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# CHEMICAL WARFARE.

(*Lecture delivered at the S.M.E. on* 8. 12. 1921, *by* CAPT. S. J. M. AULD, O.B.E., M.C., 4th (Terr.) Batt. Royal Berks Regt.)

IT is at the risk of being written down as an exponent of the worst type of inhumanity and as a person with distinctly ungentlemanly ideas of soldiering that I introduce my subject by stating didactically and without preamble that I consider chemical warfare to be the warfare of the future.

In the military quiescence following the cessation of a great war comes the opportunity for reviewing the experiences of the past and building thereon, by the application of deduction and controlled imagination, the foundation of preparedness for the future. That is the position at present. The General Staffs of the world's armies are working unobtrusively, single-mindedly, and with what imagination they can bring to play, forecasting the future on the basis of the past.

But there are some truths too large for the imagination at once to grasp, some inductions apparently too fantastical to accept, and, if accepted, too much opposed to vested interests, to the condition of things as they are, to be adopted forthwith as fundamentals of progressive development. This is the position of what we have been used to call " Gas " warfare.

We have come to a forked road in the march of military progress. During the War, by force of circumstances and against our wish, we were induced for a short distance to follow the pathway of revolutionary change. Now, many seem anxious to return to the old road. Some, after a partial reconnaissance or no reconnaissance at all, claim that the new road leads nowhere and will only dirty our feet to no purpose by following it. Others realize whither the new road leads but are daunted by its prospects. To follow it seems to imply the eventual discarding of known and approved methods, a complete dissociation from old ideas and a general committal to the adoption of strange and, to the average soldier, unnatural, methods of fighting from which he shrinks.

My lecture to you to-night is intended to be a military one, but its value would be small if I neglected to make it perfectly clear that, whether we like it or not, Chemical Warfare has come to stay. It is inconceivable that the light barriers of mutual consent or of edict can effectively close the road I speak of. Military history and human nature are against it at every turn. No case is known of a successful new weapon or a tactical advantage having been discarded once its value was approved. No agreement or treaty has proved strong enough to bind an unscrupulous enemy seeking an advantage, or for that matter one with its existence at stake. To avoid the new road is to risk being passed in the race of preparation and being outflanked and overwhelmed in the event of hostilities.

Whatever we do in the matter we can bind no one but ourselves. Until War ceases we must be prepared. Apathy is suicidal. Prejudice is a crime.

When Germany broke faith with the civilized world in April 1915, and loosed on unsuspecting and unprotected men a cloud of chlorine, a new weapon was added to the world's armoury; the deadliest weapon so far invented by man had been forged. From that date till the close of hostilities the developments in chemical warfare were so far-reaching, so fundamental, that to think of gas, as many still do, in terms of 1915 is as anachronistic as thinking of to-morrow's battles in terms of Wellington's campaigns.

It is this failure on many sides to envisage the progress already made in developing the use of gas which has made it possible for anyone to consider the relegation of gas warfare to the past and carrying on future wars without it. A full knowledge of the past, and an appreciation of the possibilities of the future should convince every soldier that the use of poisonous and irritating gases is just as fundamental as the introduction of gunpowder, and probably even more so. Couple this conclusion with the belief that you cannot enforce the fulfilment of peace-time agreements during war, and you come to the logical conclusion that the country which does not regard chemical warfare as the very basis of its military preparations for the future is deliberately risking absolute and unmitigated disaster at the hands of its more progressive, or, if you will, its less scrupulous opponents.

The present dangerous apathy in the Army with regard to "Gas" is unquestionably due to three things; the "marking time" by the G.S. pending Government decision on the basis of international agreement, or disagreement, regarding the legitimacy of the weapon; the lack of knowledge on the part of officers—both senior and junior; and the lack of sympathy with the subject *in toto*, resulting from the natural feeling that it is a rotten way of fighting anyhow. But ignorance in all ranks is the chief reason. Once the veil is lifted the "merely brave" officer who wishes to charge the enemy "sword in hand" can have little weight. Surely none at all, if it is seen that the very existence of the country may be imperilled.

The widespread ignorance is due to three main causes:

In the first place it was almost impossible for the average officer who went through the War to gauge the relative importance of Gas from his own observations, however wide his personal experience. How many of those present, or indeed in the Army as a whole, who went through it all, are aware that in their last great offensive fifty per cent. of the German shell were wholly or partly chemical-filled? Or that of the American army, the only one for which classified figures are available, nearly thirty per cent. of the total casualties were gas casualties? Or that, towards the close of the war our Special Brigade, R.E., carried out attacks in which as much as 160 tons of gas were liberated on a short front in the space of a few minutes? Not many, I will wager.

Secondly, the officers who could and should have perpetuated the war knowledge of the use of gas and who might have provided the necessary continuity of appreciation of the subject have left the Army. Practically all the commissioned personnel, whether Advisers, Special Troops Officers, or Anti-Gas Officers, were non-regulars.

How many active regular and T.F. officers are acquainted even theoretically with the military technique of gas warfare? How many infantry battalions have established a tradition of anti-gas discipline consonant with their war history or the standard of their other training? How many young officers are taught to imagine all their field work—their company training and their tactical excercise—as punctuated by gas or the fear of gas? How many artillerymen have studied the science of using gas shell? How many gas shell are fired in practice at the Artillery School?

The answers to these questions are very disquieting to one with a belief in the future of chemical warfare. More, they are thoroughly alarming.

The reason is the hiatus which already exists between the knowledge of the Army in 1918 and to-day. It would be possible to count on the fingers the active officers of to-day who were intimately connected with the Chemical Warfare organization of the past. *Yet gas might easily have had us beaten on three separate occasions in the war, and to this I can add with some confidence that had Germany not retired when she did the Gas Service was in a position to operate with greatly increased effect.*

Then there has been the secrecy maintained about the whole subject; a secrecy which, concerning the past, has only very recently been dispelled at all. This secrecy has had unfortunate results. It has caused the subject to be viewed, even in the Army, in the light of the horrors of 1915—the only period at which considerable publicity was given to it in the press. It has obscured the consideration of the military value of gas and its legitimacy for future employment. Facts have not been allowed sufficiently to speak for themselves. There has consequently been too great an opportunity to decry the effects of gas on the one hand or to magnify its brutality on the other. As a result the significance of chemical warfare, its accomplishments in the past and its potentialities for the future have been largely denied to the people it affects most—the younger generation in the Army. A frank appreciation of these facts is needed—more, I think, than anything else—for it is a bald fact, which can scarcely be questioned, that the millions we spend annually on our armed forces is money wasted unless ample provision is made for the study and practice of chemical warfare.

If you believe in the possibility of a known and powerful weapon being eliminated from war by agreement, well and good. If not, then every staff and regimental officer who does not think gas and consider gas in every phase of attack and defence is falling short of his responsibility. You cannot say in effect—"Let's pretend we don't see it, perhaps it will go away." It won't go. However unpalatable the prospect you must be prepared to face it.

It is for the purpose of emphasizing these conclusions and not as the end itself that I will tell you what I can in general of chemical warfare in the short time at my disposal.

In the first place, as you are probably well aware, the term "Gas" is a misnomer. Chemical warfare is only "gas warfare" in the sense that the toxic or irritant chemicals used are at present carried by the atmosphere. Actually the substances are mostly liquids and finely divided solids. Even the true gases, when used, are reduced to the liquid form under pressure and only become gases again when their containers are opened or burst.

The offensive in chemical warfare comprises cloud attacks, and bombardments with projector drums, T.M. bombs and artillery shell. In each case the attack has two main objects—the infliction of casualties and neutralization. Generally speaking, the infliction of casualties is the more important because if sufficient in extent it achieves the second object more effectively and for a longer period. Also, since the most effective casualty is a permanent one, chemical warfare aims to kill where it can. The possibilities of this are dependent, however, on the amount and nature of the materials available. Indeed, all gas tactics will vary from time to time according to the nature of the enemy's protection and the type and quantities of the weapons and chemicals employed.

It is in this particular connection that the extraordinary power and potentiality of chemical warfare can be realized. The whole realm of chemistry is available for exploitation to provide new materials. In organic chemistry alone the possibilities are almost infinite. Consider the steady growth during the war of the toxicity and insidious nature of the chemicals used: First came simple asphyxiating gases like chlorine and the relatively non-toxic tear gases or lachrymators; then followed the more effective asphyxiants like phosgene and paralysants like prussic acid; close at their heels came the so-called sternutators or sneezing-gases, which were powerful mucous membrane irritants; finally the important stage of the vesicants—the skin irritants like mustard gas—which at the same time combined many of the properties of their predecessors. There were others, not so easily classified by the layman.

Each of these classes had numerous members which were adopted, used or discarded according to the ease of manufacture or employment, their field effect on men, and the protection attained against them by the other side. The Germans alone used between twenty-five and thirty different chemicals in the form of cloud gases or fillings for projectiles.

It is obvious then that this whole question, if treated at all, must be treated *fundamentally*. There is no shirking it, or going in for half measures. Certain general principles are involved, a number of tactical factors are constant, but the variables are so numerous that the possibility of taking up chemical warfare in a haphazard way, or as a mere adjunct to existing methods is bound to end in disaster at the hands of an enemy more thorough or better informed than ourselves.

The "variables" I would classify from the purely military aspect as—

(1) Weapons;
(2) Physiological effect of the chemicals;
(3) Physical properties of the chemicals;
(4) Quantity of chemicals available;
(5) Nature of the enemy's protection.

I would like to say a few words about most of these divisions as the best way of giving you a rough general oversight of the whole subject.

There are practically only three special gas weapons—the cylinder, the Livens projector and the toxic smoke generator.

In all the cloud attacks of both sides during the late war the gas was enclosed in steel cylinders ranging in weight from 90–120 lbs. when full, and after installation in the trenches was liberated when the wind was favourable and the atmospheric conditions good. This method is very crude but has nearly always proved very effective because of the ground it covers. Towards the end of the war it gradually fell more and more into disuse as other methods were developed because of the arduous and lengthy preparations required for carrying it through and the decreasing possibility of effecting surprise. Just before the close of the war, however, it enjoyed a wonderful revival in special circumstances by the organization of highly concentrated "beam" attacks, delivered from light trains instead of from the trenches. Around Lens and in the Ypres Salient, advantage was taken of the network of narrow gauge lines to bring up trains loaded with many thousand cylinders of gas which were discharged simultaneously by electricity. As many as 6,000 cylinders from three trains in echelon have been discharged over a short front in the space of a few minutes. The concentration of gas produced in this way is terrific, the element of surprise is much emphasized and the effects very marked.

The "beam" attacks were really a matter of increased mobility, and to this end much attention was also paid to making portable gas cylinders capable of being carried by one man and of being used in comparatively open warfare.

Gas clouds suffer, however, from an even greater disability than their clumsiness. The concentration of a gas cloud is greatest at the point of discharge and after that decrease as a function of the square of the distance. This is wrong. The concentration should be greatest on top of one's enemy; not on top of oneself. It was to get over this objection that Livens invented his "projector."

The projector is simply an earth mortar—a steel tube buried in the ground at 45°, variation in range being obtained by altering the propellent charge. So simple was the design of these "guns" as used in the war that the electric wires for firing passed down the muzzle, alongside the drum or projectile to the charge. Yet this crude weapon was one of the most effective of the war. They were set by hundreds, sometimes by thousands, close behind the front trenches and were fired simultaneously by blasting machines. As the drums contained 30 lbs. of gas, the effect, for example, of the discharge of 2,500 at one time into Lens can be imagined. The projector is deliberately in no sense a weapon of precision. In its very crudity lies its genius. It simply allows the deadly gas cloud to be started, without warning, 500–1,000 yards closer to the enemy. It was adopted by all the belligerent armies, including Germany.

Of the toxic smoke generators I shall have something to say later.

Now, with regard to the pukka projectiles—the T.M. bombs and artillery shell.

Gas filled into 4-in. Stokes mortars was largely used by the Special Brigade, R.E., but there is little reason why gas-filled bombs should not in some circumstances be fired by ordinary T.M. batteries, and this is bound to come. Indeed, the Germans adopted this plan with much success, especially with their light Minenwerfer.

The great advantage of the Stokes 4-in. for chemical warfare is its rapidity of fire. Under battle conditions fifteen shots a minute can be got off. In this way, despite the relatively small amount of gas in the bomb, local high concentrations of gas or smoke can be produced with success. For surprise tactical purposes at close quarters or for vicious interference with everyday work in the trenches chemical-filled T.M. bombs were of the greatest use, but it is doubtful if we took full advantage of this in the latter stages of the war. I was with the American Army in the Battle of the Argonne, and it was really surprising how mobile the Yankees made this gun and how much they used it in open fighting. Their gas regiment, the 30th Engineers, was up with the infantry the whole time and accomplished some fine work in dealing with machine-gun nests with Stokes bombs filled with phosphorus or thermite. The guns were either man-handled or carried on pack animals or mounted on light improvised carriages. Transport of ammunition was the chief difficulty, but there is unquestionably a big future for the really mobile mortar of this capacity and range.

The genuine artillery chemical shell form a whole side of gas warfare by themselves. They have their own history, their own special technique and already well-developed tactics. Their importance in the warfare of the present is hardly grasped.

Artillery shell contain relatively little gas compared with projector drums or even T.M. bombs. Yet, despite this disadvantage, more gas was used in shell than in any other way. The reasons are chiefly these: Artillery rarely fire at ranges much under one mile; consequently their gas bombardments are practically independent of wind direction. The use of gas by artillery does not necessitate special personnel, nor does it interfere with the activities of other troops. By their rapidity of fire and co-ordination of fire direction, with or without previous concentration, the guns can put up such effective gas concentration as will meet the requirements of chemical warfare tactics. Moreover supply of ammunition to the artillery is better organized and much simpler than with other branches of the Service. It is small wonder, then, that with these advantages the amount of gas shell used was a constantly increasing one. But the actual quantities and the proportion attained to the total shell supplies are not generally realized.

When we started to use gas shell in 1915, less than 5 per cent. of the total shell were chemical shell. This proportion increased to 25 per cent. by 1918, with a prospect of still more for the future. The Americans, having seen most of the game from the outside, budgeted from the very commencement on at least 30 per cent. with the intention of going on to 50 per cent. The Germans during 1918 actually supplied their dumps with 50 per cent of chemical shell and in special operations used as much as 80 per cent of gas-filled shell.

These increased proportions, you must remember, referred to the enormously increased number of shell produced after the first year or so of the war, so that the actual quantity of gas fired by the artillery became very large. In the German bombardments of Nieuport and Armentières in 1917 and 1918 as many as 50,000 gas shell were used on limited objectives, and 200,000 rounds in one day over a single battle front was estimated as an inside figure.

The actual shell used by us were the 4·5-in. Howitzer, the 6-in. Howitzer, and the 60-pr. gun. The 18-pr. was only used for smoke, but the French, Americans and Germans all used field-gun shell filled with gas, and there is no question that with us it will come also, because of the accuracy and the rapidity of fire.

The great difficulty with artillery shell is the need of increasing the ratio Capacity/Weight, which at present only amounts to about 10 per cent. With Livens drums it is nearly 50 per cent. To increase the capacity of shell the whole construction must be revised, and this is a point to which much attention is being paid. Gas shell conforming to this requirement may have considerably altered ballistics and will not range the same as H.E. of the same calibre. This, however, is practically the only added difficulty to be met by the actual gunners in firing such projectiles, and with increased capacity the efficiency for all purposes will go up in leaps and bounds.

Now, with regard to the chemicals themselves: These range from compressible gases, through high-boiling liquids up to apparently inert solids. Physiologically they cover an equally wide range, as I mentioned previously. With their chemical nature and even with their physiological effects I will not worry you. Their tactical classification is more important. At present we simply divide the "gases" into two kinds—persistent and non-persistent. Each of these classes can then be subdivided into lethal and non-lethal. This gives us a line right away on chemical warfare tactics, for it is obvious that an irritant or poisonous gas which persists, possibly for hours, may be as objectionable to the attackers as the defenders, should the former anticipate traversing the same ground.

As I mentioned before, the two chief objects of chemical warfare are the infliction of casualties and neutralization. If sufficient casualties can be inflicted neutralisation is also effected, but so far, the casualties, though enormous, have never been sufficient in themselves to produce results of the strategical value of neutralization. Indeed, there were many cases in the last year of the war where the casualties produced by a heavy bombardment were of secondary importance—merely incidental to the denial of mobility and terrain to the other side.

Nevertheless, the gassing of the enemy's personnel is most important, since it reduces his man power and affects his *morale*. Casualties can always be inflicted by surprise—either the surprise of tactics or materials—and as a result of bad gas discipline. Less certain, but still probable, are casualties arising from exhaustion of the enemy's protection or from his inability to remain protected over long periods.

Gas cloud and projector attacks aim chiefly at producing casualties. For this reason the deadliest gases and the highest concentrations are aimed at in order that the minimum amount breathed may cause serious injury. During the war little hope was entertained of penetrating the German respirators with our lethal gases. Consequently the most important element of cloud and projector tactics was "surprise"—generally the surprise of secret preparation, but sometimes the surprise of tactical use, such as making several successively stronger attacks on the same night; alternating gas clouds with innocuous smoke clouds and so on.

Although the possibility of exhausting the enemy's masks was not great during the war, yet in the event of a siege, where renewal of the gas mask would be impossible, it would assume great importance. Under these conditions the enemy would be helpless after a few discharges.

Actual penetration of the enemy's protection is, of course, the desideratum of chemical warfare. Assuming this to be attained, the enemy is defenceless and incapable of resistance. He will be overwhelmed over the whole front attacked, and if this front is sufficiently extensive he must break completely. We were in a position of this kind in 1915, but fortunately the front attacked was too short and the German reserves of gas too small to effect the complete smashing which was possible.

Again, in 1917, the Germans had produced a device which emitted a gas capable of penetrating our respirators. Fortunately for us their own professional dissensions, which prevented sufficient faith being placed in the discovery, coupled with consistent misfortune in weather conditions and a timely advance by the French on to the prepared positions, caused its withdrawal to the Eastern Front, where it was lost sight of in the confusion of the Russian *débacle*. Subsequently the material was used in shell—the celebrated Blue Cross or sneezing-shell—but in this form its action was not the same.

By the end of the war the tables were turned and we had the Germans at our mercy with a similar material, used effectively. The idea was the production of a toxic smoke instead of a gas or vapour. You know how difficult a finely divided smoke, like tobacco smoke, is to filter out through cotton wool. That is the principle of the "particulate cloud." Respirators designed to stop true gases and vapours simply will not touch it.

Even when an enemy is able to recognize a gas attack and to adjust his protection in time, a considerable tactical advantage is gained by compelling him to retain it. Inconvenience is caused, activity is greatly restricted and vision interfered with, especially at night. The discomfort of prolonged wearing of gas masks is very great and requires the strictest discipline to support, especially when the gas outside is not immediately intolerable. Heavy tasks, like digging and carrying, are interrupted owing to the increased exertion of breathing, and the duties of observers, wiring parties and, in fact, everyone, suffer considerably.

Neutralization of this kind is best effected by means of persistent gases, since they hang about for a long time and require comparatively little expenditure of ammunition. The work is almost wholly that of the artillery. At first lachrymators were used and these non-lethal persistent substances are still employed where immediate results are wanted and on ground which it is hoped shortly to occupy, especially if it is impossible to cover it sufficiently with lethal non-persistent materials like phosgene. The tear-gases themselves are merely annoying, but annoyance may be an effective method of neutralizing infantry. For instance, where large amounts of supplies and ammunition are being brought up there are always cross-roads where there is confusion and interference of traffic. A few gas shell placed there make every man put on his mask, and if it is a dark night and the roads are muddy the resulting confusion can be only faintly imagined. It may thus be possible to neutralize a part of the infantry by cutting down their supplies and ammunition.

If, however, you can hurt a man at the same time as you neutralize him, so much the better. Hence the development in gas shell tactics which consisted of using materials which were persistent and also poisonous. The material of the war for this purpose *par excellence* was the notorious mustard gas. Its introduction was probably the greatest single development of chemical warfare.

As you are probably aware, mustard gas remains about a bombarded position for hours or even days. In addition, it has a most caustic blistering action on the skin. The combination of these properties to a great extent removes the necessity of surprise tactics, since its immediate effects are not very marked.

It was first used by the Germans in July, 1917. Its tactical value was quickly recognized and during one period of ten days in the succeeding autumn it was calculated that 1,000,000 shell were fired, containing about 2,500 tons of mustard gas. Our casualties were very large and practically every casualty required evacuation, though the actual deaths were very few. Its toxicity compared with other gases is not great, and only about 1 per cent. of the casualties die, but its vesicant action is extraordinary. One part in three to five million will cause a skin burn on a sensitive person on prolonged exposure and with higher concentrations the burns are very severe. One of the most marked effects is on the eyes and 1 in 14,000,000 is enough to cause conjunctivitis. The bulk of mustard gas casualties were eye cases.

The introduction of mustard gas changed the whole aspect of warfare of every kind. It produces no immediate symptoms, yet it will burn the body—inside and out—wherever there is moisture. Even in warm weather it may persist for days, and in cold weather it lingers for weeks. In the earth it remains unaffected for weeks and months, and for that time makes digging in infected ground highly dangerous.

When first used, as a defensive agent, it delayed our attacks of Autumn, 1917, by a fortnight. In the big German drives of 1918 mustard gas was used in the *offence* to cause casualties, break up units and generally undermine the *morale*; and during the battles themselves it was employed to block out extensive areas and neutralize strong points which the enemy did not wish to take by direct assault. One of the most noted cases of this was at Armentières, which was deluged with mustard gas, causing our immediate withdrawal. Although they themselves could not enter for more than two weeks, it enabled the Germans to take the city with practically no loss of life.

This use of toxic persistent gases is most important. It enables a commander to deny whole areas to his opponent, to contain successfully the strongest fortified posts or to effect their neutralization. Above all, it allows him to rest his attack safely on artificial flanks. He can form a defensive flank wherever he wishes, independent of troops or natural features. He is practically safe from counter-attacks at these points. He can also use the gas for barrage purposes to prevent or delay the arrival of supplies and reinforcements and, most important, he can use it for counter-battery work. For silencing artillery it is most effective. Every shell fired counts. The effect is cumulative.

Even allowing for the slow action of mustard gas, gun crews are forced to protect eyes and lungs with gas masks. This at once reduces efficiency and slows down the rate of fire. Sooner or later, however, the gun must go out of action, either because of the inability of the gunners to carry on indefinitely while wearing respirators, or because of body burns supervening.

The only course open to an army attacked in this way is swiftly to map out the bombarded areas according to the nature of the shell and deduce accordingly the line of attack; for the enemy himself is not in a position to traverse or occupy the areas bombarded by lethal persistent gas. If he were, his tactics would be entirely different. The initiative would be assured to him and his success certain if in possession of a sufficient quantity of the chemical. You see then roughly where we finished at the end of the late war. There were quick-killing gases like phosgene, used in clouds, projectors and shell. There were particulated materials like the toxic smokes—very difficult to protect against and possibly capable of penetrating the enemy's lung protection; in any case almost certain to make such protection progressively more difficult to wear. Lastly there were the persistent toxic vesicants like mustard gas.

To a certain extent these classes can be combined and will be still further combined in the future. Mustard gas, for example, if burst with a high charge and an instantaneous fuse on top of the ground, becomes very quick in its action and by virtue of the higher concentration effectively lethal. This effect is still more marked if the shell are shattered in the air just about a man's height from the ground.

You will gather from this summary that in some form or other gas is applicable to every phase of war. That is both its merit and its danger. It has to be guarded against. To meet gas requires above all else, understanding and discipline.

Action and reaction are equal and opposite. Sooner or later defence balances offence. But there is a lag, sometimes a big lag, before the balance is adjusted. The duration of that lag may decide a war. That is particularly so in the case of a progressive subject like chemical warfare. The cutting down of the time factor, the reduction of the margin is largely up to you. Research and production can safely be left to the specialists and the "Army behind the Army." It is to the army in the field we must look immediately to balance the enemy's tactics. In the meantime that applies especially to defence. In the future it will possibly apply equally for all arms to the offence.

Defence against gas has been proved to be based on discipline, and the discipline to be based on familiarity. Not the familiarity breeding contempt, but familiarity breeding appreciation. Make no mistake; whether we want it or not, gas has come to stay. You must accept it as affecting all military considerations, as pervading all military activity. Once that is done, gas defence discipline in a disciplined army is bound to supervene of itself.

I could give you instance after instance where our gas discipline saved lives, saved positions, saved armies. That discipline was founded on understanding, not on knowledge. There was no attempt to make every officer a chemist. Nor will there be in the future. Chemists will be attached to the staff or on the staff; but the new warfare necessitates a broader education for the regimental officer, it requires a higher level of scientific training in the Army in order that fundamental facts may be known and the specialists' conclusions appreciated and applied. That is all, but it it is a big thing.

During the war a staff officer wished to allot twice the number of men to carry gas cylinders out of the line as to carry them in. He pointed out that gas is lighter than air, and therefore the cylinders would be heavier after the discharge. I mention this in no captious spirit. The officer must have been a good staff officer to think of the difference at all; but it is indicative of the kind of thing I mean and which cannot persist as chemical warfare gradually ousts warfare of explosives from its present position.

Once the fundamentals of science become everyday thought to the military man, gas discipline will cease to be a matter of obeying instructions. It will be innate. The proper use and care of protective appliances will be automatic. Consolidation of a position against gas attacks will rank in a man's mind with consolidation against bombardment or direct assault. Decision as to the tenability of a gas-infected area will be local. Every officer will think " Gas " for himself.

That is what we must look forward to. It will arrive automatically if the importance of chemical warfare is grasped and the general principles of scientific thought inculcated.

As to the future, all that can be said with certainty is that chemical warfare will develop rapidly, and all the more rapidly should another big war occur in our time. Sooner or later, indeed, we shall have to answer the query—" Gas or Explosives ? "

The development will be all round—in weapons, in tactics, in material. Gas will apply to all arms. With the infantry it will probably start with rifle grenades and toxic smoke candles.

The mobility of the cavalry will be used for the swift transport and installation of cloud generators and the carriage of light mortars.

Tanks will be particularly concerned with chemical warfare, but even more in defence than offence. Gas will penetrate anywhere and your tank in the future will be rather up against it. The whole tank may have to be turned into a kind of gigantic respirator and that means making it air tight. Gas may prove to be the Achilles' heel of the tank.

At first, at any rate, the use of chemicals by the artillery will be greatly extended. Probably *all* shell will be at least partly filled with chemicals. Even where destruction is required, a double effect may be obtained by firing shell containing, say, 20 per cent. gas to 80 per cent. explosive. Consider the added effect of chemicals to a long range bombardment of villages, camps or cross roads. The possibilities are too great to be overlooked.

I would like to point out, however, that gas is fundamentally independent of heavy ordnance. An enemy with little or nothing in the way of heavy guns can still be a formidable opponent by combining skilful entrenchment with a copious supply of chemicals to be fired from the lightest of mortars, from projectors, or for use as toxic smoke. This is a point not to be overlooked.

Chemicals will be used by aeroplanes and against aeroplanes. Even in the late war the Americans devised, manufactured and filled immense bombs—receptacles to be slung under the fuselage of aeroplanes—containing one ton of mustard gas. They were intended for use against Metz, but were never needed. The prospects of this form of attack are also very great.

As regards materials and the dependent tactics even the immediate future is more difficult to forecast. After all, important as chemical warfare is, we are still in the blunderbuss stage. As I pointed out before, the possibilities of chemistry are almost infinite. From mustard gas it is no far cry to a persistent gas which does not merely blister in tiny amounts, but kills. It requires little imagination to suppose such a discovery already in the hands of potential opponents, but one could sit for days and use one's imagination on the effects of such a discovery without exhausting its possibilities.

Even the increased use of blistering chemicals might force men to wear special impermeable clothing, and the development of toxic smokes might force them to use oxygen breathing apparatus by making efficient filter-type respirators too difficult to breathe through. An army immobilized in this way would be at a grave disadvantage.

Purely hypothetical possibilities are unlimited. A recent writer has suggested the possibility of chemicals being discovered which would destroy the sense of equilibrium by coagulating the liquid in the internal ear. That was an imaginative picture we sometimes gossiped about during the war; but it might be made real. An army exposed to such a gas would be unable to walk straight; possibly unable even to stand upright. Its men would be no more use than children just learning to walk.

To follow such ideas in one's mind always seems to lead to a deadlock. It seems impossible to see farther than complete immobilization and "stale-mate." But there will be no deadlock. There never has been in the past, though increased rifle range, machine-guns and the never-ending contest between guns and fortifications have all pointed to it at the time. One side or the other will always have the advantage in tactics or material for a short time, possibly even the superiority to give them overwhelming advantage.

As long as war is possible we have to insure that such temporary or permanent advantage or such partial or complete superiority is ours and not our neighbours.

In conclusion, I have a few pictures to show you. They have been chosen either to let you visualize some of the conditions of chemical warfare or to excite in you a spirit of emulation as regards preparedness. To the latter type belong some photos of the American Chemical Warfare Arsenal at Edgewood, which I had the privilege to assist in founding.

The Americans have been very open in telling the world what they did in chemical warfare in the past. This very disclosure is significant in view of two pronouncements by eminent American soldiers:

Major-General Sibert, my friend and late chief says:—" There is no field in which the future possibilities are greater than in chemical warfare, and no field in which neglect to keep abreast of the times in research and training would be more disastrous."

Brig.-General Fries, the present Chief of the United States Chemical Warfare Service, says:—" Poisonous gas in the World War proved to be one of the most powerful weapons of war. For that reason alone it will never be abandoned."

From these statements, placed side by side with the American disclosures, only one conclusion can be drawn.

America is our friend and our blood relation. But we must be as well prepared as our friends and we have no wish to be dependent, even on our relatives.

What other nations which are not our friends are making equal preparations but no disclosures?

We must be prepared to follow the new road.

# SOME EXPERIENCES OF AN ENGINEER OFFICER WITH THE SALONIKA ARMY.

*By* COLONEL COMMANDANT G. WALKER, D.S.O.

THE experiences of an Engineer in Salonika must be a record of forlorn effort to compass the impossible with few materials; an effort sustained by the ever-present hope that with a little luck and a light heart he might be able to achieve something. In the short compass of a lecture it is difficult to do more than touch very lightly upon the various activities of an Engineer in such a country, and this must be my apology for what may seem to some to be a somewhat sketchy account of our work.

2. No account of the doings of any branch of the Army in Macedonia would be complete without a short notice of the reasons that brought a British Army into the country. Briefly they were these :—

(1) To relieve and support the Serbs in their dual struggle with Austria and Bulgaria.

(2) To deny the use of the seaboard of the Balkan Peninsula and the Isles of Greece to the Submarines of the Central Powers.

The first was necessary in order to fulfil our promises to the Serbs, the second to protect the sea route to the East through the Mediterranean. A cursory glance at a map will make this clear.

3. *Operations.*—The Salonika Campaign may be said to have commenced on the 30th September, 1915. The Bulgars had attacked the Serbs on the 29th without a declaration of war. France and England decided to assist the Serbs and landed troops at Salonika. The formations sent out in the first instance and landed on about 5th October, 1915, were :—The 10th British Div. from Gallipoli; the 122nd French Div. from Gallipoli; and the 113th French Brigade from France. The French Force was shortly strengthened to three complete Divisions and, with this Force, General Sarrail attempted what was really the impossible. The French advanced up the Vardar towards Stumica with a view to relieving the Serbs besieged at Veles, while the British took post on the Beles range near Kosterino to cover the right or eastern flank of the advance. The relief of Veles failed and the French then struck west to cut the Bulgar's line of communication, as they pursued the flying Serbs down the Babuna pass towards Prilep. This movement also failed through lack of

Forces and the Allied troops were forced to retire southwards to their base at Salonika.

The Allied retreat was only executed after very heavy fighting, and the troops suffered terribly from cold and frostbite; the temperature, even in the valleys, registering seven degrees below zero Fahrenheit. The French retired down the Vardar valley, the British *via* Doiran and Kilindir, and reached Salonika safely. The enemy did not pursue beyond the Greek frontier, for what reason it is not quite clear, but probably because they did not desire to upset the Greek King's arrangements. Meanwhile, further reinforcements were arriving and the 22nd, 26th, 27th and 28th British Divisions from France were concentrated in and near the town of Salonika early in January, 1916. The most urgent work was then to create a defensive position for the protection of the base. The line occupied was now from the Gulf of Orfano, on the east, *via* Beshik Lake, Langaza Lake, Tumba, Laina, Balja to Naresh on the Galiko River. This area was occupied by the British 27th Division from Orfano to Langaza Lake (east end) with the 22nd, 26th, and 28th Divisions on the remainder of the line, the 10th Division being in reserve at Hortiack. The French Army continued the line from Naresh to the Vardar near Topsin. The creation of this line was pressed forward with feverish activity in spite of great difficulties as regards transport of stores, especially in the 27th Division Area. The Brigade at Stavros was supplied by sea.

The work went on until May, 1916, when it was practically completed. Indications of a move then began to appear and ultimately the Allied Army moved up or "closed" with the Bulgar on the Frontier. The French moved first to the Doiran-Vardar area. The British followed in August. The 12th Corps (22nd and 26th Divisions) relieved the French, who moved west of the Vardar. The 16th Corps (10th, 27th and 28th Divisions) moved to the line of the Struma, an interval between the two British Corps (in the Krusa Balkan) being filled by an Italian Division which had arrived. These troops were ultimately withdrawn in November, 1916, and then the whole line from the mouth of the Struma to the Vardar, a distance of about 100 miles, was held by five British Divisions and two mounted Brigades (Yeomanry).

This situation was maintained until the spring of 1917, though the line held was modified and improved by British attacks, at both Doiran and on the Struma, in September, 1916. Early in April, 1917, preparations for a general attack by the British were initiated. The main objective was the occupation of the high ridge above Doiran. The 60th British Division had arrived from France and was placed in the 12th Corps. The attack was designed to synchronize with one to be made by the French and Serbs near Monastir, and was in effect a dress rehearsal of the victorious attack made in September, 1918. After some delay two Divisions advanced to the attack in the neighbourhood of Doiran on 24th April, 1917. The movement "drew" all the enemy opposition.

We were under-gunned and the attack from Monastir did not materialize. The result was almost complete failure with heavy loss. The effort was repeated with fresh troops on 8th May with a similar result. After this there was no attempt at a big forward movement until the following year and the Army settled down to strengthening the position, improving communications, preparing retired lines, etc. Roumania was down and out and we felt that there was every probability of a heavy offensive against us. We were weak in numbers and riddled with disease, and the outlook was black enough. To add to our troubles the 10th and 60th Divisions were moved to Egypt, together with our two mounted Brigades, in September, 1917. This state of affairs continued until early in 1918 when the re-organized Greek Army began to materialize in strength. It gradually took over the Struma line and permitted a closer grouping of the British, who closed up to Doiran and one Division (27th) relieved the French on the right (west) bank of the Vardar.

The early part of 1918 was an anxious time owing to the trend of affairs on the western front, but finally, in September, the great attack was organized. The French and Serbs attacked from Monastir towards Prilep, while the British re-enacted their old movement of April and May, 1917, with the result that is so well known. The British attack was held up with heavy loss until the Allies gained Prilep and then the Bulgar resistance gave way. After a short pursuit and a threat to the Turks, both they and the Bulgars capitulated and the Macedonian Campaign was brought to a victorious close.

4. After this brief summary of the military operations I shall now consider how this campaign differed from that in France and Belgium, and in what particulars it was of more than ordinary interest to the Engineer. The outstanding features of Macedonia were as follows :—

(*a*) The extraordinary richness and fertility of the soil, and the real beauty of the Hill Country. The land in springtime was a garden, carpeted with flowers, from the "darting speedwell" to the Madonna lily. Nothing could have been more charming.

(*b*) The almost entire absence of communications of all sorts.

(*c*) The hideous unhealthiness of the whole area. Malaria and dysentry were the principal plagues, but cholera and other diseases were also about.

(*d*) The copious water supply except in the alluvial plains.

(e) The great variation in climate between summer and winter and also between that of the hills and the plains.

All these but the first provided work for the Engineer and the first supplied him with an incentive to succeed.

5. *Communications.*—Communications are the deciding factors in most campaigns, and in Salonika they were the greatest factor of all.

Firstly, the external communications with the oversea base in England were most precarious. The sea route from England is 3,012 miles long, from Marseilles it is 1,407 miles ; both were increased in length if ships came *via* Alexandria. Salonika to Taranto is 900 miles, Salonika to Alexandria 800 miles. The result was extreme difficulty in obtaining materials and supplies of all kinds. As Salonika itself could supply nothing, the situation can easily be imagined.

Added to this the amount of shipping was so short that there was no leave, no relief except illness from the never-ending drudgery for the men. In 1917 a new route overland *via* Taranto in the south of Italy was opened (900 miles) and subsequently the sea journey was shortened by the opening of a land route to Iteá on the Gulf of Corinth whence the sea journey was short and safe. All this took time and entailed enormous labour in railway and road work. The internal communications in Macedonia in January, 1916, consisted of the following :—

1. Rail, Salonika—Monastir
2. ,, ,, —Karasouli and up Vardar Valley
3. ,, ,, —Doiran and east to Constantinople
4. Road, ,, —Seres and Drama
5. ,, ,, —Monastir
6. ,, ,, —Hortiack

The railways were single lines 4 ft. 8½ in. gauge. The roads were metalled, about 12 ft. wide, with no bottom, made for light wheeled traffic. All the other routes or roads were simply field tracks, hard enough in summer to carry motors and lorries, but all almost impassable in winter for even horse vehicles.

The Seres road was the only communication worthy of the name to the Struma front, except by sea to Stavros. The Doiran front had two lines of rail and a connecting line just behind the front, but no road movement in large bodies was possible in winter. After the troops moved to the Struma in June, 1916, their supply by the Seres road was most precarious. In fact, as early as August, 1916, this route was rapidly breaking up. It was some time, I fear, before the situation was clearly realized : that is to say, realized from a curative point of view, and the road-making organization put on a sound footing. All sorts of road-making gear, such as rollers, stone-crushers, etc., etc., had to be imported, and meanwhile the repairs were of necessity of rather a "bow and arrow" type.

Labour and its supervision were a great difficulty. At first labour was plentiful, but labour spoke an unknown tongue. Britishers who spoke Greek or Turkish were few and far between, and my first effort on a tactical road south of Langavuk with 2,000 coolies was an awe-inspiring experience. My best ganger was a private soldier of the 1st Battalion Royal Irish who, by means of a thick stick and the language of signs, proved himself to be not only a very efficient but also very popular person with the coolies. We collected them when possible in camps, paid them three drachmas (2s. 6d.) a day and gave them free rations. At first we only employed men, but, later on, men, women and children were used. The men for quarry work, loading and unloading stone and spreading; the women for breaking stone, when no crushers were available; and the children to enliven the proceedings. Incidentally hand-broken stone wears much better in a road than stone broken in a crusher. Very large numbers of women were used in outlying parts of the country for stone-breaking and did their work well. Poor creatures, if it had not been for their rations, which they drew in part payment for their labour, they would in most cases have been starving.

I remember one day seeing a Turkish gipsy woman breaking stone with her right hand while she was holding a tiny child to her breast with her left. I pointed her out to the Sapper in charge and suggested that this procedure was neither good for the baby nor the stone-breaking. The next time I visited the gang this Sapper had a *crèche* organized under an elderly lady, who took charge of all the very small children during the working hours. The old lady sat under a tree and all the children played about round her. This action of the Sapper was typical of the attitude of the British soldier to the inhabitants. Another incident of this sort, which occurred during the great fire in Salonika, is worth recording. When the fire was at its worst at night, great crowds of refugees streamed down to the sea front for safety. They were of all ages and both sexes. While some people were principally interested in looting, the British soldiers were occupied largely in sorting out and sending these refugees away in lorries, to various places of safety. There was of necessity a good deal of confusion and some of the mothers were afraid of losing their children. The lorry drivers were, however, equal to the occasion, and arranged to tie labels, marked with numbers, round the children's necks, at the same time presenting the mothers with duplicates, so that the danger of a child being lost was reduced to a minimum. I did not see this, but the story filtered through up to the line where I heard it. I know, however, that my civil work-people were full of the kindness and care bestowed on the sufferers from the fire, by the British troops. I tell these tales to show that wherever he goes and whatever he does, the British private soldier always behaves as a gentleman and is the King of Goodfellows.

6. *Road Construction.*—The first bit of new road construction that was undertaken after the arrival of the British Army was, I believe, the road from Kalamaria *via* Kapudzilar and the Akukli plateau to Hortiack.

The defensive position then ran just north of the Hortiack hills with a switch or reserve line through the latter, and it was desired to make a circular route from the town to Hortiack to relieve the congestion of traffic on the old Turkish road through Urenzik and Kireckoi.

Work was commenced with military labour from 27th Division and a Brigade of infantry was camped at Kapudzilar. It was my lot to control the work. I was first told to make a road for limbers, then a road for G.S. wagons, and finally a lorry road. All this time work was in progress and I was much troubled as to the "ruling gradient."

The ground was steep and I was in doubt as to what the grade should be. However, I settled it by making it as flat as I could and leaving the rest to luck. Time pressed, and there was none for speculation. It worked out to 1 in 12, and there was a lot of it at that grade. However, when finished, lorries and all sorts of motor traffic ran merrily up and down, especially down, until the end of the chapter. As a matter of fact, I think what saved it was that I kept the curves big and had no sharp corners. The grades were laid out with a pendulum clinometer (Indian pattern) from the Field Co. equipment. It is a rough instrument but accurate enough and, when you are used to it, a quick one to work with. One of my assistants, a young Scottish Railway Engineer, who was accustomed to theodolites and chains, was much disturbed at having to use the instrument. He could not work with it at all at first, but with practice became an expert, and admitted finally that it was all right. I had an amusing experience with the General Staff during the time we were on this road. One night I got news that a whole Brigade of four strong Battalions was to report to me for work next morning. I had nothing prepared for them, no tools and, in fact, not sufficient road surveyed, so I wired back to send them in a fortnight. This shocked the Staff but I carried my point and proved to them that road-making was not quite the same thing as the magic of a harlequin. I imagine that in a fortnight something else had been found more urgent for this Brigade to do, but I can't remember this.

This brings out an important point. Never trust your eye for grades on a steep hill road. If you do you will certainly be sold. With practice your eye will spot the probable line, but that line must be tested with an instrument of some sort. Grading is most important on steep ground, as all vehicles, whether horsed or mechanical, must have places on which they can "take a blow" on a long ascent.

Our next venture was a tactical road. The 10th Division made a very good but steep road from Hortiack to Azrumeri. It was well graded and made, but was not taken over the easiest line, owing to lack of time in reconnaissance. The Staff gave the starting and terminal points. The Engineers took the shortest route, a grave error, as it was not the most economical in time of construction, quite apart from monetary considerations. We prolonged the road from Azrumeri to Jerekaru, just behind our trenches, and then carried it on behind them across the Zaglaveri plateau to Ilanli, whence a mule track ran down to Gomenic. This road was an essential lateral communication to the defence line. It was fine weather and there was no time to metal it throughout, nor labour nor material either. We just laid it out, ditched it, 30 ft. between the ditches, bridged it and cut and metalled the approaches to the big *nullahs*. They were two in number, about 100 ft. deep. This made it a safe communication, for in dry weather vehicles could move off it, and in wet the ditches and drains kept the land dry. After the grading, drainage is the next essential for hill roads, far more important than metalling. If a road is wet you can do nothing with it. This road cost about £10,000 a mile. My civil engineers were aghast at this, but it could not be helped, as we had little transport except donkeys and men, and very few carts.

Cost what it might, we had to go on, as the completion was vital to the defensive line, as can readily be seen by reference to the map. Many times afterwards I found that in extremity the simple ditching and draining of a marked track, on the plain behind Doiran, saved the transport situation during operations. Macedonia, though very dry in summer, is subject to very violent thunder storms accompanied by torrential rain, and it is during these crises that the ditches and drains were so useful, as they kept the tracks dry and helped them to dry out and harden when the cataclysm was over, as it usually was in an hour or two. After the Army moved forward to the Struma and Doiran the question of roads was critical. In fact, it was the one problem. The only communication to the Struma line was the Seres road. It ran over steep ground, precipitous in places, especially at the Struma end. It was metalled about 12 ft. wide and there was no soleing. It was an old Turkish road and followed an ancient route. Length about 50 miles. The effect of the motor traffic, for the supply of everything to three Divisions, is more easily imagined than described. In fact, the road practically broke down. So bad was it that the lorry drivers used to be sea-sick while driving along it. It was a desperate proposition. The situation had been anticipated to a certain extent in the summer of 1916 and a certain number of quarries had been opened along the road. R.E. Co.'s also had been stationed at intervals to control the maintenance by civil labour and keep the road alive. This, however, was not enough and the road got steadily worse until, in the end, the nettle had to be firmly grasped and the resolution taken to remake the road and put in soleing. It was an immense work. A great road department was organized under L. of C. control. Rollers, stone-crushers, etc., etc., were collected, labour was swept in from all quarters and eventually the road was remade and the communication to the 16th Corps preserved. I have no time to give small details more than to say that the success of the work depended on the most minute care being taken in organization of labour, development of quarries, organization of transport and of material, and, finally, the organization of the communication transport, to divert it when the ground permitted and to keep it off the road. The work was practically completed in the summer of 1917, but the maintenance work continued always. It was calculated that the number of vehicles passing on the most used parts of this road was 5,000 per day, and that with this load the road, as remade, required retopping once every eight months.

The branch railway line from Salamanli to Guvesne was put in to save the first 17 miles of the road as much as possible and to relieve the congestion on that portion which ran through the Lembet plain. An advanced supply dump was placed at Guvesne and here also the Commander-in-Chief had his advanced Headquarters.

To turn now to the Doiran front. To this there was no road at all and in the winter it was almost impossible to get up except by rail, of which fortunately there were two lines. L. of C. in the end of 1916, or early in 1917, commenced the prolongation of the Salonika–Naresh road up the valley of the Galiko to Sarigol. A bit of good road existed from Sarigol to Kukus and the 12th Corps had to prolong this to Janes (their Headquarters) and thence to their line at Cugunci. This work began in the autumn of 1916 and was finished about May, 1917. There are two points to be noted in respect of its execution.

(1) The road from Kukus to Janes was made only 12 ft. wide, a very grave mistake. It did not allow of easy passing, and

vehicles drove into the drains and choked them, incidentally getting ditched themselves. It also meant that the 12 ft. had to bear both up and down traffic and consequently wore badly. No road should ever be metalled less than 15 ft. wide for military traffic.

(2) The route selected for the road beyond Janes was not the shortest. The road was taken about six or seven miles out of its way in order to pass a good quarry near Kirec. This diversion was useful afterwards, but I doubt of its being economical, as it entailed the negotiation of some very low-lying wet land. However, a choice had to be made and was made as stated. Such questions have always to be considered in making roads. Another road which gave a good deal of trouble was that between Kukus and Snevce-Karamudli. It had been laid out by the Italians, 12 ft. wide between the ditches—on a surface grade. The grading and bridging were well done. The road was too narrow and, when we took it over at the end of 1916, it was *in extremis*. However, we got it right for light traffic by draining it properly and finally metalling it, and in six months' time it was a good road for high-speed motor traffic.

To summarize the work, the following were the main metalled roads constructed :—

Seres road, 50 miles.
Kapudzilar road, 10 miles.
Sarigol road, 24 miles.
Sarigol-Cugunci road, 17 miles.
Karasuli road, 20 miles.
Bralo-Itea (Gulf of Corinth) road, 20 miles.

Besides these, innumerable by-roads were drained, repaired and maintained. All the work was done under R.E. supervision, the actual labour being principally native. Some labour Battalions were, however, employed. These roads were all in the L. of C. or Corps areas, the Divisions being responsible for roads and tracks close up to the line, and they had their hands pretty full. When the advance came, the experience gained during the first three years was invaluable to the R.E. when they had to tackle the question of repairs to roads and bridges destroyed by the enemy during their retreat.

One word should be said about quarries. The speed with which roads can be made depends entirely on the supply of stone. Quarries must be located at convenient distances along the route, the stone must be good and the development of the quarry must be such as to facilitate rapid output. Tools available for quarrying stone are of great importance. At first we only had jumpers and boring bars, but later, when power drills were available, the work was much expedited. The following was found to be the average output on road work :—

Soleing—8 square metres per man in 9 hours.

Metalling—12 square metres per man in 9 hours.

Rolling.—80 metres (half width, per roller in 24 hours. Roller worked continuously (by artificial light at night) with reliefs of men.

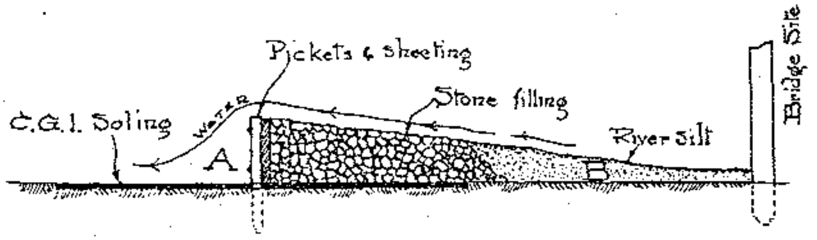
A few hints as regards methods which were found useful in Macedonia are worth recording.

(a) *Drainage.*—In alluvial plains try and keep away from the absolutely lowest levels in locating the line of road, so that drainage may be possible. A cross-section of the land on which the location is made should be at least 1/20 if possible—at any rate, avoid absolutely flat ground.

(b) *Cutting and Banking on Hill Sides.*—Always cut out the whole of the road width ; don't build on made ground.

(c) *Protection of River Crossings, Causeways, Bridges, etc., from Scour.*—Any obstruction placed in a river, even bridge piers, is liable to raise the level, increase the velocity and produce scour. The place to protect from scour is below the object to be protected.

The sketch below shows a good form of " field " protection for road crossings and bridge sites. It is really a water-tight dam of simple




construction which raises the level of the river below the site, catches the silt at B and stops the scour. A will also gradually silt up. A road crossing made as above has stood a 3-ft. flood for 24 hours. Care must be taken that this dam is taken across to above flood level on the banks, otherwise its ends will be cut out. This system is based on work done in South Africa by Colonel Waghorn (then Captain), R.E. Similar dams can be used as groins for altering the course of a stream to prevent its cutting too much into a bend. Groins which we called " sausages " were also used with effect in order to keep streams in flat land to their course and prevent them breaking out and " deltaing." These " sausages " were made of lengths of wire net filled with stone and then sewn up. Placed diagonally *inwards* at the sides of a stream and pointing down stream, they keep the scour in the centre of the channel and by thus dispersing it, prevent breaks-out.

My remarks upon road-making would be incomplete without reference to the loads which M.T. traffic of the British Army bring upon them. The normal M.T. vehicle for transport work is the 3-ton lorry. This means a total moving load of about 10 tons on 4 wheels. The pace generally is 12–16 miles an hour and the result on a macadamized road is lamentable. It is bad enough on a good road, but on badly constructed, soft roads this traffic very soon becomes impossible. In Salonika the Italians had a 30-cwt. Fiat lorry which was immeasurably superior to our 3-ton vehicle for the purpose required. This 30-cwt. lorry, even if it had to do double journeys to do the work, was much less destructive to the roads, and on the country tracks it could go where the 3-tonner dared not.

The lesson is that, when operations in a wild, roadless area commence, a light motor vehicle is essential. Light railways were in some cases (Struma) used with mule haulage to help the roads. The 60-cm. was quickly laid and it was found that two mules would haul $3\frac{1}{2}$ tons over grades of 1 in 100. That is about ten times what they would haul on a road. These tramways were subsequently in some cases converted into locomotive roads, but the light rails had to be replaced, by 20-lb. rails on 5-ft. sleepers, to make this satisfactory.

## RAILWAYS.

7. As previously stated, there were three main lines of rail, of standard gauge, in existence when the Allies occupied Salonika.

(1) Line to Monastir.
(2) Line to Belgrade *via* Karasouli and Uskub.
(3) Line to Constantinople *via* Kilindir, Seres and Drama.
(4) Link between Karasouli and Kilindir.

The link between the Monastir line at Plati and Papadouli on the Athens line was not completed until early in 1916, so that there was no through communication between Salonika and Athens when the Allies landed.

Of the above (2), (3) and (4) served the British Corps on the Doiran–Vardar front, with main railheads at Janes and Karasouli. Trains were run at night, however, on the link-line between Karasouli and Kilindir. At first all the lines were under Greek administration, but ultimately, in June, 1916, they were forcibly taken over by an Anglo-French Commission; the rolling stock being divided in proportion to the mileage worked by each nation. Rolling stock was at first most inadequate, and to make up the deficiency the British alone imported 30 engines and 2,000 wagons. The following figures show the growth of traffic between 1916 and 1918 :—

*State, October*, 1916. (Allied Armies).—
Locos, 121 ; wagons, 1,230.
*State, December*, 1917. (Allied Armies).—
Locos, 172 ; wagons, 2,806 ; coaches, 232.
*State, December*, 1918. (British Only).—
Locos, 70 ; wagons, 1,813 ; coaches, 60.

The rolling stock had no continuous brakes. Engines had steam-brakes, and brake-wagons were distributed through the trains. An allowance of one brake-vehicle to 15 loaded trucks was allowed on the level, and one to five loaded trucks on grades of 1 in 50. At first, the utmost confusion existed at the port and the stores had to be transported by lorry some six kilometres to the dumps and railing points. The first railway work was to put this right. Dudular was made the main distributing depôt and was connected by rail with the piers and with the advanced parks at Lembet. Besides this an immense amount of work was carried out in putting in sidings in the dumps and store depôts. Later on, advanced depôts were opened at Guvesne at the 26th kilo on the Seres road, which had been connected up by a branch line to Salamanli on the Doiran line. This entailed the building of a piled bridge over the Galiko river, but otherwise the work presented no engineering difficulties.

The following figures show the growth of traffic over the standard gauge lines between 1917 and 1918 :—

| | | *Men.* | | *Stores.* (tons) |
|---|---|---|---|---|
| Quarter ending Sept., 1917 | ... | 60,000 | ... | 90,000 |
| ,, ,, March, 1918 | ... | 140,000 | ... | 160,000 |
| ,, ,, Sept., 1918 | ... | 300,000 | ... | 145,000 |

After the organization was put in order the main and constant difficulties were shortage of rolling stock and ultimately shortage of fuel and constant shortage of personnel owing to disease. Indeed, at the end of the summer of 1918, the organization was on the point of breaking down for want of fuel and of men.

## Light Railways.

*Janes–Kalinova Line.*—When the 12th British Corps moved to the Doiran–Vardar front in August, 1916, its railhead was established at Janes, whence the troops were supplied by road vehicles. This served in the fine wather, but, in view of the fact that there were no roads in winter and the Kilindir and Karasouli line could not then be used, it was decided to run a 60-cm. line from Janes to Kalinova. There were no great practical difficulties on the route, which was 12 miles long, and the work was completed in three months. It was then operated by the local Divisional C.R.E. for a long time. It was of the greatest value that winter; and troops, stores and hospital patients (in special trucks) were carried.

This was the first up-country light line made by the British.

*Sarigol–Snevce Line.*—The French had previously constructed a 60-cm. line from Sarigol to Snevce (18 miles). It was roughly laid with light rails and was for a long time a constant source of trouble, owing to the engines constantly breaking down. It was completely relaid and largely relined by the British, and, with better engines, proved invaluable for supply of troops in the Krusa Balkan. This line was ultimately prolonged to Karamudli, about three miles north of Snevce.

*Stavros–Tashli Line.*—When the British 16th Corps occupied the Struma in July, 1916, the question of supply at the mouth of that river was an important one. Supply by sea was precarious because of the exposed situation and absence of landing facilities. Piers existed at Stavros and it was decided to run a 60-cm. line from thence round the coast to Tashli Derbend, a distance of 10 miles. This was done and, by February, 1917, it had been extended to Chai Aghizi.

This line ran along a perfectly flat sea-shore and was an easy proposition.

*Guvezne–Stavros Line.*—In 1917, owing to the difficulties arising from the submarine menace, it was decided to run a 60-cm. line from Guvezne to Stavros *via* the lakes Langaza and Beshik. A standard-gauge line was first thought of, but this project was abandoned. The standard-gauge was indeed taken from Guvezne to Sarakli and thence 61 miles of single 60-cm. line was run into Stavros. The survey started in October, 1917, and the line was opened in April, 1918.

Light lines were also constructed at:—

(1) Dranista Mine, 17 miles.
(2) Gramatna–Rajanova, to supply the Krusa Balkan, 24 miles.
(3) Likovan–Mirova (horse).
(4) Kopriva–Gudeli (horse and petrol tractor).

The last two lines were constructed by the Divisions in the areas. The rolling stock for the 60-cm. lines consisted of locos of Hudson 0.6.0 type and Baldwin 4-6-0 type, besides petrol tractors. The wagons were of high capacity, carrying 10 tons. The Baldwin engines would haul 45 tons over a three per cent. grade.

After the Armistice, the railway situation altered and it became necessary to open up the country east of the Struma. In order to do this, the Demi Hissar bridge over the Struma on the Constantinople line was rebuilt (it had been blown up by the French in 1916), and the line through Seres and Drama was repaired, the work being completed and communication opened with Constantinople in January, 1919. Besides this 60-cm. lines were laid :—

(1) From Vetrina to Radomir.
(2) From the Stavros line across the Struma at Neohori to Angista.

DEMI HISSAR (VETRINA) BRIDGE.

*Reconstruction.*—This bridge, which had been blown up by the Allies in 1916, had never been repaired, as it was under gun-fire from both Armies.

The bridge consisted of six spans of steel girders (each 100 ft. long) on masonry piers. It was built on a curve of 984-ft. radius. The road bridge just below had not been destroyed and was utilized both for the reconstruction and getting troops across the river, a 60-cm. line being laid over it.

The condition of the Railway bridge was as follows :—

West abutment intact. No. 1 span, blown down but repairable ; No. 1 pier, repairable ; No. 2 span, repairable ; No. 3 span, destroyed ; No. 3 pier, intact ; No. 4 span, repairable, the bottom boom was broken ; No. 4 pier, completely destroyed to foundations; No. 5 span, destroyed ; No. 5 pier, intact ; No. 6 span, destroyed ; east abutment, intact.

The method adopted was to jack up Nos. 1 and 2 spans with 20-ton jacks on cribbing, repair and reseat them so as to get at No. 3 span. This girder was cut up with explosives and removed. It was replaced with trestling set on piles. No. 4 span was treated in the same way as Nos. 1 and 2, and Nos. 5 and 6 in the same way as No. 3. No. 4 pier presented some difficulty as it was cut down below water level and a coffer dam had to be constructed round it, to make a new concrete pier.

The work started on 29th October, 1918, and was completed by the 18th January, 1919. The number of man hours taken in the reconstruction was 16,203 and the cost was £6,664.

A good deal of difficulty was experienced in breaking up the destroyed girders, as they were buried in the sand rather deeply and had to be completely removed to make room for the piling. Another difficulty was the lack of experienced men and adequate gear at first. The jib crane used would lift only about seven tons.

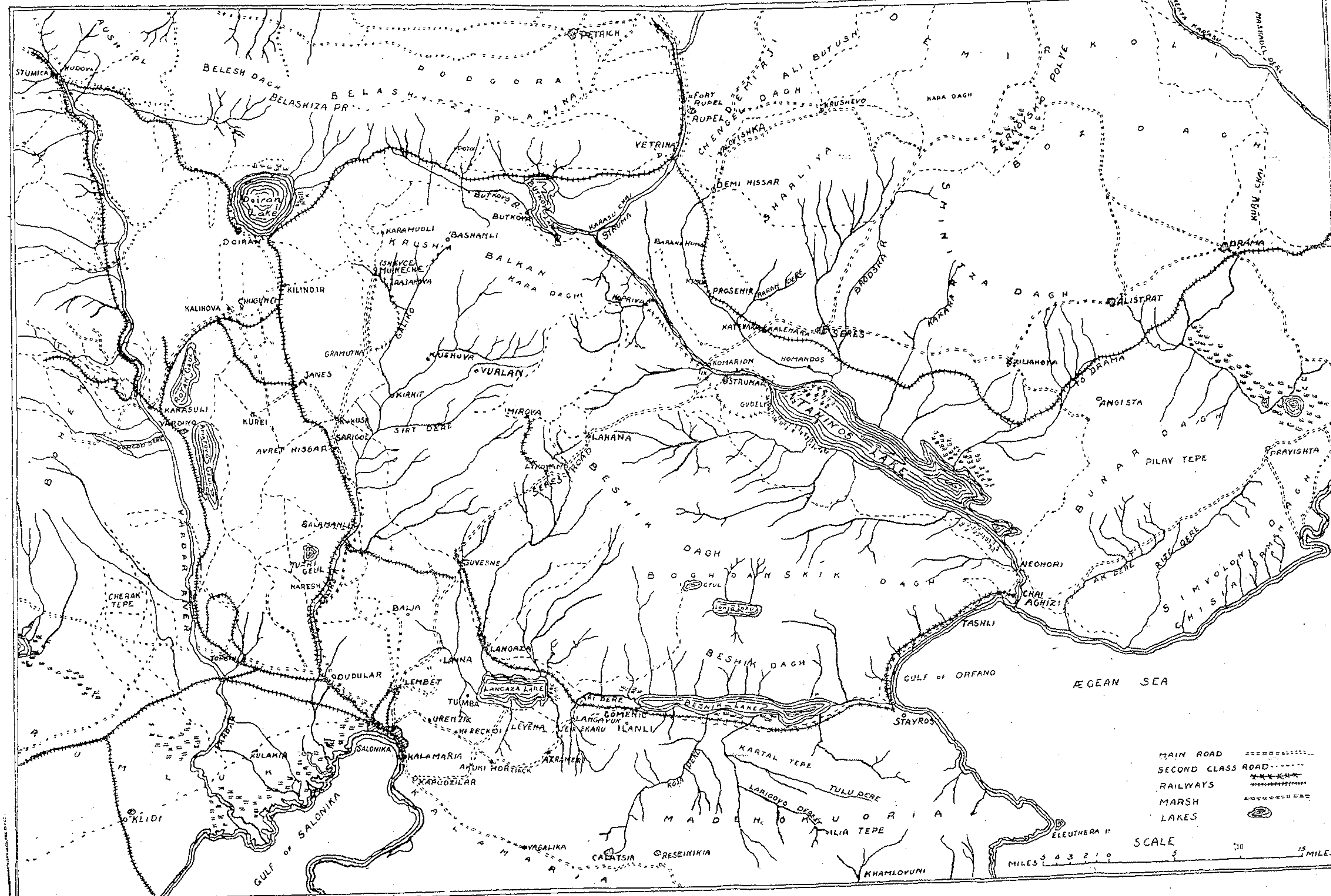
Two points are worth notice in the reconstructed bridge :—

(1) The original super-elevation of the rails had been $4\frac{1}{4}$ in. for a speed of 40 miles per hour. This was reduced to 2 in. for a

speed of 16 miles per hour, and this was given in the design of the wooden trestles (*vide Plates* I. and II.).

(2) When the bridge was destroyed, all the expansion rollers were lost in the river. As the temperature on the Struma can be as much as 106 F. *in the shade*, this was a serious matter. The difficulty was overcome by carefully buffing the bearing-plates of the replaced girders and coating them with graphite, which, it was thought, would serve for the time being.

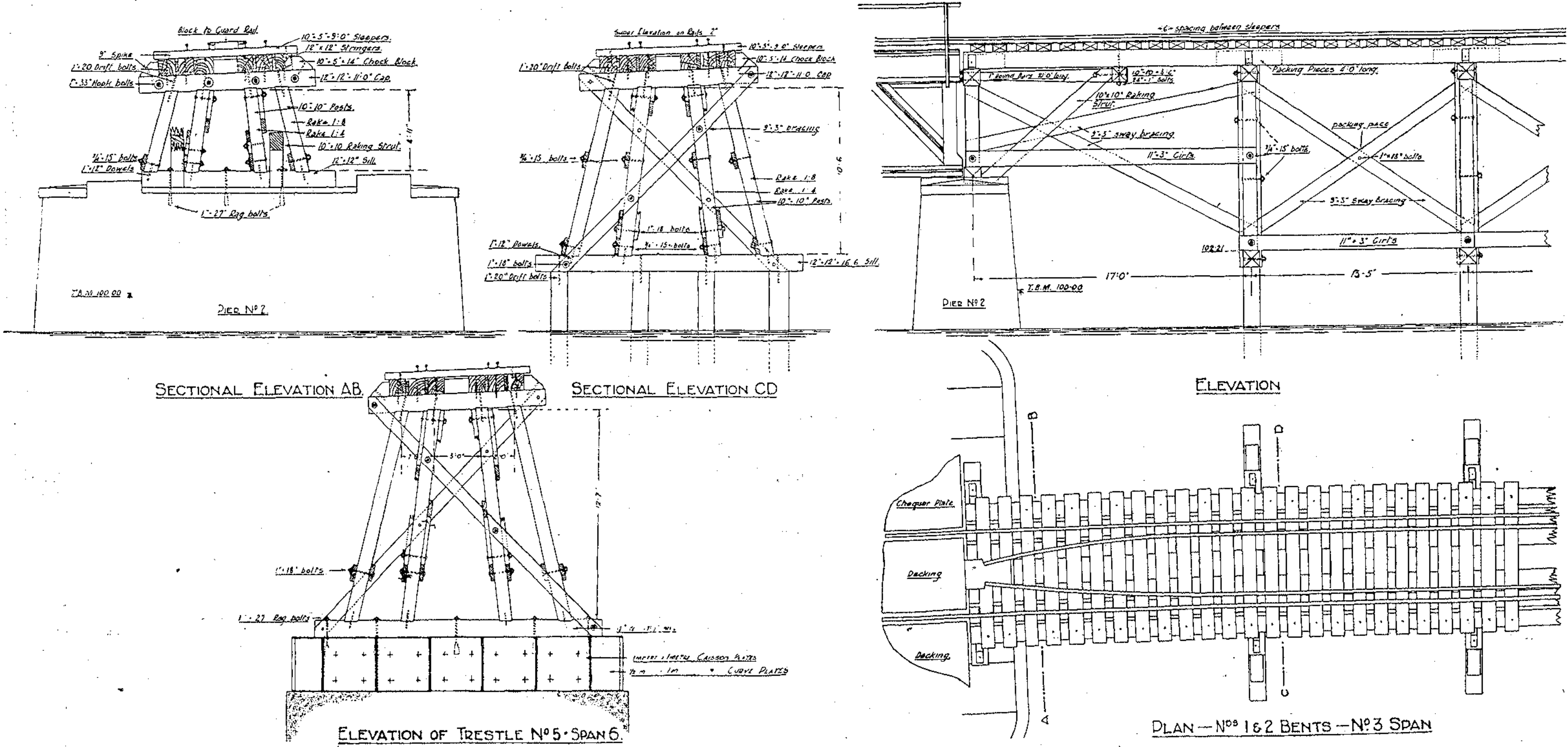
(*To be continued.*)



STUMICA
HUDOVA
BELESH DAGH
BELASHIZA PR
BELASHITZA PLANINA
PODGORA
PETRICH
FORT RUPEL
RUPEL
ALI BUTUSH
DEMIRAJI DAGH
CHENGEL
KRUSHEVO
KARA DAGH
ZERNOVSKO POLYE
BOZ DAGH
KURU CHAI
MESTA KARASU
DOIRAN LAKE
DOIRAN
VETRINA
DEMI HISSAR
SHARLIYA
SMINITZA DAGH
BUTKOVO
BUTKOVO R.
KARASU CHAI
STRUMA
DRAMA
KARAMUDLI
BASHANLI
KRUSHA BALKAN
KARA DAGH
KILINDIR
CHUGUNCI
KALINOVA
GALIKO
BARAKLI DZUMAYA
PROSENIK
BRODSKA R
ALISTRAT
SERES
KALENDRA
HOMANDOS
KOMARION
OSTRUMA
GUDELI
TAKHINOS LAKE
ZILIAHOVA
TO DRAMA
ANGISTA
PILAV TEPE
BUNAR DAGH
PRAVISHTA
GRAMUTNA
KUSHOVA
VURLAN
JANES
KIRKIT
KARASULI
ARDINO
KUREI
AVRET HISSAR
SARIGOL
SIRT DERE
MIROVA
LAHANA
LUKOVAN
SERES ROAD
BESHIK DAGH
BOGHDANSKIK DAGH
GEUL
LANJA LAKE
SALAMANLI
TUZHI GEUL
MARESH
GUVESNE
NEOHORI
CHAI AGHIZI
SIMVOLON DAGH
CHISIA DAGH
TASHLI
CHERAK TEPE
VARDAR RIVER
TOPSIN
DUDULAR
BALJA
LAHNA
LANGAZA
LANGAZA LAKE
LEMBET
TUIMBA
URENZIK
KIRECKOI
LEVENA
AKRAMERI
AKUKI HORTIACK
KALAMARIA
SALONIKA
KAPUDZILAR
ARI DERE
LANGAVUK
GOMENIC
ILANLI
BESHIK LAKE
BESHIK DAGH
GULF of ORFANO
ÆGEAN SEA
STAVROS
KARTAL TEPE
TULU DERE
LARIGOVO DEDET
ILIA TEPE
MADEM AGORIA
KHAMLOVUNI
ELEUTHERA
VASALIKA
CALATSIA
RESEINIKIA
KALAMARIA
GULF of SALONIKA
KULAKIA
VARDAR
KLIDI
MAIN ROAD
SECOND CLASS ROAD
RAILWAYS
MARSH
LAKES
SCALE
MILES 5 4 3 2 1 0 5 10 15 MILES

# RE-CONSTRUCTION OF VETRINA BRIDGE.

## DETAIL ARRANGEMENT OF TRESTLE WORK.




Elevation of Trestle No 5 · Span 6.

Plan — Nos 1 & 2 Bents — No 3 Span

# COLONEL KENT'S PATENT SYSTEM OF HOUSE CONSTRUCTION.

By Colonel H. V. Kent, C.B., M.I.C.E.

This system was evolved in 1919 to meet the Housing Problem, by reducing the cost of building and the time of erection by means of eliminating most of the skilled labour usually employed on the walls.

The writer gained much experience during the first year of the War, while he was A.D.F.W. for the Barrack Branch, in various systems of construction, temporary, semi-permanent and permanent, and after he retired he patented the "Kent" system, which is described in this article, and he claims that it is the most economical, most rapid, and most simple system in present practice, and that it gives the strongest, driest and warmest house on the market.

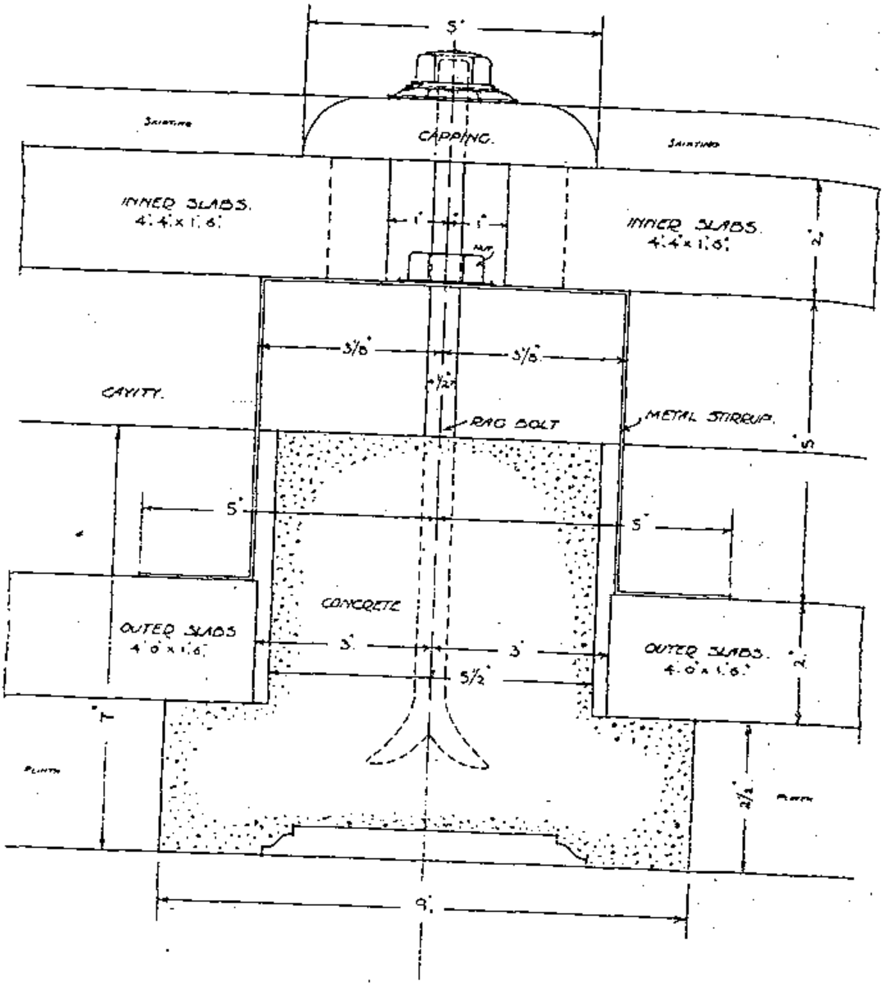
The system is based on the familiar "Pier and Panel" principle, the piers being of reinforced concrete, anchored into the foundations, and the panels consisting of long thin slabs of concrete, or other suitable material, which bridge the spaces between the piers.

The piers and slabs are pre-cast; the former have bolts cast horizontally in them, projecting inwards, and to these bolts the slabs, door-frames and window-frames are secured by nuts, by unskilled labour in a very short time.

In an ordinary small house the piers are set up at 4 ft. 6 in. intervals, and the bolts are set at 18-in. vertical intervals, the slabs being 18 in. high. In a dwelling house there are two skins of slabs, each 2 in. thick, with an air space of 5 in., which is practically continuous both horizontally and vertically all round the house, for the piers do not block more than 2½ in. of the air-space, leaving 2½ in. clear.

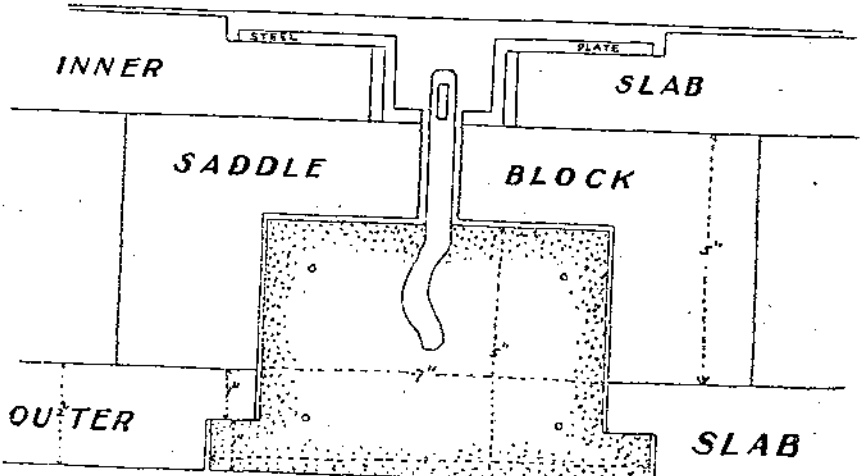
The outer slabs are secured against the shoulders of the piers by means of saddle blocks of hard wood or woodcrete, which are threaded on the bolts and pressed by nuts against the vertical edges of the slabs. *Figures* 1 and 2 show horizontal sections of pillars and slabs, but the metal stirrup shown in *Fig.* 1 has in later designs been replaced by the saddle block. *Fig.* 2 shows the saddle block, and it also shows how the outer slabs can be rebated to conceal the piers if it is not desired that they should show on the face of the wall. An alternative method of bolt with cotter-pin is also shown in *Fig.* 2.

The inner slabs are placed against the faces of the saddle blocks (which are 5 in. deep) and are secured there by nuts on the bolts or by the cotter-pins. The nuts will usually be countersunk, the corners of the inner slabs being rebated to one inch, and the inner face of the wall is then plastered to a flush surface. But where it is desired to get at the air-space, for instance in the scullery, where waterpipes, etc., will be led off inside the walls to the upper floors,




PLAN OF INTERMEDIATE PIERS.

FIG. 1.




PLAN.

FIG. 2.—*Showing Method of Securing Slabs by a Cotter Pin, and Rebating the Outer Slabs to conceal the Columns.*

etc., the bolts will project beyond the inner face of the slabs and these will be secured by means of vertical capping with ornamental nuts, showing on the face of the wall (as shown in *Fig.* 1), which will present a panelled appearance.

The air-space can be utilized for housing all the service pipes out of sight, *i.e.*, for gas, water, electricity, etc., and a hot pipe can be run right round the house inside the wall so as to give a warm air jacket round the entire house. In a block of barracks, or even in a village of detached cottages, built on this system, every house can be "mural heated" in this way from a central Refuse Destructor, super-heated air or steam at over 1000° Fahr. being laid on like gas or water, and in the same way a constant supply of hot water will also be available by using jacketed coppers, without lighting a fire in any house. Fireplaces and chimneys can thus be dispensed with, except where required for cooking, and where gas or electricity is available there need be none of these expensive items.

In a tropical climate it will be possible to drive refrigerated air into the walls, and the resulting temperature inside the buildings, in a hospital, say, should be perceptably lowered, especially if a hollow roof is cooled in the same manner.

A door-frame takes the place of five slabs, and a window frame takes the place of three slabs. The windows can be metal casements, or the ordinary wooden sash-frames can be used if preferred. Small windows for lavatories, larders, etc., can be fitted into the middle of a bay, taking up two slabs in height.

The upper floors can be laid on horizontal reinforced concrete slabs, bridging across reinforced concrete floor beams, which will rest on corbels pre-cast on the piers; and a jointless $\frac{3}{4}$-in. floor of "Woodcrete" can be laid over the slabs, with rounded-up corners at the walls in lieu of a skirting board, so that there is no place where dust can lodge. Futher details and dimensions can be seen from the annexed plan and elevation.

In carrying out the work the first operation after clearing the ground is to get in the foundations, and as all the weight is borne on the columns their footings only need be considered. Quite a small trench is all that is required for the plinth course between the columns. Any good carpenter can make the moulds for the piers and slabs, but it is necessary that great care should be taken to space the bolts accurately and to fix them truly at right-angles; the reinforcing rods must also be fixed correctly. The columns can be cast flat at right-angles to the sides of the house, and pockets should be left in the concrete foundations, as shown in *Fig.* 3 for the projecting rods to dip into, the gaps in the plinth course being just wide enough to take the 5-in. width of the columns. The latter can be up-ended by hand, with the assistance of small sheer legs, till they are vertical. They should then be guyed and set true with a plumb-bob, and the pocket filled in with a rich "super-cement" grout.

The slabs can be made of a sawdust composition such as "woodcrete," which possesses advantages over concrete in being damp-proof, vermin-proof, non-conducting and fire-resisting, while it can

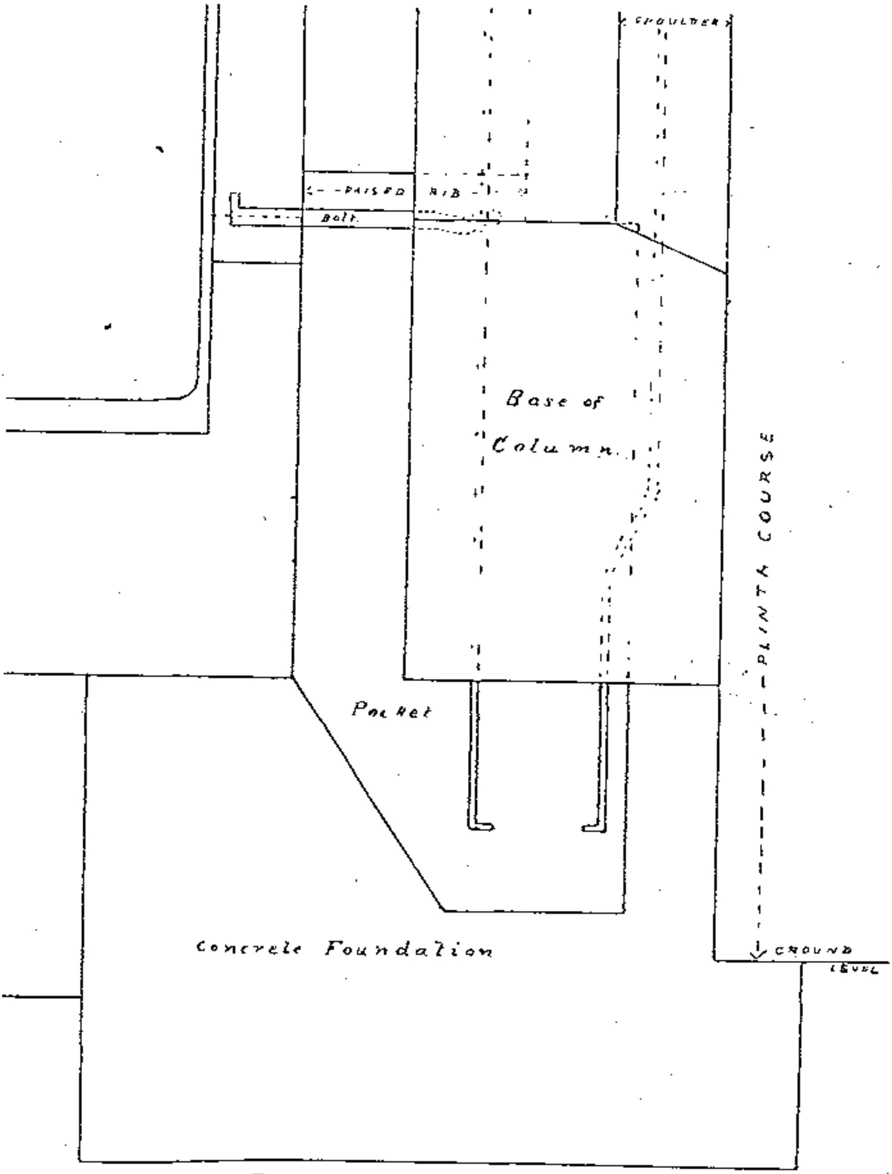



FIG. 3.—*Section through Foundations*

be moulded to take the finest edges, and it can be nailed, screwed, and even sawn. It is also a good material for "jointless" floors, curbs and stairs, and by its use practically all woodwork can be banished from the house, except in doors, cupboards, etc. A small building of "woodcrete" constructed on the "Kent" system can be seen at Bateman's Concrete Works, Hyde Lane, Battersea.

When the columns are "set" the outer slabs and window-frames and door-frames are set in position and nutted up. This operation is very simple and should not take more than a few hours for a whole house. A simple derrick, travelling on a truck, can be rigged up to hoist the upper slabs into position, and to lay the floor beams on the corbels where a concrete floor is used. No mortar or grout is required between the horizontal edges of the slabs, but they can be tongued and grooved, and no rough casting outside is required.

The laying of the reinforced floor slabs on the beams is a very simple matter. They also can be tongued and grooved, but this is not essential. If a ceiling is decided on, wooden fillets should be cast in the under side of the beams to make it fast to. Asbestos sheets or "S.X. Board" can be used for this.

The service pipes can be laid along the saddle blocks, and finally the inner slabs can be fixed in position and a thin coat of plaster applied to the faces of those walls where the nuts are countersunk. In climates exposed to extreme heat or cold double windows are recommended, and the window boards can be perforated to allow the hot (or cold) air to get between the windows.

Partition walls can be taken off any part of the outer walls by making slots, 3 in. wide, down the slabs, and they can also be made on the same principle of 3-in. breeze or woodcrete slabs, plastered on both sides, making 4-in. solid walls.

The system will lend itself to almost any style of architecture, for the form of the piers can be varied in many ways, moulds being easily made to produce round or square columns, plain, or fluted, or panelled, with pediments and capitals, or the columns can be flush with the face of the wall, as shown in *Fig.* 2.

An effective way of treating the slabs is to cast them with V cuts to represent masonry blocks, when it will be difficult to see where the joints in the slabs occur. Rock-faced slabs can be easily made, and a "vermiculated" appearance can be produced by picking out the surface after it has set.

The first "Kent" house was put up by the War Office in 1920 for the caretaker of the Havengore bridge on the artillery ranges at Shoeburyness; it is in plan a square of 5 bays on each side, measuring 23 ft. 6 in. by 23 ft. 6 in. It has three bedrooms, a bathroom, parlour, living-room and kitchen. It contains about 14,000 cubic feet, and cost £858, but access to the site was frequently interrupted by artillery firing. The War Office report that, had it been built under normal conditions, four men, three of them unskilled labourers, could have erected it in six weeks at a cost of under a shilling a foot cube.

The M.F.W. who put it up went so far as to say that in his opinion the cost per foot on a big job, where there is repetition work, should not exceed sixpence. Considering that prices at the beginning of 1920 were at top notch (2s. a foot cube, and more, in many cases), and that the house was rough-cast outside (an unnecessary expense), it is not claiming too much to say that the price to-day ought not to be more than ninepence a foot cube and the time for erection should be much shorter than it is on most systems. It is one of the chief advantages claimed for this system that the labour bill does not have time to mount up.

The occupants of this house say that it is drier and warmer than the brick houses they have lived in before, and although it is constantly exposed to the blast of the heaviest guns, they have never noticed the house to shake; this is remarkable testimony to the rigidity of the structure. A pair of "Kent" houses are to be put up at Welwyn for the *Daily Mail* Model Village Exhibition in March, 1922, and another, of 26,000 cubic feet, is shortly to be built at Wimbledon, the cost of which should not exceed £1,000. The Belgian Government has ordered four houses to be built on this system near Brussels, in order to compare them with a number of others of various British, French and Belgian systems.

To make a very lasting job the piers should be made with "super-cement," as then no rusting of the steel rods inside can take place, as no damp can penetrate such concrete. As the entire weight of the upper portion of the house is carried on the piers, and none on the slabs, the latter can be made of breeze, or "woodcrete," or chalk concrete, for they are subjected to no strains beyond wind pressure. The piers can be cast in one length of two storeys, or even three, and if they are cast on the site there is little trouble in up-ending them into position in one operation.

As all the units are pre-cast, and no mortar is required. there need be no stoppage of work in frosty weather, so that there should be no difficulty in completing a 25,000 cubic feet house in a little over a month, with 90 per cent of unskilled labour.

In a large building the "unit bay" will be naturally wider than 4 ft. 6 in.; the piers will be correspondingly heavier, and the slabs can be made deeper, for lifting-tackle will be available.

Where "mural heating" is applied on a large scale and fireplaces are omitted, it will be necessary to make adequate arrangements for ventilating the rooms, and this can be done by letting in "hit-and-miss" gratings in the panels of the walls at the top and bottom, and arranging for fresh-air inlets through the outer slabs.

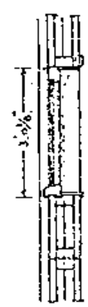
An unusual feature in these houses is that if it is desired to alter the position of a window, or to add a new one, it is a simple matter to take out three pairs of slabs and put in a window-frame. In fact, the whole house can be taken to pieces and packed up and re-erected elsewhere at very little expense beyond the cost of transport. All those who are interested in the system, or wish to know details as to royalties, etc., are invited to communicate with the writer at 19, Hanover Square, W. 1.

House designed for Erection at Croxley Green, Herts., on the "Kent" System.
Accommodation: 3 Reception Rooms; 7 Bed and Dressing Rooms, Servants' Hall, Bath-room, etc.
Estimated Cost, £1,500.

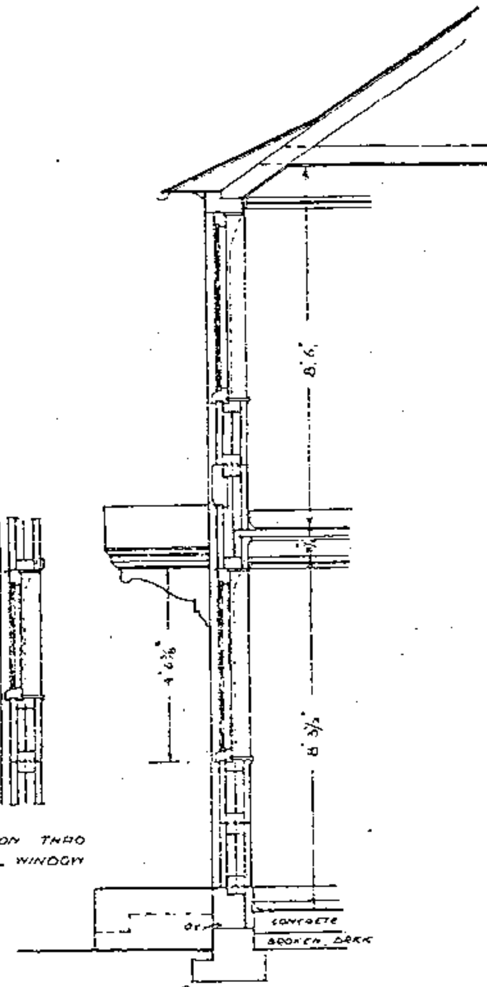
# COL. KENTS PATENT CONSTRUCTION FOR HOUSING SCHEMES.

## DETAILS.

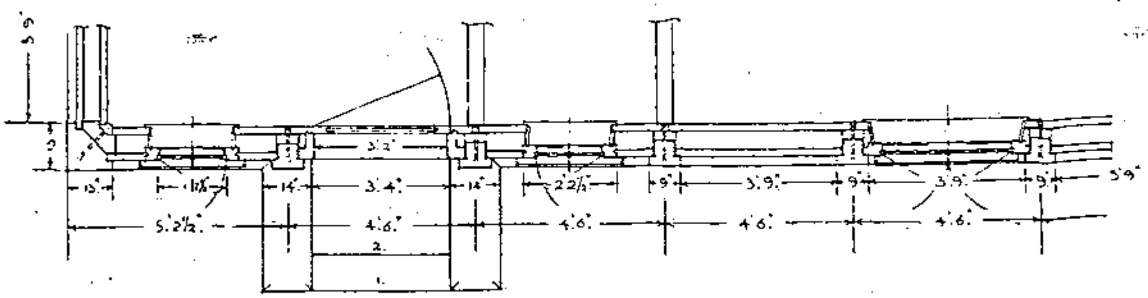

ELEVATION.



SECTION THRO SMALL WINDOW




SECTION




PLAN.

# *PROFESSIONAL NOTE.*

## THE STRONACH DUTTON SYSTEM OF ROAD RAIL TRACTION.

(COMMUNICATED BY THE R.E. BOARD.)

AN experimental installation of this system, with an improvised Tractor, working on a five-mile length of line at Chobham Ridges, near Aldershot, was recently inspected, and it is thought that the system is of sufficient interest to merit report in the *R.E. Journal.* The line on which the Tractor is working was laid in 1920, with the view of bringing up 8,000 tons of soil from Lucas Green, near the Gordon Boys' Home, to Blackdown Barracks for the formation of recreation grounds. The gauge of the line is 60 cm., laid partly with steel and partly with wooden sleepers.

The gradient for the first three miles is 1 in 30, followed by about 800 yards of 1 in 20, with a maximum gradient of 1 in 12, on which the Tractor works. The remaining portion of the line is slightly downhill. This particular alignment was chosen, partly to circumvent the danger area of Bisley Rifle Ranges, and partly because it was considered advisable, for constructional reasons, to bunch the gradient and locate the line on the good surface afforded by the Heatherside Road, and to use the Stronach Dutton System of traction which was brought to the notice of the Aldershot Command about this time.

The principle adopted in the Stronach Dutton System is to support the front axle of a short-wheel base tractor by a four-wheeled bogie running on a Decauville line. A draw-bar is carried from the bogie pivot to the back of the tractor for the attachment of such trucks as can be hauled. The tractive effort is produced by the ordinary rubber road wheels of the tractor running on the ballast.

The accompanying plates show the most recent pattern of tractor hauling a train and converting from road to rail or rail to road traction. The ball point on the bogie and the long draw bar are clearly shewn.

The tractor cannot reverse, and a circular track is required to enable the tractor to turn at each end of its run. A circle of 75-ft. radius was required for the improvised Berna Tractor used at Chobham Ridges, but a special tractor has been produced with a turning circle of 38-ft. radius. If the wheel-base of the tractor is too long the inner driving-wheel has a tendency to approach the inner rail round a curve.

The following is an extract from the inspection report:—

"The party witnessed the tractor taking a load of about 16 tons over the track. After hauling the load up the hill, the tractor, without the load, went round the circle—a radius of about 75 ft.—without difficulty, after which a demonstration was made of unshipping the bogie enabling the tractor to be used as an ordinary road tractor. The unshipping and reshipping of the bogie was a matter of only a couple of minutes.

"The conclusions drawn were as follows :—

"1. The tractor is only suitable for use where the track is laid on a reasonably good road surface, or when the permanent way of the tramway is built substantially up to a width somewhat in excess of the 'track' of the road wheels.

"2. The 'track' of the road wheels of the tractor must be greater than the length of the sleepers. With the Berna Tractor employed this necessitated the use of very short steel sleepers with the 14 lbs. Decauville rails."

The later design of tractor has a considerably wider track.

"3. It was considered that any road on active service would seldom be of sufficient width to enable a portion of it to be devoted to a tramway, and that it must be assumed that tramways would always be off the road.

"4. For tramways built off the road, normally the construction of a tramway and track for a road rail tractor will involve a greater width of formation and more ballast, and the maintenance, due to the wear of the track under the road wheels, will be heavier than in the case of a rail tractor. Under the heavy traffic conditions on active service, generally speaking, these disadvantages will outweigh the advantages of increased tractive effort, steeper grades and sharper curves (and possibly lighter section rails) utilizable with the road-rail tractor. Exceptions might be cases where ballast is plentiful, and for short lengths of line in difficult country.

"5. Accordingly, apart from exceptional conditions such as are suggested below, the system would not prove economical.

"6. For certain specific engineering schemes, the use of such system may be useful in military operations.

For instance—

(*a*) In certain cases, a more economical location for a tramway or light railway might be obtained by the inclusion of a short section with very steep gradients, the road-rail system of traction being used over this section.

(*b*) The system would be well adapted to a rocky or desert country where, under normal conditions, road transport can be used without extensive preparation of metalled roads, and where the country is sufficiently difficult to prohibit the economical or rapid construction of a light railway with grades suitable for ordinary adhesive rail tractor."

It has been suggested that difficulties in connection with the construction and maintenance of the road-wheel tracks might be reduced by the substitution of a "track vehicle" in place of a wheeled one.

The most recent pattern of tractor, a twin 25 h.p.-engined Sou-Tractor, as exhibited by the Road Rail Co., was seen at Neasdon, working on a track composed of a few inches of cinders on the top of a heavy clay soil. It hauled four empty wagons, total weight about seven tons, easily on a slight incline and round a curve of a radius of 38 ft. The weight of the tractor is about five and a half tons and weight on driving wheels three and three-quarter tons. The draw-bar in this case is attached to the underside of the bogie. The clearance between the draw-bar and the differential is only about three inches, and it appeared that if by mischance the driving wheels sank far into the ground there might be some damage. This risk is somewhat modified by the unusual size of the wheels.

The extra gearing, due to the use of twin engines must entail some loss of power. But, as each engine can be used independently, delays, etc., due to engine trouble, can be avoided under certain conditions.

It appeared to the observer that the springs under the engine were too easy, as the body rocked excessively on the track.

The tractor in question is on order for the Uganda Government.

It is stated that it has travelled four times between Wolverhampton and London with entire satisfaction.

The following tables give further particulars as regards gear ratios, speeds and loads :—

*Gear Ratios.*

Reduction Gear 1·5 to 1    Rear Axle 8·24 to 1

Gear Box 1 to 1 Top
1·73 to 1 3rd.
2·9 to 1 2nd.
3·1 to 1 1st.
5·5 to 1 Reverse.

*Overall Ratios.*

12·36 to 1 Top.
21·4 to 1 3rd.
34·8 to 1 2nd.
62 to 1 1st.
68 to 1 Reverse.

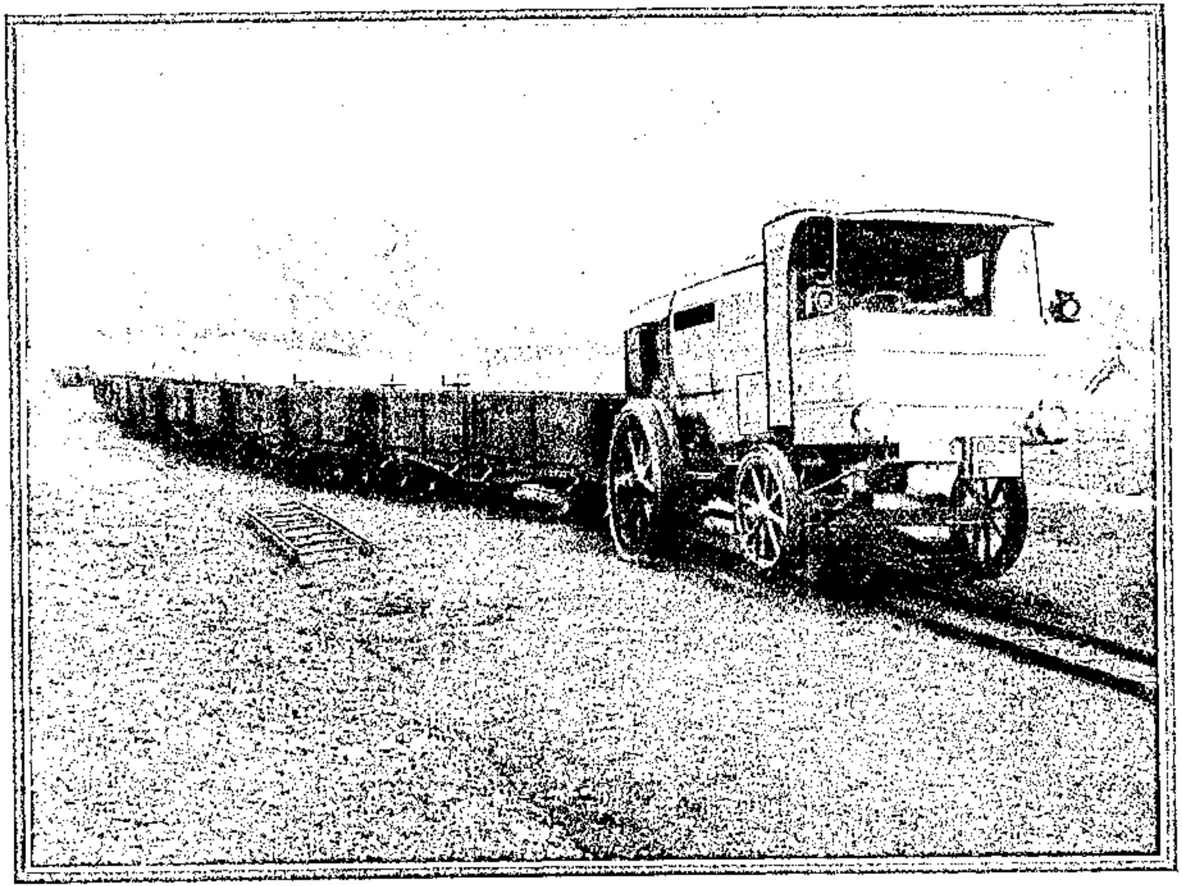
Tractor speed at Engine speed of 1,000 R.P.M.

14·15 to Top.
8·18 3rd.
4·92 2nd.
2·82 1st.
2·57 Reverse.

Max. Loads.

| Grade. | Per Cent. | Gross Load in Tons. | Grade. | Per Cent. | Gross Load in Tons. |
|---|---|---|---|---|---|
| Level | ... | 250 | 1 in 14 | 7·15 | 26 |
| 1 in 100 | 1 | 125 | 13 | 7·7 | 24 |
| 75 | 1·34 | 100 | 12 | 8·35 | 22 |
| 50 | 2 | 82 | 11 | 9·1 | 20 |
| 40 | 2·5 | 66 | 10 | 10 | 18 |
| 30 | 3·34 | 52 | 9 | 11·1 | 15 |
| 25 | 4 | 45 | 8 | 12·5 | 13 |
| 20 | 5 | 39 | 7 | 14·3 | 11 |
| 18 | 5·55 | 34 | 6 | 16·7 | 8½ |
| 16 | 6·25 | 30 | 5 | 20 | 6 |
| 15 | 6·7 | 28 | 4 | 25 | 3¾ |

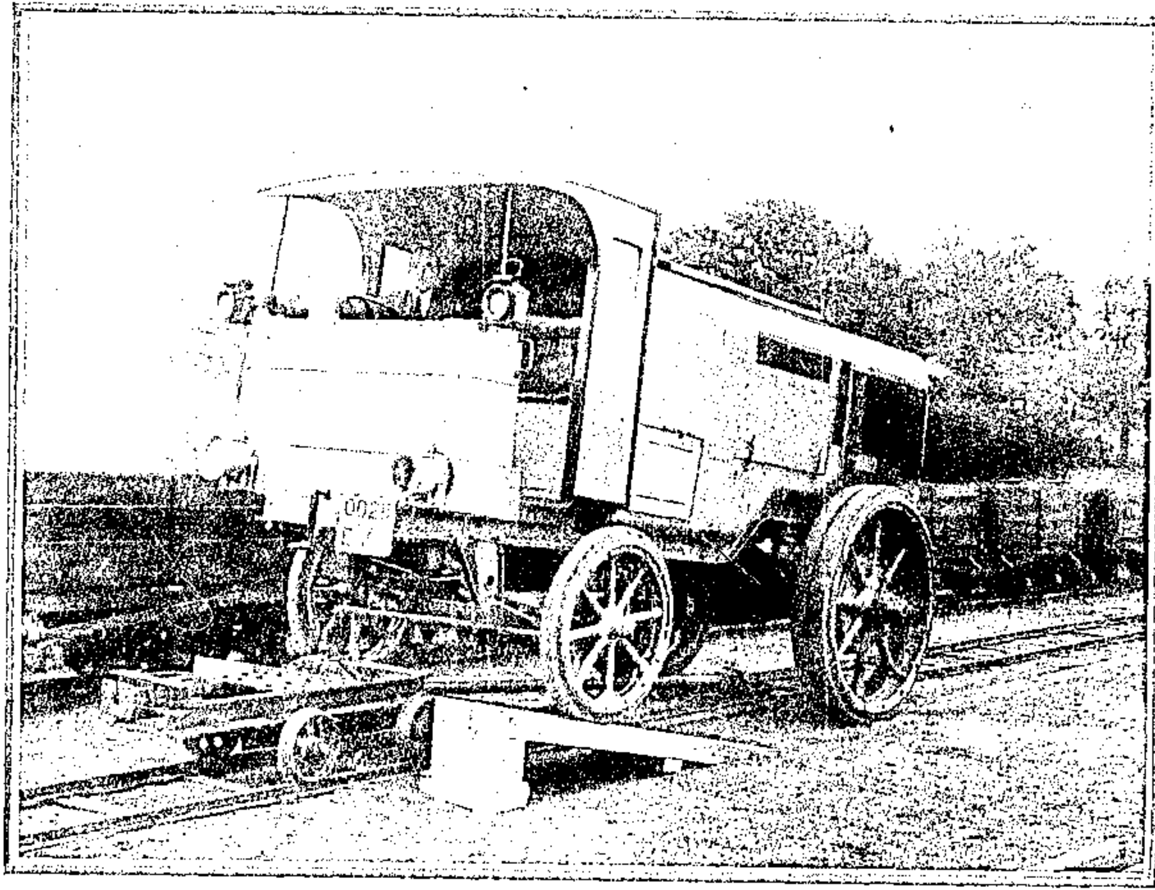
## THE STRONACH DUTTON SYSTEM OF ROAD RAIL TRACTION.



Road Rail Tractor, 50 h.p. Standard Convertible Type, with Train.

*Reproduced by kind permission of the "Commercial Motor."*

# THE STRONACH DUTTON SYSTEM OF ROAD RAIL TRACTION.



Converting from Road to Rail or Rail to Road by Temporary Sleeper Ramps.

Lieut.-Colonel P. G. von Donop, R.E.

# *MEMOIR.*

## *LIEUT.-COLONEL P. G. VON DONOP, LATE R.E.*

I HAVE been asked to compile a Memoir of the late Lieut.-Colonel P. G. von Donop, and I am only too glad to do anything which may help to perpetuate the memory of one who represented a very fine type of Royal Engineer Officer, was a highly valuable servant of the State, and a most delightful companion.

I have been assisted in this memoir by some of his brother officers who were closely associated with him in the many activities of his career.

Pelham von Donop was the son of Vice-Admiral E. P. von Donop and was born at Southsea on the 28th April, 1851.

Like many of the best type of British officers he came from a "Service family," now represented by his younger brother, Major-General Sir Stanley von Donop, to whom he was greatly attached, and who, as Master-General of the Ordnance, was closely associated with the work of the Royal Engineers.

He was educated at Somerset College, Bath, previous to passing into the Royal Military Academy in 1869, and obtained a Commission in the Royal Engineers in December, 1871.

He was from the first both a good worker and a good player, representing his school both at cricket and football, and playing in the Royal Military Academy Cricket Eleven in the years 1870 and 1871.

Von Donop joined the School of Military Engineering at rather a remarkable time. It may be said to have been the advent of a new era in the history of the Royal Engineers.

Previous to this time, the history of the Corps is a distinguished and a highly honourable one, but its duties had been chiefly confined to the construction of fortifications, military buildings, and survey work, individual officers and men being, however, not infrequently employed in extraneous duties both civil and military.

New discoveries and inventions and their application to military matters now began to take effect. Improvements in weapons and methods of defence were introduced, together with better means of communication; such were the development of railways and telegraphs for military purposes. About this period, also, it was decided that the Royal Engineers were to be entrusted with the submarine defences of our ports. It will be seen later that von Donop was destined to take an important part in all three of these new activities of the Corps.

To meet these additional responsibilities, the number of young officers at the School of Military Engineering was largely increased and a fresh impetus was, I think, given to all branches of study, duty and, last but by no means least, to games and recreation.

It can readily be imagined that von Donop soon adapted himself to these conditions. Energetic, accurate, quick and conscientious, ready to rise early or work late, he found time without neglecting his professional duties to become pre-eminent in games, for which he had a great natural capacity, and it is this side of his career which will be dwelt upon in the first place. Whilst a good cricketer he was an exceptionally fine Association football player; in fact, the *Sporting Press* at that time described him as "The Prince of Dribblers," and the description was not inapt though he would have been the last person to admit it. In addition to assisting to maintain the R.E. football team in the very front rank of clubs, he twice played for England against Scotland, in 1873 and again in 1875; he was also one of the fortunate R.E. team who won the Association Challenge Cup in the year 1875. His powers as a cricketer were perhaps only fully developed after he left the S.M.E., when his name became somewhat of a terror to most of the Garrison and Naval Elevens at Portsmouth and Bermuda, where he was afterwards stationed.

At Chatham, however, in 1875, he made a century in the celebrated match, R.E. *v.* I.Z., when the R.E. made 726 for 8 wickets and the I.Z. never got an innings.

On leaving the S.M.E., von Donop was posted to the 28th Submarine Mining Co., under the command of another well-known cricketer, Capt. Heneage. After two years this Company was moved to Gosport and became famous for defeating all comers (Brigade of Marines, R.M. Artillery, etc.) at cricket. It was also the best shooting Company in the R.E.

After one-and-a-half years at Gosport the 28th Co. was sent to Bermuda, where they again carried all before them at cricket, finally playing a combined Naval and Military Eleven representing the World. Von Donop and his brother officer, C. K. Wood (of the 28th Co.), also won the Open Championship Doubles Lawn Tennis whilst at Bermuda.

It may be interpolated here that later von Donop became a first-class lawn tennis player, finally winning the West of England Championship at Bath in 1884.

On returning to England in October, 1880, von Donop was soon afterwards appointed to the Postal Telegraph Service at Bristol, which was then the Headquarters of the R.E., entrusted with the charge of the Postal Telegraphs to the South of the Thames.

Work in a Postal Telegraph Unit was of an entirely different character to that of the R.E. units to which he had previously been attached. The personnel was scattered in small parties, in many cases even singly, over a large area, and frequently carried out their duties under and alongside civilians. At this time also the military branch of the Postal Telegraphs was still in its infancy and more or less on trial; hence many difficulties and prejudices had to be overcome by the pioneers of this service. Doubtless it was during this period of his career that von Donop developed those special qualifications which proved to be so valuable when he was placed in supreme charge of this branch of the service, and later when he became an Inspector of Railways. That he carried out his duties satisfactorily in every respect whilst at Bristol is indicated by the fact that, in 1884, he was specially selected to join the 8th Railway Co., R.E., under the command of Major (now Major-General) D. A. Scott, this company being under orders to proceed to Egypt on active service.

Major-General D. A. Scott has sent me a very interesting account of the work done by this company in Egypt, more especially as far as von Donop was concerned. Incidentally it illustrates the difficulties experienced and overcome in the first British campaign where military railway companies formed a very important feature in the supply of an army in the field.

"On the 13th June, 1884, orders were received at Chatham to make up the 8th Co., R.E., to war strength and three extra officers were at once posted to the Company. Von Donop was one of these and he was placed in command of the second half-Company, or the traffic portion. Between this date and the date of embarkation of the Company for Alexandria, through the courtesy of the Chairman and Directors of the L. C. and D. Railway, the N.C.O.'s and men of the Company were drafted on to this railway for instruction and training, and von Donop exercised a general supervision of his men during the time they were thus employed.

"The embarkation of the Company took place on the 3rd September, 1884, and it arrived at Alexandria on the 15th September, when it was at once pushed up the Nile to Wady Halfa, the terminus of the Soudan Railway, which place was reached on the 4th October.

"The working of the railway was in the hands of a scratch Staff, and with its broken-down engines and dilapidated rolling stock was found to be in a state of the utmost confusion, being practically at a standstill.

"At the beginning of November I was sent for by Sir Redvers Buller and informed that I was to have unfettered control of the Railway and that as Director of Railways I was to have free access to the C. in C., and I was also to have a free hand in making arrangements for the efficient working of the Line.

"Von Donop was appointed Traffic Manager, and he retained this appointment for the time the railway remained under military control, *i.e.*, until the 19th April, 1886, and he then returned to England with the Company in June, 1886.

"I may state here that this was the first experience von Donop had in the practical working of railways. I think I can best give an idea of how he carried out his important duties by quoting my appreciation of his services in my report of the working of the London military railway.

"'Capt. P. G. von Donop, R.E., succeeded Mr. —— as Traffic Manager; although this officer had little previous experience of railway management he at once picked up the work and has performed the onerous and important duties of Traffic Manager in a most satisfactory manner. His task has been a very difficult one, but it has been carried out in a manner that does him the greatest credit.'"

He was further reported upon by the G.O.C. Commanding, in his 'Report on Railways, Nile Expedition,' as follows:—'The onerous duties of Traffic Management were ably conducted by Capt. von Donop.' "I also reported that von Donop had done his work, often under great pressure and difficulties, in a manner deserving of commendation and reward. I should like to add a personal tribute to the way he carried out his duties. During the whole time he was under me we were on intimate terms. He was closely associated with me in all the details of his work and I always knew how things were going. Although he had had practically no experience of traffic management, at the best of times a troublesome business, he seemed to fall into the right groove instinctively. In addition to his ability he was full of good sound common sense and totally devoid of cranks and fads—he was likewise possessed of a keen sense of humour which served to leaven the mass of disappointments and troubles. He was a most loyal worker and friend, and, while he had plenty of strength of will, he was invariably courteous and tactful, which served to make rough places plain. In short, he had all the essential qualities of a good Traffic Manager and above all things he was a 'gentleman' *au bout des ongles*. One need scarcely say more than this. Personally, I shall always look back at the time we spent together in the 'womb of the desert' with pleasure and to his memory with affection."

On his return to England, from Egypt, in 1886, von Donop was sent again to the S.M.E., where he remained for two years, and then, after a short spell at Harwich, he was selected for the appointment of Inspector of Submarine Defences in India, succeeding Major Carter, R.E., who had died rather suddenly. This appointment was specially important at the time as the plans of the re-organized Submarine Mining Defences were under consideration. Brig.-Gen.

Tudor, who served under von Donop in India, says that " the plans were approved soon after my arrival, 1889, and we set to work to survey the harbours and prepare the stores. The whole of this work was completed while von Donop was I.S.D. in India. We also had some actual rehearsals of laying out the mine-fields when von Donop was present. Before he left India the whole of the S.M. Defences, including electric lights, of the Indian Ports were complete and efficient, no mean accomplishment in those days of parsimonious governments. Von Donop had an extraordinary knack of seizing on the essentials of a matter and clearly stating them in his reports. I think he accomplished with less correspondence more than any Commanding Officer I served under in pre-war days. He cut returns down to a minimum; he was an ideal C.O., always sympathetic and helpful in our difficulties." Col. H. E. Tyler, who succeeded him, says that " he left no disputes of any kind and no arrears of work whatsoever to me, and gave me all the help he could."

Whilst in India, von Donop had the good fortune to meet his future wife, Miss Ethel Farren, daughter of J. Orr, Esq., of the High Court of Bombay, who, after his marriage in 1890, was his constant companion, and nursed him most devotedly during his last long illness.

On his return home von Donop received another important appointment, being made Officer Commanding the 2nd Division Telegraph Battalion, and was entrusted with the supervision of the whole of the Postal Telegraphs south of the Thames, with Headquarters in London. The responsibilities of this appointment were extensive, as, amongst other things, they involved the whole engineering requirements of the Postal Telegraphs in this area, including heavy new construction work, costing large sums of money. Von Donop's previous experience at Bristol was no doubt invaluable, more especially in dealing with the many questions in which the public were concerned, and in the harmonious interworking of the military and civil sides.

Brig.-General Boys, who was associated with him at this time, says:

" In such circumstances as these, von Donop's personal characteristics stood the work in good stead. Firm, yet considerate to his subordinates, courteous and genial to all with whom he came in contact, he helped greatly to overcome the prejudices of the civilian element and left behind him an atmosphere which tended to smooth the course of those who followed him in the difficult and delicate positions they held."

After the completion of his four years' tenure of office with the Postal Telegraphs, von Donop was, in May 1898, appointed Commanding Royal Engineer at Dover, where he remained for rather over a year when he was made an Inspector of Railways under the

Board of Trade. He now commenced, what perhaps may be called the most valuable part of his official career extending over a period of 17 years, during the last three of which he was the Chief Inspector. Here again, as in the case of the supervision of Postal Telegraphs, it is a very difficult task which Royal Engineer Officers have to perform, and one requiring tact, courtesy and impartiality, as well as an intimate knowledge of technical matters.

How well von Donop carried out those onerous duties, and in what degree he possessed the necessary qualifications for his post, is clearly shown by the following remarks of Colonel Sir H. A. Yorke, late Chief Inspector.

"Von Donop joined the Board of Trade while Marindin was Chief Inspecting Officer of Railways, and no one could wish to serve under a better Chief. Von Donop threw himself with characteristic energy and zeal into his new duties and soon mastered the principles of block working, signalling, and all the other technical details of the construction and operation of an English railway.

"He was 'thorough' in all that he undertook, and he never spared himself in the execution of his duty. His reports were well reasoned and his decisions were always accepted as conclusive and just. The geniality of his disposition made him a general favourite wherever he went, and he was affectionately regarded, not only by his colleagues at the Board of Trade, but also by all the railway officers with whom his duties brought him in contact. His fondness for golf was well-known, and often after a hard day's work he would finish up on the local golf course, wherever he might be, in a round with one or other of his railway friends.

"In 1913, he succeeded to the post of Inspecting Officer of Railways, and in 1916 he retired from the public service under the inexorable law known as the age limit. His death is deeply deplored by those railway officers with whom he had been associated in his official capacity."

The following extract from the *Railway Gazette* of August 25th, 1916, when he retired from the appointment of Chief Inspector is much to the same purpose:

"Colonel von Donop was an ideal civil servant, painstaking, approachable, and always willing to hear both sides of a question. His inspections and enquiries were thorough, nothing being taken for granted, but always with that reasonableness that made Railway Officers most willing to assist him."

. . . . . .

This was the close of von Donop's official career, a career most useful and varied, carrying much responsibility, and exhibiting a rare combination of marked ability and special personal qualifications.

. . . . . .

After his retirement, he resided at Camberley with occasional visits to the South of France, his chief interests being gardening, golf and the society of his many friends. Early in 1921 he developed a serious illness which eventually proved fatal on the 7th November. During this long, painful period, he exhibited the remarkable patience and fortitude so typical of his character.

He was buried at East Sheen on the 10th November and round his grave were assembled many of his old comrades of the Royal Engineers. Amongst them were:

Major-Generals: D. A. Scott, Duperier, Sir Spring Rice.

Brig.-Generals: Bowles, Lake.

Colonels and Lieut.-Colonels: Abbott, Addison, Blackburn, Boys, Olivier, Pringle, B. B. Russell, Wilkieson, Sir Arthur Yorke.

Amongst the very many letters of sympathy which were received by his widow, were not a few written by young men who had received benefit from his advice or personal efforts. One of these wrote:

"He was so nearly an ideal man that the inspiration of his example must have helped many people. I know that I owe a tremendous lot to him. Always when I have wanted sound advice, he invariably went out of his way to help me. I know the advice he gave me was not just a hasty opinion, but collected from every quarter where it could be usefully found . . . . My hope is to live even half as good and useful a life."

This extract seems to me to strike the keynote of his character and disposition; it is impossible to describe the charm of his personality. Colonel C. K. Wood says "he was a staunch and loyal friend, the best one can have."

Like his intimate friends Marindin, Merriman, and Renny-Tailyour who have "gone before," von Donop undoubtedly represented a type of R.E. Officer of whom the Corps may justly be proud.

R. M. Ruck.

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## *THE LATE COLONEL H. W. RENNY-TAILYOUR.*

The Officer who wrote the Memoir on the late Colonel H. W. Renny-Tailyour which appeared in the *R.E. Journal* of September, 1920, has asked that an omission which was made in that Memoir may be made good. Colonel Renny-Tailyour not only played in the final Association Cup Match of 1875, but he kicked both goals scored in that Match by the victorious R.E. Team.

# *REVIEWS.*

## THE RIDDLE OF THE RHINE.—CHEMICAL STRATEGY IN PEACE AND WAR.

By VICTOR LEFEBURE. (Collins, Sons and Co. Price 10s. 6d.).

This is a very important and very interesting book and one which should be read, and indeed studied, by every soldier. The importance of the subject may be gauged by the fact that Field-Marshal Sir Henry Wilson has been at the pains to write an introduction in which he emphasizes the necessity for a full knowledge of the facts regarding gas warfare on the part of the public. If it is necessary to the public, how much more so to the soldier?

It is no doubt owing to the secrecy which necessarily shrouded to a large extent the use of gas by the Allied forces during the War that so little is known of the broad strategical principles which underlie the employment of this new weapon of war. Major Lefebure sets himself the task of bringing out these principles, of showing how in this matter strategic policy is closely bound up with economic policy, and how a monopoly in chemical industries on the part of a single nation may constitute a formidable military danger to other nations. The problem of how to deal with this situation as it exists after the war is what he calls "The Riddle of the Rhine."

The author gives a detailed narrative of the chemical warfare operations on the Western Front. Beginning with the first surprise use of chlorine from cylinders by the Germans at Ypres in April, 1915, and the retaliation by the English and French at Loos in September of the same year, he traces the struggles for the initiative by each side to the end of the war. He shows how each adversary made a constant endeavour to penetrate or circumvent the protective mask of his opponent, sometimes by the introduction of new substances and sometimes by improved methods of tactical employment. Of the latter the most striking example was probably the use of the Livens projector by ourselves in 1917, and of the former the introduction in the same year of mustard gas by the Germans. The development of the use of gas in artillery shell is similarly traced both in its technical and its tactical aspects.

Major Lefebure's account of the successive stages of these operations is clear, interesting and accurate. Without sensationalism or exaggerations he gives a sane and well-balanced picture of the great importance that chemical warfare has attained in modern war. He shows how the necessity for using respirators imposes on troops a very considerable physical strain which reduces their mobility and capacity for using their weapons, and also entails a special and strenuous form of training and a particularly high standard of discipline. The magnitude of the share taken by gas warfare in modern operations is illustrated by the fact that of the casualties suffered by the American armies in France those due to gas amounted to 75,000 in number, or more than a quarter of the total; also by the fact that in 1918 the German divisional ammunition dumps contained normally 50 per cent. of gas shell, and that in the preparation for certain attacks their artillery programmes included as much as 80 per cent. of gas shell for certain objectives.

The author goes on to review the production of chemical warfare materials by Germany and the Allies during the war, and in particular the immense military potentialities of the great German dye and chemical industries on the Rhine. He shows that the theory advanced by some public men that the employment of gas in war, or the manufacture of war chemicals in peace, can be prohibited by convention or treaty is in actual fact a vain dream. He points out that chemical plants and factories which had taken forty years to build up could be converted to the production of war chemicals in forty days. He states that gas is the outstanding case of a weapon whose manufacture it is difficult to prevent, and that no convention, guarantee or disarmament safeguard will prevent an unscrupulous enemy from employing poison gas, especially if that enemy has discovered some new powerful agent, or possesses, as Germany does in her well organized and strong chemical industry, a ready means of producing such chemicals in bulk at practically a moment's notice.

It is evident, therefore, that chemical warfare has become an inseparable component of modern war, and that there is no hope of abolishing it except by abolishing war itself. The "riddle" therefore is to discover the means of preventing Germany's dominant position in the chemical world from being a menace to the world's peace. Major Lefebure propounds his own solution to this riddle. It is probable, however, that there are many men who will not consider his solution a practicable one. Nevertheless, he is well justified in his endeavour to make the public realize the serious and difficult nature of the issues involved.

By soldiers, above all, it is essential that these issues shall be understood. There is a too prevalent disposition, even in the ranks where long experience might have been expected to bring mature judgment, to discuss the matter by the light of an antiquated sentiment or to shelve its consideration by an ostrich-like disposition to shun plain facts. To all grades a study of Major Lefebure's pages, whether all his arguments are admitted or not, cannot fail to be of advantage and to tend to the production of a clearer vision in regard to this important question.

H. F. THUILLIER,
*Major-General.*

## WORK OF R.E. IN EUROPEAN WAR, 1914–1919. SIGNAL SERVICE (FRANCE).

Major Priestley has produced under this title a valuable contribution to the literature dealing with the special work of the Royal Engineers during the War in France. It is to be hoped that a further instalment, as suggested, for the other theatres of war will be forthcoming.

In the present volume, written with enthusiasm for his subject and with great care, the author has managed to give a very full and connected account of the history and development of the Signal Service during the four years of hostilities.

It is perhaps unfortunate that so large a part of the book deals of necessity with the development of buried cables; these, though they undoubtedly played a prominent part in the War, were at the last fast losing favour with Signal Officers working in the forward zones. When position warfare was brought to a close, Signal Officers were turning in bewilderment towards any alternative means that would give them the same measure of security as "6-ft. buries" had provided in the great battles of '17 and '18.

While mentioning buried cables, it may perhaps be noticed that the author, on page 214, has not done justice to the prominent part played by them in the Messines battle, or in the *latter half* of the fight for the Paschendaele Ridges. In the former battle, Whytschaete was successfully connected up with buried cable a few hours after the attack opened, through the efforts of a battalion as a digging party; while throughout both battles cables were successfully maintained by all the Corps engaged. The author fully realizes the waning confidence of Signal Officers in wire carried communications, and throughout the book lays stress on the efforts made to replace them with alternative means.

Major Priestley, when dealing with the development of earth induction, perhaps hardly does justice to our Allies, for it is safe to say that no real success attended this method previous to some very successful demonstrations given at Zuytpene by a lieutenant of French Artillery at the invitation of the 2nd Army Signal School. No Signal Officer who was privileged to be present at these demonstrations will wish to give the credit elsewhere.

The author properly points to the uphill fight that wireless had to maintain throughout the War to gain even that measure of success it obtained in the later phases of the struggle. The prejudice of Staff and Signal Officers is mentioned as the stumbling-block, but the author might also have given a further reason. Nine-tenths of the Signal Officers, until trained during hostilities, were ignorant of even the rudiments of wireless, for, before the war, wireless was regarded as a mystery, to be jealously guarded by a few. In the earlier months of the War this policy was maintained with all due solemnity, even the Senior Signal Officers, outside the magic circle, were considered unworthy to approach its shrine which was safely ensconced within the hallowed precincts of G.H.Q. Surprise can hardly therefore be felt that a great dread of this magic god grew up among the great body of Signal Officers, and it is safe to say that it was this dread among the Junior Officers at the front, as much as the prejudices of Staff and Signal Officers, that was responsible for the slow progress made by this useful auxiliary in gaining its rightful place in the signal system. It is interesting to note that the Colonial Corps, as might be expected, led the way to the advancement of wireless into the front line.

To the careful student of this work (and it should be studied by all Signal and Staff Officers), many lessons can be learned; these are well enumerated on page 41, but perhaps one more lesson should be added. The Signal Officer of the future will require to be a man of high scientific attainments, for everything points to the higher branches of science being called in more and more to his aid. The era of black and white poles has passed, that of cable is passing—wireless, in forms perhaps at present unknown, may become the mainstay of the future Signal Officer: he will be useless unless he can utilize it.

Major Priestley is to be congratulated on the production of so useful a work with such a paucity of material, as he complains, within his reach.

A.R.H.

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## DIRECTIVE WIRELESS TELEGRAPHY.

By L. H. Walter. (Pitman's Technical Primers Series, 2/6.)

Electro-magnetic waves have many properties in common with light, but so far it has not been found possible to construct a wireless projector analogous to a searchlight. If such were possible, the amount of energy required to communicate with the most remote parts of the earth would be reduced to trifling dimensions and the interference of one station with another could, by suitable arrangements, be reduced to a minimum. In the present state of the art of Directive Wireless, the most that can be done is to increase the energy in one direction at the expense of the other directions. A plain aerial radiates energy somewhat in the manner of a point source of light: a directive aerial is a badly focussed projector which "spills" the greater portion of the light. Developments in this line are rapid and doubtless means will be ultimately found of directing the waves into a parallel beam or ray. The principal application of directive wireless is in determining the position of a vessel or aeroplane.

Reception can also be made directional, *i.e.*, the aerial can be made to receive mainly from any desired direction at will. By rotating the aerial or by analogous methods, the compass bearing of any distant sending station can be determined with fair accuracy, say to within 2°. If a sharp focus were possible, this figure could be improved upon greatly. If the bearing of a distant sending station, such as a ship, is observed simultaneously from two or more stations the position on the chart can easily be found. A number of radiophares or wireless "lighthouses" have been established throughout the world, particularly at the entrances to large ports. A ship approaching and wishing to fix its position calls up the radiophares which take the ship's bearing. The bearing from each radiophare is then telegraphed over land lines to a control station which, by means of a chart, similar to a gunner's P.F. chart, determines the ship's position and transmits it to the ship. Alternatively, the ship may be fitted with a directive aerial and by determining the positions of two or more known sending stations can find its position.

The book under review deals fully, but concisely, with these applications and other similar methods, the various systems being briefly described and the theory explained. As the book deals exclusively with the directive aspect of wireless telegraphy, a knowledge of the general theory and the ordinary types of apparatus is assumed. The book is attractively got up and contains numerous diagrams and illustrations and can be recommended as giving a sound exposition of the present position with regard to the use of wireless for navigation both at sea and in the air.

The use of directive aerials in order to increase the range or decrease the power for a given range and also as an aid to selectivity is also fully dealt with. An interesting application is the elimination of strays.

The extended use of wireless was only made possible by the introduction of the triode valve amplifier which permits quite small receiving aerials to be used.

The book is clearly printed on good paper and the diagrams are clear and well arranged. A very complete table of contents and list of illustrations is provided. The index, however, might with advantage be fuller. There is an excellent list of references.

R. CHALMERS BLACK,
*Captain, R.E.*

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## HANDBOOK FOR THE LIMBLESS.

Edited by G. HOWSON and Published by The Disabled Society, 48, Grosvenor Square, London, W.1. Price 1/-; Post free 1/5.

This little book, which has been published at the request of and with the assistance of men who lost limbs in the Great War, deserves to be widely read by those who wish to play the Good Samaritan towards their limbless neighbours.

F.E.G.S.

# *NOTICES OF MAGAZINES.*

## *MILITÄR WOCHENBLATT.*

No. 22.—*General Le Rond and General Nollet.* Lieut.-General von Cramon makes a violent attack on these two officers, who are in charge of affairs in Silesia, and of the Inter-Allied mission of control respectively. They embody, he says, French vindictiveness towards Germany and their activities reveal the preponderating position which France has gained in Europe. He then contrasts, to the detriment of the French, the attitude taken up by the British and Italians and, quoting Wellington when he prayed for "night or the Prussians" at Waterloo, says that Lloyd George will also soon pray for some counterpoise to the French weight. Napoleon, he says, would be astonished if he could see how proud Albion now bows down to France. Having thus done his best to make bad feeling between the Allies, he proceeds to belittle the French representatives and complains of their being in close touch with each other by means of "secret communications," though it is difficult to see why they should not; also of their sometimes exchanging individuals of their staffs. The fact that General Nollet takes strong measures whenever any of his subordinates are not properly treated while carrying out their duties of inspection is another thing that rankles. As usual, he concludes with a threat as to what France may expect when Germany is herself again.

*A French View of the Strategy of the War.*—General von Kuhl, reviewing De Civrieux's book—"La Grande Guerre, 1914–1918," says that it is the first from the allied side to give anything like a fair criticism of events. He objects, however, to its being said that the Germans looted the French wine cellars in 1914, or that the villages were strewn with empty bottles. (As von Kuhl was chief of staff of von Kluck's army, he must have a conveniently short memory). Nevertheless, the book is heartily welcomed, largely because it is hoped that it will help to dispel the opinion, still held by some ill-informed people in Germany, that their armies suffered heavy defeats in the autumn of 1918.

*German Graves in Foreign Lands.*—Arrangements have now been completed by which the bodies of her soldiers, which lie in foreign graves, can now be brought back to Germany. The difficulties and the expenses, which have to be borne entirely by the relatives, are so great that it is strongly recommended that the graves may be left undisturbed.

No. 23.—*The Washington Conference.* The *M.W.B.* has no use whatever for any talk about disarmament, so long as her neighbours maintain armies compared to which her own is negligible. The Conference is not expected to have any substantial results, though some individuals may achieve personal successes.

*Memorials in Belgium.*—The writer deplores the erection in Belgium and France of so many memorials to the victims of the war among the civil population. He produces statements in refutation of some half-dozen reported instances of atrocities, and would have the conclusion drawn that all reported atrocities are as mythical as he alleges these few are. It appears that the burden of guilt is really beginning to gall the backs of some Germans, and their uneasiness is leading to a demand for action by their government towards discrediting all reports of German atrocities.

*King Karl's Dash to Hungary.*—A Hungarian correspondent states that the government had no other course open to them but to deploy all their forces against Karl. Not only was his return not at all universally acceptable to the people, but the mobilization of Czecho-Slovakia and Jugo-Slavia showed what might be expected if Karl were accepted. In general, the good progress, which the country has been making, has not been seriously interrupted, and the spirit of the army has not suffered through recent events.

*The German Intelligence Service during the War.*—General Macdonogh's lecture on this subject has drawn a reply from General von Kuhl. The portions of the lecture to which he takes exception are—

1. That Germany's bad intelligence service had much to do with her defeat;
2. That the rate of Russia's mobilization was underestimated;
3. That the Germans knew very little of the dates and places of disembarkation of the B.E.F. or of its destination.

He says that the loss of the war was due to quite other causes than failure of the intelligence service, for which he claims success as a general rule. As regards Russian mobilization, he says that it was well known that this had recently been considerably speeded up, and that the German estimate of the time it would take was, if anything, underestimated. Of the B.E.F. he says that he, as Chief of Staff of the 1st (von Kluck's) Army, knew on the 20th August that the landing of the British had been completed on the 18th, but thought they had advanced in a rather more northerly direction than was actually the case. On the 21st he knew that the British were further south than he had thought, and were in touch with the 5th French Army, and expected to meet them on the 22nd. "The English had themselves informed us on the matter, through an article . . . which fell into our hands." He admits that G.H.Q. was not equally well informed, and did not, on the 20th, agree with the 1st Army that the landing of the British had already taken place in any large numbers. On the 22nd, however, the 1st Army's information was confirmed by G.H.Q., and on the 23rd, as was, he says, expected, the British Army was met at Mons.

*Sport in the Army.*—Great attention has been paid, in the new German Army, to the question of recreational training and sport, but it is in getting the regulations obeyed in the spirit as well as in the letter that difficulties arise. In a few instances enthusiastic officers have been able to get very good results, but these appear to be rare, and many officers are definitely destructive. The writer, Captain Suren, tries to win these over. He points out how regrettably large the number of officers who have lost their figures is, and how, too often, the fact that an officer is married, or has reached the age of 32, is given as an excuse for taking no active part in games. In fact, he declares little or no progress has been made since the days when the "pot-bellied German" was the laughing-stock of Europe. He attributes the rapid formation and progress of the new British Armies during the war to the devotion of the officers and men to games and athletics.

No. 24.—*The First Note to President Wilson.* General Ludendorff writes to the *M.W.B.* to deny statements that have constantly been made, that he was the originator of this Note. He says that it was not till the 29th September that G.H.Q. raised the question of an armistice, whereas the German Foreign Office had already on 28th September drafted its note. In the Spa Conference on the 29th September, the question of an armistice was discussed by G.H.Q. without any instructions or instigations from Berlin. G.H.Q. was not prepared to accept President's Wilson fourteen points as anything more than a basis for discussion, and was decided in its opinion that no important surrender of German territory, particularly in the East, could be considered. It hoped to bring the German people to understand that their existence was at stake, and a peace by understanding out of the question, and that, therefore, they must fight on. Furthermore, Hindenburg, on the 3rd October, expressed the same views to the Chancellor, but his statement has been omitted from German White Books, as was also one which recommended further fighting. Every effort of Ludendorff's to embody this in the Note, was frustrated by the Government, which must, therefore, alone bear the responsibility for it and its consequences.

General von Cramon, who was chief German representative in Austria, substantiates Ludendorff's statement, and then goes on with his usual ragings against the Treaty, with its confession of German guilt, the Leipzig trials and the terrible results of German party strife. The trials of German officers, which have recently been held in France in the absence of the accused, have especially aroused his indignation. The reason which he gives for this is that the accused were not warned of the time and place of the trials and were therefore unable to come and defend themselves. In this connection it is interesting to note that these trials have more effect than might perhaps be generally attributed to them. In this same number of the *M.W.B.* a German Veterinary Officers' Union takes pains to disown an alleged veterinary officer convicted, in his absence, at Lille, saying that it must be a veterinary assistant and not an officer who is referred to.

No. 25.—*Lieut.-Colonel Hentsch's Mission.* This is fully dealt with by Lieut.-Colonel Loebnitz in the first volume of his "Researches among the archives of the War," and it is claimed that as much is now known of this fateful errand as ever will be. There still, however, remains much that is uncertain, for instance, the text of Hentsch's instructions,

# RE-CONSTRUCTION OF VETRINA BRIDGE

## GENERAL PLAN SHEWING BRIDGE AS RE-CONSTRUCTED


Plan — Trestle shewing arrangem[illegible] of Stringers. — Steelwork · Spans 1·2 & 4 shewing decking removed.