53

Jun 1919

JUN 1919

NOTES ON TRENCH WAR.

By MAJOR H. A. S. PRESSEY, M.C., R.E.

(a). Trench war was evolved in the winter of 1914–1915, due to the fact that the Germans were treating the war as a battle in which they were holding a line on the Western Front, while attacking on the Eastern Front. The French and English were not capable of attacking. Original trench systems in the English line were based on the principles of *Field Service Regulations* and, with a large modicum of trained officers, proved extremely effective, *e.g.*, a German brochure on the British lines in the Ypres salient, published after our withdrawal consequent on the gas attack of 1915, holds the siting and tactics of our trenches up as a model to be followed, and laid down that in their systems, too much attention had been paid to detail and too little to principle.

Untrained officers, and officers obsessed by the detail of trench war, then regarded defensive systems as a means to an end. Trenches made as a means of covered communication between posts came to be looked on as defensive lines, the obsession of the hand grenade came in and caused the neglect of the rifle.

The necessity of upkeep of elaborate trench systems together with the inherent antipathy to manual work of the British nation necessitated the keeping of large garrisons in trenches. This necessitated provision of a large amount of accommodation. Owing to the increase in artillery this accommodation had to be provided in the shape of bomb proofs, and fortification became more elaborate and to be regarded as a means to an end.

(b). Further experience gained in attacking trench systems, which had been elaborated on the same style as our own, much the same result being obtained though, due to the fact the German is a harder worker than the Britisher, with a much greater economy of men, led to a return to the principles of *F.S.R.*; but, owing to the lack of experience and knowledge of officers and natural reaction taking the swing of the pendulum back too far, this led to a system easily penetrated.

(c). The ideal to be aimed at is that laid down in *F.S.R.* and the *Manuals of Field Engineering* modified to suit the altered conditions, due to the enormous increase in the amount of artillery employed in modern battles and the lack of initiative, which is a necessary adjunct of partly-trained officers and men. Owing to the fact that this system must be held in all weathers and at all times, the siting of the works necessary must conform to those laid down for night dispositions.

(*d*). The only object of Field Fortification is to husband men. Skilfully designed works enable large areas to be held with small numbers of men, thus enabling a weaker force to hold back a stronger, and freeing larger numbers of men to develop an offensive, and by the offensive alone can any decisive result be obtained.

(*e*). The essential spirit of a good defensive is the offensive. Defences must be designed to develop to the full the possibilities of final counter attack, and to foster the offensive spirit in the defenders.

(*f*). Artillery has increased to an extent both in number and power undreamt of by the masters of war previous to this age. It has now reached a pitch where its actual is equal to its moral effect, and, fully developed, its power is superior to that of the rifle. Hence the necessity of securing good observation and the consequent seeming objectives of the battles of this war. In this particular it should be noted that certain battles must not be quoted as examples. They were only in the nature of local operations in the general scheme to obtain a local advantage and as preliminaries to a greater scheme. The May offensives in 1915, called the battle for the Aubers Ridge, had originally the definite idea of a break through, afterwards modified to the fight for a limited objective, when that was no longer seen to be possible. The attack on the Vimy Ridge in 1917 was to provide a strong defensive flank to a break through further south. Lorette Ridge was contemporary with the Aubers Ridge attack, and had at the outset the same object; it was the same with the Chemin des Dames battle in 1917.

Messines Ridge was a preliminary objective of the battle of the 31st July. The fight for Passchendaele Ridge was to give the British a good jumping off ground for an offensive in the Spring of 1918. The gaining of Mount Kemmel is a distinctive case in point; it did not lead as was expected by short-sighted people to any result that was in the slightest decisive. St. Quentin was a preliminary objective in the turning of the German position on the Somme. In fact it is necessary for the full development of artillery to obtain good observation. This, however, is not so essential to Allies with their mastery of the air as it is to the enemy. It is absolutely essential that the strategical and tactical sighting of lines must not give way to the obsession of observation. Good communication and husbanding of men are the necessaries to be borne in mind. Remember the enemy has never expended large numbers of men and material in trying to obtain observation. His offensives have always been made with a much greater objective. Other things being equal, observation is the deciding point. Generally speaking communications are so good in this country that observation looms largely in any defensive scheme but it must be relegated to its proper position. Denial of observation to the enemy is of importance as well as observation on your own side. It is to be remembered that the nastiest knock to any troops is that, having spent men and material on capturing a place, they find another and bloodier beyond. That was the weak point of the Hindenburg line. Observation is undeniably a very important point, but it is not the only one.

(*g*). The choice of defensive lines and the general siting is well understood, much is written on it and all to the point. G.H.Q. instructions on this point are clear and complete. It is in the particular siting that much is to be improved. The principles are laid down in *F.S.R.* It is to be remembered that the defensive works should be sited so as to enable night dispositions for outpost lines to be put into force as regards the forward lines, and the main or battle lines be arranged as laid down in these regulations.

(*h*). Depth is a term that is much misunderstood and much discussed. It is perhaps the most abused word in the military vocabulary at the present moment. It must be understood that there is disposition in depth, but what is mostly achieved in existing defensive systems is dispersal in depth. Any system which allows of its lines being successively disposed of by the enemy is wasteful and inherently faulty and must be condemned. When a Unit is so disposed that it can readily present a reinforceable front in any direction, it is disposed in depth. Double echelon is perhaps the best disposal in depth that can be imagined.

(*k*). The power of appreciating a situation is at the present moment moribund, in all except perhaps the higher commands. Could the term "appreciation of a situation" be but substituted for "depth" as a popular catchword much improvement might be made in the present systems erected.

(*l*). Coming particularly to rear defence lines, which are intended to check the advance of a victorious enemy which has broken the field armies in their front and is engaged in a pursuit, the essential points are that they must be capable of being held by a thin nucleus garrison, and that they form a rallying line for the defeated troops who are coming back, on which these troops can be reorganized, and they can readily hold in a formation which is not organized. In this system the nucleus garrisons occupy the position of the outposts in ordinary terms of the word. They check the advance of the advanced guard of the enemy, and allow the main force, which is retreating disorganized, to reform behind them and deploy into the battle zone. For this purpose they must be capable of offering a resistance to the first attacks of the enemy unaided or with such aid as can be rendered by the small organized bodies of the retreating troops. The alignment of their defences must be in advance of the ground on which it is intended to fight the main battle, as the retreating armies can only be rallied and reorganized in any efficient way when they are free from enemy action. The positions must have depth, or a successful attack on any one point will lead to the giving away of the whole system. In the design and siting of the positions great attention need not be paid to the action of enemy artillery, as the enemy will not be able to develop much of his artillery power for some length of time. In the same way he will not be able to resort to the effective use of gas, so special localities susceptible to gas need not be avoided. Special mention is made of these points, as the great resisting power of villages in the absence of effective artillery, and of woods, in the absence of gas, should be developed to the utmost extent. At the same time alternative positions should be prepared in the case of these places, as the enemy, by concentrating his available resources on special points, may be able to make such localities untenable by the use of either of the above mentioned auxiliaries.

(*m*). Acting on the above conclusions, and having decided on the main line which it is essential to hold, the covering or outpost line must be immediately proceeded with. This line would, at the same time as fulfilling the above purpose, also serve as the outpost line for the main position, when matters are restored to a more stable status. In the design of the works it must at all times be borne in mind that extra trenches must be eliminated. Complicated systems lead to expense in garrisons and to dispersal of men. Men so disposed that they cannot be of service at the critical moment are men wasted. Successive lines of defence have the disadvantage of dispersing men in depth, while at the same time dispersal of men in a line renders that line weak and of no account. The limitations of the half-trained soldier should be borne in mind and the lack of initiative of the present day man allowed for. The action of an advancing enemy must be taken into account. He will be advancing with an out-thrown advanced guard in pursuit. His leading troops should act with boldness and, on meeting a check, the first attacks will be in the nature of reconnoitring thrusts. On the nature of the resistance with which these thrusts meet, will depend the action of the supporting parties. These, on being held up on a line, will proceed with vigorous action against those points which will give them an advantage; the first frontal attacks failing, they will endeavour to penetrate at weak points and advance by turning the offending localities. The object of the defence will be to check him on the line and deny him access to those points which would lead to a crumbling away of the system. This leads to the necessity for more strongly holding these points and the watching of the ground between. Owing to the paucity of the men available for this preliminary defence, the defence should be so arranged that the elimination of one or more of these points is necessary before the attacker can make a successful advance against the weakly held curtain between. The great trap to be avoided is to have a system by which the defenders sit on the hill tops, whilst the attackers march practically unopposed up the valleys, or the opposite fallacy of holding the valleys and allowing the attacker access to the hill tops, the possession of which will lead to a hurried retreat of the low-lying garrisons. But care must be taken not to fall between two stools by attempting to be strong everywhere, thus spreading the available troops and thinning the line to a breaking point over the whole front. Obstacles are erected with the purpose of helping the defender to develop to a maximum the weapons at his disposal. Normally speaking these are the rifle, the machine and Lewis guns, and the field gun. The distinct object of an obstacle is to delay the attacker where these arms can exact their full toll of him. The presence of an efficient obstacle has again and again, when used in combination with these arms, proved decisive. The design of an obstacle must conform to the local conditions. Probably the most efficient form intact is the broad belt of thick barbed wire. The development of modern artillery and the trench mortar has, however, rendered this form of obstacle easy to deal with. The form of obstacle which is at the moment considered effective, takes the form of barbed wire fences erected one behind another and running obliquely. The advantages claimed for this form are that it is not so conspicuous to aircraft observation and photography, covering a large area it is not so susceptible to artillery fire, though perhaps easier to negotiate by small highly trained parties of infantry, it is probably as efficient, as an obstacle, as the other types tried. It will be tried in the course of time, but at the present date the prevailing fashion in this respect seems fundamentally sound. It is probably most efficient when combined with belts of wire entanglement spaced at 30 to 40 yards distance. But in the design of an obstacle it must be remembered that it does not take the place of an efficient sentry, but merely aids him. It is not to keep out individuals or even small parties of the enemy, but to delay his formed bodies, break up their dispositions and enable the defender to develop the use of his arms to the maximum extent. The actual siting of an obstacle is of the greatest importance. It should so check the enemy as to bring him under enfilade fire. To enable this to be done the trenches themselves must be sited with the position, tracing, and design of the obstacle in view. This brings in the siting of trenches. To avoid confusion the following terms will be employed in this paper, the *siting* of trenches as dealing with the general choice of positions, the *trace* of trenches as the alignment of trenches and their alterations in direction in connection with the other parts of the same trench, the *plan* of a trench as the actual form in plan of a trench in detail.

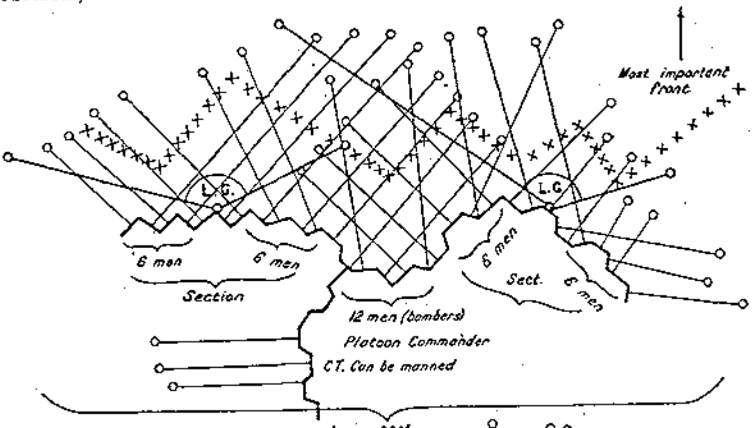
In general in the trace of trenches the British excelled in the early days of the war, but now the trace of trenches in the British Army is on the whole exceedingly poor. In the early days junior ranks sited a length of trench to be held by a unit bearing in mind the proper development of their weapon, the rifle, the position of their neighbours and the way mutual aid should be given. These trenches were afterwards joined to facilitate communication. The result was exceedingly good. Now trenches are traced in continuous lines and correspondingly suffer. In the tracing of trenches the minimum number of men essential to hold a locality should be considered, also their disposition so that they can render mutual aid. The trenches they would be disposed in should then be sited and traced, and these sectors should then be joined by travel trenches on the same plan. The practice of starting at one end of a line with a bundle of flags in the morning and returning when the day's quota have been erected on the ground is to be deprecated. This leads to the tracing of a trench line generally far too straight and which would take an unnecessarily large number of men to hold. In this particular the organization of the infantry must be borne in mind. Generally speaking the infantry unit is a platoon which consists of 40 effective men on an average. These are organized as about thirty men whose primary arm is the rifle, and ten the Lewis gun, of which each platoon has two. Not being thoroughly up to date, my statement may not be quite accurate. There is the question of the Lewis guns of a company being combined in a Lewis gun platoon. Of the Lewis gunners six can be relied on as riflemen; a proportion of these men are also organized and trained so as to develop to a maximum the use of the rifle grenade and hand grenade. Four platoons are banded together for tactical and administrative purposes as a company and four companies as a battalion; but for fighting purposes the platoon is the unit.

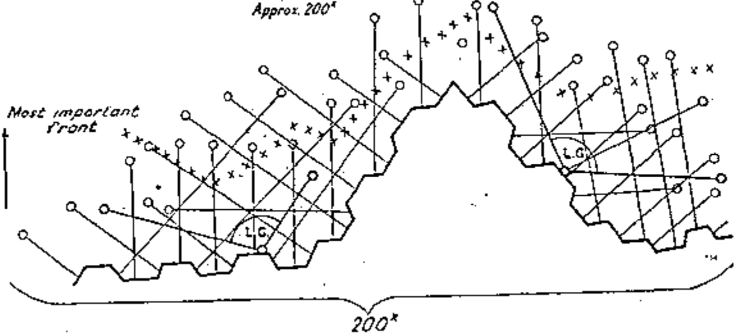
The disposition of a platoon does not necessarily insure that the men of that platoon should stand shoulder to shoulder, or even be in adjacent traverses, though they should not be scattered over too great an area. The decisive range of the modern rifle is 600 yards and a man can render very efficient aid to another by its use at 50 yards. At the same time men must be grouped in sufficient strength to give confidence and to lend support in hand-to-hand fighting. They must be sufficiently numerous to make it necessary for more than one group of the enemy to tackle one group of the defender; the German small unit is eight to twelve men, after allowing for the casualties of the latter. A convenient unit works out at the old sentry group of six men, this also suits the organization and duties the men have to perform. The plan and trace of the trenches must be so designed to enable these groups to bring mutually supporting fire, and also to support the platoons on their flanks. A good disposition is for the riflemen to be disposed to protect the Lewis guns, which protect the intervals between platoon posts, and the fronts and flanks of the neighbouring platoons. Owing to its tremendous power this weapon is particularly suitable for this purpose, but must not be absolutely relied upon, as it is delicate, liable to jam and can be easily put out of action by one hit. The rifle grenadiers and bombers can be so disposed that they may deal with parties of the enemy gaining a footing in the trenches, or attacking in a way that renders the use of these weapons desirable. In fact they can be used as the platoon commander's local reserve, using the weapons most suitable for the occasion.

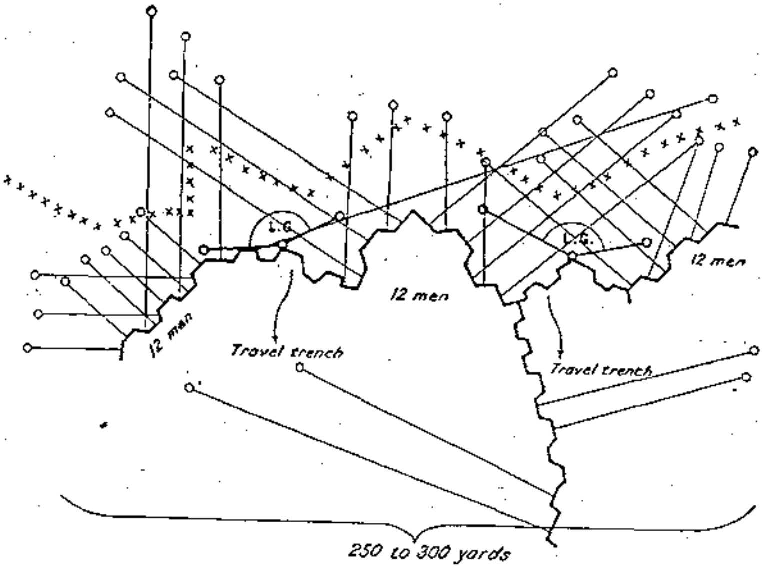
In siting the above-mentioned trenches these groups of posts should be combined in localities of one or more companies with curtain troops between. Of that more anon.

All units must be disposed in depth. No disposition will enable all the fire of the unit to be brought in any direction without movement, but the trace must be such as to bring the maximum fire in the most important direction, and as large a volume of fire as possible to the flanks, taking that as the front, at once. Some traces and plans suitable for this purpose are illustrated below.

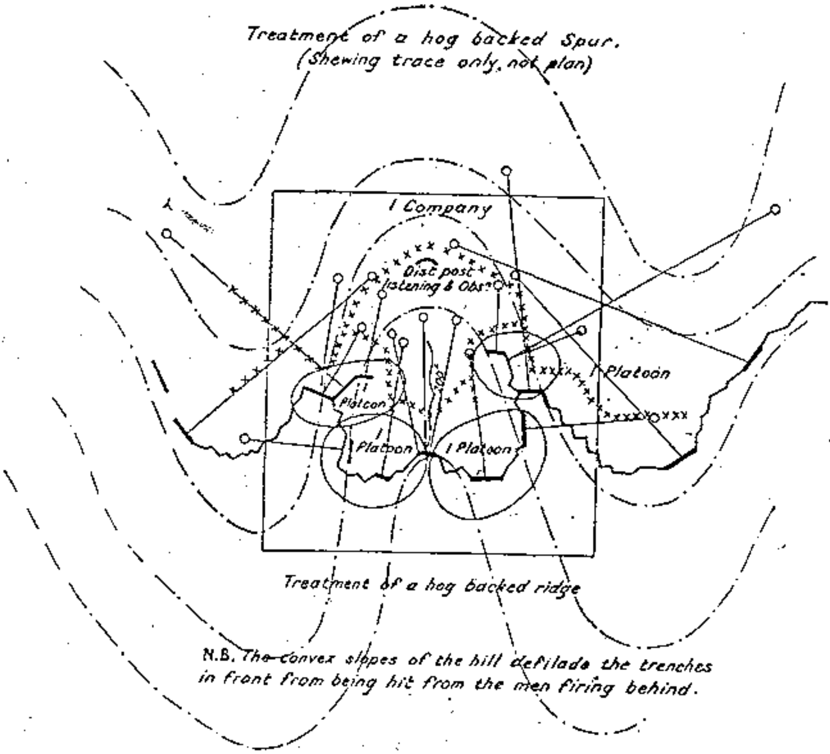
These designs, however, are only intended to be types. In each case the situation must be appreciated. The resources probable to be at disposal, the minimum number of men essential to the position, their effect on the action of the enemy and the way he would







N.B. In above the dispositions are such that any flank is readily reinforceable.



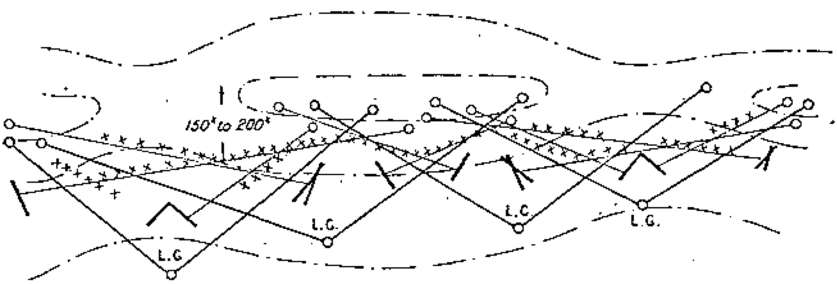
set himself to unravel the problem set him, must be considered. On these must the dispositions be made and on these the siting, trace and plan of trenches decided. All probabilities must be legislated for, but to ensure success all possibilities must be provided for. Provision for meeting these can only be efficiently made by the presence of a reserve. With the limited number of troops that would be available to meet the first action of the attacker, economy in men tied to a position is absolutely essential.

The artillery of the defender will be at the first not organized to its full capacity. Hence the absolute necessity of early warning of batteries of impending enemy action. Good observation of infantry movement is important. The farther away the enemy dispositions can be gauged the more economical will be the use of the artillery, and the more efficient will be its action. Means of visual signalling must be provided for. Telephone communication will be non-existent or ill-organized and overcrowded, and difficult for strangers to find. The defender will, in the opening stages, have to rely almost implicitly on rifles and machine guns for effect.

The reorganization of the retreating forces is the great essential. On all roads leading from the front means of checking stragglers must be provided. This should not be attempted in front of the defensive line or near it. Pickets may be placed to divert organized formed bodies to essential points, but their main object should be to divert the retreating men to the main collecting stations which should be in rear, out of view of the pursuer. These stations should have means of readily blocking the roads, and must be at some open space where the men can be formed up properly, fallen in and told off into organized formations, issued with ammunition and essential equipment, of which they will be largely short, and then marched off to their pre-determined battle stations. The choosing and provision of these rallying posts is an essential part of the defence scheme and is second in order of importance to the check line. The necessity for organization of the defence cannot be too greatly emphasized, men hold a line and not a trench system, and the provision of any means that facilitate it is the most important item of any defensive system. The parade grounds for the reorganizing of the retreating force must be laid out, should be wired off and the routes thence to the localities where the troops will be required must be developed and well notice-boarded.

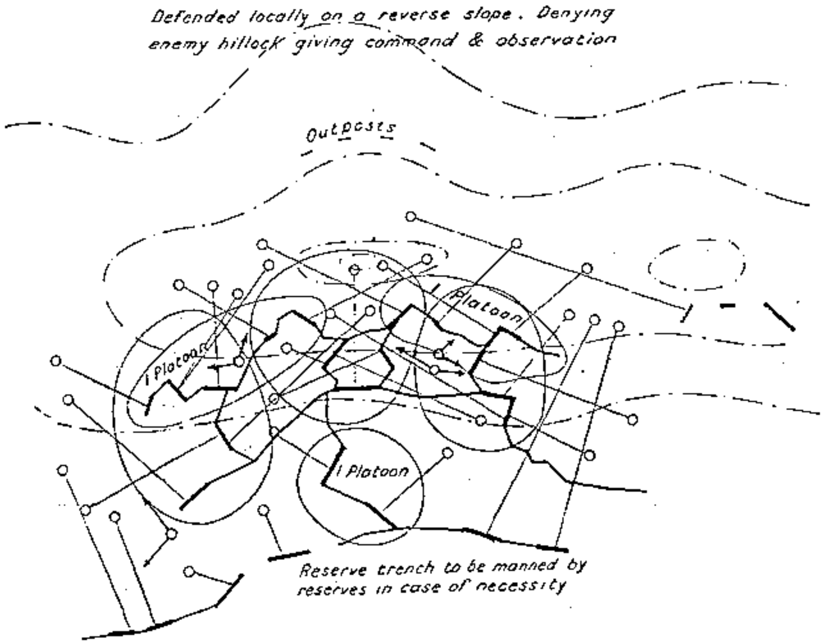
This brings us to the main battle position on which the brunt of the enemy attack will fall. The principles for its defence are all laid down in *F.S.R.* and the *Manuals of Military Engineering*. In a manner they conform to the principles for the outpost line as laid down above. Important localities, and localities unsuitable for manœuvre, will be held by garrisons told off for this purpose. These garrisons must be reduced to a minimum with the object in view, and defences sited, traced, and planned so as to develop their weapons to the utmost. As many men as possible must be released as reserves to meet eventualities. By this means alone can possibilities be insured against. Special arrangements can be made to deal with probabilities, but in appreciating the situation care must be taken to avoid the fatal error of begging the question. Before coming to the main battle position the enemy will have largely shewn his hand by the way he has dealt with the outpost position. If good communications exist his ultimate action can be met by the proper use of the reserves. Generally speaking night dispositions have no bearing on the siting of the main battle position. This line must be tactically sited on the lines of the old defensive disposition, as laid down in the text books. Modifications due to altered conditions must be made. By this time the attacker will have a strong force of artillery and will be making use of gas in effective quantities. Cover from observation should be well considered and localities susceptible to gas avoided.

This brings us to the knotty question of a reverse slope position. A reverse slope position is not one that fires up-hill as is generally supposed. It is one on which the enemy cannot observe his artillery fire, unless he himself is so close as to discount its value. To obtain this means that the trenches will have a very short field of fire to the front. In order to obtain the best value of the rifle it is essential that trenches in a reverse slope position should be traced and planned to obtain enfilading fire on the narrow piece of ground on which the field of fire lies and mutually to support each other.

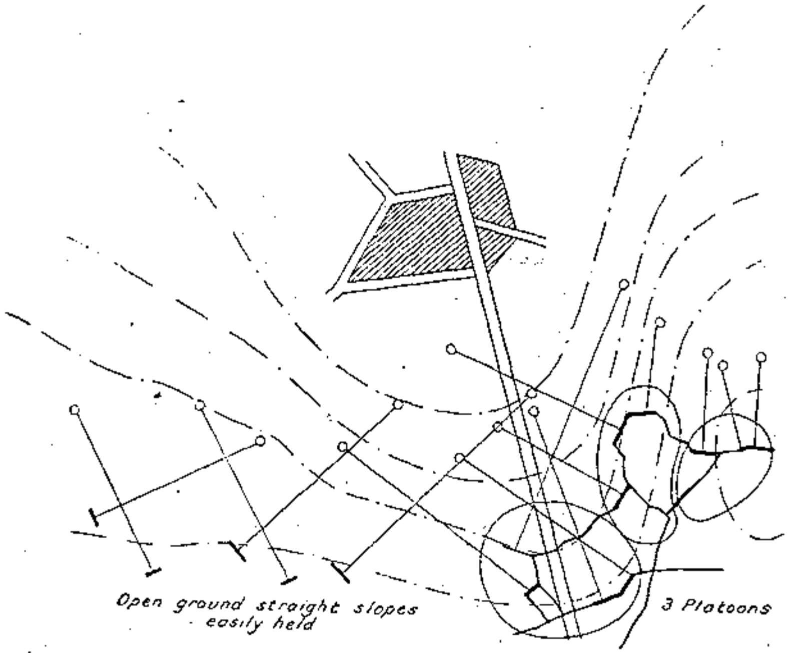


Type of trace for a reverse slope position.

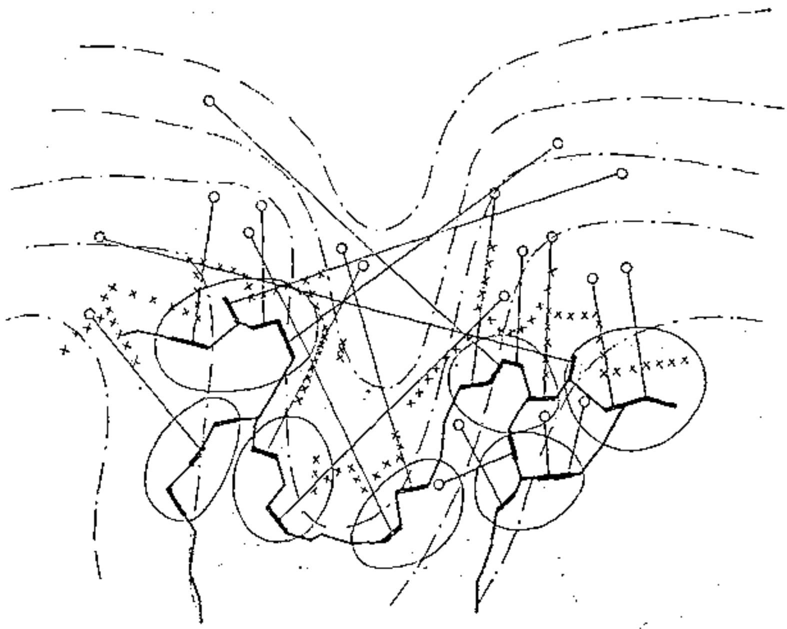
It is important that the existence of a reverse slope position should not be emphasized to the enemy by the placing of the wire where he can see it from a distance. A space of 50 or more yards in front of the wire must be in view of the trenches, that being where the casualties occur to the attacker, not in the wire. Portions of the defence system will need special measures and stronger garrisons. They will be localities the possession of which by the enemy gives him a decided tactical advantage, or which provide a dangerous approach to the systems, or which are necessary to the defence to act as points of manœuvre. These form defended localities. A defended locality consists of a combination of mutually supporting strong points. In this respect the idiosyncracy of the soldier must be taken into account. The present day soldier is not prone to stay in a position where he is in danger of being cut off. Hence we can no longer arrange for all round systems of strong points, each holding out in its own and fighting to the last. Connection must be ensured. However, falling into the opposite error of providing a complicated system of successive lines of trenches, which provide an excuse for retirement and which disperse the defence in depth, must be avoided. Any form of work which keeps a large number of men employed at decisive moments is fundamentally wrong in design. The strong points must be so designed that to obtain success in any one the enemy must operate in such numbers, and over such an area, as to bring into play its neighbours. In fact he must be compelled to attack the defended locality as a whole. The dispositions of the locality must be such that the fall of one or two of its points do not necessitate the fall of the remainder, and facilitate counter attack to regain possession of the lost points. To this end must the defences be arranged and the garrison disposed. The action of the attacker and any of his dispositions which would specially favour him must be provided for. In fact he must be given the credit of doing nothing wrong and the defence the discredit of only average intelligence. At the same time no opportunity should be lost of inveigling him into traps where he may incur serious losses and offer opportunities for a successful offensive.



The above design keeps one platoon in reserve, allows each platoon a modicum of reserves and facilitates, by the cross fire of neighbouring



Locality covering exits of a village offering approach to a convex hillock by valley. Left flank easily guarded.



Defence of valley with Convex Sides. 1¾ Companies.

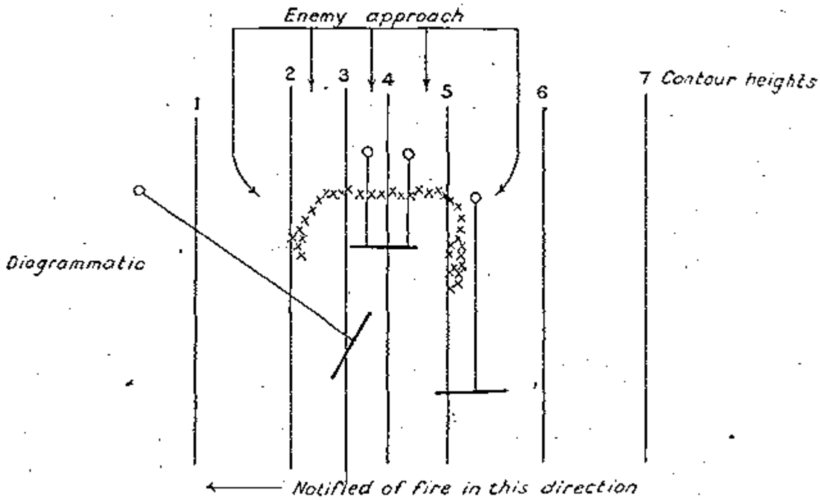
posts, the recapture of any post that may fall by means of local counter attack. In case of serious pressure the reserve trench can be manned by reserves, and render support to the defence before its fall, by aid on flanks.

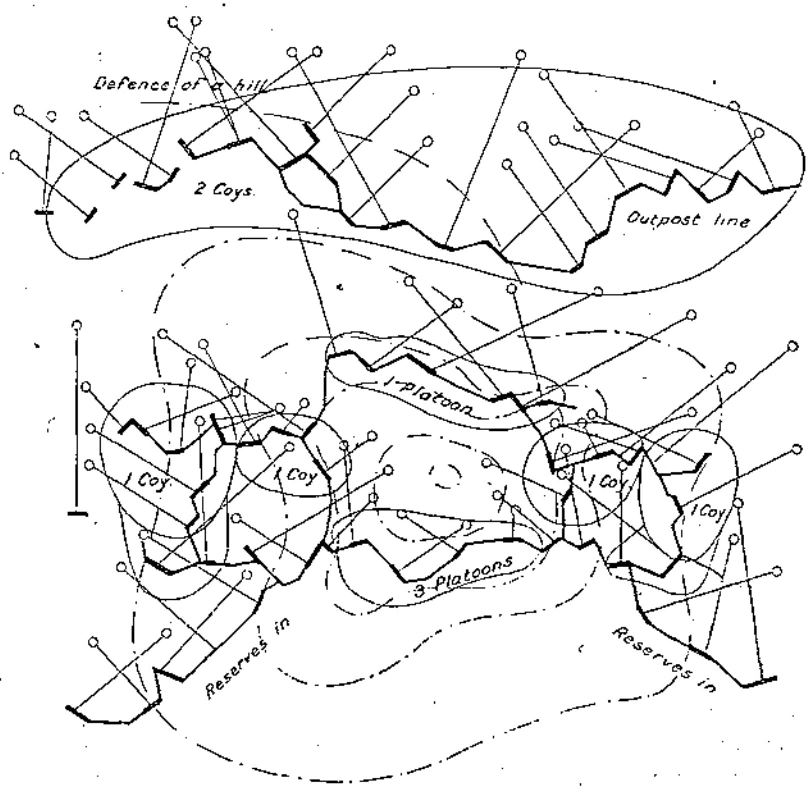
In the samples opposite the practice of retiring the trench on the top of a hog back ridge may be deemed to need some justification. It is contrary to the general practice. Much experience of these spurs shows that a fairly good shoot with grazing fire can be obtained longitudinally, but the convexity obviates any shoot transversely. The retiring of the flanks allows the attacker to approach a trench on the top from the flank in two directions, whereas placing trenches firing to the front down a hill-side, where the curve changes, enables a fire to be directed to one flank and the front. The uphill front is then flanked. Enemy attempting to approach from this flank are dealt with from the retired trench on the top. To proceed against this latter trench they are forced to approach on a narrow front. The defence of a hill lies in the shoulders and not the top. These dispositions also cover the flanking valley.

The diagrams overleaf show flank trenches on the reverse slope behind spurs with the main trench at the top retired behind the crest and a lightly held line in front of crest at the top. The reserve line is thrown back from this to reinforce defenders from an enemy working up the flanks. Enemy attaining the top without taking the shoulders can be held from exploiting their success, for they come under heavy artillery fire and are open to a counter attack from both flanks.

If it is necessary to hold a hill some adaptation of the above is suggested. But the main defence of a hill, which must always present a favourable target for artillery, should lie in covering its approaches from the front by the flanks. These should be secured. It must be remembered that observation is not obtained from the top of most hills. The observer has to advance some way down to obtain an effective view.

The reserve line should be what its name implies. It should be a line which can be occupied by reserves where necessary and thence reinforce the battle system, lending aid to defective flanks or weak points, and affording help to counter attack by the reserves. It is not part of a separate system. Being hurriedly occupied by troops in emergency, who have not the same time to acquaint themselves with the lie of the land and points which have special facilities for defence and offence, and also the necessity not existing so greatly here for the economy of men, since it would be occupied when a definite situation has developed, it can be simple in trace and designed to be held in long lengths. Its trace should be designed to develop fire to cover the points it is intended to reinforce in that area, and to facilitate counter attack. It should fire in the direction more directly of its front, as troops


Enemy approach
1
2
3
4
5
6
7 Contour heights
Diagrammatic
Notified of fire in this direction

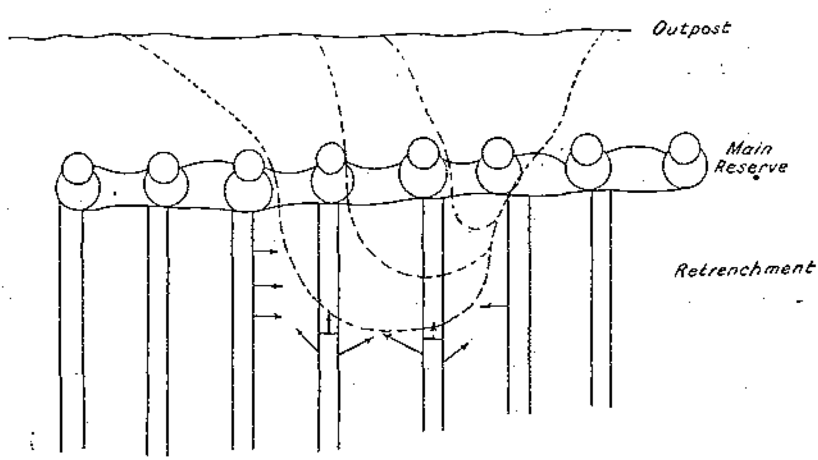

Defence of a hill
2 Coys.
Outpost line
1 Platoon
1 Coy
1 Coy
1 Coy
1 Coy
3 Platoons
Reserves in
Reserves in

being sent to reinforce a particular part will move to that part, and not to a flank at any distance. The keynote is simplicity. Plentiful and good communication to it is an essential and probably its most important point. The way in which it can be worked into defences is shewn in the diagrams of defended localities. It must not be considered as a billet for reserve troops. These are much better kept concentrated in definite centres of communication and not spread over a line.

Like other lines it should be wired, but good and frequent gaps must be provided in those places favourable for egress for counter attack. These places should be well placarded, and it is a considerable help to the reserves and to their economical employment if the positions of these gaps is denoted along the lines of approach to the reserve line.

Having dealt with the outpost line and battle positions which consist of a main, and reserve lines, there remains the retrenchment. Though the battle must be fought on these lines, it is obvious that arrangements must be made so that the piercing of the above system at one or two points will not mean the turning of the position. It is assumed that the local reserves will have been used in trying to fight the above positions, any remnants strengthening the flanks of the gap made. The enemy would essay to develop his success by widening the gap, which must be prevented, and turning the flanks of the broken positions. The retrenchment must be designed to prevent this. It does not matter how far he advances on a narrow front, by doing that he is courting a reverse. The retrenchment works must be sited, traced, and planned to support broken lines and prevent expansion sideways. At the same time by being successful against one or more retrenchments he will be able to afford a corresponding advance. The more retired portion of the retrenchment should be designed to prevent him doing this. It must be able to fight to the front as well as to the flank.

This is illustrated in the following diagram.

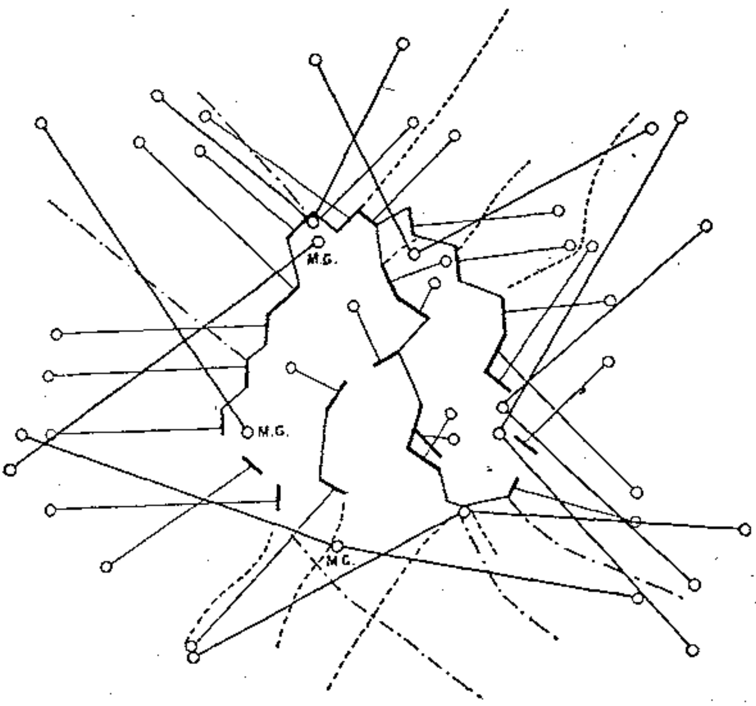


The broken lines show possibility of enemy advance according to his expansion. It is obvious he could not advance to that depth on the front he originally penetrated without running serious risks, but, in order that he may be hampered in his advance against the third line of retrenchment after having broken one, the remaining part of the broken retrenchment should be able to take him in flank. The retrenchment would then take the form of a series of localities in depth specially designed to prevent expansion from the front, but of which the rear ones would also fight to the front and form the nucleus of a new defensive line in case the reserves were not able to restore the situation. The more advanced should also serve the purpose of a gun line. These localities must also be so designed and sited that they are able to combine with their neighbours to form switches as required. In their design it must be borne in mind that they will in great probability be fought by the general reserves who may be strangers to them. They must therefore be simple in character and obvious. In this respect villages are unsuitable for them, for though villages can be made strong in these circumstances where the enemy will probably not be able to develop his artillery, village defences are always complicated and troops easily lose their way in them. Also the M.G. emplacements will be in all probability largely manned by mobile machine gunners rushed up in a hurry. Elaborate and intricate schemes should not be introduced ; a large proportion of the positions should be near good routes ; obstacles must be used with discrimination. It is on the cards that cavalry will come into play at the later stages, and the defending cavalry must not be hampered more than is essential. In the later stages the enemy will put in his cavalry and armoured cars. Special defensive measures for roads must therefore be made. Special attention must be made to the marking of artillery positions, and for the defence of batteries from small parties of enemy. Escorts for artillery may again be required, and their number can be minimized by devising defences which they can hold.

The artillery of the enemy will probably be limited to field guns and medium trench mortars. The defences should be planned and designed for these. His heavy artillery will only affect the forward ones in any large degree. Note the gorge defence is weak, the defender may lose a locality and wish to counter attack it The retrenchment inside is not in the nature of a keep, but a place for small local reserves, which can aid counter attack on any trench that is lost by covering fire and from whence they can counter attack.

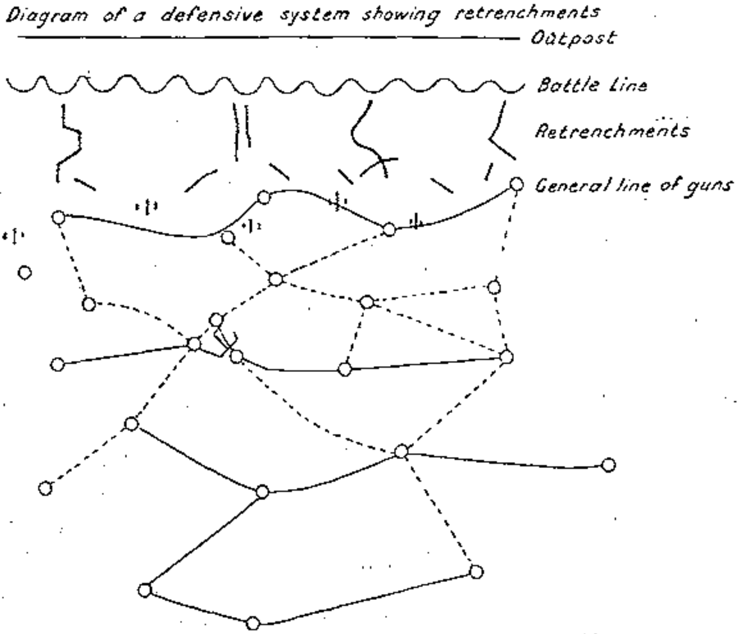
Nothing much has been said in these notes on communication trenches. By the reduction of the numbers holding trenches the traffic in the trench will be reduced, and the number of communication trenches required falls. They should, however, not be too few or the enemy will be able to concentrate his artillery on them.

A type design of a retrenchment locality on open country



Posibilities of early alteration into a south facing alternately shewn —.—.—.— or - - - - - - - - -

Diagram of a defensive system showing retrenchments



Note the distance of these localities should not appreciably increase but their interest can become greater the further they are from the line.

Possibilities of combination in Switches - - - - - -

" " " " Line ————

Generally speaking the trenches which have been traced to lend depth to the defences can be connected into communication trenches. This is shewn in the diagrams. In practice this will work out sufficient for the frontage but additional C.T's. may be added if necessary, taking care they do not interfere with and mark the tactical trenches.

Switches are a difficult question. They are much more simple on paper than in actual practice. Defences are tied by natural features, and it is seldom these fit in with the diagonal line on the ground, added to the point that a switch which proceeds over any distance serves no useful purpose as a communication trench, as it leads from one unit area to another. Additional difficulty lies in demarcating the boundaries of limits of units along it To put switches in also leads to a presumption of the course of action an enemy will take. He will quite probably act so as to turn it. It is not denied that they are extremely useful but it is held that, if the principles enumerated in these notes are held to, they will find their way in naturally. The term should not be abused as is the word " depth."

Large switches are dangerous things. They are easily turned. They should be used for retrenchments in obvious positions but, as stated above, they are liable to be based on a premature assumption of a course to be followed by the enemy. Probably their most effective use is to make the enemy attack localities the possession of which outflanks them. This to some extent pins him in his course of action. As such their use is strategical and outside the scope of this paper. When constructed they should conform to the general lines of a defensive system, but again, as they would in all probability be manned by strange troops, they must be simple and obvious in character, the economy in troops not being so essential as arrangements in this direction as they will be manned when the enemy has shown his course of immediate action. They will be based or run back to lines of the same construction as already mooted above, the portions of which would generally have to be occupied under the same conditions, *i.e.*, when the enemy has already accepted defeat on the lines in front.

The defence of villages is in these notes deliberately shirked. It requires much thought and a volume of its own, and each village requires expert treatment on its own.

The defence of woods is another question that will not receive much attention. The development of gas has much altered their defensive value. Where the enemy is not in a position to use gas the best line undoubtedly to take is through the centre with outposts in front. Where he can use gas it is a question of the back edge, or retiring and watching the exits. This latter course is not to be recommended as it gives the attacker the advantages of approaches and observation from cover. This, however, is a matter in which I have no personal experience. I know the back edge is unhealthy, as it seems to afford a very easy artillery mark. Where the attackers artillery and gas is limited, the position of the main line through the wood with an outpost line near the front edge and the reserve line on the back edge is recommended, provided a wood of the requisite size can be obtained. Woods, however, should be treated as villages, on their merits.

September, 1918.

THE SITING OF TRENCHES.

By H.B.

TRENCH work was undertaken on a vast scale in France during 1918. Sir D. Haig's dispatch revealed the fact that 5,000 miles of trenches were dug between 21st March and 31st July, forming an entirely new network of defensive systems, many miles in depth, on the British front.

Probably three-quarters of the total was in ground where reconnaissance, tracing and digging by daylight were possible; but the conditions imposed by the German offensive necessitated the work being carried out at high pressure and with the utmost speed during the first two months; a great deal of the *detailed* siting of trenches, therefore, had to be left to inexperienced officers, hastily gathered from all sorts of units and organizations.

The results, as might be expected, were by no means perfect, for zeal and hard work cannot replace knowledge and experience; and no pamphlet on the siting of trenches was in existence. Information on the subject is included, of course, in many official publications, but it is not in a form adapted for use under these conditions, and from a practical point of view, therefore, was useless.

Such a pamphlet must be logical in its sequence of thought, concise and dogmatic. General statements are of no value to the inexperienced man; they merely add to the confusion in his mind; even at the risk of error, dogmatism is a necessity.

The following notes attempted to meet this want; they represent the joint efforts of several officers, and were issued almost in their present form. It must be remembered that they were intended to meet the conditions obtaining on the Western front and that these conditions included (*a*) continuous lines, (*b*) masses of artillery and trench mortars of all calibres, (*c*) gas shelling on a big and ever increasing scale, (*d*) heavy morning mists.

A diagram and two small plans of actual trenches are appended to illustrate the notes, which (it is believed) are strictly based on the teaching inculcated in various official pamphlets.

SITING A DEFENSIVE LINE.

Preliminary Note.—A properly organized defensive system consists of three zones:—(i.) the out-post zone, (ii.) the main battle position, (iii.) defended localities and areas in rear of the main battle position in which reserves can be accommodated, and which are capable of being held as a battle position in case of necessity.

The object of the outpost zone is to secure the main battle position from bombardment by the enemy's trench mortars, to prevent the mass of the enemy's artillery concentrating on it and the defensive positions in rear, and to split up the enemy's infantry attack before it reaches the main defensive position. It usually consists of sentry groups, a picquet line and support line; but the trenches forming it are not necessarily continuous, nor so organized as in the main defensive position. The barrage of the defending artillery will fall as a rule behind the sentry line and in front of the *outpost* line of resistance. The depth of the outpost zone will be anything up to 4,000 yards, or even more in special cases. On the battle front the position of this zone has been decided by fighting.

The main battle position is constituted in much the same manner, but it is more highly organized in every way. The question of siting the main infantry line of resistance in the battle zone will now be discussed.

Main Infantry Line of Resistance. Battle Zone.

1. The general line is decided by considerations, such as the defence of a port, line of railway, some area of country, certain towns, or the like, which determine the approximate distance at which the line must run to protect adequately the piece of country in question. This general line can be drawn on an uncontoured map, 1/100,000.

2. This being settled, the next step is to take the layered 1/100,000 map and site on it the main infantry line of resistance which fulfils the requirements of the general line, according to the features of the country. The approximate line can be marked on it very quickly, as the layers show heights, ridges, spurs, etc., which must fall within our line.

3. In selecting this approximate line of main resistance the following principles should be followed:—Artillery observation of the ground, for at least 400 yards in front of the line of resistance, is essential. Where this can be obtained from higher ground in rear, or from flank positions near, advantage should be taken of reverse slopes in siting the infantry position, so that, while the enemy is under observation, our troops are concealed from his view. When such observation is not possible, the line of resistance should be on the forward slope and sufficiently far down it to cover artillery observation from the crest.

Important tactical features should be decided on first, and treated as localities or groups of trenches; the lines connecting them are altogether subservient and must be fitted in as best they may. Any attempt to make a continuous line strong everywhere will probably lead to it being a compromise and ineffective.

In dealing with woods the line must be taken either outside them, well inside, or behind them; they harbour gas and it is always difficult for the enemy to emerge from them, particularly if the edge is entangled.

Villages afford concealed approaches and a certain amount of cover in cellars; but as they are always heavily shelled, the line should run well in front of them as a rule.

4. The R.A. and M.G. officers concerned in the reconnaissance should now visit the ground, taking a copy of the layered map, with the approximate main line of resistance, marked on it.

The R.A. officer marks on a 1/40,000 map the positions necessary for O.Ps. to control artillery fire; and the M.G. officer marks M.G. positions for defence of the line in depth on a similar map.

If the line is likely to be attacked in the first instance by enemy having nothing but the usual proportion of field artillery and with little or no heavy artillery, the advanced M.G. positions may be pushed well forward in the defensive system, so as to engage the enemy with direct fire as soon as possible; but M.G. defence in depth is always essential.

The necessary information to get out the final siting of the trenches on the ground is now available.

It will save much time if a few flags are put out in prominent positions along the line before the R.A. and M.G. officers go out, as this helps identification. If the line is a long one, it should be divided into sectors of not more than 6 miles and the officers in charge of the sectors, sent out to study the ground, the enemy's lines of attack, and the best way of dealing with them. To do this it is necessary to examine the ground from the enemy's point of view.

5. The main infantry line of resistance can now be sited in detail. Generally speaking, it must not run behind any R.A.O.P., and certainly never behind any important one.

If artillery observation (*vide* para. 3) can be obtained from heights in rear, the line of main infantry resistance should be on a reverse slope with local observation pushed forward over the crest.

If artillery observation can be obtained only from the most forward ridge inside our position, then the line of main infantry resistance should be pushed forward several hundred yards to cover it. The proper construction of C.Ts. enables such forward positions to be strongly manned at short notice by troops held under cover in rear.

If the line at any point is commanded badly from the enemy's side within a range of 5,000 yards, our line should run not nearer than 1,000 yards to, and not more than 2,000 yards from, the commanding ground. If nearer than 1,000 yards, the trenches will be badly sniped, and if within 2,000 to 4,000 yards the trenches can be plastered by shrapnel to which very little reply can be made. This is a good working rule except in close intersected country, but must be used with common sense.

6. The line selected should be marked out on the ground by flags or stakes. After this line has been adjusted, a furrow should be cut with a plough to show its approximate position.

The line can then be divided among officers for the siting of the individual trenches. This can be done by using lengths of tape with pegs at each end. Normal widths of traverse can be left by eye or paced; the great point is to site the fire trenches, remembering that a man normally fires on a line at right angles to the parapet. The traverse can be put in subsequently, provided that enough space is left.

7. Trenches should be sited in general conformation to the contours so as to give mutual enfilade fire. This ensures converging fire being brought to bear on valleys, which are the most likely avenues of attack and penetration.

Enfilade fire is most demoralizing to an attacker and also most heartening to the defender, for he is shooting at men who are not attacking him and probably does not see the men advancing on his own particular trench, who will be dealt with by other trenches on the flanks. Great care must be taken, therefore, to ensure that plenty of flanking fire is provided, both by large waves in the general line and short flanks in the trenches. If any portion of the front is penetrated, enfilade fire from the flanks will prevent the enemy reinforcing or exploiting the penetration.

The general alignment of trenches will, therefore, be very irregular, following the lie of the ground, forming alternate bastions and curtains, running forward on spurs and back in the valleys. In addition to increasing the fighting strength of the system, this course adds very considerably to the difficulties of the enemy artillery barraging it.

8. Communication trenches should be numerous, capable of being fought, wired and arranged, as far as possible, as switches.

Apart from the confidence with which C.Ts. inspire forward detachments, their value, on account of the possibilities of defence which they afford, is not always sufficiently realized and exploited. They should always be sited with this in view, in combination with the fire trenches, and not left to anyone to lay out in conventional zig-zags or waves. Thus dealt with they may convert a few scattered trenches into useful tactical points.

9. Drains for all trenches must be considered and marked out when the trenches are sited in detail. They should be dug simultaneously with the trenches they serve and should always be completed to the full width and depth, even when the trenches are left to be deepened subsequently.

10. Machine guns should have several alternative positions, sited to suit the different phases of the fight. In the first instance, some should be well forward, so as to engage the enemy at long range but in addition, they should have concealed positions distributed in depth from which they can flank neighbouring defences and bring fire to bear on all main avenues of approach. They are always fought in pairs or in groups of 4 guns (*vide* para. 4).

11. *Dug-outs.*—In order of importance:—

(*a*) Brigade and Battalion H.Q.
(*b*) M.G. and selected O.Ps.
(*c*) Accommodation.

In the first instance shafts only need be sunk for (*a*) and (*b*), and it will rarely be possible to do anything for (*c*) beyond improving existing caves and catacombs.

12. *Localities.*—Positions which lend themselves for stubborn defence should be developed *in and behind* the line of main resistance. Such localities should have strong all round defences. They should be mutually supporting. The flanks should be protected by defensive lines or other localities in rear as well as on the flanks. A locality in rear should be provided with:—

(1). Wire.
(2). Protection of garrison.
(3). Organization: including water, rations, ammunition and tools.
(4). Buried cables.

Concealment from direct observation is most desirable.

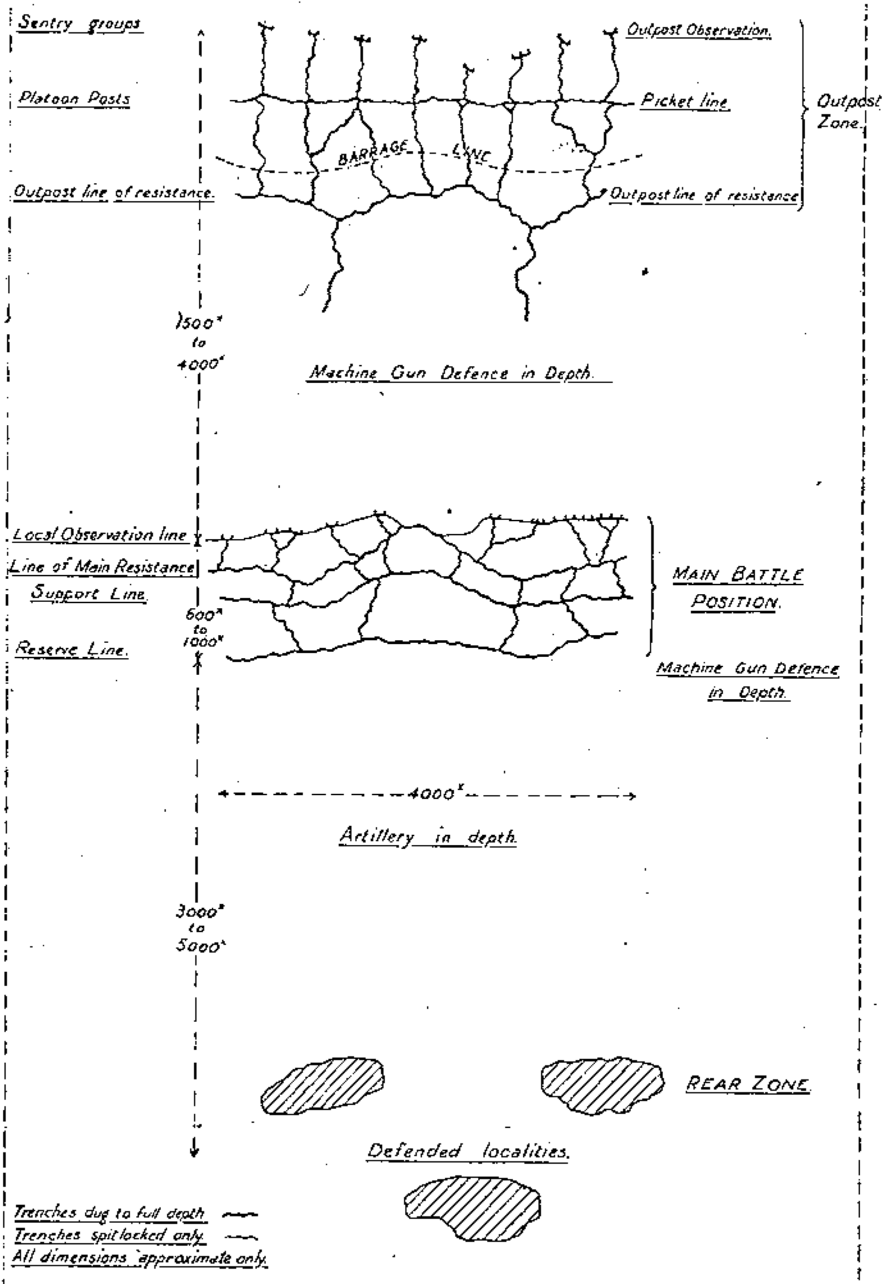
13. *Buried Cables.*—No defensive zone can be regarded as complete without a proper system of buried cable communications. Cables should be buried to a depth of six feet.

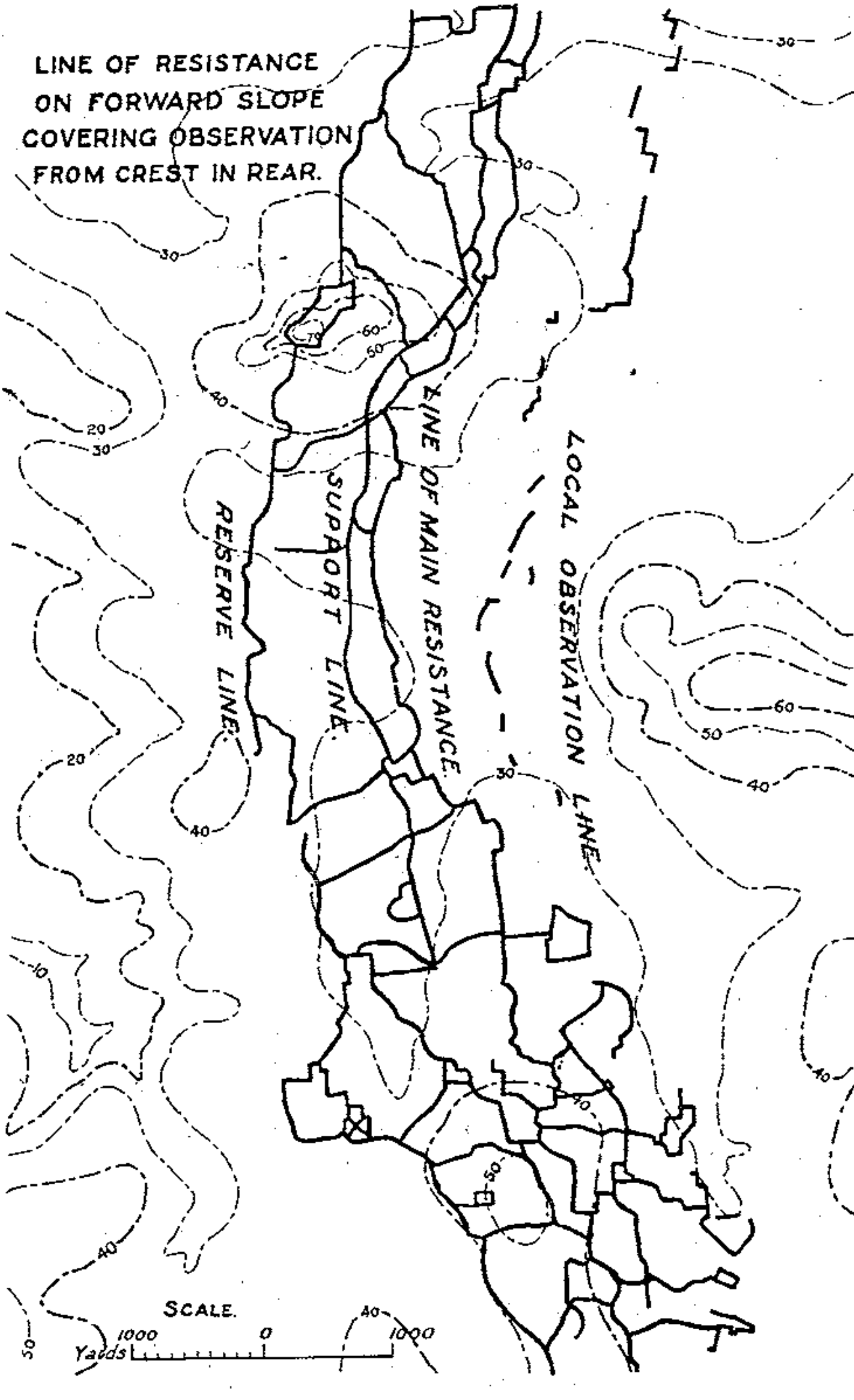
The provision of one buried route 4,000 yards in length to each Divisional front of 4,000 yards, should be aimed at, each bury containing 20 pairs.

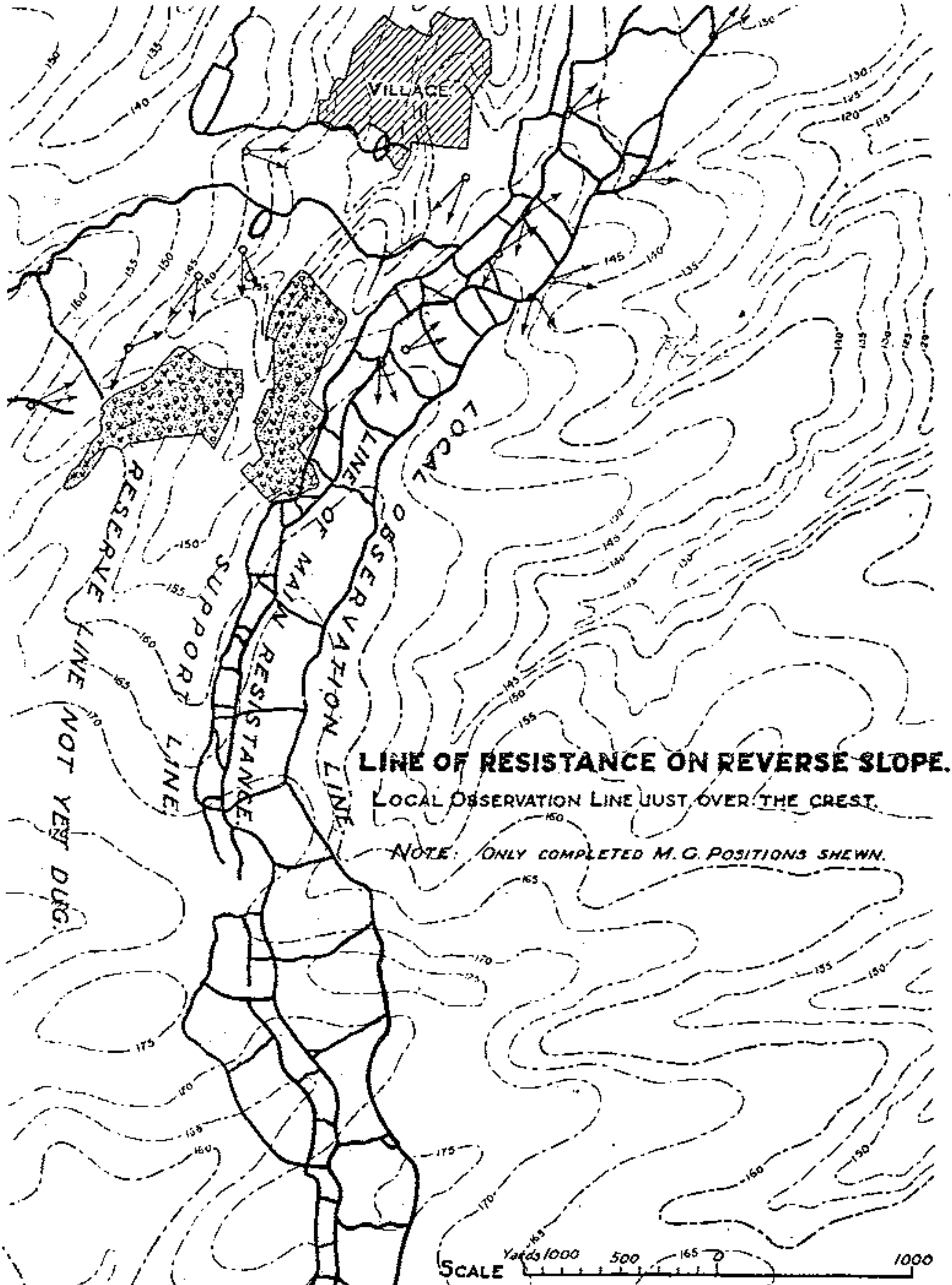
14. To sum up, a defensive system will consist of:—

(i.) An outpost zone consisting of sentry posts, picket posts, etc., eventually developed into an outpost system; the trenches forming the system need not be continuous, although the occupied fire trenches may be connected by shallow lengths, to facilitate supervision, command and concealment. In the same way the C.Ts. will be dug to full depth where absolutely essential, and in other places will be shallow with the same object in view. This zone will be fought as long as possible, but is not manned normally in any great strength. Under present conditions its depth would be 1,000—4,000 yards, or even more, depending upon the nature of the country.

DIAGRAM TO ILLUSTRATE A DIVISIONAL SECTOR OF A DEFENSIVE SYSTEM.




LINE OF RESISTANCE
ON FORWARD SLOPE
COVERING OBSERVATION
FROM CREST IN REAR.
RESERVE LINE.
SUPPORT LINE.
LINE OF MAIN RESISTANCE.
LOCAL OBSERVATION LINE.
SCALE.
Yards 1000 0 1000


LINE OF RESISTANCE ON REVERSE SLOPE.
LOCAL OBSERVATION LINE JUST OVER THE CREST.
NOTE: ONLY COMPLETED M.G. POSITIONS SHEWN.
VILLAGE
LOCAL OBSERVATION LINE
LINE OF MAIN RESISTANCE
SUPPORT LINE
RESERVE LINE NOT YET DUG.
SCALE
Yards 1000
500
0
1000

(ii.) Main battle zone, consisting of tactical localities, areas, etc., connected together by trenches, which will be somewhat as follows :—

(*a*). Main line trench (line of main infantry resistance) with a local observation line in front of it. This observation line need not be dug throughout to full depth.

(*b*). Support trench, some 200 yards in rear of the line of resistance.

(*c*). Reserve trench, about 500 yards in rear of the support trench, from which counter attacks will be launched, in case of the enemy penetrating the main line of resistance at any point. This trench should be well hidden.

(iii.) Defended areas and localities in rear of the main battle zone, in which reserves can be accommodated, and capable of being held as a fighting position should the battle zone or a large part of it be lost.

15. Should it be decided to extend the defensive system in depth, a new position will be constructed on the same principles on a line *not* in advance of the defended localities mentioned above, paragraph 14 (iii.), and far enough back to compel the enemy to move his guns forward to attack it. Switches may connect the two systems.

WOOD AND SHEET-IRON GIRDERS.

In 1917 some experiments were made by Capt. Stern, R.E., and Lieut. Allen, R.E., to ascertain the strength of girders made of wood booms and uprights and sheet iron webs nailed on either side. These experiments showed that such a girder was very strong, the various parts very portable and easily and quickly constructed at site.

Shortly after arriving at this conclusion, orders were given to construct a Bridge over the river Struma at Komarian. Capt. Ferranti, R.E., was in charge of the work and carried out further experiments and tests as a result of which it was decided to place the Pile Piers 18 in. apart in the clear and use four wood and iron girders to carry a 10-ton load concentrated at the centre (factor of safety 4). Each girder to be 20 ft. long over all, 26 in. deep (the width of the sheet iron), top and bottom booms 6 in. × 6 in. timber, uprights 6 in. × 3 in., sheet iron webs 20-gauge nailed on with 2½ in. nails, one per inch.

The number and pattern for placing the nails is shown on the drawings attached and requires to be carefully adhered to. Also particular care must be taken that the sheet iron is nailed on quite flat without any bulges or blisters which would prevent the whole sheet being in tension.

Boxes of ammunition were used to weight the sheet iron while being nailed. Provided these points are attended to in nailing, the girder is extremely easily and rapidly constructed by two carpenters.

It appears to be a most suitable type for rapid construction in the Field.

Capt. Ferranti has gone most thoroughly into the calculations and records of tests. I attach a very full and thorough report which he has made. The records which he gives of the practical tests carried out are very valuable and show what an excellent type of girder it is. Each pair of girders was braced together with diagonals at each third of their length.

H. L. Pritchard, *Brig.-General,*
Chief Engineer, 16th Corps.

2. 12. 18.

REPORT BY CAPT. V. ZIANI DE FERRANTI.

Various sizes of girders, having booms and verticals of wood, and web of sheet iron, have been constructed and tested. These girders had square ends with a half panel overlap beyond the points of support. The end verticals were let into the booms, the remainder skew-nailed. The web, which was painted inside and out, was fastened to the booms with nails.

No. 1 Girder, to Carry a Load of 5 Tons Distributed over 1 Panel.

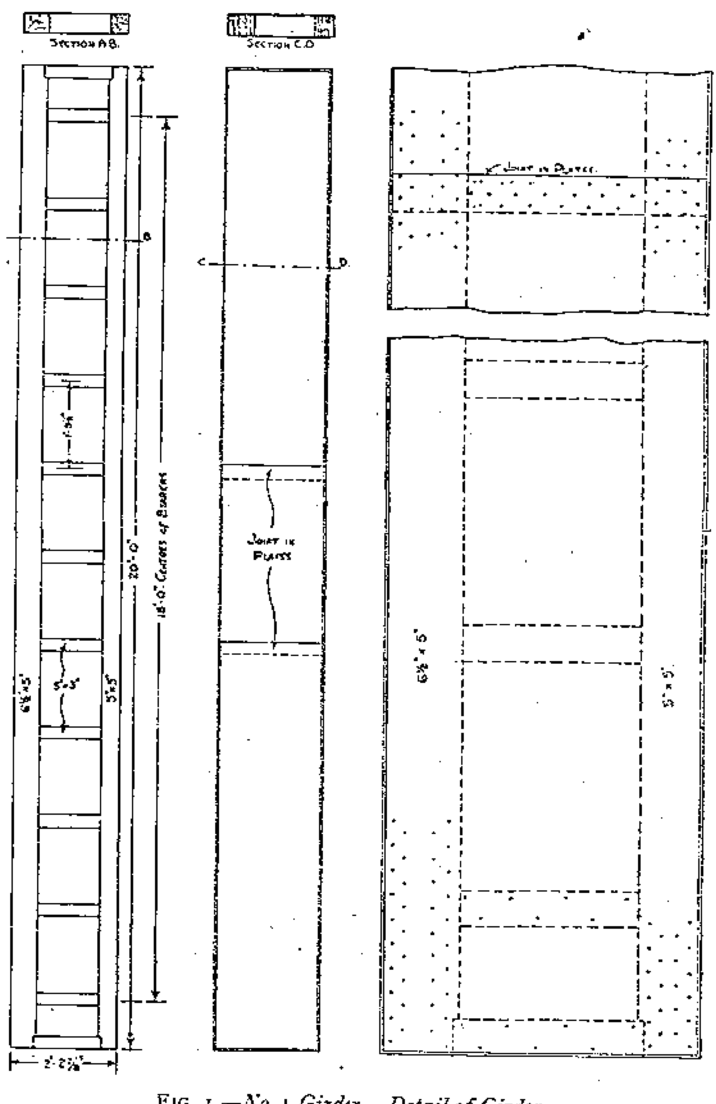


Fig. 1.—*No. 1 Girder. Detail of Girder.*

Overall length	... ...	20′ 0″
Span	... ...	18′ 0″
Overall depth	... ...	2′ 2″
Effective depth	... ...	1′ 8″
Size of booms (top)	...	$6\frac{1}{2}'' \times 5''$
,, ,, ,, (bottom)	...	$5'' \times 5''$
,, ,, verticals	... ...	$5'' \times 3''$
Distance between verticals *c* to *c*	... ...	1′ $9\frac{1}{2}''$ (1·8′) in the clear =18·5″.
Web...	... ...	No. 18 gauge iron (·048″)
Attachment	... ...	$2\frac{1}{2}''$ wire nails. 1 per inch.
Weight	... ...	5 cwt.

Booms.—Top.—As the bridge for which these girders were made was designed with the roadway directly on the top booms, these booms had to take the compressive stress due (1) to the load on the girder; and the stresses due to (2) local bending between panel points. As the unsupported length was so small, compared with the size of the boom (3 : 1) the compressive stresses in the top half of the boom were added. The position in which the load produces the greater stress in the top boom, is over the panel adajcent to the centre vertical.

The bending moment is at a maximum where

$$x = \frac{cb}{l} + a - \frac{c}{2}$$

$$= \frac{18{\cdot}6 \times 97{\cdot}2}{216} + 118{\cdot}8 - 9{\cdot}3$$

$$= 117{\cdot}87''.$$

The bending moment at any point x

$$Mx = \frac{Wbx}{l} - \frac{w}{2}\left(x - a + \frac{c}{2}\right)^2.$$

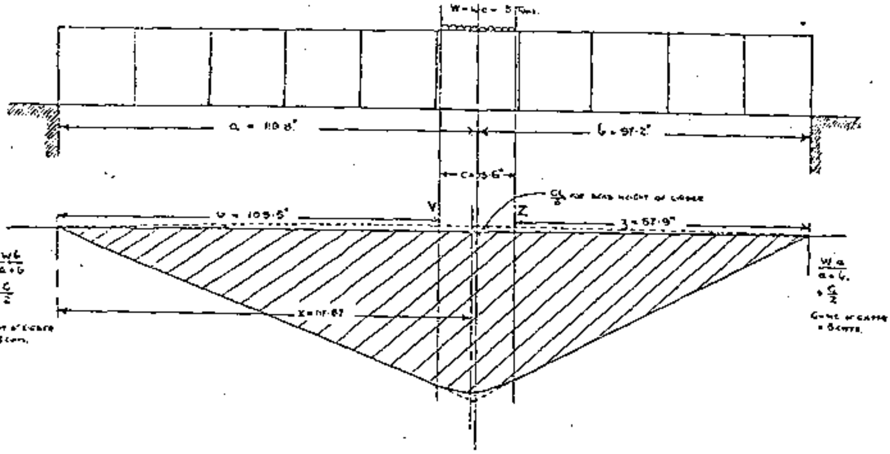


FIG. 2.

The first term is represented by the left hand straight line (in bending moment diagram) and the second by the distance between the curve and the straight line, and the value Mx by the vertical ordinate of the shaded diagram.

$$\therefore \quad M_{max.} = \frac{5 \times 97 \cdot 2 \times 117 \cdot 87}{216} - \frac{5}{2 \times 18 \cdot 6} (117 \cdot 87 - 118 \cdot 8 + 9 \cdot 3)^2$$

$$M_{max.} = 255 \cdot 8 \text{ inch tons.}$$

To this must be added B.M. due to weight of girder

$$\text{Approx.} = \frac{GL}{8} = \frac{\cdot 25 \times 216}{8} = 6 \cdot 75 \text{ inch tons.}$$

$\therefore$ Total moment $= 262 \cdot 5$ inch tons.

Bending moment = moment of resistance.

$$262 \cdot 55 = f.a.d.$$

Where f = stress in tons per square inch.
a = area of cross section of boom.
d = effective depth of girder.

$$\therefore \quad f = \frac{262 \cdot 5}{6 \cdot 5 \times 5 \times 20}$$

$$f = \cdot 403 \text{ tons per square inch} \quad \ldots\ldots\ldots\ldots\ldots [\text{I.}]$$

Local Bending.—The load is distributed by the decking over the panel. The ends of the beam (viz.—over the two panel points) may be considered to be built in at a slope and at different levels (the load on the whole girder not being central).

To find the maximum bending moment these slopes and levels must be known.

To find these, the EI of the whole girder must be known (E = modulus of elasticity and I = moment of inertia of the section).

This can be calculated as the deflection for a known load was found by experiment (see *Fig.* 3, p. 330).

Let Yc = deflection at centre of girder $= \cdot 175''$
L = span $= 216''$
W = load over centre $= 5$ tons.

Then
$$Yc = \frac{WL^3}{48EI}$$

$$\therefore \quad EI = \frac{5 \times 216^3}{\cdot 175 \times 48}.$$

$$\therefore \quad EI = 6 \times 10^6 \text{ for the whole girder.}$$

Slopes Over Panel Points.—Let V and Z be the two ends of the panel where it is required to know the slope.

Let i_v=slope at V.

i_z=slope at Z.

Then $$i_v = -\frac{Wb}{EI(a+b)}\left(\frac{v^2}{2} - \frac{a^2}{6} - \frac{ab}{3}\right)$$

$$i_v = \cdot000{,}077$$

and $$i_z = \frac{Wa}{EI(a+b)}\left(\frac{z^2}{2} - \frac{b^2}{6} - \frac{ab}{3}\right)$$

$$i_z = -\cdot000{,}715.$$

Levels of Panel Points.—Let Y_v=deflection at V.

Y_z=deflection at Z.

Then the difference in level between V and Z will be $Y_v - Y_z$.

$$Y_v = \frac{Wbv}{EI(a+b)} \times \frac{a^2+2ab-v^2}{6}$$

and $$Y_z = \frac{Waz}{EI(a+b)} \times \frac{b^2+2ab-z^2}{6}$$

$$\therefore \qquad Y_v - Y_z = \cdot00598.$$

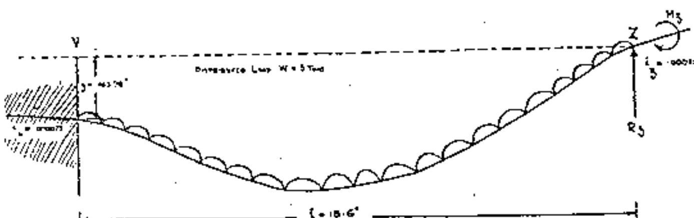


FIG. 6.

Consider the beam as a cantilever fixed at V at a slope i_v, the otherwise free end Z being propped to a height y above V and subject to a couple M_z.

Slopes.—Then the algebraic sum of the slopes produced at Z by the reaction at Z (R_z); the couple at Z(M_z); the load W and the slope at V (i_v) will be equal to the resultant slope at Z (i_z).

$$\therefore \qquad \frac{R_z l^2}{2EI} + \frac{M_z l}{EI} + \frac{Wl^2}{6EI} + i_v = i_z \text{ ((a) (c) and (e) of appendix).}$$

$$\therefore \qquad \tfrac{1}{2}R_z l^2 + M_z l + \tfrac{1}{6}Wl^2 = (i_z - i_v)\,EI \text{ ....[3].}$$

Deflections.—Also, the algebraic sum of the deflections produced at Z by the reaction at Z (R_z); the couple at Z (M_z); the load W; and the slope at V will be equal to the resultant deflection at Z (y).

$$\therefore \quad \frac{R_z l^3}{3EI} + \frac{M_z l^2}{2EI} + \frac{Wl^3}{8EI} + li_v = Y \text{ ((b) (d) and (f) of appendix).}$$

$$\therefore \quad \tfrac{1}{3}R_z l^3 + \tfrac{1}{2}M_z l^2 + \tfrac{1}{8}Wl^3 = (Y - li_x)\ EI \text{ ....[4].}$$

Where $Y = -\cdot 00598$
$i_v = \cdot 000077$
$i_z = -\cdot 000715.$

Multiplying [3] by $\frac{2}{3}l$ and subtracting from [4]

$$M_z = \frac{Wl}{12} - \frac{6EI}{l^2}\left(Y - \tfrac{1}{3}li_v - \tfrac{2}{3}li_z\right) \text{ ....[5].}$$

E was found by experiment to be 600

$$I = \frac{bd^3}{12} = \frac{5 \times 6\cdot 5^3}{12}.$$

Bending Moment at Z.—

$$\therefore \quad M_z = 7\cdot 75 - 2\cdot 89$$

$$M_z = 4\cdot 86.$$

Similarly $\quad R_z = -2\cdot 506$ tons

and $\quad R_v = -W - R_z$

$$= -5 + 2\cdot 506$$

$$R_v = -2\cdot 494 \text{ tons.}$$

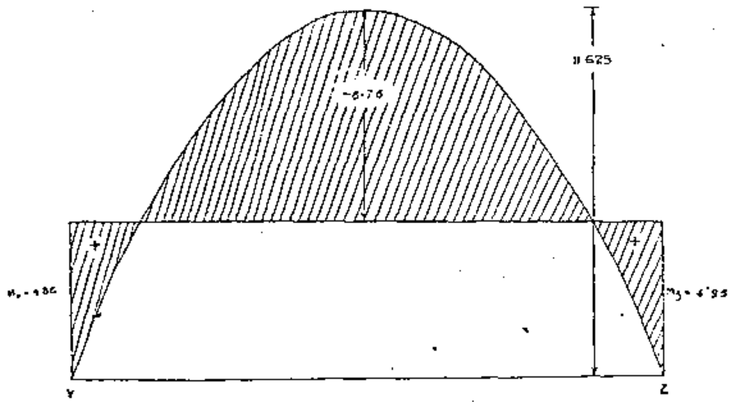
and $\quad M_v = M_z +$ moment of whole load round $V - R_z l$.

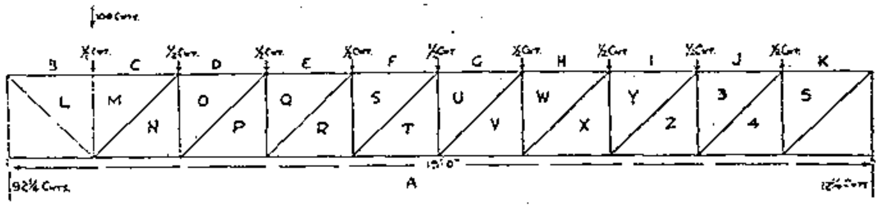
$$= 4\cdot 86 + \frac{5 \times 18\cdot 6}{2} - 2\cdot 506 \times 18\cdot 6$$

$$M_v = 4\cdot 86.$$

Bending Moment at V.—From the bending moment diagram it will be seen that the $M_{max.}$ occurs at the centre and is $-6\cdot 82$ inch tons.

Bending Moment in Centre,—Bending moment diagram for beam loaded as in *Fig.* 6, page 326.





Scale—2 feet to ½ inch.

To find the stress produced in the top boom by this bending moment—

$$p=\frac{My}{I}.$$

Where p = extreme stress at edge of beam.

y = distance of edge from neutral axis.

I = moment of inertia of section.

$$=\frac{bd^3}{12}.$$

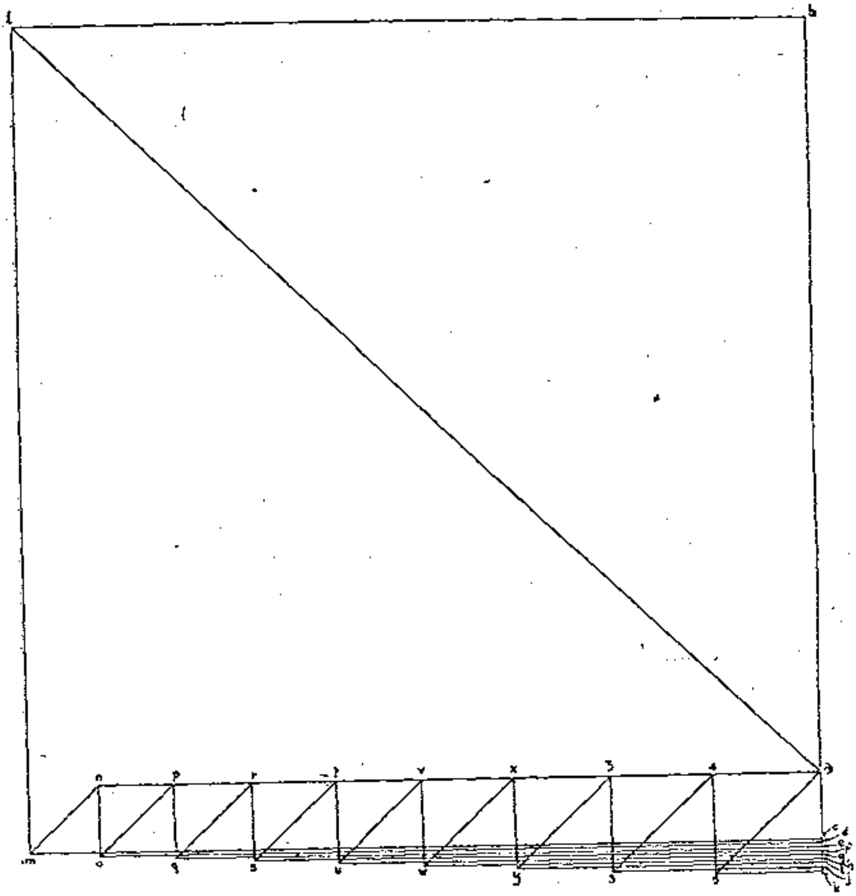
$$p=\frac{6{\cdot}76\times d\times 12}{bd^3\times 2}$$

$= \cdot 193$ tons per square inch ....[2].

Adding [1] and [2]—

Total stress in top boom $= \cdot 592$ tons per square inch.

Taking the breaking stress as 6,000 lbs. per square inch (2·68 tons), this gives a factor of safety for a dead load of 4·5.



Scale—12 cwts. to ¾ inch.
Stress Diagram for No. 1 Girder.

Bottom Boom.—Worst case when load over centre.

$$6{\cdot}75+\frac{WL}{4}=f.a.d \text{ (6·75 due to girders own weight).}$$

$$\therefore \qquad f=\frac{6{\cdot}75+270}{5\times5\times20}={\cdot}553 \text{ tons per square inch,}$$

giving a factor of safety of 5·3.

Web.—The maximum stress in the web with a heavy rolling load is when it is over the first panel point.

This gives a load of 6·79 tons in a piece of webbing of cross-section $2\times{\cdot}048\times15$.

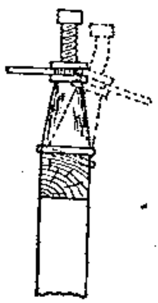
$$\text{Stress per square inch}=\frac{6{\cdot}79}{2\times{\cdot}048\times15}=4{\cdot}71 \text{ tons per square inch.}$$

(Breaking stress=20·5 tons per square inch. ∴ Factor of safety=4·35).

Attachment.—This was made the same strength as the iron, which (see experiments) required one 2½-in. nail per inch run.

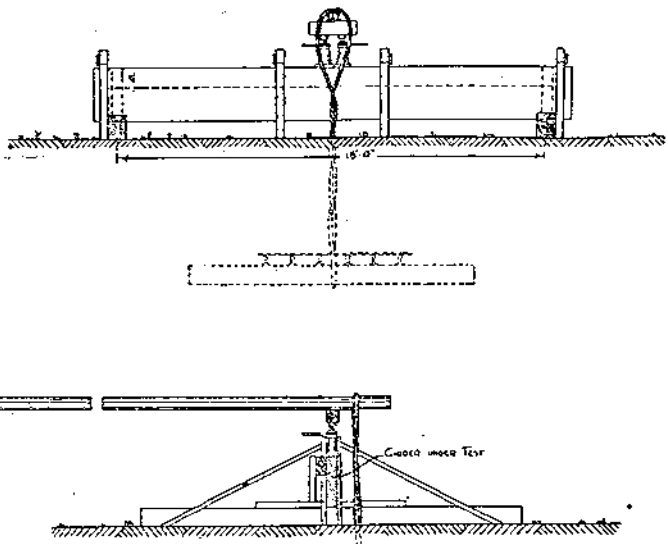
Construction.—One carpenter could complete all the woodwork in 7 hours. One sapper could nail on the web in 7 hours. One private could punch holes in one set of plates in 5 hours.

Infantry at first were employed nailing on the web but this had to be discontinued as considerable skill and care were required to prevent the plate buckling.

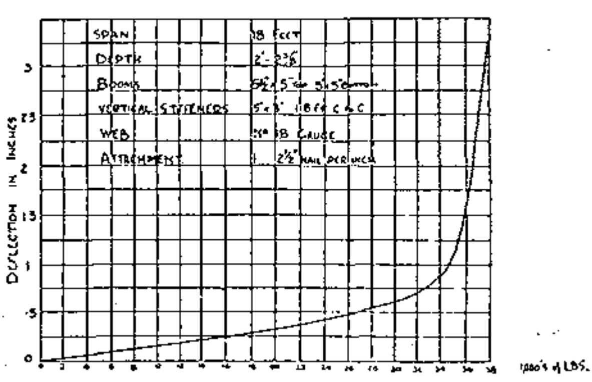


Tests.—Fig. 2.—The girder was arranged as shown in *Fig.* 2, and subjected to increasing loads up to 17 tons. Deflections were taken and a curve plotted (*Fig.* 3). When this load was removed the girder had a permanent set of ·3 in.

At this load the jacks bent, damaging the top boom locally.



Scale—4 feet to ½ inch.
FIG. 2.—*No.* 1 *Girder. Test of Girder.*



Scale—4 feet to ½ inch.
FIG. 3.—*No.* 1 *Girder. Test of Girder.*

No. 2 Girder.—This girder was similar to the first, but had hard wood booms 6 in. × 6 in. and was 2 ft. 4 in. deep over all.

It was loaded over the central panel point and showed no sign of fatigue, though left for 24 hours with 20 tons on it. It was afterwards placed in the bridge.

No. 3 Girder.—This girder was much lighter than the two preceding ones. The only differences apart from this being that the web was fastened with 1½-in. clout nails which were found to be better than wire nails in very thin iron.

It was designed so that the web should fail first.

To Carry 1 Ton Dead Concentrated Load.

Overall length	20′
Span	18′
Overall depth	26″
Effective depth	22″
Booms, top	5″ × 4″
,, bottom	3″ × 4″
Verticals	3″ × 4″
,, *c* to *c*	
Web	No. 37 gauge iron ('0068 in. thick).
Attachment	1½″ clout nails 1 nail per in.
Weight	1⅔ cwt.

Booms.—Top.—

$$\frac{WL}{4}=f.a.d.$$

$$\therefore \quad f=\frac{1 \,.\, 18 \,.\, 12}{4 \,.\, 20 \,.\, 22}=\cdot 123 \text{ tons per square inch.}$$

Local concentrated load with ends built in

$$M=\frac{WL}{6} \qquad y=\frac{d}{2} \qquad I=\frac{bd^3}{12}$$

$$P=\frac{My}{I}=\frac{WL}{td^2}$$

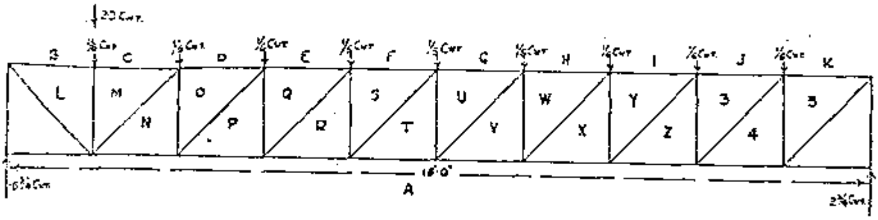
$$\therefore \quad P=\frac{1\times 20}{4\times 5\times 5}=\cdot 2 \text{ tons.}$$

∴ Total stress in top boom = ·323 tons per square inch.

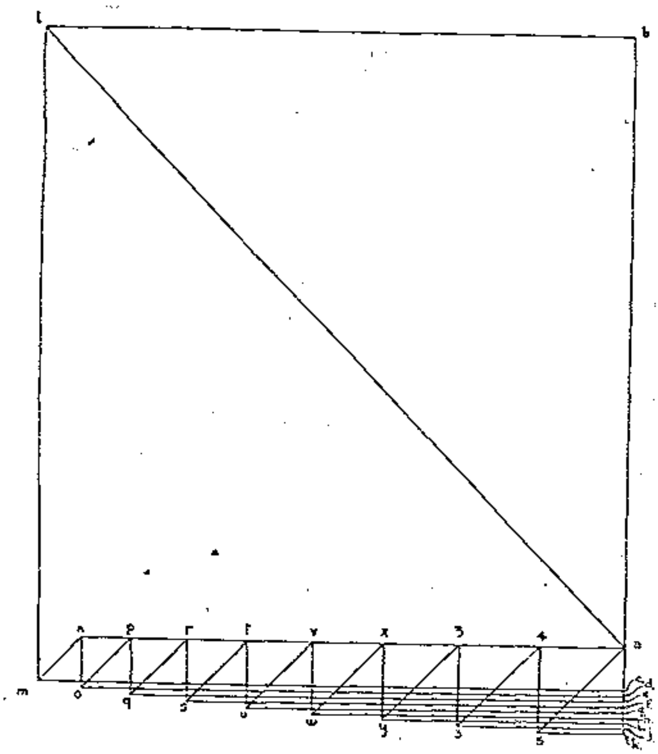
Bottom.—

$$\frac{WL}{4}=f.a.d.$$

$$\therefore \quad f=\frac{1 \,.\, 18 \,.\, 12}{4 \,.\, 12 \,.\, 22}=\cdot 2 \text{ tons per square inch.}$$



Scale—2 feet to ½ inch.



Scale—3 cwts. to ½ inch.

Stress Diagram for Light Section, No. 3 Girder.

Web.—The maximum stress with a heavy rolling load is over the 1st panel point.

This gives a load of 2486 lbs. in a piece of iron, the cross section of which is $2 \times \cdot 0068 \times 1 \cdot 28$.

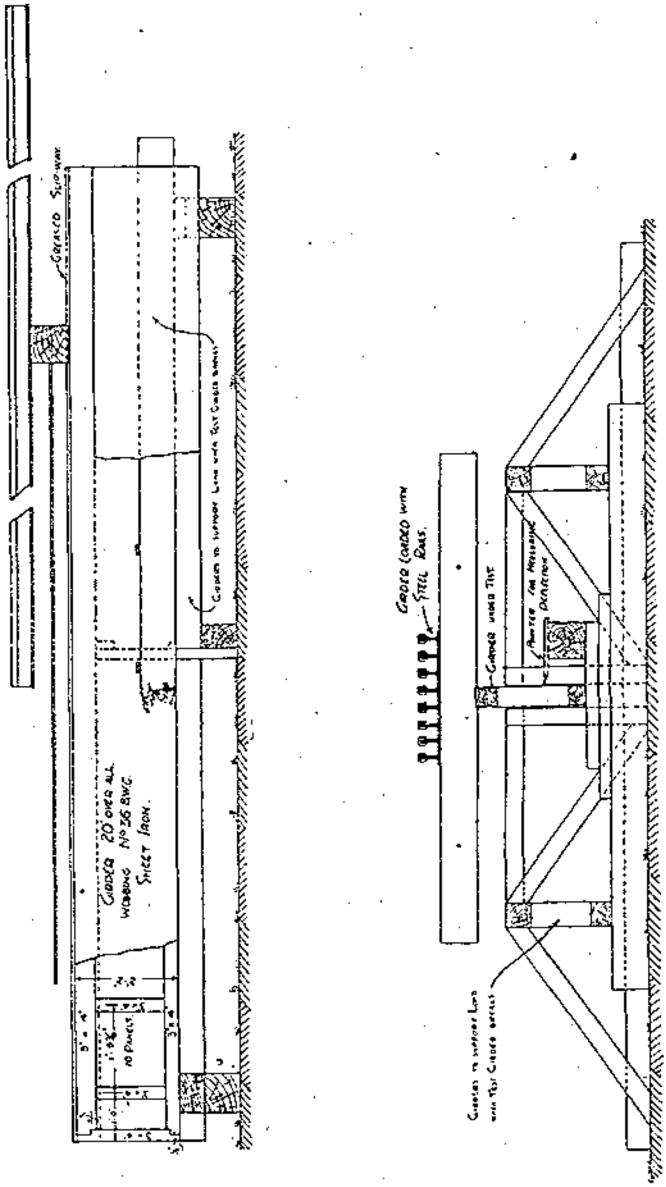
$$\therefore \quad \text{stress} = \frac{2940}{2 \times \cdot 0068 \times 1 \cdot 28 \times 12} \text{ lbs. per square inch}$$

$$= 14{,}000 \text{ lbs. per square inch.}$$

(Breaking strain of this thin iron is 65,800 lbs. per square inch.)
∴ Above gives factor of safety of 4·7.

Attachment.—One $1\frac{1}{2}$ in. clout nail per inch run along booms (see pages 334 and 335 *re* nails).

Test.—Fig. 4.—The girder was arranged as shown in *Fig.* 4 and loaded with steel rails, balanced on a 9 in. × 9 in. baulk, which was hauled along the girder by a traction engine. The load was pulled from one end to the centre, then stopped, the load increased, and pulled to the end.



Scale—$\frac{1}{8}$ *inch to* 1 *foot.*

FIG. 4.—*Test of Light Section, No.* 3 *Girder.*

Fig. 5.—Deflections were taken and plotted against load, *Fig.* 5.

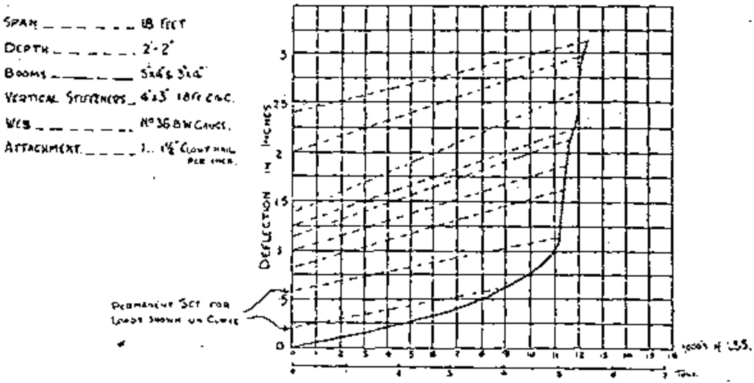


FIG. 5.

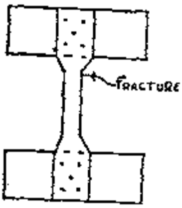
The girder supported up to 12,476 lbs. (5 tons, 11 cwt., 44 lb.) in the centre, but failed when the load reached the 1st panel point, through the web tearing away from the nails.

Very thin iron as used in this girder must be carefully selected, as a large proportion of the iron, when supplied, is rusted through.

Iron Plates for Webbing and Strength of Nails.

Iron plate ·0068 in. which is No. 37 gauge.

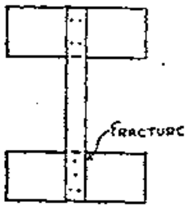
Test 1.—A strip of this plate, 2 in. wide, and larger at each end, which was held with five $1\frac{1}{2}$ in. clout nails, broke under a load of 895 lbs.



Area at break $= \cdot0068 \times 2$ square inches.

$\therefore$ Breaking strain per square inch

$$= \frac{895}{\cdot0068 \times 2} \text{ lbs.} = 65{,}809 \text{ lbs.}$$



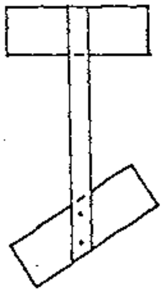
Test 2.—Three strips of iron, 2 in. wide, were placed on top of one another and nailed to pieces of 6 in. $\times$ 6 in. with four $1\frac{1}{2}$ in. clout nails at each end.

The strips broke through a nail hole at a load of 2361 lbs.

This shows that the attachment was stronger than the strip. (2 nails per inch).

Test 3.—Same as before, but only 1 nail per inch.

The nails pulled out thus  at 1400 lbs. (700 lbs. per nail).



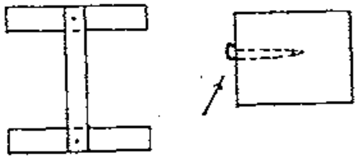
Test 4.—As above, but 1½ nails per inch pulling diagonally thus :—

Nails pulled out thus  at 2100 lbs. (700 lbs. per nail).

Therefore it appear that one 1½ in. clout fails by drawing out at 700 lbs.

The following further tests have been carried out on the strength of nails :—

A strip of sheet iron, 1 in. wide and ·048 in. thick (No. 18 gauge) was fastened to two blocks of wood with one 2½ in. wire nail at each end.



The nail failed by drawing through the iron at 1400 lbs.

This load caused the nail head to move ⅜ in. but did not draw it appreciably.

A similar strip, 1 in. wide, was fastened at the top with four 1½ in. clout nails, and at the bottom with two 2½ in. wire nails.

The 4 clouts failed by drawing at 2040 lbs.=510 lbs. per nail.

(My previous experiments gave 700 lbs. per ½ in. clout, but they were in hard wood, whereas these were in deal).

Four 2½ in. wire nails were put in place of the 4 clouts.

On increasing the load the strip broke at 2200 lbs.*

Cross-sectional area of strip=·048 in.

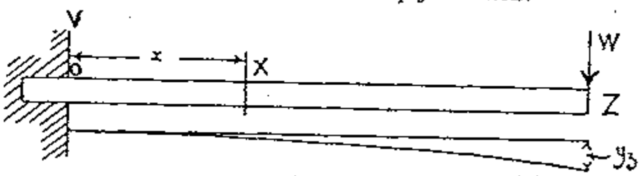
Breaking strain was 45833 lbs. per square inch=20·5 tons per square inch.

The experiments with No. 37 gauge (·0068 in.) iron showed that its breaking strain per square inch was greater than thicker material.

* This gives 1½ nails per inch run at right angles to pull or 1 nail per inch run at 45°, *i.e.* along the booms of girders

APPENDIX.

Uniform Cantilever Simply Loaded.



A.—A concentrated load W at the free end.

Take the origin O at the fixed end.

Then for $x = O$, $\frac{dy}{dx} = i_v$ and $y = O$.

At any point x the bending moment—

$$EI \cdot \frac{d^2y}{dx^2} = W(l - x).$$

$$EI \cdot \frac{dy}{dx} = W(lx - \tfrac{1}{2}x^2) + EIi_v.$$

$$EIy = W(\tfrac{1}{2}lx^2 - \tfrac{1}{6}x^3) + EIi_v x.$$

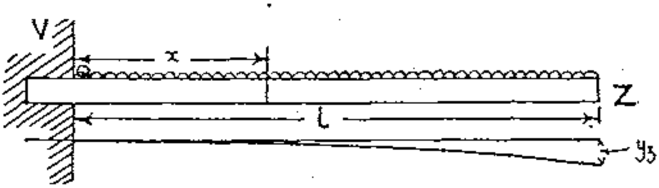
At the end Z—

$$\left(\frac{dy}{dx}\right)_3 \text{ or } i_z = \frac{W}{EI}(l^2 - \tfrac{1}{2}l^2) + i_v = \frac{Wl^2}{2EI} + i_v \quad \ldots\ldots(a).$$

and

$$v = \frac{Wl^3}{EI}(\tfrac{1}{2} - \tfrac{1}{6}) + i_v l = \frac{Wl^3}{3EI} + i_v l \ldots\ldots(b).$$

B.—Uniformly distributed load W per unit length. Origin O at fixed end.



$$M = EI\frac{d^2y}{dx^2} = \frac{w}{2}(l - x)^2 = \frac{w}{2}(l^2 - 2lx + x^2).$$

$\therefore$

$$EI\frac{dy}{dx} = \frac{w}{2}(l^2x - lx^2 + \tfrac{1}{3}x^3) + EIi_v,$$

and

$$EIy = \frac{w}{2}(\tfrac{1}{2}l^2x^2 - \tfrac{1}{3}lx^3 + \tfrac{1}{12}x^4) + EIi_v x.$$

For $x = l$—

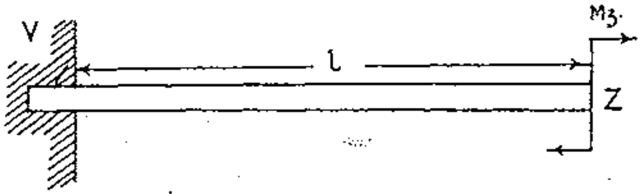
$$i_z \text{ or } \left(\frac{dy}{dx}\right)_3 = \frac{wl^3}{2EI}(1 - 1 + \tfrac{1}{3}) + i_v$$

$$= \tfrac{1}{6}\frac{wl^3}{EI} + i_v \text{ or } \tfrac{1}{6}\frac{Wl^2}{EI} + i_v \ldots\ldots(c).$$

Where $W = wl$.

Also $$y_3 = \frac{wl^4}{2EI}\left(\tfrac{1}{2} - \tfrac{1}{3} + \tfrac{1}{12}\right) + i_v l$$

$$= \tfrac{1}{8}\frac{wl^4}{EI} + i_v l \text{ or } \tfrac{1}{8}\frac{Wl^3}{EI} + i_v l \quad \ldots\ldots\ldots\ldots (d).$$



C.—Bending couple M at Z

$$EI\frac{d^2x}{dx^2} = M$$

$$EI\frac{dy}{dx} = Mx + i_v EI$$

$$EIy = \frac{Mx^2}{2} + i_v x EI + O.$$

At Z

$\therefore$ $$\frac{dy}{dx} \text{ or } i_z = \frac{Mx}{EI} + i_v \ldots\ldots\ldots\ldots (e).$$

and $$y_3 = \frac{Mx^2}{2EI} + i_v l \ldots\ldots\ldots\ldots (f).$$

DIRECTORATE OF INLAND WATERWAYS AND DOCKS.

THE following account of the work of the above, dated May, 1918, we are enabled to print by the courtesy of the Director :—

GENERAL.

The Directorate of Inland Waterways and Docks is an entirely new branch of the War Office which has been created to fill requirements arising out of the present war.

It was very early realized that it would be necessary to take the fullest advantage of the canal and river systems in France and Belgium as a means of transportation supplementary to rail transport. The waterways were therefore developed energetically in the French and Belgian theatres, and steps were taken to form an organization to control these waterways in the British zone of operations, and also to maintain them in the highest possible state of efficiency, in order to relieve the railway as far as possible in respect of the transport of war material, stores, etc. This has been carried out very successfully, and whereas for the quarter ending March, 1917, a total tonnage of war material, etc., was carried amounting to 345,439 tons, for the quarter ending March, 1918, it had increased to 672,516 tons.

The supply of *personnel*, craft, and material was made from the War Office originally, as a small branch of Q.M.G. 2. As the work increased both in France and in other theatres of war, a separate Directorate was formed, as at present constituted, under the administrative supervision of the Director-General of Movements and Railways.

RICHBOROUGH.

A Depôt for *personnel* was formed near Sandwich, and from this locality also barges, acquired for the Inland Water Transport in France, were equipped, manned, and despatched. A Stores Depôt was also inaugurated for the supply of urgent and necessary stores. So far, therefore, the establishment at Richborough dealt solely with the functions enumerated above, *i.e.*, a draft depôt for *personnel* and a Stores Depôt.

Owing to the convenience of dealing with these matters under one control, it was decided to add the finding of stores and *personnel* for the Directorate of Docks in France, which was established for the proper control and co-ordination of dock working at the Ports which were allotted for the use of the British forces. To this again was added the supplying of *personnel* and stores for the Directorate of Port Construction, which was subsidiary to the Docks Directorate, and which dealt with additions to and the upkeep of the wharfage and dock accommodation.

The next step in the development of Richborough arose owing to the fact that it became increasingly difficult to get barges built sufficiently quick to meet the needs in France, in consequence of congestion in the shipyards. A scheme was therefore commenced by which barges were constructed at works where water and slipways were not available. These barges were then railed down in plates and angles to Richborough where slips were constructed and the barges entirely put together and equipped. This was still further extended, as the shipping position became more acute, by the complete construction of barges, material being sent straight from the rolling mills to Richborough. Under this schme it was possible to keep pace with the demands for craft. It necessitated the erection of workshops, power-plant, etc., and resulted in fact in up-to-date shops, and barge-building yard entirely under Military control.

More recently this yard has undertaken the construction of special types of small craft required by the Admiralty in connection with the towage of seaplanes, and which could not be conveniently built either in civilian or Admiralty yards. The undertaking of this work has been very successful.

The adoption of these measures necessitated a supply of skilled *personnel*. At the commencement, this *personnel* was found from drafts awaiting despatch overseas, and the employment and training of these men very materially enhanced their value when finally despatched. It was not possible, however, to carry on the work with these drafts only, and a permanent establishment was therefore set up in connection with the craft construction programme.

The *personnel* for this purpose was enlisted in the Corps, but the highly skilled trades were not largely drawn upon—a nucleus only of skilled men being engaged—the majority of the *personnel* consisting of totally unskilled or semi-skilled men who were trained by means of Schools of Instruction and gradually turned into skilled tradesmen. This resulted in a very large and satisfactory amount of "dilution upwards" being carried out.

The establishments of workshops, power, plant, etc., originally intended only for barge construction, made it possible to undertake other urgent work instead of having to depend upon the civil engineering shops, which were very fully employed with orders for the Ministry of Munitions, etc. A large amount of work is therefore done now at Richborough which would otherwise have to be placed in civilian shops, in connection with the maintenance of docks, wharves, and canals in the various theatres of war. The advantage of this has been quite recently emphasized when the Richborough shops were able to accept urgent work such as repairs to Tractor Locomotives, etc., which owing to military operations could not be carried out in the war area. Richborough is becoming in effect a base workshop.

The above deals with one side of the Richborough Depôt, but there is another side which is becoming even more important, and which developed incidentally out of the original beginnings, *i.e.*, its value as a transport Depôt. When the shipping position began to assume a serious aspect, it was realized that a good deal of relief could be afforded by using barges and tugs for the transport of war material to France. A special type of barge was therefore designed and built, of sufficiently seaworthy construction to stand the cross-channel passage, and at the same time of suitable dimensions to enter the French canals and so supplement the Inland Water Transport already existing.

The advantages of this means of transport are obvious, quite apart from the actual relief of sea-going ships. They are briefly as follows :—

(*a*). The dispersal of both marine and war risks into smaller units.
(*b*). Facilities of loading.
(*c*). The relief of dock congestion owing to the fact that the barges passed right through the docks into the interior.
(*d*). The saving of double handling, the barges being discharged at an inland depôt.
(*e*). The saving of railway carriage in France.
(*f*). Comparative immunity from enemy torpedo attack owing to their shallow draft.

In order to conduct this service efficiently, it was necessary to provide adequate wharfage accommodation at Richborough. The small amount of wharfage that was in use for the equipment and despatch of the original French canal barges was therefore very largely extended. A wharf was constructed with all the necessary crane facilities, and this is being gradually expanded to handle 6,000 tons of dead-weight per diem, and the barge fleet is being augmented up to this figure.

When the service first commenced in December, 1916, the amount of tonnage transported to France during that month was 2,090 tons. In March, 1918, it amounted to 67,697 tons. Even so, the figures do not actually represent the increase, as originally only dead-weight cargo such as rails and heavy stores were handled, but at present all classes of war material are carried, including such light cargoes as hay, aeroplanes, etc., which give a very poor dead-weight result, although the service rendered is quite as useful.

The latest development of the barge service is in the direction of 1,000 ton barges, as the limit of the canal capacity has been reached with the smaller barges. These 1,000 ton barges will be discharged in the docks in France, and although therefore they do not possess the advantages enumerated above as regards the canal craft that go into the canals, yet, at the same time, they are a direct relief to shipping.

In addition to the tonnage exported from Richborough to France, a very large amount of salvage is being transported in the return barges, as well as large quantities of material for repair purposes, etc. The amount of salvage brought back up to March, 1918, for return to the filling factories is 62,601 tons.

A still further development in the way of transport has occurred by the institution of a system of Train Ferries. These ferries are operated between Richborough and Calais or Dunkirk, and also between Southampton and Dieppe. As regards the Richborough service, a terminal has been constructed at Richborough, and the necessary dredging operations undertaken to deepen the channel. This dredging is still going on, but will be shortly finished.

The Train Ferry service is an entirely new departure in sea transport so far as Great Britain is concerned, and during the time the ferry boats have been in operation they have proved of the greatest value. They are operated by means of an electrically-lowered shore bridge which connects with the deck of the steamer, and enables a complete train of 54 ten-ton wagons (or other stock in proportion) to be run straight on board the ferry, and similarly discharged on the French side where terminal facilities have also been constructed. The operation of loading and unloading these vessels averages about twenty minutes only and the passage across channel occupies about one and a half hours. A detailed note of this ferry system is attached (Appendix "A.").

This concludes the detail of the direct functions of the Richborough Depôt, but in many subsidiary ways it is used for the various undertakings of the Directorate for the supply of *personnel*, stores, etc., for other theatres of war as well as for home demands.

Poplar Depot.—A small Depôt was formed on the Thames at Poplar in December, 1915, with a sub-depôt at Gravesend for the alteration, repair, and maintenance of second-hand craft purchased for the requirements of the Directorate at Home and Overseas. This Depôt is also responsible for the provision of crews for new and second-hand craft from the various builders' yards round the coast to Richborough.

Glasgow Depot.—A Depôt was formed in Glasgow early in 1917 for the equipping, victualling, and manning of all the craft for service in the East. Officers and men complete their training at this Depôt prior to being drafted Overseas as crews of Mesopotamia, etc., craft.

The use of Inland Water Transport has not been confined to France, and the duties of the Directorate have been increased from time to time to include development and supervision over Inland Water Transport in other directions, as follows:—

MESOPOTAMIA.

When the War Office assumed control of the operations of the Mesopotamia campaign, the water lines of communication were organized under Inland Water Transport Directorate. The functions of the headquarters at the War Office consist of a supervision of policy ,the supply of European *personnel*, river craft, including hospital ships, etc., in fact, the interests generally of the river route, which is the principal Line of Communication of the Mesopotamia Expeditionary Force. The tonnage handled up the river by the I.W.T. has increased from 222,275 tons for the quarter ending March, 1917, to 464,196 tons for the corresponding quarter in 1918, and in addition to this, large numbers of troops, prisoners of war, and horses have been carried. The I.W.T. Directorate also control Port working at Basra, have carried out large wharfage schemes, and have executed a comprehensive scheme of River buoyage and conservancy. A general summary of the work done is attached (Appendix "B").

EGYPT.

The development of Inland Water Transport in this theatre has also been undertaken by the Directorate. This work includes extensive use of the Nile and the Canal system of Lower and Upper Egypt, and also the lighterage of ships at ports such as Alexandria and Port Said, and more recently at the Port of Kantara, which is the base from which the army in Palestine is supplied. The more recent returns shew that 181,886 tons of actual river transport were carried, and 280,444 tons of lighterage during January and February, 1918.

EAST AFRICA.

The operations of the Directorate in this theatre have been small when compared with the others, but very useful work has been done by the development of coastal waterways, and also in connection with the Port work.

SALONIKA.

In this Port the I.W. & D. undertook and are carrying out the discharge of ships.

TARANTO.

The Directorate supplies all craft for use at Taranto, and in addition cranes and other Port equipment have been provided.

Cranes.—The carrying out of these large and varied undertakings necessitated the development of certain special branches in connection with the supply of material: in particular cranage. It was early realized that any successful working depended to a very great extent on adequate cranage facilities wherever ships or barges had to be loaded or discharged. There was a great scarcity of available cranes in the country, and a census was taken of practically all cranes in the country, and as many as possible were acquired. In consequence there has never been any real difficulty in keeping the requirements for cranes supplied. When the supply of second-hand cranes became exhausted, the matter had to be considered with a view to coming to a decision as to the best method to be adopted to meet the situation, the crane makers' works being fully occupied, and any quick delivery being almost impossible. It was therefore decided to design and construct a standard crane. The various parts were manufactured wherever facilities could be obtained, and sent to Richborough, where they were assembled, put together, and tested. A description of this crane, which has proved to be a great success, is attached (Appendix "C").

No fewer than 645 cranes have been supplied by the Directorate up to April 30th, 1918, in fact, such an expert knowledge of the cranage conditions was obtained that requests have been made to us to supply various other Departments quite outside the activities of the Directorate, and recently to supply the American Government with cranes for their use in France (*See* Appendix "C").

Filtration Plant.—Another phase is the design and supply of Filtration plant, particularly to Mesopotamia and France. The Directorate has supplied no fewer than 32 of these plants and this work has been of the greatest utility and importance (*See* Appendix "D").

Pneumatic Grain Handling Plant.—The Directorate has also been responsible for the supervision of the construction of eight Pneumatic Grain Handling Plants for use at the French Ports (*See* Appendix "E").

Construction Works.—The highly technical staff of Engineer Officers and others attached to the Directorate for the carrying out of constructional and engineering works have been employed in other directions in addition to the development of Richborough and other I.W. & D. bases. The military labour employed in connection with these works also became well qualified and skilled, and gained a reputation for celerity and efficiency.

During 1917 it became necessary to expedite as much as possible the building of aerodromes for the rapidly-growing needs of the

Air Force. In certain localities it was found very difficult to obtain civilian workmen, and the Directorate were therefore asked to undertake large building operations in this connection. This was done by adding to the staff of Engineers and also by withdrawing from Richborough a nucleus of skilled workmen. It was also necessary to further enlist men in order to obtain the necessary labour required for the carrying out of these works. The following camps were undertaken :—

Manston.—A very large camp accommodating 200 officers and 3,120 men, together with 5 hangars, technical buildings, gymnasium, etc., amounting to approximately 15,882,000 cubic feet of building work.

Eastchurch.—A similar camp to Manston, accommodating 175 officers and 960 men, also technical buildings, institutes, etc., amounting to 3,665,000 cubic feet of building work.

Salisbury Plain.—Three large aerodromes with the necessary living accommodation, instructional buildings, etc., amounting to approximately 17,510,000 cubic feet of building work.

Hawkinge (near Folkestone).—Aerodrome, quarters, technical buildings, etc., accommodating 600 officers and men, amounting to approximately 5,573,000 cubic feet of building work.

National Shipyards.—The Admiralty were desirous of immediately starting the construction of National Shipyards on the Severn and Wye Rivers, but had no organization to commence the work. The whole of these large works were therefore undertaken by this Directorate, and were carried up to a point when the Admiralty were in a position to take over the work. The value of the work performed by this Directorate amounted roughly to £766,000.

Headquarters Organization.

The organization of the Directorate to carry out the work as outlined above is as follows :—

At the War Office.—11 Sections (as below), directly controlled by the Director Inland Waterways and Docks, 1 Deputy Director, with Assistant Directors, Deputy Assistant Directors and staff.

Administrative.—General administration and supervision, M.R.3.A. (supervised by an Assistant Director).

Mechanical Engineering.—Mechanical engineering and dock equipment for overseas, M.R.3.B. (supervised by an Assistant Director).

Purchasing.—Fulfilment of requisitions for plant, stores and material for home and abroad, M.R.3.D. (supervised by an Assistant Director).

Traffic and Marine.—Movement of I.W. & D. craft, operation of cross channel and coastwise barge services and train ferries: movement by rail and water of I.W. & D. stores and materials. Craft requirements for home service and overseas, alteration, repair and maintenance of home service fleet, equipment and outfit of new vessels, M.R.3.E. (supervised by an Assistant Director).

Personnel.—Personnel for I.W. & D. Services, M.R.3.F. (Deputy Assistant Director).

Civil Engineering.—Civil engineering, design, plans, supervision of I.W. & D. construction work in England, engineering questions arising from I.W. & D. construction work overseas, M.R.3.G. (Assistant Director).

Finance.—Finance supervision and statistics, scrutiny and checking of accounts before submission for payment: preparation of works costs of I.W. & D. works, M.R.3.H. (Deputy Assistant Director).

Statistical.—Records and statistics, M.R.3.J. (Senior Officer—Captain).

Plant Record.—Record and control of all plant, acquisition, control, and disposal of hired plant, M.R.3.L. (Senior Officer—Major).

General Office Supervision.—General office supervision, M.R.3.M. (Deputy Assistant Director).

Inspection.—Inspection of plant, machinery and general stores under acquisition, M.R.3.O. (Deputy Assistant Director).

AT RICHBOROUGH.—7 Sections (as below), under a Deputy Director, 1 Assistant Director, with Deputy Assistant Directors, and staff:—

Depôt.—Commanding Officer (Lieut.-Colonel).

Mechanical Engineering.—Commanding Officer (Colonel).

Construction.—Commanding Officer (Lieut.-Colonel).

Traffic.—Commanding Officer (Lieut.-Colonel).

Marine.—Commanding Officer (Lieut.-Colonel).

Stores.—Commanding Officer (Major).

Accounts.—Commanding Officer (Deputy Assistant Director).

At Glasgow.—1 Assistant Director and Staff.

At Poplar.—1 Senior Officer (Major) and Staff.

At Southampton.—1 Senior Officer (Major) and Staff.

APPENDIX A.

CROSS-CHANNEL TRAIN FERRY SERVICE.

THE foregoing *Report upon Train Ferries as a means of transportation and their adoption in various countries was prepared early in 1917 for the Directorate of Inland Waterways and Docks at the War Office as a basis for the consideration of a scheme for a Cross-Channel Train Ferry Service which had been submitted to the War Cabinet as an urgent war measure.

Before this scheme received sanction, various difficulties and objections had to be overcome. Although train ferries had been successful in other parts of the world, it did not follow that they would operate well in the Channel with its tidal range and other well-known characteristics. Moreover, regularity of service was an important factor, and under war conditions this could not be counted upon owing to mines and other forms of enemy activity, and to the precautionary measures rendered necessary in consequence.

The advantages gained by the saving in handling of the materials to be carried would undoubtedly be considerable, but somewhat elaborate arrangements would have to be made for the return of the wagons used (loaded, if possible, with salvage or materials for repair, etc.) as it was evident that British rolling-stock could not be indefinitely passed over into France.

A more serious objection, urged by the Admiralty, was that the vessels themselves, being necessarily of a special nature, would take a long time to build, thus interfering with the construction of urgently needed mercantile tonnage.

Eventually, however, it was decided that the advantages of being able to rush through any particular materials direct from the works in England to the fighting forces in France without intermediate handling, the ease of transportation of heavy loads such as locomotives, tanks, heavy guns, etc., and their return to England for repair, were so great that the scheme should be adopted and the necessary work put in hand with all speed.

Instructions were accordingly given on 17th January, 1917, that three ferry steamers should be built, terminal ports selected, and the necessary berths and other works pressed forward. Two routes were decided on, a northerly and a southerly—the latter being available in case of serious interruption to the former.

*A technical Report on the general use of Train Ferries in other countries—(not included.)

Choice of Terminals.

English Ports.—Two sites were chosen: one on the south-east coast at Richborough, and the other on the south coast at Southampton. In selecting the English terminals, careful and exhaustive consideration was given to all suitable sites. The advantages of using old-established ports, such as Ramsgate, Dover or Folkestone on the south-east coast, were fully weighed, but there were many difficulties owing to their already congested condition and lack of space for the sidings involved.

Richborough had already been considerably developed as the home depôt of Inland Water Transport operations and the base of the cross-channel barge service of munitions and materials of war. The whole area was under the military control of the authority which would build and operate the ferry service, railway connections already existed, ample space was available for sidings, and the necessary labour force, under skilled direction, was ready at the site. Instead of injuring commercial interests, or adding to existing congestion in a busy mercantile or naval harbour, the construction of the ferry terminal at Richborough would assist in the development of the port.

Southampton was decided upon as the south coast terminal after conditions at Portsmouth, Itchen River, Hamble River, Langston Harbour, Chichester Harbour, and Keyhaven had been examined and considered. The most suitable site at Southampton was found to be immediately west of the Royal Pier. At that spot very little dredging was required, the position was sheltered and out of the way of shipping, and there was ample room in which to turn the ferry steamers. The necessary sidings could readily be constructed along the foreshore on reclaimed ground and a connection made with the main line of the L. & S.W. Railway at Southampton West Station.

French Ports.—Three ports were selected on the French coast, namely, *Dunkirk*, *Calais*, and *Dieppe*. These sites were determined after thorough consideration of all available ports along the French coast between Havre and Belgium. In many cases the ports were already congested or sea access was unsuitable, and even in the case of the ports chosen these difficulties could not be entirely obviated.

The distance from Richborough to Dunkirk is about 54 miles, while to Calais it is about 35 miles. The distance from Southampton to Dieppe is about 130 miles.

Terminal Works.*

Bridges.—The communication bridges at all five ports were all built upon the same principle, and differed only as regards length, the latter being governed by the tidal conditions. The various spans measured from centre to centre of bearings were as follows:—

* The works at the various ports were practically complete by the end of 1917, the boats having been completed previously. Traffic commenced to be sent from Southampton in November, 1917, and a regular service between the various ports was running early in 1918.

	ft.
Southampton and Dieppe	120
Richborough and Calais ...	100
Dunkirk	80

Each bridge carries two railway tracks set to 11ft. 6in. centres, the gauge being 4ft. 8½in., which will take both British and Continental stock. The structure was made to clear the modified Berne or standard Continental leading gauge.

Each bridge consisted of two main N-type girders joined by cross-girders secured to the main girders by means of pins, the joints giving the necessary flexibility to allow the bridge to adapt itself to a heel of about 5° in either direction in the steamer. The bridges are carried at the land end on two hinged bearings and on the steamer by means of two hemispherical bearings to allow for movement due to rise and fall of tide and heel of ship during loading, the sea end connections being identical for all five bridges.

The tower from which the bridge is suspended consists of two legs 42ft. high, each about 5ft. 6in. square, and placed 36ft. 6in. apart between centres, connected at the top by a double webbed plate girder upon which the actuating winch and machinery are erected. The bridge is suspended between the tower legs by four ropes working on counterweights suspended in the tower legs, timber rubbing pieces being provided to prevent fouling. The tower legs are stiffened in the longitudinal direction of the bridge by raking struts and bracing. The feet of the towers rested upon piers placed in all cases 4ft. below rail-level on land.

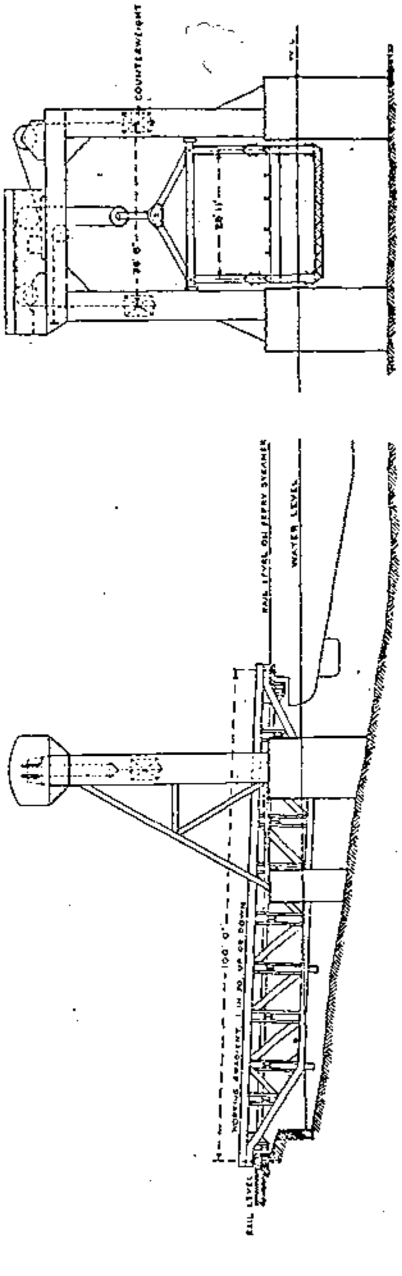
The operating machinery works in a steel cabin on the top of the connecting cross girder on the tower and consists of a 20 B.H.P. electric motor running at 500 r.p.m. and driving through work and spur gearing the cast iron grooved rope drum. Hand gearing is provided by which the bridge can be raised or lowered in case of a breakdown in the electric machinery. The gear can easily be operated by two men.

Illustrations in plan and section of the bridge and jetty, showing boat connections, are appended.

Berths, etc.—The selection of Richborough as a terminal involved the dredging of the entrance to a depth of about 10ft. below L.W.O.S.T. and the cutting of a new channel 200ft. wide at the bottom. The site chosen for the berth is situated between the end of Richborough Wharf and the sea: its distance from the sea was about 5,000 yards. This has been reduced by the dredging of the new channel to about 3,200 yards. A turning basin 500ft. wide is provided close to the berth in which to swing the steamers. The berth itself was dredged to 16.50 O.D. in order to accommodate the vessels at all states of the tide.

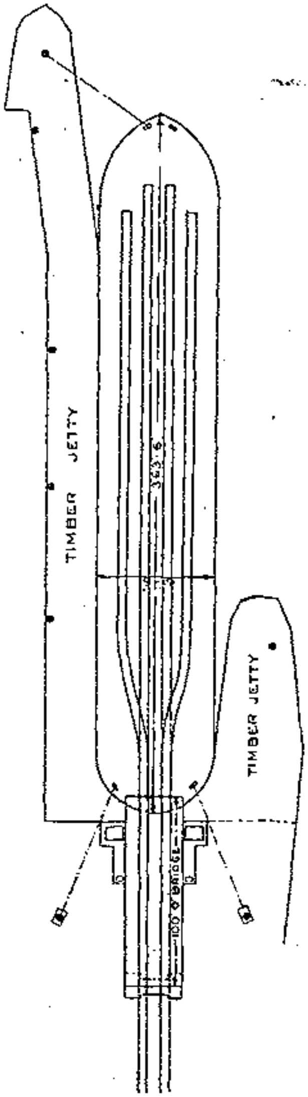
The berth was constructed as a timber jetty with arms on each side of the ship: the one on the port side was made 420ft. long by 26ft. wide, while the other on the starboard side is about 130ft. long by 50ft. wide. The jetties were built of timber piles 12in. square, spaced 10ft. apart between centres, and driven down to about 20.00 O.D. into firm sand. The piles are well braced in both directions, and alongside the port jetty a line of steel sheet piling was driven to hold the ground.

TRAIN FERRIES.
General Arrangement (Small Scale).



Scale, ⅛ inch = 25 feet.

Diagram of Berth and Bridge.



Scale, ⅛ inch = 50 feet.

A system of sidings for dealing with the train ferry traffic was laid down close to the berth and connected to the main access sidings at Richborough by means of a short length of single line, the whole system being situated near Minster Junction on the S.E. & C. Railway. Each set of ferry sidings can accommodate a complete boatload of inward or outward traffic, and two shunting locomotives work between the sidings and the boat, back shunting or hauling two trains or wagons simultaneously.

Opposite the ferry sidings four oil-fuel tanks were erected, each capable of storing about 525 tons of oil. A small pumping station was built close by, and a pipe-line laid to the port side of the jetty. By this means the oil tanks on the steamer can be filled in about half-an-hour.

At Southampton the natural conditions were considerably simpler than at Richborough. The access to the site was good, and the only dredging necessary consisted in a triangle area leading into the berth, which was dredged to about 22.00 O.D. The berth itself was dredged to 26.00 O.D.

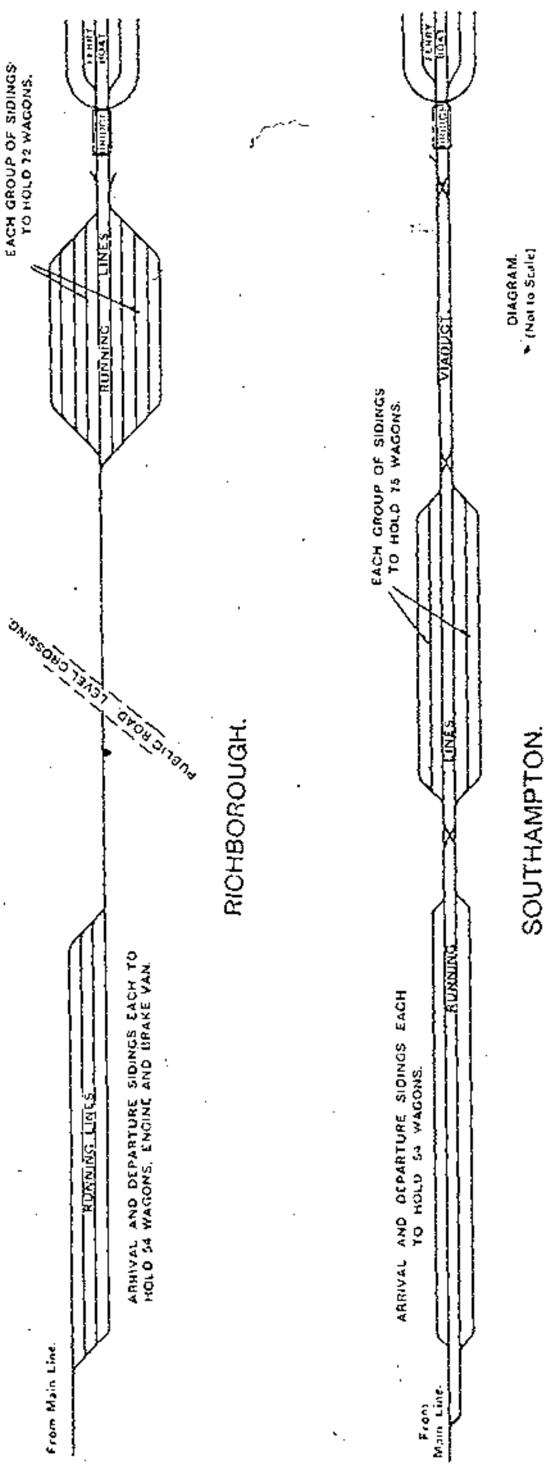
The berth is accessible at all states of the tide, the tidal range being 13ft. The berth itself was constructed on the same lines as Richborough, modified to suit the site. The long arm was arranged on the starboard side of the vessel so as to be easy of access from Southampton Water: it was made 450ft. long by 35ft. wide, the short arm on the port side being 110ft. long by 35ft. wide. The piles were well braced in both directions and were arranged so that, if necessary, the starboard jetty could easily be widened to accommodate a second boat on the opposite side of the first one.

The land end of the communication bridge is situated about 1,000ft. seaward of the existing foreshore wall. If the berth had been built nearer the shore, dredging would have been increased, and constant work would have been required to keep it free from silt. As a war measure it was decided to bridge the intervening gap by a timber viaduct, the length being reduced as much as possible by forming an embankment at the shore end. The bank carries, besides the rails, a motor road 20ft. wide, a portion of the ferry sidings, and also a scissors crossing. The timber viaduct is 630ft. long by 24ft. wide, and carries a footpath as well as the two railway tracks.

The sidings were formed partly on the embankment and partly on the site of the obsolete West Quay and several small slips and yards. They are about 700ft. long and consist of four tracks, two for outward and two for inward traffic. In addition to the ferry sidings and between them and the West Station two reception sidings were formed, each about 1,100ft. long, and able to take a complete boatload of wagons and main line engine.

Connection is made with the L. & S.W. Railway on the west side of the Station. Four oil-fuel tanks were provided opposite the sidings, with pumping station and pipe line, as at Richborough. A water supply and electric cables for power and light were also installed.

Whilst these works were proceeding at Richborough and Southampton, similar terminals were being built at Dunkirk, Calais and Dieppe, modifications being necessary owing to the conditions at each port. As stated, the communication bridges are similar to those at the English


EACH GROUP OF SIDINGS TO HOLD 72 WAGONS.
FERRY BOAT
BRIDGE
RUNNING LINES
PUBLIC ROAD LEVEL CROSSING
RICHBOROUGH.
RUNNING LINES
ARRIVAL AND DEPARTURE SIDINGS EACH TO HOLD 54 WAGONS, ENGINE AND BRAKE VAN.
From Main Line.
FERRY BOAT
BRIDGE
DIAGRAM. (Not to Scale)
VIADUCT
EACH GROUP OF SIDINGS TO HOLD 75 WAGONS.
LINES
SOUTHAMPTON.
RUNNING
ARRIVAL AND DEPARTURE SIDINGS EACH TO HOLD 54 WAGONS.
From Main Line.

ports. The works at all the French ports were carried out by military labour with the assistance of Chinese coolies. Very few of the soldiers were skilled men, so practically all the men employed had to be trained to their duties as the work progressed.*

FERRY STEAMERS.

The Cross-Channel Ferry fleet consists of three vessels. The principal dimensions are :—

	ft.	in.
Length (over all) ...	363	6
Breadth (over fenders) ...	61	6
Depth moulded ...	17	0
Draught (loaded) forward	9	0
Draught (loaded) aft ...	10	0

Speed, approximately 12 knots.

Four lines of rails are laid on the deck, capable of taking 54 ordinary 10-ton wagons or their equivalent in other stock : the total specified deck load is 850 tons, and the total dead weight, including stores, spare gear, water and oil fuel, is 960 tons. The total length of track available for the storage of wagons is 1,080ft. One of the ships is fitted with timber tracks to take the wheels of motor lorries; from 50 to 60 of these vehicles can be accommodated at one time.

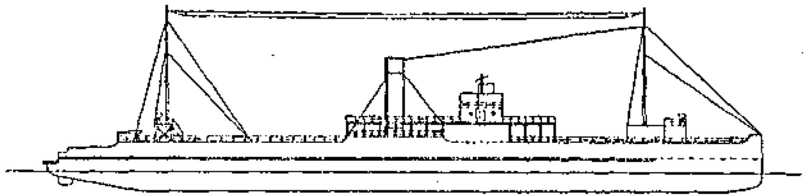
The propelling machinery consists of two sets of triple expansion engines, supplied with steam at 180 lbs. pressure by four single-ended boilers, fitted with Howden's forced draught arrangement and oil-firing appliances. The boilers are arranged in pairs on each side of the vessel, with two oil-fuel tanks between them on the centre line of the ship. Oil fuel was decided upon instead of coal; this permitted the boilers to be reduced in diameter, thereby allowing the moulded depth and consequent windage on hull to be reduced, as well as simplifying the bunkering arrangements. The tanks have a total capacity of about 80 tons at 38 cubic feet per ton. The funnels, two in number, are fitted on each side of the vessel, braced together near the top by means of a light lattice girder and guyed fore and aft.

The vessels are fitted with twin screws, and are cut away underneath for a length of about 50 feet at the stern, so that the screws and large balanced rudders placed between them have large manœuvring power. There is a single deck, on which the rails are laid. Near the stern this deck is cut away square and seatings provided for the ship end of the communication bridge to rest upon. The fore and aft peaks are built as ballast tanks, with a capacity of 160 tons forward and 210 tons aft, two wing tanks of about 45 tons capacity each being also provided.

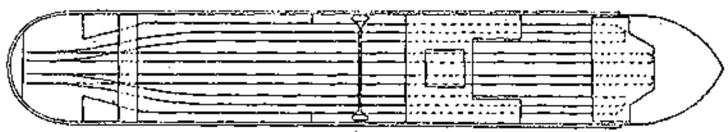
The main bridge is situated amidships and carries chart and wireless rooms and captain's quarters, the captain's bridge and wheelhouse being on top of these again. The wheelhouse contains the steam steering gear, telemotor control standard, wheel, and compass. A search-

* A plan and sections of the boats is appended.

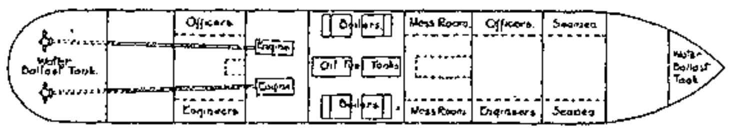
TRAIN FERRIES. STEAMER.



SIDE ELEVATION.

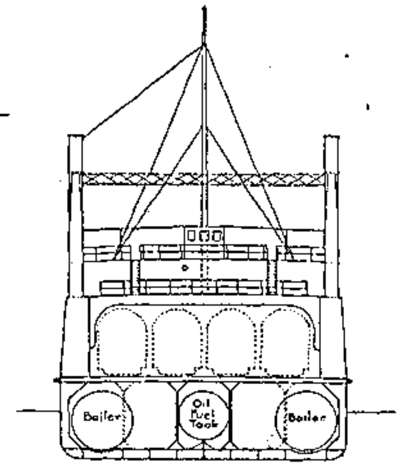


DECK PLAN.



ENGINE ROOM & ACCOMMODATION PLAN.

Scale. ⅟₄ *inch=50 feet.*



SECTION LOOKING FORWARD.

Scale. ⅟₄ *inch=20 feet.*

PRINCIPAL DIMENSIONS.

Length Overall	363′ 6″	Breadth Moulded	58′ 6″
,, Between Perps.	350′ 0″	Depth ,, ...	17′ 0″
Breadth Extreme over Fenders	61′ 5″	Draft Fully Laden,	Forward 9′ 0″, Aft 10′ 0″, Mean 9′ 6″

light is mounted on top. A docking bridge is also provided aft in order to control the transfer of traffic. This bridge as well as the captain's bridge is fitted with telegraphs, control standard and other apparatus.

Two steam capstans are installed forward and two aft for mooring the vessel, and, if need be, for assisting the wagons on and off the boat; they are each capable of exerting a pull of twenty tons.

Accommodation is provided below deck for officers, engineers, and crew, the side structure on deck being utilized for companion ways, cooking galley, etc. The *personnel* on each vessel consists of the Captain, three executive officers, four engineer officers, one wireless operator, and about 37 petty officers, gunners, and men.

Four 12-pounder guns are provided on each vessel. If need be, 4·7in. guns can be fitted. Magazines are arranged below the water-line, with trunks and ammunition hoists. Various anti-submarine devices are also carried.

All three vessels were designed and two of them constructed by Messrs. Sir W. G. Armstrong, Whitworth and Co., Ltd., Elswick; the third vessel, in order to save time, was placed with Messrs. Fairfield, Govan, Glasgow. All three were built of mild steel in accordance with Lloyds' requirements for Channel service steamers under their special survey and official inspection.

Signalling.—The signalling arrangements are designed as a complete system depending upon the communication bridge and the steamer: when the bridge has taken its correct bearing on the steamer, a certain sequence of signalling operations automatically follow: and when the bridge is raised from the steamer, it is mechanically impossible to run traffic on to it.

Traffic.—Two of the ferry steamers are employed on the Richborough-Calais route, and the third one is operated between Southampton and Dieppe—the use of Dunkirk as a terminal port having been held over for military reasons. The sailings are determined by tidal and naval conditions. On the average, a daily service is maintained between Richborough and Calais, and one sailing every 48 hours on the Southern route.

The control of the traffic, berthing and loading is in the hands of the Director of Inland Waterways and Docks at home, and in those of the Director of Docks at the French ports. The actual sailings are made under the current Admiralty regulations. The class of traffic carried is agreed upon each month by the Director of Movements in consultation with the Director of Docks.

The procedure adopted in order to secure the wagons on the ferry steamer is as follows:—

As soon as a line of wagons has been backed on to the ship, gangs of men apply all the brakes, and place a number of rail scotches in position, six to each track. When the boat has been completely loaded each wagon is made fast to the ship by four chain slings, one round each buffer casting, and shackled to ring bolts riveted to the deck. The slings are tightened up by means of union screws with fly nuts. Four jacks are then placed under each wagon at the corners of the body and its weight taken by them, thus relieving the springs of part of their load and preventing all oscillation during the sea passage. The time taken in these operations is twenty minutes to half-an-hour; to economize time the slinging and jacking is carried out while the vessel is getting under weigh, and the men put ashore either by the port tug or at the locks, according to the port concerned.

Experience has shown, however, that these security precautions are unnecessarily elaborate, and they are being modified accordingly.

Some particulars are appended of traffic at Richborough and Southampton carried by the train ferries to date. At the outset of the service, War Department trucks were carried for use in France, which had formerly been taken by ordinary steamer. In seven trips from Richborough 340 trucks were carried, and 631 trucks in 13 trips from Southampton. As a comparison of the utility of this service with ordinary shipping, it may be noted that a steamer of 3,600 tons d.w. carrying capacity could carry only 300 trucks in a month. It is calculated that, carrying heavy cargo such as tanks, guns, ambulance trains, motor transports, etc., the three boats will release six 8,000-ton ocean-going steamers hitherto entirely employed on this traffic—apart, of course, from the considerable saving in handling, etc., required by the ordinary method of double transhipment. The ferries are especially useful in regard to the carriage of heavy siege guns on their own mountings, which can be sent over intact and railed straight to the Front instead of having to be sent over dismantled and put together in France.

An addition to the train ferry fleet is now being acquired in the shape of the train ferry steamer *Leonard*, which until the completion of the Quebec Bridge carried passenger and freight trains between Quebec and Levis across the St. Lawrence at all seasons of the year. An exceptional feature of the vessel is that she has an elevating deck with a lift of 18ft. to meet the difference in tide-level. The principal dimensions are:—

Length over fenders	326	feet
Breadth moulded ...	65	,,
Depth moulded ...	23	,,
Mean depth loaded	15	,,

It is intended to run this boat from Southampton, where a second berth can easily be provided.

In view of the objections to the scheme put forward on the part of the Admiralty and the Ministry of Shipping, it may be noted that, in actual working, despite the very abnormal conditions and difficulties incident to naval restrictions which have prevailed since the inauguration of the service, the train ferries have proved satisfactory in every way and of the utmost value as a rapid and efficient means of transportation between England and France. As a war measure especially, the service has been fully justified by results already obtained, and under normal conditions of free and unrestricted running, it would be possible to maintain a constant "shuttle" service between all five ports, thus securing the greatest economy and efficiency in operation.

RICHBOROUGH.

	OUT.			IN.	
	Feb.	Mar.	Apr. to 27th.	Mar.	to Apr. 27th.
Locomotives and tenders			14		11
(Petrol)		4			9
(Steam, narrow gauge) ...					42
(Electric)					6
Wagons, new	390	150	243		
(For return and returned) ...		616	450	419	660
Steam roller			1		
Guns and Carriages		286	248		
Tanks	1	35	92		
Timber, tons	856	2871	195		
Crane parts, tons		62	143		
R.F.C.		12			
Tank Corps (Tanks as above and Stores) tons	26	1251	3115		
Petrol, tons	714				
R.E. Stores, tons			141		
Hay			216		
Machinery					1264

SOUTHAMPTON.

	OUT.					
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr. to 27th.
Locomotives and tenders						4
Number of wagons, new	38	404	99	44	298	73
Ambulance wagons					16	48
Motor lories...						172
Motor vans					60	130
Cargo, tons					104	792

Appendix B.

MESOPOTAMIA.

In July, 1916, the War Office assumed control of the operations in Mesopotamia, and in September, 1916, the I.W.T. took over the River Transport Service from the Royal Indian Marine. At that date the number of vessels of all classses operating on the Tigris was 348, and the volume of tonnage carried was 2,555 weekly, or 365 tons a day.

With the assumption of full control of I.W.T. the question of suitable type of craft was thoroughly investigated, and various improvements were effected and new types introduced. The fleet in commission at 30th March, 1918, stood as follows:—

Hospital Craft (including 71 Red Cross Launches)	98
River and Harbour Tugs	141
Troop-carrying Steamers	75
Barges for River Transport and Harbour work...	532
Special Service Barges in connection with the supply of filtrated water, chilled meat, vegetables, ice and oil	64
Launches	433
Fire Floats	3
Hydro Glisseurs for despatch work	9
Total	1,355

Further craft aggregating 146 were also in Mesopotamia under re-erection or being equipped at that date, and these, together with additional vessels under construction in India or en route from England or India, will comprise the ultimate complete fleet of over 1,700 craft.

For the week ending March 23rd, 1918, the total tonnage was 43,012, or a daily average of 6,144, with a ton mileage of 8,433,178.

It was also found necessary to make immediate and adequate provision for workshops, to deal both with the larger re-erection of craft programme and, to carry out running repairs.

The re-erection of craft despatched from England and India was undertaken at the following Stations:—

Abadan,
Mohammerah,
Mahgil (Basra),

and between September, 1916, and March, 1918, the following craft have been re-erected:—

Tugs	3
Hospital Ships	3
Refrigeration Barges	2
Cargo Barges	84

whilst the following craft, which were sent out as deck cargo or under their own power, in addition to a large number of barges, have also been fitted up for river service in these yards:—

Paddle Steamers	38
Tugs	80
Hospital Ships	12

In addition fully equipped repair shops have been established at:—

Nasiriyah,
Ezra's Tomb,
Amara,
Kut,
Baghdad,

and on an average 75 vessels pass through the aforementioned eight yards for running repairs every day.

Other I.W.T. Activities.—The question of dock and wharf accommodation was taken up, and the erection of stores and bungalows, and in practically every case sites had to be filled in to above flood level prior to the commencement of building operations. Amongst other important construction works were a wet dock basin at Mahgil capable of being used at any state of the tide, with a water area of 12½ acres and having 6,000ft. of berthing frontage; three slipways, the largest of which can take a vessel of 250ft. in length; various jetties and piers, the longest being some 230ft. in length; 1,500ft. of wharfage at Basra Dockyard and at the new port of Nahrumar, five berths each 350ft. in length, have been designed, and one is already in use. A bridge at

Amara, 750ft. in length with a 20-ft. roadway, has also been constructed, and this, together with other bridges on the Tigris and Diala Rivers, and also maintained by the I.W.T. Large tanks for oil fuel storage are also being erected at the various river stations. In connection with the wharves and jetties 34 cranes have been supplied from England.

Buoyage and Pilotage.—With the recapture of Kut and the advance to Baghdad, the operations of the fleet were considerably extended; and important work was undertaken in the direction of establishing an efficient pilotage and buoyage organizations, involving the laying of some 600 to 700 buoys, and the erection of beacons, etc., whilst The Narrows, a very difficult stretch of the River Tigris some 15 miles in length, has been lighted by electricity, thus enabling vessels to proceed by night as well as day.

Extended Operations.—With the development of the military situation the services on the Euphrates were extended, and during December, 1917, an average of 873 tons weekly was handled in that sphere alone.

Disposition of Personnel.—I.W.T. Stations are now established at Abadan, Mohammerah, Basra, Mahgil, Kurna, Zenr, Ezra's Tomb, Qualat Saleh, Amara, Ali Cherbi, Sheik Saad, Kut, Hainaida, Azizieh, Karradah, and Baghdad, on the River Tigris.

Ahwaz, on the Karun River.

Bakub, on the River Diala.

Nasiriyah, Kufa, Killa, Hindia Barrage, Museyib, Sadiyeh, Ramadi, Madhij, Foluja, and Mupraz, on the River Euphrates.

The strength of the I.W.T., including attached and labour units, has grown steadily from 7,171 in September, 1916, to 43,906 in March, 1918.

In February, 1917, the functions of the I.W.T. were extended to include :—

(*a*) The control of the discharge of cargo at the Port of Basra with the attendant tugs and barges.

(*b*) The conservancy of the River Tigris above the Port of Basra.

As regards (*a*), the average period of detention of store ships as Basra decreased from 13.5 days in January, 1917, to an average of 6.2 in March, 1918. The weekly average of tonnage discharged in January, 1917, was 19,771, and in March, 1918, 32,397 tons. In the week ending March 8th, 36,165 tons were discharged.

As regards (*b*), energetic steps have been taken to conserve the waters of the Tigris by the construction of various weirs, dams, etc., including the repairing of the Shujair Bund, wrecked by the Turks previous to their retreat, an operation involving the excavation of 15,000 cubic metres of soil, the filling in of 44,000 cubic metres and the facing of the Bund with 25,000 sandbags, and the training of the river channels in low water by a system of bandalling.

The result of this work should be reflected in the anticipated maintenance of a 5ft. minimum channel during the low water season of 1918 (June to November), the previous draught being one of 3ft. 6in. only, with an occasional drop to 3ft.

At the moment the question of the division of such duties as affect the control of the Port of Basra, the management of the Ports of Basra and Nahrumar, including the discharging of cargoes, and the control of the necessary craft, plant, and labour; constructional work at ports and maintenance of wharves and piers, and the control of harbour masters, pilots, buoyage, and lighting in these ports and their allocation under two new Directorates; port control and docks, is under review.

Appendix C.

CRANES.

I.W. & D. Standard Cranes.—The variety of requisitions for cranes of ordinary and special types to meet the particular local requirements pointed to the desirability of having a special standard crane to overcome the difficulties caused by this lack of uniformity, namely :—

(1) Delay in obtaining delivery.

(2) High cost of cranes made in small number to special designs.

(3) Expense in holding stocks of spare parts for the various types and makes.

(4) Special training of men to drive the different makes of cranes, and lack of interchangeability of labour from one appliance to another.

(5) Difficulty of transferring electric cargo cranes from one port to another when circumstances necessitate it, owing to the differences in the motive power available.

(6) Low value that will be obtained at the end of the war for cranes which have been designed for a special purpose and port and cannot be removed and used elsewhere without costly alteration.

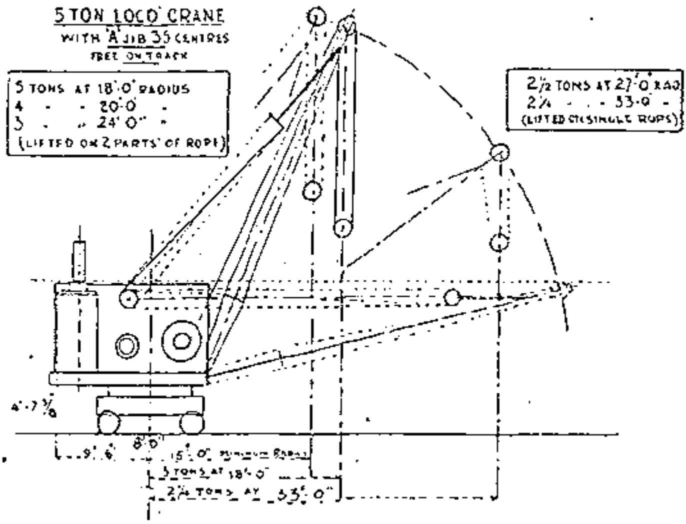
The I.W. & D. standard crane is a special design which has been prepared in detail by the Mechanical Section of the Directorate to overcome the above difficulties, and to meet as far as is possible with the minimum of alteration the varying demands from the various theatres of war.

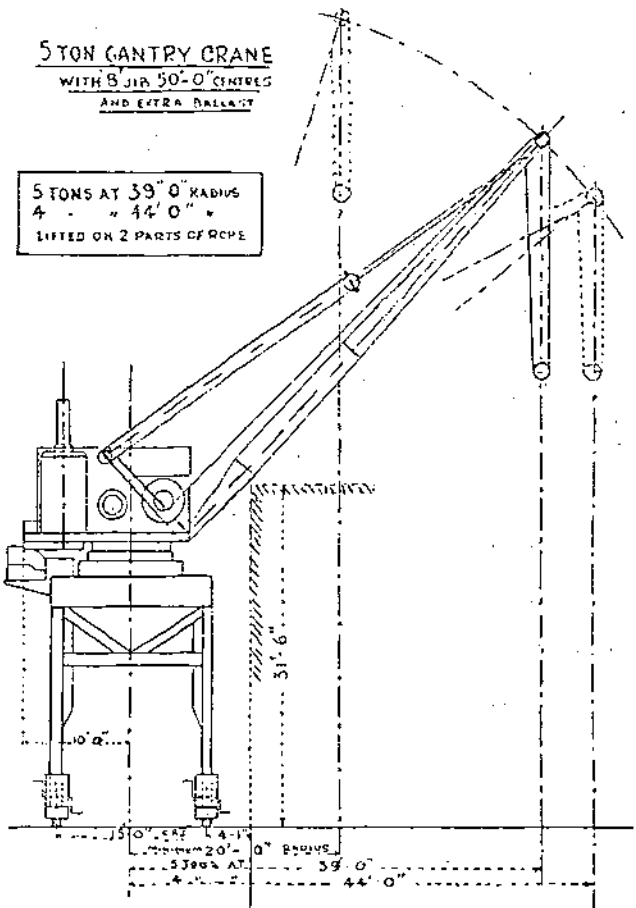
The special feature of the design is the ability to be used as a locomotive, fixed, floating or gantry crane without alteration to the machinery, the jib and balance weight only being altered to suit the location and duty to be performed. As a locomotive crane it can be used for general purposes, for grabbing or erection work for loads up to five tons; when so arranged it will conform to the French loading gauge.

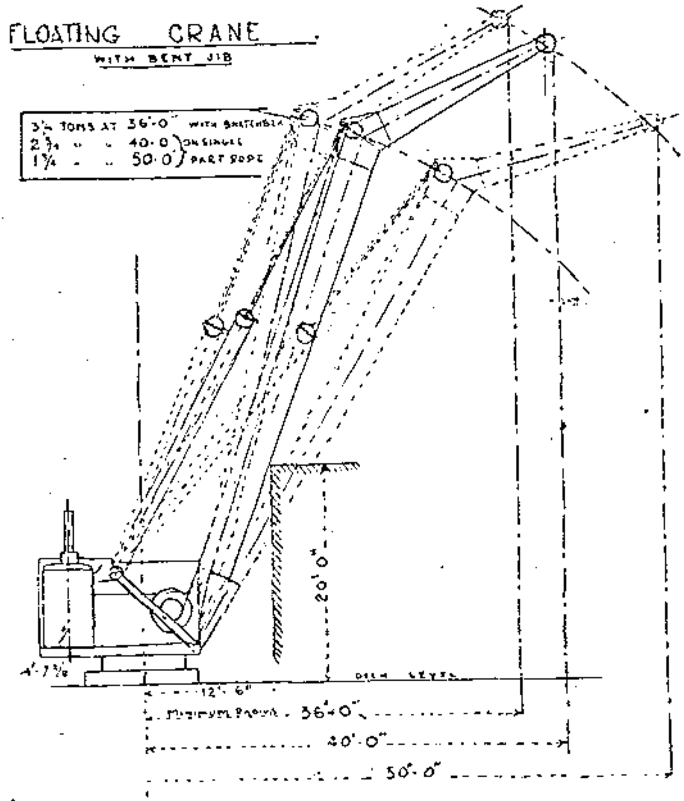
When the crane is required for dock use it can be mounted on a barge or gantry, when loads of 10 tons at 20ft. radius, five tons at 39ft. radius, or lighter loads at greater radii can be dealt with.

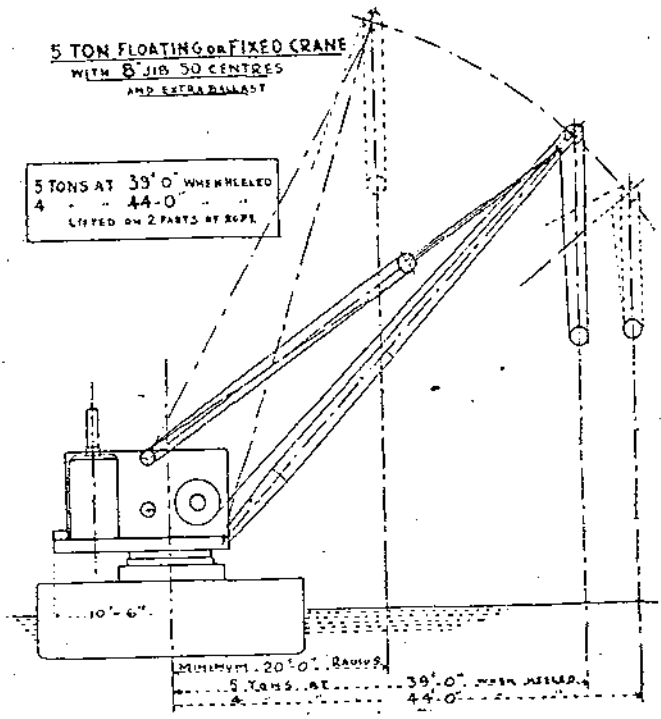
It is designed to give lifting speeds equal to a modern electric crane under these conditions, and is arranged so that the crane driver is placed in an equally favourable position at the front of the crane. Steam has been adopted as the motive power, as being self-contained, it is the only type of crane which can be sent anywhere without regard to local power supplies.

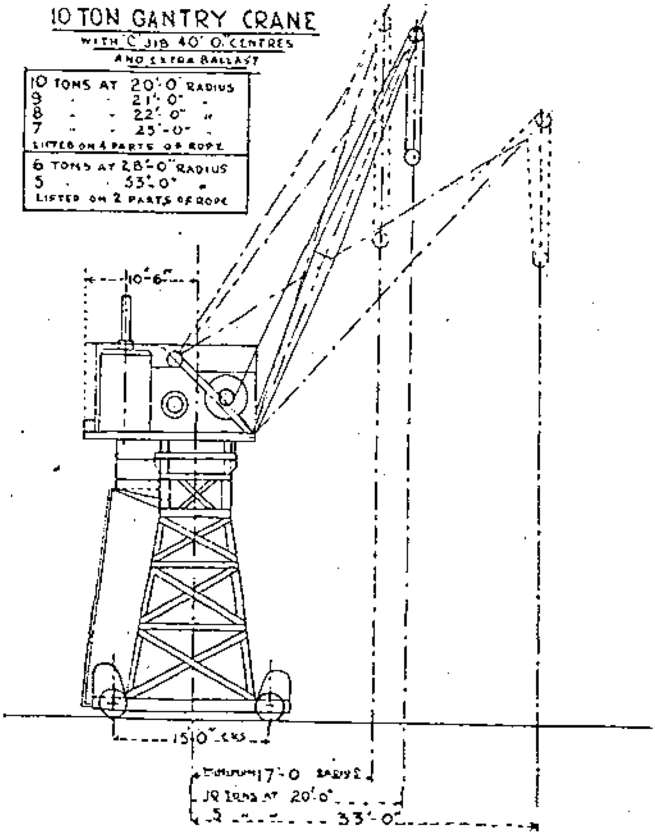
The attached diagram shows a few applications of the I.W. & D. standard crane.

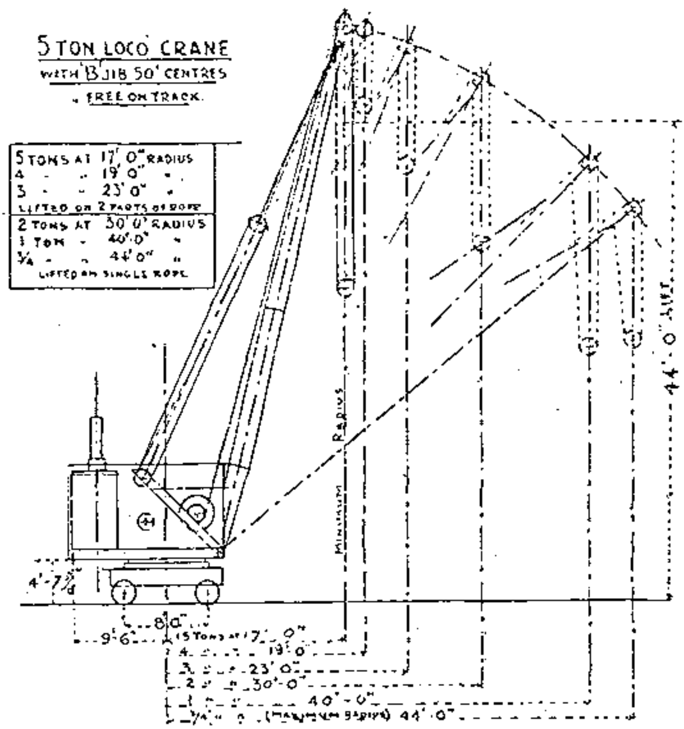

5 TON LOCO CRANE
WITH 'A' JIB 35 CENTRES
FREE ON TRACK
5 TONS AT 18' 0" RADIUS
4 " " 20' 0" "
3 " " 24' 0" "
(LIFTED ON 2 PARTS OF ROPE)
2½ TONS AT 27' 0" RAD
2¼ " " 33' 0" "
(LIFTED ON SINGLE ROPE)
4' 7⅝
9' 6"
8' 0"
15' 0" MINIMUM RADIUS
5 TONS AT 18' 0"
2¼ TONS AT 33' 0"


5 TON GANTRY CRANE
WITH 'B' JIB 50' 0" CENTRES
AND EXTRA BALLAST
5 TONS AT 39' 0" RADIUS
4 " " 44' 0" "
LIFTED ON 2 PARTS OF ROPE
31' 6"
10' 0"
15' 0"
4' 1"
MINIMUM 20' 0" RADIUS
5 TONS AT 39' 0"
44' 0"


FLOATING CRANE
WITH BENT JIB
3¼ TONS AT 36'-0"
2¾ 40-0
1¾ 50-0
20'-0"
4'-7⅜"
12'-6"
36'-0"
40'-0"
50'-0"


5 TON FLOATING OR FIXED CRANE
WITH 8' JIB 50 CENTRES
AND EXTRA BALLAST
5 TONS AT 39' 0"
4 .. .. 44-0"
LIFTED ON 2 PARTS OF ROPE
10'-6"
MINIMUM 20'0"
5 TONS AT 39'-0"
4 .. 44'-0"


10 TON GANTRY CRANE
WITH 'C' JIB 40' 0" CENTRES
AND EXTRA BALLAST
10 TONS AT 20'-0" RADIUS
9 - - 21'-0" -
8 - - 22'-0" "
7 " - 25'-0" -
LIFTED ON 4 PARTS OF ROPE
6 TONS AT 28'-0" RADIUS
5 - 33'-0" -
LIFTED ON 2 PARTS OF ROPE
10'-6"
15'0" CRS
MINIMUM 17'-0 RADIUS
10 TONS AT 20'-0"
5 " " 33'-0"


5 TON LOCO CRANE
WITH 'B' JIB 50' CENTRES
FREE ON TRACK.
5 TONS AT 17' 0" RADIUS
4 - - 19' 0" -
3 - - 23' 0" -
LIFTED ON 2 PARTS OF ROPE
2 TONS AT 30' 0" RADIUS
1 TON - 40' 0" "
3/4 - - 44' 0" "
LIFTED ON SINGLE ROPE
MINIMUM RADIUS
44' 0" LIFT
4'-7½"
8'0"
9'6"
5 TONS AT 17'-0"
4 19'0"
3 23'0"
2 30'-0"
1 40'-0"
3/4 (MAXIMUM RADIUS) 44'-0"

Cranes, other than I. W. & D. Standard Type.—In addition to the standard I. W. & D. steam cranes mentioned in Appendix "C," nearly every type of crane has been supplied to the various areas in which the B.E.F. is engaged; manufacturers' designs have been improved and brought into line as far as possible, with a view to standardization and rapid output; two standard types of electric equipment have been developed and adopted throughout, one for alternating current and one for direct current supplies.

In addition to the British Armies, cranes have been supplied to the Admiralty shipyards, the American Army in France, and a request has now been received for a supply of cranes from the French Government.

The attached schedule shows the various types of cranes which have been supplied to different Directorates and war areas.

645 Cranes Delivered to all Destinations up to 30th April, 1918.

	D.I. W.T.	D DO CKS	C.E. P.C.	D G. T.	BAS-RA	EGY-PT	D.R. T.	U.S. A.	R/B-RO	A.N. S.	D.C. A.S.	SUN-DRY	TO-TAL
Gantry Cranes	6	63							22				91
Loco Cranes	104	86	26	18	10	4	17	2	50	25	4	16	362
Derrick Cranes	5	4	18		2				45	9		9	92
Floating Cranes		17	1		1								19
Grab Cranes	10	2	5		1				13	2		.	33
Hand Cranes	12	1			20				14			1	48
	137	173	50	18	34	4	17	2	144	36	4	26	645

* This figure includes Cranes awaiting allocation, awaiting repairs and being repaired.

Appendix D.

Filtration Plants.—In all thirty-two of the above have been constructed. Of these twenty-four were for Mesopotamia, six for France, and two for this country. The aggregate capacity of the thirty-two plants is over four million gallons per day.

Of the Mesopotamia plants seventeen are stationary land plants and seven floating plants. The floating plants which are entirely self-contained and include officers' and crews' quarters, laboratory, store, etc., are reserved for the use of the forces in the field; the land plants, each of which is also a completely equipped unit with settling and storage tanks, and are placed at various points on the river to provide water on the lines of communication to passing ships, and to fill local requirements. For instance, one plant is placed at Marghil, another at the advance base, one at a group of hospitals north of Baghdad, two at Kutt, one on the left bank of the river at Amarah, one at Mohammerah, and one at Ahwaz.

These plants are capable of transforming the muddy Tigris water into a clear and potable supply, free of all disease germs. The plants sent out to France were all of the floating type and equipped for filtration and sterilization, and also capable of depoisoning water if required for this purpose.

These barges were referred to in one of Field-Marshal Sir Douglas

Haig's despatches when he mentioned that they were at work on the River Lys.

The two plants constructed for this country are in connection with air stations for the R.A.F., and are for the continuous purification and sterilization of swimming bath water.

APPENDIX E.

Forage Handling Plants.—Eight pneumatic grain handling plants, each capable of discharging from 80 to 100 tons per hour, have been completed, and six plants are at work as follows:—

Calais	2 plants
Havre	2 plants
Vendroux	2 plants

Recently the two Calais plants discharged the s.s. *Gloire de Larinaga*, carrying 6,360 tons, in 37 working hours, *i.e.*, an average rate of discharge of approximately 170 tons per hour for the two plants.

Mechanical plants for discharging hay from barges are also being supplied to France.

In addition, a large quantity of mechanical conveyors, stacking and labour-saving devices, have been supplied to various Directorates overseas.

CORRESPONDENCE.

FUTURE TACTICS.

To the Editor of the R.E. JOURNAL.

SIR,

With reference to General Walker's letter in the April number of the *R.E. Journal*, discussing the psychology of the British soldier and its effect on the design of defences.

Everyone will certainly agree with his final conclusion that all theories bearing on the principles of war should take into account the mentality of the troops concerned. But does the mentality of the British soldier affect the principles of the modern defensive as we have learnt them in the recent war?

Before abandoning principles built up on sound theory and tested finally in the war, we should examine very carefully how far these principles are affected by the soldier's mental attitude.

I cannot imagine anyone wishing to go back to the defensive methods of the early part of the war. I refer to the single continuous trench line, crowded with men, with little flanking fire, no supports, no depth in the defence, no special attention paid to points of tactical importance. I believe that method, quite contrary to our pre-war regulations, grew up through our inferiority of machine guns and of artillery compared with the enemy. We were forced to crowd men up into the front line, to stop the enemy at any cost, making flesh and blood do the work which was effectively done later by mechanical means, *i.e.*, machine guns, Lewis guns, artillery.

Surely the defended locality is the framework of the defence. One cannot imagine on any stretch of country—5 miles, 10 miles, 50 miles long,—that all the ground is equally valuable to the defence; that men must be stretched out in continuous and evenly distributed lines to defend it. There must be features whose defence will enable you to dominate and to deny to the enemy intermediate ground. The spaces you can thus deny may certainly be very small in some cases and larger in others; that depends on the ground, on obstacles, on weather, on night or day. Continuous lines of trench in the intervals are of value for communication purposes, and for concealing where you have made your defended localities.

In selecting any defensive position, the first principle is to choose ground on which all your weapons of defence may co-operate and may have the advantage over the enemy. This includes artillery, machine guns, Lewis guns, and rifles, all in their own sphere of action. Having found such a position the next step is to see which are the vital or essential portions of it, and which are the dominating features. It is on those that the first efforts of the defence are concentrated. It is along a series of such localities that the main line of resistance is constructed. There are many further principles to satisfy, such as depth in the defence, selection of an outpost zone, etc.

Now for the question of how the individual soldier is affected.

My experience has been that the individual soldier cares little and knows less of what is happening a few hundred yards on his flank, so long as he is surrounded by his own pals, the men of his own section, and his own platoon, and has a stout platoon commander to lead him. Under those conditions he will stay where he is put or advance where he is led. He probably also takes a certain interest in the troops supporting him. Now all these conditions can be got to perfection in the defended locality designed for a company, two companies, or whatever the conditions demand. You can have two platoons in front, a platoon in support, a platoon in local reserve, or some such organization. If that company is told to fight for a certain area, their own defended locality, they will do so. The fact that the flank platoon has no men in the next fire bay will not worry the private soldier or his officers either.

I have no wish to criticize previous views on this subject, but feel it right to put forward principles in which I believe.

Yours faithfully,

P. NEAME, *Lieut.-Colonel.*

24th April, 1919.

TRANSPORT FOR R.E. FIELD UNITS.

To the Editor of the R.E. JOURNAL.

SIR,

The following observations regarding transport for R.E. field units are put forward in case they may be of interest for discussion, and are based on experience of casualties inflicted on horses by aircraft and long-range guns. These two weapons have been developed to such an extent, that latterly the provision of horse lines within reach of advanced units became a matter of considerable difficulty.

Horses are extremely difficult to conceal, and are also very vulnerable to splinters from shells or bombs. Cases occurred where a single shell, of comparatively small calibre, from a high velocity gun, knocked out 20 to 30 horses on a picket line, and the losses from bombing were sometimes very serious.

In any future operations of a similar nature to those of the past war, with large numbers of improved aircraft and guns in action, it is to be expected that such losses would be very much greater, and probably prohibitive, in the case of fighting units. These units must necessarily have their horse lines fairly close up, *i.e.*, within ten to twelve thousand yards of the front, to be able to bring up stores or ammunition, etc., without too great a strain on their animals. In consequence the congestion of horses in the zone behind the battle front of an army which is temporarily stationary, must become very great and provide a large target. It is therefore suggested that the provision of some form of motor-tractor of tank type, to draw all first line vehicles, should be considered now, with other questions affecting the reorganization of R.E. field units. A form of tractor should be practicable that would be comparatively immune from damage due to splinters from bombs or shells, which are so fatal to horses, the losses from direct hits being few in comparison to those caused by splinters.

Tractors should also produce a saving in "man power"; for example a machine driven by one man should be capable of doing the work of at least eight horses, requiring four drivers. When the numbers of men employed in the remount and veterinary camps behind the lines, required by horse-using units, are also considered, and compared with the numbers that would be necessary in corresponding mechanical workshops, a further saving in "man power" would probably be found.

If a change on a large scale to mechanical traction instead of horse traction should become necessary, it would be better to experiment and make it slowly in time of peace than to be forced to carry out the change during active operations.

The rapid advance in the fighting power of aircraft, made during the past war, is likely to continue, and make the life of the horse, who cannot take cover from splinters in a ditch or trench, more and more precarious, in any phase of warfare in the future between two nations well equipped with aircraft.

Yours faithfully,

J. A. C. PENNYCUICK, *Capt., R.E.*

6th May, 1919.

NOTICE OF MAGAZINE.

REVUE MILITAIRE SUISSE.

No. 3.—March, 1919.

(Continued).

The German and French Cavalries in the Great War.

Colonel Poudret, the author of the original article, expresses the opinion that, if the former practice of sending officers on the instructional staff of the Swiss Army on foreign tours is revived in the future, it is to France that such officers should be sent and not to Germany as in former times. Lessons of greater value are to be learnt, it is pointed out, from the handling of the French Cavalry in the Great War than in the case of the German Cavalry.

The German cavalry at the outbreak of war took the field with 110 (active) regiments; of these regiments 66 were formed into cavalry divisions, whilst the remaining 44 were employed as divisional cavalry. Prior to the date when Roumania came into the war, the Germans had 11 cavalry divisions in the various theatres of operations; when Roumania joined the Entente Powers, the number of German cavalry divisions was increased to 14. Up to this time the German cavalry had played a most important rôle in the war.

The exploits of von der Marwitz's and von Richthofen's Cavalry Corps during the advance through Belgium into northern France in August and September, 1914, will be ever memorable in the annals of cavalry warfare. Later, the German cavalry played a brilliant part in the conquest of Courland.

As soon as the completion of the trench systems from the North Sea to the Swiss frontier brought the two belligerent groups to a halt in the Western Theatre, the Germans began to concentrate their cavalry in the East; they hoped by this means rapidly to crush the Roumanian Army and to bring about the surrender of Roumania.

However, so far as purely cavalry action is concerned, the German cavalry from this time forward ceased to play a predominating rôle in the war. A deficiency in horses led to a reorganization of the German cavalry in the spring of 1917; and a reduction both in the number of cavalry divisions and in their establishments took place at this time. A second reorganization of the German cavalry had to be effected in the spring of 1918 and this led to the formation of dismounted cavalry divisions.

At the time of the great German push in March, 1918, the German Army was without any large mounted formation on the Western Front for the purpose of exploiting the successes upon which von Hindenburg was reckoning. For this reason, some have doubted the wisdom of the Great General Staff in leaving the considerable forces of cavalry in Finland, Roumania and the Ukraine, which remained there throughout the critical days of March, 1918; this cavalry would have been of immense value on the Western Front at that time.

At the outbreak of war France had ten cavalry divisions; their organization, armament and tactical training were not so up-to-date as those of the German cavalry.

The French cavalry was, however, thoroughly imbued with the spirit of offensive warfare. It made what proved to be a fruitless raid into Belgium in the early days of the war and later made its presence felt at the first Battle of the Marne. However, it was not able to carry out the essential rôle of cavalry, on any scale, in the first stages of the war.

During the period of the " Race for the Sea," it was realized that the French cavalry would have to play, in the great War, a very different part to that for which it had been maintained and trained. Therefore, in November, 1914, the French cavalry was served out with the bayonet and began to prepare itself for the new rôle it was to be called upon to play. When the days of trench warfare arrived, it took its turn of duty with other troops in manning the parapets, and in holding the enemy in check.

The French cavalry was never reduced to the same straits as was the German cavalry for want of horses. Further, the French High Command was far-seeing and kept the future well in view, so that the French cavalry continued to be trained for mounted action. Some Cuirassier Regiments were dismounted in the spring of 1916, but the men remained available for reinforcing cavalry formations.

As the war progressed the equipment and training of the French cavalry continued to be improved and brought up to date. Not only was it provided with the bayonet, as already stated, but hand and rifle grenades were also issued to it, the number of machine guns with cavalry units were increased, etc., and finally in the spring of 1918 light 'tanks' were also attached to cavalry divisions and corps.

Colonel Poudret calls attention in the original article to the regulations relating to the employment of cavalry which were issued from the French G.H.Q. at various periods of the war, and deals at some length with the instructions of the 26th May, 1918. The instructions, last referred to, state that the training and organization of cavalry should be based on the following fundamental ideas:—" Under the conditions of present day warfare, dismounted action is the normal method of fighting for cavalry. Whenever cavalry is employed dismounted, it is essential that it should, as far as it is possible to do so, adopt the infantry organization, in order that it may thereby utilize to full advantage the experience of the war in relation to fire-tactics, manœuvring and the maintenance of touch throughout the several parts of the fighting line."

The changes introduced in the organization of the French cavalry for the purpose of giving effect to the foregoing "Instructions" are discussed in some detail in the original article.—(*To be continued.*)

Field Railways.

The author of the original article, Capt. Raoul de Diesbach, points out that the importance of the transport services in rear of the fighting line of an army has long been recognized. Although mechanical transport can to some extent be utilised to supplement the railway communications between the forward zone and the main supply depôts of an army, nevertheless, a resort thereto is accompanied by many disadvantages, such as congestion of traffic on the roads, the heavy wear and tear of their surface, etc. For this reason, for many decades past the armies of great powers have made use of the 60-cm. gauge railway invented by Capt. Péchot. A history of this invention and some technical details in relation thereto are given in the original article.

Captain Raoul de Diesbach gives, in the original article, an extract from the issue of December 4th, 1915, of the French paper *Liberté*, wherein is described the method adopted in the German Army for the rapid construction of field railways during the early days of the war. It is said that by working three shifts of 8 hours per day, the Germans were able to construct 12 miles of light railway in 24 hours; one railway company was employed during each shift.—(*To be continued.*)

The Future of the Swiss Army.

The anonymous author of the original article deals with the question of the retention, or not, of conscription in the Armies of the world, a question which has been occupying so large a place in the discussions at the Peace Conference in Paris. He points out that the adoption by revolutionary France in 1791, and by Prussia in 1813, of the Roman doctrine, that the claim to citizenship implied in return the obligation to render military service, arose from the necessities of the moment; in each of these cases it was the question of a defensive war, the Fatherland was in danger, independence could alone be secured by reconquest. Experience teaches that personal and universal service enforced at times of great crises inevitably results, in the cases of Great Powers, in the retention of such services as a permanent institution of the State. The militarising of a people increases the risks of war, and, at the same time, renders war more inexorable and its consequences more disastrous.

The author of the original article expresses the opinion that universal military service, although regarded as a victory for democracy, as a general rule favours militarism and increases the possibility of conflicts between the Great Powers. On the other hand, he thinks that the small nations, since they do not usually pursue an aggressive policy, can remain faithful to the principle of compulsory military service without any danger. This principle has been an ancient tradition with the Swiss; the Confederation adopted it at its birth in 1291.

The view is expressed that Great Powers, such as Great Britain and the United States of America, which have adopted conscription for the period of the war, can well abandon it on a return to peace. The dangers which beset them having passed away, these Powers can once more revert to their former system of professional armies. Not so is it the case with the small Powers; so far as the Swiss are concerned, not only is conscription, a hereditary tradition to them, but the very existence of their country, and the safety of their people depend upon it.

The author of the original article thinks that the British Premier and Mr. Wilson in advocating the suppression of conscription have overlooked the fact that the needs of the various nations are not identical. The question whether nations are to be allowed to maintain some form of conscription, or not, is considered to be of vital importance to Switzerland from the point of view of the steps to be taken for the defence of the Republic in the future and it is urged that a study of the problem should be taken in hand by Swiss diplomats without delay.

Notes and News.

Switzerland.—The anxiety which exists in Switzerland in relation to the proposal to create a League of Nations is reflected in the repeated references which are being made to this subject in the Swiss press. It is evident that a large section of the Swiss people do not look with favour on the proposal and, indeed, fear that should a League of Nations come into existence, a situation is likely to be created which will militate against the interests of the Helvetic Republic. The Pact of Paris recalls the early conventions of the Helvetic Leagues; short extracts are given in the original notes relating to the Alliance of August 1st, 1291, of the Pact of Brunnen of December 9th, 1315, of the Charter of the Priests of October 7th, 1370, the Covenant of Sempach of July 10th, 1393 and the Covenant of Stans of December 22nd, 1481. The changes which have taken place in the general character of human society since the days of these early conventions have in no way altered the fundamental principles upon which schemes for collective defence rest.

The Swiss Federal Council appears to have been busy in preparing a scheme to secure the peace of the world. It is said to differ widely from that drafted by the Peace Conference at Paris. The Paris scheme, it is argued, attempts to create a positive military alliance for the maintenance of peace; the Berne scheme, on the other hand, binds the States of the League more loosely and distinguishes between those States which will be compelled to undertake military duties on behalf of the community at large and those that will be freed from such an obligation. The aim of the framers of the Berne scheme is to maintain the *statu quo* in Switzerland; they desire that the defence of their country should be left entirely in the hands of their own government as an independent matter. The Paris scheme, it is thought, would impose upon Switzerland military obligations of a different kind to that which her citizens have been accustomed and would therefore necessitate a complete reorganization of the Helvetic Army.

INFORMATION.

The Defeat of the German Army.—A note is published in relation to the article on this subject which appears in the *Revue* for February last (*vide R.E. Journal* for May). It is pointed out that the statement made by Erzberger, the German Foreign Minister, at Weimar on the 18th February last, proves clearly that the German High Command capitulated in spite of the fact that nine out of the ten conditions imposed by the victor were held to be intolerable. Would a Commander-in-Chief, it is asked, have accepted such terms had it been possible for him to extricate his army from the position in which he found it under the circumstances?

Philately in the Swiss Army.—Philatelists may be interested to learn that during the war Swiss soldiers have been busy designing war stamps. Many of the regiments of the Swiss Army have their own special war stamps and it is said that the rarer specimens have been fetching ten francs and more. The following firms have made a speciality of this branch of philately:—E. Locher of Zurich, Zumstein et Cie. of Berne, and E. Sauer of Berne.

A short notice on Dr. Jancovici's work *La Paix de Bucarest* (Payot et Cie, Paris) appears in the *Bulletin Bibliographique* of this number of the *Revue*.

No. 4.—*April*, 1919.

MORALE AND CIVICS AS INFLUENCES IN THE TRAINING OF THE RECRUIT.

The original article consists of a lecture given by Lieut.-Colonel A. Fonjallaz to the instructional Staff of the Swiss 1st Division and is published in the *Revue* at the express request of the Inspector of Infantry of the Swiss Army.

Colonel Fonjallaz points out that the moral factors have exercised a decisive influence in the Great War. The troops of the Entente Powers have been sustained throughout their great effort to wrest the victory by their *morale*, whilst it was on brute force and in numbers that the Germans primarily placed their reliance.

The orders issued by Marshal Joffre and by the generals in command at Verdun, at Amiens and in the Champagne, during the critical days, all disclose the same fact, namely that it was the moral factors that gave the French the will to conquer and enabled them to accomplish great things.

It is pointed out that whether a man be Francophil, Germanophil, or strictly neutral, in every case it is admitted that had it not been for the *morale* of France, the French troops could never have made the stand they did in the early days of the German invasion.

The results obtained by the leaders of the French Army have been extraordinary, and are due entirely to the important measures taken to develop the moral qualities of the soldier during his military training. The French Army of 1915 was transformed into a most powerful instrument of war by a process in which the discipline of the heart and of character replaced the German scheme of individual training, a scheme which relies chiefly on mechanical discipline for its success.

It is urged that the most effective way to develop the moral qualities of a soldier is by establishing the closest personal contact between him and his officers, and by the latter setting him a good example. Officers can, it is pointed out, have direct and close relations with their men without jeopardizing in any way their authority; they should, it is suggested, make a point of getting to know each individual recruit, of studying his idiosyncracies, of advising him and of directing him.

Colonel Fonjallaz sets out the principles upon which each instructor should, he thinks, prepare his programme of instruction; they are as follows:—

(*a*). Lectures should be given on simple, practical and useful subjects likely to appeal to the better side of a man's nature.

(*b*). The language employed should be accommodated to the intelligence of the soldier, a sparing use should be made of notes and of abstract science.

(*c*). The soldier should be addressed familiarly and made to feel that an ordinary mortal, like himself, is speaking to him and not a superman.

Every effort should be made to provide bright and comfortable rooms for the purposes of these lectures. Environment is to education, what fertility of the soil is to the production of crops.

Another kind of moral preparation consists in officers mixing with the men on as well as off parade, and chatting with them with a view to ascertaining what is most pre-occupying their thoughts. In this way a great school is formed for character study; and officers are thereby enabled to classify those under their command according to the categories to which each man belongs.

The great thing is for officers to talk on matters which will interest the men; to tell them the history of their colours, of the campaigns in which the regiment has taken part, etc. An outline of a proposed course of lectures is given in the original article, which concludes with a short list of books likely to prove useful in the preparation of lectures.

Field Railways.

The improvements which have been made in the methods of construction of field railways, have, it is pointed out, very materially increased the mobility of troops in relation to the strategic aspects of warfare. On the other hand, field railways involve the use of expensive materials and the raising of a large body of highly technical troops—10 to 12 companies, *i.e.*, from 2,500 to 3,000 men, are required for the construction of 100 kilometres of field railway. About one-third of this number are required for dealing with and attending to the traffic on a similar length of line.

Some details are given in the original article of the railway troops maintained in various armies at certain periods before the outbreak of the Great War.

A brief description of the Henry portable steel bridge is also contained in the original article. There are three types of this structure, intended respectively for bridging gaps of (*a*) 6 to 33 metres; (*b*) 33 to 40 metres; and 40 to 54 metres. The design of the elements of the bridge is such as to permit the construction of a bridge which will simultaneously carry a load of 2 locomotives of 87 tons and 4 wagons of 15 tons. By using the Henry structure a 30-metre gap can be bridged in 32 hours.

It is pointed out in the original article that the Henry portable bridge would be exceedingly useful in the mountain regions of Switzerland, and it is suggested that the Swiss Bridging Battalions should therefore be equipped with the materials for constructing such bridges.

A New Measure of Physical Strength.

The orginal article is contributed by Dr. F. E. Koby, a Surgeon-Lieutenant in the Swiss Army. He uses the term "robusticity" to describe the physical qualities required in a soldier; qualities summed up by him in the three words *strength*, *agility* and *resisting power*. It is pointed out that it is essential that medical officers engaged on recruiting duties should be able rapidly to come to a decision as to whether a man is physically fit for military service or not. Having ascertained that a man is not suffering from any malformation or disease which will disqualify him, the medical man must finally base his decision in relation to the morphological type to which the subject belongs and to measurements. The various morphological types and the question of measurements are dealt with briefly in the original article.

A formula is given by Dr. Koby to represent the "index of robusticity," whereby it is possible to classify individuals into four medical categories according to their physical development.

The Training of Troops.

The original article is from the pen of Colonel Monnier who takes exception therein to the tenour of the contributions which have been appearing in the *Revue* on the above subject. He points out that the readers of the *Revue* would imagine from the attitude taken up by the authors of the contributions in question that only since the mobilization of 1914 has any real progress been made in the training of the Swiss

Army. To combat this view, he quotes the opinions of French officers who visited the recruits' school at Colombier, in 1913, and also those of other foreign officers who have had occasion to attend the manœuvres of the Swiss Army in the pre-war days.

The Army and Unemployment.

The sudden cessation of hostilities in November, 1918, appears to have produced a critical situation in Switzerland by throwing large numbers of men out of work. At the beginning of the war large numbers of Swiss went into foreign countries to work in munition factories; when the war ended some 60,000 of them were dismissed from their jobs and returned to their homes in Switzerland. The demobilization of the Swiss Army towards the end of 1918 aggravated the situation, which was taken advantage of by the labour agitators for their propaganda purposes.

The military authorities have come to the rescue in order to provide some relief in the cases of demobilized soldiers; regional bureaus have been opened at Geneva, Lausanne, Neuchatel, Zurich, Soleure, St. Gallen, Lucerne and Berne with the object of helping to place discharged soldiers into suitable situations. These authorities have also placed the use of barracks, bedding and other equipment at the disposal of private undertakings for the purpose of housing their men.

Notes and News.

Switzerland.—It is announced that the *Revue* will shortly publish a pamphlet entitled *La Ligue des Nations et la Neutralité de la Suisse*; Colonel Feyler is its author (price 2.50 francs).

It is stated that Swiss newspapers are advocating the raising of a Swiss Corps for active service against Bolshevists. The opinion is expressed that the employment of Swiss troops for such a purpose would in no way affect Switzerland's position as a neutral State: the existence of civilization is seriously threatened at the present time, and it is urged that the Swiss should participate in a crusade for the preservation of law and order in the world.

The *Société fédérale des officiers* is considering the question of starting a journal of its own; it is proposed to publish the articles therein both in French and also in German. This idea has been mooted on two previous occasions, but serious difficulties were met with in the attempt to produce a bilingual publication; these difficulties may, however, now be overcome.

The agitation for the appointment of officers from the "Suisse romande" to the General Staff is again in evidence; the "Affair of the Colonels" would appear to be still disturbing military society in Switzerland.

Portugal.—A special correspondence raises a protest against officers of the army intermeddling in politics. It is stated that Military Committees, the *Juntas*, were recently formed in Portugal and were being consulted by the Government. A critical situation supervened in consequence, but apparently the Civil Power has once more established its supremacy in the State.

INFORMATION.

In a short note is described Lieut. Dagoberto Godoy's great exploit of flying over the Andes, at an altitude of 7,000 metres, in a "Bristol" monoplane. He crossed the range over "Tupungato" (6,500 metres); the journey from Santiago to Mendoza occupied 1 hour 25 minutes.

W. A. J. O'MEARA.