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THE R.E. JOURNAL.

As already announced, the present number of the *R.E. Journal* is its last appearance as a monthly publication. The first quarterly number will be published on the 1st March, 1923. The *R.E. Journal* was first published, in quarto form, in 1870, and was taken over by the R.E. Institute at the end of 1875. It first appeared in its present form in January, 1905.

ORGANIZATION OF ENGINEER SERVICES.

A Lecture delivered at the S.M.E., Chatham, on 19th January, 1922, by BRIG.-GENERAL W. BAKER BROWN, C.B.

IT is not possible, in the time allotted for a lecture, to go into every detail of such an intricate subject as our Organization for Engineer Services.

All I can hope to do is to lay before you some of the principal points I have noted in my 38 years of service in the R.E., spending a little more time on points which are not fully dealt with in the *Regulations for Engineer Services*, and leaving you to read for yourselves details which are adequately covered in that publication.

There is, however, very little in *R.E. Services* on the general question of organization and there is very little literature on the subject.

I hope, therefore, to be able to interest you in what is really the framework into which all your work as Engineers must fit if it is to be effective.

GENERAL PRINCIPLES OF ORGANIZATION.

Principles of Organization.—The object of all organizations is to enable a number of men to work together effectively for a common object, or, shortly, to get team work. To effect this, such a *body* of men must be given *organs* with varying duties and varying capacity, and experience has shown that, to get good results, the whole body of men must be under one controlling head which may be either an individual, such as Commander-in-Chief, or a corporate body, such as a Council or Board. We have examples of both kinds in our Army organization. Experience further shows that it

is not possible for one head to control directly more than a limited number of individuals. Napoleon is credited with saying that no man can control more than seven subordinates, and this has been confirmed by experience, while it is generally undesirable to have less than three subordinates, or the controlling authority will not be doing a full day's work.

The simplest form of organization is to group the individuals into squads or parties of about seven men each under a leader or foreman, and then, if the number of squads is more than seven, to bring them together into sections, and then, if necessary, to group the sections, and so on. By this means we establish a chain of responsibility or "chain of command" through which the controlling authority imposes his will on every individual worker.

"Territorial" Form of Organization.—If the work to be done is such that all the units, groups, etc., are interchangeable, we get an organization of the form shown in *Diagram* I. A good example of such an organization is an infantry battalion, with its sub-division into companies, platoons, sections and squads. The only variation possible in such organization is in the number of subordinates which each superior can supervise, and this will depend on the nature of the work to be done, the amount of supervision required at each stage, and the relative capacity of the supervisors and workers. Such an organization is said to be arranged on a "Territorial" basis.

DIAGRAM OF CHAIN OF COMMAND ARRANGED ON A TERRITORIAL BASIS

LINKS OF THE CHAIN ON THE SAME HORIZONTAL LINE HAVE EQUAL DUTIES & POWERS.

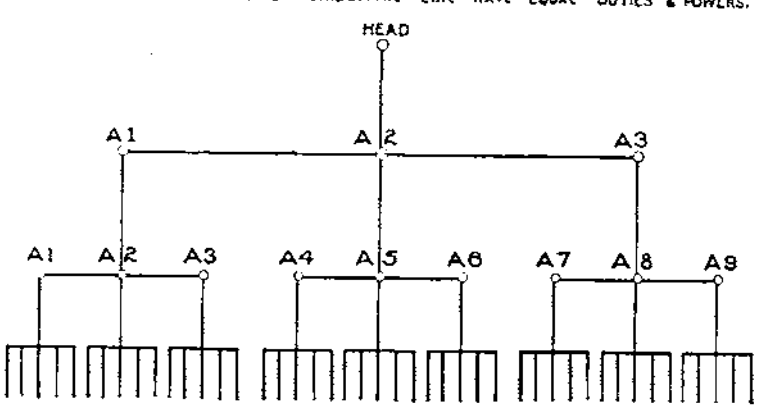


DIAGRAM I.

"Functional" Form of Organization.—When, however, the work to be done can be sub-divided into jobs of a different character, the organization required is not so simple. In such cases the original grouping of individuals will be by qualifications, and groups with different qualifications will not be interchangeable. This distinction

may be maintained up to the head, and the diagram would take the form of *Diagram* II. The most familiar example of this form of organization is that of an ordinary railway, in which the branches of traffic, locomotion and construction are quite distinct, each under its own Superintendent, all the Superintendents being under the General Manager. Such an organization is said to be arranged on a "Functional" basis.

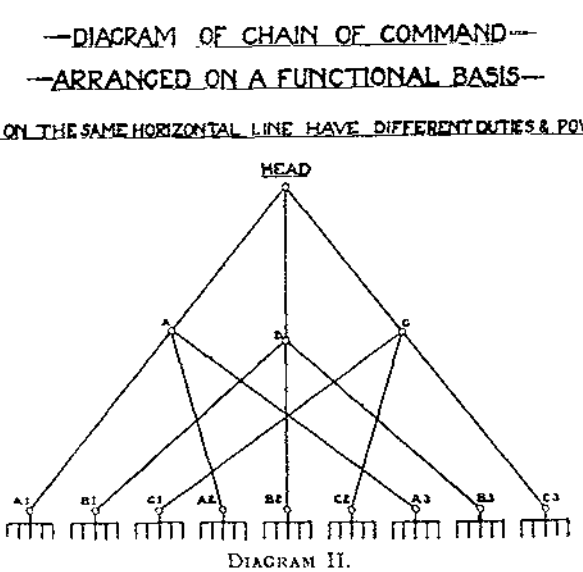


DIAGRAM II.

Combination of Both Forms.—In practice most businesses require a combination of the Territorial and Functional forms of organization, and it may happen that a Chain of Command will take partly one form and partly another. For instance, in an Army Division, the sub-division into Cavalry, Artillery and Infantry is on a Functional basis, but the lower stages of the organization in each case are on a Territorial basis, into Brigades, Battalions, Companies, etc.

The higher organization above the Divisions into Corps and Armies is also on a Territorial basis, but the organization of Administrative Services is usually Functional at the top and Territorial at the bottom.

A further complication arises when, as often happens in the Army, a subordinate Commander of a Technical service is under a Commander of another arm for certain limited duties. For instance, the enforcement of military discipline throughout the Army is, with minor exceptions, on a Territorial basis and does not follow the same Chain of Command as the control of Technical services.

I have laid some stress on the above principles as I have found that, while everyone is familiar with the principles of the Territorial system of grouping, comparatively few officers are familiar with the

principles underlying the Functional system. In fact, it is only since the appointment of the General Officers in charge of Administration that we have recognized that Technical services require a special form of organization.

The Functional form is most used in civil life, and I anticipate that in future this form of organization will be more fully employed in the Army.

Staff.—It will be noted that in the above descriptions of the "Chain of Command" I have made no mention of Staff, and this for the reason that the "Staff," as such, has no place in the Chain of Command.

The primary conception of a Staff officer is that of a secretary or subordinate who assists with the correspondence of a Commanding officer, and issues orders in his name. Such an officer performs no executive duties and has no responsibility.

In the Navy all secretarial duties are done by a special non-combatant staff.

In our Army the term "Staff" is used, in such expressions as the General Staff or Imperial General Staff, to include a large body of officers who are not true Staff officers, but are performing highly technical duties not covered by any of the recognized arms or Corps of the Army. Such duties include the preparation of schemes for military operations, intelligence, various forms of training, recruiting and the control of movements and quartering. In each of these branches the officers concerned are really employed on executive duties and are organized on a Functional basis. In many cases these officers combine these duties with those of a secretarial nature.

All Technical branches of the Army require a secretarial staff of their own.

Second-in-Command.—Another appointment which may be referred to is that of Second-in-Command. Such an officer must, under our military system, be the next senior officer to the Commander and be ready to act for the latter when absent. He generally is given executive charge of a portion of the duties allotted to the Commander. He is not a Staff officer. A familiar example is that of the Major of a Battalion who relieves the C.O. of many Administrative duties. A few years back it was customary to appoint one of the Staff officers of a Command as Chief Staff Officer, such an officer combined the position of a Second-in-Command with that of a Staff officer. The position is not now recognized in our Army.

Technical Inspectors.—When the technical side of a business is not sufficiently important to justify the complete organization of a technical branch, "Inspectors" are sometimes appointed to visit stations to advise and report on technical questions. Such officers have no executive authority unless such authority is expressly

delegated to them by their superiors for special cases. There are many examples of this in our Army organization.

Necessity for Putting the Right Man in the Right Place.—However carefully you may arrange any organization, your business will not work properly unless you put the right man in the right place. Everybody has his personal equation, and it is one of the most important duties of the Head of any organization to see that each individual under him is employed to the best advantage.

The method of Army Administration under which the personnel of all Combatant branches is dealt with by the Adjutant-General Staff rather tends to obscure the importance of this point. Once an officer or man is selected for a job, the routine of movement, orders, etc., can be carried out by the "A" Staff, but the original "posting" of the individual must be made by the Head of his branch.

Regulations.—It will be seen from the above that in a complete organization the duties of individuals will overlap to some extent, and such overlapping is unavoidable. Hence arises the necessity of Regulations and Standing Orders.

In the Army, as most of you are aware, there are a good many volumes of Regulations of all kinds, and the casual observer often says, in consequence, that the Army is bound and tied by red tape. Personally I dissent from that view. The issue of Regulations is by no means confined to the Government service. Every business of any importance has elaborate sets of office rules, bye-laws and orders for subordinates. In fact, no business could work without them. Regulations are meant to help, and must be applied with common sense. But no officer or subordinate can be regarded as efficient unless he has a complete knowledge of the regulations of his own arm, and also of the regulations of other arms with which he has to work.

Regulations are of two kinds: those laying down what you have to do, and those laying down what you may not do. The latter are of especial importance in connection with the Chain of Command, as showing what each link in the Chain can do on his own responsibility, and what must be reserved for decision by higher authority.

Necessity for the Use of Identical Organizations in War and Peace.—The above considerations apply almost equally to any form of business, but in the Army we must always keep in mind one other consideration—which may be covered by the saying, "In peace prepare for war." Nothing is more fatal, in my opinion, than a change of organization taking effect on the outbreak of war. The whole object of our existence as soldiers is to prepare for war, and this should be always kept in mind in all our peace work. In the late war we began our campaign with a system of Administrative work in the field which differed in nearly all details of organization from that adopted in peace, and this system was continually patched

and altered without, however, reaching finality. The organization which we have developed for the R.E. work in peace is, in my opinion, well adapted for our work in war.

DEFINITION OF ENGINEER SERVICES.

I will now consider for a few minutes what is the nature of "Engineer Services." Engineering is a very wide term, and might be defined as any form of activity which is devoted to controlling the forces of nature for the use of man. But in the Army certain forms of engineering are allotted to special corps and are no longer carried out by the Royal Engineers. Among these are included "Artillery and the manufacture and use of explosives for offensive warfare in guns or rifles," "Mechanical Transport," "Flying," and "Signals." The first split off from the Engineers about 200 years ago; the last three have been handed over by our Corps during the last 20 years.

There are also some Engineer Services, such as the construction of vehicles, which are carried out by the R.A.O.D.

During the late war the services connected with Railway work and Transportation were formed into a separate Transportation service and the services connected with Forestry and the supply of timber were also given a separate organization; but the amount of Engineer work left to the E.-in-C. was very large indeed.

Division of Engineering Work.—This may be best considered, not by the results to be obtained, *e.g.*, Bridging, Mining, etc., but under the ordinary civil grouping of engineer work as performed by Architects, Engineers, Quantity Surveyors, and Electrical and Mechanical Engineers. Some knowledge under all these heads is necessary to a Military Engineer, whose motto should be "Jack of all trades and Master of one."

The last two headings are of rapidly growing importance and include the large group of services connected with the use of electric lights for coast defence and against air-craft. They are very technical and require rather special training. Quantity surveying is also technical, but I will deal with this later. There remain the two heads of Architecture and Engineering which, between them, constitute the larger part of the work of the Royal Engineers.

Some of you may wonder how I can reconcile the inclusion of Architecture with the close connection which I want to uphold between duties in war and peace, and may hold the opinion—which I consider heretical—that the work of the Architect in the Army should be done by a non-combatant branch and not by the R.E. Such an opinion is often based on the idea that the duties of an Architect are mainly concerned with producing a good elevation of a building; this is not the case, an Architect is primarily a builder,

and is responsible for all details of buildings with roofs, from their foundations upwards, including details of construction and the use of materials, and also the arrangements for distribution in the building of water, light and drainage. The Civil Engineer, on the other hand, carries out engineer work other than building, such as schemes of water supply, disposal of sewage, roads, bridges, power-stations of all kinds, railways, canals, wharfs, docks and similar services. For the Military Engineer we must add Fortification.

Now both the Architect's and Engineer's work are of great value to all Military Engineers, both directly and indirectly.

Take the latter point first; we want, in our Military Engineers, to encourage the soldierly qualities of quick decision, a good eye for country, and the will to take responsibility, but all these will be useless unless behind them there is sound knowledge of Engineering principles and details. Further, this knowledge must be backed by much experience of practical work, and this can only be obtained by the execution of definite jobs. It is here that the R.E. has the advantage of the regular soldier, the latter cannot practise his full trade until the bullets begin to fly, while every job of work gives training and experience to the Engineer.

But our training as Architects has also a direct value in military operations. One of the most essential details to attend to in all campaigns is the health of the troops, and this depends on the careful carrying out of a lot of details. Of these, good and sufficient food is, perhaps, the first, and for this the R.E. are not responsible. But they are interested in the arrangements for cooking the food, the supply of good water, sanitary services, the provision of dry and warm accommodation in billets, camps or huts, and the provision of hospitals, laundries, bakeries and many other things. The Medical service is, of course, responsible for advice on all such questions, but the Engineer's is the executive hand which gives practical effect to such recommendations. Even at the front such questions form a very large part of the work of an R.E. officer, and behind the front line the work on accommodation is our primary duty. In such work we could not wish for a better training than that involved in the construction and maintenance of barracks in peace. The latter gives an unequalled opportunity for the study of every detail such as water supply, drainage, lighting, heating and cooking that may be required in the field.

As an example, I may refer to my own experience during the war as Chief Engineer Eastern Command.

In the summer of 1915 we had 550,000 men in the Command, and in addition to huts for about 200,000 men and barracks for 70,000 we had to arrange tented camps for 250,000 men in 250 localities. These camps were permanently occupied for the whole summer—seven months. The ordinary rules for camps laid down in camping

manuals were quite inapplicable to the conditions. Every camp required a good water supply distributed throughout the camp, hot baths and ample cooking accommodation. Trench latrines were barred, and we had to instal a bucket system, or in some cases a water carriage system with treatment tanks. Without a sound knowledge of civil practice such a task would have been impossible.

Now a word as to Quantity surveying. Put shortly, this is a technical method which has been developed in the course of experience for the measurement and payment of engineer work which is performed by contract. To learn the schedule thoroughly and how to use it is essential for all architects, and such study incidentally provides a liberal education in the methods of work and the relative importance of different items and trades. While this method is of most use in peace procedure it is by no means negligible in war time, when economy of money and material is as important as it is in peace. Even in the fighting area itself, civilian labour has constantly to be employed and much of the work behind the front is done by contractors. Of course, under war conditions some of the minutiæ of measurement are dropped, but an engineer officer would find it very difficult to supervise any contract work unless he knows something of the schedule.

As an example of the importance of contracts in time of war I may mention that, in the Eastern Command in 1915–1916, about 3,000 contracts a year, made by C.R.E.'s and D.O.'s, passed through the C.E.'s office for review, and this excludes small contracts, under £100 each, reviewed by C.R.E.'s.

The alternative to contract work is the use of direct labour supervised by R.E. In this case the labour is often civilian and the R.E. officer is in the position of the contractor.

Lands.—There is one other technical branch of our work which must be considered, and that is the group of questions connected with lands and property.

Normally the R.E. are the responsible custodians of all Government property in lands and buildings. They hold the legal documents on which the possession of such property is based, and the Chief Engineer of a Command has special authority, which used to be given personally to each individual, to sign deeds, transfers, etc., in the name of the Secretary of State for War. During the war the transactions connected with land and buildings became very numerous, and a very large increase had to be made in the staff of the Lands branch.

In France the work became so important that a special Directorate was formed under a Major-General to deal with such questions.

Engineer Stores and Workshops.—In connection with Engineer work it is necessary to maintain in every area a stock of stores and tools and to provide an organization for the purchase of stores other

than those supplied by contractors as part of a contract. Whenever military or direct labour is employed, workshops with machine and hand tools are required.

During a war overseas, the supply of stores becomes very important, and special attention must be given to the organization. During the late war the organization for stores and workshops in France increased continually until it was raised to the status of a Directorate, with a Brigadier-General in charge.

Personnel.—Our organization must also provide for the command and control of the personnel allotted for each command. This may include :—

Staff for R.E. Services.
R.E. Field units.
R.E. Works units.
Civilians permanently employed.

The Staff for R.E. Services is a military body of officers, warrant and non-commissioned officers, specially formed for dealing with certain technical branches of our work, and is, in some respects, outside the regular regimental organization of the R.E.

The officers are obtained by promotion from the ranks of the R.E. and are divided into two classes—Quartermasters and Assistant Inspectors of Machinery. The latter are selected from the various classes of mechanists referred to below, the former are selected from foremen of works, mechanists or warrant and non-commissioned officers on the regimental list. Quartermasters promoted from foremen of works are usually employed in control of works, the others are employed in charge of stores, in performing the duties of regimental quartermaster, or in special technical work, according to qualifications.

The subordinate staff of warrant and non-commissioned officers is selected from the ranks of the R.E., or may, in some cases, be specially appointed from civil life. It includes clerks, draughtsmen, foremen of works, store-keepers and electrical and mechanical mechanists, the nature of the work done in each case being indicated by the title.

Under the officers, this group of subordinates forms the backbone of the Engineer Works Service. The standard of qualification obtained by individuals is very high, and I should like to take this opportunity of testifying to the valuable services and the unfailing support which I have always received from these members of the Corps.

Field Units.—The R.E. field units are maintained primarily for duty with a force in the field, and their establishment and organization are settled accordingly. They usually form part of a Division of the Field Army. Such units necessarily spend a good deal of the

year in training for field duties and in assisting with the training of other arms of the Division. But in order to maintain the technical skill of the tradesmen in these units, and to give officers and other ranks practical experience in carrying out work, the C.R.E. of the fighting Division and field units should be included in the works organization of the area in which they are quartered.

Works Units.—R.E. Works units include two classes: (1) men trained in the special duties connected with defence electric lights and telephone service in fortresses, and (2) men of ordinary trades employed on fortification and other Works services; men of class (1) can also be employed on Works. These two classes are combined into suitably sized companies, according to the size of the Garrison to which they belong. These companies always remain at the same station in peace and their reliefs are effected by drafts. It should be noted that the companies are in this case only administrative and not fighting or working units.

Civil Staff.—The civil staff—many of whom are pensioners or reservists—includes clerks, foremen, technical superintendents of all kinds, engine drivers, boiler attendants, land bailiffs, caretakers, messengers and so on.

In connection with these, one of the most important questions at the present day is the fixing of a fair rate of wages. It is a definite principle of Government policy that the rates of wages paid to all subordinates and the hours worked shall conform to those prevailing in the locality, and moreover, the Chief Engineer in a Command is responsible for ensuring that the wages paid by all civilian contractors employed by him are the standard rates of wages of the District. At the present time these rates are discussed and controlled by a series of Committees and Councils centring in the Ministry of Labour, and it is necessary for the R.E. to keep in touch with each link in that chain. The work involved is very considerable, and in my last Command in Ireland I found it necessary to detail one officer of my staff solely to deal with labour questions.

The arrangement for the Command and control of the staff will be apparent from the next section, but one point of organization I may mention here which saves a good deal of work. The military subordinate staff are, of course, soldiers and are treated as such, and they have the usual military documents which have to be guarded. If a separate pay and clothing account is kept for this staff, some member of the staff has to be detailed to keep these accounts and the same procedure has to be followed for, say, six men as would suffice for a unit of 200. My suggestion is, therefore, that whenever a unit of R.E. is available in the area, the military staff should be attached to the unit for discipline and administration. The addition of a few names in the pay list, etc., makes little difference to the company staff and one complete set of accounts is saved.

Organization for R.E. Services.

And now I can go on to the main subject of this lecture, the Engineer organization actually adopted in the British service. Broadly speaking, this is based on a Territorial distribution for the ordinary duties, coupled with a Functional distribution for technical services.

The organization in India, though based on similar principles, differs somewhat from that in force in England, and as I am purposely basing this lecture on personal experience and I have never served in India, I have omitted all details of that country.

I may say here that some details of the organization are under consideration at the War Office and I must rather be taken as describing what exists as an illustration of the principles I advocate than as attempting to forecast the future form of the R.E. Regulations.

The principal links in the Chain of Command for Works are the Chief Engineer, Commanding Royal Engineer, and Division officers. One Chief Engineer is appointed to each of the Commands at home and to Gibraltar, Malta and Hong Kong abroad. They have the rank of Colonel-Commandant or Colonel, according to the size of the station. The Chief Engineer is the head of all the Royal Engineers in a Command, he administers the R.E. services of the Command, ascertains the requirements, obtains W.O. approval and funds, and distributes these funds to C.R.E.'s. He inspects throughout the Command.

Under the C.E. each command is usually divided into two or more Districts, each under a C.R.E., who is responsible for the executive work connected with the expenditure of the funds allotted by the C.E.

Under each C.R.E. the District is divided into Engineer Divisions, each under an experienced officer of Engineers called a "Division officer," who is responsible for the executive work connected with the expenditure of the funds allotted by the C.R.E. A Division officer has often one or more assistants, but the Division is the lowest link in the chain of organization for works and may be considered as the "unit" of our works organization.

There are a few exceptions to the above. In some of the fortresses abroad there is not enough work to justify more than one C.R.E., while the total duties of the R.E. are too heavy to be done by the C.R.E. alone. In such cases the duties are divided between the C.E. and C.R.E. in rather a different way. I give an illustration of this on p. 349. In the case of the large fortresses at home, the work before the war was so large that two or more C.R.E.'s were required. In these cases a special Chief Engineer was appointed to control and co-ordinate the work of the C.R.E.'s in the fortress. With the recent reduction of coast defences these appointments are now

abolished. In small stations abroad there is no C.E., and the C.R.E. combines both sets of duties.

Chain of Military Command.—The chain of military command in the R.E. has also three stages—the Chief Engineer, C.R.E. and O.C. Company. The Chief Engineer of a Command has much the same military duties and responsibilities as a Brigadier of an Infantry Brigade. He controls the distribution of all officers and other ranks throughout the Command, whether belonging to the R.E. Staff or units, but as the R.E. organization necessarily covers the whole Command, the R.E. personnel is always scattered, so that some subjects, such as training and discipline, which are dealt with by an Infantry Brigadier, are not dealt with by the Chief Engineer personally, but are delegated to C.R.E.'s.

The duties of C.R.E.'s correspond closely to those of a Lieut.-Colonel commanding a Battalion of Infantry, subject to the same principle of delegation in the case of companies on detachment residing away from the C.R.E.'s Headquarters. When two or more Companies are quartered in the same barracks, a battalion organization is formed by detailing an officer or officers as Adjutant and Quartermaster and by attaching a regimental staff—usually a Regimental Serjeant-Major and a Quartermaster-Serjeant. It will be noted that a Division officer, unless he is also the O.C. of a Company, only commands the members of the R.E. Staff who are placed under his orders, but if he is the senior officer of R.E. at an out-station a Division officer would be the O.C. R.E. of the station for all local purposes. The above organization is, of course, subject to exception, for instance, the depôt and schools at Chatham have a special organization. Cases may also occur such as the reconstruction of a barrack, where it may be necessary to appoint special officers as D.O.'s and even C.R.E.'s of such reconstruction, and such officers may be left outside the military chain of command.

But, exceptions apart, the two chains I have described for "works" and for "military command" form the backbone of our organization, and the nearer these two chains can be made identical, the closer we shall get to the ideal combination of engineer and soldier which makes the Royal Engineer.

Division into Areas.—Before discussing the functional part of our organization I may here say a few words on two points affecting the above organization which are closely allied to one another:—

(1) The subdivision of a Command into R.E. Districts and Divisions.
(2) The relations of the R.E. organization to the general organization of the Command.

The subdivision of a Command into Engineer Districts affects a great many interests and the final decision is reserved for War Office

approval. In peace time changes in these areas are few, but during the war it was necessary to make many changes, and I may lay down a few general principles based on my own experience. These principles may be of value in arranging the R.E. districts on the L. of C. The first principle has already been referred to, that the number of C.R.E.'s supervised by one Chief Engineer must not be excessive; when the C.E. is single-handed, three or four C.R.E.'s can be usefully supervised by one Headquarters, and if the number of C.R.E.'s required is over four, the C.E. will require a deputy in his office to relieve him of some of the routine and to enable him to make personal visits to out-stations. Similarly, C.R.E.'s cannot usefully supervise more than three or four D.O.'s.

Secondly, in arranging the area of C.R.E.'s districts, it is, in practice, necessary to consider the subdivision of the Command for military purposes, and also the areas adopted by the R.A.S.C., R.A.M.C. and the other administrative services.

The larger Commands at home are now divided into Areas, each under a General Officer. These officers have no power to order services. But it is obviously convenient that the area controlled by each C.R.E. should be wholly within the area commanded by one General. If such an area contains so much Engineer work that it has to be divided into two or more Engineer Districts, then the whole of both Districts should be in the one General's Command. In practice, however, there are many exceptions to this principle. Theoretically, there is no reason why in such cases the two C.R.E.'s in one Command area should not be considered as parallel organizations, just as two or more Infantry Brigades exist side by side in the same Command, and certainly, for military purposes, two or more C.R.E.'s can correspond with one Command Headquarters. But for technical questions, my experience is that such an arrangement gives rise to difficulty. The General Commanding an area and his staff have usually no technical knowledge and like to refer technical questions to one qualified adviser who can deal with their whole area, and this would be especially felt on mobilization or if troops are used to give support to the civil authority. In such cases, either a Chief Engineer or Deputy Chief Engineer should be appointed, or the C.R.E. at the Headquarters of the area must be given some of the powers of a Deputy C.E. and be able to advise the G.O.C. on all Engineer questions in his area.

Similarly, in the case of Engineer Divisions, it is advisable that they shall be coterminous with the areas of stations or other subdivisions of the Command. Such arrangements are not always easy and they may result in making some Districts or Divisions larger than others, and thus produce an inequality of work. Provided this is recognized and the best and most energetic

officers are appointed to the more difficult jobs, there is even some advantage in such inequality.

I am an advocate for what are termed "large" Divisions, each in charge of an officer of the rank of Major or Captain, officers below Captain being employed as Assistant Division officers. The alternative of many small Divisions with only one officer to each Division has been defended in the past as giving the young R.E. officer responsibility early in his career. The principal objection to it is that it involves a large number of offices and a consequent waste of clerical staff.

As regards other administrative services, the two branches with which the R.E. are most intimately concerned are the R.A.M.C. for sanitary services and the R.A.S.C. for quartering and barrack services. Where there are several R.E. Divisions in one station, it is very desirable that the boundaries should coincide with those of the R.A.S.C. officers in charge of barracks. Similarly it is desirable that C.R.E.'s Districts should coincide with the R.A.S.C. and R.A.M.C. Districts whenever possible.

Relation of C.R.E. to Subordinate Commanders.—Since 1905 Generals commanding areas have been relieved of the responsibility for the efficiency of the administrative services and are able to give their whole time to their military duties and the training of troops. If the General considers the administrative work is not being properly done he would not attempt to improve matters himself by altering the local organization, but would refer to the Headquarters of the Command. On the other hand, the General is responsible for indicating the nature of the work which he wants done and the relative importance of various services, and it is the primary duty of the representatives of Administrative services to carry out the wishes of the G.O.C. as far as may be possible. It may, however, often happen that a C.R.E. (or other head of an administrative service) is unable to do what he is asked, either for want of funds or perhaps because the proposal would give accommodation in excess of the scale allowed, or in some other way would conflict with the orders of higher authority. In such cases the C.R.E. would explain to the G.O.C. that he could not do what was required without further authority, and ask if the proposal could be modified or whether it should be submitted to the H.Q. of the Command. In no case has a C.R.E. or any R.E. subordinate a right to definitely refuse to carry out work, but he has the right to ask that a question may be referred.

I have dwelt at some length on this point as it is an important principle in the working of any functional organization and is not peculiar to R.E. work.

Position of C.E.—The Chief Engineer exercises much of his personal control by frequent visits to all stations, when he will have

opportunities of personal discussion, not only with C.R.E.'s and R.E. officers, but also with Generals and other officers commanding areas and stations.

The military relation of the C.E. to subordinate Commanders is very much that of a Brigade Commander of Infantry whose units are on detachment and consequently come under the orders of local Commanders for certain purposes while remaining part of the Brigade.

In Commands where there is a General or other officer in charge of Administration, this officer has delegated responsibility for all financial expenditure and the Chief Engineer is responsible to him for the control of the funds allotted for all Engineer services. But in order to ensure that the Engineer side of all questions should be fully considered the Chief Engineer is granted direct access to the Commander-in-Chief of the Command and is usually consulted on all important questions.

At the Headquarters of the Command the Chief Engineer has relations with all the various branches of the staff. With the Military Secretary he arranges all questions affecting Engineer officers such as the posting of officers within the Command. With the representative of the General Staff he discusses questions of defences, engineer work on manœuvres, including camps, and questions affecting training, such as the provision of gymnastic apparatus and all questions connected with rifle ranges. The latter are especially important, as the R.E. are in charge of all rifle ranges and are responsible as regards their safety. With the representative of the Adjutant-General he arranges all questions affecting personnel other than officers, the decision as to where each individual can be employed to the best advantage being made by the C.E. With the representative of the Quartermaster-General he arranges details of barrack accommodation and discusses the best method of using the funds allotted to the Command for barrack repair and improvement.

In arranging the duties of the staff and subordinates in the C.E.'s office it is necessary to consider the above subdivision of duties among the staff of the Command.

Organization of Technical Branches.

Having now discussed the framework of our organization and its relation to other branches, we can consider the best method of fitting in the more technical branches which, as I have said, are organized on a functional basis.

Electrical and Mechanical Group.—The most important of these is the Electrical and Mechanical group. Formerly these two subjects were separately dealt with, but they are very much interlocked and may conveniently be considered together, though the whole of the personnel provided is not interchangeable between the two sides. We have had a special organization for Mechanical work for the

last 40 years or more. On the completion of the young officers' course a few officers volunteered or were selected for a special course of Machinery, usually carried out at Armstrong's or some civil works. One officer with this training was posted to each Command as Inspecting Officer for R.E. Machinery. In a small Command he may combine such duty with that of a D.O. or of an O.C. Company. In a large Command the I.R.E.M. was a member of the staff of the C.E. Under the I.R.E.M. there were and are a trained body of Machinery mechanists. Some of these are posted to each Command and are distributed at the more important centres so that all machinery in the Command is in charge of some Mechanist.

The Electrical work of the Corps was for 40 years in charge of the Submarine Mining Service, a branch of the R.E. which was specially trained for charge of the submarine defences and defence electric lights. These officers, in addition to their normal duties, were placed in charge of all Electrical work at their respective stations, including telephones and barrack lighting, the senior officer of the Submarine Mining service acting as Inspector of Electrical services. As electric light was gradually introduced in barracks inland, such as Aldershot or the Curragh, selected officers were placed in charge. When the submarine defences were handed over to the Navy in 1905, the R.E. retained control of the Light defences, but as the use of Electricity was becoming more general, a special course at the works of civil firms was arranged for selected officers similar to that for machinery work. Electrician mechanists assist the officers in all classes of Electrical work.

Within the last ten years there has been a great increase in the use both of Electrical and Mechanical machinery, and after the war some changes were made in the organization. There is now in each Command at headquarters an officer in charge of Electrical and Mechanical work who replaces the I.R.E.M. For machinery work a new class of officer has been introduced with the title of Assistant Inspector of R.E. Machinery; they are distributed as required, and this class is being extended to cover Electrical work.

The specially trained R.E. officers are so distributed by the C.E. that each C.R.E., at any rate in the larger Districts, will have under his command an officer who has specialized in Electrical and Machinery work. The two classes of Mechanists work under these officers.

It will be observed that this organization is not extended to Divisions, and where a special officer is appointed for E. and M. work, the R.E. Division officer is only responsible for notifying requirements and is not responsible for technical detail.

Organization for Quantity Surveying.—To deal with this technical subject we have a special class of officer called an Inspector of Works, selected from gentlemen who have expert qualifications in surveying. These officers are not combatant and cannot exercise

military command. They have necessarily considerable knowledge of constructional work, and most are well qualified to perform the duties of Division officer. During the war these officers rendered the greatest assistance to the R.E., many of them received temporary commissions in the Corps and some performed the duties of C.R.E.

At the Headquarters of each Command, a senior officer of this branch is appointed with the title of Superintending Inspector of Works. This officer checks all bills prepared by C.R.E.'s and is also employed in dealing with the placing of contracts and all questions arising in connection with contracts.

An Inspector of Works is appointed to each C.R.E.'s office for similar duties and also carries out some of the more important measurements, and is available to advise D.O.'s on technical questions. The ordinary measurements are carried out by D.O.'s and Foremen of Works.

Under the Inspector of Works, there is a class of Surveyor's clerks, who are drawn from civil life and have to be specially engaged and paid.

Land Questions.—The control of land questions is at present rather unsettled. Before the war at stations abroad the work was in charge of an R.E. officer in the C.E.'s office, usually the staff officer, assisted by one or more of the Clerks and Draughtsmen on the staff for Engineer services. At home stations this arrangement was supplemented by the appointment of a Land Agent to each Command, who dealt with the technical side of all land and property questions. The Land Agent was not in charge of a branch of the C.E.'s office, but acted as a technical adviser only. The actual custody of land and buildings in all cases devolved on the C.R.E.'s, and the official records or "terriers" were kept by the C.R.E. or C.E. as convenient. The special Lands branch formed during the war is still dealing with the settlement after the war.

I do not see how there can be work for a separate Lands branch in the future, and the work connected with land and property is so intimately connected with the other R.E. work that I do not think the two sides can be usefully separated.

In some cases, where manœuvre ground has been purchased outright, it may be necessary to employ a land bailiff and a staff of labourers to keep the land in order and look after grazing, hedges, ditches, etc. This staff would normally work under the D.O. of the area.

Design Branch.—In connection with the ordinary construction work, it is necessary to provide for the preparation of designs for new services. By the Regulations for Engineer services a C.R.E. is responsible for designs for new services under £500, and the C.E. is responsible for new services of £500 and over. But when this regulation first came out in 1910 no staff was provided in C.E.'s

offices for a design branch, and in practice all designs were prepared by C.R.E.'s. The latter have, of course, to provide the information on which much of the design is based, such as the local arrangements for water, light or drainage, but the C.R.E. has plenty of other work to do and cannot spare much time for the preparation of designs. But apart from this, I consider that as much designing as possible should be done in the C.E.'s office, as this makes a more economical distribution of staff and, besides, gives the C.E. an opportunity of impressing his personality on the work of the Command. The question of whether a separate officer should be put in charge of the Design branch depends on the amount of new work in hand; in any case a good draughtsman is required for charge of this work and he may want one or more assistants. He will also be in charge of all plans and records in the C.E.'s office. Each C.R.E. will also require a draughtsman for small designs and for charge of plans and records.

R.E. Stores.—The distribution of stores and store charges is an important part of the general organization. It is necessary, in order to reduce transport, to have an R.E. store in each important centre, but where barracks are concentrated several divisions can draw from one central store. We shall, however, require some or all of the following:—

1. One or more central store offices for the Command where a ledger account is kept, and where copies of orders for stores are guarded. In this office the accumulation of stocks is watched so that surpluses at one station can be transferred to other stations where they are required.

2. One or more central stores holding stock for the whole Command. This is mainly wanted at stations overseas and should be located at the port of disembarkation of stores.

3. One central store for each C.R.E.'s District for stores common to the whole District.

4. One Division store for each outlying Division not within reach of the C.R.E.'s store.

The stores in 2, 3 and 4 will each keep an account on tally cards.

5. Expense stores for each foreman of works' charge not within easy reach of a Division store. Such stores do not keep tally cards, but draw small quantities of consumable stores in bulk periodically, usually monthly, and also hold ordinary tools for current work.

To control the above we shall require an experienced officer as officer in charge of stores to take charge of each Central office and to carry out the periodical inspection and stock-taking of all stores. I strongly recommend that this officer, wherever he may be located, should be considered as a direct subordinate of the Chief Engineer.

For each C.R.E.'s District an officer is required as O.C. stores and if no special officer is available one of the Division officers must be

detailed for this duty, in which case the size of his Division must be curtailed. Division and expense stores are in charge of Division officers and foremen of works.

The central stores office will require several good clerks and ledger keepers, and storekeepers will be required for each tally card store, also one or more storemen for cleaning, moving stores, etc.

R.E. Staff Officers.—To assist Chief Engineers in supervising and directing the above organization, two classes of specially appointed officers are recognized—a Deputy Chief Engineer and a Staff Officer. The Deputy Chief Engineer is allowed only at the four largest Commands at home. He combines the duties of a Second-in-Command and a Staff officer, but his most important function is to carry on the routine work of the office and allow the C.E. to visit and inspect all stations in the Command at frequent intervals. The appointment is gazetted and is filled by an officer on the Colonel's list.

The Staff officer, R.E., is usually a Captain or Major, R.E., specially selected but not gazetted. His duties usually include all the work connected with the military personnel, such as confidential reports, training or the posting of drafts and individuals. In the smaller commands he also performs the duty of a Deputy in the absence of the C.E.

If additional officers are available, one may be usefully detailed to look after rifle ranges and training questions, while the officer in charge of the Design Branch can assist with quartering questions.

Subordinate Staff.—In addition to the special subordinate staff referred to under each branch of work, all offices and branches will require clerks, typists and messengers. It is a common idea that all clerks can be considered as interchangeable, but in practice this is not the case, and each man should, as far as possible, be put to the work he can do best. Practically we recognize two classes of clerks: (1) correspondence clerks, (2) finance clerks. Correspondence clerks deal with incoming and outgoing letters, attend to files, prepare general letters for signature and keep all regulations up to date. Finance clerks keep expense ledgers, and deal with bills, vouchers and all correspondence connected with expenditure. I consider that each Division officer requires at least two clerks, one for correspondence and one for finance, and also a surveyor's clerk if the Division is a large one; each C.R.E. will require a chief clerk with one or more assistants for correspondence, a good finance clerk and one or more typists.

A Chief Engineer requires a similar but rather larger staff.

Conclusion

In concluding this portion of my subject I would again draw attention to the necessity of studying the personal equation. For instance, the distribution of work in a C.E.'s office between

C.E., Deputy C.E. and Staff officer must depend a good deal on their personal tastes and qualifications.

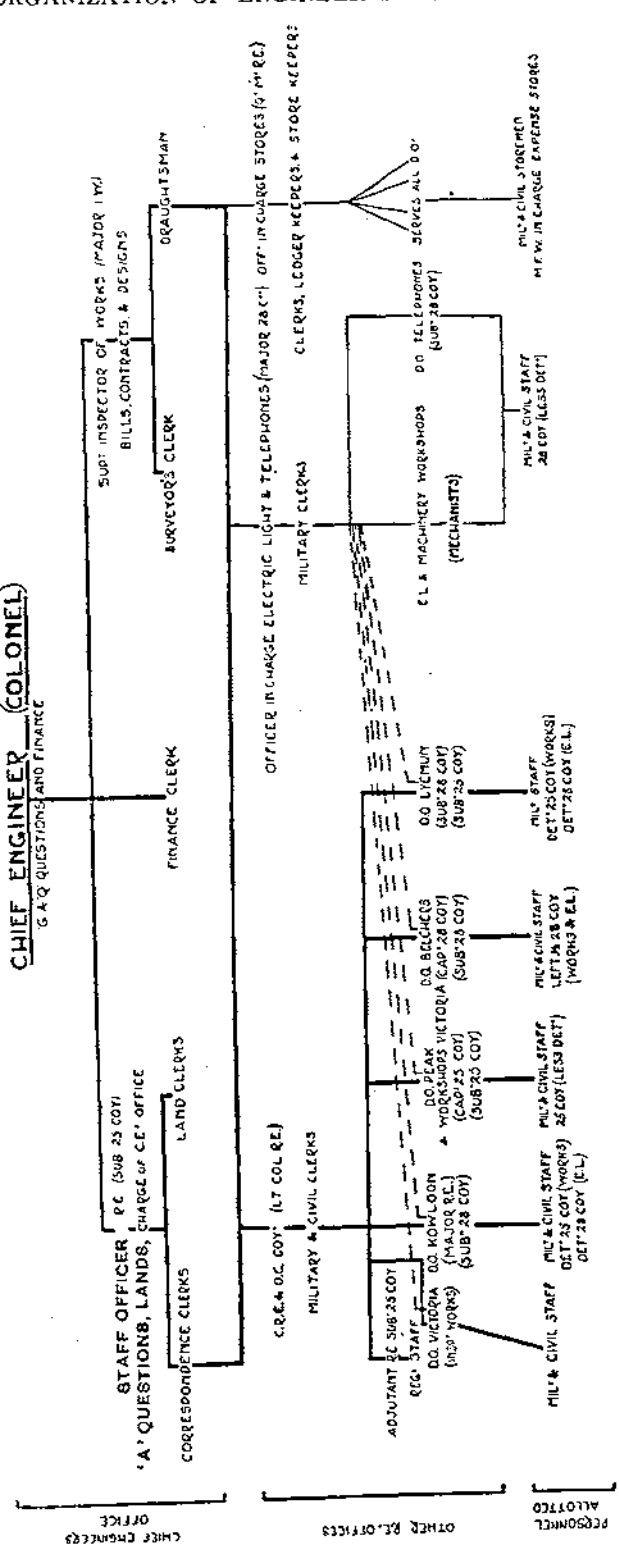
I hope I have been able to show you that the organization for Engineer services can and should include our military organization as soldiers, and our technical organization as engineers, and can and should be applicable in war as in peace. While there may be many perfectly legitimate opinions as to the wisdom or otherwise of many points I have alluded to, there can, I think, be no difference on the main points which I may thus express :—

1. Establish a working organization, thinking out all details.
2. Put the right man in the right place.
3. Lay down a few simple rules to govern the chains of Command and the relative responsibility of each link in the chain.

As an example of the application of the above principles, I attach a diagram of the organization of the R.E. at Hong Kong as arranged on the outbreak of war in 1914.

The garrison of Hong Kong at this date consisted of five companies R.G.A., two companies R.E. and five battalions of Infantry, with a local Volunteer Corps. The perimeter of the area to be defended is about 25 miles in length and is divided into four sections—two land fronts and two defended entrances to the port.

The four R.E Divisions of Kowloon, Peak, Belchers and Lyemun corresponded with the four defence sections, and the D.O. automatically became O.C.R.E. of the section on mobilization. The Victoria Division comprised the offices and barracks at and near Headquarters. I may add that on the outbreak of war the change from peace to war conditions worked perfectly smoothly.


ORGANISATION OF ENGINEER SERVICES.
DIAGRAM OF CHAIN OF COMMAND IN HONGKONG 1914
CHIEF ENGINEER (COLONEL)
G.A.Q. QUESTIONS AND FINANCE
STAFF OFFICER 'A' QUESTIONS, LANDS, CHARGE OF CE' OFFICE
P.C. (SUB 2.5 COY)
LAND CLERKS
CORRESPONDENCE CLERKS
SUPT INSPECTOR OF WORKS (MAJOR I.W.)
BILLS, CONTRACTS & DESIGNS
DRAUGHTSMAN
SURVEYOR'S CLERK
FINANCE CLERK
OFFICER IN CHARGE ELECTRIC LIGHT & TELEPHONES (MAJOR 2.8 C.M.)
OFF. IN CHARGE STORES (CAPT R.E.)
CLERKS, LEDGER KEEPERS & STORE KEEPERS
MILITARY CLERKS
E.L. & MACHINERY WORKSHOPS (MECHANISTS)
D.O. TELEPHONES (SUB 2.8 COY)
SERVES ALL D.O.
MIL'Y & CIVIL STAFF 2.8 COY (LESS DET')
MIL'Y & CIVIL STOREMEN M.F.W. IN CHARGE EXPENSE STORES
C.R.E.& O.C. COY (LT COL R.E.)
MILITARY & CIVIL CLERKS
ADJUTANT R.E. SUB 2.5 COY
REG' STAFF
D.O. VICTORIA (MAJOR R.E.)
D.O. KOWLOON (MAJOR R.E.) (SUB 2.8 COY)
D.O. PEAK & WORKSHOPS VICTORIA (CAPT 2.5 COY) (SUB 2.5 COY)
D.O. BELCHER'S (CAPT 2.8 COY) (SUB 2.5 COY)
D.O. LYEMUN (SUB 2.8 COY) (SUB 2.5 COY)
MIL'Y & CIVIL STAFF DET' 2.5 COY (WORKS) DET' 2.8 COY (E.L.)
MIL'Y & CIVIL STAFF LEFT IN 2.8 COY (WORKS & E.L.)
MIL'Y & CIVIL STAFF 2.5 COY (LESS DET')
MIL'Y & CIVIL STAFF DET' 2.5 COY (WORKS) DET' 2.8 COY (E.L.)
MIL'Y & CIVIL STAFF
CHIEF ENGINEER'S OFFICE
OTHER R.E. OFFICES
PERSONNEL ALLOTTED

PROFESSIONAL NOTE.

RAFT APPROACHES WITH LIGHT BRIDGE EQUIPMENT FOR FIELD SQUADRONS.

(Communicated by the R.E. Board.)

1. The following ("draw-bridge") method has been tried for the raft approach with Light Bridge Equipment.

2. A Weldon Trestle and shore bay were erected and snatch blocks secured to the heads of the trestle legs.

The ends of two 3-in. cables, which passed through these blocks, were fastened to a transverse baulk which was lashed under a bay of superstructure connecting the Weldon trestle with a pontoon raft. This baulk was lashed to the five road baulks 2 ft. 6 in. from their outer ends. By pulling on the running end of the 3-in. ropes the "gangway" pivoting on the transom of the Weldon trestle could be lifted clear of the saddle of the pontoon raft.

A 9-in. lift was sufficient to do this.

3. The minimum height of the snatch block above the transom should be 6 ft. With this height and the raft on a level with the trestle transom, the pull on each running end was 700 lbs. (9 men)

When the raft was 2 ft. 6 in. below the trestle transom, the pull on each running end came to about 1,000 lbs. (13 men).

The number of men can be reduced by using tackles.

4. When trestles cannot be used or are not available the same method can be adopted by erecting 8-ft. posts with a strut and tie at each end of the shore transom.

5. By using cut baulks the operation can be simplified, provided the slope from the transom to the raft is not too great. The cut baulk saddle should be lightly lashed to the shore (or Weldon trestle) transom.

6. This drawbridge method appears to be much more easily worked than the method shown in *M.E.* Vol. III., p. 67.

AN OUTLINE OF THE EGYPTIAN AND PALESTINE CAMPAIGNS, 1914—1918.

By MAJOR-GENERAL SIR M. G. E. BOWMAN-MANIFOLD, K.B.E., C.B., C.M.G., D.S.O., *p.s.c.*

(Concluded).

CHAPTER XIII.

THE MAIN ATTACK. THE BATTLE OF SHARON.—Preliminary advance by XXth Corps. Destruction of the Turkish telegraph centres early on 19th September—Operations of XXIst Corps: Attack by 60th and 75th Divisions—Start of the Cavalry—Wheel of XXIst Corps—Capture of Tulkeram—Advance of XXth Corps on 20th September—Five phases of the Operations.

THE MAIN ATTACK. THE BATTLE OF SHARON.

THE concentration was completed on 18th September. The main attack was ordered to commence at dawn on 19th September.

During the night 18th–19th September, in the XXth Corps area, the 53rd Division made its advance on the east of the Nablus road; and the Royal Air Force bombing squadron set out to attack Afule, Jenin, Nablus and Tulkeram, and particularly with the object of destroying the telegraphs at the headquarters of the lines of communication, and of the VIIth and VIIIth Turkish Armies.

The objectives for the XXIst Corps were as follows:—

First Objective.—Three Bushes Hill (north of Rafat) to the Nahr Falik. (See *Plate* XI.)

The infantry were to advance under a barrage, put down at the moment they were to move out from their places of deployment.

The French contingent to advance north of the Wadi Ballut.

The 54th Division to take ground north and west of Mejdel Yaba.

The 3rd, 75th and 7th Divisions to overrun the Tabsor defences.

The 60th to reach the Nahr Falik and form a bridgehead there.

The 5th Australian Light Horse Brigade were under the orders of the G.O.C. 60th Division, but took post to start with behind the 7th Indian Division.

The 4th and 5th Cavalry Divisions were placed behind the 75th and 60th Divisions respectively.

Immediately the first objective had been secured, the XXIst Corps had to wheel to the east, clear the Kalkilieh–Tulkeram road, seize the high ground east of the railway, and be ready to continue the advance on Jenin.

The cavalry were to set out on their great envelopment.

The French were to be the pivot for the wheel of the infantry.

The 54th Division had to move north-east into the hills by Hableh.

The 3rd Division was to pass Kalkilieh and face east.

The 75th and the 7th Divisions were first to secure the Et Tireh defences, and then the 7th was to come up on the left of the 3rd.

The 60th Division, on the extreme left, with the 5th Light Horse Brigade, was to swing across the Plain of Sharon—half-right—occupy Tulkeram, and cut the railway east of that place.

At 0430 hours the artillery barrage in the coastal plain opened with an intense bombardment, lasting for 15 minutes, while the infantry moved out from their positions of deployment.

The attack of the XXIst Corps was supremely successful and according to plan. The speed of the infantry exceeded all expectations. A few details of the attack of the 75th and 60th Divisions will be of interest.

The 75th Division put two brigades in front and attacked in two waves. The leading wave of each brigade consisted of two companies of each of the two attacking battalions in depth. The second wave comprised the remaining two companies of each battalion, also in depth. Leading platoons of the first wave were extended, the remainder followed in artillery formation. The distance between the first and second waves was two hundred yards, and 500 yards from the second wave to the support battalion.

The 75th Division had, besides its divisional artillery, the support of four batteries of Royal Horse Artillery, six heavy howitzers, an armoured-car battery, and a squadron. The barrage had lifts at fixed times. No reliance was placed on the artillery for wire-cutting.

The 232nd and 234th Brigades advanced rapidly at first, and overran their part of the Tabsor defences, but the 232nd Brigade was checked at 0815 hours south-east of Et Tireh. The man-handled machine-guns had been outpaced, but got up in time to co-operate in the capture of the Et Tireh works which were taken by 1100 hours.

On the coast, the 60th Division advanced with the 180th Brigade Group leading. Its task was to cross the Nahr Falik, and form the bridgehead. Then, the 181st Brigade was to pass through 180th Brigade and with the 179th Brigade make Tulkeram in three more bounds of about five miles each.

The 5th Australian Light Horse Brigade were directed to keep away on the west, and come down on Tulkeram from the north.

The barrage had opened at 0430 hours. By 0500 hours in the 60th Division front the first line was taken.

By 0530 hours all the second line was occupied

At 0630 hours the 5th Cavalry Division were told they might send up two brigades along the beach, where they had a covered way to move by.

At 0700 hours, the bridgehead was established, and half an hour later the 5th Australian Light Horse Brigade were ordered forward.

No bridge was necessary for the cavalry to cross the Falik. The cavalry now were fairly launched.

By 1100 hours, the wheel of the XXIst Corps had taken effect; the broken VIIIth Turkish Army was streaming across the plain towards Tulkeram—where chaos ensued. Horse and foot, artillery and transport of the VIIIth Army were striving to escape east, along the road which becomes a defile towards Messudie. Upon these the bombers of the Royal Air Force descended and returned again and again.

The road to Nablus became hopelessly blocked; and in the afternoon, when the 5th Australian Light Horse got on to that road, four miles east of Tulkeram, and the 60th Division reached that town, great booty was secured.

The XXth Corps now got orders to advance that night (19th–20th September) on Nablus; a difficult task, as the VIIth Turkish Army was not disorganized, and was holding a strongly-entrenched series of ridges across the main Nablus road.

The attack of the 10th Division was, therefore, delivered from the left flank, over broken roadless country so as to avoid a frontal advance. The 10th Division took Furkhah, Selfit, and Kefr Haris, and advanced about seven miles. The 53rd Division moved forward about two miles.

On 20th September, the XXIst Corps continued to advance eastward and, by the evening, the 5th Australian Light Horse Brigade and 60th Division had seized Messudie Station and the Jenin road; and, with the 7th Division on their right, had completely turned the right flank of the VIIth Turkish Army, and shut off their exit to the Jenin road.

Next day the 10th Division was just outside Nablus, having covered 24 miles of the roughest country within 24 hours, while the 53rd Division arrived six miles on the east of Nablus, after overcoming considerable opposition in the morning. The XXth Corps may be said to have secured Nablus on the 21st September. And this crowned the first phase of these operations.

Altogether there were five phases:—

(*a*) The first phase had been barely 36 hours. By 1700 hours on 20th September, the VIIIth Turkish Army had been overwhelmed; and the VIIth was in full retreat, through the hills of Samaria towards exits which were already held by the Desert Mounted Corps.

(*b*) In the second phase, of three days, the fruits of the first success were reaped. The infantry, pressing on the retreating enemy, drove him into the arms of the cavalry, with the result that the whole of the Turkish VIIth and VIIIth Armies were captured. Haifa, Acre, Tiberias, and the country south and west of the Sea of Galilee were occupied on 23rd September. On 22nd September, the IVth Turkish Army east of the Jordan began to retreat, and Maan was evacuated.

(*c*) The third phase commenced with the pursuit of the IVth Turkish Army by Chaytor's Force and ended in the capture of Amman on 25th September, and the surrender of the intercepted garrison of Maan on 29th September.

(*d*) The fourth phase included the advance of the Desert Mounted Corps to Damascus (taken on the 1st October), the capture of the remnants of the IVth Turkish Army, and the advance of the XXIst Corps by the coast to Beirut by 8th October.

(*e*) The fifth phase was the advance through Syria to Homs and Tripoli, and the occupation of Aleppo on 26th October.

All these operations form one story which is continued in the next Chapter.

CHAPTER XIV.

THE BATTLE OF MEGIDDO: DESTRUCTION OF THE THREE TURKISH ARMIES.—Instructions issued to Desert Mounted Corps—The advance of the Cavalry: Moves of 4th and 5th Cavalry Divisions—Charge of the 2nd Lancers at El Lejjun—Capture of El Afule, Nazareth, Beisan and Jenin within 36 hours—Destruction of VIIth and VIIIth Turkish Armies—Capture of Amman; Destruction of IVth Turkish Army—Action of Sherif Feisal's Column.

THE BATTLE OF MEGIDDO—DESTRUCTION OF THE TURKISH ARMIES.

THE narrative in the previous Chapter showed how the infantry opened the way for the cavalry into the Plain of Sharon, and outlined the five phases into which the operations became divided. It now remains to follow the progress of the rest of the first stage. (See *Plates* XII and XIII.)

The full text of the instructions issued to the G.O.C. Desert Mounted Corps is given in *Appendix* IV. Three features in these orders require emphasis:—

(*i*) The cavalry were on no account to get drawn into local fighting at the outset.

(*ii*) If any enemy retreated on Haifa, only the minimum detachment might be made to cover the lines of communication of our cavalry, so that the greatest possible force should be brought on for the task in hand, *viz.*, to seize El Afule and Beisan.

(*iii*) The action of the cavalry was to be characterized by the greatest vigour and rapidity.

The Advance of the Cavalry.—Before daylight on 19th September, the Desert Mounted Corps had assembled behind the 7th (Meerut) and 60th Divisions.

The leading divisions moved out through the gap created by the infantry, at 0900 hours by two routes, and by noon they were on the line Jelame–Hudeira, 18 miles away. The 5th Cavalry Division thence proceeded north for about ten miles, and, crossing the ridge of hills, entered the Plain of Esdraelon at Abu Shusheh, and then directed the 13th Brigade to raid Nazareth, and the 14th Brigade to seize El Afule.

The 4th Cavalry Division turned north-east, entered the narrow Musmus Pass at 0100 hours, just in time to forestall its occupation by a Turkish battalion. The 2nd Lancers, moving from El Lejjun on El Afule, encountered this battalion, barring the road. One squadron, a machine-gun section, and L.A.M. Battery held the enemy in front, while the remainder of the regiment made a detour, and charged down on the left of the Turks. They speared 46 Turks, took 470 prisoners, and six machine-guns, and their casualties were one man wounded and three horses killed.

The leading troops of the 4th Cavalry Division reached El Afule at 0800 hours, half an hour after it had been occupied by the 5th Cavalry Division.

After a rest of four hours, the 4th Cavalry Division marched over the Valley of Jezreel and reached Beisan at 1630 hours, having covered 85 miles in 34 hours. The 19th Lancers, however, went 12 miles further that evening, to seize the bridges over the Jordan at Mejamie.

The 13th Brigade of 5th Cavalry Division, meanwhile, at 0530 hours, had entered Nazareth, headquarters of the Yilderim Army Group. Street fighting ensued; 2,000 prisoners, including some of the Headquarters Staff, were taken, and the office and records were captured. General Liman von Sanders himself escaped to Damascus. The 13th Cavalry Brigade then came in to El Afule.

The Australian Mounted Division (two brigades only) followed behind the 4th Cavalry Division to El Afule, but at Lejjun it detached a brigade which occupied Jenin at 1730 hours, and there took 8,000 prisoners.

Thus, within 36 hours, while the infantry had broken, and was following up the VIIIth and VIIth Turkish Armies, the cavalry had closed all their main roads of escape.

So ended the first phase of this campaign.

Destruction of the VIIth and VIIIth Turkish Armies.—On 21st September all organized resistance was at an end, the retreat had become a rout.

The 5th Australian Light Horse Brigade entered Nablus from the west, and the 10th Division from the south. By nightfall, the right of the XXth Corps was on the Wadi Fara, and the XXIst Corps were in Samaria.

All roads leading north and east were thronged with fleeing troops and transport and were targets for persistent bombing by the Royal Air Force. Those who got through alive merely walked into the net spread by the Desert Mounted Corps. In the Wadi Fara, leading from Nablus to Jisr ed Damie, the retreating column some eight miles long was caught in a gorge, and bombed to destruction. The drivers deserted their vehicles, and the road became indescribably blocked for miles.

The 4th Cavalry Division now was moving down the Jordan,

closing the crossings below Beisan. Early on 22nd September, Jisr ed Damie was taken by a detachment from Chaytor's Force, and all escape towards Amman was cut off.

On 23rd September, the 5th Cavalry Division captured Haifa, after some resistance, while its 13th Brigade re-occupied Nazareth, and then took Acre.

Practically the whole of the VIIth and VIIIth Turkish Armies, horse, foot and artillery were now rounded up ; and it became a serious difficulty to water and feed the throngs of prisoners.

The Capture of Amman and Destruction of the IVth Turkish Army.—The destruction of the VIIth and VIIIth Armies, and the occupation of Jisr ed Damie, with the bridge intact, on the morning of 22nd September, compromised the position of the IVth Turkish Army. That night it withdrew from the Jordan Valley, and on 23rd September—four days after the blow fell on the coast—it was in full retreat on Es Salt and Amman, pursued by the Australian and New Zealand Mounted Division, and bombed by the Royal Air Force. On the same day Maan was evacuated and Es Salt was taken on 23rd and Amman on 25th September. The enemy retreated north, harassed by the Arabs, and leaving 5,000 prisoners in the hands of Chaytor's force.

Chaytor's force was now ordered to remain at Amman to intercept the Turkish IInd Corps, in retreat from the south, and pursued by the Arabs. On 28th September, the Corps had arrived within ten miles of Amman, and next day it surrendered, thankful to escape the attentions of the Arabs surrounding it.

Sherif Feisal's column continued at Um Taiye until 26th September, when it moved to Sheikh Saad, north-west of Deraa. Large accessions of Arabs had joined, so that it now numbered over 12,000. The Arabs captured almost all the guns and transport of the IVth Turkish Army, on the march near Er Remte, and greatly harassed the retreating enemy ; and on the 28th September they occupied Deraa.

CHAPTER XV.

THE ADVANCE ON DAMASCUS.—Desert Mounted Corps moved in two columns—4th Cavalry Division east of the Jordan, remainder at first on the west—Rearguard fighting at Jisr Benat Jakub and at Katana—Seizure of Barada Defile—Closing of the Aleppo road—Occupation of Damascus—Advance to the line Rayak-Beirut—Occupation of Northern Syria, Aleppo, and the Bagdad railway—Observations employment of cavalry in mass.

THE ADVANCE ON DAMASCUS.

THE total defeat of the VIIth and VIIIth Turkish Armies opened the way to Damascus. On 25th September, orders were issued to the Desert Mounted Corps to occupy the capital of Syria, and to intercept the retreat of the last of the IVth Turkish Army. (See *Plate* XIII.)

The headquarters of the Corps were then at Nazareth, the 4th Cavalry Division was about Beisan, the Australian Mounted Division on the Sea of Galilee, and 5th Cavalry Division at Haifa and Acre.

The Corps advanced in two columns. The 4th Cavalry Division crossed the Jordan, and met with considerable opposition in the very broken country about Irbid and Er Remte. The first day's march was 38 miles. The approach to Er Remte was blocked by Turkish infantry; and so the Dorset Yeomanry were left dismounted to hold them in front, while the Central India Horse and 2nd Lancers worked round the flank. Meanwhile, the Turks launched a counter-attack on the Dorset Yeomanry. The latter withdrew rapidly behind the ridge they were holding, mounted and charged directly on to the advancing Turks. They killed twenty-five and dispersed the remainder. The Division joined up with the Arab force on 28th September about Mezerib and pressed up the Mezerib–Damascus road on the heels of the remnant of the IVth Turkish Army, with Sherif Feisal's force on its right, on the Deraa–Damascus road.

At the same time, the Australian Mounted Division, having assembled at Tiberias, marched on Damascus by the Kuneitra road, followed by the 5th Cavalry Division.

They met first with opposition at Jisr Benat Yakub. This ancient stone bridge was damaged, and the crossing was held by a German and Turkish rearguard sent down in lorries from Damascus. After some delay, on 27th September, the 5th Australian Light Horse Brigade forded the river lower down, outflanked the enemy and cleared the main road.

The divisions now had to climb up out of the Jordan valley, 3,500 feet in 16 miles, to the foothills of Mount Hermon; and for the first five miles the road was most difficult—boggy in places—and metalled with stones which Mr. Massey has described as varying in size from a man's head to a camel's body.

The villages in this locality—Circassian colonies—were hostile towards the British, and there was a good deal of sniping. Further fighting ensued at Kuneitra, and at Sasa, 20 miles from Damascus.

The Desert Mounted Corps and the Arabs now bore down on Damascus, on a broad front on three roads. At 1000 hours on 30th September, the 4th Cavalry Division and the Arab forces on their right, swollen to about 35,000 men, were near Kiswe; part of the 4th Cavalry Division were approaching Sahnayah, and the Australian Mounted Division were at Katana, checked by a strong rear-guard.

About noon on 30th September, the rearguard at Katana was driven in, and the Australian Mounted Division worked round the west and north-west of the city. The 5th Australian Light Horse Brigade and French Cavalry seized the Barada defile of the Beirut road four miles out, and entrapped a great column of troops. Many Turks were slain, and 4,000 prisoners were taken. That evening the 5th Cavalry Division was in the southern surburb of Damascus. The 4th Cavalry Division bivouacked 15 miles south, having fought continuously and marched 140 miles in six days.

Meanwhile, Damascus was in turmoil. Turks and Germans were literally fighting for vehicles, and no enemy administration remained to arrange any formal surrender of the city.

In the early hours of 1st October, the 10th Australian Light Horse and the Shereefian Camel Corps both were in the centre of the city; and, in the afternoon, part of the Desert Corps marched through the streets in a scene of the wildest enthusiasm.

During the morning, the Aleppo road on the north was finally closed, and the Turks along it were pursued for seventeen miles by the 3rd Australian Light Horse Brigade, and about 1,500 Turks were captured. For the next three days, stragglers and fugitives kept coming in. Altogether about 20,000 prisoners were taken in and round Damascus.

Out of all the three Turkish armies which, 12 days before, had numbered a ration strength of 104,000 men, some 17,000 men (of whom 4,000 only were effective rifles) dispersed north—a rabble, without artillery, transport or supplies.

The Advance to the Line Rayak–Beirut.—The Commander-in-Chief determined further to exploit the success by advancing to the line Rayak–Beirut. Beirut was a good port and harbour, and the railway and road over the Lebanon to Damascus would provide a much shorter line of supply. Besides, the Hedjaz railway had been so effectively damaged that it would require several weeks to restore traffic on it for our use.

Accordingly, the XXIst Corps was ordered on 29th September to move by the coast on Beirut; and on the 3rd October the 7th (Meerut) Division set out from Haifa and entered Beirut unopposed on 8th October. Meanwhile, on 6th October, the Desert Mounted Corps had occupied Rayak Junction without fighting, and captured immense depôts of stores at that place.

The Occupation of Northern Syria, Aleppo, and the Bagdad Railway.–Immediately Beirut had been entered, the Desert Mounted Corps and XXIst Corps were ordered to advance on Homs and Tripoli, respectively. The Australian Mounted Division was left at Damascus, pending relief by infantry. (See *Plate* I.)

The 7th (Meerut), followed later by the 54th Division, continued its march up the coast; the 5th Cavalry Division moved between the two Lebanon ranges, it met with no opposition, and reached Homs, 120 miles from Damascus on 15th October.

The roadstead of Tripoli, and a fair road across to Homs, rendered possible the supply of the mounted troops north of the Lebanon. In fact, it was only the simultaneous advance along the coast that enabled the force to be fed. The moves inland had been so fast, and had gone so far, that the troops outstripped the work of repairing the railway and the roads behind them. The Hedjaz railway had been extensively damaged by the Arabs, and the standard gauge

railway north of Rayak was almost devoid of serviceable rolling-stock. Consequently, the bulk of the supplies had to go by motor-lorry, and the distances were immense, and much of the road atrocious.

Aleppo lay 120 miles north of Homs, and the enemy there was reported to number about 20,000, of whom about 8,000 were combatants demoralized. The Commander-in-Chief determined to press on. The 5th Cavalry Division advanced from Homs on 20th October. The weak rear-guards they encountered were dispersed by the advanced groups of armoured cars, until these were held up on 24th October, five miles south of Aleppo, by a strong line of resistance. The 15th (Imperial Service) Cavalry Brigade came up on the evening of 25th October; and that night a detachment from the Arab Army broke into Aleppo, and inflicted heavy casualties on the enemy.

Next morning, the 15th Brigade worked round the west of the city, and interposed itself on the Alexandretta–Katma road to prevent the Turks from re-entering Aleppo.

The 5th Cavalry Division occupied Muslimie Junction on the Bagdad railway on 26th October, but was too weak to proceed further to open up the way to Alexandretta, and the Australian Mounted Division from Damascus was ordered up in support; but, before it arrived, the Armistice with Turkey had been arranged, and on 1st November, Edmund Allenby's remarkable campaign officially terminated.

In twelve days, the enemy's armies had been routed and rounded up, and the front had been moved forward 160 miles.

Four weeks later the whole of Syria had been taken, the Bagdad railway had been cut, and touch was established with Mesopotamia. The front of the Egyptian Expeditionary Force was now 360 miles from its starting-point of six weeks earlier.

In this period the marches of the 5th Cavalry Division had totalled 500 miles, and it had expended 25 per cent. of its personnel, and 21 per cent. of its horses.

Comments.—The employment of cavalry in mass was the great feature of the operations conducted by Sir Edmund Allenby. At Beersheba, he first employed this arm on the open flank and rode right round the enemy. Twice later on he struck at distant objectives, Es Salt and Amman, and so impressed the Turks that they dreaded what he might do next, and kept their forces dispersed, and so caused their downfall. In the culminating operations, the Commander-in-Chief's plan was framed to enable him to use his cavalry mass so as to destroy the Turkish Army, instead of merely to complete a local success. And, having achieved his purpose, he used it to carry out—in spite of extraordinary difficulties—one of the most relentless pursuits in history.

CHAPTER XVI.

REMARKS OF GENERAL LIMAN VON SANDERS.—Deficiencies of the Turkish Armies—Difficulties of the line across the Plain of Sharon—Effect of the loss of Jericho—Mussalabeh—Views on the Amman raids: Anxiety for Deraa—Three factors which impaired the Turkish resistance—The break-through, as seen by the enemy commander—Result of the destruction of the telegraph system—Plans for the retirement and protection of Damascus—Conclusion: errors committed by the Turks.

REMARKS OF GENERAL LIMAN VON SANDERS.

GENERAL LIMAN VON SANDERS has recently published his reminiscences, entitled *Fünf Jahre Türkei*, in which he depicts the events of 1918 from his point of view, and his views are worth examining. He makes the most of the stupendous difficulty of his problem, and particularly of his deficiencies in troops and supplies. If we were to believe his figures, he had in his three armies of ten divisions only 13,000 rifles and 1,200 sabres, and six weak German battalions. He gives the VIIIth Turkish Army only 3,900 rifles for their eighteen-mile front.

These figures are less than half those with which his opponents credited him; and the British captures (nearly 100,000 prisoners and 400 guns) tend to confirm their figures, rather than his.

General Liman von Sanders blames Enver for starving him in men, in order to invade the Caucasus in the summer of 1918, so that he was compelled always to act on the defensive, and he says he was so weak in transport that he could not move his troops to fresh positions.

Reviewing the actual position of the Turkish forces, when he took up the command in March, 1918, General Liman von Sanders' opinion is that the line adopted across the Plain of Sharon lacked natural strength. The only suitable line, he says, was the Carmel–Samaria range. But, to use that, the greater part of Palestine would have to be abandoned. This the higher command in Constantinople would not sanction. Besides, the loss of this territory would have given great impetus to the Arab movement.

He also objected to the retention of the Hedjaz railway (below Amman), but says Enver ordered this to be held.

General von Sanders' views on the course of the British operations confirm remarkably the correctness of the appreciations of their Commander-in-Chief. The loss of Jericho was a great worry to him. He wanted to reduce the fronts of his VIIth and VIIIth Armies, and explains that he could only have effected this, if he could have straightened the bulge the British has made north of the Wadi Auja.

This explains his employment of so many German troops to try and drive in the Desert Mounted Corps at Mussulabeh on 14th July, when, as he says, too, the Turks let the Germans down badly.

The first raid on Amman was considered to be a serious attempt to break through. The British surprise failed, but the German General tells us that the garrison of Amman on 30th March was on the point of surrender, and that he himself kept on urging the com-

mander to hold out. So Amman affords yet another case of the last ounce turning the scale.

The second raid, on Es Salt, is admitted to have been a complete surprise. The flank march of the Australian Division is called "quite extraordinary"; and the track used by the 5th Mounted Brigade was unknown to the German Staff.

General von Sanders always had his eye on the Jordan valley. He noticed the presence of the British and the Overseas troops there in the hot weather, and comments bitterly on the order he received from Berlin to withdraw all German troops from the Jordan and place them in healthy stations. He replied that it was impossible to do so. He was obsessed with the conviction that the British Commander-in-Chief would try to cut across from the Jordan to Deraa, and refers to it again and again.

The raid of the 10th Division on 12th August is claimed as a victory for the Turks. Sir Philip Chetwode is credited with employing ten battalions in it. Actually, he used three. So this bears out that the General's figures must be taken with caution.

Coming to the preliminary events of September, three interesting facts are presented :—

(*i*) The great fire at Haidar Pasha Station in July deprived the Turkish armies of long-expected and sorely needed stores.

(*ii*) The Taurus tunnels were being converted to broad-gauge track, and this section of the Bagdad railway was closed during the last ten days of September—an inconvenient moment to choose.

(*iii*) The German Air Force was in a bad way. They were outclassed, and, when desperately short of machines, the replacements from Germany arrived seriously damaged; not once, but as a rule. This confirms the story in *Eastern Nights and Flights* of the passing British officer of the Royal Air Force who remonstrated with a prisoner working-party in the Taurus for working too hard in transhipping enemy stores, and found that, while the quantities they shifted seemed highly satisfactory to the Turks, the damage they were systematically effecting was equally satisfactory to themselves.

On 17th September, a deserting havildar is said to have reported that a great attack in the coastal sector was to open on the 19th. As a result of this information, apparently, the 46th Turkish Division was moved into the Et Tireh defences. But on the same day the news came in of the wrecking of the railway all round Deraa. General Liman von Sanders says he concluded that "major operations were beginning," and immediately ordered up the German battalion at Haifa to Deraa.

Thirty-six hours later the major operations did begin, indeed.

But General von Sanders' introduction to them was that his line of communication centres were bombed, and he was cut off from news or control of what was going on.

He reverts to the failure of his communications frequently. He says that not only were the various headquarters heavily bombed but that, elsewhere, the Arabs broke down the permanent telegraph lines—a tribute to the efficiency of Colonel T. E. Lawrence's arrangements. Anyway, the German commander had only precarious and intermittent communication with the front, and scanty and inaccurate information.

About 0930 hours, he heard that some cavalry had penetrated by the coast and were going north. He considered that their objective was Haifa, and warned the Commandant there. The possibility of a total collapse on his right did not enter his head. He expected the VIIIth Turkish Army would fall back on successive positions, and display the usual stubbornness of the Turk on the defensive. During one of the moments of intermittent repair of the telephone, about 0930 hours, he ordered a counter-attack from Kalkilieh towards the coast, and was told this was already proceeding. Only, when the wire was again momentarily restored, about mid-day, did he first hear that the coastal front was lost, and the remnants of the VIIIth Army were falling back on Anebta. With the headquarters of the VIIIth Turkish Army he never had any communication at all.

General von Sanders then gave orders for Lejjun to be held, and sent a *Gendarmerie* regiment from Nazareth under a German officer to do it. The 2nd Lancers disposed of this force (page 355).

He was unable to draw on the VIIth Turkish Army for troops, because they were being attacked now. But, even in the afternoon, General von Sanders does not seem to have realized his desperate situation, and, lacking precise information, he hoped that his right was falling back systematically, fighting. He issued orders for the IVth Turkish Army to retire to the Zerka, the VIIth to Beisan, and remnants of the VIIIth to Jenin. Only some days later was the full extent of the rout known to the Yilderim Headquarters.

General von Sanders' own comment is that his front had been too dispersed and that behind it, for 200 kilometres, the country was devoid of troops, except Arabs and Labour Corps.

When Nazareth was raided on 20th September, it was not entirely surrounded. General Liman von Sanders reached Tiberias at 1530 hours, and there tried to organize resistance. His plan was to hold the line of the lakes, Hule and Tiberias, and the Yarmuk valley to Deraa, whither he went himself—by trolley, presumably—after ordering Yilderim Headquarters to re-open at Damascus. Semakh, which was the keystone of this position, was held by Germans, who put up a stout resistance when it was captured on 25th September.

It is interesting to note that the move of the Desert Mounted Corps across to Damascus was not what the Germans expected.

According to General von Sanders, Sir Edmund Allenby's rôle should have been to stick to the coast, to land a force at Beirut, and to send mounted troops up the Litani valley direct to Rayak Junction. This looks very direct on the map, but the tracks were hopeless for a large force, whereas the Kuneitra road, bad though it was, proved passable for lorries.

The Rayak line, which the German General hoped to hold, was unsound. When the British had taken Damascus, they had a direct road to Homs behind him, and could cut his forces off. General von Sanders abandoned Rayak Junction on 2nd October, and retired to Aleppo. Then the Arab movement spread to Homs, Hama, and Aleppo, and the situation became hopeless in the north, too.

General von Sanders complains, with justice, that his government did not understand the situation and conditions in Palestine, and greatly over-estimated the military capacity of Turkey. It seems to have been no fault of his that he was out-numbered and ill-supplied, but it is also undisputable that on the field of battle he was out-generalled, misled, and out-manœuvred everywhere.

Conclusion.—The progress of the *Entente* Powers in the War is reflected in the campaigns of Egypt and Palestine. In 1914 and 1915, the British were on the defensive everywhere and the Turks had the initiative. During 1916, the tide began to turn. The defensive was abandoned, Sinai was retaken, and the initiative passed to the British while the Turks got into difficulties. In 1917, the Turks were staggered by defeats entailing the loss of Mesopotamia and half of Palestine. And when the knock-out blow fell in September, 1918, their collapse was complete.

Turkey was misled politically and strategically. She was the cat's-paw for Germany, and stood to gain little, as Germany meant to have a lot. The Turks were handicapped from the outset. They began war-weary; their difficulties were immense, no sea-power, inadequate communications, insufficient military resources: Gallipoli had ruined their army. It was a prime strategical error to attack Egypt at all; but, having done so and brought trouble on themselves, they aggravated that error by neglecting the menace from Egypt on Palestine.

Even after the Turks had lost Jerusalem, they continued to commit errors. For example, when the Russian revolution relieved them from pressure in the Caucasus, instead of coming away from that front, they indulged in a race for Baku with the Germans, and even tried to invade Persia.

Again, they would not cut their loss at Medina and Maan, but played the part mapped out for them by Colonel Lawrence, of expending their men and resources to no advantage.

They did contemplate withdrawal from Medina, but perhaps gave it up because they feared their troops would all be cut up in traversing the hostile Arab country. They might have abandoned

Maan, but probably feared that their hold on Deraa would then be imperilled; and the latter place was vital to them so long as they remained in Central Palestine.

Their worst mistake was, perhaps, to credit Sir Edmund Allenby with the intention of operating directly against Deraa, by taking Amman. Fear of this induced them towards the end to keep nearly a third of their total force east of the Jordan, and in a country almost devoid of roads. But, as already pointed out, they had been encouraged in every possible way to believe in his intention to make a big move across the Jordan. It might be argued, that Sir Edmund Allenby later on did feed and maintain his cavalry corps over 100 miles from railhead, in spite of the abominable roads. And so he did, but he was able to do so, because he had first crushed the Turkish armies.

The great anxiety at our General Headquarters was lest the Turks, who knew the British intended to attack eventually, should fall back. No doubt, they would have been very promptly followed up, but such a course would have gained them some time. The British forces would have lost the advantage which their railways and roads, built close up to the front line, had given them, and also the surprise which was the essence of Sir Edmund Allenby's success would have been lacking.

The greatest feature of the operations which crushed the Turks was the achievement of the cavalry, and in this connection, the views of Field-Marshal Lord Allenby himself on *Cavalry in Future Wars** are of special interest :—

> "The truth is that cavalry can and will fit in its tactics to any country . . . " (and the Field-Marshal instances its use) "in . . . . the deserts east and west of Egypt, the rocky hills of Judea, the plains of the Palestine coast, the deep valley of the river Jordan, and the mountains of Moab."
>
> Then the Field Marshal continues :—
>
> "Experience teaches that a mounted attack, exactly timed, is almost always successful, and is less costly than a fire fight."

APPENDIX II.

Copy No.....

EXTRACTS FROM FORCE ORDER NO. 54, BY GENERAL SIR EDMUND ALLENBY, K.C.B.,

Commander-in-Chief, Egyptian Expeditionary Force.

Reference maps :— GENERAL HEADQUARTERS,
PALESTINE 1/20,000. *22nd October*, 1917.
PALESTINE 1/63,300.

1. (Intelligence will be issued periodically.)

2. It is the intention of the Commander-in-Chief to take the offensive against the enemy at Gaza and at Beersheba, and when Beersheba is in our hands, to make an enveloping attack on the enemy's left flank in the direction of Sheria and Harcira.

* A Foreword for the *U.S. Cavalry Journal*, January, 1921.

3. (*a*) On Zero day the XXth Corps (with the 10th Division and Imperial Camel Brigade attached), and the Desert Mounted Corps (less one Mounted Division and the Imperial Camel Brigade) will attack the enemy at Beersheba with the object of gaining possession of that place by nightfall.

(*b*) As soon as Beersheba is in our hands, and the necessary arrangements have been made for the restoration of the Beersheba water supply, the XXth Corps and the Desert Mounted Corps will move rapidly forward to attack the left of the enemy's main position, with the object of driving him out of Sheria and Hareira and enveloping the left flank of his army. The XXth Corps will move against the enemy's defences south of Sheria, first of all against the " Kauwukah " line, and then against Sheria and the Hareira defences. The Desert Mounted Corps, calling up the division left in General Reserve during the Beersheba operation, will move north of the XXth Corps to gain possession of Nejile, and of any water supplies between that place and the right of the XXth Corps, and will be prepared to act vigorously against and round the enemy's left flank if he should throw it back to oppose the advance of the XXth Corps.

(*c*) On a date to be subsequently determined, and which will probably be after the occupation of Beersheba, and 24 to 48 hours before the attack of the XXth Corps on the Kauwukah line, the XXIst Corps will attack the south-western defences of Gaza with the object of capturing the enemy's front line system from Umbrella Hill to Sheikh-Hasan, both inclusive.

(*d*) The Royal Navy will co-operate with the XXIst Corps in the attack on Gaza, and in any subsequent operation that may be undertaken by the XXIst Corps.

4. (*a*) On Z–4 day the G.O.C. XXIst Corps will open a systematic bombardment of the Gaza defences, increasing in volume from Z–7 day to Z–4 day at least.

(*b*) (*c*) (Details of naval co-operation).

5. (*a*) The XXth Corps will move into position during the night Z–1—Zero, so as to attack the enemy at Beersheba on Zero day south of the Wadi Saba with two divisions, while covering his flank, and the construction of the railway east of Shellal with one division on the high ground overlooking Wadis El-Sufi and Hannafish. The objective of the XXth Corps will be the enemy's works west and south-west of Beersheba as far as the Khalasa–Beersheba road, inclusive.

(*b*) The Desert Mounted Corps will move on the night Z–1—Zero from the area of concentration about Khalasa and Asluj, so as to co-operate with the XXth Corps by attacking Beersheba with two divisions and one mounted brigade. The object of the Desert Mounted Corps will be the enemy's defences from the south-east to the north-east of Beersheba and the town of Beersheba itself.

6. The G.O.C. Desert Mounted Corps, will endeavour to turn the enemy's left with a view to breaking down his resistance at Beersheba as quickly as possible. With this in view, the main weight of his force will be directed against Beersheba from the east. As soon as the enemy's resistance shows signs of weakening, G.O.C., Desert Mounted Corps, will be prepared to act with the utmost vigour against his retreating troops, so as to prevent their escape, or, at least, to drive them well beyond the high ground immediately overlooking the town from the north. He will also be prepared to push troops rapidly into Beersheba, in order to protect from damage any wells and plant connected with the water supply not damaged by the enemy before Beersheba is entered.

Special instructions will be issued to G.O.C. Desert Mounted Corps, and a copy of these instructions will be forwarded for information to G.O.C. XXth Corps.

7. The Yeomanry Mounted Division will pass from the command of G.O.C. XXth Corps, at 0500 on Zero day, and will come directly under General Headquarters as part of the General Reserve in the hands of the Commander-in-Chief.

8. When Beersheba has been taken, G.O.C. XXth Corps, will push forward covering troops to the high ground north of the town to protect it from any counter-movement on the part of the enemy. He will also immediately put in hand the restoration of the water supply in Beersheba. G.O.C. Desert Mounted Corps will be responsible for the protection of the town from the north-east. . . . . (Line of demarcation . . . . .)

9. As soon as possible after the taking of Beersheba, G.O.C., Desert Mounted Corps, will report to General Headquarters on the water supplies in the *wadis* west of Beersheba, and especially along the Wadi Saba and the Beersheba—Tel-el-Milah road . . . . . A preliminary survey having been made, G.O.C. XXth Corps, will report by wire to General Headquarters on the condition of the wells and water supply generally in Beersheba, and on any water supplies found west and north-west of that place. He will telegraph an estimate as soon as it can be made, of the time required to place the Beersheba water supply in working order.

10. When the situation as regards the water at Beersheba has become clear, so that the movement of the XXth Corps and Desert Mounted Corps against the left flank of the enemy's main position can be arranged, G.O.C. XXIst Corps will be ordered to attack the enemy's defences south-west of Gaza, in time for this operation to be carried out prior to the attack of the XXth Corps on the Kauwukah line of works. The objective of the XXIst Corps will be the defences of Gaza from Umbrella Hill, inclusive, to the sea about Sheikh Hasan.

11. Artillery (ammunition supply and expenditure).

12. Aircraft.

13. Communications—(*a*) with Royal Navy; (*b*) towards Beersheba.

14. Maps.

15. Liaison.

16. Medical (three Casualty Clearing Stations at Imara, and two at Deir-el-Belah. Former to be sited, but no tents to be erected until after sunset on Z–1 day).

17. Prisoners of War.

18. Issue of Official Time.

19. The date of Zero will be notified in due course.

20. General Headquarters will remain in its present position.

(Signed) L. G. BOLS, *Major-General,*
Chief of the General Staff, Egyptian Expeditionary Force.

Copy No. *Issued to*

APPENDIX IV.

Secret and personal. *Copy No. 2.*

Z/96/16.

Instruction to General Officer Commanding Desert Mtd. Corps.
(*Reference Force Order No. 68, dated 9. 9. 18*).

1. The General Officer Commanding XXIst Corps, has been entrusted with the task of breaking down the enemy's resistance in the coastal

plain and opening the way for your Corps to cross the Nahir Falik and the Khez Zerkiyeh Marsh. In view of the long marches which you have to make and the necessity of conserving your full strength to carry out the important rôle assigned to you in the enemy's rear, you must on no account allow your troops to be drawn into the infantry fight south of the Nahr Falik, nor, after the passage of this stream, to be diverted from your objective by the presence of hostile troops in the Tul Keram–Kulunsaweh–et-Tireh area, which will be dealt with by the XXIst Corps. The advance of your Corps from its positions of readiness will be regulated by the progress of the XXIst Corps, and you will be responsible for arranging that the line Khez Zerkyeh–Mouth of the Nahr Falik is crossed at the earliest possible moment. In your approach march care must be taken that there is no interference with the movement of units and formations of the XXIst Corps engaged in the attack. It is particularly important that the fire of the Corps Artillery should not be masked.

2. Should any portion of the enemy's force retreat in the direction of Haifa, you will detach only sufficient troops to keep touch with it and protect your line of communications, as it is vital that as large a proportion of your force as possible should be available to carry out the rôle assigned to you, which is to place your troops about El Afuleh and Beisan where the enemy's railway communications can be cut at their most vital point, and whence you will be in a position to strike his columns if they endeavour to escape in a northerly or north-easterly direction. The action of your troops must be characterized by the greatest vigour and rapidity, as it is essential that they should reach El Afuleh and Beisan before the enemy can withdraw his rolling-stock and material or assemble troops for the defence of the railway.

3. On arrival at El Lejjun you will detach a Brigade to block the roads and railways passing through Jenin and to gain touch with the Cavalry Brigade attached to the XXIst Corps, which will be directed on Jenin from the south if the situation permits.

4. From El Afuleh a detachment will be sent to seize the road and railway bridges over the Jordan at Jisr Mejamie, moving by the road through Nein, Endor and Sirin (1/250,000 map). The railway bridge should be prepared for demolition, but not destroyed so long as we are able to hold it.

5. Demolitions on the railway should be limited to such as can be easily repaired.

6. Please acknowledge.

(Signed) L. J. Bols, *Major-General,*
Chief of the General Staff, Egyptian Expeditionary Force.

G.H.Q., E.E.F.
9th September, 1918.

Copies to G.O.C. XXth Corps; G.O.C. XXIst Corps, for information.

THE SUPPLY OF BULK STORES IN WAR.

To the Editor, R.E. JOURNAL.

SIR,

As one who was concerned, in a small way, with both the provision and consumption of engineer stores in France during the war, I should like to express my appreciation of Colonel Sewell's admirable article in the July issue of the *R.E. Journal,* and to make one or two brief comments.

In para. 16 the author touches on the local purchase of engineer stores in the theatre of war, and remarks that it is a "subject which requires some control." I think that the facts would justify a stronger emphasis on the squandering of public money which actually took place and which always will take place if C.E.'s and C.R.E.'s are given a free hand in the matter. At the time of which he speaks (1915), I am afraid that I myself was among the "spenders" and joined merrily in the fierce competition with neighbouring Divisions; but what is a poor C.R.E. to do when confronted with the dilemma of either delivering the goods or being scrapped?

The root of the evil lies in the human tendency of the Higher Command, under the strain and stress of war, to judge solely by results achieved, without regard to attendant circumstances; a tendency which is apt to result in more or less unscrupulous competition between formations, from Armies down to Platoons, for the wherewithal to make a splash, and which led to such incredible absurdities as the removal, at a vast cost of labour and transport, of their respective outfits of workshops, laundries, theatres, etc., on the part of two Corps changing places in the line.

In para. 50 the author discreetly refers to another thorn in the flesh of the long-suffering C.R.E., who not infrequently found himself between the devil of the G.S. and the deep sea, as personified by the C.E. (the pun is unintentional but rather a good one). The former would demand that certain work should be carried out, and the C.E. would firmly refuse to supply the necessary stores, either on the flimsy excuse that he had not got them or that it was a silly game to play at and he was not going to encourage it.

Such a situation is always possible as long as the principle is accepted that a formation is responsible for the defence of the sector which it occupies, and the supply of engineer stores for that purpose is controlled by an independent authority. The Higher Command has, as a rule, a somewhat imperfect appreciation of the importance of the R.E. trinity, "Stores, Labour, Transport," in the execution of field defences.

The remedy lies, at any rate in position warfare, in the curtailment of the powers of Divisional and Brigade Commanders to initiate ambitious works of defence.

Yours, etc.,

Hong Kong. 21. 9. 22. C. W. DAVY, *Colonel.*

THE EMPLOYMENT OF DIVISIONAL ENGINEERS IN CONJUNCTION WITH OTHER ARMS IN WAR.

Part of a Lecture delivered at the S.M.E., Chatham, on 10th July, 1922, to the Senior Officers' Class (all arms) by Brevet Major G. E. H. Sim, D.S.O., M.C., *p.s.c.*, R.E., Brigade Major, S.M.E.

1.—Necessity for a Clear Doctrine of Engineer Employment.

Engineers exist solely to help the other arms to function. It is, therefore, most desirable that there should be some well-defined policy, doctrine, normal practice (call it what you will) governing the employment of engineers in conjunction with the other arms in war.

A lot of people are apt to jib at the word "Doctrine," but I think it is because they confuse it with the word "Dogma." A dogma is something we are asked to believe blindly without proof. A doctrine is something to be taught: evolved from accepted principles, logically deduced, based on experience and susceptible to variation in accordance with varying conditions.

The doctrine of engineer employment and the principles upon which it is based should be well known and understood, not only by the engineers themselves, but also by the commanders, staffs and troops of all arms. It is only where such understanding exists that the engineers of a force can be used to the best advantage.

The "Doctrine" crystallizes out into a "Normal Practice." Just as there is a normal practice for the supply of troops with rations and ammunition in the field, so must there be a normal practice for the employment of engineers, which everybody understands. The practice can, of course, be varied in abnormal circumstances, but it is advisable to stick to it, unless there is good and sufficient reason for departing from it. It will usually give the best results.

It is this "doctrine" or "normal practice" of engineer employment which we aim to put before you in this Course. You will find it clearly set out in Chapters VII. and VIII. of the new *Engineer Training*, 1922. Its detailed application to various operations of war will be dealt with subsequently in lectures and schemes during the course. This evening I want to explain the doctrine generally and the principles on which it rests, and, if possible, to enlist you as its champions.

2.—Principles on which the Doctrine is Based.

First let us see what are the principles on which any doctrine of engineer employment must be based. They are very few and very simple. They can, in fact, be boiled down to four. They are:—

(i) *Economy of Force.*
(ii) *Avoidance of Divided Control.*
(iii) *Continuity in the Execution of Works.*
(iv) *Conformity of Work to the Tactical Situation.*

There is nothing new or controversial about these four principles. A moment's thought will enable you to see that unless they are observed the work is bound to suffer. It is the application of them which presents so many practical difficulties, and attempts to dodge the difficulties by departing from the principles led to an enormous waste of engineer effort during the late war.

3.—Lack of a Doctrine before the War.

Before the war nothing was laid down anywhere as to how engineers ought normally to be employed tactically, except the somewhat nebulous doctrine that every main body of troops should have its complement of engineers, which was to assist the infantry (in particular) in every possible way. This was much too vague to be of any use. Some commanders and engineer officers had given little or no thought to the subject. Those who had thought about it evolved theories of their own, some of them sound, some the reverse of sound, and all different.

4.—Violation of the Four Principles and its Results.

During the early part of the war, therefore, this absence of an accepted doctrine led to various methods being employed by individual commanders, with the result that in most divisions, one might almost go so far as to say in all at that time, each of the four principles was violated almost daily.

Economy of force was conspicuous by its absence. The skilled engineers were frittered away on work, such as wiring the front line, which the other arms ought to have done for themselves.

Divided control was rampant. The engineers were usually serving several masters, who gave contradictory orders as to the work to be done.

Continuity in the execution of works suffered because there was no settled policy and in many cases the newcomer scrapped the unfinished work of his predecessor.

Work, in many cases, did not conform to the tactical situation because it was nobody's business to see that it did.

5.—Evolution of Two Schools of Thought.

As the war progressed, however, bitter experience led to the evolution of doctrines of engineer employment. I say "doctrines," in the plural, advisedly, because there were two of them, and they both obtained right up to the end of the war and both have their adherents and advocates still. To these two schools of thought I

shall refer in future, for shortness, as the "Brigade Group School" and the "Divisional Control School."

(i) *The Brigade Group School.*—One school held that the way to get the best value out of divisional engineers was to attach a field company permanently to each infantry brigade of the division, to work under the orders of the brigade commander at all times. This resulted in the C.R.E. becoming in practice merely an adviser to the G.O.C. Division on questions of engineer policy and having no direct responsibility for the execution of engineer work. Having allocated all his engineers to brigades, he had none with which to carry out work not normally coming within the jurisdiction of a brigade commander unless he could persuade a brigade commander to lend him some.

(ii) *The Divisional Control School.*—The other school held that the best way was to concentrate the responsibility for all engineer work of the division in the hands of the C.R.E. and that he should normally have the field companies under his own hand to allot as he, under the general staff of the division, thought best for its execution.

It is this second system, namely, the concentration of the whole engineer problem in the hands of the C.R.E., that has now been officially adopted in our Army and on which the doctrine taught in *Engineer Training* is based.

6.—Comparison between the Two Systems in the Light of the Four Principles.

If we examine the two systems outlined above in the light of the four principles of engineer employment already enunciated, we will, I think, find that the Divisional Control System wins every time. Let us take each principle in turn and see which of the two systems is likely to give us the best results.

(i) *Economy of Force.*—There is always in war more engineer work to do than there are engineers to do it. But some is more urgent and important than the rest. It may be vitally urgent to concentrate all the engineer resources of the division on some particular work in one of the brigade areas, leaving the other brigades for the time being to fend for themselves At another time it may be necessary to concentrate on work in which the brigades, at the moment, have little or no direct interest, such as rearward positions, artillery observation posts, burying cable for the signal corps, horse-watering points, preparations for demolitions far in rear in the event of a retreat, construction of roads, bridges, railways, inundations, hutted camps, etc. It is very difficult to arrange for this if every brigade has a vested interest in a field company and feels aggrieved if it is taken away, as it will if it is used to the Brigade Group System. The only person who can arrange that the engineer

resources of the division are used economically (*i.e.*, used to the best advantage on the most important work at the most important place at the right time) is the C.R.E., after he has received his instructions from the general staff of the division. To enable him to put his plans into effect he must have his field companies at his disposal all the time.

It may at first sight appear that this "Economy of Force" will benefit the engineers at the expense of the infantry. Where the Divisional Control System was worked, however, infantry units soon came to take a great pride in doing without engineer assistance wherever possible, and they soon realized that it was to their advantage to set free the engineers for the work they could not do for themselves, but of which they reaped the benefit, either directly or indirectly, in the long run.

(ii) *Avoidance of Divided Control.*—This is a counsel of perfection in any case, and is usually unattainable in the case of the engineers. An engineer officer may consider himself lucky if he has to serve only two masters. This does not mean that he likes serving two masters. He gets used to it after a bit and puts up with it, but he does not like it. Under the Brigade Group System the field company commander always had two masters, the C.R.E. and the brigade commander, who often pulled opposite ways. When things were humming, the system could not be got to work at all unless all three, the two masters and the servant, were most tactful and reasonable beings. Any system which depends for its success on the tact and reasonableness of the individuals who have to work it must be radically unsound and liable to break down under stress. Take, for example, the case of a field company handed over to a brigade for an operation. The brigade commander makes his plan, which includes certain jobs for his field company. Everything goes swimmingly till the C.R.E. comes along and tells the field company commander that the division has ordered certain other work to be done at once and that he is to take half his company and get on with it. Not to do so will call down the righteous wrath of the divisional commander. To do so will seriously inconvenience the operations of the brigade commander who is relying on having the whole field company for his own jobs and has made his plans accordingly. It may mean that some bridge that he is relying on to get his ammunition up at night will not get built in time. The result is generally a compromise. Neither job gets done properly and everybody is peevish about it. That is an example of divided control which occurred times without number during the war where the Brigade Group System of engineer employment was in vogue. Under the Divisional Control System this difficulty is avoided as far as practicable. The C.R.E. has the whole of the engineer problem of the operation in his hands. The general staff decide what engineer

works are necessary (among which, no doubt, will be the brigade commander's tactical bridge) and the C.R.E. details off his engineer companies to the various jobs, keeping an engineer reserve in his hands for eventualities. If it is desirable to do so he may allot a field company, or part of one, to a particular brigade for a specific job of work which, owing to the technical nature of the job, the Brigade cannot do for itself, but which must, for tactical reasons, be carried out under the direct orders of the brigade commander. In this case the C.R.E. knows that those sappers are out of his hands for the time being and that he cannot count on using them for work for which he is responsible. Under this system everybody knows where he is and the brigade commander knows what, if any, sappers he can count on. Everybody is happy and, what is much more important, the really necessary jobs of engineer work have a fair chance of getting done.

(iii) *Continuity in the Execution of Works.*—All engineer work takes time, sometimes an almost unbelievably long time, to do. Provision must, therefore, be made to ensure that, when brigades change and move on, the engineer work is continued on some settled line of policy. As a rule an engineering job is more or less useless until it is finished. Take a bridge, for example. It may take days or weeks to build but it is quite useless until the last plank of the roadway is laid and the first vehicle can cross. Unless the work is continued until that last plank is in position, all the work that has gone before is wasted and has done no good to anybody. The same is, to a greater or less degree, true of all engineer work. The best people to finish a job are usually in the unit that started it. When brigades are relieved or move on, the engineers must stay and finish their jobs. Under the Brigade Group System the field company moves with its brigade and leaves its jobs unfinished and therefore useless. The new brigade that comes along may continue them, but often the new brigade commander is impatient to get on with some pet scheme of his own and the old jobs get left. Then he, in turn, moves on, leaving the jobs his field company started also unfinished. In this way a theatre of war becomes littered with unfinished engineer jobs which represent millions of man-hours of absolutely wasted labour. Under the Divisional Control System the C.R.E. allots the jobs and is responsible for seeing that they get finished. He is in a position to do so, for divisions do not change nearly so frequently as brigades.

(iv) *Conformity of Work to the Tactical Situation.*—The division has a much more comprehensive view of the engineer requirements of the tactical situation than any brigade can possibly have. The C.R.E., who is in close touch with the G.O.C. and takes his orders direct from the G.S.O.1., is the best authority to advise as to what work is to be done, where, how, by whom, and in what order of priority. This is especially the case in rapidly moving warfare,

though at first sight this would not appear to be so. Some say, "Leave the decision to the man on the spot, and the man on the spot is the brigadier." But is he? Undoubtedly the brigade commander is the "man on the spot" so far as fighting the battle is concerned, but is he as regards the engineer requirements of the situation? Surely he is not. The vital spot for engineer work may be, and probably is, right outside the purview of any brigade commander and can be located only by the man who can see the trend of the operation as a whole. That man in a division is not any one of the brigade commanders, but the divisional commander himself—and the C.R.E. is his prophet. In order that the C.R.E. may be able to put into effect the wishes of his divisional commander, he must have the field companies of the division at his disposal. Again, during a battle, the tactical situation is constantly changing, and with it the engineer requirements. Elasticity of the engineer resources and their adaptability to the changes of the situation are therefore essential. This elasticity and adaptability cannot be attained if the engineer units are rigidly attached to brigades.

7.—Liaison and Administration.

There are, however, two respects in which the Brigade Group System would appear at first sight to have the advantage over the Divisional System. These are Liaison and Administration. The permanent allocation of field companies to brigades renders liaison and personal knowledge between the engineer officers and the officers of other arms with whom and for whom they work much more easy of attainment. In the same way all administrative problems, such as supplies, billets, etc., are much more easily solved if the field companies are firmly attached to Brigades. But these advantages can be enjoyed to an almost equal extent under the Divisional System if it is properly worked, as I hope to show you later, and in any case both liaison and administration are only means to an end, not ends in themselves. The "end" is to get the right engineer work done as expeditiously, economically and effectively as possible.

8.—Description of the Normal Practice under Divisional Control.

I have gone into the arguments for and against each of the two systems at some length, because the whole accepted doctrine of engineer employment in conjunction with other arms is based on the assumption that the Divisional System is the normal practice. As the new *Engineer Training* is the first and only book that I know of that has ever attempted to teach a doctrine of Engineer Employment, it is as well to have a clear idea of the reasons which led to the adoption of that doctrine before proceeding to study the details of its application.

The normal practice of engineer employment in a division is, therefore, this :—

(i) The control of the whole engineer problem of the division is concentrated in the hands of the C.R.E., working under the direction of the general staff of the division. He assists the staff in the drawing up of a programme of work to be done, allocates the work to the engineer units of the division, receives their progress reports and generally takes charge.

(ii) Brigades and other formations requiring jobs to be done for them by the engineers indent on the division for the execution of the job, not for a company or part of a company of engineers. It is then for the division to decide what, if any, engineers can be spared for the execution of the job and its order of priority in the general scheme, having regard to its urgency in comparison with the other jobs on the waiting list of the programme.

(iii) Engineer units will normally not be allotted to infantry brigades or other formations except for the execution of some specific job or operation which, for some reason, can better be done under the supervision of the brigade or other commander than it can under the C.R.E.

(iv) The abnormal practice of attaching engineer units to formations should be resorted to only when the formation is detached from the division on an independent mission. In such cases the engineer units so attached would be directly under the command of the commander of the formation and would cease to be available for work for which the C.R.E. is responsible. The normal practice should be reverted to as soon as the formation rejoins the division.

(v) To facilitate administration (supplies, billeting, etc.) it is usual to attach field companies to brigades for administration. It is desirable that this attachment be changed as infrequently as possible, but administrative considerations must never be allowed to outweigh the tactical which, in the case of the engineers, is the rapid and economical execution of the most important jobs of engineer work.

9.—Need for Good Liaison and Good Communications.

In order that the Divisional System of Engineer Employment may be efficiently worked, it is essential, not only that the C.R.E. be in the closest possible touch with the divisional staff so that he may know what is going on and what is required, but he must also be able to get intelligent reports on engineer matters from all the

formations of the division, especially the infantry brigades, sift them quickly and, having made up his mind what ought to be done, convey his orders to the engineer units under his command. This is especially necessary in moving warfare.

To provide for this, two things are necessary and must be arranged for :—

(i) An efficient system of liaison between the C.R.E. and the infantry and other formations of the division.

(ii) An efficient and independent system of engineer communications.

10.—How Liaison is Provided for.

The reasons for and the method of carrying out engineer liaison are described in some detail in para. 59 of *Engineer Training*, and are so important that I recommend their careful study. The idea is that each brigade commander should have attached permanently to his staff an engineer officer for liaison purposes. His duties and functions are described fully in *Engineer Training*. Here are some extracts :—

" The main objects to be attained by such liaison are :—

" (i) To furnish the formations in immediate contact with the enemy with :—

" (*a*) A channel of communication respecting works between the commanders of such formations and the engineer commanders furnishing them with engineer assistance.

" (*b*) Technical information and advice respecting works for which the formations are responsible."

" (ii) To furnish engineer commanders with :—

" (*a*) A means for obtaining under all circumstances immediate and accurate technical information respecting the engineer assistance required by commanders of formations, and of forming a close and personal link between the engineers and the formations.

" (*b*) An agency for effecting all purely local preparatory measures necessary to ensure the rapid execution of works required of the engineers.

" (*c*) An effective agency for the organization and execution of engineer reconnaissances.

" The duties of the engineer liaison officer include the following, in addition to those specified above :—

" (*a*) To foresee and suggest to the staff of the formation to which he is attached the nature and occasions of the demands for engineer assistance.

" (*b*) To take all measures necessary and practicable to facilitate the rapid execution of any work for which engineer assistance is furnished.

" (*c*) Executive work if required in special circumstances in connection with the carrying out of works for whose execution engineer assistance is forthcoming."

Such a liaison officer can be an extraordinarily useful person at all times, but in moving warfare or when things are really humming the Divisional System of engineer employment cannot work efficiently unless one is provided, at least, with every infantry brigade headquarters. If possible, therefore, a liaison officer should be provided at all times with each infantry brigade. They may also be provided for other formations, such as divisional artillery, tanks, etc., as and when occasion demands.

11.—How Communications are Provided For.

It is also essential that the C.R.E. be able to communicate quickly and directly with the engineer companies under his command. The divisional signals cannot adequately supply this need. During a battle their resources are stretched to the utmost to deal with operations messages, and engineer messages get held up. Also the nature of engineer work often necessitates the field companies working, and even living, at a considerable distance from any signal office on the divisional signal system. To obviate this difficulty, there must be a small number of motor-cyclist orderlies at the C.R.E.'s headquarters, independent of divisional signals altogether, for conveying his orders direct. For the same reason field companies must have their own motor-cyclist orderlies.

12.—How the System Worked during the War.

That is the system that has now been officially adopted in our Army. It was tried in many divisions during the latter part of the war and, in spite of circumstances which rendered its execution difficult, such as shortage of engineer officers for liaison purposes and the difficulty of improvising an engineer communication system, it was found to give excellent results during the 1918 retreat and in the advance afterwards in those divisions where it was adopted.

13.—Comparison with the Artillery System.

If we compare it with the system adopted for the employment of divisional artillery, we shall find that the two are practically identical.

The whole artillery problem of the division is concentrated in the hands of the C.R.A., who issues his orders to his artillery brigades in accordance with the needs of the division as a whole.

Artillery brigades and batteries are not normally put under the command of infantry brigade commanders, unless it be for some specific operation, or when a brigade is detached from the division on an independent mission. They return to the fold of the C.R.A. as soon as the mission or operation is completed.

Infantry brigades ask the division for artillery support for a certain operation and the C.R.A. decides the nature and amount of support to be given.

A great deal of the work of the artillery does not come within the purview of the infantry brigade commander at all and must be arranged for divisionally.

The artillery have their own system of communications, the artillery brigade sections of the divisional signal company.

They also make extensive use of liaison officers with infantry brigades, whose duties are on all fours with those of the engineer liaison officers described above.

In fact, the problem of the employment of divisional artillery in modern war has been solved by the adoption of the system of Divisional Control. The engineer problem is capable of solution in the same manner.

14.—COMPARISON WITH THE FRENCH SYSTEM

As a nation we are very apt to run ourselves down and to think that foreigners do things on a much better system than ours. It is, therefore, consoling to note that the French think precisely as we do on this subject of engineer employment.

I have here the translation of the notes of a lecture delivered at the French Staff College in March, 1918. The organization of the engineers in a French division differs slightly from ours in that they have two field companies instead of our three, but their teaching as to the duties of the C.R.E. and the employment of divisional engineers generally might have been written in close collaboration with the author of Chapters VII. and VIII. of our *Engineer Training*. As a matter of fact, the chapters in our manual were written without the knowledge of the existence of this pamphlet. I will conclude by reading you a few extracts from the French lecture which confirm our doctrine in a very remarkable manner :—

" *(a) Duties of the C.R.E. of a Division.*

" C.R.E.'s are alike technical advisers to their respective commanders and executive officers.

" As technical adviser the C.R.E. keeps his general posted as to :—

" (i) The requirements in time, labour and material of any proposed work.

" (ii) The method in which works are being carried out by subordinate formations.

" As executive officer,

" (i) He collaborates in the preparation of programmes of work (in particular of that part in which the engineers are to take a hand) ;

" (ii) He is responsible for the completion of work entrusted to him by the commander and carried out by the engineer units.

" The programme of work for engineer units is always drawn up by the commander.

" Decisions with regard to important works are not the province of the C.R.E."

" The C.R.E. cannot carry out his duties efficiently unless he is always familiar with his general's thoughts, and never ceases to work in close touch with the staff. He must likewise keep in close touch with the commanders and staffs of subordinate formations, help them with his technical knowledge, keep abreast of their needs, foresee them if possible, and concentrate all his resources on satisfying them.

" (*b*) *Employment of Engineers.*

" The normal work of field fortification, construction and repair of trenches, barbed wire entanglements, etc., must be carried out by the infantryman. These tasks call for a large amount of labour, and engineer companies will only furnish an insignificant amount of supervising detail in any case.

" Engineers will, therefore, only be employed on tasks demanding skill greater than that possessed by the infantryman.

" (*c*) *Distribution of the Engineers.*

" Engineers, like infantry, work in properly constituted units, if possible, in companies ; it will only be in exceptional circumstances that they are employed by less than sections. A sapper only works well and gives full value when his organization is intact.

" An engineer unit, when engaged, must, like any other force, be given an objective. Hence, the attachment of parties of engineers to assaulting troops, without any definite reason, but as a matter of course, will be avoided.

" Engineers will only be attached to such regiments or battalions whose objectives involve types of work which justify the employment of technical troops.

" So we have established the principle that engineers are to be employed by whole companies, or, at least, by organized fractions, and that they are to be employed where their special skill will be of advantage. *It follows that they will not be permanently allotted to subordinate formations.*"

*THE MATHEMATICAL CONCEPTION OF THE UNIVERSE.**

By COLONEL A. M. MANTELL (late R.E.).

IT is somewhat presumptuous of me to undertake to write a paper on the "Mathematical Conception of the Universe," as I must begin by confessing that there are many points which I cannot grasp even in the less advanced literature of the subject. As regards the more abstruse writings of authorities like Einstein, Whitehead and Weyl, there are probably only a few dozen people in the world who can follow them to the last word. However, as I have devoted a good deal of time to the subject, there is a possibility that some of my remarks may be of use or of interest to those who have not paid so much attention to it.

Mathematics in General.—It seems well to begin by reminding you that mathematics may be regarded as a sort of game like chess. Certain axioms are assumed—such, for instance, as the axiom that two straight lines cannot enclose a space. These axioms correspond to the chess-men. We deal with these axioms in accordance with certain logical processes which correspond to the "laws of chess," and we arrive at certain theorems which may be said to correspond to the result of the game of chess.

The supreme interest of mathematics lies in the fact that these theorems correspond, not only to the result of the game of chess, but also to the observed sequence of events in nature, *i.e.*, they give us what are called the "laws of nature."

Einstein and his co-workers have modified the axioms and carried mathematical processes further than their predecessors, and have thus arrived at theorems or theories which correspond more closely to the laws of nature than the theories of Newton and other earlier scientists.

I hope to be able to indicate roughly some of the points in regard to which these modern theories differ from the earlier or so-called classical theories of mechanics.

Mathematical Methods.—Mathematical methods may be divided broadly into two great classes :—

1. Purely geometrical methods, such as those used by Euclid.
2. Analytical methods, in which equations and formulæ are used as, for instance, in algebra and trigonometry.

* A paper read before a local Scientific Society.

In analytical geometry the position of each mathematical point dealt with is fixed by means of certain measurements called co-ordinates. Thus, for instance, the position of the corner of a table in a room might be fixed by stating its distance from two walls of the room and its height above the floor. Other kinds of co-ordinates are used for special purposes, and during the last hundred years or so mathematicians have found it convenient and, in fact, essential, sometimes to use curved co-ordinates (the so-called "Gaussian" co-ordinates).

In using mathematical phrases to describe physical phenomena it is sometimes better to use the language of pure geometry, and sometimes that of analytical geometry, but both modes of expression have, of course, the same essential meaning.

During the last twenty or thirty years it has been more clearly recognized that there is one very weak feature in all this analytical geometry, *viz.*, that we do not know of any fixed point or body from which co-ordinates or distances may be measured. For most purposes the earth may be considered to be fixed; for some purposes the sun may be taken as fixed; but for certain cosmic questions in which the ether is involved, it is not possible to measure any co-ordinates whatever, and the most that can be done is to deduce equations—called "differential equations"—which give the relationship between the differences of the hypothetical co-ordinates.

To take a simple illustration, suppose a bottle is dropped from a window in a train: the person who drops it will see it fall in a straight line relatively to the train, while an observer outside the train will see it move in a curve (a parabola) relatively to the earth. No one knows what its absolute movement is; nor, indeed, can we be certain that it is moving at all, but modern mathematicians have succeeded in finding differential equations which represent with extreme accuracy the movement of such an object as the bottle in question, and of all other objects which are dealt with in physical science.

Space and Time.—If we endeavour to describe the movement of the bottle, we naturally do so by saying that it travels through a certain space in a certain time. This raises another profound difficulty.

In the classical mechanics it was assumed:—

1. That we had available rigid foot-rules, etc., for measuring a uniform entity, called space, and
2. that phenomena, such as the rotation of the earth or the vibration of an atom, gave an invariable measure of a uniformly flowing entity called time.

But it is now recognized that we do not know of any such uniform entities as space and time existing on their own account.

What we call space is really the expression of certain properties of matter, and for all we know a foot-rule may change its length entirely when it is carried from one side of a room to another, or when it is turned round. In fact, it is possible that all spatial dimensions are a hundred times greater or smaller to-day than they were yesterday.

Similarly as regards time: it is possible that the earth is rotating and the atom vibrating a hundred times faster or slower to-day than yesterday.

Practical Importance of the Above Considerations.—The above doubts as to the nature of space and time were familiar to philosophers long before Einstein began his researches. They were, in fact, involved in the paradoxes propounded by Zeno in the fifth century B.C. But they were not at first of practical importance, because the conclusions deduced by the methods of classical mechanics seemed to agree in all cases with the results of observation and experiment. During the last hundred years, however, the methods of measurement used by physicists have become far more refined, and have brought to light certain minute but perfectly definite discrepancies between theories and practice, and therefore (quite apart from philosophical considerations) it has been necessary to revise the theories.

The way in which this may come about may be illustrated as follows:—

Imagine a sphere of the size of the earth covered with a thin film of water, and imagine that there is a community of highly intellectual microbes living in the water, who are able to move about in the water, but who cannot leave it. These microbes would be living in a spherical space of two dimensions, and would have no conception of a third dimension. Imagine, further, that they are confined to a small area—say, within a mile or two of the north pole. They would naturally think that their space was flat—or, to use the correct technical term, "homaloidal."

If, then, they described a number of circles anywhere within the mile or two available for their observations, they would discover by measurement that the circumference of a circle was always equal to the diameter multiplied by π, or say $3\frac{1}{7}$, and this would confirm practically the conclusion which we may suppose them to have reached by mathematical reasoning.

If, however, the microbes were to improve their methods of measurement sufficiently, they would find that the circumference was not, after all, quite as great as π times the diameter, and that the larger the circle the more the circumference would fall short of this theoretical amount.

In this way they might arrive at the conclusion that the space in which they lived was not flat or homaloidal, and they might even

be able to conceive of a third dimension, to discover that they were probably living on the surface of a sphere, and to measure approximately the size of the sphere.

Human beings are now in a similar position. The most accurate modern measurements have led to the conclusion that our three-dimensional space is not homaloidal, and that there is something which must be called a fourth dimension. The shape of this four-dimensional space is still under discussion, but it has been found possible to make a rough estimate of its size. It has been calculated that a ray of light travelling with its usual velocity of 186,000 miles per second would take about a thousand million years to travel round it.

Discrepancies between Classical Theories and Modern Measurements.—The modern measurements which led to these startling conclusions were obtained :—

1. In electro-dynamical and optical experiments, by Fizeau, Clerk-Maxwell and Lorentz during last century.
2. In regard to the velocity of light, by Michelson and Morley in 1887.

These experiments have not only led to the conclusion that our three-dimensional space is curved—*i.e.*, non-homaloidal—but, as mentioned above, have revolutionized our ideas as to space and time, and shown that they are not absolute as usually supposed, but relative to the material objects with which we are dealing.

The discrepancies between theory and practical experiments brought to light by Fizeau, Clerk-Maxwell and Lorentz led to the assumption that a so-called rigid body has no definite dimensions, and that when it is in motion it becomes shorter in the direction in which it is moving. A fairly simple formula, called the " Lorentz transformation," was devised for expressing the amount of this contraction. This formula was invented to cover these electro-dynamical and optical results, but it was unsatisfactory in that it was invented merely to fit a particular set of observations.

The Michelson-Morley experiment led to more fundamental conclusions, and it is worth while to devote a little time to it.

Imagine we are on a small island in the middle of a large river, and have no ordinary means of discovering which way the river is flowing. Suppose that a motor-boat is started off from the island in any direction and taken one mile in a straight line, and is then brought back to the island along the same straight line. Suppose, further, that this experiment is repeated in a number of different directions. It will be found that along one line—say north to south —the time taken by the motor-boat to complete the double journey will be a maximum, while in the direction at right angles—*i.e.*, east and west—it will be a minimum. From this we may conclude that

the river is flowing from north to south or else from south to north. (This conclusion is based on a simple mathematical calculation.) We have thus discovered the direction of flow of the river.

Michelson and Morley applied this principle to the propagation of light through the ether. If the ether exists, there must be a current of ether flowing through or round the material objects on the earth because of the movement of the earth in its orbit (to say nothing of any movement of the solar or stellar system as a whole), and therefore the velocity of light in different directions ought to vary with the direction of the ether-flow—*i.e.*, it ought to be a maximum, say, along the east and west line, and a minimum along the north and south line. But no such difference in velocity could be discovered, although the accuracy of the measurements was quite sufficient to show this difference if it existed.

From this experimental fact that light moves at one and the same velocity in every direction regardless of the ether-flow, it is possible to show, by comparatively easy mathematical processes :—

1. That every body which is in motion contracts along the direction of its motion.
2. That a clock or other time-piece, *e.g.*, an oscillating atom, goes more slowly when in motion.

In each case the Lorentz transformation referred to above is arrived at, and it is obtained by a method different from that used by Lorentz himself.

These changes in length and time are, as shown by the Lorentz formula, very minute for any ordinary velocities, and thus escaped notice in classical mechanics, but they become appreciable or even very large at velocities approaching the velocity of light ; and thus the greatly increased accuracy of modern methods of measurement, combined with the fact that electrons moving with a velocity approaching that of light are used as the material of modern experiments, has made it necessary to take such changes into account.

Special and General Theories of Relativity.—The above considerations relate only to the case in which the motion is a uniform motion of translation in a straight line, and the ideas sketched out are embodied in what Einstein calls " the special theory of relativity," as published by him in 1905.

But if the motion is not uniform, or if it is in a curved line, the question becomes vastly more complicated, and we are led to what Einstein calls the " general theory of relativity," published by him in 1915. The formulæ in this latter theory are very lengthy, and it requires a super-wrangler to deal with them efficiently. Even the most advanced mathematician is obliged to disregard the more minute terms in these formulæ in order to reduce them to manageable

limits, and in this less complicated form the formulæ are used for dealing with the most subtle phenomena hitherto observed.

If, again, other still less minute terms are omitted, we arrive at the formulæ of classical mechanics, which are fortunately accurate enough for the vast majority of practical purposes.

Time as a Fourth Dimension.—In these formulæ the symbol representing time is on all fours with the symbols which represent distances. In fact, time is regarded as a fourth dimension essentially indistinguishable from the three dimensions of space. We are thus led to the conception referred to above, *viz.*, the conception of a four-dimensional space ; or, to word it more accurately, we are led to the conception of a four-dimensional "space-time manifold," as it is called, in which manifold all the physical phenomena of nature occur.

This conception of time as a fourth dimension may be illustrated as follows :—

Suppose that a cinema film is cut so as to separate all the different scenes which it contains, and that these different photographic scenes are piled up in order like a pack of cards on a table. Then imagine that this pack of views is gradually pushed down through the surface of the table, and that the result is observed by a two-dimensional being inhabiting the surface of the table. Such a being would see each scene as it passes through the surface. He would not see the scenes which had not reached that surface, and they would, for him, constitute the "future." The scenes which had passed below the surface would constitute for him the "past." Thus, for our two-dimensional being time might be regarded as a third dimension.

Similarly, for us three-dimensional beings time may be a fourth dimension, and the passage of time may really be the passage of a four-dimensional body through our three-dimensional world, and our past, present and future may all be visible simultaneously to a four-dimensional being.

This is essentially the conception of time which is introduced into the relativity formulæ.

If, furthermore, we imagine the above four-dimensional body to be twisted round as it passes through our three-dimensional world (in the same way as we may imagine the pack of cinema scenes to be twisted round while it passes through the surface of the table), there would be, from our point of view, a distortion of both space and time corresponding to the distortion of space and time which results from suitable manipulation of the formulæ. In other words, we arrive at the philosophical idea that space and time are relative and not absolute.

From a mathematical point of view, this twisting round of the pack of cinema scenes or of the four-dimensional body is essentially

the same thing as an alteration of the system of co-ordinates used for the relativity formulæ.

Further Results of Relativity Formulæ.—It remains now to mention three unexpected results which have been obtained by calculation from the relativity formulæ.

1. For many years astronomers have been puzzled by a certain feature in the motion of the planet Mercury. The longer axis of its orbit turns gradually round in a way that Newton's formulæ will not account for. This rotation of the orbital axis is completely accounted for by the relativity formulæ.

2. Einstein predicted that there would be a certain minute displacement in the apparent positions of stars visible near the sun during a total eclipse of the sun. This was tested during the eclipse of 29th May, 1919, and a displacement was observed which agrees remarkably well with the prediction. The amount of this displacement is so small that it is only equivalent to a shift of about one-thousandth of an inch as seen from a distance of ten feet, but the accuracy of the observations is such as to leave no doubt as to the reality of the displacement.

3. Einstein has calculated that the lines in the spectrum of the sun and stars are to a minute extent shifted towards the red end of the spectrum through the action of gravity. This has not been confirmed as yet, but there is some reason to think that it may be confirmed during the next few years.

In fact, it looks as if the relativity formulæ might include in one system, from a mathematical point of view, all the physical phenomena which have as yet been observed, including even gravitation, which it has hitherto been impossible to classify with the other forces of nature.

It may be mentioned that Professor Whitehead does not accept all the ideas put forward by Einstein, nor all the formulæ, but the formulæ deduced by these two authorities agree in all those cases in which it has been possible so far to test them by experiment or observation. Therefore, it is not yet possible to say whether Whitehead's views or Einstein's will ultimately be found to be more true to nature.

Complicated Character of Relativity Theory.—The relativity theory is far more satisfactory than the theories of classical mechanics, not only because it fits observed facts more closely, but also because it sweeps away various illegitimate hypotheses which have hitherto been adopted; as, for instance, the hypothesis that space and time are essentially different, and the hypothesis that gravitation acts instantaneously and at a distance. The reason for preferring the new theory is, in fact, the same as the reason for preferring the Copernican view of the world to the Ptolemaic view, *viz.*, that it leads in its broader aspect to a simpler system of mechanics.

But the relativity theory, as indicated above, is far from simple when it is a question of applying it to observed phenomena. An illustration of this is given by Professor Eddington in connection with a certain equation which contains the innocent-looking factor 24. This number has been arrived at from an expression which contains 65,536 terms. It has been necessary to consider every one of these thousands of terms. Most of them apparently prove to have the value zero. But it is only when all these vanishing terms have been rejected, and the other terms have been taken into account, that Eddington is able to say, "I believe that the numerical factor 24 is correct."

Professor Weyl appears to have gone still further than Einstein and Whitehead, and to have developed a theory which is even more complicated in its application, but which there is reason to believe is, in a sense, simpler in that it will weld together electricity and gravitation into one geometry, and that it will pass experimental tests even more satisfactorily than the theories of Einstein or Whitehead. His views are, however, not altogether accepted either by Einstein or by Whitehead. Mons. Painlevé, too, has excogitated several possible laws of gravitation, differing from Einstein's, one or other of which may, after all, prove to fit the facts more accurately than any law previously suggested.

Essential Truth of the Mathematical Conception of the Universe.—In the sixth century, B.C., the Pythagoreans held the doctrine that "All things are numbers." They also held a doctrine of "The harmony of the spheres." Through the centuries down to the present time other doctrines have been held, until we come to the various systems of equations suggested by modern thinkers.

The question naturally arises:—What essential truth is there in these ideas, or in other words, why do the phenomena of nature conform to mathematical theories? The answer is that we choose our mathematical theories so as to conform to the natural phenomena. There is no reason known to us why the phenomena should conform to the theories.

As mentioned above, systems of geometry have been devised by taking certain axioms and dealing with them in accordance with certain logical processes. We have all of us been brought up on the axioms of Euclid, and, therefore, our minds find it very difficult to adopt any other axioms.

But in the nineteenth century there were bold and profound mathematicians—Riemann, Bolyay, Lobatchewski and Poincaré—who adopted other axioms, and founded new and different geometries. Thus, Euclid taught us that "Through a given point there can be only one straight line parallel to a given straight line." Riemann, on the other hand, assumed that "Through a given point there cannot be any straight line parallel to a given straight line"—that is to say,

two straight lines will always meet somewhere. Upon this Riemann founded a quite consistent system of geometry.

All these different systems of ideal geometry are called by Einstein "purely axiomatic geometry."

The next step is to select one of these purely axiomatic geometries, and to adopt *as an hypothesis* the idea that it fits in with the phenomena observed in nature. Geometry, as so used, is called by Einstein "practical geometry." It is evidently a "natural science," and it may be regarded as the most ancient branch of physics. The recent advance which is puzzling so many of us merely amounts to this—that modern refined methods of measurement prove that the phenomena of nature do not conform to Euclidean axiomatic geometry, but that they seem to conform to one or other of the nineteenth century axiomatic geometries.

Incidentally it may be said that such paradoxical statements as "Time is a fourth dimension" and "Space has been found to be bent" could be more correctly expressed by saying, "The phenomena of Nature can be described more accurately than hitherto by the adoption of a geometry which postulates the existence of a fourth dimension analogous to the three dimensions of space, and by the adoption of Riemann's axiom on the subject of parallel straight lines instead of Euclid's axiom."

In other words, a purely axiomatic geometry has been discovered, in fact, perhaps several have been discovered, which fit the observed facts better than Euclidean geometry; and it remains now to be ascertained which of these new systems it is (as Poincaré puts it) more "convenient" to use.

Remarkable Conclusions.—A few of the remarkable conclusions obtained from the relativity theory may here be added:—

Two straight lines may enclose a space.

The three angles of a triangle are together not equal to two right angles.

The universe is unbounded but finite (as is the surface of a sphere in three-dimensional space).

With a sufficiently powerful telescope a man might look round the universe and see the back of his own head.

A so-called double star may be one single star seen simultaneously in two different directions.

A spiral nebula may be a blurred image of our stellar system, produced by light which has passed round the universe.

Gravitation is not a force; it is a distortion of space and time in the presence of matter.

The effect of the gravitation of the sun on a light wave moving radially (*i.e.*, directly towards the sun or away from it) is a repulsion. The effect on a light wave moving transversely is an attraction.

If we could utilize the fourth dimension, we could make bodies

materialize or dematerialize, and we could turn a lawn tennis ball inside out without stretching or tearing it.

The mass of a body is not constant, as hitherto supposed, but varies with the motion of the body.

No material thing can travel with the speed of light, for it would require an infinite force to impart such a velocity to the smallest particle.

The word "ether" lacks physical meaning. All phenomena occur as if the ether did not exist.

If an aeroplane were travelling at 160,000 miles per hour, its length would appear to be halved, but the time taken by the aviator to smoke a cigar would appear to be doubled.

If a steamer is travelling at 20 miles an hour, and a man on board walks forward at 3 miles an hour, his speed relatively to the earth will not be 23 miles an hour but a minute fraction less.

The interval between a man's birth and death may be for one observer 1,000 miles and 75 years, while for another observer it may be millions of miles and 76 years.

General Attitude towards Mathematical Conceptions.—I have given above a slight sketch of some of the ideas introduced of late years into the mathematical conception of the universe. It might be also of interest to glance at some of the mental attitudes which have at various times been adopted by thinkers towards such a conception.

In the first place, with regard to its truth, Professor Cayley, one of the most eminent mathematicians of the nineteenth century, wrote as follows in his Presidential address to the British Association in 1883 :—

"I think that it may be at once conceded that the truths of geometry are truths precisely because they relate to and express the properties of what Mill calls 'purely imaginary objects'; that these objects do not exist in Mill's sense; that they do not exist in Nature may also be granted; that they are 'not even possible,' if this means possible in an existing nature, may also be granted. That we cannot 'conceive' them depends on the meaning that we attach to the word 'conceive.' I would myself say that the purely imaginary objects, as Mill calls them, are the only realities, the *ontos onta* (things that really exist), in regard to which the corresponding *physical objects* are as the shadows in the cave (of Plato)."

(I am indebted to Prof. Sonnenschein for this quotation.)

As against this, I may quote the dictum of a distinguished living mathematician, Mr. Bertrand Russell :—

"Pure mathematics consist entirely of such asseverations as that, if such and such a proposition is true of *anything*, then such and such a proposition is true of that thing. It is essential not to discuss whether the first proposition is really true, and not to mention what the anything is of which it is supposed to be true. . . . Thus mathe-

matics may be defined as the subject in which we never know what we are talking about, nor whether what we are saying is true."

We are, in fact, on the one hand told by Cayley that mathematical statements are the only truths, and on the other hand by Bertrand Russell that we never know whether such statements are true.

Again, for some thinkers mathematical theories seem to have an æsthetic aspect. That is to say, the contemplation of a formula, such as the binomial theorem, or the perception of a relationship such as that between the sections of a cone and the movements of the heavenly bodies, may induce a thrill analogous to that obtained from the contemplation of a beautiful sunset or the perception of a grand waterfall.

And again, religious awe may form an element in the mental attitude. "God thinks in sines and cosines" was the exclamation of one medieval thinker.

Richard A. Proctor was differently affected. He wrote as follows in his *Familiar Scientific Studies* :—

"I personally have often found relief from the dreary infinities of homaloidal space (that is, space where straight lines are straight and planes plane) in the consoling thought that, after all, this other (*i.e.*, non-homaloidal space) may be the true state of affairs."

It would have comforted him to read the modern evidence that our space is curved, and that straight lines and planes may ultimately bend back on themselves.

A feeling of religious awe is, of course, to be seen in the writings of many non-mathematical authors when they are contemplating the phenomena of Nature. "An undevout astronomer is mad." And it seems clear that for those of us who are mathematically inclined, however far we may lag behind the leading authorities on the subject, a similar feeling of religious awe may be associated with the equations and the geometrical forms which together make up the mathematical conception of the universe.

With these vague ideas I bring my paper to a close.

STEAM RAISING BY LIQUID FUEL

By CAPT. J. H. DYER, M.C., R.E.

THE increasing demand for petrol and the lighter oils makes it essential to extract from the crude petroleum the maximum of these products, leaving a heavy residue suitable only for steam-raising, furnace work or Diesel engines. In cases where the petroleum has an asphalt base, certain of the residual products are only suitable for steam raising, as the asphalt is liable to cause scoring of the cylinder walls if used in Diesel engines.

The average calorific value of this product is 18,500 B.T.U.'s per lb. Oil firing has recently been widely adopted for mercantile marine as well as naval work, and a number of land plants are now adopting oil firing in place of coal.

SYSTEMS OF BURNING.

(*a*) *Mechanical-Pressure Jet.*—The oil is delivered at a pressure of from 20 to 150 lbs. per sq. in. by a Simplex steam pump through a steam heater to the burners, where it is forced through fine holes to emerge as an atomized oil mist.

(*b*) *Steam Jet.*—The oil gravitates from a storage tank through a steam heater to the burners, where it is drawn into the furnace and atomized by a steam jet (injection action).

(*c*) *Air Jet.*—The oil gravitates from a storage tank through a steam heater to the burners, where it is drawn into the furnace and atomized by a blast of air moving across the end of the oil pipe (injection action, similar to scent spray).

In all the above systems the oil is burnt in an atomized state.

(*d*) *Vaporization.*—The oil, under an air pressure (from 5 up to 50 lbs. per sq. in.) is passed through piping heated by the oil flame and completely gasified: example, Primus stove burner.

CHOICE OF SYSTEM.

(*a*) *Mechanical-Pressure Jet.*—This gives the highest efficiency, as there is no cooling down of the flame by steam as with the steam-jet system, and only about 3 per cent. of the boiler output is required for heating and jetting the oil (2 per cent. for heating + 1 per cent. for driving the oil pump). Boiler efficiencies of 80 to 83 per cent. are regularly obtained under good conditions. Unsuitable where boiler pressure is below 70 lbs. per sq. in., as the steam temperature

is not sufficiently high at pressures below 70 lbs. to reduce the viscosity of heavy oils sufficiently in the heater for use with a pressure jet to give good atomization. Capital cost slightly greater than for other systems. Suitable for outputs of 3,000 lbs. of steam per hour and upwards; saving is greatest for a battery of boilers, as one pumping and heating plant can supply two or more boilers. This system has been exclusively adopted for marine work and for large land installations.

(*b*) *Steam Jet.*—Less efficient than pressure jet, as more steam is required than with the pressure system (from 5 per cent. to 8 per cent. of the boiler output for jetting + 1 per cent. for heating: total 6 to 9 per cent.). The steam does not promote combustion, as it must undergo dissociation before it can re-associate to promote heat. The steam displaces air which is required for combustion and also absorbs sensible heat, cooling down the flame (as the steam enters at, say, 400° F. and leaves with the flue gases at 600° F.). Boiler efficiencies of 70 to 73 per cent. may be obtained. Cheap in first cost and simple to operate and install. Used for single boiler work for small outputs and where generating low-pressure steam (say, below 70 lbs. per sq. in.). This is the system adopted for oil-fired locomotives.

(*c*) *Air Jet.*—High efficiency, only about 3 per cent. of the boiler output required for compressing the air, but the system is unsuitable for steam raising, as it tends to give an intense local heat, giving unequal expansions in the boiler. Suitable for metallurgical work, cupola, rivet-heating, galvanizing, muffle, billet-heating furnaces, etc.

(*d*) *Vaporization.*—Suitable only for very small outputs, such as a small boiler for obtaining steam for starting up a steam-jet or pressure-jet system. A light oil must be used or carbonization takes place in the heating coils.

DETAILS OF INSTALLATION.

(*a*) *Mechanical-Pressure Jet.*—Drawing shows system adapted to a Lancashire boiler. The oil passes from the storage tank (provided with a steam-heating coil to assist the flow in cold weather), through a coarse-mesh suction strainer, thence through a Simplex steam pump to a steam heater (consists of pipes inside which steam circulates, the oil circulating over the outside or *vice versa*).

From the heater the oil, at a temperature of 100° F. to 250° F., passes through a fine gauze filter which eliminates any particles of carbon liberated by the heating and which would tend to choke the fine nozzle holes in the burner, which vary from 1 to 2·5 mm. in diameter. Thence the oil passes to a distribution box, having a screw-down valve for each burner, enabling it to be cut out if necessary. When starting up, the burners are all cut out and the oil circulated round to the suction side of the pump until it attains

FIG. 1.

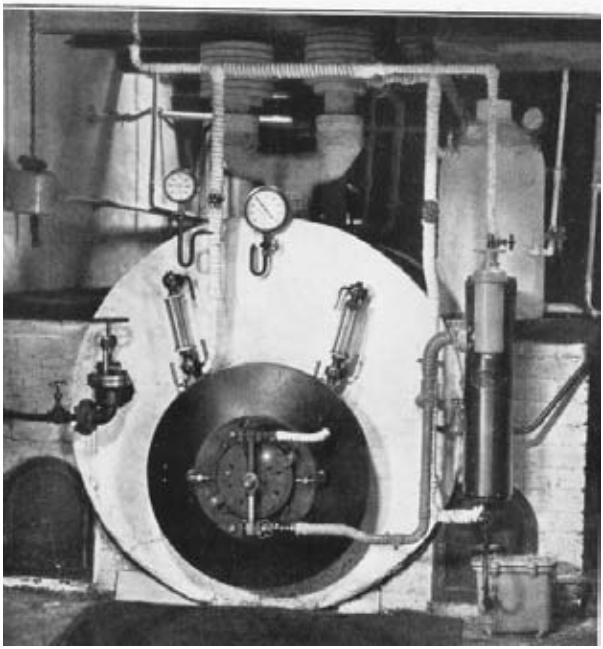


FIG 1 & 2

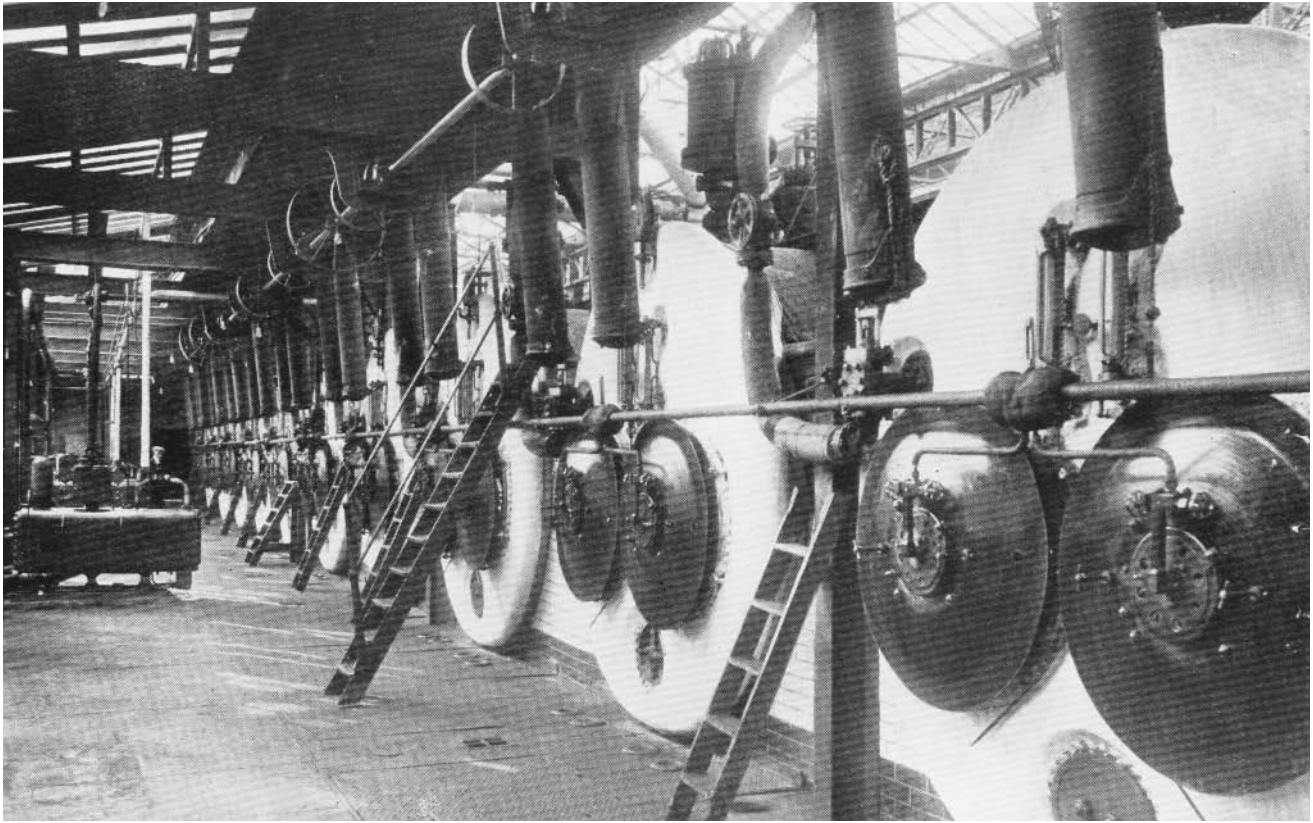
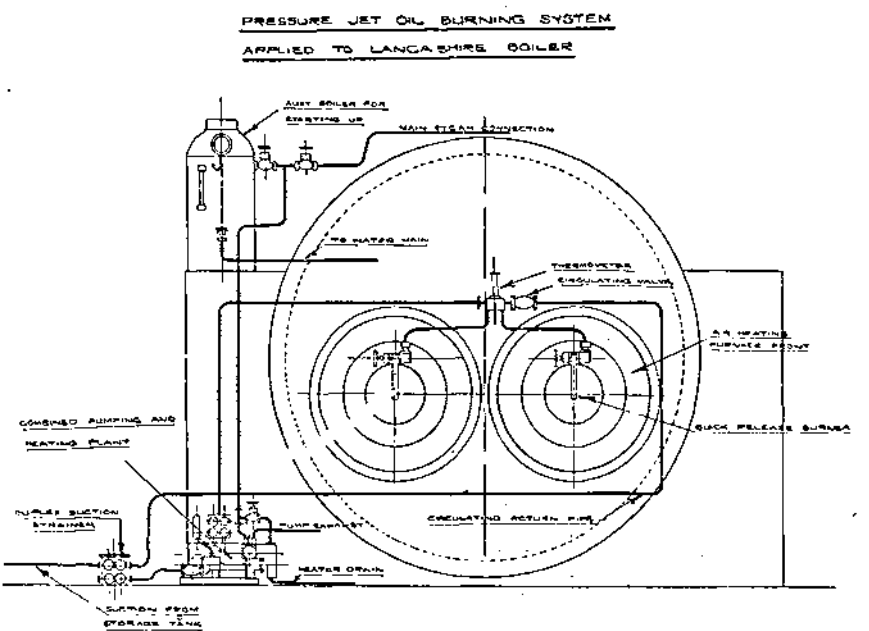


FIG 3

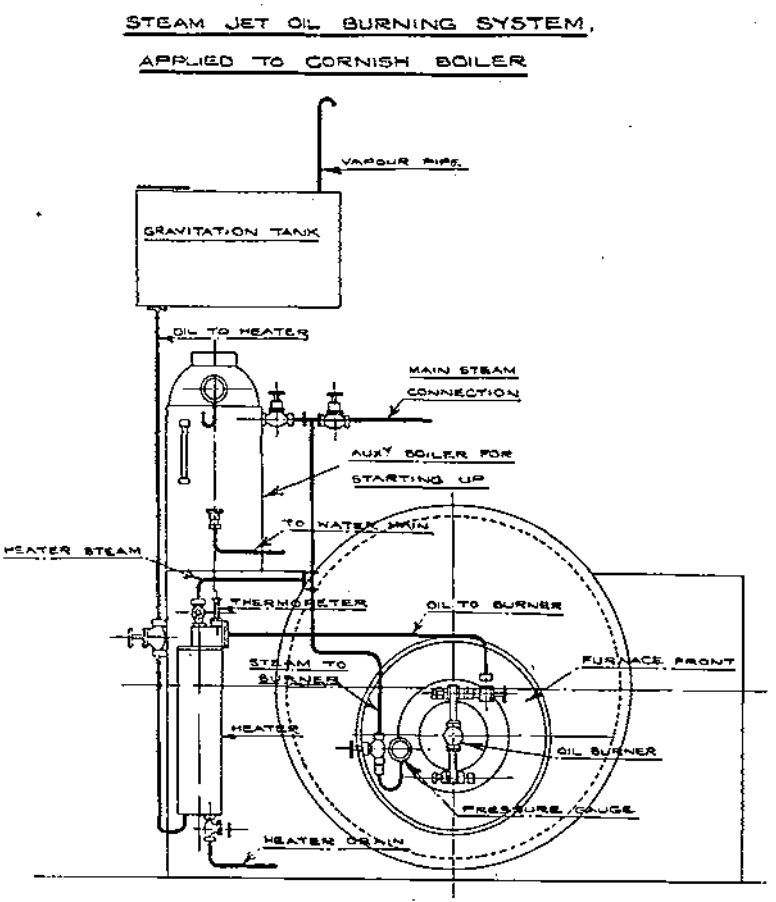
the correct temperature on leaving the heater, when the burners are lit up. The nozzles break the oil up into a fine mist, having a whirling motion, and air directors admit air with a whirling motion to give an intimate mixture of oil and air. The flame should begin about 2 or 3 inches from the nozzle, it should be short and in breadth and height should completely fill the cylindrical furnace flue in a



Shell boiler or the combustion space in a water-tube boiler: otherwise cold air will pass through to the flue between the edge of the flame and the inside of the furnace, greatly reducing the boiler efficiency.

(*b*) *Steam Jet.*—Drawing shows system adapted to a Cornish boiler. The oil is pumped direct by tank wagon to a storage tank, having a minimum head of 4 ft. from the bottom of the storage tank to the burner. No further pumping is necessary: the oil gravitates to the storage tank (which has a steam coil near the outlet to assist the flow in cold weather), through a small steam heater (the oil does not require to be pre-heated to such a high temperature with the steam-jet as with the pressure-jet system). Thence the oil gravitates to the burner or burners, where steam is used to induce and atomize the oil, in the majority of designs working on the scent-spray injection principle. It is very essential that the jetting steam should be absolutely dry: any moisture would tend to extinguish the burner and would cause rapid corrosion of the furnace tube due to the formation of sulphuric acid with the sulphur present in some fuel oils.

For starting up both the pressure-jet and steam-jet systems where all the main boilers are shut down, a small auxiliary boiler is required: this may be fired with rubbish, wood, town gas or a Primus type burner.



REGULATION OF OIL FURNACES.

(*a*) *Flame.*—Should be dazzling white; if red and smoky, steam pressure is too low; if the flame is ragged and tends to go out, the steam pressure is too high, in the case of a steam-jet system

(*b*) *Oil Temperature.*—Regulated by throttling the steam to the heater. Black smoke may indicate too low a temperature, while white smoke and carbon deposits in the furnaces indicate too high a temperature.

(*c*) *Air Admission.*—Controlled by flaps and shutters on the furnace front. Avoid smoke. Too little air gives black smoke, too much air, white smoke. Best combustion gives a faint trace of black smoke.

(*d*) *Oil Pressure.*—In pressure-jet systems varies from 30 to

150 lbs. per sq. in., average 60 lbs. per sq. in. Black smoke is produced if the pressure is too high or too low. Work at the minimum pressure consistent with smokeless combustion and sufficient output of steam. If the demand for steam increases considerably (say, during peak load) it is better to alter the size of the burner (which can be done in less than one minute) than to vary the pressure widely from that found to give correct atomization with a given sample of fuel oil at a given temperature.

Advantages of Liquid Fuel.

(*a*) *High Boiler Efficiency.*—Due largely to perfect regulation of combustion. With oil fuel the excess air is rarely more than 20 to 50 per cent. in excess of the amount theoretically required for complete combustion, representing a maximum fuel loss of about 5 per cent. due to heating up the extra volume of air. With coal the excess air cannot usually be reduced below 100 per cent. to avoid risk of incomplete combustion: this represents a fuel loss of about 20 per cent. For best results great attention must be paid to stopping air leaks in the brickwork setting of the boiler and the flues.

(*b*) *Reduced Wear and Tear of Boiler.*—Uniform temperature is maintained over long periods. No sudden rushes of cold air causing uneven expansions when fire door is opened, as with hand firing.

(*c*) *Greatly Increased Capacity of Boiler.*—In many cases up to 50 per cent. more steam than could be obtained by coal firing is obtained with oil firing, without any appreciable falling off in efficiency from normal load.

(*d*) *Reduction of Labour Costs.*—Easier handling and stoking.

(*e*) *No Stand-by Losses.*—No banking of fires, and steam can be quickly raised from cold.

Photographs.

Fig. 1 shows self-contained pumping and heating plant for Pressure-Jet System. This photograph shows clearly the pump, heater and duplex discharge strainer, enabling one strainer to be cleaned whilst running, without shutting down the plant.

Fig. 2 shows a Steam-Jet System applied to a Cornish Boiler. Note small starting-up boiler in background on right, also oil heater strainer and steam trap for condensate from oil heater in foreground on right.

Fig. 3 shows a large battery of Lancashire boilers converted from coal to oil firing on the Pressure-Jet System. Note the pumping and heating plant on the left. Each pumping and heating unit can supply six boilers.

MEMOIRS.

COLONEL E. H. GROVE-HILLS, C.M.G., C.B.E., D.Sc., F.R.S.

EDMOND HERBERT HILLS was a man of outstanding ability, as all who knew him will agree. He impressed his contemporaries in the Corps as an officer of singular originality and capacity, and his career in the world of science justified the high regard in which he was held. For his host of friends his death is a grievous loss.

He was the son of Judge Hills, of Highhead Castle, Cumberland, and was born in 1864. Judge Hills had been, for many years, judge of the Court of Appeal in Egypt, and had previously been Secretary to the Lord Privy Seal, for which post he had been officially recommended by Dr. Jowett, the Master of Balliol. Edmond Hills's mother was a daughter of Sir William Grove, the eminent judge and man of science, the inventor of "Grove's cell," President of the British Association, and a prominent Fellow of the Royal Society. His uncle was Major-General Sir Coleridge Grove. Edmond Hills inherited excellent endowments of the mind from both sides of the family.

He was educated at Winchester, passed into Woolwich at the head of the list in 1882, and was commissioned in July, 1884. He went to Gibraltar for a tour of service in 1887, was promoted Captain in 1893 and in August, 1893, was appointed Instructor in charge of the Chemistry and Photography School at Chatham. At the end of 1899, on the outbreak of the South African War, he was selected for the important post of officer in charge of, what is now styled, the Geographical Section of the General Staff, at the War Office. It was during his service there that he did his most important work for the Army.

The Geographical Section of the General Staff is derived from the Depôt of Military Knowledge, which was founded by the Duke of York, then Commander-in-Chief, in 1803. The Section went through various changes in the course of the next century, and from 1877 to 1901 was known as "Section F." In 1904 the Intelligence Department was reorganized and Hills pressed successfully for an enlargement of the staff of the Geographical Section to enable it to fulfil its proper functions. Thanks to this enlargement and reorganization the Section was able, later on, to make adequate preparation for the Great War. The Geographical Section has, in the course of its

COLONEL E H GROVE-HILLS CMG CBE DSc FRS

history, had many distinguished chiefs, amongst whom may be named Sir Henry James, Lord Cromer and Sir Charles Wilson, but none of these rendered more excellent services to the cause of military geography than did Edmond Hills.

In 1905 he retired from the active list and in 1906 contested Portsmouth in the Conservative interest. He took up Army duties again on the outbreak of war in 1914, and served in the Eastern Command, eventually as Deputy Chief Engineer, with the rank of Brigadier-General. He finally retired as Colonel after the Armistice in 1918.

Throughout his life he took a keen interest in all branches of knowledge, but especially in physical science. Whilst Assistant Instructor at Chatham he developed, and greatly improved, the method of determining terrestrial longitudes by photographing the moon and star trails. More would have come of this method but for the introduction of wireless methods. He took an important part in three eclipse expeditions ; notably the expedition to Fundium in West Africa in 1893, when he obtained photographs of the spectrum of the prominences reaching further in the ultra-violet than had been obtained before ; and the expedition to Pulgaou, in India, in 1898. He was a member of the Joint Eclipse Committee. In 1906, in conjunction with Sir Joseph Larmor, he investigated the irregular movement of the Earth's axis of rotation. In 1914 he devised the suspended zenith telescope for use at Durham University. He wrote a number of scientific papers on a considerable range of subjects, such as the use of slit spectroscopes in the eclipse ot 1893, the optical distortion of a doublet lens, the " green flash " at sunset, and the suspended zenith telescope

In 1902 he was awarded the C.M.G. for his work in connection with the Chile–Argentina boundary dispute.

In 1907, on the recommendation of the Colonial Survey Committee, he was appointed to inspect and report upon the Survey Departments of British East Africa, Uganda, Ceylon, the Federated Malay States, and S. Nigeria. This mission was admirably carried out, and the suggestions made were almost all adopted.

Hills was elected Honorary Treasurer of the Royal Astronomical Society in 1905, and held the post till 1912. He resumed it at the special request of the Council of the Society in February, 1922. He was President of the Geographical Section of the British Association in 1908. He was elected a Fellow of the Royal Society in 1911. He was appointed Honorary Director of the Durham Observatory in 1913 and, in the same year, he received the degree of Doctor of Science at Durham. He was President of the Royal Astronomical Society from 1913 to 1915.

But, remarkable as his scientific activities were, it would be an entire mistake to regard him as having lived the life of a recluse,

wrapped up in research and study. He had many out-of-door interests, and all his life thoroughly enjoyed shooting and fishing. Many of those who served at Gibraltar in the late 'eighties will remember happy shooting trips with him in Southern Spain, and in later years he was always the possessor of some good sporting place where he entertained his numerous friends.

In 1892 he married the daughter of J. Spencer-Bell, Esq., M.P. There were three children, two sons and a daughter. Both sons were, alas! killed in the Great War; a terrible sorrow, bravely borne by his wife and himself. A few months ago Edmond Hills was stricken with an incurable illness. It was thought that he might be spared for a year more of life, but, perhaps mercifully, this was not to be. He died on the 2nd October, having faced the end with the greatest fortitude.

Those who were privileged to be counted amongst his friends will retain in their minds the picture of a man devoted to science, transparently sincere, a brilliant talker, who would illuminate any discussion with striking and original ideas and contributions from the treasures of a remarkable memory; a man of equable disposition, not easily provoked, who took a broad, sane outlook on the affairs of life.

And so passes a brother officer of fine character and unusual ability. Peace be to his memory.

C.F.C.

COLONEL HENRY S. ANDREWS-SPEED.

HENRY ANDREWS-SPEED, son of James Andrews-Speed, merchant, of Gibraltar and Malaga, was born at Gibraltar on the 6th June, 1852. He was educated at Wimbledon School, whence he passed into the Royal Military Academy at the examination of December, 1870. Youngest member of a large family, he had at the age of thirteen lost his father, and he was thereafter given a certain control over the funds left for his education. He determined to compete for Woolwich, and he made all those arrangements himself which usually devolve on parents or guardians. This experience rendered him exceptionally self-reliant. He joined the Academy early in 1871, and in March, 1873, received a commission in the Royal Engineers which was ante-dated September, 1872. After the usual two years' course of instruction at Chatham, followed by a brief period of home service, he embarked in January, 1876, for Bermuda. Two years later he was transferred to Malta, where he remained until January, 1881. A few months in England were followed at the end of the year by embarkation for India, to which land he devoted the rest of his service.

Joining the Madras "Queen's Own" Sappers and Miners at Bangalore in January, 1882, Lieut. Andrews-Speed soon saw active service. An Indian contingent under Sir H. Macpherson was detailed to form part of Sir Garnet Wolseley's Egyptian expedition of 1882, and Andrews-Speed accompanied the contingent as Company Officer in the Madras Sappers and Assistant Field Engineer. He went through the campaign, was present at the battle of Tel-el-Kebir on the 13th September, and received the Egyptian medal and Khedive's star. Returning to India in October, he served for three years at Bangalore and Ootacamund, obtaining his Captaincy in September, 1884, after 12 years' service.

In the province of Mysore the great annual festival of the Dusserah is celebrated with peculiar fervour by all classes, from the Maharaja downwards; and it is the practice of the native officers of Indian regiments to assemble on these occasions and glorify their European superiors. At the Dusserah of 1885 the native officers of the Queen's Own Sappers and Miners at Bangalore thus expressed themselves regarding Captain Andrews-Speed :—

"We sing in praise of Captain Speed, who possesses a charming countenance, and one who is at all times bent on the good of the men entrusted to his care. We sing in praise of one who is heroic in actions, and one who well merited war decorations for the part played in the Egypt war."

Through the veil of quaint native phraseology one can discern the genuine affection and respect in which the subject of this memoir was held by his Company and Corps.

Towards the end of 1885 Captain Andrews-Speed was selected to accompany the expedition to Upper Burma under General Sir Harry Prendergast, v.c. Embarking on the 4th November, he commanded "D" Company, "Queen's Own" Sappers and Miners, and took part in the capture of Pagan, Myingian, Ava and Mandalay. On the fall of the capital King Thebaw was dethroned and sent to India as a State prisoner. Captain Andrews-Speed, who received the Burma medal and clasp, returned to India in August, 1886, and resumed duty at Bangalore. Having accepted the conditions of continuous Indian service offered to R.E. officers in India, he went home in February, 1888, to join the Indian class of that year at Chatham. A year later he returned to India and, entering the Military Works Department, served four years at Bangalore and three at Umballa. In January, 1893, he married at Bangalore Ethel, daughter of Major-General Alfred Anderson, Indian Army, by whom he had two children, a daughter and son.

A year's leave to England from October, 1896, was followed by eighteen months' service at Aden, during which Major Andrews-Speed made a brief trip to India for examination in Tactical fitness to command—a test he passed at Mhow in December, 1898, under

General Sir Richard Westmacott. While at Aden, he sat as a member of the Harbour Trust, and received from the Board at his departure a glowing tribute to the value of his services. After a period of six months' leave to England he returned at the end of 1899 to Indian Military Works, first at Ootacamund, and afterwards at Madras combined with Wellington. In 1901 he suffered a severe attack of enteric fever, and lay unconscious for many weeks, during which his life was despaired of. He, however, made a gradual but complete recovery, and after a year's leave, resumed duty at Madras and Wellington. He was promoted substantive Colonel in August, 1903, and two years later was transferred to the Poona Division, whence he retired in June, 1906.

On quitting the service Colonel Andrews-Speed settled with his family at Cossington, Somerset, whence he removed in 1910 to Enmore, near Bridgwater, occupying himself with gardening, carpentry, golf, various parochial services and the social amenities of the neighbourhood. At the outbreak of war in 1914 he made offer of his services, but was informed that applications from officers over 60 years of age could not be entertained. In 1915, however, his knowledge of Spanish and Italian led to his employment in the Cable Censor's office in London, where he remained four years. His labours were very exacting, involving much night-work.

The death in September, 1921, of their only son, a young man of high promise, was a crushing blow to Colonel and Mrs. Andrews-Speed. The father's health failed from that time, but it was not until August, 1922, that signs of a mortal malady were discerned. He bore his illness with profound patience and resignation, and expired on the 23rd October at Enmore.

The watchword of Henry Andrews-Speed's life was Duty. In the performance of duty, of which he had a lofty conception, he never spared himself. He was a keen soldier, and seized every opportunity of seeing active service. His modesty and his reserve concerning himself concealed a certain bull-dog tenacity; and he was no respecter of persons, speaking his mind to his official superiors as to his subordinates. He possessed ample common-sense, formed his judgments deliberately, and adhered to them. He was an excellent companion, always cheery and full of amusing anecdote; and he displayed a quaint and whimsical humour in conversation and correspondence. These qualities made him popular wherever he went. He was a sound churchman who did good by stealth, and a trusty friend who could always be depended on. The present writer was privileged to enjoy his friendship for more than half a century. His loss, irreparable to his widow and daughter, will be regretted by his many friends in and outside the Corps.

H.D.L.

Colonel Henry S. Andrews-Speed.

COLONEL HENRY S ANDREWS-SPEED

HISTORY OF THE GREAT WAR—MILITARY OPERATIONS, FRANCE AND BELGIUM, 1914.

Compiled by BRIG.-GENERAL J. E. EDMONDS, C.B., C.M.G., R.E. (retired), *p.s.c.* (Macmillan & Co., Ltd. Vol. I. with 8 Sketches of Operations. 8vo. Price, 21s. net. Thirty-four General, Battle and Situation Maps in separate case. Price, 21s. net.)

THE first volume of the Official History of the Great War has now been published. In the preface Brig.-General Edmonds states:—"The present volume covers events from mobilization up to the middle of October, 1914" (the last days of the B.E.F. on the Aisne) "only, a period of two and a half months, and is on a scale which to a large extent treats the battalion, squadron and battery records as the basis of the story. In succeeding volumes it will not be possible or desirable to adhere to this, and successively the brigade, division and even corps may become the unit of narrative. For this volume the scale adopted seems appropriate, in view of the importance of small units in the early operations, of the lessons to be derived from the study of the work of these units in open warfare, and of the desirability of leaving a picture of what war was like in 1914, when trained soldiers were still of greater importance than material, and gas, tanks, long-range guns, creeping barrages and the participation of aircraft in ground fighting were unknown."

A review of this important work will appear in the next number of the *R.E. Journal*.

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

Nos. 10 *to* 13 *incl. September*, 1922.

THE custom has come down to us from the long ago of ancient times that he who is the loser, whether it be in mere sport or in the more serious field of industry which Prussia made her particular occupation, shall be called upon to pay a penalty; the custom has in the past very generally been acted upon, and, when Germany has been the winner in a war, she has demanded a very strict observance of the custom. It would appear that in very recent times Germany's views upon the subject have undergone a radical change. In an article contributed to the *M.W.B.* for September 2nd (No. 10) by Lieut.-General v. Altrock, a regular tirade is delivered against the "villainous" Treaty of Versailles, which, it is demanded, shall be referred to a *neutral* Court of Arbitration (*sic*) for revision. The General seizes the opportunity

to call upon his countrymen, whether they be University Professors or mere ignorant labourers, to unite together for the purpose of exposing the "uncivilizing policy" of the Entente Powers. In the same number of the *M.W.B.* in an anonymous article, entitled "The Best Answer for Poincaré," attention is called to the speech made recently by the French Premier at Thiaucourt, when very strong language was used by him with regard to Germany's methods of conducting war. The remarks made on that occasion are much resented in Germany, and it would appear that there are people in that country who hold that the result of the trials of the War Criminals at Leipzig has been completely to refute the idea that there was anything exceptional in the methods adopted and course pursued by Germany in connection with, or during, the Great War. Not only is Germany completely exonerated, but it would appear that she has been most forbearing in not utilizing her chief weapon of defence, which apparently consists in some formidable counter-list in which are set out charges against Entente War Criminals! The said counter-list has been prepared officially, and a demand is now made for its production, as by its publication, somehow, Germany's honour will be vindicated.

The military situation in foreign lands receives its share of notice in the September issues of the *M.W.B.* Lieut.-General v. Winterfeldt deals with the situation in Poland and the Border States in the number for September 2nd. He informs us that the scheme for a two-years' period of colour service—the project is not yet Law—will provide Poland with a peace-time Army of 300,000 all ranks, which on mobilization will be capable of expansion up to a million men. It is stated that there has been a reduction in the number of the French Commissions in the military districts, but at the same time the number of officers serving individually with the Polish Army has increased. Poland, it is said, has experienced disappointment at the turn which events took at the Genoa Conference. The Border States, it is alleged, are on the whole opposed to the provisions contained in the Treaty of Warsaw, signed last March: they feel that, both politically and commercially, it will be injurious to their best interests should they become more closely bound to Poland, as planned by the said Treaty. Lieut.-General Balck undertakes the task, one which, no doubt, is congenial to him, of passing in review, in the issues for September 2nd and 9th, the situation in Great Britain. Naturally, the articles open with a reference to the differences which arose between Great Britain and France in August last. The General thinks that the policy pursued by France in increasing her Air Force and submarines is causing concern in this country, as these war preparations must be aimed against Great Britain. Dealing with the domestic aspect of Great Britain's affairs, the General credits the political leaders of the country with great astuteness in having erected a Free State in the south of Ireland: it is alleged that they have intentionally adopted the despot's maxim, *Divide et impera*, as the keynote of their policy. Ireland having been split up into fighting factions, England can now look contentedly on, whilst the disputants settle their quarrels between themselves. India, too, comes in for a share of attention. The crisis which led to the resignation by Mr.

Montagu of his office as Secretary of State, and Lord Sydenham's article in the *Revue de Paris*, in which the Indian situation is discussed, are both touched upon; Lord Sydenham is alleged to be supporting the cause of the reactionaries. A summary of the Establishment provided in the current Estimates for the British Army is set out: the reduction in the British Army of to-day as compared with that of pre-war days, and the deficiency of 32,000 men in the Territorial Army are particularly mentioned. As might be expected, the results of the Washington Conference receive attention at the hands of General Balck. He refers to the resolution passed at the Washington Conference involving a curtailment of Naval expenditure, and expresses the opinion that Great Britain will not be running any serious risks in cutting down the number of her fighting ships. The situation of to-day is compared with that which came into existence in 1815, after the conclusion of the Napoleonic wars, when Great Britain emerged victorious and was able, in consequence, materially to reduce the size of her Navy. The Air Arm is also brought under review, and the decision arrived at to maintain the Royal Air Force as an independent organization, with a definite rôle assigned to it in the British defence scheme, is noted. The manœuvres carried out in the Channel in the beginning of July last, when an attack was carried out by an Air Squadron on the Fleet engaged in mimic warfare, is commented upon and attention is called to the large percentage of hits scored by the airmen on that occasion. The agitation, in Parliament and in the Press, which followed, is duly noticed, as well as the decision taken to increase the Royal Air Force units. General Balck shares the views of those who hold that our Island Kingdom can no longer rely on a Navy alone for the adequate protection of its shores against external foes, but must also at the same time be strong in the Air and provide itself with adequate means to deal with aerial attacks. The situation in Switzerland is dealt with in an anonymous contribution published in the issue for September 16th. The Genoa Conference comes in for some ridicule. So far as Home affairs are concerned, the matter of highest importance consists in the very drastic reduction in the vote for the Army: so great has been the reduction that it would appear to be in contemplation to abandon the principle of universal service in Switzerland, at least temporarily. The annual contingents now being called to the colours are so small that one fusilier company is being suppressed in each battalion, which now consists of three fusilier companies and one machine-gun company. Again, owing to the shortage of funds, considerable delay is taking place in the proper equipping of the various units of the Army with such necessaries as range-finders, heliographs, trench-mortars, Very pistols, etc. The projected increase in the number of long-range guns is also held up; and even such important matters as the training of reservists and the customary autumn manœuvres are now in abeyance.

Oberleutnant Kurt Hesse, the author of *Feldherr Pshchologos*, completes, in the issue for September 10th, his article on the value of psychology in military training. In the concluding part of the article the subject is treated under four heads: (*a*) the training of general levies; (*b*) instruction in military schools; (*c*) the advanced instruction

of officers; and (*d*) the scientific treatment of problems. Oberleutnant Hesse emphasizes the importance of selecting only first-class men for the instructional staff of military schools; a matter which apparently was not as carefully handled in Germany as it should have been in the pre-war days. The reduction in the size of the German Army has brought about a very wide distribution of the Officer Corps and it would seem that Regimental Commanders can no longer play the part that they did in the Kaiser's Army in connection with the advanced training of their officers. It is, therefore, urged that officers who show sufficient ability ought to be given an opportunity of obtaining higher education by being passed through the Universities and the Technical High Schools. Psychology, as a subject of study, is attracting considerable attention in the German Army to-day: in the issue for September 16th a correspondent, who served for four years during the Great War as a Company Commander, contributes his views, anonymously, on the subject in an article entitled *Psychologie und Taktik*. He relates some of his experiences on the Balkan Front and claims to have made the discovery that psychology and tactics are intimately bound up together.

The question of Staff appointments and the duties of regimental officers are discussed in an anonymous article, appearing in the issue of September 9th, from the point of view of a "career." The ambitious officer is as anxious to escape from regimental duties in Germany as he is in many other countries. In consequence, on the expansion of the German Army in the early days of the Great War, large numbers, if not the whole, of the regular officers of the Kaiser's Army left their regimental units to join the Staff. This condition of things did not altogether promote the best interests of the German Army as a whole: the command of battalions and companies passed into the hands of the Reserve Officer and the Kriegleutnant, who, however ready to serve their country, were not properly qualified to undertake the responsibilities thrust upon them. The results which followed were most unfortunate: the prestige of the officer class was lessened thereby in the eyes of the men; the non-commissioned officers, at the same time, increased their authority and began to clamour for promotion to commissioned rank, in spite of their lack of qualifications for the higher positions. Again, the failure to recognize and reward the services of regimental officers had the effect of disheartening them and led to a general disparagement of the status of the regimental officer. It is rightly pointed out that, however brilliantly a staff may plan operations, yet, if there are not efficient regimental officers to carry such schemes into effect, the high quality of the staff loses a considerable part of its value from the practical standpoint. The mischief which was done in the matter during the war has had an after-effect: the Socialist Press in Germany is now carrying on a campaign with a view to bringing about a replacement of the former class of officers by those of the understanding and training of non-commissioned officers. Owing to the paucity of officers now serving in infantry units, the non-commissioned officer is still in the ascendant, and has to play a prominent rôle in the training of the recruits. The complaint is made that whilst the

non-commissioned officer who is engaged in clerical duties has good openings in civil life on the termination of his colour srevice, on the other hand, the non-commissioned officer who is engaged on, perhaps, the more important duties " on the square," has an exceedingly poor chance of obtaining lucrative employment on passing into the reserve.

Notices are published on two important works: in the issue of September 16th, on *Wehr und Waffen*, 1914–1918, by General v. Wrisberg, and, in the issue of September 23rd, on *Ballistik* by Dr. Theodor Vahlen. General Wrisberg was, during the years of the Great War, in the Prussian War Ministry, and gives an account of his experiences in connection with the provision of arms, ammunition and equipment for the portion of the German Army with which he was particularly concerned. The interesting statement is published that during the first month of the Great War 100,000 rifles were lost in the German Army, and it became necessary, therefore, to issue obsolete types of rifles, and even captured weapons, to the Lines of Communication troops and those in the Home garrisons. To those who have been directing their criticisms against the Prussian War Ministry, the reply is made that the French Army took the field in 1914 with an obsolete type of the Lebel rifle (model of 1886), and that there was a similar unforeseen wastage in France, where the authorities had to resort to the issues of converted rifles manufactured so long ago as 1874. A defence is also put up to the charge that the French field artillery was greatly superior to the German: it is met by the statement that the armament of the German field artillery consisted, as to 20 per cent. thereof, of light field howitzers, and that the French had nothing to compare with them from any point of view. General v. Wrisberg provides important information on many other points. Dr. Vahlen's work deals mainly with the mathematical theory of ballistics and is said to be one of the most valuable of the contributions made to this branch of military literature.

W. A. J. O'MEARA.

TECHNIK UND WEHRMACHT.

The two Double Numbers, 7 and 8, 9 and 10. 1922.

Technik and Wehrmacht is a periodical of considerable interest to technical soldiers. There are several articles dealing with gunner questions. One, " Relativity and Gunnery," may develop into something of interest in the next volume, although, so far, the title is more ambitious than the matter. The history of mechanical transport of artillery, 1914–1918, and a review of " Ballistics " by Professor Vahlen are also worth reading.

Engineering is represented by a short description of a single trestle footbridge, two planks wide, of simple construction, and by a review of the first volume of Major von Kretschmann's book on the reconstruction of railways on the western front, a review of which appeared in the last number of the *R.E. Journal*.

The most interesting articles, however, are those which deal with the third volume of General von Wrisberg's memoirs. *Wehr und Waffen*

(the title of this volume) deals with the activities of the Kriegsministerim in the design and provision of technical stores and new weapons. An extract on the tank question is printed at length. In General von Wrisberg's opinion Germany could not have overtaken the start we had secured in the construction of tanks before their first appearance on the Somme. He considers that the lack of raw material, workshop facilities, etc., would have prevented it. As contributary causes he states that tanks were not used by the Allies in sufficient number to overcome anti-tank defence before the summer of 1918, and that for this reason German Headquarters were not convinced of the necessity of building them in number until it was too late. Ludendorff comes in for a certain implied criticism in that he failed to see the importance of the subject and considered them of less value than a regular supply of guns, trench-mortars, machine-guns, etc., whilst the number of mechanics employed on U-boat and aeroplane construction was not interfered with. Von Wrisberg is emphatic in his opinion that isolated tanks constitute no formidable danger.

This volume does not please all its critics. Captain Jussrow, writing from a technical man's point of view, has a tilt at the " altpreussische Geist " as illustrated by the German Corps of Officers in general and by General von Wrisberg in particular. He complains of a lack of technical foresight before the war and a lack of recognition of the services of technical officers during and after the war.

Volumes 4 and 6 of the official series *Schlachten des Weltkrieges*, 1914–1918, have appeared and are reviewed by General Schwarte. Volume 4 deals with the capture of Novo-Georgievsk. Volume 6 describes the fighting on the Lorraine front, " von Nancy bis zum Camp des Romains " in August and September, 1914. The German lack of success and heavy losses on that front are attributed to faulty deduction from the capture of Liége and Namur.

It is stated that the 6th and 7th armies were given none of the information which had been collected in peace regarding the armament or organization of the French defensive arrangements, and the opinion is advanced that reserve and territorial formations should have, if anything, more artillery than first line troops, instead of less, as was the case with the German troops engaged.

H. ST. J. L. WINTERBOTHAM, *Colonel.*

REVUE MILITAIRE GÉNÉRALE.

July, 1922.

The Revision of the Regulations embraces the seventh period, *i.e.*, from the commencement of the Allied offensive on 18th July to the signing of the Armistice on 11th November, 1918. The conditions under which the German offensive in the spring was opposed are first described.

I.—*The First Battle in the Open.*—On 21st March the Germans succeeded in forcing a way through to open ground, and the French troops hastened up to fill the gap, and not trained as the Germans had

been, were inexperienced in this type of combat after their three years of position warfare. Want of information, or at least uncertainty as to the enemy's movements was at first a great difficulty; events succeeded each other very rapidly. In these circumstances plans should be based on the commander's intentions rather than on the situation of the enemy, and orders issued in short general terms, leaving details to be worked out by the junior commanders, especially in the case of the improvised defensive. Moreover, the fronts held by the larger formations were more extended than in the war of position, and tended to be split up into fighting groups, separated by intervals covered by fire alone. Infantry experienced a feeling of isolation to which they had to grow accustomed, since they could no longer depend on the immediate and constant support of artillery, which either could not come into action at once, or, when in action, had not always ammunition sufficient for the multifarious duties lately demanded from it in position warfare. In nearly every division the distribution of the guns was revised; in some they were under the orders of the Divisional Commander, in others at the disposal of the infantry regiments in front line. The telephone as a means of communication failed entirely, and artillery, as a general rule, had to be contented with the 1/80,000 map for all purposes.

On the other hand, the enemy's artillery fire was no longer so powerful, and concentrations of gas-shell were not to be feared, so that it was possible, within reasonable limits, for the infantry to take greater risks. Still, the inaptitude of the troops for open warfare was marked; the higher commanders issued orders in too great detail and frequently too late to be of use, the infantry had almost lost the idea of manœuvre and kept looking for the support of artillery, while the only activity acquired by the last-named was that of precision achieved by processes inapplicable in a war of movement. It could not make use of the ground, and, deprived of telephones, showed little dash, awaiting accurate information before firing and losing many favourable opportunities. The junior commanders, so long deprived of initiative, hesitated to come to decisions based on the necessities of the moment, although events at Verdun and on the Somme had shown that, after the first assault, battle would have to be engaged on, or against, improvised positions.

General Foch directed the commanders of the Allied Armies towards essentially active warfare, in which the formal procedure of the Instruction of 31. 10. 17 would be no longer applicable. To General Pétain he wrote, " Our offensive must not aim at objectives limited of our own free will . . . if we attack it must be to beat the enemy and disorganize him as much as possible, and the battle entered upon with this object must be as rapidly as possible pushed home as far as possible, and not aim simply at ameliorating the situation of the moment. . . ." However, this doctrine could not be stated in full till rather later—*Directive* No. 5 of 12th July, 1918—on the eve of the general resumption of offensive operations by the Allies.

II.—*Return to Simple, Bold and Rapid Procedure.*—*Directive* No. 5 of 12th July, 1918, completed by a Note of 6th November, 1918, defines the new conception of offensive operations, and the *Instruction* of 31. 10. 17, was now only considered as " a collection of technical in-

structions from which a commander is at liberty to make a choice." Simple, bold and rapid action will ensure strategic surprise by secrecy in the preparations, tactical surprise by suddenly delivered attacks, deep penetration and an immediate and far-reaching development of the success by rapid and sustained pressure. The *Directive* enjoins secrecy as a point of honour on all ranks, and recommends short, concise orders, leaving the means of carrying them out to the initiative of the recipient. The artillery preparation will be as short and violent as an ample supply of heavy quick-firing guns, using gas and smoke shell for neutralizing the opposing forces, will admit of, and can even be omitted if tanks can be counted upon. Rapid progress depends not on an increase of pace, but on rapidly surmounting obstacles; deep progress on aiming from the outset at a distant objective without any *a priori* restriction due to thoughts of ill success. The prompt capture of the ground occupied by the enemy's artillery is the best guarantee of rapid and deep progress. To exploit the success reserves must be employed to ensure sustained effort and prevent the enemy from re-establishing his situation. When a breach is to be made, infantry divisions should cover fronts of 2,000 metres or less. From the infantry is demanded initiative, boldness, and flexibility, an advance in communication with neighbouring troops, but without exact alignment, and faith in the possibility of exploiting its first success with its own resources in armament without artillery support. Artillery will afford infantry as constant and powerful support as possible, and it may be useful to place batteries or sections at the disposition of divisional, regimental, or battalion commanders. This procedure, already practised in the defensive, was employed during the French offensives with general satisfaction, so much so that a Note of 25th October, 1918, promulgated rules for the more efficient utilization of guns accompanying infantry, and for their rapid centralization in the hands of the divisional general or *vice versa*. A Note of 6th November revised these rules to ensure continuity of action, especially if the enemy made a definite stand, and to check a tendency to too great decentralization leading to disjointed local actions. *Directive* No. 5 thus returns to sound principles from which an extended period of stabilization and defective means had compelled departure. The attempt of the same nature made at the end of 1916 unfortunately failed owing to lack of means and modification of the doctrine, or the operations of 1917 might have been more decisive.

III.—*Application to the Offensive Operations in* 1918 *and Open Warfare.*—Here follows a short summary of the Allied offensive, which opened on 18th July with a brilliant counter-attack long prepared for by General Foch. By intelligent application of the principles enunciated above the Allies finally brought the war to a conclusion, and the Armistice was signed on 11th November, 1918. At this date the Allies had 205 divisions in the field, of which 103 were in reserve, while the Germans had 184 only, of which 17 in reserve.

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