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RAILWAYS IN WAR.

A Lecture delivered at the S.M.E., Chatham, on 10th January, 1929, by COLONEL R. OAKES, C.B.E.

THE subject is so large and complex that it is only possible, in a single lecture of an hour's duration, to deal with it in part, very generally and very briefly.

Many, varied, and intricate, are the peace time problems which arise in railway management, construction and operation; and war introduces additional complications.

It is not my intention to discuss civil railway organization or to refer in any detail to the everyday engineering and operating problems which arise both in peace and in war time would not permit. My remarks must be mainly confined to a few of the special problems which war introduces.

I purpose, therefore:

Firstly, to consider some of the main differences between peace and war conditions and working, and the special problems arising therefrom, which confront the railwayman in war, and which are met with in the handling of the requirements of an army in the field.

Secondly, to deduce some of the lessons of war railway history, and,

Thirdly, to glance at our military railway organization to see to what extent the special conditions of war have been provided for.

Before proceeding to the first of our considerations, the problems arising out of the fundamental differences between civil and military railway conditions, let us get an idea of the extent of the railway problem in war.

I read a paper the other day, in which the writer, having reviewed the increasingly important part played by railways in the wars of the last hundred years, arrived at the conclusion that to all intents and purposes railways won the Great War. I believe the author was a railwayman.

It is nevertheless a fact that efficient transportation is absolutely vital to a modern army.

In this connection it is a matter of interest that it was represented

by Brig.-Gen. H. O. Mance in 1916, when the advance into Palestine was under consideration, that we must have overwhelming rail power, *i.e.*, sufficient to maintain the necessary margin of troops over a possible Turkish army and on the more elaborate scale necessary for our troops. As a result, it was decided that a standard gauge railway with a minimum grade of 1/100 was essential. As the campaign advanced, it was found that our single line had to handle up to 24 trains a day in each direction, which was cutting the capacity too fine, and, therefore, the doubling of the line, which had been started in 1917, was continued as far as the junction with the Beersheba line, before the final attack.

I think it may be said without fear of contradiction that victory in civilized warfare may well rest with the army with full freedom and power of movement, strategical, tactical, administrative, *i.e.*, with the army with the best and most efficient transportation services.

I have used the word transportation, and not railways, because it is necessary, particularly for the British Empire with its scattered territories and practically world-wide interests, to realize that the problem of movement in war involves every kind of transportation, by sea, by rail, by inland water transport, by road, and by air.

In any war in which the B.E.F. takes part, the transportation chain will consist of a number of links, of which, in the theatre of war itself, railways may be the most important.

I have deviated somewhat from the subject of my lecture, but it is necessary always to keep in view that railways are a part of a larger service - transportation.

Now to return to the railway problem itself in the theatre of war :

Firstly, railway construction, both new work and repair, will be necessary.

Secondly, railway operation, with the subsidiary services of rolling stock repairs, stores, statistics, etc., will have to be undertaken.

Thirdly, it may be required to transport guns on special railway mountings and to construct and work armoured trains. The heavier guns may be fought from specially-constructed sidings, whilst armoured trains may be in action at any threatened point of the railway system.

The abnormal conditions which war produces will invariably necessitate some modification of normal civil practice in organization, in construction and in operation, as will become apparent later.

Great as has been the part which railways have played in the wars of the last three-quarters of a century, it is not an exaggeration to say that an efficient railway system and service are becoming more and more essential to the success of a modern army in civilized warfare.

The increase of, and improvement of, mechanical transport and the progress of mechanization, whilst increasing the power of manœuvre, are not likely to oust the railway in any way and do not relieve it, but rather impose additional burdens.

The railway must now be able to carry this transport, to load and off-load it with ease and rapidity, to provide it with its petrol, oil and spare parts, whilst its very mobility will tend to more rapid advance and, therefore, to the necessity of more rapid railway construction. In addition, the impedimenta of a modern army is vastly in excess of what it used to be.

Except in a European war, a parallel rail and road service is unlikely on the main L.-of-C. in a theatre of war, more especially where it is a long L.-of-C. On the other hand, the heavy tonnage to be carried will fix a more or less arbitrary boundary, at railhead, between rail and road transport; and, in most theatres of war, the construction and maintenance of the roads will present such a vast problem, as to result in invariably requiring the railway to carry the maximum and to put the minimum on to the roads.

I think I have said enough to show that there is no rail versus road competition, in war, at all events, but rather that they are entirely complementary.

I have stressed this, because one hears so much of road versus rail competition nowadays, in order to emphasize that "railways in war" is not a problem of less magnitude than in the past.

Now for some of the chief technical differences between practice on a civil railway, in peace, and that on a military railway, in war.

Firstly, as regards construction:—

In peace, ample time is taken to ascertain that the best route is adopted to obtain and carry the maximum traffic at minimum cost.

In war, rapidity of construction is all-important, consistent with a route of sufficient capacity.

In peace, designs of all works must be got out in detail and the cost be estimated.

In war, lack of time will seldom admit of working out and comparing designs in detail.

In peace, temporary work is kept to a minimum, and permanent work, once sanctioned, is put in hand.

In war, the proportion of temporary and semi-permanent work will be comparatively high, owing to the necessity for working traffic through as early as possible. Temporary bridge work is likely to be a feature of railway construction in war.

In peace, financial sanction from headquarters is necessary before any but very trivial new work can be begun.

In war, executive officers must be prepared to take responsibility in starting necessary new works.

On civil railways, heavy earthwork is undertaken to avoid steep grades and sharp curves and the consequent limitations they impose; and large works, such as deep cuttings, high embankments and tunnels, are justified to shorten the line, to increase the train-load and otherwise to improve and to cheapen the working conditions.

On a war railway, rapid construction and, consequently, the avoidance of heavy earthwork, are of primary importance. Reduction of the ruling grade to a minimum must be obtained by lengthening the route, rather than by undertaking heavy construction work.

A civil line must be sufficiently heavy for the rolling-stock, and must be well ballasted and constructed to a high standard generally.

In war, the standard of permanent way need only be sufficient to stand the comparatively slow traffic for a few years. Ballast may not be available, or the line may be only very poorly ballasted, unless ballast is found alongside.

In peace, expenditure is justifiable on good permanent soft-water supplies.

In war, an ample supply of water is all-important, but permanent installations take time; and water-tank wagons and water trains may become a necessity in more or less waterless regions.

Secondly, as regards operation:—

On the civil railway, policy is principally determined by financial considerations; and the granting of reasonable facilities to all traders without discrimination is a fundamental principle of commercial railway operation.

On the military railway, commercial requirements give place to military requirements, which will strictly determine the priority of traffic.

The volume of traffic can be estimated with reasonable accuracy in advance on a civil railway, and the line be economically equipped to meet it.

In war, the volume of traffic may undergo sudden and unforeseen changes. The capacity of the railway will certainly be strained to the utmost, at times, if not continuously, and may fall short of full requirements.

On a civil railway, comfort of passengers and care of goods must be given first consideration.

On a military railway, the prior consideration is often to carry the greatest possible number of troops, provided they do not suffer excessive exposure, and the maximum tonnage of supplies and stores irrespective of risk.

In civil railway working, truck-loads and train-loads vary according to traffic requirements;

whereas it is an axiom of railway operation in war, to work as heavy trains as possible, composed of high capacity wagons, loaded to the full and hauled by powerful locomotives—full truck-loads and full train-loads.

Trains on a civil railway are run at varying speeds to suit the convenience of traders and of the travelling public.

In war, timings are more uniform, thus admitting of a maximum tonnage on fewer and heavier trains at comparatively slow speeds, which are to be preferred to a greater number of fast trains more lightly loaded.

Breakdowns due to accident or exceptional weather conditions are rare on the civil railway:

whereas the military railway is liable to interruption by hostile aircraft, long-range shelling, raids, sabotage, armoured trains in action. Suspension of night running may be necessitated, particularly in the forward areas. On the other hand, it is conceivable that night running might be preferred to daylight working if the enemy were superior in the air.

The technical operating personnel on a civil railway is thoroughly trained and organized, generally well disciplined and accustomed through long service to a routine of work.

In war, work will not be of such a routine nature, exceptional conditions will be met with, and railway personnel will, at times, have to work for very long hours at a stretch. In addition to the railway troops, it may be necessary to employ hastily-collected personnel, only partially trained. Operating may not be as efficient, therefore—an additional reason for fewer and, therefore, heavier trains.

In peace, it may be generally assumed that locomotives and rolling-stock are sufficient to meet demands, that they are designed to suit the nature of the traffic and the curves and gradients of the route, that a regular programme of repair and replacement is practicable and that a high standard of efficiency is maintained. Multiplication of types is avoided as far as possible and standardization and interchangeability of parts are aimed at.

On a military railway, locomotives and rolling-stock will probably be scarce and, in an endeavour to increase numbers, a diversity of types will be introduced. All this complicates the questions of repairs and spare parts. Engines and rolling-stock will be retained in service after they should have been turned over to shops, and margins of safety will be reduced below normal standards.

In civil practice, electric block instruments and interlocked signalling are considered essential for safe and expeditious train working.

In war, whilst these would continue to be used, if available and in good order, on existing lines, they are unlikely to be provided,

at all events at first, or lines recovered from the enemy or newly-constructed.

In peace, the absolute block system is enforced almost universally for passenger lines.

In war, permissive working will be adopted whenever the additional line capacity it affords is required.

On civil railways, the block telegraph and certain telegraph wires are entirely at railway disposal.

In war, though the same necessity exists for allocation of certain wires to the sole use of the railway, this may not always be adhered to. Traffic working, however, is entirely dependent on the telegraph and line clear message system, unless electric block instruments have been installed.

These obvious differences in peace and war conditions do not, however, indicate that the general principles which have resulted from experience in civil practice do not hold good in war.

Even the dethroning of the paramount factor in peace—finance—is more apparent than real.

Time is the governing factor set up in its place which makes speed of construction all-important, and necessitates the less strict adherence to technical standards and "safety first" methods. That time is money requires, perhaps, to be kept in view even more in war than in peace.

The general principles of efficient working must be always adhered to. Efficiency and economy go hand in hand.

My object in enumerating these differences between peace and war conditions is not to suggest any general justification of the relaxing of peace time technical standards or standards of safe working, but rather to indicate the need of versatility, adaptability, judgment and decision in the military railwayman of all grades. His work cannot be governed by such rigid standards as in peace.

It is essential, in war, that all ranks should be able to take the necessary responsibility. This necessitates a proper appreciation of the position, and this again requires training and experience.

I have already pointed out that railways are a link, or rather a series of links, in the transportation chain. Each of the railway links must then be at least equal to the strength required of that chain.

The weak points in the railway links of the chain may be individual sections of the line, with heavy ruling grades and sharp curves, necessitating reduction in train loads. All possible steps must be taken, of course, to improve the capacity of these sections, but it is at the junctions of individual links that congestion may occur. These are the possible bottle-necks to be avoided.

In war, the traffic is mostly special—ammunition, ordnance stores,

supplies, etc. These must be stored in great bulk in railway-served depots and must be somewhat dispersed in those depots, in order to localize damage from air attack. Hence, the necessity of large railway-served areas for storage, and large railway yards, wherever bulk storage may be required. Congestion will otherwise occur. The most important of these large storage areas are the base depots. The proper lay-out, initially, of base depots of adequate size, and with room for expansion, is the first and most essential step towards satisfactory railway working in a theatre of war. A badly laid out base depot area, or depots of inadequate size, will cramp transportation style from the very outset, for it will hamper the clearing of the docks. No congestion of docks or of railway yards should be permitted. Hence, the necessity of ample facilities to clear them, and of depots to accommodate the vast tonnage of stores, etc., required by a modern army. These are the reasons why it is invariably found that an extensive railway-served depot lay-out, hundreds of acres in extent, is required at any base port, notwithstanding that the commercial tonnage handled at that port, in peace, may greatly exceed the tonnage of army stores to be handled. The tonnage is not for the most part for immediate dispatch up country, nor can it be stored in the dock area—this must be kept clear for transit purposes—nor in adjacent warehouses, if any, which would be unsuitable for housing military stores. Further up the line, if any bulk storage be required, advanced depots of similar lay-out to the base depots and of adequate size, must be provided. Regulating stations and railway yards must be of ample capacity not only for the normal flow, but for periods of intensive flow, when also such intensive flow may be checked.

It is quite impossible to visualize any definite set of conditions on a war railway.

The country may be densely populated by a civilized community, and may be intersected with a network of double line railways, equipped with the most modern plant and apparatus. It may have no railways at all, initially; whilst every variation between these two extremes may be met with.

Consider the varying conditions that obtained during the Great War in France, in Salonika, in Mesopotamia, in East Africa, in German South-West Africa, in Palestine; in South Africa during the Boer War; in the Sudan campaigns, 1896–98, and on the Indian Frontier in the Afghan War of 1919.

It is easy to enlarge on the difficulties and diversities of the railway problem. We do not know even the gauge, or gauges, of the railways we may be operating and constructing. The country may be easy, or difficult, from a construction point of view. It may be largely waterless.

The base and points of contact with the enemy may be com-

paratively close. On the other hand, there may be a L.-of-C. many hundreds of miles long, and, therefore, some days' journey between the base and the front. There may be several lines of communication or only a single trunk line which must carry everything for the army in the field, and possibly also for a civil population, large or small.

The operation of the railway, up to railhead, in British or friendly territory, will initially be in the hands of the normal civil agency or agencies. Various methods of working may be adopted, according to circumstances, on the arrival of the B.E.F. The civil authorities may continue to operate and reconstruct, or newly construct, as the troops advance, assisted only by the railway troops, as and where required. A definite length of railway may be taken over by the military railway authorities, *e.g.*, the hundred miles immediately in rear of railhead, and all new and reconstruction work may be undertaken by military personnel. The military railway personnel may take over the whole working of the line, retaining, in whole or in part, the civilian staff. There may be a combination of these systems of working.

We cannot say we will adopt the British Railway rules and regulations, or those of any other railway. We must begin with what we find and we may have to continue throughout, to work under the existing technical organization according to the local rules and regulations. It is quite clear, therefore, that in every case the existing rules and regulations and method of operating will remain in force, at all events initially.

The need of a flexible organization, and of a very broad unprejudiced outlook on war railway problems, is plain.

Having considered a few of the points of difference between war railway working and peace time operation, let us turn to the lessons of war railway history.

The part played by railways in war, up to the beginning of the Great War, is given in some detail, in a very excellent publication, *The Rise of Rail Power in War and Conquest, 1833–1914*, by the late Mr. E. A. Pratt, which was published in 1915. I am indebted to it for some of the following historical references.

Time does not permit of a review of the earliest opinions as to the strategic value of railways and their use in war, nor to trace the progress in the effective use of railways and in military railway organization in the wars of the last 100 years.

We will confine our attention to the American Civil War, 1861–64, the Franco-German War, 1870–71, the South African War, 1899–1902, and the Great War, 1914–18.

Suffice it to say that, in the earlier wars, troop concentrations had been carried out more or less expeditiously, but there was a lack of organization, and arrangements to deal with the transport of supplies and stores were faulty.

The importance of railways in the American Civil War, 1861–64, is at once obvious. The area of operations was nearly as large as Europe. The lines of communication were some thousands of miles long and the country for the most part was only partially developed. The railways, in addition to their importance for strategical movement of troops, were vital for the maintenance of the armies. Many battles were fought, primarily for the control of particular railways, for the safeguarding of lines of communication, for the possession, more especially, of important junctions. Nevertheless, it was not until January, 1862, after a considerable period during which efficient and successful operation of the railways had been rendered impossible, owing to the want of proper organization and resultant interference by local commanders, that steps were taken to create an organization for efficient railway working and construction. The organization then introduced may be said to be the forerunner of military railway organizations which have proved successful in more recent years, and to be the basis of present-day organization. The necessity of a proper railway organization was not, however, fully realized, nor its introduction appreciated, by individual commanders, who were ignorant of the intricacies of the railway machine, and still imagined, apparently, that they could interfere with the working in their own areas, without dislocating the railway as a whole.

In the later stages of the Civil War, the railways being now properly organized, and local commanders no longer interfering in the technical working, there were many notable achievements, not only in the carrying out of large strategic troop movements, but in the transport of supplies, stores and ammunition required for their maintenance, and in the engineering work undertaken—bridge building, construction and both provision and repair of rolling-stock.

Such is the progress which followed recognition of the facts that the maintenance of a force must receive adequate attention conjointly with its movement; and that a centralized organization for handling the whole business of transportation, and one free from local interference, is essential to success, if success is dependent on efficient transportation. And what success in these days is not so dependent?

In the Franco-Prussian War, 1870–71, Germany's more efficient regulations for the control of the military railway machine and her superior war railway organization contributed largely to her military success. The lessons of earlier wars had not been neglected, but had not been fully learnt. Thus, as the German advance continued, the military railway organization proved inadequate to repair and operate the railways in occupied territory, and supply arrangements again broke down. The situation on the French railways was far worse, due to the inefficiency of their organization.

Both countries profited by the experience gained. As a result,

both France and Germany remodelled their war railway organization, which included not only railway troops for construction, repair and operating, but an organization to control the military use of the railway service, to determine priority, and to be intermediary between the army generally and the technical staff.

The necessity for a control organization in addition to the technical agency for railway working has been recognized in the British Army. In the South African War, and for the most part in the various theatres of operations in the Great War, these duties were undertaken by a more or less distinct branch of the Railway or Transportation Directorate. They are now a function of the Movement section of the "Q" Staff, and are no longer a railway or transportation responsibility.

In the period 1882–98, during the wars in Egypt and the Sudan, British military railway history was made. The expedition for the relief of Gordon was the occasion of the raising of the first R.E. Railway Companies, the 8th and 10th. In the advance in the 1882 campaign, and more particularly in the later war, which culminated in the victory of the troops under Lord Kitchener at Omdurman, success was largely dependent on rail transport as well as on transport on the River Nile.

In the South African War, 1899–1902, railways were a material factor in the success of the British forces. Major Girouard, R.E. (now Colonel Sir Percy Girouard), who had been responsible for the railway work in the Sudan campaign a year or two previously, was appointed Director of Railways. Thanks to his previous study of war railway history, to the fact that he, at all events, had learnt the railway lessons of the American Civil War and of the Franco-German War, and to his organizing powers, the British did not have to buy experience all over again at the expense of initial mistakes and failures. The organization he created provided not only for repair and construction and for the technical working of the railways, where necessary in Cape Colony and later in the occupied territories of the Orange Free State and Transvaal, but for a Military Railway Controlling Staff, whose duties, to all intents and purposes, were to see that the best possible and maximum use of the railway facilities was made. They were the co-ordinating link between military requirements and the technical services, always working in the closest possible co-operation with the technical railway staff. The necessity for this link of military control is now recognized in official regulations, its duties being fully defined in the *Manual of Movement*, 1923, but there were no such regulations in 1899.

Minor modifications in organization were, of course, necessary in South Africa, as the result of experience, and new organization became necessary as military operations progressed; but there was never the need for wholesale reorganization, as in the United States

in 1862, or on the Continent after the 1870–71 War, due to previous attempts to work contrarily to the principles of efficient transportation.

In the later, guerilla, stage of the South African War, a fleet of armoured trains played a considerable part in the military operations. It will be realized that the use of the railway itself as part of the fighting machine introduces considerable complications into normal railway working.

The outbreak of the Great War, 1914–18, found Germany prepared. She had a railway organization ready, and railway construction and operating troops available. Thus, from the outset, railways played their part efficiently in the concentration of troops and in rapidly following up the initial Allied retreat. It would, however, have been much more difficult to have followed up the retreat of the Allies, had it been possible for them to have undertaken more complete destruction; von Kluck might have overrun his communications earlier.

France, also, had learnt the railway lessons of 1870–71. In the early stages of the Great War her railway preparations were on the whole adequate.

It is sometimes represented that the fact that such vast British transportation organization subsequently became necessary, indicates failure in this country to appreciate, prior to the War, the importance of the transportation service. The answer to this is, I think, to be found in the model success of those transportation services for which Britain was responsible, *viz.*, the mobilization, concentration and dispatch of the E.F. France undertook to provide and operate the necessary transportation services in her own country. Later, certainly, these did not suffice. As with every other service, it was subsequently necessary to create vast organizations to deal with transportation and railway problems, not only on the Western Front but in all other theatres of war.

The problem on the Western Front was its concentrated intensity under the conditions of static warfare.

A force of 2,700,000 men had to be moved as required and to be maintained. The daily maintenance tonnage, including all stores, approximated 25,000 tons per diem. An initial British railway strength of approximately 400 increased to over 35,000 skilled railway troops, whilst some 1,400 locomotives and 50,000 trucks were obtained. A more or less static front during the greater part of the War did not, however, mean that no railway construction had to be undertaken. On the contrary, the total mileage of new (standard gauge) line constructed was approximately 2,000 miles. Mention should also be made of the considerable use of the railway to provide alternative firing positions for heavy guns, mounted on specially designed railway trucks.

On the other fronts, mostly under conditions of mobile warfare, in German South-West Africa, in the Balkans, in Palestine, in Mesopotamia, and in East Africa, the railway had to follow up the advancing troops. *Existing* railways had to be repaired, or new railways to be constructed, and to be operated, often under pressure of maximum traffic, as soon as they could be opened. There were some 10,000 railway troops and approximately 50,000 non-Europeans employed on railways in these theatres of war. Approximately 2,000 miles of new routes—probably involving over 3,000 miles of actual track—were constructed, partly in difficult and waterless country. Throughout, the British followed up their South African experience in the creation of a branch of the Transportation, or of the Railway, Directorate, to receive and co-ordinate demands on the railway—a link between the army generally and the technical branches—in addition to raising distinct technical branches and units for construction, operating and repair.

I will not enlarge on the railway activities on the various fronts during the Great War. A complete history would fill many volumes and may yet, I hope, be written. These brief reviews indicate, however, how large a part railways have played in the wars of the last three-quarters of a century, and that they have been largely, if not chiefly, responsible for the ultimate victory in several campaigns, also that a centralized military control as well as a complete technical organization is essential.

It is obvious that railways can only be controlled as a whole by G.H.Q. Hence, they must be a centralized G.H.Q. service: control and administration cannot be arbitrarily sub-divided, geographically, according to military areas of control or administration. This necessity for a central control, without interfering with the technical working, is one of the chief lessons, if not the chief lesson, of war railway history.

Apart, then, from such obvious necessities, alike in war as in peace, that a railway must have a sufficient capacity for the traffic to be carried, and adequate engines, rolling-stock and equipment, the principal lessons of war railway history may, I think, be summed up as follows:

(*i*) An adequate centralized organization to control utilization and to prevent local interference with the technical working.

(*ii*) An adequate technical personnel, fully trained and sufficiently versatile to realize that the railway is part of the army machine, and that essentially railway interests are no longer paramount.

(*iii*) Recognition of time as the all-important factor.

This at once emphasizes:

(*iv*) The importance of early information as to policy.

(*v*) The importance of rapid survey and construction work, involving a capacity for improvisation.

(*vi*) Less stringent "safety first" precautions.

Let there be no mistake that improvisation and reduction of safety appliances involve either the waiving of principles or the introduction of slovenly methods. Only those who know proper and best practice in survey, construction and railway operation can adequately improvise.

Appreciation of the all-importance of time teaches:—

(*vii*) the necessity as much for wholesale destruction in retreat, as for rapid construction on advance.

Highly important technical lessons are:

(*viii*) Do everything possible to avoid congestion.

(*ix*) Look ahead when designing, so that expansion may be practicable if traffic should increase.

In my experience of railways in war, I have never known of a new railway or branch which was not required to carry, very soon after opening, a greater tonnage than the maximum estimated by the staff.

(*x*) Make lay-outs, depots, yards, water supply installations, etc., sufficiently large to cope with checks and uneven flow during periods of intensive traffic.

(*xi*) Provide very adequate facilities for engine and rolling-stock repair.

This is particularly important in a distant theatre of war, or where the gauge of the railway is such that additional rolling-stock is not easily obtained.

(*xii*) Have adequate plant and material available, *i.e.*, look ahead and be prepared.

This provision of adequate plant includes construction plant and special rolling-stock and tackle to carry, to load and off-load, and to handle all special military traffic, *e.g.*, tanks, guns, other heavy or bulky loads, petrol in bulk, horses in large numbers, etc.

Railway preparedness for war is naturally divided into two main divisions; what can be done in peace and what must be delayed until hostilities are imminent or war breaks out.

However ready may be our organization and our railway troops,

on the plant, stores and material side, it can never be hoped to be fully prepared. In the first place, complete stocks cannot be determined when neither the gauge of the railway nor the length of the L.-of-C. are known; and even if these were known, it could not be afforded to hold vast quantities of plant, stores and material in peace. What can be done, however, is to be so far prepared with railway intelligence and with complete lists as to be in a position to order all that is wanted as soon as the locality is known and the emergency arises. Many of the stores will be readily procurable.

Now let us just glance at existing organization with particular reference to these lessons.

Present day organization is set forth in *F.S. Regulations*, Vol. I, and in the *Manual of Movement*. It makes transportation, of which railways is a sub-directorate, a centralized G.H.Q. responsibility. It provides also for the control and utilization of transportation services by the "Q" Staff, whilst the technical organization includes Transportation, Railways, Docks and I.W.T. Directorates, as may be required.

In no two wars are the transportation or railway conditions alike. It needs no emphasis, bearing in mind the very varying conditions which may be met with in different theatres of war, that the British military railway organization must be elastic and adaptable to local conditions. It is obviously impossible to have numerous alternative regulations. Regulations, nevertheless, must go into some detail.

The *Manual of Movement*, mainly based on conditions such as existed in the later stages of position warfare on the Western Front, has chiefly in view several short, or comparatively short, Ls.-of-C., more or less of a network of railways and numerous railheads. With the very altered conditions of a long single railway as L.-of-C. these regulations may require adaptation to the individual theatre of war.

Hence, the importance of the study of the history of railways in war, both by the Staff and by the technical railway officer. Particularly, it is necessary for the officer at the head of the Movement section of the Staff in war, and for the senior officers in each of the Transportation Directorates, to be thoroughly conversant also with the regulations. Then, while carefully guarding the principles of sound transportation, they will be quick to interpret such detailed modification of procedure as local conditions may necessitate. I have already drawn special attention to the necessity of adaptability in the military railwayman, and this applies to all concerned in the proper working of the railway machine in war. If they are adaptable, the special provisions necessary in any particular theatre of war will be introduced in anticipation, instead of being forced upon them later as the result of experience, and perhaps at the expense of initial failure.

Regulations must be definite, but everyone must be progressive, always on the look-out to improve and never satisfied with the dictum that because things were done this way in the last war, they must necessarily be done the same way in the next.

As regards the directorates, war establishments for all of them have been prepared, and peace establishments include railway troops for survey, construction, operating, shop work, stores and also for dock working. The composite and survey units are raised from Regular sources, and the other companies are Supplementary Reserve units, raised by the four British Railway Groups.

It will be obvious, however, that transportation requirements will vary according to the theatre of war. Directorates and units not required need not be mobilized or raised.

It might be suggested, since you do not know your theatre of war, or your gauge, why not consider separately every likely, or possible, theatre of war and have a different organization for each, according to the circumstances, making use, in British territory or in a friendly country, of the local railway authorities and their staff as far as possible? These, presumably, know and would work their own railways better than any imported troops?

Or, it might be suggested, why make any railway preparation at all, seeing your problem is so varied, and war, we hope, so remote? Think of the economy thereby? Wait until war breaks out and then improvise as fast as you can?

The answers to these suggestions are, I think:

Firstly, that time, often the most important consideration in war, may never again, in these days of speeding up in every direction, admit of any breathing space in which to create or to perfect an organization.

Secondly, that we cannot depend entirely on an unknown quantity, and cannot, therefore, be wholly dependent on any local organization.

Thirdly, that our organization, though it cannot be full and complete, must be elastic and that it does take into consideration that the local railway authorities may very largely be employed in the construction and operation of the railways, in the various possible theatres of war; and,

Fourthly, that if we are to start off at 100 per cent. efficiency, which may be necessary, we must have a trained military organization, a military nucleus who realize the essential differences between military and civil transportation problems, a versatile and adaptable body of men who are soldiers as well as railwaymen.

The question then becomes, shall we train soldiers to be versatile

railwaymen, or shall we train railwaymen to be more versatile and to be soldiers?

Under the present organization, it is attempted to train a small number of Regulars to become versatile railwaymen, whilst certain of the Supplementary Reserve railwaymen undergo a fortnight's training, every year, at the Railway Training Centre, Longmoor, to improve their military knowledge and to learn some of the possible differences and variations from peace time practice which may confront them in war.

It would be impossible, obviously, to raise any considerable body of Regular railway troops in peace.

Firstly, the cost would be prohibitive.

Secondly, a commercially run railway would be essential to their training.

Thirdly, their colour service would have to be long, unless they were trained railwaymen on enlistment; and if they were railwaymen on enlistment, why not, for the most part, leave them as such, teach them the necessary versatility, and make soldiers of those of them who were not already soldiers?

Some railwaymen, who live in the military atmosphere, are, however, essential, to be immediately available in the small emergency in which but a handful only of railwaymen are required, and for which it may not be desired to call up any Supplementary Reserve from their civil employment. They are also required to form a training centre and depot for all military railway units. Hence, the two Regular R.E. Companies. Hence, also, the training of Regular officers as and when opportunity offers, firstly, on initial courses at the Railway Training Centre and on Home railways, and subsequently on Colonial railways, or more particularly on Indian railways, not only to fit them to officer these units but to train them to fill the important positions in the Transportation and Railway Directorates in war.

The bulk of the railwaymen who will be required to accompany the B.E.F. are in Supplementary Reserve units, raised in peace by the Home Railway Companies, to whom also we look to supply the Army with such additional units as may subsequently be required.

The training of railway troops at the Railway Training Centre, Longmoor, is designed to give that changed outlook, that versatility, that capacity for rapid work, the importance of which has been emphasized.

Thus, it will be seen that in the B.E.F. transportation organization of to-day, it is endeavoured to put into practice the lessons of the past and to be in a state of readiness so far as is practicable, both as regards organization and personnel.

THE 23rd (FIELD) COMPANY, R.E., IN THE GREAT WAR, 1914–18.

(Continued.)

By MAJOR R. L. BOND, D.S.O., M.C., R.E.

PART V.—FEBRUARY, 1917–APRIL, 1918.

Battle Honours during the period—"Ypres, 1917," "Passchendaele" (2nd battle).

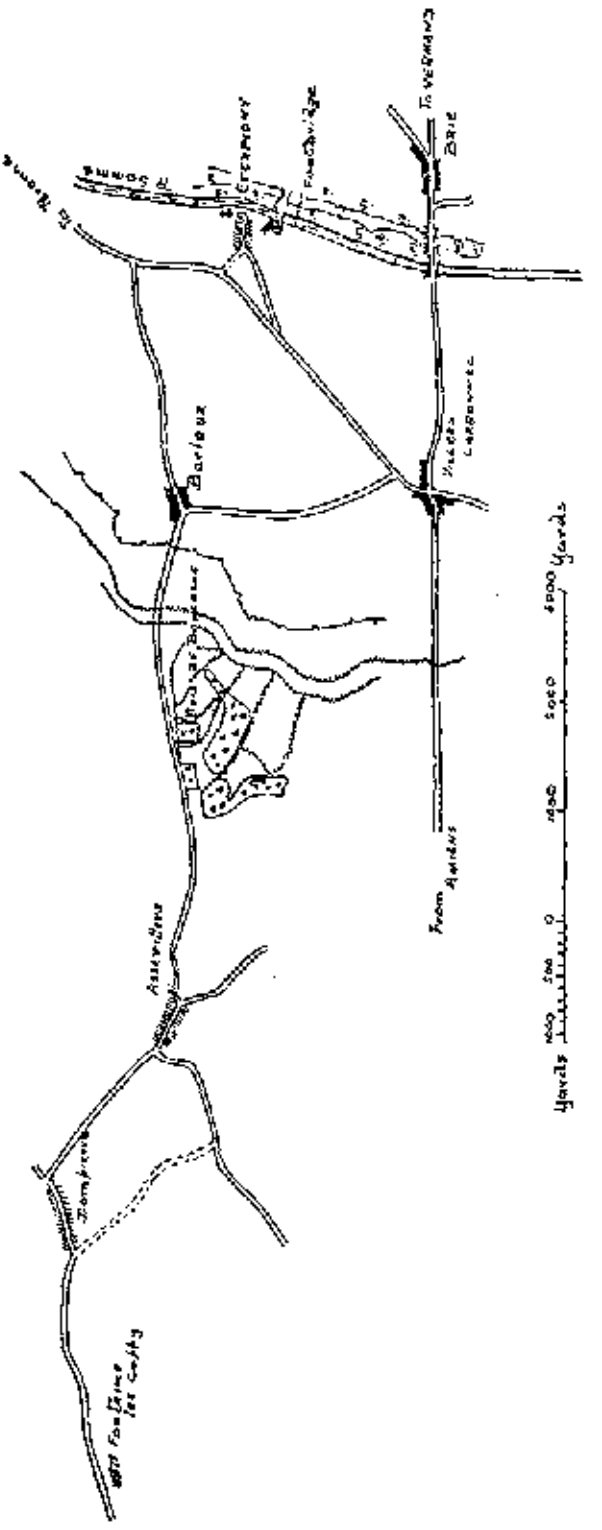
EARLY in February, 1917, the extension of the British line southwards commenced and the III Corps took over from the French 18th Corps in the Bois de Boulogne area (Sketch No. 21). The 23rd (Field) Company marched with the 2nd Infantry Brigade from Warloy *via* Baisieux, Ribemont, Cerisy, Morcourt to Mericourt-sur-Somme. The following day, the Brigade group marched to Moulin de Becquincourt, marching past Gen. Herschauer, 18th French Corps, and Gen. Pulteney, G.O.C. III Corps, on the way. That night, Gillespie and a reconnaissance party went forward to the Bois de Boulogne to take over from the French *Génie*.

Normal trenchwork ensued, deep dugouts, machine-gun posts, defences in Corps line and improvements to horse lines, shelters, and so on in rear areas.

On 26th February, the Company was withdrawn into reserve at Chingnolles, and on the 28th the Corps Commander presented the ribbon of the D.C.M. (gazetted 1st January) to C.S.M. F. E. Simmonds, who had already, in October, 1916, been awarded the Meritorious Service Medal. C.S.M. Simmonds, who went to France with the Company as Saddler-Corporal, had been promoted to C.S.M. *vice* C.S.M. Hudson, D.C.M., in the summer of 1916, the latter having been promoted R.S.M. 35th Division. C.S.M. Simmonds' work, "particularly as section-sergeant, had been consistently of a high standard, and his example to those under him in times of danger and of difficult work was beyond praise." His many friends, including all those officers who served with the Company immediately before the War, feel no surprise that he should have collected so many honours (he was later to win the bar to his D.C.M.), for this splendid, energetic and self-reliant N.C.O., with quiet yet forceful personality, was typical of all that was best in those fine N.C.O.s who have always formed the backbone of the Corps, and have contributed so much to its high reputation.

SKETCH No. 21.

BARLIEUX—BRIE. 1917.



On 5th and 6th March, the Company again moved to the forward area, and was joined by 100 infantry for working on roads which now assumed the greatest importance. On 12th March, Cohen left the Company, Edwards becoming second-in-command.

On the night of 16th March, a raid on a big scale was carried out by the 10th Gloucesters on the right and 1st Camerons on the left, Cowley and a party of Sappers (No. 2 Section) going with the right battalion and Smith with his party with the left battalion. In order to make the necessary gaps in the enemy's wire, Bangalore torpedoes were brought up, but the Camerons got forward successfully without their use. On the right, Serjeant Elcombe went out with two Sappers at 4.0 a.m., and with great gallantry and in spite of German machine-gun fire, which severely wounded him, succeeded in putting his torpedo in place with leads connected. The serjeant was, however, caught by our own barrage fire, and was unable to fire the torpedo, and with much difficulty just managed to get back to our lines. Cowley, however, then went forward, fired the torpedo, and created a gap ten yards wide, through which the infantry were able to advance. For his gallantry on this occasion Serjeant Elcombe received the Military Medal.

The Advance.—Eterpigny and Brie Bridges.

On the following day, 17th March, the good news was spread abroad that the enemy were on the point of making off; all the energies of the Company were directed to pushing on forward roads and the construction of trench bridges suitable for artillery. Dozens of trees had fallen or been felled across the roads and had to be removed. The enemy's withdrawal was already in full swing, and at 9.30 a.m. on 18th March Smith and Cowley were ordered forward to Eterpigny to reconnoitre the Somme bridges. Cowley returned later on with his report and took his section to Eterpigny, commencing work at 2.0 a.m. on the 19th. In the first place, a footbridge 300 yards upstream from the main crossing was repaired, and by 9 a.m. two companies of the 1st Infantry Brigade were across the Somme.

The weather was very wet, but work nevertheless went on till 10.0 p.m. On the following morning, all four sections were employed on the main bridge to make it fit for field guns. It was evident that it had been very fully used for transport by the enemy, the decking having worn thin. The bridge was well demolished, particularly at the larger water gaps, partly by explosives, partly by fire, and much tarred lining was found in position. Several packets of howitzer charges were found wrapped in wood shavings, and a few packets of explosives were discovered intact. The total length of the bridge was 1,600 ft., including the canal bridge and approach ramps, and of this some 700 feet had been destroyed. The

river was partly canalized, partly flowing fast in its normal bed, with a marshy strip on the east.

The bottom of the marsh was most treacherous, piles sinking 12 ft. to 15 ft. with a hand maul, whilst trestles gave much trouble owing to shell craters, demolition craters and "dud" shells.

Work on the bridge continued throughout the 20th and the morning of the 21st, being opened for field gun traffic by 1.30 p.m. on this day. In construction it consisted of a mixture of pontoons, Weldon trestles, pile piers and wire-lashed trestles.

As soon as this work was complete, all sections were switched on to road-making on the Barleux and Villers Carbonnel roads, but on the 23rd, owing to the trouble due to sinking piles and the failure of the old decking, all sections were again employed on the Eterpigny bridges.

On the 24th, the 23rd (Field) Company was diverted to work on the Brie bridges, where, on the main through route, it was essential to have a bridge fit to take all loads.

The whole of the 24th was occupied in clearing the debris of demolished girders from the bed of the main stream by demolition, excavating for the new abutments, and driving piles to act as temporary abutments, the latter work, including laying timber footings for crib work of the abutments, being continued on the 25th.

The main bridge consisted of a Portable Type B bridge, of 60 ft. clear through span, each girder in sections bolted together. In the first instance, in accordance with the instructions of the III Corps Bridge Engineer, foundations 20 ft. x 14 ft. were started; these were found to be too deep. The timber footing was eventually 16 ft. x 10 ft.

The girders were launched singly from the west bank, using a steel lattice derrick, and no difficulty was experienced in this operation. The girders were in place by the evening of the 26th, and all decking was completed and bridge open for traffic by midday on March 28th. The main difficulty that had arisen was due to the fact that only one set of plans had been provided with the bridge. This set had to be shared with the 26th (Field) Company, the drawings were on thin paper, and as the weather was very wet the condition of the plans after a short time can be imagined.

That the work of getting this big bridge into position was achieved so quickly and well was in large measure due to the ability and experience of Wilson, the O.C., who had done much railway work in civil life.

As soon as this bridge was complete (Bridge No. 5), a light semi-permanent timber bridge, parallel to it, was constructed on piles to take some of the lighter traffic.

On this day, the following wire was received from III Corps: "Army Commander expresses his high appreciation of the energy

and skill shown in the early completion of the Brie crossing. Corps Commander endorses this, and desires to be conveyed to the C.R.E., Field Engineers, Bridging Detachments and Field Coys., 1st Bn. Northants, details R.A., and L.N. Lancs., whose efforts have obtained these results."

Later on, the following encouraging message was received:

"A most valuable piece of work which has been of the highest importance to the Army, by enabling the enemy to be followed up with the least possible delay. I request that all concerned may be informed of the value which I attach to the success of their efforts.

D. HAIG,

4th May, 1917. *Field-Marshal.*"

To celebrate the occasion, a combined dinner was held by the 1st D.E., which was attended by General Buckland, Chief Engineer 4th Army.

Bridge No. 5 having been completed, work was required on advanced Army Headquarters at Villers Carbonnel, where the village had been entirely obliterated.

On April 1st, the rapid flow of the stream having undermined the trestles of Bridge No. 5 (medium bridge) at Brie, the Company was diverted to this bridge, the work being completed in spite of heavy snow and blizzards by April 5th.

On April 6th, work was commenced on a bridge which had already been started at Lamire Farm. The work was in a very bad condition. The original German bridge had been partly pile, partly crib pier, demolition had been thoroughly carried out, half a dozen field companies had already had a finger in the pie, and the whole thing would have provided a puzzle to the most expert spillikin player.

A new line was, therefore, set out, avoiding the worst portions of wreckage, a 20-ft. pile-driver with half-ton monkey was brought down from Brie Bridge and re-erected on a two-pontoon raft, and two small pile-drivers were also utilized. A deviation footbridge was constructed to keep traffic off the main bridge.

Pontoons, which had been in bridge over the eastern main channel, were taken out to allow piling, and first a 24-ft. pile (made up of two piles strapped together) was driven to 1 in. sinkage with a 4-ft. drop of the 10-cwt. monkey. Work was well under way when, on April 7th, orders were received to stop work on this bridge, then to put all pontoons in the water and get a bridge through quickly, then another order cancelling the last. Finally, two sections were left to complete the Lamire Bridge as a footbridge only, one section was diverted to Eterpigny Bridge to replace the pontoons by 40-ft. pile piers, and one section was taken out for training under the section officer.

Eterpigny Bridge was completed on April 12th.

On April 17th, the Company moved to reserve billets at Mericourt, where the ensuing fortnight was spent in Company training. On April 20th, the Corps Commander inspected the unit and presented the ribbon of the Military Medal to Sergt. Elcombe.

On May 2nd, the various sections went off on different jobs, No. 1 (Lieut. Wales—attached from 26th Fd. Coy.) to Carnoy to take down XIV Corps H.A. headquarters, No. 2 (Cowley) to Mericourt to dismantle the XIV Corps main dressing station, and Nos. 3 and 4 Sections (Forwood and Smith) to Nurlu to work on a new aerodrome.

On May 27th, the Company entrained at Marcelcave for the north, and after spending ten days at Thieushoek, near Caestre, and ten days near Cassel, marched on June 19th and following days to Coxyde, on the Belgian coast, where work in the Nieuport Bains sector was taken over from the Field Companies of the 32nd Division on June 22nd.

The Coastal Sector.

The area in which the 23rd (Field) Company now found itself was quite unlike any other part of the line. One flank rested on the seashore at Nieuport Bains, at the mouth of the Yser river.

The strip of sand dunes running the whole length of the coast from Ostend to Dunkirk varied in width from a few hundred yards to nearly a mile. On the sea side, the shore consisted of miles of fine firm sand, but bathing east of Coxyde was prohibited by day owing to being overlooked by the enemy, and by night by the activities of sentries. Even west of Coxyde, where a bend in the coast hid the beach from direct observation, bathing was apt to be a somewhat lively performance; on one occasion, the inhabitants of La Panne were shocked at the appearance of an entire battalion, kilted in more normal moments, arriving at a steady double on the sea front, with not even a sporran amongst them, having been temporarily cut off from its clothing by a minor barrage of 4·2-in. H.E. whilst bathing between La Panne and Coxyde Bains.

Beyond the sand dunes, which consisted of sandhills running up to thirty or forty feet in height, the country was flat and low-lying; water lay permanently within a foot or two of the surface, and any defences, except those in the railway embankment and in the sand dunes, consisted of breastworks.

Nieuport Bains consisted in the main of one long row of four- or five-storey houses joined together, separated from the shore only by the sea road. All these houses had excellent cellars, and these had been turned into a long underground passage by the French, lighted with electricity. This passage was continued towards our lines by a semi-underground passage dug in the sand, with a light timber roof about ground level which, although providing no cover from fire, yet hid parties and individuals from view and induced the spurious

confidence of the ostrich. There were two or three of these curious passages running back nearly three-quarters of a mile from the river, and having been built apparently for troops less than 5 ft. 10 in. in height, the journey, for anyone over 6 ft., was productive of serious stiff neck. On the other hand, invisible O.P.s in the sand dunes gave both sides splendid views over the opposing areas, and movement above ground by daylight invariably drew unwelcome attention. Many of the houses in Nieuport Bains had suffered but little, and, for the more light-minded, billiards or a song and dance with piano were to be had in several places.

The work of the Engineers was mainly directed to the maintenance of communication across the R. Yser, for at this time two battalions were in the trenches on the east of the river, a satisfactory enough situation during the peaceful years of the French occupation, but actually as precarious as could possibly be imagined should trouble boil up, for the Yser at this point was fully 100 yards in width, with a rise and fall of tide from 10 ft. to 15 ft. Communication was by pontoon bridges, which were constantly broken by the enemy's artillery fire, and the maintenance of which was a task of unending danger and difficulty. An attempt was made to construct a floating bridge to take a decauville track, a somewhat optimistic operation. The conditions under which these bridges were maintained is exemplified by the fact that more than one Sapper was actively seasick whilst employed on the work. Carrying parties moving up to the front at low tide by night had great difficulties in negotiating the steep ramp, and occasionally men were drowned. It was hardly to be wondered at that when the enemy decided the time had come to remove our bridgehead the bridges were broken within a few minutes, leaving the isolated units without a fighting chance.

The 1st Division, on taking over the sector, had at once started to prepare the ground with a view to an eventual advance along the coast, and the programme of work issued to the C.R.E. was as follows (Sketch No. 22):

Maintenance Work.

Covered way marked —·—·—·—.

3 floating bridges over R. Yser.
Electric power station in Nieuport Bains.
Camouflage screens along road Nieuport—Nieuport Bains.

New Work.

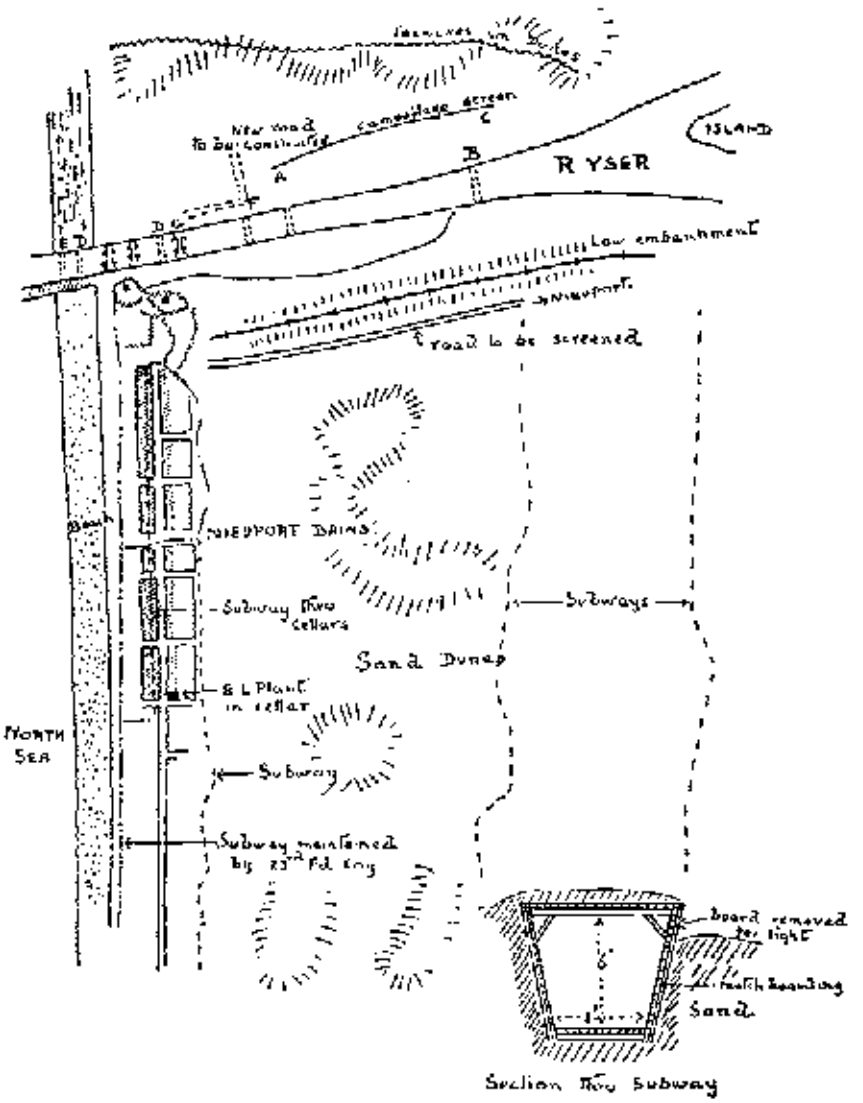
(*a*) Erect camouflage screens A—C to hide river from the enemy, leaving room to form up four lines of troops between the river and the screen.

(*b*) Collect and make up into rafts, material for one medium and two footbridges.

(*c*) Reconnoitre for footbridges at E, A and B, and medium at F. Ferries at D, D.
(*d*) Transport road to be made connecting with route *pavée*.
(*e*) Erect cupola shelters between E and G.
(*f*) Bomb-proof shelters at Div. H.Q.
(*g*) The greatest care to be taken to camouflage all new work.

NIEUPORT BAINS.

SKETCH No. 22.



On July 6th, 7th and 8th, work was handed over to the 458th (Field) Company, and the 23rd withdrew to Le Clipon, leaving, however,

Lieut. Smith and two Sappers to take part in a raid opposite the right battalion at Nieuport Bains on the night of the 9th. No record of this raid exists, unfortunately.

Le Clippon Camp. (Sketch No. 23.)

Le Clippon, or "Hushville" Camp, was, as all the world now knows, the home of the 1st Division whilst training for the projected landing on the coast about Ostend, which never materialized.

The erection of this camp was carried out by Field Companies, accommodation being in Nissen huts.

The camp being situated in the dunes, water supply was an interesting problem. In the first instance, it was proposed to pump water from the pond and snipe bog into tarpaulin reservoirs, thence through sterilizers and by 4-in. pipes to distribute throughout the camp. For this purpose three miles of 4-in. pipe, and 3,000 yards of 2-in. pipe, were laid, and pumping engine installed. Unfortunately the pond, once emptied, refused to refill, and it became necessary to improve the snipe bog supply by cutting irrigation channels and sinking a cased well. At the same time, wells 6 ft. to 10 ft. deep were sunk at the rate of two per unit. Each well was provided with a L and F pump and a 200-gallon tank and these wells gave an average yield of 1,000 gallons per day each.

In addition, a reserve supply of 12 400-gallon tanks was maintained at the camp entrance, water sterilized at Zoon Plage being supplied by tank lorries and distributed through the camp by rail.

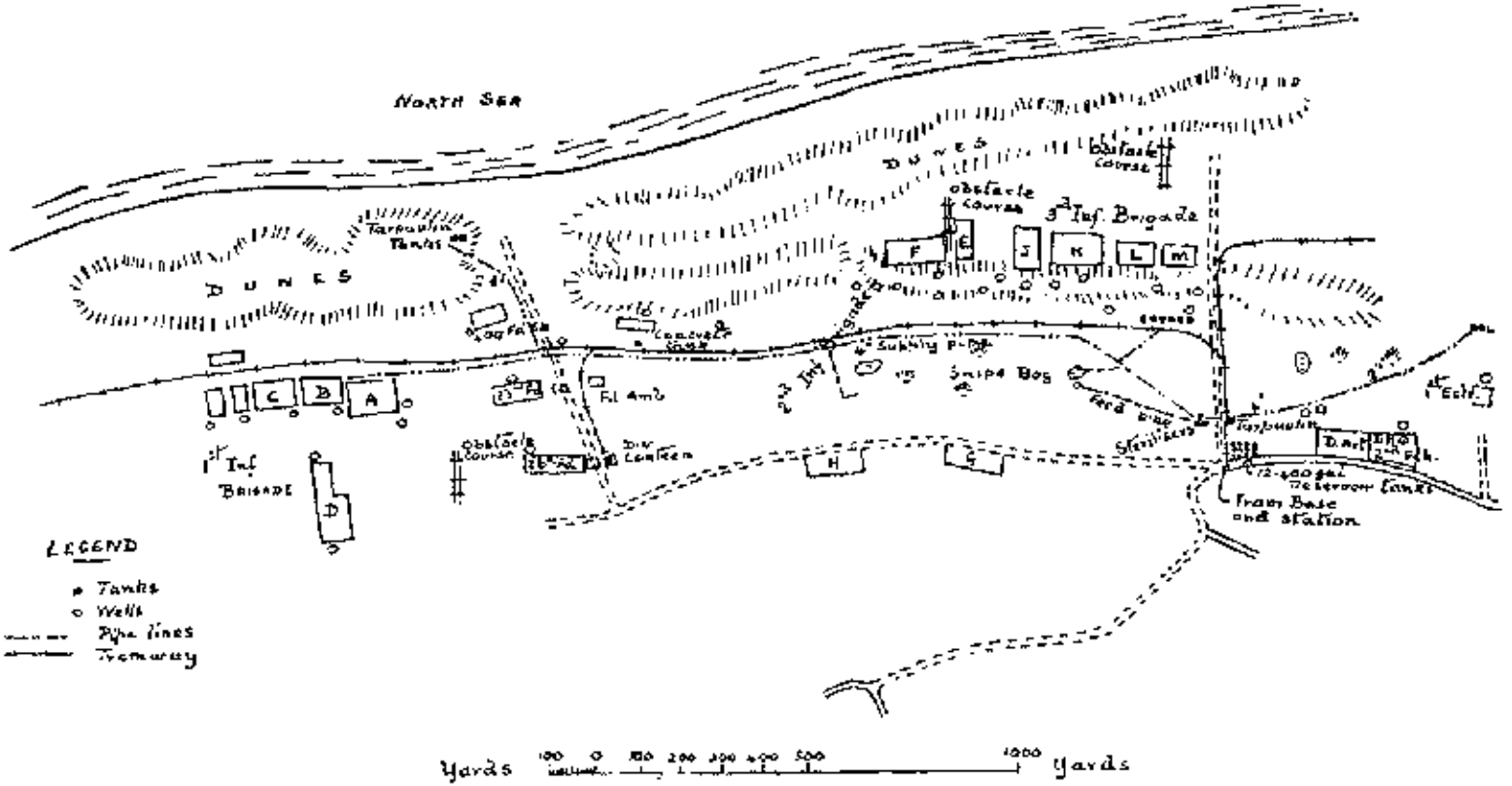
A further work carried out by each company was the construction of an obstacle course for its Brigade.

About this time there took place an epic football match. As happens in the best regulated families, there had been for some time a slight coldness between the 23rd and 26th Companies, and, to clear the air, it was decided that a match should be played by company teams of officers and N.C.O.s. Excitement was intense. To a supporter of the 23rd, armed with pebbles in a tin, the 26th replied with a gas rattle. The 23rd riposted with trumpeter and two friends with bugles. The crowd thickened, and every touch of the ball was greeted with enthusiasm, until the din reached the ears of Brigade H.Q., who, fearing a riot, turned out the guard, on which a cynical Sassenach was heard to remark that they must have thought the Camerons had got at the Black Watch at last! Finally, the match finished with loud cheers, and the hatchet was buried good and deep.

By Sept. 29th, it was apparent that the projected operations would not be carried out, and the Division left Le Clippon camp and moved into the forward area, Oost Dunquerque. The transport moved into Perth Camp, where a most unhappy event occurred, for the

LE CLIPPON CAMP.—WATER SUPPLY.

SKETCH No. 23.



horse lines were shelled, 29 horses being killed and 16 wounded. The lines were thereupon moved back behind Coxyde. Many old friends amongst the "hairies" were lost, but they had, poor things, never fully recovered from the effects of the winter on the Somme, and the well-conditioned lot of young remounts, if a bit untrained, were welcome.

YPRES, 1917. (SKETCH NO. 24.)

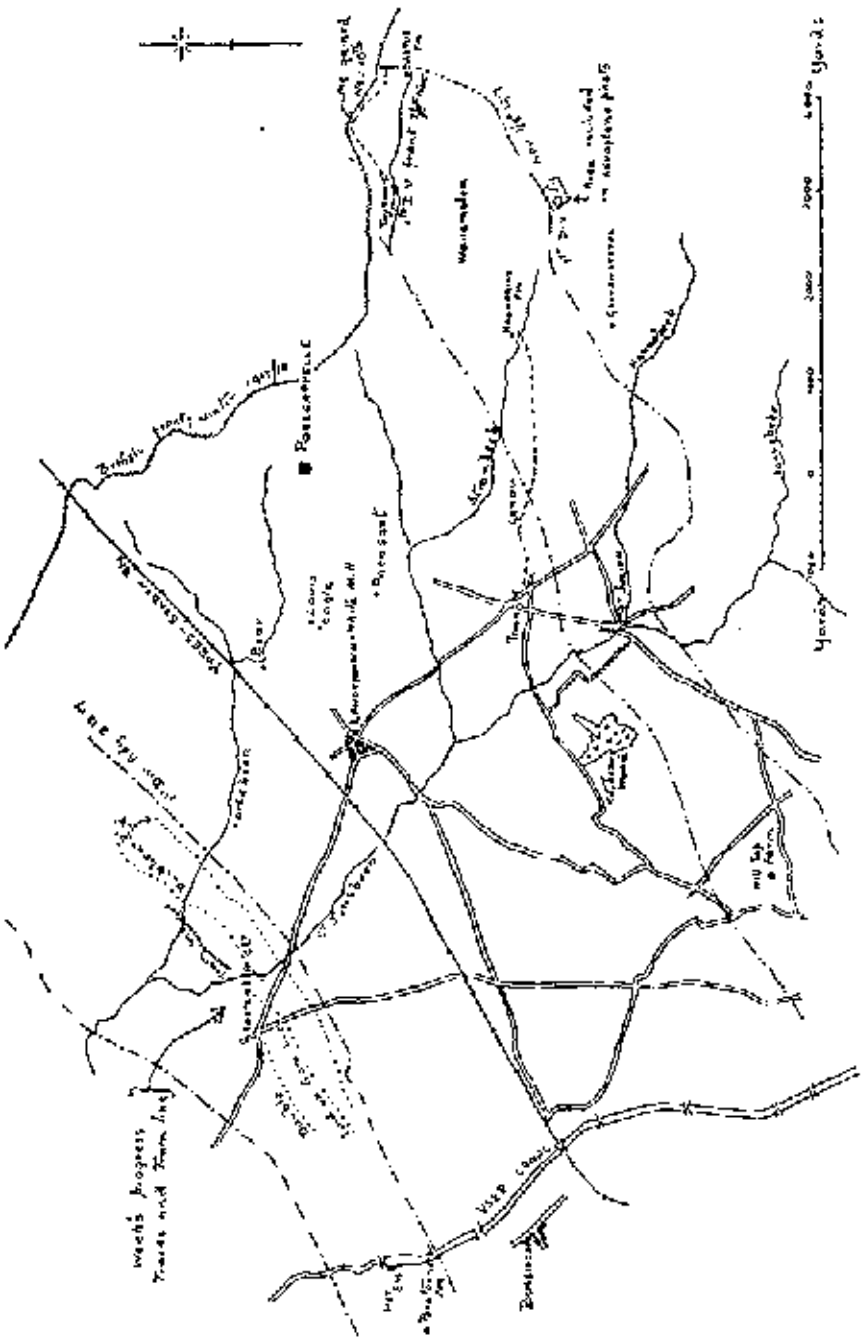
The 1st Division turned its back on the coast in the middle of October, the Company moving on the 18th to Ghyvelde, on the 22nd to Arneke, the 26th to Herzeele, and eventually on the 31st to the battle area, billeting in the first instance at Hospital Farm Camp, and a couple of nights later at Hill Top Farm Camp, the Division taking over from the 63rd Division on November 7th/8th. This pleasant-sounding name belied the reality, for here was no pleasant grassy meadow with neat rows of huts in the shelter of a peaceful farm, but a few tin shelters in a wallowing waste of water-filled shell-holes, a bare bleak swelling in the shattered plain, with here and there a concrete "pillbox" embedded to its eyes in the morass to mark where once a quiet homestead had been, now peeled like a nutshell from the sinister kernel within.

Almost nightly the camp was shelled by heavy high-velocity guns, and frequently bombed by aircraft, but by marvellous good fortune hardly a casualty was sustained, even though on one occasion a delay action 8-in. shell, having buried itself deep in the ground, lifted a Nissen hut complete with No. 4 Section into the air. Poor No. 4 were just sleeping off the effects of a heavy night's work in the mud. Spectators dashed to render first aid when No. 4 were seen crawling out of the debris in all directions, choking and spluttering, little the worse. The heartless C.S.M. was heard muttering, "That's all right, we've a full complement for work to-night, after all!" After this, C type steel shelters were built under the lee of pillboxes. Company H.Q. was in the canal bank quite close to the remains of the old barge bridge of 1914. The hulks were still there, but the old billet nearby had passed from mortal ken, and the barges had had a rough time in the previous three years.

The 23rd (Field) Company was now mainly employed on the construction of a forward road from about the Triangle to Genoa and the Strombeek. The aeroplane photograph, showing a portion of the Strombeek Valley in which the Company was working at this time, gives a clear indication of the difficulties of the undertaking, which consisted of filling in shellholes and making up a firm bed for the wooden slab road. In addition to the new construction there was a great deal of maintenance work owing to the nightly shelling. Movement to work was by duckboard tracks, sometimes laid on the ground, sometimes where the ground was more than usually flooded

YPRES.—November '17—April '18.

SKETCH No. 24.



raised on small piles, the route avoiding St. Julien, an unhealthy spot.

In addition to the work on the road, the construction of a tramway was pushed on as rapidly as possible, the 248th, 5th, and 226th (Field) Companies, R.E., and 14th Worcesters (Pioneers) being also employed on this work. In order to support the attack of the 1st Division on the 10th November, it was necessary to get 60 field guns into the Strombeek Valley and the railway was the only means of doing this, hence the urgency. The work was most difficult for the line had no connection with any existing system, and the materials had, therefore, to be carried forward from Corps dumps by G.S. wagon, and the marshy ground caused awkward constructional problems.

Constant shelling added to the difficulties, and where all did splendid and gallant work it was difficult to pick out the finest. But for outstanding leadership, courage, and the inestimable quality of cheerfulness, two stood out—Lieut. W. G. Smith and Sapper C. B. Collier, who received the Military Cross and D.C.M. respectively.

Between the 6th and 23rd November, the 1st Division Field Companies took over the responsibility for all front line work east of Kronprinz Farm, and it will give some idea of the work involved when it is stated that in the Divisional area there were 35,000 yards of duckboard tracks to be maintained, requiring a daily supply of 1,000 duckboards for maintenance. Owing to transport difficulties fixing the position of R.E. dumps so far behind the line, sections very frequently covered 15 miles moving to and from work, carrying tools, and often duckboards, in the forward journey.

The utter misery of the conditions at this time are indescribable. The photograph of the Strombeek Valley gives some idea of the waterlogged waste. Soaked to the skin by the incessant rain, weighed down by equipment, tools, and the duckboard or what not for use on the work in hand, stumbling and dragging along the slippery slats on the narrow ridges between the shellholes, meandering sloughs hardly recognizable as paths, or digging, mauling, building in squalor and sludge, it was one long struggle of horror. Add to this physical effort the psychological effect of the dismal outlook, the waste of treeless, houseless, greenless landscape, destruction incarnate, the all-pervading smell of stagnant shellholes, with their frequently dreadful contents, and the ever-present expectation of a sudden "area shoot," a storm of high explosive and shrapnel breaking out at a moment's notice; and one marvels that any human being could live through such conditions and keep sane. But never for a moment did the splendid courage of the men fail; catching mirth from a mishap and laughter from the weariest work, matching depression with optimism, they won through, doing cheerfully and efficiently hour by hour, day by day, and week after week, deeds

that, for the spirit which inspired them and the conditions over which the triumph was won, stand amongst the proudest in the history of the Corps.

On November 28th, the Company moved to rest camp at Proven, where it remained barely long enough to scrape off the accumulated mud, for on the 1st December it moved to La Minoterie, and on the 3rd to Paratonnerre Farm, taking over from a French *Cie du Génie*, the 1st Division having taken over from the French a line in front of Houthulst Forest.

On November 30th, Lieut. P. L. Forwood left the Company to join G.H.Q. Survey Company.

The work in the Houthulst sector consisted in screening Kortekeer Cabaret from direct observation, in pushing on the divisional tramline, and in maintenance of the Broenbeek bridges, the latter involving continual patrol and daily repair.

The tramline progressed at a fairly rapid rate, the figures being: Dec. 9th, 300 yards; Dec. 10th, 400 yards; Dec. 11th, 150 yards and 50 yards formation; Dec. 12th, 100 yards; Dec. 14th, 80 yards and 75 yards formation.

In addition, repairs were required to concrete pillboxes and also improvement in their limited amenities.

Christmas was spent in this area, and a good old-fashioned Christmas it was, with hard frost and deep snow. The Padre had mysteriously disappeared a few days before, returning with a real fine pig, which was, needless to say, an object of the greatest solicitude to the Company. History relates that one cold night, a loud squealing was heard about 1.0 a.m., which, on investigation by the C.S.M., proved to be a kind Sapper endeavouring to put a horse-rug round his prospective Christmas dinner. The thoughtful Padre had not forgotten that pig requires liquid assistance, with the result that all ranks had a festive evening, so much so that at a late hour the N.C.O.s' Mess turned out to sing carols round the officers' billets, four camps anything up to half a mile apart, through the snow. Their efforts were properly appreciated, Cowley getting an additional serenade. It was a tired, wet, but still cheerful party that turned in to bed about 4.0 a.m.

After this pleasant interlude work went on as usual. The frost was hard and prolonged, but whilst it lasted the consequent hardening of the muddied waste made it easier to get about off the duckboard tracks which were always an easy and popular mark for the enemy's artillery. Maintenance of the bridges over the Steenbeek and Broenbeek was an arduous daily task, culminating on January 16th in days of strenuous exertion, for a heavy storm following on prolonged frost and a sudden thaw caused the Steenbeek to rise 7 ft., a very serious matter in this low-lying and waterlogged area.

From January 24th to March 9th the Company was in reserve and

working on the defences of the Army Battle zone, machine-gun emplacements, pillboxes and wiring.

On March 9th, work in the forward area was taken over from the 409th (Field) Company, in the Poelcappelle sector, the tasks being mainly wiring and shelters, later concentrating on strong posts for all-round fire in the support system of the forward zone; posts Bear, Eagle, Louis Farm, White Mill and Pheasant Farm.

Much of this work consisted of the construction of concrete pillboxes, the value of which we had learnt from the enemy. Every effort was made to camouflage the work, for signs of new construction, whether shown by a gathering of tracks at a given spot or by signs of the work itself, the flat square of concrete or the regular hollow of the walls stood out at once on an aeroplane photograph in this bare waste of mud and shellholes. The management of tracks required great care, and the replacement of camouflage on completion of each night's work was most carefully attended to. In spite of this, working parties from time to time found that their efforts had been spotted by the enemy. One night, the 16th/17th March, Corporal G. Sims was in charge of a party of R.E. and attached infantry, working on a post, when the enemy suddenly opened heavy shell and machine-gun fire on the area, causing some dispersion of the party. This gallant N.C.O., however, got his men together again, and on to the work, until another burst of fire again stopped them. This happened two or three times, but each time Sims returned to the charge, a fine example of courage and leadership under difficult conditions which was deservedly recognized by the award of a Military Medal. Two nights later, a similar situation arose, but this time the shelling was so persistent and accurate that it was impossible to keep the party at work, and it was withdrawn. Nevertheless, Sapper R. W. Wade volunteered to return and replace the camouflage over the post, a task which he successfully completed, although the place was still being shelled. He, too, received the immediate reward of the Military Medal.

But the Sappers would be the first to admit that their efforts would have availed little had they not been ably backed up by the mounted section. The drivers' lot was a terribly hard one in this horrible battlefield. Moving up night after night with loads of stores on the crowded roads of slippery timber, constantly exposed to heavy shell-fire, horses and wagons sticking in the mud, and the stout-hearted, willing old "hairies" day by day showing signs of the long strain, it required the greatest skill and courage to keep the dumps supplied. One night in particular may be mentioned, when the route was heavily shelled. Lorries and wagons were in a jumbled mass, shells coming over at regular intervals were throwing up columns of mud and water over the road in the darkness, and horses became restive and difficult to control. Nevertheless, Corpl. C. H. Sole, by his

example and quiet determined courage, kept his drivers and teams in hand, brought them safely through the turmoil in the darkness and duly delivered the goods, earning thereby his Military Medal as well as any honour received by the Company.

As the ground dried, it became possible on the higher ground to commence construction of mined dugouts, and to save the time, four hours, taken in marching up to the work and back to billets, sections lived on the work, increasing working hours to nine per day.

On the 21st March, the great German offensive in the South had commenced and as more and more Divisions began to go in that direction, rumours of a move became rife. In the words of the diary: "Rumour says we are going to nearly every place imaginable—quite a Cook's Tour, in fact." That a move was in prospect was a fact, for on the 7th April the Company turned its back on the Salient, and moving to Elverdinghe, Caestre (where old friendships were renewed) and Annezin, found its way once more to the old battle-ground of Cambrin.

Before leaving the Salient, a sad parting took place, for on a March evening the 23rd (Field) Company officers and others of the 1st D.E. gave a farewell dinner to "R.B.," nearly the last of the old "diehards" in the Division. Having commanded the Company from 1913 to the end of 1915, and having since then been C.R.E. of the Division, R.B. had served continuously with the Division in France for three and three-quarter years, and it must have been a deeply-felt breaking of the closest ties when the time arrived to say good-bye, though if rumour is correct the deeper feelings of regret were not allowed to spoil the festivities of the occasion. It was a great blow to R.B., who had aspired to see the War through with his old comrades, but in 1918 G.H.Q. ruled that officers who had served continuously in front line Divisions since 1914 were to be posted elsewhere for six months' rest.

It remains to note that, on March 15th, Capt. B. B. Edwardes, M.C., left the Company on transfer, 2nd-Lieut. E. T. G. Carter and 2nd-Lieut. J. C. Pocock joining the unit, whilst on April 1st, Lieut. W. G. Smith, M.C., was posted to the 26th (Field) Company as 2nd-in-Command.

(To be concluded.)

Strombeek Valley. November, 1917.

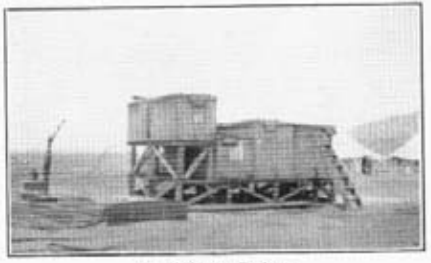
Strombeek Valley

5.—Lorry Shelter.

6.—Stables for Field Company Section, R E.

7.—Stables for Battalion, less M.G. Co.
(Writer's Chinese "charger" on the right.)

8.—Stables and Vehicle Shelter for M G Co.



9.—Water Point.

10.—Men's Cooking Shelter and Serjeants' Mess Cookhouse.

Improvisation in North China

WITH AN IMPROVISED A.C. COMPANY ON MANŒUVRES.

By " POL."

" No names—no pack drill."

INTRODUCTION.

IN the early part of 1928, enquiries were made by the Powers that Be as to whether Chatham could furnish an improvised Armoured Car Company, to take part in 4th Divisional Training.

Broadly speaking, the intention was to call for officer volunteers, using their own cars on a mileage allowance basis, to represent armoured cars.

Each car, according to seating capacity, was to have a crew composed of other ranks, armed with rifles, blank S.A.A., rattles, etc.

The Commandant, S.M.E., undertook to provide the " unit " complete, and volunteers were called for, officers under instruction being granted leave from their various courses during the period of the Command Scheme, in which alone the A.C. Coy. was required.

The required volunteers, with cars, were quickly forthcoming, and the scheme was launched.

FORMING UP.

On Saturday, 15th September, the Improvised Armoured Car Coy., R.E., formed up.

Officers, N.C.O.s and men paraded in the S.M.E. workshops yard at 9 a.m., the officers with their cars, and personnel and cars were allotted to sections.

Each fighting section of six cars (*vide* note on Organization at end) was sub-divided into three sub-sections of two cars, and, as far as possible, cars were allotted so that sub-sections were fairly balanced, one against the other, as regards seating capacity and power.

In each case, the Section Commander's " other half " was the smallest car in his section and was allotted the enviable job of " reconnaissance car," which in practice was apt to come down to the " sacrifice " to gain warning for the whole !

Personnel were then allotted to their individual cars and warned to learn definitely the appearance and numbers of their own vehicle.

Trial loading was then carried out, and " embussing " and " debussing " practised.

The distinguishing marks were also fitted on to cars. These consisted of a light three-ply box, without top or bottom, fixed on top of the hood by divers and diverse methods of padding and lashing, all hoods being kept permanently up while "in action." The boxes measured 22½ in. square by 15 in. high, each face being painted in a black and white chequer, with 7½-in. squares.

This was found sufficiently definite to allow of no doubt on the part of units as to what the car represented, though it was felt to be somewhat of a handicap to a car trying to lie "doggo" in ambush.

No trouble was experienced with them, and two spares, taken along in case of eventualities, were not used.

The men were dismissed at 10.45, and a short conference of officers was held before lunch, at which the outline of the Command Scheme was discussed and a few principles as regards tactical handling of sections and sub-sections were laid down.

THE MOVE TO THE MANŒUVRE AREA (Sunday, 16th Sept.).

The Company's destination was Cockwatch Camp, Colchester, and the success of the move was felt to be largely dependent on the "unit transport" provided.

Two vans, one per section, were originally asked for, but this was found to be impracticable, and one 3-ton lorry was promised. The final allocation of transport by 4th Division gave us a 30-cwt. Crossley, and an emergency scale of loading for cars was, therefore, made out.

It was just as well, for when the fatal day arrived, the kit lorry which actually appeared turned out to be a 15-cwt. Guy.

N.C.O.s and men paraded at 9 a.m. with their kits, and the lorry was loaded.

Officers and cars paraded at 9.30, the Company in improvised formation of column of sections making quite an imposing though very definitely improvised unit, and personnel, at the emergency scale, "stood to their cars."

The "official" photographs followed, and at 10 a.m. the Company embussed and moved off as a formed body.

The start through Chatham and Rochester was a fairly high test of "march-discipline" to start off with, and was made no easier by the fact that the lorry, which started immediately behind the H.Q. car, so as to set the pace to that of the slowest vehicle, moved in low gear and very gingerly through the traffic.

Eventually, the Company got clear and halted at the top of Strood Hill, where the lorry was segregated and the driver told to follow in rear as fast as possible, in the hope that he would reach the ferry at Gravesend by the time the rest of the Company was aboard.

We started again, moving at about 25 m.p.h., so as to reach the ferry up to time.

The lorry came, too, and refused to be shaken off so that when, after sending the D/R ahead, we reached Gravesend at 10.40, and found an empty ferry waiting for us, we embarked straight away as a single formed body.

From Tilbury to Brentwood, the column formation was kept, the lorry moving on its own in rear. Cars then proceeded individually, and at 12.55 all were present at the rendezvous at Mark's Tey. The Company entered Colchester as a formed body, and after taking one wrong turning, which proved to be a dead-end and provided some excellent turning practice, halted in "column of sections" in Cockwatch Camp at 1.20 p.m.

The lorry arrived at about 2.15.

Two incidents of the journey recur to the mind, sufficiently trivial to show that, mechanically speaking, it was without incident.

At one small wayside pub., the name and location of which cannot, for obvious reasons, appear, the request for beer was met by an offer of tea. Watches were consulted and we realized the worst. A request for really nice strong tea in a glass—was, however, more successful, and the secrecy of our potations went only to improve an excellent sample of the national beverage.

Essex accepted us fearlessly, to the credit of its inhabitants, but speculation was rife as to the purpose of our chequered "turrets," and we got no small amusement from such conjectures as we overheard.

"Camouflage" was heard more than once, but the palm for apt retort goes to a cycling club, overtaken on the journey up.

Every motorist will understand the arising of a swift though brief conversation.

They won the leader, disdaining that more usual suggestion, requesting us to "go home and play draughts with yourselves."

In view of our conspicuous "label," there was no reply to give.

At Cockwatch Camp, the O.R. were soon comfortably settled, the 1st Bn. Argyll and Sutherland Highlanders being responsible for their rations and accommodation throughout our stay in the area.

Officers sorted themselves out among the Colchester hotels and, after a short conference at 3 p.m., they all went out to reconnoitre the southern half of the scheme area in preparation for the "war" next day.

Our arrival was reported to O.C. Skeleton Enemy, under whose command we were, orders were received for our move out to the ground next day and a warning order issued to the men, who reported "all comfortable and food good."

THE FIRST DAY.

Operations were timed to start at 5.30 p.m., and the morning was spent in further reconnaissance on the part of all section officers.

This previous reconnaissance, which was fairly thorough, perhaps made the "war" somewhat unreal, as every driver was able to get a fair idea of the area he was likely to work over before "war" was declared, but as it was vital to the success of the scheme that the Company should function efficiently in the various stages in which it was engaged, and as, in addition, the country was particularly close and blind, it was considered essential rather than as merely admissible.

While the section officers were quite legitimately running up their mileage claims, Headquarters received a variety of set-backs from the Administrative point of view.

The most serious one was that the rattles, which had been indented for some time previously and on which we depended to a large extent for the realism of our show, had not arrived. In the course of a hectic hour, copies of indents, vouchers, advice notes, way-bills and the whole glorious paraphernalia required to get ordnance stores out of their permanent abode and into a "unit's" possession (on temporary loan and *via* a private railway company) came to light, but the bitter fact remained that no rattles had arrived. Attempts to borrow from units proved abortive, each unit having, quite rightly, determined that its Lewis guns should receive due credit. So the A.C. Coy. went without.

A further disappointment was in store.

One of our jobs was to raid the enemy outpost line at night, with the sole purpose of keeping the weary soldier awake. Our nefarious purpose, previously blessed with official approval, was to shoot off Verey lights from a comparatively safe distance and at intervals during the night, over a fairly wide front. The juxtaposition of a vigilant compensation staff and a number of haystacks and other inflammable materials, however, negatived this proposal, and our night raid became, in consequence, a totally different proposition.

Eventually, however, available stores (consisting, in fact, of a large quantity of blank S.A.A. and six large white flags) were drawn, definite timings for the phases of the day's operations were received and, after yet another of those inevitable conferences, without which it appears impossible to "manœuvre" adequately, the Company was ready to move off.

At 1400 hours (how subtly do we indicate the start of war), we paraded and left Cockwatch Camp in column of route, moving to the inn at Fordstreet.

Apart from having to overtake a travelling circus on the way, the

move was without incident. On arrival, blank S.A.A. was issued and we sat down to await operation orders and the umpires.

Both arrived at 1500, and verbal orders for Phase A1 (driving in of cavalry and reconnaissance for the enemy outpost line) were issued at 1645, after considerable discussion as to how the umpires were to work, as the Company cars could not transport them and the keeping of touch otherwise was bound to be difficult.

It is not proposed to go at length into the scheme. Suffice it to say that the 4th Division was advancing northwards, with an imaginary Division on either flank, opposed by a Skeleton Enemy, whose intelligence was, of necessity, amazingly good!

Thus, we knew at the outset that the Southland Corps, of which 4th Division was the centre, had issued orders to halt for the night, that its cavalry had reached the line of the Colchester-Braintree road and was about to withdraw behind the outpost line.

Phase A1.

The frontage was divided into two sectors, roughly as shown on sketch map; No. 1 Section right, No. 2 left. Coy. H.Q.—Inn at Fordstreet.

A time-table of bounds was given and at 1730 hours, both sections crossed the River Colne.

Coy. Headquarters got itself under cover and sat down to await eventualities, watching a C/R machine working along the line of the river, and wondering where the infantry, whose orders were "to occupy the crossings of the R. Colne," had got to.

At 1820, a message was received from No. 2 Section, timed 1804, stating: "Have secured line of main road. Met slight opposition. Am proceeding to Copford."

Headquarters then moved forward to Aldham, and the D/R was sent out to locate No. 1 Section.

Shortly afterwards, a car from No. 1 arrived with a report of lurid battle, as a result of which the other car of the sub-section had been put "out of action." Section Headquarters had disappeared and the situation on the right was distinctly obscure.

Here the inadequacy of our communications was immediately shown. Single cars received short shrift from umpires and sub-sections could not communicate with Section Commanders, nor Section Commanders with Coy. H.Q. without detaching fighting cars. The story of the day emerged at a conference when the Company reassembled after dark.

An intermediate, untimed bound, running east and west through Aldham was, as anticipated, reached without incident. The object of this line was merely to get sub-sections disposed over the frontage to ensure that all roads running north and south were patrolled.

To take the right sector first.

A theoretical harrow and some real cavalry were encountered at Little Tey House, but the cars were judged to have pushed them back and were subjected merely to a short delay, for the purpose of removing the obstacle.

The main road, forming the first main bound, was reached on time and found to be clear.

South of it, however, a great battle developed, particularly on the right.

A well-sited anti-tank gun fairly early accounted for one car at Langley Green, but the second car of the sub-section was allowed to have dealt firmly with the gun and crew. This car was then badly chivvied. Proceeding southwards, it spotted a second A/T gun, turned and tried to get out by Old Wills Farm. There further cavalry were found, so the driver made a dash back, passed the located gun at speed, turned right past the Warrens (there taking an A/T gun in reverse), and so returned to safety, having located enemy troops at five points. After reporting to Coy. H.Q., he returned and was shortly afterwards put out of action by an umpire who had got tired of his depredations.

Another car from No. 1 Section got through Easthorpe, where cavalry were shot up, and went south to Messing. This village was found to be full of enemy infantry, who were bivouacking there, and the car most unsportingly disturbed the weary "feet" who were fraternizing with the local youth and beauty, by driving through the village at high speed, with its crew deliriously getting off blank in a valiant endeavour to reproduce the effect of machine-gun fire.

A definite identification was obtained here, and the car, having penetrated the outpost line, was in some miraculous way allowed to get home again *via* the main Witham-Mark's Tey Road.

No. 2 Section, on the left, first met enemy cavalry at Mark's Tey Station, and then located them at seven or eight points in the area south of Copford. The umpires dealt rather harshly with the A.C.s in this Sector, but one car from this Section also got into the outpost line, and obtained an infantry identification at Smyth's Green.

It was disturbing to find that the umpires had put out of action no less than nine of the twelve fighting cars, but the job had been done in the face of some difficulty.

Two things contributed to make this bit of war unreal and unnecessarily difficult.

Barriers, in practice, take time to assemble, and are usually visible unless very cunningly sited.

Even a harrow in the road is likely to be spotted in time to pull up and reverse if necessary, for an A.C. cannot crash blindly along in enclosed country. A piece of paper on an overhanging branch, backed by an umpire stepping out from behind a bush at the critical moment, is a poor substitute.

The green flag with a white cross is a readily recognizable symbol for an A/T gun, but its concealment in a pocket is more complete than that of the actual gun and crew are ever likely to be. It was felt that in some cases, at all events, the armoured cars were hardly dealt with, and in one particular case, where the green flag was produced out of the pocket of a gentleman who had just arrived on horseback, the car-driver, very rightly, " took a life " in defiance of all argument.

Thus ended Phase A1, and the dead cars came to life again.

Phase A2.

The next item on the programme was the raiding of enemy outposts.

As previously stated, the original scheme had been considerably modified, and it was subsequently decided that one section only should carry out a raid on one selected locality.

As a result of the information obtained by the evening's reconnaissance, the point selected was Smyth's Green. Messing was not considered so suitable as, firstly, there was but one road leading into the enemy's position there and, secondly, although the village was known to be full of infantry, the location of the outposts was unknown, as they were apparently not in position when the armoured car passed through earlier in the evening. The Easthorpe-Messing road is also very narrow and enclosed by high hedges and winds and twists considerably, so that its use at night would have been very risky. The raid, therefore, fell to the lot of No. 2 Section.

It had been decided that one section should be on duty at two hours' notice throughout operations. This meant that officers and their cars had to remain at Coy. H.Q., as time was necessary to pick up O.R., so that the section on duty could not count on finding a comfortable pub. in which to spend their sleeping hours.

No. 2 lost the toss and so had a night out after the raid.

No. 1 Section then departed to find beer and beds, while No. 2 made arrangements for the forthcoming raid, which was timed for 2300.

Company Headquarters remained at Fordstreet, and at 2220 hours, No. 2 left for Copford, on which the actual raid was to be based, accompanied by the D/R, loaned for the operation.

The raid was, apparently, a success, although two cars were put out of action. It is thought that the leading (reconnaissance) car got through too far before being spotted and was then unable to get back, while the second car was bagged by an A/T gun, which was probably produced in a hurry from somebody's pocket in honour of the occasion.

What was really supposed to have happened will probably never be known (though one sub-section sent by an alternative route,

arrived in the nick of time, from the opposite direction !)—in actual fact, there was considerable argument, mainly noisy, between all parties concerned, including the unfortunate umpire detailed for the job.

Honour was apparently satisfied by balancing an entire picket, with sentry-groups and A/T gun complete, against two cars, though one car only saved its draught-board " turret " with some difficulty, an infantry officer being particularly anxious to obtain it as a souvenir of the occasion.

History does not definitely relate whether the driver *did* help him to finish the bottle or not.

The completion of the raid was reported at 2330 to Coy. H.Q., which withdrew at 2345 to a pin-point, where was H.Q. of the Battalion to which the Coy. O.R. were attached.

No. 2 Section arrived there at 0040 hours, having unfortunately listened to a Highlander who was thought to have said, in his own tongue: " Straight down the road. You can't miss it." There was, of course, the inevitable fork, and they did miss it, but fortunately only once.

In all, nine officers " slept " in their cars, the remainder found an excellent inn in Bures, which was promptly marked down as a future Coy. H.Q.

During this raid, the first real casualty occurred. One of No. 1 Section's cars, after dropping the crew at Battalion H.Q., was looking for a night's lodging and was involved in a purely civilian accident on the main road.

The telegraph pole won and the car was a casualty for the rest of manœuvres, though its owner most sportingly turned up in a truly marvellous hired barouche on the third and fourth days.

THE SECOND DAY.

Phase B.

Phase B was practically the reverse of Phase A.

The 4th Division, preceded by cavalry, advanced northwards, while the A.C. Coy. fought a delaying action back to the line of the River Colne, which was held by our infantry.

Tea was issued to the men at 0500 hours by the Battalion, who never failed to do their utmost for our comfort.

The company formed up by sections in column of route and moved off, No. 2 at 0515, No. 1 at 0525, with orders to secure the main Colchester-Braintree road. Both sections crossed the River at 0545, No. 1 at Wakes Colne, No. 2 at Fordstreet, and reached their objective without incident, no enemy being sighted till 0700 hours.

Very full information was sent in once contact had been gained,

and there can be no doubt that the cavalry were seriously delayed and would have suffered very heavy casualties.

The experiences of the previous day had made a big difference in the handling of the cars, everybody now knew what to expect, and with the change-over of functions between cavalry and cars, the boot was on the other leg.

Great difficulty had been anticipated, owing to the enclosed nature of the country, and everyone had been warned to look out for cavalry working round behind sub-sections and blocking the roads behind them.

By working sub-sections in depth, however, this was overcome, and no cavalry succeeded in getting past the cars.

The main road proved a tremendous obstacle to the unfortunate mounted men, for its long, straight, wide stretches gave the cars a wonderful field of fire, and they were able to cruise up and down and totally deny its passage. There appeared to be no artillery fire on the road to help them, and they could not get their A/T guns forward, as the umpires were now very stringent as regards their vulnerability on the move.

On our extreme right, patrols did succeed in working across, and it was subsequently found that the maps on either side differed entirely as regards the western boundary, beyond which movement and fighting was taboo.

In due course, the Company withdrew, " according to plan," and the fun started.

Two methods were employed. In the first, the leading cavalryman was shot as he came round a corner. Bearing the charmed life of manœuvres, he promptly galloped away and gave the alarm. The troop leader made his plan, put it into execution, and—found the quarry gone. Two hundred yards further back, the game began again. The delay caused was simply marvellous and the cavalry must have hated it.

The second method was more subtle.

The " advance guard," or " point," was not shot. He was merely very firmly, but in complete silence, stopped and removed from his horse as he came round the corner.

The troop followed, having no alarm given this time, and either the whole or the greater part was shot up from the car. The umpires always let one man get away to give the sorry news and, by the time a new troop came up, the ambush had gone once more and the game began again.

In accordance with orders, the sections withdrew over the Colne at 0910 and 0915 respectively, though it seemed a pity to have to leave the game unfinished. The bridges were " blown " and the infantry took on the war.

Casualties to cars—*nil.*

The Company was not scheduled to appear again till the next (third) day, so the men were returned to their bivouac of the previous night. Coy. H.Q. and No. 2 Section (on duty) repaired to an excellent inn at Bures and the officers of No. 1 retired to Colchester and elsewhere for the day.

The men moved about one and a half miles by march route, with Bn. H.Q. when they moved back at 1730 hours.

In the evening, orders were received that the Coy. would form part of a rearguard next day—the O.C. Rearguard being the C.O. of the Cavalry Regt., against whom we had so far been in action, and who changed sides at this stage, their *rôle* with the Division being now at an end.

THE THIRD DAY.

While the Company had been out of action and in reserve, the infantry of the Skeleton Enemy had been pushed back from the line of the R. Colne to a line running roughly east and west through Beak Farm and Jenkins Farm, known as Line D.

The further retirement, back to the River Stour, was not easy owing to the shape of the ground, and it was decided to effect this under cover of a counter-attack by the tanks, after which the enemy would be delayed by a rearguard, composed of the Cavalry Regt. and Armoured Car Coy., until such time as infantry positions about the Stour could be taken up and the new line of defence organized.

O.C. Rearguard held a conference at 1000 hours and issued his orders for the conduct of the operation, which, in fact, was in some ways the most interesting and instructive part of the scheme from the point of view of the Company.

The main idea was to form, as it were, a line of mobile forts, each consisting in fact of a sub-section of A.C.s, with a troop of Cavalry.

This involved the temporary reorganization of the Company. One sub-section was withdrawn from each Section, and Nos. 1 and 2 Sections were placed under the command of Cavalry Squadron Commanders.

The two sub-sections withdrawn were formed into a temporary No. 3 Section, which, with Coy. H.Q., was retained as a reserve under the hand of O.C. Rearguard.

The leading sub-sections were allotted one to each of four important roads, and were disposed in depth, each having its troop of cavalry to fill gaps and carry out scouting and patrolling duties. The principle was a modification of that adopted for the delaying action of the second day, and was completely successful.

The reserve, unfortunately, was used piecemeal, and its power of counter-attack was thereby wasted.

One car was first taken to replace one of those of No. 1 Section, which had been put out of action for two hours. Then a sub-section

was removed on a special mission, leaving one fighting car and the H.Q. car in reserve. These two were asked to form a fighting sub-section, which was promptly done, and shortly afterwards the longed-for counter-attack was launched on the initiative of O.C. Sub-section, *alias* O.C. Coy.

This was, perhaps, quite wrong, but, as the D/R had been taken by O.C. Rearguard for his own use, and there was, in consequence, no news or knowledge of what was going on, the sight of a number of tin-hats, just over the crest behind which the reserve was located, was too tempting.

The counter-attack was very successful.

The tin-hats seen were found to be already " dead " or " captured," having been accounted for by one of No. 2 Section, but further down the road two companies, with transport and in column of route, were very completely shot up.

A/T gun flags were, however, rapidly produced as the cars passed, and it was judged impossible to attempt to return the same way.

Turning right, more troops were caught " on the hop," the best of the bag being a Battalion Headquarters and two " brass-hats," who were having lunch. One of the Directing Staff put them out of action, but his car, which was completely blocking the lane, was a most unfair obstacle. The delay and noise gave ample warning and, on proceeding, the leading car took two rounds of blank from a field-gun at about four yards' range, fortunately without actual damage to car or crew.

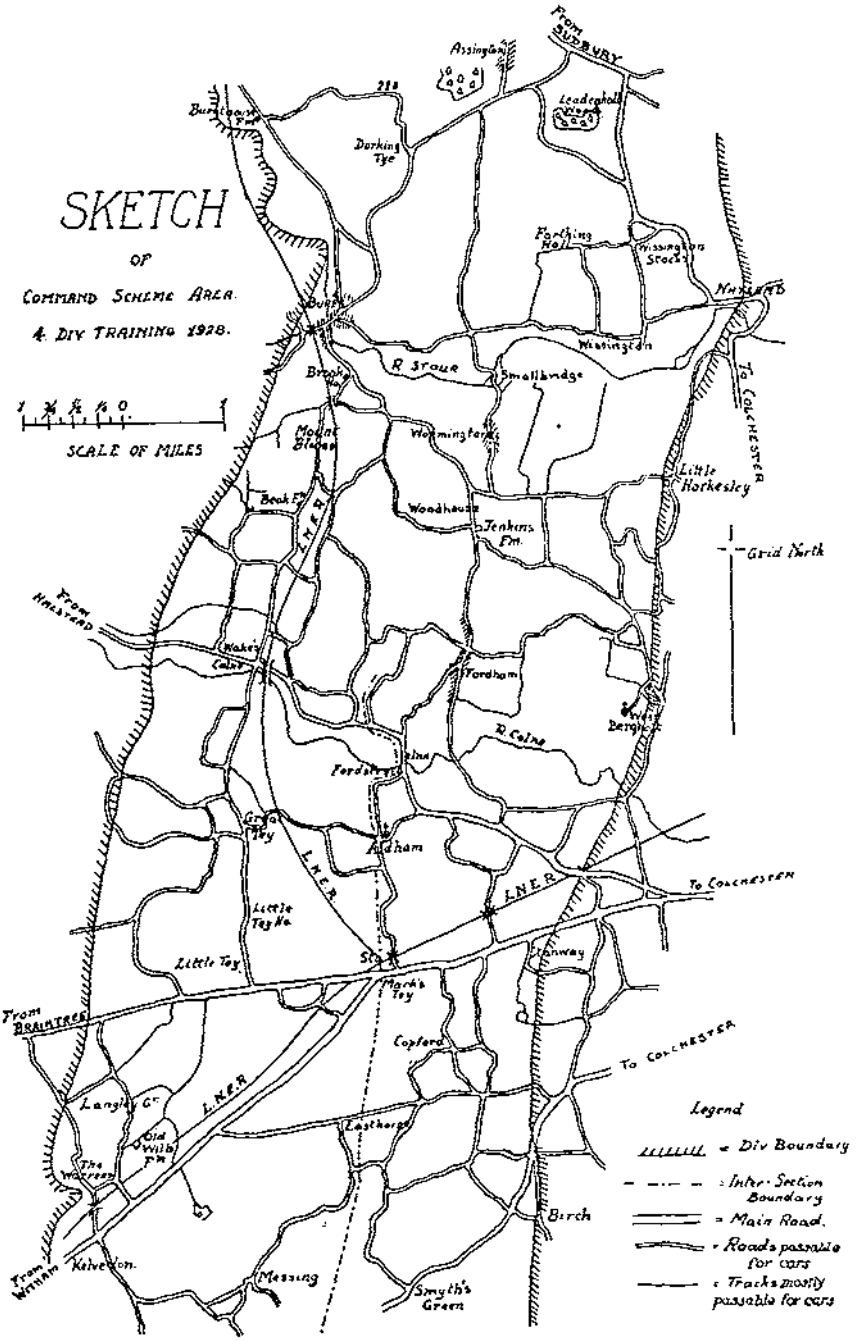
There being no umpires, however, the sub-section completed its circuit and returned to reserve.

The fog of war now descended and it was here that the greatest training value was received. No. 2 Section, on the left, had a straightforward task in getting back across the Stour at Smallbridge, but No. 1, on the right, was left to its own devices while its cavalry retired across country, and No. 3, hopelessly split up, had no orders for the future at all.

Retirement *via* Bures involved an awkward move across the front, in which two sub-sections helped back a troop, finding many " advanced elements " of enemy infantry across the road on the way.

Arrived in Bures, No. 3 miraculously materialized complete, and was sent out again to Brook House (about half a mile south of the river), with definite instructions for an independent *rôle*, as all the cavalry seemed to have disappeared. No. 1 also collected, were given definite orders, and sent out to Mount Bures.

Eventually, orders were received to retire across the river, O.C. Rearguard released the Coy. from his command and returned the D/R, No. 2 Section arrived and the Coy. moved back to bivouac at about 1800 hours.


SKETCH
OF
COMMAND SCHEME ARLA.
4. DIV TRAINING 1928.
SCALE OF MILES
From SUDBURY
Assington
Burnt House Fm.
Dorking Tye
Leadenhall
Farthing Hall
Nr. CHELMSFORD
R. Stour
Smallbridge
Brook Fm.
Mount Bures
Wormingford
Little Horkesley
Book Fm.
Woodhouse
Jenkins Fm.
L.N.E.R.
Grid North
From HALSTEAD
Wakes Colne
Fordham
R. Colne
Fordham Hse.
Great Tey
Aldham
To COLCHESTER
Little Tey
Little Tey No.
Sta.
Conway
Mark's Tey
From BRAINTREE
Copford
Langley Cr.
Old Wilds Fm.
The Warrens
Easthorpe
Birch
From WITHAM
Kelvedon
Messing
Smyth's Green
Legend
= Div Boundary
= Inter-Section Boundary
= Main Road.
= Roads passable for cars
= Tracks mostly passable for cars

The O.R. rejoined Battalion H.Q., now at Wood Hall, from which they had subsequently to move about three miles by march route, and officers and H.Q. repaired to Assington.

During the day, one car had been put "out of action," and two actual casualties were sustained.

One car, in turning in a very narrow lane to get away from an A/T gun, got ditched and broke a torque tube, putting it definitely out of action for the rest of manœuvres, and another, taking a corner rather fast on the way "home," skidded on the appallingly bad surface, burst two tyres and upset, slightly buckling one wheel, but without damage to personnel, except for one bleeding nose.

The Fourth Day.

H.Q. and No. 1 Section (on duty) spent the night at the inn at Assington, after a musical evening provided by the landlord's wife and daughter, who also produced most substantial haversack rations at 0430 next morning, and filled all the thermos flasks available in the Company.

O.R. had been warned overnight to be prepared to move at 0515, and the Company paraded at men's bivouacs at 0530.

No. 2 Section were sent out to the right to the vicinity of Bures (held by the cavalry) to fight a delaying action along the two roads running northwards from Bures, with orders not to become seriously involved but to withdraw to the road running east from Burnthouse Farm, and create an "impasse" on that line.

No. 1 Section were ordered to form a similar "impasse" along a portion of the Nayland-Sudbury Road, and Coy. H.Q. formed a "block" at a centrally situated road junction.

The idea of this plan was to force the attacking Division forward into a sort of arrow-head towards Assington and, at the psychological moment, to launch a counter-attack with tanks and infantry from the vicinity of Leadenhall Wood. To make this counter-attack reasonably heavy and realistic, practically all infantry had been withdrawn from the line, so that the Division were more or less unopposed except by the "impasse" of cavalry and armoured cars, and the counter-attack was launched by two battalions nearly at full (manœuvre) strength.

No. 2 fought a very successful action on the right and, by occasional dashes into Bures, seems to have prevented any effectual attempt at crossing the Stour there in any force.

One battalion, however, did get across further east, and the Section was able to help the cavalry whose left had been threatened thereby.

No. 1 had a very dull morning and did not come into action.

Headquarters had, probably, the most instructive morning, during which several quite interesting photographs were obtained, the

opportunity for getting which is perhaps best explained by a bald extract from the Company log:

"Was instructed to attend conference at Force H.Q. at Y9847 at 0800. At that hour H.Q. was represented solely by R/T Tender.

Col. C— (*O.C. Skeleton Enemy, telegraphic address 'Bones'*) arrived later and gave me zero-hour for counter-attack as 0845 instead of 1130.

Lorry had been adorned with (spare) Distinguishing Mark to represent A.C. road-block at Y8859.

H.Q. Car was neutralized and asked to pick up Col. C— on 1st objective.

Got car to Farthing Hall, Y9536, in time to find counter-attack checked on right and enemy F.A. Section in action in hedge just west of Farthing Hall. A car from No. 1 had followed H.Q. car up from Wissington Stocks and got fire in partial reverse on gun crews, who were rushed and captured by 91st two minutes later.

Sent car back to normal *rôle* and moved down to Y9725 (on second objective), where good view of tank action was obtained.

Cease fire went shortly after."

The Company returned to Colchester by sections under orders given previously. O.R. were taken back to Cockwatch Camp, the remaining blank S.A.A., empties and white flags were handed over, two conferences attended and a warning order issued for the return to Chatham next day.

THE RETURN TO CHATHAM.

The Coy. paraded at 0800 and moved off at 0815, moving as a formed body to Mark's Tey and thence individually to a rendezvous just outside Tilbury, at 1020. The ferry was reached at 1035, and the Company crossed at once, moving from Gravesend to Chatham as a unit, and forming up in S.M.E. workshops yard on arrival.

The Acting-Commandant and the Brigade Major inspected officers and men shortly afterwards, and disbandment of the Company was completed by 12 noon.

CONCLUSION.

General Remarks and Lessons Learned.

The organization of the unit and the administrative arrangements made proved very satisfactory. As regards the domestic provision for O.R., we were undoubtedly very lucky in being allotted to the particular battalion selected.

They at all times did everything possible to ensure the comfort of our N.C.O.s and men, and it is doubtful whether any future improvised unit could count upon being as well looked after as we were in this respect.

The main flaw in organization was the difficulty of communication. From the experience gained, it is considered that a minimum of 1 D/R for Coy. H.Q. and 1 D/R *per section*, should be provided. This would ensure proper co-operation and a fuller and more timely flow of information.

Perhaps the most noticeable feature of the short period of training was the difference in control and initiative brought about in all ranks. From this point of view, at all events, the training received was of great value, even if the tactical "lessons" may be open to more doubt.

At the outset, the majority of the young officers were, as was only natural, not quite sure what they were up against; but in a very short time, measurable almost in hours rather than days, they had all gained a little experience and considerable self-confidence, with the result that tactical handling, initiative and power of quick decision were improved out of all knowledge. N.C.O.s and men also quickly adapted themselves to an entirely new set of conditions (the men, it must be remembered, were all recruits) and were invariably cheerful and resourceful.

The tactical lessons learned can, of course, only be put forward with some diffidence.

Manœuvres and war are very different propositions and, however good the umpiring, a makeshift unit of this kind can in no way adequately represent the real thing in war.

The outstanding lesson appeared to be that, particularly in enclosed country with narrow roads confined between banks and hedges, the lot of the armoured car advancing or reconnoitring against a mobile enemy, who disposes and utilizes his A/T weapons adequately, is by no means a happy one. On the other hand, their value in delaying action appears tremendous, especially if one can assume that the A/T weapon is likely to be big and cumbersome and require a fair-sized crew. It would, in fact, appear essential to provide a mechanized and probably armoured weapon to enable infantry or cavalry to get forward against a screen of armoured cars without fearful delay and waste of time and lives.

The value of co-operation between armoured cars and cavalry in delaying or rearguard action was clearly brought out.

Finally, there is no doubt that really excellent weather, such as was experienced throughout the scheme, is the main factor in making manœuvres an enjoyable proceeding.

APPENDIX "A."

ORGANIZATION.

Thirteen officers with cars were originally authorized, *i.e.*, O.C. and 12 fighting vehicles, and "A" Company of the Training Battalion offered a complete Recruit Party, due to pass out a day or two before the start of the Command Scheme, with a proportion of N.C.O.s.

After some preliminary office work and correspondence the organization decided upon was as follows:

Headquarters.

2 Officers, 2 N.C.O.s, 3 Sappers.
1 car, 1 motor-bicycle, 1 light lorry.

2 *Fighting Sections.*

Each:
6 Officers, 1 N.C.O., 12 Sappers.
6 cars (4 four-seaters and 2 two-seaters).

Total Strength of Unit.

Officers	14
N.C.O.s	4
Sappers	27
Cars	13
Motor-bicycle	1
Light lorry	1

The extra officer and motor-bicycle were approved for D/R purposes, for inter-communication and liaison generally.

The light lorry was supplied by 4th Division to carry men's kits and bedding, unit stores, etc.

It will be noticed that the organization adopted makes no attempt to follow that of the genuine Armoured Car Company. This was done deliberately, for the following reasons:

(1) The unit formed part of the Skeleton Enemy, and its *rôle* in every phase of the scheme was, therefore, accurately known in advance.

(2) The Skeleton Enemy kept no reserves in hand.

Each unit represented only the "front-line" troops of the enemy force, reserves and reliefs being purely imaginary.

(3) The ground lent itself more readily to division into two fairly wide sectors than into three.

(4) Apart from the O.C. Unit, only two officers had completed their Y.O. course at Chatham, and it was felt that Section Commanders should have rather more experience than an officer under instruction could reasonably be expected to possess.

APPENDIX "B."

ADMINISTRATION.

The administrative problems involved were a source of a good deal of trouble and preliminary work, but, owing to the very helpful co-operation of all those in authority, were satisfactorily solved before the unit formed up.

Officers were granted Detention allowance and Mileage allowance while in the manœuvre area, as it was impossible to organize a mess, and kit, etc., had necessarily to be reduced to a minimum.

They, therefore, made their own arrangements and were, in fact, very well looked after and catered for by the country inns in the area.

Other ranks were attached for rations, etc., to one of the two battalions, forming part of the Skeleton Enemy, and were made welcome and comfortable by the 1st Bn. Argyll and Sutherland Highlanders.

Steel helmets, packs and bayonets were not taken on manœuvres, as they were not required, and would have been an encumbrance in the cars.

Each N.C.O. and sapper carried the "pack" scale of clothing and necessaries in his haversack, and carried a waterproof sheet (cape), while the following kit per man was carried in unit transport:

3 blankets.
1 waterproof sheet (making two in all for bivouac purposes).
Greatcoat.
Kit-bag with change of clothing.

Notes on Organization and Employment and *Administrative Instructions* were issued to all officers and N.C.O.s, and, after two conferences had been attended at Colchester, at which tactical and administrative details were finally settled, the unit existed on paper and was ready to come into actual being.

PSYCHOLOGY AND THE FIGHTING SERVICES.

A Lecture delivered at the S.M.E., Chatham, on 7th February, 1929, *by* F. C. BARTLETT, Esq., M.A.

VERY briefly and simply, psychology is a sustained attempt to find out why people act as they do. For various reasons, this attempt seems to meet with much opposition. Some people think that it lowers the dignity of human nature, for there is, they say, in all our activity, something completely incalculable and out of control. But these people are just as annoyed as the most ardent psychologist if they are called fickle and unreliable, and the success of innumerable forms of organized human effort makes it perfectly certain that, provided people are given fairly stable conditions, they will act in a tolerably uniform manner. Other critics at once assert that human conduct is too complex to be studied successfully with this aim in view. But instead of arguing at length whether or not this is a fatal stumbling-block, it seems better to see what the psychologist, who is himself most ready to admit the complexity of his subject matter, can do before insisting that he cannot do it. At least, it is obvious that if the psychologist can successfully find out important truths about why people act as they do, this knowledge must be useful in any practical organization of human conduct. This is now coming to be widely admitted, and it is upon this that the importance of psychology to the efficiency of the fighting services rests.

In every age, the main business of an army is to be ready to fight, and to be ready to fight well. There is no dispute about that. But fighting in these days is a very different matter from what it was when standing armies were first raised. It now rests largely upon the co-ordinated and harmonious operation of a vast mass of highly-skilled and highly-technical activities. Every one of these activities depends upon some special ability, or some group of special abilities, which must be trained to the highest possible pitch of efficiency. If all these abilities, or capacities, were showered upon all of us equally at birth, the matter would be comparatively simple. We could take in recruits haphazard to the Navy, the Army, or the Air Force, send them wherever there were vacancies and, if the training were good enough, be sure of arriving at a satisfactory result. Everybody who has had even a small amount of practical experience knows that this is not the case. The first-class fighting pilot may make a bad infantry officer. The Tank expert may be of little use in an intelligence department. Signalling demands different capacities from those required in artillery or gunnery. Hundreds of training courses, most

of them making particular demands upon some special executive skill, are needed to develop the modern fighting force. It is not a matter of indifference how people are distributed around these courses and sent eventually to their own main arm of the service. The actual training given may be as good as it can possibly be, but as a man moves from one course to another the speed of his learning and the efficiency of his final performance are bound to vary. As it is, we pay little attention to this obvious fact. A man may go into a signalling service whose speed of response to auditory or visual signals is slower than the normal, whose immediate memory span is small, whose capacity for delicately-adjusted manual movement is slight. He may enter some branch of mechanical transport and turn out to have a mechanical mind only so far as the *understanding* of the construction of his mechanisms goes, and not for their *practical* manipulation. He may be trained as a gunner, though he has some slight but readily detectable defect of binocular vision, or a lack of co-ordination between visual and manual response. He may go through an expensive course of training in musketry, though he has a marked left eye predominance. With a strong social trend, he may be given a job demanding individual initiative above everything else, or, with any amount of individual initiative and little social sentiment, he may be pushed into team work. In all these cases and in very many more, the training will go against the grain, and, however good it may be in itself, it must fail to produce the efficiency that is desired and that is possible, because it has not got the best material to work upon.

A great amount of this training is expensive. It may take £200, £300, £400, to produce a reasonably trained man for a technical branch of a fighting force, even if the rank and file alone are considered, and much more in the case of many officers. I wish it were possible to know exactly how many men, trained in these ways, turn out each year to be relatively inefficient. Many of the failures are eventually got rid of; many more remain to put the general standard low or to become permanent and dangerous centres of discontent.

This is one of the things which the psychologist wants to alter. Even if he can do only a little towards setting the matter right, it is worth while. The cost of a few efficient psychologists would be far less than the cost of a lot of inefficient soldiers, sailors and airmen. And cost in money is only a very small part of the matter. The psychologist's proposal is simple commonsense. He says that, before the would-be fighting man is given his special training, we ought to know something more about him than that he has a fit physical frame and at least a minimum of intelligence. We ought to find out the sorts of things that body can best do, the directions in which that intelligence can most efficiently turn. If we know this, and if we know what bodily and mental skills a particular arm of the service makes most demand upon, we can then direct him towards the kind

of fighting for which he is naturally most gifted. The modern fighting force is big enough and varied enough to take every fit man and put him where his special fitness will have the best chance.

It is of little use to discuss these proposals in general terms. I will take one or two illustrations, though here they can be worked out only in scanty detail. Defence against attacking aeroplanes consists largely in the co-ordinated operation of aircraft detection groups, defence aeroplanes and, at night, searchlights. Aircraft detection is a very complex business, but at present it makes use of certain powers which the human ear possesses in picking up, recognizing and localizing sounds of a certain pitch, quality and rhythm. Some men can be trained to be good listeners with comparatively little effort, some with greater effort, some not at all. Now it is demonstrably possible to take a group of men, and, by putting them all through certain simple but special tests, to predict how they will behave when their ears have to solve the kind of problem which the detection of aircraft demands. This was actually done in various ways and with much success during the War, but the lessons of a war are speedily forgotten, and much that was then learned was later allowed to disappear once more.

Take signalling also. There are, of course, many different ways in which this must be carried out. Each way has its basis in some simple group of bodily and mental capacities: swift auditory or visual reaction; the power of readily grouping symbols which vary slightly in form, number, length, colour, or some other assignable character; in transmission, a capacity for delicately-graded and accurate control of finger, hand and arm movements. The experimental psychologist has devised readily applicable tests for all of these, and again it is demonstrable that a group selected on the basis of test records contains fewer potential failures than a group of the same size selected merely on the basis of a written examination of some kind, a simple medical test and an interview.

Working for the Industrial Fatigue Research Board, under the general direction of the Medical Research Council, Farmer and Chambers have very extensively applied a battery of about nine tests of mental, manual, muscular and co-ordinated dexterities to aircraft apprentices. The results show definitely that the tests are a more efficient instrument of selection for this sort of work than any of the other methods now in use. A similar research is proceeding in connection with naval gunnery, with the same promise.

Finally, let us take so simple and basic a performance as shooting with a rifle. For the past eighteen months or so, we have been trying, in the Cambridge Psychological Laboratory, to find definitely the conditions of good marksmanship so far as these reside in the marksman himself. Keenness of vision, the only thing that is now specifically tested, is relatively unimportant. Dominant right eyedness is essential for obvious reasons, though it is never officially

considered. The evidence is accumulating that the rest is mainly a matter of certain simple kinds of muscular control—visual control and hand, shoulder and arm control—and of a certain temperamental constitution. For all of these it will soon be possible to have definite and easy tests by means of which probable duds can be straightaway eliminated and time, money and temper saved.

Much more than I can even hint at has been done, but far more yet remains to do. Some of the most important questions of selection demand a different type of psychological observation. Take the very interesting problem of the difference between the typical field-and the typical staff-officer. The former is the man of action, of social tendencies, never really happy unless he is in close touch with men, the executive type. The latter is the man of schemes, often rather aloof from personal contacts, interested in trying to see things as a whole, rather than in trying to carry out things in part. The difference between the man fundamentally interested in life and the man mainly interested in schemes, in things and their inter-relations, is a tremendously deep-seated one and probably innate. Give either the work of the other and he will be unhappy, very often relatively inefficient. Questions of just the same character, differing according to the groups concerned and the tasks set, arise in all choice of non-commissioned officers. At bottom, all of these matters are psychological. They depend (1) upon knowing what conditions make people do certain things, (2) upon knowing what sorts of things certain tasks demand that people should do, and (3) upon bringing together these two sets of knowledge, so as to make as sure as possible in practice that the people who can do certain things under the given conditions shall have the chance to do them.

I had better make it quite clear that no sane psychologist ever claims that in this matter of selection he can proceed without mistake. His methods may let through some bad individuals and keep out some good ones. But it has been proved again and again that, in groups of the magnitude dealt with in the sectional organization of a fighting force, his mistakes will be fewer in number than those of the more haphazard methods now in vogue. That is enough to justify their use.

So much, for the present, about problems of selection. Even when you have selected material, however, there remains the question of how that material can best be trained. Here the psychologist comes in once more. There is now available a great amount of carefully-collected information of the course of normal learning of a large variety of human activities. Much of this has direct application to the training of the fighting man, and instructors would be all the better if they knew more about it. The questions raised at this point are so various and many of them are so specific that I can say little about them in a single lecture, and what I can say must for the most part be of a general nature.

It is often assumed that, when a man is to be taught some kind of bodily or mental skill, all that is needed is that the task should first be demonstrated or described to him clearly and the rest comes by constant repetition. This, most emphatically, is a mistake. No skill of any kind is learned merely by routine. Repetition that is not backed by interest, an active urge of some kind to do the thing required, is utterly useless. A man may do a thing automatically, mechanically every day for a year, and be little or no better at the end than at the beginning. Apparently, it used to be popularly supposed that a good soldier is a man who simply does things and does not bother about reasons. This may be made into a great untruth. Of course, he does not constantly finger his own reasons, or those of his superior officer; but he is not so far removed from any ordinary human being that he can achieve any sort of efficiency without the provision of an adequate stimulus. What is an adequate stimulus must vary widely from individual to individual, but a good trainer will always make it his business to find out, and in so far as he does this he is a psychologist. With a few men, probably always a minority when the training is in fairly simple bodily activities, it is pride in the thing itself cleanly done. With more it is social, competition within the group or between groups, and this is a stimulus which the inevitable group organization of the fighting force makes it possible to use with great effect. With others, it may be, not direct social competition, but just the understanding of how what they are doing fits together with the part performances of others in a large combined plan of execution. Whatever it is, the trainer must know it and play upon it.

Another general point is often less considered than it ought to be. Just as there is no efficiency merely by repetition, so there is no real efficiency without confidence. Go back to the case of detecting the presence and position of aeroplanes or submarines by listening. Normally, we do much with our eyes, little with our ears. So when conditions force a man to rely upon his ears, he is apt to remain doubtful about the accuracy of his judgment. This doubt impairs his efficiency. How best to dispel a learner's lack of confidence is a psychological problem of some delicacy. Almost no general rules are possible. Often, however, a trainer may so arrange conditions that a task of the type required may be carried out with demonstrable ease and accuracy. The attitude of confidence thus set up may extend over to the precise activity which the teacher is trying to develop.

Even with first-rate learners and excellent conditions it must never be forgotten that the course of progress is rarely, if ever, uniform. Periods of improvement inevitably alternate with periods of stagnation or even of decline. This irregularity is often a source of unjustifiable annoyance. Its normality must be recognized.

More attention than usual ought to be given to the effects of

distributed practice, particularly in the learning of routine operations. Very continuous practice is often definitely harmful. Distributed, or spaced, efforts generally have both better and speedier results.

Finally, it must be noted (1) that improvement may continue for very much longer periods than is commonly thought possible, and (2) that a bodily skill once learned may persist with extremely little practice for extraordinarily long times. A man's maximum efficiency, even in relatively simple routine operations, may perhaps not be reached for years, provided he can be kept fresh and keen; while once he is tolerably well-trained there is no need for constant, reiterated and boring practice. He will be more profitably treated if he is given plenty of time for recreation.

I have spent the greater part of my time in talking of the relatively concrete and unexciting questions of selection and training because they offer a field of immediate application to the organization of the fighting services. Conclusions within this field are well-established and definite. No doubt, the future will see great improvements of method and many new facts and principles will be discovered, but as far as they go, the main results are not now in the realm of dispute. These apart, however, there is almost unlimited scope for the application to a fighting force of more general, and perhaps less final, psychological observations. To some of these I will now turn.

A fighting force in the modern world is a large social group organized into a very considerable number of smaller groups, and its most important operations are group operations. Consequently, its main problems are those of the stimulation and control of social conduct. Obviously, an individual acting within a group and the same person outside a group are often remarkably different. The grouping itself introduces conditions which directly affect what he does. At the back of all social grouping there must be some active factor holding the group together, a tendency or a number of tendencies in the human mind or organism. In the case of the fighting group, this is the strong and almost universal tendency to vigorous and, if possible, pugnacious assertion. Lacking this, no decent fighting group can be developed, and if this fades away the fighting group becomes slack and inefficient. This pugnacious assertiveness is important not only in times of national crisis or of actual fighting, for directly or indirectly, it is this alone which can keep the group keen and alert during peaceful intervals. Hence, it has to be constantly stimulated and we must ask how, in the light of what we know about human nature, this can best be done. Obviously, the stress of civil competition, as the world is now organized, is, in a way, able to do this. The late War showed that great parts of the civilian population of most European countries have the pugnacious instinct very ready to leap into active expression. But this in itself is not enough, for war is now a combination of highly-skilled activities, and the pugnacious assertiveness that is at the base of the fighting group

must be linked up with those very skills through which, when fighting comes, it has to be expressed.

The first essential, if this is to be done, is never to allow any unit, or sub-group, in the whole to get completely cut off and self-contained. The more isolated a group becomes, the more its bonds of organization slacken, and its keenness deteriorates. Social vitality demands that group shall be in touch with group, that the members of one group should be encouraged to know something of what the members of other related groups are doing and how they are doing it. This is, perhaps, the main psychological argument against a very highly centralized and unified command. There are some people who would like to see the great arms of a country's fighting services all controlled from a single source. Such a scheme I believe to be psychologically unsound. It might have certain initial and certain economic advantages, but in the long run it would be far more likely to devitalize the whole group. For again and again in social history, a group which has gained a position of supreme ascendancy and so has been able to ignore the criticism of other groups, has slowly but surely lost the driving force that once held it together.

Often it is possible to secure the contacts that are necessary in a professional sense. It is not easy to exaggerate the importance of having men and officers of one fighting unit attached temporarily to others, whether at home or abroad, whether in a native or in a foreign friendly service. Outside of these professional contacts a vast amount may be done by the organized group game. The latter method is already pretty fully exploited in this country. I have, in fact, met several people lately who think it is overdone. I cannot agree. The value of the hard group game, fought out at top speed, with all its pugnacity and assertiveness controlled and directed at every moment, is tremendous for the development of sound discipline and lasting morale.

Perhaps this final thing, the development of high morale, is the most difficult of all the general problems in the organization of a genuinely efficient fighting force. Much depends on the group leaders and upon their taking pains to understand the real basis of their power. But I have discussed this elsewhere, and I will close the lecture by considering briefly some other aspects of this problem.

Morale may be defined as a capacity to withstand persistent danger, difficulty, pain, distress and ill-success with enduring fortitude and good spirits ; and further to withstand great and unexpected success with a calm mind, glad, but not over-exalted by the tricks of fortune. Its basis seems to be a grim but optimistic courage. In the first place, what can be said about courage ? No man is born courageous, though probably many are born dare-devils. Dare-devilry goes blind, either naturally or wilfully, and fails to see danger. But courage goes open-eyed, and knows and faces the danger, controlling the natural impulses to escape. Hence, courage has always some-

thing intellectual about it. It knows, and does not hesitate to study the objective facts of the situation. There is one characteristic about a fighting group which displays persistent steady morale in the face of continuous distress or continuous success that seems to me extraordinarily interesting. It is, I think, found without exception that every such group is capable of joking about the very situation that produces its distress or its exaltation without losing touch with the seriousness of that situation. All such joking about serious things turns upon a capacity to face the situation in an open-eyed manner, and neither to be swept by it into reckless action nor plunged by it into a mere welter of feelings. Broadly speaking, there are three classes of fighters. The first, faced by danger, are swept into immediate and unrestrained action. They may be recklessly brave, but they do not control their action by the immediate demands of the situation. Consequently they are apt to have little or no reserve, and to be overwhelmed by continued failure or continued success. The second are far more influenced by their own feelings than by the objective situation, so any depression or exaltation that may be set up causes them to lose sight of the real outside situation, and these again have little power to keep for long in touch with circumstances. The third are primarily interested in what is actually going on outside of them, and their own feelings about this, though they may be intense, take a secondary place. These are the people who can joke about a failure, or grouse about a success. It is this habit of mind which promotes high morale. Is it possible to train this habit of mind? I must leave that as a question, for there is no time to try to answer it. I will merely state that I am almost certain it is, and quite certain that if it is, its discovery must be a further instance of applied psychology.

One further practical point, and I have done. How may psychological knowledge be satisfactorily applied to the organization of an efficient fighting service? By the academic, laboratory psychologist? No. The problems involved are too technical on the fighting side, too special to be properly dealt with by anybody who does not meet them face to face all his life, who has not a first hand chance to know them inside out. Two things ought to be done. First, *every* Army, Navy, or Air Force officer ought to have a chance to know what a sane psychological point of view is. Many will not take the chance; a few will and it will do them a lot of good. This, it cannot be too strongly asserted, does not turn self-confidence into self-consciousness and produce a lot of odd and vacillating individuals who are for ever fingering their motives. If it does, it fails absolutely; but it never does, unless it has bad fighting material to work on from the beginning. Secondly, a few Service men who have a flair for this sort of thing, ought to have a chance of a thorough training in modern psychological method; not a book or lecture training merely, but what is far more important, a laboratory training. Then they

can tackle the special and technical problems with a fair chance of finding valuable solutions.

Such more specialized training need not occupy a very long time. A man with aptitude and keenness who is efficiently directed can be set upon the way to work out his technical problems for himself within about twelve months. Obviously, a general introduction to the bearing of psychology upon Service problems should come near the beginning of a man's professional career, but the more detailed instruction in psychological methods has the best chance of achieving practical success if it comes a little later, when a man has already had some opportunity of learning for himself where the most pressing difficulties of organization and of Service training lie. The plan of offering to certain specially selected officers the chance of a training along the line of their particular interests and abilities, outside of regular Service courses, has already been followed in various directions and with admitted practical success. The time is ripe for widening that plan so as to include the possibility of specific training in psychology. Naturally, the plan would have to be applied judiciously and with caution, for it must be admitted that there is no subject that is a more happy hunting ground for the crank than psychology. But this danger could be very readily avoided. The best commanders at every age have been keenly alive to the need for considering the human side of the fighting forces whose activities they have controlled. With the gradual rise of the standard of education and technical skill of the men who make up these forces, the need for this type of consideration has become more and more pressing. I have attempted to indicate that modern psychology has already developed and organized a great amount of knowledge which can focus consideration of the human factors in fighting in a most practical manner. It has also built up methods by which such knowledge can be advanced most rapidly and accurately. For its bearing upon problems of the selection and training of recruits, the development of sound health of mind and body, and the foundations of social control, psychology may now fairly claim the serious consideration of all those who believe that the efficiency of our fighting services is a matter of the greatest importance in national organization.

Note.—It may be useful to add a brief list of publications in which some of the topics mentioned in this lecture are more fully discussed. If we take English publications only, the following will be found of interest :—

C. S. Myers : *Industrial Psychology in Great Britain*. London : Jonathan Cape, 1926, 7s. 6d. net.

C. S. Myers and other : *Industrial Psychology*. London : Home University Library, 1929, 2s. 6d. net.

E. Farmer and E. G. Chambers : *Psychological Factors involved in Proficiency and Accident Rate*. London : Industrial Fatigue Research Board Report No. 55.

T. H. Pear : *Skill in Work and Play*. London : Methuen and Co., 1924, 5s. net.

J. T. MacCurdy : *War Neuroses*. Cambridge University Press, 1918.

F. C. Bartlett : *Psychology and the Soldier*. Cambridge University Press, 1927, 7s. 6d. net.

KEUAI RIVER BRIDGE.

By LIEUT. R. GARDINER, R.E.

THE following is a description of a job carried out during 1927–28, on the Central Indian Coalfields Railway construction:

General description.—The Keuai River in the Bijuri division of this construction is crossed by 6 spans of 60-ft. girders, on stone masonry piers. As originally constructed, there were pier abutments with the slopes of the approach banks stone pitched.

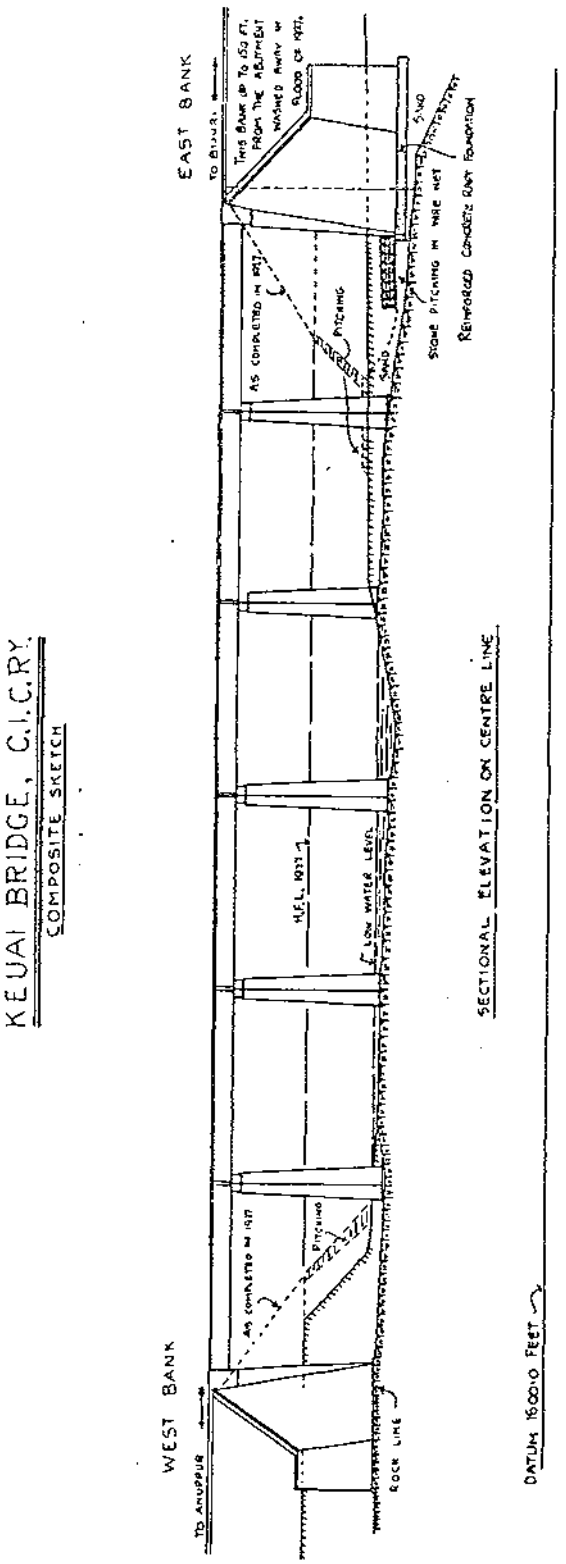
The river at the point of crossing has tended, for the last two years, to have its main stream on the west or right side, where the bank has been worn to a vertical cliff, some twenty to thirty feet high, whilst on the east side, a shelving bank of sand has been deposited with a gradual slope. On the west side, the rock is bare, whilst on the east side it is some twenty feet below the sand. The sketch gives a rough idea of a cross-section of the river bed along the centre line of the bridge. All the piers and both abutments had open foundations on the rock.

Monsoon, 1927.—In July, 1927, just previous to the monsoon, the bridge and approach banks had been completed except for the steelwork, which was still at the storeyard at Anuppur, 23 miles away.

Linking of the permanent way had reached mile 11, the Keuai being at mile 23, measured from Anuppur. There was a gap in the line of communication at mile 7, where the bridge across the Sone River was not complete. This prevented any heavy stores, such as girders and permanent way materials, being sent up the line. There were, however, sufficient permanent way stores already across the Sone to enable the linking to be continued to mile 21, and work was to continue throughout the rains. The Sone had been crossed by a diversion previous to the time in question (July), but this had been dismantled in the middle of June, in anticipation of the rains.

On the night of August 19th, after four days' nearly continual rain, there was an abnormally high flood in the Keuai River, and on the following morning it was found that, on the west side, the pitching and front slope of the bank had been washed away, and, on the east side, in addition to the pitching, 150 feet of the approach bank behind the abutment had disappeared.

Preliminary scheme.—Nothing could be done until the monsoon had ended and the river subsided, but a preliminary scheme was got out to build wing walls to the west abutment, and to add an additional span of 60 feet on the east side.


KEUAI BRIDGE, C.I.C.RY.
COMPOSITE SKETCH
EAST BANK
TO BIJUAR
WEST BANK
TO ANUPPUR
AS COMPLETED IN 1917
PITCHING
H.F.L. 1937
LOW WATER LEVEL
ROCK LINE
SECTIONAL ELEVATION ON CENTRE LINE
DATUM 15000 FEET
ORIGINAL BED OF RIVER SHOWN THUS :-
PORTIONS WASHED AWAY IN FLOOD OF 1937 -

River diversions.—By the beginning of October, the linking had reached mile 21, and preparations were made to open the Sone diversion, round which the whole work of the division centred. This diversion was similar to the one made during the previous year, the waterway being of sleeper crib piers, with 75-lb. F.F. rail clusters. That at the Keuai was just under one mile long, and the waterway was spanned by a pair of 40-ft. girders. The gradient on the west bank was approximately 1 in 23 for a distance of 1,000 feet. A flatter grade was not possible, without making the diversion bank excessively high.

Further schemes.—Meanwhile, what to do with the Keuai Bridge was being further discussed. With the west abutment, the only and obvious plan was to add wing walls and so do away with the slope and pitching in front of the abutment. A point to notice here is that, although the bridge was of 6 spans, the effective waterway was only 4½ about, the remaining 1½ being blocked by the slopes in front of the abutments which had originally extended to the foot of the first pier on each side. With the addition of wing walls, however, the full 6 spans were open to the river. It was thought that this may have had quite a lot to do with the damage done in August, in that the water may have been banked up on the upstream side of the bridge, topped the pitching and worked a way behind the abutment.

The time factor.—In deciding what course to take, time was an important factor. It was intended to open the first section of the line, as far as Bijuri at mile 30, before the rains of 1928, the first date given being the 1st May. The first suggestion, as already mentioned, was to turn the east abutment into a pier by adding masonry cutwaters and building a new abutment with wing walls, thus adding another span. The necessary girders for this were at Anuppur.

Drawings were got out and excavations started in November for this new abutment and the additions to the old one. In the first week of January, however, after having got down to about three feet above water level, it was discovered that in order to reach rock at the site of the new abutment, there was still 18 ft. to be excavated. Under the circumstances, this was an impossible task, and all idea of adding another span had to be abandoned. The only thing left was to add wing walls to the east abutment, similar to those already in progress on the west side, and the excavation of the foundations was started immediately. The intention was to found the walls on the rock, but it soon became apparent that even this would take too long, as it was found that the rock shelved both north and south of the abutment, and at the end of the proposed wings was 13 ft. below water level. The difficulty was that this 13 feet consisted of nothing but sand, and in order to reach this depth, the sides of the excavation would require continual shoring and a coffer dam of some sort.

Final scheme.—Foundations.—The sketch shows what was finally decided upon, namely, to give up attempting to reach rock and to found the wing walls on the sand, using a strongly reinforced concrete raft, on which to build the masonry superstructure. This concrete raft ran continuously behind the abutment, and the masonry was built right up against the abutment, but not bonded to it in any way, thus leaving the walls free to settle if they want to.*

The reinforcement took the form of 75-lb. F.F. rails, laid with their lowest portion 6 in. above the bottom of the concrete, and at 4-foot intervals. The concrete was of 1 : 3 : 6 proportion, using cement, and 3 ft. 4 in. thick. In order to ensure having the full 6 in. of concrete below the rails, approximately 8 in. of concrete in empty cement bags was first laid and the top surface got as level as possible. This also prevented any chance of the concrete being weakened by coming into contact, when laid, with the wet sand.

Superstructure.—Once the concrete was complete, the masonry work was straightforward, and only a question of hustling the contractor. The stone came from a quarry on the west bank and was brought to the site by a Décauville tramway, the distance to the east abutment being just half a mile. In order to speed up the progress, courses of concrete were used with a masonry skin, each pair of these mixed courses having a complete masonry course between.

In spite of all efforts the date of opening had to be postponed from the 23rd May until June 16th. The west wings were completed, except for the coping, on May 15th and the east wings on May 29th.

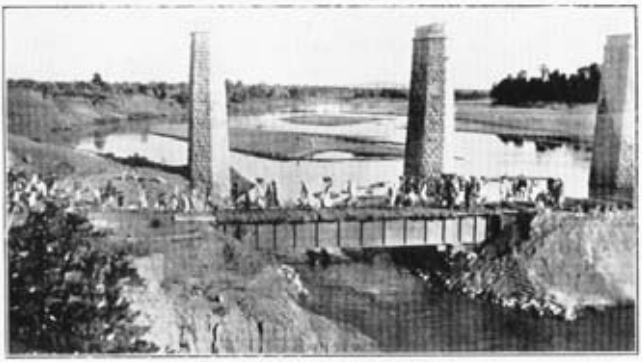
Earthwork.—Behind the east abutment there were approximately 7 lakhs (700,000) cu. ft. of earthwork to be done, and the contractor responsible kept pace with the masonry. The height of the bank was 50 ft. and, therefore, considerable settlement was to be expected, particularly as we should be opening the line only a few days after the completion of the work, and also as the rains would commence very shortly afterwards. In order to counteract this and to obtain as much sinkage as possible previous to opening, each day's work by the contractor was well watered.

Owing to the urgency of the job, a 10-ft. bank with as steep a slope as possible was first put across the gap, and then the permanent way linked on to the bridge. Low-sided wagons were then filled with earth which was unloaded on this narrow bank.

In order to further counteract sinkage on the approaches, the top 18 in. of the banks were made with stone soling, of about 9 in. in size, this being hand-packed as close as possible for a distance of 50 feet from the abutments. This gave a good bottom for the ballast, and also spread the pressure from the traffic over the whole width of the bank.

* The north wing wall sank approximately half an inch shortly after the earth behind had been filled and after the first shower of rain.

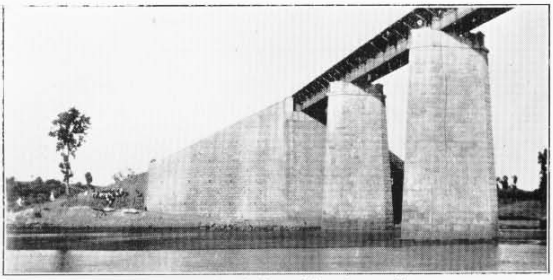
The 40 ft. span in the Keuai diversion being launched.



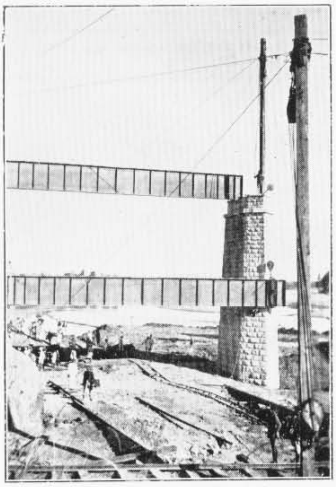
The 40 ft. span in position.

The reinforcing rails in position and further concreting in progress.

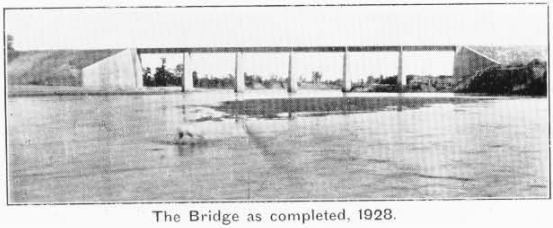
Keuai River Bridge



The completed East side wing walls.



The erection of a 60 ft. girder.



The Bridge as completed, 1928.

The Bridges as Completed.

It should be noted that the wing walls were designed to be entirely self-supporting structures, and did not rely on any support from the abutments. A batter of 1 in 8 was allowed on the front faces.

Protection of foundations.—The wings on the east side were, as has been explained, founded simply and solely on sand, and some steps were necessary to make sure that this sand could not be removed by scour at some later date.

The following suggestions were put forward and the last one finally adopted.

(*i*) To put in timber sheet piling all along the front face of the concrete raft foundation reaching to rock. The tops of this sheet piling to be tied back into the masonry, so that if the sand in front should scour away, the pressure of the sand behind would not push the piling forward.

(*ii*) To lay a thin concrete (reinforced) apron on the sand all along the front of, and extending to about 50 ft. from, the face of the wing walls. This apron to be carried well upstream and downstream of the bridge.

The idea was that, should scour occur, it would do so first at the edge of the apron, which was to be 40 or 50 feet in front of the abutment and wing walls. The apron would then gradually sink on its outer edge, until it finally reached the rock. Thus scour would then automatically cease. This and the third scheme were both helped by the fact that there was a ridge of rock running at right angles to the centre line, 30 feet in front of the abutment, and the top of which was about level with the bottom of the wing wall foundations. Thus the outer edge of the apron would only have had about 4 feet to sink.

(*iii*) In place of the concrete apron, one of stone pitching or boulders laid in wire netting—but otherwise performing the same functions as the concrete apron. In this case, wire netting of 1-foot mesh made on the site was first laid on the sand, and then stone pitching of as large a size as possible laid on top. At the forward edge it was 4 feet thick, and at the back, against the wing walls, 10 feet. Here again, in the event of scour, the front edge would drop first, and on reaching the ridge of rock, would prevent any further scour taking place. The wire netting was turned back over the top and tied back under the top layer of pitching.

ECONOMIC READINESS FOR WAR.

A Lecture delivered at the S.M.E., Chatham, on 21st February, 1929, *by* L. C. ROBBINS, Esq.

I.

IN my remarks this evening I want to do two things. I want, firstly, to discuss the general problem of economic readiness for war as it may present itself at any time to any nation. Then, secondly, I want to discuss the special nature of this problem as it presents itself to us, citizens of this small island, in the year of grace 1929. Needless to add, what I have to say on both parts of my subject will be very crude and lacking in precision. It is not possible in a single hour to do justice to what, after all, is one of the great problems of modern civilization, but it seemed better to attempt to provide a general view of the subject as a whole than to spend the time in mapping out in greater detail only a part of it.

II.

I turn first then to the general problem. How best can a nation make provision for the contingency of war? How can it secure a continuous supply of the things that are essential to a satisfactory issue of any probable conflict? How can it secure enough guns, enough ships, enough food for the maintenance of its civil and military population?

Now it is important, I think, that we should realize that this problem is not always present. The possibility of a real shortage of war material and foodstuffs may not always have to enter into the considerations of statesmen. There may be still a problem of how best to transform existing resources, of how, given a sufficiency of ploughshares, they may most rapidly be beaten into swords. That, of course, is a problem which must always be present when the needs of war are greater than the provision which is made in time of peace. But if a nation produces—or can produce at short notice—all those materials which it is likely to need in war time, then no problem of the kind I have to discuss to-day need enter into its calculations. It runs no danger of the cutting off of supplies from potentially hostile countries, or of the cutting off of supplies from friendly countries or colonies by hostile blockade or siege. Its problems, such as they are,

are all problems of organization, and difficult as these may be, they are still of the second order beside the problems I wish to examine.

Now there can be no doubt that for very long periods of history many nations were to all intents and purposes in the position I have just mentioned. Save in the case of very small city states—whose condition, curiously enough, was more closely akin to what ours is nowadays—the problem of how to secure essential supplies of food and war material was not one which greatly troubled our ancestors. The outbreak of a war might produce grave disturbances in the luxury trades—it was with the exchange of luxuries that trade between nations in those days was very largely concerned—but these, after all, were not essential to the business. Bare subsistence for the population, sufficient armour and the rest for the military forces—these were not likely to be absent.

In modern times, however, the number of States which in this respect can be regarded as self-sufficient has greatly diminished. In the absence of special provision for the purpose, there are now few important States which would not suffer some direct inconvenience, of the sort I am discussing, in the event of the outbreak of war on a large scale. The United States is perhaps an exception, though I fancy that the problem of rubber supply may from time to time cause her experts some misgiving. But leaving the new world on one side, there is no European nation which can regard its position in this respect as being in all respects satisfactory. It may be well supplied as regards food—as, for instance, pre-war Russia—yet be lacking in guns and munitions. Or it may be well provided with the means of producing ammunitions—as, taking a broad view of the matter, we ourselves can be said to be—yet be utterly lacking in an adequate supply of foodstuffs. I have chosen glaring examples, but in lesser degree everywhere there are parallel disabilities.

How is it that this change has come about? It will elucidate the main problem, I think, if we go into the matter a little further.

(1) Partly, I think, it is due to what, as an economist, I classify as changes on the demand side. The technical changes in the art and the scale of war make the procuring of the necessary materials a matter of much greater difficulty than it was at earlier periods. In early times, when the various weapons employed were so undifferentiated and simple that a representative collection can be kept in a single glass case in a local museum, there can never have been much difficulty in procuring a sufficiency of materials, even if the iron ore necessary were not produced within the borders of the nation. It cannot have been difficult to procure a sufficient supply in peace time to furnish all the weapons necessary for the longest conflict. In those times, I am told, a good knight used a Toledo blade. I have never heard that an insufficiency of Toledo blades prevented good knights fighting with one another.

But if you turn to modern times, what a difference you find. Instead of a few steel instruments you have a variety of complicated appliances, for the manufacture and service of which the resources of whole continents may be insufficient. These are matters on which it is not necessary for me to dwell in addressing an expert audience. It is clear that to satisfy a demand of this *qualitative* complexity the small resources of single nations must often prove insufficient.

Moreover, and this is a point which is not so frequently realized, the mere *quantitative* demands of modern war are so great that even if, in the absence of special provision, *some* products of the kind desired are produced within the national boundary, yet it is not improbable that, in a major war, the total national production may prove insufficient and have to be supplemented by similar products from abroad.

(2) All this has been brought about by changes in the technique of war, changes acting, as I have put it, on the demand side of the problem. But beyond this there has been a series of changes on the supply side, changes unconnected with the technique of war, but vitally bound up with the development of economic organization in general, which still further complicate the position. I refer, of course, to increasing specialization of national production. If nations produced within their own borders all that it was *possible* for them to produce, the requirements of modern war are such that it is probable that there would yet remain many important raw materials for the supply of which they would have to depend on other parts. There would still be a problem of ensuring a proper supply of these materials during time of war. But, in the actual world we live in, the situation is still further complicated by the fact that we do not produce many things that we could—or if we do produce them we do not produce them in such quantities as we might—preferring to procure our requirements in these respects by exchange with other peoples. In such circumstances, the dislocation which may be caused by cessation of trade either by way of war or blockade becomes much more serious.

It is not difficult to see why it is that specialization of this sort has come about. After all, territorial specialization—division of labour between the inhabitants of different parts of the earth's surface—is almost as obviously convenient as personal specialization—division of labour between individuals. It is obviously convenient, from the point of view of production, that different people should do the different jobs for which they are best fitted, and it is scarcely less obviously convenient that different groups of people, inhabiting different parts of the earth's surface, should put their resources to the uses for which they are best suited. This is true even when the efficiency of different men or different lands for all kinds of jobs are on different levels. An officer may be better than a private, both as officer and private, yet it is better that he should stick to the function

he can do best, and the private to his. A piece of land in the city may be superior to a piece of land in the country, both as a site for offices and as a cornfield, yet it is obviously better that it should be reserved for offices and the other kept for corn growing. If there were no danger of war, there can be little doubt that the widest possible division of labour between nations would be regarded as desirable, and there can be little doubt that it is its obvious commercial advantages which, the danger of war notwithstanding, have led to the very high degree of territorial specialization which is characteristic of the world as we know it.

Moreover, it must not be thought that, from the point of view of national power, wide ramifications of international trade are altogether without their advantages. During the recent war it is clear that our own dependence on foreign supplies was a source of many dangers. On the other hand, when we reflect how much of national wealth has resulted from our trade relations and when we reflect what a tower of strength this national wealth was for us and all our allies, it is hard to believe that even from this point of view our position as a trading nation was altogether a disadvantage.

Nevertheless, in a world in which it is impossible both to have your cake and eat it, it is clear that developments of this sort must be a source of anxiety so long as the danger of war persists. For, quite clearly, specialization of the sort I am discussing is not always a process which is reversible. If it were merely a question of putting given resources to certain uses during time of peace and putting them to different uses during time of war, all might be well. The problem would be merely one of rapid adaptation. But, of course, it is not so. For one thing, capital and labour which have been specialized to do one thing, cannot always be rapidly re-adapted to do others. For another, the very process of specialization may make possible a concentration of population which could not otherwise be supported. For example—to anticipate a little—there can be no doubt that our own high degree of industrialization has made possible a density of population of a degree which could not easily be supported by a less highly specialized organization of industry. It should be clear then that these changes on the supply side, that I have been discussing, introduce complications of no inconsiderable magnitude.

It follows, I think, from all that I have been saying, that the problem of economic readiness for war is essentially relative. It assumes different forms for different nations at the same time, and for the same nation at different times. You cannot say that it is a question of supplying so much of commodity A, so much of commodity B, over and above the normal production of these commodities. Everything depends (*a*) upon the geographical circumstances of the nation you are considering and its trade relationships with the rest of the world, and (*b*) upon the demands which the type of

war you are likely to wage is going to make upon its resources. One nation may find its chief difficulty to consist in the supply of foodstuffs, another in the supply of shipping, a third may chiefly need coal—and so on.

None the less, if we approach the problem with a view to the discovery of practical solutions, we can make a certain formal division which I think is "useful."

(1) In the first place comes the problem of securing a supply of commodities which cannot in any circumstances be produced in sufficient quantities within the national area. Minerals of various sorts will be the most numerous members of this class in most cases, but, in some circumstances, vegetable and even animal products may be included. For all practical purposes, for instance, it would be impossible to produce all the rubber needed in a great war within the glass-houses of these islands.

(2) In the second place comes the problem of securing a supply of commodities which could be produced in sufficient quantities within the national area, but which, for the reasons of economic convenience I have explained, are *not* so produced in the normal process of trade. Illustrations of the sort of thing I have in mind will readily suggest themselves to the members of this audience.

So far as the first of these problems is concerned, the possible solutions are severely limited. The possession of adequate supplies of some commodity falling under this head may be a matter of life and death to a nation, but short of the forcible acquisition of the sources of supply—a solution which, I hope, at this stage in world history would be unacceptable to any of us—there are only two ways of securing them. Either you can accumulate a sufficiency during time of peace, or you must see to it that your communications with the sources of supply are adequately safeguarded in time of war. There is no third alternative open.

But so far as the second problem is concerned—the problem of securing a supply of things which could be produced at home but are not—a wider range of action is possible. If a thing can be produced at home, then, if the State decides that it is desirable that it should be so produced, it is possible to take steps to carry out this policy. It does not follow that the State will make this decision: it may decide that such a policy would be too costly. It may prefer, as in the case of the other class of commodities, either to accumulate during time of peace, or to pay attention to the safeguarding of communications. Clearly this is a matter of balancing costs and results. If the extra cost of domestic production is small, as in the case of the so-called key industries, the probability is that domestic production will be encouraged. If it is great, then it may be decided that, on balance, it is better to trust to the Navy—or those forces which are charged with the maintenance of communications.

Once it has been decided to produce at home, there are various ways in which this policy may be carried out.

(1) The State may go into business itself, erecting the necessary plant and carrying out the process of manufacture. This is most likely to happen where the commodity whose production it is desired to foster is one which is chiefly needed by the State itself in the direct performance of its functions. Armament manufacture is, of course, a case in point. Few nations of any importance are likely to be content to procure all their armaments from abroad. Most have, at some time or another, done some of the production for themselves.

How efficient such an arrangement is likely to be is, of course, a question which it is difficult to answer in advance. Those who regard State enterprise as uniformly desirable will predict great efficiency. Those who think that State enterprise is the work of the devil will be of the contrary opinion. Most of us, I imagine, will be content to judge particular cases in the light of particular circumstances. It is worth noting that sometimes, from the point of view of secrecy, this plan is superior to other arrangements.

(2) Secondly, it may subsidize the form of production it is desired to encourage. Such subsidies may be either open or concealed. An open subsidy is a simple matter. A certain sum per unit of output is paid to the producers in question. Concealed subsidies, as their name implies, may be much more complicated. The most obvious are grants of special transport facilities. If the producers of certain kinds of goods receive especially low rates for transport on State railways or canals, they are receiving a subsidy just as much as if it were paid them directly. Similarly, if the government always places orders with home producers at prices higher than it would have to pay abroad, it is paying a subsidy to these producers just as much as if it handed over a sufficient sum of money to enable them to under-bid the foreigner in the first place.

(3) Finally, it may impose such a duty on foreign imports as to make the price prevailing profitable to domestic producers. This is a familiar device and needs no special description.

Of these two methods, subsidies and tariffs, it is difficult to say which is the better instrument. A tariff has often the recommendation of administrative convenience. But against this it can be urged that it tends to throw the cost on the shoulders of people not always the best fitted to bear it. This would certainly be the case with a bread tariff. A subsidy on the other hand, being, in the first instance, paid out of the national exchequer, rather than the pockets of the consumer, can be raised by graduated taxation, and is therefore immune from this objection. Moreover, from the point of view of the citizen, anxious to live as cheaply as he can, there is always this in

favour of a subsidy: it tends to come off; a tariff, on the other hand, tends to stick. On the whole, people are more alive to what they lose as taxpayers than to what they lose as consumers.

III.

That is all I wish to say about the general problem. I now turn to the consideration of the special problem with which we in this country are confronted. How ready are we for war, from the point of view we are adopting?

Now, speaking very broadly, I do not think that, as regards the supply of the direct instruments of war, our position is at all disturbing. No doubt there are raw materials essential to the conduct of modern warfare which are not to be found within these islands. The problem of providing a sufficient store of these does not seem to me very difficult. And so far as the manufacture of war material is concerned, our position is surely very favourable. The experience of the last war has shown that there are hundreds of factories which, at very short notice, could be transformed for the manufacture of munitions. The problem here is simply a problem of preparing suitable plans, and being willing to act on them without hesitation.

As regards our food supplies, however, it is not possible to be so complacent. Indeed, I do not think it is any exaggeration to say that our position is one of almost unique disadvantage. I must ask your patience a little further while I enlarge on this matter.

The change in the position of this country as regards food supply is, I suppose, a classic example of the way in which the process of territorial specialization which I was describing earlier in my lecture, although enormously advantageous from the point of view of productive efficiency, may lead to a quite peculiar position of danger from the point of view of military security. Two hundred years ago, in normal years, this country was self-supporting as regards foodstuffs. In normal times, indeed, we produced a slight surplus for export. In spite of the growth of population, that position remained roughly unchanged until the beginning of the nineteenth century. But from that time onward there came a change. With the development of world transport, it became cheaper for us to obtain a larger and larger proportion of our food from abroad. Rather than cultivate poorer lands or expend our capital and labour cultivating lands already in cultivation more intensively, it paid us to use our resources in manufacturing industry, obtaining our food supplies by way of exchange for our industrial products. That change in the character of our national production has persisted right down to the present day, with the result that we are now dependent on sources overseas—sources from which we might at any time be cut off by blockade or naval defeat—for at least 60 per cent. of our total food supplies. Speaking very roughly

indeed, 80 per cent. of our wheat and 40 per cent. of our meat, comes from abroad. Our dependence on foreign or colonial sources for eggs, sugar, fruit and other minor items of the national diet is also very considerable. That is a position, I suggest, which, if war is to be regarded as a permanent fact, can be regarded by no one with equanimity.

But the way out is not apparent. It is not possible simply to reverse the policy of a century. If the population of to-day was the population of a hundred years ago, all would be quite simple. We might prefer to get our food abroad in time of peace, but in war time we could plough up our meadows. That solution to-day is not open to us: the population is too numerous. It is almost as though you were to hope to support the inhabitants of the City on the produce of London Squares. No doubt it is possible to extend the area of cultivated land in this country—on that I shall be saying something further in a moment. But I think you may take it as an axiom of policy that it would be quite out of the question to produce at home all the food needed for our present population, save at the cost of wiping out the material gains of a century. These are strong terms, but I am not alone in this opinion. Let me read you the opinion of the late Deputy Director General of Food Production.*

"It has been asked," says Sir Thomas Middleton, "is it not possible for the United Kingdom to feed its entire population, or at least to supply all necessary foods, except the small percentage that could only be grown in tropical or semi-tropical climates? From the purely agricultural point of view it may be answered that there would be no special difficulty, if the people of this country were content to place themselves under the direction of some all-powerful food controller, who would feed them with what was necessary, as a farmer feeds his cattle. If they would be satisfied with the rations of protein, fat, and carbohydrate which their bodies must have, and if they would be prepared to pay for their food on a calorie basis, the farmer could, no doubt, supply the necessary protein and energy. But the public would not be content with rations of protein, fat, and carbohydrate, and would not pay on a calorie basis. They must have bread, meat and many other things in certain customary quantities: and thus, under present circumstances, or under any circumstances that can be foreseen, there is no possibility of providing the foods they demand from the soils of the United Kingdom. It would require more than twenty million acres of land to supply the grain alone that is consumed in this country, and to secure this quantity of grain it would be necessary to plough every acre of land not subject to flooding and not too far above sea level to prevent corn from ripening. The cost would be prohibitive, and the suggestion that we might furnish our people with their normal food supply may be dismissed as absurd."

It is clear, therefore, that to some extent food falls into the

* *Food Production in War*, p. 323.

first of our two great classes of commodities—commodities which cannot be produced in sufficient quantities within the home area—and as we saw, the only way of ensuring a continuous supply of such commodities during war was by the safeguarding of communications or by storage during peace time. In the case we are discussing the latter policy can, I think, be dismissed as impracticable. Before the war, the possibility of building great granaries for storing corn against the contingency of war was sometimes discussed, but it is not heard of now, and I should suppose—I speak subject to correction—that recent developments in the art of aerial warfare rule it out of court completely. If there is to be war, the main source of security is and must be the safeguarding of communications.

Of course, within limits, the supply of food is capable of variation. A policy of subsidies or tariffs would produce some extension of arable farming. At the height of our effort during the War we succeeded in raising supplies for 155 days out of 365 instead of 125. We could also in course of time reduce the pressure by redistributing our population through the Empire. It is conceivable that in the course of the next century the continued fall in the birth rate may bring about a similar relief.

But when all is said and done, it cannot be pretended that the position is anything but profoundly disquieting. There was a period during the War when we were but three weeks off starvation. If a new war were to break out next year against a naval power, I see no reason to suppose that the danger would be greatly diminished. The very forces which have brought us so high in the industrial world have placed us in a position of economic insecurity in time of war, from which, so far as I can see, there is no way of escape. One error of judgment on the part of the commander of the Grand Fleet, and the fate which was Germany's and Austria's, might be ours also. A terrible responsibility rests upon the shoulders of those who are responsible for the conduct of our foreign relations.

INSPECTION OF BUILDING WORKS.

By CAPT. A. MINNIS, R.E.

THIS article is primarily intended for the guidance of the young officer on first appointment to D.O. work, and for field company officers, whose tradesmen may be employed during the winter training season on buildings.

Even the most self-confident of us must find it difficult to appear authoritative when criticizing work under the sardonic eye of a foreman old enough to have built the house we were born in, and in such a situation ignorance is the father of embarrassment.

All the matter which follows is (or should be) common knowledge; but the reminders here given may focus such knowledge and give the young officer inspecting his first job something definite to look for.

Only the most common mistakes and malpractices are mentioned; the finer points of building inspection will be learnt by experience.

A word of warning may not be out of place; be careful what work you condemn, and when. It often happens that a job is so far advanced when a defect in earlier work is noticed, that it cannot be remedied without great expense. If such a thing should happen, you are practically bound to let it go, partly because, by not seeing the fault at the time, you have tacitly passed it, and partly because work dismantled and rebuilt can seldom be made really sound.

Therefore, inspect work thoroughly and often.

It should be borne in mind that this article is necessarily written with the idea of pointing out faults and frauds—one does not inspect building work in order to admire it, but to see that it does not fall below specification.

For this reason, the general impression may be given that contractors are all cheating sharps, and workmen all lazy scamps.

That attitude of mind must be avoided; as a rule, contractors are honourable and workmen conscientious; a moment's thought will show that their own interests are best served by giving value for money. At the same time, there are others.

It is better to trust contractors or workmen until you have reason for distrust, than to consider them rogues until they prove otherwise. If you go about with the obvious intention of finding fault with all you can, the contractor will retaliate by giving you the minimum standard of quality in everything, counting a point in the game to himself for every time he succeeds in getting the better of you.

The attitude calculated to get the best service from everyone concerned with the carrying out of building works is extremely well shown in the article by Capt. Tosh in the March issue of the *R.E. Journal.*

DRAWINGS.

Make sure that the building as designed will fit the site. W.D. designs usually assume a level site and sound foundation soil at a moderate depth. Your site may necessitate modifications, especially in the matters of floor levels and drainage.

Trial pits should be put down in case of doubt as to the quality of the foundation bed.

SETTING OUT.

The contractor will usually do the setting out, but you must make a check before excavation is commenced.

WORKMEN'S CONVENIENCES.

Before any work is commenced, latrines for the workmen, and a shelter in which they can have their meals (where no such place is already handy), must be provided. Unless these provisions are made, the building itself will become both.

EXCAVATION.

Foundation trenches become puddled at the bottom, due to workmen walking about in them, and it is difficult to judge them by the appearance of the bottom, except in the early morning after the mud has had a chance to settle, when running water from small springs can be detected. Generally speaking, it is better to judge trenches by the condition of their sides. Widths and levels should be checked by measurement.

When the bottom is stepped in sloping ground, see that the terraces are level, and the steps a multiple of the height of a brick course in depth. Concrete to these terraces should overlap at the steps (*i.e.*, each step must have a concrete "riser" as thick as the concrete foundation itself).

Pegs are usually driven to show the actual depth of concrete by indicating the level of the surface. See that concrete is actually placed at several places to these peg levels before you leave the job.

Contractors have been known to drive all the pegs down a few inches when this precaution has been neglected.

DRAIN LAYING.

Pipes.—Good pipes ring like sound crockery, are straight, and show no pimples or abrasions in the glazing.

Joints.—Joints are most likely to be scamped underneath. When bricks are used to pack up pipes to make the underside of the joints accessible, care must be taken (unless the pipes are bedded in concrete), to remove them as soon as sufficient earth has been filled under the pipes to hold them up. If these bricks are left in they form rigid supports, and the pipes may break when the earth above them settles down.

Sight test.—Straight lengths of drain should be inspected by using a mirror at one end to reflect the light of a candle placed at the other, when any fixed obstructions (such as cement mortar), likely to hold up paper, etc., will show themselves. If they cannot be removed by pulling through a wad of rags, you will have to decide whether to have the drain relaid or not. Obviously, such an obstruction is more serious in a flat drain than in a sharply-graded one, and on the bottom of the pipe than on the sides or top.

Water test.—The water test should be applied before and after the trenches are filled in, the first time so that defects may be easily remedied, and the second to ensure that damage has not been done during filling.

This test is automatically applied if a stoppage occurs, so that any objections the contractor may raise on the grounds of its severity should be overruled. Make sure that no taps draining into the system are left dripping to replace water leaking away during the test.

Concrete.

It is not proposed to go into the subject of cement quality here; any book on materials contains details of many tests, field and laboratory, which may be carried out if doubt is felt as to the quality of cement.

Nowadays, cement from a reputable source may be relied upon to pass the British Standard Tests, so long as it is fresh and has been stored in a dry place. If cement is more than six months old, or has been kept in a draughty or leaky shed, it should be tested by one or other of the approved methods before it is passed for use.

Concrete mixing should be supervised as carefully as possible, to see that the specified proportions are adhered to.

Do not be fussy about the wetness or dryness of the mix. In text-books, a great deal of stress is laid upon the necessity for using the smallest possible allowance of water. It is true that a "dry" mix gives the best laboratory results; it is equally true that workmen cannot be made to use it. Even for mass work it is hard to "work"; it sticks to the shovel and requires a great deal more ramming to consolidate it than it will ever get. It would, therefore, be liable to be honeycombed with holes, were it not for the bucketful of water which the labourer keeps at hand "for washing his shovel." As you will certainly get wet concrete when your back is turned, you may as

well have it all the time, knowingly, instead of pretending that it is "dry." Uniformity in quality is the first essential.

For reinforced work, the concrete must be sufficiently soft to flow slowly, otherwise it will not get into proper contact with the steel; and the more complicated the reinforcement, the less the chance of proper tamping being done and the more fluid must the concrete be.

If the work is sufficiently important to warrant it, the weakening effect of using a wet mix should be compensated for by increasing the allowance of cement, otherwise your only worries should be to see that your concrete is not really sloppy, and that all batches are of the same consistency.

Do not allow "killed" cement to be used; that is, a mix more than two hours old. Workmen like it because it "works like butter" if it is turned over with a little more water.

Ensure that concrete is mixed on a "banker." To utilize a hard road or paving is common with contractors, consequently dirt from road or paving gets mixed with the concrete.

Salt water does not affect the ultimate strength of concrete, but it retards the setting. It should never be allowed for buildings, because the concrete will always be slightly hygroscopic.

Concrete floors.—The only satisfactory proof that concrete floors have been laid to an even fall is to swill them with water and note whether any pools remain.

REINFORCED CONCRETE.

This article can cover only a few of the more elementary points to be noticed in R.C. work.

Lintels.—Unless a lintel has a distinctive outward appearance, which will show definitely its right way up, there is a danger of it being placed with the steel on top, where it is useless. The only safe way of avoiding this is to put in steel at both top and bottom. Where lintels run continuously over one or more intermediate supports, double reinforcement is more practical and fool-proof than the most careful bending of bars to take up stress variations.

Beams.—Fill in concrete from one end, working straight through to the other. To keep the steel at its proper distance from the bottom of the form, a piece of piping should be placed about two feet from the end of the beam, underneath the bars, and pulled forward as the concrete is filled up to it. Wherever possible, beams should be filled in one operation, but if work planes are unavoidable, keep them at places between the points where bending and sheer stresses are at maximum, usually at about quarter-span.

Columns.—Columns over 8 or 10 feet high cannot be filled in one operation with certainty of solid filling. The bases and caps, especially the latter, will usually be subject to stresses due to beam

connections, and must be completed along with the ends of such beams, in one operation. No interruption of filling must be allowed at mid-height of the column ; so that work planes must be at about quarter and three-quarter heights.

Steel.—Reject all bars which are not perfectly straight between intentional bends. See that steel is brushed before use and is free from grease or oil.

Concrete.—This has already been referred to. Remember that the wetter the concrete, the less the punning required or desired. Punning concrete always tends to separate the water and cement from the aggregate, and this is especially so in the case of wet concrete.

Forms.—Forms should be watertight, smooth where the work is required to show a finished surface, and covered with oil, or an emulsion of oil and water, to prevent adhesion of the concrete to the timber. When the work is set, strike forms gradually, taking down the sides of beam-forms first.

Mortar.

The sand used for lime or cement mortar must be clean. Contractors like dirty sand, because the more loam or clay there is in it, the less lime or cement it requires to make it work fat.

Pick up a handful of the sand and work it about with your fingers ; if it soils your hand, it should be rejected until washed. Crushed bricks make a good "sand," but old lime mortar should not be allowed to be ground up for re-use.

For lime mortar the sand should be sharp. You can test this by rubbing a pinch of it between fingers and thumb, when it should feel harsh to the skin. For cement mortar, sharpness does not matter ; some authorities go so far as to say that round grains are better. Lime used for mortar must be specified to be measured before slaking. This is the usual assumption, but contractors have been known to pretend, when nothing was written in the specification about this, that they thought otherwise ; and as most building limes nearly double in bulk after slaking, such a misunderstanding may mean a 1 : 4 mix instead of 1 : 2.

Bricks.

Good bricks are even in colour (unless specially made for a special colour effect), burnt through, have straight sharp edges, and are truly rectangular on all faces. Any bricks containing stones, or showing lumps or marked faces, should be rejected. A good brick rings like a good coin when struck with a trowel. Clamp-burnt bricks usually have a marked face and should not be rejected on this account, unless, of course, facing bricks are wanted.

Note the number of broken bricks when a load is delivered. There

will always be some, and such are necessary for bats and closers; but suspect the brickwork when there are too many. A contractor will not go to the expense of carting them away; they will be built into walls as snap-headers and hearting when your back is turned.

BRICKLAYER.

Finished brickwork can only be judged by its appearance. See that perpends. are true, the bed joints horizontal and straight, the quoins plumb and the face without any trace of bulges. Bonding will rarely be defective *on the face;* never if the perpends. have been "kept."

It is whilst brickwork is being laid that faults can be seen—finished work shows nothing of the crimes committed behind the face. For this reason, brickwork is probably the most exacting part of building work to supervise; to be quite sure that work is well done, it must be watched continuously. As this is usually out of the question, it is safe to say that a large proportion of brickwork is not up to specification.

So long as supervision is maintained, headers are headers, joints are flushed with mortar, and the hearting of a thick wall is built of whole bricks.

When you are not on the job, a bat becomes a header, bricks are laid on a fid of mortar at the back and front, with nothing under their beds, and the hearting of thick walls is made up of spalls and rubbish.

The flushing of mortar joints is extremely important if a wall is to be really weatherproof; but it is expensive in material and labour. Even if the contractor is scrupulously honest, the bricklayer may not be; it is easier for him to lay bricks without flush bedding; also he considers his beast, the hodman, who has to carry mortar up to him.

It is easier to press down a brick to its level when the joint is not flushed, or when the brick is laid with the frog downwards, but in neither case will the wall be solid.

Bricks must be wetted to avoid soaking up moisture from the mortar.

Damp courses must be set above ground level *all round the building*, and try to allow for probable banking up of flower-beds by the occupant.

You cannot legislate for the individual who builds rock gardens against the wall of his house, but you can usually foresee flower beds.

Slate damp-proof courses are often scamped. See that each slate is well bedded in cement mortar, and that the courses of slates break joint.

A common error in building hollow walls is to lay the D.P.C. on

the top of the solid wall and commence hollow construction from that level. This does not allow for the drain, provided for condensation and other water, to lead water away below the D.P.C., and it will soak up the wall. Therefore, put in your D.P.C. a course above the bottom of the cavity so that water in the bottom will not wet the brickwork above.

Bonding faults, which are rare, will not occur on the face of a wall, but may usually be detected by pushing a length of hoop iron vertically down a joint near to a jamb or a return. "Awkward" bonding is usually the fault of the architect, who has not taken care to plan his piers and openings to multiples of a half-brick in width. It will usually be possible to make the slight alterations needed, (which can never be more than 2¼ in.) to correct this; but you must do it before the woodwork for doors and windows is put in hand.

In setting out brickwork, see that reveals come over perpends. and that the broken bond, if any, comes under the sill.

Arches in general must have a total depth from the bottom of the springing to the top of the crown of a multiple of the depth of a course, to avoid cutting for a shallow course over the crown, which is never done neatly.

Relieving arches must spring clear of wooden lintels, taking their support from the brickwork only.

Rubbed arches must have all voussoirs exactly alike, and all with clean arrises. Mortar joints must be fine, and even in thickness. See that the soffit of a flat arch is cambered.

Rough arches must have all joints between voussoirs V-shaped and of the same thickness, and must not show a crescent-shaped joint between rings.

This crescent-shaped joint is usually due to the lowest ring dropping after the centre is removed, the cause of this dropping being that joints between the bricks forming this ring have not been fully flushed up.

A very common error is the solid bedding of stone and concrete sills. It is essential that sills and thresholds be "bedded hollow," that is, with a clear space of at least half an inch or, better still, a course of brickwork left out, underneath their centres to allow for settlement, due to weight of the jambs above. Unless this allowance is made, stone sills will break after a few months. The spaces left under the sills will close appreciably and must not be pointed up until the whole building is completed.

Chimney breasts, flues, and the backing of ranges and stoves afford the bricklayer his best opportunities of scamping work and using odds and ends of material: and it is in these places that good brickwork is specially required. Badly-built flues leak air, and will not draw, and rubbishy backing to stoves is a source of annoyance, and of expense also, when the grate requires to be renewed.

Do not allow coke breeze concrete anywhere near a flue or fireplace —as often as not, it is inflammable.

Pay particular attention to the brickwork of chimney stacks, especially the flaunching. Being out of sight once the scaffolding is removed, it is often scamped, and the chimney pots are badly set. This may or may not be dangerous, but it will usually leak smoke, and the stack will become unsightly.

See, as far as you can, that pargetting is sound, and that the flue is cored as the work proceeds—*and that the core is not left in when the job is finished.*

Best practice in fixing joinery in brickwork completes the brickwork first and makes joinery to fit the openings. The practice of fixing door and window frames first and building the brickwork round them is becoming prevalent.

This is certainly quicker than the orthodox practice, and it is easier to make a close joint between brickwork and frame. There are no great objections to it, so long as care is taken not to use the frames as weight-bearing members. For this to be certain, some allowance must be made between lintels and the tops of the frames for settlement.

It may be remarked here that the use of door and window frames to support the brickwork above them, wicked as it is, is by no means rare. Hundreds of doorways in jerry-built houses have been, and are being, erected without lintels. The self-corbelling of brickwork will look after most of the weight until the frames require renewal, and when that day arrives the small triangle of brickwork immediately over the opening will probably stick up in place by force of habit.

MASON.

Comparatively little masonry work is now done in W.D. buildings, and it is easy to lose touch with it.

A few reminders of the essentials in masonry follow, but only the most frequent malpractices can be mentioned in a short article.

STONE.

It pays to look up all the information it is possible to get about the particular stone specified for use in a building. You must know your material before you can accept or reject it, and all the information you need is readily available in text-books such as *Rivington* or *Mitchell.*

It may be mentioned here, in particular reference to Portland Stone, that blocks should be washed before being placed, if they come ready worked from the mason's yard to the building. It is usual to whitewash such blocks with Whit-bed slurry after working, to protect the face ; and many a block of Roach-bed has taken the

place of the finer and more expensive Whit-bed, due to the white-wash hiding its real character. A visit to the mason's yard to see the stone being worked is the best safeguard.

Natural Bed.

See that stones carrying weight have the natural bed normal to the direction of the stress. This is easy in most cases, but Bath and Portland and a few others do not show their beds clearly. Stones from these quarries are usually marked at the quarry with figures giving the cubic content of each block, and these figures are cut to read the right way up when the stone is resting on its natural bed.

An exception to the rule of bedding on the natural bed is made in the case of cornices with deeply-undercut mouldings. The pendant parts of such mouldings will flake off if the natural bed is horizontal —assuming that the cornice is horizontal. The stone must be so worked that the natural bed is vertical and at right angles to the face of the wall.

" Face bedding," which means that the bed is vertical and parallel to the face of the wall, must never be allowed.

This fault, though everybody knows about it, is very common, and it was committed even in the building of the Houses of Parliament with disastrous results.

Most of the useful supervision of mason's work, where wrought stones are used, is done before the stones are actually laid. Once a stone is laid it is almost impossible to replace it if a defect is noticed, without spoiling the appearance of the work. Similarly, chipped stones cannot be " invisibly repaired," so that arrises and mouldings must be protected until the building is completed. Stones accidentally chipped during preparation, or containing flaws, are often " repaired " by filling the hole with a paste made of stone dust and resin. This repair is difficult to detect, but it should not be allowed, as the patch will spall off from frost action in a short time.

Points to notice in the building of walls are :—

See that sufficient through stones are used, except in buildings intended for habitation, when long headers should be used instead, as through stones conduct moisture from outside to inside.

Do not allow any stone which is deeper at the front than the back to be used. Such stones will be packed up behind with spalls to level their tops, or filled up on top to make a level bed for the next course with rubbish and mortar. Anyway, the wall will not be solid.

See that each stone is covered by parts of at least two stones above, and that it overlaps parts of at least two below.

Try the tops and beds of wrought stones with a straight-edge to see that they are not hollow or hogbacked.

SLATES AND TILES.

There is little to be said about this trade. See that the gauge specified is adhered to, tilting fillets put in, and torching properly done. This last will often be scamped in places difficult to get at.

CARPENTRY AND JOINERY.

The specification will contain an instruction laying down the quality of timber to be used, and the usual clause that the "timber used shall be free from large, loose or dead knots, shakes or defects of any kind, etc." This clause has been in use so long that a contractor would miss it dreadfully if it were omitted, but familiarity has had its usual result. Nobody takes any notice of the clause now; it has become hackneyed.

It will do no harm if you examine timber with one eye on this clause, but do not take it too literally.

Timber without knots cannot be insisted upon—there is none. All you can do is to see that it does not have too many and that none are loose or very big.

Small shakes do not matter, but cup shakes extending to a fairly large arc must not be allowed, *e.g.*, a cup shake which subtends an angle of 30° to the centre is a definite flaw.

Do not allow more than 10 per cent. of sapwood, and see that such sapwood as there is, is dry.

(Sapwood is the young wood on the outside of a tree, and it is very prone to decay, being porous and often sappy. It has much less strength than the heartwood.)

The following distinctions between good and bad timber are easily made:

Sound timber gives a sonorous clang when struck with a hammer; bad timber a dull thud. The sound of timber being sawn should be harsh and sharp and the edges of the cut should be clean. A timber which is beginning to decay will sound muffled when sawn, and the surface left will be woolly.

Run a plane over suspected timber, if it is good the newly-made surface will be faintly lustrous; if bad, it will show a dull chalky appearance.

In these days, owing to the enormous quantities used during the War, properly seasoned timber is very difficult to get. There is, therefore, all the more reason to give timber a chance to complete its seasoning in the building by seeing that it has plenty of ventilation. Even well-seasoned timber will rot if placed where it cannot have fresh air circulating round it; and if it is not well seasoned, it is already in a state favourable to decay, and must be specially well ventilated.

For this reason, the practice of laying floors directly on top of the

concrete seal is bad. No concrete is waterproof; damp will soak up to the underside of floorboards in sufficient quantity to provide a favourable condition for starting rot, and the impossibility of providing ventilation under the boards will do the rest. If you cannot get the design altered, have boards coated with solignum on the underside and edges before laying, even if it entails an "extra."

(Similarly, linoleum, if well laid, prevents ventilation, and may cause rot. A wooden floor laid on concrete and covered with linoleum has a very poor chance of a reasonable length of *life*.)

Take care that floor and roof timbers are well clear of flues and fireplaces.

See that carpentry joints are correctly designed, *i.e.*, that compression joints *are* compression joints and not tension joints or scarfs.

Do not allow scarfing of purlins, except over supports, and not there if the purlin is calculated as continuous.

Examine doors and windows in the shop before the priming coat is put on. Putty has made up many bad joints, and it is not easy to detect after painting.

See that door panels fill the grooves, and that brads, fastening mouldings to framing, do not go through the edges of the panels, or the panels will split when shrinkage takes place.

See that joinery is protected from damage by workmen. Newel posts should be swathed in sacking, stair-treads should have a strip of wood nailed on to cover the nosings, doors should be secured open so that traffic is not impeded and dirty handmarks are not rubbed into the wood by constant opening and closing, and so that there is no danger of slamming by wind. Protect both the stone sill and the inside window boarding from workmen's boots. Workmen use window openings instead of doors and they suffer damage from such traffic.

Plumber.

The makers of sheet lead and lead piping usually mark the weight per foot super or foot run on the outside sheet or coil of a new lot. If this mark is missing, it will sometimes repay the trouble to weigh a sample. It requires a great deal of experience to distinguish 4-lb. from 5-lb. sheet by inspection.

Before laying lead flats and gutters the woodwork should be inspected to see that all nails have been punched home, so that none remain to puncture the sheet. Also, see that bearing timbers run across, and the boarding with, the flow; otherwise, the ridges which form when the boards warp may hold up pools of water. In any case, test flats and gutters with water to see that no pools remain.

See that soakers have their proper lap and that flashings cover the soakers. Wherever lead sheets, whether in flashings, drips, or rolls,

lap over each other, see that they do not lie close to each other, except at the end of the overlap, or capillary attraction will cause water to soak up between the sheets.

When lead pipes are bent, look at the bends to see that they have not flattened.

Make very careful inspection of the connections between closet pedestals and soil pipes; and see that the flush pipe is not larger than the outlet from the cistern. It is better if slightly smaller.

Unless the overflows from baths and lavatory basins are contained in the fittings (as is usual now), make sure that the plumber does not connect the overflow to the waste pipe beyond the trap.

All water pipes must be fixed to a regular fall, so that if the system requires to be emptied for repairs, or during frosty weather, no dip will be left full. This precaution is doubly necessary in the case of a hot water supply system, to prevent accumulations of air which would collect in the top of a bend and cause noises or even stoppage of the circulation.

Notice details of hot water systems, such as the provision of a draw-off cock, which will empty the system without leaving a pocket full of water in the bottom of the boiler; the safety valve; and the expansion pipe.

The stop cock on the cold main must be inside the building and easily accessible.

Do not allow taps to be fitted on the ends of pipes or there will be trouble from water hammer. Taps should be fitted on a short arm at right angles to the pipe, and a few inches from the end.

See that all sanitary fittings, especially water closets, are filled with sand until the building is finished, to prevent workmen using them. A W.C. pan which has been used before the water supply is laid on can never be cleaned.

PLASTERERS.

The remarks on mortar apply equally to plaster, and there is in addition the hair which is mixed in to bind it together. If the hair is properly mixed, and in sufficient quantities, it should show like a fringe over the edge of a trowelful of plaster picked up and shaken so that the overhanging plaster drops off.

Where it is possible to see the backs of the laths, see that the plaster has curled over to form a key. It is not usually possible to inspect ceilings which have a floor over them, because it would be likely to cause trouble if a floorboard were lifted and then nailed down before the plaster had set properly; but bedroom ceilings can be inspected from the roof spaces.

See that the plaster is taken down to the floor level. Plasterers will try to avoid plastering the few inches which will be covered by the skirting, and a convenient home for vermin is left.

Test the work, preferably before the setting course is applied, with a long straight-edge, to see that it is flat.

Keene's cement angles should have a Portland cement backing.

Portland cement rendering will always show fine " hair " cracks, due to the shrinkage on setting. To avoid this, the finishing coat should be worked up with about 20 per cent. of lime putty or plaster of Paris.

Painters.

Paints are now nearly all purchased ready made, and their quality is a matter over which you will have little control.

Your interest is to see that the paint is applied as received, and not let down to make it cover more ground; and that the specified number of coats are put on. Your best safeguard is to have sufficient difference in tints between all the coats. If two or three coats of the same shade are used you will be lucky if you get them all.

At the same time, you must not have great differences between tints, or the under coats will " grin " through if ever the work is knocked or has heavy wear.

Do not try the old dodge of making pencil marks with the idea that they will show if another coat is not put on. A fraudulent painter knows that trick at least as well as you do, and the only result will be that you will appear foolish in the eyes of the boy who follows you round with a brush to paint out your marks.

If Keene's cement is to be painted, it must be done as soon as it is hard enough to stand the brush.

Cement rendering will not take paint for at least twelve months, unless the natural maturing process is hurried up by washing the work with weak carbonic acid.

All steelwork, fall pipes, etc., must be painted before fixing, or hidden joists, the backs of cisterns, and spigot ends of pipes, will never be painted.

Conclusion.

Finally, when the builder quits the building, see that he removes all odds and ends of timber, bricks and other material, and that he fills in the lime pit, if any, and all other holes which may be a source of danger.

Pudlock holes should be neatly filled, holes where pipes came through walls made good, and the hollow bedding of sills can now be pointed up.

THE OLYMPIA TANK MOUNTAIN.

By LIEUT. P. W. G. HUME, R.E.

THE task of designing and building a "Mountain" for tanks to go over, at the Royal Tournament at Olympia, was given to the 23rd (Field) Company, R.E., in the middle of February, 1926.

The requirements of the mountain were to take mules, tanks and dragons up to the height of the gallery (20 feet) and down again to floor level, in the breadth of the arena (80 feet). Owing to the structure encroaching on the arena, and having to be in position during the other displays for which it was not intended to be used, a limit of 13 feet width at ground level was imposed. A doorway, 16 feet wide and 13 feet high, was required, with doors, for the entrance to the arena in the centre, so that the door lintel would be a bridge taking all the mountain traffic. The cost was to be between £300 and £400. The mountain was first to be put up at Farnborough, to allow the tanks to practise, and then dismantled and re-erected at Olympia.

For the purposes of this article, it is not intended to give a complete account of the construction, but rather an explanation of the difficulties that arose and how they were overcome.

SLOPE.

(*a*) *Grip of track.* The capability of the tank of climbing the slope of 35 degrees was the first doubtful point. It was ascertained that the new Vickers tank would climb a slope of 45 degrees on a suitable surface, but nothing was known about its performance on timber. The track, on inspection, was found to present to the ground a surface to all intents smooth, with no part to dig into the roadway, and it therefore seemed probable that the steepest angle that it would climb would be the limiting angle of friction—steel to timber. *Molesworth* gives μ for this as ·6, giving an angle of 31 degrees, and so it seemed probable that the track would slip on the 35 degrees slope.

To test this, a short length of 35-degree ramp was made with sleepers, on Miles Hill, Aldershot, at the top of a hill slope of 20 degrees. The roadway was 2 sleepers wide, with 6 runners dug into the ground, and the decking spiked to them. The ramp represented the top 12 feet of the mountain slope, and was curved over to the horizontal at the top, with the corner rounded off. Theory proved

accurate on trial, the tracks slipping just before the tank was completely on the ramp.

The first expedient for increasing the grip of the tracks was a series of spikes driven into the sleepers, leaving about one inch of each projecting. The result of this might have been foreseen; the friction now became that of steel to steel, or less than it was before.

It was then realized that, if additional grip was to be supplied by steel, it would have to be in the track, and the roadway left plain. Small half-inch bolts were put in the track plates, one per plate, with the nuts towards the roadway, and this enabled the ascent to be made.

(*b*) *Impact.* Although the change of slope at the top of the ramp was fairly gradual, it was noticed that a good deal of bumping occurred when the tank went over it. This was principally due to the centre of gravity of the machine being behind the centre, with the result that it proceeded past the point of change of slope, still at the steep angle, and then crashed down on the gentler grade.

With anything but a very steady use of the accelerator, the tank started a wobble, which increased this effect.

Other factors affecting the amount of impact to be allowed for were that the tank might stop suddenly or start with a jerk on the sloping portions of the roadway, and that if any steering was done, great cross strains would occur in the decking, owing to the bolts in the tracks preventing free skidding. All calculations were accordingly made, using an impact factor of 2.

As regards the impact caused by the tank bumping down at a change of slope, this was most inconvenient at the top of the up slope, as it would occur at about the middle of the bridge span; so the top 9 feet of the 35-degree slope was eased to 24 degrees, making two points of impact both less than the one previously. It was not possible to overcome the fact that the top point of impact occurred in the centre of the bridge span, because of the level length required at the top.

(*c*) *Wear.* The bolts in the tracks would evidently wear out the decking rapidly, and so it was decided to use 3-inch decking to take the weight, with 2-inch decking superimposed on it to take the wear, and be renewed if necessary.

(*d*) *Dragons.* As a tank could only just get up the slope with bolts in its tracks, it was obvious that a dragon with gun would be unable to do so.

(*e*) *Mules.* Two-inch chesses were nailed to the trial ramp at various distances apart, and mules ridden up.

It was found that 3 inches clear between chesses enabled them to be ridden up with ease, but later it turned out that the 35-degree slope had such an upsetting effect on their loads, that the mule could not climb up.

DIMENSIONS.

(*a*) *Length.* After seeing the tank descending the trial ramp, it was decided that an easier slope would improve matters, and a straight run-off of 25 degrees was decided on. This meant a greater length of floor space would be required for the mountain, and it was arranged that 12 feet run of seating on either side of the arena would be removed to make room; the value of the seating accommodation thus lost worked out at £2,000.

A removable ramp was to be placed as on right of Plate IV, to enable tanks to get on to the mountain from the arena; the level portion at the top of this ramp was covered with cinders, to prevent the track bolts digging in and stopping the 90 degrees skid turn, which had to be made there.

(*b*) *Height.* Owing to the limit of width at ground level imposed (13 feet), the structure was necessarily rather top-heavy in the centre, where it was 20 feet high; it seemed probable that some wobbling would take place when the tank got near the top, more especially as the tank would weigh at least three times as much as the portion of the structure immediately beneath it, and would be a live load.

It was found, however, that the ground sills of trestle piers could project underneath the gallery and so increase the base width of 13 feet.

(*c*) *Bracing.* Looking at the mountain in elevation, it is seen to consist of two main portions, connected by the bridge span over the door, so that there could be no effective cross-bracing between these parts. So each ramp would have to be made absolutely firm to act as abutment to the bridge span. To help steady the mountain, two pillars (supporting the roof of Olympia) might have been utilized to tie trestles to, but as they would not be there at Farnborough, they could only be looked upon as an additional help.

(*d*) *Roadway width.* The width of the roadway was intended to be about 12 feet in the clear.

The width of the tank, from outside to outside of tracks, was measured as 8′ 8″, which, with a 12-foot roadway, would allow the tracks to "wander" over about 3 feet.

Preliminary calculations having shown that timber roadbearers were out of the question, owing to there not being enough room for them to be lap-jointed over the trestle capsills, R.S.J. roadbearers were decided upon. It became apparent that the roadway width might well be reduced, giving the following advantages:

1. Fewer joists required to cope with the "wander."
2. In the event of a track breaking, the tank would hit the ribands earlier, before it had gained much slewing momentum.

3. There would be less chance of a track riding up on a riband, owing to the tank being kept at a more oblique angle to the ribands.

A width of 9′ 6″ in the clear was fixed, allowing only a total of 10 inches to spare.

Design.

(*a*) *Roadbearers.* As these would evidently be a large item in the total expenditure, every effort was made to avoid buying joists. Some 12″ × 5″ joists, 22′ long, part of some old bridging equipment, were found to be available at Chatham, and suitable for the main joists of the bridge span. The only other useful size available was 8″ × 4″, 16′ long, and these were used for the removable ramp and the level span at the top. For the sloping ramps, some 8″ × 5″ R.S.J.s were bought ready cut to the required lengths.

The maximum unsupported span for any of these joists being taken as 8 feet, one would take the weight of one track, allowing 100 per cent. impact. Two of these joists were accordingly put to support each half of the roadway, placed under the two extreme positions of the tracks.

The method to be employed for fixing the R.S.J.s to the trestles provided an unusual problem, as slopes of 35 degrees are hardly likely to be met with in heavy bridges. The bearing between the joist and the trestle had to be such that it would transmit the weight normal to the joist, the component along it, and the additional force along the joist due to the tank starting or stopping with a jerk. An acute angle on the lower flange being too costly, a normal equal angle, 4″ × 4″ × ½″, was used, to butt up against a shaped capsill-piece on the trestle; the joist would rest on the capsill-piece also (Plate 1).

The joists would, where possible, run over three trestles, making a length of joist of about 19 feet; by inserting packing, the angles could be made to distribute the thrust from the joists equally on to the trestle capsills, or in any required ratio.

To stiffen the joists, on most of the spans the angles were continued across each pair of joists, similar angles being put across the top flanges to take the thrust of the decking. To make the angles serve yet another purpose, in some cases additional ones were put on at the lower side of the capsill-pieces, so that the joist would both strut and tie the tops of the trestles. The joists, spanning two bays where possible, were placed so as to break joint on the down slope.

The decking was kept from slipping down the roadbearers by the angles on the top flanges, but the chesses could not be actually fixed to the joists in any way; so between each pair of joists an 8″ × 4″ timber roadbearer was spiked to the capsill-pieces, and the decking nailed and spiked to it.

(*b*) *Trestles.* The special point in the design of the trestles was

that they would have to be dismantled after erection at Farnborough in order to be taken to Olympia.

This meant using the split-sill design for all trestles too large to be carried whole. The three centre trestles were made of this type, as they were of 8″ × 8″ timber and weighed about 1½ tons each. The remaining trestles were of 6″ × 6″ timber, and as the largest only weighed half a ton, it was decided that they would be carried complete, and they were spiked and dogged in the usual manner.

Plate III shows the split-capsill and -groundsill design of trestle, with bolted joints throughout.

The chocks on the ends of the legs, to transmit the weight from the sills to the legs, were 2′ long and spiked on. The end of each leg was cut to a 4″ tenon, leaving a 2″ shoulder on each side, so that the chocks had to be of 2″ stuff. It was calculated that with the arrangement of legs shown, the two legs together at points where weight was taken were more economical than using legs of 12″ × 12″, made the parts easier to handle, and gave a longer bearing for the sills on the legs. The space between the legs was for the heads of the bolts taking the cross-bracing to the next trestle.

It will be noticed that no rakers could be used on the arena side of the trestles, owing to the limited width allowed. The timber used for all trestles was British Columbia pine, costing 4s. a cubic foot.

(*c*) *Door span.* The 12″ × 5″ × 22′ R.S.J.s from Chatham were to rest on the two large trestles, and left some 4 feet spare on one end. As with the sloping joists, angles were put across the lower flanges to stiffen joists, and were packed up to the capsills with double wedges, so as to strut and tie the trestles and help to stiffen the connection between the two main parts of the structure.

For superstructure between these joists and the roadbearers, cribwork was expensive, and trestles too small to make bracing effective, so, as dimensions were favourable, steel cubes were used. Each cube rested on two timber bearers running across the large joists, and there were similar bearers on top of the cubes with the roadbearers resting on them. Bolts and spikes were used for fixing. The detail of bracing for the cubes was left till the actual erection.

As any thrust along the sloping joists of the top spans would have an upsetting effect on the cubes, for which it would not be easy to provide in the fixing down, the packing of the angles at the top of these joists was made slightly looser than elsewhere, so that any thrust along the joists would be taken by the trestles rather than by the cubes.

(*d*) *Longitudinal cross-bracing.* There was no means of calculating the size or amount of cross-bracing required between trestles, and it was decided to have three complete X's in each bay, and three runners along capsills and groundsills. 8″ × 4″ was used for all bracing of the large trestles, and 6″ × 3″ for the 6″ trestles.

In the case of the large trestles, the holes for the bracing bolts had to be augured and the bolts inserted before the trestles were put together, so the positions of the braces had to be worked out for all the trestles from sketches. The positions of the braces were not the same for all the trestles because the legs varied in position, according to the roadbearers above, which overlapped on the capsills.

(*e*) *Removable ramp.* This ramp, taking the tank up the first 6 feet on to the level span, had to be removable as it encroached on the arena, and would only be in position for the one display at the Tournament.

The 8″ × 4″ R.S.J.s from Chatham were used for roadbearers, the top ends being cut off at half the angle of the slope, the end pieces turned over and bolted on to the remainder with two ⅜″ cover plates. The top piece then rested flat on the capsill of the first trestle. Four joists were used, in pairs with angle pieces across them to stiffen them and take the thrust of the decking, and to transmit the thrust to the groundsill.

The " unit " formed of two joists and their angles weighed 576 lb., and so could easily be placed in position by 8 men. The decking for this ramp was 4″ thick, to allow for wear without replacement. No ribands were used, in order to save time in putting the ramp in place.

Construction at Farnborough.

A suitable site for the erection having been chosen in Pinehurst Barracks, a foundation of sleepers running longitudinally as mudsills was laid down and levelled. Time being rather short, it was decided to get the large trestles up without putting up a derrick if possible. The two trestles of the bridge span were built with their groundsills roughly in the correct position, and the tops of the legs resting on steel cubes so as to give the initial lift. The groundsills were strutted apart, and footropes taken back to picket holdfasts, while a 3–2 cordage tackle was put between the capsills. Two headropes were taken back from each trestle to holdfasts. From a scale drawing, it was found that the initial pull on the tackle would be rather greater than the weight of one trestle, probably 2 tons. No 3″ cordage blocks were available, and a 2″ tackle had to be used, thus straining the cordage to the full $2C^2$.

A tank was put on the end of the fall, to save man-power and as many men as possible got round the capsill of one trestle, which was raised by the tank till just short of the vertical. The headropes of this trestle were now checked and the pull continued, now raising the other trestle.

As soon as both trestles were up, the groundsills were levered into their exact positions, and squared off with the centre-line of the mountain ; the trestles were then braced together. The third large

trestle was built with its head away from the other two, and raised by the tank in a similar manner.

The remaining trestles were easily erected by hand.

It should be mentioned here that, prior to the erection at Farnborough, preparation of material had been going on for some time: the 6″ × 6″ trestles were made at Farnborough, and the parts of the large trestles; the R.S.J.s to be used were drilled and the angles prepared in the shops at Aldershot. The drawings of the trestles and joists were got out, taking dimensions from a large drawing showing them together, and it followed that there would have to be a good deal of cutting and packing in fitting them all together. Actually, there turned out to be surprisingly little. As in the case of the large trestles, the bolts for the cross-bracing were put in these trestles at the time of building them.

Before the large joists of the bridge span were got up, it was seen that the angles to be fitted across their lower flanges would catch the nuts of the capsill bolts, and so a 1½″ × 12″ board was cut and nailed along the tops of the two trestles to pack the joists up. In order to minimize departure from the drawing, the 8″ × 6″ cube bearers were cut down to 8″ × 5¼″, to bring the height of the decking of the top level span the same as on the drawing.

The 12″ × 5″ R.S.J.s were got up as soon as the trestles were sufficiently braced to take them. The joists were raised by tackles attached to spars on either side of the gap.

The spacing of the joists in threes made it impossible to bolt each cube bearer to more than four of the joists, and made some of the bolts holding the angles to the lower flanges very difficult to put on.

The cubes were slid up the joists of the "up" ramp when these were in place, and fixed to the bearers with spikes and coachscrews, using as few as considered safe, to facilitate dismantling.

The 2″ decking did not arrive in time for this erection, and so the 3″ was used alone, nailed through to the timber roadbearers. It was found, when the decking had been laid, that it was impossible to walk up the 35 degrees slope, the 25 degrees being just possible.

The ribands consisted of two sleepers laid one on top of the other and bolted right through to the top flanges of the roadbearers.

TANK ASCENTS AT FARNBOROUGH.

For the preliminary ascents the removable ramp was placed in prolongation of the mountain in order to give the driver of the tank no greater task than necessary to start off with. Plate IV shows the mountain completed, but with the removable ramp in the correct position; the two spars at the top were to act as a guide for the driver, while ascending, as he could not then see anything except sky.

The first ascent was watched with bated breath, but was entirely successful; there was quite a distinct sideways wobble of the whole centre portion of the mountain, when the tank landed on the level bay at the top (Plate III), but otherwise all was well. The descent was done very slowly, especially near the top (Plate IV). The time taken from ground to ground was 2½ minutes, the tank's lowest gear being used.

It was thought advisable to put higher ribands on the top bays, as the tank might bump down on one when going over a point of change of slope. An extra sleeper was put on the other two, on the four top bays, and a 4″ × 6″ angle-iron riband spiked on top of that, making a total height of 21″. During one ascent a track actually did mount a riband, but the driver noticed the guide spars moving sideways and corrected the course!

The removable ramp was next placed in its correct position as in Plate IV, and the level span covered with cinders; but it was found to take five minutes to turn through the 90 degrees, which would be too long for the display, and permission was got to leave the removable ramp in prolongation of the mountain.

The ascent of the first 6 feet on to the level span was the most spectacular part of the whole performance (Plate V).

All parts of the structure were next labelled in order to recognize them on re-erection, a fairly elaborate system being necessary.

It took one full week, from the time that the first trestle was laid out on the ground till the tank made its first ascent, the average number of men employed for this period being 30. It was completely dismantled by fewer men in 2½ working days, and stored in a hangar.

The Strike occurred about the time the mountain was erected, and the Tournament was postponed for six weeks.

During this time, various odd jobs were done, such as the bolts run down and the doors made.

The construction of the doors is perhaps worth mentioning, as they were of quite a considerable size—7′ 4″ wide by 11′ high. They were made of framing of several sizes of timber, but all having a 4″ dimension, which was in the thickness of the door. There were three main rails of 4″ × 3″, to take the hinges, with two diagonals of the same size between them. The remaining space was filled in with 4″ × 1½″, so as not to leave more than 1′ 6″ between parts of the framing, and three-ply was nailed on both sides. The result was a fairly light door for its size, but heavy enough to make slamming impossible.

Transport to Olympia.

This part of the work was not without its excitement. Altogether, some 12 tons of steelwork and 30 tons of timber and stores had to be carried to London.

The most difficult load was the two largest 6″ × 6″ trestles, which were respectively 10 and 11 feet high. They were mounted on a 4-ton lorry, with their capsills tied together and groundsills at either side of the lorry's body. The overall height of this load was 15′ 6″, and the lorry was unable to get under Staines Bridge, and had to go some way round to avoid it. One load of timber, stacked rather high on a Sentinel steam wagon, caught fire twice on the journey from sparks from the smoke stack.

ERECTION AT OLYMPIA.

This proved a good deal easier than at Farnborough, as the pillars supporting the gallery were used for taking the lifting tackle for the large trestles, though there was rather a lack of holdfasts for foot-ropes.

Although the concrete floor was a much more even surface than the sleeper foundation had been, most of the bracing fitted without re-auguring.

All joints were made stronger at this erection, all the bolted joints being spiked and/or nailed in addition. Some stout bracing was put across the cubes, and successfully checked the sideways wobble. The L.C.C. representatives would not allow any part of the structure to touch the pillars or gallery, so that no steadying could be got from them as was originally intended, but the wobble did not now exceed an eighth of an inch during any part of the tank's journey.

The guide spars were dispensed with, as the roof of the building gave the driver sufficient indication of his course.

The 2″ decking was put on in this erection, chesses being spaced 3 inches apart. The spaces between the chesses were filled in each side, where the tracks came, with chocks, to make the roadway more solid, as this decking was for the most part only nailed to the 3″ decking underneath.

A light removable ramp was made to get troops and light field guns up on to the level span, and this was placed at right angles to the mountain.

On completion, tan was filled in underneath the structure to make the base more solid, and to deaden vibration.

Time for erection. The mountain was erected at Olympia by 22 men working for 6 days, making a total of 1,184 man-hours worked, which included unloading the lorries.

Cost. As soon as the design was got out, an estimate of the cost came to £500, and this was allowed.

The actual total cost, including transport, was £480, of which £305 was timber and £114 steelwork.

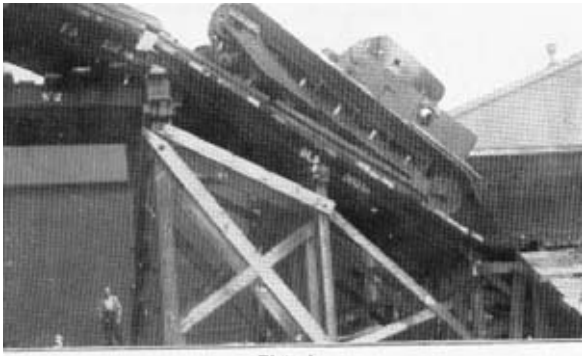


Plate I.

Plate II.

Plate III.

The OlympiaTank Mountain

Plate IV.

Plate V.

Plate 4 & 5

IMPROVISATION IN NORTH CHINA.

By LIEUT. J. V. DAVIDSON-HOUSTON, R.E.

INTRODUCTION.

BETWEEN the middle of April and the middle of May, 1928, the writer was employed on the following tasks at Wei-Hai-Wei :

(1) Preparation of Ma T'ou Barracks, at Port Edward, for the Convalescent Depot.
(2) Adaptation of the old Coolie Depot, at Tung Shan, for the reception of an infantry battalion (less machine-gun company).
(3) Preparation of a site at Huai Shu Ti for a machine-gun company and machine-gun range.
(4) Construction of a rifle range at Tung Shan.

A complete description of the work would be out of place in the *Journal*, as the preparation of camps is one of the commonest duties of the Royal Engineers. It is proposed, therefore, to touch only on those points where the normal practice was departed from, owing to the rapidity with which the work had to be done, to the use of native materials and labour, or to the necessity for improvisation.

1.—MATERIALS AVAILABLE.

The following are the only materials to any extent used in Wei-Hai-Wei territory : (*a*) Bamboo matting. (*b*) Stone. (*c*) Timber. (*d*) Metal.

and the greatest of these is matting. This consists of squares of woven bamboo fixed to a framework of China fir poles, and was used wherever temporary shelters were required and there was no risk of fire. In Shanghai, it is possible to obtain a practically waterproof material made of paper sandwiched between two thicknesses of matting, but in Wei-Hai-Wei, it was necessary to cover the roof with felting in order to resist the penetration of heavy rain. The Chinese are adepts at the art, and can erect almost any type or size of mat building in two or three days, provided there is a sufficiency of labour on the job. Such structures are strong enough to resist the ordinary climatic conditions of North China.

Stone is the most commonly used building material, and is quarried locally in slabs up to 12 feet long. It consists largely of red and grey granite, and is frequently cheaper to use than wood. The timber is all imported, and consists of Oregon pine and China fir. The former is, of course, more expensive, and good enough for most work; the

latter is badly seasoned and full of knots, but is readily obtainable at short notice, as the local contractors hold large stocks of it. Metalware, such as bolts, nuts, and water supply fittings, is entirely imported, as the local Chinese use practically no metal in their buildings.

2.—LABOUR.

Work was carried on through two term contractors, the reason for this strange situation being that one was only capable of undertaking carpenter's work, while the other was in a position to obtain water supply fittings from Chifu, up the Coast.

Neither contractor could speak, read or write English, and each one employed an English-speaking agent. One of these was unfortunately entirely ignorant of all engineering or building processes. A Chinese will make a verbal contract and as a general rule, will not go back on it, which facilitated matters, as it was possible to do much of the paper-work after the construction was over. In common with his *confrères* all over the world, he is prepared to put in inferior work if allowed to. The Chinese labourer is a cheerful and hard-working soul, and takes a pride in his work. Weather, however, easily upsets him, and as he frequently possesses only one suit of clothes, a sharp shower in the morning will often put him out of action for the rest of the day.

Masons are available in large quantities, and can undertake concrete and brickwork if required. It is noticeable that they will always hand-pack stones most carefully even when laying hard core for floors.

Carpenters are few, and as the work of all trades is carried out by hand, timber construction is slow and wants continual urging on.

Smithing is well carried out, both in iron and copper, but smiths are few. As the supply of water is entirely by well, cart and bucket, no plumbing work can be done, and all water supply fittings and experts must be brought from Chifu or Tientsin.

The supply of coolies is practically unlimited, and such labours as digging and filling can be carried out with remarkable speed.

3.—WELL BORING.

The camp site at Huai Shu Ti lay on a sandy waste between the hills and the sea, and was reached by a cart road from Port Edward, four miles away.

In six weeks, the following had to be done:

(*a*) Ascertain whether sufficient water could be obtained from a well sunk on the camp site.
(*b*) Discover what other resources could be drawn on.
(*c*) Make the necessary arrangements for the supply of water from whichever of these sources turned out to be practicable.

As the supply from the neighbouring wells was not satisfactory, as regards either quality or quantity, and as the carriage of water from Port Edward would prove very expensive, it was resolved to go on trying for water on the camp site till the last possible moment.

The following information was available:

(*a*) The remains of an old filled-in well were found on the site.

(*b*) Owing to the drought, all the water courses were dry, and the native wells throughout the Territory were getting low.

(*c*) The Chinese said the sand was 20 or 30 feet deep.

(*d*) The only boring plant available was an old jumping-bar machine at Chifu, which had been previously used in boring artesian wells near Port Edward.

(*e*) An artesian basin was said to extend under a large part of Eastern Shantung.

(*f*) There had never been a geological survey of the district.

The boring plant was ordered by telegram from Chifu on the 20th April, and arrived on the site by the 25th. On the morning of the 27th, the oil engine was started up and boring began. By the afternoon, the tube had already sunk 20 feet, and some water was brought out. By the time 30 feet had been reached, however, the water disappeared, showing it to have been merely a small surface supply, and boring was ordered to continue.

As bad luck would have it, the tool struck a slanting rock at 33 feet, and could not be persuaded to penetrate it. It was impossible to tell whether this was a tilted stratum or an isolated stone, so there was nothing to be done except lift out the whole tube and start again somewhere else, and by the 4th May the plant had been re-erected on a spot about 150 yards further along the cart road.

At 24 feet, black sand and traces of water were encountered. This was again only surface moisture, and at 50 feet the bore stood in a clay stratum with no water in it. On the 7th, water was struck at 72 feet, and rose to within 25 feet of the ground level; later this rose to 20 feet. A test indicated a small yield, however, so boring was continued down to 90 feet, where rock was met with. The clay had by this time become more sandy, and the water was very cloudy.

The contractor announced that he could bore no further. "The machine is roo-ined, you see," was his explanation. It was found that the tool had broken itself on rock, and could not be replaced within a month, so the well had to be taken as it stood.

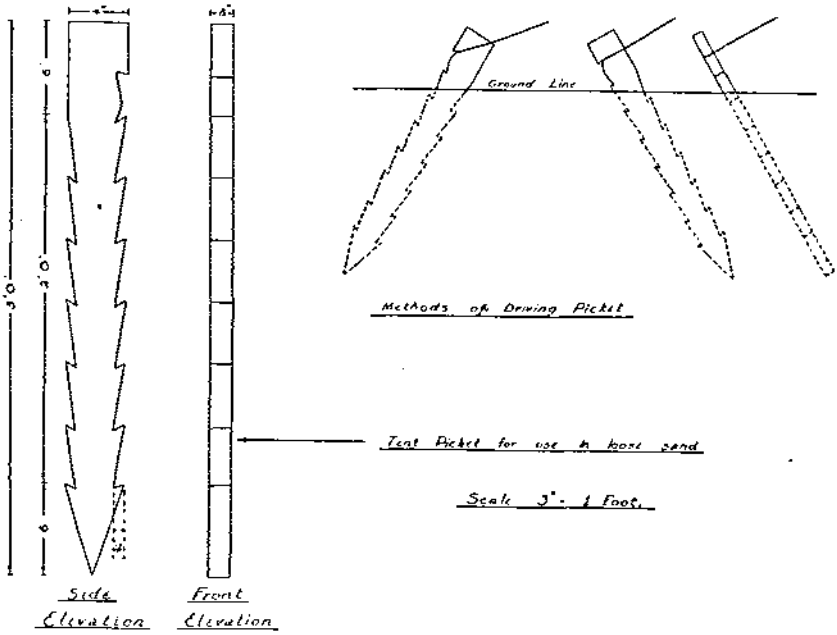
A small hand pump was obtained from Chifu by the 13th May, and coolies were set to pumping the well for several hours a day. This enlarged the water-bearing cavity at the bottom, and the yield improved slowly. At first, only 156 gallons were obtained in 2½ hours, by which time the bore was empty, and took 40 minutes to refill. Later, it was found that about 35 gallons an hour could be relied on, and by the 5th June, 800–1,000 gallons were being produced

in the 24 hours. A hand-worked beam pump was eventually sent from Tientsin, and was operated by shifts of coolies. The water was slightly coloured by suspended matter, but was good to drink.

Tribute must be paid to the Chinese crew of the boring plant. Suited, as the Chinese seem to be by nature, to tend engines and cover themselves with oil, they maintained in working order the most unreliable-looking piece of machinery that has ever been seen.

4.—HOLDFASTS.

Considerable anxiety was expressed as to whether tents could be made to stand up in the loose sand at Huai Shu Ti, and as the tent



pegs issued were obviously useless for the purpose, orders were received to devise some other means.

In the interests of economy and simplicity of use, it was evident that the normal method of pitching tents could not be interfered with, and that something which could be used in the same manner as a tent peg, but with much greater holding powers, and ability to be produced locally by hundreds, would have to be employed.

These conditions ruled out picket holdfasts, buried holdfasts, and screw pickets. A barbed picket was then considered, and two samples made. Sample No. 1 consisted of a piece of ash $2\frac{1}{2}$ in. x $2\frac{1}{2}$ in. in cross-section, each of the four edges being notched in several places. Although three feet long, a trial showed that a direct pull with one arm would easily remove it from the sand. Sample No. 2 required a strong direct pull with both arms to remove it. Sample No. 1 was rejected.

Sample No. 2 was driven into the ground in three different ways, to see which method would take the pull of the tent rope most satisfactorily: (*a*) The picket in prolongation of the line of the tent rope. (*b*) The picket at right angles to the line of the rope, with its edge towards the tent. (*c*) The picket at right angles to the line of the rope, with its face towards the tent.

As a result of tests, method (*c*) was adopted, and proved efficacious. No wind ever caused a picket to be pulled from the ground. The barbs were retained, as it was noticed that the picket moved in the direction of its length when considerable force was exerted on the tent rope.

5.—Cookhouses.

Cookhouses for officers' and serjeants' messes were required both at Tung Shan and Huai Shu Ti, and a type design was therefore evolved. The governing factors were:—(*a*) To be reasonably weatherproof. (*b*) To be cool. (*c*) To have adequate ventilation. (*d*) To be reasonably safe against fire. (*e*) To afford protection from direct rays of the sun. (*f*) The style of building not to be more costly than that for a standing camp. (*g*) To be flyproof.
Conditions (*a*) and (*d*) ruled out bamboo matting, (*b*) prohibited the use of corrugated iron, while (*f*) prevented the employment of brick or stone.

The design finally adopted entailed a double-roofed structure of half-inch boarding on a timber frame. The top roof was covered with felting, while a square opening was made in the lower one to allow the escape of hot air. Window openings (no glass) were made in each of the three sides, while a flyproof door was fixed in the fourth (leeward) side.

Shutters were provided for the windows in case of inclement weather. The window frames and the gaps between the two roofs were covered with flyproof gauze. These cookhouses were pronounced by units to be the coolest places in the camps.

6.—Rifle Range.

The site of the range having been chosen by the General Staff, the work required was divided between: (*a*) The butts. (*b*) The firing points. (*c*) The targets.

(*a*) The only possible place for the markers' gallery was behind the rampart of an old Chinese fort, as otherwise the necessary earthwork could not have been completed in the time. This, then, was the reference point which determined the positions of all the other parts of the range. The ground behind the rampart rose to a sufficient height to form a stop butt at certain ranges, but in many cases the bullet passed over it into the sea, to the imminent peril of those that went down to it in ships.

The design of the gallery and bank was adapted from that in

Small Arms Training, Vol. III, and a wooden profile was erected in a gap in the rampart, so as to indicate the extent to which additional building-up was required.

(*b*) The positions of the firing points were then selected. Two main difficulties had to be faced. One was that at certain ranges the butts lay in dead ground, necessitating the building up of an earth bank or a wooden platform in order to see the target, and the other was that some of the firing points lay in the neighbourhood of nullahs, native graves, or cultivation. Instructions had been given that the country should be disturbed as little as possible; consequently all the firing points could not be sited in a direct line with the targets.

On a certain day, while considering these problems, the writer was approached by a farmer and an interpreter, who said: "My client is a poor man, and has no occupation. He has a numerous family. He is the tenant of the land on which you build the rifle range, but he will not ask for compensation if you will let him have the swill contract." He was referred to O.C. Troops.

The 500 yards firing point almost coincided with the officers' mess, which had been erected last year, thus adding one more to the conveniences already installed.

(*c*) A means of lowering and raising targets had to be devised, as the "Hythe Pattern" frame was, of course, unobtainable and only local resources could be drawn upon.

The "windmill" method, referred to in *S.A.T., Vol. III*, was undesirable, as eight targets were required, and that system would have necessitated an undue length of gallery.

It was decided to connect the pairs of targets by cords passing over pulleys, supported at the requisite height from the ground. A trial gantry was put up, and demonstrated the system to be satisfactory, but showed the following defects:

(1) Much friction where the cords passed over the pulleys, causing the targets to stick and the cords to come off the pulleys.
(2) The target would frequently strike portions of the gantry and become wedged.

The whole secret of smooth running was found to lie in the way the pulleys were fixed. The correct method turned out to be hanging the pulleys loosely from a beam, and not to fix their axles rigidly. Triangular fenders were also screwed to the sides of the gantries to prevent the targets sticking as they went up or down. The target frames were subject to considerable stresses, especially in wind, and had to be made extra strong.

When asked to comment on the finished range, a Company Commander remarked: "Very sporting course."

1.—Revetting the bank.

2.—Improvised Target Gantry.

3.—Markers' Gallery.

4.—Firing platform at 500 yards.

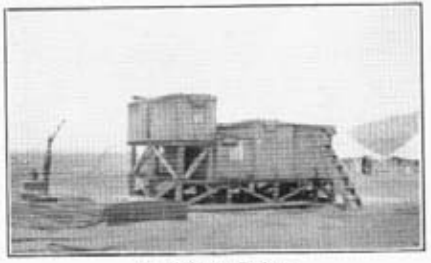
Improvisation in North China

5.—Lorry Shelter.

6.—Stables for Field Company Section, R E.

7.—Stables for Battalion, less M.G. Co.
(Writer's Chinese "charger" on the right.)

8.—Stables and Vehicle Shelter for M G Co.



9.—Water Point.

10.—Men's Cooking Shelter and Serjeants' Mess Cookhouse.

Improvisation in North China

THE DEMOLITION OF A PYRAMID.

By LIEUT. G. R. MACMEEKAN, R.E.

ABOUT 500 miles south of Khartoum, the country on both sides of the White Nile is inhabited by primitive negroid tribes, known collectively as Nuers. These tribes are at present wholly uncivilized. They are also extremely treacherous. Owing to the entire absence of communications away from the river, administration of the area has always been a problem of great difficulty, and although wonderful work has been done by a handful of isolated District Commissioners, our control over the tribes is still somewhat nominal, the real power in the land lying with various witch doctors.

Throughout 1927, it was known that there was a good deal of unrest among these savages. Various acts of insubordination were reported, culminating in open defiance of Government authority, and, towards the end of the year, it was decided that military operations should be undertaken with a view to re-establishing the prestige of the Government and giving the recalcitrant tribes a really good lesson.

At first, it was thought that punitive measures would be confined to the area east of the Nile. In December, however, Capt. T. Fergusson, District Commissioner of a large area to the west of the Nile, was treacherously murdered, and this necessitated a considerable extension of the theatre and general scope of the operation.

Actually, there were two distinct columns and, except for the formation of a common base at Malakal, their operations were in no way connected, the areas involved being widely separated, and the tribes implicated being totally different entities although all coming under the collective title of Nuer.

Those operations against the assailants of Capt. T. Fergusson were carried out on the west bank of the White Nile, and consisted mainly in drawing a cordon of troops round the swamps in which the enemy had vanished, and bombing the scattered islands on which they had collected with their cattle with aeroplanes, until their resistance was crushed and they surrendered to the cordon.

The other operations were directed against the followers of Messrs. Gwek and Pok, two Nuer witch doctors, who had a considerable local following on the east bank. Mr. Gwek had been fortunate in having a particularly successful magic season, having skilfully claimed the credit for arranging an eclipse in November, and the death of the

District Commissioner's best pony from " fly," in the same month. This greatly increased his prestige, and when he was able to persuade his adherents that the Denk-Kurs Pyramid had been emitting blue smoke, a sure sign that the days of the foreigner were numbered, he announced his intention of murdering the District Commissioner and advancing on Malakal, the Headquarters of the Province.

While his followers were thought to be reasonably few, there was always the risk that any initial success on his part might bring in the rest of his section of the Nuers, the Lau, who were reported to be able to raise 20,000 spearmen and a number of ancient muskets variously estimated at from 200 to 5,000. Accordingly, a force of one company M.I., two companies Infantry and half a platoon of the Sudanese Field Company, all native troops of the Sudan Defence Force, with four aeroplanes from the R.A.F., were sent down to deal with him.

The grand finale of the expedition was to be the destruction of the pyramid, thus destroying Gwek's last claim to importance, and demonstrating the superior magic of the Sudan Government in general and the Engineer troops in particular.

The Denk-Kurs Pyramid, erected about 50 years ago, as the tomb of a Nuer witch doctor of unusual potency, was made of mud and reputed to be 60 feet high. Nobody in recent years appears to have seen it, but a rather poor photograph was discovered in an ancient number of *Sudan Notes and Records* (the photograph, by the way, was taken by the late Lt.-Col. Hugh Pearson, R.E.) from which it appeared that the diameter of the base was about twice the height.

The problem of blowing it up proceeded to cause much deep thought on the part of all concerned. The text-books preserved a strong silence on the subject of pyramids; the only useful information to be obtained was that gelignite was a most unsuitable explosive for the job, and gelignite naturally was the only explosive available in the country. The only help or sympathy received from the staff was a lurid picture of the consequences which would result from failure, when the assembled Nuer chiefs, called to witness the destruction of their holy hill by the superior magic of the Government, saw it still standing placidly as before.

Accordingly, it was decided that some sort of experiments must be made. A mud pyramid, 6 feet high, with 12 feet square base, was made in Omdurman, one foot height being laid per day to give the mud a chance to dry, this being roughly to a scale of 1/10th. Much poring over a cross section of the alleged shape of the pyramid, and treating it variously as an undercharged mine, an overcharged mine, a brick wall 35 feet thick, a bridge pier 60 feet thick, and various other ways, and putting in odd corrections for the probable effect of gelignite in highly fissured earth, produced an answer of 900 lb. for the actual pyramid. As all formulæ seemed at some points to bring

in L.L.R[2], it seemed that 9 lb. would be the right amount for the 1/10th scale model.

Accordingly, a charge of 9 lb. was placed on the centre line of the pyramid one foot from the ground level (a shaft had been left for the purpose), the shaft securely tamped, and the charge touched off. The result was most gratifying; one of the more senior spectators was partially stunned by a lump of mud at a range of 105 yards, the remainder of the spectators fled in confusion, and nothing was left of the pyramid but a large hole in the ground.

As, however, it was of the utmost importance from the point of view of impressing the enemy, that there should be no danger of the real charge acting as a *camouflet* and shaking the pyramid down rather than blowing it up, it was decided to double the charge for the actual operation. A second model pyramid, built rather more slowly and tested with an 18-lb. charge, produced the same result.

Accordingly, the actual charge was settled at 1,600 lb. of gelignite and 250 lb. of guncotton, the latter being a consignment which had come into the country by mistake, and which had for the past three years been causing the maximum of annoyance to all concerned by its habit of going dry and having to be re-wetted.

To deal with the pyramid itself, if the charge were placed 10 feet above ground level, a tunnel about 60 feet long would be required. Naturally, neither the equipment nor training of the Sudanese Field Company had ever envisaged mining, though all the men were trained in handling the explosive for road-making and well-sinking purposes. All equipment, therefore, such as miners' picks, trolleys, an electric lighting set (the accumulator to be charged by the wireless set accompanying the column) and a ventilating plant, contrived from a field forge and some standard delivery hose, had to be made up locally and sent down, together with a mile of copper telegraph wire and some porcelain insulators, to enable the firing party to get well away.

It was fortunate that, although finally the troops moved at only 18 hours' notice, there was ample warning to have things ready to blow up the pyramid when required.

The early stages of the advance from the river base gave some useful opportunities for construction of flying bridges, rafts being made of petrol tins to supplement the collapsible 24-man raft which forms part of the equipment of a sapper platoon in that sort of country, and which was left at the worst crossing. Later, while the ground troops were scouring the country in search of the enemy, the various *khors* dried up, and a M.T. road was then pushed through to a point about 30 miles from the pyramid. The operation of road-making consisted chiefly of clearing the grass and bush and towing an American grader over the cracked cotton soil at the tail of a lorry. The blacksmiths of the platoon were heavily employed on repairs to

the grader, as the manipulation of the knives on the latter needed considerable practice, and when a 6-wheel Thornycroft lorry made up its mind to go forwards, no protests on the part of the grader, whose knives might have met a rock or a tree stump, were of any avail. The grader proved very successful, but it is worthy of note that a considerable amount of practice is necessary in operating these machines if disaster to the knives is to be avoided.

When finally it was decided that the pyramid should be tackled, the Platoon moved there with an escort of one company (100 men), as it was hoped that the news that the Government was actually working on the pyramid would inspire Mr. Gwek to make an effort to save it. Half of this escort went off at once to guard the only water supply, 15 miles away, whence convoys came in every other day with a supply of 1½ gallons per man per day, no large amount for men working underground with the temperature up to 105°F. daily, and no shade other than their blankets and ground sheets. There was one tree, but that was occupied by the unexpired portion of the water ration, and its guard. There was, therefore, considerable relief all round when it was found that the gallery could be dug without any timber lining, thus halving the time involved.

Naturally enough, no Sudanese soldier had ever heard of a mine before (the subsoil at Headquarters in Omdurman being all rocks, it had not been possible to practise any of the men before starting off), though well-sinking had given them some practice in working in a confined space. Fortunately, they were immensely interested in the forthcoming explosion, and worked with amazing energy. The length of the gallery was 62 feet, and, working continuous shifts, four hours on and eight hours off, this was completed in exactly 62 hours' work. This, in spite of the fact that some enthusiastic miners excavated a gallery big enough to pass a laden pack-mule, while others wandered off in all sorts of queer directions, if not constantly watched. The last shift of seven men at the extreme end of the gallery excavated 72 cubic feet in a four hours' shift, without changing the man working on the face; this in an average temperature of 95°, and on a limited water ration.

The charge chamber was cut at right angles to the end of the gallery, to avoid risk of blowing out the tamping. Six 50-lb. boxes of gelignite were left intact, with only their lids removed, with the idea that they might explode instead of detonating, thus increasing the lifting effect, while the remainder were unpacked, and the sticks stacked in solid, together with the guncotton. Two independent firing circuits were put in, each having 3 detonators in gelignite and 1 in guncotton. In his relief at the completion of this task (the Sudanese treat explosives and detonators with cheerful familiarity), the sapper officer stole the whole of one man's water ration and had a bath in it.

Work having proceeded well ahead of schedule, the opportunity was taken to tamp the whole gallery to the mouth while waiting for the spectators to arrive.

Finally, on the morning of February 8th, the spectators, consisting of all the troops who could get there, the District Commissioner and 34 Nuer chiefs of varying degree, with their followers, were assembled three-quarters of a mile from the pyramid, the District Commissioner harangued the assembly, explained that the magic of Mr. Gwek was powerless against the magic of the Government, pointed the obvious moral and announced that he had only to lift his hand for their sacred pyramid to dissolve in a cloud of dust. The late enemy were extremely subdued and rather nervous—the sapper officer was also somewhat subdued and extremely nervous. At last, the District Commissioner raised his hand, a concealed sapper trod on the exploder, and a vast cloud of dust where the pyramid had been, caused one man at least to cease feeling nervous and subdued.

Actually, although the pyramid was completely wrecked, there were two rather disappointing features. One was that, presumably due to a strong cross-wind, the explosion was almost inaudible at the firing point; the second, was that the explosion, instead of spreading the pyramid all over the surrounding country, sent it almost straight into the air, hardly anything of any size falling more than 50 yards away. The charge blew upwards and outwards at an angle of about 15 degrees to the horizontal, leaving an irregular crater wall about 15 feet high, which was partially filled up by the falling debris. The probable explanation for the charge failing to act like those in the model pyramids is that, in the course of years, the rains had washed the mud down from the sides of the pyramid, and deposited it round the base, with the result that the bottom 15 feet, instead of having the same slope as the remainder, and as appeared in the ancient photograph, had flattened out to about 25 degrees, and consequently the base at ground level was a great deal thicker than had been allowed for.

Like all natives, the spectators very soon recovered from their fright, and within a very few minutes were swarming over the debris, with shouts of delight, hooting with laughter when anyone asked what they thought of Gwek's magic now. The British members of the party swarmed over the debris, too, hoping to find some of the ivory which was said to have been buried there (one English paper went so far as to describe the pyramid as built of mud and ivory), but beyond a number of decayed and crumbling tusks near the altar, at the foot of the pyramid, there was nothing to be seen, nor were any other curios found.

IMPACT.

By LIEUT.-COL. L. E. HOPKINS D.S.O., O.B.E., R.E. (*retd.*).

THE coefficient of impact for railway bridges is an empirical allowance to provide for the extra stress or deflection produced in an iron or steel girder by a moving load, compared with the same load when stationary. It has, for many years, been a popular subject for investigation and controversy.

The impact coefficient does not provide for centrifugal forces or longitudinal forces or secondary stresses, which theoretically might be included in the above definition. Such forces can be calculated with reasonable accuracy. It is the vibration of the beam or girder, producing deflections over and above the static deflection, and the relation between the forces which causes the vibration and the effects, which have given rise to such long controversy.

From about 1870 onward, the usual practice was to double the live load stresses, and add them to the dead load stresses, and allow 8 tons per square inch for steel. The Board of Trade rules, down to 1923, merely provided that stresses should not exceed 6½ tons per square inch, without any allowance for impact, but in practice, stresses were calculated by doubling the live load stress.

At the close of last century, the American Bridge Company introduced the Pencoyd formula :

$$I = \frac{300}{300+L}$$

I = percentage to be added for live load ; where L is the loaded length of girder for the maximum stress in the member under consideration.

This formula was very largely used down to 1923, when the British Engineering Standards Association introduced the formula :

$$I = \frac{120}{90+L}$$

where I is the percentage increase for live load stresses, *i.e.*, for 30-span, the stresses were to be doubled, and for 150 feet span the increase was 50 per cent., where the whole girder was carrying a live load.

In 1908, the American Railway Engineers' Association had carried out a large number of tests of girders under moving train loads, and these had confirmed the theories of Professor Turneaure and others, that the added deflection produced by live loads was due to the vibration of the girder. This vibration was not due to the

rapidity in application of the load, nor to inequalities or imperfections in the track or the locomotives to any great extent. The principal cause of the vibration in the case of railway bridges of 30 feet span and over, was what is commonly known as the hammer blow of the balance weight on the engine driving wheels.

Unfortunately, theory could not be reconciled with the results of tests in practice, and although the Americans recommended the use of a new formula, practically the old Pencoyd formula was not superseded. In India, it was decided to make further investigations before scrapping the Pencoyd formula.

The object of all these investigations was not merely a thirst for academic knowledge. It was desired to reduce the cost of girder work.

For instance, the stresses in the lower boom of a 150 feet span Pratt Truss, may be:

Dead load, 91,700 lb.
Live load, 227,500 lb.

If the live load is doubled, the cross-section of steel required is 30 square inches for a stress of 18,000 lb. per square inch. If the live load is increased by the Canadian formula:

$$I = \frac{L2}{L + D}$$

where L is live load,
,, D is dead load

and 16,000 per square inch permitted, according to Canadian practice, the area required is again about 30 square inches.

If the Pencoyd formula is used the live load must be increased 66 per cent., and the area required for 18,000 per square inch is 26 square inches only. If the new B.E.S.A. formula is used, the impact is 50 per cent., and the new Indian formula, $\frac{65}{45+L}$ reduces the impact allowance to 33 per cent., and the area of the cross-section is reduced to 22 square inches. Approximately, this means a saving of nearly 27 per cent. in the amount of steel for a new girder. In the case of an old girder, the load which can be permitted to cross the bridge can be largely increased, and the life of the girder prolonged, and the cost of renewal postponed.

The importance of the whole subject can, therefore, be easily understood, if economy of management is given proper consideration.

In 1917, the Indian Bridge Committee commenced its new investigations. Large numbers of new tests were carried out, and abstruse mathematical calculations were followed up, but by 1924 the practical conclusion of the Committee was that no reduction of the impact factor was possible, and recommended further investigations and experiments. The view of the Railway Board

now was that if the experiments already made could not solve the difficulty, it never would be solved, and the Committee was dissolved by Sir Danvers Waghorn, then President.

Meantime, there was a growing conviction among all bridge engineers in India, that higher loads could be permitted over their bridges, and the need for economy in renewals pressed their views to the front.

The new Chief Commissioner, Sir Clement Hindley, was anxious to arrive at some conclusion, and when I joined the Board and promised him results in a few months, he decided to assemble a new committee of practical bridge engineers, to see what could be done.

The solution of the difficulty was really very simple, and had occurred to me one day while crossing the Jumna Bridge, at Delhi.

This is a series of 300-foot girders, carrying the railway on the top, and the roadway on the bottom boom.

Driving across the bridge, I noticed that an *ekka* (native pony cart) which, standing, could cause no deflection, actually when trotting across caused very considerable vibration. In other words, the ratio between the added vibration and the standing deflection must have been enormous.

It immediately occurred to me that impact coefficients obtained when the load on the bridge was small, could not possibly apply to cases where the bridge was fully loaded, and that if one were to run an engine across a bridge with the smallest possible loading, it would produce vibrations which would have no application to the case of the fully-loaded bridge.

This elementary principle could be found in the existing mathematical formulæ, which it had been found difficult to reconcile with the tests results.

In all these formulæ, the added deflection is shown to vary inversely as the static deflection and the total load.

Consequently, the percentage of added deflection arrived at by experiment, with small loads, could not be applied to calculate the effect of impact on a fully-loaded bridge.

Working on this principle, the Committee were able within a year to reconcile the tests with the mathematical theory, and the formula they recommended has now been adopted by the Indian Railway Engineers Conference.

$$I = \frac{65}{45+L} \text{ (For modern designs)}$$

where I is the percentage by which the live load stresses are to be increased,

,, L is the loaded length of the bridge when the member under consideration is fully stressed.

For old-fashioned shallow girders, a lower factor would be sufficient.

In adopting this formula, Indian Engineers are enabled to design

their bridge work with confidence that they are nearer to the truth than either American or English engineers.

German engineers have already adopted a formula which gives slightly lower results than our new Indian formula.

In short spans, where impact is mainly a question of imperfections of track, bad joints, bad approaches, imperfectly bedded girders, defects which are difficult to avoid in the maintenance of tracks over small girder bridges, the formula gives factors in excess of 100 per cent. It is thought by many that 100 per cent. is sufficient, but there is no doubt that with bad maintenance, much higher factors can be needed. The Committee, however, recommend 100 per cent. as a maximum, relying on the factor of safety to take care of anything worse than that, and influenced by the cost of strengthening the enormous number of small bridges, which might be affected.

Obviously, if the locomotive balance weights are the main cause of impact on railway bridges, the first thing to do was to reduce the cause or get rid of it entirely. I endeavoured to induce the locomotive designers to adopt the four-cylinder engine which would eliminate the need for balancing, or in the case of two-cylinder engines to reduce the weight of the reciprocating parts by the use of high tension steel.

The weight of reciprocating parts is usually about $\frac{1}{10}$ of the weight of the engine, but this can be reduced to $\frac{1}{14}$ by the use of special steel.

I did not meet with much encouragement at the time, but I understand that these views are gaining ground, and likely to be adopted. But, of course, large numbers of older locomotives will remain in use. But the point is, that when heavier locomotives are required, they can be run over existing bridges by designing them with four cylinders or less over-balance, and in this way largely eliminating vibration.

It was necessary, however, to tie the locomotive engineers down to some limit in their methods of balancing locomotives, and the Committee laid down that the ratio for the heaviest loading

$$\frac{Mr}{C} \text{ should not exceed } 830,$$

where M is the weight of balanced portions of the reciprocating parts on one side of the engine in lb.,

„ r=the radius of crank in inches,

„ C=circumference of drivers in feet.

An influential Committee has been working on the whole subject in England for some years, and I understand their report is about to be issued. It will be interesting to see to what extent they agree with the work of the Indian Committee.

Further information on this subject can be obtained in *Technical Paper, No. 247, Railway Board,* published by the Government of India, Central Publication Branch, Calcutta, 1906.

WELLINGTON COLLEGE FOOTBRIDGE.

By LIEUT. E. H. IEVERS, R.E.

THE erection of a permanent bridge over a railway does not often fall to the lot of a Field Company in peace time, but the 38th Field Company at Aldershot was fortunate enough to secure such a task, during its 1928 Fieldworks Course, in the erection of a steel footbridge over the Southern Railway at Wellington College. It is thought that a description of the work may be of interest, especially to Old Wellingtonians in the Corps, and that mention of how various small problems were tackled may be useful to anyone who has to undertake similar work without previous experience.

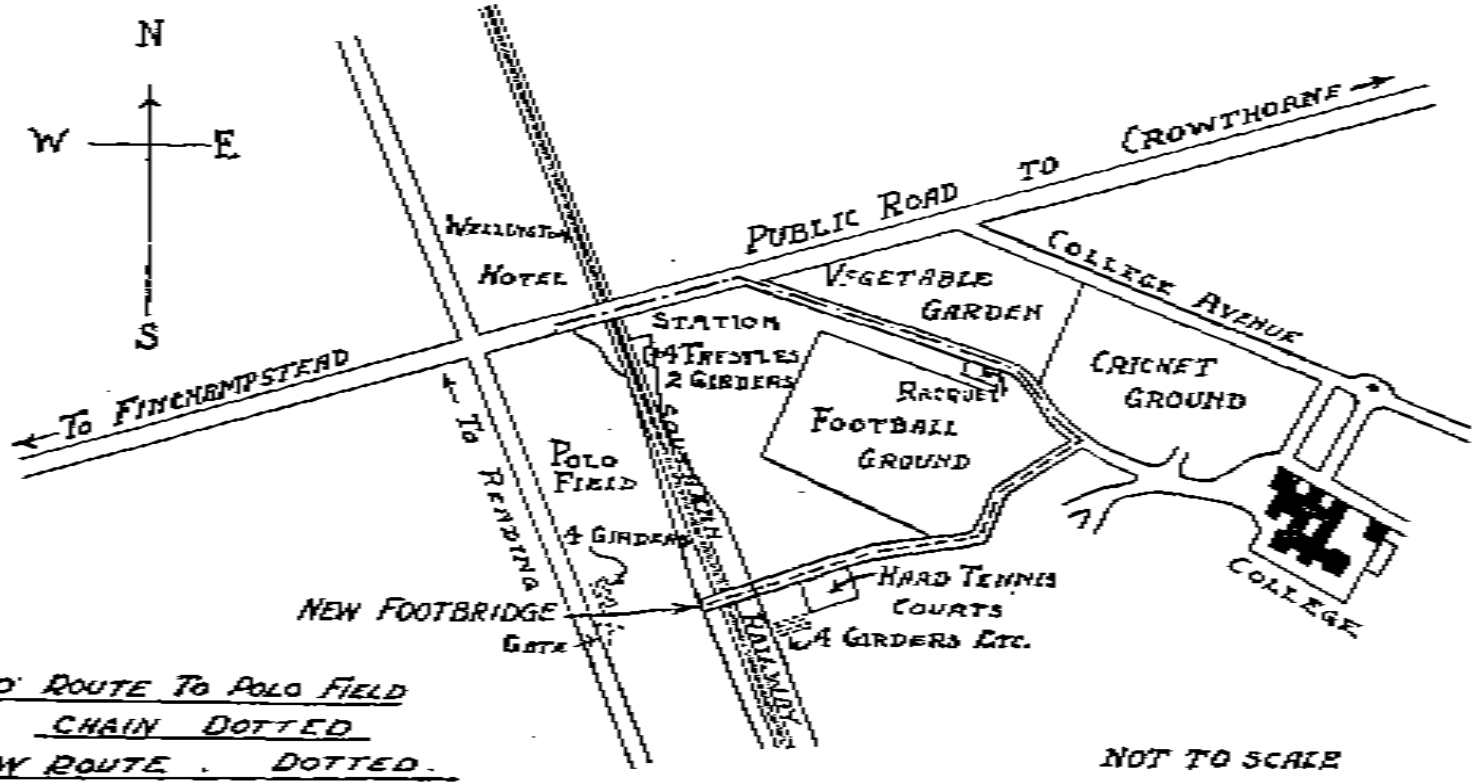
In 1926, the Wellington College authorities purchased the large Polo field, on the west side of the railway, in order to provide additional recreation grounds. It was a long way round from the College to the south end of the Polo field, by way of the existing road-bridge at the station, and, consequently, it was proposed to build a footbridge over the line in the position shown on the map. After much delay, a design was approved by the Southern Railway, an order placed with the Furness Shipbuilding Company, and the steelwork delivered.

As the result of a suggestion by an Old Wellingtonian, that the bridge should be put up by the R.E., the task of erection, except for the centre span, was eventually given to the 38th Field Company. The Railway Company insisted on erecting the centre span themselves.

Owing to the fact that the bridge was over a railway, the steelwork was very much heavier than would be expected for a mere footbridge. The roadway, of 4″ concrete slabs, was to be carried on two I-beams, each 20″ × 6½″, and weighing 65 lb. per foot run. These were to be supported on steel trestles—weighing about 1,750 lb. each—bolted down to fairly large concrete bases.

The railway at the site runs in a cutting nearly three times as wide as necessary to accommodate the double line of metals. The bottom of the cutting, on both sides of the railway, was undrained and marshy. The centre span of the bridge had to be 40 feet, and there were four other spans, each of 28′ 9″, making the total length of the bridge 155 feet.

The diary which follows shows the progress of the work. It will be seen that the concreting was done in under four days, that the



WELLINGTON COLLEGE BOOKPLATE

concrete was given a clear fortnight to set before erection began, and that the Field Company's share of the erection was done in four days. The party, shown as forty other ranks, varied from day to day between 35 and 45. It included a proportion of N.C.O.s, and also a cook and assistant, who provided dinners on the site. The men had breakfasts and teas in barracks, and went to the job daily in two 3-ton lorries. Though the party paraded in barracks at 8 a.m., owing to the time spent in transit between Aldershot and Wellington College, and the lunch hour, only about 5½ hours per diem were actually spent at work.

DIARY.

Date.	*Party.*	*Task.*
10th April	2 Officers, 2 College Workmen	Made section of gap with Dumpy Level. Dug test pits.
Wed., 25th April	2 Officers, 2 Sappers	Laid out centre line and taped out foundations ready for excavation.
Thurs.,26th, and Fri., 27th	1 Officer, 40 O.R.s	Drained site, excavated for foundations. Placed shuttering in position, erected store tent. Dug and revetted steps into sides of the cutting.
Mon., 30th April	1 Officer, 40 O.R.s	Laid water supply. Prepared bankers and chutes. Began concreting.
Tues., May 1st, May 3rd (Thurs.) May 4th (Fri.)	1 Officer, 40 O.R.s	3½ days concreting.
May 5th (Sat.), to May 14th	4 Sappers	Went to site daily on bicycles. Struck all shuttering and floated off the tops of concrete bases.
17th (Thurs.), 18th (Fri.)	1 Officer, 40 O.R.s	Laid Decauville across Polo field. Moved two girders up to site. Began preparation of derrick. (Rained both days.)
May 20th (Sun.)		Southern Railway Company erected centre span. Two trestles and two girders, with cross-bracing.
21st (Mon.)	1 Officer, 40 O.R.s	Erected derrick, then one trestle and both girders of first bay. Fixed ballast plate, handrail standards and cross-bracing.
22nd (Tues.)	1 Officer, 40 O.R.s	(Late starting work, owing to lack of transport.) Launched one girder of second bay, and moved the other up ready for launching.
23rd (Wed.)	1 Officer, 40 O.R.s	Launched second girder of second bay. Moved derrick and erected trestle at College side of the bridge.
24th (Thurs.)	1 Officer, 40 O.R.s	Launched all four girders at College side. Fixed ballast plate, handrail standards, etc.
25th (Fri.)	1 Officer, 40 O.R.s	Removed derrick, completed cross-bracing, tidied up site and evacuated. (2 hours' work only.)

Setting Out.

The four concrete bases for the trestles were designed to be 12 feet long and 4 feet wide, and the first matter to be decided was their depth. Test pits were therefore dug: as a result of which, it was proposed that the foundations should be 2 feet below the lowest ground level. This meant that the bases had to be 4 feet deep altogether, in order that the bridge should have the necessary clearance of 15′ 3″ above the permanent way. It was decided to make the abutments at the top of the banks 4′ 6″ deep, on account of the rather loose sandy nature of the sides of the cutting. Eventually, however, the trestle bases were made 4′ 6″ deep and the abutments 5′ 6″ deep, in order to satisfy the Railway Company.

The centre line was laid out at right angles to the railway by theodolite. A stout peg was driven into the ballast in the middle between the two lines of railway, and a post driven in rear of each abutment. The centre line was marked accurately on each of these by a nail. The theodolite could then be set up over either of the posts for checking the centre line without having to worry about when the next train was due.

The marking-out of the positions of the four trestle bases was straightforward, as they could be measured direct from the centre peg. This was not the case with the abutments, as these were at a higher level and 150 feet apart in the clear. In order to locate them, a distance equal to half this span was measured along the railway from the centre peg. At the end of this the theodolite was set up, and an angle of 45 degrees laid out on each side of the railway. Intersections were thus obtained on the centre line of the bridge, which fixed the positions of the two abutments. A steel tape was used for all horizontal measurements, the same tape being employed throughout.

Two pairs of pickets were driven in on each side of the trestle bases, and slats were nailed across each pair so that the tops of the slats were at the level of the tops of the finished bases. These slats were also used for marking the two lines of holding-down bolts.

Concreting.

Concreting was carried out on both sides of the railway simultaneously—two separate working parties being employed. Ballast and cement were delivered as required, close to each abutment, under College arrangements. Bankers, for mixing the concrete on, were placed at the foot of the cutting on both sides, and the materials run down to them by chutes. A piped water supply was laid on to each banker from a 400-gallon tank, on the top of the cutting on the College side. This tank was filled through fire hose from a hydrant about 400 yards away.

The proportions of concrete used were one of cement and six of ballast. The latter was naturally graded and of good quality, and no sand was required with it. The total volume of the concrete was 1,300 cubic feet, and it was laid in 18 working hours. Hence, the average rate of laying was 72 cubic feet per hour. As sufficient men were available, namely, about 17 each side, the rate of work was limited almost entirely by the size of the bankers. These were each 18′ × 8′. One-third of each was taken up with the ballast and bags of cement which came down the chute, the middle was used for gauging up the proportions and mixing them dry, and the remainder for wet mixing. As soon as one batch was mixed, it had to be taken

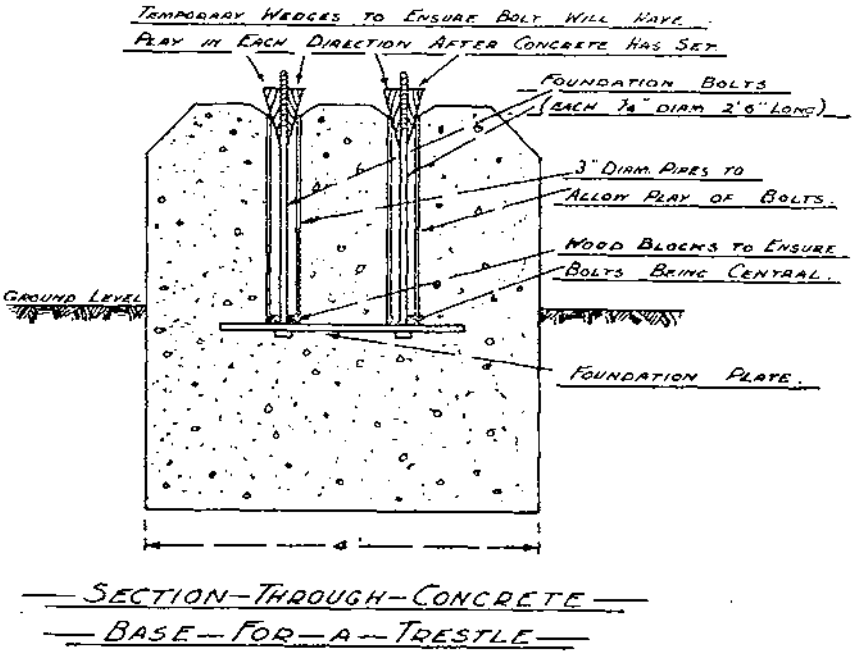


FIG. 1.

away before there was room to mix the next. Thus, half the time the "mixing" men were waiting for the wheelbarrow men to "clear the decks," and the rest of the time the wheelbarrow men were waiting for something to barrow. The rate of concreting could have been nearly doubled if the bankers had been twice as large. There would then have been room on each banker for one batch to be mixed dry, while the next was being gauged up, and for one batch to be mixed wet while the previous one was being barrowed away.

The other source of delay in concreting was the accurate placing of the foundation bolts and plates. There was a pair of bolts and a foundation plate to hold down each foot of each of the four trestles. Owing to their size, it was not practicable to leave holes in the con-

crete, so that the bolts and plates could be put in position with the rest of the steelwork and grouted in afterwards. It was impossible to fix them absolutely accurately in a mass of wet concrete, and in order to ensure that the feet of the trestles would fit over the bolts, it was essential to provide for a little movement of these during erection. This was arranged by placing lengths of pipe, of 3″ diameter, round the bolts, as shown in Fig. 1. Channels were left on the surface of the concrete to enable the pieces of pipe to be grouted with cement after the trestles were erected.

There were no holding-down bolts in the abutments, but, in the end, handrail standards had to be let into the concrete for a depth of one foot. Slots 15″ × 6″ were left in the concrete for this purpose. The timber casing used for forming slots such as these in concrete should be tapered, well soaked, and finally greased on the outside to facilitate removal. It should not be nailed together, but tied round the outside with string, while the sides are kept apart by distance pieces. The removal of the latter will then allow the casing to collapse inwards when it is required to take it out.

Erection of Steelwork.

The positions in which the steelwork had been dumped are shown dotted on the map. Chiefly with the object of giving the Company some practice in laying Decauville track, it was decided to lay a line across the Polo field, on which the girders for that side of the bridge, and heavy stores brought out from barracks, could be moved up to the site. The girders weighed 65 lb. per foot run, and as it was possible to get men lifting on both sides, they were put on the truck by hand.

Little need be said about the method of erection, as this is illustrated in Figs. 2 to 8, and also in Photos 2 to 6.

When the Railway Company came to erect the centre span, they also brought down the two outer trestles from the station, and dumped them on the site for us. The crane they used had a 40-foot jib, and a safe working load of 20 tons; consequently, their part of the erection was simple, and soon completed.

We began work from the Polo field side and used one 30-foot derrick with its foot placed between the first two trestle bases, at a distance of one-quarter of the span from the centre of the one next the abutment. In this position it was used (*i*) to erect the trestle; (*ii*) to haul out the first two girders, in conjunction with the preventer tackle; (*iii*) to swing the next two girders into position in the second bay.

Each of the first two girders was launched on the centre line of the bridge, and the tail was lifted off the launching roller and moved into position, with a lifting and traversing jack. After the first bay

Fig 2. ERECTING 30 FOOT DERRICK.

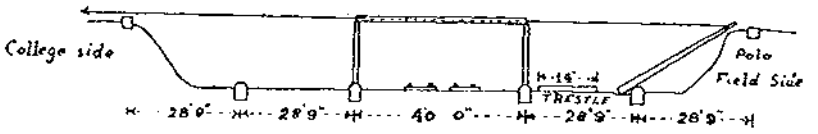


Fig 3. ERECTING TRESTLE

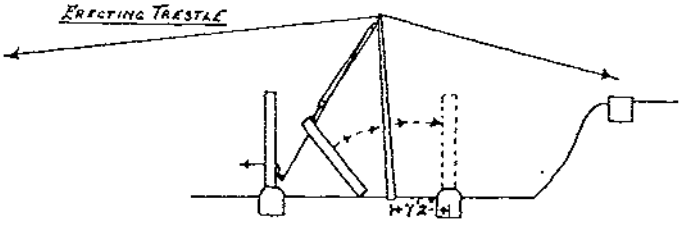


Fig 4. HAULING OUT A GIRDER FOR 1ST BAY.

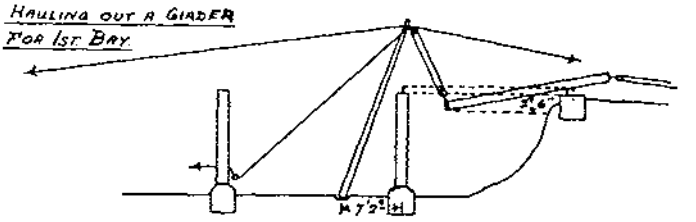
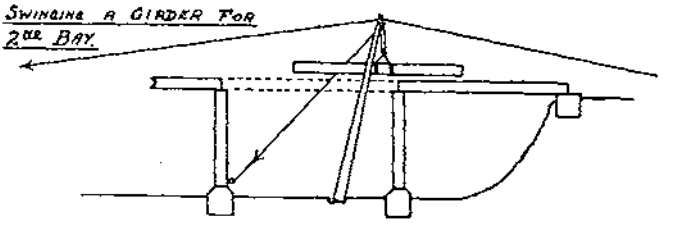


Fig 5. SWINGING A GIRDER FOR 2ND BAY.



HOISTING UP DERRICK BETWEEN GIRDERS

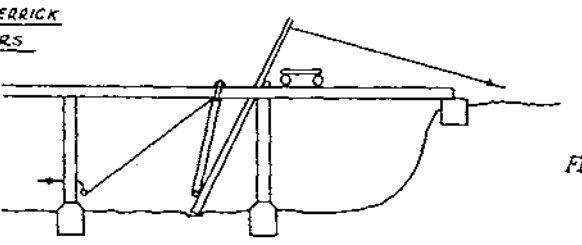


Fig 6.

LAUNCHING DERRICK OFF END OF BRIDGE INTO NEW FOOTING.

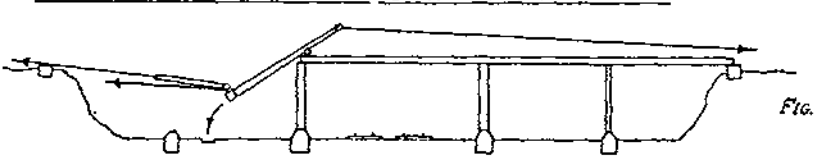


Fig 7.

LOWERING LAST GIRDER INTO POSITION

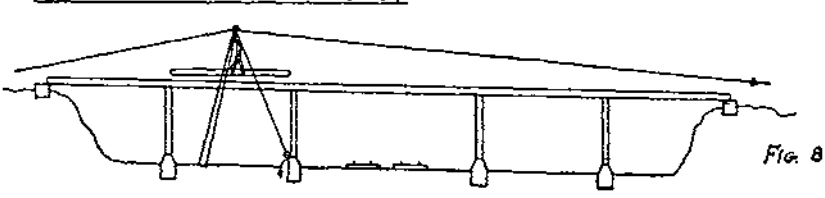


Fig 8.

was completed with cross-bracing, ballast plate and handrail standards, Decauville track was laid on top. Each girder for the next bay was then run out over the first bay and swung into position.

Before the second girder could be slung, the top block of the lifting tackle had to be unlashed from one side of the derrick and lashed on to the other side, which caused some delay. This was avoided when working on the College side of the bridge by having a S.W.R. strop lashed over the head of the derrick, as seen in Photo 4. This enabled the tackle to be removed from one side of the derrick and hooked on to the other very quickly.

A long chain sling was borrowed from the Stationmaster and used throughout the erection. This was very much more convenient than a S.W.R. one would have been. It could be passed round the head of a trestle or round a girder without the trouble of putting in packing, in order to round off the sharp bends. Had they been available, two separate chain slings would have been ideal, each sling being 6 feet long; since the use of a single long sling with the girders necessitated distance pieces, as seen in Photo 3, to keep the two branches of the sling apart.

After the four girders on the Polo field side of the bridge had been bolted into position, the side guys of the derrick were removed, and it was pulled up between the girders, as shown in Fig. 6. When the erection of the second bay was complete, the Decauville line over the first bay was continued to the end of the bridge. The derrick was then moved across and launched straight into its new footing (Fig. 7).

The erection of the College side of the bridge was similar to the other, but as a result of the previous experience, there were no delays. All four girders were put into position on the same day; and the derrick and all stores were removed, and the whole site tidied up in a couple of hours on the next morning. The painting of the bridge, and the laying of the roadway of concrete slabs were done by the College workmen subsequently.

While the erection was in progress, spare sappers were employed in banking up earth round and between the concrete bases and digging protective drains. This has resulted in the ground round the foundations becoming dry and firm.

Owing to the marshy ground, it was essential to have a bearing plate under the foot of the derrick, and a strong box-footing was made. This was held in place by pickets driven in round it. To enable the men on the fall to pull along the bank beside the line, which was the only dry place, the leading block was not lashed to the foot of the derrick as usual, but fastened to the base of the trestle already erected next to the railway. This also enabled footropes on the derrick to be dispensed with, as the pickets round the footing were quite sufficient to take the small horizontal stress. When

moving the derrick, the pickets round the footing were pulled straight out by means of the main lifting tackle.

In the design of the steelwork, no allowance was made for expansion and the girders butted tightly together where they met over the trestles. It was thought advisable to leave room for expansion at one end of the bridge at least, and accordingly clearance was left in the slots for the handrail standards at the College end. These spaces were unfortunately filled in by the College workmen when laying the roadway and concrete steps; and although the expansion for a 50 degrees (Fahr.) rise of temperature works out at only about half an inch, it was nevertheless sufficient to force the steps that amount back from the end roadway slab of the bridge.

CONCLUSION.

For various reasons, the erection of this bridge provided an excellent task for a Field Company. Firstly, all materials required were supplied at the site by the College Clerk of Works. Consequently, no days allotted for training were spent in collecting materials, transporting them to the site, and dismantling and returning them to store afterwards, as is usual in barracks. Secondly, the work afforded the opportunity of employing an exceptionally large proportion of sappers at their trades. Carpenters were wanted for making the shuttering, masons and bricklayers were employed on the concreting, plumbers laid on the water supply, and the fitters did the bolting together of the steelwork. The blacksmiths also had their turn when a special launching roller, suitable for the girders, was required. Thirdly, it was a novelty for many of the Company to see a derrick put to real practical use, and all gained some experience in the use of tackles, anchorages, strops, slings and so on.

The chief merit of the work, however, apart from the practical training afforded, was the satisfaction which all ranks could feel in knowing that they were building something which was to last, instead of something—as normally in a fieldworks course—to be dismantled the following day. The result was that a really live interest was shown by all ranks.

1.—Ready for erection of steel work.

[Men in this photo belong to Southern Railway Co., and are replacing overhead telephone wires by cables.]

2. Putting first trestle in position.

3.—Lowering a girder into position.

Wellington College Footbridge

Maj Gen Sir Gerard Heath KCMG CB DSO

MEMOIR.

MAJOR-GENERAL SIR GERARD MOORE HEATH, K.C.M.G., C.B., D.S.O.

MAJOR-GENERAL SIR GERARD HEATH died at Mentone on January 9th, 1929. His health had broken down immediately after the end of the War, and had always been a matter of anxiety, although with his usual courage he still " carried on " to the best of his physical strength. It was, in fact, as a result of trying that strength too far that he was ordered immediately to the South of France, and he arrived at Mentone on Christmas Eve, 1928.

Sir Gerard was the youngest son of the late Admiral Sir Leopold Heath, K.C.B., *J.P.*, of Anstie Grange, Holmwood, and a brother of Major-General F. C. Heath-Caldwell, C.B., late R.E., who, among other appointments, held those of A.A.G. R.E., and Inspector of R.E. He was born at Anstie Grange on June 7th, 1863. He obtained his Commission in the Royal Engineers on February 22nd, 1882, being by some months the youngest of his batch.

On leaving the S.M.E. in June, 1884, he joined the 1st Divn. Telegraph Battalion at Aldershot, and at the end of January, 1885, went with a detachment of it on the Bechuanaland Expedition under Major-General Sir Charles Warren.

After nearly a year's absence he rejoined the Telegraphs at Aldershot and remained with them till he went to India in November, 1887, serving with the Bengal Sappers and Miners at Roorkee.

He joined the Staff College, Camberley, in January, 1891, and remained there for the prescribed two years. After a short spell in the I.G.F.'s office and at Aldershot, he returned to India in the autumn of 1893, rejoining the Bengal Sappers and Miners. He served with them in command of the Pontoon Section with the Chitral Relief Force, 1895, being employed in bridging the Swat River and other smaller rivers, and remained in charge of bridges and the control of the traffic over them. In connection with this, General Sir Bindon Blood, who was Chief Staff Officer in this campaign, writes :—

" The construction and maintenance of the bridge over the Swat in 1895 was one of the best bridging performances ever carried out by the R.E. on active service. The Swat River is a torrent when it is in flood in the summer, and, if I remember aright, the current in 1895 went up to nine miles per hour, while the bed consisted of rock with loose boulders of all sorts and sizes, so that the anchorage of the pontoons used (doubled end-to-end) was an aerial wire rope. My recollection is that the bridge was maintained for some months,

until it was replaced by a more permanent structure, in such a manner that our communications, which depended upon it, were never seriously interrupted. Our Corps somehow never made enough of the bridging in the Chitral Expedition, especially the Swat Bridge and the two over the Panj-Kora."

Captain Heath was mentioned in dispatches with others as "having brought the greatest credit on the Corps to which they belong."

He came home in June, 1896, and commanded the Balloon Section at Aldershot till September, 1899, when he proceeded with it to South Africa.

An officer who was then at Aldershot, but did not come closely in contact with him, writes:—

"I always looked up to him as a real gentleman. . . . He had a fairly tough time commanding the Balloon Section, as it was the Cinderella of the Troops and Companies, and the Powers-that-were had a down on it, but his tact and good temper always turned away wrath."

Being ordered, at the outbreak of the South African War, to join Sir George White's Command at Ladysmith, he was present with the balloon at the battle of Lombard's Kop, after which he was shut up in Ladysmith during its siege by the Boers. For his services he was mentioned in Sir G. White's dispatches.

After the Relief of Ladysmith in February, 1900, Major Heath, having no further use for the balloons, obtained permission to convert the Section into a troop of mounted Sappers, for work with Lord Dundonald's mounted Brigade under Sir Redvers Buller.

Advancing with that force through Natal and the Transvaal, he was present at the action of Laing's Nek, and round Belfast and at many minor skirmishes, being mentioned in dispatches by Sir R. Buller and being awarded the Distinguished Service Order.

At the close of 1900, he joined General Alderson's Mounted Infantry and, in 1901, became Intelligence Officer to General Gilbert Hamilton's Cavalry Brigade, being subsequently appointed D.A.A.G. to that Column, an appointment which he held till near the end of the war in June, 1902.

As Intelligence Officer he formed a small troop of Scouts, some from his R.E., and some from cavalry, and "these would do anything for him or go anywhere with him." He did some very enterprising work in marking down Boer laagers, etc. In those days of guerrilla warfare, when Briton hunted Boer and Boer hunted Briton over the deceptive openness of the rolling veldt, or in the intricate death traps of the broken hills, it was upon the skill and courage of such scouts that the success or otherwise of mobile columns chiefly depended.

In August of the same year, he was promoted a Brevet Lieut.-Colonel for his services, and received the Queen's Medal with five clasps and the King's with two.

In June, 1902, he was appointed Instructor of Field Fortification at the S.M.E., Chatham, a post which he retained till 1906.

After a short period as C.R.E., London District, he was ordered to India to command the (then) P.W.O. Sappers and Miners at Roorkee. An officer who served with him then writes :—" He particularly set out to apply the lessons of the Russo-Japanese War to the practical training in Field Engineering, and I am certain that the ability with which the Indian Sappers and Miners were able to deal with the conditions in France, were very largely due to his foresight and appreciation of what Sappers would be called on to do. As one under whom to serve, it would be hard to find a better. A strong disciplinarian, yet sympathetic and always ready to discuss and help, he had the attributes of getting the very best out of those under him."

In 1910, he was appointed General Staff Officer to the Burma Division ; early in 1912, he was appointed Brigadier-General of the General Staff in South Africa, under General Sir Reginald Hart, V.C., K.C.B., K.C.V.O.

There are several tributes to his service during this period. As, however, the severest ordeal of judgment to which the character of a senior officer can be subjected is perhaps that of a body of subalterns, it is felt that no more fitting tribute to the memory of Sir Gerard Heath at this period of his career can be given than quoting verbatim from a letter as follows :—

" I met him again in South Africa, where he was B.-G., G.S., from about 1912–1914. It was then that I got to know him well. I was Signal Officer to the Command, and, as such, dealt direct with him in many ways, went with him on Staff exercises, etc. Professionally, he gained our respect and admiration to the highest degree. He was always so clear, concise, and to the point in his instructions and criticisms. He gave us all an example of the very best type of Staff Officer.

" What I remember best was that he never lost the spirit of youth. The result was that it was always a pleasure for us subalterns to be with him. If we had guest nights he would come and preside, and as all the dining members were subalterns, you can imagine how we appreciated this. He was so keen on the Corps, and we were very proud of him. He played golf with us, and often rode nine miles from his house up to the Cantonments to practise tent-pegging with us. He would then breakfast with us and ride back seven miles to his office. It was always obvious that he had been, and was then, a first-class horseman.

" I am afraid I cannot help you more than this ; but what I am trying to describe is that, though a senior and very successful officer, he gained the real affection and respect of juniors in a way that few men can or do."

On the outbreak of the Great War, he was on leave from South

Africa, and was appointed an Inspector of Recruiting in England in connection with the raising of Kitchener's Armies, and subsequently Inspector of Royal Engineers.

In May, 1915, he went to France as Chief Engineer of the II Corps, under Sir Charles Ferguson. This Corps was then strictly on the defensive; trench warfare prevailed, and his duties were almost entirely devoted to supervising the construction of lines of defence and their maintenance. His beat extended at one time from Armentières to Ypres.

In November, 1915, he was appointed Chief Engineer of the 1st Army, then under Sir Douglas Haig, afterwards under Sir Charles Munro, and finally under Sir Henry Horne.

His duties were mainly "defence," upkeep of roads, water supply, etc., over an area extending from Arras to Armentières and for an Army of about 300,000 men.

At the end of 1916, preparations were begun for an "offensive," the task of the 1st Army being the capture of the Vimy Ridge.

This involved new roads, gun positions, infantry positions, the laying of forty miles of pipe line for the supply of water for 30,000 horses, etc.

The attack, in conjunction with the 3rd Army on the right, took place on April 9th, 1917, and was entirely successful.

Concerning that period, a General Staff Officer, then and now in a high position, writes:—

"During these months from April to October, which, as you well remember, were months of strenuous attack at Vimy and round Lens and Arras, we were, I think, as happy a family as could be found at any Headquarters on the Western Front, and a very good deal of this was due to the quiet, pleasant and unselfish manner of Gerry Heath." He then speaks of his services for the offensive, and describes how he was wounded, and gives as his personal opinion that Heath never fully recovered from the wound, though at the time it appeared a lightish one.

In October, 1917, he was appointed Engineer-in-Chief at General Headquarters, and as such was Advisor to the Commander-in-Chief, Sir Douglas Haig, on matters of engineering, and he remained in that appointment till the end of the War.

There are many tributes to the memory of Gerard Heath when he held this appointment, but it is thought that the following words of a senior R.E. officer are representative of the opinions of others, and give a correct impression:—

"My general memory of him is of one of the most charming and unselfish personalities I have met. I do not remember a single disagreement, or disappointment with one of his decisions.

"He was all out to help, never spared himself mentally or physically; gallant, and with a very keen appreciation of any work done

for him or gallantry in others; human and cheerful and humorous; friendly and generous with all the world, and as straight as a die in all his dealings—I doubt whether he ever had an enemy.

* * * * *

"He had wide experience of administrative work, and kept in personal touch with all under him, as well as the other branches of the Army."

This personal touch with those under him appears to have been appreciated especially by the Tunnelling Companies, who in turn looked on him as their special friend, both when he was in 1st Army and at G.H.Q.

The following points noted by one who served in close contact at this time must also be quoted:—

1. His wonderful energy and the example he set of maintaining the personal touch by constantly visiting Formation Headquarters, to find out where the shoe was pinching and where he could help.
2. The delightful and hospitable atmosphere of his E.-in-C.'s Mess was due very largely to his own charming character.
3. His straightness of mind and unwillingness to think or believe evil of anyone; his loyalty to his staff with the inevitable response and affection from them.
4. He visited French and American G.H.Q.'s to keep in touch with his opposite members, and the Q.M.G. branches at those two Headquarters.
5. Though his nature inclined his thoughts to the front line, he kept intimately in touch with the Director of Works on the L. of C., and was *au fait* with the larger undertakings and Engineer Store Depots at the Base Ports and on the L. of C. generally.
6. At the outset of the German successes in March, 1918, the Commander-in-Chief sent for General Heath, gave him a map of the British Zone with a wavy blue line across it, and told him to construct a "Hindenberg" Line of Defences approximately on the blue line, and no personnel of any sort was to be drawn from Army Areas for this line.

   Under General Heath's instructions, an organization was created from most miscellaneous sources and a defensive system achieved, the trenches alone totalling five thousand miles."

The writer feels that he must refrain from quoting further from expressions of appreciation of Gerard Heath's personality or services, but there is one point that he must touch on—one that he always felt himself, and one that a General Staff Officer, at one time under him, has emphasized, and that is that, although he never showed it by word or deed, his real desire, and his real *rôle* by instinct and training,

was to be in executive command in the Field, and it was for this that he was eminently fitted.

The latter added, "He had a remarkable tactical flair, and his criticisms on manœuvres, etc., were always extraordinarily good, terse, and to the point. But, above all, he had that invaluable quality in a Commander, the gift of gaining the affection and loyalty of all who served under him, and indeed the reason is not far to seek, for he himself loved his fellowman, and one knew instinctively that he would never let you down."

As Engineer-in-Chief of the British Army in France from 1917 to the close of hostilities, he was one of the Generals who accompanied Sir Douglas Haig to receive the thanks of H.M. the King at Buckingham Palace on the successful conclusion of the War.

Honours in the Great War :—C.B., American Distinguished Service Medal, K.C.M.G., Order of St. Stanislaus—1st Class, Croix de Guerre (*avec palmes*). Promoted Major-General for distinguished service in the Field. Mentioned in dispatches six times.

Sir Gerard Heath retired from the Army, December 4th, 1919. He married in 1893, Mary, daughter of Philip Egerton, Esq., I.C.S., of Gresford, North Wales, and had one daughter, now the wife of Captain L. R. Hall, M.C., Royal Corps of Signals, and a son, Gerard William Egerton, born in 1897, now Captain, R.H.A., in Egypt. His son received an immediate award of the Military Cross, and was later severely wounded in the leg, but has been prominent since in show jumping and in steeplechases. He was till recently commanding the Riding Establishment at Woolwich.

After retirement Gerard Heath joined the Building Research Board, under the Department of Scientific and Industrial Research, to which he gave his services gratuitously.

He succeeded Lord Salisbury as Chairman, and devoted much time and energy to the furthering of its objects. The following is an extract from a message of condolence from the Board :—

"They felt that the present position of the Building Research Station in itself constituted a lasting memorial to the great work Sir Gerard Heath had done during the six years he was Chairman of the Board."

He also became a director of Chislet Colliery, Kent, and an extract from *The Colliery Guardian* may well be repeated :—"He was ready and willing to give his powerful support to any in trouble or difficulty, and many are the tales that could be told of his own unselfishness and of the way he helped forward younger men. All this could only spring from real goodness and kindness of heart, and he was in every sense of the word a great and good man. His life and work will ever remain a precious and fragrant memory to those who were privileged to work with or under him."

There can be no more fitting words with which to close this memoir.

A.L.S.

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

AN EXPERIMENT WITH TIME.

By J. W. DUNNE.

Second Edition. (Black, 10s. 6d.).

(By J. C. Squire.)

(Reprinted by permission from *The Observer*.)

The first edition of this extraordinary book was reviewed in these columns over a year ago by Mr. Kenneth Richmond. It was also noticed in many other places, mostly with an admiration that approached stupefaction. The professed scientists and philosophers were, perhaps, more cautious than the others; but Professor Eddington was not the only one of those to take Mr. Dunne seriously. Yet even now neither the learned world nor the general public has faced the book as it should be faced. Whatever may happen to Mr. Dunne's theories, his facts constitute a tremendous challenge: if they are confirmed, the book is a landmark in human history. Its origin is as curious as its nature. Mr. Dunne, who has a brilliant expository gift, was once famous as the designer and builder of the first British military aeroplane, saw service in two wars, and has hitherto published only one book—which was about fly-fishing. This book should get him the best rise he ever saw.

The work, which is short and mostly comprehensible by the layman, contains the results of certain experiments, and the outline of a theory devised to fit the facts. Mr. Dunne states that for many years he has been recording his dreams immediately after waking, and that various friends have recorded theirs for his benefit. That past incidents, variously grouped and transmuted, appear in our dreams goes without saying. Mr. Dunne's central allegation is that these are, at any rate, sometimes blended with incidents from the future. There is no question here, he says, of coincidence; and none of that self-deception which frequently makes one think that one dreamed something in advance when one probably did not. It is a question of quite peculiar phenomena noted down after dream without knowledge of their significance, and found, after the lapse of days or even years, to have been foreshadowings of "later" events. It is one thing to dream that one's dearest friend is dead, and then to find that he dies: one's fears and affections breed that sort of dream frequently, and one may be sub-consciously influenced by knowledge of his state of health. It is quite another event to dream that one is being chased by an angry horse, to note down the dream (with its surrounding complex), and then to go out and to encounter this very unusual experience. Mr. Dunne tabulates a number of such events, and concludes that the fabric of dream is an interweaving of past and future.

It would be enough for most men to accumulate enough facts to demonstrate that. Not so with Mr. Dunne. Without taking a breath, he proceeds to formulate a new theory of the most remarkable kind. The

" observer " of the humdrum daily world is replaced, in sleep, by an observer who moves along the Fourth Dimension, Time. Here we come to the crux. Mr. Dunne, in a somewhat hasty preliminary argument, has established a consciousness which is aware of " the first observer," and is superior to the three-dimensional world. The moment that movement in the fourth dimension is granted to be normal, consciousness moves into a fifth dimension. The deduction is an infinity of dimensions and an infinity of observers– a series with one at the mundane end (who has nobody on the hither side to keep him warm and for whom death is postulated) and an " Ultimate Observer " at Infinity who is conscious of all the dimensions. This last conception may be thought the last straw. This whole business of " Serialism " (as Mr. Dunne calls it) makes the lay mind reel : one begins to sigh for a right little, tight little, Four-Dimensional World ! Einstein may have chastised us with whips, but Mr. Dunne chastises us with scorpions. We cannot but hope that, if Mr. Dunne has followers, the earliest of them may find some plausible means of eliminating the vast superstructure of dimensions which he projects in order to account for the initial relations which he discusses. Happily, it is not necessary for the layman to bother his head about " Serialism," or even to go and ask the nearest mathematician what he thinks of an Observer at Infinity. Nor, perhaps, is it as yet imperative for the scientific person to concern himself overmuch with the theory until there has been further investigation of the facts that it is meant to fit. At this stage the facts are the important things. Are they established ? Can they be supplemented ?

At present they are altogether too few. One horse may have chased one man after one dream. We want to know that six horses have chased six men after six dreams. One does not throw doubt upon the good faith of Mr. Dunne and his friends when one says that their stories are not sufficient to convince one, though they certainly impress one. We must have not merely the evidence of Mr. Dunne, and his friends Major X. and Miss Y., but that of large numbers of people of repute and of the most sceptical turn of mind. If all is as Mr. Dunne says it is, there should be no difficulty about this, provided that the physicists and the psychologists have the curiosity to explore this momentous possibility. The written word remains : it is only a matter of getting enough records of dreams and enough evidence of their fulfilment : it is almost laboratory work. A very little organization and we should be able to say definitely whether Mr. Dunne's basic proposition is proven or whether it is not proven to the point of being virtually negligible.

Should it be proven, what a world we are being launched into. Once grant that dreams do actually draw upon the future, and there is a whole new fourth-dimensional branch of scientific activity. In what proportions do the various elements in dreams mingle ? Can constants be found with due allowances for this, that, and the other influencing circumstances ? Does the element of divination in an individual's dreams bear any determinable relation to his particular mental or physical constitution ? Does it vary at all according to age, race, or state of civilization ? If such variations are found can the faculty for prophecy during sleep be fostered ? Are the researches of the psycho-analysts in the

transmutations and groupings of dreams to be superseded by others far more momentous, which will be concerned with the minglings of past and future images, the affinities of memory and prediction, or, rather, of the observations of past and future made by this voracious Time-Traveller? Will it be possible ever to recognize, in a dream as yet unfulfilled, the stigmata of the "future" event as distinguished from those of the "past" event? And, for that possibility must certainly be confronted, may it not be possible so to surrender one's three-dimensional self, which is so dependent upon the outer impacts of this sensual world, as to lapse deliberately into day-dream, releasing our consciousness for journeys into the future? Or—for that matter—into the past, and even a remoter past than the past of our physical selves. I cannot quite conceive (though it may not be beyond the powers of scientific people to formulate) a parallelism which would preclude our travelling in the Fourth Dimension beyond some point analogous to that of our birth into a three-dimensional world.

However, the Future is enough to start with. If Mr. Dunne is correct—and his abilities and qualifications are quite enough to entitle him to a hearing—we shall be compelled to admit that we all habitually move in a fourth dimension, certainly in sleep, and very possibly, on occasion, when we are not asleep. Granted that, and granted a positive answer to all those questions which I have just posed, we come to a point at which an almost inconceivable abyss of speculation has to be looked into. Once given the ability to isolate the prophetic elements in dream, with certainty or even with reasonable probability, we shall be bound to consider whether or not the foreseen future can be avoided? If we look at the matter in one aspect—thinking of Time as a form of Space with all existing objects stuck in it as prolonged lines with definite shapes, graphs as it were—we are compelled to say "No." Yet there is that obstinate reason in us which obliges us to say, "Yes: I cannot very well fall out of an aeroplane if I blankly refuse to go up in one." This is put crudely, but the problem is evident: we must be given a somewhat strong side-light upon Determinism and Free-Will! And if the dimensional dice are not strongly loaded in favour of the former, what sort of Dimension is this? The old murmur reaches my ears: "A thing cannot both exist and not exist." To that, amid the storms of this changing world, which is curving its straight lines, joining its parallels, and abolishing its matter, I have been clinging with some desperation. I fear that it may have to go into limbo, where the ghost of Aristotle moans to the ghost of Sir Isaac Newton.

Let us keep cheerful: as cheerful as Mr. Dunne, whose book contains more high spirits than I have ever seen in a book with diagrams "so many, and so many, and so free." It is more amusing to see the frontiers of knowledge being extended than to see them fixed. I feel a little doubtful about my own dreams. It was bad enough to think that they were crowded with wish-fulfilments and the reflections of my more disreputable desires: that even one per cent. of them anticipate my personal future is almost too much to contemplate. Yet

> things are what they are; their consequences will be what they will be; why, then, should we deceive ourselves?

This new thing is better than some new things. Nobody has yet, I think, suggested that the discovery of the fourth dimension will blow our "home-planet" into pieces. As to the possibility that, forewarned, we might begin messing up each other's futures, mankind has been doing very little else since the world began.

Mr. Dunne's "Ultimate Observer," I may add, seems to me to dwell on the confines of Theology. That is another reason why his book is fascinating.

THE EMPIRE AND THE ARMY.
(Cassell, 10s. 6d.)

HISTORICAL AND MILITARY ESSAYS.
(Macmillan & Co., 10s. 6d.)

By the Hon. Sir JOHN FORTESCUE, LL.D., D.LITT.

It is not often that one has the pleasure of welcoming at the same time two books from the pen of the historian of the British Army. Of these two, that which will appeal most to military readers is the first-named, for it has been written expressly for soldiers. It is intended to be a text book, which has long been needed by those who have to teach candidates for the higher certificates of education. It is in part a short history of the British Army, and it can perhaps be criticized for its very brevity. But it is easy to imagine how enormous were the difficulties which faced the writer. The subject is so wide that the inclusion of detail might have obscured the important features of the story which now stand out so clearly. The very fact that the reader is constantly led to demand more detail will provide an incentive to the deeper study of army and regimental history. But this book is more than a history of the army: it is a story in which the author has traced the growth, side by side, of the Empire and of the Army, showing clearly how the two have been interdependent: how it was the necessity for security in some colony or dependency which led to the raising of new regiments, some to be disbanded as soon as the danger was overcome, a few to remain till the present day.

The book will therefore appeal to a wider public than that for which it was written. As Field Marshal Sir George Milne says in the foreword, "it should find an honoured place on every boy's bookshelf," and should be read, not only by those who aspire to certificates, but "by every officer, non-commissioned officer and man."

The second book contains a collection of essays, most of which have previously appeared in periodical publications. The greater number deal with the character of King George III. as it is revealed in his private correspondence, which was discovered in 1912, and has since been edited and published by the author of these essays. Their aim is to re-establish the good name of the King, and to show that the current estimate of his worth has been wrongly biased by the "vindictive hostility of Whig writers." The part more interesting to military readers is that which contains the letters from the Duke of York to the King giving his experiences in the Flanders campaigns of 1793-94.

The remaining articles in the volume are mostly in a lighter vein. There is an interesting account of the origin and duties of the Lords Lieutenants of the counties, which concludes with a warm tribute to the services rendered by them during the period of the Great War. The last essay is an account of two conversations between Napoleon and Lord Ebrington, Sir John Fortescue's grandfather, at Elba in 1814. These were first published in a pamphlet in 1823, and are now republished from the original manuscript. Much of it is in French, " in as nearly as I could recollect them the very words used by Napoleon," and is of considerable interest.

———— N.W.N.-C.

THE PRACTICAL ELECTRICIAN'S POCKET BOOK, 1929.

(Published by Odham's Press, Limited, 2s. 6d.)

Thirty-one editions of this Pocket Book have been called for since its first appearance—reliable evidence that it appeals to a large number of readers. Although a good many of the articles of previous years have been retained, the edition is a new one in that thorough revision has taken place, many articles being removed to make room for new ones, contributed by authors well known in the profession.

Engineering year books range from massive tomes, published at a guinea or more, to pocket books in size as well as in name, costing two or three shillings. The compiler of one of these latter is, of course, severely limited in space, and any reviewer has an easy task in criticizing his choice of subject matter.

It would appear that one of two objects should be aimed at :—

(1) The collection of formulæ, tables, and facts which an experienced engineer cannot keep in his head and which he requires in his work.

(2) A collection of short informative articles on all branches of the subject matter of the pocket book.

It is to the second class that the book under review belongs. The information contained is of necessity descriptive rather than precise, and on most subjects is of little use to anyone seeking help for any particular job. As an instance, there are two and a half pages, and small ones at that, on alternating currents—not enough for a novice and unnecessary to anyone with an elementary knowledge of the subject.

Turning to the individual sections, the preface rightly lays stress on the detailed and complete index provided at the beginning of the book—a reference book with a faulty index being worse than a plan unprovided with a scale. Following the index comes a calendar and 14 pages of elementary facts, definitions of units, etc., the next six brief pages on D.C. Generators and Motors, and the two on A.C. theory already referred to, are followed by twenty on boilers, steam and oil engines—this valuable space could better have been devoted to purely electrical matter. The remarks on boilers are admirable, but the turbine section of half a page is entirely useless. The cold-starting type of engine should be referred to in the oil engine section.

Primary and secondary batteries are well discussed, though the range of specific gravity of electrolyte in the latter, from full charge to full discharge, is given as 25 to 30 points ; the usual range is double this.

Parts of page 70 are too reminiscent of advertisement matter to be in place in a pocket book. To quote :—

"A new type of accumulator . . . is manufactured by the Young Accumulator Co., Ltd., London. . . . In the ordinary lead battery . . . during discharge, the different oxides formed by electrolytic action are transformed into lead sulphates." (Quite true ; this is the main action, and if it did not take place the cell would not function.)

"The special process developed by this company is such that the necessary chemical reactions are greatly strengthened. In this way the formation of sulphate is obviated and greater capacity is obtained from the plates." Apart from the fact that stronger chemical reactions would presumably *increase* the formation of sulphate, the capacity of a cell in which this formation did not occur must of necessity be zero.

When writing on accumulators, it is essential to keep in mind the difference between the normal formation of lead sulphate on which the action of the cell depends, and the abnormal injurious sulphation, and this distinction is not made clear to the reader.

Switchgear, transmission and distribution are ably dealt with, tables of pole sizes, depths to be buried, and conductors being given. Static transformers have as good treatment as space permits, though rotary convertors (spelt wrongly "converters") are dismissed in one and a half pages, while motor convertors and mercury arc rectifiers escape mention. This last is an important omission which ought to be corrected in the 1930 edition. In view of the fact that no transverter is in commercial operation, the page devoted to it might be better filled.

Wiring and lighting account for eighty-seven pages, and are well done. It is a pity the tables of lamps on pages 185 and 203 were out of date before the book was issued, as the 1929 edition of B.S.S. 161 has altered the standard sizes to 15, 25, 40 and 60 watt.

The elaborate tables of depreciation factor are unnecessarily precise in view of the inaccuracy of photometric methods.

The section on wireless includes a short glossary of terms—kilo hertz might be given with advantage in view of its growing use. Sections follow on electric cooking, lifts and cranes, electricity in farming, traction, railway signalling, measuring instruments– the British Standard requirements as regards accuracy should be given here– electro-chemistry, welding, armature construction and repair, and insulation.

The table of the particulars of supply in a large number of towns in Great Britain is a valuable feature.

To sum up, the book is an admirable encyclopædia, but like all encyclopædias is apt to be unsatisfying to an engineer seeking for details. References are given at the end of each section to appropriate text-books.

K.H.T.

TEXT-BOOK OF ORDNANCE AND GUNNERY.

By Lt.-Col. EARL MCFARLAND, Professor of Ordnance and Gunnery, U.S. Military Academy.

(Chapman & Hall, 32s. 6d.)

The first impression obtained by the reader on picking up this book is that in doing so he has only himself to blame.

For this is a text-book avowedly compiled for the benefit of students at the United States Military Academy, and those who of their own free will wrestle with its contents must be akin to the monks of old, who would heartily flagellate themselves for the good of their souls.

Yet it is quite possible that readers of the *R.E. Journal* may have the curiosity to investigate the trade of the gunner, and further the result of such investigations may perchance result in profit—are we not deeply indebted for research in Ballistics to a clergyman of the Church of England?

Besides, nothing is sacred to a Sapper.

And I can assure the curious that this is a sound book; without going too deeply into details it presents a comprehensive view of the whole field of Ordnance, put forward in simple form and amply illustrated by admirable diagrams. In fact, it clearly justifies the claim of the author that he has attempted therein to "assemble in one book the more permanent and fundamental theories of ordnance design."

One regrets, however, that he had limited himself to these terms of reference, for the chapter on "Motorized Material" is so curtailed as to make one wish that it was not confined to designs of an admittedly permanent nature.

R.H.A.

GREAT BRITAIN IN EGYPT.

By Major E. W. Polson Newman.

(Cassell & Co., London, 1928.)

Half a century has passed since the Khedive Ismail Pasha abdicated in favour of his son Tewfik Pasha, and many of those who took part in the events of that time and of the first years of the British Occupation of Egypt have passed away. It is both useful and fitting that the story of Egypt's recovery from bankruptcy, and her rise to prosperity, should be told, and should be shown in their relation to the conditions which prevail to-day. Much now existing has its origin in those early days and cannot be fully understood without a knowledge of the events of that time.

Major Polson Newman does this very effectively and impartially, pointing out the many difficulties inherent in the situation, the mistakes that have been made from time to time, as well as emphasizing the ever-changing political and social conditions in the country which have repeatedly made any solution more difficult.

Ismail Pasha's reign began under favourable conditions, since the public debt did not exceed three millions sterling, and the revenue was easily collected, but by 1876 the public debt exceeded 94 millions, and the revenue was only collected with the greatest difficulty. In his desire to make Egypt a modern State, he spent vast sums of money and continually raised loans to pay off the interest on previous debts, until European intervention became inevitable. To meet the interest due for the various loans, the arbitrary methods of tax collection which had been practised since the days of Mohammed Ali were ruthlessly applied, until the fellahin were reduced to extreme poverty. The discontent in

the country was matched by the complaints of the Egyptian officers of the Army that all the higher posts were held by Turkish and Circassian officers to their exclusion. It was under these conditions of universal discontent that the outbreak headed by Arabi occurred. At the time, it was held to be and was treated as a military revolt, but the author maintains that it was really a national movement to free the people from the intolerable burdens due to the Ismail *régime*. That it began in the Army was determined by circumstances, and it may well be that, had the situation been recognized as a popular movement, it might have been dealt with in such a way as to avoid at least some of the difficulties which subsequently arose. The whole story of the Arabi revolt is treated well and impartially, the various influences at work being clearly indicated.

After the rout of the Egyptian forces at Tel el Kebir and the taking of Cairo, the British occupation of Egypt was an accomplished fact, and Great Britain became responsible for the reorganization of the country. The choice of Lord Cromer to direct this was a particularly happy one, and in the course of twenty-four years Egypt under his guidance passed from bankruptcy to solvency, and thence to such a condition of wealth and prosperity as she had not known hitherto. This is well and clearly described, as well as the many difficulties incident in the situation, such as the extra-territoriality enjoyed by all Europeans under the capitulations. But gradually taxes were reduced, forced labour (corvée) was replaced by paid labour, municipal and provincial councils were instituted to deal with local affairs.

Under such circumstances, a politically young community naturally desired to have a share in the management of its own affairs, and, though it was an essential part of Lord Cromer's scheme that this should be so, progress in this direction seemed slow to those whose knowledge of administration was theoretical rather than practical. The growth of nationalism in Egypt is clearly sketched and its aims are indicated.

The outbreak of the World War seriously affected the situation for the worse, for though at first Egypt was not greatly affected, many of the British officials with long experience of the country left to take up War service in Europe. The declaration of a Protectorate in 1914, the extension of the War to the Eastern Mediterranean and the Palestine campaign, together with the repercussion of these and other events related to them on the people of Egypt are well described, and the numerous causes and their effects are critically discussed.

After the War, Egypt, like many other countries, suffered from considerable unrest, which was actively fomented by Nationalist extremists and serious anti-British disturbances ensued. The final chapters of the book give a very interesting account of the various phases of the Egyptian situation during the last ten years, which cover Lord Allenby's High Commissionership, Lord Milner's Mission, the recognition of Egypt's independence, and the accession of King Fuad, who succeeded his uncle, King Hussein. A good many awkward situations have arisen, but they have been dealt with, and at the present time the earnest endeavour to reach an agreement acceptable to reasonable persons of both countries has made considerable headway. The Declaration of 1922 and the "four reserved points" still govern British policy, and anyone who wishes to

gain a clear idea of the present position can be recommended to study the history of the relations between Great Britain and Egypt, as they are set out with great clearness and fairness in this book.

H.G.L.

EMBATTLED BORDERS.

By F. ALEXANDER POWELL.

(John Long, Ltd., 16s.)

This is a book which is well worth while. Written by a distinguished American novelist and globe-trotter, it may cause some to remember the famous case of the M.P. who travelled from Bombay to Calcutta, and who then wrote a history of the inhabitants of India. But Alexander Powell has some intuitive gift, and in *Embattled Borders* he has presented in most readable and clear form the main racial, political, and national problems which beset post-war Europe. Czechoslovakia, Yugo-Slavia, Esthonia, and Finland are to most of us names. We know that the Czechs do not like the Croats, or is it the Albanians, or the Moravians? Are the Esthonians a kind of offshoot of the Lithuanians? What happened in Hungary immediately after the War, and why does Admiral Horthy call himself a "regent"? The Treaties of Versailles and of the Trianon carved up Europe in an inexplicable manner, and now in 1929 we want to know how it is all working. Are those ethnographical boundaries likely to stand the test of time, or are minorities so seething with discontent that another European upheaval is likely? This book gives one to think. It is the work of a keen observer, and of a man who apparently possesses the "entrée" to most of the inner sanctums of the present rulers of Europe. Signor Mussolini, Marshal Pilsudski, Herr Masaryk, and Herr Sahm, at any rate, thought fit to grant him interviews, to mention only a few.

Books which have appeared since the War which deal with the whole of the main problems of Europe are few and far between, and they are usually deadly dull. *Embattled Borders* can be read like a novel, and will certainly not be put down until the last page is reached.

To judge of its accuracy of statement is not, of course, so easy, but Chapter VIII, which is entitled "The resurrected land," deals with the complicated problem of Poland, and in particular her relations with the Free State of Danzig, and also explains the situation in the so-called Polish Corridor between East Prussia and Pomerania; Chapter VIII in the reviewer's opinion is about as clear and truthful an exposition of those particular problems, of which he has first-hand knowledge, as one could wish for; and it seems fair therefore to assume that the views expressed in other chapters dealing with other countries are likely to be as closely allied to the truth.

Officers of the Corps will read with pleasure the remarks by this American writer, who is no anglophile let it be said, on page 276, in which, *apropos* of the Polish police force, he says, "thanks to the efforts of a British Mission, the police are as smart and nearly as efficient as London

bobbies." That Mission was commanded in 1919 by a quite junior R.E. regular captain and brevet major, camouflaged as a Brigadier-General.

On the very important question of "Anschluss," or the tendency of modern Austria to unite with Germany, the author is extremely interesting (Chapter VII), whilst Chapter VI, which deals with the problems of Czechoslovakia, is an absolute mine of information. The famous Land Act of April, 1919, which was so cruelly unjust to Germans and Hungarians left to the newly-formed State, is explained at some length (pages 217–225), and one is left in no doubt as to how far westward the tide of communism lapped.

Chapter I is a masterly description of present-day Italy. Chapter IV, "The Danger on the Danube," is interesting, but it contains one rather stupid reference to so-called "inner history" (pages 154, 155), though the author has the grace to say the story is in no way authenticated.

Racial antagonisms are the causes of wars. It behoves every soldier, therefore, to learn all he can of such antagonism, and of the problems which are at the root. *Embattled Borders* is the most readable book on European problems that has appeared since the Great War.

P.K.B.

FIELD-MARSHAL EARL HAIG.

By BRIG.-GEN. JOHN CHARTERIS, C.B., D.S.O., *M.P.*

(1 Vol. 8vo. Cassell. 25s. net.)

(*By the Hon. Sir John Fortescue.*)

Reprinted by permission from *The Observer.*

This is an exceedingly good book. Arrangement, proportion, language are all alike excellent, and the craftsmanship is so fine that it has the supreme merit of appearing unconscious and effortless. Inevitably the background of the central figure consists of a tangle of complicated military operations, but these are skilfully unravelled and disposed in broad, clear, simple lines, so that a very few rough maps suffice to explain them. No one who has not tried to accomplish the like feat himself has any conception of its difficulties; and the apparent ease with which General Charteris has surmounted them makes one understand the better the intense labour which he has thrown into his task. Lastly, the tone of the whole volume is exactly suited to the subject. It is modest, restrained, and straightforward, the story of an officer and a gentleman told by an officer and a gentleman. Very respectfully I presume to offer General Charteris my congratulations.

There are no figures in British military history which can be set up in comparison with Haig's except those of Marlborough and Wellington. He was widely different from either, though with Wellington he had some remarkable points in common. We see Haig first as a small boy of ungovernable temper; and he drifts through life at public school and university, aimless, discontented, solitary, and somewhat Olympian. Then, rather later in age than usual, he goes to Sandhurst and discovers his life's work—the study of the art of war. He enters a very good

cavalry regiment, and, since he is beautifully made, very good-looking, meticulously careful in his dress, and an excellent horseman, we expect to see him expand a little. But no! He remains solitary and aloof, holding everyone still and always at a distance; and so, indeed, he remained to the end of his life.

The truth is that he was by nature very shy and very emotional, and that his whole life was spent in crushing and holding down these emotions. Wellington was exactly the same; and both occasionally broke down. Wellington was painfully shaken at the funeral of Somers-Cocks; Haig abandoned his routine for half a day when John Gough was killed. Wellington galloped for miles to creep in by stealth and kiss an officer who was thought to be dying; Haig openly embraced the doctor who told him of the birth of his son and the welfare of his wife. Both commanded deep affection from those about them; neither of them returned it nor pretended to return it.

Their training was widely different. Wellington had to do with politics and parliaments at a very early age, and even thought of abandoning a military for a civil career. Haig detested politics and devoted himself wholly to the study of his profession. For him, as for Foch, literature and art had no attractions. (Wellington was a lover of music.) But the study of war is by no means so narrow a field as is generally supposed. It is really less a matter of strategy and tactics than of broad human nature; and as such Haig understood it. He thought out questions with intense concentration, formed his opinion, and thenceforward clung to it with vehement tenacity. A new fact might make him revise that opinion, but not a new view of old facts. There again he resembled Wellington. Neither would argue, and neither would give way one inch. And the strange thing was that, though Haig could set forth his thoughts admirably on paper, he could not for the life of him express them with his tongue. He was incredibly inarticulate. General Charteris emphasizes the fact, but I could not without experience have realized the full extent of it.

With the loquacious of all professions— the Lloyd Georges and the Henry Wilsons— such a man was at a disadvantage. He had, moreover, an instinctive aversion from many words, looking upon them as mere impediments both to thought and action, and he was especially impatient of debates which issued in no decision. He mistrusted Mr. Lloyd George at first sight; and Mr. Lloyd George, instantly conscious of the fact, naturally retorted, if not with immediate mistrust, at least with immediate dislike. Haig's rigidly, frigidly Olympian courtesy must have been more disconcerting than a thousand polished speeches; and it is not surprising that the relations between the two men were the reverse of cordial. Nevertheless, Haig shared Wellington's strongest point, the sense of duty and discipline, which made him bow always to the ruling of the supreme civil government; and he strove steadily to make the best of its orders. If the War did bring forward one great man, it was Haig. Strong, silent, much enduring, he saw further and more clearly even than Foch, and his masterful will prevailed. His trials and troubles, his successes and mistakes, may be read in this book. Let me note only two facts. The British, though defeated in March, 1918, were not

demoralized. Though there were serious mutinies in the armies of every one of the great continental powers engaged in the War, there was none in the British Army. Haig, deeply impressed by religion rather late in life, had a strange exalted (if one may use the term of so sane a man) idea that it was his mission to lead the British Army to victory in that War; and this persuasion cannot have been without its unconscious influence. It made itself felt by sheer force of character. He had no nickname. He was not the darling and the deity of his troops as had been Corporal John. But he was trusted fully, firmly, faithfully, and he was worthy of the trust.

THE WORLD CRISIS.—THE AFTERMATH.

By THE RT. HON. WINSTON S. CHURCHILL, C.H., *M.P.* Maps and Plans. (Thornton Butterworth, Ltd., 1929. Price 30s.)

This, the last volume of the series entitled *The World Crisis*, is probably the most valuable portion of Mr. Churchill's stupendous work. In his earlier volumes, the unsoundness of Mr. Churchill's arguments in the domain of strategy and his biased judgments on the men who won the War detracted greatly from the value of his writings. In this volume he is on firmer ground when he describes the inner history of the drafting of the Peace Treaty and the events which took place in the years following the Great War. Thanks to his inside knowledge, he is able to give us an intensely interesting account of the drafting of the Treaty of Paris, our intervention in Russia, the Russian Civil War, the Irish Settlement, and the War between Turkey and Greece. His chapters on these events contain much that is new even to the careful reader of the contemporary Press, and will have a lasting value when the history of the period comes to be written.

From beginning to end the book is well worth reading, and will give the reader a much clearer insight into the march of events than anything that has been written since the War.

H.B.-W.

MAGAZINES.

REVUE MILITAIRE FRANÇAISE.

(*January*, 1929).—"*La division Exelmans le 28 août*, 1914," by Capitaine Minart, is completed in this number. This instalment describes the gallant counter-attack of Exelmans' 35th Division against Guise and its retreat after the attack had apparently failed. Actually, Général Exelmans' action had the effect of holding up General Von Bülow's Second Army, and so allowed the French, under Général Lanrezac, to get away, but this was not clear to the unfortunate Division, who suffered terribly heavy losses. There has been much discussion as to whether Général Exelmans was right or not in attacking, as he had been ordered to retreat, but from reading the article, one cannot but agree with the

writer that he could not be blamed, although perhaps his attack was rather hasty. Général Lanrezac himself considered that the action was correct, according to Général Exelmans' own knowledge of the circumstances. The article is well written and easy to follow, as there are not too many sub-units mentioned.

"*Les populations du Maroc*," by Capitaine Loup, is a short description of the tribes which inhabit Morocco. The basis of the population is provided by the Berbers, who are the ancient stock who fought against Rome, many centuries ago. The other important tribe is the Arabs, another Moslem stock from the east; in addition, there are Moors, Jews and negroes. The writer's object is to make it clear that the Berbers are the most important, and that they will only yield to the civilizing influence of the French, not to pressure from the Arab civilization and doctrines of the Koran.

Lieut.-Col. Grasset continues "*Montdidier, le 8 août, à la 42e division*," in this number. He deals with all the final preparations for the great attack, in which the French 1st Army, of which the 42nd Division was on the left, came under the orders of Sir Douglas Haig. The preparations are given in great detail, but Col. Grasset does not forget the humorous side of the mass of moves which had to be carried out, and he is also extremely pleased with the co-operation of the Canadians, on the left of the French, who did everything they could to ensure the support of the 42nd Division, including the loan of a section of tanks. The most intense secrecy was observed, but all the same, everyone knew that an attack was in the wind, including the enemy, although it turned out to be of little advantage to the latter. Good sketch maps are given.

"*La rupture du front de Salonique en* 1918," by Général Kalafatovitch, consists of a lecture given in 1928, on the occasion of the celebration of the tenth anniversary of the Salonika victory, with a foreword by Général Franchet d'Espérey. It is a short but most interesting description of a really marvellous campaign. The Serb sector, in most difficult country, was selected by Franchet d'Espérey for the break through, and in six weeks the Serbs averaged ten kilometres a day, a most amazing performance.

"*Le salon d'automobile en* 1928," by Lieut.-Col. Doumenc, comprises a bird's-eye view of the Paris Motor Show. Not only were all types of car and lorry to be seen, but demonstrations of radio-photography were given. The writer discusses the advance of the Diesel engine as a new type of motive power which may be introduced commercially in the not too distant future.

(*February*, 1929.)—Lieut.-Col. Grasset, in continuing "*Montdidier, le 8 août, à la 42e division*," describes the first advance of the division, who met no opposition to start with. The various preparations were only made just in time, but everything was ready by zero hour. Although the Germans expected an attack, they evidently did not know the day, as they were surprised by the appalling outburst of shell-fire which broke out at 4.20 a.m. on 8th August. The instalment closes with the appearance of the dawn of a beautiful day shortly after the launching of the attack.

In this instalment of "*De l'ancien au nouveau règlement du Service de*

Santé," Médecin-Général Uzac discusses the effect of typhoid, influenza and typhus during the Great War. The effect of inoculation in reducing typhoid and the appearance of influenza in 1918 are well known, but he also draws attention to the appalling results of typhus, which broke out in the Balkans during the latter half of the Great War.

"*Une heure tragique de Napoléon,*" by Général Camon, describes a little known period in the Emperor's history, when he was actually imprisoned at Antibes, near Nice. The French armies had been on the defensive in Italy, and Bonaparte was anxious to revert to the offensive and clear the Austrians out of north-west Italy. He succeeded in convincing the younger Robespierre, who went to Paris to put Napoleon's views before the Committee of Public Safety, but the *coup* of 9th Thermidor followed and Napoleon was actually imprisoned, by order of Carnot, who had driven out the elder Robespierre, and hated the idea of an Italian offensive. However, Bonaparte was released and finally received permission to carry out his plans, which he did with remarkable success.

In "*Une journée de crise à la 3e armée allemande,*" Col. Rozet describes the situation on the Meuse on 28th August, 1914, when both Von Hausen, commanding the German 3rd Army, and the left of the French 4th Army were in a state of considerable overstrain. Von Hausen's Army had been marched off its feet, and was suffering from appeals from the German Armies on either flank, while the French were having great difficulty in extricating themselves. Both sides had the chance of striking an effective blow at the other, but neither knew the situation well enough for the blow to be delivered. As the writer points out, this is not an unusual situation in war.

Capitaine Marchand begins "*La vocation coloniale de la France,*" in this number. He describes the great French empires of the past, as built up first by Louis XIII. and XIV., and again by Napoleon I., and how, in each case, they fell to the ground. It was intense Catholicism which was more effective in killing the first empire than any other factor, while the loss of the command of the sea was fatal to the second. The writer then describes how the present empire was built up and points out how its preservation depends on the might of France at home. Had she lost the Great War, it is clear that her empire would again have been torn from her. Security at home and the colonizing spirit are essential for the maintenance of great overseas possessions.

(*March*, 1929.)—In the fourth instalment of "*Montdidier, le 8 août, à la 42e division,*" Lieut.-Col. Grasset describes the capture of the Bois de Moreuil. The progress of the French was not quite according to plan here, partly owing to the Canadians not being up on the left, but with the aid of a British tank the operation was finally completed. The story is again given in great detail.

Médecin-Général Uzac completes "*De l'ancien au nouveau règlement du Service de Santé,*" with a technical discussion on the treatment of different kinds of wounds in war. One of the great difficulties during trench warfare was the effect of dirt on ordinary wounds and fractures, but considerable strides were made in dealing with these difficulties. The writer ends by pointing out that an efficient medical service is an

important branch of the army as well as the various other factors which go to build up success.

"*Une documentation nouvelle sur la campagne Polono-Russe de* 1920. *Le livre du Général Sikovski*," by Général Faury, appears in this number. This is a most interesting account of Général Sikovski's book, which describes, from first hand information, the events of the War between the Bolsheviks and the Poles. This War is one little known to the British public, and as Sikovski commanded a Polish Army, his book invites attention. At the outbreak of the War, the Poles tried to guard their frontier with a line of posts, while the Bolsheviks delivered a concentrated attack. The posts were naturally unable to withstand the attack, the Polish forces retreated hurriedly and the Bolsheviks nearly reached Warsaw. Fortunately, Marshal Pilsudski, supported by General Weygand, who had been sent to Warsaw by the French, saw that linear defence was of no use whatever where insufficient numbers were available. Pilsudski therefore allowed the Bolsheviks to sweep on north of Warsaw, while he reorganized his forces and struck them from the south. This blow came as a complete surprise and the Bolsheviks were utterly routed. It needed another battle to complete their defeat, but the main work was done north of Warsaw. The campaign is well worth studying as showing the effect of vast areas of country on comparatively small armed forces, as it must be realized that the Bolsheviks were only able to employ a small proportion of their man-power in this war.

Capitaine Marchand completes "*La vocation coloniale de la France*," in this number. He looks forward to the day when France will be animated by the same spirit as Great Britain all over the world, and he thinks that this "imperial" spirit has already begun. The effect of the Great War, which brought many more square miles under French dominion, has made the imperial outlook all the more necessary, and the writer shows what has been done already in the government of the colonies and by the reduction of distances by modern means of locomotion. It is pointed out, however, that France depends largely on the African man-power to protect herself against further attacks from the north-east, a situation which does not exist in Great Britain. H.A.J.P.

COAST ARTILLERY JOURNAL.

The December number (1928) contains an article on "The World Situation in Coal and Iron," in which the writer points out that an estimate of the world's coal resources, made by the International Geological Congress in Toronto in 1913, shows that the American Continent possesses five or six times the total resources of the British Empire in coal. The minimum thickness of seams considered were 12 inches down to 4,000 feet, and 24 inches between 4,000 and 6,000 feet of depth. Working coal at depths greater than 5,000 feet is not economical owing to cost: in fact, a Royal Commission on Coal Supply in 1905, put the lowest level at which coal could be got advantageously in England as 4,000 feet.

The largest carboniferous field in the United States extends through

Western Pennsylvania, Eastern Ohio, Western Maryland, West Virginia, Eastern Kentucky, and the State of Tennessee to Central Alabama. The area, in fact, which was the original home of the coon song. It is 875 miles long by 30–180 miles wide.

The Congress considered that the world's ultimate coal supply will last for some 3,000 years.

As regards iron ore, the United States is said to produce about 33 per cent. of the world's supply, the Lorraine field of France producing about 25 per cent.

In the January number (1929), there appears an article on mechanization as being evolved in the U.S. Army. Last summer, the Experimental Mechanized Force was born at Fort Leonard Wood, but it was found to answer to the title of a Motorized Force, rather than a Mechanized Force, as the tanks which could travel under their own power were not fast enough. The force included light and heavy tanks, infantry, field and anti-aircraft artillery, engineers, signals, chemical warfare service, armoured cars, ammunition train, medical corps and motor repair units, with the addition of air units for certain exercises. Altogether, about thirty different makes of old and new commercial vehicles.

At first, sections composed of about fifty vehicles made preliminary marches of about fifty miles: later, the whole force made marches up to the maximum of 420 miles. Unit and combined tactical training was carried out between the marches, to find original solutions for the various problems, without the benefit of precedent.

Deductions made from the exercises showed that the entire force must be able to march and manœuvre at a much more definitely high speed, and that air units need not form part of the Mechanized Force itself, but should be attached as required for a specified object. As all "non-combatant" vehicles need combatant elements to protect them, they must be eliminated as far as possible, and self-propelled elements substituted for them. A proposal was made for a 3-in. A.A. gun, mounted on a fast chassis, to be recognized as the unit of field artillery as well as for A.A. duties. This would necessitate a double training for each crew, as well as the provision of all the mechanical details essential for both *rôles*.

One solution for the organization and administration of the future Mechanized Force is to divorce it from the other arms and make it into a glorified Tank Corps, comprising all formations: the advantage of this suggestion lies in the fact that the whole of the interdependent training would be co-ordinated by one commander.

This number also contains a very interesting historical account of the Colonial Coast Forts on the South Atlantic Coast of the United States, beginning from the times of the original Spanish claim to the whole continent, based on the Papal grant following the discoveries of Columbus. If Spain had only kept quiet about the whole discovery and had set to work steadily to colonize and populate the new possessions, she might have had a more consolidated hold on all the best landing places and ports of the future before the English adventurers were able to oust them. But they made the additional mistake of antagonizing the natives by decoying them on board ship and carrying them off to be sold as slaves, while

religious bigotry earned them a reputation amongst the other white nations which was never forgotten. When the Spanish Commander captured the French Fort Caroline in 1565, he put the Huguenot garrison, men, women and children, to the sword, and left an inscription on the site: "Not because they were French, but because they were Lutherans."

An article on "Camouflage for Artillery" describes the scientific method of blending colours. The author looks upon camouflage as a counter-intelligence service, designed to defeat or neutralize the intelligence gained by enemy observers. The observer who is the most difficult to lead astray is the aerial photographer, who is provided with a good camera. In the case of a large position on the ground, such as some concrete defensive post or battery, the best result can be obtained by using the five-colour system. This depends upon the scientific blending of brown, yellow, green, cream and mauve, with a narrow dividing and border line of black. This dividing line has the effect of impairing the line of vision. The mass of the position is thus broken up into fragments and the eye of the observer is compelled to record the portions painted green and brown, while it fails to record the portions painted cream and mauve. Yellow is used to counteract shadow. The camera can be defeated by a suitable chemical preparation of the pigments which upsets the results obtained through ray filters. The cream and mauve portions give the appearance of being on different planes to those parts coloured green and brown, so that the information recorded is false. The writer affirms that even when viewed or photographed from low altitudes, the reality is hidden by this five-colour system.

A photo taken by a stereoscopic camera is rendered untrue by the scientific application of the laws of light and colour, by the use of opaque pigments for the nearer planes, by the employment of mauve in juxtaposition with its complement and yellow for the neutralization of shadow. There are certain chemically-prepared ray-proof pigments which interfere with the normal action of the rose filter. This filter is used to turn green pigments to rose colour while leaving natural foliage green.

A definite silhouette, such as that of a big gun, can be broken up by means of fins bound to it, which are cut out to resemble the shape of foliage.

The writer then passes to the normal use of camouflage in the form of coverings and dummies. For use in connection with smaller screens or nets, the three-colour system with green, yellow and cream only, but separated by irregular heavy black masses, instead of lines, will be found to be the most satisfactory. The five colours are necessary only for large surfaces. It is easier to hide a battery in a position where more than one uniform colour generally exists, than on a flat equable desert, because in the former case the exact shade of colour of the covering is unimportant. Both during and after the construction of the disguise, very strict camouflage discipline is indispensable, for it is then that the real trouble is beginning.

The same number contains a description of the new plant for the production of helium for airships by the Amarillo Oil Company at Soncy, about six miles west of the city of Amarillo, in the Panhandle district of Texas. It seems that the existing Petrolia field, in Northern Texas, is

now in the last stages of its life, after producing gas for more than twenty years. The gas from the new field is said to be twice as rich in helium as that from the old field. The three gas wells already driven, produce 27 million cubic feet of gas per day, and a fourth well is being opened.

The helium is recovered by cooling the gas to approximately 300 degrees below zero, at which temperature all the constituents but helium are liquefied, thus permitting the helium to be drawn off as a gas for compression into storage cylinders. This low temperature will be produced by compression and the subsequent expansion of the gases. At the minimum temperature, atmospheric air is a liquid, carbon dioxide and mercury are solids, lead and copper have the properties of steel, and rubber is as brittle as glass. The United States is the only nation, as far as is known, having sufficient resources of helium to develop a commercial supply. Before the War, the cost of production was about £400 a cubic foot, now it is in the neighbourhood of a few shillings.

The February number continues the historical survey of the Early Coast Fortifications. Towards the close of the eighteenth century, the threat of war with Great Britain, growing out of disputes over unsettled boundaries and over the alleged English ill-treatment of American seamen, turned the thoughts of the youthful American State from the backwoods to the undefended seaboard. As very strict economy was necessary, the earliest conception of defence for the coastline consisted of an earthen battery and, behind it, a redoubt or large blockhouse, to be used as a barrack for the garrison and a keep protecting the battery from the land side. The batteries were armed with 24- and 32-pounders. As the only garrison seems to have consisted of gunners for the battery, the method of meeting an attack was novel. If the guns were able to keep the enemy at bay, all well and good: but if the attackers managed to land for a close assault, the gunners would retire to the keep, take up the small arms provided for the purpose and act as infantry till the assault had been repulsed, and the enemy forced back to the sea, when they would resume their original *rôle*.

From the September number was given an extract from an article on the Tacna-Arica question.

In *The Times* of May 3rd, 1929, there appeared the following despatch: "Lima (Peru), May 2: The settlement of the long-standing Tacna-Arica dispute is officially announced here to-day. It is understood that the province of Tacna will go to Peru and that Arica will go to Chile, with the establishment of a small port there for Peru (*Reuter*)."

It will be remembered that the United States had been asked to adjudicate this vexed question, and that, after a very carefully thought out attempt, General Lassiter, of the U.S. Army, had reported that a fair plebiscite was quite impossible to obtain. Peru thereupon turned to the League of Nations. Evidently the thought of world-wide publicity was enough to modify the sentiment of Chile. Direct negotiation was preferred and has led to a fifty-fifty division of the coveted area.

Thus, of the territories as distributed before the war of 1880, Chile has gained Antofagasta from Bolivia and Iquique and Arica from Peru. Bolivia has lost all footing on the sea coast and Peru has lost 150 miles of it.

D.M.F.H.

REVUE MILITAIRE SUISSE.

(1928. Nos. 7 to 12 inclusive.)

L'aviation militaire en Tchécoslovaquie. This article is contributed to No. 7 of the *Revue*, by Lieut E. Naef, who points out therein that the Republic of Czechoslovakia has paid considerable attention to the development of the "Fifth Arm," and, with a view to being independent of foreign sources of supply for the purposes of military aviation, has sedulously fostered the national aeronautical industries. At the beginning of 1928, all the machines in use, and also their motors, were of home manufacture. The peace establishment of the Air Force consists of 25 squadrons, viz., 10 fighter squadrons (of 15 machines each), 12 observation squadrons (of 15 machines each), and 3 bombing squadrons (of 12 machines each). Particulars regarding the types of machines in use and the organization of the Czechoslovakian Air Force are given in the original article.

Le commandement Français au début de la guerre Européenne. This article appears in Nos. 8 and 9 of the *Revue*, and is contributed by Col. F. Feyler; the information contained therein is drawn principally from *Les armées Françaises dans la grande guerre, tome 1er.* Col. Feyler points out that from the date of the signing of the Treaty of Frankfort, 1871, the French General Staff had the menace of another war with Germany in the near future constantly before it. In consequence, at various dates between 1875 and 1914, no fewer than 17 mobilization plans were drawn up by it. In the first part of the article (in No. 8), the developments in the international situation up to the outbreak of the Great War are very briefly sketched, and an appreciation of the military situation, from the French standpoint, is given. The second part of the article deals with the steps taken in France, immediately prior to the mobilization of the army; the occupation of the Duchy of Luxemburg by German troops; and the appointment of Joffre as Commander-in-Chief of the French Army. An outline is also given in this part of Plan XVII, which provided for the concentration of five French Armies on the Franco-German frontier line between Switzerland and Belgium.

La défense anti-chimique chez les nations armées et les perspectives du modernisme militaire. The article under this title, which is in three parts, appearing respectively in Nos. 9 to 11 inclusive, of the *Revue*, is contributed by M. S. de Stackelberg (an engineer) and Dr. D. Zweit (a chemist), who point out that war is no longer confined in its aims to narrow dynastic and political interests, but has now taken the form of a relentless conflict for the preservation of national existence. The desire to secure decisive results in the shortest possible time has been accompanied by two marked phenomena: (*a*) the disappearance of the relatively shallow fronts of opposing armies—due to the great range of aerial attacks; and (*b*) the disappearance of non-combatants or civil population, in a juridical sense, by reason of the necessity of mobilizing the entire people of a country for work essential for the conduct of military operations on a big scale. This fact is clearly recognized in the law for the organization of the nation in arms recently passed in France. In consequence, the whole of the national territory has become

a " front de combat," and the distinction between combatants and civil population has ceased to exist.

Air attacks and chemical warfare are, the authors of the original state, destined to become the weapons for relentless and indiscriminate use by the dominant arms in a future war, and they urge therefore that this fact should be brought home to the masses of every nation, and also that citizens at large should be familiarized with the defensive measures suitable for meeting chemical warfare waged against the civil population.

In the first part of the article (in No. 9), a reference is made to the abortive Conference assembled at Washington in 1921, for the purpose of prohibiting chemical warfare. Some particulars are also furnished regarding the provisions for the conduct of chemical warfare made in the United States of America and in Japan. The second part deals with the situation, as regards chemical warfare, in Europe; the measures which have been adopted in relation thereto in France, Poland and Russia are also briefly reviewed. In the third part, a table is given showing the casualties inflicted during the Great War by gas attacks, artillery fire, trench weapons, mines and hand grenades; summarized the results were as follows:

	Wounded.	*Killed.*
Gas attacks	6·5%	1·5%
Artillery and other weapons ...	5·5%	30·0%

The authors of the original article are of opinion that promiscuous chemical warfare cannot be prohibited, and put forward certain suggestions as regards the defensive measures which should be adopted to meet it; they also publish the proposed articles of a code in connection with the protection of civil populations against gas attacks, which code they have named the " Violet Cross " Convention.

La guerre Européenne. The original article is contributed to No. 11 of the *Revue*, by Col. F. Feyler. After passing in review the information contained in some of the more important volumes relating to the Great War, Col. Feyler proceeds to discuss the question: Would it have been possible to avoid the armed conflict of 1914–1918? The conclusion which he arrives at is that, after the Sarajevo incident, the Austro-Hungarian Government was bent upon bringing about the humiliation and submission of Serbia by violence, rather than by resort to the slower methods, of which the issue was uncertain, of diplomacy.

Dealing with the diplomatic campaign for the " localization " of the conflict, Col. Feyler takes the view that the desire for the " localization " of the Austro-Serbian differences was not less in one of the camps than in the other, but there was considerable divergence on the subject in relation to the method to be adopted for realizing the desired end. Whereas, those who followed the lead of Sir Edward Grey hoped, by securing " localization," to ward off the general conflict likely to be born from a regional war, and endeavoured, therefore, to bring about a reconciliation of opposing interests by preventing even the outbreak of a regional war; on the other hand, the Central Powers looked at " localization " from the standpoint of obtaining for Austria an oppor-

tunity for trouncing Serbia, without any interference on the part of the latter's friends.

Col. Feyler points out that the information available for dealing fully with the origin of the Great War, both in its immediate as well as its remote political bearings, is still far from complete; some of the diplomatic correspondence which has been very recently published has filled up some of the gaps, and when the further diplomatic correspondence, which is being now got ready in some of the Continental countries for the Press, is made public, it may be possible to deal with this difficult subject comprehensively.

W.A.J.O'M.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1928. TOME II.—NOS. 4 TO 6 INCLUSIVE.)

Les opérations de l'Armée Belge. 1914–1918. The authors of this series of articles consider it desirable, before entering on the narrative of the active operations during the period of trench warfare in Flanders, to deal with matters of an administrative nature. The two parts of the article which appear in Nos. 4 and 5, are devoted to the various steps taken in relation to the reorganization of the Belgian Army during the War period. No. 4 of the *Bulletin* contains an outline of the special legislation brought into force to meet the wastage of war, and for the purpose of providing for the expansion of the Belgian Army in view of the greater effort demanded to cope with the magnitude of the task imposed upon the Entente Powers by the Central Powers. The numbers of men enrolled under the special ordinances at various dates are set out. The steps taken for training officers and other ranks; the measures adopted for the acquisition of war material; and the developments brought about in the armament and equipment of the Belgian Army are also dealt with in No. 4.

A brief description of the organization of the Belgian Army as it was in 1914, is contained in No. 5 of the *Bulletin*; the successive changes introduced therein during the continuance of the War are also described in considerable detail, and in a form to show at a glance how very considerable were the increases which took place in the case of the technical troops.

An account of the Lines of Communication services during the period of trench warfare appears in No. 6 of the *Bulletin*. The general situation is first sketched out; later, particulars are given relating to the supply services; to the Ministry of Supply created in February, 1916; to the ordnance services; artillery establishments; the utilization of the engineers on various technical services, *e.g.*, forestry, mining, quarrying, etc.; and engineer supplies.

Du rôle de l'armée de campagne et des forteresses Belge en 1914. The final part of the article under this title, contributed by Lieut.-Col. Duvivier and Major Herbiet, appears in No. 4 of the *Bulletin*. The authors point out that, when the Great War broke out, the military preparations in Belgium to meet a sudden attack, such as that launched against it by Germany, were far from complete. Nevertheless, the Belgian troops fought with courage and tenacity, but they did not

possess any manœuvring power, nor were they capable of undertaking offensive operations on any scale. Consequently, if the comparatively small Belgian Army only yielded ground in its retreat from Liège to the Yser, step by step; if it faced a powerful enemy for three months and managed to escape disaster; if, by its activities, it caused the enemy to divide his forces, and, therefore, to be unable to display his full strength at the decisive point; if this small force managed to hold together until it made a junction with Belgium's Allies, and was able to raise its standard aloft on the Yser with the cry: "*On ne passe plus*," these results were alone achieved thanks to the great part played by the Belgian fortresses.

Appendices are annexed; they give particulars of the German forces which were detached to meet the menace of the Belgian Army during the progress of the frontier battles, during the period immediately subsequent thereto, and during the Battle of the Marne. A table is also given, setting out in a summary manner the references contained in German publications in relation to the influence exerted by the Belgian forces on the operations of named German formations—the titles of these German publications are recorded.

Historique du Génie. The third and the final parts of the original article under this title, by Lieut.-Col. Coppens, appear respectively in Nos. 4 and 5 of the *Bulletin*. Part 3 is devoted to the vicissitudes of the engineer arm during the ascendancy of the Vallières, father and son, and to the history of the arm during the periods of the French Revolution, the Empire and the Restoration. The elder Vallière was an advocate of the absorption of the engineer arm into the artillery; owing to his distinguished services as an Engineer officer, he was given important artillery commands. The engineer company under his command was reorganized in 1718, and he was then promoted to high rank; later, he was appointed an artillery general, when one of his first acts was to bring about an assimilation of the engineers and the artillery. Various cross-currents now made themselves felt in the French Army; at one moment, the ardent reformer in the ascendant would be an officer who pinned his faith on the efficiency of the arrangement, which combined the artillery and engineers into a single Corps, at another moment the deciding authority would be an officer, or a Minister, who entirely disapproved of the fusion scheme, and, in consequence, would undo the work of his predecessor, and re-create separate artillery and engineer arms. During a part of the period in which these repeated reorganizations were in progress, Vallière junior was the Director General of the Artillery and Engineer Corps.

Further difficulties arose towards the end of the eighteenth century; the whole Army was now completely disorganized, and during the periods of the Revolution and the Empire, incessant changes were made. The engineer arm had, by this time, ceased to exist; and, in consequence, the art of the sapper and the miner had been completely lost; to such an extent had this taken place, that in 1792, at the Siege of Antwerp, it was necessary, before sending troops into the trenches, specially to train them in sapping in a small work which was conveniently placed for the purpose. The various steps taken to rectify the unsatisfactory

state of things referred to, are set out in the original article; mention is also made of the development in the scope of the duties assigned to the engineers.

The final part of the article (in No. 5), is devoted more particularly to an account of the engineer arm in the Belgian Army, from the time it came into existence on the outbreak of the Revolution of 1830; the history of the arm is divided into three periods, viz., 1832–1868, 1868–1913, and 1913–1926, and its growth and the changes in its duties and organization, in each of these periods, are briefly traced.

Les Chars de combat. The final part of the article, by Major Liévin, appears in No. 4 of the *Bulletin*. It deals with some of the types of tanks in use in the American Army, in Spain, Russia, Poland, Czechoslovakia and Germany. A list of the works consulted is appended to the original article, and a table is also furnished wherein dimensions and other particulars relating to tanks in use in various countries are recorded.

L'Organisation de la Défense Nationale en Suisse. An anonymous article under this title is published in Nos. 4 and 5 of the *Bulletin*. Part I deals with the Swiss Army; its organization and recruiting system are explained, and the provision made in the Estimates for National Defence is briefly touched on. In Part II, particulars are given of the method adopted for preparing the youth and manhood of Switzerland for military service. Extracts are also given from the ordinance of July 10th, 1928 (published in the *Feuille officielle militaire* of July 18th, 1928), which set out the legal requirements in relation to this matter.

Les deux batailles de la Marne. The original article, which appears in No. 5 of the *Bulletin*, is an interesting review of a work (published by Payot, Paris, in 1928) under this title, containing contributions from Joffre, the ex-Crown Prince of Germany, Foch and Ludendorff, relating to the two battles named.

Emploi de la défense terrestre contre aéronefs. The first part of this article, contributed by Major Molhant, appears in No. 6 of the *Bulletin*. In view of the fact that the Belgian anti-aircraft defence arrangements are still in an embryonic stage, as an introduction to the subject Major Molhant summarizes the French regulations, contained in *Aéronautique au combat, Livre IV—La défense contre aéronefs*. The aspects of the subject dealt with in the part of the article under review, relate to the duties assigned to the A.A. defence organization, *i.e.*, (1) the patrolling of the air and reconnaissance; and (2) protective measures and the means employed, *i.e.*, A.A. artillery, machine-gun fire, searchlights, aerial entanglements, and camouflage; and the methods of utilizing each of these means.

Les armées dans les Alpes occidentales. The first part of an article under this title, contributed by Major Delvaux, appears in No. 6 of the *Bulletin*; it contains brief descriptions of the important features of the mountain systems lying immediately to the eastward and westward of the River Rhone. Some particulars relating to the industrialization of these regions, *i.e.*, the utilization of the water power therein, are also given.

Tannenberg. D'après les ouvrages officiels Allemands. The first part

of this article, by Capt. Vandaele, appears in No. 6 of the *Bulletin*; it is based on a monograph on the battle named, compiled by Lieut.-Col. von Schäfer (Chief Keeper of Archives), and issued by the *Reichsarchiv*. The part of the article under notice deals with the general situation in East Prussia in 1914; the recall of General von Prittwitz; the situation on August 3rd, 1914, and the plans of the new Commander (von Hindenburg) of the German forces in this region; and the engagements fought by the German XX Corps in the neighbourhood of Frankenau, Lahna and Orlau on August 23rd and 24th, 1914.

W.A.J.O'M.

HEERESTECHNIK.

(*July*, 1928.)—*Wireless Direction-Finding*, by K. Müller. This 20-page article, containing many diagrams, forms a very good introduction to the subject. It treats first of underlying principles and of the various methods.

Direction-finding is primarily an optical procedure, and consists in measuring the angle between a given object and a known direction, generally the magnetic north. If the radiation from the object is not that of light, but of Hertzian waves, we get the special case of wireless direction-finding.

At any point where such radiation is received, three definite directions are distinguishable, each of which is at right angles to the other two. These are:

(1) The direction of propagation or travel of the wave.
(2) The direction of oscillation of the electrical component.
(3) The direction of oscillation of the magnetic component.

Of these the receiving apparatus determines either (2) or (3), but generally (3), and deduces (1).

In the coils of a frame aerial, the oscillation of a magnetic field produces oscillating currents, varying from zero, when the frame is at right angles to the direction of travel of the wave, to a maximum, when the frame is pointing at the source.

It is usual to determine direction by reading, not maxima, but minima, and this for two reasons, (1) in general, sound minima are more easily determined by the ear than sound maxima; (2) in particular, because the sound intensity $\propto$ current strength $\propto$ field strength (or number of lines cut) $\propto$ *cos* the angle of inclination of the frame; and the difference between *cos* 89° and *cos* 90° is over 100 times the difference between *cos* 0° and *cos* 1°.

Methods. 1.—The Frame Aerial.

Consider a frame, rotatable about a vertical axis, being swung through 360°. It is obvious that the currents set up in it by electro-magnetic radiation from an external source, will pass through two maxima and two minima. That is, its characteristic if plotted will be two equal circles, touching at a point. A directional linear aerial has the same characteristic, while that of a non-directional linear aerial is a single circle.

In thus determining the line of travel of electro-magnetic radiation, the direction of the transmitting station found is ambiguous, as there

are two solutions differing by 180°. This ambiguity can be avoided by using a combination of aerials of different types: thus, a frame aerial and a non-directional linear aerial, suitably coupled and adjusted as to phase, give a characteristic which is a compound of their respective characteristics, viz., a dipole and a circle. This curve is a cardioid, having only one maximum and one minimum.

An English method (Robinson), is to have two frames fixed at right angles to one another and capable of rotating as a whole. By switching, the coils reinforce or counteract each other. When signals remain of the same strength, whether the second coil is assisting or reversed, the second coil is idle, *i.e.*, the frame of the second coil is at right angles to the incoming wave. The method has the advantage of being applicable without interfering with message work. Another frame method has two frames movable independently about the same axis. The frames are placed one on either side of the minimum, and then adjusted to be on points of equal loudness, when the line bisecting the angle between them gives the direction required.

Frame direction-finding, the simplest method, has come latest into prominence, since the amplification necessary to keep the frames from becoming so large as to be unwieldy, has only latterly become available.

2.—The Goniometer.

This arrangement uses two linear aerials fixed at right angles to one another, each of which includes two coils situated axially, so that the coils of one aerial are at right angles to the coils of the other, and leave a space for an independent rotatable coil which is in circuit with detector, potentiometer and telephones. This exploring coil thus lies in the field, which is the resultant of the fields produced by distant radiation affecting the coils of the respective aerials, and plays in the field the part of a miniature frame aerial. This is the Bellini-Tosi system. If, instead of the resultant being obtained, the intensities are compared, the system is that of Marconi and Prince.

3.—The Star Antenna.

This is the original "Telefunken Clock," used by shore stations working to the German Navy. It consists of a large number of aerials, usually of the umbrella type, say, 32 to 45, laid out in a great star, and connected to a ring coil inside which a pair of movable brushes connects with the receiving apparatus.

All the foregoing methods have the same drawback, viz., that not all people have equal acoustic sensitiveness, and especially that the fixing of points of equal sound intensity cannot be learnt by everyone. Hence, optical methods are very desirable.

The first proposal to substitute sight for hearing was simple enough in theory. Two aerials at right angles to one another, had each its receiving apparatus. From the latter, rectified currents were led to a differential galvanometer, on which the correct angles were marked corresponding to a certain degree of amplification. Practically the difficulty of building, let alone maintaining, two circuits with the same degree of amplification, especially for different strengths of signals received, was prohibitive of such an arrangement.

Two visual methods are then described, the first by Watson Watt

(this, like the other English method described above, also originating from Aldershot), and the second, by the author himself.

The former " very elegant ' method has as indicator a Braun's tube, and the position of the spot of light on the fluorescence screen, showing the deviation of the kathode rays, gives a reading of the direction.

Müller's method is not only pleasing to the eye, but, as requiring only one receiver instead of two, is more practical. A glow-lamp on slip rings is fed by the amplified current received, and rotates synchronized with the exploring coil. As the minimum points are passed, the glow lamp is momentarily extinguished. If the exploring coil is driven by a small motor at not less than 10 r.p.sec., an illuminated circle is seen interrupted by two dark lines at the minima.

Sources of error are then dealt with, followed by the uses of wireless D.F., intelligence and navigation.

The Invention of Sound-Ranging. It is not surprising that last month's article on sound-ranging in the Swiss Army, the publication of which might be taken as implying some backwardness in this subject in the German Army, should call forth immediate protest.

Capt. Löwenstein writes an interesting article in which he shows that sound-ranging was not only successfully practised by the Germans, but that early in 1915, it was so far developed that there were eight S.R. sections working on a line of overlapping bases from Ypres to Arras. Sound-ranging was also used successfully for registering, and in general, the results achieved were such that the number of German stations was being increased as late as the end of 1917.

He disposes of the claim that sound-ranging started in France, in November, 1914, as the invention of the astronomer Nordmann, by quoting the wording of the State Patent taken out by himself on the 6th October, 1913:

" A proceeding for determining the position of sound-producing objects, characterized by reception of the sound, conveyed through air, water, or the earth, at not less than three places, and by determining the differences in the times of arrival of the sounds, either by persons or by means of electrical receiving and registering apparatus."

Capt. Löwenstein also quotes from a memorandum addressed by himself in October, 1913, to the Artillery Proof Committee, in Berlin, a proposal to use microphones for listening purposes.

In October, 1914, at La Bassée, he made the first observations and measurements, which immediately brought such good results as to win over the artillery commanders of the VIIth and XIVth Corps, who at first had been sceptical. The first successful instance of the use of sound-ranging by the troops occurred in November, 1914, when the 76th F.A. Bde. located a gun in a wood south of the La Bassée Canal. Soon after this, and at a time when it was unknown to the Germans that we possessed any gun on a railway mounting, sound-ranging results had caused them to suspect the existence of such from different points being located along the Béthune–La Bassée Railway. Confirmation of the sound-ranging work was then strikingly afforded from the notebook of a captured R.E. officer, who had been employed working for the railway gun.

During 1915, Capt. Löwenstein says, sound-ranging was "invented" on all sides. Prior to that, it seems to have been invented independently in Germany and in France. If the German patent quoted disposes of the claim on behalf of Nordmann of priority, he has still, as is the case with many inventions, a parallel claim of originality.

Thoughts about the Tasks of Weapon Technics, by Lt.-Gen. Baron Botzheim (*concluded*). In considering the tasks which, irrespective of the future, even now have devolved upon weapon-technics, the author, for reasons which become apparent later, starts with the air. He reviews in turn the means with which aircraft act upon ground targets, the nature of their action, classed according to the heights to which it is necessary for them to descend, the various types of weapon which are consequently necessary for engaging aeroplanes from the ground, the fundamental requirements common to those weapons, and, what is also a matter of special importance for the construction of A.A. weapons, the intended fire procedure. He then discusses the various methods of fire procedure against aeroplanes from the ground, from the water hose method with light-tracer ammunition, the burst of fire, and the barrage, to snap-shooting. This leads to the next important point to be cleared up, viz., the effects to be expected from the various calibres and the different kinds of projectiles. "The solid bullet from small calibre m.g.'s has little effect on a modern aeroplane, unless it happens to hit specially vulnerable parts, like the propeller, the engine, the steering-gear, or the pilot, and it generally is of no consequence whether the hole it makes has a diameter of 8, 13 or even 20 mm. Accordingly, the generally accepted idea that the troops have in small calibre m.g.'s efficient protection against direct action by hostile aeroplanes, up to 1,000 metres, is a false one. Some extent of moral effect can be conceded. Only through the use of the method of the water hose with tracer ammunition, and the assembling of several machine-gun barrels into a single weapon, can the troops hope for anything like sufficient effect through chance hits in vulnerable parts.

"Generally, it must be emphasized that nothing but direct hits by explosive shell with sensitive fuse can cause such damage that the aeroplane's flying power is prejudiced."

To what calibre the large calibre m.g.'s can be reduced, retaining the tracer, so as still to have sufficient destructive effect, is by no means certain; but the Germans have gathered the idea from abroad that 20 mm. is the limit.

The calibres of A.A. artillery are also for reconsideration, since it appears doubtful if the 7·5-cm. gun has sufficient effect against large modern metal aeroplanes.

From such considerations, two deductions are made. First, how extraordinarily complicated are the weapon-technical questions which affect the further developments of A.A. defence, and what a mass of tasks for weapon-technics in all countries awaits solution. Secondly, how pressing these tasks must be considered in the light of the increasing significance of the air-forces for the safety and existence of the states liable to be attacked.

"It is no passing catchword that air forces are universally becoming

regarded more and more as taking the first place among the weapons to be immediately at a nation's disposal. Further requirements for successful A.A. defence are flights of fighters, a well-organized Air Observation Service, and powerful independent air forces ready to answer with reprisals."

The author recognizes that for Germany, as a compulsorily disarmed State, there is no question of air armament on such a scale as this, but he urges that immediate permission should be obtained for a sufficient number of A.A. weapons and the appropriate number of fighters to guard the country, "so long as in the immediate future no general disarmament of military air forces is decided upon and carried out," a state of affairs which he is bound to admit "would stand in sharp contrast with the existing tendency to increase military air forces urged with all means among the victor States."

After dealing with the air, Gen. Botzheim turns to mechanized armoured vehicles and the general motorization of armies. The latter he considers a quite natural development, corresponding as it does to the like tendency in civil life. In fact, the question of the complete replacement of the horse in armies depends upon the progress of motorization in civil life, in agriculture and in forestry, since the provision of purely military vehicles for this purpose on account of their high cost and the superannuation to be expected, "cannot be considered by any of the victor States—except perhaps by England, with its small professional army—much less by impoverished Germany, to which the number and type of motor vehicles in the army is moreover exactly prescribed."

The matter can, however, be speeded up, as has been done in some countries, notably France, by subsidies. Motorization of armies by means of requisitioned cars, omnibuses and lorries, will increase in any case, owing to the increased effect of hostile aircraft on railways.

In the full utilization of motor power, the most important question is that of the mechanical armoured fighting formations intended to be able to take the field as independent forces. They would also to some extent have to act as operative storm troops in connection with the rest of the army, which would further exploit the successes they gain. Besides, immediately war began, they would have the task of breaking through the frontier protection and seriously interfering with the enemy's mobilization and assembly march.

"The different possibilities of use of mechanized armoured fighting formations, on account of their great operative and tactical mobility, combined with very great offensive strength, ensuring immediate and full exploitation of operative surprise, have something so alluring to the higher command, that their full development can no longer be considered Utopian and is worthy of the closest attention."

The author then discusses the attitudes of the Great Powers towards this form of warfare in turn, starting with England and finishing with Germany. Regarding the restrictions on the latter, he confines himself to *difficile est satiram non scribere*, and, by thus falling back on Juvenal, shows that for himself the difficult is still achievable.

A list of twenty of the more important data to be considered in

judging of the effectiveness of anti-tank and anti-aircraft weapons closes the series.

(*August*, 1928.)—*Questions of Motorization in Foreign Armies.* Taken from an article in *Army Ordnance*, September-October, 1927, by Major Quinton, United States Ordnance Dept.

1.—Tractors; Light, Medium and Heavy.

As regards light tractors in the United States Army, the present policy is to rely on the economic life of the nation to furnish these when required for mobilization. An army type has, however, been produced, the Tractor 1920, which is described as an excellent model, and which will be the standard if the present policy is changed. As regards civil types, the Fordson has been tried out and is looked upon as a good standby. The McCormick-Deering 10–20 is undergoing trials and is likely to come under the same category. A 2-ton Caterpillar that was tried failed to drag both gun and limber over difficult ground. A new and heavier model is being built.

In the class of medium tractors, civil life cannot be relied upon to the same extent as with the light tractors. A special military construction for this purpose is called Corps Tractor 1921. At the same time, Caterpillar 30 has been chosen as the civil type which may be required.

For heavy tractors, there is no type available from civil life which can anything like meet military requirements. However, a type has been chosen, Caterpillar 60, which will serve if two tractors are coupled together. Meanwhile, military trials are being made with the chassis of the Mark IX motor gun-carriage, and these promise a workable solution.

2.—Cross-Country Vehicles.

The first class of these is converted lorries. The first conversion made was the fitting of tracks of different sorts to the ordinary 3- to 5-ton lorries. The result of trials was the decision that the track lorry did not show sufficient superiority across country to the ordinary lorry for the conversion to be worth while; especially as, at about the same time, a very promising solution was found in the six-wheel lorry. With both rear axles driven and pneumatic tyres, the six-wheel type has done some splendid performances; so much so, that the principle is being extended to other classes of vehicle.

The next class is that of tractors with trailer. It was decided that the trailer should have wheels, and the type chosen, called the "1-ton trailer," has been made out of two coupled field gun limbers. The same, but built rigid, so that the two limbers make up a wagon, was not successful. It is known as the "2-ton trailer."

Class three consists of the "Tractor, ammunition wagon." It was built for the use of the Tank Corps on a light tank chassis, the Tank Corps having insisted upon an ammunition wagon, having the same ability to negotiate country as the tank itself. The next is also a special class. It consists of the Infantry light motor-lorry, with four-wheel drive and pneumatic tyres, required for carrying weapons, ammunitions, signal stores, etc., in forward sectors. This lorry has gone to the Infantry for trial.

The last of the cross-country classes is the Reconnaissance Car. It

was originally demanded for the conveyance of the personnel of mechanized units who had previously been mounted on horseback. Several designs were made and tried, until such excellent results were obtained with the Ford cross-country car, that all trials with special cars became unnecessary, and the Ford was adopted.

3.—Tanks.

The whole position as regards tanks in the U.S.A. is curious. The 6-ton tank and the 40-ton tank had their origin in war. Since 1919, while all the other great military nations have shown great interest in this problem, the U.S.A. have produced a single type, the medium tank of 22½ tons. This tank has been tried with the troops and reported as too heavy. The Ordnance Dept. does not propose to make other than slight alterations in it during the next 10 to 15 years, but the question is being studied whether another medium tank of 15 tons should be produced.

4.—Dragons.

As regards light artillery, the decision has been reached that the horse is still preferred. Should motorization be decided upon later, the first step would be the provision, not of a motor gun-carriage, but of a tractor. The demands made upon anti-tank guns can, however, only be met by providing them with self-propelled carriages, and this has been done with the 75 mm. gun, and also with a howitzer on agricultural tractor T35. Very little alteration was required either to the tractor or to the howitzer-carriage. For medium artillery mechanization is certain, and a tractor most likely, but the Ordnance Dept. is producing a motor gun-carriage, known as Mark X. The same applies to the heavy artillery, except that the carriage known as Mark IX and taking the 6-in. gun or 8-in. howitzer has passed its trials.

5.—Armoured Cars.

This subject has only been taken up recently, and it is intended to design an armoured car to accompany the cavalry reconnaissance.—(*To be continued.*)

Neck Collars v. Breast Collars. Lt.-Col. Müller shows how the neck collar of peace was, during war, at the request of the mounted troops, ousted by the breast collar. The higher commands all asked for breast harness for its ease of fitting, suitability to different sizes and types of horse, and, indeed, to the same horse in different conditions. The advantages of the neck collar, viz., larger bearing surface and better direction of pull, were outweighed by these, and by the further great consideration of suitability for mass production.

The Leipsic Lorry Exhibition, March, 1928. One of Dr. Stadie's careful articles based upon thorough statistical investigations, and with photographs, tables and graphs. Of the 38 firms exhibiting, 5 only are foreign (Citroën, Renault, Ford, General Motors and Steyr), so it would not be fair to draw any conclusions from these, and the exhibition must be looked upon as entirely a German one.

Nearly half the exhibits consists of omnibuses, special vehicles (fire brigade, conservancy, tip-wagons, etc.), and transport tri-cars. The remaining 59 exhibits are lorries, classified as follows: up to 1·5 tons, 19; 1·5 to 2·5 tons, 8; 2·5 to 3·5 tons, 15; over 3·5 tons, 17. As opposed to ideas abroad, heavy lorries are still much preferred in Germany, but

these figures seem to show that even there the light lorry is increasing in favour.

Dr. Stadie says that in future we must distinguish fundamentally between light lorries up to 2 tons useful load, ordinary lorries, and omnibuses (which have now entirely separated themselves from the lorry class). The light lorries incline strongly to be built of car components, and this tendency is noticeable also in the next category, up to 2·5 tons.

Taking pre-War prices as 100%, the following changes in price have taken place in Germany during the last four years: cars, 125% to 66%; lorries, 100% to 66%. That such a reduction should be possible, can only be explained by the broader basis of production.—(*To be continued.*)

England's Equipment Industry in the World War, by Lt.-Gen. Schwarte. Notes on Winston Churchill's *The World Crisis*, in which the author, while pointing out the sharp contrast between England's position and Germany's in regard to providing the munitions of war, is still able to draw interesting comparison of common difficulties in industrial troubles, help to allies, etc. Amongst many matters in which his praise is not stinted, Gen. Schwarte can "only acknowledge with admiration" the task of equipping the American Army. Finally, he is too shrewd to fail to understand Churchill's apostrophizing, "Truly, O Germans, you have done enough for history," and adds thereto, "also it is to be hoped for the right to a better future for the living!"

Recent Meteorological Instruments and Methods. The practical Meteorological Service of Germany is in the hands of four different departments, each of which has affected instruments and methods. They are: the Storm-Warning Service of the German Marine Observatory (1876); the North German Public Weather Service Organization of the Prussian Ministry of Agriculture (1906); the Air Travel Warning Service of Lindenberg Observatory (1911); and the Army Meteorological Service (1913).

Among the recent methods and instruments due to the foregoing are: a distant wind measuring establishment alongside the artillery range at Kummersdorf, with measuring stations at 3, 6 and 9 kilometres distance; a wind gauge on telescopic mast, for use in wooded country; a light anemothermograph for use with small kites, registering wind and temperature up to 500 metres; a kite-balloon, which having certain flying properties, bridges the gap hitherto existing between the measurements recorded by registering balloons and those recorded by kites; an improved theodolite for measurement of wind at night, with a special lighting arrangement for reading the scales; and a rocket meteorograph.

Air Service, Berlin–Teheran. Berlin to Baku, daily, except Sundays, leave 11 p.m.; first night, Moscow; second night, Armavir; arrive Baku, 2.15 p.m. Leave Baku 6 a.m. Tuesdays; arrive Teheran, 12 noon. Leave Teheran on Tuesdays and Sundays by Junkers or Ukrvosduchputj aeroplanes week and week about.

(*September*, 1928.)—*Motorization Questions in Foreign Armies.* Compiled from Major Martel's article in the *R.E. Journal* for December, 1927.

The Leipsic Lorry Exhibition, March, 1928 (*continued*). Besides what was said last month about the increasing use of car components in light lorry construction, the following are the chief conclusions drawn:

The arrival of the fast six-wheeler of 3 to 4 tons useful load continues the line of development started in the light lorries. The six-wheeler far surpasses all former lorries in adaptability to the ground, speed, and lightness in proportion to useful load, so that these, as well as economic advantages, favour its introduction. The adoption of pneumatic tyres and of the 6-cylinder engine continue to make headway. The percentage of six cylinders at the Exhibition has risen in one year from 21 to 50.

The use of Z.F. Standard gears has also much increased.

Gears which are very promising and should be watched are the supergears of Maybach and the N.A.G. plate-coupled magnetically actuated. The latter take 40 watts at 12 volts, but require no more than a button to be pressed, which can be done with one finger while the hand remains on the wheel.

Four-wheel brakes are now universal, since with large and fast lorries it is no longer possible to brake adequately with hand- or foot-brakes. The question of the auxiliary (mechanical, air-pressure, suction or hydraulic) is not yet decided.

The English practice of rear axle drive by worm-wheel continues to be adopted: its further introduction is to be reckoned with.

The use of home fuel as hitherto, rests with the Diesel engine, which has already gained ground.

The day of the slow, heavy lorry (10 to 12 m.p.h.) is over.

Photographs are shown of:

Mannesmann-Mulag 6-wheeler for 3-ton useful load.
Krupp 6-wheeler for 4-ton useful load.
Daimler-Benz 6-cylinder engine, 70 h.p.
Junker 2-cylinder Diesel engine for lorries.
Sectional model of Junker compressorless double-piston Diesel engine (the two pistons in each cylinder move in opposite directions, the one near the crank-shaft having a short connecting-rod and moving as usual, while the other, further from the crank-shaft, has two long connecting-rods and is reversed, *i.e.*, works towards the crank-shaft).
Dürkopp 6-cylinder engine.
The same—a valve in its cage being changed.

A diagram shows the lockhead brake, which introduces the hydraulic brake for lorries. The foot-lever works a piston, which actuates the pistons in the brakes by means of the pressure conveyed through pipes containing an acid-free mixture of castor-oil and alcohol, which is insensitive to temperature changes up to 100°F.—(*To be continued.*)

F.A.I.

MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*November–December*, 1928.)—*The Last War of Austro-Hungary.* Apart from the pathos of its title, with its reminder that the Austro-Hungarian Empire no longer exists, the Austrian Official History of the Great War will be a model if it observes the lines here laid down for it

by the Keeper of the State Archives, Glaise-Horstenau. After dictating the general lines of the work the writer treats of tone. The history must keep itself apart from any party position whatsoever; no easy task when the sudden collapse of an army standing everywhere on enemy soil has to be explained. In order to remain non-political, it must be strictly objectively written, establishing events reliably and reproducing them with fidelity, leaving judgments to the reader. It must give a clear and true picture, embellishing nothing, and concealing nothing of importance. It would miss its object as a scientific work, were it conceived as a patriotic work of edification. The jingo spirit must be kept remote, and the history must serve truth and military science, even at the cost of prestige.

The Course and Collapse of the German Offensive of 1918 *in France*, by Capt. Ritter, late of the German General Staff. The story is very shortly told (only 13 pages, including 5 sketches), very clearly told, and thrilling in its simplicity throughout. It has no space for adjectives or hot air.

The idea of the offensive was born on the 11th November, 1917, a date which might well have contained in it the seeds of misfortune. As a result of a conference held on that day between General Ludendorff and the Chiefs of the General Staff of the two Army Groups of the Crown Prince Rupprecht and of the German Crown Prince, a protocol was drawn up, containing the following: "Our whole position demands that we should strike as early as possible, the end of February or beginning of March, before the Americans can throw large numbers into the scale. *We must beat the English.*"

The first proposal in order to give expression to this was an offensive both sides of Armentières, general direction, Hazebrouck. This, at any rate, as the *first* act of the coming offensive, was turned down, as, owing to the waterlogged condition of Flanders, April would have been the earliest date possible. The next proposal was to attack from St. Quentin, advancing to the line of the Somme, between Ham and Péronne, then with the left flank on the river to turn N.W. and roll up the English line. This plan, too, was dropped. A memorandum was then issued by G.S. Operations at German G.H.Q., which was opposed to any *single* great attack as likely to fail through the line bending back before it, and enemy reinforcements coming in on both flanks of the advance. The memo proceeded: "The whole offensive falls into two acts, an attack on a broad front, Cambrai-St. Quentin, and, about 14 days later, an attack, general direction, Hazebrouck."

Preparations were started accordingly on these lines, but a very curious change took place. Owing to increasing confidence, there came about almost by imperceptible degrees a fundamental change. The idea of two attacks, the first preparatory, the second decisive, was gradually dropped in favour of one great break-through, from which a rolling-up operation was to proceed. The St. Quentin attack (known as Michael), instead of being the first act, creating favourable conditions for the second, the Hazebrouck attack, which was to bring the decision, became the sole source of victory, in fact, exactly what the G.S. Memo had said a single break-through could not hope to be.

The question then arose from this new state of affairs, of what nature was to be the development of a successful offensive at St. Quentin. As long as Michael was to be only a preparation for another attack elsewhere, the chief demand upon this attack, in accordance with the protocol, was for it to do the British Army the greatest possible damage. Hence, it would have to be applied where it promised the greatest *tactical* success, strategy taking for the time a secondary place. This promise was to be found on the German left, where reconnaissance had shown that the least resistance would be found. The 63 divisions for the attack were accordingly allotted to the 3 German armies concerned, from north to south, as follows: 19, 20 and 24.

Now that Michael had changed from being a preliminary operation, destined to stop on the Somme, to being the only attack, it became evident that the centre of gravity had shifted from the German left wing to the German right wing, since it was the right wing, which, the Somme having been once reached, would have to lead in the further development, viz., in the task of rolling-up the British front from south to north. Strategy had now come into the picture, and the claims of tactics and of strategy stood in sharp conflict.

Nor was a solution easy to find, since the transfer of a dozen or so divisions from the left wing to the right wing, on a front of 50 miles, would be a manœuvre necessitating a halt in the operations and allowing the enemy the time to go over to the strategic offensive. Two alternatives presented themselves. Either a re-grouping of the divisions, weakening the left in favour of the right, or the whole attack must be given a fresh object, which should suit the armies as they stood, with the preponderance of strength on the left. G.H.Q. could not agree to the first plan, owing to their determination "to break through somewhere," and the best chances for this lay on the left wing. They therefore agreed to the attack being pushed beyond the Somme, and a defensive front being formed against a possible French counter-attack from the south-west.

On the 23rd March, two days after Michael started, this extension of the original plan had swollen into a new double operation, viz., an advance on both sides of the Somme to separate the French and English, and an offensive against the French towards the line Amiens–Montdidier–Noyon.

These should, in the opinion of the author, not have been undertaken except against a badly-shaken enemy, whereas the experiences of the German right and centre armies showed that certainly powerful resistance on the part of the British was still to be reckoned with. In fact, the Germans were heading straight for the position of deadlock, which their own G.S. had foretold as certain to result from a single break-through.

The German successes of the 24th and 25th March caused their G.H.Q. to order a still greater extension of the objectives. The fronts of the three German armies flowed outwards like a fan, until the extension of their frontage brought about so great a reduction in depth, that the French reserves hurrying up were able to hold them.

The strategic result of Michael was, first and foremost, that it had not

brought the great decision. It had, however, severely damaged the British Army. Against this, the extension of its operations beyond the line originally intended had so far weakened the German Army, as to leave a quite insufficient number of divisions for an attack on Hazebrouck, should that idea be resumed. As a result of the deadlock existing, the Hazebrouck idea was revived, but the scale of its execution was too small (only 22 divisions taking part at first, and 36 in all, compared with Michael's totals of 63 divisions at first, and 92 in all), for it to have any real chance of success; and the second break-through also fought itself to a standstill.

With both attacks unable to progress and no strategical decision reached, German G.H.Q. was faced with the difficult task of discovering a new way of carrying out their intention which remained as before, "we must beat the English."

The plan chosen was to attack between Scarpe and Somme, against the line St. Pol–Abbeville, and at the same time on both sides of Lens towards St. Pol, thus pinching out Arras. On the 15th May, it was decided that there were not sufficient troops for this operation. Before such a stroke could succeed with the forces available, it would be necessary to draw off the reserves by attacking elsewhere first. A break-through for this purpose was, therefore, arranged and carried out against the French from the Chemin des Dames to the Marne. Its real aim of drawing off the British reserves from the intended next point of attack in Flanders was completely successful. But it provided the German front with one more bulge, and consequent increase of front, and it necessitated further attacks for the improvement of the front and securing it against being outflanked.

The most important of these took place on July 15th at Rheims. It was foreseen by the French, who reduced the defenders to a minimum, in order to carry out a counter-stroke. This took place on July 18th, on both sides of Villers–Cotterêt in the direction of Soissons–Laon, "and here we find the same interesting phenomenon which had already shown itself at the end of the Marne battle in 1914, that being forced to allow the strategic initiative to pass into the enemy's hands (provided one has insufficient strategic reserves immediately capable of re-seizing the initiative by attacking) leads irresistibly to the final loss of that initiative."

"On the 18th July, 1918, German G.H.Q. lost the strategic initiative irrevocably, exactly as they had done on the 10th September, 1914. The hopes of finishing the War by a victorious offensive had to be finally buried."

F.A.I.

CORRESPONDENCE,

WIRE-NETTING ROADS.

The Editor, *The Royal Engineers Journal.*

SIR,

The recent correspondence in *The Royal Engineers Journal* about the origin of the wire-netting roads laid in the Sinai Desert during the Great War prompted me to mention these roads to a gentleman who had served in the Egyptian Public Works Department.

He stated that, before the War, wire-netting had frequently been laid on sandy ground in order to enable the motor cars of the Department to traverse country where camels were the only other means of transport, and that this method had been employed as long ago as 1910.

It would be interesting to know if the experience of the Egyptian P.W.D. was the real inspiration to our military engineers, and if not, to reflect how much valuable information may be lost by inadequate co-operation with civil departments, some of the main sources of Engineer Intelligence.

I am, etc.,

J. V. DAVIDSON-HOUSTON, *Lieut., R.E.*

"HANDBOOK ON TIDES."

The Editor, *The Royal Engineers Journal.*

SIR,

Referring to Professor Proudman's review of my *Handbook on Tides* in *The R.E. Journal*, September, 1927, and my letter in reply thereto, I would be greatly obliged if you would kindly allow me to supplement the latter. The learned Professor complained that I had not allowed for inertia, the effect of which "is by no means negligible," but did not challenge my definition of a perfect fluid, which is one that would offer no resistance to change of shape.

Differing from all previous writers, Mosely contended that tidal force cannot produce current, but only deformation of the spheroid by differential pressure and that the tidal wave is due to the transference of differential pressure to keep pace with the moon. If water was a perfect fluid this continuous *change of shape* would be effected without the interference of inertia. Water differs so little from a perfect fluid that the effect of inertia is very slight, as that mute but powerful witness *Nature* proves by placing high water at full and change as nearly as possible under the moon at Tristan D'Acunha, Kerguelen and the south point of Stewart Island, N.Z. (*see* p. 49 of *Handbook*).

In the currents of all previous theorists where the movement is one of translation, inertia would, of course, play an important part.

Yours faithfully,

J. F. RUTHVEN.

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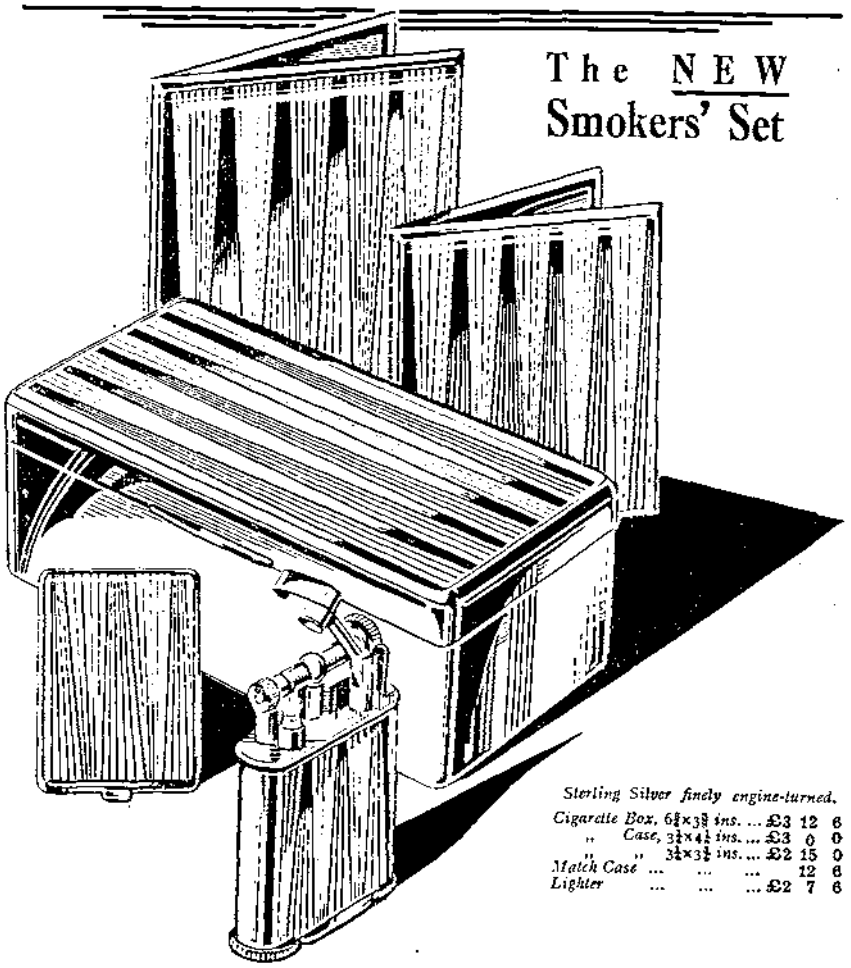

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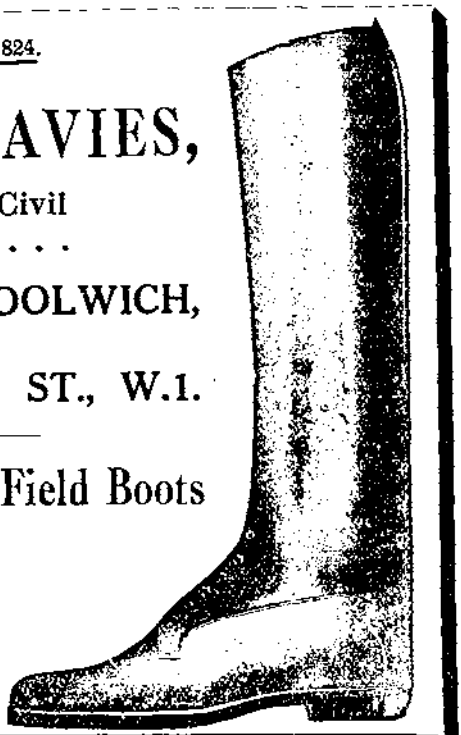

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ATTENTION is invited to the conditions under which this prize, in value about £14, is offered for competition each year.

1. The Prize is awarded by the Council of the Institution of R.E. in the manner considered best for the encouragement of contributions on professional subjects, by R.E. Officers, to the Corps publications. It has been decided that the Prize shall be confined to Officers on the Active List not above the rank of substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

The following are suggested as subjects for contributions.—

(*a*) Descriptions of works actually carried out in peace or war.
(*b*) Invention.
(*c*) Design (excluding works of defence).
(*d*) Labour organization on work.
(*e*) Scientific investigations generally.
(*f*) Accounts of exploration work and surveys.

THE COOPER'S HILL WAR MEMORIAL PRIZE ESSAY, 1929.

THE following subject has been selected for the above prize, which is the third of the triennial prizes presented to the Corps by the Cooper's Hill Memorial Fund:—

"The Bridge Problem of the British Army."

Essays must reach the office of the Secretary, Institution of Royal Engineers, Chatham, not later than the forenoon of the 2nd September, 1929. Essays must not be signed, but each must bear a pseudonym and the name of the writer enclosed in a sealed envelope must be attached.

The Cooper's Hill Memorial Prize is a bronze medal, a parchment certificate, and a sum of money, about £20.

(*a*) Qualifications of the Competitors.—To be a regular officer of the Royal Engineers under the age of 35 on the 1st January of the year in which the award is made.

THE ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY.

THE Council of the Institution of Royal Engineers has decided to award the Arthur ffolliott Garrett Prize to the best article, received and published in the *Royal Engineers Journal* in any year, which deals with any of the following subjects:—

1. Irrigation and Water Supply. 2. Railways. 3. Survey.

This will be retrospective for 1928. The notice in the January, 1929, *Supplement*, concerning the Arthur ffolliott Garrett Prize is therefore cancelled, and no special setting for an essay is to be considered as given for 1929.

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Will any officers who have had experience of any of these and can supply useful information, or are prepared to criticize such notes as are available, get into touch with the Officer i/c Training Manuals Revision, Room 037, War Office, Whitehall, London, S.W.1.

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