the upper extremity of the diagonal brace placed in the interval of the corresponding uprights of the framework already mentioned.[2]

(*d*) *Sanitation of the terrain.*—This question is of the greatest importance. By not giving it the consideration it deserves, there is a risk of losing the benefit of long and important work and depriving the men in the trenches of good shelters they had counted on.

In this connection every effort should be made—

(1) To drain off the surface water within a certain radius which varies according to the nature of the terrain and the depth of the shelter. For this purpose a ditch should be dug around the shelter by means of which the draining of the water will be assured. Without this precaution, which is not always taken, the infiltration will prevent the drying out of the trench.

(2) To prevent the access of drainage water coming from the communication trenches or the trenches into which the shelters debouch. This can be done by making the bottom of the com-

[1] School of Mines, No. 114 (p. 90). [2] See sketch No. 8.

munication trench very high on both sides of the beginning of the descent. In some cases (uncovered communication trenches) nothing will remain to be done except to dig small water sumps to catch the rain water falling on a small surface.

(3) To drain, except in very permeable ground, the bottom of the shelters by digging small water sumps at points chosen with a view to the convenient manipulation of the drain pumps.

It should not be forgotten that during the rainy season any deep shelter which has been flooded can not be drained for a very long time, in spite of all efforts.

VI. DEFENSE OF ENTRANCES.

Experience has shown that during an offensive conducted by enterprising troops whole units could easily be destroyed or made prisoners before having been able to get out of the deep shelters in which they had been staying during the violent bombardment preceding the attack.

It is therefore absolutely necessary, at least as far as shelters other than those designed for the reserves are concerned, to organize the defense of the entrances of these shelters.

The defense may be organized from the exterior or the interior of the shelter by means of flanking works, as, for instance, vertical or horizontal obstacles. A few of the devices used in the armies for this purpose are described hereafter.

(*a*) *Exterior defense—Blockhouse traverses* (see plate 12).—The obstacle employed to defend the entrances from the exterior of the shelters, and known as *blockhouse traverses*, is nothing else than a kind of caponier installed in the communication trench or the trench through which access is gained to the entrances of the shelters.

This obstacle consists principally of a large traverse invisible from the front of the trenches and containing a room in which several infantrymen or automatic-rifle men are stationed, who rake by their fire the trench or communication trench through which access is gained to the entrances, and take it in reverse. In addition to the loopholes required by the above-mentioned flanking works, and the defense of the opposite reverse of the trench or communication trench, it would be wise also to provide a few openings or *grenade chutes*, through which these projectiles may be thrown in the immediate vicinity of the traverse to insure the local defense of the obstacle and to shell

the parts that are in a dead angle in regard to the shots fired from the loopholes.

The firing room communicates with the deep shelter, the traverse of which is designed to defend one or several of the entrances.

The entrance or entrances held under fire by the obstacle in question should be sufficiently near to the latter so that the probable upheaval of the ground resulting from the bombardment preceding the attack will not prevent the traverse from insuring the flanking of these entrances. It might even be wise to include one of the entrances in the system of defense, as indicated by the sketches of plate No. 12.

The blockhouse should be bombproof to the same degree as the shelter, and as it can not be sunk very deep underground, it must be constructed of *cement and reinforced cement* or of *rails and cement.*

To avoid the projection of the blockhouse above ground, which would attract the enemy's attention and cause a systematic demolition fire to be directed on it, the terrain in rear of the reverse of the communication trench should be made to slope. The small slopes surrounding the traverse should moreover have wire entanglements with deceptive passages covered by the loopholes of the firing room.

If the terrain is not badly torn up the immediate vicinity of the traverse will be inaccessible and the enemy's movements will be greatly impeded in the neighborhood of the obstacle.

The blockhouse can be made to appear on the aerial photographs as a large traverse by surrounding it with a small communication trench, which must not be very deep, in order not to increase the size of the surrounding wall (of cement) of the firing room.

The following remarks should be noted in regard to blockhouses:

(1) The trenches or communication trenches in which they are constructed have to be much deeper in their immediate vicinity. This is a cause of great inconvenience as regards the revetment of the banks of the trenches and communication trenches, and also of serious difficulties from the point of view of the drainage of rain water.

(2) The sloping of the reverse must be fairly pronounced in order to give a sufficient field of fire around the traverse. This

greatly diminishes the amount of protection ordinarily needed for trenches or communication trenches.

(3) On account of the nature and importance of the work (cement and reinforced cement work) it is very difficult to construct traverses of this kind in first-line positions.

The result is, in the first place, that unless the emplacement is very suitable as regards the nature of the surrounding terrain, the blockhouse traverse is very difficult to construct, and, in the second place, its utility in first line is limited to a few special cases.

The defense of entrances by means of interior obstacles, as described hereafter, seems to offer a very acceptable solution of the question.

(*b*) *Interior defense.*—This can be obtained by a kind of interior obstacle placed in the descents proper, either in the middle or at the lower end (see pl. 13).

In both cases the obstruction is obtained by widening the descent and constructing a barrier in a suitable place. This solution is simple, easy to carry out, and appears to give satisfactory results. Moreover, it can be installed without difficulty in the ordinary shelters previously constructed.

It is also possible to use the arrangement which has been worked out in the type of shelter of the Engineer Instruction School of the Army Group of the Center (see pls. 9 and 10), which has already been described. It consists in giving a turn to the horizontal descents, and establishing on the prolongation of the end of the descents, parallel to the direction of the trench, a lookout post, enfilading this offshoot. The two lookout posts of a same shelter communicate with each other by means of a gallery which connects them also with the third underground exit of the shelter, opening on the open country. This arrangement, which is complete in every way, has the disadvantage of being very complicated and slow to construct.

In each case the barriers generally consist of sandbags or layers of stone held together by two vertical sheathing planks. The barriers are provided with loopholes for firing, and, if necessary, with a grenade chute.

It should be pointed out that the above-mentioned obstacles cut off the sunlight, and it is therefore necessary for the descents in which they are installed to be permanently lighted.

VII. PROTECTION OF SHELTERS AGAINST GRENADES.

The defense works of the entrances of the shelters should be supplemented by protective measures against grenades thrown by the assailant from the entrance into the descents.

The interior obstruction barriers erected in the descents proper stop the fragments of grenades exploding in front of these obstacles, but can not prevent the grenades from rolling into the obstacles and exploding behind them.

This installation should therefore be supplemented by a device which will hold the grenades in front of the obstacle.

For this purpose one or the other of the following solutions may be adopted:

(1) Place in the descent and in front of the barrier a movable panel with a special metal grating. A convenient system consists in establishing a frame which can be let down on a determined horizontal axis by means of pulleys fixed to the cap of one of the frames of the descent gallery. The frame is ordinarily fastened to the roof of the descent by means of a lock device which is operated from the shelter itself by means of a system of rods.

(2) Provide the entrance of the obstacle proper with a door of thick planks strong enough to resist the effects of the grenades (see sketch No. 13).

If the defense of the entrances is insured from the outside, or even if the system adopted is that of the descent forming an angle with a lookout post enfilading the first part of it, a complete device should be established in the descents themselves to protect the shelter against grenades.

Among the various devices which can be used for this purpose are the following:

(*a*) The horizontal obstacle with grenade-proof grating in a movable frame or a door of thick planks, which has already been described.

(*b*) A device called "vertical obstacle" (see pl. 10), in which the profile of the gallery of access is bent. This gallery therefore includes, after the entrance to the shelter, a descent, then a ramp. These two parts are naturally separated by a landing.

The grenades thrown from the opening of the descent are naturally stopped by the lower landing, which acts as a pit. Sand-

bag traverses judiciously placed at the entrance to the main body of the shelter hold the fragments of the grenades exploding on the lower landing and shield the grenadiers stationed at this entrance. These grenadiers thus overlook the lower landing; they can see the assailant approach and reach him with their grenades while it is still inconvenient for him to throw his.

This arrangement may be supplemented by a panel of special metal grating placed at the entrance to the landing, and which will cause the grenades thrown in this direction by the enemy to rebound. It might also be made of a door of thick planks with a loophole, strong enough to resist the fragments of grenades. If established on the middle landing, it would constitute an advance defense to the descent. It can be made in the form of two folding doors, or can be let down like a drawbridge.

It should be noted, however, that the considerable length of the descent required by the vertical obstacle makes the shelter slow to construct, and the ramp leading from the lower landing to the shelter is often very difficult to build.

VIII. PROTECTION OF SHELTERS AGAINST ASPHYXIATING GAS.

Every possible precaution should be taken to prevent the entrance of asphyxiating gas, for the shelters act as receptacles in which the gas tends to accumulate.

SIMPLE MEASURES OF PROTECTION.

The method most generally adopted for this purpose consists in closing up the descents with canvas which has been made impermeable with boiled linseed oil or paraffin, or else moistened at the time of need by a pulverization of neutralizing solutions.

In cases of emergency, when nothing better can be found, the entrances can be closed up with army blankets.

The canvas can be set up in the form of curtains extending beyond each side of the framework of the descent against which they are placed, or, better still, they can be stretched on wooden frames so as to form panels, by means of which the descent may be hermetically sealed.

They should be arranged in such a way that when the alarm is given they can be put up almost instantaneously.

Each descent should have two canvas curtains placed at an interval of not more than 1 meter and forming an air lock. By

means of this arrangement it is possible to enter the shelter or to go out, while at the same time the descent remains hermetically sealed.

As to the position of the air lock in the descent, it seems best to place the curtains or panels as near as possible to the exits in order to avoid the accumulation of poisonous gases in the descents; however, it should not be placed at the top of the descent. The closing will be thus protected by a layer of earth sufficiently thick to prevent a falling shell from destroying the roof of the descent between the curtains and the shelter.

PROTECTION BY VENTILATION AND NEUTRALIZING OF POISONOUS GAS.

In the case of certain underground shelters which are to be occupied during a considerable length of time, ventilation may be obtained by introducing air which has previously been rid of poisonous gas by passing through a filter. The organization of the latter must be made the subject of a special study in each separate case.

IX. ORGANIZATION OF EXCAVATION WORK.

When the nearness of the enemy makes it impossible to utilize processes for the evacuation of earth on a large scale, the organization of the work is the same as for mine work. The descents are started simultaneously, and as soon as they are completed the excavation of the main body of the shelter is started with the largest number of squads possible. Work is generally started by two squads at once, working toward each other, excavating the shelter according to the profile of the grand gallery, or, as the case may be, of the half gallery. Other squads follow and proceed to widen the gallery and case it, or else to construct the cells.

Whenever local circumstances permit, the construction of the shelter should be accelerated by using all available mechanical devices for excavating and removing the earth (M. D. elevators or trucks).

The following plan, which is merely given as an indication, may be adopted in the organization of construction work for a shelter of the type adopted by the Engineer Instruction School of the Army Group of the Center. (See sketch on pl. 9).

Start three distinct excavations, A, B, C, with inclined planes and with hand or electric winches for removal of the earth.

Use a 40-centimeter track for carrying the earth away from the shelter. (See circuit of the sketch.)

Accelerate the work on the central exit 3, in order to facilitate the removal of earth from the body of the shelter A B by the inclined plane C–3, which has a slope of only $\frac{15}{100}$.

Place the maximum of workers at the excavation heads (specialize their functions). Proportion the rapidity of evacuation to the work of the miners (miners trucks 200 to 300 cubic decimeters on inclined plane with 40-centimeter track, or M. D. elevators).

APPENDIX.

Material required for the construction of some of the various types of shelters shown in the sketches accompanying the present note.

I. SINGLE SHELTER FOR ONE-HALF PLATOON (CENTRAL BODY WITH MAIN GALLERY FRAME).

Name of parts of shelter.	Framework of main gallery.	Special framework of great gallery.	Special framework for officers' room.	Special framework for half gallery.	Mine cases, 0.50 by 0.80 meter.
1. Shelter proper:					
(*a*) Main gallery	8				
(*b*) Great gallery		20			
(*c*) Officers' room			3		
2. Entrances and descents		12			50
3. Periscope room and landings		6			4
4. Niches (*e*) (grenades, etc.)				6	8
5. Interior arrangements:					
(*a*) Beds for 12 men					
(*b*) Benches for 12 men					
(*c*) Stores (shelves)					
6. Closing panels (4 alike)					
Total	8	38	3	6	62

Name of parts of shelter.	Boards.				Mine battens.	Boards, 2.7 by 22 centimeters, and 2 meters in length.
	Length of roofing.		Length of casing.			
	1 to 1.10 meters.	1.20 to 1.30 meters.	1 to 1.10 meters.	1.20 to 1.30 meters.		
					Meters.	
1. Shelter proper:						
(*a*) Main gallery		84	44	154	54	
(*b*) Great gallery	144		344	22	105	
(*c*) Officers' room	20		66		24	5
2. Entrances and descents				210	200	22
3. Periscope room and landings		28	100	44	32	
4. Niches (grenades, etc.)	12	12	36	18	16	
5. Interior arrangements:						
(*a*) Beds for 12 men						60
(*b*) Benches for 12 men						6
(*c*) Stores (shelves)						6
6. Closing panels (4 alike)						12
Total	176	124	590	448	431	111

Material required for the construction of some of the various types of shelters, etc.—Continued.

I. SINGLE SHELTER FOR ONE-HALF PLATOON, ETC.—Continued.

Name of parts of shelter.	Logs.				Rafters, 4 by 8 centimeters.	Strips, 3 by 1 centimeters.
	Diameters of 10 centimeters and length of—		Diameters of 15 centimeters and length of—			
	3.50 meters.	4 meters.	3.50 meters.	2.10 meters.		
1. Shelter proper:					*Meters.*	*Meters.*
(*a*) Main gallery	14	.....	.....	10	7	.....
(*b*) Great gallery	16	.....	.....	.....	11	.....
(*c*) Officers' room	3	.....	.....	.....	2	.....
2. Entrances and descents	.....	8	80	.....	7	.....
3. Periscope room and landings	4	.....	.....	4	4	.....
4. Niches (*e*) (grenades, etc.)	.....	8	.....	.....	1	.....
5. Interior arrangements:						
(*a*) Beds for 12 men	.....	.....	.....	.....	.....	.....
(*b*) Benches for 12 men	.....	.....	.....	.....	.....	.....
(*c*) Stores (shelves)	.....	.....	.....	.....	.....	.....
6. Closing panels (4 alike)	.....	.....	.....	.....	.....	20
Total	37	16	80	14	32	20

Name of parts of shelter.	Wire nails.		Sheet-iron pipes, 15 centimeters in diameter.	Canvas.
	6 to 10 centimeters.	15 to 18 centimeters.		
1. Shelter proper:	*Kilograms.*	*Kilograms.*	*Meters.*	*Meters.*
(*a*) Main gallery	1.5	.....	.....	.....
(*b*) Great gallery	.....	2.0	.....	.....
(*c*) Officers' room	.25	.25	.....	.....
2. Entrances and descents	2.0	1.75	.....	.....
3. Periscope room and landings	1.0	.....	7.50	.....
4. Niches (*e*) (grenade, etc.)	.5	.....	.....	.....
5. Interior arrangements:				
(*a*) Beds for 12 men	2.0	.....	.....	.....
(*b*) Benches for 12 men	.5	.....	.....	.....
(*c*) Stores shelves)	.25	.....	.....	.....
6. Closing panels (4 alike)	.5	.....	.....	1.50 by 2.80
Total	8.5	4.00	7.50	4, 1.50 by 0.70

NOTE.—To the material enumerated above must be added the wooden wedges needed in the construction of the galleries and wire to bind the logs forming the bursting layer. The material for the third exit and the defense of this shelter is not included in the above estimate.

Material required for the construction of some of the various types of shelters, etc.—Continued.

II. SINGLE SHELTER FOR ONE-HALF PLATOON (BODY OF THE SHELTER WITH GREAT GALLERY FRAME, FIRST ARRANGEMENT).

Name of parts of shelter.	Special frame for great gallery.	Special frame for half gallery.	Mine cases 1.50 by 0.80 meters.	Planks.			
				Length of roof.		Length of casing.	
				1 to 1.10 meters.	1.20 to 1.30 meters.	1 to 1.10 meters.	1.20 to 1.30 meters.
1. Shelter proper	36	.....	.....	208	.....	544	66
2. Entrances and descents	12	.....	50	.....	.....	.....	210
3. Periscope room and landings	6	.....	4	.....	28	100	44
4. Niches (*e*) (grenade, etc.)	.....	6	8	12	12	36	18
5. Interior arrangements:							
(*a*) beds for 12 men and officer	.....	.....	.....	.....	.....	.....	.....
(*b*) benches for 12 men	.....	.....	.....	.....	.....	.....	.....
(*c*) Shelves	.....	.....	.....	.....	.....	.....	.....
6. Closing panels (4 alike)	.....	.....	.....	.....	.....	.....	.....
Total	54	6	62	220	40	680	338

Name of parts of shelter.	Mine battens.	Planks 0.027 by 0.22 meter and 2 meters long.	Logs.			
			Diameter of 0.10 meter and length of—		Diameter of 0.15 meter and length of—	
			3.50 meters.	4 meters.	3.50 meters.	2.10 meters.
	Meters.					
1. Shelter proper	205	8	23	2	.....	.....
2. Entrances and descents	200	22	.....	8	80	.....
3. Periscope room and landings	32	.....	4	4	4	4
4. Niches (*e*) (grenades, etc.)	16	.....	.....	8	.....	.....
5. Interior arrangements:						
(*a*) Beds for 12 men and officer	.....	70	.....	.....	.....	.....
(*b*) Benches for 12 men	.....	16	.....	.....	.....	.....
(*c*) Shelves	.....	22	.....	.....	.....	.....
6. Closing panels (4 alike)	.....	12	.....	.....	.....	.....
Total	453	150	27	22	84	4

NOTE.—To the material enumerated in Tables I and II must be added the wooden wedges needed in the construction of the galleries and wire for binding logs forming the bursting layer. Material for the third exit and defense of the shelter is not included in the above estimates.

Material required for the construction of some of the various types of shelters, etc.—Continued.

II. SINGLE SHELTER FOR ONE-HALF PLATOON, ETC.—Continued.

Name of parts of shelter.	Rafters.		Strips, 0.03 by 5.01 meters.	Batten, 0.018 meter.	Wire nails.		Sheet-iron, pipe, diameter 0.15 meter.	Canvas.
	0.04 by 0.08 meter.	0.08 by 0.08 meter.			0.06 to 0.10 meter.	0.15 to 0.18 meter.		
	Meters	*Meters*	*Meters*	*Meters*	*Kilograms*	*Kilograms*	*Meters*	*Meters*
1. Shelter proper	30			[1] 8	7	2		
2. Entrances and descents	7				2	1.75		
3. Periscope room and landings	4				1		7.5	
4. Niches (*e*) (grenades, etc.)	1							
5. Interior arrangements:								
(*a*) Beds for 12 men and officer		28			3			
(*b*) Benches for 12 men					1			
(*c*) Shelves					2			
6. Closing panels (4 alike)			20		.5			0.50 by 2.80
Total	42	28	20	[1] 8	16.5	3.75	7.5	4 (1.5 by 0.7)

[1] Canvas for closing panels (4 alike), 1.5 by 2.8 meters; total=4 (1.5 by 0.7) meters.

Material required for the construction of some of the various types of shelters, etc.—Continued.

III. SINGLE SHELTER FOR ONE-HALF PLATOON (BODY OF THE SHELTER WITH GREAT GALLERY FRAME, SECOND ARRANGEMENT).

Name of parts of shelter.	Special great gallery frame.	Special half gallery frame.	Mine cases, 1.5 by 2.8 meters.	Planks.				Mine cases.	Planks, 0.027 by 0.01 meter and 2 meters long.
				Length of roof.		Length of casing.			
				1 to 1.10 meters.	1.20 to 1.30 meters.	1 to 1.10 meters.	1.20 to 1.30 meters.		
								Meters	
1. Shelter proper	38	.....	.....	208	12	374	90	145	18
2. Entrances and descents	12	.....	50	.....	.....	.....	210	200	22
3. Periscope room and landings	6	.....	4	.....	28	100	44	32	.....
4. Niches (*e*) (grenades, etc.)	.....	.....	8	.....	.....	.....	.....	8	.....
5. Interior arrangements:									
(*a*) Beds for 12 men and officer	.....	.....	.....	.....	.....	.....	.....	.....	70
(*b*) Benches for 12 men	.....	.....	.....	.....	.....	.....	.....	.....	16
(*c*) Shelves	.....	.....	.....	.....	.....	.....	.....	.....	22
6. Closing panels (4 alike)	.....	.....	.....	.....	.....	.....	.....	.....	12
Total	56	.....	62	208	40	474	344	385	160

Material required for the construction of some of the various types of shelters, etc.—Continued.

III. SINGLE SHELTER FOR ONE-HALF PLATOON, ETC.—Continued.

Name of parts of shelter.	Logs.				Rafters.		Strips, 0.03 by 0.01 meter.	Batten, 0.018 meter.	Wire nails.	
	Diameter of 0.10 meter and length of—		Diameter of 0.15 meter and length of—		0.04 by 0.08 meter.	0.08 by 0.08 meter.			0.06 to 0.10 meter.	0.15 to 0.18 meter.
	3.5 meters.	4 meters.	3.5 meters.	2.1 meters.						
	Meters				*Meters*	*Meters*	*Meters*	*Meters*	*Kilograms*	*Kilograms*
1. Shelter proper	22	2	.....	.....	26	.....	.....	[1] 8	8	4
2. Entrances and descents	.....	8	80	.....	7	.....	.....	.....	2	1.75
3. Periscope room and landings	4	.....	.....	4	4	.....	.....	.....	1	.....
4. Niches (*e*) (grenades, etc.)	.....	.....	.....	.....	.....	.....	.....	.....	.25	.....
5. Interior arrangements:										
(*a*) Beds for 12 men and officer	.....	.....	.....	.....	.....	28	.....	.....	3	.....
(*b*) Benches for 12 men	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
(*c*) Shelves	.....	.....	.....	.....	.....	.....	.....	.....	2	.....
6. Closing panels (4 alike)	.....	.....	.....	.....	.....	.....	20	.....	.25	.....
Total	26	10	80	4	37	28	20	[1] 8	17.50	5.75

[1] Sheet-iron pipe 0.15 in diameter, for periscope room, 7.5 meters.

IV. GROUP OF DOUBLE SHELTERS, PORTION FOR ONE PLATOON.

Name of parts of shelter.	Main gallery frame.	Great gallery frame.	Special frame, 1.33 by 1.90 meters.	Half gallery frame.	Special frame, 0.80 by 1.64 meters.	Planks (roof), length.		
						1 to 1.10 meters.	1.20 to 1.30 meters.	1.50 meters.
1. Shelter proper:								
(*a*) First story	5	.....	19	5	7	150	41	5
(*b*) Second story	16	8	.....	.....	6	62	120	36
2. Entrance and descent	.....	9	3	23	.....	126	6	12
3. Interior arrangements:								
(*a*) Camp beds for 12 men and officer	.....	.....	.....	.....	.....	.....	.....	.....
(*b*) Benches for 10 men	.....	.....	.....	.....	.....	.....	.....	.....
(*c*) Shelves	.....	.....	.....	.....	.....	.....	.....	.....
4. Closing panels (4 alike)	.....	.....	.....	.....	.....	.....	.....	.....
Total	21	17	22	28	13	338	167	53

Material required for the construction of some of the various types of shelters, etc.—Continued.

IV. GROUP OF DOUBLE SHELTERS, ETC.—Continued.

Name of parts of shelter.	Planks, casing.			Mine battens.	Logs.			
	Length.				Diameter of 0.10 meter and length of—		Diameter of 0.15 meter and length of—	
	1 to 1.10 meters.	1.20 to 1.30 meters.	1.50 meters.		3.50 meters.	4 meters.	3.50 meters.	2.10 meters.
				Meters.				
1. Shelter proper:								
(*a*) First story	196	202	54	130	20	4	.....	.....
(*b*) Second story	226	330	.....	112	18	5	.....	.....
2. Entrance and descent	340	20	58	208	43	41	2	.....
3. Interior arrangements:								
(*a*) Camp beds for 36 men and officer	.....	.....	.....	.....	.....	.....	.....	.....
(*b*) Benches for 10 men	.....	.....	.....	.....	.....	.....	.....	.....
(*c*) Shelves	.....	.....	.....	.....	.....	.....	.....	.....
4. Closing panels (2 alike)	.....	.....	.....	.....	.....	.....	.....	.....
Total	762	552	112	450	81	50	2	.....

Name of parts of shelter.	Intervening uprights for great gallery frame, 0.11 by 0.17 by 2.10 meters.	Timbers, 0.17 by 0.065 meters.	Wood-en stakes, diameter, 0.10 meter; length, 1.50 meters.	Planks, 0.027 by 0.22 meter; length, 2.10 meters.	Rafters.		Strips, 0.03 by 0.01 meter.	Batten, 0.018 meter.
					0.04 by 0.08 meter.	0.08 by 0.08 meter.		
					Meters.	*Meters.*	*Meters.*	*Square meters.*
1. Shelter proper:								
(*a*) First story	2	.....	.....	.....	16	.....	.....	5
(*b*) Second story	10	.....	.....	.....	17.5	.....	.....	.....
2. Entrance and descent	.....	33	4	.....	40.0	.....	.....	.....
3. Interior arrangements:								
(*a*) Camp beds for 36 men and officer	.....	.....	.....	180	.....	12.5	.....	.....
(*b*) Benches for 10 men	.....	.....	.....	7	.....	.....	.....	.....
(*c*) Shelves	.....	.....	.....	6	.....	.....	.....	.....
4. Closing panels (4 alike)	.....	.....	.....	8	.....	.....	12	.....
Total	12	33	4	201	73.5	12.5	12	5

Material required for the construction of some of the various types of shelters, etc.—Continued.

IV. GROUP OF DOUBLE SHELTERS, ETC.—Continued.

Name of parts of shelter.	Wire nails.		Planks, 0.22 by 0.08 meter.	Canvas.
	0.04 to 0.10 meter.	0.15 to 0.18 meter.		
	Kilograms.	*Kilograms.*	*Meters.*	*Meters.*
1. Shelter proper:				
(*a*) First story	4	2		
(*b*) Second story	3	1		
2. Entrance and descent	5	3	30	
3. Interior arrangements:				
(*a*) Camp beds for 36 men and officer	6			
(*b*) Benches for 10 men	0.50			
(*c*) Shelves	0.15			
4. Closing panels (2 alike)	0.35			1.50 by 1.80
Total	19	6	30	2 (1.50 by 0.90)

NOTE.—The following must also be provided: Wedges, slope templates, and wooden lining for the construction of the galleries; 6 clamp irons with points in the same direction; 24 bolts 24 centimeters long, 5 bolts 18 centimeters long, and 21 bolts 13 centimeters long for the entrance to the shelter, and also the wire to bind together the logs forming the cover of this entrance.

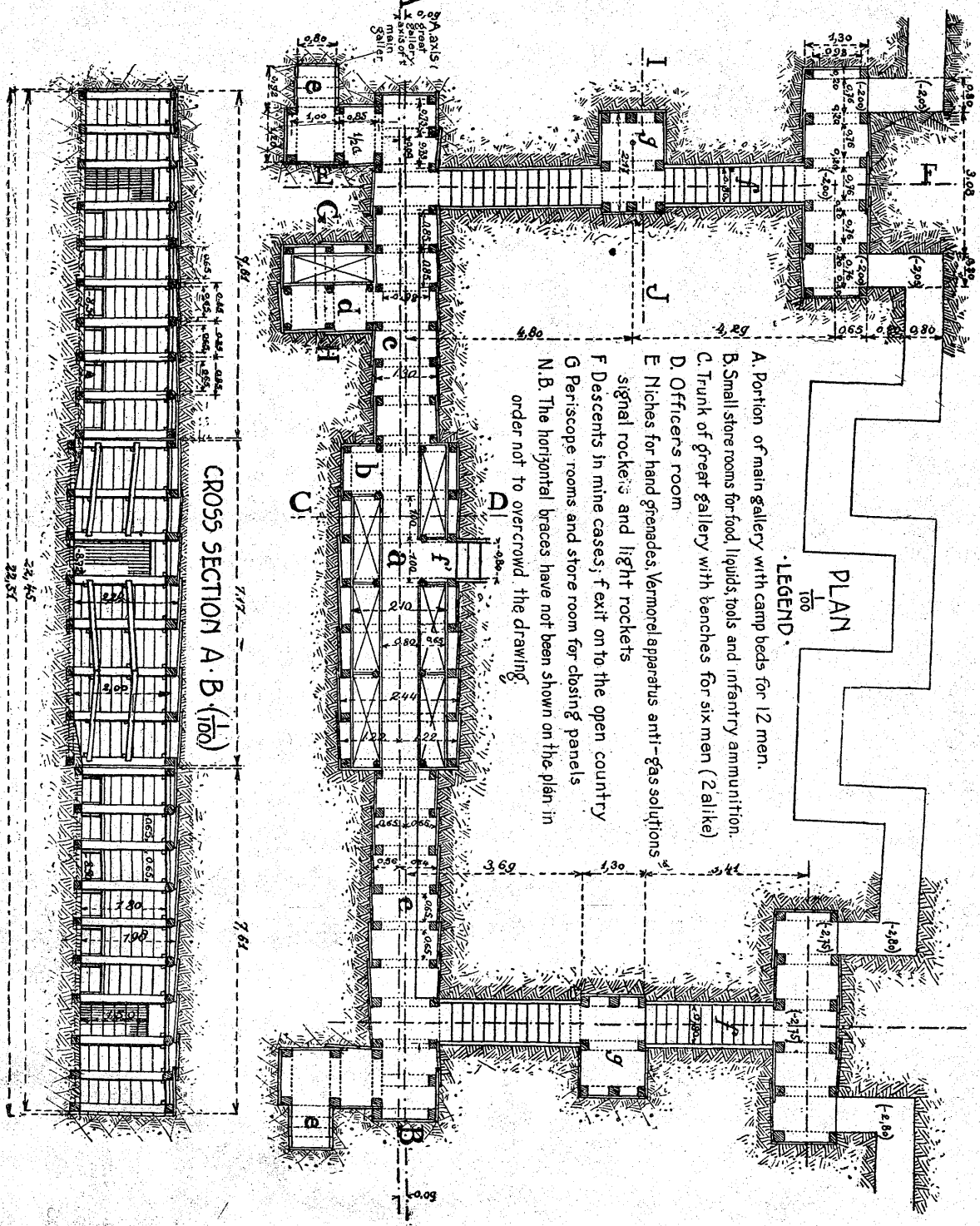
The material for the third exit and for the defense of this shelter is also not included in the above estimates.

Sketch No. 1 attached to note of January 21st, 1917.

TYPE OF SINGLE SHELTER

FOR ½ PLATOON 1/100

SHELTER · WITH · CENTRAL · BODY · WITH · MAIN · GALLERY · FRAME

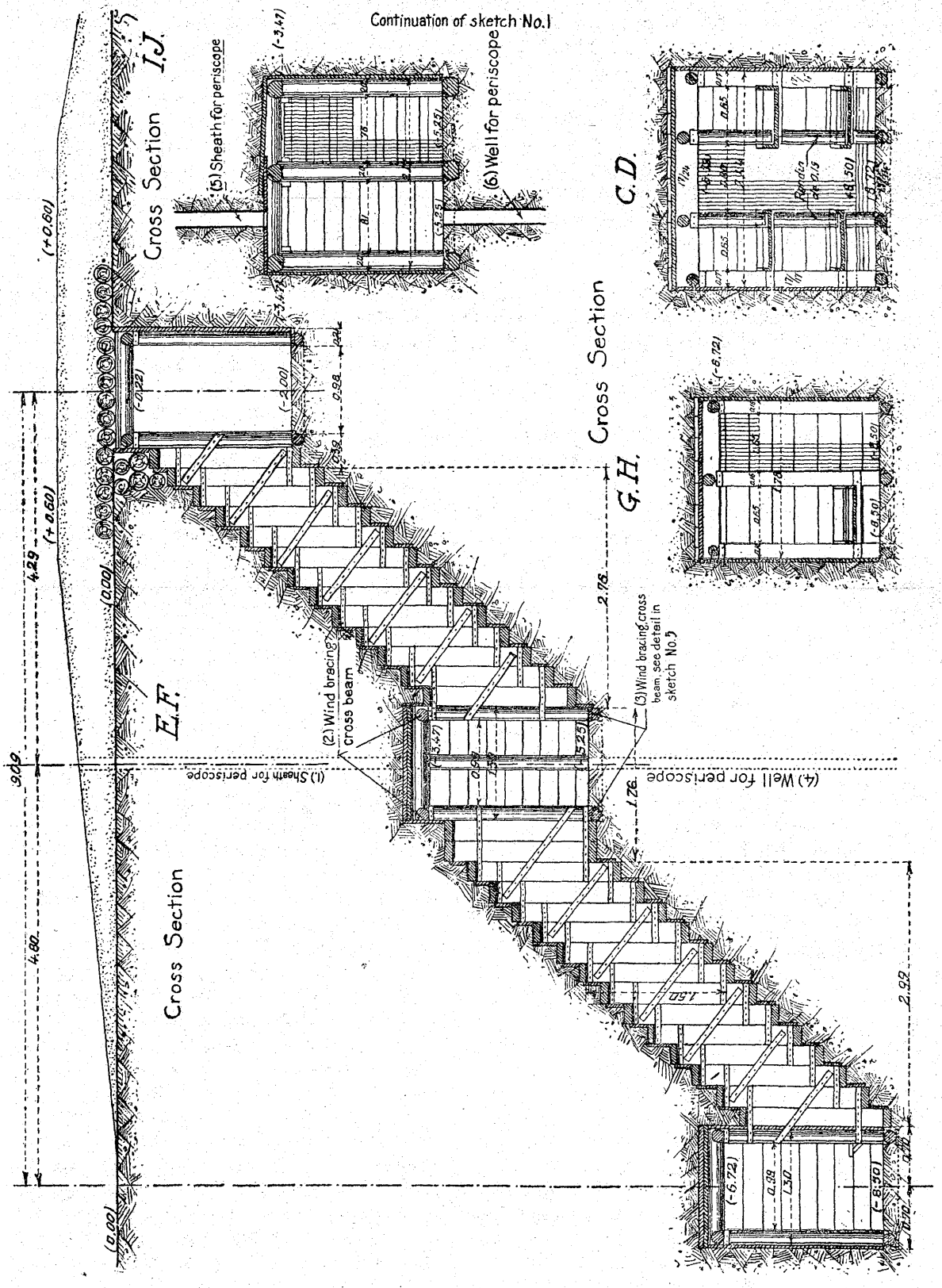


Sketch No. 2 attached to note of January 21st 1917.

TYPE OF SINGLE SHELTER
FOR ½ PLATOON

SHELTER WITH CENTRAL BODY WITH MAIN GALLERY FRAME

Continuation of sketch No. 1

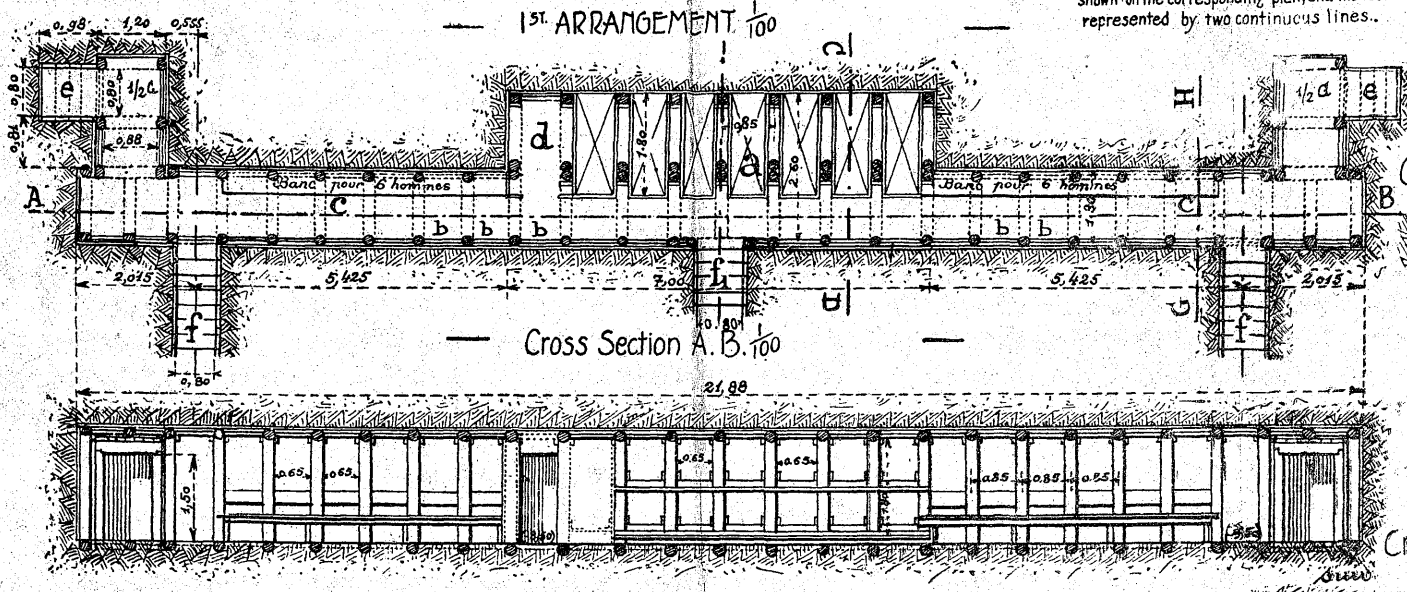


Sketch No. 3 attached to note of January 21st 1917.

TYPE OF SINGLE SHELTER FOR ½ PLATOON

Body of shelter with great gallery frame

Note.- In order not to overcrowd the drawing, the braces (shown in the cuts) are not shown on the corresponding plan, and the roof and casing planks are represented by two continuous lines..



LEGEND

a-a' camp bed for 12 men.

b-b' Spaces with shelves for food, tools, infantry ammunition, signal rockets.

c-c' Benches for 12 men.

d-d' Officer's room

e-e' Niches for hand grenades, Vermorel apparatus and anti-gas solutions.

f-f' Descents in mine cases (see drawing of these descents in sketches 1 & 2

f_1-f_1, 3rd. exit onto the open country

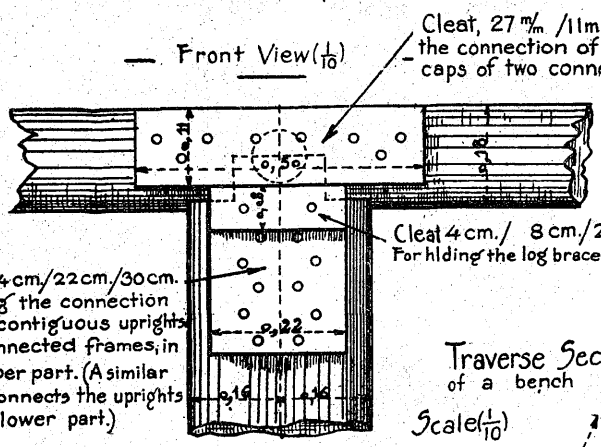
TYPE OF SINGLE SHELTER
FOR ½ PLATOON

Details of the type having body with great gallery frame

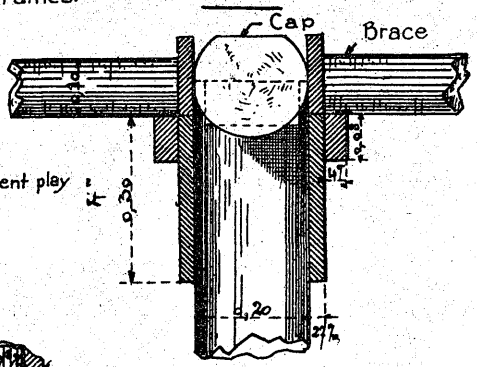
Sketch No.4 attached to note of January 21st. 1917

Detail of the junction M of the uprights and the caps
(See Sketch No.3 Cut following CD)

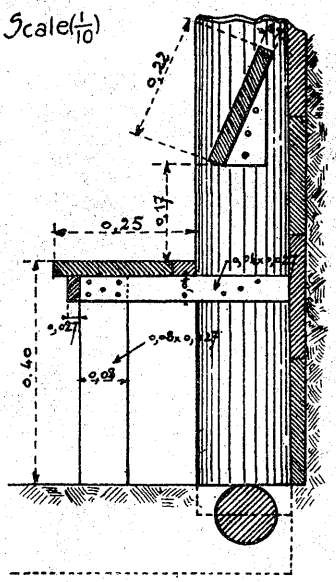
— Front View($\frac{1}{10}$)



— Side View($\frac{1}{10}$) —



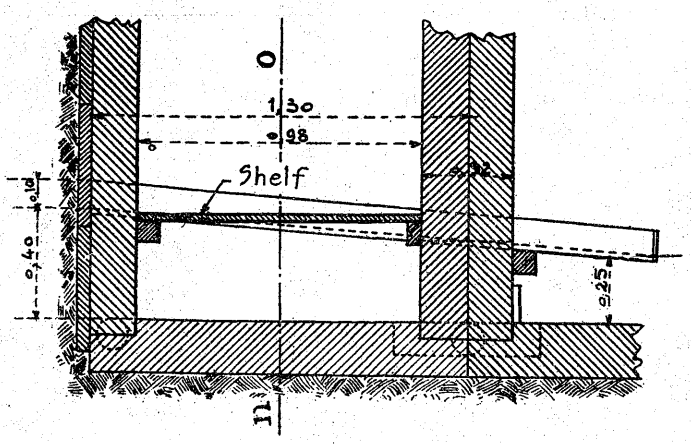
Traverse Section
of a bench
Scale($\frac{1}{10}$)



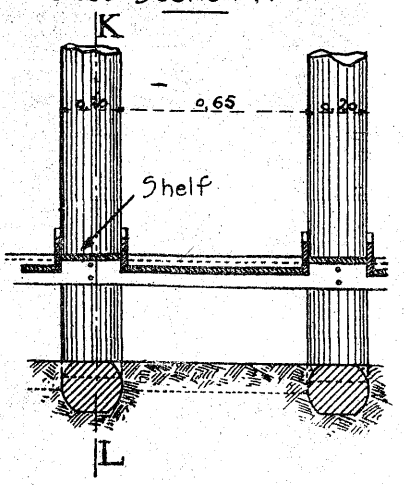
DETAIL OF A BED

Scale $\frac{1}{10}$

— Cross Section K-L —



Cross Section M-O —



TYPE OF SINGLE SHELTER
FOR ½ PLATOON

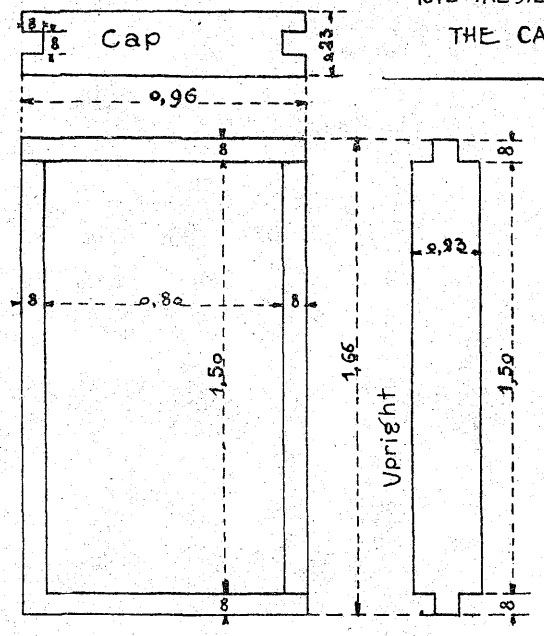
Sketch No. 5 attached to note of January 21st. 1917

DETAILS OF THE FRAMEWORK USED IN THE TYPES SHOWN IN SHETCHES 1·2·3·4

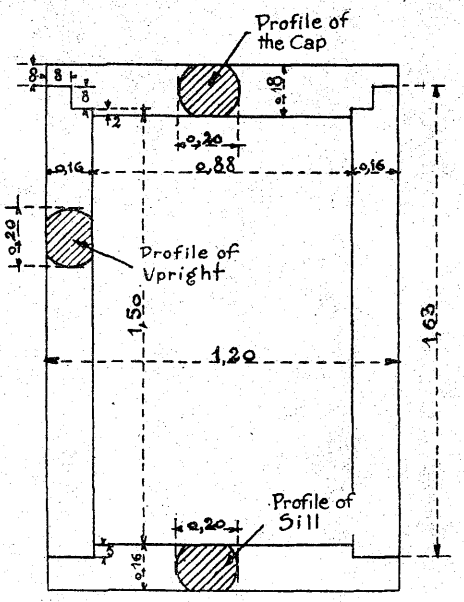
SCALE 1/20

MINE CASES FOR DESCENTS.

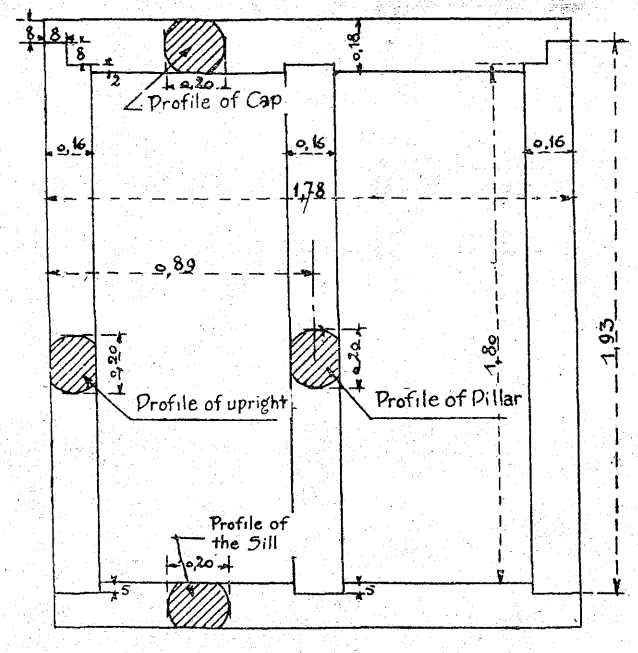
NOTE: THE SILL IS LIKE THE CAP



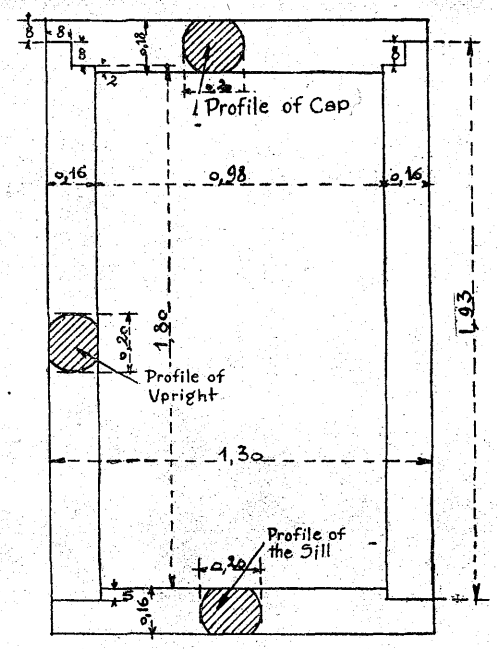
FRAME OF HALF GALLERY



FRAME WORK FOR OFFICERS ROOM



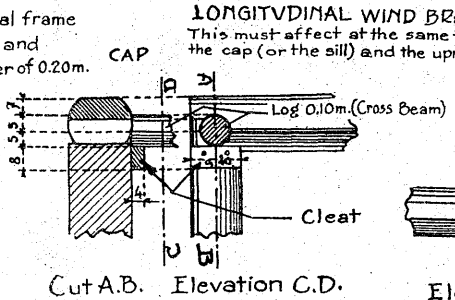
Frame work of great gallery



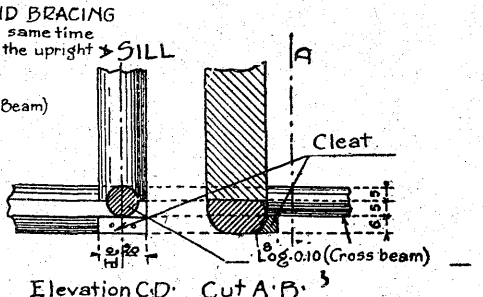
Note: The logs in the special frame work are roughly squared and have a minimum diameter of 0.20m. The framework of the main gallery which is simply the regulation frame work has therefor not been shown on the present sketch.

LONGITUDINAL WIND BRACING

This must affect at the same time the cap (or the sill) and the upright



Cut A.B. Elevation C.D.



Elevation C.D. Cut A.B.

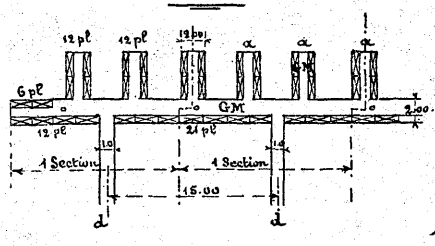
DIAGRAMS OF TYPES OF SINGLE SHELTERS WITH CELLS

Scale of 1/500

Sketch No.6 attached to note of January 21st 1917

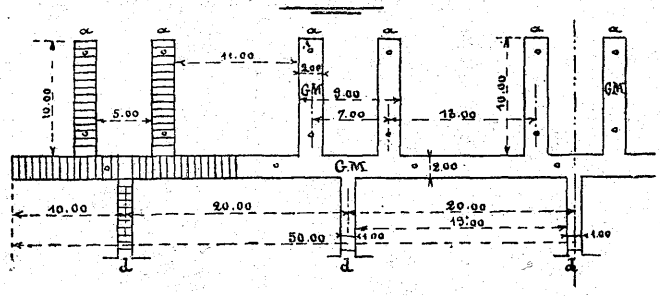
Sketch No.1
Shelter with short cells.

This type is generally substituted for type of double shelter shown in sketches 7 and 8

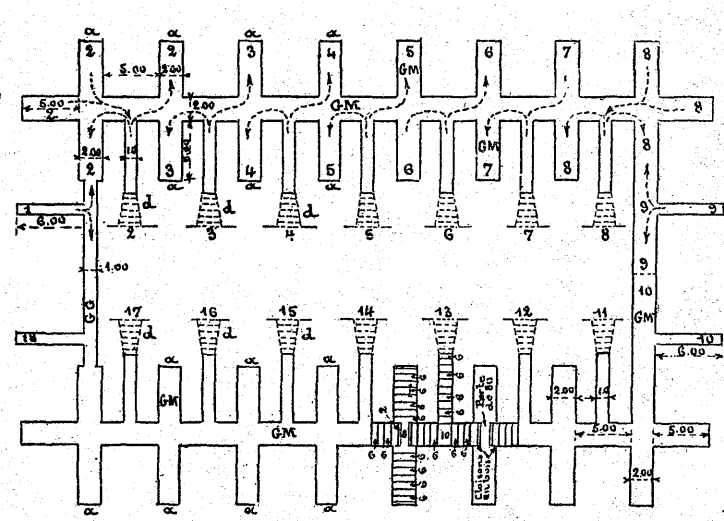


By using three story beds and arranging them in the manner shown by the sketch the capacity of a shelter for a company will be 231 places. The necessary room can therefor be reserved for officers for a small office-store room, and for an electric plant.

SKETCH NO.2
Shelter 100 meters long with large cells

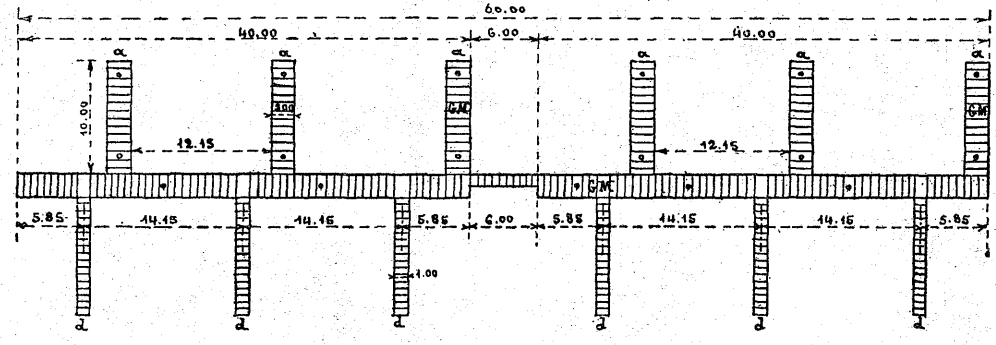


SKETCH NO.4
Army Corps Command Post.



The sketch shows the arrangements adopted by a unit of a battalion MD in the construction of this command post

SKETCH NO.3
Group of two shelters with large cells

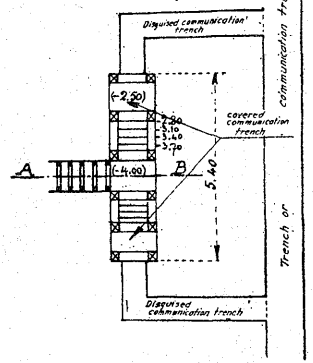


LEGEND
A-Cells
D-Descents
GM-Main gallery
GG-Great gallery
o-Ventilation shaft

GROUP OF DOUBLE SHELTERS * PORTION – FOR ONE PLATOON

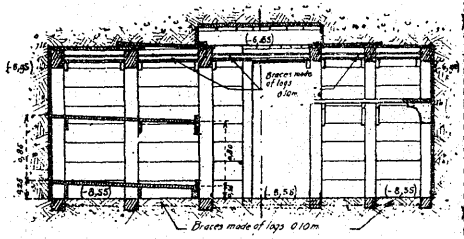
Sketch No. 7 attached to note of January 21st 1917

Variant of entrance plan



N.B. On the plan A-B-C-D-E-F the horizontal braces of both stories of the body of the shelter are represented by a dotted line. The various braces of the descents are not shown on this plan in order not to overcrowd the drawing

Cross Section O-P



PLAN FOLLOWING A B C D E F G H

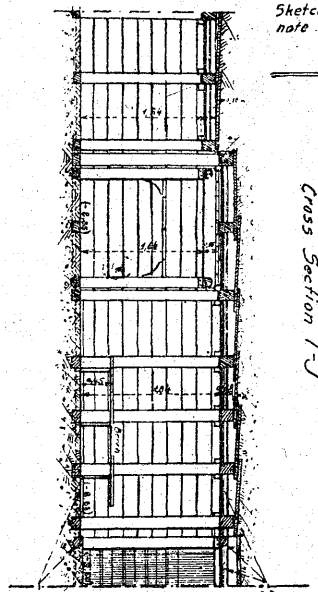
(1/50)

Variant of entrance Cross Section A-B.

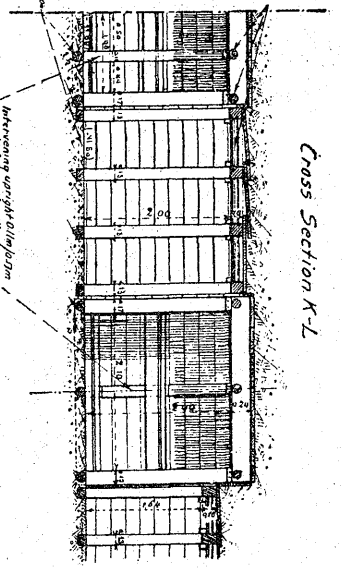
Plan of ensemble of a group of platoon shelters

N.B. Rooms shown by provincial for other officers besides the platoon commanders and for commanding officers and various other rooms

Cross Section I-J



Cross Section K-L



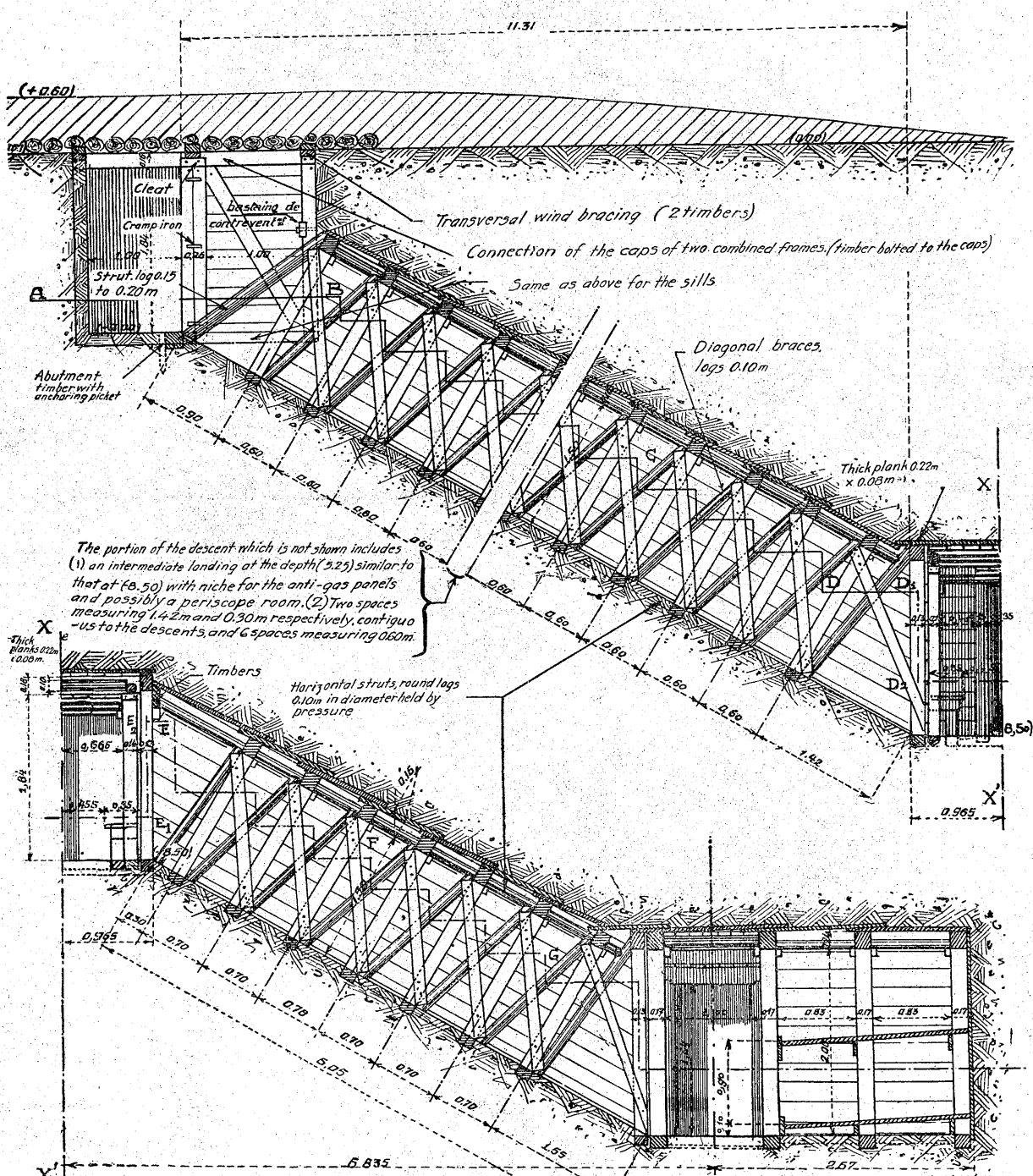
GROUP OF DOUBLE SHELTERS

Sketch No.8 attached to note of January 21st 1917.

TYPE OF PORTION FOR ONE PLATOON

CROSS SECTION M-N

$\left(\frac{1}{100}\right)$



Note:- Vertical frame work in the casing of the descents is generally preferred to the arrangement shown above in which the casing requires the frame-work to be placed perpendicular to the axis of the descent it is merely shown above for information

Sketch No. 3 surrendered to the Nuremberg Tribunal on January 21st 1947.

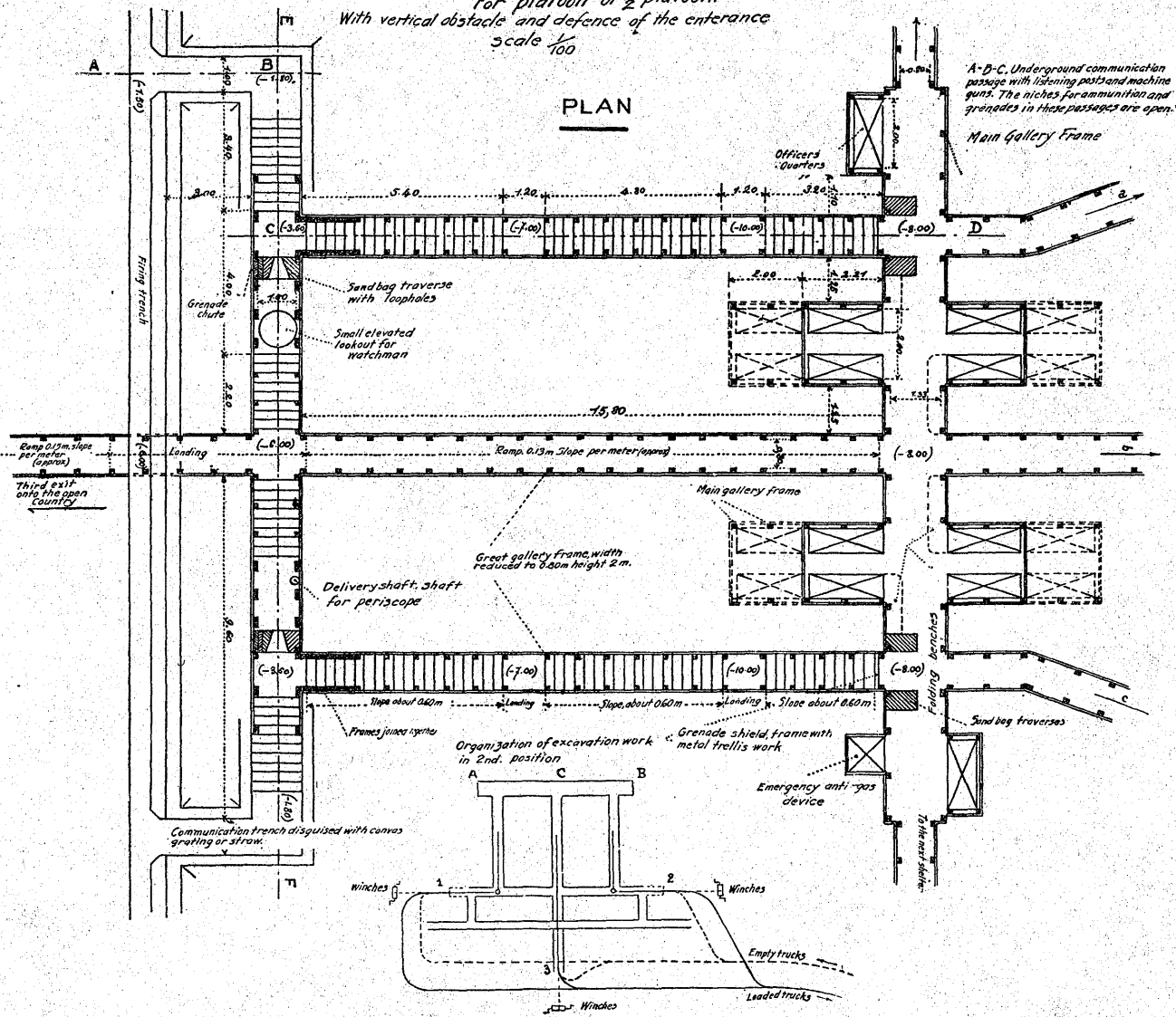
TYPE OF SINGLE SHELTER OF THE ENGINEER INSTRUCTION SCHOOL OF THE ARMY GROUP OF THE CENTER

For platoon or ½ platoon.

With vertical obstacle and defence of the enterance

scale 1/100

PLAN



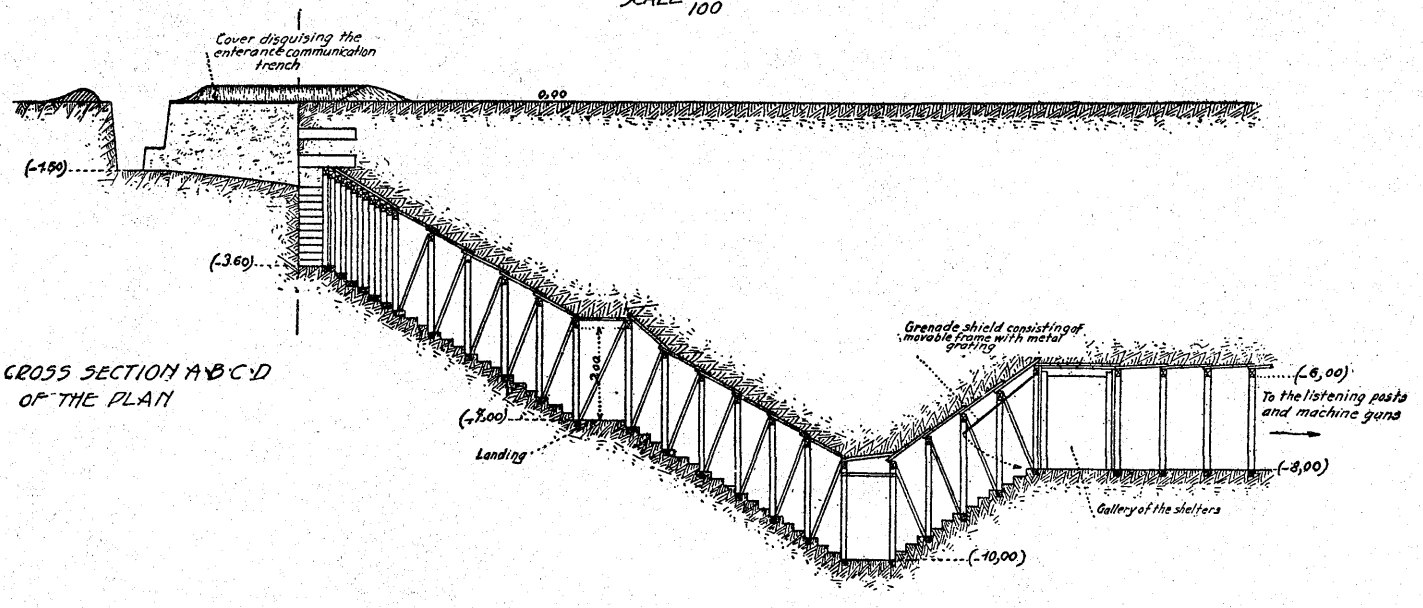
Sketch No. 10 attached to note of January 21st 1917

TYPE OF SINGLE SHELTER OF THE ENGINEER INSTRUCTION SCHOOL OF THE ARMY GROUP OF THE CENTER

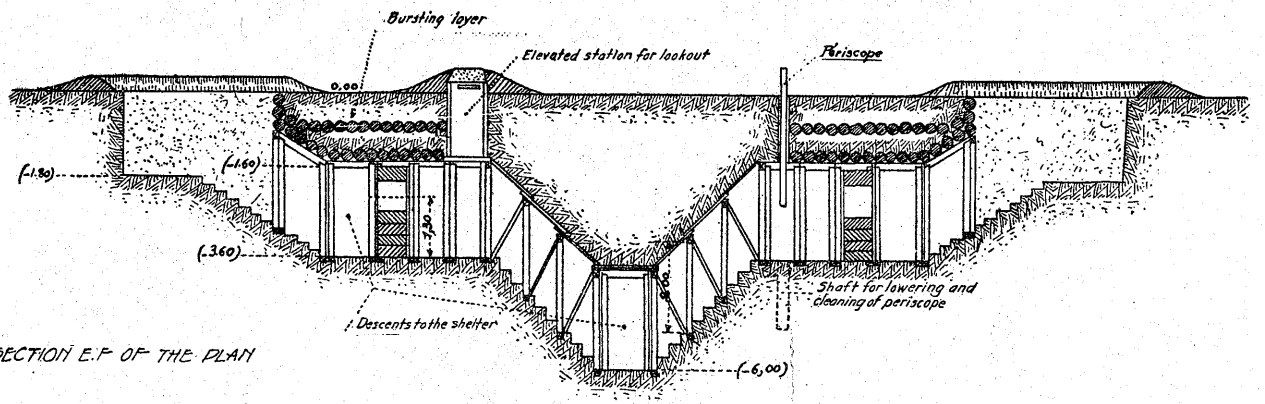
For platoon or ½ platoon

With vertical obstacle and defence of the enterance

SCALE 1/100



CROSS SECTION A B C D OF THE PLAN



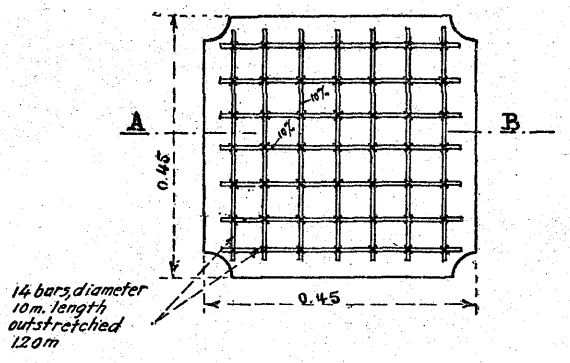
CROSS SECTION E F OF THE PLAN

CEMENT BLOCK FOR BURSTING LAYER

Sketch No.11 attached to note of January 21st 1917

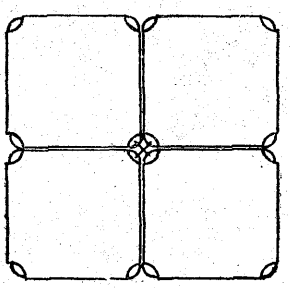
Reinforement of Bottom

Scale $\frac{1}{40}$

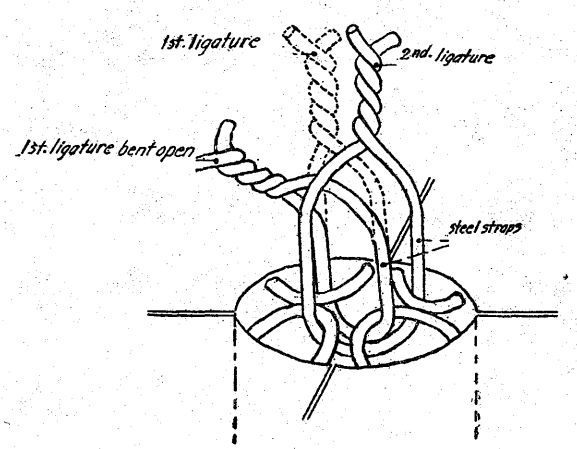


Assemblage of Blocks

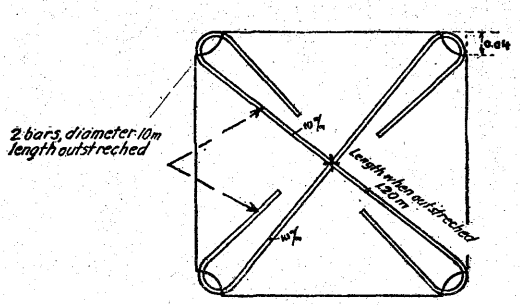
Scale $\frac{1}{20}$



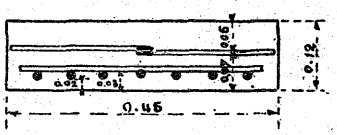
Manner in which Blocks are joined



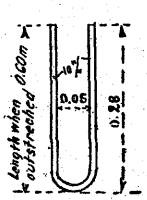
Reinforement of Middle



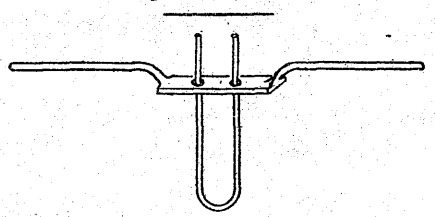
Cut on A-B



Strap very soft steel



Twisting of a strap



Materials composing a block for bursting layer

CONCRETE { 400 liters of sand +800 liters of gravel +400 kilograms of Portland cement: $0.024 m^3$

Round steel bars 10mm. in diameter, weight: 5 kilograms

BLOCKHOUSE · TRAVERSE FOR DEFENSE OF THE ENTRANCES

Sketch No.12 attached to note of January 21st 1917

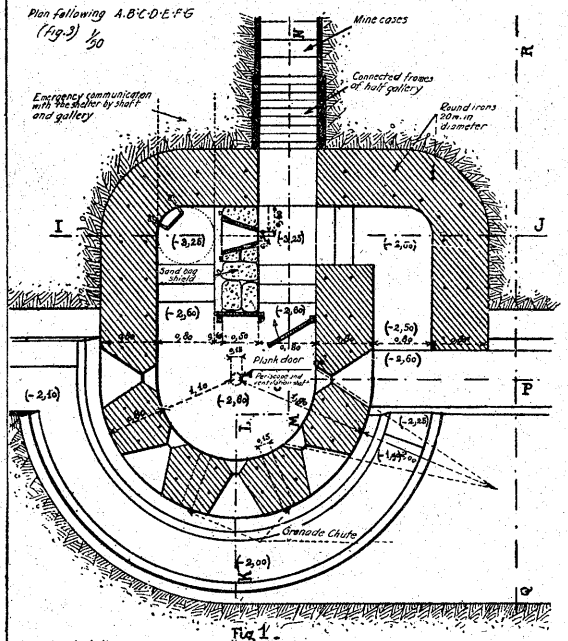


Fig 1.

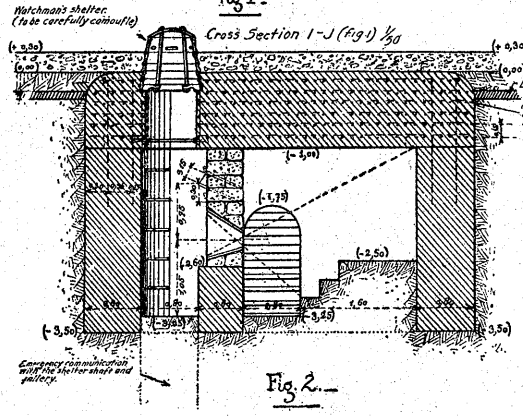


Fig. 2.

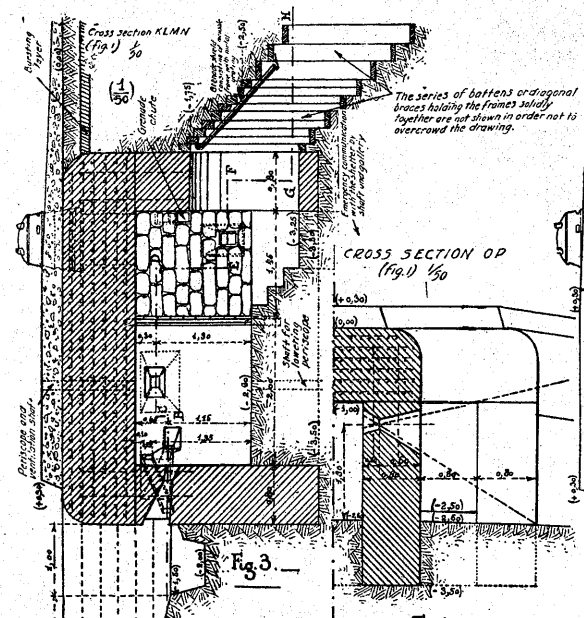


Fig. 3.

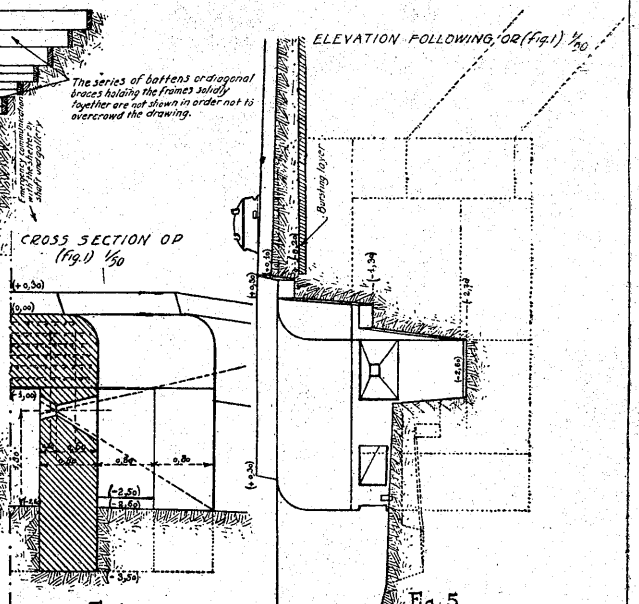


Fig. 4.

Fig. 5.

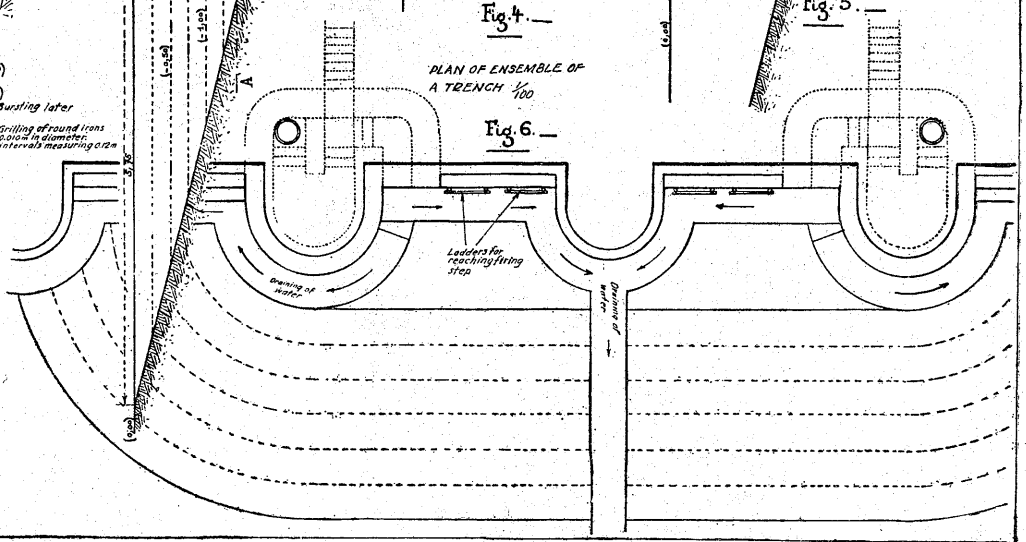


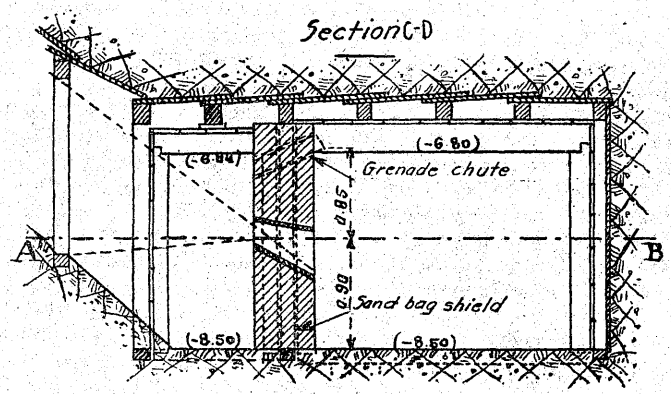
Fig. 6.

DEFENSE OF DESCENTS AND PROTECTION AGAINST GRENADES

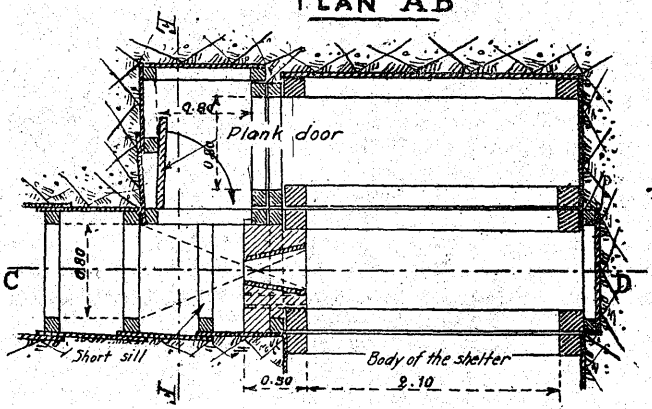
Obstacles at bottom of descent 1/50

Sketch No. 13 attached to note of January 21st 1917

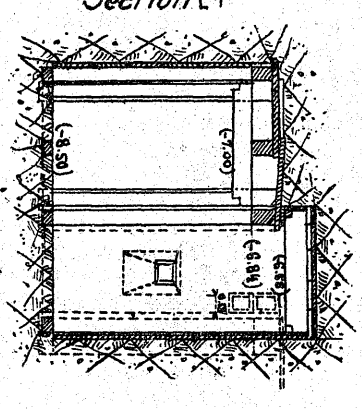
Section C-D



PLAN AB

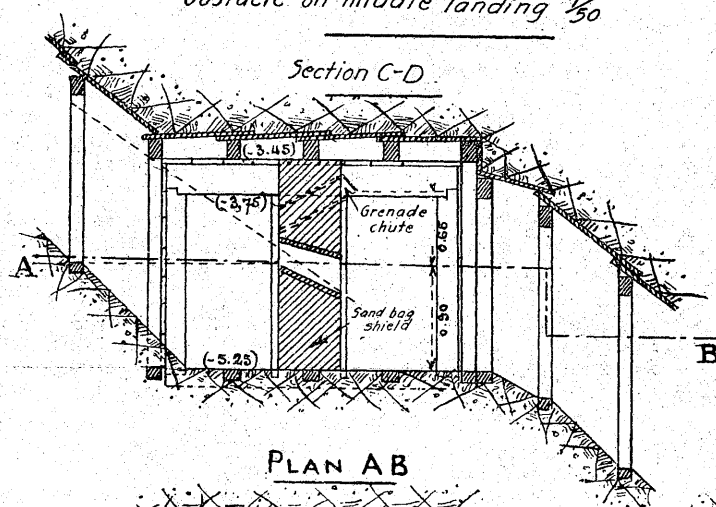


Section E-F



Obstacle on middle landing 1/50

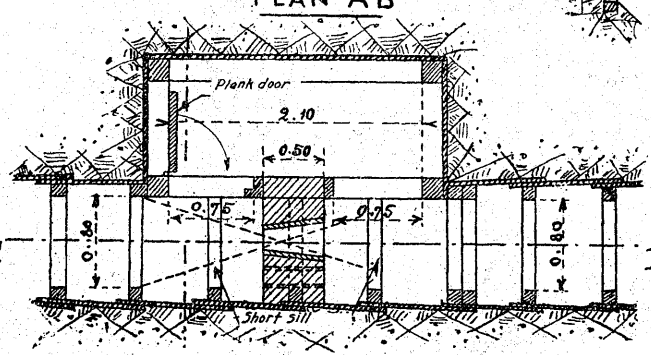
Section C-D



Note: In drawing these sketches it is supposed that the ground is of medium hardness and that the obstacles are to be built after the shelter is finished.

In order not to overcrowd the drawing the mine battens and various wind-bracing struts are not shown.

PLAN AB



Section E-F

