THE ROYAL ENGINEERS JOURNAL.—JUNE, 1925. Pages 177—360.

The Royal Engineers Journal.

PUBLISHED QUARTERLY.

VOL. XXXIX. No. 2. JUNE, 1925.

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2200—1-6-25.

THE INSTITUTION OF ROYAL ENGINEERS.

By F. E. G. S.

The Institution of Royal Engineers, of which this *Journal* is, perhaps, the most prominent outward and visible sign, was formed, as our Charter affirms, "for the general advancement of Military Science, and more particularly for promoting the acquisition of historical and scientific knowledge in relation to Engineering as applied to military purposes." It has now been in existence for fifty years, and the occasion of its Jubilee suggests an opportunity for looking back into its records and recalling the ideas which instigated its inception, and enquiring to how great an extent the hopes of those who took a prominent part in its creation have been fulfilled in its performance.

The date which has been taken as that of the inauguration of the Royal Engineer Institute, as it was first called, the 22nd May, 1875, is that of the sixth of the series of Annual Corps Meetings, the first of which was held in 1870. Long before this, in fact, since 1837, the officers of the Corps had subscribed among themselves for the publication of the *Professional Papers*, which had been published under the management of an important committee with a secretary and separate editor; and here it may be mentioned that the publication of this valuable series, the last item of which appeared as long ago as 1918, has never been considered as definitely abandoned, but many recent causes have led to its being held in abeyance, principally the lack of suitable contributions, for, owing to the growth of the *Journal*, many papers and lectures which would formerly have been published as *Professional Papers* now appear in the *Journal*, and partly also the increased cost of printing, which has led to the concentration of all available resources upon the single and more widely distributed publication.

The Corps Libraries were started in 1846, and, in 1870, besides the Libraries in London and at the S.M.E. and Dublin, they included 27 branches, as widely separated as Quebec and "Van Dieman's Land," St. Helena and Hong Kong. These also were mainly provided by subscriptions among the Officers of the Corps, but they have always received some official support, as the most suitable means of providing Engineer Officers with necessary books of reference.

The Royal Engineer Journal was first issued in 1870. At the first Corps Meeting, held in May, Major R. Harrison proposed and Captain R. Home, R.E., seconded a proposal, "That a Corps periodical should be started, if found practicable, embodying the

proceedings of the Corps Meetings, etc., with a complete Officers' Directory." The motion "met with general approval, but in the absence of an organisation to conduct the contemplated periodical, it was not considered by the Meeting advisable that a formal vote should be taken upon it." The *Journal*, however, appeared in August, in the foolscap form in which it existed until 1905. The Editor was Major V. G. Clayton, and in an introductory notice it was stated that the new *Journal* was "far humbler in its aim than the *Professional Papers*," that it was intended "to enable Officers widely separated from one another to know what their brethren are doing and where they are quartered."

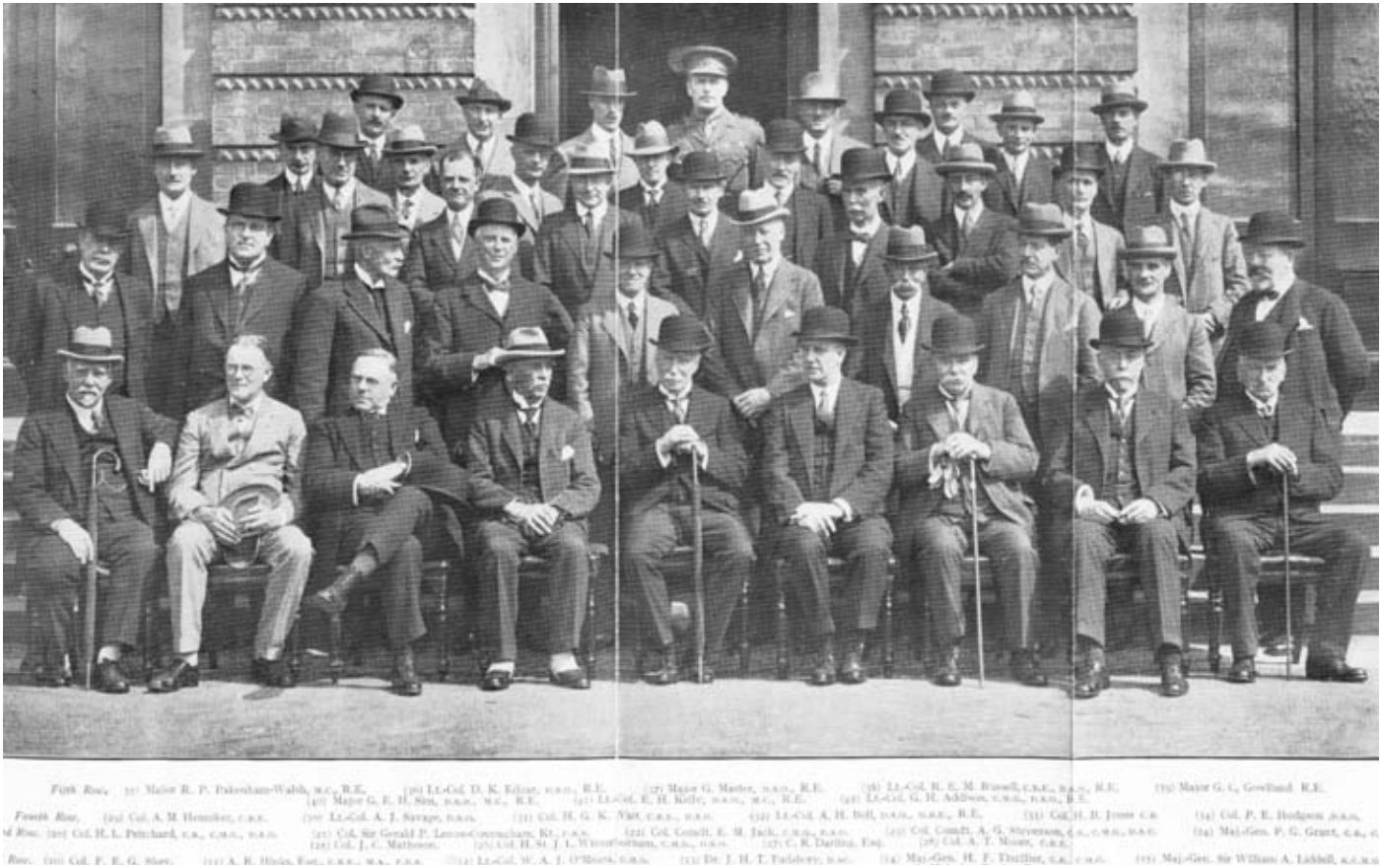
It must be gratifying to the veteran General, Sir Richard Harrison, to remember that among his many beneficial contributions to the Corps, this *Journal*, which we like to think is still read with interest in many quarters of the globe, owed its original existence to his initiative.

In 1905 the *Journal* was published in its present form, but was still issued monthly, and a *Supplement* was published separately to contain what may be called the domestic concerns of the Corps.

The *Journal* of 1905 was intended to include "articles interesting to the Army at large, and of a less technical and less fully illustrated character than those in the *Professional Papers*." The new venture proved a success, and in 1923 a further development converted the monthly *Journal* into its present quarterly form. If it has at the same time become more technical, perhaps at the expense of the *Professional Papers*, it is the hope of the Editor and of the Publication Committee that in this they have rightly interpreted the wishes of the members of the Institution.

The nominal Lists of Officers of the Corps were published as a *Supplement* to the *Journal* from the earliest days of its existence. In 1905 they were given the title of the *Monthly List*, and since the Great War the *Quarterly List*. They have always retained the foolscap size in which they were originally published.

For the inception of the R.E. Institute we must not look to private initiative. It appears to have been entirely official and originated in the erection of the building at Chatham, now called the S.M.E. Main Building, but for many years known as the R.E. Institute. It was designed by Lieut. (now Sir Montague) Ommanney under the directions of the then Inspector-General of Fortifications, Lieut.-General Sir Frederick Chapman, and was begun in 1871. On the 22nd May, 1872, H.R.H. The Duke of Cambridge, Commander-in Chief, laid the foundation stone. On its completion, early in 1875, a committee, consisting of Sir Lintorn Simmons, Sir Henry Harness and the then Commandant of the S.M.E., Colonel (afterwards Major-General Sir) Thomas Gallwey, who had been previously consulted on the accommodation required in the building, was



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The Celebration of the Jubilee of the Intitution of Royal Engineers, Chatham May 1925

re-assembled to report upon the manner in which the Institute should be organised and worked. From their report, which received the approval of the Commander-in-Chief and of the Secretary of State for War, a précis was presented to the Corps Meeting on the 22nd May, 1875, in which it was stated that the new building would accommodate a Professional Library, a Museum, a Lecture Theatre and Classrooms for the various courses of instruction then being carried out at the S.M.E. Stress was laid on the importance of preventing all possible interference with the scheme of the S.M.E., and, with this object, "the Institution (*sic*) should be placed for discipline under the Commandant of that School, and that he must have absolute control of the theatre, the schools, and all the establishments housed within it, and that no experiments made at the S.M.E., nor lectures, nor other matters connected with the course of instruction given at it, should be published by the Committee without the consent of the Commandant being first obtained." They were "of opinion that with the subscriptions now raised (for the *Professional Papers* and *Journal*) or which might be raised from the Corps, and by the sale, within approved limits, of publications, the School of Military Engineering may be made to contribute greatly to the circulation of useful professional information calculated to promote the progressive instruction of the Officers, and by their means to advance the public service."

With this outline of the plan, and a proposal to elect a Committee of nine ex-officio and 15 elected members, the Committee left the project in the hands of the Corps, who at the above-mentioned meeting adopted the proposal and elected by ballot the 15 unofficial members. It is needless to publish here the names of the original Committee of the Royal Engineer Institute, as they are given in full in the opening paragraph of the Royal Charter. The Duke of Cambridge was Patron and President, and Sir Frederick Chapman, succeeded on 1st July by Sir Lintorn Simmons, the I.G.F., was the first Chairman, or, at any rate, the senior ex-officio member, for it is not stated that he was definitely nominated as Chairman. Major Clayton, the editor of the *Journal*, acted as Secretary until Brevet-Major W. H. Collins was elected (in August), but the latter resigned within a year and was succeeded by Capt. R. H. Vetch, who held the appointment for seven years, until February, 1884. Up to 1910 the office of Secretary was held by an Officer on the active list of the Corps, but since that date by a retired officer.

The first annual report of the Institute was presented to the Corps Meeting held on 26th May, 1876—at one o'clock! It contains little of interest. The *Rules* had been drawn up and circulated to all officers of the Corps, and it proposed that the publications of the Institute should be the monthly *Journal* and half-yearly *Occasional Papers*, "should there be sufficient matter to justify"

their publication. No copy of the original *Rules* can now be found in the Secretary's office. The *Journal* was taken over as a going concern and was issued free to members from the beginning of 1877. The *Occasional Papers* were in no way different from the *Professional Papers*, but a new series was begun in 1877.

Other work of the Institute was the support of classes in foreign languages and landscape drawing, the arranging of a few lectures, and the collection of objects for the museum—in three classes (i) geology and mineralogy, (ii) chemistry and electricity and (iii) artillery. In 1882 the Committee also took over the Model Room—formerly a Chapel—now the Museum—but then full of a heterogeneous collection of Corps archæologia, which gained nothing by the room being periodically used for Band Concerts. Later on, the Institute took up the publication of books, text-books for the S.M.E. and others. But perhaps the chief use of the new organisation, and one which made itself felt almost immediately, was as an information bureau. In the report for 1879 it is stated:—"Officers now apply freely to the Secretary for information and for books, instruments, etc., and some idea may be formed of the appreciation of the Institute by members from the large correspondence that takes place; during the year 1879 the Secretary having received and acted upon, and replied to, more than 4,500 communications." The present Secretary can assure members that in this direction the Institution fully maintains its vitality.

But the word "Institute" as applied to the building at Chatham rapidly became a misnomer. Accommodation was far too necessary at the School of Military Engineering for any, except the offices of the Secretary and his clerks, to be spared for Institute purposes. As the pressure became greater the library was removed to the Mess and the Museum was given up—the geological specimens, it is believed, are now in the possession of the Rochester Museum. There was no room at Chatham for an Engineer organisation independent of the S.M.E. The Institute Committee saw this from very early days. Colonel Vetch, speaking in 1904, said: "When the R.E. Institute was originally proposed, it was intended to reproduce for the R.E. what the R.A. had in their Institute at Woolwich. But when the Institute buildings were completed they were practically seized by the S.M.E., which was greatly in want of accommodation, with the result that an influential Committee found themselves without their Institute, in which, however, rooms were found for their Secretary and his clerks. The Committee could not even get their printing and lithography done, except occasionally as a favour from the Commandant. Under these circumstances it was considered that some provision should be made for the future, and the suggestion was made that, at any rate, all entrance subscriptions should go to a capital account . . . the

Fund has grown to nearly £4,000; this is but a nest egg, but if it is allowed to grow, then at some future day a real establishment, either at Chatham or in London, may result, which would bear some resemblance to the original intention." The money, as we know, was soon after spent in freeing the Model Room from the incumbrance of social functions (by remodelling the theatre) and in developing the museum as a true temple of Corps archæologia—a pet scheme of Sir Richard Harrison, the brilliant success of which all who visit it must agree in acknowledging.

A proposal to provide "Premises for the R.E. Institute in London" had already been the subject of a lengthy discussion at the Corps Meeting of 1888, when it was complained that the Institute had become merely a Secretariat and that no provision was possible for meetings of members to hear and discuss lectures. It was suggested that the Corps Library should be moved into unofficial premises, which, with lecture and reading rooms, should be hired at the charge of the Institute. There was also an amendment to obtain the required facilities from the Royal United Service Institution, and this was finally carried. The negotiations were placed in the hands of a committee, who, in the following year, were obliged to confess that they had resulted in pious aspirations and "notes for future consideration" only. At the 1892 meeting it was announced that the negotiations with the R.U.S.I. had definitely failed and there was nothing for it but to continue to put by funds with which the object of the acquisition of an Institute building in London could be eventually realised. It must be considered as fortunate, in view of the lean years that were to come, that this heavy additional expense was never thrown upon the resources of the Institution. Few members will now be found to complain of the accommodation so generously provided for the Corps Library in London, except those who would like to see it moved bodily to Chatham; and should the desire arise at any time to promote lectures, with discussions, as a part of the Institution activities there is no doubt that a theatre—for instance that at the R.U.S.I.—could be hired for the occasion at a small cost. Further, it is doubtful if any Secretary could ever have desired to see his office moved from Chatham, where he has always owed so much to the generous assistance of the Commandant and the Instructors of the S.M.E.

It may be mentioned that at the same time as this proposal, another, to frame a scheme for a Portrait Fund for the Corps, was laid before the meeting and discussed, but when the above-mentioned amendment was passed, this other proposal fell to the ground.

The ill-fated R.E. Gold Medal was first proposed at the Corps Meeting of 1875, by Colonel (afterwards Major-General Sir Wilbraham) Lennox, V.C., for a prize essay, the subject of which should be set each year, and, after some counter proposals had

been defeated, was unanimously agreed to. The first medal was won by Captain (afterwards Major-General Sir Thomas) Fraser against four other competitors, and he repeated his victory in the following year, when only two essays were sent in. The gold medal for 1877 was won by Lieut.-Colonel (now General Sir Richard) Harrison against four other competitors, and after that it was withheld for two years, when five and two respectively were the numbers who competed.

At the Corps Meeting of 1880, these results led to a long discussion, in which various proposals, of new terms under which a gold medal or some equivalent prize should be given, were put forward, and it ended in a decision that the award should be discontinued. The subject for the Prize Essay of 1880 had already been published, and the last R.E. Gold Medal was won against two other competitors by Lieut. R. da Costa Porter.

In 1879, the Committee elected the first Honorary Members of the R.E. Institute. At the head of the list was the name of the eminent chemist, Sir Frederick Abel, F.R.S. In proposing his election, Colonel Graham said that "considering how closely he was associated with them in their work, they could not propose the election of any civilian as their first special Honorary Member, who would be more acceptable or would do them more honour than Professor Abel." Since 1879 many men distinguished in the world of science have been closely associated with the Corps in its work and have honoured the Institution by accepting its Honorary Membership, and the recent gathering at Chatham, in celebration of our Jubilee, will be recognised by members as a gratifying reminder of the eminent men who rallied to the assistance of the Corps in the anxious days of the Great War.

In 1876 the new Secretary, Captain Vetch, proposed that the word *Institution* be substituted for *Institute*, but it was decided that the Committee had not the power to alter the name, and this change was not made until 1921. In 1881, however, an "s" was added to the names of all the Corps institutions, and we became The Royal Engineers Institute.

At the Corps Meeting of 1886 a proposal was adopted: "That the Committee of the R.E. Institute, in conjunction with the Trustees of the R.E. Widows' Society, are authorised to take the necessary steps for the incorporation of the Corps under a Royal Charter, with a view to the appointment of Trustees, with a Common Seal to hold the various Corps Funds now or hereafter to be established." The petition was duly made to the Privy Council, and in 1889 it was announced that the law officers of the Crown had decided to refuse it. Further applications, made during the following year to the law officers by the I.G.F., Sir Lothian Nicholson, remained unanswered, and the I.G.F. was bound to admit that the law officers

"had certainly not treated them courteously." The Institution, without the co-operation of the Widows' Society, made a similar petition in 1922 and was successful, and the Royal Charter was granted by the present King on February 27th, 1923. The present title, "The Institution of Royal Engineers," was adopted by the Council on 22nd July, 1921.

An account of the activities of the Institution would be incomplete without a mention of its usefulness in the collection and administration of Corps Funds—War Memorial Funds, Portrait Funds and other Memorials to individual officers and other ranks of the Corps. From the very first its use as "an organisation" capable of conducting these schemes declared itself, and the long list of medals and prizes still administered by the Institution, which led recently to the decision that this form of Memorial must be restricted in future, represents but a fraction of the many funds with which it has dealt in the fifty years of its existence. The administration of the Scholarship Funds, resulting from the Memorial of the Great War, is, perhaps, the privilege of all others most treasured by the present writer and probably by all the members of the Institution Council. In this we are carrying on the great work, instituted by Sir Ronald Maxwell and the War Memorial Committee, as representatives of the whole Corps, past and present, in paying a tribute to the service of our Comrades who fell in the service of their King and Country.

In conclusion, it will probably be admitted that the Institution has developed on the lines of its greatest usefulness. Members of a military Corps have their messes and clubs at which they can meet, and being also members of the larger organisation—the Army, or, rather, of the Armed Forces of the Crown—would probably make greater use of the Royal United Service Institution than of a building of their own, did such exist in London. They do not experience exactly the same necessities of association as their brethren in the Civil branches of the Engineering profession. But they do require—widely separated and isolated as they so often are—to know what other members of their Corps are working at and achieving, what views and opinions are operating at the War Office and the S.M.E., and what have been the developments in the various branches of their profession since they last were in touch with these establishments. These wants the Institution does its best to supply. Through the Institution and the pages of this *Journal* they can further, to a certain extent, keep in touch with the progress of the science of military engineering and of military thought in the Armies of foreign Powers, while the exchange of the *Journal* with those of the engineering branches of foreign Armies is a friendly "gesture" which should appeal to all who recognise the importance of international courtesies. As an example of this

last, a letter may be quoted recently received by the secretary from the veteran American engineer, General Henry L. Abbot, who writes from Massachusetts (March 20th, 1925): "Please accept my thanks for the copy of the *Royal Engineers' Journal.* I have seen my 93rd birthday, and I assure you it is very pleasant to be remembered by old friends."

The Institution has no motto. Should we adopt Earl Kitchener's "Thorough"? Another suggestion is "In Armis Scientia."

Or perhaps some would prefer the following, as quoted on the title page of Sir Francis Head's book, "The Royal Engineer," published in 1869:—

Enter Some bringing in the Clerk of Chatham.

SMITH: The Clerk of Chatham: He can write and read and cast accompt.

CADE: Here's a villain! . . . . Away with him, I say: hang him with his pen and inkhorn about his neck.

(*Exit one with the Clerk.*)

Second Part of Henry VI., Act IV., Sc. 2.

THE POSITION OF ENGINEERS IN THE ARMY ORGANISATION.

A LECTURE PREPARED FOR DELIVERY AT THE S. M. E. ON 15TH JANUARY, 1925, BY MAJOR-GENERAL H. F. THUILLIER, C.B. C.M.G. DIRECTOR OF FORTIFICATIONS AND WORKS, BUT NOT DELIVERED OWING TO ILLNESS.

WHEN speaking of the position of engineers in the army organisation I do not refer to the tactical or technical employment of engineer units, but to the position and functions of the senior engineers at the headquarters of Corps, Armies and at G.H.Q. This subject has been one of controversy for a great many years past. Fifteen to twenty years ago, when the organisation of our modern army was being fashioned by the then newly-created General Staff, views of the most diverse nature prevailed regarding it and no definite doctrine or policy was formulated or promulgated. During the War, when that organisation was being melted down in the crucible of the world-struggle and re-cast on a vastly broader scale, the question was still officially unsettled, with the result that in every formation the difficulties of working without a fixed conception of what the position of the senior engineers should be in relation to the rest of the staff organisation frequently became very apparent. Since the War we have been engaged in sorting out from our experiences some principles to guide us in forging an organisation suitable for conducting our future wars. The time has now come, not only to decide and lay down definitely what these principles are in the subject now under discussion, but to instil them into all who may have to work them so that they may be accepted loyally and carried out unquestioningly.

Let us first consider the organisation of the Army. In this connection I do not mean merely its division into formations or the composition of those formations in the various arms, but I mean also the whole method by which the plans of the Commanders are formulated, issued to subordinates and carried out, and the system under which the various arms and services co-operate for the furtherance of those plans.

It is evident that the organisation in the above sense is liable to change. This must be so, for without change there could be no progress. The normal developments of invention are always bringing about new weapons and new tactics, and these in their turn necessitate changes in organisation and in the methods of control.

Progress in weapons directly affects methods of control. You will no doubt remember that 150 years ago, if one may judge from the artists of the period, generals led their troops to the attack riding at their head, in conspicuous uniform and a cocked hat. The enemy against whom they were thus acting was armed with a flint lock musket, ranging not much over 200 yards, and after it had been discharged requiring about nineteen motions to reload it from its muzzle end. The modern leader has, alas! had to abandon this inspiring practice and to adopt methods resembling those of that famous nobleman, the Duke of Plaza Toro, who, you will remember, not only led his army from behind, but also was noted for digging himself in deeper than any of his gallant men. To these mean shifts we have been compelled by the advent of the machine gun and the high explosive shell.

As I have already said, the experiences of the Great War afford us the opportunities of formulating an organisation suitable to the conditions of the next few years, as far as we can visualise them. When we come to the position of the engineers in that organisation we must not confine our regard to the personal status, rank or dignity of the officers holding the senior engineer appointments, but must look at the question from a more objective point of view. What we want to consider is how to ensure that the engineer troops, plant and stores are used to the best effect in co-operation with the other arms, and how to permit of the great resources, which engineering science in these days makes available, being employed to the utmost extent practicable in the assistance of the Army in its mission, whatever that may be.

There are many who believe that the best way of securing these ends would be to have at the headquarters of an Expeditionary Force an Engineer-in-Chief in whom is centralized the whole of the engineering operations of the Army. Following the theory that the best and most economical results are obtained by co-ordination and centralization of authority—which is quite true—they would have the Engineer-in-Chief control the engineer work of all the formations subordinate to the Commander-in-Chief, by direct action through engineer commanders in each formation right down to the division. They would have him also control all work on the Line of Communication and at bases, through a Director of Works subordinate to himself.

The argument in favour of this last is that control of works entails control of the available stores with which works are carried out, and that only an official at G.H.Q. acquainted with the plans of the Commander-in-Chief and in touch with all branches of the Staff, can judge of the relative importance of the Line of Communication works and the field engineering needs of the fighting troops.

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This lecture to be read in conjunction with amendments to F.S.R. Vol. I, 1923, issued with Army Order 491 of December, 1924.

very apparent. Since the war we have been engaged in sorting out from our experiences some principles to guide us in forging an organisation suitable for conducting our future wars. The time has now come, not only to decide and lay down definitely what these principles are in the subject now under discussion, but to instil them into all who may have to work them so that they may be accepted loyally and carried out unquestioningly.

Let us first consider the organisation of the Army. In this connection I do not mean merely its division into formations or the composition of those formations in the various arms, but I mean also the whole method by which the plans of the Commanders are formulated, issued to subordinates and carried out, and the system under which the various arms and services co-operate for the furtherance of those plans.

It is evident that the organisation in the above sense is liable to change. This must be so, for without change there could be no progress. The normal developments of invention are always bringing about new weapons and new tactics, and these in their turn necessitate changes in organisation and in the methods of control.

There are even some who would go further still in the direction of centralization of engineer control and would place under the Engineer-in-Chief the transportation services, that is to say, the construction, maintenance and operation of railways, and I have heard it suggested that the organisation for surveys and map production, which requires engineer personnel, should be divorced from the General Staff branch and put under the Engineer-in-Chief, and, indeed, that the latter should be responsible for everything throughout the army which is of the nature of "engineering" and requires personnel of the Royal Engineers.

This school would similarly in peace have at the War Office an Engineer-in-Chief who would control all branches of engineer activity, would be the "Head of the Corps," and, as some have suggested, be a member of the Army Council. We will defer for the moment the consideration of the organisation in peace and confine ourselves to that for war.

How is an army organised in war? Every one knows the pivot of the army organisation is the division, which is the smallest formation composed of all arms and capable of acting alone. In the division all the arms, infantry, artillery, engineers and cavalry (if there are any), are under a single commander. Remember this—it is the basis of all army organisation, several arms under one commander, and it is *only in the division* where one commander directly commands them.

Two or more divisions constitute a corps, which may also have certain "Corps Troops," principally artillery and engineers, who are directly under the corps commander. Two or more corps are an Army, and two or more Armies compose the body which we know by the curious title of a "British Expeditionary Force."

Now, remember that all orders go from the Commander-in-Chief to the Army Commanders, from Army Commanders to Corps Commanders, and from Corps Commanders to Divisional Commanders. They are always issued by superior commanders to the *commanders* of the formations immediately below; *never*, by any chance, direct to units which form part of a subordinate formation. It must always be borne in mind that an Army—or, say, rather a "British Expeditionary Force"—is not composed of infantry, cavalry, artillery, engineers, &c., but of armies, "corps" and "divisions." It is *only* the division that is composed of infantry, cavalry, artillery and engineers, each under separate commanders, but in the higher formations this is not the case, except in a very limited degree in the case of certain troops additional to the divisions, who are directly under the Corps Commander.

Now, I ask you, keeping that organisation in view, how can an Engineer-in-Chief at G.H.Q. exercise direct control over the engineering work of the formations subordinate to the Commander-in-Chief?

To do so he would require to give orders to the engineer commanders of the subordinate formations, and how could he give orders to some one who is under a Corps Commander or a Division Commander? The answer is, he *cannot*. The Engineer-in-Chief *cannot* function as executive controller of the engineer work carried out in Armies, Corps and Divisions—Neither can Chief Engineers of Armies or Corps perform such functions. The only officers who can exercise functions of executive control, in other words, of command, are Commanding Royal Engineers, *i.e.*, Commanding Royal Engineers of Divisions and Commanding Royal Engineers of Corps Troops.

What, then, are the functions of the Engineer-in-Chief at G.H.Q. and of Chief Engineers of Armies and Corps? Do we want any at all? Yes, we do, and their functions are most important. These functions are, however, entirely of an advisory nature; the Engineer-inChief and Chief Engineers have no responsibility for methods of execution, and do not exercise any powers of command. Orders to subordinate formations are, and must be, issued by the staff of the higher formation concerned.

There are officers, both senior and junior, who believe that the doctrine that Chief Engineers and Engineers-in-Chief should be only advisers and not commanders is in some way a lowering of their status and a lowering of the dignity of the Corps—With such opinions I am in total disagreement. I would remind those who hold them that engineers are combatant troops. Now, combatant units must be under the command of the commander of their formation. Their chain of command cannot run through specialist chiefs from bottom to top. Services where the latter is the practice are departmental services. To bring about this practice in the case of the engineers would be to departmentalize the latter, to lower its status from that of a combatant branch to that of a departmental service.

So far I have been talking about field engineering work, namely, that work which is intimately connected with tactical operations in progress or in contemplation. There are, however, other classes of engineering work which are equally important and take up an equally large, and sometimes even larger, share of the activities of the engineers in a theatre of war. These are labelled in F.S.R., Vol.I, as "Works Services" and defined as "all engineering work of a general nature not having an immediate bearing on tactical operations in progress or in contemplation." They cover, practically, all work at the bases and on the line of communication, and even in the zone of the armies they cover most of the works connected with the movement, housing, comfort and health of troops and animals behind the actual fighting zone. These works are carried out under the direct responsibility of the Director of Works and his representatives. Where the magnitude of the operations warrants

it, work in connection with the railways, docks and harbours in the theatre of war will not be under the Director of Works but under a Director of Transportation.

Now to return to the query suggested previously. Why should not these directors, whose functions are of an " engineering " nature, be subordinate to the Engineer-in-Chief ?

The answer is exactly the same as in the case of the Engineer-in-Chief and Chief Engineers in connection with Field Engineering. In the same way as there are Army Commanders, Corps Commanders and Division Commanders controlling the operations of definite sub-divisions of the Expeditionary Force, so also is there a single official responsible for everything connected with the supply of that force. Under our present regulations that official is the Q.M.G. He is responsible for the transportation of the troops and stores to the theatre of war, for the organisation of the bases, for the provision of food, ammunition, equipment and stores of all kinds, for the transportation to the fighting zone of reinforcements, for the removal of wounded and the provision of base hospitals. He, and he alone, can say what quarters, stores, factories, railways, roads, wharves, docks and engineer works of all kinds he requires for the performance of these services, and the necessary works will assuredly not be carried out rapidly and efficiently unless the Director of Works functions in direct subordination to the Q.M.G. To give the Engineer-in-Chief any authority to direct or to interfere in any manner with the control of work on the Line of Communication would have a similar effect, and probably, in a greater degree, to that of allowing him to give direct orders to the Chief Engineers who are subordinate to Army and Corps Commanders.

But, it may be argued, what about the control of engineer materials and stores ?

These are limited in regard to the quantity available in the theatre of war. Is it to be tolerated that the Director of Works shall have a free hand in deciding how much of the available stores he shall take for use on the Line of Communication Works, regardless of the wants of the fighting troops, for works connected with tactical operations ? Certainly not. It is undoubtedly necessary that some one at G.H.Q. shall decide the relative priority of field engineering work and work on the Line of Communication respectively. The inadequacy of stores for the former might result in inability to undertake a tactical operation which depended on some engineering work, or might seriously affect the security of some part of the line occupied by the armies. But the person to make this decision is not the Engineer-in-Chief.

I have said earlier that it is true that the best results are obtained by co-ordination and centralisation of authority. I say it again. But I mean that the centralized authority should be that of the

Commander-in-Chief—not that of the Engineer-in-Chief. It is the authority of the Commander-in-Chief, exercised by or through the Staff, that must settle the question of whether field engineering requirements or those of the Line of Communication shall have precedence.

Now I know that this theory—that the function of control or management should be vested in the Staff and not in the Engineer-in-Chief—is one that some engineer officers dispute. They hold that such control can only be exercised by those having the technical qualifications of the engineer.

Let us consider the question from a detached point of view. The control of an army, in this particular connection, does not differ in principle from that of a great civilian undertaking, such as a line of railway or a manufacturing business. In the latter "engineering" forms an important proportion of the work (probably a larger one than in the Army)—and there will very possibly be an engineering branch with a Chief Engineer at the head of it. But the Chief Engineer, as such, is not responsible in any way for the management of the business. For the latter there will be a 'management branch,' probably under a 'General Manager,' which co-ordinates and controls the work of the engineering branch, the stores branch, the production branch, the sales branch, the publicity branch, and what not. The management branch obtain technical advice, designs, estimates, &c., from the heads of the engineering and other technical branches, and on these they formulate proposals for the decision of the general manager or other ultimate authority.

In the Army there is also a 'management branch,' namely, the Staff, acting as representatives of the Commander-in-Chief. The control, that is to say, the rationing, of all stores, munitions and supplies of every nature, is and must be their function. This must be looked on as one of the basic principles of war administration.

It is essential, on the one hand, that none of the technical branches shall usurp that function, and, on the other hand, that the responsibility for it shall be definitely fixed on the Staff.

This, as regards engineer stores, has now been done. In the recent amendments to F.S.R., Vol. I, it is for the first time clearly laid down that it is necessary that the Staff should—

(i) Control the supply of engineer stores.

(ii) Co-ordinate and control the general scheme of field engineering work and subordinate formations.

The amended regulations go on to describe in detail what the above responsibilities involve, in the case of Staffs at G.H.Q. and of subordinate formations. Time does not admit of discussion in detail of the duties thus laid on the General Staff and Q.M.G's branches, but it will be seen that the Staff as a whole is clearly charged with the following duties :—

In regard to control of stores :—

(a) Estimating requirements of stores.
(b) " Rationing " to formations or areas.
(c) Transportation to sites where required.

And in regard to control of field engineering :—

(a) Preparation of general schemes of field engineering works, including demolitions, having in view the available supplies of labour, materials and transport.
(b) Organisation of any special arrangements, such as re-distribution of engineer units or provision of special plant, which such schemes may require.
(c) Allocation to subordinate formations of the works to be executed.
(d) Inspection to insure that subordinate formations are devoting their energies to progress on the lines ordered.

It has been argued, why should these functions be exercised by the Staff; and are they competent to do so? Admitting that an Engineer-in-Chief, or Chief Engineer, cannot give orders to the engineers of a subordinate formation, why should they not issue to the Commanders of subordinate formations the orders of their own Commander on engineer matters as his Staff Officer? In fact, should not the Engineer-in-Chief and Chief Engineers be Staff Officers?

The answer is, no! Such an arrangement would be contrary to the fundamental principles on which armies are organized. The Staff issue *all* orders to lower formations, whatever branch of the Service they concern. We do not and cannot have an infantry staff issuing the orders for the infantry, a cavalry staff issuing the orders for the cavalry, an artillery staff issuing the orders for the artillery, nor an engineer staff issuing the orders for the engineers. A combined staff issues all orders. To keep the engineer orders distinct from the others and issued by engineer staff officers would be a reversion to departmentalism for the engineers. If it were done for all branches we should have, instead of an army, a congerie of departments and combined action would be impossible.

It has been definitely ruled by the Army Council that the orders of the Commander-in-Chief in the field will be issued through three Staff Officers only—The C.G.S., the A.G. and the Q.M.G., Even if it were ever decided to add a fourth I cannot conceive that it would be an engineer staff officer.

The more one examines the functions which are described as those of the Staff in connection with field engineering work, the more one must recognise that they are in fact functions of "management," that is to say of command and administration, and must be exercised only by those who represent the Commander.

As regards the competence of the Staff from the technical point of view :—Here is where the Engineer-in-Chief and Chief Engineers come into the picture. No staff could possibly carry out these functions without competent technical advice.

The amended regulations say :—" To assist the Staff in the execution of the responsibilities assigned to them, engineer officers are affiliated to the General Staff of G.H.Q. and Armies. Their functions are advisory ; they have no responsibility for methods of execution, and do not exercise any functions of command. Orders to subordinate formations are issued by the Staff of the higher formation concerned. The Senior Engineer Advisor at G.H.Q. is designated the Engineer-in-Chief and those at Army and Corps Headquarters Chief Engineers."

You will all, I am sure, be glad that the military titles of Engineer-in-Chief and Chief Engineer have been definitely and officially adopted for the designation of these officers. The title Chief Engineer is of great antiquity. Its use for the senior engineer for forces at sieges and in the field can be traced back some 400 years, and there is reason to believe that it dates from considerably earlier still. In the armies of Cromwell, Marlborough and Wellington ; in the sieges of Gibraltar, of Sebastopol and of Delhi ; in every war where a British army has fought, there have been Chief Engineers. The abolition of this time-honoured title and the substitution of the unmeaning one of Brigadier-General (or Major-General), R.E., as was actually done before the great war, merely on the grounds that the functions of these officers in a modern army are different from what they were in other days, was a sad example of unnecessary destruction of a Corps tradition.

There are certain points in the new regulations, which I should like you to note. You will observe that the Engineer-in-Chief and Chief Engineers are " affiliated to the General Staff." It is the General Staff whom they will advise and for whom they will prepare the estimates of requirements of field engineering stores and the general schemes of field engineering works. You will also observe that it is definitely laid down that the General Staff are responsible for ascertaining from the Q.M.G. branch of the staff whether the required stores can be produced and whether transport is available for them to the places where they have to be delivered. In the past, in the absence of any definite regulations, this responsibility has generally fallen on the Chief Engineer. When the latter has obtained the General Staff's acceptance of a programme of works involving a considerable supply of materials, it is often left to the Chief Engineer to arrange for the supply of the latter. If he subsequently discovers that the movements branch cannot transport it the blame for the failure of the programme of works is apt to be laid at the door of the Chief Engineer. But field engineering works are " operations,"

and the General Staff, before deciding on an operation, have the duty of ascertaining from the supply and movements branches whether the necessary materials and means of transport are available. If they are not, then it is for the General Staff to decide whether the engineer stores are of such urgency as to be given priority of transport over other stores (such as ammunition), or whether the works shall be abandoned. This is essentially a decision for the Staff and not for the Chief Engineer. The latter's position will be strengthened by not having to wrangle for transport with the "Q" staff himself.

Another point to notice is the function of the Chief Engineer of a corps which differs from that of the Chief Engineer of an army. Normally he, like the others, has advisory functions only, but it is expressly provided that at times centralized control of Engineer work may be called for, and at such times at the discretion of the Corps Commander, the whole or any portion of the corps and divisional engineers may be concentrated under the direct control of the Chief Engineer of the Corps, who will in such cases issue orders direct to them. This is a parallel case to that of the Corps artillery adviser, who may sometimes for a specific operation be put in charge of all the artillery of the Corps, including divisional artillery, who are temporarily withdrawn from divisional control.

Also Chief Engineers of Corps and Armies, and even the C.R.E. of a division may on occasion be required to act as the agent of the Director of Works for the execution of specific and important "works services" which may have to be carried out in an area occupied by a fighting formation. Such services might be hutting or water supply schemes or large schemes of road communication, and in these cases, and only in these, they would of course exercise executive functions. It is to be hoped that such occasions will not often occur, since the Chief Engineer concerned may then find himself subject to the difficulties which arise when men serve two masters, but there are few engineer officers who do not frequently find themselves in that situation and have to meet it with tact and goodwill.

The Director of Works who, under the regulations, controls the Works Services in the theatre of war, is not, like the Chief Engineers of Armies and Corps, an adviser only. He does himself directly administer and control the works on the Line of Communication and at bases, and carries them out by the agency of C.R.E's and other officers who are directly under him. The reason for this difference is obvious. As I have said before, tactical operations are not carried out departmentally. G.H.Q. issue instructions to the Armies, Army H.Q.'s to Corps, Corps H.Q. to Divisions, and the actual field engineering work is done by the Divisions. In the other case the Q.M.G. directly controls the

administrative services on a departmental basis. The heads of the supply, transport, ordnance works, and other services are directly under him and each of the latter not only advises the Q.M.G. as to the possibilities of production of the particular service with which he is charged, but also arranges himself for production.

I need say no more about the position and functions of the engineers in the field, and in the short time remaining I should like to refer to an analogous question connected with the peace organisation. At an earlier stage in this lecture I mentioned that some of the advocates of a centralized control of field engineering operations by an Engineer-in-Chief at G.H.Q. would similarly like to see in peace at the War Office an Engineer-in-Chief, who would control all branches of engineer activity, would be the "Head of the Corps," and, as some suggest, a member of the Army Council.

Let us consider what this means and how it would fit in with the actual organisation of the Army Council and War Office as they are.

First of all, what is it that men have in their minds when they say we need a "Head of the Corps"? I have often read arguments stating that a "Head of the Corps" is required in order to look after the interests of the Corps. Do those who say this mean the interests of the Corps as a regimental organization or of the engineer services of the Army? They are not quite the same thing. The difference is of a similar nature to that between the infantry when spoken of as an arm of the service, and individual regiments such as the Gordon Highlanders or Durham Light Infantry. If the Corps as a regimental organisation is meant, then it is already provided with a Head to look after its interest. In the same way as infantry regiments have an Honorary Colonel, the R.E. have Colonels Commandant and have also the honour of having as Colonel-in-Chief His Majesty the King.

It cannot therefore be to regimental interests that the advocates of a "Head of the Corps" are referring, and the interests in question are, presumably, not "R.E. interests" (*with capital R and E.*) but "engineer interests," (*with a small e*), that is to say, *the interests of the Army in getting its engineers' services of all kinds carried out with efficiency*, which you will admit is a different thimg.

Incidentally it is a curious thing this practice of using a capital E instead of a small one. Many R.E. officers will unhesitatingly use a small *i* when writing of infantry organisation or infantry tactics, etc., but will invariably use a capital E (or even R.E.) when referring to the same subjects in connection with engineers. In fact, one sees this misconception cropping up in all sorts of unexpected places—in official correspondence, in official books of regulations and even in the *Army List*—and I can assure you that it has taken a lot of careful editing to keep it out of the training manuals.

Now, in order to ensure the efficient execution of all engineering

work for the army in war and peace, would it be desirable, as proposed, to have a "Head of Corps," whether a member of the Army Council or not? Is there a "Head" of the infantry, the cavalry or the artillery? No, there is not, neither is there, nor can there be, under our Army organisation as it exists, a head of the engineers.

We must take the War Office organization as it exists. The Army Council has four military members only. Strange as it may seem, these are not members representing the infantry, the cavalry, the artillery, the engineers. Their functions are quite different. The Council is a council and its decisions are collective ones, but each military member is responsible for administering certain *subjects* for all branches of the Army. Thus the C.I.G.S. deals with training of the army in peace and operations in war. The A.G. with supply of men, their organization in units, and their discipline. The Q.M.G. with provision and distribution of clothing and equipments and with moving and quartering. The M.G.O. with production of weapons, *i.e.*, guns, rifles, machine guns, ammunition, tanks, etc., and also with construction and maintenance of barracks and fortifications.

How would it be possible to separate out the engineers' share of each of the above subjects and give the responsibility for it to an engineer member of the Council? It would be quite impossible. The training of engineers must be the responsibility of the General Staff who direct the training of the rest of the army. Engineer work in the field is part of the general operations and must be the responsibility of the same body as the rest of the operations—again the General Staff. The recruiting and organization of engineers cannot be separated from the recruiting and organization of the rest of the Army. Railway work is transportation and cannot be run by a different authority from the one who arranges for shipping transport and road transport; they all form a single problem. This idea of separating the engineers and their work from the rest of the army is an impossible one, and the notion of having a head of the engineers on the Army Council is one that would cut across the whole principle on which the War Office is organized. So far from it being desirable to separate the engineers and their work from the army, what is really wanted is to bring them more into it—they are too much separated already.

But, it may be argued, if each branch of the War Office is to deal with the engineer work pertaining to it, does it not require competent technical advice? Yes it does, and in most cases it has got it. The M.G.O. has an engineer directorate to deal with the works for which he is responsible, the Q.M.G. has a branch, staffed by engineer officers, to deal with railways. The A.G. has an engineer branch, the General Staff has engineers forming a map production branch. There is, however, one extremely important branch of

engineer activities for which no machinery exists for getting competent technical advice. For the training of engineers, both by themselves and in co-operation with the other arms, for the organization of their work in the field, for the consideration of the engineering requirements for any given plan of operations, there is no branch whose duty it is to provide the General Staff with technical engineer advice. This is the point where there is a blank in the existing organization.

What is wanted, however, is not a head of the Corps but an engineer adviser affiliated to the General Staff. A senior and experienced officer in that position would be able to advise the General Staff on all the above matters, on the compilation of training manuals, on the preparation of the engineering part of schemes of operations. He could frequently visit engineer units, explaining and expounding as necessary any points in the staff doctrines which he found were not understood and similarly acting as a 'liaison' channel by which any difficulties or wants on the part of units could be made known to the General Staff at the War Office; he would also see that technical and other training was being conducted on right lines and act as liaison officer on matters of engineering training with local Commanders, Staffs and Chief Engineers. Such an organization would dovetail into the War Office organisation and correspond to the organization authorized for war.

Why have we not got such an organization? Well, it has to be remembered that the engineers are not the only branch that requires it. Most, if not all the other arms—certainly all the technical ones—want it also, and to provide an advisory (or, as it is sometimes called, an inspectorate) branch for all of them would cost a lot of money, and money is tight in these days. The principle of having such branches has been recognised, and in the case of some of them, namely, the artillery, the tanks and the air defence branch, they have been established. It may be hoped that in due course the need for it for field engineer units and their work will be considered as sufficient to justify the expense.

Lastly, I would like to say this: There may be some who do not agree that the theory I have been expounding as to the position of engineers in the army organization is a sound one. As I have said, it has been for many years an indeterminate question and a subject of controversy, and many have from their own experience formed opinions on it which they find it difficult to abandon. But when an army policy, or an army organization, has at last crystallised out and has been accepted and formulated, then the time has come when it becomes necessary for us to subordinate our individual ideas, and our individualistic modes of thought, to the larger conception—the group mind of the Army.

Original thought is an admirable thing, and without it neither

an army nor any other organization can progress. But there comes a stage when original thought must give way to *disciplined* thought. We have now got to that stage. After much discussion, in which original thought has had full play, we have now got the considered decision of the Army Council embodied in the regulations. It is the official and the only authoritative doctrine, and the contrary views to which I have referred in the course of this lecture must now be regarded as heresy. Whether we agree or not with the official doctrine it is our plain duty to accept it loyally, and to do our best, when the occasion arises, to make it a success.

We have got in fact to do, what sometimes men of original minds are apt to forget, that is, to get into the boat with the rest of the Army, to remember we are only part of the crew, and must conform to the stroke, and not persist in trying to row in our own individual time.

"THE MAINTENANCE OF THE OBJECTIVE."

By BREVET-COLONEL W. G. S. DOBBIE, C.M.G., D.S.O.

"He that wavereth is like a wave of the sea, driven with the wind and tossed. Let not that man think that he shall receive anything. . . ."—*St. James.*

It must be admitted that the above words are true, not only in the special connection in which they were written, but also in all departments of life and not least in the domain of Military Science. The underlying truth of this maxim has many synonyms. It is sometimes described as the "single eye"—or as the impossibility of serving two masters. The modern military counterpart is the first "Principle of War" as enunciated in *Field Service Regulations*, and is styled "The Maintenance of the Objective." It will be seen that this principle is no new discovery of a modern military writer. It is as old as history and has always been recognised as being of vital importance, albeit, as will be shown later, it has frequently been disregarded.

That this principle is of the greatest importance is evidenced by the position of honour given to it among the other principles of war, and this fact is acknowledged by all military writers and thinkers. It is important not only in the strategical domain, but in the tactical as well. It applies to the smallest operation of war as much as to the biggest—to the nation as well as the platoon. Success cannot be attained if this principle is flouted, and its neglect may well spell disaster.

It must also be recognised that this principle which is so easy to enunciate, is evidently, judging by history, very difficult to carry out. There are innumerable instances of its disregard by commanders of all calibres. It is one thing to theorise on the principle, but quite another thing to apply it to the actual circumstances of a concrete situation, a lesson which has been learned in the hard school of experience by many.

All these considerations point to the necessity of all officers, of whatever rank or appointment, making a careful study of the matter, so that we may profit by the mistakes of others and thus avoid the danger of falling into the same pitfalls. A proper appreciation of the true meaning of this principle will also assist us to make the right decision in difficult circumstances, as it will enable us to separate essentials from non-essentials.

If we are to carry out the spirit of the first "principle of war," two things are necessary:—

(*a*) We must be quite clear as to what our object really is, and
(*b*) Having decided on our object, we must not allow ourselves to be deflected from its pursuit by anything whatsoever.

It is proposed to consider these two points separately and to deduce from history or otherwise such lessons as will help us to put the principle into practice.

As regards the first problem, viz., deciding what the object really is, it is extraordinary how often disaster can be traced to failure here. If we are not absolutely clear about the object we have in view, confusion of thought and wavering of determination will result. Hence the paramount importance of seeing the object clearly, and keeping it constantly in view. Too often the "object" is confused with the means to attain it, a state of affairs which leads to the fatal mistake of pre-judging the question when the plan is being considered. It is, therefore, of the very greatest importance that before considering the plan of action we should be absolutely clear in our own minds as to what the "object" in view is. If this is correctly assessed the difficulty in deciding between the various possible courses of action is automatically removed, or at any rate greatly reduced. In war a commander can have, or should have, only one object at any given time. In the case of a subordinate commander the object for him will be defined by the orders he has received from his superior, and will, generally speaking, be different in nature and in degree to the object kept in view by the superior. In other words, the object of a subordinate is in reality one of the means to attain the object of the superior. It is probably much more immediate in its application and does not look so far ahead. Putting it the other way, the course of action decided on by a superior as the best means of attaining his object becomes, through the medium of orders, the "object" of his subordinate commanders. These objects, though differing among themselves all tend to the one end. The Army commander and the platoon commanders all have widely different objects—but they are all working toward the same goal, provided that each is clear as to the part he has to play, and that the task of each unit has been co-ordinated by the mind guiding the whole, viz.: the mind of the superior commander. The problem for junior commanders as already hinted is usually fairly simple. Their "object" is given to them by their superior in the form of a definite order couched in exact terms, which admit of no misunderstanding or latitude. They have simply to devote all their energies to carrying out the orders they have received, and so long as the circumstances have not changed, the problem of deciding on their object presents but little difficulty.

As pointed out above, the "object" of a subordinate is generally defined by the orders received from his superior. This, however,

is only true so long as the circumstances prevailing when the superior gave his orders remain unaltered. Should the circumstances have radically changed, the subordinate must ask himself what orders he would have received from his superior had the latter known or anticipated the new conditions. Thus the "object" for the subordinate has to be reviewed afresh and decided on by him in this light. This process will require deep thought, especially when the superior cannot be communicated with, but the care expended on deciding on the new object will be amply repaid by facilitating the choice of a course of action. In the case of higher commanders the orders they receive have of necessity to be framed in more general terms, leaving more latitude as to the definition of the object. But whether this definition is easy or difficult, the air can usually be cleared by the commander asking himself some simple question, such as "What is my *raison d'etre?*" "Why am I here?" The very simplicity of such questions is frequently the cause of their being overlooked, and yet they are the essence of the whole art of war. It is necessary to turn one's eyes away from the immediate surroundings, with all their bewildering confusion, and view the goal set before one, so that at the outset of the operation a true course may be set. But it is not only necessary at the commencement of an operation to assess correctly the object in view—it is also essential to keep it constantly in view throughout the course of the operation. There are numerous instances of operations having been initiated with the true object in view, but this has gradually been lost sight of and has almost insensibly been replaced by a totally different one. At first the deviation from the true course may be so minute as to be almost imperceptible—but gradually it becomes more pronounced. Local circumstances and conditions have assumed an undue importance and have distracted the attention from the real reason for the undertaking of the operation. A new object comes into being, and makes demands on the available resources which prejudice the attainment of the original and true object. This would all be avoided if the commander in question were to remind himself constantly of the real object which he set out to attain.

The origin of the deviation from the true course has been shown to be very subtle. Sometimes the suggestion has been made:—"Now that we are here, we might as well go on to . . . , or do this or that thing? It will not need a great addition to our force, and it would be so useful. It would be a thousand pities, and so unenterprising of us, if we were not to take advantage of the favourable position in which we are placed to prosecute this further enterprise." How often have those arguments been put forward and how difficult it has often been to detect the fallacy underlying them! The consequence has frequently been that the commander

concerned has been drawn on and on. His requirements have constantly grown. An increasing strain has been imposed on the available resources, which have had to be diverted from their proper employment, and the plans of the superior commander have been rendered ineffective owing to the lack of means to carry them out.

It is, however, not desired to deprecate enterprise and initiative, but to show that since the nation or any part of its forces is only capable of a certain amount of effort, it is most desirable that *all* the available effort shall be directed towards the desired end. All other effort is wasted, however attractive the scheme in question may be, and no force can afford this waste. It is a luxury beyond our means.

It must be realised that this truth applies to small affairs of tactics as well as to major strategical conceptions. The principle holds good for the platoon as well as for the Army Group. It, therefore, has its meaning for all of us irrespective of rank or appointment. A force composed of individuals who have thoroughly grasped this principle will be capable of almost anything, as effort will be economised and not wasted and will all be tending irresistibly toward one end.

It has been pointed out that a commander should only have *one* object. That is to say, that he should only receive from his superior orders to do one thing at a time. Dual duties are usually conflicting; they mutually interfere with each other. To take a simple illustration, one body of cavalry should not be ordered to carry out a particular reconnaissance and at the same time to screen the main body. The two things are conflicting, and attempts to do both may well lead to success in neither. The same principle applies equally on a bigger scale. An expeditionary force is landed to protect certain vital interests for the prosecution of the war, *e.g.*, the Persian oil fields. If that is the object of the Expedition, let it be clearly laid down. But if the additional object of, say, threatening Baghdad is superimposed, either by letter, word or even implication, the commander is placed at a grave disadvantage. The conflicting interests pull different ways—the force required to achieve the one object differs essentially from that required for the other—the first object hampers him in the execution of the second, and at best he becomes committed to an expedition far larger than was intended, and the principle of economy of force is shattered.

It may be useful at this stage to refer to one or two examples from history of the neglect of this principle. The great German plan for the attack on France is a case in point. Originally the whole essence of the German plan was an overwhelmingly strong right wing, which was to sweep irresistibly through Belgium and outflank the French left. The rest of the German forces deployed

between this right wing and the Swiss frontier were to have a role entirely subsidiary to this great mass of manœuvre. Such was the conception of the author of the plan. His successor, however, allowed the plan to be whittled down in some vital points. Pressure was brought to bear on him to strengthen the left wing with a view to covering Alsace. Troops were taken from the right wing for this purpose. Again it was considered advisable to strengthen the force on the Russian frontier. It was the right wing again that had to find these troops. The result was that the preponderance of the right wing was greatly diminished and the success of the original plan altogether prevented. The original object had been lost sight of.

Another instance is supplied by the great German offensive of the spring of 1918. In March this offensive was launched against the right of the British line with a view to driving a wedge between the British and French Armies and thus separating the Allies. After the first impulse was exhausted and further progress was temporarily held up, the Germans launched another offensive against the Lys sector. It is necessary to be perfectly clear about the original purpose of this second offensive, in order that the after events may be correctly weighed. There seems to be no doubt that this offensive was undertaken as a subsidiary operation in order to assist the main operation towards Amiens. It was intended to draw our attention and reserves away from our right flank to the threatened area further north. Ludendorff, in his memoirs, when discussing the preparations for the German offensive of 1918, uses the word "feint" in connection with this northern attack. What actually happened? The German attack achieved considerably more success than was anticipated, and it would seem that this success led the German Higher Command to attempt to turn the subsidiary operation into a primary one, and to lose sight of the true object. This battle, or the "Bataille du Nord," as Marshal Foch used to refer to it, absorbed more and more of the German energies and resources, so that sufficient troops were no longer forthcoming for developing and extending the initial success at the decisive point. The final German attack toward Amiens took place on the 24th April. It all but succeeded. If they could have delivered a heavier blow then, the result might have been disastrous to the Allies. The error cost the Germans dear. It may be said, without exaggeration, that it lost them the war.

The foregoing considerations clearly show the importance of the "maintenance of the objective," and the disastrous results when this principle has been ignored. It must be recognised that the problem to be solved is often presented in an extremely complex fashion so that the big underlying and fundamental verities are not easily recognised. It is frequently very difficult to see the

wood for the trees, and, this being so, it is of the greatest importance that officers should train themselves to pick out the essential points from a mass of unimportant and irrelevant though specious considerations. And this training should be insisted on in small matters as well as in big. It is the habit one wants to cultivate of separating essentials from non-essentials.

In the higher domain of strategy, and to a lesser extent in the sphere of tactics, political considerations arise to confuse the military problem. It would be out of place here to discuss the relation between politics and strategy—but it is important to realise how this element increases the difficulty of the military commander in solving his problem, and confuses the issue. What must be grasped is, that when once the military commander has been given his objective (and in the choice of the objective all political, economic and other relevant considerations have been taken into account), he must not allow himself to be diverted from its pursuit. As Clausewitz says :—" He who would yield to these impressions (outside influences), would never carry out an undertaking, and on that account perseverance in the proposed object, as long as there is no decided reason against it, is a most necessary counterpoise."

The problem sometimes presents itself in the guise of a suggested " detachment " or " diversion." These enterprises can be made to appear most attractive and alluring, and one is very easily drawn into a false position. One finds oneself weighing many and various considerations, and becoming more and more undecided as to the best course of action to pursue. The consideration of the object however, should lead one to a rapid and correct solution of the problem, and save one from being affected by these cross currents and complex arguments.

Diversions are suggested for a variety of reasons. Those who are uneducated in a military sense frequently look upon them as a short cut to success. They think that the direct road can only be forced by severe fighting, and, therefore, they argue that they are following the principle of " economy of force," if they try to go round by a road where the difficulties are less, irrespective of whether the new road leads to the desired goal or not. It is as if a motorist were to select a road merely for its surface and gradients and without regard to where the road leads to.

Again, they are sometimes suggested as offering a chance of an immediate success. It is urged, perhaps, that it is most important for political reasons to be able to announce a victory. The military commander must, however, be very careful to take the long view rather than the short view. He must consider the effect of the proposed operation on the final success of the cause. A local and immediate success will be of little value if it spoils the chance

of final victory, and it is this aspect that it is the duty of the military commander to scrutinize most carefully. In other words, he must keep the "big" object in view and judge every suggested enterprise by its effect on the main plan. As a matter of fact, the very name "diversion" should make one treat them with suspicion. The name suggests a deviation from the true course, and in considering the advisability of a diversion, one must repeatedly and definitely bring before one's mind the "object" one is striving to attain. If one is quite clear as to the object, it is not difficult to decide on the desirability or the reverse of the diversion or detachment. The matter is really quite simple. If the diversion helps toward the attainment of the "object," it is justified; if not, it is not justified. Defined in this way, the decision appears to be very easy, but it is extraordinary how complex it often seems to be. So many conflicting considerations are advanced—political, economic and military. It is impossible to reduce these considerations to one common denominator, so as to decide the relative value of each, and weigh one against another. One cannot arrive at a conclusion that way, but, fortunately, the matter can be decided by an answer to the question "Does this enterprise assist the attainment of my true object?" That is a question which can usually be answered without difficulty, and its answer solves the problem. This goes to prove, as has already been pointed out, the importance of deciding on the "object" before considering the plan of action, and that energy expended for this purpose is very well spent.

It forms an interesting study, to examine the diversions and "side shows" undertaken by this country at various times in her history, in this light, and to apply this test to them.

To sum up—the following lessons stand out as being of vital importance to all military commanders in the conduct of operations however large or small:—

(*a*) Be sure you are quite clear as to the object you have in view.

(*b*) During the course of the operations constantly review your action in the light of this object, and make quite sure your course is still heading in the right direction.

(*c*) Bring every suggested enterprise to this test:—"Will it assist me in the attainment of my object?"

An officer whose conduct is dominated by these principles will not go far wrong.

THE EARLY YEARS OF THE ORDNANCE SURVEY.

(Continued.)

VI. Progress from 1820 to 1825.

Drummond, Gardner, Dawson.

Progress of the Survey, 1820-25.—In 1824 a Select Committee of the House of Commons, under the chairmanship of Mr. Spring Rice, was appointed to consider the question of a Survey and Valuation of Ireland, and Colby, as Director of the British Survey, gave evidence in March and April of that year. The Ordnance Survey had now been in official existence for thirty-three years, and it appears from Colby's evidence that the triangulation of Great Britain was nearly completed, though it must be noted that many of the stations were subsequently revisited: the latest observations were not made, in fact, until 1853, and most of the angles in Great Britain, used in Clarke's reduction, were observed after 1837. Colby stated that the one-inch map of England and Wales was two-thirds completed in the field. The one-inch map of Scotland had not been begun.

Some of the questions and answers are interesting, for instance :—

" [The Survey of England] was begun upon six inches to a mile? Part of Kent, which was considered of consequence for military purposes, was surveyed upon that scale.

" It was actually protracted upon that scale?—Yes.

" Are there any means now in existence of protracting the surveys you have made in England upon that scale?—No, certainly not; the survey has been made upon the scale of two inches to a mile.

" You could not now protract the survey of England from your field notes upon the scale of six inches to a mile?—Not with the degree of accuracy which that scale would require."

It may be noted that the Committee made use of the term Ordnance Survey, thus: "In the ordnance survey do you distinguish the different descriptions of roads?"

As regards the strength of the department in 1824: "What is the force employed in England and Scotland now?—We have ten officers of Engineers.

" What force have you under them; what is the whole force employed in the survey?—I have ten surveyors under them.

" Is that the whole force?—Yes, the whole force."

It may be supposed that we should add to this number the engravers at the Tower. In the draft of a minute to the Board, written probably by Colby about 1820, it is stated that Mr. Baker

was the principal engraver, and there were three apprentices who were engaged because "much difficulty had been found in procuring a sufficient number of persons already initiated in the art of engraving who were accustomed to the style of accuracy required in the maps." How many other engravers were employed at the Tower is not known. On completion of his apprenticeship, an engraver was paid £2 12s. 6d. a week.

The Peace of 1815 had freed officers for this employment. Lieut. Richard Mudge was appointed to the Survey in 1816; then followed Lieuts. Dawson, Robe, Renny, Captain Gossett and Captain Vetch, in 1819; Lieut. Drummond in 1820 and Lieut. Larcom in 1824.

It is sometimes supposed that, in 1825, the whole personnel of the Survey was transferred to Ireland. Sir Henry James, who was then Director of the Survey, stated in 1859, that, in 1824, the one-inch survey had extended from the Land's End to the boundary of Yorkshire and Lancashire, including the whole of Wales. He went on to say that, "it was then decided that there should be a general valuation of Ireland, and that as a necessary basis for that valuation, there should be a town land survey. . . The whole survey force was then sent to Ireland; and the survey of Great Britain was altogether suspended. We commenced first in the North of Ireland, I myself taking part in the survey."

But this was not quite the case. The office in the Tower was still kept in existence, and some field work was still carried on, in order to keep the engravers at the Tower supplied with material for the one-inch map. Colby was frequently at the Tower. It would appear to be more correct to say that most of the officers and men were transferred to Ireland in 1825, leaving only Captain Mudge in the Tower with a very small staff to deal with the one-inch sheets of England and Wales.

In December, 1822, there came a visitor to the Survey Office in the Tower, whose name is very familiar to most British topographers, namely, Robert Shortrede. All who have painfully interpolated the logarithms of trigonometrical functions, in the absence of their copy of Shortrede, will always recall his name with gratitude, and swear never to go without him again. On the 22nd December, Robert Stevenson, the engineer, wrote the following note to Colby:—"The bearer, Mr. Robert Shortrede, was for some time in my office and now goes to India under the auspices of Sir Walter Scott. He is a very keen mathematician, and I beg to be allowed to give him an opportunity of seeing the extent of the trigonometrical survey in the Drawing Room."

Robert Stevenson, the writer of the note, is justly celebrated as the designer and builder of many lighthouses, notably that on the Bell Rock. But he is, nowadays, even more celebrated as the grandfather of R. L. Stevenson, who was, however, born after

his grandfather's death. In the Colby collection there are many letters from Robert Stevenson, who frequently corresponded with Colby. The little letter above quoted brings into pleasant juxtaposition the names of Sir Walter Scott, Stevenson, Shortrede and Colby—literature, lighthouses and logarithms.

In January, 1823, died that old mentor and friend of the Survey, Dr. Charles Hutton. His son wrote to Colby from 34, Southampton Row, on the 29th of that month :—

" It is my painful task to inform you that my venerable Parent, your Friend, Dr. Hutton, departed this life on Monday morning, after an illness of several weeks, in the 86th year of his age. It will be pleasing to his numerous friends to learn that he happily retained his mental faculties to the last. So recently as Friday afternoon, he dictated a letter, in reply to a communication which he had received in the morning, soliciting the favor of his opinion as to the form of the Arches, which it would be most advisable to adopt, in the construction of the Bridge proposed to be erected over the Thames, on the removal of the old London Bridge."

The Survey owed much to Dr. Hutton, who advised the Duke of Richmond to appoint Mudge, and the Duke of Wellington to appoint Colby. It is true that he advised the appointment also of the ineffective Williams; but, fortunately, no great harm was done, and Hutton could hardly have foreseen that Williams would be a failure.

Dawson, Robe, Renny, Gossett, Vetch, Drummond and Larcom, with Henderson, Murphy, Portlock and James, were all employed on the Irish Survey in the early days. The outstanding men amongst them being Drummond, Larcom and James. Of Larcom and James we shall hear later on, but this may be a convenient place for a brief sketch of Drummond's career.

Thomas Drummond.—Drummond was born in Edinburgh in 1797, and, after passing through the R.M. Academy, was commissioned in the Royal Engineers in 1815. In 1820 he was posted to the Ordnance Survey and remained on that duty until 1831. " During his winters in London he attended the lectures of Professor W. T. Brand and Michael Faraday at the Royal Institution, and the mention at one of them of the brilliant luminosity of lime when incandescent, suggested to him the employment of the limelight for making distant surveying stations visible. In 1825, when he was assisting Colby in the Irish Survey, his lime-light apparatus (*Drummond light*) was put to a practical test, and enabled observations to be completed between Divis Mountain, near Belfast, and Slieve Snaght, a distance of 67 miles."*

Trials were also made in the " long room " of the Ordnance Office in the Tower, a room which is stated to have had a length of 300 ft.

* *Encyclopædia Britannica. Art. Thomas Drummond.*

The block of buildings of which it formed part was burnt down in 1841. Sir John Herschel thus describes the impression produced when the lime-light was shown on this occasion :—" The common Argand burner and parabolic reflector of a British lighthouse were first exhibited, the room being darkened, and with considerable effect. Fresnel's superb lamp was next disclosed, at whose superior effect the other seemed to dwindle, and showed in a manner quite subordinate. But when the gas began to play, the lime being brought now to its full ignition and the screen suddenly removed, a glare shone forth overpowering, and as it were annihilating both its predecessors. . . . A shout of triumph and of admiration burst from all present." *

In a letter from Colby to his wife, written from the Tower, May 28th, 1830, he says: " To-morrow I go to the visitation at the Royal Observatory, and on Monday we have another exhibition of Drummond's light. We expect Lord Melville, Sir George Cockburn, Sir Thomas Hardy, etc., to be there with the Trinity Board. The last exhibition was quite triumphant. We had a strong shadow by holding the finger before a piece of white paper though the light was 10 miles off !"

This light was first used in practice for the 67 mile ray between Divis and Slieve Snaght; Drummond was in charge of his light on the latter mountain, which is in Donegal and is over 2,000 ft. high. The party did not begin operations until the end of October, 1825; the season was late, and the weather was bitter. Drummond writes from Slieve Snaght on the 28th October: " The tent is now up and in a few minutes the wall round it will be completed, so that we may consider ourselves safe against any storm; the wind has, fortunately, been Moderate, the fog still continues." Drummond was also using a heliotrope invented by himself. On the 4th November he writes: " This Morning about 9 a.m. the weather cleared, the sun broke out, and I gave you instantly a reflection which kept up till 2.13—with several eclipses intervening. A storm of snow came on at that hour. . . I am just going to make preparations for the camp. . . My tent is blown [down] and I now write from a kind of Cave, formed on the lee side of the Hill. Shall commence with the lamp at ¼ past seven."

Drummond suffered much from wind, cold and fog at varying intervals. The tents were sometimes blown down, and it was only with great difficulty that it was possible to direct the light to Divis at night. " The wind encreased to a gale and a sweeping Shower of rain passed over the Mountain. . . What a Villainous Climate. If this evening proves at all possible I shall blaze away till ¼ before 11. . . ¼ past seven is my first appearance."

* *Dictionary of National Biography. Art. Thomas Drummond.*

On November 5th, writing to Murphy, on Divis: "Give me credit for doing all I can and be thankful for what you get." On the 8th: "Yesterday proved an impossible day. . . Squall succeeded Squall."

On the 9th things were better: "This day promises well; at 9.18 a.m. the first reflection commenced and Mr. Larcom is now at work—sun bright. . . If this day holds you shall have the lamp every appointed time and I trust our labours will be finished." On the 10th: "I forward you the account of our operations yesterday—if not successful—I despair of success; there must be a hill in the way."

The operations were successful; there was no hill in the way. But Drummond did not know this for two or three days. On the 11th at 3 a.m. he writes: "The poor devil who went for the letters has been wandering on the hills since 5 in the evening. . . I look for to-morrow's letters with much anxiety." On 12th November, 1825: "Of the successful termination of our labours the letters from Divis will already have apprized you. . . . At the last we had nothing remaining but the lamp tent and the walls of the Cooking House. I believe that we should have been compelled to abandon the hill but for the efforts of the men. . . I subjoin a list. . . Corporals Williams, McLaren, Moulton and 9 privates." From Belfast on the 19th: "I arrived here yesterday from my Snaght expedition."

On 12th Lieut. Henderson writes from Divis:—

"On Wednesday I gave you a very hurried intimation of our having seen the reflector. I have still greater pleasure in communicating the result of the light, it was most brilliant. . In the evening, when preparing for our observations, one of the watch called out that there was a much stronger light than the one at Randalstown and a little above it; we immediately turned to that direction and we there saw the light; it was most brilliant, exceeding in intensity any of the Light Houses. . . . These two days' observations have completely established the advantage of this admirable invention . . . the light . . . can be very easily intersected from its steadiness and brilliancy. . . At night the light was observed on one arc and reverse; it was taken with all the Light Houses from Corsil to the Lower Light House on the Calf of Man.—Lt. Henderson, Observer."

On the 13th, Henderson writes from Divis:—

"It was most fortunate that the reflector and light were seen on the two days, as since that the weather has completely changed, so much so that yesterday it was with difficulty the places to mark the station by could be seen. Everything is now arranged and to-morrow [we] commence taking down the observatory tent and prepare for the staff and pile.

All those of us who have waited patiently on inhospitable hills, for the glimpse of a ray of light from a distant trigonometrical point, will sympathise with Colby, Murphy and Henderson on Divis;

and still more with Drummond and Larcom on Slieve Snaght, for they were uncertain up to the last as to whether their labours had been successful. One says to oneself sometimes: "It's a dog's life—but it has great compensations."

In June, 1830, Colby writes: "Lt. Drummond is trying for a situation and is pretty well supported." The "situation" was in connection with the great Reform Bill; Drummond was, in 1831, appointed head of the Boundary Commission, which was necessary for laying down the new electoral areas. In 1833 he became Private Secretary to Lord Althorp, Chancellor of the Exchequer; and in 1835 he was appointed Under-Secretary for Ireland.

Neither the Lord-Lieutenant nor the Secretary, Lord Morpeth, took an active share in the administration of the country, and Drummond found himself the Governor of Ireland. There was, thus, a great change in the relative positions of Colby and Drummond; from being an officer on the Survey under Colby, Drummond became the ruler of the country which Colby was surveying; and it was, perhaps, inevitable that the situation should be a somewhat difficult one for Colby; though it must be remembered that the Survey was under the Ordnance and not under the Irish Government.

Some years later Colby writes to his wife: "I have doubts of Drummond having really committed himself by the observations attributed to him. He is incautious, but such observations are not like what he would have made on any subject when under me. However, I do not excuse him for not having written to me before he acted." And again on February 8th, 1840:—

"Lord Morpeth's letter was perfectly gentlemanlike and friendly to the Survey—but Drummond's was the most intemperate and offensive attack on the Survey you can possibly conceive. It fortunately happened that his zeal to injure the Survey carried him into a good many sheets of writing, and when there is great length and great bitterness, there is always room for a reply. I was, therefore, enabled clearly to establish his error quite to the satisfaction of the Master General on every essential point."

The particular cause of their dispute was the execution of the geological survey as an adjunct to the ordnance survey—the former being included in the term "matters of mere curiousity" by a subordinate of the Board. But the Master-General stood by Colby; the Master-General, indeed, was not a little annoyed at receiving "a most impertinent letter from a Captain of your Corps, who because he is Secretary for Ireland takes upon himself to be insolent to the Ordnance.'

It is to be regretted that the relations between Colby and Drummond were strained over this matter of the geology of Ireland, for Drummond had done good work for the Survey, and he died two months after the letter last quoted was written—worn out by overwork. He left the reputation of a real friend of the people

Capt Thomas Drummond Royal Engineers
Under-Secretary to the Lord Lieutenant of Ireland 1841

of Ireland; "moved by the miseries of the people, touched by the injuries to which they were being subjected, and pained by the evidence of misrule which everywhere met his eye."* It was he who told the Irish landlords that "property has its duties as well as its rights." O'Connell, convinced of his goodwill to the country, supported him.

Perhaps his chief administrative act was the foundation of that fine body the Royal Irish Constabulary, but no side of the administration was neglected by him. The continuous and overwhelming work, and the difficulties that he had to contend with, told rapidly on his health, and he died on the 15th April, 1840. It is not often that a man, who has distinguished himself in a technical sphere, becomes equally eminent in that of government; and Drummond, who had that double distinction, may properly be regarded as one of the most talented officers who have ever served in the Army.

Before giving an outline of Colby's career, it will be right to describe, very briefly, the lives of two officials of the Survey, who carried out much useful work under Mudge and Colby. Their names appear frequently in the accounts of the Trigonometrical Survey and in the technical correspondence of the period. These two officials are James Gardner and Robert Dawson.

James Gardner.—An important member of the Survey staff, during the whole of Mudge's directorate and later, was James Gardner, who, apparently, before the formal establishment of the department, was the "chief draughtsman" of the Board of Ordnance at the Tower. He was probably posted, as a Warrant Officer, to the Corps of Surveyors and Draughtsmen, in 1802. But it is not in connection with drawing that we usually find his name mentioned, but almost always with observing. It is recorded that he observed with the large theodolites at thirty-eight stations. The last stations he observed at being the cross-channel group, at which angles were re-observed in 1822, viz.: Crowborough, Fairlight, Folkestone, etc. He also assisted in the observations with Ramsden's zenith sector at Kellie Law, Cowhythe, Balta, and at Dunkirk across the water. And from the very commencement of the one-inch map he was constantly employed in fixing minor points for the "interior survey," as Mudge mentions in the accounts for 1791 to 1795.

We do not know much about him, except that he appears to have been a very efficient observer, who was connected with the survey for thirty years or so. But five letters from him to Colby have been preserved, and a few extracts from these may serve to give some information with regard to the personality of this old public servant.

* *Dictionary of National Biography.*

From Edinburgh, 31st May, 1816:—

"I am glad to inform you that after watching night and day I have at length succeeded in catching the Dunrich hill, having got nine observations, seven of which agree remarkably well. To-day I expect to have the tenth Western elongation. . . I have not since you left seen further to the westward than the Orchills, and the only thing done in that quarter is taking the Camproys twice—Meridian marks are not so easily placed as I imagined."

He mentions the difficulty he had in getting permission to cut down a few trees that obstructed the rays:—

"A shrub in the neighbourhood of Falkland is as much thought of as the largest oak in Sherwood Forest."

"I have given the Woolwich party [of R.A.] money to buy shoes and shirts, and taken care that they have done so. At Woolwich they imagined perhaps that as the men were to get to Scotland, the nearer approximation to nudity they would the more easily pass for Scotchmen."

From Lincoln, 30th December, 1818:—

"I have at length succeeded in getting points for Mr. Metcalf and Mr. Budgen. I am now at work in Mr. Stevens' district, and if the weather permits, shall have a stiffening of points for him by the end of next week, when I shall return to town unless I receive orders to the contrary. . . . I am sorry I did not take your advice and wait till spring. I never suffered so much fatigue and cold in my life. Glush Mull is a paradise compared to Lincolnshire at this season of the year; we have been out several times till 10 and 11 o'clock at night, on account of thick fogs and bad roads, and when I return I shall be happy at the *novelty* of dry feet."

In another letter he sends his "best respects to Mr. Robe, Mr. Drummond and Mr. Dawson."

Wallingford, 18th November, 1821:—

"I have just completed a week's work, but what with bad weather, short days, and roads almost impassable, the progress has not been such as I should have wished. Am sorry also to observe that I can derive but little advantage from Mr. Woolcott's work, not but that there is a good deal done, but the angles seem so roughly taken that it would be almost dangerous to incorporate them with anything that deserves the name of a trigonometrical survey, in some instances the great differences betwixt arcs arise from the clumsiness of the objects, many often clump objects at the distance of several miles have covered the field of view of my telescope!!! . . The angles of Mr. Dawson's series seem to be very well taken; I shall obtain a base to verify his series direct almost from the great instrument."

The last letter preserved deals with the printing of the maps of the Survey of Ireland. This letter is dated Regent Street, 7th February, 1827. Gardner had been appointed agent, *i.e.*, map-seller, to the Board of Ordnance. The reasons for the appointment are described by Colby, in a minute from which the following paragraphs are abstracted. The subject of map sales is dull enough, but it affects the finance of the Survey and is one which continually

recurs in its history. The matter was not satisfactorily settled until a few years ago.

Colby writes:—

"When I had the honour of receiving from the Duke of Wellington the appointment of Superintendent of the Survey in 1820, I found the sale of the maps carried on in two ways, the one by the principal engraver at the Office in the Tower, the other by Mr. Faden, the mapseller, at Charing Cross. A trade price and a selling price were established, but all those who came to the Tower received maps at the trade price, whilst those who purchased of Mr. Faden paid the selling price. The sale of the maps at the trade price to the public at the Tower irritated all the mapsellers against the Ordnance . . . and they most strenuously opposed the sale of the maps by every means in their power. . . On the 30th August, 1820, the Master General and Board were pleased to grant Mr. Faden an allowance of 10 per cent. to enable him to supply the rest of the trade. . . He received maps from the Tower on sale or return. . . Mr. Faden was not bound by any agreement to sell the Ordnance maps in preference to others."

This arrangement did not work well, largely because the discount allowed was too low.

"When Mr. Faden retired from business the Honourable Board entere into an agreement with Mr. James Gardner, who was well qualified as a geographer, to act as their agent. And he on the faith of his agreement purchased a house in Regent Street to carry on the sale of their maps, and bound himself down not to sell any other maps which would supersede them."

That is almost all that we know about James Gardner; but, perhaps, even less will be known about most of us a hundred years hence.

Robert Dawson.—The Survey was such a small department, in those days of the early nineteenth century, that the personality of each member of it counted for a good deal; and, happily, there were no failures amongst the five who, until 1916, were chiefly responsible, namely, Mudge, Colby, Woolcot, Gardner and Dawson. Robert Dawson was born in 1776 and, when he was eighteen, he was employed as a draughtsman under the Board of Ordnance, at a salary of £54 a year. The Corps of Royal Military Surveyors and Draughtsmen was formed in 1802, and consisted of warrant officers, selected for their skill in carrying out the "interior" survey. Amongst those appointed, on the formation of the corps, was Dawson. It appears that he had already been selected to instruct, in drawing and surveying, the officers intended for that branch of the Q.M.G.'s department which eventually became the Intelligence Division.

"To General Morse . . was due the very judicious idea of rendering this corps useful in instructing the young Engineer officers in sketching and surveying. . . At his request, General Mudge allowed Mr. Stanley

and Mr. Dawson, two of the most able surveyors and draughtsmen of the corps, to undertake this task."*

The young officers were attached to the Survey and were sent to the field wherever Dawson happened to be working. When Addiscombe was established, in 1810, Mudge entrusted the field instruction of the cadets, in surveying and drawing, to Dawson. So that probably Dawson, more than any other man of his time, formed the ideas of the Army in this branch of military art.

It is said that :—

" Besides his other qualifications, Mr. Dawson had the merit of bringing topographical drawing to a degree of perfection that had given to his plans a beauty and accuracy of expression which some of our eminent artists had previously supposed unattainable."†

Portlock speaks of Dawson's great artistic talents. Some of Dawson's topographical drawings of the Welsh mountains are said to have been the finest ever produced. Two sheets of Dawson's hill drawings on the 2-inch scale (Snowdon and Cader Idris) are preserved at the Ordnance Survey Office, Southampton. Whilst it may be said that they do not, perhaps, deserve the unstinted praise given to them by contemporaries, they are, nevertheless, excellent examples of the art, and admirable guides for the engravers.‡

He died at Woodleigh Rectory, Devon, in 1860, aged eighty-four.

Some letters written by Dawson to Colby show that they were on very friendly terms. On the 6th February, 1812, he writes from Worcester :—

" I see you are within one step of a 1st Captain and hope to live to see you many steps above it, and as much my friend as ever, though the progress of rank may increase our distance."

In another letter he writes that Mudge has permitted him " to take his East India pupils and engage in a reconnoitring and sketching essay for their instruction, with the usual travelling allowance from the Company," into the mountains of North Wales. The party travelled sometimes on horseback, sometimes on foot, and sometimes by chaise. They surveyed with the compass (he writes in one of his letters about testing the variation of the compass), made " panorama views " and perspective sketches. He says that he has been so pressed to project his work that he had not even written to Colonel Mudge. In an undated letter he writes of " the gratification you must have felt in visiting the Quarter Master-General's office. The stone printing interests me much, and I should

* Portlock's *Memoir of Major-General Colby.*

† *Memoir of the Mudge Family,* p. 140.

‡ The portion of Dawson's drawing of the Snowdon district, here reproduced, hardly does justice to his skill, owing to the bad state of the paper. The date should be " about 1820," and not 1815, as printed.

HILL DRAWING OF PART OF THE SNOWDON AREA.

By Robert Dawson, of the Ordnance Survey 1776-1860.

Drawn in the year 1815.

like to try it of all things, for if it can be done with good definition and effect it must be an admirable contrivance."

In April, 1814, he writes from Shiffnal :—

" Perhaps you have seen the letter I sent yesterday with the Reports of the Candidates' Progress to Colonel Mudge. I fear that he will think it too severe. I wrote quick and meant to be just, and I believe was so, but I was certainly a good deal chafed with the friction I encounter in some of the young men—and besides a little bilious, and perhaps not a little splenetic from its effects. However, it is necessary that Colonel Mudge should know that these young men want some check from his hand. . . Mr. Blackiston is a very well bottomed young man, rather heavy, and his faculties not yet pointed. . . Would it be too much to ask, through Colonel Mudge, for a copy of Major Lambton's account of his trigonometrical survey in India. . . I think it might be useful to have it to shew to the E. India Cadets."

On the 8th December, 1815, from Lichfield :—

". . . May I not aim at a large and striking example of topography in my new Welsh work—and may not the Cader Idris plan be a sort of coup d'essai on the effect to be produced ? "

On the 14th of the same month :—

" Perhaps it will be best to have all the plans of the survey done in Indian ink for the future, and as near the effect of engraving as may be. . . Mrs. D. and myself were wishing last night that we could have the quiet leisurely comfort of your company once more, before a deluge of pupils comes upon us."

On the 8th January, 1816 :

" I have given a good deal of time to Cader Idris, which now is getting into something like its finished effect. . . It must necessarily be a long time before there are many competent judges of these particulars. . . The Geological Society has a direct tendency to increase intelligence and interests in the thing, and by its means it probably will be brought to a high pitch of improvement."

In 1824 he describes some of the officers whom he is instructing :—

" Mr. Durnford has hardly been long enough with me yet for his character to come out. I think he has good capabilities and does everything in a solid and accurate manner."

In the same year he complains that the Master-General will not give him a permanent position. Later on this was rectified. He found it hard work to get out of the Honourable Board the money due for surveying and correcting sheets ; the Board appears to have been always behindhand in payments :

" Allow me to beg you to not let the money be delayed for my surveying. I want it much, and shall be extremely obliged for your interference to hasten its payment." " I am very sorry to learn you have met with delay and objection in regard to the Contingent Bill," etc.

He kept up a correspondence with his Indian pupils :—

" W. N. Forbes . . poor fellow, had been extremely ill from the climate, but had struggled on, and got nearly thro' a very extensive survey of

part of the Delta of the Ganges. Of Macleod we have twice heard lately and of his excursions on the Ghauts and with Sir John Hislop's Army. Oliphant has written me an account of his journey with the Madras Army," and so on.

Certainly Robert Dawson was an important member of the limited staff of the old Survey, and his letters give a very pleasant idea of his character.

Robert K. Dawson—his eldest son—was educated at the R.M.A., Woolwich, under Mudge. He was commissioned in the Royal Engineers in 1818, and was employed under Colby on the Ordnance Survey. He retired as a Lt.-Colonel and became head of the Survey Department of the Commons Enclosure and Copyhold Commission. He died in 1861, less than a year after his father. A few of his letters to Colby remain, mostly on technical subjects. In March, 1822 :—

" The churchwardens at Frant are a little annoyed at having your Gothic Pole on their modern edifice and wish it removed from their new church as soon as possible."

In the same month :—

" The sketching of Budgeon's work (in the neighbourhood of Sleaford particularly) is decidedly bad."

From Mull, 13th September, 1822 :—

" The observatory was taken down on Tuesday last and embarked at the small isles, where we were detained till Friday morning by a tremendous gale of wind, which if we had awaited it on the hill would certainly have sent us down without horses. We arrived here last night, and as the weather now appears to promise well we are compelled to make this a working day. . . Captain Melville [R.N.] is as usual rendering us great service."

On the 30th of the same month :—

" . . . Allow me, my dear sir, to offer you now my sincere thanks for your kind attention and consideration to my father—and particularly for your regulation, which secures to him the advantage of an assistant, for his health is now declining so fast." N.B.—The old gentleman lived for 38 years more.

In another letter he says :—

" Most happy shall I be to leave this gloomy hill [Jura]. As yet we have only on one occasion ventured more than a mile from this camp, and then the hill was covered from morning till night."

After the commencement of the Survey of Ireland, he writes from the Tower on 10th October, 1825 :—

" By the Liverpool Canal on Saturday we forwarded to Major Reid at Dublin six cases of instruments. . . The characteristics [*i.e.*, conventional signs] shall be sent in a Frank to-morrow."

A SHORT ACCOUNT OF THE TRAVERSING OF A BUILDING AT DELHI.

By COLONEL J. ROBERTSON, District Engineer, East Indian Railway.

Under conditions existing prior to the carrying out of this work at the Delhi Main Station the road leading from Queen's Road to the Inward Parcel Office passed through the compound of the 3rd Class Waiting Hall at the east end of the Station, and was most inconvenient, enabling all and sundry to obtain access to the platforms. It was, therefore, decided to remove the existing latrine westward, so as to permit the approach road to the Inward Parcel Office to pass behind and between it and the Outward Parcel Office, thus enabling the compound of the 3rd Class Waiting Hall to be one circumscribed and bounded area.

On considering the best method of carrying out the work it appeared feasible to remove the 20-seated water borne latrine bodily from its original foundations to a new site, so as to give room for the approach road, without dismantling the building and erecting another, which it was hoped would prove a cheaper method, besides being an interesting engineering work and one which had not been previously attempted with a masonry building of this size in India.

The building, erected in 1918 (Plate No. 1), is 38-ft. long, 14-ft. wide and 17-ft. high above plinth, and is of first-class brickwork in lime mortar. The foundations were 3-ft. 6-in. deep.

The longitudinal walls comprise five Gothic arches of 6-ft. span on piers, the intervening spaces being filled in with 10-in. brickwork; the end walls have each three Gothic arches, two of 2-ft. 6-in. span and a central one of 3-ft. span, which latter are open and give access to the latrine.

Within there is a 10-in. cross wall, dividing the latrine for males and females from floor to roof and on each side of the central passage way partition walls 6-ft. high, dividing the building into compartments; these partition walls are of 5-in. brickwork plastered with cement and supported on light supplementary foundations, carried to a depth of 2-ft. 6-in. below floor level, and the walls are reinforced by a frame-work of old rails. Each compartment is fitted with a door of corrugated iron in an angle iron frame.

Longitudinally, on both sides of the building, run semi-circular E.W. channels, connecting in a master trap at the end of the building.

Outside, the building has pillars, corbelling and cornice work, but the inside is absolutely plain with no projections; the floor of Indian patent stone on ash filling.

The total weight of the building is calculated approximately at 150 tons.

In order to shift the building it was necessary to divide it from the old foundations, which was done by inserting a frame of channel iron box girders below the plinth level (Plate II, Figs. 1, 2, 3 and 4).

For traversing, six compound rail joists (Plate III, Figs. 5 and 6) and the following additional material whose functions will be explained hereafter :—

1 Pair $1\frac{1}{8}$-in. diameter tie rods 39-ft. long with turn buckles (Plate No. III, Fig. 7).
2 D.H. Scrap rails 15-ft. long.
6 Tie rods, 14-ft. 6-in. long, $1\frac{1}{8}$-in. diameter with 6-in. x 6-in. x $\frac{1}{2}$-in. washers at each end. (Plate III, Fig. 8.)
6 Sal Sleepers 12-in. x 6-in. x 11-ft.
5 Sal Sleepers 12-in. x 6-in. x 15-ft.
80 Firewood Deodar sleepers.
2 Pine baulks 14-in. x 14-in. x 25-ft.
6 Screw jacks of 10 tons lifting capacity.

PRELIMINARY ARRANGEMENTS.

The above materials, illustrated in Plates II and III, were prepared and the building carefully examined.

Two small cracks were detected in the roof, one of them laterally across the whole roof; across these were pasted paper tell-tales to enable the cracks to be watched, otherwise the building was sound.

New foundations were now built, identical with the old (Plate V); work was then started.

The top of the building was tied by means of tie-rods with turn-buckles longitudinally and rails at each end (Plate III, Fig. 7), the ties being tightened by means of the turn-buckles: above the position of the channel framing and 1-ft. above ground level, five transverse tie-rods were introduced with five Sal struts 12-in. x 6-in., to absorb tensile and compressive stresses (Plate III, Fig. 8). Special holes were drilled in the 10-in. walls for the tie rods, but the struts were driven tight with wedges to insure an even pressure and bearing.

Sleeper pieces 2-ft. long were introduced between the outside of the walls and the iron washers on the tie-rods.

The under pinning was now started.

One channel, 40-ft. long, was taken from the frame and fixed as follows :—

concrete to set. When the building was actually bedded on the foundations there was no settlement at all.

The cause of the cracking is one which calls for remarks, and it would be interesting to have the ideas of other people on it.

The writer is of opinion that the crack was due to uneven and irregular pressure being transmitted to the building by the jacks, although every possible precaution was taken to work the jacks absolutely synchronously, the human element entered, and it was found that some jacks had completed their stroke while the strokes of others were still in progress. Another contributory cause in the opinion of the writer is the packing at the back of the jacks when they were moved forward. The packing used consisted of firewood sleepers; these were worn and had by no means an even bearing surface, the packing was wedged with wooden wedges at intervals, but the writer is inclined to believe that bending occurred in these sleepers, and as they were not continuous, this was a contributory to uneven pressure against the building.

A curious fact is that in the two cracks in the roof, which were found before the building was moved, no movement whatsoever took place.

It should be mentioned that the arch openings above the 10-in. walls were not bricked up, vertical struts only, tightly wedged, were introduced from the apex of the soffit to the top of the 10-in. wall; it is doubtful, however, whether the bricking up of these arches would have prevented the cracking, as immediately the crack was observed these arches were bricked in, but it did not prevent the crack extending.

A point which leads the writer to believe that the cracking was due to uneven pressure is that the west wall, *i.e.*, that furthest from the jacks, was undamaged in any way; the pressure was equally distributed to this wall by the cross bracing channels of the frame and the diagonal timber struts.

TOTAL EXPENSES INCURRED IN SHIFTING THE LATRINE BODILY, INCLUDING ALL CHARGES WHATSOEVER UP TO 15TH MAY, 1924.

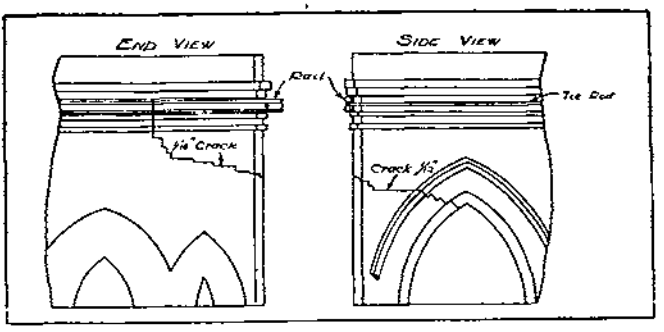
	Rs.	A.	P.
Labour (as per detail below)	1,274	0	0
Material (Do.)	1,256	0	0
TOTAL	2,530	0	0
Total amount sanctioned in Resolution 1066 of 1923-24	5,000	0	0
Net saving..	2,470	0	0

Building was shifted on April 12th and 13th.

Latrine was restored to use, absolutely completed in its new position May 11th.

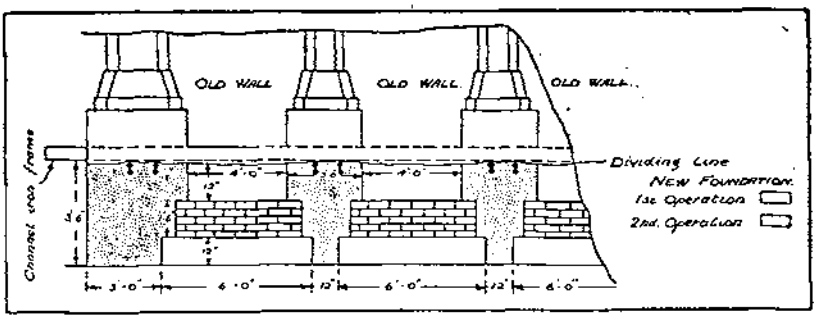
NOTE.

The building was moved successfully for 11-ft. 4½-in. without any sign of cracking or other injury, but after this at 11-ft. 9-in. a slight crack was noticed about 5-in. from the apex of the S.E. Gothic arch and tell-tales were fixed; on further movement this crack extended, and when it had moved a total distance of 12-ft. 4-in.,



by which time the eastern wall was centrally over the old foundation of the west wall, the crack had opened to ⅛-in. and showed signs of further extension. It was, therefore, decided to stop further operations, as sufficient room had been made for a 16-ft. road between the building and the Outward Parcel Office, and to excavate and build new foundations under the west wall and bed the east wall on the old foundations. It was not worth while risking serious damage to the building, which might necessitate the rebuilding of a considerable portion of the latrine.

The foundations were constructed sectionally between the rail girders, stepping them, so that when the portions under these were taken in hand they would bond and key.



These foundations were made of cement concrete throughout, rather an unnecessary expense, but the object was to get the work finished quickly, and we did not want to have to wait for lime

the channel frame, each jack being placed centrally opposite each pier, and directly opposite the cross braces provided inside.

The bases of the jacks to start with butted true against the 14-in. x 14-in. pine baulks, which in their turn bore against six rails, 9-ft. long, sunk 6-ft. into the ground (Plate IV, Fig. 10 and Plate V), which were themselves strutted against the foundations of the Outward Parcel Office. The jacks were fixed slightly above the centre of the channel iron frame. Sal wood pieces, 3-ft. long, bearing flush against the face of the channel and the vertical face of the brickwork piers to produce a cushion and extend the area of pressure.

Every endeavour was made to work the jacks exactly the same amount in each stroke and all together. The handles of the jacks at the beginning of each stroke were placed at the same angle, and were worked to the word of command. The rails were kept well greased throughout the operation.

After four strokes of the jacks the building began to slide.

The extension of the jacks was 15-in., so that when the building had moved forward by this amount the jacks had to be screwed down again and packings introduced behind the bases, when the operation was repeated. The packings used in this work were firewood sleepers.

BEDDING BUILDING ON THE NEW FOUNDATIONS.

The 10 gaps, each 6-ft. long, between the double rail joists, were packed up with cement concrete (special frames having been made out of old Deodar planks) rammed home with wooden rammers from both sides so that it flowed right through under the channels and filled up all crevices between the bottom flanges of the two channels forming the box girders.

The concrete having been allowed to set, the packings under the rail joists were removed and the rail joists pulled out, one by one, the holes of the first joist having been filled in before the second was touched.

The under pinning frame was then dismantled, and was the reversed procedure of putting it in. One channel was taken out at a time, and all masonry made good with cement brickwork. Cement slurry being forced in under the old walls before refilling the channel gaps.

The whole of the iron work used in the operation was recovered. Levels were carefully taken and no settlement whatever occurred after the building was seated on its new foundations.

The replacing of the fittings inside the latrine was taken in hand, the original E.W. channel was re-used with the exception of 6-ft., which was broken in the course of dismantling.

The latrine was put out of use on March 30th.

A horizontal recess 3-in. x 6½-in. was carefully cut in the outside of one of the longitudinal walls and the channel iron introduced; the positions of the 10 holes for the binding bolts marked off, the channel was then removed and these holes carefully drilled right through the wall, the diameter being slightly larger than that of the bolts. Great care was taken to prevent shaking and cracking of the brickwork.

The channel was then filled with brickwork in cement, leaving the holes clear, and then placed in the recess, wedged and built in with cement brickwork.

This procedure was repeated inside, and the two channels were bolted together, forming a box girder, the faces of the girder being flush with the faces of the 10-in. brickwork.

This process was repeated in the other longitudinal wall and the two end walls and the whole frame bolted up and made secure. The whole was now imbedded in the building. The cross bracing channels were now fitted and bolted to the frame, and the five diagonal timber struts (Plate II, Fig. 1) were fitted and tightly wedged.

Fixing the Rail Joists.

Under each of the six pillars, holes 14-in. wide and 6-in. high, immediately below the channel frame, were cut, and the rail girders passed through (Plate IV, Fig 9), 16-ft. projecting beyond the west wall, and the west ends resting on the new foundations previously built; the ground had previously been floored with sleepers to give a solid foundation for the rails throughout both outside and inside the building, and when placed in position the rail girders were levelled and tightly wedged up. Timber sleepers had also been sunk into the brickwork of the new foundations (Plate V).

The level of the rail girders was very carefully maintained throughout.

The weight of the building was now carried on the rail girders under the channel frame and the foundations of that part of the brickwork which had not been cut away to allow for the fixing of the channel frame were now cut away with chisels; the whole weight was thus transferred to the six rail girders under the pillars.

Note.—At the time of cutting the 6 holes for the rail girders temporary brick piers were built under the projecting ends of the 40 ft. channels, these were now dismantled so that the whole of the building was separated from the foundations.

The co-efficient of friction was taken for steel on steel as 0.2, which, taking the weight as 150 tons, gave the friction to be overcome as 30 tons; this was probably high, as the rails were greased.

Six screw jacks of 10 tons lifting capacity were used, and were placed horizontally, so as to give a true horizontal pressure against

Detail of Labour.

	Rs.	A.	P.
(1) Workshop charges for month ending 15th March, 1924	125	0	0
(2) Inspector of Works, Special Works, labour pay sheet charges for month ending 15th April, 1924	279	0	0
(3) Workshop charges for month ending 15th May, 1924	70	0	0
(4) Inspector of Works, Special Works, labour pay sheet charges for month ending 15th May, 1924	400	0	0
(5) Contractor's Bill	400	0	0
	1,274	0	0

DETAIL OF MATERIAL.

Debit	Rs.	A.	P.	Credit.	Rs.	A.	P.
(1) Old sleepers 197 @ Re. 1	197	0	0	Old sleepers 132 @ Re 1 each	132	0	0
(2) Channel Iron 6" x 3" 256-ft. @ Rs. 12 per Cwt.	397	7	0	Channel Iron 6" x 3" 256-ft. @ Rs. 6 per Cwt.	198	11	6
(3) Angle Iron 3" x 3" x ⅜" 8-ft. @ Rs. 14 per Cwt.	7	3	0				
(4) W.I. Rivets 2" x ⅝" 6 lbs. ... @ Rs. 35 per Cwt.							
(5) W.I. Bolts 1½" x ⅝" 13 lbs.							
(6) W.I. Nuts ⅝" 17 lbs. ...	11	4	0				
(7) Iron round ⅞" 123-ft. @ Rs. 16 per Cwt.... ...	35	14	6	Bolts 1'—4" x ⅞" 30 Nos....	15	0	0
(8) W.I. Bolts 11" x 1" 1 Cwt. 2 qr. and 20 lbs. @ Rs. 28 per Cwt.	47	0	0	W.I. Bolts 11" x 1" 1 Cwt. 2 qr. and 20 lbs. @ Rs. 28 per Cwt.	47	0	0
(9) Iron round 1¼" 110-ft. @ Rs. 16 per Cwt. ...	65	9	0	Iron round 1¼" 100-ft. @ Rs. 16	59	9	6
(10) Rails D.H. 183-ft. ... @ Rs. 0.62 per Lft.				Rail D.H. 183-ft. ... @ Rs. 0.62 per Lft.			
(11) Rails Bull headed 348-ft.	329	3	6	Rail Bull head 348-Lft. ...	329	3	6
(12) Iron sheet ⅜" 6 Sft. @ Rs. 16 per Cwt. ...	13	1	9				
(13) Iron round 1⅛" 13-ft. @ Rs. 16 per Cwt.... ...	6	4	6	Iron round 1⅛" 13-ft. ...	6	4	6
(14) Nuts 1⅛" 2½ lb. @ Rs. 28 per Cwt.	0	10	0				
(15) W.I. bolts 8" x ¾" 17 lb. @ Rs. 28 per Cwt. ...	4	4	0				
(16) Nails 6" 2½ lb. @ Rs. 35 per Cwt.	0	12	6				
(17) Paint chocolate 4 galls. @ Re. 1 per gall. ...	4	0	0				
(18) Spun yard 6 lbs. ...	2	8	0				
(19) G. I. Bolts 1" 3 gross and 4 dozens @ Re. 1 per gross	3	5	3				
Carried over ...	1,125	7	0	Carried over ...	787	13	0

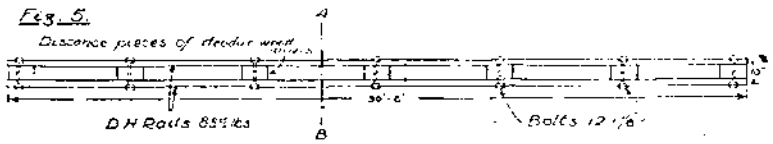
DETAIL OF MATERIAL—(*cont.*)

DEBIT.	Rs.	A.	P.	CREDIT.	Rs.	A.	P.
Brought forward ...	1,125	7	0	Brought forward ...	787	13	0
(20) Nuts ⅜" ¾ lb. @ Rs. 28 per Cwt.	0	3	0				
(21) Iron round ¾" 10-ft. @ Rs. 16 per Cwt. ...	0	8	6				
(22) Steelhex ¾" 1-0 ft. ... (23) Steel round 1¼" 21-ft. ... } As. 8 per ft.	15	8	0				
(24) Rail metre gauge 6-ft. @ As. 6 per ft.	2	4	0				
(25) Angle Iron 4" x 4" x ⅜" 5-ft. @ Rs. 14 per Cwt.	6	1	9				
(26) Bolts 1½" x ⅝" 16 lbs. @ Rs. 28	4	0	0	Bolt 1½" x ⅝" 16 lb. @ Rs. 28...	4	0	0
(27) Cement 173 Mds. @ Rs. 3 per Md.	519	0	0				
(28) Leather 2½ lbs. @ Re. 1 per lb.	2	8	0				
(29) Socket G.I. ¾" 10 Nos. ... (30) Elbow G.I. ¾" 1 No. ... (31) Tee G.I. ¾" 1 No. ... (32) Bend G.I. ¾" 1 No. ... ... } As. 8 each	6	8	0				
(33) Nuts ⅜" 4 lb. @ Rs. 28 C.	1	0	0				
(34) E.W. pipes 4" dia. 2 No. @ Re. 1 each	2	0	0				
(35) Stone chips 250 Cft. @ Rs. 34% Cft.	85	0	0				
(36) Sutna lime 149 Cft. @ Rs. 35% Cft.	52	2	6				
(37) Ashes 275 Cft. @ Rs. 6¼% Cft.	17	3	0				
(38) 1st Class bricks 9,300 @ Rs. 18 per %.	167	6	6				
(39) Brick ballast 456-Cft. @ Rs. 9% Cft.	41	0	9				
	2,047	13	0		791	13	0
				Net amount debitable 1,256 0 0			

TRAVERSING A BUILDING AT DELHI.

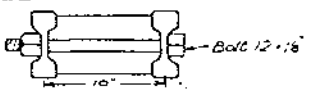
Plate 3.

Fig 5.



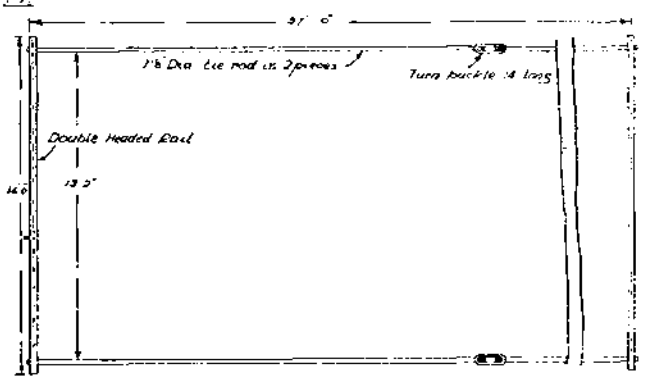
PLAN

Fig 6.



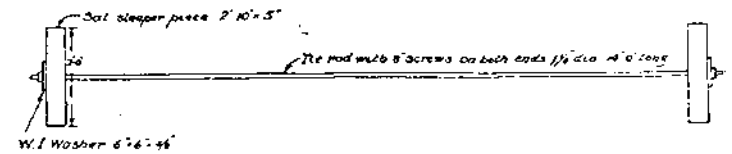
SECTION ON A.B.

Fig 7.

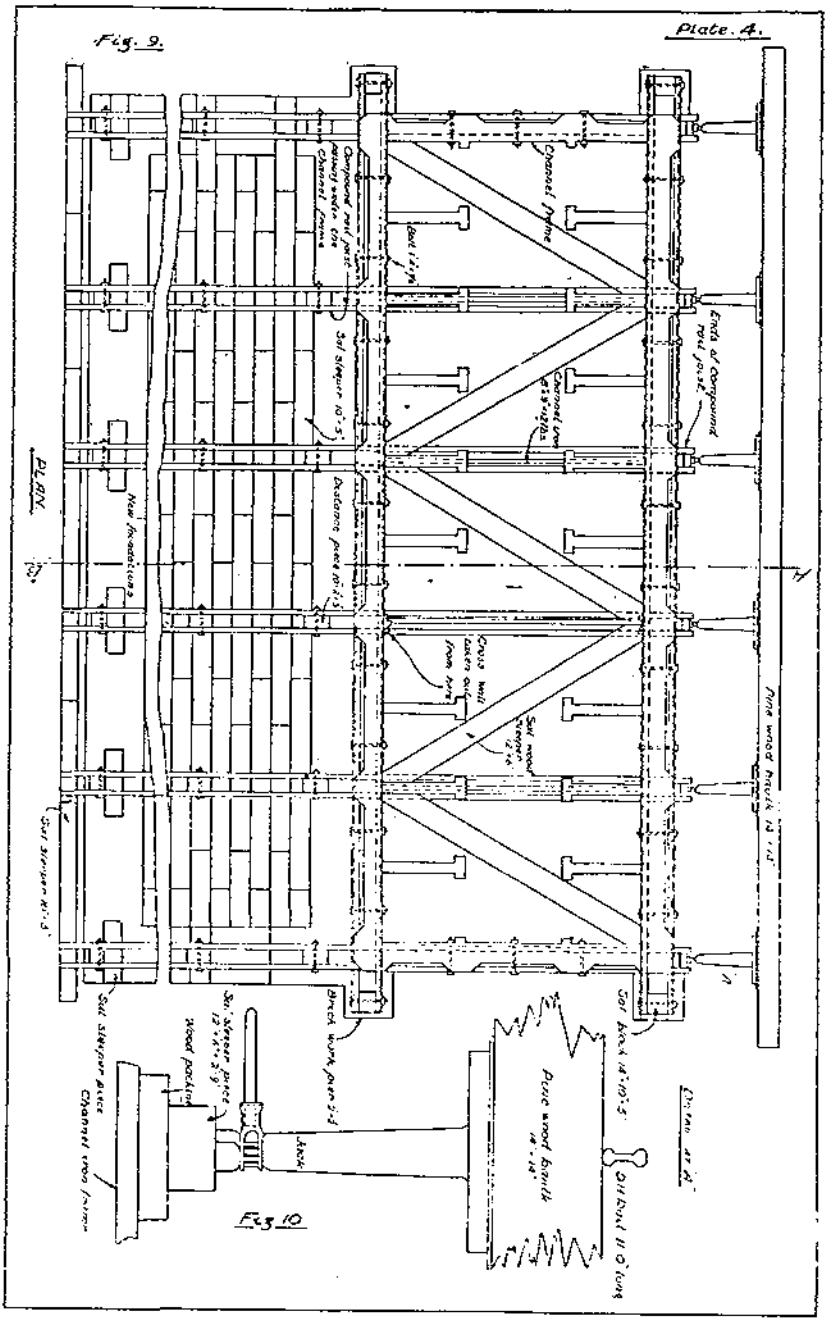


PLAN

Fig 8.

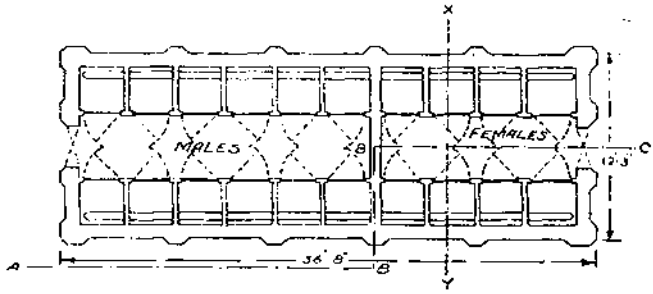


TRAVERSING A BUILDING AT DELHI.



TRAVERSING A BUILDING AT DELHI.

Plate I



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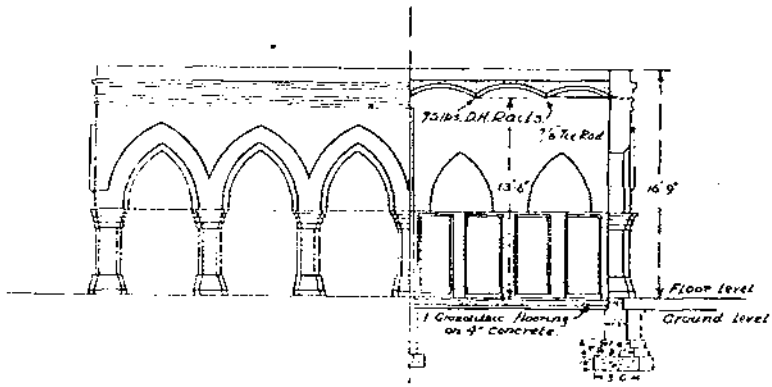
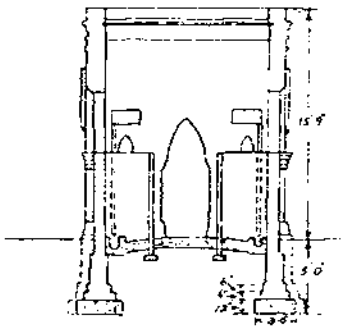
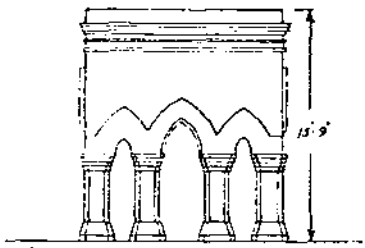


SECTION ON ABC



SECTION ON XY.

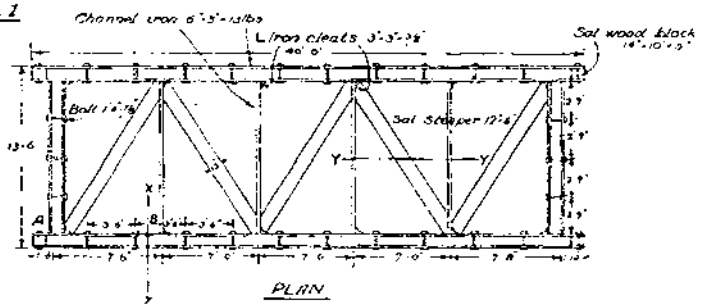


END VIEW.

TRAVERSING A BUILDING AT DELHI.

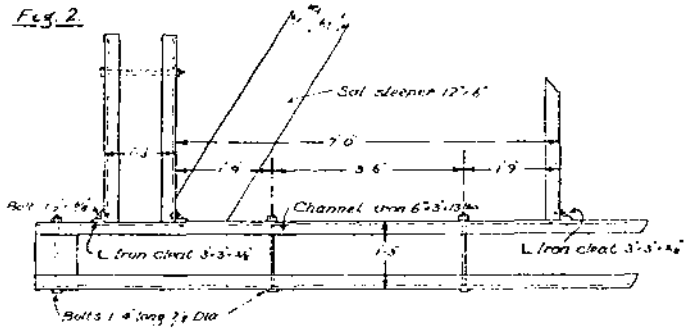
Plate. 2.

Fig. 1



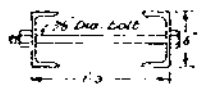
PLAN

Fig. 2.



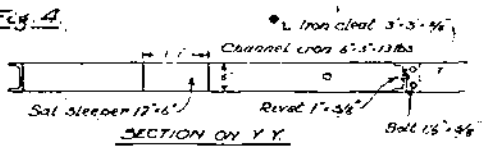
DETAILS AT A.B

Fig. 3.



SECTION ON X.X.

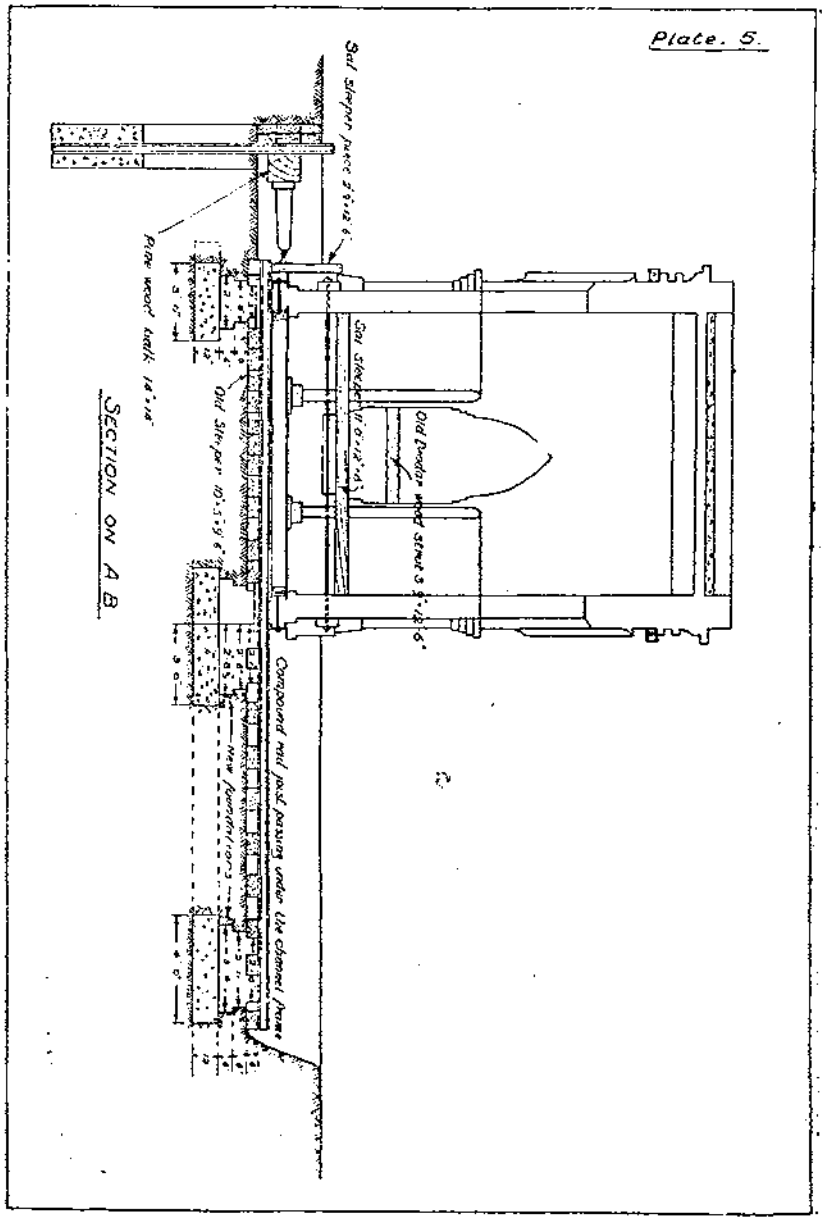
Fig. 4.



SECTION ON Y Y.

TRAVERSING A BUILDING AT DELHI.

Plate. 5.



THE PRINCIPLES OF DEFENSIVE WARFARE.

By COLONEL J. F. C. FULLER, D.S.O.

INTRODUCTION.

BEFORE the outbreak of the last Great War, all armies were organised for mobile warfare, and many soldiers considered that the war would be rapid and short. To-day, for similar reasons, all armies are organising for a war of movement, and the greatest surprise of the last war, namely, its static nature, is not only being forgotten, but to mention its reoccurrence is to risk being classed as a heretic. In 1914, as M. Bloch had foreseen twenty years earlier, it was fire power and human nature which were the parents of the trench. Since 1914, human nature has not changed, but whilst, then, an infantry division possessed 24 automatic weapons, to-day it possesses over 500. In 1914, the maximum (aimed) fire-power of a division, in S.A.A., was about 55,000 rounds a minute, to-day it is 155,000. Thus far the conclusion is that, if a great war broke out to-morrow, unless armies possess large numbers of tanks, it would be a war of trenches, for, if they do not, it will take at least a year to produce them in any quantity.

1. THE FOUNDATIONS OF THE DEFENSIVE.

The following theory is based on the experiences of history, therefore to discard it is an act both dangerous and foolish :—

(i) The offensive should be assumed on all occasions when circumstances permit of it.

(ii) Offensive action should spring from a strong defensive base.

(iii) The defensive should be so organised as to permit of it changing into an offensive at the shortest possible notice.

(iv) The offensive cannot be too strong, therefore the defensive should not employ a weapon beyond the minimum necessary to establish security.

The following drawn from the past are errors worth remembering :

(i) The offensive languishes on that side which is least prepared to wage war, and which is, through ignorance of the principles of war, blinded by the belief that the enemy must be held back at all points and that, consequently, it is necessary to be everywhere equally strong in men, and superlatively strong in defences.

(ii) The neglect of peace teaching, based on the experience of former wars, generally leads to the creation of

"impregnable positions," in place of such preparations as will aid a rapid assumption of the offensive.

(iii) The all but total depletion of a reserve, that is, a striking force, on account of the stringing out of troops for purely defensive tactics, such as the passive holding of trenches, villages and fortified positions, renders a sustained offensive impossible.

(iv) The general demoralization and disorganisation of all ranks by the incessant creation of new defences, and the repair of old ones, detrimentally affects training and leadership, and, consequently, lowers the offensive spirit of all concerned.

I will now briefly consider the principles of war in their defensive aspect. Bearing in mind that there is no hard and fast dividing line between the offensive and defensive in warfare, we find that the object is the same. Shielding does not consist solely in preserving our own existence, but in preserving it in order that we may the more economically destroy the enemy, consequently, a defensive battle should be based on an offensive plan, which through force of circumstances cannot at once be put into operation.

Superiority of weapons at the decisive point means superiority of offensive power, and the lack of this superiority is frequently the direct cause of defensive action. If men are squandered in the attempt to avoid blows they will never be in a position to give them, and not giving them, they allow their enemy to reduce his defensive strength to a minimum and to increase his striking force in proportion. It was against this type of warfare that Napoleon inveighed when he wrote to his brother, the King of Spain, saying: "The cordon system is only good against smugglers," yet, for over three years, the grand tactics of the Great War on the Western Front were based on this system.

Infringing the principle of concentration, the cordon system simultaneously infringes the principle of economy of force. The defensive becoming the main object, a time arrives when the offensive becomes inoperative, not through lack of weapons, but through the impossibility of massing them. Garrisons must be in proportion to the trenches they occupy, and if trenches are over large, garrisons cannot be relieved without seriously weakening them. Ten men will hold a blockhouse, and a blockhouse may delay a brigade, ten men will not hold a fortress; therefore, in our defensive plans, do not let us build fortresses when blockhouses will suffice. The strength of defences does not rest in their size, but in the harmony between their size and the strength of their garrisons.

Besides the danger of weakening established defences in order to build up a strong reserve, another danger presents itself, namely,

the danger of excessive immobility due to over extension, which leads to an infringement of the principle of mobility.

Consequently, before we plan our defences, we should carefully consider the following maxims :—

(i) When from a state of defence the offensive is assumed, this act should in no way disorganise the existing defensive arrangements.

(ii) Any delay in the assumption of the offensive from the defensive may prove fatal to both operations.

(iii) In offensive action, moral weakens in proportion as improvisation increases.

The first is a violation of the principle of security, the second of mobility, and the third of co-operation.

The principle of surprise finds an all but unlimited application in the defensive. I will take one small instance as an example—the siting of wire entanglements. During the Great War, the tactical effect of wire was immense, but the use made of it during the first two years of the war was beneath contempt. The true use of wire does not lie in fencing off areas of ground as British, French or German, which, during the Great War, was so frequently the case ; but of so increasing the offensive power of weapons that their numbers can be reduced in defensive positions. For instance, in trench warfare great risk was experienced in placing a little wire in front of the front line fire trenches, which, more frequently than not, constitute a target for the enemy's guns. Instead, entanglements should be constructed behind those trenches where acres can be set up in a single night. In front of the fire trenches, ground, for this purpose, is normally limited, in rear of them, unlimited, and, being so obviously the place for wire, is frequently overlooked. This error is mainly due to the spell of the cordon system, which aims at holding ground, as if ground were the object of battle ; it is not, for the object is the destruction of the enemy's strength.

To avoid the excessive use of men for purely defensive work, we have recourse to a very simple arrangement known as outposts. These perform two duties: the first, watching for the enemy ; the second, delaying his advance so that the troops in rear may assume the offensive before the enemy can surprise them.

If in field warfare it has been found that seldom more than one-eighth of a force is required for protective duties, a greater number should be unnecessary in trench warfare, where defences and obstacles abound. True, in trench warfare, the opposing forces may often be as many yards apart as in field warfare they are miles ; but military spaces are not measured with a foot rule, but by the obstacles they contain and the time taken in crossing them.

In order to obviate the inherent disadvantages and vices of the cordon system of defence: firstly, the line of resistance must be chosen from the point of view of the grand offensive; and, secondly, from that of the decisive counter attack. The line of resistance should be a fortified line, and the ground behind it should be prepared:

(i) To aid the offensive forward of the line.

(ii) To assist the defence of the line itself.

In front of this line of resistance should be constructed a line of observation, consisting of a continuous trench line or a line of posts. Between this line of observation and the line of resistance should be constructed a line of strong works, the tactical object of which is:

(i) To protect the observation posts if they are attacked.

(ii) To break up, like groins, an enemy's attack should it sweep through the observation posts, so that a counter-attack, from the line of resistance, may find before it a morcelated and demoralised force.

The ground between the observation line and the line of resistance should be prepared:

(i) To facilitate our own offensive.

(ii) To hinder the enemy's offensive.

Masses of trenches should be avoided, they deplete military endurance and also the national exchequer.

We now come to our last principle, the principle of co-operation. Before the outbreak of the Great War, the doctrine of the offensive, due to lack of logical thinking, grew top heavy—through the defensive being ignored; the result of this, during the war, was a chaos of defensive actions.

One system, even if an unsound one, is safer than a score of brilliant ones simultaneously attempted, because the former means unity of action, whilst the latter spells dispersion of force. We cannot afford to regulate our defences on guerilla lines. Given a doctrine, given a definite system of defence, based on the proved principles of war, this system should be applied to the whole of a defensive line, whether the length of this line be five hundred yards or five hundred miles. This is sound generalship. Whatever the length of the line may be, it should be viewed as a unit, that is, as one zone of possible attack. It should be viewed from an offensive as well as a defensive standpoint, and the frontage of ultimate attack should be selected in accordance with the objective. Its holding and decisive attacking forces being distributed according to the principles of concentration and economy of force. Once viewed as a unit, it should be divided into sections, the extent

of each section being arrived at after a careful tactical study of the ground. Further, each section should, when possible, bear a direct relationship to the larger tactical units—divisions, corps and armies, and all sections should be placed under the command of their own generals and their respective staffs; and, as long as the line is held, these should be its permanent officials. The garrisons may come and go, but the staffs should remain; they form the skeleton of the whole defensive system, the garrisons being the changing tissues.

In trench or siege warfare, until each section is organised under its own fortress commander and ceases to be a mere tactical "doss-house," the offensive will languish, for it cannot be carried out effectively on the maxims of partisan warfare—each unit carrying out separate operations on its own, or hesitating to do so for want of faith in the commanders on its flanks.

To sum up:—

(i) The objective must be decided upon.

(ii) The plan of defence for the whole front must be worked out.

(iii) The entire defences of the whole front must be placed under one commander.

(iv) The front must be divided into sections.

(v) The sections must be divided into sub-sections.

(vi) The sections and sub-sections must have their own commanders.

(vii) The requisite garrisons must be placed under the orders of these officers.

(viii) The remaining troops must be kept in reserve under their own commanders and trained for offensive warfare.

In one word, "organise." The trenches must be looked upon as defended barracks, to and from which units may come and go without altering rules, structure and accommodation; and not as mere camping grounds where each unit selects its own pitch. This will lead to co-operation in its highest sense, for not only will all know what they have to do, but all will know that, as they are part of *one* organisation, those on their flanks will equally know it, and that all will act together according to *one* plan (and not on a hundred and one), irrespective of reliefs, irrespective of changes.

2. The Tactics of Trench Warfare.

General Dragomirov once wrote, with reference to field defences: "Make the firing line at right angles to the direction you want to command, and see that the enemy is unable to enfilade this line. All fortification is contained in these two principles." Though

this is correct, it is necessary somewhat to amplify this statement as follows :—

(i) Trench systems must be planned so as to enable the offensive to be assumed from them.

(ii) Troops must be so distributed as to gain complete liberty of manœuvre behind the front held; for an attack is generally more easily frustrated by attacking the enemy in some other quarter. To meet it directly is, frequently, to play into the enemy's hands.

(iii) Defensive lines must be planned with the idea of counter-attack, especially the rear lines, and the troops must be massed in accordance with this idea. This means that all reserves—men, munitions, guns, etc., are ready for immediate action, are mobile and that the men are in a high state of training.

(iv) Minor attacks must be made in order to create a favourable opportunity for decisive action. A definite policy must unite them, in order to improve the possibility of an eventual offensive.

(v) The defence must never be content with warding off the enemy's blows, for the object, the destruction of the enemy, forbids this.

(vi) Trench warfare must be looked upon as subsidiary to the ultimate destruction of the enemy's field armies. This being so, our trenches must be garrisoned so as to enable sufficient men to be trained in field warfare.

(vii) Trench warfare must be based on the maxim that "the offensive is the soul of the defence;" trenches, in themselves, being merely a temporary protection.

(viii) Defensive positions must be selected in view of economising personnel so that the power of the offensive may be increased. Consequently, before ordering new trenches to be dug, it should be remembered that every extra yard or two may mean one man less wherewith to strike a blow at the enemy.

(ix) Defensive frontages must be considered with reference to the offensive. Trenches having been garrisoned and their reliefs detailed, at least half the total force should remain in hand for decisive action.

(x) Trenches must be dug with the object of reducing the number of men required for the defensive in order to add to the general reserve or striking force.

(xi) The trench garrisons, those troops represented by sentries, picquets, supports and reserves, should seldom, if ever, exceed one quarter of the total troops allotted to any one section.

(xii) As trench warfare adds little to skill, better organisation, training and *moral*, every attempt should be made to reduce the number of men employed in it, so that more can be trained for offensive action.

To return once again to General Dragomirov's maxim, for centuries past, in fact, from the earliest days of warfare, both his requirements have been met by disposing the defenders in such a manner that they could take in flank an enemy's attack directed against their front or flanks.

There are two means of doing this :

(i) By the use of weapons.
(ii) By the use of barrier and deflecting obstacles.

To use weapons with the greatest effect, it is necessary to be shielded ; therefore, in former times, walls or ramparts were built, and in order to enfilade an attack these walls were provided with bastions. In other words, a series of towers, or strong points, were linked up by curtain walls, and between these bastions were constructed sally ports, from which the offensive could be assumed. The entire work was surrounded by a moat or ditch, which not only constituted an obstacle, but a trap, which once entered would be difficult to escape from, on account of enfilade fire sweeping down it from flanking works.

Throughout the history of war, whenever an improvement in artillery has rendered the cannon superior to the musket or rifle, fortresses and field defences have abounded ; and, if we want to study the principles of these defences in detail, we cannot do better than go back to the days of Vauban and substitute, in place of bastions, strong points ; in place of curtains, narrow trenches ; in place of moats swept by grape shot, wire and trenches swept by machine guns.

Analysed, all these systems may be reduced to three tactical requirements :—

(i) The maintenance of an unbroken front.
(ii) The enfilading of a hostile attack.
(iii) The rapid assumption of the offensive.

I will consider these in turn.

The Maintenance of an Unbroken Front is generally dependent on the denial of flanks to an enemy's attack. This may be accomplished by :—

(i) A continuous system of trenches.
(ii) Detached works linked together by vast quantities of wire entanglement.

If the enemy is to be attacked, the advantage of the first system needs no explanation, as a continuous system of trenches is a

necessity as a jumping off line. If the enemy is simply to be withheld, the advantage of the second system is that it requires very few men for defensive work, consequently it permits of the majority being relegated to the offensive reserve. Its disadvantage is that vast fields of entanglement and the absence of lateral communications seriously impede our own advance and assault.

Considering these points, there can be little doubt that for those sections of the front which have been selected for offensive operations, the system of the continuous line is best; and, as men are never unlimited in number, it will, consequently, be necessary to adopt the system of detached works for those sections of the line which are purely defensive. Unless this rule be strictly observed, the principles of concentration and economy of force will be violated.

If this contention be correct, it also follows that, whenever the conditions render the offensive either impossible or ruinously costly, it is only right to adopt the second system in place of the first, for, by so doing, endurance will be economised. The most important condition which regulates this adoption in Western Europe is weather; consequently, during the winter months, the system of detached posts should, when possible, be adopted.

What did the Great War teach us of entrenchments from the constructive point of view? This: that, though it is possible to dig hundreds of miles of trenches in the summer, it is next to impossible to maintain hundreds of yards in the winter, unless these trenches be most solidly revetted and boarded and most carefully drained. When trench systems run into thousands of miles, seldom are material and labour sufficient to complete all the trenches dug during the summer or to maintain them during the winter. The result being that, though in places the system of the continuous line is most suitable during the summer time, it is not only most unsuitable during the winter, but a positive danger, for the more it is patched up the more it falls in. When once a trench is half full of water, unless this water can be removed by drainage, and it often cannot be, nothing destroys it more than trying to clear it out and revet it; every soldier knows this.

It would appear, therefore, that when once the offensive is brought to a standstill through the opposing forces going to earth, the defining of the zones of attack and defence should be a commander's first consideration; and that, until these have been defined, no elaborate system of trenches should be dug, so that every board, every hurdle, every gabion may be economised in the purely defensive zones in order that the trenches in the offensive ones may be able to withstand the rigour of the winter and be in a fit condition to aid an early spring advance. Further, the less work required during the winter, the more men will the units, destined for the offensive, be able to train. To trust on weapons

as the best means of defending the offensive zones, and on obstacles for defending the defensive zones, because our own weapons are the best means of aiding our advance, whilst our obstacles often impede our movements as much as they impede the enemy's. During the winter time it is generally feasible, temporarily, to convert such portions of the offensive zone, as are rendered unattackable on account of weather, into defensive ones; and though this will mean that many of the trenches necessary to an offensive will fall in, these can be more thoroughly repaired during the first fortnight of fine weather than during months of rainy.

In truth, the entire problem of defence is one of the most rudimentary common-sense; it may be summed up as follows :—

(i) Trenches from which an offensive may be assumed must be defended by missiles, consequently a continuous line is necessary.

(ii) Trenches which are purely defensive must be defended by obstacles flanked by fire, consequently detached posts (well hidden machine gun blockhouses) are necessary.

(iii) During the summer an army should be prepared to assume or repulse an offensive.

(iv) During the winter an army should be prepared to assume a strong defensive, that is, one which will require as few weapons as possible so that a maximum number of men may be trained for offensive action the following summer.

The Enfilading of a Hostile Attack.—The power of enfilade fire cannot be exaggerated in trench warfare; in the offensive it constitutes the chief means of accelerating an attack, in the defensive of frustrating it. This is not usually observed on account of the obsession that parallel entrenchments are the surest means of defence. As the flank of an attack is the most vulnerable point, our tactics should aim at forcing an enemy, should he attack us, to offer us a flank in such positions as will cause him the greatest inconvenience and loss. If nature does not furnish us with these positions, then, by the aid of obstacles, must we create them; we must so place our entanglements that they will not only come as a surprise to the enemy, but will force him to halt in such positions as will render his flank, or flanks, an easy target to our fire.

Take, for instance, the wire entanglement in front of a fire trench. If, instead of constructing it parallel to the trench it protects, it is constructed in a zig-zagged manner, it will not only form a more difficult target to the enemy's artillery fire, but it will enable an enfilade and cross fire to be directed along its salients. Again, if behind this entanglement we dig an observation trench, this again should consist of a series of salients, or untraversed zig-zags, in principle much like the old pentagonal fortresses of two hundred

years ago. Such a trench will not only flank the wire, but will, in itself, constitute an obstacle, for internally it can be flanked by rifle or machine gun fire. Every trench dug should help the offensive. If lost, its existence should at once add to the strength of the defensive; this is the whole art of entrenchments.

If between the line of observation and that of resistance, an intermediate line of works is constructed, these works should be so sited as to cause the enemy, should he attack them, to form perpendicularly or obliquely to the line of resistance and so offer either one or both flanks open to counter-attack.

Siting of wire and siting of fire trenches is simply a matter of common-sense, based on the simplest of simple maxims, namely: "All obstacles and trenches should be so sited as to cause the enemy to offer a flank to our fire without compromising the advance of our counter attack."

The Rapid Assumption of the Offensive.—The possibility of rapidly assuming the offensive depends on distribution, ground and observation. If the front line be made the line of resistance, the offensive may be rapidly assumed from this line if our observation be good and the enemy's bad; but, if reverse conditions prevail, it is probable that the garrison will be pounded to death before an offensive can be launched. If a rear line, not observable by the enemy be chosen, then the ground between it and the front line must be sufficiently clear of obstacles to permit of a rapid advance. The chief reason why a rear position should be chosen for resistance is that whilst the adoption of the front line for the offensive is immediately restricted by the proximity of the enemy's trenches, a rear line is not so affected, and the further back this rear line is dug the more room have we wherein to manœuvre our entanglements.

This manœuvring of entanglements, with a view to the disorganising of an enemy's attack and the facilitating of our own counter-attack and offensive, is a point which has not met with sufficient recognition in the past.

3. Siting and Garrisoning Trenches.

As a trench is virtually a shield, it should be dug where it will provide the greatest protection against whatever weapon can do its occupants the greatest harm, and also assist in the development of the power of such weapons as will prove most effective against the enemy. In a war of trenches, excluding mechanically propelled weapons, such as tanks, it is the gun and howitzer which to-day rule the field, consequently our best plan is:—

(i) Offensively, to select for our artillery the very best observation stations possible, positions from which those of the enemy can be commanded.

(ii) Defensively, to site our infantry trenches in such places in which they cannot be directly observed from the enemy's artillery observation posts.

If we do this we shall be carrying out the principles of the offensive and security, namely :—

(i) The destruction of the enemy, or the maintenance of a position from which the maximum artillery effect can be obtained.

(ii) The protection of ourselves, or the maintenance of a position against which the minimum artillery effect will be felt.

Subsidiary to these are the following :—

(i) The selection of a position which will enable our guns eventually to advance rapidly and safely.

(ii) The selection of a position which will not permit of the enemy's guns doing likewise.

Combined, we obtain the following theory :—

That a position to be considered sound must be one which cannot be enfiladed, but which will facilitate our artillery enfilading the enemy, whether stationary or advancing; further, that it will facilitate our advance by securing our batteries from enfilade fire as they move forward.

A position should first of all be looked at from our possible observation posts, next from those possible to the enemy, and only then should trenches be sited. This system is always practicable in the case of our rear lines of defence. The front line, the siting of which is so often governed by the enemy's position and opposition,* should, as far as possible, be treated in the same way. A position should always be considered from the point of view of enfilade fire, particularly that of artillery and machine guns. Purely parallel systems of defence should seldom be allowed. When such are inevitable, they should be connected up by a system of fire—communication—trenches which will divide the spaces between them into a series of fortified triangles and quadrilaterals. A system of trenches should always be sited so that at least a part of it commands a direct view of the enemy's position, whilst the remainder affords direct protection against his fire.

Having sited our trenches the next question is how to garrison them.

The correct manner of garrisoning a line of trenches depends entirely on the purpose for which the trenches are built, whether for an offensive or defensive operation. If offensive, the strength of the garrison may roughly be arrived at by weighing the con-

(*) In the Great War, most front lines had little relationship to security, as they were generally entrenched field battle fronts.

ditions of numbers, ground and armament, that is, by calculating how far these favour the enemy or ourselves. If defensive, then the number of detached posts requisite to enfilade the wire fields. Thus, by an application of principles to conditions, may economy be effected and guessing reduced to a minimum.

The front line should be looked upon as an outpost line :—

(i) When a strong line of resistance runs behind it.
(ii) When the front to be held is purely a defensive one.

The front should be looked upon as a battle front when it constitutes the line of resistance itself. Resistance, here, being interpreted in a twofold sense :—

(i) Resistance due to the formation of the ground.
(ii) Resistance due to the intention of holding the front line offensively.

In trench warfare, as in field, the whole question of holding the line dwindles down to the simple formations of outposts and battle outposts. In field warfare the former are used when the opposing forces are so placed that they are unable to attack one another without giving some warning of their approach ; the latter, when a surprise attack is possible, that is, when the enemy, in force, is close to us and few obstacles lie between us and him, and, further, when the ground which we occupy is of great tactical value.

By combining these two systems we get a third, which admits of both being adopted according to circumstances. This system demands the most careful co-ordination, for being based on a dual conception of defence, it is liable to lead to doubt and disorder. To control it, we must fall back on our principles and consult these : determine our zones of offensive and defensive action, consider conditions and then plan accordingly, making absolutely certain that every commander knows what he has to do, and only allowing those commanders to adopt the outpost system in which a retirement of the garrison will not uncover the flanks of the sections on its right or left, or will create for the enemy's attackers a cul-de-sac completely raked by enfilade fire.

BATTLE HONOURS OF ROYAL ENGINEER UNITS.

The Army Council has recently issued the "Complete List of Battle Honours Awarded," to the regiments of Cavalry and Infantry "for the Great War." The location of every battalion was determined after a great deal of research and the Battle Honours were awarded in accordance with the terms laid down by a "Battles Nomenclature Committee," appointed in August, 1919. This Committee tabulated Actions, with a definite system of nomenclature denoting their relative importance, and defined the geographical and chronological limits of each action. The Report of the Committee is an official publication, and can be obtained through a newsagent for two shillings.

Although the granting of Battle Honours to Royal Engineer Units is unfeasible—since the motto "Ubique" covers the whole field of operations—it is considered that it would be of very great interest to the Corps if complete lists were compiled to show what Battle Honours would have been gained by the various units which participated.

Lieut. James has already given, in the *Journal of the Royal United Service Institution*, most interesting lists of the higher formations which were present at each battle. The lists published below have been prepared by Colonel G. R. Pridham, D.S.O., O.B.E., and show the units of Royal Engineers which were actually engaged in each Battle. It is recognised that there may be possible mistakes and omissions from the lists, especially in the case of smaller units, as these have not so far been traced, and their omission from the lists does not necessarily mean that they are not entitled to the Honours. It is further regretted that the present lists do not extend beyond September, 1916, and that of the many "side shows" only the Gallipoli Campaign is at present included.

It must be clearly understood that the lists are in no sense authoritative.

RETREAT FROM MONS, 23rd AUG.—5th SEPT., 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
1st. Fd. Sqdn.	1st. Cav. Div.	E.	
1st Sig. Sqdn.	,,	,,	
23rd. Fd. Co.	1st. Div.	,,	
26th Fd. Co.	,,	,,	
1st Sig. Co.	,,	,,	
5th Fd. Co.	2nd Div.	,,	
11th Fd. Co.	,,	,,	
2nd Sig. Co.	,,	,,	
56th Fd. Co.	3rd. Div.	,,	
57th Fd. Co.	,,	,,	
3rd. Sig. Co.	,,	,,	
17th Fd. Co.	5th Div.	,,	
59th Fd. Co.	,,	,,	
5th Sig. Co.	,,	,,	
7th Fd. Co.	4th Div.	,,	
9th Fd. Co.	,,	,,	
4th Sig. Co.	,,	,,	
1st A.C. Sig. Co.	1st A.C.	,,	
2nd A.C. Sig. Co.	2nd A.C.	,,	

Verifications.

6th Div. units not arrived.
No Works Co.
No Bridging trains.
No Ry. Units.
No Fortress Co.

*E.—Eligible. *N.E.—Not Eligible. *D.—Doubtful.

BATTLE OF MONS, 23rd-24th AUGUST, 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
1st Fd. Sqdn.	Cav. Div.	E.	
1st Sig. Sqdn.	,,	,,	
23rd Fd. Co.	1st Div.	,,	
26th Fd. Co.	,,	,,	Working with 3rd. Bde.
1st Sig. Co.	,,	,,	Communication to all Brigades.
5th Fd. Co.	2nd Div.	,,	
11th Fd. Co.	,,	,,	
2nd Sig. Co.	,,	,,	
56th Fd. Co.	3rd Div.	,,	
57th Fd. Co.	,,	,,	
3rd Sig. Co.	,,	,,	
17th Fd. Co.	5th Div.	,,	U.W.D. Missing.
59th Fd. Co.	,,	,,	
5th Sig. Co.	,,	,,	

Verified that remaining units shown in B.E.F. Order of battle (Appendix to Official History of the War) were elsewhere.

BATTLE OF LE CATEAU, 26th AUGUST, 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
1st Fd. Sqdn.	1st Cav. Div.	E.	
1st Sig. Sqdn.	1st Cav. Div.	,,	
56th Fd. Co.	3rd Div.	,,	
57th Fd. Co.	,,	,,	
3rd. Sig. Co.	,,	,,	Communication to Bdes.
17th Fd. Co.	5th Div.	,,	U.W.D's missing. verified from U.W.D. of 5th Sig. Co.
59th Fd. Co.	,,	,,	
5th Sig. Co.	,,	,,	
2nd A.C. Sig. Co.	2nd A.C.	,,	

Verified that remaining units shown in B.E.F. Order of battle, (Appendix to Official History) were elsewhere.

*E.—Eligible. *N.E.—Not Eligible. *D.—Doubtful.

THE MARNE, 7th—10th SEPTEMBER, 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
1st Fd. Sqdn.	1st Cav. Div.	E.	
1st Sig. Sqdn.	,,	,,	
23rd Fd. Co.	1st Div.	,,	
26th Fd. Co.	,,	,,	
1st Sig. Co.	,,	,,	
5th Fd. Co.	2nd Div.	,,	
11th Fd. Co.	,,	,,	
2nd Sig. Co.	,,	,,	
56th Fd. Co.	3rd Div.	,,	
57th Fd. Co.	,,	,,	
3rd Sig. Co.	,,	,,	
7th Fd. Co.	4th Div.	,,	
9th Fd. Co.	,,	,,	
4th Sig. Co.	,,	,,	
17th Fd. Co.	5th Div.	,,	
59th Fd. Co.	,,	,,	
5th Sig. Co.	,,	,,	
1st A.C. Sig. Co.	1st A.C.	,,	
2nd A.C. Sig. Co.	2nd A.C.	,,	
3rd A.C. Sig. Co.	3rd A.C.	,,	

Verified that remaining units shown in B.E.F. Order of battle (Appendix to Official History of the War), were elsewhere.

THE AISNE, 12th—15th SEPT., 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
1st Fd. Sqdn.	1st Cav. Div.	E.	
1st Sig. Sqdn.	,,	,,	
23rd Fd. Co.	1st Div.	,,	
26th Fd. Co.	,,	,,	
1st Sig. Co.	,,	,,	
5th Fd. Co.	2nd Div.	,,	
11th Fd. Co.	,,	,,	
2nd Sig. Co.	,,	,,	
56th Fd. Co.	3rd Div.	,,	
57th Fd. Co.	,,	,,	
3rd Sig. Co.	,,	,,	
7th Fd. Co.	4th Div.	,,	
9th Fd. Co.	,,	,,	

*E.—Eligible. *N.E.—Not Eligible. *D.—Doubtful.

THE AISNE—*continued.*

Unit.	Formation.	*D. *N.E. *E.	Remarks.
4th Sig. Co.	4th Div.	,,	
17th Fd. Co.	5th Div.	,,	
59th Fd. Co.	,,	,,	
5th Sig. Co.	,,	,,	
1st Bridging Train	Army Troops	,,	Sent pontoons forward to Fd. Co.
2nd Bridging Train	,,	,,	,, ,, ,,
1st A.C. Sig. Co.	1st A.C.	,,	

42nd Co. L. of C. were in Braine 15.9.14, but took no part in battle technically or otherwise.

Verifications.

No Work Coys.
No Railway Units.
No Fortress Co.
3rd and 2nd A.C. Sig. Co., not in area.

LA BASSEE, 10th OCTOBER—2nd NOVEMBER, 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
56th Fd. Co.	3rd Div.	E.	
57th Fd. Co.	,,	,,	
3rd Sig. Co.	,,	,,	
17th Fd. Co.	5th Div.	,,	
59th Fd. Co.	,,	,,	
5th Sig. Co.	,,	,,	
3rd Co. 1st S.& M.	Meerut Div.	,,	
4th ,, ,, ,,	,,	,,	
Meerut Divl. Sig. Co.	,,	,,	Hd. Qrs. of unit outside area, but unit worked within area.
20th Co. 3rd S. & M.	Lahore Divn.	,,	
21st Co. ,, ,,	,,	,,	
Lahore Divl. Sig. Co.	,,	,,	Hd. Qrs. of unit outside area, but unit worked within area.
2nd A.C. Sig. Co.	2nd A.C.	,,	Communication to Divisions in area.

Diaries of remaining R.E. Units in the Field inspected and units found to be elsewhere. 1st A.C. Sig. Co. not in area.

*E.—Eligible. *N.E.—Not Eligible. *D.—Doubtful.

MESSINES, 10th OCTOBER TO 2nd NOVEMBER, 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
1st Fd. Sqdn.	1st Cav. Div.	E.	
1st Cav. Div. Sig. Sqdn.	,,	,,	Change of designation, the unit being formed in Oct.
2nd Fd. Sqdn.	2nd Cav. Div.	,,	
3rd Cav. Div. Sig. Sqdn.	3rd Cav. Div.	,,	
2nd Cav. Div. Sig. Sqdn.	2nd Cav. Div.	D.	No diary, presumptive evidence.

Verifications.

No other R.E. Units present under headings Works Cos., Bridging trains, Railway units, Fortress Cos.
3rd Fd. Sqdn. not present.
2nd Cav. Div. Sig. Sqdn. Diary commences 8/15.

ARMENTIERES, 13th OCTOBER to 2nd NOVEMBER, 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
1st Fd. Sqdn.	1st Cav. Div.	E.	Had men wounded.
7th Fd. Co.	4th Div.	,,	
9th Fd. Co.	,,	,,	
4th Sig. Co.	,,	,,	
12th Fd. Co.	6th Div.	,,	
38th Fd. Co.	,,	,,	
6th Sig. Co.	,,	,,	
20th Fortress Co.	L. of C.	,,	

Verifications.

No other Fd. or Sig. Co. of 1st to 6th Div.
No Bridging trains.
No other Works Co.
No other Fortress Co.
No other Cavalry Div. units.
No A.C. Sig. Cos.

*E.—Eligible. *N.E.—Not Eligible. *D.—Doubtful.

YPRES, 1914, 19th OCTOBER—22nd NOVEMBER.

Units.	Formation.	*E. *N.E. *D.	Remarks.
1st Fd. Sqdn.	1st Cav. Div.	E.	
1st Cav. Div. Sig. Sqdn.	,,	,,	
3rd Fd. Sqdn.	3rd Cav. Div.	,,	
3rd Sig. Sqdn.	,,	,,	
23rd Fd. Co.	1st Div.	,,	
26th Fd. Co.	,,	,,	
5th Fd. Co.	2nd Div.	,,	
11th Fd. Co.	,,	,,	
56th Fd. Co.	3rd Div.	,,	
17th Fd. Co.	5th Div.	,,	Detached from its own Division.
59th Fd. Co.	,,	,,	Detached from its own Division.
54th Fd. Co.	7th Div.	,,	
55th Fd. Co.	,,	,,	
1st Div. Sig. co.	1st Div.	,,	
2nd Div. Sig. Co.	2nd Div.	,,	
3rd Div. Sig. Co.	3rd Div.	,,	
7th Div. Sig. Co.	7th Div.	,,	
1st A.C. Sig. Co.	1st A.C.	,,	

Verifications.

57th Co. 3rd Div. not present.
7th & 9th Cos. 4th Div. not present.
12th & 38th Cos. 6th Div. not present.
4th, 5th & 6th Sig. Cos. not present.
29th, 20th & 42nd Cos. not present.
1st and 2nd Bridging Trains not present.
Railway Cos. not present.
2nd Fd. Sqdn. not present.
Indian Units not present.
2nd and 3rd A.C. Sig. Cos. not present.

*E.—Eligible. *N.E.—Not Eligible. *D.—Doubtful.

LANGEMARCK, 1914, 21st—24th OCTOBER.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
23rd Fd. Co.	1st Div.	E.	
26th Fd. Co.	,,	,,	
5th Fd. Co.	2nd Div.	,,	
11th Fd. Co.	,,	,,	
54th Fd. Co.	7th Div.	,,	
55th Fd. Co.	,,	,,	
1st Divl. Sig. Co.	1st Div.	,,	
2nd Divl. Sig. Co.	2nd Div.	,,	
7th Divl. Sig. Co.	7th Div.	,,	
3rd Fd. Sqdn.	3rd Cav. Div.	,,	
3rd Sig. Sqdn.	,,	,,	
1st A.C. Sig. Co.	1st A.C.	,,	

Verifications.

56th & 57th Co. 3rd Div. not present.
7th & 9th Cos. 4th Div. not present.
12th & 38th Cos. 6th Div. not present.
1st Fd. Sqdn. 2nd Fd. Sqdn. not present.
1st Cav. Div., Sig. Co., not present.
3rd, 4th, 5th and 6th Sig. Cos. not present.
17th & 59th Cos. 5th Div. not present.
Works & Fortress Cos. and B.T.'s not present.
2nd & 3rd A.C. Sig. Cos., not present.

GHELUVELT, 29th—31st OCTOBER, 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
23rd. Fd. Co.	1st Div.	E.	
26th Fd. Co.	,,	,,	
5th Fd. Co.	2nd Div.	,,	
11th Fd. Co.	,,	,,	
54th Fd. Co.	7th Div.	,,	
55th Fd. Co.	,,	,,	
1st Div. Sig. Co.	1st Div.	,,	
2nd Div. Sig. Co.	2nd Div.	,,	
7th Div. Sig. Co.	7th Div.	,,	
3rd Fd. Sqdn.	3rd Cav. Div.	,,	
3rd Sig. Sqdn.	,,	,,	
1st A.C. Sig. Co.	1st A.C.	,,	

*E.—Eligible. *N.E.—Not Eligible. *D.—Doubtful.

GHELUVELT—*continued.*

Verifications.

56th & 57th Fd. Co., 3rd Div., not present.
7th & 9th Fd. Co., 4th Div., not present.
12th & 38th Fd. Co., 6th Div., not present.
17th & 59th Fd. Co., 5th Div., not present.
3rd, 4th, 5th, 6th Sig. Cos., not present.
1st Fd. Sqdn., 1st Cav. Div. Sig. Sqdn. not present.
Works, Fortress and B.T.'s not present.
2nd Fd. Sqdn. not present.
2nd & 3rd A.C. Sig. Cos. not present.

NONNE BOSCHEN, 11th NOVEMBER, 1914.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
23rd Fd. Co.	1st Div.	E.	
26th Fd. Co.	,,	,,	
5th Fd. Co.	2nd Div.	,,	
11th Fd. Co.	,,	,,	
56th Fd. Co.	3rd Div.	,,	
17th Fd. Co.	5th Div.	,,	Detached from its own Division.
59th Fd. Co.	,,	,,	Detached from its own Division.
1st Div. Sig. Co.	1st Div.	,,	
2nd Div. Sig. Co.	2nd Div.	,,	
3rd Div. Sig. Co.	3rd Div.	,,	
3rd Fd. Sqdn.	3rd Cav. Div.	,,	
3rd Sig. Sqdn.	,,	,,	

Verifications.

57th Fd. Co., 3rd Div., not present.
7th & 9th Co., 4th Div., not present.
12th & 38th Cos., 6th Div., not present.
4th, 5th, 6th & 7th Div. Sig. Cos., not present.
1st Fd. Sqdn. and 1st Cav. Div. Sig. Sqdn. not present.
54th & 55th Fd. Co. 7th Div. not present.
Works & Fortress Cos., & B.T's not present.
2nd Fd. Sqdn. not present.
1st, 2nd, 3rd A.C. Sig. Cos. not present.

*E.—Eligible. *N.E.—Not Eligible. *D.—Doubtful.

FESTUBERT, 1914, 23rd—24th NOVEMBER.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
3rd Co. 1st S. & M.	Meerut Div.	E.	Reliefs carried out during the period.
4th Co. 1st S. & M.	,,	,,	
20th Co., 3rd S. & M.	Lahore Div.	,,	
21st Co. 3rd S. & M.	,,	,,	

Verifications.

Meerut & Lahore Divl. Sig. Cos., not present.

NOTE.

Up to this period no units under about 100 strong have been included. This leaves out all Signal units except English Infantry Corps Sig. Cos. and Divl. Sig. Cos. Also Field Troops.

GIVENCHY, 1914, 20th—21st DECEMBER.

Unit.	Formation.	*E. *N.E. *D.	Remarks.
20th Co. 3rd S. & M.	Lahore Div.	E.	
21st Co., 3rd S. & M.	,,	,,	
Lahore Div. Sig. Co.	,,	,,	
4th Co., 1st S. & M.	Meerut Div.	,,	

Verifications.

23rd and 26th Co. not present.

1st Sig. Co. not present.

3rd Co., 1st S. & M. not present.

Meerut Divl. Sig. Co., not present.

*E.—Eligible. *N.E.—Not Eligible. *D.—Doubtful.

(To be continued).

THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR, 1914-19.

EXPERIMENTAL SECTION (*continued*).

CHAPTER 9.—SURFACE LAND MINES AND TRAPS, AND DELAY FUZES.

From the earliest days of the War various devices were in use for exploding mines by some form of trap. Several methods were described and illustrated in the *Manual of Military Engineering*. These consisted chiefly of trip wires introduced amongst barbed wire entanglements. These traps, except under special circumstances, were liable to be as much a source of danger to one side as to the other, and, except on the occasions of raids into the enemy trenches, or in a withdrawal from a position, they were not used to any great extent. The necessity for repairing the wire entanglements in " No Man's Land," demolished from time to time by shell fire, did not encourage the use of traps except under certain conditions and in certain specified areas.

In raids, however, where such devices could be left in enemy trenches, or on the withdrawal from recognised positions, mines and traps were frequently used. Plate XVIII illustrates the German pattern of land mine which could be fired by wire traps and other means. Types of somewhat similar design were used to a fair extent in the British Army, and were made up in army workshops.

In 1916, the Experimental Section was called upon to devise a suitable delay fuze for raid purposes. The mine could then be concealed in the enemy dug-out or trench, and fired after the raiding party had left. Portable charges were developed from this device, and Plates XIX and XX illustrate the standard patterns with two recognised types of fuzes, the original samples of which were made by the Section. Petrol tins and oil drums were used for the purpose and filled with ammonal; the 50-lb. standard tins of ammonal supplied by Ordnance were also used for mine charges. The delay fuze, which was designed and made by the Experimental Section, consisted of lengths of ordinary safety fuze wound in various ways and reaching a maximum time of delay of about 20 minutes; and large numbers of these were made by the First and Second Armies. A series of interesting experiments were carried out in May, 1917, to determine the effect of these charges on dug-outs. The conclusions arrived at were that :—

(*a*) Charges of 10 to 30 lbs. had little effect on the dug-out shaft itself, and in no case could the entrance be regarded as effectively sealed;

(*b*) A charge of 20 lbs. would almost certainly kill—or, at all events, incapacitate—all the inhabitants of a dug-out;

(*c*) From the point of view of the dug-outs being available for use by our own men after they had been cleared of the enemy, the results were satisfactory.

In time a demand arose for something more scientific in the form of a delay fuze. Ordinary safety fuze could not be used for long delays, and even for short delays there was a fear of discovery owing to the smell of the burning fuze.

In July, 1917, a series of experiments with clockwork mechanism was carried out by the Section. The R.A.F. had felt the need of such a fuze for special use, and the results of these trials were closely watched by the R.A.F. Staff. After a short time the fuze illustrated in Plate XXI, Fig 3, was developed, and special incendiary bombs were made up for the R.A.F. with this fuze. Although the watches used were not of good manufacture, and were not entirely suitable for the purpose, the design of the fuze was satisfactory and the principles laid down were detailed in a letter to the War Office in calling for experiments from England for the development of delay fuzes for portable charges and mines. These principles, as illustrated in the Section's clockwork fuze, were adhered to in the chemical fuze designed by the M.I.D., which was brought out to France in April, 1918, and is illustrated on Plate XXI, Fig. 2.

The delay obtained with the clockwork fuze could, of course, be accurately set by minutes up to one hour by the use of the long hand, or, roughly, from 10 minutes up to 12 hours when using the small hand.

The clockwork fuze was not developed by the Ministry of Munitions, who had turned their attention to the development of the chemical pattern as being easier to manufacture. Repeated demands by the General Staff, France, for an accurate delay fuze caused many experiments to be carried out with the chemical pattern, but accurate results were not obtainable. The fuze illustrated on Plate XXI, Fig. 2, gave hours of delay—12, 24 and 36, with intermediate six hours of delay if required. The striker was held up by a brass plug "A" kept in place by a disc of celluloid of varying thickness according to the time of delay required. Acetone in a bottle carried above the chamber behind the disc dripped into the chamber when the bottle was crushed by the screw plug "H," and the celluloid being eaten away, the brass plug was forced back by the pressure of a spring and also of the striker itself, and the striker was then released. The plug "H"

could not be unlocked when once screwed down as it was caught by the spring pellet "K." If "A" was unscrewed, the striker was released and the mine fired. The whole fuze could not be unscrewed as it was fitted to the 3-in. Stokes bomb, and the bolt "C" slipped into the holes in the top plate of the bomb and locked it.

A certain number of these were used, but after the change from the defensive to the offensive in 1918 there was little demand for them.

Experiments carried out showed that the time of delay was very erratic and affected greatly by the temperature. This was only to be expected from a chemical fuze, and agreed with the results obtained with the German delay fuze which depended for its time of delay on the action of acid on wire.

A similar fuze was experimented with by the Experimental Section in consultation with the Director of the Central Laboratory, with a view to improving the accuracy of the delay, but the decision arrived at was that, if anything, the German pattern was more inaccurate than the British, owing to the extra cause of inaccuracy introduced by the varying tension in the wire.

The range of inaccuracy of both patterns is illustrated by the following results obtained :—

> The celluloid disc in the British pattern gave a 10 per cent. variation at the same temperature. The mean time at 60° F. was halved in some cases at 120° F., and more than halved in others; and practically the time of delay increased in proportion to the rise of temperature.
>
> The German pattern had a similar variation of 10 per cent. mean at the same temperature, but the temperature being 60° F. the time of delay was halved at 100° As an example the 72-hour delay at a normal temperature of 60° F. was increased to 103 hours at 45°, a very ordinary temperature in wet wintry weather.

The German delay fuze was introduced for use with shell fuzes for demolition only during 1918, and a description of this is given on Plate XXI, Fig. 1.

The Experimental Section carried out trials with a large number of these for determination of accuracy, but longer delays than 72 hours were not available for trial.

During 1918 samples were also obtained of an existing commercial pattern. This mechanism consisted of a clockwork device which could be set with accuracy to close a circuit at any desired time of day on any day up to seven days from the day of setting, and was used to a large extent commercially in connection with automatically-controlled lighting of streets and factories. It consisted simply of a clock and cut-out mechanism, and by electrical contact the

circuit was closed when the time at which it was set arrived. It was not, however, introduced owing to the change in operations during the summer of 1918. It is interesting to record that from the point of view of the Experimental Section there was little demand from the troops for the use of traps or similar devices. To anticipate demands, a list of methods was prepared by the O.C. Experimental Section and was circulated in pamphlet form, but although the delay fuze was used to a considerable extent in the destruction of bridges, ammunition dumps, etc., interest in methods of laying traps was never great.

CHAPTER 10.—ANTI-TANK DEVICES.

At the beginning of 1918 there was reason to think that the Germans would employ numbers of tanks in their expected general attack, and the Experimental Section was called upon to devise a suitable contact mine for use against tanks.

It was necessary that any form of mine selected should be capable of being produced in large quantities almost immediately, and the 2-in. trench mortar bomb, of which large numbers were surplus in store, was chosen.

Experiments showed that the ordinary detonator and cap of the Newton percussion fuze were not fired by the gradual pressure exerted by a tank, but required a sharp blow. A suitable fuze was produced by the Experimental Section in February by removing the ordinary detonator, and replacing it by the standard brass lighter. The safety pin was replaced by a piece of shearing wire, and pressure coming on the head of the striker sheared the wire and allowed the spring to force the striker forward and fire the cap. This fuze is illustrated on Plate XXII, Fig. 1.

A better pattern was adapted from parts of the Mills' grenade, and is illustrated on Plate XXII, Fig. 2. The advantage of this pattern was that the shearing wire was strong and could safely bear the weight of a heavy man. There were greater difficulties, however, in local manufacture of this pattern, and the brass lighter type was generally used.

Mine fields were actually laid on a considerable part of the Third and Fifth Army fronts, but it was subsequently almost impossible to obtain definite proofs of their utility or otherwise.

In the event, the enemy used few tanks, and a few months later the British Army had themselves to cross the mine fields.

There is at least one case on record in which the Field Company, which had had the unpleasant job of laying the mines on their Divisional front in February, had the even more dangerous duty of clearing passages through the mine field when the Division advanced over precisely the same front in September. From the point of view of the Experimental Section, it was interesting

to know that the majority of the fuzes remained active throughout this space of seven months.

Experiments were carried on for some time, the main object in view being to produce a fuze that would be fired by the pressure of a tank, but that would be safe when crossed by light vehicles or men. Several patterns were evolved, but the change in the tactical situation gave no opportunity for them to be tested practically.

In March, 1918, the Tank Corps suggested the use of rifle grenades against tanks, and various experiments were carried out, from which it was found that 1 lb. of high explosive caused severe damage to the $\frac{5}{8}$-in. armour plating of a British tank, making a hole in the plating about 1-ft. in diameter.

Trials were also made with a tin of ammonal fitted with the percussion mechanism of the Hales grenade. This gave sufficiently good results, but was not further investigated. Careful design was necessary to prevent distortion on contact, for the jar on striking the tank was so great that in all the first experiments grenades buckled up and collapsed before they had time to function.

A satisfactory pattern was produced in April, and is illustrated on Plate XXIII. This functioned if it struck the plating up to angles of 45° to the plate; it could be fired from the shoulder with an 8-in. rod, and had a maximum range of 100 yards. Under 30 yards range the flight was so erratic that it could not be depended on to function. Manufacture was taken up in England, and experiments continued, to improve the flight in the first 30 yards by the addition of tails.

When the first new German tank was captured in July, and became available for experiments, parts of the plating were found to be of great thickness, and apparently of mild steel instead of armour plating. The effect of the grenade was not as good as expected, and efforts were made to increase its effectiveness. The final pattern was filled with T.N.T. instead of ammonal, and had tremendous bursting effect, but supplies did not reach any great quantity before the change in the situation cancelled the need for them.

Various interesting experiments were carried out in connection with anti-tank defence work, in the course of which it was found that a 5-lb. tin of ammonal was sufficient to break the track of a British tank, and a simple portable charge of this kind would certainly have been made if any serious opposition had been experienced from enemy tanks.

During the final advance in the summer of 1918, various patterns of German anti-tank mines and fuzes, of more or less similar design to our own, were found, and were sent to the Experimental Section for examination.

CHAPTER II.—ARMOUR PLATING AND AMMUNITION.

Experiments with plating and armour piercing ammunition were called for from time to time during the four years in which the Experimental Section existed, chiefly to determine the standard of penetration of ammunition, and the power of resistance to penetration of various types of armour and parapet plates.

The most important trials were :—

(i.) Armoured cars and experiments to protect the plating.

(ii.) Trials for penetration and protective facings of Japanese shields, the steel plating being made in England.

(iii.) Comparative trials between British K.A.P. and K.16 Mark VII Ammunition.

(iv.) Comparative trials between German and British A.P. ammunition.

(v.) Comparative trials with paper and Aluminium-tipped S.A.A. for effect on human flesh.

It was found as a result of experiment that body armour, sufficiently light for mobility, could not be made to resist S.AA. at decisive ranges, but sniper's body armour, which could be worn at rest and not carried into action, could be made proof down to 100 yards against ordinary, but not A.P. ammunition.

On the other hand, snipers' parapet shields of practical weights could be made to resist S.A.A. down to 50 yards, but not against A.P. ammunition.

Body armour could then only be expected to resist fragments of bombs or small pieces of shrapnel, and might be used for bombing fights, for which purpose bombing shields were, therefore, developed.

Many inventions were submitted to G.H.Q. in France and also to the M.I.D. in England in connection with materials and designs of suitable body armour, but plain steel curve plates carried in canvas or leather were never improved upon by any special design or other material. Chain mail splintered, and caused worse wounds if seriously dented, and failed for various reasons.

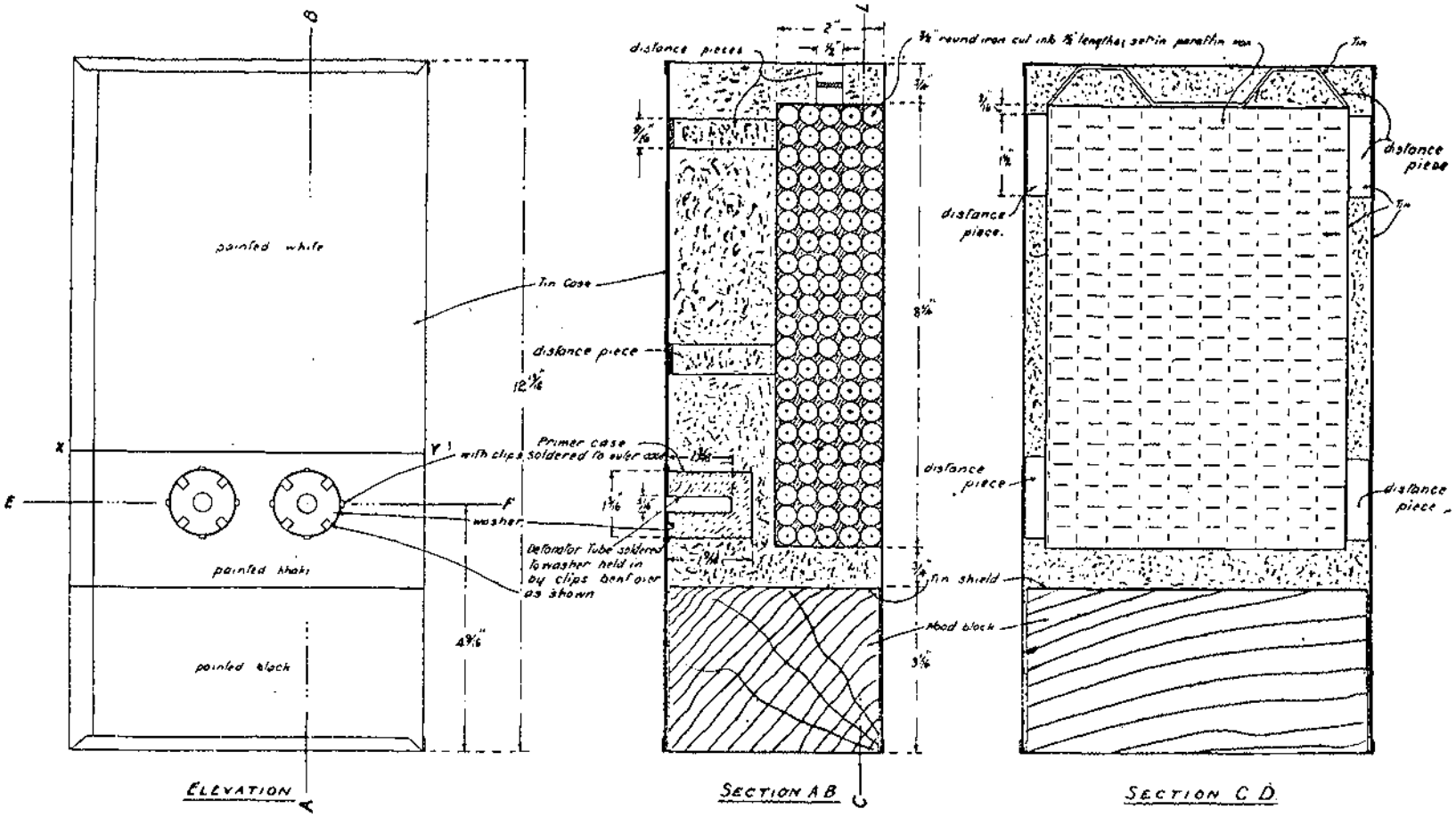
A shield with a covering of woodite $\frac{1}{8}$-in. thick was tested and found proof against the German bullet reversed, but its weight—20-lbs.—was considered excessive.

Tests on the German bombers' shield gave similar results. It was useless against rifle fire, but gave good protection against revolver bullets and bomb fragments.

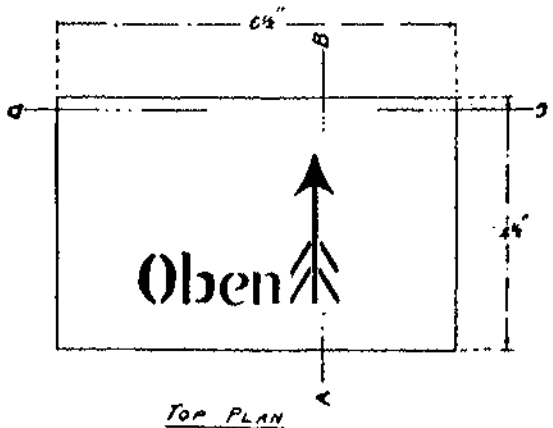
In early 1915 it was suggested that a light shield, to be pushed along the ground on wheels, would be useful, and a vast number of inventions and suggestions were submitted, and the French made patterns of all sizes. As a result of experiment, however, the opinion was formed that no shield good enough to protect one

Plate XVIII.

GERMAN LAND MINE.



Weight - Total. 30lbs 6ozs
" - Explosive 7lbs cast T.N.T
" - Bullets 19lbs
" - Primer 03s powdered TNT



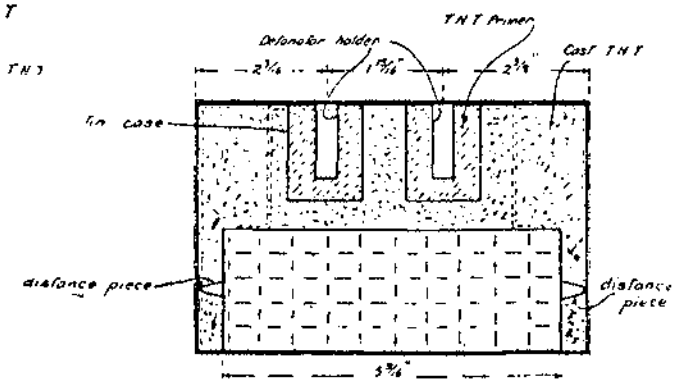
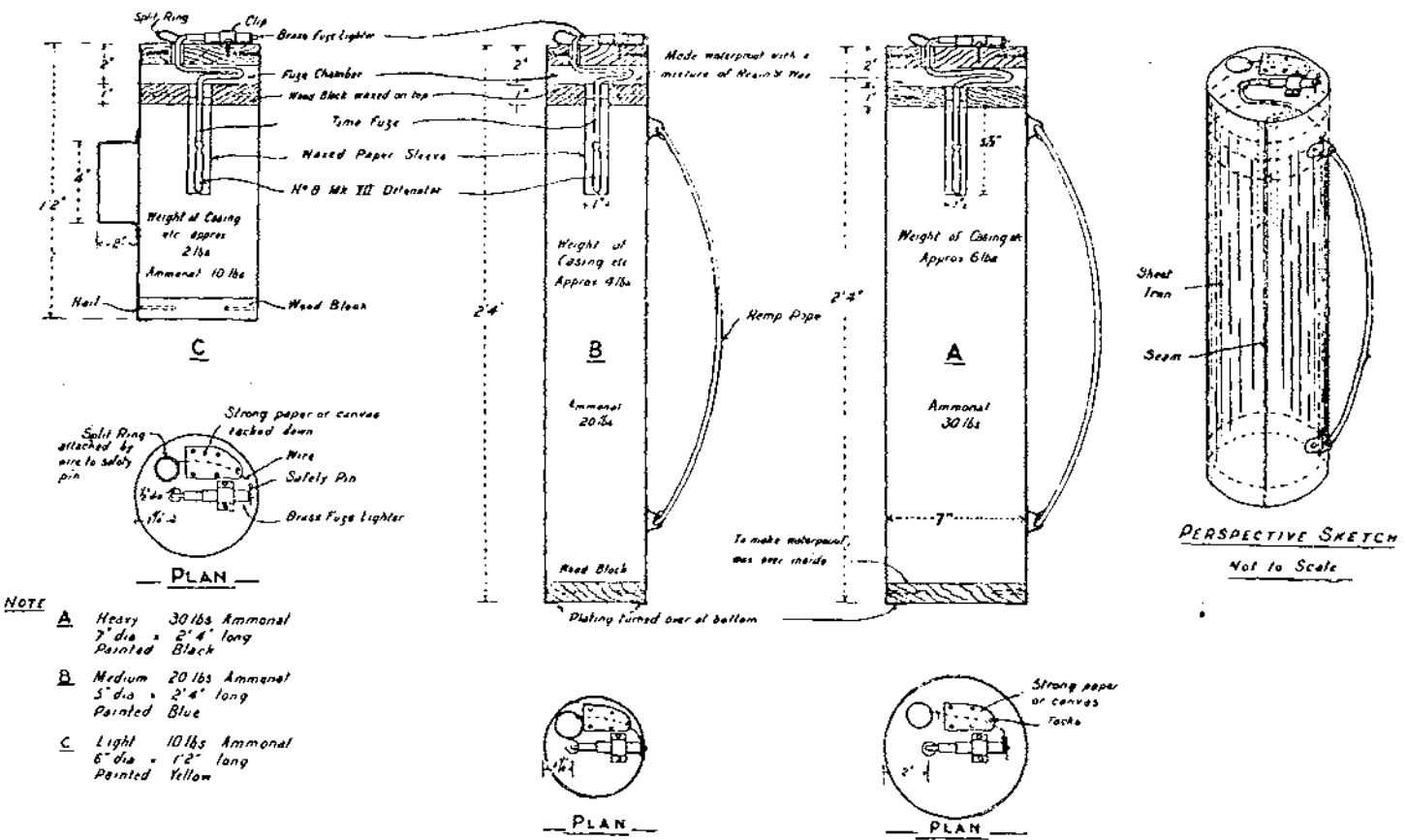


Plate XIX.

MOBILE CHARGES IN THREE SIZES.



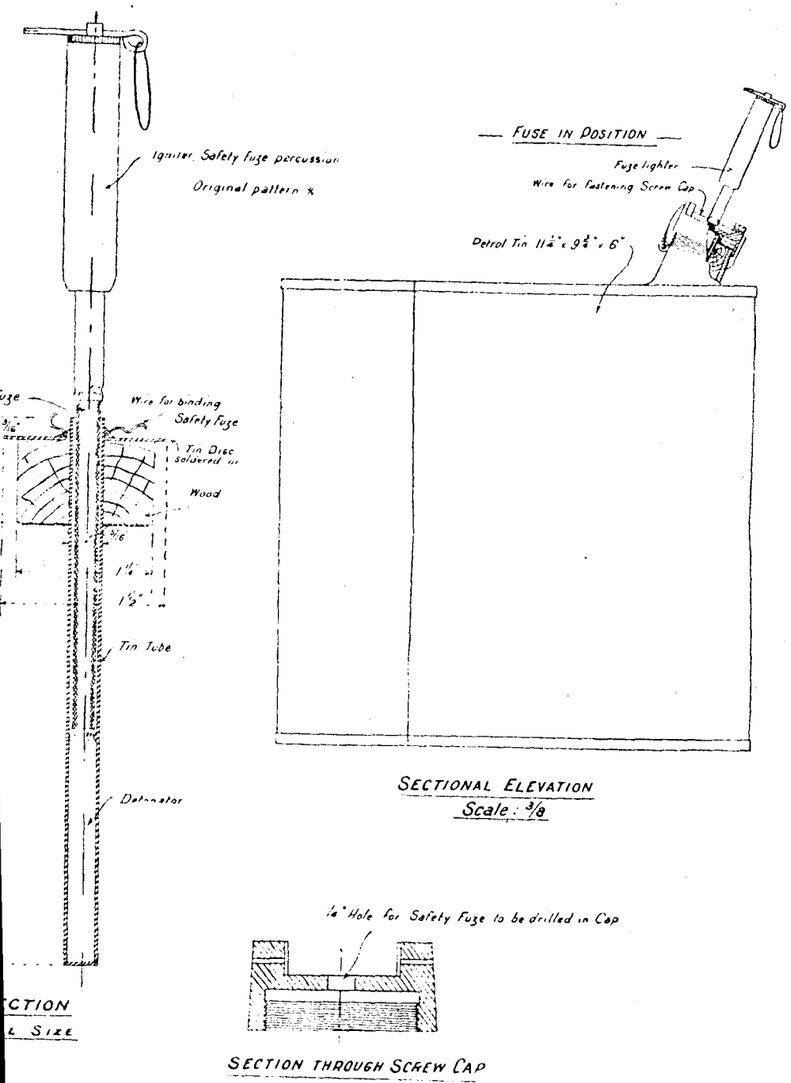
NOTE

A Heavy 30 lbs Ammonal
7" dia × 2'4" long
Painted Black

B Medium 20 lbs Ammonal
5" dia × 2'4" long
Painted Blue

C Light 10 lbs Ammonal
6" dia × 1'2" long
Painted Yellow

FUZE FOR USE WITH A 2-GALLON PETROL TIN

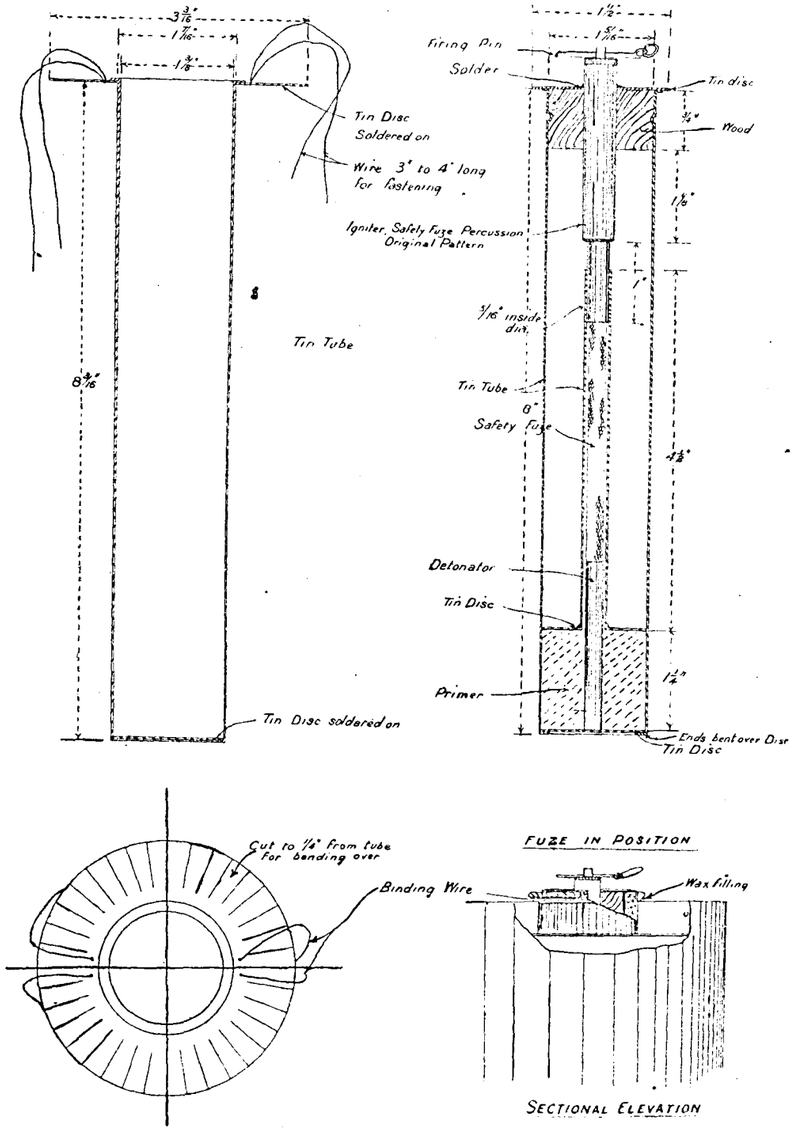


SECTIONAL ELEVATION
Scale: ⅜

SECTION THROUGH SCREW CAP

* Igniter Safety Fuze. Percussion Mark I. would also be suitable.

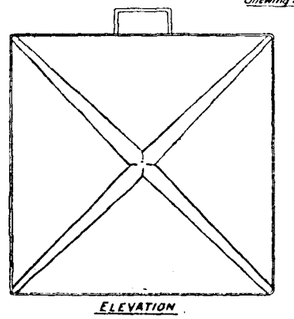
FUZE FOR USE WITH A 5-GALLON OIL DRUM.



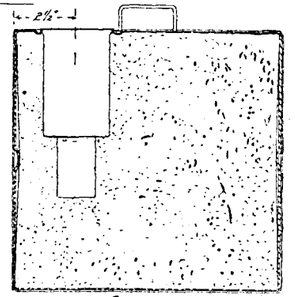
SECTIONAL ELEVATION

PORTABLE CHARGE

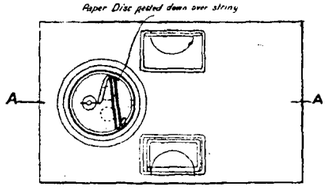
STANDARD AMMONAL TIN
Shewing Igniter set in Position



ELEVATION

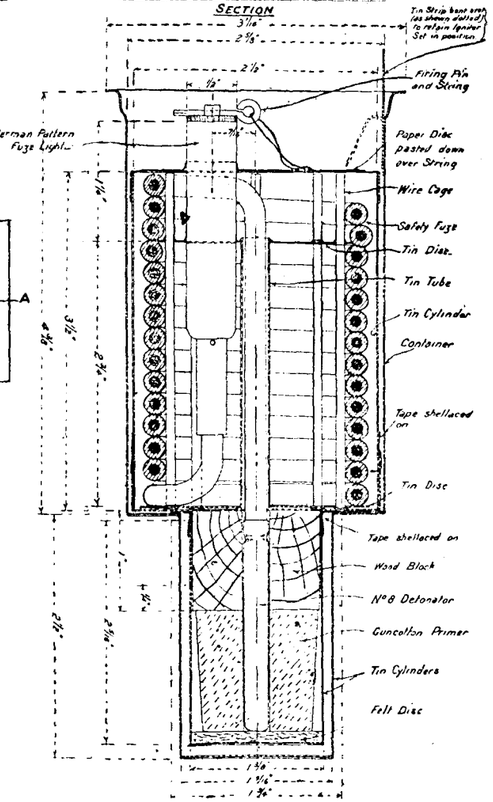


SECTION



— PLAN —

IGNITER SET
SECTION ON A A



man, which could be pushed on wheels, was light enough to be pushed, by less than two men.

An inventor at G.H.Q. submitted a design to the Experimental Section, and this shield, known as the "Van der Weyden," was made principally in order to demonstrate the truth of the above opinion. The inventor claimed that, if made and balanced like a wheel barrow, the weight when lifted would come near the wheels and so be easy to push along. Also that in this position it protected the man, and that when dropped down over him the plates could be so sloped as to defect the bullets, unless fired across the line of his direction. Against flanking fire it was useless, which was the case with most of such devices.

The vehicle when cut down to a minimum weighed 1 cwt., and no one man with his equipment on could handle such a protective shield, except under the best conditions on smooth ground.

Shields for machine guns were considered from time to time by the Experimental Section, and a sample was made which had a sliding plate with a loophole, through which the machine gun projected, and which ran on rollers while the gun traversed. It was large and cumbersome, and could only be used in trench warfare; also it was always conspicuous. After about 50 had been sent out and tried, reports were unanimous that they were too cumbersome and did not give sufficient protection.

The whole question of providing shields for machine guns was a very difficult one, as the conditions required for artificial protection are antagonistic to the important tactical considerations of invisibility and mobility. It was clear that such shields could only be treated from the point of view of trench warfare, and in this they were finally rendered unnecessary by the development of "pill-boxes."

The Experimental Section was called upon in the summer of 1918 to demonstrate to a National Commission that none of the types of ammunition in use by the British Armies in France were explosive. Trials were carried out with sample boxes of all kinds of ammunition sent up from the base, all types in use being fired, and the fragmnts collected and examined.

MODERN SCHEME OF WATER SUPPLY FOR A LARGE CANTONMENT OR TOWN WITH POPULATION OF ABOUT 20,000 *INHABITANTS IN A TROPICAL OR SEMI-TROPICAL COUNTRY.*

SECOND ESSAY FOR ARTHUR FFOLLIOTT GARRETT PRIZE, 1924.

By "BERGER," (LIEUT. O. S. G. SHEPPARD, R.E.).

ANY water supply scheme consists of three parts: the source of supply, the plant for purifying and treating the raw water, and the distribution system. It is proposed to consider these in this logical order; but before we do so, it will be well to consider generally the special conditions in the tropics.

The rainfall will probably be ample. Very often it will be found that the whole of it falls during a few months, necessitating the use of larger impounding reservoirs than would be required in places where the rainfall was more equally distributed. The fury of tropical rainstorms will make the water very turbid, and, therefore, sedimentation arrangements will surely be required. All the above considerations apply only to surface collected water.

A white man needs more water in a hot country than in a temperate climate But it does not follow from this that the consumption per head in a tropical country will necessarily be very high, for the native part of the population will very likely be small consumers.

Instead of having to take precautions against frost, the engineer's difficulty will be to supply as cold a water as possible. Anyone who has lived in the tropics knows what a boon a cool water is.

That the water supplied should be absolutely free from pathogenic bacteria, and that every precaution must be taken to ensure that it cannot become contaminated between the water works and the consumer is a *sine qua non* anywhere. Owing to the prevalence of water-born diseases such as typhoid and cholera, this is, if possible, doubly important in the tropics.

It is reasonable to expect more trouble with the growth of algae in the reservoirs in tropical countries than in colder climates.

In any water works scheme the first thing to be decided is the quantity to be supplied. It is unnecessary to labour the necessity for an ample supply, but it is interesting to note that opinion as to what constitutes an ample supply has changed in the last decade. [1] Burton, writing in 1907, suggests 20 galls. per head per day, and

1 *The Water Supply of Towns*, p. 20.

this is the figure given in the *Water Supply Manual* of 1909. Adams, in his *Waterworks* (1922), gives a figure of 25 for "residential towns," excluding any allowance for trade purposes. The new *M.E.*, Vol. VI, gives a figure of 50 galls. This, the writer considers, unnecessarily large, if this figure is meant to be exclusive of any allowance for trade purposes (but this is not quite clear).

It is true that, in America, the consumption is usually quite as much as this, very often more, but it is universally recognised that American waterworks are extremely wasteful. It is this factor of waste, which may often be as much as 50 per cent. of the actual consumption, that is a determining factor in the amount used. It is false economy to cut down the supply below what is required: economy is attained by the prevention of waste.

A few statistics may be interesting. [2]A new water scheme at Jacksonville, U.S.A. (population 4,500), has been designed to provide 55 galls. per head per day. In 1923 the London water consumption was 35 galls. per head per day. The figure for Glasgow is 45, for Liverpool 28, Norwich 11, and Berlin 16. (This low figure for Berlin is undoubtedly very largely due to the fact that the supply is fully metered, and paid for by meter.) The proposed additions to Hong Kong's waterworks will give a total supply of 26 galls. per head per day. (Hong Kong has not a waterborn sewage.) New York uses the immense quantity of 100 galls. (Imperial).[3]

The great diversity of these figures is eloquent of the impossibility of laying down any hard and fast rule. The engineer must consider each case on its merits, taking advantage of the records of neighbouring towns, and allowing for the habits and needs of the inhabitants of the town under consideration. The writer's own opinion is that 40 galls. should be normally sufficient in the case of a cantonment, provided that wastage is kept to a minimum. In the case of towns, it will vary according to the relative sizes of the white and coloured population. This figure is for domestic supply only, and any trade requirements must be added.

The probable growth of the town or cantonment must be taken into consideration when estimating the average daily consumption. Here, again, it is impossible to lay down any rules; the advice of the local government and merchants must be obtained. But it should be remembered that of two pipes having their diameters in the ratio of 4 to 3, the larger will deliver more than twice the quantity the smaller will deliver. The price of the pipes, however, will vary only about as 3 is to 2; while the costs of jointing, laying and trenching will vary very little. Without labouring this point,

2 *Engineering News Record*, May 15th, 1924.
3 *World Almanac and Book of Facts*, 1924.

it is obvious that it pays to be generous in the original layout, as regards piping. Reservoirs and filter-beds can be added to, or duplicated, at a later period, fairly easily.

It should be unnecessary to recapitulate here the qualities of a good water. The two essential requirements are that it should be free from pathogenic bacteria and from poisons.

The analysis of the various possible sources of supply is a job for the chemist; but the engineer must decide which source of supply he will utilise, and in this he is very largely guided by the comparative costs. Experience in the War proved that a potable water could be extracted from the most unpromising supply, and a source of water must not be rejected simply because it is contaminated with sewage. Will the cost of purifying a near-at-hand foul water exceed, or be less than, the cost of laying a long pipe line to a distant uncontaminated source? This is the question that the engineer must answer.

In the case of military waterworks, there is another factor besides cost. If the cantonment is of the nature of a fortress, it may be essential that the water supply should be inside, and not drawn from an external source.

Having decided on the source of supply, it now remains, from consideration of its chemical and bacteriological analysis, to decide in what ways it is to be purified and rendered fit for use.

Suspended solids are removed by sedimentation, though in nearly every case this slow process is artificially hastened by the addition of a coagulant, such as alumino ferric. In fact, if there is much colloidal matter in the water, coagulation is essential. In any case the use of a coagulant hastens the action, thus permitting the use of smaller tanks.

At many plants, where the water is filtered after coagulation, trouble is caused by some of the gelatinous coagulated matter passing through into the effluent. [4] Recent investigations have shown that this is due to using an excess of alum, when an easily broken "floc" is formed, and this readily passes through the sand. The "floc," when microscopically examined, should consist of just sufficient of the hydroxide to bind the solid particles together, and no more.

Another coagulant sometimes used is ferric hydroxide. The crude water is circulated through scrap iron, and then aerated, when the iron dissolved is precipitated as ferric hydroxide.

The oldest method of removing bacteria from the water is by slow-sand filtration, though this was only discovered by accident, the first filter being made solely for the purpose of removing suspended matter.

4 *Engineering News Record*, May 1st, 1924, p. 768.

M.E., Vol. VI,[5] states that a square yard of filter-bed is required for every 675 galls. to be filtered in 24 hours. This is a rather high rate of filtration, and the common practice is not to allow a greater rate than 450 galls. A too rapid flow leads to the formation of cracks in the sand, uneven settlement, and unreliable filtration.

Considering this particular scheme, the filters must be able to deal with 1,200,000 galls. a day.[6] An area of 2,600 sq. yds. of filter-beds will, therefore, be required, without allowing for extra beds for use when others are laid off for cleaning, or for the paths, etc., between the beds, and space for washing the sand. Land is often expensive, and the large amount of sand required may have to be brought from afar.

These objections led to the introduction, fifty years ago, of rapid mechanical filters. A battery of these to deal with this quantity of water would occupy only some 600 to 700 square feet, costing about one-third of the price of slow sand filters (in England).

In the tropics, land and labour are usually cheaper than at home, and, therefore, these factors do not carry such great weight. Also the price of the transportation of the mechanical filters must be considered. Nevertheless, it is believed they would usually be cheaper in first cost, and certainly cost less in maintenance.

There is, moreover, another advantage of the mechanical filter, and that is that it is possible to distribute the flow of water more evenly, with less likelihood of channels forming in the sand, through which the water can pass without being properly filtered.

Except in the case of the Candy Compound Filter, in which suspended matter is first removed in a coarse grit pre-filter, all suspended matter must be eliminated from the water before it is passed to the filters. If this is not done, the filters will clog very rapidly, and need very frequent cleansing.

The usual method of cleaning is by reversing the flow of water, at the same time stirring up the sand by means of revolving scours; the process taking about a quarter of an hour. This method is not always successful over long periods, and more drastic methods are necessary.

[7] Just before the War, it became necessary to add to the Berlin water-supply, and sixty "Bollmann" filters were installed. These much resemble the ordinary types, but with the addition of an "injector" at the bottom. Water is forced through the injector, sucking with it the sand, up the injector discharge, which is a vertical pipe in the centre of the filter, terminating above the surface of the sand. The sand is very thoroughly scoured in its rapid

5 p. 207.
6 Viz., p. 10, paragraph 2.
7 *Engineering News Record*, September 13th, 1923, p. 428.

passage through the injector discharge, and the dirty water is removed from the top of the filter. This method of "spring cleaning" is resorted to about once a month, the usual back-washing being employed in the interim.

One of the great difficulties in working a batch of mechanical filters is to ensure that each unit does its fair share of work, and that the proper rate of flow is not exceeded. There is not space here to consider the various automatic regulators that have been devised: one is described in the *Engineer News Record* of September 13th, 1923.

The efficiency of a filter, from the bacteriological point of view, depends entirely on the integrity of the gelatinous film on the top of the sand. This film, formed of algae and zooglea in the case of a slow-sand filter, and of aluminium hydroxide in the case of a mechanical filter, is never more than a fraction of an inch thick, and is easily broken. No form of filter can absolutely ensure that no bacteria will pass into the effluent, and a few bacteria may, under suitable conditions, soon multiply rapidly; and this is especially the case in the warm waters of the tropics. Where, therefore, the source of supply is liable to any degree of sewage contamination, further means of purification should be resorted to. The most usual method is chlorination, a method that has been widely practised in America, and which is being gradually adopted in England.

Sterilisation by gaseous chlorine is the most efficient and exact method, owing to the purity of the gas as compared with its salts. But the great objection to it is the prime cost of the apparatus, which is intricate, needing skilled supervision. The cost of the apparatus would be practically the same, whether it is required to deal with 10 millions or one million gallons a day; and, therefore, this method cannot be recommended for use in a comparatively small installation, such as that under consideration.

Of the chlorine salts, bleaching powder (calcium chloride) has been most widely used, and is the cheapest. It is more trouble to make into a solution, and deteriorates very rapidly in a damp climate; though this defect could be overcome by obtaining it in sealed tins. Sodium hypochlorite, in the form of a solution known as "Eau de Javelle," and sold as "Chloros," is also used. Some engineers maintain that, in germicidal properties, it is better than chlorine or bleaching powder, and it is certainly more convenient to use than the latter; but it is a little more expensive. Chloramine is another sterilising agent, prepared by adding ammonia to sodium or calcium hypochlorite.

Various simple devices for measuring the quantity of chemical to be added to the water can be bought, or easily constructed. The essential is that the possibility of the apparatus failing to func-

tion, and thus allowing unsterilised water to pass, must be reduced to a minimum. The amount of chemical is regulated according to the flow of the influent. It is very important that the attendant should be able to see, at a glance, if the feed is working properly.

An excess of at least half part of chlorine in a million must remain in the effluent, and, as this is only effective as a germicide after five hours' contact, it is much safer to allow an excess of up to two parts in a million, which kills all bacteria in half-hour. The excess is then removed by a reducing agent.

Sodium and potassium permanganate are useful re-agents which have been used for years. Sulphur di-oxide, which has to be stored in a cylinder as a compressed gas, carbon, sodium bi-sulphate and hydrogen peroxide are also used.

But if the water has to flow through two or three miles of pipe before being drawn off, de-chlorinisation is effected without the use of any re-agent. An excess of two parts in a million is reduced to half-a-part in a mile or so of pipe. This excess of chlorine has, moreover, been repeatedly proved to be the best means of preventing water containing iron from developing "rustiness," and of preventing the pipes becoming fouled with "crenothix."

De-chlorinisation by carbon is carried out in the "De-Chlor" Filter, a battery of which is in use at Reading. A solution of bleaching powder is admitted, through a regulator, into the top part of the filter, where it is in intimate contact with the water for half-an-hour. The water then passes through a bed of carbon, which removes the excess of chlorine. The carbon can be used for several months, and can then be revivified at a very small cost. The rate of working is 32,000 galls. per square yard per day. As the filter units (17-ft. x 8-ft.) deal with 200,000 galls. a day, a battery of six would be needed for our scheme.

Two other methods of sterilisation must be mentioned *en passant*—ultra-violet ray treatment and purification by ozone. Both are hardly past the experimental stage, and both depend on cheap power in order to be a commercial proposition.

The latest invention in the realm of water purification is the stream-line filter, which was first exhibited in 1923 at Olympia. The action of this filter, which is very simple, has already been described in the *R.E. Journal*. It should be noted that it is a case of real mechanical filtration, not depending on the presence of a skin, formed by bacteriological or chemical action. The largest unit shown at Olympia was a battery of sixteen vertical filters, with a rated capacity of 10,000 gallons an hour. The cleansing of these filters is done, either by means of a reversal of flow, or by scouring out the influent tubes with a piston. As they need very frequent cleansing, the water should be first passed through a pre-filter.

The writer has been unable to find any record of this novel type of filter having yet been installed as a commercial proposition, but it seems that it should have an extended use. The cost of such an installation is comparatively cheap, and it would probably cost less in maintenance and labour than a bleaching-powder plant.

To recapitulate: the greater portion of suspended matter is removed by sedimentation and coagulation, the remainder of the solids, taste and smell, and most of the bacteria are removed by filtration; finally, chlorination kills the few bacteria still in the water. Practically every water will need treatment by sedimentation and filtration, a good proportion will be advisedly chlorinated, some will need further treatment for excessive hardness.

The problem of water softening is much more urgent in manufacturing towns than in residential ones. For domestic purposes a fairly soft water is undoubtedly desirable, but cannot be said to be really necessary. The funds available will decide whether it is possible to treat the water for hardness.

Two methods can be employed, the old soda-lime treatment, or the Permutit system. As regards relative cost, when the permanent hardness is high compared with the total hardness, the latter will be usually the cheaper, but if most of the hardness is temporary, the former will probably be the cheaper.

Unless the water was of exceptional hardness, funds would not generally allow of a cantonment water supply being softened. But if there is a central power house and workshops, this should have its own softening plant.

The water, purified and treated as necessary, is now ready for distribution; and, for this purpose, is first passed into a service reservoir.

The function of this is three-fold. Firstly, to provide a fire reserve; secondly, a reserve against a breakdown of the pumps, or a break in the pipe line from the impounding reservoir; and, thirdly, to maintain a constant head in the mains.

The Water Supply Manual of 1909 lays down a fire reserve equal to one day's consumption, and a breakdown reserve equal to two days' consumption. Other books also suggest a "normal" capacity of three days' consumption.

That such rules of thumb are practically valueless can be seen from a moment's thought. The reserve that should be kept in hand against a break in the line from the reservoir depends entirely on the distance of that reservoir from the town, and on the number of sources of supply. A town of 10,000 inhabitants might quite conceivably need a larger reserve than one of double that population. The engineer must first of all decide how long it would take to repair the worst break in the line (or breakdown of the pumps)

that might reasonably happen: the reserve required will then equal the amount of water that would be consumed in this time.

As regards fire reserve, Burton gives a formula. [8] $Q = 200\sqrt{P.}$, where Q is the quantity of water in cub.-ft. required as a fire reserve, and P. is the population. With a town of 20,000, Q is 176,000 galls. (about 1/5 of the day's supply). This quantity is sufficient to keep 20 hydrants at work for about 70 minutes, which should be sufficient. This formula, like all other empirical formulæ, should be used with caution. Each case must be considered on its merits.

We have noticed that the third function of a service reservoir is to maintain a constant head in the mains. If the pressure in the mains is allowed to fall, a vacuum will be formed in the higher parts of the system, and this will lead to an infiltration of surface water, and possibly sewage, with disastrous results. This was one of the great objections to the "Intermittent Service," now never seen in permanent work.

In the case of a pumped supply, a stand pipe is often substituted for the service reservoir, to save the cost of constructing the latter. The fire reserve must then be provided for by a stand-by pumping plant.

The position of high ground will determine whether the reserve is to be installed in one large reservoir, or in several smaller ones. If one portion of the town is at a considerably lower level than the remainder, it may be impossible to maintain a good working pressure, with a single reservoir, in all parts of the system. In such a case special arrangements must be made. The alternatives open to the engineer are to install separate service reservoirs for the different parts of the town, or to employ break-pressure tanks, or pressure-reducing valves.

Service reservoirs should be covered. Although open air storage improves bad water, good water deteriorates in open reservoirs, owing to the growth of algae and other micro-organisms that need light. The water also will keep cooler (and really cool water is a great comfort in the tropics), and dust and dirt will not get in.

From the service reservoir the water passes into the town main. The distributing mains should be so arranged that there are as few dead-ends as possible. If carefully thought out, this "reticulated" layout will not require a greater weight of pipe than the "tree" pattern, as, although there will be a greater length of pipe, the pipes can be smaller, as any point will be supplied from at least two directions. The advantages of the system are that it ensures a continuous flow in the pipes; and that, in case of a large fire, it enables a great portion of the whole water supply to be concentrated at the threatened point.

8 *Water Supply of Towns*, p. 212.

The size of the mains is the next consideration, and to determine this it is necessary to decide on the greatest rate at which they will have to deliver water. The [9]figure of 40 galls. per head per day is an average for the whole year. Owing to seasonal and daily variations, the mains will have to deliver at a much greater rate than this.

It is obvious that more water will be used in summer than in winter, and for a few days the consumption may rise to 50 per cent. above the average, and this maximum consumption must be allowed for.[10]

The demand varies throughout the 24 hours, being negligible at night, and maximum during the morning. The usual practice is to design the mains to discharge 50 per cent. of the maximum daily consumption in six hours, or a maximum flow during each of these hours at 8⅓ per cent. of the daily flow. Owing to the greater diversity in the habits and occupations of a large town, this daily variation is less than in the case of small towns. Thus the [11]*Water Supply Manual* (dealing with a battalion barrack supply) says that the mains should be capable of delivering the whole day's supply in eight hours, a maximum hourly flow of 12½ per cent. of the daily flow.

As the habits of the soldiers in a cantonment are much more similar than those of the civilian inhabitants of a town, the daily variations will be greater in the former case. To keep this variation in bounds, and thus to save the use of very large pipes, a judicious supply of house cisterns can be installed, but sparingly, as any cistern is liable to contamination. Water for drinking and cooking purposes, or that might be so used, should invariably be drawn direct from the main. Cisterns should not be on the roof, where they get dirty, and the water hot, but underneath it, in some easily accessible place. The design of barracks, with latrines and ablution houses grouped together, especially lends itself to cistern supply.

The case of towns is different. It is impossible to arrange for a strict water discipline to ensure that cisterns be kept properly clean as with cantonments; and the necessity for them is not nearly so great. They should be installed in only large houses and hotels, or in houses far removed from the main.

In the particular scheme being considered, the average daily flow (at 40 galls. per head per day) will be 800,000 galls. Adding 50 per cent., the maximum daily flow becomes 1,200,000 galls. Assuming a maximum hourly flow equal to 8⅓ per cent. of the

9 Viz., p. 256.

10 In the case of places very near the Equator, this consideration does not arise, winter and summer being nearly the same.

11 *Water Supply Manual*, 1909, p. 51.

daily flow, the mains must be designed to deliver 100,000 galls. an hour, or 1,666 galls. per minute.

As each half of the ring main supplies only half of the town, it need only be able to take half this amount, or 800 galls. a minute.

In the design of the whole system, the question of fire protection must be borne in mind. The necessary fire reserve has already been considered, but it remains to be decided at what rate it is necessary to supply water for this purpose, as on this the size of the mains may depend.

Two fires at the same time, each requiring five hoses, is not an unreasonable suggestion. Each hose requires 120 galls. a minute, and, therefore, the main must carry 1,200 galls. a minute. As the two fires may very possibly occur in close proximity, each half of the ring main should be capable of delivering this amount. It will, therefore, be seen that fire requirements are the deciding factor in this scheme—as in all small schemes.

Some writers[12] go to the length of suggesting that the principal mains should be able to carry the fire provision (a minimum of 1,200 galls. a *minute*) in addition to the absolute maximum consumption—*i.e.*, in this case, 2,000 galls. a minute. This the writer cannot help thinking is over generous, leading to unnecessary expense. The great majority of fires occur at night, when the domestic consumption is very small; the mains have, moreover, already been designed to carry 50 per cent. more than the average daily flow, and they will only be worked at this rate for a very few hours during a few days of the year.

Therefore, if the principal mains are designed to carry 1,200 galls. a minute, there should be a reasonably ample supply in case of fire. With the usual hydraulic gradient met with, a pipe of 14-in. to 16-in. diameter would be necessary.

Hydrants should be spaced at 100-yard intervals. It is, therefore, evident that the smallest main will probably have to supply two hydrants, each of which will consume water at the rate of 120 galls. per minute. A 4-in. main will usually be sufficient, with the heads normally used. This is absolutely the smallest main that should be allowed in permanent work, owing to the rapid incrustation of a smaller pipe. American practice favours 6-in. as the smallest permissible diameter, and this is certainly more desirable, if the funds available will permit the extra expense.

The head in the mains should everywhere be such that the fire hoses can bring a stream of water to bear on the roofs of the houses. This will, of course, vary with the height of the buildings in use: a 40-ft. head would be sufficient for two-storied buildings. In no case must the head in the mains be less than 10-ft. But it will

12 *e.g.*, Burton, p. 196, *The Water Supply of Towns.*

not always be possible to arrange for a sufficient head for fire fighting purposes, especially if six or eight-storied buildings have to be catered for; and, in this case, the extra pressure required must be supplied by fire engines. A head greater than 200-ft. should not be allowed, as this brings an undue pressure on the house fittings.

Pipe calculations are bound to be very much guesswork. A carefully-designed pipe layout is of much more practical use than a lot of intricate mathematics; and it should always be borne in mind that putting in a slightly larger pipe than necessary is a fault on the right side.

Pipes can be either of cast or wrought iron, steel or reinforced concrete. Wrought iron is ruled out of court by its cost; and, in permanent work, its use is confined to house connections.

The advantages of steel pipes over cast iron pipes are many. They are stronger, made in longer lengths, which reduces the time and labour expended in jointing, and very much lighter. In a tropical station, removed from the sea, this question of weight and transport might be of paramount importance. Steel pipes are also cheaper.

But there is one very serious drawback to steel pipes, and that is that they are apt to suffer very badly from corrosion. The most notable instance of their use was in the construction of the Coolgardie pipe line, a 30-in. main, 350 miles long. The pipes were coated with a mixture of coal tar and Trinidad asphalte, but in five years internal corrosion had reduced the discharging capacity from 14 to 53 per cent. in various sections. On the other hand, 15 miles of cast iron pipes, 12-in. to 20in. in diameter, put in at Versailles 250 years ago, are still in use and working efficiently. At the Tay Bridge, at Dundee, the same identical water is carried by a cast iron pipe without corrosion, and by a steel pipe which so corroded as to render renewal necessary. These examples are given to show that experience points to the fact that steel pipes are much more liable to corrosion than cast iron ones. At the same time, there are numerous examples of steel pipes giving satisfactory service, and cast iron pipes have also perished.

The cause of corrosion is not yet accurately known: the chemists have accused carbonic acid, hydrogen peroxide and electrolysis of being responsible. The nature of the water undoubtedly has something to do with it, but that it cannot be the only cause is conclusively shown by the experience at the Tay Bridge.

In view of the manifest advantages of steel pipes, particularly in places where transport is a difficulty, their use should be certainly considered; but it would be unwise to adopt them without careful consideration of the character of the water. Previous experience in the locality will be the most useful guide. Whether cast iron or steel pipes are used, they should invariably be coated with a protective coating, inside and out. Dr. Angus Smith's composition

is very widely used, and lately cement is finding favour. This latter method was highly recommended at the Royal Sanitary Congress, 1923.

Cast iron pipes made by centrifugal action are a recent development, and should be in wide use in a few years' time. As we have seen, one of the great objections to cast iron pipes is their weight; and this is diminished to the extent of 25 per cent. in the case of Stanton "spun" pipes; and they are more free from blow-holes and defects. At present they are only made up to the 12-in. size.

Reinforced concrete pipes are also now made, from 4-in. size upwards, but the writer has been unable to find any records of their capabilities. As cement is used as a protective covering for iron pipes, it seems probable that concrete pipes will not suffer from corrosion.

We noticed that one of the chief reasons accounting for the widely differing consumptions of various towns was waste. A fact not always realised is the immense amount of water that runs to waste through a small leak or hole. A tap steadily dripping will easily waste water at the rate of a gallon an hour. Assuming 3,000 taps in the cantonment, and that 10 per cent. are leaking, 7,200 galls. will daily run to waste. A hole of $\frac{1}{8}$-in. diameter, under a pressure of 45 lbs. per square inch, will pass 3,840 galls. a day. It can be thus readily understood that the water wasted can soon amount to 50 per cent., or even more, of the consumption, if leaky fittings and mains are not repaired.

The best method of reducing waste is not to employ cheap fittings and pipes, but to carefully supervise the pipe laying and to ensure that the joints are water-tight, and to test all mains before the trenches are filled in. Cheap materials are false economy.

But the best fittings and pipes are still liable to faults, and arrangements must be made to detect leaks. This is done by dividing the town into wards that can be shut off by means of stop-cocks. A recording meter, such as the "Deacon" (the Venturi or other inferential types of meter are not suitable, as they do not function if only a small quantity of water is passing) is installed immediately below the service reservoir. During the early hours of the morning, when an infinitesimal amount of water is being used, a turncock closes the various stop-cocks in order, at special times. The chart recorded by the meter will then show the various amounts of leakage in each ward.

The leaks are then definitely located by inspection of the road surfaces for signs of moisture, and by acoustic means, using a stethoscope or aquaphone.

In cantonments a strict water discipline should be enforced. In towns waste is undoubtedly much reduced by installing a house-to-house water supply, charged on meter registration. This

naturally makes the householder careful. But the system cannot be recommended, as it is an inducement to people to use less water than they should, to be miserly to the detriment of the public health. In England, the only town so served is Malvern, though in America and on the Continent the system has found more favour.

Many householders seem to imagine that a continually running tap keeps the drains "sweet." This is a fallacy. What is required is not a continual ineffectual dribble, but a large flush of water from time to time. This is provided by the W.C. cisterns, which should be large. In some towns the installation of W.C. cisterns of more than two-gallon capacity is forbidden, but this is a very bad policy: it saves water at the expense of sanitary drains. Unless the house drain is very short and with a good fall, a two-gallon flush is not sufficient. In the tropics a generous flush of the drains is especially important.

This is the dividing line between water supply and sanitary engineering.

It will have been noticed that the tropics do not present any startlingly new problems to the engineer, and that the differences between water supply at home and in the tropics are not very great. In both the object is to provide an ample supply of good water.

In conclusion, it cannot be too strongly urged that true economy is attained, not by cutting down the supply or by saving money on necessary purification, but by the adoption of all means that will prevent waste.

THE TRAINING OF THE REGULAR OFFICER IN AUSTRALIA.

By C.H.F.

In these notes it is intended to describe briefly the training in particular of the officer who becomes, and is, an officer of Engineer or Signal Units. It is not practicable to entitle the notes "The Training of the Regular Sapper Officer," for the reason that, with a few exceptions, principally in the Works Branch, all Officers serving with Engineers and Signals are officers of the Staff Corps, a Corps formed in 1921, to which the majority of the Regular Officers then serving were transferred, and in which all young officers are now commissioned.

The Staff Corps was formed in order to regulate promotion among Regular Officers; previously these had taken promotion in their Corps, *i.e.*, the "Administrative and Instructional Staff," the Gunners and the Sappers respectively, with the result that many anomalies had occurred, officers of the two latter Corps finding themselves junior to officers of the "A. and I. Staff" of many years' less service.

There is but one avenue of entrance to the Staff Corps, that is, through the Royal Military College of Australia, an institution founded at Duntroon in the Federal Territory in 1911, under the advice of Lord Kitchener, for the initial training of young officers.

Entrance to the Royal Military College is obtained normally by the passing of the public examinations held annually throughout Australia.

Practically every boy (and girl) in Australia who desires a decent education passes (or attempts) one or both of these examinations, which are known as the "Junior" (or "Intermediate"), and the "Senior" (or "Leaving") Public Examinations. These examinations are held by the Universities of which there is one in each State in Australia.

A candidate must be between 16 and 19 years of age on joining the College, and the College course covers a period of four years. In certain special cases, entrance of youths over 19 years is permitted, but such cases are rare.

At the end of the third year of any particular "batch," certain cadets are selected, according to suitability and (to a certain degree) their own desires, for allocation to particular Arms—*e.g.*, Cavalry,

Gunners, Sappers, Flying Corps—and during the fourth and last year of their cadetship, they specialise along the particular line required.

In selecting officers for allocation to Engineers, great stress naturally is laid on their knowledge of mathematics and kindred subjects, as well as on their natural or disclosed aptitude for the work.

Having graduated on completion of his fourth year, a cadet is commissioned as Lieutenant in the Staff Corps, and it is at this point that the technical training of the budding Gother Mann really commences.

The following is a brief resumé of the courses and training to be undergone by the young officers commissioned on graduation :—

(1) Regimental duties, Administration, "Q" and Ordnance matters ; one month.

(2) Attachments :

(*a*) First period, to the Headquarters of an Infantry Brigade, under the supervision of the B.M., to obtain a general knowledge of Organisation, Administration and Training ; one month.

(*b*) Second period, to a Battalion Area to study Area work, under the supervision of the B.M. and Area Officer ; five or six weeks.

(NOTE.—An "Area" is that from which Trainees under the Compulsory Service Act are drawn for the Citizen Forces. A Brigade Area consists of four Battalion Areas and normally supplies recruits for a F.A. Brigade, a Field Company, four Battalions, and a moiety of other Divisional Troops.)

During either (*a*) or (*b*) attachments young officers attend a camp of continuous training, usually as an "attached officer" to a unit of the Citizen Forces.

(*c*) Third period, to a unit of the arm to which the young officer is allocated.

In the case of officers allocated to sappers, this attachment is to Headquarters, Divisional Engineers or Divisional Signals, for a period of two months.

Thus, within six months after graduating in December, the young officer has acquired a certain knowledge of the "machinery" of the Force, particularly in regard to the working of the Compulsory Clauses of the Defence Act, and the corresponding Regulations under that Act. This knowledge is essential, as the majority of officers, even those posted to the Technical Arms, will become Adjutants of Units or formations, *e.g.*, Divisional Engineers.

Young officers allocated to Field Engineers or Signals continue their attachment to Divisional formations as above, until such time as they are posted to a further technical training, usually within some six or eight months—*i.e.*, in the first quarter of the following year.

In the case of those allocated to Field Engineers, this further training consists of two years at either Sydney or Melbourne University. The standard of knowledge required for graduation from the Royal Military College is accepted by the Senates of these Universities as being equivalent to the first and second year Engineering Course, and the young officer, therefore, enters forthwith practically on his " third year " of that course.

Two years at the University are thus allowed at Commonwealth expense, the young officer meanwhile receiving the pay of his rank and being posted nominally for duty to a formation in either New South Wales or Victoria. Actually he does little, if any, military duty, his energies being devoted to study.

Usually, the degree of B.E. is gained at the end of two years—*i.e.*, at the completion of the normal four-year University Course, and three years after graduation from the College.

Failures to graduate have been few—in the only case within the writer's recollection the failure was not of a serious nature, and the officer concerned was retained in his " nominal " posting for another year.

During this year he became responsible for the University charges, and his military duties had to be performed, instead of being merely nominal. The wisdom of this procedure was justified by his " pass " at the end of the year.

Young officers allocated to Signals are lent to the Postmaster-General's Department for two years. They are posted " nominally " to Signal units during this period and draw military pay. The Postmaster-General's Department will not accept responsibility for any expenses incurred except where these officers are actually performing duties for members of the Postmaster-General's staff.

During attachment they conform to the regulations of the Postmaster-General's Department as regards hours, leave, duties, etc. Any breach of discipline, however, is reported to the Defence Department.

Monthly reports are forwarded by heads of Departments in order that the suitability and progress of each officer may be continually under review.

The Postmaster-General's Department have, since its inception, displayed an active interest in the course. They will at all times listen to suggestion from officers in training and assist in every way in giving them a sound practical knowledge of their telephone and telegraph practices.

It has been found that two main advantages are derived from the course. The first would apply equally to the Home Forces, while the second is peculiar to Australia.

(1) The officer gains a practical knowledge of the installation, maintenance and operation of those heavier systems of communication employed behind divisions.

(2) The bulk of Signal personnel of the Citizen Military Forces are drawn from the Post Office and consist mainly of junior operators and mechanics, and consequently an officer who has passed what they term a "Junior Engineers' Course" is looked up to with some degree of respect.

The course comprises the following work :—

(*a*) Telephone Equipment—9 months :—

(1) Workshop experience, including use of tools, assembling and repairing of instruments and minor bench work.
(2) Test room work.
(3) Testing of materials and instruments.
(4) Trunk line equipment, including superimposed systems.
(5) Installing subscribers instruments.

(*b*) Telegraph equipment—12 months :—

(1) Telegraph operating—preliminary instruction.
(2) Operating actual telegraph circuits.
(3) Installing apparatus, including duplex wheatstone and multiplex apparatus.
(4) Circuit diagram, plans and specifications.

(*c*) Line construction—3 months :—

(1) Metropolitan gangs.
(2) Jointing.
(3) Country Survey.

Sections (4) and (5) of part (*a*) include work in C.B., Magneto, and Auto Exchanges.

Four officers have completed this course and two are undergoing instruction.

One officer completes and one commences annually.

Officers for Fortress Companies are drawn from those possessing the B.E. degree, and are not posted to such units until that degree has been obtained.

Finally, the Staff Corps Officer allocated to Engineers or Signal Units will go to England for one or two years' instruction with the R.E. or R.C.S., as may be required.

This tour of instruction will usually take place after the young officer has spent a year or so with units in Australia, in order that he may be more capable of benefiting by a study of British methods and conditions.

Up to the present, the scheme is of too recent origin to have allowed of this final addition to the training of the young officer.

The following Table summarises the periods of Training and shows the approximate age of the individual at the end of each period :—

Detail.	Years.	Approx. Age on Completion.
At R.M.C., Duntroon	4	17-19 (Entry) to 21-23 (Leaving).
Administration Attachment to Unit	1	22-24.
University	2	24-26.
Regimental duty in Australia ..	1	25-27.
Attachment to R.E. or R.C.S. ..	1	26-28.
Total	9	

HISTORY OF THE 12th COMPANY, ROYAL ENGINEERS.
(Concluded.)

By LIEUT. M. R. CALDWELL, R.E.

CHAPTER VI.

Louverval Sector (*See Map* 9).—The new sector was the quietest the Company had so far encountered during the War, the German lines were about 1000 yards distant, and there was little or no shelling. On the 23rd January Headquarters and one section moved to back billets, the other three remaining forward and carrying out routine trench work until February 10th. The 400th Field Company then took over this sector and the 12th Company side stepped and took over work on the Pronville Sector from the 105th Company, the transport moving to Favreuil.

The Company were now busily engaged in strengthening the line, building dug-outs, machine gun emplacements, etc., and preparing for the attack which was known to be coming soon. During March the work increased in intensity and was hurried on as fast as possible. Two of the most important jobs were the erection of a Brigade Battle Headquarters, consisting of fifteen elephant shelters let into the side of a sunken road and fitted up with tables and chairs, all of which was completed in four days and drew a warm letter of praise from the Brigadier, and, on the 12th March, the laying of two large minefields, each consisting of several hundred 60lb. Trench Mortar bombs, in No Man's Land as a protection against tanks. There was also, of course, the usual work of strengthening the defences and improving shelters and Aid Posts.

A detailed defence scheme had been prepared, and on March 9th a practise " stand to " was carried out at 5.30 a.m. by all the Divisional Troops, this being repeated on the 12th and 14th, so that all men knew their battle positions.

German Offensive Launched.—At 1.30 a.m. on March 21st all troops were ordered to " stand to " in their battle positions at 5.30 a.m., as the attack was expected that day.

At 5.0 a.m., just as the Sappers were forming up on the road outside their quarters, a terrific bombardment opened, and guns of every calibre plastered the sector with gas and high explosive from the Corps Line to the Front. One shell struck the officers' Mess, where were Major Williamson and C.S.M. Rouse, killing them both. In spite of this loss, however, the Section Officers (Lieuts. Noble, Veitch and Newcombe) rallied their men, and, in the semi-darkness, made worse by the wearing of gas masks, led them, without further serious casualties, to their positions in the Corps Line.

MAP 9.

THE BATTLE OF MARCH 21 & 22 1918

Scale 1/40,000

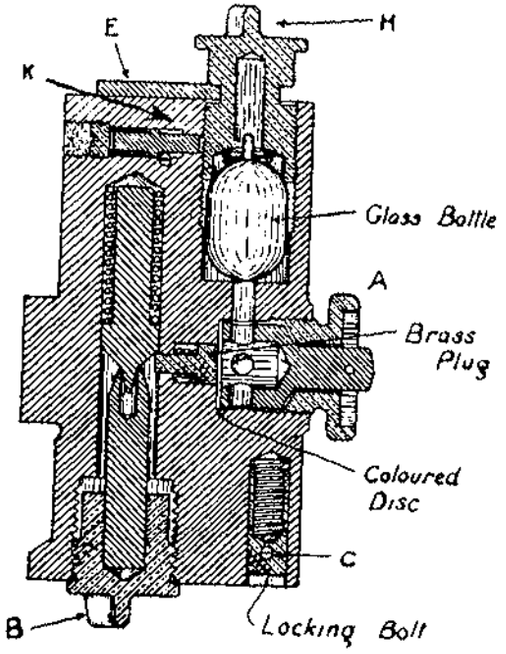
0 ¼ ½ ¾ 1 Mile

British position 5 a.m. 21.3.18 shewn
" " 7 p.m. 21.3.18 "
" " 6 p.m. 22.3.18

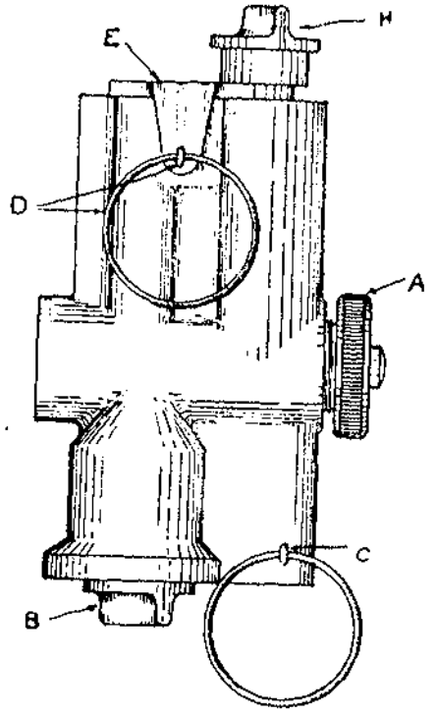
German position 5 a.m. 21.3.18
" " 7 p.m. 21.3.18
" " 3 a.m. 1.4.18

Noreuil
Queant
Pronville
Lagnicourt
Vraucourt
Bois de Vaulx
Vaulx-Vraucourt
Morchies
Morchies Wood
Louverval
Boursies
Beetroot Factory
Beugnatre
Doignies
Favreuil
Bugny
Beaumetz-les-Cambrai

DELAY ACTION FUZE



SECTION.



ELEVATION

TO RENDER FUZE ACTIVE:—

1. Unscrew base plug "B," and screw fuze into spigot on head of bomb
2. Remove pin 'C' and see that spring locking bolt drops into nearest tommy hole in head of bomb.
3. Draw out pin "D" and remove plate "E"
4. Screw down plug "H" slowly as far as possible

NOTE.—The time of delay starts from the screwing down of "H".

Do not touch "A"; this is a sealed joint

Plate XXI. Fig 1.

THE 1917 GERMAN LONG DELAY FUSE FOR 2in. T.M. BOMB.

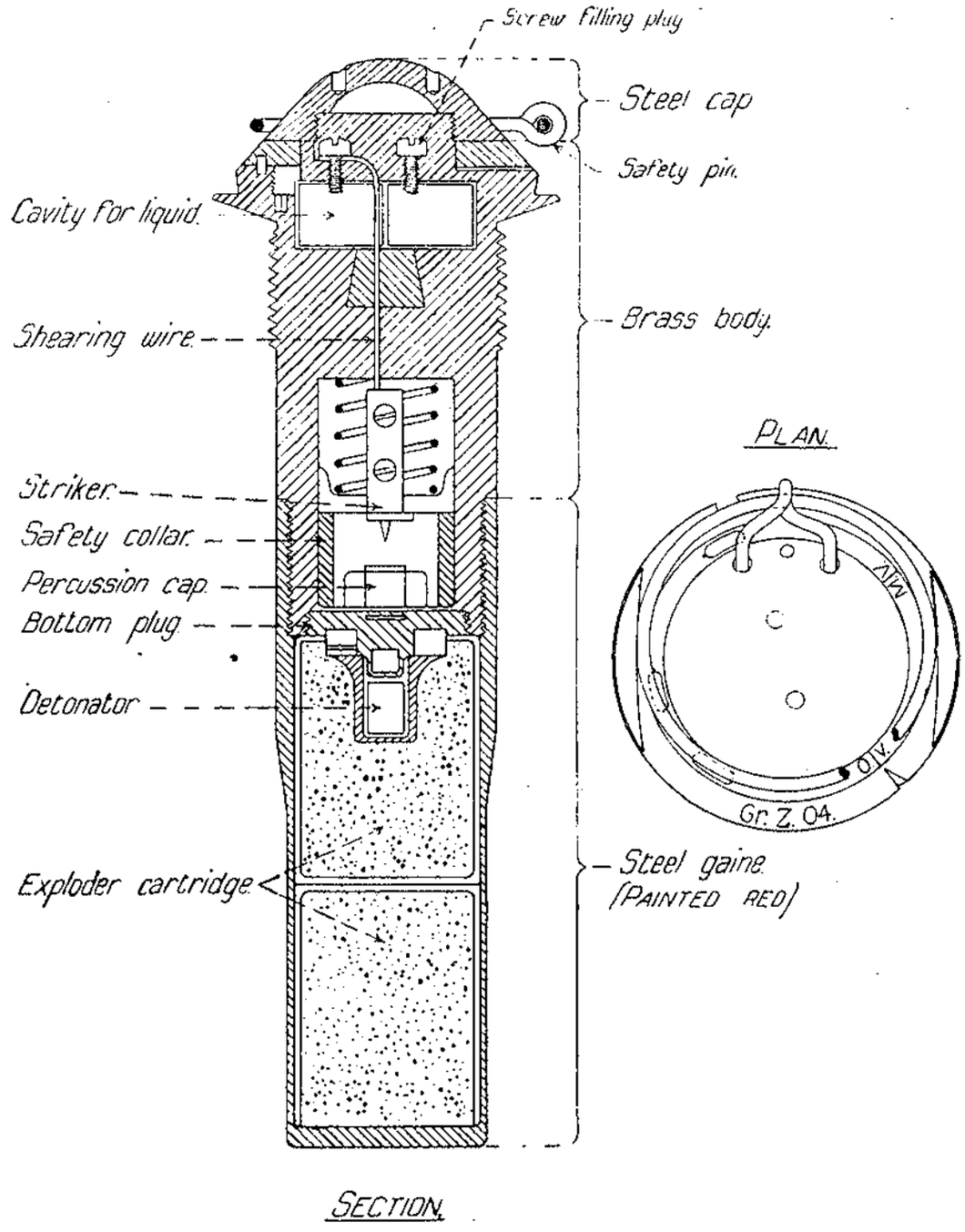


Plate XXIII.

ANTI-TANK RIFLE GRENADE.

WEIGHT 1 lb 10½ ozs

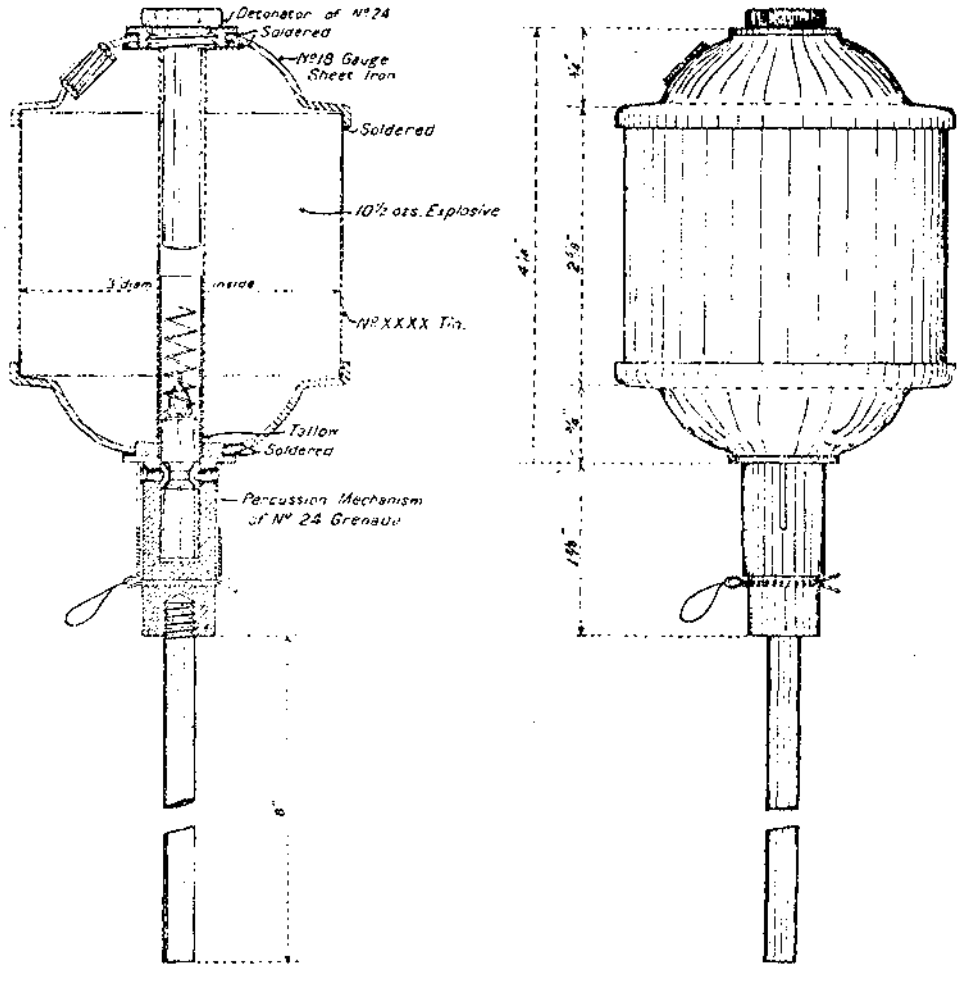


Plate XXI. Fig 3.

ELECTRIC DELAY ACTION IGNITER SET FOR LAND MINES.

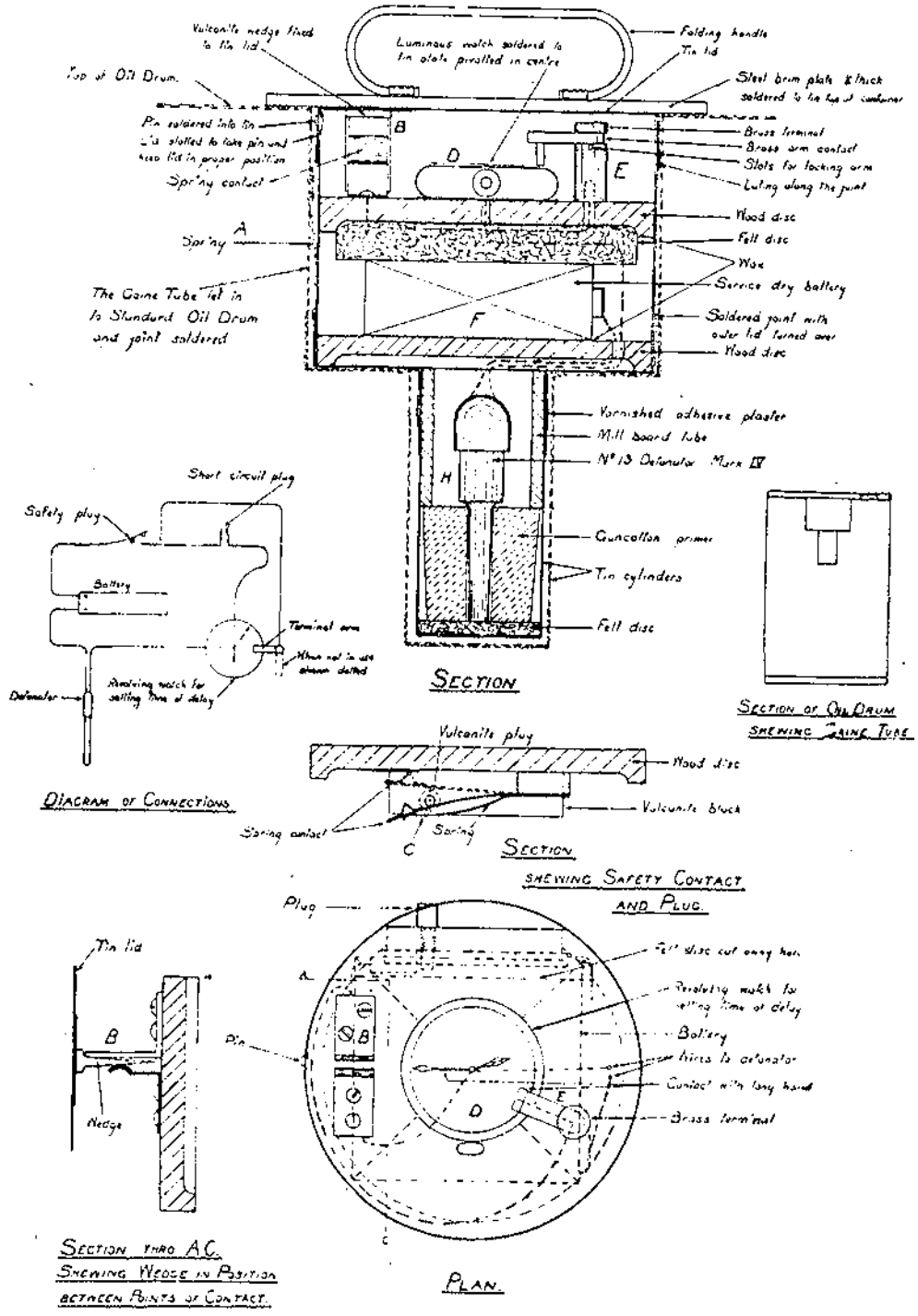
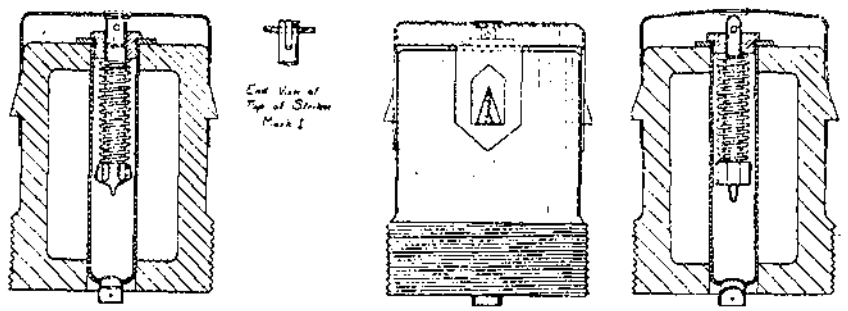


Fig. 1. Plate XXII.

ADAPTED NEWTON FUZE FOR 2-INCH T.M BOMB.



SECTION MARK I LIGHTER. ELEVATION SECTION. MARK II LIGHTER

ADAPTED NEWTON FUZE WITH MILLS STRIKER FOR 2-INCH T.M BOMB.

REVISED PATTERN.

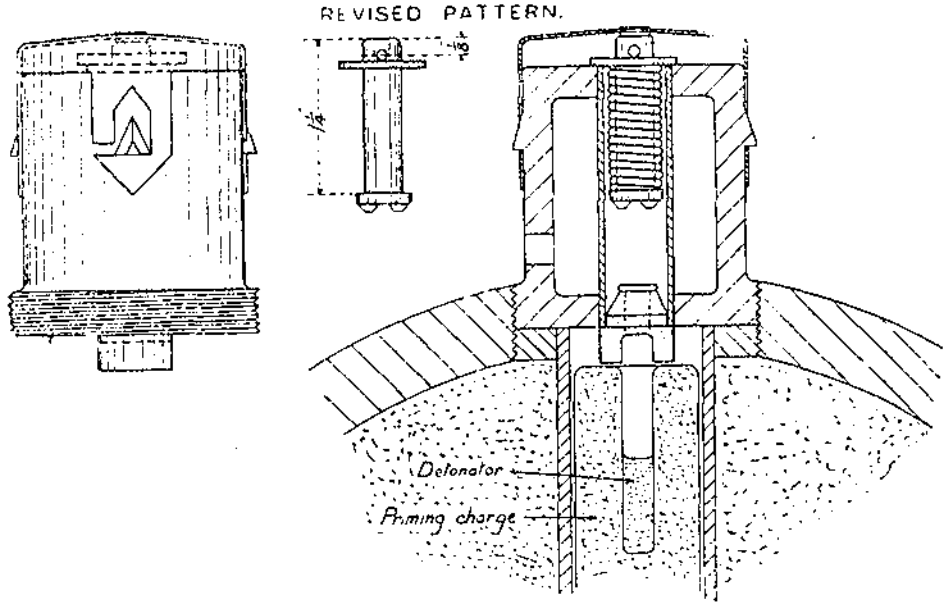
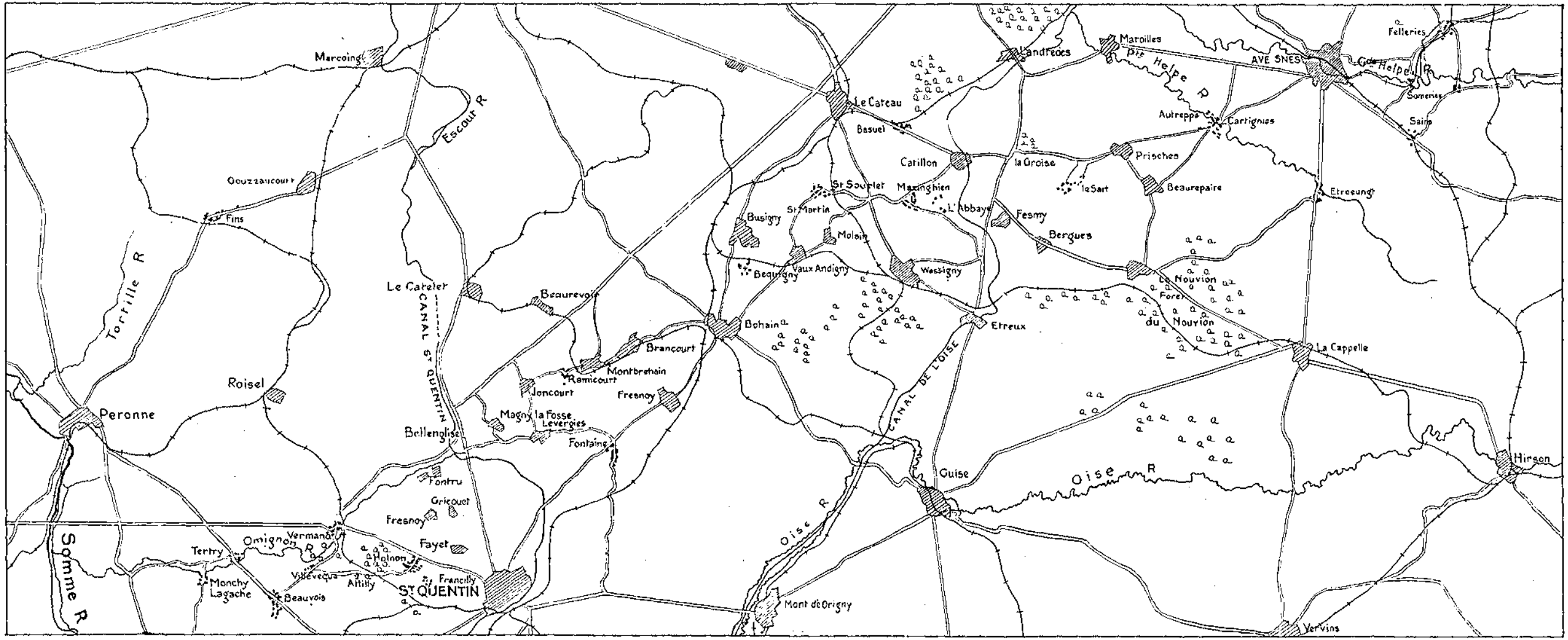


Fig. 2.

THE FINAL ADVANCE 1918

MAP 10.



Scale $\frac{1}{250,000}$

Miles 5 4 3 2 1 0 5 10 Miles

Of the attached Infantry, the Durham Light Infantry were at the horse lines and took no part in the day's fighting; the West Yorkshire detachment, under their officer, took a wrong turn and were not seen again, but the Essex Regiment party, under a Sergeant, reached their allotted positions and behaved with the greatest gallantry throughout the fighting.

The bombardment continued with unabated fury for five hours, but luckily the Company was well extended and was able to avoid serious casualties. Several casualties had occurred at the horse lines, and teams were sent forward to remove Tool Carts, etc., from the forward billets. On Captain Langley leaving to take command of the Company, the transport was put under the orders of Lieut. Hudson of the 459th Field Company.

At midday there a lull in the shelling of the Corps Line, which enabled the Company to be reorganized. The situation at this time was as follows:—The 18th Brigade was still holding on to its positions in the Reserve Line, but the right flank was gone, and on the left the 71st Brigade was holding a defensive flank thrown back from the Reserve Line to the Corps Line at the old Company billets. The 12th Company were in the Corps Line in front of Morchies with a company of the 11th Battalion Leicestershire Regiment, on their left and 11th Essex on their right. The Company was organized in section posts, each with four or five fire bays, there being two sentries per section. The 11th Essex attached infantry were used to keep touch with their own battalion on the right, and to bring up ammunition from behind Morchies. In this latter work they behaved most gallantly, twice moving up through the shell-swept village. The sergeant was subsequently awarded the D.C.M.

Heavy Losses.—At 1.0 p.m. the bombardment reopened and increased in intensity till 3.0 p.m., continuing with terrific violence till five o'clock and then gradually dying down until by 6.30 p.m. there was comparative quiet. During this period the Company suffered heavily as there were gun pits in front and Morchies village behind their section of trench, and, owing to the arrival of reinforcements on the flanks, they were unable to extend outwards as had been done in the morning.

Situation at 4.0 p.m.—Meanwhile the situation had become most critical. The 18th Brigade, although still holding its positions, was being gradually surrounded, and by 4.0 p.m. the enemy was established on the Lagnicourt Ridge and was threatening the Corps Line near the Beugny-Lagnicourt road. On the right also the Germans were advancing on the Corps Line through the 51st Division trenches.

At dusk a mist came down and a retirement to the Corps Line was ordered, the last troops reaching the trench at 7.25 p.m. The enemy followed up rapidly, and a few moments later his patrols appeared

on the far side of the wire. The Sappers, who at last saw a chance of "getting some of their own back," opened rapid fire and quickly drove them off. Our men then went out and closed the gaps in the wire left for the retreating troops.

At 11.0 p.m. the Line was reorganised, and the Company, together with Sections of the 459th and 509th Field Cos., were withdrawn to a position along the Vaulx-Beugny Road.

March 22nd.—A comparatively quiet night was spent, but at 5.0 a.m. the men were moving again. It was now decided to strengthen the position between Morchies and the Army Line, and accordingly a strong point was laid out, commanding the valleys up from Bois de Vaulx and Maricourt Wood, with a good field of fire. Work was begun at 6.0 a.m., tools and wire having been collected from Beugny, and after a few hours an effective rallying point for 200 men had been constructed.

By about 10.0 a.m. the enemy had broken through the Corps Line and was forcing his way into Vaulx. Orders were then received to form a defensive flank facing the village, and a line was taken up about a mile to the North of Beugny, astride the Vaulx road.

The attack continued throughout the morning, and at 2.0 p.m. all the troops west of the Beugny-Lagnicourt Road began to retire. In view of this situation the Company wheeled round to face the retreating infantry, who were very disorganized with few officers and little ammunition.

12th Company hold the enemy's attack.—With some difficulty, however, the officers of the Company rallied them, and they began once more to advance. An extended line was now taken up some 300 yards behind the Vaulx-Morchies Road, with the left flank back, to connect with the troops retiring from Vaulx, and the right flank on the strong point built earlier in the day.

During the afternoon the enemy brought up field guns to the high ground north east of Vaulx and began shelling the position over open sights at 2000 yards' range. Their Infantry continued to advance up the Vaulx valley, and the troops on either flank of the Company fell back once more. In spite of its isolation, the Company, together with about 60 Infantry under the command of the Sapper Officers, still remained in this position facing north east. Heavy fire was directed against large bodies of the enemy advancing up the valley south east of Vaulx, and all attempts to cross the Vaulx-Morchies Road were frustrated, thus preventing the Germans from pushing on to Beugny and so cutting off the 18th and 71st Brigades who were fighting behind Morchies.

The fighting continued during the afternoon and evening, and although the Company had been isolated since four o'clock and had been attacked not only by enemy infantry and artillery but also by low flying aeroplanes, the men never wavered, but continued

fighting steadily till 6.30 p.m., by which time there was a great lack of ammunition. The situation was also serious. On the left the Army line was being attacked over a mile in rear, and on the right Morchies had been taken and the line was being pushed back behind the Bapaume-Cambrai Road. The Company was therefore withdrawn to the Army Line, where they dug in with 25th Division troops on either flank, remaining there till midnight, when they were withdrawn.

Losses.—During the two days' fighting the 12th Company had suffered heavily, for, out of an effective strength in the line of 5 officers and about 100 other ranks, the casualties had been 2 officers and 13 other ranks killed, 30 other ranks wounded and 7 missing. The attached Infantry casualties were 1 officer and 12 other ranks missing and 6 other ranks wounded. Two Tool Carts and the Technical Wagon had also been lost.

Honours Awarded.—The Company was subsequently specially mentioned in both Brigade and Divisional Reports for the part they had played in the fighting of these two days. Individual acts of gallantry are difficult to pick out. On the 21st Sergeant Fern (who was wounded), and Corporal Bryden of Headquarters, had remained under heavy fire with four wounded men and the Company stores. As the enemy began to approach, Sergeant Fern sent Corporal Bryden back with the secret papers, and, after evacuating the wounded men, retired himself saving what he could. Sergeant Fern was awarded the Distinguished Conduct Medal and Corporal Bryden the Military Medal. Also for their conduct during the operations Captain Langley was awarded a Bar to his Military Cross and Lieut. Veitch the Military Cross. In all, about eight Military Medals were won, while several other men were mentioned in Despatches.

After being withdrawn on the night of the 22nd-23rd the Company marched across country to Biefvillers and thence to Achiet Le Grand where they arrived at 6.0 a.m., and were allotted quarters in Buchanan Camp, all being footsore and dead beat after the nine mile march on the top of the heavy fighting of the last two days. At 9.0 a.m., however, they were roused once more to 'stand to,' though nothing further happened.

Move to the North.—On March 24th the Company marched to Puisieux and entrained, arriving at Mondicourt the next day, afterwards moving on to Peselhoek where they arrived on the 26th, and marched again the same day into camp at Elverdinghe.

The next day they marched to St. Jan ter Biezen and on the 28th to Eeke, south of Steenvoorde. The company at once set about reorganising and re-equipping, no light task after the losses they had sustained, for not only had two complete Tool Carts and the Technical Wagon been lost, but also nearly all the stores and the men's kits. After some days, however, many of the casualties had been replaced and things were once more becoming 'ship shape.'

On March 29th H.M. the King visited Steenvoorde to congratulate the 6th Division on its work in the recent retreat, and on the 30th General Sir Herbert Plumer, commanding the Second Army, visited the Company and congratulated the men in glowing terms on the part they had played.

The Salient Once More.— On April 3rd the Company moved into the Ypres Salient once more, marching from Ypres to 'Sapper Camp' near Potijze, the scene of their labours in 1915 and 1916. The work on which they were employed was chiefly in the Reserve Line, and besides the old mud and drainage problem, the work consisted almost entirely of the erection of reinforced concrete pillboxes and shelters.

On the 10th the enemy attacked to the south of the Divisional front and caused a retirement, the 6th Division having to fall back to conform with the new line. The Company was, therefore, employed on the preparation first of this line, and then of a new line from Zillebeke Lake to the point where the Messines Road crosses the Canal south of Ypres, which was dug and wired with a complete line of reserve strong points. Other important work was the preparation for demolition of bridges, dug-outs, water supply and roads in case of retreat. These preparations were carried out all over the area south east and south of Ypres.

On April 16th, the Divisional front having been changed, Company Headquarters and Nos. 1 and 2 Sections moved to a farm half a mile south of Vlamertinghe, No. 3 and 4 Sections moving to forward billets in the Ramparts near the Lille Gate. The line was now back to the 1916 defences, and even behind them in places, and the Ramparts once more became extremely unpleasant! On the 21st four other ranks were killed and five wounded by a bomb which fell at the forward billet.

During the middle and end of April constant attacks were carried out by the enemy and in consequence the Company had frequently to 'stand to.' Ypres and the neighbourhood were constantly having heavy concentrations of gas put down upon them, in consequence of which the gas proofing of dug-outs and cellars formed a large item in the work of the Company.

About this time the enemy captured Mt. Kemmel, and thus had complete observation of the country all round. The Sections at Headquarters, therefore, had at once to set about camouflaging roads and all work. Several miles of really substantial camouflage on hop poles 12 feet high were therefore erected on nearly all the roads in the neighbourhood.

Demolitions prepared.—On May 3rd the sluice gate of Zillebeke Lake was blown up in order to flood a large tract of country to the south, in anticipation of an enemy advance. At one spot, however, a light railway embankment diverted a considerable volume of water into the trenches occupied by an unfortunate infantry

battalion. This battalion was, needless to say, avoided very carefully after this by the officer who had carried out the demolition!

The remainder of the month was a period of anxiety owing to another heavy German attack being expected. Work was therefore pushed on feverishly, and the forward area was strengthened with machine gun posts, strong points and wire, and the back areas with new lines of trenches and breastworks.

During April and May, owing to constant enemy attacks and demonstrations, the Company was frequently ordered to 'stand to,' although they were not again called upon to take an active part in the defence.

On June 9th the Company was relieved by the 11th (Field) Company (33rd Division) and marched back to rest billets near Poperinghe, where they remained training until the 25th. A comprehensive sports and training programme was organized, culminating in a sports competition, including driving and section drill, which was judged by the C.R.E. (Lieut. Col. H. A. L. Hall, M.C.), and which was won by No. 1 Section (Lieut. Vachell).

Dickebusch Sector.—On the 25th the Company moved up and took over the Dickebusch Sector from the 28/3 Compagnie du Génie (46th French Division). Company Headquarters and Nos. 1, 2 and 3 Sections went into Lanbouver Farm while No. 4 moved to forward billets north west of Dickebusch. The enemy here held a most commanding position in Ridge Wood, which necessitated practically all work, even on rear lines, being done at night. On July 14th, however, the 18th Brigade carried out an attack on Ridge Wood, which not only captured its objectives, but also established a superiority in moral over the enemy which was subsequently never lost.

The work in this sector chiefly consisted of the improvement of the defences by means of dug-outs, machine gun emplacements and the erection of pillboxes, many of which were of the 'Moir' pattern, consisting of concrete blocks and steel roof. Several tunnelled machine gun emplacements were also constructed in the banks of Dickebusch Lake. A Reserve Line was also constructed, with the help of large infantry parties, just east of Zevecoten and Ouderdom, and a considerable amount of help was accorded the R.F.A. in work on their battery positions.

On July 5th Captain Langley left to take up the duties of Adjutant to the C.R.E., Lieut. Noble becoming second in command.

U.S.A. Engineers Trained.—One feature of the work in this sector was the training of two platoons of the 102nd American Engineers, who were attached to the Company from July 25th to August 18th, and with whom a very good liaison was established.

Move to Somme Area (See Map 10).—On August 21st, the 6th Division was relieved by the 27th American Division, D Company,

1st Battalion 102nd U.S.A.E. taking over from the 12th Company, who withdrew to rest at Wizernes near St. Omer. Here they remained, carrying out training and musketry on the range at Lumbres, until the 29th when they moved to Moulle. On September 1st they marched to Arques and entrained, proceeding to Bonnay on the Ancre, where they remained carrying out further training from September 2nd to 11th. On the 11th they marched to Vaux sur Somme and the next day moved by bus to Tertry for further work in the line. Company Headquarters and two Sections were in Tertry, while two Sections were forward between Villevèque and Atilly. The front line at this time ran along the east side of the St. Quentin and Holnon woods.

On the night of 17th/18th September, Lieut. Veitch laid out a tape line as a 'jumping off point' for the Divisional attack at dawn the next morning. The work was done under extremely heavy shell fire and in strong concentrations of gas, but was completed satisfactorily, and for his bravery Lieut. Veitch was awarded a bar to his Military Cross.

Unsuccessful attack.—The next day Nos. 3 and 4 Sections were with the R.F.A., in order to clear tracks and construct bridges, Nos. 1 and 2 being kept in Reserve, as it was intended that they should move forward for consolidation after the attack. The attack however, was a failure, only very little progress being made. During the next two days the 18th Brigade launched further attacks in which the Company participated, consolidating captured ground and making reconnaissances of wells and dug-outs. Holnon village was eventually captured on the 20th.

During the next week the Division carried out further attacks on the high ground north east of Holnon, eventually making good the ground on the 26th. The 12th Company again took part, helping to consolidate the ground won.

On the 29th the Division was relieved by the 47th French Division, and the Company moved back to Tertry where they remained for four days resting and training.

On October 4th the Division moved into the line once more, the Company going into bivouac in fields west of Bellenglise, and working for two days on repairs to cellars and captured dug-outs for use as Divisional Headquarters. On the 6th, Company Headquarter moved to Magny la Fosse and two Sections forward into gun pits near Presselles Farm.

Further Attacks.—The next night forming up lines were taped out for the Divisional attack on the morning of the 8th, with which parties went forward to consolidate, repair roads and wells, and reconnoitre. This was repeated for another attack on the morning of the 9th. This attack captured Bohain, a small town in which civilians were found for the first time during the advance. The

12th Company parties were about the first troops in the town, and in consequence were given an extraordinarily cordial welcome by the inhabitants.

Craters and Mines.—The streets in Bohain had been heavily mined, about a dozen large craters having been blown. Many cellars also had delay action mines in them, calling for very skilled and careful work in their detection and removal.

On the evening of the 9th the Company moved forward to Montbrehain, and early on the 11th moved up to Bohain and immediately began work on the craters in the roadways. Fortunately there was a large dump of German engineer stores at Bohain which helped the reconstruction a great deal, for there were no infantry parties available, and the Company worked almost continuously for several days before the work was completed. Reconnaissances and repair of roads east of Bohain were also carried out.

On the night of October 16th the Company taped out forming-up lines for the 18th Brigade attack next morning, with which repair and reconnaissance parties were sent forward.

On the 19th a lot of repair work on the wells and roads in and to the east of Vaux Andigny was carried out, and the next day the Company moved up to St. Souplet. During the next two days repairs and reconnaissances were carried out in the area east of the River Selle.

On the night of the 22nd/23rd Lieut. Horne laid out tape lines for an attack which was to take place the next morning. The work was carried out under an extremely violent enemy bombardment with high explosive and gas shell. Lieut. Horne was wounded early, but, after having his wound dressed, he returned and completed the work, which was of the greatest importance as the attack was to be delivered in the dark. That the attack was entirely successful must in a large measure be attributed to Lieut. Horne's courage and devotion to duty. He subsequently received the Military Cross.

The attack was again followed up by reconnaissance and repair parties. On this day Lieut. Vachell carried out some very daring and gallant reconnaissance work in an area which was being heavily bombarded. For this he received a bar to his Military Cross.

This attack was followed by another on the 24th, which brought the Division up to the bank of the Sambre-Oise canal. Attention was then turned to the repair of the metre gauge railway from Catillon to Basuel, and further road repairs. After this, until the end of the month, a considerable portion of the Company was engaged in constructing floating foot-bridges for an attack on the Sambre-Oise canal early in November. Although this attack was not carried out by the Division, the footbridges were used by the 218th Field Company for the 32nd Division's attack.

On October 30th the Officer's Mess was hit by a shell, and 2nd Lieut. Hanstock, who had only just joined the Company, died of the wounds he received.

On the 31st the Company were relieved by the 218th Company, and marched back in the early morning to rest billets at Fresnoy le Grand. Here they remained for five days, training and making targets for the use of the 18th and 71st Brigades.

On November 5th the Company moved to Busigny and on the 7th to Catillon, carrying out work on bridges over the canal, and repairs to roads and wells, and moving forward again on the 10th to Autreppes near Cartignies.

Armistice declared.—Early the next morning a message was received stating that an Armistice had been declared and that hostilities would cease at 11 o'clock that day, thus bringing 4¼ years of fighting to a close.

Repair Work on Roads.—On the 12th the Company moved forward to Avesnes where further repairs to roads, and the filling in and bridging of craters was carried out until the 14th, when they went on to Felleries. While here, two important and difficult pieces of work were carried out. North east of Felleries the railway crosses the road to Solre le Chateau by means of a heavy plate girder bridge of about 36 foot span. The Germans had fired charges at one end, dropping that end into the road, which was thereby blocked. The 12th Company was ordered to clear the road for traffic.

It was found that there were no jacks or other stores available for raising the fallen end on to a trestle, and it was not desirable to cut the bridge up by means of explosives. The only alternative, therefore, was to haul it up into a vertical position standing on one end at the side of the road, thereby leaving all but 6 feet of the road clear. This operation took a considerable amount of care and forethought, for only the light tackles of the 12th and one other Field Company were available. It was, however, accomplished successfully and the bridge secured in position.

The other work done was the repair of the road and the culvert about 1½ miles east of Felleries. The road, which is here on an embankment about 20 feet high, crosses the Felleries rivulet by a brick culvert. This had been mined, though only the charge on one side of the road had gone, the remainder of the culvert being blocked as a result of the explosion, thus damming the stream, which had formed a lake 15 to 16 feet deep and several acres in extent. It was necessary to let this water escape slowly down the valley, or enormous damage would have been done. A shaft was therefore sunk through the side of the crater down to the undamaged part of the culvert and was carefully lined with mine cases, and down this the water was allowed to escape slowly. When it was all drained off a new culvert was put in, the embankment being reinforced with

large tree trunks, above which the roadway was filled in and well metalled. The Company gained considerable praise from the Chief Engineer, Fourth Army, for this work.

This completed a period of extremely hard and trying work during the recent advance. Much of this work had been of a most dull and monotonous character, and had often been carried out under heavy fire. Four or five hours' work would invariably be done either before or on the top of a day's march, and rest and sleep were somewhat elusive quantities, often being conspicuous by their absence. All ranks, however, had worked willingly and uncomplainingly, and their efforts had at last been crowned by Victory.

March to the Rhine.—On November 20th the March to the Rhine began with a move to Solre St. Gery (13½ miles), moving again on the 22nd to Erpion (6 miles), and on the 24th to St. Aubin (13½ miles). Here they remained, carrying out training until the 30th, and were inspected by the G.O.C. 6th Division (Major General T.O. Marden, C.B., C.M.G.) on the 29th.

The remainder of the march is best given in the form of a table, as follows :—

December.				Miles.
1st	St. Aubin	to	Ermiton sur Biert ..	8
4th	Ermiton sur Biert	,,	Evrehailles	13½
5th	Evrehailles	,,	Chateau de Fontaine ..	13
6th	Chateau de Fontaine	,,	Havelange	7
8th	Havelange	,,	Terwagne	7½
9th	Terwagne	,,	Comblain la Tour ..	13½
11th	Comblain la Tour	,,	Lorce	9
12th	Lorce	,,	Stavelot	13
13th	Stavelot	,,	Weismes (Germany) ..	10
14th	Weismes	,,	Elsenborn Barracks ..	7
19th	Elsenborn	,,	Montjoie	8½
20th	Montjoie	,,	Olef	16½
21st	Olef	,,	Roggendorf	9
22nd	Roggendorf	,,	Elsig	9
23rd	Elsig	,,	Erp	12

The march to the Rhine was now completed and the 6th Division settled down for the first time for five years to a Christmas under peace conditions.

For the remainder of December and January, the Company carried out training in more or less the same manner as during rest periods in the War, doing a certain amount of drill, musketry, &c., as well as works on billets for the Division.

On January 2nd the Company moved to Borr and on the 4th one section was attached to the 16th Brigade at Kettenheim and another to the 18th at Lechenich. Extensive reconnaissances were also carried out by the officers to obtain information regarding roads,

railway stations, bridges, waterways, electricity, water supply and factories in the occupied territory.

During February and March the chief work was on hutting, baths, incinerators and other billet and camp improvements, training and sports being also largely carried out.

On March 23rd the Company moved to Lechenich and on April 3rd marched back to Brühl, Lt. Kerr and a detachment remaining to hand over the work at Lechenich to the 93rd (Field) Company.

Divisions renamed.—With the departure of most Regular Units a reorganization of the Army of Occupation now took place, the old Divisions being broken up and new ones formed.

On April 5th the G.O.C. Midland Division (which had taken the place of the 6th) inspected the Company, and the C.R.E. of the 6th Division (Lieut. Col. H.A L. Hall, M.C.) made the Company a farewell speech.

Demobilization was now proceeding very fast, and during the early part of April large numbers of officers and men were sent Home or to other units for demobilization, and on April 18th the Company was reported as down to Cadre 'A.' There were now no officers and very few men left who had known the Company for more than a few weeks.

During the remainder of April and most of May the Company was chiefly occupied in sorting and checking equipment, cleaning up, and a few minor barrack works.

Return Home.—At last the Company was ordered Home, and on May 23rd the Cadre entrained at Brühl station. They arrived at Antwerp the next day and proceeded to the embarkation camp, where they remained four days.

On the 29th the Company, together with the Cadres of many other Regular Units, embarked, the personnel on the S.S. Arbroath and the transport on the S.S. Huntsclyde. Both vessels arrived at Tilbury the next day, when the Company disembarked, having been on Active Service for four years and nine months. Of the Cadre who disembarked, there was no officer or man who had left England with the Company in 1914.

CHAPTER VII.

Ireland.—The Advance Party left for Ireland on May 30th, while the remainder went into camp at Purfleet for a few days, after which they proceeded to their pre-war Command, arriving at Limerick on June 12th. Here they were allotted quarters in Ordnance Barracks, the old Artillery barracks, in which were already the 415th Lowland Field Company T.F. The Cadre was then amalgamated with this Company, the whole becoming the new 12th (Field) Company.

Demobilization was still going on apace, and it was not long before practically all the men who had been with the Cadre or the Territorial

Company had left, and had been replaced by men on normal regular engagements, the majority of whom were recruits.

Irish Rebellion.—There was not much chance, however, for the Company to arrive at any complete state of organization, for very shortly the Irish Rebellion broke out afresh, Limerick being a particularly hot Republican centre.

The Company now found itself scattered in small detachments, varying from two to fifteen men, over an area comprising the whole of Cos. Clare and Limerick, as well as more than half Kerry and Tipperary. The work on which they were engaged consisted of hutting, defences of billets and Police barracks, as well as minor routine works on barracks, etc. Many reprisals were also carried out. These usually took the form of demolishing houses of leading Sinn Feiners in the neighbourhoods in which outrages occurred.

Owing to more than half the Company being always on detachment, and also to the unsettled state of the country, it was impossible, during the two and a half years that the Company was in Limerick, to carry out any combined work in the way of either training or sport, both of which consequently suffered heavily.

On many occasions officers and men came into violent contact with the Rebels. On one occasion, on June 6th, 1920, while on his motor bicycle on his way to Castle Fogerty, 2nd Lieut. R. R. Gillespie was held up and attacked by some twelve Sinn Feiners. He at once drew his revolver and replied to their fire, and, in spite of being slightly wounded, succeeded in wounding two or three of his assailants and putting them all precipitately to flight. He was then attacked by two more men from behind, one of whom succeeded in hitting him in the thigh, but they also bolted when he fired his last two rounds at them. Lieut. Gillespie then rode off, but was knocked off his motor bicycle by some cattle as he was unable to apply the brake owing to his wound.

He then walked a mile and a half to obtain a conveyance, passing several parties of Sinn Feiners on the way, all of whom allowed him to pass unmolested although he had only an unloaded revolver in his hand.

The following is an extract from 6th Division Orders dated 10th June, 1920:—

294 *Congratulatory Order.*

Please convey the congratulations of the G.O.C. in C. to Lieut. Gillespie, Royal Engineers, on his gallant conduct at Drombane.

The Divisional Commander wishes to express his great admiration of the gallant conduct of Lieut. Gillespie, Royal Engineers, in fighting and routing a body of armed men when

he himself was wounded, and wishes to convey his hearty congratulations on his act and escape. This is a brilliant example of what initiative, presence of mind and gallantry can do.

Ordnance Barracks were shared from time to time with various other units, chief among which were the 43rd Oxfordshire Light Infantry.

In July, 1921, the so called "Truce" was declared, and, in the south, active operations on both sides having ceased almost entirely, things became considerably quieter.

Evacuation of Southern Ireland.—During January, 1922, rumours about the movement of units to England began to spread rapidly, and it was not long before rumour materialized into fact, and orders were received.

Move to Aldershot.—Preparations for the move of the Company were begun at once and the Advance Party left for Aldershot on February 11th. The Company still remained split up, however, until late in February, when the detachments came into Limerick on the evacuation of the various stations.

On the morning of February 28th, the Company, under the command of Captain A. J. Cruickshank, D.S.O., finally left Limerick, and sailing from Waterford to Fishguard, arrived at Aldershot, with the 38th Company, on March 1st.

Here, after nearly three years, the whole Company found themselves together once more, and having been allotted, with the 23rd and 26th Companies, to the 1st Division, were able to reorganize and carry out the normal annual training for the first time since the War.

During the Fieldworks course, the Company were selected to carry out experiments with a new type of Heavy Pontoon Bridge with steel superstructure, and with the Martel Box Girder Bridge.

Chanak.—The 12th Company were not to remain in peace long, however, for, on September 18th, owing to the increasing probability of trouble in the Near East and the necessity for increasing the garrison at Constantinople, orders were suddenly received to prepare for service overseas, at war strength in officers and peace strength in other ranks. The work all went smoothly, and on September 22nd the Company, under the command of Major A. H. Bell, D.S.O., O.B.E., with Captain K. B. S. Crawford and Lieuts. H. B. Foy, S.StD. Skinner, S. R. C. Shaw and P. G. Wavish, and C.S.M. R. P. W. White, D.C.M., as the Sergeant Major, entrained at Aldershot and proceeded to Glasgow, where they embarked with the 2nd Battalion Grenadier Guards on H.T. "Empress of India," on the 23rd, sailing for Chanak the same day.

The dispatch with which the units, who had been suddenly warned for service, got ready, was mentioned in the following Aldershot Command Order, dated 23rd September, 1922 :—

1242 *Despatch of Drafts* (*Appreciation*).

The General Officer Commanding in Chief wishes to record his appreciation of the energy, good organization and keenness displayed by the Units, Services, Corps and Departments (particularly the R.A.O.C.) concerned in the rapid preparation and despatch of units and drafts overseas from the Command.

He wishes especially to bring to the notice of all ranks the two instances below, which are typical of the fine soldierly spirit and readiness in emergency which has ever been an asset of the British Army :—

2nd Battalion Grenadier Guards.

12th Field Company, Royal Engineers.

1st Infantry Brigade Signal Section (from 1st Divisional Signals).

September 18th (Monday).

20.30—Received orders to prepare for immediate service overseas. Drafts to complete to be prepared for.

September 21st (Thursday).

18.55—All vehicles, baggage, stores, ammunition loaded on train.

September 22nd (Friday).

21.25—Main bodies entrained.

* * * * * *

The transport arrived at Chanak on October 2nd, and the Company disembarked at Aeroplane Pier and unloaded stores that evening, arriving in camp very tired at 6.0 a.m. on the 3rd.

The Company now formed part of the 28th Division which was in this area, and which was commanded by Major General T. Marden, C.B., C.M.G., Lieut.-Colonel C. B. O. Symons, C.M.G., D.S.O., being the C.R.E.

The Company was at first under canvas just north of the town, but as winter approached they were moved into rather indifferent billets in the same area.

No horses had been brought with the Company from England, but shortly after its arrival 49 draught horses, mules and riders were issued.

The 12th Company took over works from two Sections of the 55th (Field) Company, who returned to their Headquarters in Constantinople.

Three days after arriving, No. 3 Section (Lieut. Foy) moved on detachment to Tekke, about two miles north of Chanak. They did not rejoin Headquarters until January 3rd, 1923.

On November 4th, No. 1 Section (Lieut. Skinner), was sent to Soghanli Dere on the Gallipoli Peninsula, where a battery of 8" Howitzers was encamped, to put up Nissen huts and other buildings. No. 2 Section (Lieut. Wavish), joined it on January 3rd, 1923, returning to Chanak on February 23rd, while No. 1 remained on until March 29th. In addition to hutting, this detachment started a masonry and pile pier near Soghanli, intended for the evacuation of heavy guns and ammunition. This work was eventually finished by the 24th Company.

The Military situation at this time was peculiar. A hastily entrenched line had been taken up about a mile from Chanak on the south and east and extending to the sea shore about three miles to the north. The trenches had been dug and wired by infantry and sailors, and wire was being added every day. The Turkish picquets were, in some places, only a few yards from ours, so that sentries were within speaking distance and in full view of one another.

During the winter the Company was chiefly employed on repair and maintenance of water supply, piers and roads, work on billets, such as erection of cookhouses, etc., erection of shelters near the front line and building retaining walls along the Nagara road (about $2\frac{1}{2}$ miles long), which road was also remetalled by an Armenian contractor under R.E. supervision. Electric light and hot water apparatus were also installed.

The next spring, the troops were again all moved out under canvas to avoid the Sandfly Fever which had previously been prevalent. This entailed considerable work on water supply by the Field Company, which included not only the upkeep of the old supply system, but also the erection of three new pumping stations, in which Merryweather pumps were installed, and the laying of a large amount of 4" steel piping.

The various piers in and around Chanak were a fruitful source of trouble, the timber being quickly demolished by some marine insect, greatly assisted by the bad seamanship of the Greeks. This entailed a very large amount of piledriving.

A rifle range of 20 targets was constructed at Nagara for the infantry, and another for the artillery south of the Koja Chai.

A large amount of work was also expended on the repair of Jibidelik Farm.

In all these works the Company was assisted by local labour, both skilled and unskilled, consisting of Russian refugees, Armenians, Greeks and the Black Sea Labour Corps, all of whom did useful work.

On March 17th Major Bell became C.R. E. as well as O.C. Company, and on July 24th Captain Crawford took over the duties of Adjutant in addition to his own.

The Peace with Turkey was eventually signed on July 23rd, and orders for the evacuation were not long in being issued.

On August 18th Lieut.-General Sir C. H. Harington visited Chanak, and after inspecting the Camps, thanked the men for their good work.

All the 4" steel pipes had to be returned to England, but the remainder of the stores were purchased by the Turks. The piping was therefore taken up as soon as the camps were vacated.

On September 13th the Company moved to a camp near Aeroplane Pier, preparatory to embarking on the 18th on the transport "Hecuba." A few days before, the following message had been received from Colonel A. S. Cotton, C.M.G., C.B.E., D.S.O., who had taken General Marden's place as Divisional Commander :—

> "In bidding goodbye and Godspeed to the 12th (Field) Company Royal Engineers on the break up of the 28th Division, Colonel Commandant A. S. Cotton desires to place on record his appreciation of the good work cheerfully and invariably performed by the Company frequently under very trying conditions.
>
> He wishes Major A. H. Bell, the officers, W.O.'s, N.C.O's, and men the very best of luck, and hopes that it may be his good fortune to have this fine unit at some future time again under his command."

Return Home.—On the day of embarkation the following telegram was received from Lieut.-General Sir C. H. Harington :—

> "Thank you and all ranks of your Unit for all you have done and wishing you every success. I am very proud to have had your Unit under my Command."

The voyage was a particularly good one. The "Hecuba" anchored in Southampton Water on September 30th, and the Company disembarked the next day, and arrived at Aldershot about 1.0 p.m. on October 1st, proceeding to Gibraltar Barracks. Most of the men then proceeded on a month's leave.

The Company now rejoined the 1st Division, after almost exactly a year's absence.

The year 1923 closed with the usual Christmas Festivities.

THE EXPERIMENTAL PONTOON EQUIPMENT.

Contributed by the R.E. BOARD.

INTRODUCTION.

Now that the new equipment has nearly reached the stage of production, it is thought that a history of the various stages of its development and the investigations that have led up to the final designs may be of interest.

The length of time required to carry out the necessary experiments and trials to evolve a new equipment will be realised from the following notes.

Certain information has already been published in the *R.E. Journal*, but it is thought that a complete *resumé* of the position would be more useful, and this paper embodies much of the previous articles (October, 1920, and September, 1921).

DEVELOPMENT AFTER 1918.

At the date of the Armistice the pontoon equipment was essentially the same as in 1914—a slightly improved pontoon of the same dimensions as before, some experiments in chesses and a design of wagon modified to withstand mechanical traction being the sole alterations.

To carry any transport heavier than a 2-ton axle load there were available: (*a*) a method worked out at the S.M.E. in 1914—embodied in an addendum to *M.M.E.*, but not re-published in the 1920 editions, and (*b*) the "Sankey" method, described in *M.E.*, Vol. III, p. 62.

It was clear that it would be necessary sooner or later to face the problem of an improved equipment capable of dealing with all loads up to the tanks.

At the date of the Armistice it must be remembered that the latter implied a monster of 35 tons, which rendered the problem a far greater one than it is at the present moment, when the tendency is greatly to reduce the weight of the fighting tank.

With this in view the first experimental work undertaken was to ask Professor Inglis to design a continuous steel girder, suitable for erection upon a "medium" bridge of normal pontoon equipment. Such a bridge was constructed and tried at Christchurch (described in *R.E. Journal*, October, 1920); it possessed certain mechanical defects which rendered it unsuitable in its original form.

Since, however, in the interval between the date of ordering the bridge and that of its erection it had become clear that the then existing pontoon would have to be replaced by one of greater buoyancy, the further development of this bridge was abandoned.

In July, 1920, a proposal was made to provide greater buoyancy with our existing pontoons by decking the service pontoons and strengthening the couplings, thus providing sufficient buoyancy to admit of bays of 21-ft., using 9-in. x 4-in. steel joists.

Several pontoons were accordingly decked and much attention was devoted to various methods of strengthening the couplings. Piers of these pontoons were tested for " medium " and " heavy " loads, and were found to stand up to their duty in this respect.

A bipartite pontoon was submitted to a crushing test of 100 per cent. overload without damage, and the special strengthened couplings were tested to a breaking load of about 20 tons, giving a factor of safety of $2\frac{1}{2}$.

Meantime, it was obvious that the Weldon trestle was not equal to the increased load, and a steel trestle was designed, constructed, and first tried in September, 1920.

This trestle as originally designed weighed 1,645 lbs. It was considered advisable to reduce this weight, and between October, 1921, and August, 1922, various suggestions and experiments were made. Two screw jacks were substituted for the Morris blocks, the legs were reduced to 14-ft. from 16-ft., and a special bracket was designed to give the 10-ft. variation required in height of roadway. Finally, in 1923, a nickel chrome steel transom was used, involving complete re-design of this member, with a consequent reduction in weight of 150-lbs.

The weight of the improved steel trestle is 1,200 lbs. as compared with 1,000-lbs. for the Weldon trestle; the steel trestle, however, will take an 8-ton axle load, whereas the Weldon trestle will only take a light load, *i.e.*, up to a 2-ton axle. (See Plate 1, Fig. II).

The decked-in pontoons and steel trestles went to Aldershot for trial in August, 1922.

A report was made in December, 1922, which, while holding that " any attempt to reconstruct the service pontoon equipment into such a form as to make it suitable for all grades of vehicles, must result in an equipment at once most unsuitable for quick work and light traffic, and difficult to assemble for heavy loads," went on to recommend concentration upon three bridges only, viz. :—

(*a*) Infantry Assault Bridge,

(*b*) Lorry Bridge,

(*c*) Bridges for 12 to 20-ton loads,

particularly emphasising that the normal Divisional bridge should carry lorries, and, if possible, " Infantry " tanks.

Detailed criticisms on the equipment indicated objection to decking (as adding weight, difficulty in rowing, and in keeping clear of water), to the weight generally (especially of the joists, which were of mild steel 9-in. x 4-in. x 21-ft. and weighed 441-lbs.) and to the inconvenience of the couplings (particularly in loading and unloading wagons). Many detailed criticisms and suggestions were made which proved of much value in later designs.

The steel trestle was found to be generally satisfactory, subject to certain criticisms.

Experiments were proceeded with in order to work out "cut bays" for this bridge, but, owing to the developments now to be described, these were stopped.

Early in 1921 the question of stocks of pontoons and the problem of rapid production in war time came to the front. It was realised that the construction of wooden pontoons was slow, and the possibility of producing a metal pontoon was considered, in order to supplement production in an emergency.

It was hoped that a design made of pressed steel might be practicable, to facilitate rapid production once the very expensive dies were provided, but investigations showed that the thickness of metal necessary to give the pontoons adequate strength would render the weight excessive. Consequently it was decided to design a built-up pontoon of steel, and in the first place the following conditions were laid down :—

1. Limit of weight about 86-lbs. per foot run.
2. Buoyancy as for the experimental decked-in service pontoon.
3. To be unipartite, with bulkheads.
4. To be partially or fully decked with timber decking, and if fully decked, provision to be made for man-holes. No camber to be made in the decking.
5. Same facilities for coupling together as with the experimental decked-in service pontoon.
6. The "form" to be studied with a view to offering minimum resistance to the current—sides to be vertical (not "tumbled home" as in the German pontoon).
7. The possibility of carrying it on the existing wagons to be considered.
8. The pontoon for light bridge to be capable of being used for medium and heavy bridges.
9. Saddle loading to be adopted.
10. Ease and speed of construction of "Light" Bridge to be considered as a determining factor in the design.

By this time, however, it had become more and more obvious that efforts to make the best of existing pontoons by the means already referred to were not hopeful, and while the conversion of

a number of these for trials was going on, the complete re-design of pontoon equipment was initiated.

The necessity for a bridge to carry 3-ton lorries had become more obvious; it had been found that a modified bridge using three sections of service pontoon per pier would not carry 3-ton lorries.

It was decided to concentrate on unipartite pontoons, and it was hoped that a 3-pontoon pier would carry lorries.

The investigations in connection with the proposed steel pontoon, though it has not proved entirely successful, have affected the subsequent design of the consuta wood pontoon finally adopted to such an extent that they will be given in some detail.

The design was limited, by the necessity of making use of the service wagon, to the following dimensions:—

Overall width 6-ft.; length 21-ft.; weight not to exceed 80-lbs. per man when carried.

The freeboard for a decked pontoon was agreed upon as 9-in. for normal load and 6-in. for heaviest load, and the loads foreshadowed were—on each pier—

For Light Bridge—	4½	ton.	max.— Amm. wagon and limber for 4.5 How. and team.
	3½	,,	normal—Infty. in fours in normal formation.
For Medium Bridge—	14½	,,	max.— (Foden Lorries continuous).
	10¼	,,	normal—(3-ton Lorries continuous).
For Heavy Bridge—	21	,,	max.— (medium D tanks).
	15	,,	normal—(8-in. How. drawn by 11-ton caterpillar).

Span to be determined.

The foregoing loads were based on an assumption of 15-ft. bays (wooden baulks) for light and 21-ft. (steel joists) for medium and heavy bridge.

Based upon these data several alternative schemes for the length and grouping of piers were worked out, involving bi-partite pontoons of two sizes—20-ft. and 10-ft.; 18-ft. and 6-ft.; 18-ft. and 27-ft.; and 18-ft. and 24-ft.; and also one with single 20-ft. pontoons only. All these proposals involved twinning the piers for both medium and heavy bridge.

Each of these proposals involved different dimensions for beam and depth.

After consideration of these proposals the idea of using two sizes of boats was rejected, as complicating equipment, especially not lending itself to transport upon a single type of vehicle.

A 20-ft. boat, 2-ft. 11-in. deep and 5-ft. 6-in. maximum beam, with 5-ft. deck beam, was accepted as a basis for detailed design for all purposes, and to be calculated to weigh 75-lbs. per carrier, spaced 18-in. apart. One boat to suffice for light bridge; two coupled for medium; two pairs for heavy bridge. The boats to stand total immersion, with the weight placed on a 10-ft. saddle in the centre, without distortion, and similarly the maximum dead working load when standing on a sand bed without collapsing. It would not be expected to stand the latter test without some risk of damage.

The first design produced was actually 21-ft. long and gave a calculated buoyancy of 13,044-lbs. with 6-in. freeboard. The freeboards for the foreshadowed loads given above were calculated to be $11\frac{1}{2}$ and $15\frac{1}{2}$, 15 and $19\frac{1}{4}$, $8\frac{1}{4}$ and $14\frac{1}{8}$-in., respectively, with a waterway of 9-ft. 6-in. in heavy bridge. It was calculated to weigh 2,000-lbs., *i.e.*, 77-lbs. per man with 26 carriers.

This boat was, in the first place, designed for gunwale loading. A second design was proposed with straight vertical sides and a central girder for saddle loading.

These alternatives raised the crucial question of the relative merits of gunwale versus saddle loading. Certain experiments were made, but were rather inconclusive, owing to the use of service pontoons and baulks not designed for gunwale loading. A decision, however, in favour of saddle loading was arrived at, on the grounds of greater rapidity of construction, shorter and lighter baulks in saddle loading, that gunwale loading involves each side of the pontoon being capable of carrying the maximum pier load in case of grounding, thereby involving extra weight, and of the complications involved at junctions between shore and floating bays and in securing the roadway over overlapping joists. Further, gunwale loading being of the nature of a continuous girder, presents indeterminate stresses. The merits of gunwale loading which are essentially greater simplicity of detail, facilities for adjusting length, variation in the number of roadbearers and interpolation of extra pontoons, were not considered sufficient to compensate for its disadvantages

The shape of the bow now required consideration, and an estimate was obtained from the National Physical Laboratory for experimental work on models in their tank. It was decided, however, that experiments should be made at Christchurch, with the assistance of the National Physical Laboratory, by towing various full-size shaped bows in the river, and it was agreed that such tests were more conclusive than those with models.

The shapes of bow tested were as shewn in Figs. 1 and 2.

FIG. 1.

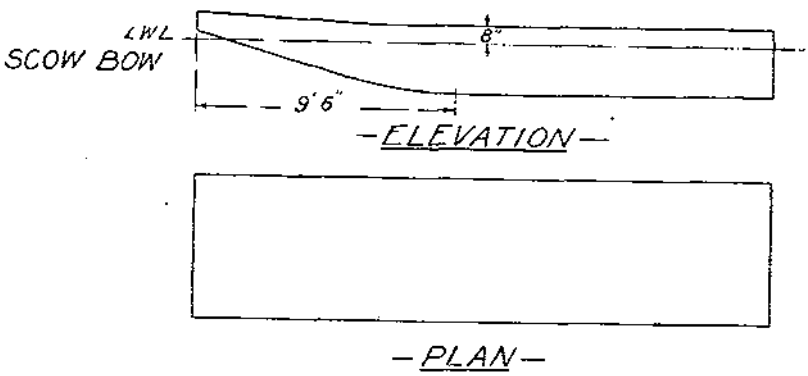
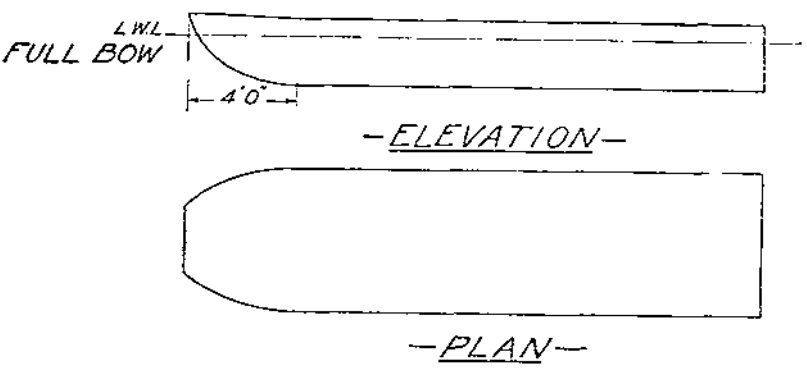


FIG. 2.



Two series of tests were carried out upon service pontoons provided with mock-up bow and stern. The first was under the direct observation of Mr. Baker, of the National Physical Laboratory, and the following is taken from the official report from the National Physical Laboratory :—

" In order to eliminate any effect due to velocity differences, the results have been put in the form of factors—

$$\frac{\text{resistance or pull in lbs.}}{(\text{velocity in miles per hr.})^2}$$

" For any limited range of speeds this factor for any form would not be seriously affected by small differences of speed, and may be considered as a criterion of resistance. The lower it comes, the better will the float be as regards anchor forces. This factor is shown in the last column of Table I, and shows the effect of difference of form fairly clearly.

"The actual speeds through the water were probably somewhat in excess of the measured speed, as the tow was not sufficiently distant from the pinnace to be clear of some wash from the slip stream of the propeller. But this effect would be the same in all, and the figures can be used for purposes of comparison, and should err a little on the safe side for quantitative work."

"The general conclusions are as follows (See Figs. 1 and 2 and Table I) :—

(*a*) The parallel stern has a high resistance compared with the "full" stern (compare (1) with (3) and (6) with (7)).

(*b*) The scow bow is better than the full bow (compare (1) with (4) and (5) with (6)).

(*c*) Twin floats are not quite so resistful as two single floats (compare $\frac{R}{V^2}$ in (5) with 2 x $\frac{R}{V^2}$ of (3) and $\frac{R}{V^2}$ in (7) with 2 x $\frac{R}{V^2}$ of (4)).

(*d*) The "full" stern loses some of its advantages over the parallel stern when used in two floats, but is still definitely better. (The drop in $\frac{R}{V^2}$ passing from trial 7 to trial 6 is 1.8. The drop in $\frac{R}{V^2}$ passing from trial 1 to trial 3 is 2.0.) The latter is for a single float and the former for twins, and the result suggests that the advantage is gained from the outer corners of the stern only, the inner corners acting for all practical purposes as blunt ended or parallel sterns. The best combination is undoubtedly the scow bow with full stern, either as single or twin floats. It is understood that the scow bow is defective as regards buoyancy, requiring 4-ft. greater length than a "full" bow to give the same buoyancy. The trials showed that the scow had been cut away more than was really necessary, the fore end being about 9 or 10-in. above the water at 4.18 knots. It is understood that with a heavy bridge the floats will be loaded some 4-in. deeper, and the form can be filled out by dropping the scow bottom 3-in., keeping its slant about the same, and leaving a vertical fore end just clear in this deep condition in a fairly rapid stream. This would go a considerable way to eliminate the buoyancy defect and should not seriously affect the resistance."

TABLE I.

Towing Tests of Bridge Pontoons. 7th and 8th July, 1921.

Pontoons towed on about 20-ft. rope behind 30-ft. motor-pinnace—

SINGLE FLOATS.

Trial.	Shape of Pontoon.	Speed m.p.h. V	Horizontal tow rope pull in lbs. R	R / V²
(1)	Full bow and parallel stern	4.0	140	8.75
(2)		3.45	105	8.82
(3)	Full bow and full stern ..	4.31†	122	6.6
(4)	Scow bow and full stern ..	4.18	119	6.81

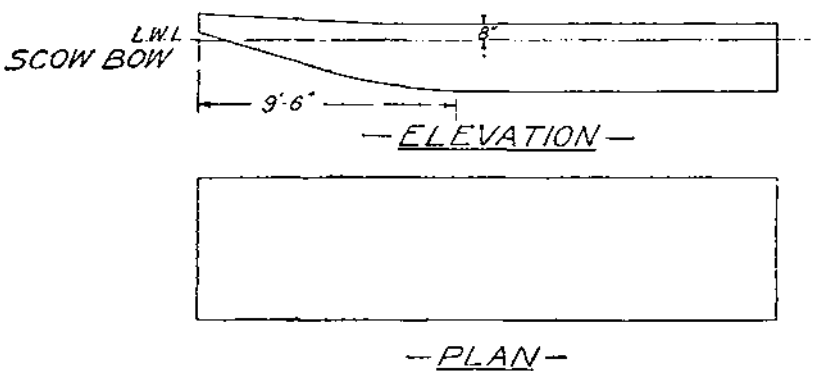
TWIN FLOATS.*

(5)	Full bow and full stern ..	3.47	154	12.8
(6)	Scow bow and full stern ..	3.73	142	10.2
(7)	Scow bow and parallel stern ..	3.67	161	12.0

Depth of water about 9-10ft.

The boats were in all cases loaded to 12-in. freeboard. The boats were towed behind a motor boat on a fixed and measured course in fairly slack water; one run up tide and one run with

FIG. 3.



* Twin floats consist of two single floats lashed together, there being only about two inches of water between them on their faying sides.

† Doubtful whether speed ought to be 5.18 giving $\frac{R}{V^2}$ 4.55

FIG. 4.

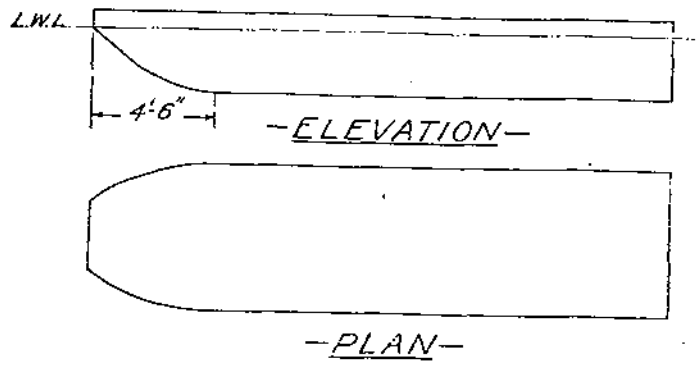
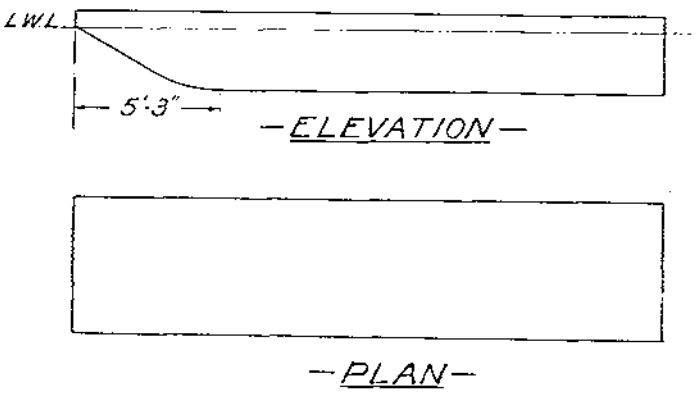


FIG. 5.



the tide were taken in each case, and the figures above are the average, so that the effect of the tide was neutralised.

The general conclusions from this report were (see Figs. 3, 4 and 5) :—

(1) The present full bow (equipment pontoon) is not good enough for speeds of current over 5 knots, as the bow waves would then be excessive and would swamp the boats.

(2) The present shape of bow is the best for use as a stern, as far as resistance to current is concerned.

(3) The scow bow (Fig. 3) is the best as far as resistance to current is concerned, but gives less buoyancy (63 per cent.). From observations of the waves, however, the scow portion could be lowered about 3-in. so as to bring the top of it to the load water line.

(4) It would appear that the best result would be obtained by striking a mean between the full type and the scow type bow, as in the design of the steel pontoon (Fig. 4) or as in an amended type, shown in Fig. 5. The difference between these two is that in Fig. 4 the bows

are turned in in plan, whereas in Fig. 5 they are square in plan. Each type gives practically the same buoyancy (81½ per cent. and 79 per cent). Fig. 4 is better for the stern, but not quite so good for the bow as far as resistance is concerned. Fig. 5 is much easier to make.

As the stern for the light bridge must be square on account of coupling, favour was given to the bow of the new pontoon in Fig. 5.

(5) A prow bow does not appear necessary, but experiments at greater speeds should be carried out to test this.

A second series of tests was carried out in a choppy sea in Poole Harbour, with bows as in Fig. 4, in comparison with the service bow. In the case of the single pontoon the towing cable was weighted to bring the direction of pull as near as possible to that of an anchor rope.

The results of the tests were as follows (See Figs. 6 and 7) :—

FIG. 6.

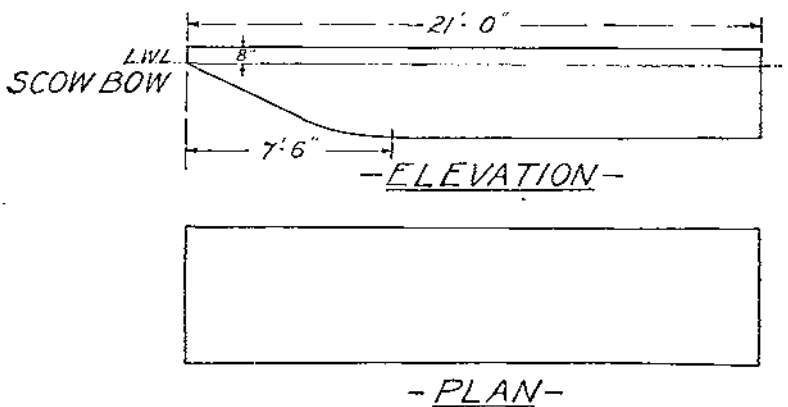
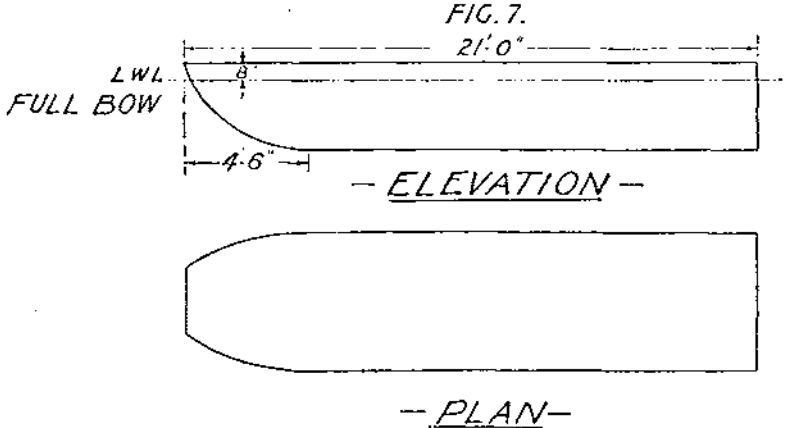


FIG. 7.



Type.	Speed (V) m.p.h.	Anchor Strains (R)	$\frac{R}{V^2}$	Free-board.	Remarks.
Single boat. Scow bow and square stern . .	4.95	222	9.1	9″	The result of one up tide and one down tide run. On the run against the waves the boat swamped at a speed of 5.1 m.p.h.
Single boat. Full bow and square stern.	4.00	224	14.00	9″	Boat swamped on up tide run at speed of 4 m.p.h., equivalent to a speed of about 4½ m.p.h. in slack water.
Single boat. Scow bow and square stern.	7.85	728	11.8	16″	Stern waves practically up to the gunwales. On the down tide run the actual speed was 8.6 m.p.h.

From the above it will be seen that the scow bow as designed is considerably better than the full bow.

In order to test the relative merits of the scow bow and full bow as a stern for medium and heavy bridge, three sections were connected together and run as under :—

Scow bow, scow stern with one stern section between.	4.70	226	10.2	11″	Up tide at an actual speed of 5.12 m.p.h. The bow waves were up to the top of the gunwales, crest lopping inboard.
Scow bow, scow stern with one ordinary stern section between down tide trip only.	4.32	182	9.7	11″	
Scow bow. Full stern, with one stern section between (neglecting up tide a boat swamped early in run).	5.5	315	9.6	11″	Boat swamped on up tide trip at a speed equivalent to 6½ m.p.h. in slack water.

The speeds and freeboard at which swamping took place are as under, the speed given is the relative speed of boat and water, allowing for the tide, and notes on the observed waves are added :—

Type.	Speed.	Free-board.	Waves.
Scow bow.	5.1	9″	Bow waves up to gunwales during run.
,, ,,	5.3	9″	Bow waves up to gunwales, swamping occurred after 200 yds.
,, ,,	4.3	11″	Waves 6″ below gunwales.
,, ,,	6.0	11″	Waves 3″ below gunwales.
,, ,,	4.1	9″	Waves 3″ below gunwales.
,, ,,	6.0	9″	Swamped after 100 yards run.
	7.1	16″	Waves 18″ below gunwales. Stern waves up to gunwales.
Scow bow.	8.6	16″	Stern waves up to gunwales.
Full bow.	4.1	9″	Bow waves up to gunwales.
,, ,,	4.8	9″	Swamped after 200 yards run.

Eliminating doubtful figures and taking the results broadly they can be indicated by a graph which shows the limit of swamping and the limit of safe loading for an *undecked* pontoon.

The following information can be obtained from such a graph for the new steel pontoon if undecked :—

	Safe in average water.	Swamp in.
Heavy Bridge Max. Loads.	$4\frac{1}{2}$ m.p.h.	5 m.p.h.
,, ,, Normal Loads.	$5\frac{1}{2}$ m.p.h.	6 m.p.h.
Unloaded.	Limit of allowable current.	
Light Bridge Max. Loads.	$4\frac{3}{4}$ m.p.h.	$5\frac{3}{4}$ m.p.h.
,, ,, Normal Loads.	6 m.p.h.	$6\frac{1}{2}$ m.p.h.
Unloaded.	Limit of allowable current.	
Medium Bridge Max. Loads.	6 m.p.h.	$6\frac{1}{2}$ m.p.h.
,, ,, Normal Loads. (3-ton lorries)	$7\frac{3}{4}$ m.p.h.	$8\frac{1}{2}$ m.p.h.

As regards speeds of current up to which it is possible to use pontoons in bridges, a fresh consideration arises, namely, the pull which the current induces on the anchor.

Although a chain was put on the towing rope to sink it and to make it of about the same slope as the anchor cables in a pontoon bridge, the slope of the cable varied according to the pull, and it would have taken too long to adjust the weight to make the slope the same in all cases.

In dealing with the strain on an anchor, however, allowance must be made for the above, and the measured pulls should be increased by $\frac{1}{\text{Cos}\,\theta}$ where θ is the angle between the towing cable and a supposed anchor cable. For the latter we will take the cable from an anchor cast 20 fathoms from the pontoon in 6-ft. of water. The following figures give the relations between speeds and anchor pulls.

	Speed.	Measured pull. Lbs.	θ	Anchor Strain. Lbs.
Down 1	5.35	280	7°	314
Up 2	4.6	190	7°	213
Down 3	6.0	336	5°	365
Up 4	5.3	215	3°	226
Down 7	4.1	196	2°	203
Up 8	5.4	238	4°	255
Down	7.1	700	7°	785
Up	8.6	756	7°	849

These results may be indicated by a graph, by eliminating unreliable figures. It should be realised, however, that the experiments were not designed with a view to testing this particular point, and that the results can only be taken as a broad general indication of what may be expected to happen. It will be seen that in currents of over 5 miles per hour the anchor strains increase rapidly for small increases of speed of current.

This is for a single pontoon; in the case of a bridge with each pontoon anchored the strains would be increased, and in the case of heavy bridge they would be still further increased.

We can now summarise the conclusions arrived at from these tests:—

(*a*) The scow bow (Fig. 6) is the most suitable bow for the steel pontoon.

(*b*) A prow bow does not appear necessary in currents of under 8 miles per hour; for currents of over 8 miles per hour further experiments are necessary.

It will be seen from the above report that the ideal form of bow was unpracticable, owing to the loss of buoyancy and consequent lengthening of the boat thereby involved.

Further, the necessity for waterway between pontoons no longer exists, for the scow bow enables the pontoon to ride on the water, and when pontoons with scow bows are placed close together the

water goes under the pontoons, whether the stem is bow-shaped or square, and there is a tendency to lift the pontoons.

Former experiments with heavy pontoons at Christchurch and recent experiments by the French are in accordance with this fact.

These recommendations were accepted. Two detailed designs for a metal pontoon were prepared accordingly—one with straight sides and a central girder, the other with slightly curved sides and designed to distribute the strength throughout the structure. The dimensions of these were 21-ft. long, beam 5-ft. 6-in., depth 2-ft. 11-in.

It will be observed that this section did not admit of coupling with the existing service pontoon, and in the case of the central girder type a central coupling was necessitated by the design—as will be seen later, this factor has proved a serious difficulty.

The departure from the standard section was unavoidable, because a greater depth was required to provide the necessary girder strength. The beam was consequently reduced to avoid superfluous weight, the necessary buoyancy having been provided by the increased depth, but this reduction of beam was found in practice to render the pontoon unstable to an undesirable extent.

The two designs were submitted to Professor Inglis for technical criticism, and he reported in favour of the central girder type with certain modifications.

Material.

The next subject for consideration was the material, especially for the skin, in view of corrosion difficulties.

The different materials considered were a copper steel mixture, stainless steel, soft chrome steel, and stainless iron.

Corrosion tests were carried out upon "Galahad" stainless steel, air hardened steel, air hardened and tempered steel, unpolished pickled sheets supplied by Brown, Bayley and Co., and two steels containing $\frac{1}{2}$ per cent. and 2 per cent., respectively, of copper.

Of the above materials the air hardened and tempered sheets appeared to stand best, while the "Galahad" appeared most suitable for framework.

The "copper" steel which is not seriously (as is the case of "Galahad") greater in price than mild steel, compared very favourably with the latter, while its strength was stated to be much greater, but was not tested.

Improved copper steel sheets and sheets of 12 per cent. to 14 per cent. chromium steel supplied by Firth were tested subsequently.

Trials of several preservative compositions were made simultaneously with those of the steels described above.

Three months' immersion of plates so coated and exposed between wind and water indicated that a material diminution of rusting was obtained both on mild steel and on the other materials; the improvement in the case of mild steel was very marked and showed these compositions to be superior to ordinary paint.

All the above tests took a considerable time, and the designs and construction of the steel pontoons proceeded without awaiting them; steel of B.E.S.A. specification for "S 3" was specified for sheeting and frames, and of B.E.S.A. specification No. 15 for structural steel. After certain slight modifications the trial pontoons were delivered in March, 1923, and having been ordered in advance of the preservative tests, were painted with red oxide.

It may be asked if consideration was given to the idea of using aluminium or an alloy thereof either for sheets or for framing.

Against this there were two reasons: Firstly, that the metal pontoon was always regarded as a makeshift substitute for one of wood, only to be provided where the demand was so great that rapid output of wooden pontoons would be impracticable, and, secondly, that under such circumstances, as proved in the Great War, the provision of the material might be very difficult in view of more urgent requirements for other services.

More immediate objections were the extreme difficulty of providing a non-corrodible alloy or a practicable protective covering.

It is possible, however, that the use of this material may have to be reconsidered, as it has since appeared that the weight of a steel pontoon, in other respects suitable, renders it difficult to handle.

The two trial steel pontoons were tested in March, 1923, and were found to be water-tight and strong enough for the work; they gave $7\frac{1}{4}$-in. mean freeboard for a 5-ton load.

The main defect of the steel pontoon was its weight (1,792-lbs.). The couplings also presented considerable difficulties. They were strong enough under test, but on account of the central position of the lower coupling it was extremely difficult to couple up on dry land and impossible when the pontoons were afloat. No satisfactory type of coupling has been found, and Messrs. Thornycroft could suggest no method of lightening the steel pontoon, while retaining the present beam and other dimensions.

CONSUTA WOOD PONTOONS.

While the service pontoons were being decked, attention was drawn to a new form of plywood called "Consuta," in which the

layers of wood are sewn together as well as cemented, and Messrs. Saunders, of Cowes, re-covered a service pontoon with this material for trial. Investigations were set on foot as to the history and durability of boats constructed of this material, especially in hot climates. Later, Mr. Saunders offered to make, free of charge, a new pontoon entirely covered with this material, claiming that the use of this material would enable a considerable lightening of the framework. This offer was accepted and a second pontoon ordered. The dimensions and calculated weight and buoyancy of this pontoon were (See Plate I, Fig. 1) :—

Length	21-ft.
Width	6-ft. (including handles).
Depth	2-ft. 8½-in.
Buoyancy	5.8 tons with 8-in. freeboard.
Weight	1,250-lbs.

Owing to certain modifications while under construction, the actual weight, when delivered, was 1,350-lbs. as compared with 1,200-lbs. for two sections of service pontoon, while the buoyancy test gave the following results :—

Weight of Superstructure and Load in Tons.		Freeboard in Inches.		
Total.	On each Float.	No. 1 Float. (mean).	No. 2 Float. (mean).	Calculated from displacement curve.
3.25	1.62	21.6	21.2	22
8.25	4.1	11.5	11.0	12
10.5	5.25	6.8	7.3	7.5
12.5	6.25	4.8	5.5	4.2

Test of Couplings.—Two pontoons were coupled end to end, and a nett load of 12 tons 7 cwts., which introduced a strain of 8½ tons on each coupling, was applied to them for over 12 hours without damage.

When fully loaded in heavy bridge, the maximum strain on the couplings would be 7 tons, so the test was a 20 per cent. overload. The mean freeboard was 5-in.

Investigations into the merits of consuta wood as a material showed that, though in seaplane construction it has proved un-

suitable, satisfactory results over a long period of use in motor boats, in various climates, including 12 years in Egypt, had proved its durability.

Special dry and moist heat tests were also carried out with satisfactory results—and also practical comparisons with other forms of plywood, very much to the advantage of consuta.

The following tests of the effect of rifle fire were carried out :—

" (i) at 30 yards range above water line.

(ii) at 30 yards range below water line.

(iii) at 100 yards to 300 yards above water line, normal to the surface.

(iv) at 100 yards to 300 yards above water line, obliquely to the surface.

" *Above water line.*—In all cases above water line the ingoing bullet left a very small hole, which partially closed up at once, and later, when the float was immersed, closed up yet further. The outgoing bullets made jagged holes about $\frac{3}{4}$-in. x breadth of bullet.

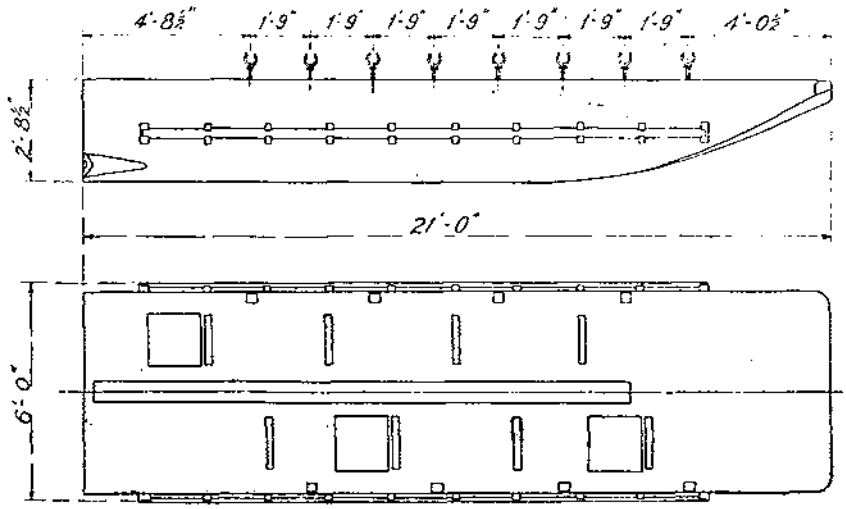
" *Below water line.*—Ingoing bullets made very small holes when the float was filled with water, to the same depth as the immersion. Ingoing bullets aimed below water line into the empty float made jagged holes about 1-in. x $\frac{1}{2}$-in. In no case was an outgoing hole made by a bullet aimed below water line.

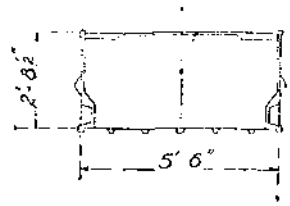
" *Rates of leakage.*—After plugging certain of the holes made, the following rates of initial leakage ' in ' were measured :—

" (*a*) Ingoing holes above water line (Av.) 1.5 g.p.h.
" (*b*) Outgoing " " " " 140 "
" (*c*) Ingoing " below " " 168 "
" (*d*) " " " " " 8.5 "
(float flooded.)

" (*e*) Outgoing holes below water line, none obtained.

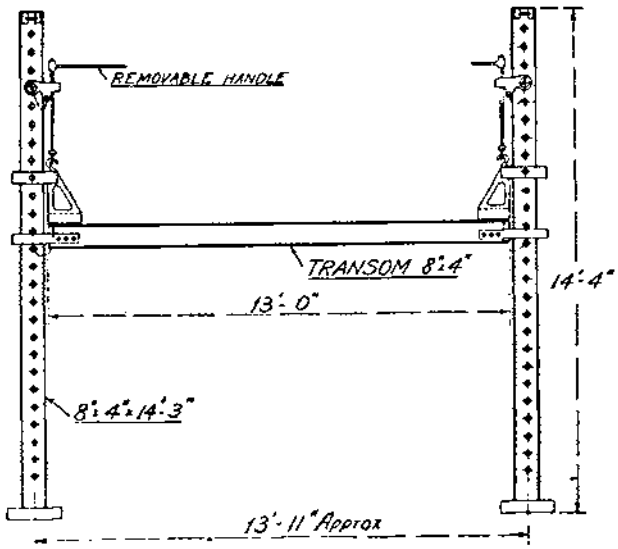
" The worst case would probably be that for a bullet aimed just below water line in such a way that both in and outgoing holes were made. In this case the initial flow would probably be in the region of 300 gallons through the pair. The best way of stopping small holes would appear to be by small wooden cones 3-in. x 0-in. x $\frac{3}{8}$-in.; and larger ones with lathe 1-in. x $\frac{1}{2}$-in. section, which could be quickly shaped with a knife, and driven in from either inside or outside the pontoons."





— PONTOON —

FIG I



— STEEL TRESTLE —

FIG II

PLATE I.

Two additional pontoons were ordered in September, 1922, with modifications in certain scantlings, whereby it was hoped to reduce the weight to about 1,200-lbs. These were delivered in January, 1923; they weighed 1,288 and 1,316lbs. respectively, and underwent satisfactory tests.

The handles in the original design were wooden bars projecting out from the sides and housing into sockets when not in use—very convenient for carrying, but liable to injury and difficult to repair. These were replaced in the second pair by a continuous bar along the side of the pontoon. (See Plate I, Fig. 1).

The new shape bow involves a change of position of the centre of buoyancy, as the load varies along the length of the pontoon when used singly, and consequently the roadway cannot under all conditions of loading remain level in a transverse direction. The results of trials for the best position for the saddle found one such that no load gave a difference of 2½-in. immersion by the head, while infantry in fours caused a difference in the opposite direction of 3-in.

In loading a bridge on 12.4.23, with a fully loaded 3-ton lorry and a dead weight of 1 ton, the couplings opened, necessitating re-design.

Four hooks in mild steel were prepared and tested at King's College (London) and from the results a fresh design was prepared, calculated to stand without deformation a strain of 14 tons, giving a factor of safety of 2 on the elastic limit.

The attachment of the hook and of the pin and its attachment were also re-designed with the same object—and by the end of August, 1923, a fully loaded 3-ton lorry had crossed the pier, to which a dead load of 2 tons had been added, 440 times without signs of strain or any appreciable leak.

Up to the date of writing probably some 15,000 loaded lorry crossings (6,000 with a 2-ton overload) have been made without injury.

For the complete pontoon the only details remaining to be settled were the pump, the hatches and the positions of the rowlocks.

For rowing the pontoon is somewhat awkward, both from being decked and from the forward slope of the deck when unloaded. It was found after trials that the number of side rowlocks in the first pontoon, six, had to be increased to eight, both for the above reasons and because, in raft, some of those on one side could not be used. The eight side rowlocks were finally "staggered" to allow eight rowers all to row together. (See Plate I, Fig. 1).

This re-arrangement of rowlocks necessitated altering the hatches. The position of the hatches is a result of a compromise. The difficulty was so to arrange access to each section of a pontoon that it should be accessible in light and in medium or heavy bridge. One hatch was originally provided in each section of the pontoon, but no disposition of them could be found to render both accessible under either circumstance; so it was decided to provide an extra hatch for the stern half. (See Plate I, Fig. 1).

As regards the pontoon itself the foregoing completes the history; it remains to deal with the superstructure.

The design of superstructure for the 21-ft. span that had been selected was based upon the following assumption for loads—

(1) An impact allowance of 50 per cent. for lorries and other fast moving traffic; 25 per cent. for tanks.

(2) A factor of safety of two for the heaviest loads intermittent and discontinuous.

(3) A factor of safety of three for continuous loads and any large single load likely to be frequent, *e.g.*, lorries.

On a first assumption of 12 bearers for heavy bridge and six for lorry bridge, the maximum equivalent distributed dead loads were calculated at 6 tons (medium C Tanks) and 5.8 tons for lorries on any one joist—the unloaded span was taken as 20-ft. 6-in. This involved (using 9 x 4 joists) stressing a joist up to 15 tons per square inch.

Professor Inglis, to whom this was referred, advised against this risk as almost inevitably involving permanent set—but suggested that, for our purposes and speeds, 33 per cent. impact would suffice—also that the actual distribution of the loads on the joists was obscure.

This led up to preparations being made for more precise tests of this action, which will be described later.

To be continued).

MEMOIR.

MAJOR RICHARD VICTOR MORSE.

The death of Major Richard Victor Morse, D.S.O., who died at Lecton on 26th January, removes one of Sydney's most prominent engineers, and a distinguished soldier. Major Morse contracted an illness while engaged in an inspection tour in the Murrumbidgee irrigation area in connection with the electrical branch of the Public Works Department. He was a son of Mr. Richard Morse, formerly of the designing department of the Sydney Harbour Trust. Educated at the Sydney Grammar School and Technical College, he entered the service of the Standard Waygood Company, and in 1905 proceeded to England, and joined the engineering works of Dick Kerr and Company, Preston, Lancashire, to obtain further practical experience.

Returning to Sydney after four years in England he eventually entered the electrical branch of the N.S.W. Railways and Tramways, under Mr. O. W. Brain. In February, 1916, he left for active service as a captain in the Mining Corps, and in France was promoted to the rank of major, and placed in command of a specially formed unit termed the Australian Electrical and Mechanical Mining and Boring Company, the only electrical unit which did front line work. For his services while in command of this unit he was awarded the D.S.O., and twice mentioned in despatches. This unit also obtained the almost unique distinction of being mentioned by the Commander-in-Chief, Sir Douglas Haig, on a "Special Order of the Day," on December 4, 1918. Major Morse returned to Sydney as O.C. troops on the transport *Kanowna* in October, 1919.

In February, 1920, Major Morse went to Tasmania, and joined the hydro-electric department of that State. After two-and-a-half years' strenuous work there he was appointed to the position of chief assistant electrical engineer in the New South Wales Public Works Department.

Major Morse was severely gassed on a number of occasions while on active service, and since his return to Australia had suffered from gradually failing health.

Major Morse was a member of the Institute of Mechanical Engineers, and an associate member of the Australian Institute of Electrical Engineers.

He is survived by a widow and three young children, the eldest of whom is 11 years of age.—*Extract from the "Sydney Morning Herald" of 28th January*, 1925.

BOOKS :

THE ROLL OF HONOUR OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

THE Corps has received from the President and Council of the Institution of Electrical Engineers a copy of their Roll of Honour for preservation in our Library in London. The Roll, which has taken over three years to prepare, has been edited by Lieut.-Colonel W. A. J. O'Meara, C.M.G. (late R.E.), under the instructions of a War Memorial Committee, with the late Mr. C. H. Wordingham, C.B.E., as Chairman and Mr. P. F. Rowell as Secretary. In an Introductory Chapter Colonel O'Meara discusses the Origin and Causes of the Great War, and this is followed by the Roll with full obituary notices, and in most cases also portraits of the 162 Members and Associates who gave their lives in the War. It is natural that very many wear the uniform of the Royal Engineers. The Roll includes the names of two regular officers of the Corps, Lt.-Col. A. H. Dumaresq and Major A. Gardiner, and among the Territorial members the most distinguished is Colonel Bertram Hopkinson, C.M.G., F.R.S., whose father raised the Tyne Electrical Engineers and who himself joined the R.E. Volunteers as long ago as March, 1896. It is hoped that we may be able to reproduce the obituary notice of this distinguished officer in our next issue.

F.E.G.S.

HISTORY OF THE GREAT WAR. MILITARY OPERATIONS, FRANCE AND BELGIUM, 1914.

By BRIGR.-GENERAL J. E. EDMONDS, C.B., C.M.G. (Macmillan & Co.) 12/6 and Maps 5/6.

THE British Official Account of the Great War is now to consist of approximately ten volumes, viz., for 1914, two; for 1915, one; for 1916, two; for 1917, two; and for 1918, three.

In view of the special interest relating to the operations in 1918, it has been decided to speed up the volumes for that year, but it is disappointing to learn that, presumably on the score of expense, the narrative is to be further condensed, and that 1918 will be dealt with by another pen than of Brigr.-Gen. Edmonds. We are, however, fortunate in having his experience, and the plan he has adopted in the first two volumes will doubtless be followed. His well-known book on the Civil War in the United States, written with the collaboration of Mr. W. B. Wood, is a masterpiece, in one volume, of the art of eliminating the non-essentials and at the same time by copious references in footnotes enabling the student to know where to find the details if further information is required.

The second volume for 1914, the subject of the present review, completes the narrative of the operations of the British Army down to

the close of the great battles in Flanders—La Bassée, Armentières, Messines and Ypres—which continued without a break from October 10th to November 22nd, 1914. In it Brigr.-Gen. Edmonds confines himself, as in the first volume, strictly to accurate narration of the facts; and by the omission of all criticism he leaves it to the reader to draw his own conclusions. To the military student this is easier than to the uninitiated, but even to the latter the book is full of suggestion if carefully read. To those who know the writer the brief statement of a fact may imply much more than meets the eye, and where opportunity for criticism is almost obvious, its omission is suggestive. In the first volume Brigr.-Gen. Edmond's method re-established without question, the reputation of General Sir Horace Smith-Dorrien, and dissipated once for all the fog lying over the Battle of Le Cateau. In the second volume the same method will compel the historian of the future to probe more deeply than is permitted to Brigr.-Gen. Edmonds, into the question whether the co-operation of the Allies could not have been more complete in the early stages of the war. In his review (*R.E. Journal*, March, 1923) of the first volume, Major-General Thuillier was led to ask some pertinent questions as to the conduct of the Battle of the Marne; in the second volume there is ample material for similar questions, particularly in regard to the operations resulting in the fall of Antwerp and the responsibility of each of the Allies for that disaster. In this connection it is satisfactory to know that, in so far as it has progressed, the French Official Account is straightforward and impartial, and that the authorities charged with the compilation of the official histories, both in France and Belgium, have willingly supplied all the information asked of them.

It will not be out of place here to suggest that in future volumes space might be found in the appendices for an outline of the contemporaneous operations, on the Western Front and elsewhere, in order that the reader may have some idea, without having to refer to other publications, of the general situation on a given date, and of the factors which are likely to have influenced the Supreme Commands of the Allies, and of the enemy, in any particular phase, especially as regards the information *available at the time* as to the enemy and allied strengths in the various theatres of war.

It would, for instance, be interesting to know what prevented more reinforcements being sent, or what delayed the despatch of those that were sent, to the northern flank of the Allied line in the early days of October, 1914? Not only our Allies, but we ourselves, should have more definite knowledge of the intensity of the effort on our respective fronts, if only with a view to arriving at an earlier decision in the future as to the absolute necessity for unified command in all operations where allies are involved.

It is difficult to review the "Introductory Chapter," in that it was originally intended to devote a whole volume to an account of the expansion of the Army and the preparations which were made at home and in other parts of the Empire during the months which immediately followed the outbreak of hostilities. The material collected has been condensed into a single chapter, and the reader will be well repaid by reading it through. Brigr.-Gen. Edmonds briefly records the various

measures that were taken, but only in one or two instances does he allow himself the luxury of criticism. He mentions that there was a fortnight's delay in authorizing the enlistment of ex-N.C.O.'s of the Regular Army, when instructors and men used to discipline were in such urgent demand. He then puts it on record that " in the middle of September, 1914, when the total of recruits reached 500,000, it was deemed advisable that a *brake should be put on recruiting* (the italics are his), and the standard of physique was raised. This measure had the effect of reducing the stream; so much indeed that when organisation had been introduced, although the restrictions with regard to physique were removed on October 11th, it became necessary to adopt special measures to stimulate recruiting." Consequently it was not until February 23rd, 1915, that the million mark was reached, and not till September 3rd, 1915, that the figures reached a million and a half.

Brigr.-Gen. Edmonds recalls the fact that "on the very day, August 7th, 1914, that Lord Kitchener called for the 'First Hundred Thousand,' offers of assistance came from the Dominions Overseas. The War Office accepted 20,000 men from Canada, 20,000 from Australia and 8,000 from New Zealand." The mistake made in the South African War was not perhaps repeated, but in view of the enthusiasm with which the call to aid the Mother Country was received in the Dominions, it is hard to understand why the contingents were limited in the first instance. The effect was probably similar to what occurred when the " brake on recruiting " was applied in the home country.

The shortage of gun ammunition is necessarily dealt with at some length, but the official historian abstains from apportioning the responsibility for the shortage or the delays that occurred in remedying it. It seems strange that the authorities were so slow to profit by the numerous pre-war reports of officers who were attached to the Russo-Japanese Armies or who attended the Autumn Manœuvres of the great Continental armies after the Russo-Japanese War. Those reports were printed, and reiterated the need of increased ammunition supply for q.f. field artillery, the provision of H.E. shell for field howitzers, the great increase in the number of machine guns, the advent of the trench mortar, and the revival of the hand grenade. The Germans profited by similar reports by their military attachés; we did little or nothing. The constant cry for economy in the Army Estimates was undoubtedly responsible for some of the failure, but there seems to have been a general disinclination to face the facts.

It is said that the South African War woke us up from the effects of a long peace. But did it wake us up as a nation? In the Army, in organization, in staff duties, in infantry training and musketry, great improvements were effected. The same measure of progress did not show itself in material. When the money was insufficient to go round the provision of material was perhaps sacrificed to the improvement of the personnel. We muddled through once more, but at what a sacrifice! What can we do now to prevent the nation being blinded in the future by the dream of a prolonged peace? The story of Lord Roberts' vain efforts (mentioned by Brigr.-Gen. Edmonds) to wake the nation up to a realization of the dangers ahead must never

be forgotten. Brigr.-Gen. Edmonds, in a short paragraph, describes the success of the mobilization arrangements and the Home Defence Scheme. It says much for the laborious care with which the Officers, staff and regimental, of the Regular and Territorial Armies and the Special Reserve had prepared the various schemes in time of peace, in conjunction with the General and Administrative Staff at the War Office and the Railway Companies, that the arrangements were carried out without a hitch. Mention is also made of the effective measures taken to deal with enemy agents, which resulted in completely paralysing the German Intelligence Service, and spreading a veil over the British effort for a considerable period after hostilities commenced.

Returning to the Territorial Force. By the end of 1914 the Territorial Force, which, on 4th August, was some 5,700 officers and 150,000 men short of its establishment of 15,977 officers and 401,556 other ranks, had more than doubled its original strength, and practically all the new men had undertaken the obligation to serve wherever they might be required. And this, in spite of the inevitable competition with the New Armies in attracting recruits, and the fact that the War Office had a preferential call on the resources of the country in clothing, boots, and other necessaries. The lesson has not been forgotten, and the recent decision to base the expansion of the Army in a future crisis on the Territorial organisation is the outcome of our experience in 1914.

The housing of the troops is passed over in a few lines, but it would be instructive for Sappers to have access to the original draft. "The accommodation in barracks at the time of mobilization was sufficient for 174,000 single men; it was increased to 262,000 by clearing out the families of soldiers from the married quarters and using every accessory building that could be made available. Even this development provided only for a small portion of the total increment of recruits, and though large numbers were placed under canvas and others housed in hired public buildings, as many as 800,000 men had to be quartered at one time on the population in billets. The late Sir George Scott-Moncrieff has done much to enlighten us on the difficulties, and the measures he took to surmount them by hutting. Judging by our experience on the L. of C. and at the front in France, it was many months before wasteful competition in the purchase of materials was got rid of by a controlling authority.

The chapter concludes with a brief reference to Supply & Transport, from which it is evident that the provision of Supplies was ably handled; the Remount system inaugurated before the war stood the test well on the whole, though the supply of grooms and the provision of shelter for the animals was inadequate at first; and steps to remedy the shortage of motor vehicles suitable for the New Armies were taken in hand promptly.

The Antwerp Campaign. The fall of Antwerp, involving as it did the loss of the Belgian coast and the ports of Zeebrugge and Ostend, was a far-reaching disaster to the Allied cause, insomuch as these ports became the principal bases for the submarines of the German Fleet. To an amphibious Power it was, from all points of view, essential that the

Belgian coast should not fall into enemy hands. It is not surprising, therefore, that the British Naval and Military Authorities made a desperate effort to prevent the disaster, but it was made too late. The great entrenched camp of Antwerp was a dangerous menace to the German communications only so long as there were field troops in it. It was soon obvious that unless the fortress could be included in the general line of the Allied front, in the same manner as Verdun, Nancy and Belfort, it was sooner or later bound to fall, and the sooner if the 12-inch Skoda howitzers (the existence of which should not have been a surprise—if it was) and the German heavy mortars were employed against it.

Gen. Joffre's plan was to push forward his left wing, outflank the German right flank, and so relieve the pressure on the fortress. Its premature fall seems to have been left out of his calculations. The enemy's super-heavy artillery became available after the fall of Maubeuge, on September 7th.

The bombardment of the outer forts commenced on September 28th, and its inevitable result was apparent on the following day. The bulk of the Belgian Field Army was withdrawn westwards behind the line Ghent-Selzaete, by the night of October 8/9th, and the city capitulated on October 10th. It is left to the historian of the future to decide whether the Allies could have done more to avert the disaster.

The forts of Antwerp were of obsolete type, and were mere shell traps. "After the siege of Port Arthur, it was known that the casemates and magazines were not 6-inch shell proof, and although steps had been taken to strengthen some of the shelters with a layer of concrete," the work was badly done and the result ineffective. A German report says: "Nowhere had measures been taken for ventilation nor for dealing with the invasion of the cupolas by deleterious gases." Probably also, as at Liège, the gun crews were driven out of the cupolas by the gases liberated when the breech blocks were opened to re-load. Something of the same sort occurred later in some of our concrete machine-gun posts. There was no smokeless powder, every gun was given away by its discharge. There were no high explosive shells.

"The Belgian Engineers had done an immense amount of work subsequent to the commencement of hostilities. Inundations had been made; field defences between the forts constructed; and the foreground cleared," with ruthless regard to the amenities of the suburbs of a wealthy city. But the clearing had done more harm than good, as it rendered the forts clearly visible to the enemy, who, owing to the enclosed and timbered nature of the surrounding country, remained hidden. The trenches were little more than a foot deep owing to water near the surface, and the breastworks had no shell-proof cover, even against field guns. There was no fortress telephone system, and no means of observing the fire of the guns. The armament was inadequate; only one German battery was within range of the fortress guns.

Brigr.-Gen. Edmonds goes to the root of the trouble when he writes: "It would appear that the great mistake of all the Allies as regards fortresses in the early days of the war, was that they considered any second line troops good enough to hold and defend them." He instances

Namur, Maubeuge, Novogeorgeviesk and Fort des Romains, as compared with Grand Couronné and Verdun, and reminds us that the Germans came to the same conclusion after 1870-1. Further, he quotes from a written statement to the Belgian Court of Inquiry—" the lamentable state of the Belgian troops, most units having ceased to exist as formations and being no longer in a state to offer effective resistance . . . ., and the men of the (British) Naval Division being for the most part untrained and badly equipped." Brigr.-Gen. Edmonds draws the obvious deduction :—" Experience went to show that the best troops, or, at any rate, a good proportion of young troops, are required to conduct an active defence and resist the moral effect of being abandoned by the Field Army, the strain of heavy shelling, and the destruction of works supposed to be impregnable."

The position of the fortress, close up against the Dutch frontier, proved to be very unfortunate for the Allies, for as soon as the enemy drove back the Belgians from the line of the R. Dendre and across the R. Scheldt, there was only a narrow " corridor "—13 miles wide at Termonde—by which help could come or escape westwards be effected.

The original German plan was to attack the fortress with eleven divisions from the east, where no inundations were possible ;" but the investing forces, the equivalent of only six divisions, were given the extra tasks of guarding the Tirlemont-Brussels section of the Liège-Brussels railway (absolutely vital for the supply of the German right wing) and of preventing communication between Brussels and the Belgian Army. " These various tasks could only be solved by an attack from the position held by the Germans south of Antwerp. The general idea was to break through the outer line of forts at one place due south of the city and then extend the gap northwards. A covering line was formed between the R. Grande Nethe and the R. Scheldt, just in front of Mechlin (Malines), which was occupied by three German divisions who advanced from their entrenchments on the north side of Brussels and drove back the Belgian outposts some four or five miles." The heavy artillery was then deployed east and south of Mechlin. It consisted of 160 heavy and 12 super-heavy guns and howitzers. The bulk of the Belgian Field Army (six divisions) was south of Antwerp, with one of these divisions and the Cavalry Division in the vicinity of Termonde, at the junction of the Scheldt and Dendre rivers, south-west of the fortress.

On September 25th, that is shortly before the bombardment of the outer forts was commenced, the Belgians attempted one sortie. This, originally planned on a large scale at the urgent request of Gen. Joffre, to threaten the German communications, was subsequently limited, owing to the obvious preparations for immediate attack. It came to nothing, and was easily defeated by a Landwehr brigade supported by the fire of the heavy artillery.

Later, on October 5th, when two battalions of a German Reserve regiment crossed the R. Nethe a mile below Lierre, by means of a trestle bridge prepared on barrels in a convenient creek near at hand, the Belgians lost a great opportunity for counter-attack. Supported by artillery fire, though in a critical position, the two battalions managed to hold on until reinforced at nightfall by two more battalions. A counter-attack

was ordered, but owing to the orders not reaching some of the units (including the British Marine Brigade) in time, it was limited to a few Belgian units, who, though successful at first, were unsupported and driven back seriously shaken. During the next day (October 6th) the Belgians retired from the line of the R. Nethe to another partially prepared position halfway between that river and the inner line of forts, and the Germans were free to push their heavy artillery forward to positions whence they could bombard the inner forts and the city itself.

On October 7th the Germans succeeded, after several unsuccessful attempts, to push a Landwehr brigade across the Scheldt at Schoonaerde (9 miles above Termonde) in boats in the face of the Belgian troops, which had been reinforced on October 6th by another division from Antwerp. On October 8th two more brigades crossed the Scheldt, and in the course of the day, opposed only by Belgian flank guards, these three pushed their advanced guards nearly 8 miles, towards Lokeren, where they were about the same distance from the Dutch frontier. Brigr.-Gen. Edmonds remarks: " the action may seem extraordinarily bold for a small force, but no serious opposition was expected, as the German aviators had reported in the afternoon that the roads leading west from Antwerp were in general still clear." It seemed to the German Commander that no effort to escape was being made by the Belgian Army, and that he might proceed to invest the fortress on the western side. As a matter of fact, by the night of the 8th October, the bulk of the Belgian Army had escaped and were west of the line Ghent-Selzaete, leaving only the 2nd Division, some fortress troops and the R. Naval Division to follow. Brigr.-Gen. Edmonds gives a graphic account of the tragedy of the three battalions of the 2nd Naval Brigade, and of the Portsmouth R.M.L.I. Battalion, which formed the rear guard; and describes how the remainder of the Royal Naval Division, the 2nd Belgian Division, and the bulk of the fortress troops effected their escape during the night of the 9th/10th October.

Could the Allies have acted more promptly? Brigr.-Gen. Edmonds says: " It was obvious that a strong British force landed at Dunkirk or Ostend would serve General Joffre's offensive plans if things went well with the Allies, for it might be in time to out-flank the Germans; and if the enemy's movements were too rapid for this, and Antwerp were in danger of being isolated, it would be on the spot to assist the Belgians to cover the retreat of their Field Army."

Early in September the British General Staff had suggested a movement from Dunkirk and Calais; and on September 16th General Joffre, acting on this idea, had asked that all available British troops might be sent to these ports to act against the enemy's communications. A Royal Marine Light Infantry Brigade, the Oxfordshire Hussars Yeomanry, and a detachment of R.E. had accordingly been sent to Dunkirk on 19/20th October, under the Command of Brigr.-Gen. Aston, and under the control of the Admiralty. It was all along the intention of the British authorities—should circumstances permit—to suggest to the French the transfer of the whole of the British Army in France from the Aisne to the neighbourhood of Calais, but it was not till General Joffre visited British G.H.Q. on September 26th-28th, that he gave his

consent, and indicated Lille as the place of concentration of not only the original B.E.F., but also for that of 7th and 8th Divisions when ready, and the Indian troops which had commenced to disembark at Marseilles on September 15th. Brigr.-Gen. Aston's force, which by energetic action might well have been made to appear to German eyes as the advanced guard of a much larger force of Territorial and newly-raised troops, remained in the neighbourhood of Dunkirk till September 28th, when one battalion was at the request of the French sent to Lille. The command then was assumed by Brigr.-Gen. Paris, owing to the illness of Brigr.-Gen. Aston, and on September 30th, headquarters and three battalions were moved to Cassel, the recruits being left at Dunkirk. The Marines patrolled the neighbourhood on cycles and in motor buses, whilst Commander Samson's armoured cars working with local French troops, searched the country further east and cleared it of German Cavalry patrols. The German I and II Cavalry Corps were then approaching Lens, 30 miles S.E. of Cassel.

It would seem, therefore, that from September 18th, when British G.H.Q. directed attention to a probable intensifying of the German effort against Antwerp, till September 30th, the possibility of its early fall, and the isolation, if not capture, of the Belgian Field Army, had not impressed itself on either the British or French Supreme Commands. At all events, no steps had been taken to try to avert it or to help the Belgians to prolong the defence.

On September 29th Belgian Headquarters began definite preparations for the withdrawal of the Field Army, it being their intention to leave the fortress troops (some 80,000 men) to continue such defence as was possible.

On September 30th the Belgians appealed to the Allies for help, but it was a message from the British Minister on October 2nd, that awoke the Allies to the imminence of the danger if the Belgian Field Army was prematurely withdrawn from Antwerp. Reading Brigr.-Gen. Edmonds' account, it would indeed seem as if General Joffre had based all his plans solely on the successful advance of the Allied left wing. Nor would it appear that the British Government had visualized the possibilities of an early collapse. For the reply sent on October 2nd/3rd to the Belgian appeal read as follows: " urged them to hold the fortress, if possible, until the issue of the main battle in France had been determined, and in any case to continue the struggle with the Field Army, if only for a few days. Immediate help was promised in the shape of the R.M.L.I. Brigade (then at Cassel, Lille and Dunkirk), but hopes were held out that other troops might be sent from the main Armies, and if possible from England also."

The British Government immediately communicated with the French Government, and ordered certain moves to be carried out at once. On October 3rd the British R.M.L.I. Brigade was moved by rail to Antwerp, and reached that place at 1.0 a.m. on October 4th. A battery of artillery was also sent direct, and at Mr. Winston Churchill's instigation, two naval brigades were ordered to Dunkirk. This was moral support, but little else, for by that date hopes of saving the fortress had nearly disappeared, and it was merely a question of what could be done to assist

in the withdrawal of as many Belgian soldiers as possible from the fortress before it fell.

We must remember that at this critical moment the B.E.F. was only just about to leave the Aisne. The leading Corps (IInd) was to entrain on October 4th, on which date the 7th Division and the 3rd Cavalry Division, formed in England mostly of troops relieved from Overseas garrisons, would be nearly ready to move. But in England there were "thirteen Mounted Brigades (T.F.) and thirteen Territorial Divisions (including two warned for India, the 42nd had already gone to Egypt); sufficient men had been recruited to form twelve New Army Divisions, and the 8th Regular Division was in process of formation." However, the same reluctance on the part of the Government to part with its troops which delayed the dispatch of the 4th and 6th Divisions of the original B.E.F., in spite of the fact that two Territorial Divisions had unexpectedly not been required to proceed to Ireland on mobilization, again made itself felt. It was only Lord Kitchener's insistence that induced them to allow the 7th Division and the 3rd Cavalry Division to go to Belgium, and it was Mr. Churchill who stepped into the breach by offering the two Naval Brigades of the Royal Naval Division, which were not nearly as ready for service abroad as the thirteen Territorial Divisions. Dispatched at a day's notice, the two Naval Brigades disembarked at Dunkirk on the night of the October 4/5th, and were in action at Antwerp on the evening of October 6th. The 7th Division landed at Zeebrugge on October 6th and 7th, and the 3rd Cavalry Division reached Ostend on October 8th.

Now as to the French effort. After the Belgian appeal for help, on September 30th, the British Government asked General Joffre to send one Regular Division. "He did not see his way to send Regulars as all his troops who had been brought to the left wing were heavily engaged." All he could do was to suggest—not promise—one Territorial Division to arrive at Ostend from October 6th to 9th, and a Marine Brigade from Havre in ten days' time. "Lord Kitchener considered that the force offered was inadequate to raise the siege, and informed the French that if nothing more could be done, it would be better to retain the troops and not risk them against the superior German forces." That meant that Antwerp was to be abandoned.

If the Germans could transfer several Corps from other parts of their line to their right, as they did, it is difficult to understand why the Allies could not have sent more than the three British Corps and two Cavalry Divisions; for General Joffre's plan was based solely on the ability of the Allied left to turn the German right flank, and for this superior numbers were obviously required. No doubt the authorities in Paris and Bordeaux were as short-sighted as those in London.

In describing the operations that ensued, Brigr.-Gen. Edmonds pertinently remarks that: "the situation, on October 7th, was somewhat complicated, *and there was no Supreme Commander in charge of the operations as a whole* (the italics are not his). The garrison of Antwerp (80,000 men) was, with the Belgian 2nd Division and the R.N. Division, holding the line of the inner forts (southern sectors); the Belgian Field Army (six divisions and a cavalry division, 65,000 men, less the 2nd

Division and presumably casualties) was moving away westwards from Antwerp, between the coast and Ghent; a French Naval Brigade (6,000 men) was on its way by rail from near Paris to Ghent, where there was already a small mixed Belgian force of all arms, 4 battalions of partially trained Belgian volunteers, and two companies of the French 5th Territorial Regiment; the newly landed British 7th Division was concentrated at Bruges, waiting for the 3rd Cavalry Division, which was in transports off Dover awaiting a naval escort to take it to Ostend. Between these forces and the left of the general line of the Allies, which was near Lens, some fifty miles south-west of Ghent, covered by French Cavalry extending to near Hazebruck, three German Cavalry Divisions were attempting to move westwards. Of the original B.E.F., the 2nd Corps was approaching Abbeville by rail; the 3rd Corps was entraining near Soissons to follow it to Flanders; the 1st Corps was still in position on the Aisne; the 1st and 2nd Cavalry Divisions were on the march north behind the French line, and, being delayed one day at Montdidier, the leading (2nd) Division was not to reach St. Pol till the 9th October.

A pretty problem of time and space, with troops of three nations involved! For the late Lord Rawlinson and the late Major-General Sir Thomas Capper, it was indeed an anxious period, but nothing to what was to follow when the IVth Corps had succeeded in finding itself in the general Allied line east of Ypres.

Antwerp surrendered on October 10th. The Germans stated that surprisingly few prisoners were captured beyond wounded men and detachments found in some of the forts.

"By a prodigious effort the Belgian Army had baffled its colossal adversary and finally escaped him, but now, after more than 2 months of uninterrupted operations and all the moral suffering which the gradual abandonment of national territory brought with it, time was required for rest and re-organization." This, however, was not to be, and "it was decided that, as the Germans were pressing on, the Belgians must take up the position on the Yser from which the Germans were never able to drive them."

As to the Royal Naval Division, Brigr.-Gen. Edmonds writes: "The wonder is, not that they failed to accomplish what was hoped, but that they fought so well. Had it not been for the unfortunate mistake in the delivery of a message for the 1st Naval Brigade to one of its battalions, and the report that it had been duly acted on, the whole Division would, no doubt, have got clear, for the Belgian 2nd Division easily did so."

The verdict of the Official Historian on Antwerp is as follows: "the continued resistance of the garrison for several days after the bombardment had rendered the outer forts untenable, had a lasting influence on the operations. Had Maubeuge held out only a few hours longer, the German VII Reserve Corps could not have been on the Aisne to stop the advance of Haig's Corps. Until Antwerp had fallen the troops of the investing force were not available to move forward on Ypres and the coast; and though, when they did, they secured Zeebrugge and Ostend without a struggle, they were too late to secure Nieuport and Dunkirk and turn the northern flank of the Allies, as intended. Further, since General von Beseler's divisions (from Antwerp) were required to cover

the approach march of the four new German Corps in their advance on Ypres, the whole general movement of the German forces in the north was affected. We have seen that on the 7th October, Besçler received a reminder to accelerate matters (at Antwerp). The advantage of a day, nay even a few hours, in the advance of the Germans on Ypres, or an equal delay in the arrival of the French and British re-inforcements, might, as will be seen, have tipped the scale to the enemy's side. Had events turned out more favourably for the main Allied armies in the first week of October, the defence of Antwerp might have proved decisive."

Battles of Ypres. The situation in the north has already been given, and it is important to see what were Gen. Joffre's intentions on that critical date :—The First, Third, Fourth, Fifth and Sixth French Armies were generally to hold their positions, in that order from the right, but to maintain an offensive attitude. The Second and Tenth Armies, under the direction of General Foch, were to continue the action they had begun against the right flank of the enemy in the " Race to the Sea." Should they fail to drive him back, they were in any case to check his advance and prevent him from withdrawing any troops from their front.

" The B.E.F. was to assist in the action of the Tenth Army (General Maud'huy), and it was hoped that the Belgian Army would also be able to co-operate (from the direction of Antwerp)."

The concentration of the B.E.F. on the north was covered by the French XXI Corps, which, by the 8th October, had extended the main battle line to Vermelles, only four miles short of the La Bassée Canal, and further north by Conneau's and de Mitry's Cavalry Corps. These, with one brigade of the 87th Territorial Division and a Chasseur Battalion, by October 9th held a line Bethune-Estaires-Merville-Aire, bending round to the north of St. Omer through the Forest of Clairmarais. Thence the other brigade of the 87th Territorial Division carried it northward to connect with the defences of Dunkirk. Cassel, in advance of the general line, and Lille, were still held by French Cavalry and local Territorial troops.

On October 10th, at a conference at Doullers, between Sir John French and General Foch, it was agreed that the French and British troops in the north should endeavour to make a combined advance eastward, the B.E.F. passing to the north of Lille. The enemy's cavalry appeared to be falling back and there seemed to be every prospect of an easy advance.

To show how close a thing the " Race to the Sea " was, the German XIV Corps had come up opposite the XXI French Corps on October 9th, only 24 hours after the latter was in position to Vermelles. The German I and II Cavalry Corps (4 cavalry divisions) were thus freed and had at once been sent further north to break through between La Bassée and Armentières, and turn the Allied flank. They were checked by the French Cavalry, but the German IV Cavalry Corps, moving independently, had actually passed through Ypres on October 7th, and were only checked by local French Territorial troops near Hazebruck, when they fell back on Bailleul.

General Foch's position up to October 10th was " *delégué du général en chef,*" but on October 11th he was appointed Commander of the

Northern group of armies (G.A.N.). Possibly the news of the fall of Antwerp on October 10th had induced General Joffre to give more attention to the question of co-operation. The effect of the appointment was immediate and made itself felt throughout the heavy fighting which ensued. " The most important point in these first days' fighting in Flanders was the establishment of that close liaison with the French which was to have such wonderful results . . . . even before the great welding of the two armies later in the month in the long and fiery ordeal of the Battles of Ypres." Incidentally, it was during this period that the French word " barrage " came into use as a term to describe the support of the infantry attack by covering fire. The fact that a French word was used tended to conceal the origin of this mode of using artillery fire in bursts to facilitate the infantry advance, which was undoubtedly English, and based on *Field Artillery Training*, April, 1914, pp. 155-7, but with the difference that no one then contemplated an ammunition supply which would enable fire to be continued without intermission for long periods of time.

Thanks to the admirable co-operation of the French, as each British Corps of the B.E.F. came up in échelon on the left, the Allied line was formed with French Cavalry Corps in the intervals. Pivoting on the French on its right at Vermelles, the line swung forward, until the extreme left nearly reached the defences of Lille, while the British Cavalry secured the Messines and Wytschalte ridges and connected with the 3rd Cavalry Brigade of General Rawlinson's force, which had fallen back from Bruges to cover Ypres, and thence through the British 7th Division, with the Belgian Army and French troops along the Yser.

All efforts, however, to advance beyond this line failed, for simultaneously the Germans also transferred troops to the north, and, after Antwerp had fallen, brought up not only the troops released from the siege, but four newly organised " Reserve " Corps which they hurried forward to turn the Allied flank and reach the Channel ports which was their objective. The occupation of Lille and capture of its garrison of 4,000 French Territorials marks the beginning of the stalemate, for it enabled the Germans to hold the line of the Lys facing north-west, and prevented the British Cavalry advancing and turning the German flank. Later the advance of Rawlinson's IVth Corps, with De Mitry's Cavalry Corps on its left towards Roulers was similarly frustrated by the extension of the German line.

This extension of the line resulted in a series of encounter battles, in which the operations were the outcome of a definite plan of attack by each belligerent in turn against the northern flank of his opponent. Brigr.-Gen. Edmonds quotes General Gallieni, who says: " the Allies were always 24 hours and an Army Corps behind the enemy, sometimes more." This was only true in so far that had the Allies had the extra 24 hours and the extra troops in hand, the victory would have been decisive for them. They were not too late to stem the tide of the German advance. In view of the German superiority in numbers the Allies did more than well, and probably the only soldiers who experienced disappointment at the result were General Joffre and Sir John French, whose persistent optimism received a rude blow. It was only the tenacity

of all the Allied forces in the fighting line that frustrated the Germans reaching the Channel ports, for reserves there were none. Brigr.-Gen. Edmonds again refers to the subject of unity of command on p. 127, when describing the first phase of the Battles of Ypres, October 19th-21st: "There were troops of three nations defending Flanders. Nominally, General Foch had no command over the Belgian and British Armies, and officially he could do no more than forward to their commanders copies of the orders issued to his own troops, and make suggestions for co-operation. As a matter of fact his influence was considerable; and his proposals, so far as means allowed, were carried out by the Allied Armies, without waste of time and without friction of any kind. French and Belgian, and French and British, as circumstances required, and as far as difference of training, war material and language permitted, fought side by side and sometimes as an army."

The results of this comradeship of early days were far-reaching; and, in the reviewer's own experience later on in 1915 at Ypres, and in 1918, south of Amiens, the knowledge which the French had gained of British character in the 1914 fighting made co-operation very simple and at once established mutual confidence. The name of General Hély d'Oissel, who commanded the French 7th Cavalry Division in 1914, and afterwards the French Corps north of Boesinghe, is well known to many British officers, but there were many others. He was only one of many distinguished French Officers who were quick to understand the British character, and it was 1914 that enabled them to do it, for they knew little or nothing of England or the British soldier before the war.

On October 11th General Foch's idea was that the B.E.F. should advance eastwards north of Lille to outflank the enemy. On October 18th he still hoped that the Allied forces could move forward from Ypres-Nieuport towards Roulers-Thourout-Ghistelles (5 miles south of Ostend) in order to break the enemy's front, and separate Gen. von Beseler's III Reserve Corps (from Antwerp), which had followed up the Belgians, from the enemy's main forces. "This accomplished, the Belgian Army and the French left were to endeavour to drive Beseler against the coast, whilst the rest of the French Army in the north, with the British, were to wheel south-east, in the direction of the Lys from Menin to Ghent (30 miles north-east of Menin), force the passage of this river, and attack the main German forces in flank and in reverse. It was never possible to put this plan into execution, but it forms the clue to the general operations of the Allies in the north." The Belgians were, however, too exhausted, and the enemy had the advantage, both of initiative and numbers. The French and British forces brought up for the offensive had to be thrust in piecemeal, as they arrived at Ypres, to maintain the front against the heavy German attacks.

"Though the offensive remained the guiding principle it was the German, not the Allied, attacks which marked the different phases of the battle. The first British and French attacks led to a 'battle of encounter,' and then the Allies were thrown on the defensive."

The German plan was the exact converse of that of the Allies. Then, "Failing to break in north of Ypres against the Belgians, the enemy

made desperate attempts against the British, first east and then south-east of Ypres, until the battle died away."

"The German General Staff for a time asserted that the first battle of Ypres was a German victory, for it marked the 'failure of the enemy's intention to fall on the rear of our Western Armies, to free the rich districts of Northern France and the whole of Belgium,' but it is now admitted that it was a failure, to which the subsequent difficult position of Germany must to a great extent be attributed."

The narrative of the fighting must be left to the reader. It is extremely clear, and the maps are excellent, showing the situation from day to day.

Brigr.-Gen. Edmonds has something of interest to say on the employment of the British Artillery (p. 164) and a good deal on the lack of ammunition (pp. 164 and 203 and many other places). On p. 154 he remarks on the curious fate by which "the German and British Cavalry instead of being in reserve, where their mobility might have been of value, were both enmeshed as connecting links in a trench system." He emphasizes the value of the musketry training which enabled two British Cavalry Divisions to preserve an unbroken front against the attacks of six German Cavalry Divisions on the Messines-Hollebeke section of the front. The French Cavalry were so badly armed that they were greatly handicapped in this respect.

Naturally, he has a tender feeling for the magnificent resistance of the 4th Division of the IIIrd Corps (General Pulteney) in front of Armentières, where, on October 24th, that Division held a front of 8 miles, opposed by a force of double its strength. "The 4th Division was left with the impression that by straight shooting over the parapet, backed up by a crossfire of artillery and flanking fire of machine guns, it could stop a German attack of almost any weight. The action of the divisional artillery, then commanded by Brigr.-Gen. (now General) G. F. Milne, was extraordinarily effective," but it always somehow managed to keep one of its four brigades out of the line for rest. This was easier, of course, when ammunition was scarce, for some days it was limited to 40 rounds per 18-pdr., and 20 per 4.5inch howitzer. This was doubled on 1st November. The casualties of the IIIrd Corps between October 15th and 31st, were 207 officers and 5,572 o.r., of which 125 officers and 3,585 o.r. were incurred in the other division (6th) of the Corps and Corps units. It is of interest to R.E. that a distinguished officer of the Corps, Brigr.-Gen. Hunter-Weston, commanded the 11th Infantry Brigade of the 4th Division during all this fighting.

The reader must, on no account, omit to read the notes though they are in small type. In them are concealed some of the most interesting information in a volume where everything must be of value to the soldier student. For instance, at the end of one of these "Notes," p. 259, there is the brief statement that while at Ypres the British heavy artillery consisted of only two batteries of old 6-in. howitzers, two batteries of 4.7-in. guns, and one naval armoured train with one 6-in. and one 4-in. gun—18 guns in all, or 26 including the 60-pounders, the heavy artillery of Fabeck's Army Group for the break-through at Gheluvelt was 8 batteries of mortars, 60 batteries of heavy field howitzers and a 12-in. "coast defence mortar," over 250 heavy guns in all.

In another note, p. 261, the difficulties of motor transport on the narrow Belgian *pavé* roads are described, and how the British gradually came to ignore the French cut and dried method of "fixed circuits," and directed the traffic regardless of the circuits, with the tacit consent of the French themselves—one of the many instances where the French inherent love of the theoretical and logical was up against the British "flair" for the practical and perforce succumbed to it.

There are frequent references to the R.E. On p. 176, for instance, "The engineer field companies worked on defences when shelling permitted, but the sappers were often called upon to take up their rifles to form a reserve, to assist in repelling the enemy, and even to join in attacks." In this connection, the action is described—in a footnote on p. 187—of Major H. L. Pritchard and the 26th Field Company at Langemarck on 23rd October; the counter-attack in which the 5th Field Company lost its Commander, Major A. H. Tyler, 2 other officers and a quarter of its men, killed, at Nonne Bosche, on November 11th (vide also *R.E.J.*, October, 1919, p. 179); the sacrifice of the 20th and 21st Companies of Sappers and Miners in the counter-attack at Neuve Chapelle on October 28th. As to the latter a footnote is worth quoting—"The use of the engineer companies as 'storm troops' in a situation that was not desperate, was a mistake. It crippled the Lahore Division for a considerable period, and . . . was ascribed to ignorance of Indian organization. But elsewhere in 1914 engineer troops were employed without a due sense of their technical value, and it became necessary for Sir John French to issue a memorandum calling attention to the misuse and waste of highly skilled specialists in work that should be performed by infantry."

In still another footnote, on p. 204, Brigr.-Gen. Edmonds directs attention to what was one of the most striking features of German tactics throughout the war, namely that "every opportunity of seizing important points on their immediate front," must be taken. Time after time, one found the Germans in possession of some point on the front, where either facility for observation or its inherent tactical value made it a thorn in the side (or rather front) of our troops. On p. 220 he refers to "their (the Germans') characteristic probing for a weak spot. The combination of the two, the probing for a weak spot in their attacks, and the prompt recognition and seizure of important tactical points went a long way to counterbalance what he describes on another page as the failure of the rank and file to follow up a successful attack: "Time after time during the battles of Ypres the same phenomenon will be observed: the Germans having come on in overwhelming numbers and succeeded in penetrating our line, sat or stood about helplessly and without precaution. Either they were content to rest after reaching the objective that they had been given, or they did not know what to do next. In any case, whether units of the Regular Army or newly raised Reserve formations, they usually fell an easy prey to the British counter-attacks." The same tendency has been noticed by the Germans in regard to the divisions of the British New Armies, *e.g.*, at the battle of Loos (footnote p. 199).

Almost the most valuable portion of the book is the Retrospect, pp. 460-5, which no reader must miss. One statement in it gives much food

for thought:—"That British troops have fought comparatively few successful offensive battles is due mainly to their commanders never having at their disposal forces adequate for such a purpose. Yet Minden, Blenheim, Salamanca, and Vittoria had shown what they were capable of in attack, and the counter-attacks at Ypres were not only crowned with success, but had truly marvellous results. . . . . When the opposing sides are of nearly equal value in training, courage and experience, and equally well commanded, decisive success can only be obtained—given even the advantages of surprise and preponderance of material—by superior numbers. The Germans had a numerical superiority of nearly two to one in their favour on the Ypres front as a whole, and far more favourable odds in particular sectors, but it did not avail them for inferior leading and other factors."

To conclude:—

The following extract from a letter is not printed in this volume.

"The Autumn of 1914, saw the Old Army for the last time. Everyone knew their parts, and acted and did not wait for orders; all were accustomed to work with other arms. Everyone was fully trained in the use of his weapon. The New Armies never knew the Old Army, for it was dead before they came into existence. The Officers and Men who filled up the New Armies' ranks were never fully trained; the staff was diluted and doubled, so that the all-round staff officer ceased to exist and was replaced by a number of specialists."

That the Old Army died in 1914 is borne out by the figures given on p. 467:—

The grand total of losses from the commencement of the campaign was:—

	Officers.	Other Ranks.
Killed	842	8631
Wounded	2097	37264
Missing	688	40342
	3627	86237

The greater part of this loss had fallen on the infantry of the first seven divisions, which originally numbered 84,000. The reinforcements sent out, apart from new formations, were:—962 officers, 108,610 other ranks.

The German losses in the three battles, of Lille, the Yser, and Ypres, from 15th October to 24th November, were 3,015 officers and 131,300 other ranks, which apparently excludes the wastage during the period in formations not actually engaged in the battle areas. But Brigr.-Gen. Edmonds does not think that there is much to be learned by a comparison of the figures, as the British and German methods of recording casualties differed.

It only remains to be said that there are two excellent Indices, a General Index, and an Index to Arms, Formations, and Units. The 40 maps are in a separate case, and are uniformly good and clear; but it is quite possible to read the volume, though not with a view to deep study, with the aid of the maps and "sketches" included in the letterpress.

The Appendices include the "Order of Battle" of the British (including Indian Corps), French, and German Armies, and most of the important orders are given in full.

H. BRUCE WILLIAMS, *Major-General* (retd.), late R.E.

LA GRANDE GUERRE SUR LE FRONT OCCIDENTAL.

Vol. X. La Ruée sur Verdun (5 août 1915-30 juin 1916). By GENERAL PALAT. (Paris: Berger-Levrault) 25 francs.

THE previous volumes on the great war by General Palat, well known before 1914 as a writer, under the name of Pierre Lehautcourt, on the war of 1870-1, have not been reviewed in the *R.E. Journal*. Whilst the French official account, which has only reached 23rd August, 1914, is mainly a reprint of documents, General Palat's work is not well *documenté*: he relies on books and pamphlets that have appeared, private diaries and notes lent to him, and the assistance of very numerous friends, mostly in the higher ranks, who took part. With each new volume he publishes corrections received of his former ones. In general, therefore, his book, although it has not the authority of an official work, and although it has some gaps in the narrative, is a most useful summary, full of details not likely to be given in the official history. In the present volume on the opening phases of the German attack at Verdun, which is of special interest to engineers, there is already such a mass of printed official and unofficial matter, that, except in the matter of operation orders, his account is very complete. It is unfortunately lacking in good maps, for only portions of the 1/50,000 and 1/80,000 maps, without any troops or trench lines marked on them, are provided; but at the low price of the book this must be expected. There is a small plan of the underworks of Fort Vaux.

General Palat takes up a somewhat critical attitude as regards the Commander-in-Chief and the operation staff. In 1914, during the great retreat to the Seine, although French G.Q.G. had ordered the field Armies to retire past Verdun, General Sarrail, commanding the Third Army, had clung to it with his right flank, and thus had formed the eastern side of the bag—Paris and Galliéni's troops being the western—into which the Germans thrust themselves on the eve of the battle of the Marne. Henceforward Verdun formed a salient in the general front, a salient dangerously narrowed on the east by the Germans' lucky thrust to St. Mihiel during the retreat.

French fortresses were specially protected by law and could not legally be declassed without what we call an Act of Parliament; their commanders were responsible to the Government for the safe-guarding of their trust, and were independent of any commander-in-chief. On 5th August, 1915, General Joffre, who badly wanted the heavy artillery locked up in Verdun, managed to get the place secretly declassed as a fortress by a decree of the Executive, and converted into the *Région Fortifiée de Verdun* (R.F.V.), and an integral part of the field Army; and he superseded the Governor by a corps commander, General Herr. Then he set about despoiling the fortress of its men, its guns, its ammunition and its stores, and bled it white to feed the battles in Champagne:

> " A fort as important as that of Douaumont was left without even a security garrison, without mobile *materiel*, without ammunition, and, by inexcusable blindness, without even guns to flank its ditches."

The strong, carefully chosen line of defence, the forts, was abandoned for a trench line in front, far less strong.

> " It is natural that the commander-in-chief desired to have more direct power over the fortresses in the zone of the Armies. To go beyond that and destroy an existing organization, like that of a great fortress, without being certain of the power of reconstructing a substitute, was an imprudence difficult to justify."

The author is inclined to attribute the course taken "to the false ideas, or rather the lack of ideas," in the General Staff as to the rôle of fortresses. To prepare the new line General Herr had neither men nor *materiel*.

The state of the defensive line near Verdun became so notorious in the army that Colonel Driant, a member of the Chamber of Deputies, who was serving in the " Region," informed the Standing Committee on the Army. There was much talk, but little done; for Joffre would brook no interference, and when the German attack came, the first position, which consisted of three lines, not continuous, but organized as a series of strong points, was incomplete as regards wire and practically without shell-proof cover. There were concrete shelters for machine guns in the 2nd and 3rd lines, but none in the first. The second, third and fourth positions had been laid out in 1914, according to the ideas of that time—half a metre wide trenches, nearly straight, with metre traverses and plain wire. They had not been kept up, and, except the fourth, were hardly fightable in 1916.

One of the great weaknesses of Verdun was the insufficiency of its communications with the interior of France. Owing to the position of the enemy round the fortress, it was only served by a single metre gauge railway; of the two broad gauge railways that ran to it in peace time, one was in the hands of the enemy, and the other under his fire. Finally, as if to complete the confusion in the organization, on 30th January, 1916, three weeks before the German attack, the *Région Fortifiée de Verdun* was transferred from the Group of Armies of General Dubail (East) to that of General de Langle de Cary (Centre).

The fighting is described at considerable length. Bad weather, which prevented the Germans from moving their guns forward after the first phase, probably saved the French from the loss of Verdun in the spring. But General Palat considers the most important factor was that the German 16-in. howitzers were marked down by artillery experts and knocked out by French long-range guns (155 and 100 mm.), " Long Tom had the better of Fat Bertha," and that the great German artillery dump of 450,000 heavy calibre shell was blown up, thanks to the Germans keeping their shell fuzed.

There is a very interesting report by General de Grandprey, a distinguished officer of engineers, on the resistance of permanent fortifications to modern heavy artillery, and what he says can be verified by the casual visitor, for Thos. Cook & Sons' tour of Verdun includes a long visit to Fort Vaux, which, with Douaumont, suffered the heaviest

and longest bombardments. Nothing built before 1885—this would include most of Antwerp—was of any use. A layer of 2.50 metres of good concrete, or 1.75 metres of reinforced concrete, as we already knew, was not pierced by the heaviest shell. The whole of the casemates, passages and under works of Vaux are intact; at Douaumont, where there was an internal explosion during the German occupation, owing to the accidental ignition of some hand-grenades, five casemates only are unfit for occupation; the remaining 13 upper ones and the whole of the basement ones are intact. Large masses of concrete, and large steel shields resisted well; small buildings, and the small shields of machine-gun emplacements were of little use. There is no detailed description of the concrete; nor is the method of ventilation touched on.

Though not a technical engineer study, the book as showing the resisting power of a well-fought fortress is of considerable interest, and is the most compact account of Verdun that is available.

J.E.E.

SIR JOHN MOORE'S SYSTEM OF TRAINING.

By COLONEL F. J. C. FULLER, D.S.O. (London: Hutchinson & Co.) 10/6. Illustrated.

IN a smaller work on "Training the soldier for war," published in 1914, the author referred to Sir John Moore's system, based on intimacy between Officers and men, and not on familiarity, on self-respect and not fear, which produced a body of men—the renowned Light Division—unsurpassed in war. He has now collected together many details of that system, which was so soon to prove its worth that it cannot fail to command the attention of all students of military matters. We can readily accept Seaton's assertion that the foundation of Wellington's successes was laid at Shorncliffe.

Moore was a believer in what we are pleased to call the human touch, as distinct from the then more universal but brutal methods of Frederick the Great. We are given a short account of his life, in which we could find no mention of the fact that he was once a Member of Parliament. "*De Mortuis . . !*"

Interesting *résumés* are given of the existing regulations and orders regarding training and organization. These are followed by the principles which Moore observed and the ideals to which he pointed, as exemplified in the standing orders of the units of his Brigade. The numerous extracts contain much to think about and much to smile over, and make it abundantly clear that military progress is merely cyclical. For example, here is the gist of a recent Army Order, but dated 1800: "Every Sergeant is expected to be master of reading, writing and the first four rules of arithmetic," and here is Recreational training and amateur status in a nutshell: "The Captains and other Officers are requested to show every encouragement to their men to amuse themselves at the game of cricket, hand or foot ball, leap-frog, quoits, vaulting, running, foot races, etc.; money is never to come in question as a prize, but any other descriptions of premium which can be thought of." "All soldiers should be able to cook. To doom one soldier to perpetual cooking is wrong, no

man worthy to bear arms should be degraded to the office of perpetual scullion for his comrades." (Cf. Courses of Instruction, 1925).

They held downright opinions in those days, and even dared to express them. We read that one Colonel Hanger addressed himself to Lord Castlereagh as follows: " I hold in detestation and abhorrence all *Button* and *Buckle* Officers, and I never yet have seen a real *Martinet* or a *tip-top Adjutant* (excuse, my Lord, the vulgarity of the latter expression) ever turn out a good soldier on service; . . . . their ideas soar no higher than pipe-clay, buttons, lacquering of caps, the precise length of the pigtail, even to the quarter of an inch."

Knowing our " Reformation of War " we half hoped for a little futurism. Would death-rays (on both sides) have affected the issue at Sahagun? What if the concentration at Boulogne had been one of televisionaries? And supposing Castlereagh, busy penning Moore's appointment to the Chief Command in Spain, had fumbled with his face-piece (for all proper wars start with the gassing of Ministers)?

The references, which are mostly to James Moore's " Life," and to Sir J. F. Maurice's " Diary," are complete and accurate, so that the context of the many quotations is easily found. This is Sir William Napier's opinion of Moore's system: " The Officers were never averse to being made to acquire, amidst the private soldiers, a complete knowledge of what, as officers, they were to exact from, and superintend with, those privates. Never did the system lead to disrespect or undue familiarity on the part of the soldiers; on the contrary, it produced the natural effect of knowledge combined with power, willing and entire obedience from the soldiers, while the officers were proud of their acquirements, knew their men and were known to them; knew when to exact and when to relax, and were in every sense commanders."

I.S.O.P.

MILITARY ENGINEERING.

(Technical Training. Vol. II. Electrical Engineering. 1924.)

" What knowledge should an engineer have in his head and what knowledge should he have in his books? " That is a question which every one has to consider who has to do with the training of engineers. The question is not of such vital importance to an engineer stationed in England, where he can surround himself by an unlimited number of books, and moreover has more or less frequent access to the best stocked libraries and where the telephone can put him into instant communication with any expert on any subject. It is a much more important problem for the sapper officer or civilian engineer working overseas and having to rely on his own knowledge and commonsense and on a small collection of text books strictly limited by transport considerations.

Both the military and the civilian electrical engineer thus situated, would be better served by a Molesworth and the book under review than by a whole shelf full of other books. The second part of the above question can, therefore, be answered since the appearance of this publication. It is not possible to anticipate every engineering problem someone may be up against at some future date, and in an unknown

place and faced with an unforeseen situation; but the anonymous editor and authors have shown themselves to possess just the kind of imagination that enables them to picture the sort of information a sapper officer is likely to require, and to supply that information in a form that is both clear and inspires confidence. The book covers all the electrical engineering ground that may, in the ordinary way, come within the scope of a sapper officer's activities.

If he has to design an electric generating station, he will find facts and figures to help him to decide on the size and type of plant, the type of current, the voltage, the best site for his station. Full descriptions of existing military stations will guide him on orthodox and proven lines. He is told what switch gear is required in various cases, what he may need in the way of transformers and how to instal them and phase them out, what protective gear is required, and he is advised on earthing, with an emphasis which is very welcome, considering how often this subject is carelessly treated.

For those whose problem is mainly one of transmission and distribution, methods for calculating cross sections and voltage drops on both H.T. and L.T. systems are given. The method given for calculating complicated L.T. networks is not the neatest possible one, but, for the purposes of the book it is the most serviceable, as it involves nothing more abstruse than simple arithmetic and it is easy to understand. The D.C. three-wire and the A.C. three and four wire systems are explained, and their economics over two wire systems worked out. The A.C. six-phase system now coming into favour might, with advantage, be included in future editions. Cables are very fully dealt with from the points of view of choice of type and size, manufacture, laying, jointing and testing. Design, calculation and erection of overhead lines are given an amount of space proportional to their importance in military work.

So far the first part of the book. The second part is devoted to the utilisation of electric light and power. Guidance is given as to the necessary intensity of illumination, the proper disposition of lamps and the best type of lamp and reflector for all possible cases of indoor and outdoor lighting. Different methods of indoor wiring are explained and compared, points requiring special attention are emphasised, methods of calculation and most valuable information about fittings are given. All types of electric motors and secondary batteries are dealt with in the same sound and practical way. The characteristics of different motors are explained, together with their field of application. Rating, protection switching arrangements, installation, are all discussed.

One hundred and eight plates at the end of the book give a variety of pictorial information. There are typical station load curves, model diagrams of connections for a number of circuits, drawings and photographs of all kinds of electrical gear, pictures of indoor wiring and overhead line work. The plates are well selected to impart a maximum of knowledge, while avoiding redundancy. At the end of each chapter a bibliography is given. Official regulations and B.E.S.A. standards are quoted wherever they are relevant to the subject matter.

So much for the ground covered. The kind of knowledge conveyed is concerned with the type of machinery, apparatus or material required for a given purpose and the basis on which to decide between available alternatives; the way to determine the size and capacity of the individual parts of an installation; the cross section and voltage drop of transmission lines; design of buildings; care of batteries; the dimensions and weight of individual articles, and where these are obtainable through official channels, the rather mysteriously worded official designation, and frequently, though perhaps not as frequently as one might wish, the cost of articles. In short, the book gives guidance as to what to instal, how to instal it, what it looks like, where to get it, what it costs, what it does, how to look after it. Such questions as maintenance, log sheets, diagnosis and repair of breakdowns receive less space than one might expect. The index is carefully worked out, but errs perhaps on the side of economy. A great deal of information is given in the form of tables.

In a short summary like the above, it is not possible to convey an impression of the large amount of detailed information contained in this publication. The editor's sense of proportion in assigning to each subject just about the amount of attention and emphasis justified by its probable importance in the work of the Royal Engineers deserves special comment. The authors have managed to make the book more up-to-date than one might have thought possible, considering the inevitable lapse of time between compilation and publication. It is inevitable that some of the most recent practice cannot always be included, such as the saving with the use of transformers with tappings on static condenser installations for stepping up to the highest voltage the condensers can stand, or the employment of Maconite cable for indoor wiring.

On the whole admirable thought has been devoted to ensuring that every statement shall be accepted practice, strictly relevant, comprehensible and helpful. The book aims at giving clear cut facts and opinions; something as definite as possible for the reader to work to. This method has the defects of its virtues. Engineering facts cannot always be accurately put in quite such unqualified terms as found here. But what the user of the book needs above all things, is positive guidance. Too many "buts" and "ifs," too many qualifications and niceties would unsettle him. The authors, therefore, have wisely contented themselves with giving facts and figures which are broadly true for the conditions likely to arise in military work, even though they may be open to doubt for other conditions. Thus it is broadly true within the range of size of military stations to say that 11 pounds of steam per k.w. hour is the absolute minimum steam consumption of turbines, although this figure can be improved on with high steam pressures, large sized units or exceptionally cold circulating water. The rule that a generating station should be at the centre of gravity of the load for maximum economy applies where voltage drop determines the cross section of transmission lines, as is usual for military systems. Where heating of conductors is the limiting factor this rule does not apply by any means. In all such cases the authors' method of giving information in quite definite terms, though a simple definite statement cannot possibly be a completely

accurate one, seems to be perfectly justifiable and greatly preferable to the alternative of confusing the reader by a lengthy dissertation on limiting conditions and the factors involved in the problem. The extra information conveyed in this way would be rarely, if ever, required by the reader. Considering how many factors influence anything in engineering and how difficult it is to say anything that is strictly true without limitations or qualifications, the authors have shown remarkable skill in getting down just such facts and figures as can be safely expressed in definite terms without marked scientific inaccuracy.

All this shows that the book under review is a thoroughly practical one in the best sense of the word. That blessed word "practical" has come to be so thoroughly abused that one hesitates to use it. We all know the self-styled practical engineer. He knows next to nothing, thinks very little, but is generally good at keeping a motor car in perfect repair. Anything he cannot understand he dismisses a little contemptuously as theoretical. Hence a great many things appear to him theoretical. Such a man will not find the book under review conspicuously practical. For one thing it contains too many quantitative statements, and the self-styled practical man prefers his books to combine a maximum of description with a minimum of information.

The engineer, on the other hand, who is out to get the best job done, the one who wishes to obtain a maximum of reliability, simplicity, economy and efficiency, will find in this book those facts which are most relevant to his problems. He can rest assured that even if the why and wherefore are not always told, the authors have based their statements on principles that are sound theoretically, as well as practically. Nevertheless, he will not be able to make full use of the book unless he has had a sound previous training embodying a certain amount of theory. Without this he may come to rely too much on the printed word, particularly when the printed word appears so definite, and too little on first principles. He may fail to realise that engineering is a living craft and that the last word has not yet been said on any of its subjects. He may miss important things in the book, not because they are not expressed in terms that he can understand, but because it is not easy to appreciate the full import of every statement in a condensed piece of writing unless one is prepared for it by one's general knowledge of the subject.

We can now give some sort of an answer to the first part of the question formulated at the beginning of this review. What the engineer should have in his head is at least an understanding of the why and wherefore of things. Thus equipped mentally, and armed with the book under review, he need not fear to tackle most electrical engineering jobs the sapper officer is likely to be faced with at home or abroad.

REGINALD O. KAPP, B.Sc., Chartered Electrical Engineer.

MILITARY GEOGRAPHY OF THE BRITISH COMMONWEALTH.

By MAJOR A. E. W. SALT, B.A. (Balliol College, Oxford), M.A. (McGill University), Army Educational Corps. (Gale & Polden, Ltd.) Price 10/-

THE choice of books for study is the first care of an Officer about to work either for a Promotion Examination or for the Staff College. For some

subjects he finds himself hard put to it to lay hands on the book which will give him the information that he wants. This is not the case with Military Geography. With this subject his difficulty is rather to select the one or two books which will best suit his requirements from the galaxy of works which are now available.

Any new book on this subject must, therefore, be a star of some magnitude to command attention.

The ground covered by Major Salt's book includes all the geographical matter required for examination purposes, and the book contains a lot of very useful information.

The first chapter deals with the history of the development of the British Commonwealth; but it is hardly possible to condense this history into fifty pages, and still to retain a form in which it can be read and remembered.

It is, therefore, mainly from the geographical point of view that the book must be considered. Under this heading accuracy of detail is of the first importance. Here Major Salt's book fails badly.

On the subject of India we read that "British troops are organised into Brigades and Divisions with the Indian Army, the normal proportion being 3 British Battalions to 1 Native." This is probably only a slip; but confidence is not restored when we find "it is so intensely hot in the plains in the summer that Europeans have to retire to Simla, Darjeeling and Poona in the hills."

We turned to Canada feeling that the author's connection with McGill University justified the hope of accuracy here at least. Comparison with the Canada Year Book 1922-23, however, showed a whole series of discrepancies. The population of Toronto is given as 377,000, whereas in 1921 it was 521,000 odd. Similarly Hamilton 82,000 instead of 114,000; Winnipeg 137,000 instead if 179,000.

Other figures were no more correct. The number of Chinese and Japanese in Canada are given as 27,000 and 6,000, respectively. The figures of the 1921 census are 39,000 and 16,000.

Nor can the inaccuracies on Canada be confined to figures, for to say that all over Canada "except in British Columbia and in the Maritime Provinces . . . . the thermometer stands always below freezing point from November to April" is sheer nonsense.

The book really needs careful revision before it can be recommended to Officers working for examinations. When it is revised it is to be hoped that an index will be added. Without one a book of this type loses much of its value.

R.H.D.

THE HISTORY OF THE TELEPHONE IN THE UNITED KINGDOM.

By F. G. C. BALDWIN, M.I.E.E. (Chapman & Hall, Ltd., 42/- net).

It is now nearly half-a-century ago that the general public in this country first had the opportunity of making practical acquaintance with the telephone as an instrument possessing commercial value. Towards the end of the 70's of the last century, an Exhibition was held at the

Crystal Palace and there among the novelties then shown was the then recently invented Bell telephone. Within the great building, two primitive call-boxes, which were roofless, had been erected a few hundred feet apart and a wire had been run between these two structures, each end of which was equipped with a single hand telephone. Those were days before Hughes had announced his discovery of the microphone, and consequently apparatus which to-day does duty as "receiver" only had to do the double duty of "transmitter" and "receiver," being held alternately before the mouth and at an ear to enable a conversation to be carried on. At the Exhibition a charge of 1/- a call was made to those who desired personally to test the efficiency of this new means of communication. There were no secrets to be told over this circuit, so that the designers of the call-boxes were not called upon to make an attempt to construct them as "soundproof" cabinets, nor did they do so; in consequence, a number of persons (mostly schoolboys) who were either unwilling to risk a shilling on a telephone talk which might come off or might not, or perhaps hadn't this sum to spare, were able to look down from one of the galleries (parallel to which lay the telephone circuit) and watch the proceedings in the call-boxes and listen to the words spoken at one end of the line. Many of those who entered the call-boxes were either shy and nervous or were overcome with awe in the presence of the uncanny apparatus with which they were closeted; anyhow, they became bereft of speech and could not proceed beyond the preliminary hailing words: "Hello! Hello! Are you there?" Since those days, improved telephones have invaded the county-house, the workshop, our homes and our public places and they have no terrors either for the very young or the very old, and to-day, either from the most public places in our great cities, or from a comfortable chair in an office, or a home, any one desiring to do so can, for a charge calculated in many cases in pence only, carry out, by means of the telephone, without any fear of being overheard by mischievous eaves-droppers, most important transactions requiring the utmost secrecy, and that with a correspondent many hundreds of miles away. In the volume under review, which is excellently illustrated, its author describes in considerable detail the successive stages by which the telephone and its simple circuit of half-a-century ago has been gradually improved and perfected so as to provide the elaborate telephone systems which are utilised to-day by millions of people resident in widely-separated localities daily to settle thousands of far-reaching business transactions with certainty and rapidity, and also in comfort to fix up in a few moments thousands of social engagements on the spur of the moment, so to say.

Mr. Frank Gill, Past President I.E.E., formerly Engineer-in-Chief of the late National Telephone Company, has kindly contributed a "Foreword;" in the last paragraph thereof; he says: "There is much in this book of great interest, but I think it has, to the student of social history, a value even greater than to the student of telephony"; such undoubtedly is the case. The details which are given in the volume of various types of apparatus, of the different circuit arrangements and of the process of evolution which has been continuously going on since the telephone took practical shape, and is still continuing, are necessarily

very technical, and, therefore, are likely to appeal alone to the student of telephony; on the other hand, there are many other aspects of the history of the telephone, particularly those which affect its introduction and exploitation in this country, which cannot fail to excite the interest of a very wide circle of readers; such is likely to be the case, *inter alia*, in the parts of the volume which tell the story of the many vicissitudes through which the telephone has passed in this country owing to the vacillating policy of the General Post Office; the great law suit, the Attorney-General v. The Edison Telephone Company of London, in which the Attorney-General, on behalf of the Postmaster-General, successfully argued that the wires and apparatus of the Telephone Company were telegraphs within the meaning of the Telegraph Acts, and that messages and other communications transmitted by means of any such wires and apparatus were telegrams within the meaning of the same Acts, and, consequently, that the operations of the Telephone Company constituted an infringement of the exclusive privilege conferred upon the Postmaster-General by the Telegraph Act of 1869; the imagination of the pioneers who put their faith in the telephone as a weapon of commerce and, undaunted by many and serious obstacles, helped to establish the telephone as a public service; the rivalry of the early telephone companies and the internecine war carried out by them, which really was beneficial neither to themselves nor the telephone users, ending finally in the triumph of the keen and competent business men who succeeded in bringing about the amalgamation of the competing telephone companies and eventually in creating the powerful and highly efficient organisation known as The National Telephone Company, which, after an existence of some 28 years, came to an end on the expiry of its licence on December 31st, 1912, the Government taking over the greater part of its plant and its officers and employés, excepting those in the highest grades; the attempt to establish municipal telephone systems in this country under licence from the Postmaster-General and its failure; and the question of tariffs.

The story of the development of the telephones in the United Kingdom told by Mr. Baldwin is, as might be expected, to a great extent the history of The National Telephone Company, until its plant was taken over by the General Post Office, but the author of the volume has, at the same time, been at great pains to seek out and record information in relation to the work done by Post Office engineers, much of which has been most valuable and of a pioneer order, both prior to and since the acquisition of the National Telephone Company's undertaking by the State; the story of the development of telephone systems has been brought down to date, all recent advances, e.g., the improvements in and introduction into this country of machine-switching equipments and the progress made in telephone repeating devices, resulting in the installation of valve-repeaters on our long distance trunk lines, are duly recorded. The contents of the volume under review constitute a valuable piece of research work into the history of telephony, not only in this country, but also in other parts of the world, and, with the progress of time, the information collected by Mr. Baldwin, particularly that in relation to the original work in the telephone field done in this country;

cannot but become increasingly interesting and useful, and will give a new starting point to those of a later generation who desire to compile a record of the further progress made in the science and art of telephony. In a work of this kind, and of its dimensions, it is practically impossible, even with the most careful proof-reading, altogether to prevent small errors from creeping in; the author is, therefore, to be congratulated, as the number of errors observed is exceedingly few and not of a kind to mar the value of the volume.

W. A. J. O'M.

THE HODSOCK BALLISTIC TABLES FOR RIFLES.

By F. W. JONES, O.B.E. With an introduction by LIEUT.-COLONEL MELLISH, C.B., V.D., and an Appendix on THE BALLISTIC PENDULUM. By COLONEL LORD COTTISLOE, V.D. (Publishers: Edward Arnold & Co.) Price 10/6.

THESE tables are difference tables, having as their object the facilitation of the calculation of the striking velocity and time of flight of bullets and the elevation of rifles; they have been compiled from experiments made with the ballistic pendulum on the private range of Colonel Mellish, of Hodsock Priory, near Worksop, by the Author and Major, the Hon. T. F. Fremantle, now Lord Cottisloe, in the years 1897-98. The first three chapters of the book, which comprises 80 pages, are devoted mainly to the mathematics of ballistics, the fourth explains an empirical formula for the ballistic constant and the last deals with the practical use of the tables

If a mass M be suspended from a point A vertically above it, and be given a velocity V, it will swing through a certain angle which can be computed, and conversely if the angle of swing is known V can be found.

If a bullet moving with velocity v give such a pendulum of mass M as velocity V, then, by the principle of momentum $mv = (M + m)V$, supposing the bullet to become embedded; now as, m and M are both known and V can be observed, it follows that v can be calculated.

The formula used was

$$v = \frac{M + m}{m} \times \frac{\Pi}{12t} \times a.$$

Where t is the time in seconds of a single swing and a is the horizontal distance moved.

The pendulum used was 132½ inches long, weighing 147 lbs., and consisted of a hollow 6-in. x 6-in. steel bar, 133-in. long, suspended by wires, on to one of the 6-in. x 6-in. ends a hard steel socket, 10-in. dia., was fixed, into which was bolted a 3-in. thick hard wood plug, into which the bullets were fired; the apparatus was protected by a 12-ft. x 12-ft. shield, having an 8-in. circular hole so placed that all bullets passing through the hole would strike the pendulum; for a velocity of 2,800 f.s., and a bullet of 175 grs., the displacement is about 4-in.

Suitable arrangements are provided for recording the motion of the pendulum.

Experiments have been carried out up to a range of 1,000 yards.

If the velocity of a projectile moving nearly horizontally decrease from v_1 to v_2 (a little less) in passing over a space s, then the average air resistance is m $(v_1^2-v_2^2) \div 2s$. Mr. Jones applied this formulæ to calculate the resistance for specific velocities and space intervals as established by experiment, and the information thus obtained enabled him to deduce the following empiric formulæ for velocities above 1120 f.s. :—

$$R = \frac{1}{12.07474}(v-950)^{\cdot 7}$$

For velocities 1120 to 1040 f.s.

$$R = \frac{1}{46.4186}(v-980)$$

For velocities 1040 to 800 f.s.

$$R = \frac{1}{804.6}v.$$

Given these formulæ, the methods explained in any text book on particle dynamics can be applied to obtain space, time, velocity relations.

The changes of inclination of the tangent to the trajectory in terms of time intervals and velocity, have been calculated from a method devised by the late Professor W. D. Niven, F.R.S., an eminent mathematician ; it is too lengthy to explain in a review.

The tables have been computed for a ballistic coefficient of unity ; to use the tables the proper ballistic coefficient must be applied, this depends on weight and diameter of bullet and on what is termed the "coefficient of form."

It is stated that recent experiments have shown that the ballistic pendulum gives results which very closely agree with those obtained by the much more elaborate chronograph method. The velocities, etc., deducible from the table have been extensively checked by experiment, and the remarkable coincidence is a tribute to the accuracy of the empiric formulæ. The mathematics of the work is simple and clear. I consider the book an admirable one and an instructive exposition of the use of mathematics and experiment in combination.

J. M. WADE, Lieut.-Col., B.SC., London.

30-3-25.

THE ELEMENTS OF MECHANICS.

By F. S. CAREY, M.A., Professor Emeritus in the University of Liverpool ; and J. PROUDMAN, M.A., D.SC., Professor in the University of Liverpool. (Longman, Green & Co., 39, Paternoster Row, E.C. 4.) Price 8/6.

THIS is an elementary work on statics, dynamics and hydrostatics, suitable for advanced classes at schools, and for first year students at universities ; its study does not require a knowledge of the calculus. The scope of the treatise is almost precisely the same as that of other elementary works ; it is not and does not purport to be suitable for a complete beginner though the subjects are treated *ab initio*. I may mention that the term " elementary " as applied to mechanics constitutes a domain

not requiring the calculus or a knowledge of analytic geometry of three dimensions, consequently such subjects as forces, and motion in three dimensions, wrenches, the equilibrium of strings, attractions, and the general theory of rectilinear, orbital and constrained motion are necessarily excluded.

The features of this treatise which differentiate it from others are:

(1) Statics and dynamics are developed side by side.

(2) The theory of vectors is largely used, and two chapters are devoted to their purely mathematical theory.

As to the first of these innovations, there is little doubt that the parallel development of statics and dynamics makes these sciences more interesting and intelligible to the young idea.

With regard to the use of vectors, some teachers will approve, others may not; there are already several excellent works on statics and dynamics, noticeably those by Professor S. L. Loney, of London University, and the authors may have felt that there was no necessity for another treatise on the lines with which all of us are more or less familiar; the importance of vectors is becoming more and more recognised and the book under review is a good illustration of the conciseness and generality gained by their use.

Chapters 22 and 23 contain an elementary, but useful, introduction to rigid dynamics; the inclusion of the elements of this subject in an elementary work is an innovation with which most will agree; though rigid dynamics is much more difficult than particle dynamics, it is, nevertheless, much more interesting and stimulating, and the sooner the student is introduced to this important branch the better. There are but two chapters on hydrostatics; the examples are numerous and well chosen. The treatment of the subject by the authors is novel, and there is a marked preference for geometrical methods, but the subject matter is, as might be expected of two mathematicians occupying the high position of a university professorship, quite beyond criticism as regards lucidity, arrangement and conciseness. The book should hold its own amongst the leading treatises on elementary mechanics.

J. M. WADE, Lt.-Col., B.Sc., London.

THE MECHANICAL DESIGN OF OVERHEAD ELECTRICAL TRANSMISSION LINES.

By EDGAR T. PAINTON. (London: Chapman Hall, Ltd., 11, Henrietta Street, W.C. 2.) 1925. Price 21/-

THE author of this volume has set out to produce a book describing the latest constructional details of overhead lines for the transmission of electrical power, together with the present trend of thought on design methods.

He points out those features which experience has shown to be desirable and indicates how far the limits of commercial manufacture enable requirements to be fulfilled.

Different forms of conductor are first dealt with, copper, aluminium, aluminium steel and copper clad steel wire are described and their

various merits compared. The information on copper clad steel wire is interesting. The tensile strength for hard drawn wire of this type is given as being of the order of 100,000 lbs. per sq. inch in the smaller sizes. Sag and stress problems are fully dealt with under varying conditions, and numerical examples illustrating the use of deduced formulæ are worked out.

Four chapters are devoted to the subject of supports; various types, from the plain wood pole to the complicated steel tower are described and illustrated. Re-inforced concrete supports are not, however, touched on.

A table is given shewing the basic loading conditions and the various factors of safety insisted on in different countries; whilst another gives the voltage, conductor material, and spacing particulars of some lines that are in operation in different parts of the world.

No mention, however, is made in this table of any line using the latest form of copper clad steel conductor.

The chapter on wooden supports is one which should appeal to the military engineer, since he will mostly deal with supports of this kind. The information given on foundations and ground re-actions on loaded supports is most valuable.

Constructional details shew various forms of insulation binding and mechanical clamps, different methods of jointing, various forms of guards and lightning arresters.

The final chapter on the erection of an overhead wire lays stress on the necessity for organization, in order that the construction may proceed in a continuous progression.

The information given is good, and provides food for thought for anyone who may have to organize an engineering undertaking spread over a large distance. An outline of such processes as insulation manufacture and design is included, in order that the reader may appreciate possible causes of failure and the reasons for particular kinds of tests.

The book has been written principally for the consulting engineer, and, generally speaking, the schemes, etc., considered are on a larger scale than anything that has, in the past, been taken on by British military engineers. In spite of this, the practical side of construction has not been omitted, and the book contains any amount of information that would be of great assistance in putting up the less spectacular type of overhead line likely to be erected by Royal Engineer officers.

G.C.G.

AUTOMOBILE ENGINES—MOTOR MANUALS, VOLS. I and II. By ARTHUR W. JUDGE. (Chapman Hall, Ltd., 11, Henrietta Street, London.) Price 4/- each.

Volume I is the first of a series of motor manuals intended to present in a non-technical manner the various aspects of each branch of the subject.

The author states in his preface that his object is to produce a book for the use of motor owners, students and others, who desire a sound informative account of the practical and theoretical side of automobile engineering.

He manages to compress into a comparatively small volume a great deal of information, much of which is not to be found in the ordinary motor manual published at about the same price. Fuels, combustion processes, pressures, efficiencies and indicated horse power, etc., are clearly dealt with, and the two and four stroke cycles are described and compared.

Various components of the petrol engine, e.g., valves, different types of cylinder heads, valve forms and valve dispositions, pistons and piston rings, etc., are described, and their various merits compared.

Following this is an account of how these different engine components are arranged by different engine designers, examples and diagrams of almost every type of car or light car engine, from one to twelve cylinders, being given to illustrate various points.

There are, in addition, chapters on the lubrication, cooling, testing, and maintenance of the ordinary car engine. These latter, apart from being of value to the owner-driver, would be of great use to anyone who had to get up lectures, etc., for the instruction of lorry or car drivers.

Volume II of the series deals with various fuels used in motor car engines, together with the elementary theory of carburation. A simple form of single jet and air intake carburettor is then described and its various defects are pointed out; e.g., starting difficulties, acceleration difficulties, etc.

From the consideration of the defects of this simple carburettor it is possible to summarize the conditions that should be fulfilled by the perfect article.

Different methods of arriving at this ideal are then described; all the various classes of carburettor being classified in five typical groups; explanation being given as to how and why these different types fail or succeed in reaching the ideal.

The next step is to illustrate and describe in detail some 14 types of British, and 6 types of American motor car carburettor, showing how different makers strive after the ideal in different ways.

Following this is a description of a number of motor bicycle carburettors.

There is a final chapter on Testing, Tuning, and Trouble-tracing from the carburettor point of view.

The book is a good one, and should appeal to the type of person for whom it was written, viz., the motor owner, driver, garage engineer and mechanic.

G.C.G.

MAGAZINES.

REVUE MILITAIRE GÉNÉRALE.

(*November*, 1925, *continued.*)—*Ludendorff's Battles on the Russian Front.* The conclusion of the article by General Camon, dealing with the Battles of Lodz and Augustowo, both of which were "Battles of Cannae." At the former the Russians escaped encirclement, but at the latter the greater portion of the 10th Army was taken prisoner. The conclusions drawn are that from the German success at the two

battles of Augustowo and Tannenberg one might be tempted to think that Hannibal's tactics are better suited to warfare of the present day than those of Napoleon as applied at Insterberg (the Masurian Lakes). But it must be remembered that the Russians made the Germans pay dearly for their successes, although the counter-measures of the Russian Commander were scarcely suited to the occasion, also the Germans having secured the key to the Russian cypher were always perfectly acquainted with the dispositions of their enemy. Again, in the combats preceding the battle of Lodz the Cannae plan was not so well executed that the Russians could not extricate themselves. The fact is that the longer the battle front the fewer the facilities for encirclement; on the contrary, the greater are the enemy's opportunities for overwhelming one of the outflanking bodies while containing the other. The infallibility of the Cannae design, given the resources of modern warfare, is very doubtful.

The Ouaouizert Column in 1922. By Squadron-Commander Perney.—The operations provide no noteworthy points, except that on one occasion the main body with artillery and native levies seems to have been caught in a defile; the resulting confusion would have been disastrous with less seasoned troops and a more enterprising enemy. Some of the lessons afforded are of interest, but referring almost entirely to North African conditions, are not of universal application.

Military Chronicles of Economic Questions. By Pierre Bruneau.—This article discusses the conflicting demands of the Army and of agriculture in France on the man-power of the nation. The rapid progress made in the United States for industrial mobilization in case of war is also commented upon.

(*December,* 1924).—This is the last number of the *R.M.G.* to issue. An editorial note explains that the *Revue Militaire Francaise* having been adopted by the General Staff, and the demand for two periodicals dealing with the same subjects having ceased, it has been decided to discontinue the *R.M.G.*, at any rate for the present. Our sympathies are due to the management in their misfortune.

The Aulic Council of War in Austria, 1799-1801. By Commandant Weil; the last article written by him before his death.—An argument in favour of unity of command in war, drawn from a book by Col. Cordon on the futilities manifested by the Austrian Council of War before and after the Battle of Zurich up to the Battle of Marengo and the peace of Lunéville.

Operations of 1923 *in Morocco, near Marrakech.* By Squadron-Commander Perney.—There is little of particular interest in this article. Thanks to the investigations of the political officers before, and to the dispositions and tact of the Column Commander during the operations, all objectives were occupied with little or no fighting.

Essay on the 4th Bureau of the General Staff. The conclusion of Major Raoult's article, in which is explained with fuller detail the relations between the 4th Bureau and Artillery, Engineers, and the Army Services. Suggestions are made for possible improvements in certain particulars, especially as regards Artillery and Engineers. For the latter one store

depot and one park were formed, generally speaking, for each Army Corps, the sites being selected by the 4th Bureau, and organization arranged for by agreement between the engineers, the road service and the 60 c.m. railway management. At first formations sent their demands to the G.O.C. the Engineers, who met them as far as he could from stocks in hand, and sent the rest to the 4th Bureau with his remarks. The writer thinks that this was wrong, that all demands should be sent to the 4th Bureau, and that the G.O.C. Engineers should only issue the amounts passed by it with his concurrence. As the war lengthened this was, in fact, what took place, the main determining factor being the necessity for concentrating all transport in the hands of the 4th Bureau. It led to the happy result of relieving the G.O.C. Engineers of a quantity of administrative work, leaving him more free to meet his heavy responsibilities to the 3rd Bureau in regard to defensive works. In view of the magnitude of his duties further decentralization was gradually effected, and roads, water supply and hutting became independent services, although, apparently, some engineer units were employed on them, either for execution or superintendence.

Conneau's Cavalry Corps on the Marne. In this article Col. Monsenergue sketched the course of the French retreat from 3rd to 6th September, 1914. Trained for shock tactics the cavalry had now learnt the impossibility of employing them against the Germans, and restricted themselves to providing escorts for their artillery, using cyclists and dismounted action with the few machine guns available. By these means they were able to close the gap between the French left and the British right and frustrate Von Kluck's determined effort to break through the gap and turn the French left. The result, after some days of struggle, paved the way for the victory of the Marne.

Books. Quelqu'un Dira? By Henri Bouvier (Jouve). Awarded a prize by the *Académie Francaise.*—A magnificent recital of the most dramatic incidents in the author's experiences of the war, which should be read by all the youth of the nation to whose lot it falls to complete the work of their elders.

Lettres à un ami. Souvenirs de ma vie Politique. By Alexandre Ribot (*Editions Bossard*). M. Ribot was Finance Minister from 26th August, 1914 until he became President of the Council and Foreign Minister from March to October, 1917. His book contains admirable pen portraits of the most distinguished French politicians and soldiers of the period, and its evident sincerity entitles it to a prominent place in the annals of the war.

Artillerie de Campagne. By Lt.-Col. Rimailho (Gauthier-Villars).—Few men are better qualified to elucidate this subject than Col. Rimailho, who was one of the designers of the 75 c.m. gun. Commencing with a short history of the weapons in use from 1870 onwards, the major portion of the book is devoted to descriptions of the guns of to-day, and is illustrated by photographs. It is pleasingly written and should interest foreign artillery officers.

L'Allemagne et la Guerre de l'Air. By General von Hoeppner. Translation and preface by Major de Castelnau. (Payot.)—General von

Hoeppner, after being C.G.S. of the 2nd Army, in 1916 became Commander of the German Air Forces, his book is always interesting, often impartial, and sometimes fantastic.

Franchissement des Fleuves en Présence de l'Ennemi. Col. R. Normand (Fournier).—Napoleon's dictum that a river is passed wherever and whenever it is desired to do so he qualifies elsewhere by admitting that careful preparations are required. The author confirms this by examples taken from history, and from various river crossings effected during the late war. A book rich in instruction.

A.R.R.

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*REVUE MILITAIRES FRANCAISE.**

(*January*, 1925.)—*Organization by the Council of the League of Nations for the Exercise of its Right of Control in Ex-Enemy States.* By Col. E. Requin. In a resolution passed on 27th September, 1924, the League of Nations has practically and definitely adopted a system for the control of military, naval and aerial activities in Germany, Austria, Hungary and Bulgaria, imposed upon it by the various Treaties of Peace, and destined to be introduced the moment it is decided that the existing inter-allied Commission of Control can be dissolved. The system is explained, but the writer considers that its efficacy will depend entirely on the way in which its investigations are carried out. The objects of an inquiry may be known, but the methods adopted should be unexpected, and not confined to visible acts, but include clandestine preparations. The powers of the Council are unlimited, and its action should prove more effectual than that of the inter-allied Commission, the more so because its international character removes any suspicion of partiality.

An Encounter Battle—Virton, 22nd August, 1914. By Commandant Grasset. An interesting account of the battle, fought at first in a thick fog which precluded any tactical display on either side. This part ends at 8 a.m., when the German Army Commander, von Below, broke off the action, thus saving the head of the main body of the French 4th Corps from being caught in confusion in the streets of Virton. The article is illustrated by a general map 1/40,000 and three sketches. (*To be continued.*)

Material for the French, Morale for the Germans. A reply by Commandant Grenier to a pamphlet lately written by the German General von Taysen, in which the latter accuses the French of relying too much on superiority of fire and on mechanical aids for winning their battles, to the detriment of the morale of their infantry. Major Grenier considers that this pamphlet, written by a late Inspector-General of Infantry, is prompted by a desire to uphold the excellence of his own arm, and to persuade the German infantryman that he can do without the heavy artillery, tanks and aircraft, which have been forbidden to him by the

* *Copies of R.M.F. will be placed in the Corps Library for issue to members who wish to read articles outlined in this necessarily brief review.—Ed., R.E.J.*

Treaty of Versailles. In spite of what the General now says, there is no doubt that the machine will again take its proper place in German preparations for war.

Signals in the Army Corps. A tactical exercise carefully worked out by Capt. Joubert, illustrating the organisation of signal communications of a Corps derailing, marching into cantonments, and providing an outpost line. Although wireless must be used to a great extent at first to communicate both with aeroplanes and scattered units, the writer considers that a complete telephone system should be installed as soon as possible, and as an instance asks what might have happened had von Kluck been able to talk direct with the Great General Staff at the time he abandoned his march on Paris.

Anti-Aircraft Fire and Defence. By Colonel Pagézy. This is Chapter II of an article commenced in the *R.M.F.* for December, 1924. Although somewhat discursive, it states clearly and not too technically the problems confronting the A.A. gunner, and the various steps taken to solve them. (*To be continued.*)

The Genesis of Trench Artillery. By Colonel Duchêne, of the Engineers. Interesting as a matter of history and written with some sense of humour.

Foreign Military News—Japan. A few remarks on the recent naval manœuvres, and the effect of the Washington Agreement on the numbers of vessels in the fleet.

United States. Short descriptions are given of the new medium tanks of 1921 and 1922 patterns, of the new medium guns now being tried for arming the Corps artillery, and of speed and endurance tests of naval aeroplanes.

Italy. Rifle clubs abound and technically and administratively are under the Minister for War, who supplies instructors, arms and training grounds. In these the youth of the nation is trained before being called up for service. After the War the period of colour service was eight months, which, since January, 1923, has been extended to eighteen months. Fascism is getting into its hands the pre-military training and also that of the voluntary militia for home defence.

Bibliography. Places fortes et fortifications pendant la guerre de 1914-1918. By General Lebas (Payot). Dealing more particularly with the northern end of the allied line in Europe, the writer upholds the value of fortification, and asserts that if Lille and Maubeuge had been kept up to date, and if on mobilization the works recommended by the Commission of Defence after the war of 1870 had been constructed, they would have sufficed to limit the progress of the German armies.

Cinq Ans du Turquie. By General Liman von Sanders. Translated by Lieut.-Col. Mabille (Payot). These memoirs are of great interest, furnish much information hitherto unpublished, and throw a new light on several events of the war in the East.

Un des problèmes de la Paix ; Le désarmament de l'Allemagne. André Honnorat (Alfred Costes). Supported by official documents, this work is concerned with two of the burning questions of to-day—the work

of the Inter-allied Commission of Control and the development of the militarist movement in Germany, and is, therefore, of capital interest.

L'Infanterie allemande au Combat. By Commandant Grenier (Charles Lezangelle). A critical study of the German Infantry Manœuvre Regulations of 26th October, 1922.

Historique des Corps de Cavalerie Commandés par le Général Conneau (Charles Lezanville). A worthy successor to the histories of the cavalry corps of Sordet and Robillot, which have already been published.

Mémoires de l'Amiral Scheer (Payot). Written by one of the most senior German naval officers, and one who was behind the scenes in German foreign and domestic policy, this work is of considerable military interest. A stalwart upholder of the submarine war, Admiral Scheer expatiates on the political, economic, and military considerations which decided Germany to adopt that mode of action.

(*February*, 1925.)—*Concerning a German Opinion on French Military Ideas.* General von Taysen's pamphlet, "Material over Moral," appears to have aroused as much interest in France, at least in military circles, as generally in Germany. Reviewed in last month's *R.M.F.*, it is criticised at greater length this month by Col. Alléhaut, who begins by observing that lessons are to be learnt even from enemies, especially when they have offered such formidable resistance as Germany. The military ideas of Germany, victor of 1866 and 1870, were adopted more or less by France and other nations (it is to be regretted that they were not followed in the matter of mobile heavy artillery and the use of the spade), but it would be unfortunate for France, as victor in the last contest, proudly to consider that her ideas must now be the best. Von Taysen's criticism may, therefore, be of value to France, although this would be the last thing he would desire. But his remarks must be read with discrimination; he occasionally fails to appreciate shades of meaning in the French regulations, and sometimes reads into them words which cannot be found. Again, it is curious that the advocates of sledge-hammer methods should now be belittling the machine as a means towards victory, and to belittle one's adversary is to show one's own defeat in a more humiliating light. After these preliminary observations, the German pamphlet is dealt with chapter by chapter. Chapter I—general remarks on the French principles of battle—being dealt with in this number, arguing that the German general's contention that the French follow on all occasions a stereotyped plan is incorrect. (*To be continued.*)

Reflections on the Accompanying Artillery. By Commandant Menjaud. The need for specially designed guns for closely accompanying the infantry regiment under the direct orders of its commander is evident. In this article are discussed the best means of communicating with these guns, their number, distribution, organisation and employment, both in attack and defence, with some remarks on the effect they will have on the employment of the divisional artillery.

An Encounter Battle—Virton. Commandant Grasset's article is continued, and leaves the 4th Corps to follow the fortunes of the 2nd Corps, whose right flank the 4th was intended to secure, but of which the leading

division was now well on its way to Bellefontaine, some miles to the north. Soon after 8 a.m. the fog lifted and von Below, meeting with strong opposition in front, and receiving word of strong bodies of French troops on his flanks, ordered his leading divisions to halt and entrench. (*To be continued.*)

The Decline of the German Effectives in 1918. By Lieut.-Col. Paquet. This article is of interest as showing the shifts to which Germany was reduced during the latter half of the war, and specially in 1918, in order to maintain the strengths of her units in the field, but would appeal more to the statistician and historian than to the general reader.

Anti-Aircraft Fire and Defence. The continuation of Col. Pagézy's article, describing various instruments in the French service, and the manner in which they are used. The duties of the different numbers in the command and gun detachments are given, with some remarks on aiming on sound. (*To be continued.*)

The Tactical-Employment of Minenwerfer in the German Army. By Commandant H. Martin. A concise and well-expressed article, worthy of study.

Foreign Military News—Roumania. The new Act of 24th June, 1924, for the organisation of the Army makes a few changes, the most important of which is that commands in recruiting regions are duplicated: (i) the command proper, *i.e.*, the Army Corps Commander, dealing with the preparation for war of troops and services, and (ii) the Territorial Commander, on whom devolves the preparation for and execution of mobilisation, both military and industrial, and whose office continues in being throughout the duration of a war.

A.R.R.

REVUE DU GÉNIE MILITAIRE.

(*January*, 1925).—*A Field Railway of Standard Gauge.* The article describes the development of the railway from Dernancourt to Maricourt during the Somme Offensive of 1916.

At the commencement of the offensive the only line available was a single line which had been built by the British. This line was practically coincident with the British-French boundary and it was put directly under the *Commissaire Militaire du réseau du Nord.* The line was originally made with the idea of economising labour at the time of construction rather than with a view to an ultimate use for heavy traffic. The curves were of too small a radius, the gradients were too steep, the rails were only fixed to the sleepers by dogspikes, which were not strong enough to hold the outer rail in position at curves, and several stations were badly sited on curves or slopes, with too short sidings.

The article describes in some detail the work which was carried out during the various stages of the offensive.

The conclusion is drawn that while giving full credit to the British for initiating the system of pressing on the construction of standard gauge lines to the front line, yet in this case, hampered probably by lack of technical troops, the writer considers that the British were over hasty and lacked foresight. Emphasis is laid on the importance, while

keeping the line as close to the front as possible, of constructing it so that it can be exploited as the front moves forward. In particular, attention is drawn to the survey of the route with its ruling gradients, the minimum radius for curves, the laying of ballast and the siting of stations so that they are capable of extension.

The art consists in arranging the preliminary lines so that the eventual improvements can be made by extension and not by reconstruction; contrasting examples of the inconvenience of transformations and the ease of extending a well-designed station are taken from the experience of the improvements of this line.

The Communications of the Fortress of Metz. A very full description of the progressive developments from 1900 to 1918.

All artillery posts had loud speakers; cables, some with dry core paper, others with rubber insulation, were buried at a depth of 1.5 metres, sometimes more.

The whole system served 3,800 "subscribers" with 93 switchboards by the end of the War.

Reviews. "*Ce qui tout aviateur doit Savoir.*" By André Laini.—This is claimed to be a classic manual on aviation, simple and complete. The five parts of the book deal with (1) Aerodynamics, (2) Construction, Care and Testing of Aeroplanes, (3) The Motor, (4) Atmospheric Phenomena, (5) Instruments.

(*February*, 1925).—"*Revues Etrangéres.*" *The Adventures of a Bridging Train in Mesopotamia.* By Major Sandes, D.S.O., M.C., R.E. This is a translation of the article published in the *Royal Engineer Journal* of June, 1924, with concluding remarks by Chef de bataillon Lazard. He comments upon the resourcefulness of engineers and their power of adapting inadequate local resources to their requirements, and discusses the relative advantages of saddle loading versus gunwale loading, noting particularly that with the slippery teak chesses of the standard equipment saddle loading made it impossible for horses and difficult for men to keep their footing in stormy weather.

The British method of forming cut by swinging a portion of the bridge is commented on; it is quicker and requires fewer men than the French method of rafts.

Chef de bataillon Lazard concluded by saying that the work done in such bad conditions and with such small resources and the results obtained by incessant efforts in a very unhealthy country do honour to the Royal Engineers.

"Là, comme partout, les camarades du Royal Engineer Corps se sont montrés des 'gallant gentlemen'; ils ont été dignes des grands chefs que leur arme a donnés à l'armée anglaise, des Napier, des Gordon, des Kitchener et ils ont fait honneur à leur belle devise: 'Ubique quo fas et gloria ducunt!'"

The reviewer feels that the Corps will the more appreciate Commandant Lazard's complimentary remarks, knowing that during recent years he has by interchange of visits seen much of our work and established himself firmly in the friendship of those members of the Corps with whom he has come in contact.

Other articles are :—

The Artistic Taste of Vauban. An illustrated article by Colonel Normand, indicating Vauban's genius for the combination of artistic work with simplicity, economy and sound engineering.

The Earliest Military Bridges of Boats. Extract from Herodotus, describing the arrangements of Xerxes for crossing the Hellespont.

The Crossing of the Oued Bou Regreg (Morocco). A raft was made from two boats and was used for transporting animals and baggage. The camels were made to sit down on the raft; those that would not do so were made to sit on the shore and were then tied up thoroughly and carried on board; the camels succeeded in inflicting one or two casualties. More than 10,000 men, 4,000 animals and 7,000 loaded camels crossed the river in 15 days.

The Engineer Parks of the Greek Army. A description of their organisation and equipment.

(*March*, 1925).—*A Contribution to the History of the French Engineers in the East.* The aim of the *Revue du Génie* is to collect information about the work done in the Near East and the Balkans during the War. The work described in this article mainly consisted of roadmaking, camps, water supply and the exploitation of forests. The expansion of the small workshops established at the ports at the commencement of the campaign into well-equipped shops capable of a large variety of work is mentioned. The account is chiefly a historical record containing some account of the organisation and of the work done, without going into technical details.

The Water Supply of Labry Barracks. A description of the installation of a barrack water supply obtained from a deep source in the neighbourhood of mine workings.

The Military Railway Bridge on the Oued Bou Regreg at Rabat. A detailed description of a railway bridge across the River Bou Regreg. The bridge was of three 146-ft. (44m.50) spans resting on pile piers, total length of bridge 572-ft. Each span was made of six independent reinforced concrete arches with a rise of about 20-ft., giving a 16-ft. width of roadway. The greater part of the article is an account of the way in which the foundations were made in difficult ground without using any special material. The only plant used were a pile driver, a skip with jaws and standard steel sections.

Revues Etrangères. The Articulated Bridge K. (Kirchner). A translation from *Heerestechnik*, March and April, 1924, giving a general description of a type of military bridge for normal railway track, designed to cross the Save near Belgrade in 1916. The article lacks detail, but comments on several interesting points of design. By using 5-metre sections for the girder and 3-metre sections at the ends, the length of the bridge can be adjusted to the nearest metre. All sections are made similar and are interchangeable; this makes the erection uniform and simple. The bridge is specially designed for cantilever erection, the parts are few and, therefore, too heavy for manhandling, but are very simply and quickly placed by moveable derricks on the top of the girders. The girder is designed to take a normal track over a maximum span 106 metres.

Statistical Data. This is the first of a series of articles giving notes on actual work done by engineers. The notes give general details and description of the work, the number of men employed, the time taken, the materials used and remarks. In this number examples are taken from the construction of four roads, which include details of roadmaking (various types), quarrying, stonebreaking, walls and bridge building. Also time, men and material tables for constructing and launching six light infantry bridges.

Reviews. Etude sur les Operations de Guerre en Montagne par le Lieutenant-Colonel breveté M. Abadie. An account of the lessons drawn from operations in the mountains during the last War. The author explains the use of troops in the mountains and their maintenance, particularly during winter.

Ce qu'il faut savoir de l'Infanterie. Lieutenant-Colonel breveté M. Abadie. Discusses the qualities required by modern infantry and its use and support by other arms.

L'Instruction sur l'Organisation et le Fonctionnement des Etat-majors en Campagne, 28th May, 1924. Two main principles are laid down: (1) A complete distinction between the prerogative and responsibility of Command and the Staff; (2) The necessity of intimate liaison between the Chief and his immediate subordinates.

H.G.K.W. and G.N.T.

BULLETIN BELGE DES SCIENCES MILITAIRE.

(*Nos.* 10 *to* 12 *inclusive*).

The account of the operations of the Belgian Army during the Great War is continued (Nos. 10 to 12 inclusive); events connected with the defence of Antwerp taking place on October 6th in the Sub-Sector of the 5th Division are recorded in some detail. At dawn on that morning, the headquarters of the 5th Division were at Bouchout and those of the 1st Division at Contich; and Belgian troops were still holding positions extending along the north bank of the Néthe between Rumpst and Duffel, but westward of the latter place the allied line had fallen back to positions approximately parallel to the railway connecting Boom and Broechem, part of the defending troops being westward of the railway and part eastward of it. Units of the German 6th Reserve Division had by now firmly established themselves on the north bank of the Néthe between Lachenen and Lierre; the pioneers of the Division had bridged the river and thus enabled the batteries of a field brigade to cross over and come into action on the north bank of the Néthe. Lierre was in the hands of the German 35th Reserve Infantry Regiment, which had established itself along the north-eastern limits of the town, on the south bank of the Néthe. Having realised that the Belgians were weak in artillery—the heavy guns promised by the Allies to the Belgian High Command had not arrived in Antwerp—the Germans moved their heavy artillery up to the line of the outer forts and pieces of various calibres—10 to 42 centimetres—were in action, *inter alia*, in proximity to Forts de Wavre St. Catherine, de Koningshoyckt and de Lierre. At this time, the Germans had assumed a defensive attitude and were waiting

for their artillery to put down an effective barrage. The delay on the part of the enemy to push on was an unexpected piece of good fortune for the defenders; the Belgian troops which had taken part in the counter-attack on the previous day had been obliged to retire to their original line running by Lachenen and Hulst to Pullaer, and the units were without cohesion and much intermixed. Had the German High Command grasped the true character of the situation and acted boldly and with promptitude, it is probable that the resistance of the Belgians in the neighbourhood would have completely collapsed; a catastrophe of this kind must have produced serious consequences in connection with the further operations of the Belgian and British troops in this region. The troops under Generals Coveliers and Deruette had on the previous evening been grouped and placed under the command of General de Stein d'Altenstein, who still hoped to keep the Germans at bay on his front and, with this object, issued orders for a further counter-attack. These orders did not reach General Coveliers, who, during the night of October 5-6th, had moved forward first to Hulst and proceeded thence to Zevenhuyzen. His intention was to get into closer touch with the troops under his command, but, as might have been expected, he and his staff became isolated in their forward position and, after a time, owing to the intensity of the fire in this part of the field, they had continually to be shifting their headquarters; touch was, in consequence, completely lost for a considerable time with the Group Headquarters. However, in view of the dispersion of the troops and the general situation, it is highly probable that had the orders sent him reached General Coveliers, he would not have been able to give effect to them. The orders for the counter-attack issued by General de Stein d'Altenstein were duly received by General Deruette, who, having obtained information from his subordinate commanders in order to be in a position to appreciate the situation, issued orders with a view to maintaining a hold on the river line. The reports which reached the Defence Headquarters of the Citadel on the morning of October 6th, seem to have created an impression that the situation in the fighting line was more serious than was actually the case; in consequence, at 8 a.m. General Deguise decided that the time had arrived for him to utilise his last reserve, the 2nd Division, and he accordingly issued an order to the commander of the Division to move forward a part of his artillery and infantry to the neighbourhood of Linth. These moves were carried out. From the narrative in the original article, it is gathered that the staff arrangements at the headquarters of the British section of the line were not working satisfactorily. Information as to the disposition of certain Belgian units in this part of the Sub-Sector appears to have been faulty; further, a proper chain of command does not seem to have been established and, in consequence, the commander of a Belgian unit received orders from the Brigadier commanding the R.M. Brigade as well as from the latter's immediate superior, General Paris; unfortunately, these orders were contradictory and placed the recipient in a dilemma. At this time, the two brigades of the R.N.D., which had been hurried to Antwerp, were being detrained at Wilrijck and Kiel; they were under orders to proceed to a part of the second line position, near Vieux Dieux, on the main road from

Antwerp to Lierre. The units of these brigades were without rations and without ammunition and arrangements were accordingly made to supply them with both before they were sent forward. The situation was now developing very rapidly and it was already evident at the Headquarters of the Citadel as well as those of the 5th Division that the hour was fast approaching when the defenders would be obliged to abandon their forward positions and even retreat from Antwerp. General Paris had, on the evening of October 5th, been placed in command of the two naval brigades sent to Antwerp by the Admiralty; the Belgian High Command, apparently being ignorant of this fact, had placed these two brigades under General Dossin, who was responsible for the retrenched position prepared between the two lines of detached forts. Comment is made in the original article on the part played by the British First Lord of the Admiralty, who appears to have assumed command of the two naval brigades himself and to have issued orders to them; orders which were contradictory to those issued to these formations by the Belgians. Many most elementary rules appear to have been ignored by high authorities in relation to the conduct of the defence of Antwerp, and it is a miracle that a disaster did not follow. At 12.45 p.m., the R.M. Brigade fell back, towards Eggerseel, on to the retrenched position mentioned above; owing to the obstacle formed by the Petite Néthe, northward of Lierre, the enemy did not follow the retiring British troops. The Germans had become extremely cautious and were no longer taking any risks. Instructions were issued at 10.10 p.m. for the troops under Generals Coveliers and Deruette to retire from their advanced positions at Duffel and Lachenen, but it was not until towards midday that the necessary orders reached those concerned. The measures taken in connection with the retreat from the Néthe are described in the original article.

The article by Lt.-Colonel B. E. M. De Grox, entitled *Le Terrain et la Guerre* is continued and completed (Nos. 10 and 11); among other articles of interest in these numbers of the *Bulletin* are *La Bataille de Saint Quentin*, by Lieut. Fraeys (Nos. 10 and 11), and *1814 et 1914 en Belgique*, by Maior B. E. M. Van Egroo (No. 12).

(1925. *Nos.* 1 *to* 3 *inclusive.*)

THE account of the operations of the Belgian Army during the Great War is continued in the three numbers of the *Bulletin* under notice; therein are recorded the incidents connected with the retirement of the Belgian troops from the line of the Néthe during October 6th, 1914. Properly to understand the events dealt with it is necessary to read the account of the operations as set out in the original article; it contains matter of much interest to which justice cannot be done within the limits of space available for this notice. The part of the story which deals with *L'agonie du fort de Broechem* (in No. 1) is likely in particular to appeal to Sappers; illustrations are provided showing a part of the fort after it had been damaged by the German artillery, and a plan of the fort is given whereon are plotted, in distinctive colours, the positions of the hits made by (1) the 42 centimetre pieces, (2) the 30.5 centimetre pieces, and

(3) pieces of which the calibre is uncertain. At this time, the Germans had reached the vicinity of Termonde, and, on October 6th, were attacking the Belgians in that neighbourhood; they were also making preparations to force a passage across the Scheldt at Schoonaerde. General Deguise, who was in command at Antwerp, in consequence, issued an order at 9.20 on this day (addressed to the 6th, 4th and 3rd Divisions, then in No. 4 Sector of Defence), directing the 6th Division to support the 4th Division; to the latter was assigned the task of preventing the enemy gaining a footing on the left bank of the river within its zone of defence. The outposts of the 6th Division were withdrawn without incident, the 3rd Division taking over from the 6th the latter's part of the front in No. 4 Sector. The 3rd Division had now to hold a front of about 12 miles with six battalions; in view of the wide extension of the front he had now to hold, coupled with the fact that the enemy was attacking Fort Breendock with vigour, the Divisional Commander, who had no reserves at his disposal, became much concerned and reported the situation to G.H.Q. in Antwerp. Fortunately, the enemy was content to confine his activities to artillery action, and no infantry attack was launched in combination with the bombardment of the "heavies." A few particulars are given in the original article concerning the bombardment of Fort Breendock, a bombardment which was temporarily suspended by the Germans on October 7th, but only to be resumed on the following day. During the first bombardment, a cupola containing a 15 c. gun was hit and put out of action, the caponiers were seriously damaged and the barrack-rooms in the fort were rendered uninhabitable; however, in no case were the vaulted roofs pierced, nor was the armament damaged.

In an article entitled *Les destructions* (in No. 1) Capt.-Comt. B. E. M. Beretze-Colet, having briefly reviewed the pre-war French and Belgian regulations relating to demolitions, describes some of the important demolition work carried out by the Belgians and the Germans during the Great War, and points out some of the lessons which the experiences of this conflict teach on the subject. The present day views held in France, Belgium, Great Britain and Germany on the subject of demolitions are also dealt with in the original article, much matter of interest being compressed into a relatively small space.

Major B. E. M. Heirman contributes an article to the February number (No. 2), entitled *Quelques Considérations sur l'emploi du Génie*; it is an interesting summary of work done by the Belgian Engineer Arm in the Great War, and contains suggestions in relation to the better utilisation of this arm in the future. In a short introduction Major Heirman points out that the duties upon which the Belgian engineers were employed during the Great War varied very considerably; at no time were any precise and definite regulations framed with a view to determining the manner in which the services of this arm could most usefully be utilised. In the early months of the war, the divisional engineers were divided and again sub-divided into a considerable number of small parties, which were attached to units of the other arms; the dispersion was very great and no indication was given as to how the engineers should be employed. In consequence, during the first phase of the great conflict,

the engineers did quite a lot of marching and were always at hand when fighting was going on, but, unfortunately, they were not given an opportunity of doing any really useful work of a technical order. However, once the opposing forces settled down to the realities of trench-warfare, every advantage was taken of the specialised knowledge and training of the Belgian sappers; at the same time, it soon became apparent that there was a great deal more technical work for the sappers to do than there were sappers to be employed thereon, and, therefore, working parties, drawn from the other arms, had to come to their aid. Later in the war, in fact, during the Entente offensive of 1918, the problem of restoring the communications destroyed by the retreating enemy on a colossal scale on a comprehensively planned scheme became a matter of high importance; the solution of this problem engaged the attention of the Chiefs of the Engineer Arm. The task of making good the damage done was assigned to the sappers, and they became, in consequence, the *arme des communications;* their chief effort had now to be concentrated on the work which had to be carried out to enable the other arms to keep touch with and, if possible, to overtake the great hosts who were hurrying back to seek safety in the Fatherland. The main part of the article is treated under two heads:—(1) *Le génie comme arme* and (2) *Le génie comme service.* In conclusion, Major Hierman points out that, to ensure that the Engineer Arm shall be effectively and efficiently employed in a Theatre of Operations, it is essential that the engineer units should carry out their work under the control and direction of their own chiefs. Consequently, if engineer units are widely dispersed and removed from the control of their own commanding officers, and the latter are not provided with the working parties required by them, the inevitable result must be that the utility of these officers will be destroyed and the specialised work which ought to be carried out under their direction must at the same tine suffer in design, quality and punctuality of performance. Finally, Major Hierman considers, rightly, it is thought, that a three-fold rôle attaches to an officer occupying the position of a C.E. or a C.R.E.; the duties which rightly appertain to officers occupying such positions constitute them, at one and the same time, technical advisers, commanders of troops and administrative chiefs of a service.

Certain works have appeared in France which deal with the defence of Namur; they are reviewed by Capt.-Comt. B. E. M. Herbiet in the March number of the *Bulletin* (No. 3) in an article entitled *La Défense de Namur en* 1914.

W.A.J.O'M.

MILITÄRWISSENSCHAFTLICHE AND TECHNISCHE MITTEILLUNGEN.

(January-February and March-April numbers.)

Major Franz Stuckheil continues his history of the offensive period of the garrison of Przemysl during its second investment.

The Battle of Limanowa led to hopes of co-operation between the Austrian 3rd Army and the garrison and a really serious attempt was

made on the 15th, 16th, 17th and 18th of December, 1914, to breach the Russian lines by sortie and to threaten the Russian retreat. As it turned out the Austrian third Army had no further success. But the sortie, in which about two divisions (24 battalions, 15 batteries, etc.) took part, actually did break the Russian lines, and was in a position to have given valuable aid to a further Austrian advance.

The action is well described and illustrated.

Captain Fritz Heigl contributes an article on the art of smoke-screening, which well repays study. The subject is well written up and the experience of all armies drawn upon.

The objects of smoke-screening are :—

1. Prevention of tactical and visual observation.
2. Prevention of aimed fire.
3. Deception.
4. Simulation of poison gas and enforcing gas masks.

Smoke from projectiles and smoke from nozzles or containers fill different roles. The one to cloud the enemy, the other oneself. Different smoke producers are compared with respect to density, poisoning (which must be avoided for obvious reasons), endurance and availability.

French, English, American, German and Italian apparatus and producers are enumerated and the expenditure of ammunition compared.

As an aid to the offensive, the first point brought out is the hiding of artillery concentrations forward and the main offensive role of smoke may be considered to be the denial of observation to O.P.'s. It should be used, where possible, to help and simulate morning and evening mist. Tank concentrations the same. The experience of French tank attacks is quoted at length. Heavy artillery and even field artillery may be made powerless against opportunity targets (*e.g.*, tanks), although not against fixed ones, for which adequate location, calibration, and meteorological measurement should suffice. Tanks may cover the advancing infantry or their own retreat. Aircraft envelop the target (ship or factory) with low-lying smoke (bombs), which will define the target and yet render it powerless, or conceal their movement by high thin clouds. Aircraft offer the cheapest and best screen against O.P.'s in the thin continuous curtain. River crossings, attacks on prepared positions, and temporary delays due to local strong points, call for the smoke masking of bridges, of the trench objective, or of flanks respectively. (The 9th Divisional attack north of the Scarpe in 1917 is quoted.)

As a defensive measure, the author is not on such sure ground. He is frankly of two minds as concerns the defensive value to the artillery itself (he is a gunner). It is possible to avoid direct observation, impossible to "spoof" the sound ranger. Possible to avoid bombs and the eye above, impossible to get "line" from a respectable R.O. He himself, with a howitzer battery, secured a four hours' life on the Piave (June, 1918) against heavy concentrations from Italian batteries by this means, but could only see his night R.O., does not think much of his own shooting, and was finally knocked out by an area concentration. On the other hand, if the whole of a defensive area is screened (thinly,

as by mist), after good preliminary survey of the approaches and likely positions in front, the defence stands to score and the immediate danger is the soundranger. The front line and the field of fire, on the whole, are better left (to secure best fire effect), but the approaches, for supports, reserves, etc., should be masked.

The obvious drawbacks of smoke screening are that you cannot spoil the view for the other fellow and retain it yourself, and that it adds yet another weight on transport, and on the industrial " home front."

Nothing is said of the value of smoke in orienting the attack and parcelling the objective.

The student of the German plan of campaign will be interested in "East or West Front," by Colonel Kiszling. He thinks Schlieffen's plan of campaign was out of date in 1914. Although Germany's industrial areas and mineral reserves lay near her eastern and western frontiers the latter were, none the less, easier to defend. France, by far the tougher and more dangerous enemy, could not be squashed in six weeks. A concentration on the Russians might have had immense effect, brought in Bulgaria, possibly, too, Roumania or Sweden, or both. The political effect of the infringement of Belgian neutrality was a far greater burden than had been contemplated.

L., who recently wrote an article on the place of the Air Arm in the State, now writes under the title "Final Decision in the Air?" The final decision is generally won through a variety of factors and ends generally in the actual occupation of enemy territory. L. thinks, then, that no actual decision can be considered " in the air," but that it may be " through the air." It is impossible to imagine a three dimensional battle of aircraft which in itself shall be decisive. In fact, the action of aircraft must, like that of a blockade, work indirectly rather than directly. In the indirect sense, however, it is extraordinarily important and extraordinarily hard to combat, because anti-aircraft measures are robbed, in the main, of mobility. They must, in fact, be arranged as more or less stationary defences for the vital spots of a nation. They may be effective, peculiarly so with an adequate equipment of search-lights, but can never be absolute, or do more than to add to the risks of the aircraft. They may be such, however, as to prevent the success of massed attacks, and, without massing, aircraft lose much of their offensive power. By analogy with wasps and other insect plagues, the author considers they are best attacked on their breeding grounde by the destruction of aerodromes and aircraft factories. Even so, however, in a highly developed state there will be so many opportunities for repair and so many places where landing is possible, that such measures will be very difficult to carry out. In fact, logically speaking, it is possible to consider two States at war whose respective aircraft shall be so powerful as entirely to cripple the States themselves, whilst the respective air forces remain comparatively innocuous to each other. He does not think that the term "command of the air" can ever be strictly applied in the sense in which we think of the "command of the sea." If an actual decisive battle is sought, then aircraft must act with the sailor or soldier. With the sailor, L. thinks his contribution not very large in actual battle, though all important to reconnaissance. With the

army, his help may be of very great value—on occasions being decisive.

With regard to war upon the country and the civil population, the vital spots may, of course, be attacked, and, therefore, States of the largest population and of the highest organisation are the most vulnerable. Unfortunately, it will not be possible to ensure the destruction of such politicians as temporarily rule the destinies of the State. However that may be, there will always be a large population living in more scattered wise upon whose patriotism and strength of will fresh resistance may be built up.

An article by Captain Heigel describes the French *char de rupture*. He claims no extensive knowledge of this tank and compliments the French on their successful measures of secrecy. General Estienne is really responsible for the appearance of this tank, and his opinion as to its use is quoted frequently. Dimensions are 10.275 metres long, 2.95 metres broad, 4.015 metres high. It has 45 m.m. of armour forwards, and 22 m.m. on sides and back. As armament it carries one 155 m.m. gun and four machine guns, or, alternatively, one 75 m.m. gun and four machine guns, with a garrison of 10 men; but the author thinks that probably many more machine guns are mountable than this and considers that the number four has been cleverly spread around as a false impression. The caterpillars are not armoured or protected in any way. The tank can climb over obstacles of 1.7 metres in height. It is engined with 250 horse-power. Its role in war is to destroy those anti-tank weapons which the lighter and more mobile tank cannot deal with, and to open a way for them and for the Infantry. There is no good manual as yet written for its employment, which tends to show that the ideas concerning its use are not yet fixed.

Colonel Rudolf Rieder contributes an article on the heaviest guns which accompany a field army. The old division between field and heavy, on the one hand, and siege, on the other, has ceased to have practical meaning, since the heaviest of guns and howitzers have come to be employed in the field army and to be entrusted with more or less the same tasks as, and to be placed side by side with, the smaller calibres. The old siege material had nothing like the mobility of the guns which accompanied the troops. The Russo-Japanese War showed the extreme importance of heavy artillery, so mobile as to be brought up almost at once by investing troops against the permanent defences of a fortress. The Austrians took up the task of making their then heaviest howitzers fully mobile with mechanical transport. The 24 c.m. and later the 30.5 c.m. howitzers were made mobile accordingly, but as the bridges of Austria were not capable of carrying the whole load it had to be divided into parts, and as the existing patterns of motor lorries in Austria were not capable of taking the weight over soft ground, special waggons had to be made. These howitzers were used in the first attack on Belgian and French fortresses. The Germans, though not so fully prepared, were able to take their part with howitzers of a lesser size. The war immediately developed into a combat of the heaviest calibres, drawn partly from naval and partly from fortress material. On the side of the Allies these were mostly railway guns with small field of fire, and all the troubles consequent on the building of spurs and possible duplica-

tion of the permanent way. The Austrians, on the other hand, faced with warfare in mountainous country (both in the Carpathians and in the Carso), arranged eventually to make their heaviest calibres mobile on petrol electric carriages, either for railway or for road. Some details of these carriages are given and of the calibres which were employed in this way.

H.St.J.L.W.

HEERESTECHNIK.

(January, February and March Numbers.)

THE January number opens with a long article on the Berlin Motor Exhibition of 1924. German and Austrian cars only are dealt with.

In the March number the Amsterdam Exhibition of February last is reported, and includes details of practically all European and American models.

An article in the *Militärwissenschaftlichen Mitteilungen* of last August gives rise to a long discussion on the tactical and technical aspects of modern war and leadership. The pre-war German staff officer, gunner and infantryman considered technical matters as bad form. Horsemanship was almost the be all and end all of the gunner. The French artillery was superior, and even giving full credit to the offensive spirit and dash of German troops, their officers had insufficient sympathy with, and understanding of, modern progress either to foresee, or to allow the development of, more efficient technical method. Specialists are necessary, but if regarded as " wild men " will become so, and a collection of wild men in charge, each obsessed with an idea, is unthinkable.

The officer and pre-eminently the staff officer must have so much technical and scientific interest and understanding as to allow him to judge of the soundness of technical invention. The staff officer should understand predicted shooting, the work of the artillery survey company (location and battery survey), the same problems of the machine gunner, the probable effect of their fire, and the results to be expected from the ammunition available. He should be able to gauge the effect of meteorological factors on gas, artillery fire, sound ranging and flying. He should understand the survey problems of Artillery, Infantry, M.G., and R.A.F., and be able to co-ordinate them. Maps, signals, wireless, mechanical transport, must be well understood. An educated person!

January and February numbers contain a short article on armoured trains. Austrian and Russian armoured trains existed. The former were used on the Russian and Roumanian fronts, to cover advance and retreat respectively. The Germans had none ready, but used some temporarily prepared in Belgium, to secure the country after the advance, in France and in East Prussia and Poland, to reconnoitre ahead. In 1918 German armoured trains were useful in Russia. The largest, best equipped and armed trains mentioned were those used by the French in Cilicia in 1920.

In February appears the first of a series of articles which are to deal with questions of gunnery and ballistics. The first is on the necessity for, and possibility of, a system of calibration in the field. The Boulangé, Duda, Aberdeen and other chronograph systems are discussed, after a good but somewhat unoriginal analysis of the corrections for the day.

Heerestechnik has already raised the question of the best small theodolite for military purposes. The matter of a survey of sufficient precision to serve the needs of indirect fire, not only for artillery, but for machine guns and trench mortars is, obviously, taken very seriously. In the February number certain models are discussed, including the latest Zeiss. But this model, good as it is, probably represents an earlier stage of the model now made by Wild, of Switzerland, and would seem then to be already, in certain respects, out of date.

Major Kretzschmann describes the damage done to temporary bridges over the Polish rivers by ice and floods after a thaw. Naturally enough, the larger the span, and the more room for the ice to get away, the less was the damage, but in a large number of cases railway communication was interrupted. Every pier in such cases should be armoured and upstream an ice breaking triangular erection of piles made. Carpenters' joints should be used, as well as bolts, to take the thrust and prevent trouble from sheering.

Major Klingbeil reviews two manuals—"*Bridging*, Part III.A., *Heavy Bridging*," and Volume VI of the Pioneer manuals for all arms, "*Camps and Hutting*." The reviews are interesting, but do not indicate much of importance.

The third volume of *Der Grosse Krieg* 1914-18, edited by M. Schwarte, is reviewed in the March number.

H.St.J.L.W.

VOINA I MIR.

No. 15 (*continued*). THIS number also contains the first part of an article by Engineer Captain Hegel, of the Austrian Army, on "Artificial Cloud," which is illustrated by several photographs. He says that cloud was first used in the naval battles of 1914. During the war its use was in an embryo state; there is no doubt but that in future wars it will acquire great significance. He describes the objects for which cloud will be used, the various means of spreading it, the materials employed and the properties of the ideal cloud. He states the methods adopted by various armies, French, English, German, American, and Italian. He then considers its tactical application with reference to artillery, tanks, infantry and aircraft, and during the forcing of rivers, citing its use by the Austrians at the crossing of the Piave on June 13th, 1918.

No. 16. In the war-technical section there is the completion of Captain Hegel's article on "Artificial Cloud." In it he discusses the use of artificial cloud (or smoke as we call it) by artillery and infantry in the defence, explaining the difficulties and advantages. He considers the use of smoke by artillery an advantage, provided accuracy of shooting is not impaired, and especially so if used continuously from the moment

a new battle position is occupied. He considers that smoke is worse than useless for infantry in forward positions, as it prevents accurate fire, but is most useful for covering movements and dispositions in rear.

He discusses the use of smoke for the defence of the interior of a country from aerial attacks. The English, and more so the French, now consider their chief task to be the defeat of the rear, *i.e.*, industrial centres by means of aircraft. It is a maxim that aerial attack can only be successfully opposed by an aerial fleet, but a defeated country would not possess an aerial fleet, and its single hope of salvation would be in the use of smoke. An example is then given, showing how smoke could be used to screen a town. It is shown by means of plans that smoke should be applied in such a way as to conceal, not only the town up to the limits of its extent, but any conspicuous object beyond; for instance, in the case of large barracks on the edge of the town with two ponds a few hundred yards away, if the ponds were not screened as well as the barracks, they would remain as an indication of the position of the latter.

Some remarks are made about the technical application of smoke. According to an article by Colonel Chédeville, in the *Revue Militaire Francaise*, when the French apparatus Berger and Verdier are used, to screen 15 square kilometers for a period of 2 to 2½ hours, 6 tons of chemical material would be required, and from 6 to 12 specialists per square kilometre.

He describes how false impressions could be produced by making the smoke denser or thicker in certain localities. For instance, the line of a river flowing through a town might be represented by a denser line of smoke parallel to the real course of the river, but several hundred yards distant from it, and dense patches of smoke might be laid at the correct relative distance from the false line of river to represent the positions of important buildings.

A.H.B.

COAST ARTILLERY JOURNAL.

(*August-November*, 1924.)—*Anti-Aircraft Doctrine.* The author lays great stress upon the necessity for a very detailed and thorough "indoctrination" of the theory and correct policy of anti-aircraft defence, which should be so absorbed into the being of the local commanders as to become a second nature. This would ensure that their mental processes on any given occasion would be as like that of the high commander as is humanly possible. The opportunities for action are so fleeting that a better result is obtained by decentralization so long as the mind of the local commander is trained to work along the recognised channel.

He says, "Our primary arms are (*a*) the A.A. Gun Battery, (*b*) the M.G. Battery. All other elements of the command exist for the purpose of placing and keeping these primary arms in action."

In addition to this primary role the Searchlight has a direct offensive function of considerable importance, in that the beam, even when un-

attended by gunfire, confuses and demoralises the night flier, and may prevent him from accomplishing his mission, backed up as it is by the threat of deadly assault by the gun or defending aircraft. It is only necessary to read the personal narratives of night flying pilots, or to listen to their conversation, to appreciate the great moral effect which the systematic and unhesitating use of searchlight beams has upon them when they are approaching their objectives on the ground. They know that once the searchlight succeeds in laying on them they become the potential target for every gun and aeroplane within reach—an experience to be avoided as far as possible. Many air raids have been stopped short of their objective simply by a searchlight display while the attacking units were still far enough away to give their commanders time to think matters over before venturing further.

Communications from higher commanders to local commanders will normally have to do with :—

1. Strategic disposition of mobile reserve units.
2. Dissemination of information.

The latter of these two items is of the utmost importance to enable the local commander to make the same estimate of the situation as his commander would make if he were present.

It is more essential in an Anti-Aircraft Command, than in any other, that the fighting system should be based upon indoctrination rather than upon detailed battle order, because the essence of Anti-Aircraft action is time.

D.M.F.H.

THE MILITARY ENGINEER.

(*March-April*, 1925.)

Civil work of the Corps of Engineers.—An account of the river and harbour maintenance work for which the U.S. Engineers are mainly responsible.

Military Railways in the World War.—The evolution of the railway organisation behind the A.E.F. Contains interesting statistics showing the large quantities of rolling stock and track supplied, and the Government organisation for production and shipment.

The Training of Engineer Officers.—A cadet spends four years at West Point. After a period of service with troops, he undergoes a year's course at the Engineer School—a military institution. This is followed by one year at a Civil Engineering College, where an engineering degree is obtained.

Demolition of Linda Vista Bridge.—Experiments carried out on a reinforced concrete bridge to test the accuracy of the formulæ in the *American Field Manual*. The results tend to show that to destroy reinforced concrete, two separate charges are necessary, the first to expose the rods, and the second to cut them.

R.I.M.

PALESTINE EXPLORATION FUND.

QUARTERLY STATEMENT, APRIL, 1925.

In this number General Sir Charles Warren, G.C.M.G., K.C.B., F.R.S., writes a short article on *The Diamond Jubilee of the Palestine Exploration Fund,* from which we may be allowed to cull the following extracts on a subject so intimately interesting to the Corps, which has sent to the work such distinguished men as Earl Kitchener, General C. G. Gordon, Sir Charles Wilson, Sir Charles Watson, Colonel C. R. Conder and Sir Charles Warren himself. " The basis of the movement was the accurate Ordnance Survey of Jerusalem (and its water sources), at present in use, carried by out Captain C. W. Wilson, R.E., in 1864-5, the necessary funds for which were supplied by Miss Burdett Coutts. This survey was followed up by a rapid examination of all Palestine by Captain Wilson and Lieutenant Anderson, R.E., and the conclusion they came to was that the most interesting site in the Holy Land for exploration was the Holy City itself."

" In the autumn of 1866 I had recently returned to England after nearly seven years in the Mediterranean, and I was offered the post of explorer to the P.E.F. I took it up early in 1867, and held it for three years, until forced to relinquish the work through malaria contracted in the souterrains of Jerusalem. In relinquishing the work I called attention to the fact that the most pressing work in Palestine at that time was an accurate Topographical Survey of the Holy Land, because treasures underground would keep safely a few years longer, but, above ground, the march of civilization was causing a disruption of all the Holy sites, and most valuable relics were being burnt up into lime.

" Accordingly the Survey of Palestine was next taken up and carried out most successfully by Lieutenant C. R. Conder, subsequently assisted by Lieutenant H. H. Kitchener. Let me state in parenthesis that since 1871, there have been very few excavations in the very ancient sites of Jerusalem. We all had to await more favourable circumstances for such work, and the time has now struck—fifty-five years afterwards.

" My work during those years in Palestine consisted chiefly of excavations in the Holy City and reconnaissances of the Plain of Philistia and the Jordan Valley. At first money failed to flow into our coffers, and for months we were at our wits' end as to how to survive the crisis. The Committee sent me S.O.S. messages, ' Get results and we will send you money,' and I retorted ' Send me money and I will get you results.' George Grove telegraphed ' For Heaven's sake find the Tomb of David or we shall be bankrupt,' and I replied ' If I do find the Tomb of David I shall certainly seal it up again : such good things are not for the like of us.' I firmly believe that up to the day of his departure George Grove had an uneasy notion that I had struck the Tomb of David and, on account of my views about the desecration of tombs, would not give it out to the public."

But Sir Charles looks upon controversy as the chief means of obtaining subscribers to the Fund. "I do not think that there can be any elucidation of the problems of the Holy Land without controversy and criticism" "For many years we had a *Controversialist-in-Chief*, in season, out of season, he blossomed forth in some new theory and we found our wits sharpened up to keep pace with his propositions. I should guess his speculations brought in at least £1,000 a year to the coffers of the P.E.F."

"I sincerely trust that what I have said in this paper will not be agreed to by all, but that it will arouse the antagonism of many who may think my observations worth powder and shot. We want to be on the war-path to succeed. I consider that controversy is the breath of life to undertakings like the P.E.F.

"As for myself, I am ready to fight on any of the theories I uphold, but how can one enjoy shooting if one's antagonists lie low or hold up their hands?" And Sir Charles is nearly 88!

He offers a donation of £100 towards excavations on the ancient site Hill of Ophel (Jerusalem), south of the Haram Esh-Sherif, provided forty-nine other persons will subscribe £100 each, making in all £5,000. The money to be collected before 1st April, 1926. Sir Charles Close has been recently making a survey of the Hill.

F.E.G.S.

OFFICIAL HISTORY OF THE WAR.

A preliminary draft of the first six chapters of Volume III, dealing with the events on the Western front, December, 1914—March, 1915, to the end of the battle of Neuve Chapelle, has been prepared in type-script. It has already been seen by a number of the principal officers who took part, but it has not been possible to get into communication with all and obtain their views as to its general accuracy and completeness.

The compiler will be glad to send the typescript on loan to any officer who was present, for remarks and additions.

Application should be made to

The Director, Historical Section (Military Branch),
Committee of Imperial Defence,
Audit House, Victoria Embankment, London, E.C. 4.

Or the typescript can be seen at that address.

THE R.E. WAR AND R.E. KITCHENER SCHOLARSHIPS.

INFORMATION regarding these educational scholarships may be obtained on application to the Secretary, Institution of Royal Engineers, Chatham. The scholarships are of two kinds: "A," of value not exceeding £55 per annum and tenable between the ages of 10 and 18; and "B," of value not exceeding £20 per annum and tenable between the ages of 11 and 16. The *R.E. War Scholarships* are still restricted to the children of dependents of officers and other ranks of the Royal Engineers who were killed or died of wounds or disease contracted on service, or were permanently disabled, in the Great War. The *R.E. Kitchener Scholarships*, which are unfortunately very few in number, are open to the children or dependents of all officers and other ranks of the Royal Engineers who have either died or been permanently disabled while actually serving.

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